Ansökan om bidrag till forskningsprogram från Naturvårdsverkets miljöforskningsanslag

AVFALL	KLIMAT	FRILUFTSLIV	LUFTFÖRORENINGAR **X**

Programtitel (svenska) **Ren luft i Sverige**			Kommunicerbart namn (svenska) **SCARP**		
Programtitel (engelska) **Swedish Clean Air Research Program**			Kommunicerbart namn (engelska) **SCARP**		
Sökande Efternamn Grennfelt	Förnamn Peringe		Födelseår 1944	Kvinna	Man X
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	2006	2007	2008	2009	Total
Ansökt belopp i **tusentals SEK** (kSEK) För fas 1 (36 mån ber. start 1 sept 2006).	2 000	6 000	6 000	4 000	18 000

Sammanfattning på svenska (ska överensstämma med den engelska, max 1500 tecken inkl. blanksteg):

Ren Luft i Sverige (SCARP)

Målsättningen med forskningsprogrammet Ren Luft i Sverige (SCARP) är att stärka det vetenskapliga underlaget rörande luftföroreningar och luftföroreningars effekter och att ge ett stöd till politiska beslut i Sverige och Europa. Vi föreslår ett sexårigt forskningsprogram med start 2006 och med en årlig budget på 6 MSEK.

Programmet inriktas mot fyra områden:

- Hälsoeffekter, där målsättningen är att öka förståelsen av vilka parametrar som är betydelsefulla för observerade hälsoeffekter och att vidareföra resultaten in i arbetet med internationella hälsoriskuppskattningar och för att sätta luftkvalitetskriterier.
- Att genom mätningar, datautvärderingar och modeller bidra till den vetenskapliga förståelsen av partiklars uppträdande i atmosfären samt till utveckling av källa-receptor samband.
- Ekosystemeffekter, där målet är att ytterligare utveckla och sammanfoga modeller för kemiska och ekosystemeffekter (biodiversitet) till följd av atmosfäriskt nedfall av kväveföreningar.
- Integrerade beslutstödsmodeller, där målet är att bidra till utvecklingen av integrerade åtgärdsmodeller, speciellt inom området icke-tekniska åtgärder och för tillämpning av sådana modeller för Sverige och omgivande områden.

All forskning kommer att utföras i nära samarbete med relevanta internationella organ inom luftvårdsområdet, inkluderande CLRTAP, WHO och organisationer inom EU.

Ansökan om bidrag till forskningsprogram från Naturvårdsverkets miljöforskningsanslag

Summary in English (max 1500 characters):

Swedish Clean Air Research Program (SCARP)

The aim of the Swedish Clean Air Research Program (SCARP) is to increase the scientific understanding of air pollution effects to human health and environment with the aim to support policy development in Sweden and Europe. We propose a six-year program, starting in 2006, with a yearly budget of 6 MSEK.

The program is directed to four areas:

- To assess health effects related to short- and long term exposure to ambient air pollution relevant for the Nordic countries. Particular emphasis is put on effects associated with exposure to particles from sources, such as road traffic, local wood burning and long range transport
- Particles, where the objective is to give significant contributions to the understanding of the behaviour of particles in the atmosphere and the quantification of source-receptor relationships through measurements, data evaluation and modelling.
- Ecosystem effects, where the objective is to further develop models related to chemical and ecosystem effects from deposition of N compounds. In particular, research will be directed towards N processes and responses in terrestrial systems.
- Contribute to the development of integrated assessment models (IAM), in particular the inclusion of non-technical measures and the application of IAM models for Sweden.

All scientific work will be done in close collaboration with relevant international bodies for the development of air pollution policies, including CLRTAP, WHO and organisations within the European Union.

Datum och sökandes underskrift	Datum och underskrift av prefekt eller motsvarande med namnförtydligande
Peringe Grennfelt	Peringe Grennfelt

Ansökan ska bestå av tre delar: denna ansökningsblankett; programplan (max 20 sidor) med bilagor (varje projektbeskrivning på max 4 sidor); CV (max 2 sidor vardera). Ansökan ska vara inne hos Naturvårdsverket senast den **10 april 2006**. Den fullständiga ansökan skickas sammanhäftad och på hålslaget papper (original och 12 kopior) till **Naturvårdsverket, Forskningssekretariatet, 106 48 Stockholm**. Ansökan ska även skickas elektroniskt till ansok@naturvardsverket.se. Den elektroniska ansökan ska bara omfatta två dokument: denna ansökningsblankett; en pdf-fil med programplan, bilagor och CV.

Bilagor

1. Program description
2. Project descriptions
3. Short CVs of the main program participants

Appendix 1

SCARP

Swedish Clean Air Research Program

Frisk Luft i Sverige

Program description

Proposal to the Swedish Environmental Protection Agency

Programme co-ordinator: Peringe Grennfelt, Swedish Environmental Research Institute, PO Box 5302, 40014 Göteborg, Sweden. Tel +46317256234, Email: grennfelt@ivl.se.

Project leaders:
Human health: Tom Bellander, Bertil Forsberg, Anna-Carin Olin, Göran Pershagen, Thomas Sandström, Gerd Sällsten
Particles: Hans Christen Hansson, Christer Johansson, David Simpson, Valentin Foltescu
Ecosystems: Cecilia Akselsson, Salim Belyazid, John Munthe, Filip Moldan
Integrated assessments: Mohammed Belhaj, Salim Belyazid, Catarina Sternhufvud, Stefan Åström

10 April 2006

Abstract

The aim of the Swedish Clean Air Research Program (SCARP) is to increase the scientific understanding of air pollution effects to human health and environment with the aim to support policy development in Sweden and Europe. We propose a six-year program, starting in 2006, with a yearly budget of 6 MSEK.

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The Objective

The overall aim of the Swedish Clean Air Research Program (SCARP) is to increase scientific understanding of air pollution effects to human health and environment and to support policy development on a national and European scale. Our aim is to

- Deliver well documented scientific evidence within key areas on the behaviour of pollutants in the atmosphere and on the effects to human health and ecosystems.
- To participate and interact with national and international bodies supporting the development of science-based air pollution policies,
- To develop tools in order to support integrated assessment approaches on air pollution.

The Problem

Air pollution is still an issue of major concern in Europe. Upcoming EU legislation and revisions of CLRTAP protocols are expected to improve the European air pollution situation significantly but they will not be sufficient to solve the problem. The citizens in Europe will still suffer from adverse health effects related to air pollution such as particles and ozone and the threats to ecosystems from nitrogen deposition will still be large. Remaining effects due to historical deposition of acidifying substances will also be substantial.

Science has always been an important driving force for air pollution policy and control. For example, the epidemiologic evidence generated during the last 10-15 years has lead to a major reassessment of air pollution standards. An increased understanding of soil processes has formed the basis for the inclusion of recovery in air pollution policies. Long-term dedicated scientific research is therefore important for the general understanding, for setting control priorities and for verification of the effectiveness in control. Sweden has played an important role in this development and has over a period of more than 30 years formed a scientific community of high international standard. Today most of this research is done through or in close collaboration with the research programs SNAP[1] and ASTA[2].

Scientific support will still be of crucial importance in the development of future air pollution policy, in particular within areas where uncertainties are large and where there is a need for long-term data. The program outlined in this proposal is intended to build on the well established scientific research and international contacts within the ASTA and SNAP programs. Furthermore, it will take advantage and use results and experience developed in the national sector-oriented research programs BHM[3] and EMFO[4]. It will also build on a well-developed international collaboration, in particular within EU-supported research projects. The involved research groups are also well positioned in relation to priorities indicated in the outline of the 7th Framework Research Program, expected to start within a year.

The proposed program will meet all the requirements in the call. It should be seen in relation to ongoing policy-related activities within the European Commission, in

[1] SNAP Swedish National Air Pollution and Health Effects Program: http://www.snap.se/.
[2] International and National Abatement Strategies for Transboundary Air Pollution: http://asta.ivl.se.
[3] "Biobränsle Hälsa Miljö" a research program financed by the Swedish Energy Agency.
[4] EMFO "Emissionsforskningsprogrammet. A research program financed by *i.a.* Swedish Road Administration, the car manufacturing industry and the Swedish Environmental Protection Agency.

particular the Clean Air For Europe (CAFE) initiative[5], the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the Swedish Environmental Objectives. The EU and UNECE activities are in a phase of policy development and revisions and the scientific research outlined in this proposal is not expected to influence these processes, which are expected to come to a decision within 1-2 years. Instead, the proposal is directed towards the support of further revisions of directives and protocols and towards the implementation of the international agreements. Such revisions may be expected in the period 2010 - 2012. It is expected that these revisions will focus on issues related to health effects from particles and ozone, nitrogen deposition and its effects on biodiversity and intercontinental transport/hemispheric air pollution. The link to climate change (both with respect to emission control and environmental effects) is also expected to be brought into the strategies. In addition, uncertainties are expected to play a more important role. This proposal aims to give support to all the mentioned aspects except the intercontinental/hemispheric dimension.

The program will also highlight national needs, in particular in relation to the Swedish environmental objectives (miljömålen)[6]. The project will support at least three environmental objectives: *Clean air, Natural acidification only* and *Zero eutrophication*. These objectives are not expected to be fulfilled within the next decade. International agreements (e.g. the NEC directive) should also be implemented in Sweden and the outlined research is intended to contribute to the implementation. It will also have connections to the environmental objective *Reduced climate impact*, both through the consideration of links between air pollution and climate change in the atmosphere and ecosystems but also through the inclusion of combined climate and air pollution measures in research on integrated assessment modelling.

Air pollution issues

Air pollution is considered a major threat to man and ecosystems in Europe. European Union points in their 6th Environmental Action Programme to environmental and health and quality of life as main priority areas for its further work. The overall aim of the action plan is to set out long term priorities for the environment. Air pollution was given particular emphasis as being one of the seven thematic strategies.

The thematic strategy has been developed under Clean Air For Europe (CAFE). Its first strategy report was presented in September 2005, in which European objectives for 2020 were set out[7].

Human health is the main driver of the European air pollution policies today. Particulate matter has been identified as an important causative agent for adverse health effects. However, there are still large uncertainties with respect to which characteristics of the particles that determine the effects. A better understanding of underlying mechanisms and source related health risks is urgently needed. Identification of susceptible groups and assessment of health effects from long term exposure are particularly important.

Significant progress in air pollution research with relevance for the health risk assessment has been made within the SNAP programme. For example, new findings

[5]http://europa.eu.int/comm/environment/air/cafe/index.htm
[6] http://www.miljomal.nu
[7] Thematic Strategy on Air Pollution. COM(2005) 446 final. Brussels 21.9 2005. Commission of the European Communities.

on particle exposure in urban areas were produced as well as on airway and cardiovascular effects by diesel exhaust in patients with chronic obstructive lung disease. Furthermore, long term exposure air pollution generated by motor vehicles seemed to increase the risk of airway disease, allergy and lung function effects in children as well as of mortality from myocardial infarction. However, there is a need to better characterize health effects of particles from different sources, both in relation to effects of short-term and long-term exposure.

Atmospheric models. Presently there is no policy-related model that can give a satisfactory description of the atmospheric concentrations of particle matter (PM2.5 and PM10) for Europe. This induces large and unnecessary uncertainties in the estimates of the general health effects due to anthropogenic particles. A better theoretical understanding of aerosol formation and dynamics in the atmosphere is urgently needed both for the assessment of effects and for the development of cost-effective control strategies.

Ecosystem effects. The negative environmental impacts of acid rain have decreased greatly in recent years, mainly due to emission reductions of sulphur dioxide in Europe. Today the N-compounds dominate the anthropogenic deposition and contribute to both acidification and eutrophication. Together with potential interactions with changes in climate and land use, the N-deposition poses a risk for terrestrial and aquatic ecosystems that is difficult to assess, especially in a long term perspective.

Integrated assessments. Present policy processes are to a large extent based on quantitative estimates of the relations between economic activities, emission control options and effects to human health and environment. The main instrument for policy advice is Integrated Assessment Modelling (IAM). The Regional Air Pollution Information and Simulation (RAINS) model is developed by the International Institute for Applied System Analysis (IIASA) and is frequently used in the development of air pollution strategies within the framework of CLRTAP and CAFE. More recently an extension of the RAINS model has been developed to include air pollution and greenhouse gases in the same model[8]. Sweden has been active in supporting the development of IAMs but have not so far made use of the models in national assessments and strategies.

Climate change. Climate issues are becoming increasingly important both with respect to observed effects and with respect to policy development. We intend to further elaborate both these aspects in the program.

Connections to ongoing research

National research

The EMFO program

In 2003, the Swedish automotive industry together with Swedish Road Administration and the Swedish Environmental Protection Agency started a five year research program called EMFO (Emissionsforskningsprogrammet) on emissions and emission control from motor vehicles. The objective of the EMFO research program is to support Swedish industry and Swedish authorities with state-of-the-art knowledge on air pollution and noise emissions in order to develop vehicles to meet future needs.

[8] The Greenhouse Gas and Air Pollution Interactions and Synergies model (GAINS). For more information see http://www.iiasa.ac.at/rains/index.html

The program has given priorities to particles. We intend to have a continuous contact with the EMFO program.

The SNAP program
SNAP (Swedish National Air pollution and health effects Programme) funded by the Swedish Environmental Protection Agency and was initiated in 2001 and will finish in 2006. Close to 30 different projects were included focussing on exposure assessment, risk estimation and mechanisms of toxicity. The aim was to characterise population exposure to air pollution from different sources, to generate quantitative estimates of various health risks related to short-term and long-term exposure to air pollution, and to identify susceptible groups of the population in relation to health effects of air pollution. The health section of the SCARP programme will draw heavily on the experience gained in SNAP.

The ASTA program
The Mistra.funded research programme ASTA (Abatement Strategies for Transboundary Air pollution) started in 1999 and will finish in 2006. Its main aim is to run scientific research projects to support air pollution policy development under the European Union and the Convention on Long-Range Transboundary Air Pollution. The aim is also to support the national policy work, in particular in relation to the national Environmental Objectives. SCARP will build on research on long range transport of particles, ecosystem effects from acidification and eutrophication and the development of integrated assessment tools.

The ecosystem research is also connected to problems associated with forestry and extraction of biomass from forests. This research is mainly supported by the Swedish Energy Agency and the Swedish Forest Agency.

International research

The partners of the consortium have for a long time been involved in international scientific projects involving several research organisations, often financed by the European Commission. There are several programs within FP6 that will give support to the SCARP program as mentioned below. In addition, support to the SCARP program will greatly enhance the competitive edge of participating groups and the possibilities for obtaining additional funding for air pollution research from other sources, e. g. the European Commission.

The Consortium will have close contacts and collaborate with relevant international bodies including WHO, ICPs, Task Forces and expert groups under the CLRTAP and expected initiatives under the second phase of CAFE.

Key international collaboration partners and projects

Health

The health section of SCARP will benefit from the extensive collaboration between the participating Swedish groups and several internationally leading groups in air pollution research, primarily in Europe. In particular, this collaboration has developed in the framework of many large multinational projects funded by the European Commission. Some examples include the APHEA projects, AIR ALLERG, HEAPSS and AIRGENE. Currently there are plans for extensive European collaboration in cohort studies focussing on air pollution intended for support within FP7. Furthermore, several members of the team have participated in international risk assessment activities coordinated by WHO and EU.

Particles
The scientists within the research area *Regional and national atmospheric models for particulate matter* have an extensive international co-operation. Several of the groups are partners in the EU FP6 Network of Excellence ACCENT. Further ITM and LU are partners in the Nordic Centre of Excellence, BACCI. David Simpson in the GU group is a member of EMEP's modelling group at MET-NO. This will give the necessary exchange and cooperation with the leading aerosol modelling group, as at the Helsinki Universty, led by Markku Kulmala and the necessary framework for implementing the developed modules in the EMEP- model. Further the modelling work will be presented and discussed within the integration task group on modelling in ACCENT, led by Ivar Isaksen, University of Oslo. Valentin Foltescu and his group at SMHI are involved in GEMS (Global and regional Earth-system Monitoring using Satellite and in-situ data), an Integrated Project coordinated by ECMWF. In 2006-2009 the GEMS project will extend forecast capabilities to atmospheric composition on the global scale and will improve regional air quality forecasts, hindcasts and analyses across Europe with a strong emphasis on aerosol particles. The MISTRA-funded project on "Development and application of analytical methods for characterisation of organic aerosol particles" includes measurement campaigns in cooperation with a number of international institutes, detailed analysis of OC composition, levoglucosan, C14 analysis, and flux-measurements of particle number over Göteborg. This project should provide good data for evaluation of new models for predicting PM levels in urban areas.

Ecosystem effects.
There is an increasing international interest in nitrogen. The increasing interest is related to the increasing anthropogenic fixation of nitrogen, both within the agricultural sector and from combustion. The level of nitrogen fixation as well as the overall fate of nitrogen is still poorly understood and there are several activities started and underway in order to give a more comprehensive picture of the nitrogen fluxes and fates on different scales. In Europe, COST and ESF have both started projects with the aim to prepare assessments of the nitrogen problem. The COST activity is directed towards a better understanding of atmosphere-biosphere nitrogen fluxes in Europe in relation to the main economic sectors, interactions with the natural environment and current policies, in order to establish a sound scientific basis for strategies to reduce the environmental impacts of nitrogen[9]. The ESF project is directed towards more genuine scientific issues and takes a broader view. Issues of particular importance are links between different media (the cascade effect), interactions with climate change and effects on biodiversity. A just started EU project, NitroEurope, with the aim to study SCARP will contribute and take advantage of these activities.

A recently started EU project NitroEurope, will also include important aspects on nitrogen, and activities within SCARP will link up to this project. There are also plans for a larger EU project on N effects on biodiversity udner FP7 and we intend to take part in proposals.

Integrated assessments.

The most important international partner will be IIASA, as the GAINS model constitutes the base of the integrated assessment sub programme. A close collaboration with other countries which are developing or already have their own national IAMs, such as the Netherlands (MNP) and Italy (ENEA) will also be valuable. An informal network of international researchers involved in national IAM has already been suggested. There are also discussions on a joint effort to develop a Nordic integrated assessment model. If such an initiative will be taken, there will probably be changes in the program plan, especially for phase 2.

Organisation

The project will be organised in four topic areas and an administrative unit responsible for co-ordination and overall communication. We also foresee a

[9] http://www.cost729.org/

Reference "Steering" Group with the objective to support the leadership of the program, involving national policymakers and experts participating in international and national policy-making. This part of the organisation will be developed in collaboration with the Swedish EPA.

The program will be lead by a program manager, responsible for the overall program and that the different parts of the program are fulfilling their scientific, economic and communication objectives. The program will also have en "executive board" comprising the program co-ordinator and the leaders of the four thematic areas and the program communicator. This group will take the overall responsibility for the development of the program in terms of scientific planning, yearly reports, communication, gender issues etc. The board will meet approx. three times a year.

The program will have a yearly two-day meeting inviting all scientists involved in the program. At this meeting results will be presented and discussed.

Scientific day-to-day work within the themes will be co-ordinated by the team leaders.

Competence of the Consortium

The Consortium will build on competence and scientists involved in the ongoing SNAP and ASTA programs. Most of the key scientists will also have important roles in the new program. Through merging the ASTA and SNAP programs, the competence will be broadened and cover practically all aspects in relation to the work under CAFE or CLRTAP.

The group of scientists behind this proposal has also been involved in the support of international policy development in Europe with scientific expertise for several years. It consists of well-established scientists with long experience in international collaboration. The consortium is not only ready to take the responsibility of the scientific fulfilment of the program but also to make sure that the results are presented at relevant international policy forums.

Gender issues

Both the SNAP and the ASTA programs have an unbalanced gender distribution with a large excess of male scientists. With the overall aim to build on already existing competence and networks, there is only a limited ability to change the situation with respect to the gender situation shortly. Some groups will take important steps forward already in this proposal but for others, it will take some time before the situation will change. The participating groups are also obliged to follow the policies in their own organisations to establish better gender equality[10]. A specific gender program will be set up to at least partially correct the imbalance within the program period.

At present 6 out of 24 (25%) main scientific projects will have women as leaders covering 24% of the budget.

Research activities

We have decided to divide the program in four research areas according to the call. These areas should not be seen as research fields isolated from each other. Instead

[10] See for example http://ki.se/content/1/c4/04/99/jamstalldhetspolicy.pdf and

there are several relations in particular between area 1 (health) and area 2 (particles). Area 4 will also be closely connected to all the other areas in terms of the development and application of integrated assessment tools.

Area 1: Exposure and health effects

Objective To assess health effects related to short- and long term exposure to ambient air pollution relevant to the situation in the Nordic countries. Particular emphasis is determination and quantification of effects associated with exposure to particles from different sources, such as road traffic and wood burning locally as well as long range transport.

Participating organisations The principle researchers in the area of particulate and health are: Anna-Carin Olin and Gerd Sällsten from Göteborg University, Tom Bellander and Göran Pershagen from Karolinska Institutet as well as Bertil Forsberg and Thomas Sandström from Umeå University. Collaboration between these centres is well established and developed within the SNAP program, and the area will be coordinated by Göran Pershagen.

Evaluation of exposure and health effects related to particles from different sources and with differences in characteristics. Various regions in Europe differ in the relative importance of local, regional and international sources of air pollution, due to differences in geography, meteorology, population density and industry. In Sweden, important contributions to the population exposure load from air pollution come from all these sources. Our use of studded tyres adds a road-surface related source virtually absent in most other countries. Solid-fuel burning is increasing rapidly in the Nordic countries, although it is present also in several other European regions. In the present legislation, all particulate air pollution (as PM10) is treated as equally harmful.

There is, however, a great need for studies that can separate health effects of particulate air pollution from different sources. All the 12 studies we propose aim at contributing to this, either in experimental setups with controlled exposure, or with source specific modelling of the population exposure. The different sources of particulates that will be possible to distinguish include road traffic, vehicle exhaust from different type engines, tyre wear, road dust, wood smoke, and long range transport from different regions.

Health effects caused by air pollutants related to short-term variation in levels and sources. The short-term relation between air pollution – mostly particular air pollution – and mortality has been well studied in many urban areas, although not extensively at moderate air pollution levels as in Sweden, and has greatly contributed to the understanding that present levels of air pollution may cause serious health effects. Because these studies cannot quantify the mortality displacement, there is consensus that the impact of air pollution-related mortality should be evaluated from long-term studies only.

There is however a number of less serious health effects that are inherently transient. But not all acute effects are “visible” in readily accessible databases. The acute effects of particulate air pollution are thus believed to be only partially described, but may constitute a considerable burden of disease even at moderate air pollution levels as in Sweden. The representativeness of population exposure data has been questioned, and there is some evidence that the effect of local sources is systematically underestimated and correspondingly the disease burden. Also, the differences in susceptibility to

health effect from air pollution between different parts of the population are less well described.

We propose seven studies which will investigate short-term effects on health from particles, either in experiments or in the population. The differences in susceptibility to health effect from air pollution between different parts of the population will be described. The studies are experimental using test systems as well as human volunteers, and observational of panels, focussing on markers of inflammation, and observational of the general population, focussing on susceptible subgroups. They will show differences in toxicity between particles of different origin as well as differences in airway and systemic inflammatory response, and local cardiovascular effects in humans exposed to wood smoke and engine exhausts. Differences in risk of acute events according to previous disease status or source characteristics will be further explored.

Studies of long-term effects from air pollution using existing study populations. Mortality is the most important health effect from air pollution in existing impact and health-economy studies, that currently drive policy, and there is consensus that the impact of air pollution-related mortality should be evaluated from long-term studies only. There are however only a handful of studies of long-term effects, most of them performed in North America. Recent European data confirm the presence of long-term effects, but considerable doubt remains on the quantification of the effects, as well as on modifying factors. Other long-term effects that may carry high costs of illness include incidence of asthma and COPD in adults, and long-term effects on children's lung functions, allergy and airway diseases.

Five of the proposed studies focus on long-term effects, primarily based on already assembled study populations, both adults and children. We will study lung function development in children, asthma, COPD, chronic inflammation, myocardial infarction and cancer in adults, as well as causes of death. Interaction between exposure to particulate air pollution and genes will be possible to evaluate in two of the studies.

Relevance The achieved knowledge may be used to develop more specific measures against specific source categories, and a differentiation of ambient standards according to source-specific characteristics as particle size and chemical composition. Health effects from typically Nordic particles are well covered. The results will be useful not only in the understanding of the mechanisms of air pollution causing health effects, but also in devising specific measures to protect the most susceptible parts of the population. The proposed long-term studies will greatly contribute to the quantification of such effects, as well as to which modifying factors are important in the Nordic countries.

Budget The budget frame required for the proposed research on particulate and health is a total of 12,3 MSEK over a 6 year period

Area 2 Regional and national atmospheric models for particulate matter

Objective: Develop and validate modes for particulate matter (PM), from urban to regional scales for the assessment of effects to human health and climate.

Participating institutions: Stockholm University (HC Hansson, Peter Tunved, Christer Johansson), Swedish Meteorological and Hydrological Institute (Joakim Langner, Valentin Foltescu), Lund Institute of Technology (Erik Swietlicki), Chalmers / Gothenburg University (Mattias Hallqvist) and Norwegian Institute of

Meteorology / EMEP (David Simpson). HC Hansson will act as subprogram co-ordinator.

The problem: Today, health effects can only be addressed through PM-concentrations as policy-relevant models (e.g. the EMEP model) are lacking a detailed description of other parameters, e.g. particle size distributions of inorganic components, black and organic carbon (possibly related to health effects, as indicated by the WHO review for CAFÉ). The EMEP model is presently limited in its ability to provide data for use in health studies.

The concern on how interaction between air quality and climate change is growing as it is recognized that a changing climate influences atmospheric concentrations as well as deposition of air pollutants. Further, it is also recognized that anthropogenic particles might have a considerable climate forcing, at least in the major industrialized parts of the world, including Northern Europe. The EMEP model is not yet prepared to deliver necessary input parameters for such climate forcing calculations.

The research proposed in this program area aims at improving understanding of aerosol particles' importance for health effects by the ability to reproduce both the number and the mass concentration distributions of the multi-component atmospheric aerosol. The project will also enhance the scientific understanding of the source-receptor relationships as a result of including explicit formulation of in-situ particle formation (nucleation) in addition to the direct emission of particulate matter.

The following sub-goals have been identified:

1. To develop and validate a robust module describing the chemical (including organic) PM fraction and its relation to natural and anthropogenic sources.
2. To make a comprehensive description of particle dynamics ready to be implemented in a 3D Eulerian model
3. To make an evaluation of present urban models, concerning their description of particle size distributions and related chemistry.
4. To describe a methodology on how to develop and construct emission databases for dynamic particle models.

Sub-projects:

The overall aim of the urban and regional scale modelling work is to develop evaluated modules dealing with both dynamics and chemistry, which ca be applied in 3-D models for the prediction of health-related PM data. As a basis for this, we will make use of a comprehensive "reference" modelling system against which to develop and evaluate computationally efficient models, which can be used in 3-D models. The reference scheme will be based upon existing models from e.g. the University of Helsinki or U.S. groups, and modified as necessary. The same reference model will be used in sub-projects (1) and (2), with a focus on chemistry in sub-project (1) and on dynamics in sub-project (2). These two sub-projects will interact continuously, with frequent exchange of routines in order to merge the chemical and dynamical methodologies into one module.

1/ Further develop and validate a model describing the chemistry of aerosols, with a focus on the organic fraction of PM. The final description should be able to use for the calculation of the organic mass fraction in 3D Eulerian models.

The work should focus on development of chemical schemes, which can be applied within MATCH and EMEP. Evaluation will be against the comprehensive reference model and against measurements, e.g. those of the EMEP EC/OC campaign, EU

CARBOSOL project. The evaluation will also be done in co-operation with a MISTRA-project on organic aerosols co-ordinated by GU and MET.NO and the recently funded FP6-infrastructure project EUSAAR, which develop and coordinate measurements at 20 super sites in Europe. Additional measurements of 14C to determine the fractionation between fossil and recent carbon might be added. SU and LTH are partners in EUSAAR.

2/ Develop descriptions of dynamic particle processes.

The aim is to describe how the emissions influence the number, mass and chemistry of the atmospheric particles with high spatial and temporal resolution.The work should be conducted in close co-operation with sub-project (1) with the specific objective to develop and evaluate a computationally fast aerosol dynamics module, capable of simulating the aerosol size distribution and composition in the framework of 3D Eulerian models (MATCH and EMEP) on local to regional scale.

Detailed process descriptions are already evaluated in Lagrangian studies, which will be used in the evaluation of suitable parameterizations that can be implemented in the 3D models. The first dynamic formulations have been implemented in the EMEP-model in earlier and ongoing NMR-projects (NORPAC) and in the MATCH-model. The proposed work will focus on tracking the number, mass and composition of particles simultaneously. The main processes involved in aerosol dynamics are nucleation, condensation/evaporation, coagulation, deposition and cloud interactions. The above processes will be coded and validated against the reference modelling system (outlined above) and the available size resolved and chemically resolved aerosol data (same as in sub-project 1).

3/ Construct emission databases for dynamic particle models and validate urban models concerning particle size distribution and chemistry.

The aim is to develop source specific particle-size resolved emission factors for both number and mass. The emission factors will be implemented in an emission database suitable for both urban and regional particle dynamic models that should describe how the particle-size distribution develop and disperse over an urban area. This will be input for larger scale modelling of the urban plume, how it develops on a mesoscale and regional scale. The importance of aerosol dynamic processes for urban scale modelling will also be evaluated and the dispersion model calculations will be validated by comparison with observations.

Relevance

The suggested program aims first at developing an operation model giving a satisfactorily description of the natural and anthropogenic organic particle fractions. This should be done in close co-operation with EMEP / MET-NO. Further shall the program develop a dynamic particle model with suitable emission data base that can be used for evaluation of health effects of single and combinations of different particle components. The model should be useful for calculation of climate forcing by particulate air pollutants.

Budget estimate: 8,0 million SEK over the program period.

Area 3 Ecosystem impacts of air pollution - nitrogen and acidification

Objective The objective is to improve our understanding of short and long term effects of nitrogen deposition with respect to recovery from acidification, biodiversity

and eutrophication and to provide scientific support for measures to reduce negative impacts on the environment.

The following sub-goals have been identified:

- To further clarify the role of nitrogen accumulation in acidification and recovery of forest soils and surface waters
- To evaluate and further develop dynamic models for nitrogen in forest ecosystems including-vegetation interactions.
- To assess impacts of climate change and forestry on leaching of acidifying and eutrophying substances from forest soils.

Participating institutions IVL Swedish Environmental Research Institute (John Munthe, Cecilia Akselsson, Filip Moldan, Olle Westling); Lund Institute of Technology (Harald Sverdrup); Umeå University (Lars Ericson); Swedish University of Agricultural Sciences (Annika Nordin, Annemieke Gärdenäs, Stefan Löfgren, Henrik Eckersten); SkogForsk The Forestry Research Institute of Sweden (Lars Högbom). John Munthe will act as a subprogram co-ordinator.

The problem The negative environmental impacts of acid rain have decreased greatly in recent years, mainly due to emission reductions of sulphur dioxide in Europe. Today The present and future anthropogenic deposition, after the reduction of SO2 emissions, is dominated the by N-compounds dominate the anthropogenic deposition and that contribute to both acidification and eutrophication. The predicted reductions of N emissions in Europe to 2020 are relatively limited. Together with potential interactions with changes in climate and land use, the N-deposition poses a risk for terrestrial and aquatic ecosystems that is difficult to assess. Such assessment is especially difficult in a long term.

Methodology We propose to organise the work in three main areas: Core activities

1. Nitrogen cycling in forest soils. This activity will mainly focus on existing field experiments and observations and assessment of data related to nitrogen accumulation, leaching and transformations. Links to carbon cycling will also be established. Primarily the existing experimental data will be mined, complementary measurements and investigations may be performed if relevant. Potential field experiments include Gårdsjön NITREX, Skogaby, low dose fertilisation experiments as well as terminated N fertilisation experiments in areas with low background N deposition, and integrated monitoring areas.

2. Dynamic nitrogen model development and evaluation. This activity will focus on refining dynamic models for acidification and eutrophication of forest soil and runoff (such as MAGIC, INCA-N, SOILN and ForSAFE) by including an improved parameterisation for nitrogen cycling. It also includes extensive testing and evaluation of the ForSAFE Veg model for vegetation response. This activity will be based to a large extent on the findings of area 1. It will also involve a review of other existing model concepts and data on interactions between biogeochemistry and vegetation.

3. Impacts of forestry and climate change on N and S cycling. This activity will draw heavily on the results of activities 1 and 2 as well as results from on-going research projects (e.g. EU project Eurolimpacs, www.eurolimpacs.ucl.ac.uk/). Experimental and field observations of impacts of forestry and climate change on S- and N-cycling in forest soils and runoff will be used to calibrate and test models. The models will then be applied to future scenarios of climate change and forestry. The national ASTA database and data from monitoring and inventories will be used to model future

impact of N deposition over regional to national scales. Leakage of inorganic aluminium and possibly mercury will also be included in these activities.

Relevance The research described above will be directly relevant to national and international policies to reduce impacts of air pollution and to reach environmental objectives. The models employed in this work are directly applicable to the development and refinement of critical load concepts and environmental criteria used for policy assessment. The proposed research is synthesising several earlier and ongoing program activities in Sweden and maintains and develops the Swedish scientific network, as well as the future participation in international networks (e.g. EU research and expert groups in LRTAP).

Budget: 7,7 MSEK over the program period.

Area 4 Integrated assessment modelling

Objective The overall objective of this sub program is to provide a basis for optimisation and assessment of future air pollution policies in Sweden and Europe. To fulfil this objective, we propose to adapt the current structure of the integrated assessment model GAINS to include additional non-technical measures, such as structural and behaviour changes. We also suggest to develop a national version of the GAINS model.
Participating institutions IVL Swedish Environmental Research Institute (Catarina Sternhufvud, Mohammed Belhaj, Stefan Åström, Olle Westling, John Munthe), LTU (Salim Belyazid), and VTI (Lena Nerhagen). The sub programme will be co-ordinated by Catarina Sternhufvud.

The problem
Current international air pollution policies are mainly based on results from the application of RAINS. However, the use of the GAINS model, which includes GHG emissions and abatement costs, is expected to increase. In GAINS, the abatement costs are mainly based on technical measures and some energy savings as well as fuel switch measures. However, structural changes and behavioural changes are, despite their importance for emission reductions not taken into account. Another limitation with the model is that on a national level, more detailed and geographically resolved integrated assessment tools are needed. As an example related to ecosystems, the magnitude of impacts from air pollution is very variable and depends on local conditions and external factors, such as climate change and land-use. These factors make it difficult to estimate ecosystem effects in the current GAINS. This motivates the development of a national application where assessment of costs and benefits of future more relevant abatement strategies can be made on a more detailed geographical scale, and with better information on local conditions.

Sub projects:
1. Costs of non-technical measures in IAM models - theoretical considerations
The objectives of this project is to evaluate different concepts on how costs o non-technical measures could be included in IAM models and to develop a practical theory able to be used in such models. Such an approach should take into account the parallel inclusion of both technical and non-technical measures in model formulation and assumptions.

2. Inclusion of non-technical measures in the GAINS model

The objective of project 2 is to harmonise the cost theory developed in project 1 with the operative features of the cost calculations in GAINS. This requires both the cost theory developed in project 1 to be adapted to the operational requirements in GAINS as well as it requires the GAINS methodology to be expanded so that new abatement measures can be taken fully into account.

3. Development of a GAINS Sweden model
The purpose of this project is to adapt the GAINS model developed at IIASA to test new theories and implement regional and local simulations on a Swedish, and eventually Nordic level. The result will be a "GAINS Sweden", with possible Nordic extension, yet directly based on the European GAINS model and developed in close collaboration with IIASA. The aim for the national development of the model is to have access to the model structure in order to implement the following changes (and other eventual developments):

- Adapt GAINS into a functional version on a Swedish (Nordic) level/resolution;
- Implementing the cost module as developed in project 2 into the current GAINS Europe model or into the GAINS Sweden version;
- Possible structure adjustments of the GAINS model to enable the introduction of alternative scenarios and baseline costs as discussed in subproject 1 and 2.

4. Integrated assessment modelling at a national scale
The aims of project 4 are to continuously up-date GAINS Sweden with new findings from other subprograms and to carry out a case study in GAINS Sweden based on national cost estimates, latest dose response relationships as well as alternative scenarios. The focus of the case study will most probably be the transport sector.
Budget estimate: 5,0 million SEK over the program period.

Area 5. Programme co-ordination and support to policy

Objective: To co-ordinate the program and ensure communication with stakeholders as well as between different areas of the program and to make sure that results within the program are used in an optimal way.
Organisation: Program leader Peringe Grennfelt, Swedish Environmental Research Institute.
Activities:
a) Co-ordination of program activities. Communication with the Swedish Environmental Protection Agency.
b) Information of the program and its results through yearly reports and via Internet
c) Workshops and co-ordinated program in order to make sure that the results are communicated within the program and to stakeholders and discussed in the perspective of policy development. Most of the necessary financial support for the organisation of synthesises and workshops will be taken within the respective areas. In some cases, there are good possibilities for finding grants through various international bodies.

Budget: 3,0 million SEK over the 6 year period.

Communication

Communication of results and interaction with the scientific and policy communities nationally and internationally is a key issue for SCARP. As can be seen from the CVs from the participants in the program, contacts and communication activities are a main interest for all key participants. We intend to structure this work and identify particular activities and processes for our communication.

The key international organisations for handling air pollution issues have mostly a clear structure for how scientific results are taken on board, synthesised and brought into policy advice. We will make use of this system and in particular interact with

- *The EU CAFE program.* DG Environment will continue its supporting activities under the Clean Air For Europe initiative. The CAFE program
- *CLRTAP*. The Convention has a well-developed structure for scientific support through various expert groups. It is also a main source of information for CAFE. The main groups with which this program will interact are Task Force on Health, ICP Mapping, ICP Vegetation, ICP Forests, ICP Waters, Task Force on Measurements and Modelling, Task Force on Integrated Assessment Modelling and Expert Group on Particles.
- *WHO,* through the development of Air Quality Guidelines
- *The Swedish Environmental objectives.* The objectives as well as the work on the fulfilment of the objectives are continuously reviewed.

Ways of interaction

We have identified and will use various ways of communication with policymakers, other stakeholders, the scientific community and the public. The following ways of communication have been identified:

- *Direct participation expert groups under international and national organisations.* Several of SCARP the scientists have long experience in science to policy communication through participation in various organisations, which is obvious from attached CVs.
- *Interactions with NGO organisations.* The Swedish NGO Secretariat on Acid Rain has for more approx. 25 years been active in collecting scientific information on air pollution and communicating the information to policy actors and the public. We intend to keep a continuous contact with the secretariat and make sure that our results will become available.
- *Support to Swedish experts in international and national organisations.* Swedish experts have been closely involved in refernce and steering groups in earlier projects and programs on air pollution, which has given a very good opportunity for a two way communication; results have been presented and discussed with stakeholders and problems and requests from the policy side have been communicated back to the scientists.
- *Support through scientific assessments.* Within some areas (in particular human health) scientific assessments form a strong platform from which policy may develop. SCARP participants will be encouraged to participate in assessments when appropriate.
- *Scientific publications.* Publication in peer-reviewed scientific journals is an important activity in the program and more details are given in the description of the different activities. In addition, SCARP scientists will participate and give presentations at international and national conferences and meetings.
- *SCARP web page.* On the web page all actual information regarding the program will be available, including, reports, publication lists, important links etc.
- *Internal communication within the program.* All meetings will have a standing agenda point on the actual issues within international and national organisations and processes followed by an analysis of how this will influence our work and if there is a need for

action. There will also be a yearly meeting, to which all participants, the external advisory board and key stakeholders will be invited.

- *Information in relation to stakeholders e.g. the industry and local and regional authorities.* Some aspects of the program are of particular interest for local and regional authorities and the industry. Local authorities have several responsibilities that may cause an interest in results from the SCARP project. They are responsible for the protection of human health and have particular obligations in relation to air quality regulations. They are also involved in permitances for industrial production and also in decisions related to city planning and traffic. Industry may be interested in the research since results may result in changes in control priorities. If health effects can be attributed to particular properties of particles, this may direct development of control techniques. Cost-efficiency results from theme four may also have direct implications for industry. This activity will be done in close collaboration with the secretariate for the national environmental objectives (Miljömålssekretariatet)
- *Information in relation to the public.* Air pollution is of general concern for the public. Local conditions may vary and there is concern with respect to health effects from air pollution in many urban areas. We do not intend to have a particular SCARP activity in this area. Instead our intention is to communicate our results through the secretariat for the National Environmental Objectives.

Since most of the contacts and communication should be undertaken directly with the above mentioned international organisations, we will work with a distributed responsibility for communication. This means e.g. that each area has to follow the work within relevant bodies and interact when appropriate. Our intention is also that several scientists should be directly involved in the science-to-policy interaction through participation in expert groups under any of the international bodies mentioned above. In addition the executive board of the program will take responsibility for necessary co-ordination and collection and communication of schedules for the different organisations, meeting reports, deadlines for reports etc.

The Communication part of the program will be lead by Jenny Arnell IVL. Jenny has been responsible for the communication issues of the ASTA program.

During the first year of the program, we will, in addition to the establishment of the web page etc., present and advertise the program in connection with the planned ASTA workshop, the so -called Saltsjöbaden III workshop. This workshop is aimed to outline short and long term science and policy needs within the field of air pollution. This workshop, which will be organised in collaboration with CLRTAP and the European Commission and others, will be an excellent opportunity to present the program.

Budget

The overall budget for the program is presented at the end of this application. We apply for an overall funding of 36 MSEK over the six year period with a yearly budget of 6 MSEK.

Additional resources

As can be seen from the descriptions of national and international collaboration as well as from project descriptions in Annex 2, all groups involved in program will also receive support from other projects, which are closely related to SCARP. In fact, the Swedish EPA and other stakeholders will through a support to this program get access to scientific research of policy relevance several times larger than supported through the Swedish EPA.

Area	Project	Name	Project leader	Organisation	Year 1	Year 2	Year 3	Year 4-6	Sum
1	1	Exposure to traffic related air pollution in early life, lung function and airway disease in 8-year-old children	Tom Bellander	IMM	200	200	100		500
	2	Short-term health effects in susceptible subgroups, using newly developed source-specific local time series of air pollution	Tom Bellander	IMM	200	200	400		800
	3	Health effects of short-term and cumulative seasonal exposure to road dust and wood smoke particles at real-world exposure conditions	Bertil Forsberg	OEM UmU	250	250	250	750	1500
	4	Long-term exposure to traffic exhaust and incidence of obstructive airway disease in a prospective cohort – planning grant	Bertil Forsberg	OEM UmU	83	83	83	250	499
	5	Is exposure to particulate air pollution associated with exhaled nitric oxide and blood markers of inflammation?	Anna-Carin Olin	OEM GU	233	233	234	900	1600
	6	Is long-term exposure to particulate air pollution associated with an increased risk for ischemic heart disease	Anna-Carin Olin	OEM GU	100	100	100	100	400
	7	Cohort study on total public health burden related to long term-exposure to air pollution	Göran Pershagen	IMM	66	66	167	2000	2299
	8	Long term exposure to traffic related air pollution and genetic susceptibility in relation to myocardial infarction	Göran Pershagen	IMM	200	200	0	0	400
	9	DISOZPOLL: Diesel and ozone effects on the cardiovascular system	Thomas Sandström	RMA UmU	167	167	267	1000	1601
	10	PMMECH - Mechanisms behind particulate matter air pollution induced toxicological effects	Thomas Sandström	RMA UmU	167	167	66	0	400
	11	WOODPART-2: A human experimental model using wood smoke for studies of acute effects of particulate air pollution on inflammation, coagulation and oxidative stress	Gerd Sällsten	OEM GU	200	200	200	900	1500
	12	Health effects of long range transported particles: a population study using air mass trajectories	Gerd Sällsten	OEM GU	134	134	133	100	501

		Synthesis				50	100	150	300
		Sum			**2000**	**2050**	**2100**	**6150**	**12300**
2	1	Chemical Modelling of Aerosol Formation	David Simpson	Met.no & CTH	600	550	550	1700	3400
	2	Developing dynamic particle description including formation, growth and deposition	Valentin Foltescu	SMHI	350	350	400	1100	2200
	3	Construct emission databases for dynamic particle models and validate urban models concerning particle size distribution and chemistry	Christer Johansson	ITM	400	400	400	1200	2400
		Sum			**1350**	**1300**	**1350**	**4000**	**8000**
3		Coordination and communication	John Munthe	IVL	100	100	100	300	600
	1	Nitrogen cycling in forest ecosystems	Cecilia Akselsson	IVL	800	600	550	350	2300
	2	Dynamic nitrogen model development and evaluation	Salim Belyazid	LTH	300	650	650	200	1800
	3	Future impacts of forestry, deposition and climate change	Filip Moldan	IVL				3000	3000
					1200	**1350**	**1300**	**3850**	**7700**
4		Coordination and communication	Catarina Sternhufvud	IVL	100	100	100	300	600
	1	Costs of non-technical measures in IAM models - theoretical considerations	Mohammed Belhaj	IVL	500	300		200	1000
	2	Inclusion of non-technical measures in the GAINS model	Stefan Åström	IVL		150	450	700	1300
	3	Development of a GAINS Sweden	Salim Belyazid	LTH	250	250	300	400	1200
	4	Integrated assessment modelling at a national scale	Catarina Sternhufvud	IVL				900	900
					850	**800**	**850**	**2500**	**5000**
5	1	Program management	P Grennfelt	IVL	200	150	150	500	1000
	2	Program communication	J Arnell	IVL	250	250	150	650	1300
	3	Program coordinated activities	Peringe Grennfelt	IVL	150	100	100	350	700
		Sum			**600**	**500**	**400**	**1500**	**3000**
		Overall yearly budget			6000	6000	6000	18000	36000

Appendix 2

Swedish Clean Air Research Program -

SCARP

Project descriptions

10 April 2006

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Exposure to traffic related air pollution in early life, lung function and airway disease in 8-year-old children. Tom Bellander

Project leader: Tom Bellander, Department of Occupational and Environmental Health (AMM), Stockholm County Council, Norrbacka III, 171 76 Stockholm; tel 08-737 3670, fax 08-737 3770, e-mail tom.bellander@sll.se.

Other senior researchers: Magnus Wickman (AMM), Magnus Svartengren (AMM), Göran Pershagen (Institute of Environmental Medicine, Karolinska Institutet), Christer Johansson (Department of Applied Environmental Science, Stockholm university).

Sammanfattning
Denna studie kommer att undersöka sambandet mellan luftföroreningar från trafik och hälsoeffekter i barns luftvägar. Detaljerad modellering av luftföroreningshalter utomhus kommer att utföras för bostäder, förskolor och skolor, från födelsen till åtta års ålder. Dessa individuella exponeringsdata kommer att analyseras med flera indikatorer på hälsoeffekter i luftvägarna, som lungfunktion, astma diagnos och symptom samt sensibilisering för vanliga allergen.

Summary
This study will examine the relation between air pollution from traffic and long-term effects on respiratory health in children. Detailed modelling of outdoor air pollution levels at home, day-care and schools from birth to the age of eight will be used. The individual exposure data will be analysed with several different indicators of respiratory health, including lung function, asthma diagnosis and symptoms as well as sensitisation to common allergens.

Aim
The aim of this study is to assess the impact of life-time exposure to traffic-related air pollutants and heating-related air pollutants on lung function, wheezing, asthma and allergic sensitisation, in children at the age of eight.

Contribution to programme
The project contributes to the priority area “Long-term effects”.

Practical relevance
Children are considered to be a susceptible group to effects of air pollution, and long-term respiratory health effects have been shown in some studies. This study will greatly contribute to this knowledge, and give a good foundation to Swedish policy related to children and air pollution.

Background
Urban air pollution can trigger asthma symptoms but there is conflicting evidence on effects of long-term exposure on lung function, the onset of allergy and airway disease.

Several cross-sectional studies have shown negative correlations between air pollution and lung function in children at about 10 years of age (Brunekreef et al 1997, Boezen et al 1999). Recent prospective studies also indicate that high levels of air pollution may impair the lung function development between ages 8 to 18 years, resulting in persistent damage (Jedrychowski et al 1999, Frischer et al 1999, Gauderman et al 2004).
No study on lung function development in children and air pollution has previously been made in the Nordic countries.
Traffic-related air pollutants are important triggers for asthma exacerbations (Nicolai 1999, Pope 1989) but results regarding the role of air pollutants as causative agents in the initial disease development are not consistent. Some cohort studies in children have shown associations between traffic-related air pollution and parent's report of doctor's diagnosis of asthma (Brauer et al 2002, Shima et al 2003) while others find associations with wheezing, "cough without infection" or "cough at night" (Gehring et al 2002). Other studies have not shown any relation between air pollution and asthmatic symptoms in children (Braun-Fahrländer et al 1997, Baldi et al 1999).
Some cross-sectional studies have shown positive associations between air pollution and allergic sensitisation to several different allergens in children from 7 years and up (Kramer et al 2000, Janssen et al 2003, Pénard-Mourand et al 2005) at average air pollution levels of 22 µg/m3 NO2 and 18 µg/m3 PM10 and above. Associations were found with elevated total IgE (Janssen et al 2003), sensitisation to pollen (Pénard-Mourand et al 2005 and Kramer et al 2000) and to outdoor allergens (Janssen et al 2003). These findings are supported by experimental data showing effects of diesel exhaust on allergic sensitisation in mice and human cells (Takano et al 1997, Miyabara et al. 1998) and the observation that pollen proteins may be chemically modified by air pollution (Franze et al 2005). No such study exists from the Nordic countries.

Materials and methods
In the present study, the exposure during the first year of life, and during subsequent years up to 8 years of age, will be related to respiratory health status at 8 years, and how this has changed since 4 years of age. Indicators of respiratory health status include wheeze and asthma, as well as lung function development and sensitisation.

Study subjects. Between 1994 and 1996, 4089 infants were recruited from Child Health Centers in a prospective study, BAMSE (Wickman 2002). The study population comprised 75% of all eligible children born in predefined areas in four municipalities in Stockholm. The areas were chosen to represent both urban, semiurban and suburban environments. Data on parental allergic diseases, pet contact, detailed residential characteristics and socio-economic factors were collected with a postal questionnaire filled out by the parents at recruitment, when the median age of the children was 2 months. When the children were approximately 1, 2, 4 and 8 years old, similar questionnaires were mailed to all parents. On these occasions the main focus was on the children's symptoms related to wheezing and other allergic diseases, and information on exposure factors. The response rates were 96%, 94%, 91% and 84%, respectively. At approximately 4 years of age 2965 children attended a clinical investigation (73% of the full cohort) and 2926 performed a lung function test (72%). Blood samples were drawn from 2614 children (64%,). The lung function test was repeated at 8 years of age, with participation of 2628 children (64% of total cohort).

Air pollution assessment. Addresses for home and day-care have been retrieved from the questionnaires at age 2 months and 1, 2 and 4 years, and will be retrieved for the 4-8 year period, also including school addresses. All addresses will be transformed into geographical coordinates (geocoded) using standard GIS (Geographical Information Systems) computer software in combination with a regional geographical address database (Tätort 2000).
The assessment of residential outdoor air pollution levels is based on a methodology previously developed for a study on air pollution and lung cancer in Stockholm (Nyberg et al 2000), described in detail elsewhere (Bellander et al 2001). It entails geocoding of the individual's address information, and using an emission inventory together with dispersion models to map outdoor levels over time at the relevant geographical locations of selected pollutants from selected emission sources. Emission databases, describing traffic-generated nitrogen oxides (traffic-NO_x) and particulate matter less than 10 µm (traffic-PM_{10}) in aerodynamic diameter as well as sulphur dioxide from heating (heating-SO_2) within Stockholm county are available for the year 2000 and 2005. For traffic-NO_x and heating-SO_2, emission databases were also available for 1990.
The temporal and geographical resolution of the modeling of air pollutants will be increased in comparison with previous studies. The geographical distribution of air pollution will be assessed in three layers of different resolution, applied to regional/countryside area (500×500 m), urban area (100×100 m), and inner-city area (25×25 m).
Monthly levels of nitrogen oxides and sulphur dioxide will calculated from 1994 to 2005.For traffic-generated PM_{10}, the levels from the year 2000 will be used for the 1990-2000 period. The air pollution data for each month from the dispersion models will be linked to the individual address coordinate for each subject for the corresponding month. Thus, yearly individual source-specific levels of PM_{10}, nitrogen oxide and sulphur dioxide at the residential address will be calculated from date of birth until the date of response of the 8-year-questionnaire.

Preliminary results
Exposure to air pollution from traffic during the first year of life has been evaluated for this cohort, with a similar method as described above, but with less temporal resolution. It was analysed for respiratory outcomes at age four. The preliminary results show an association. with decreased PEF (lung function), with sensitisation to inhalant allergens, especially pollen, and with an excess risk of persistent wheezing. Results were similar using traffic-PM10 or traffic-NOx as indicator. No associations to heating-SO2 were seen.

Time plan
The project will start in 2007 and end in 2009, with most of the work performed in 2007 and 2008.

Budget plan
The costs will be dominated by salaries for junior researchers

2007	200 000 SEK
2008	200 000 SEK
2009	100 000 SEK
Total	500 000 SEK

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Short-term health effects in susceptible subgroups, using newly developed source-specific local time series of air pollution - Tom Bellander

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Other senior researchers: Christer Johansson (Department of Applied Environmental Science, Stockholm university), Mårten Rosenqvist (Department of Cardiology, Stockholm South Hospital), Bertil Forsberg (Department of Public Health, Umeå University).

Sammanfattning
Nyligen utvecklade tekniker för utvärdering av korttidsvariation av luftföroreningar från olika källor, med hög geografisk upplösning, möjliggör beräknandet av tidsserier för valfri tidsperiod för valfri plats. Dessa kommer att användas för att skapa inividuella tidsserier av luftföroreningar för två material med observerade nivåer av inflammationsmarkörer, ett datamaterial med arytmier och vissa serier av utfall i ett dataset med 110 000 dödsfall.

Summary
The novel technique of assessing the short-term variation of air pollution from different sources in high spatial resolution allows for the calculation of a time series for any given time period at any given place, and will be used to assign individual time series of exposure to two collections of inflammatory markers, a collection of arrhythmic outcomes, and selected series of outcomes in a dataset comprising 110 000 deaths.

Aim
The aim of the project is to further explore the association between short-term variation in health effect and air pollution in sensitive subgroups. It will apply the best available exposure assessment technique to time series of cardiovascular outcomes.

Contribution to programme
The project will contribute to the programme priority area “Short-term effects”.

Practical relevance
The results of the studies of different patient groups will be directly applicable to the prevention of renewed cardiac events in these groups. Management of the air pollution risk may thus be included in the general management of post-MI patients as well as of arrhythmic patients. Counselling may be quite detailed, since the study will identify susceptible groups based on age, sex, and previous diseases.

Background
The short-term health effects of air pollution have been extensively studied, showing positive but heterogeneous results throughout both Europe and the USA. It is not clear if the differences are due to differences in exposure attribution or differences in susceptibility.

Differences in exposure attribution could be because of differences in source panorama or because of differences in the representativity of the monitoring stations

to the study population. The differences seen in the USA in short-term health effects between the Eastern and Western part of the continent may be because of differences in sources that are not well represented by the contaminants measured. Also in Europe there are important differences in sources, although this does not seem to be the only reason for the differences between cities. In order to resolve problems related to source compositions it is important to better characterise the time variation of the population exposure to pollutants from different source groups.
The representativity of a monitoring station results for the general population is different for different pollutants and for different sources. There are typically three different geo-temporal modes: uniform changes over large areas (due to changes in long-range transport), smooth changes over built-up areas (due to changes in diffuse city sources and changes in ventilation), and sharp local changes (due to changes in localised sources like transport, house heating and industry, and to changes in ventilation). While the time course of population exposure to air pollution from long-range transport is well reflected in regional background measurements, the time course of population exposure to the more local sources is less so.
The potential differences in individual susceptibility between and within different populations have been widely debated. Some of these differences have been proposed to be related to differences in exposure, while others seem to be related to more genuine host factors like e.g. previous disease, nutritional status, smoking status and age. The "population susceptibility" for some diseases may be seen as consequence of fluxes in and out of the "susceptible pool", that are on average determined by the average levels of many ill-health determinants, including the average level of air pollution.

In Sweden, and in Northern Europe in general, there is a need of further understanding the relative importance of different air pollutant sources to short-term variation in morbidity and mortality as well as how this relation differs between different parts of the population.

Materials and methods
The study will be based on patient materials and the general population. The Swedish part of a previously assembled panels of post-myocardial infarction patients (AIRGENE; n=200) will be used, mainly in relation to already collected levels of inflammatory markers. The sample of the general population used as referents in the SHEEP study (n=2315) will be used, with the already collected observations of levels of inflammatory markers. The ongoing sampling of events of acute ventricular arrhythmias (at present n= 263) in patients with implanted cardioverter devices (ALVA) will be extended to 2008. A subset of a large (110 000 deaths) time-series study of short-term health effects in different patient groups (SENSI) will be used.

The exposure assessment will aim at creating individual time series for pollutants from different source categories at the home address of the individual, for a period surrounding the studied health event. It will be based on the ongoing development of separate time series for long-range transport from different source areas (IMPORT), the ongoing development of source-specific time series of local air pollution (TRAPART), the previous (HEAPSS) and ongoing (PASTA) development of time series for ultrafine particulates, as well as the ongoing development and validation of local time series (EXPOSE). The project will also profit from the parallel project "Construct emission databases for dynamic particle models and validate urban models

concerning particle size distribution and chemistry", proposed by ITM to SCARP. The main focus of the exposure assessment will be on particulate air pollution, but the additional value of gaseous pollutants will also be analysed.

The relation between the exposure series and the different outcome series will be analysed with several different tools, according to the type of outcome data, including ordinary regression and case-crossover analysis.

Time plan
The project will start in 2007 and finish in 2009, with most of the work performed in 2008 and 2009.

Budget plan
The costs will be dominated by salaries for junior researchers

2007	200 000 SEK
2008	200 000 SEK
2009	400 000 SEK
Total	800 000 SEK

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Health effects of short-term and cumulative seasonal exposure to road dust and wood smoke particles at real-world exposure conditions - Bertil Forsberg

Project manager

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Sammanfattning

De viktigaste orsakerna bakom överskridanden av de svenska miljökvalitetsnormerna för PM10 är vägdamm och vedrök. Det är inte troligt att omgivningsluftens partiklar med dessa källor eller andra har samma hälsoeffekter, ändå behandlas de som om de var lika skadliga till följd av att jämförbara undersökningsresultat saknas. Vi kommer att genomföra 4 panelstudier i verkliga miljöer dominerade av vägdamm respektive vedrök, och fokusera på inflammationsmarkörer respektive besvär från andningsvägarna för att belysa kvalitativa skillnader i risk vilka har relevans även för kroniska effekter.

Abstract

The major sources behind violations of the Swedish limit value for PM10 is road dust and wood smoke. It is not likely that ambient particles from these sources and other have the same health effects, still they are treated as equally harmful due to lack of comparable health studies. We will perform 4 panel studies in real environments dominated by road dust and wood smoke, respectively, and focus on inflammatory markers and respiratory symptoms illustrating qualitative differences in risks relevant also for chronic effects.

Aim and project goals

The primary aim is to provide comparable data on health effects of short-term exposure to ambient particle mass (PM) originating from road dust and wood smoke, respectively, associated with existing exposure situations in Swedish cities and towns.

Contribution to the goals of the programme

The project will provide comparable epidemiological data on the short-term responses to ambient particles originating from road dust and wood smoke.

Practical relevance

The two most important sources behind violations of the Swedish limit value (MKN) for PM10 is road dust close to major roads, and wood smoke in small communities. Even at low levels it is not likely that ambient particles from these sources have the same effects on health, but still today they are treated as equally harmful. This situation affects today’s abatement strategies. We will perform panel studies in real environments highly influenced by PM from road dust and wood smoke, respectively. These panels studies will investigate and compare responses associated with short-term exposure to road dust and wood smoke in healthy as well as asthmatics. The

project will mainly contribute results on early responses illustrating qualitative differences in risks. However, repeated occurrence of inflammatory responses likely contributes also to long-term effects.

Performance, theories and methods

The evidence on airborne particles supports an inference of causality for a broad range of health effects. The risk for cardiovascular and respiratory effects has, as mortality, been shown to increase with exposure. There is little evidence to suggest a threshold below which no increase in risk would be anticipated. During the last 8-10 years there has been an intensive discussion on particle components and characteristics hypothesized to contribute to the health effects. The list of candidates include mass concentration, number concentration, particle size, particle surface area, metals, acids, organic compounds, biogenic material, soot, and other factors including correlated gases. There are yet no definite answers, and quite inconsistent results have been reported from epidemiological and especially toxicological studies. One likely explanation is the existence of several different mechanisms for the various effects.

The regulated indicator for PM in Sweden and EU is PM10. The extensive evidence on PM health effects is mainly based on studies using PM10 as the exposure indicator. The two major sources behind violations of the Swedish limit value (MKN) for PM10 is road dust close to major roads and wood smoke in small communities, although less investigated (Forsberg et al, 2005). It is not very likely that these sources produce particles with the same toxicological effects, but still today all sources are lumped together and considered equally harmful in health impact assessments as in the recent report from CAFE. This situation affects the abatement strategies. Thus, there is an urgent need for comparable data on the specific health responses to ambient particles originating from different sources, to be used for health impact assessment and decision support.

Road dust

Swedish studies have found suspension of road dust to be the most important local sources of PM10 (Areskoug et al, 2004), much stronger than the vehicle exhaust emissions, even on a yearly basis. The reasons are mainly the use of studded tires and sanding of roads in winter. In addition, estimates for Stockholm show emissions from the brakes to be in the same order as exhaust emissions (Westerlund och Johansson, 2002).

PM10 from road dust mainly consists of coarse particles, for many years often referred to as less harmful. However a recent systematic review found that in studies of COPD, asthma and respiratory admissions the coarse fraction has a stronger or as strong short-term effect as the fine fraction (Brunekreef & Forsberg, 2005). These results suggest that coarse PM may lead to adverse responses in the lungs, possibly inflammation, triggering the processes leading to hospital admissions. Results in line with these have been found for asthma and high urban background levels of PM10 from road dust in Stockholm (Segerstedt & Forsberg, submitted). Since the geographical gradients are quite strong for coarse particles, the potential for misclassification of exposure is larger when a wide area is represented by one monitor. This would normally “dilute” the true associations, resulting in too low and unprecise relative risks. Health effects of road dust would be better studied in subjects

in highly exposed areas closer to the source, that is, in panels of persons living and/or working close to roads with strong fluctuations in the concentrations of road dust.

Our strategy is to perform studies around the E4 highway (Västra Esplanaden) where it is passing the city off Umeå. With this approach we will be able to find both residents (healthy and asthmatics) and workers (for example postmen, shop assistants) who spend a lot of time in the close surroundings of the road. Our plan is to perform repeated measurement of inflammatory markers such as exhaled NO, CC16, fibrinogen and CRP over a 10 week period in March – May when fluctuations depending on humidity and temperature are large in road dust concentrations. Each panellist would be invited to 10 – 20 examinations (partly depeding on size of panel). In addition we will study effects on lung-function, respiratory symptoms and airway medication.

Wood Smoke

The mass concentration of particles from heating with wood fuels and vehicle exhaust are about the same in many small Swedish cities. Wood smoke particles mainly consist of soot, organic compunds, and ash which mostly consist of alkali oxides. Emitted amounts of soot and organics depend strongly on the combustion process. Particle size varies strongly during the different phases of the combustion process (Hedberg et al, 2002). Measurements in a neighborhood dominated by wood combustion emissions show a mixed size distribution originating from different combustion phases, with particles from the start-up phase dominating.

Wood smoke is a complex mixture of a large number of gaseous and particulate air pollution components that can certainly possess a risk factor for human health (Boman et al, 2006). A number of epidemiological studies have studied the health effects of outdoor PM in areas where wood smoke was the major particle source. A recent review (Boman et al, 2003) found nine relevant papers that focused on the effects of variations of short-term exposure, such as asthma admissions, respiratory symptoms, daily mortality and lung function. All the included studies reported associations between short-term air pollution levels and one or more adverse health outcomes. Interestingly, studies from areas where wood smoke was a major source reported, in general, stronger effects of PM10 in comparison with WHO and other state-of-the-art estimations of risk coefficients for PM. This potentially stronger effect of wood smoke particles has not yet been taken into account in health impact assessment. Since emissions from wood stoves and boilers depend so much on the combustion process, there is an urgent need to further study exposure-response functions for real-world wood-smoke particles. In the Swedish BHM project it was concluded that during the heating season combustion of wood can be the major contributing source to particles in residential areas close to the emissions, and also a reason for violations of limit values (MKN). People in such areas may be at high risk.

Our strategy is to perform panel studies in one or more communities in northern Sweden where there are blocks of small houses generally individually heated with wood fuel. These areas will be identified from records and maps with data on stoves and boilers. In addition, a dispersion model will be used to select study areas and measurement sites for PM. Also portable monitors will be used for a monitoring route a large number of study days. With this approach we will be able to assess exposure for residents (healthy and asthmatics) who spend a lot of time in a home within “hot

spot" areas. Our plan is to perform repeated measurement of inflammatory markers such as exhaled NO, CC16, fibrinogen and CRP over a 10 week period in January – March when fluctuations in PM10 levels depending on dispersion conditions are large. Each panellist would be invited to 10 – 20 examinations (partly depeding on size of panel). In addition we will study effects on lung-function, respiratory symptoms and airway medication.

Work steps of the project:
Year 1: panel study asthmatics - road dust, Year 2: panel study asthmatics – wood smoke,
Year 3: panel study healthy - road dust, Year 4-6: panel study with children, synthesis

Deliverables:
15 mo: manuscript asthmatics - road dust, 28 mo: manuscript asthmatics – wood smoke,
40 mo: manuscript healthy - road dust, 50 mo: manuscript children

Swedish research team:
Bertil Forsberg, Associate Professor, project manager
Bengt Järvholm, MD, Professor
Kadri Meister, PhD, statistician
Bo Segerstedt, PhLic, statistician
Lars Modig, MSc, research engineer
Helen Bertilsson, research nurse (funded by our clinic's ALF grant for research)
We also plan collaboration with researchers from Basel and Barcelona.

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Panel studies - Budget per year

Year 1-4	
Personell (excl nurse funded by ALF grant)	100 000 SEK
Biomarkers	45 000 SEK
Participants	40 000 SEK
Air monitoring	Other projects
OH costs	65 000 SEK
Sum	**250 000 SEK per year**

Year 5-6	
Personell and analyses	185 000 SEK
OH costs	65 000 SEK
Sum	**250 000 SEK per year**

Long-term exposure to traffic exhaust and incidence of obstructive airway disease in a prospective cohort – planning grant. - Bertil Forsberg

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Sammanfattning
Det finns väldigt få studier angående luftföroreningars betydelse för uppkomst av astma och kroniskt obstruktiv lungsjukdom (KOL) hos vuxna, trots att dessa sjukdomar är tämligen vanliga och medför höga samhällskostnader. I ExternE beräknas exempelvis kostnaderna för luftföroreningseffekterna på KOL utifrån den gamla amerikanska ASHMOG studien. Den nordiska-baltiska RHINE-studien ger goda möjligheter att studera hur halten av trafikföroreningar (NOx/NO2) vid bostaden påverkar incidensen i en kohort av vuxna. Ett mindre anslag söks för detaljplanering och som bidrag till finansiering av studier baserad på fyra RHINE-centras 10-årsdata. Vid en ny uppföljning 2008 skulle uppföljningstiden bli 18 år för ca 2000 personer per centra.

Summary
There are very few studies on urban air pollution and the incidence of asthma and chronic obstructive pulmonary disease (COPD) in adults, despite the fact that these diseases are quite common and the cost of illness is very high. In ExternE calculations for example, the PM effect on COPD is the major morbidity cost, calculations based only on the old Californian ASHMOG study. Effects of traffic pollution on airway disease have been reported in many studies, however most based on cross-sectional data from children. Studies with a longitudinal design provide much stronger data. A recent Swedish case-referent study found that for stable residents with a positive skin prick test, asthma incidence increased with the measured level of NO_2 outside home (Modig et al, accepted). The Nordic-Baltic RHINE cohort offers a very good opportunity to prospectively study the incidence of asthma and COPD in adults (Torén et al, 2004).

Our plan is to investigate the long-term effect of modelled traffic pollution levels (NO2/NOx) at home addresses on the incidence of COPD and asthma. This relation will be studied in 4 centres (Umeå, Gothenburg, Uppsala and Tartu) in the RHINE study. Five years ago more than 16 000 persons born 1945-73 from 7 centers were followed over 10 years, in 2008 we may use approximately 18 years of observation time with prospectively collected data on smoking and other risk factors for approximately 2000 persons per centra.

For this study we apply for a smaller planning grant in order to find co-funding of the cohort study. Our aim is to seek fundings initially from EMFO and Hjärt-Lungfonden for the 10-year analysis possible with existing data.

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Modig L, Järvholm B, Rönnmark E, Nyström L, Lundbäck B, Andersson C, Forsberg B.
Vehicle exhaust exposure in an incident case-control study of adult asthma (accepted for publication in Eur Respir J)

Torén K, Gislason T, Omenaas E, Jögi R, Forsberg B, Nyström L et al. A prospective study of asthma incidence and its predictors – the RHINE study, Eur Respir J 2004;24:942-946.

Requested amount: SEK 60 000 per year + OH 35% = 81 000 SEK per year

Is exposure to particulate air pollution associated with exhaled nitric oxide and blood markers of inflammation? - Anna-Carin Olin

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Summary
There is probably a causally association between exposure to air pollution and coronary heart disease. The proposed mechanism is that air pollution gives rise to airway inflammation, especially in the distal airways and alveoli. This inflammation enhances the production of pro-inflammatory cytokines causing an increased concentration of inflammatory proteins in the blood. The fraction of exhaled nitric oxide (FENO) is elevated among subjects with airway inflammation. The aims with the present study are to investigate whether exposure to air pollution is associated with increased FENO and/or increased concentration of blood markers of inflammation. The project is performed in a random population-sample consisting of 10.000 subjects in 25 to 75 years of age. They will be investigated with a questionnaire, pulmonary function and with blood samples. Their exposure to PM_{10}, $PM_{2,5}$, NOx, ozone and sulphur dioxide will modelled using data from adjacent sampling stations and related to different outcomes such as FENO, fibrinogen and other blood markers of inflammation.

Sammanfattning
Det finns sannolikt ett samband mellan exponering för yttre luftföroreningar och insjuknande i hjärtsjukdom. Yttre luftföroreningar kan orsaka en inflammation i luftvägarna och denna inflammation kan via förändringar i blodet leda till en ökad risk för hjärtsjukdom. Fraktionen av utandat kväveoxid (FENO) är förhöjt hos individer med astma, även hos individer med mild astma, varför FENO uppfattas som en markör för luftvägsinflammation. Projektets övergripande målsättning är att öka vår förståelse varför luftföroreningar orsakar en inflammation i luftvägarna som sedan ökar risken för hjärtsjukdom. Merspecifikt avse vi att undersöka om exponering för yttre luftföroreningar är förknippade med en förhöjd koncentration av NO i utandningsluft och/eller inflammatoriska förändringar i blodet. Projektet genomförs på ett slumpmässigt urval av 10.000 personer i åldrarna 25-75 år, som får besvara en postal enkät och därefter undersökas avseende FENO, lungfunktion och blodprover. Exponeringen för PM_{10}, $PM_{2,5}$, kvävedioxid, ozon och svaveldioxid kommer för varje att modelleras utgående från befintliga luftföroreningsdata i relation till FENO och olika blod/plasma parametrar. I modellen kommer att tas hänsyn till meterologiska data, rökvanor, luftvägssymptom m m, och dessutom kommer olika lag-tider att användas.

Aims and contribution to overall aims
The general objective of the project is to increase our understanding about the links between airway inflammation induced by exposure to ambient particulate air pollution and coronary heart disease. More specifically, this study aims to elucidate the relation between exposure to air pollution, especially particulate air pollution, and the fraction of exhaled nitric oxide and blood markers of inflammation

Background
A number of investigations have reported an association between ambient air pollution and excess mortality from cardiovascular and respiratory diseases, even in air pollution levels that exist today in Western Europe and United States. Several studies indicate that the mortality increase 0.5% to 1% for each increase of PM_{10} with $10\mu g/m^3$. The relation between exposure to particles and mortality is most obvious for total mortality, but subjects with heart diseases are major part of the deceased. There is evidence of an association between ambient particulate air pollution and disturbances of the cardiac autonomic nervous system, as several groups have reported changes in heart rate or heart rate variability associated with ambient particulate air pollution. Another proposed hypothetical mechanism is that particles reaching the lung lining cells could induce airway inflammation which might influence blood coagulability and thus lead to heart disease (Seaton 1995). There is also accumulating data suggest that ambient particle pollution may lead to pulmonary inflammation, resulting in the dissemination of systemic proinflammatory products, i. e. cytokines, that may influence cardiovascular function.

In the beginning of 1990s it was shown that NO was a constituent of the exhaled breath, both in animals and humans. It was soon shown that exhaled NO was increased in patients with asthma and a number of studies have shown that FE_{NO} is associated with airway inflammation (Ricciardolo 2003). The method of measuring FE_{NO} has been internationally standardized (ATS/ERS 2005). Further is new data suggesting that using different exhalation flows when measuring FE_{NO} might help in identifying subjects with alveolitis (Lehtimäki 2001). This indicates that FE_{NO} with different exhalation flows could be a marker for inflammation in the small airways, which might be of special interest in studies of health effects due to air pollution.

Few studies have examined the effect of air pollution exposure on subclinical inflammatory markers such as NO. The majority of the studies have been performed on children by a group in Holland (Amsterdam 1999, Steerenberg 1999, 2003). Their main results are that increased exposure to air pollution (PM_{10} and NO_x) is associated with small increases in FE_{NO}. The studies are, however, small and they use a very low exhalation flow rate, 8 mL/s. In two small panel studies there has been an association between exposure to $PM_{2.5}$ and FE_{NO}, among children (Koenig 2003), and adults (Adamkiewicz 2004). In a study of 72 children in six summer camps it was found that evening values of FE_{NO} among children exposed to ozone exceeding 150 $\mu g/m^3$ was doubled (12 ppb vs 30 ppb) compared to those exposed to lower levels (Nickmilder 2003). Exposure to air pollution has in most studies been assigned to each subject by using information from permanent monitoring stations. In those stations is information available regarding particles, nitrogen dioxides, ozone and metereological conditions.

Methods
The present study APOLLON (Air POLLution and airway inflammatiON) started in 2001, and is aimed to investigate a random population sample of 10.0000 adult subjects in the age interval 25 to 75 years. We have until now, beginning of 2006, investigated 4.500 subjects. The selected subjects will be asked to answer questionnaires about respiratory symptoms, occupational exposures, smoking habits, diet and psychosocial conditions. They are then invited to a clinical investigation,

where they will be asked about addresses to home and their current workplace and where they have been the last three days. They will be investigated with FE_{NO} (three exhalation flow rates, 50, 100 and 280 mL/s), spirometry, blood samples (serum, plasma and blood), blood pressure, height, weight and hip-waist ratio. The design with three exhalation flow rates will give us a possibility to assess FE_{NO} from the small airways. We will use data about levels of different air pollutants that are available from the city of Göteborg, which include PM_{10}, nitrogen dioxides, ozone, sulphur dioxide and metereological data. The exposure for particles (PM_{10}) and nitrogen dioxides will be modelled for each subject, based on sampling data and information from the extended exposure questionnaire. The modelling work will be performed by the group in Umeå. We will then analyse the relation between particulate air pollution and different inflammatory markers. The main modelling will be regarding FE_{NO}, with different exhalation flow rates, but there will also be modelling regarding CRP, fibrinogen and coagulation factors (factor VII). We will also separately analyse the results for men and women to explore if there are different patterns of reactivity according to sex.

Budget, preliminary results and other fundings

The study have been funded by FAS, FORMAS and Hjärt-Lung Fonden, until now with about 8 000 000 SEK. We are funded until 2007 regarding the field staff, but study needs additional funding for the staff 2008-2009 to reach the size of the sample. In addition funding is needed for the analysis of different inflammatory markers in blood. For 2007 we apply for 500 000 SEK for analysis of inflammatory markers in blood. For 2008 and 2009 we apply for 1 000 000 SEK in salary for two assistants during 18 months years. In addition to the PI Anna-Carin Olin are Bertil Forsberg, senior lecturer, Bo Segertstedt, statistician and Kjell Torén, professor members of the research team.

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Is long-term exposure to particulate air pollution associated with an increased risk for ischemic heart disease - Anna-Carin Olin.

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Summary
The risk for ischemic heart disease is a major public health problem, but its association with particulate air pollution is not fully understood. The study under planning will include a case-control as well as a case-crossover analysis of incident cases of IHD (ICD 410-414) in the Gothenburg area including 650 cases and five times as many controls. We can obtain addresses for all subjects, and long-term exposure for traffic pollution indicators will be modelled. Recent exposure to PM_{10}, $PM_{2,5}$, NOx, and ozone in the case-crossover analysis of short-term effects will be assessed from air pollution measurements and models. We will subanalyse cases with out-of-hospital death.

Sammanfattning
Det är ett stort folkhälsoproblem att exponering för luftföroreningar ökar risken för hjärtinfarkt. Föreliggande fall-kontroll studie avser att undersöka sambandet mellan långvarig exponering för luftföroreningar och insjuknande i hjärtinfarkt. Studien baseras på 650 nya fall av hjärtinfarkt och fem gånger så många slumpvis utvalda befolkningskontroller. Både långvarig och kortvarig exponering för olika typer av luftföroreningar modelleras med hjälp av adresser och befintliga mätningar av luftföroreningar.

Aims and contribution to overall program aims
The aim of the project is to investigate whether exposure to different types of air pollution increase the risk for myocardial infaction

Background, methods and relevance
The risk for ischemic heart disease is a major public health problem, but its association with particulate air pollution is not fully understood (Delfino et al, 2005). Hospital admissions for myocardial infarction, congestive cardiac failure and cardiac arrhythmia all increase with a rise in the concentration of both particulate and gaseous pollutants, as does mortality in ischemic heart disease. An unusually strong effect of short-term exposure on cardiac admissions was, despite quite low concentrations of PM10, observed in Stockholm (Le Tertre et al, 2002).

In the American Cancer Society II study, where air pollution data was included for each metropolitan area, long-term PM exposures were most strongly associated with mortality attributable to ischemic heart disease, dysrhythmias, heart failure, and cardiac arrest (Pope et al, 2004). New data give support for an association between atherosclerosis and ambient air pollution (Kűnzli et al, 2005).

The study under planning will include a case-control as well as a case-crossover analysis of incident cases of IHD (ICD 410-414) in the Gothenburg area during the

period 2000-2004, approximately 650 cases. For the analysis of long-term effects, controls will be randomly selected from the same source population, five times as many controls as cases, stratified for age and sex. We can obtain addresses for all subjects, and long-term exposure for traffic pollution indicators will be modelled. Recent exposure to PM_{10}, $PM_{2,5}$, NOx, and ozone in the case-crossover analysis of short-term effects will be assessed from air pollution measurements and models. We will subanalyse cases with out-of-hospital death.

Budget and project group

The program grant will be used to design the study more in detail and seek additional fundings (400 000 SEK). In addition to the PI Anna-Carin Olin, Bertil Forsberg, senior lecturer, Bo Segertstedt, statistician, Annika Rosengren, professor and Kjell Torén, professor are members of the research team.

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Cohort study on total public health burden related to long term-exposure to air pollution - Göran Pershagen

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Summary
The health impact of exposure to air pollution in Europe is estimated to be very large. However, evidence on health effects of long-term exposure to air pollution in Europe is very limited. We plan to conduct a cohort study including about 100 000 subjects from Stockholm to assess life style and environmental health risks. The study will utilize methodology already available to estimate individual exposure to air pollution components and noise. International collaboration with other similar projects in Europe is ongoing.

Aim
The project aims to assess the total public health burden related to long term-exposure to air pollution, with particular focus on road traffic emissions.

Contribution to programme goals
Health effects of long-term exposure to air pollution.

Practical relevance
Eventually the study will provide comprehensive estimates of cancer and cardiovascular risks related to ambient air pollution. Furthermore, the role of specific air pollution components and sources will be assessed. Such evidence is crucial for prioritization of preventive measures.

Background
Ambient air pollution has been identified as the environmental health risk leading to the largest loss of quality adjusted life years and excess mortality in Europe. However, important gaps in knowledge still exist, such as identification of susceptible subgroups and assessment of the total public health burden. Only very large cohort studies with detailed exposure information can resolve these questions.

Current risk estimates of health effects related to long term exposure to air pollution particles are based primarily on studies from the US. There is a lack of studies on long term effects of air pollution in Europe. Three small cohort studies have been

published, which have primarily utilized within-city contrasts in traffic-related pollution (Hoek et al. 2002; Nafstad et al. 2003; Nafstad et al. 2004; Filleul et al. 2005). None of these studies has been able to directly address effects of fine PM, either as PM10 or as PM2.5, although other PM metrics such as “Black Smoke” and TSP have been used in some studies.

Interest in studying the joint effects of traffic noise and traffic related air pollution on the cardiovascular system is growing. It is estimated that about 30% of the population is exposed to traffic noise level at their homes exceeding current guidelines. Studies have linked community noise exposure to hypertension and one recent study found an increased incidence of myocardial infarction (Babisch et al. 2005), but the evidence is till inadequate for detailed risk assessment.

Material and methods

A unique database and methodology for detailed estimation of long-term exposure to ambient air pollution in Stockholm County has been developed and validated (Nyberg et al. 2000; Bellander et al. 2001). Information on home-addresses during several decades is combined with historical emission databases and dispersion models to obtain annual mean level of nitrogen dioxide, carbon monoxide, and particulate matter with an aerodynamic diameter of less than 10 μm (PM_{10}) from traffic, and sulphur dioxide from heating. Recent methodological developments imply that various particle components can also be modelled in more detail. In addition, we have developed and validated a methodology to estimate individual residential noise exposure.

A workshop was convened in January 2006 with participation by leading air pollution and health scientists in Europe as well as by representatives of the European Commission. It was agreed that new collaborative cohort studies in Europe were needed to assess health risks of air pollution and that this would form the basis of a call under FP7. Such new studies can be optimized to answer specific questions on health effects related to air pollution, including the role of various characteristics of particle exposure. Our proposed cohort study fits very well into this European initiative.

We propose a major cohort study including about 100 000 adults from Stockholm County, who will be followed prospectively using repeated questionnaires, biologic samples and registry information. An important feature is that the cohort will be used as a sampling frame for more intense studies, e.g. to select individuals with certain exposures or symptoms. The cohort would also function as a vehicle to foster collaboration between researchers of various disciplines. Another important aspect is to assess interactions between life style and environmental factors, which necessitates large sample sizes. The availability of biological samples will enable detailed dose estimation and studies of early signs of disease which would facilitate the understanding of etiological mechanisms as well as identification of susceptible groups.

Detailed planning of the project will take place during phase 1 of SCARP. Briefly, the project will utilize the unique exposure data bases for air pollution and noise described above, as well as registry information on cancer and cardiovascular disease.

In addition, more detailed exposure and health outcome information will be obtained via repeated direct contacts with study participants. Extensive experience of organizing and maintaining large cohort studies is available in the study team.

Budget

The proposed cohort study forms an essential part of an application to the Swedish Research Council for a Centre of Excellence based on a 10 year programme. The application has successfully passed the first stage in the review process. Obviously, the total resources needed to conduct the proposed cohort study far exceed those available within SCARP and would rely on contributions from several sources, both nationally and internationally. The initial 3 years are devoted to planning and pilot studies (300 000 SEK) and the major costs are incurred during the following years (2 000 000 SEK).

Deliverables

Extensive planning including pilot studies, is necessary to launch the project, and this is partly based on European collaboration. It is estimated that the planning process will take place during phase 1 of SCARP.

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Long term exposure to traffic related air pollution and genetic susceptibility in relation to myocardial infarction - Göran Pershagen

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Summary

Both environmental and genetic factors are of importance for developing cardiovascular disease, including myocardial infarction. However, little is known about possible interactions between ambient air pollution and genetic variants in relation to myocardial infarction. We will assess such interactions among more than 2300 cases of myocardial infarction and controls with detailed estimates of exposure to ambient air pollution components during 30 years. Genotyping of several genes of interest for myocardial risk will be performed, including IL-6, TNF-α, PA1-1 and fibrinogen-β. It is expected that the results will shed light on possible etiological mechanisms and serve as a basis for identifying susceptible groups.

Aim

The aim of the study is to investigate interactions between long-term exposure to source-specific urban air pollution components and genetic variants in relation to myocardial infarction morbidity.

Contribution to programme

The project will contribute to the programme priority area “Long-term effects”

Practical relevance

It is expected that the results will shed light on possible etiological mechanisms and serve as a basis for identifying susceptible groups.

Background

Long-term exposure to air pollution has been associated with cardiopulmonary mortality in cohort studies (Abbey et al. 1999; Dockery et al. 1993; Pope et al. 1995; Hoek et al. 2002; Grazuleviciene et al. 2004). The air pollution assessment has been based on average air pollution levels from urban background monitors in large metropolitan areas, ignoring individual differences due to within-city variation, or calculated according to large grids (kilometers) or as the distance to major roads. Usually only the baseline address has been available, and changes in residential pollution exposure due to subsequent relocation during the follow-up have not been possible to account for. Although some studies assessed potentially sensitive sub-groups for health effects from air pollution, there is a lack of conclusive data on possible effect-modification by other factors. Several genes have been identified, which are of interest in relation to the risk of myocardial infarction. For example, IL-6, TNF-α, PA1-1 and fibrinogen β affect inflammation and atherothrombosis (Hansson 2005). Since such mechanisms may be involved in air pollution effects on the cardiovascular system, there is a great need to assess gene-environment interactions.

Material and methods

The study originates from a large population-based case-control study of myocardial infarction (MI) in Stockholm (SHEEP–Stockholm Heart Epidemiology Program), described in detail elsewhere. The study includes all first events of MI among Swedish citizens in the ages 45-70 years resident in Stockholm county during 1992-1993 (1992-1994 for women), and population controls from the corresponding study base. Cases of first-time MI were identified from the coronary and intensive care units at emergency hospitals in Stockholm county, the Hospital Discharge Register for the county, or death certificates from the National Cause of Death Register at Statistics Sweden. Controls with no history of previous MI were randomly selected from the study base after stratification on age, sex, and hospital catchments area. In total, the study included 2,246 cases and 3,206 controls. A postal questionnaire was answered by 4,067 subjects, with a response rate among cases of 72% for women and 81% for men, while the corresponding figures among controls were 70% and 75%.

The questionnaire covered a large set of potential risk factors for MI, including physical and psychosocial work environment, social factors, life-style factors and dietary intake. A supplementary telephone interview was performed to reduce non-response and missing data. A health examination was also carried out (except for fatal subjects) to collect data on various biological parameters related to cardiovascular disease. The biological variables for analysis were primarily based on data from the health examination, but questionnaire information was used for some variables (e.g. BMI) for subjects not participating in the clinical testing.

The air pollution exposure was assessed using a methodology previously developed for a study on air pollution and lung cancer in Stockholm, and is described in detail elsewhere.[37] Briefly, all addresses inhabited during more than two years since 1960 were transformed into geographical coordinates using standard GIS computer software, in combination with a regional geographical address database.

Blood samples and DNA are available for 2315 subjects. Genotyping will be performed using DASH-methodology (Bennet et al. 2005) in collaboration with Ulf deFaire´s group at the Institute of Environmental Medicine.

Budget

PhD salary during 2 years and costs for genotyping, totalling 200 000 SEK per year.

Deliverables

The data for this project have already been collected but analyses have to be performed. It is expected that a final project report will be available during phase 1 of SCARP.

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DISOZPOLL: Diesel and ozone effects on the cardiovascular system - Thomas Sandström.

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Abstract

Cardiovascular events associated with air pollution are well known from epidemiological materials. The present study uses state-of-the-art plehtysmography techniques to determine the direct and local events in the blood and blood vessels caused by air pollutants. Effects of diesel engine exhaust, ozone and nitrogen dioxide are addressed in groups of human subjects, as based on earlier experiments by the applicants.

Sammanfattning

Hjärtkärlhändelser av luftföroreningar är välbeskrivna i epidemiologiska material . Den aktuella studien använder direkta provtagningar lokalt i blodkärl och pletysmografiteknik på försökspersoner för klarlägga vilka mekanismer i blod och blodkärl som ger upphov till dessa effekter. Effekter av dieselavgaser, ozon och kvävedioxid studeras, baserat på tidigare undersökningar.

Hypothesis and project goals

- The basal hypothesis is that exposure to air pollutants induces vascular changes with disturbed vasomotor and coagulation-fibrinolysis functions. It is postulated that common air pollutants like diesel engine exhaust, ozone and nitrogen dioxide have different potency to affect the circulatory system.
– By the use of validated and well established exposure chamber systems and bilateral plethysmography methodology we expect to further clarify mechanisms behind adverse cardiovascular health effects, as reported by a population based epidemiological research.

Contribution to the goals of the programme

The project adds novel pollutant related and mechanistic understanding to the sizeable contribution to cardiovascular morbidity and mortality by particulate matter air pollution.

Practical relevance of the project

The project is intended to increase the biomedical understanding of how air pollutants affect the cardiovascular system and thereby elicit the adverse health effects reported by epidemiological studies. This contributes to interventive technical, medical and regulatory actions.

Performance, theories and methods

An immense amount of short term studies have demonstrated increased mortality and hospital admissions, also in Sweden, in association with increased air pollution levels. The mortality is mainly cardiovascular and respiratory, with sudden death, myocardial infarctions, stroke, asthma and COPD as indicated conditions. A strong relationship between myocardial infarctions and traffic exposure was reported by Peters et al in NEJM 2004. The study gave interesting mechanistic indications by showing a very early increase at 1 – 2 hours after traffic exposure, followed by a period without increase, and then followed by another peak around 6-8 hours after traffic exposure. Mechanistically, this indicates at least two separate biological events with different time courses, but there could possibly be several, which interact over the hours after exposure.

The associations between health effects and air pollutants are commonly strong for particulate matter (PM), and nitrogen dioxide (NO_2). There may also be strong associations for ozone (O_3), that in certain contexts appear independent of the earlier. While there are clear toxicological indications for particulate matter, diesel engine exhaust and ozone to contribute to adverse and reactive effects both in-vitro and in-vivo in animals and humans, there is far less support for NO_2 to have an independent morbidity propagating role. NO_2 has during the last years increasingly been suggested to be a surrogate marker for traffic exposure. Neither after exposure to NO_2 nor to O_3 have potential cardiovascular effects been investigated in-vivo in humans. The indications for independent effects are more compelling for ozone, but an effect of nitrogen dioxide also demands attention to confirm or exclude.

The present investigators have performed experimental exposure studies investigating effects on lung function as well as systemic and airway inflammation, as reflected in bronchoalveolar lavage and bronchial mucosal biopsies, over two decades. Both for nitrogen dioxide, ozone and diesel engine exhaust we have in extensive experimental series in healthy subjects, as well as allergic, asthmatic and COPD subjects determined magnitude and detailed mechanistic aspects behind the development of inflammation, oxidative stress, bronchial hyperresponsiveness, bronchoconstriction and other adverse effects. Detailed mechanistic cellular studies of human bronchial biopsy materials have determined kinase and transcription factor activation pathways and downstream cytokine expressions.

During the last years we have extended our respiratory and allergy air pollution research programme into detailed studies on of how diesel engine exhaust modulates and causes adverse effects on the cardiovascular system. These studies have addressed the ability of blood vessels to widen and dilate after diesel exhaust exposure in-vivo in humans, in demand to increased demand of blood flow, effects on the local coagulation-fibrinolytic system, as well as the regulatory role of the endothelium. This has been achieved in collaboration with Prof D.E. Newby and colleagues in Edinburgh who have many years of experience with the techniques, and have also validated the effects in relationship with the coronary arteries (ref). This indicates that effects demonstrated with the plethysmography methods in the right and left arms in research subjects in the supine position, correlates with events in the coronary vessels, as based on parallel measurements during open-chest thoracic surgery with coronary angioplasty.

With this technique we have established time course effects following diesel engine exhaust exposure in healthy subjects and have recently published a paper in the highest ranked cardiovascular journal (Circulation, IF=10) demonstrating that six hours after diesel engine exhaust exposure there is a highly significant suppression of the vasal motor dilatory response as well as reduction in tissue plasminogen activator (t-PA) which locally regulates the important fibrinolysis, that prevent thrombosis formation. The endothelium does of necessity have to work properly and propagate increased t-PA release, especially in situations with arteriosclerosis and plaque rapture, in order to prevent a heart attack or stroke.

Three groups of 20 subjects each with normal lung function are included. A treadmill exercise test with ECG are performed before participation. Each subjects is exposed on two occasions in randomized blinded sequence to filtered air, as well as in air pollutant with an interval of at least two weeks. Separate groups of healthy subjects are exposed to diesel engine exhaust, ozone and nitrogen dioxide during one hour vs. a control exposure filtered air. Healthy subjects are complemented by subjects with established c-v disease. During all exposures the subjects alternate work on an ergometer cycle with minute ventilation 20 liter/min/m^2 body surface and rest, in fifteen minutes intervals. The exposures with ozone and nitrogen dioxide are performed in the exposure chamber we have well established, with well established and validated technique. The exposures with diesel engine exhaust are performed in the exposure chamber at Svensk Maskinprovning (SMP), Umeå, in collaboration with civil engineering competence, as well as chemistry and particle physics expertise. The exhaust is generated from an up to date Volvo diesel engine. A small proportion of the exhaust is shunted and diluted with filtered air and passed into the exposure chamber. Gases and particle concentrations and mass are determined by online instruments.

Bilateral plethysmography is performed in both arms, one serving as a control. Arterial needles for infusions of vasomotor active agents are used together with peripheral venous canules. Cuffs on both upper arms are used for blood flow measurements with start six hours after exposures and for four hours the endothelial and non-endothelial dilators are infused in a series with wash out in between, for determination and vasomotor response, t-PA release and effects on the coagulation system and thrombocyte adhesion (Webb 1995, Newby 1997, 1998, 1999, 2000). IL-1, IL-6, TNFα, CRP is determined. 24-hour Holter ECG:s are analysed for changes in heart rated variability and arrhythmias. Lung function changes are measured together with exhaled NO (nitric oxide). Breath condensates are sampled and analysed by the Anna-Carin Olin group in Gothenburg for oxidative stress and inflammation.

Staff and collaboration

The Umeå group is lead by the main applicant and Associate professors Anders Blomberg and Assoc Prof Stefan Söderberg: The latter at the Department of Cardiology. Three physicians during specialist training, two in respiratory medicine and one in cardiology are Ph.D. students engaged in this project, and experienced plethysmographists after training in Edinburgh. Four research nurses, two from respiratory, one from cardiology and one from anaesthesiology are likewise trained there. Collaborators in Edinburgh include Prof DE. Newby, Dr N Mills and Prof N Boon. Competence in chemistry physics and engineering have for long been locally established.

Deliverables:
Understanding of contribution of 1/ diesel exhaust 2/ ozone and 3/ nitrogen dioxide to acute vascular events.

Budget
The cost for the project is estimated to approximately 2 million SEK. We request 1.6 million in the present application including overhead. Exposure systems 0.2 million, staff 1.1 million, consumables and analyses 0.3 million. Full equipments for exposures and two parallel plethysmographies are present. Complementary funding has been secured from the Umeå university and additional support will be applied for.

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PMMECH - Mechanisms behind particulate matter air pollution induced toxicological effects - Thomas Sandström

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Abstract

The mechanisms behind the adverse health effects of air pollution particulate matter effects are still very unclear. The present investigation is intended to extend on the EU sponsored project HEPMEAP and will continue studies of archived and newly collected PM from a range of different sources in order to increase the understanding of how PM size, surface chemistry and sources determine toxicological capacity. The in-vitro experiments are all based on established techniques. The forthcoming activities may also include in-vivo instillation experiments in order to define coherence between different levels of experiments.

Sammanfattning
Det är fortfarande betydande oklarheter kring vilka partikelkomponenter som orsakar hälsoeffekter. Den aktuella ansökan är en utvidgning av den forskningslinje som etablerades under det EU sponsrade EU projektet HEPMEAP. De fortsatta studierna analyserar ny insamlade partiklar från olika miljöer i relation till arkiverade HEPMEAP partiklar, med avseende att ytterligare öka förståelsen för hur partikelstorlek, partikelyta, kemiska komponenter och olika källor påverkar den toxikologiska kapaciteten. Kommande försök kan även komma att inkludera instillationsförsök i likhet med tidigare EU projekt för att bekräfta experimentella fynd i djurmodeller och försökspersoner.
Contribution to the goals of the programme
The project extends the understanding of how source, size and chemical characteristics of particulate matter air pollution contributes to adverse cellular and biomedical events.

Practical relevance of the project
The understanding of toxicological mechanisms need to develop in parallel with other research techniques to give a combined increase in the knowledge of air pollution.

Performance, theories and methods

The adverse health effects from particulate matter (PM) air pollution on respiratory and cardiovascular health are well known. Less clear is what properties of the PM are causing the adverse effects. Based on a recently completed EU funded project co-ordinated by the main applicant (see www.HEPMEAP.org) we proposed to determine further into detail, the size and chemical characteristics responsible for different biological effects by PM. By further use of archived PM from across Europe, PM from different diesel and gasoline engines on different running conditions and fuel,

road and tyre wear PM, as well PM sampled wood smoke burning and national outdoor sources will be examined in different in-vitro models. Oxidative stress, transcriptor factors, mechanistic pathways, DNA adduct production, cytokines and arachidonic acid release are determined as earlier established.

The major hypothesis is that the toxicology of PM is dependent on size, with nanoparticles being especially toxic, with transition metals and organic components being major contributors. We propose oxidative stress to be a common dominator behind both initiation of respiratory and cardiovascular toxicological events through biotransformation of PAHs resulting in oxidative species and by quinines and transition metals by themselves carrying oxidative properties. The majority of experiments are performed with established in-vitro techniques within a research network. In similarity with the EU HEPMEAP project, the forthcoming activities may include in-vivo instillation experiments in animals and human subjects in order to establish coherence between different experiments.

Scientists engaged: Assoc prof Anders Blomberg, Assoc prof Anders Bucht, PhD Christoffer Boman, Prof Anders Nordin, Prof F J Kelly, PhD I Mudway, Assoc Prof F Cassee. Research fellows: Jamshid Pourazar, Maria Sehlstedt and Jenny Bosson.

Budget

We apply for funding with 400 000,- SEK in the present research programme which will support the development of this research programme. For the completion of the project, additional funding will be applied for.

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WOODPART-2: A human experimental model using wood smoke for studies of acute effects of particulate air pollution on inflammation, coagulation and oxidative stress - Gerd Sällsten

PI Gerd Sällsten, Department of Occupational Medicine, Sahlgrenska Academy, Göteborg University. P.B. 414, SE-405 30 Göteborg. E-mail: gerd.sallsten@amm.gu.se

Summary
This project uses an experimental model of wood smoke exposure in humans. A hypothesis regarding mechanisms of effects of particulate air pollution is that a mild pulmonary and systemic inflammation affects hemostasis and cardiovascular risk factors, increasing the risk of respiratory and cardiovascular disease. In a recent study we found clear effects of wood smoke exposure on airway inflammation, acute phase reactants, and blood coagulation compared with clean air. We propose new studies with a similar design, lower PM mass dose but a higher number of ultrafine particles. Fifteen healthy subjects (men and women) will be examined before and after:

- 3 h of exposure to wood smoke with $PM_{2.5}$ mass of about 200 µg/m^3 and number concentration of about 400 000/cm^3
- 3 hours of exposure to normal indoor air (control session)

The study is relevant for air pollution research in general. However, the issue of health effects from wood and other biomass burning is also very relevant for society since it is common in many countries, including Sweden.

Sammanfattning
Partikulära luftföroreningar ökar risken för sjuklighet och dödlighet i hjärt-kärl- och lungsjukdom. En hypotes om bakomliggande mekanismer är att partiklar orsakar inflammation i luftvägar och generellt, vilket via olika signalsystem påverkar blod, blodkärl och riskfaktorer för hjärtinfarkt. Vi har nyligen visat att kontrollerad exponering för vedrök i kammare framkallar tydliga effekter på blod (akutfasproteiner och koagulation) och luftvägar. I detta projekt vill vi undersöka om effekterna kan upprepas vid lägre dos av partiklar, mätt som masskoncentration, men en högre dos, mätt som antalskoncentration.
Femton friska försökspersoner ska undersökas före och efter:

- 3 timmars exonering för vedrök med $PM_{2.5}$ massa cirka 200 µg/m^3 och antalskoncentration cirka 400 000/cm^3
- 3 timmars exponering för ren luft (kontrollsession)

Modellen har generellt intresse inom luftföroreningsforskning, men effekter av vedrök är i sig en viktig fråga då småskalig användning av ved och annan biomassa är vanligt och står för en betydande del av emissionerna.

Aims and contribution to overall program aims

The overall aim is better understanding of the link between particulate air pollution, airway inflammation and cardiovascular disease. The specific aims are to find out whether

- effects of wood smoke on airway inflammation and blood coagulation found in a recently performed study (see preliminary results) can be repeated at lower levels of particles
- effects differ in relation to the fraction of ultrafines (UFP < 100 nm) in the smoke; i.e. if the number concentration has a greater impact on the response than mass concentration.

The project is focussed on issues listed in the program call: Swedish perspective, results within 5 years, relative effects of particles from different sources, short term exposure

Background

Exposure to air pollution, especially fine particulates (PM) increases mortality and morbidity in cardiovascular and respiratory disease (Pope 2004). Hundreds of short term studies have shown that mortality and hospital admissions increase on days with high particulate air pollution levels. This has been confirmed in a few long term studies. Several mechanisms have been suggested. Fine PM cause an inflammatory response in airways, which may affect acute phase proteins, risk factors for cardiovascular diseases. Increased levels of fibrinogen (Seaton 1995, Pekkanen 2000) or plasma viscosity (Peters 1997) have been postulated or found. Thereby a common mechanism may explain respiratory and cardiovascular disease. Possibly penetration of ultrafine particles (UFP) into the circulation affects coagulation factors from the liver. It is unclear whether PM in the accumulation mode or UFP (Pekkanen 2002) or both, are essential for health effects.

Human experimental studies

In vitro and animal studies have been performed, but this summary focuses on human experimental studies. The Sandström group in Umeå used diesel exhaust exposure for 1-2 h with a PM_{10} mass concentration of 100-300 µg/m^3. The results indicate that high exposure enhances gene transcription and expression of IL-8 in bronchial epithelial cells and adhesion molecules for migration of leukocytes to the bronchial tissue are upregulated (Salvi 1999). Standard lung function tests showed no effects. The main mechanism seems to be oxidative stress. In summary there were signs of inflammation in brocnhial biopsies and BAL, while findings in peripheral blood were small. In subjects with mild allergic asthma, Svartengren et al. (2000) showed that exposure for 1/2 h in a road tunnel with $PM_{2.5}$ just above 100 µg/m^3 increased airway resistance after subsequent exposure to allergens. There were no clear effects on standard lung function tests, nor on blood markers. Recently human experimental studies using concentrated ambient air (CAP) have been performed (Ghio 2004), and in one study an increase in fibrinogen was noted in healthy humans.

Wood smoke

Residential wood burning is assumed to contribute about half of the Swedish emissions of fine PM. The possible impact on health has received increased attention. While specific carcinogens (benzene, 1,3-butadiene, and PAHs) have been a concern, exposure to PM has rarely been studied. Wood smoke increases ambient PM levels in many countries (Forsberg 2005). Indoor levels may be high ($PM_{2.5}$ 50 – 5000 µg/m^3) when open fires or simple stoves are used. We recently showed that also Swedish subjects using wood burning for space heating are exposed to increased levels of certain elements (Molnar 2005).

Methods of the present study

Our group was the first one to perform experimental studies of human exposure to wood smoke. Based on the findings in our recent study (Barregard 2006, and "preliminary results" below) we propose experimental studies with a similar design, but a lower PM mass dose (3h instead of 4h, lower mass concentration) and higher number of UFPs.

Subjects, timing of examinations, ethics

15 healthy subjects (men and women) will be examined before and after:

- 3 h of exposure to wood smoke with a $PM_{2.5}$ mass of about 200 µg/m^3 and a number concentration of about 400 000/cm^3
- 3 hours of exposure to normal indoor air (control session)

A general health check-up and spirometry will be performed in all subjects; never smokers without history or signs of relevant heart or lung disease. The subjects will be examined on several occasions after exposure, and the timing will be optimized taking into account the results of our first study (see below). Approval by the Ethics Committee has been obtained.

Exposure set-up and characterization

The exposure will take place in the exposure chamber built at SP, Borås (Barregard 2006). Wood smoke is generated in a wood stove and mixed with indoor air to the required concentration. An appropriate phase of the combustion cycle will be used to obtain the desired PM mass and number concentrations, surveyed using TEOM and ELPI instruments.

The following measurements will be performed: Fine particles mass ($PM_{2.5}$, PM_1) will be collected on Teflon filters (Molnar 2005). Elements will be analysed using XRF (Molnar 2005). "Black smoke" will be determined by reflectance. Number concentrations of particles will be measured by an ELPI equipment. NO_2/NO and CO will be measured with direct reading instruments. Formaldehyde and acetaldehyde will be determined, as well as benzene, 1,3-butadiene and PAHs. Temperature, RH and CO_2 will be registered.

Breath, blood and urine analyses

Subject will be examined with respect to FENO (three exhalation flow rates). The fraction of expired NO (FENO) is associated with airway inflammation and asthma. FENO at different exhalation flows can reflect inflammation in various parts of the airways; possibly also in studies of air pollution (Adamkiewicz 2004), indicating that PM_{10} and NO_x are associated with increased FENO. Expired breath condensate will be collected by a condenser (Jaeger). EBC will be analysed for MDA (own lab), and isoprostanes. Malondialdehyde (MDA) is elevated at oxidative stress and airway inflammation (Kneepkens 1994). We have developed specific and sensitive methods for MDA in expired breath condensate (EBC) (Lärstad 2002).

Blood counts, acute phase proteins, cytokines, and coagulation factors will be measured in serum/plasma at the Sahlgrenska University Hospital. Clara Cell protein (serum/urine) will be determined at our own lab. As a marker of lipid peroxidation, the isoprostane 8-iso-PGFα will be analysed in urine by S. Basu in Uppsala. Genotypes for GSTs will be determined.

Budget

The estimated costs will be 1.9 MSEK: salaries 0.8, blood and other clinical and chemical analyses 0.3, smoke generation and chamber 0.2, and equipment 0.2, OH 0.4 MSEK. 0.4 MSEK has been obtained from Hjärt-lung-fonden, and therefore 1.5 MSEK is requested.

Collaboration and other funding

Project group: Occupational and Environmental Medicine, Sahlgrenska University Hospital and Academy: PI: Gerd Sällsten, assoc. prof., environmental and occupational hygienist. Further: L Barregård, prof., chief physician, K Torén, prof., chief physician, B Strandberg, assoc. prof., chemist, A-C Olin, assoc prof., physician. Five PhD students will be engaged: Pernilla Gustafson, MSc, Peter Molnar, PhLic, Lena Andersson, MSc, Sandra Johannesson, MSc, Ann-Charlotte Isacsson, MSc. Swedish National Testing and Research institute (SP), Dept. Energy Technology: Claes Tullin, R&D Manager, Linda Johansson, researcher. The first study was funded within SNAP, ending 2006. For the present study a grant of 0.4 MSEK was obtained from Hjärt-Lungfonden. Kjell Torén has funding for studies of air pollution and inflammation in small airways. There is a continuous sharing of knowledge with SNAP partners including the Sandström and Svartengren groups. The ELPI at SP is partly funded by the Swedish Energy Agency and the EMFO-programme. The group collaborates with Steffen Loft's group (Copenhagen), who makes some of the analyses in WOODPART, and some analyses in Loft's experimental studies (AIRPOLIFE) are performed in Göteborg.

Preliminary results

We recently performed a study in 13 healthy subjects exposed to wood smoke in the above-mentioned chamber (Barregard 2006). $PM_{2.5}$ levels were about 250 mg/m^3, 100% of which was in the PM_1 fraction. Number concentrations were 100-180 000/cm^3 with about half in the ultrafine size fractions (<100 nm). The results show clear and statistically significant effects on ***several of the serum and plasma markers*** mentioned above (CC16, factor VIII, and acute phase proteins) as well as ***FENO and MDA levels in breath condensate***. In summary, the results indicate that we have a suitable experimental model for the aims described.

Relevance

Researchers struggle with the questions: "Which properties make PM hazardous for health?" and "Are ultrafine particles more hazardous?". The present project has the potential of contributing to the answers. Health effects from biomass burning products are relevant for society since wood burning is common. In order to reduce CO_2 emissions, an increased use of renewable biomass is desirable. Conclusions drawn from exposure to fine PM from wood smoke can also be valid for other combustions products like traffic exhausts or coal burning.

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Health effects of long range transported particles: a population study using air mass trajectories - Gerd Sällsten.

PI Gerd Sällsten, Department of Occupational Medicine, Sahlgrenska Academy, Göteborg University. P.B. 414, SE-405 30 Göteborg. E-mail: gerd.sallsten@amm.gu.se

Summary

Long range transported air pollution (LRT) is important for levels of PM in Sweden. Epidemiologic studies have, however, focussed more on disentangling possible differential effects of various PM size fractions, chemical characteristics of PM, or gaseous components of air pollution. Another approach is to focus on the sources, in particular the origin of air masses. We have recently used this approach in two studies in Hagfors, and Göteborg (Molnar 2005, Molnar 2006).

The impact of long distance air pollution on health effects will be investigated in a sample from a random population (The APOLLON study) of 10,000 subjects. The subjects will be classified with respect to air mass back trajectories showing paths and sources of the air (e.g. marine air vs continental air) on the days of examination for those days where a clear classification can be performed. Mass concentrations of PM_{10} and/or $PM_{2.5}$ at background stations will be taken into account, as well as other known factors that could affect the results of the clinical examinations. All subjects are investigated with fraction of exhaled NO, pulmonary function and blood markers of systemic inflammation. Results for days with marine vs continental exposure will be compared regarding inflammatory outcomes. The hypothesis to be tested is that certain air masses are associated with markers of pulmonary and/or systemic inflammation. Possible associations will be compared with those found for PM levels alone.

Sammanfattning

Långdistanstransporterade luftföroreningar står för en mycket stor del av partikulära luftföroreningar i Sverige. En del epidemiologiska studier har inriktats på att jämföra utfallet när det gäller hälsoeffekter med beräkningar av olika källors bidrag (lokala motoravgaser, vägdamm, långdistanstransport etc.). Det är emellertid också möjligt att använda luftmassornas ursprung som input, genom så kallade bakåt-trajektorier. Vi har nyligen använt denna teknik i studier i Hagfors och Göteborg (Molnar 2005, Molnar 2006).

I detta projekt önskar vi använda tekniken för att studera inverkan av långdistans-transporterade partiklar i en befolkningsstudie (APOLLON) med cirka 10 000 slumpvist valda individer. De dagar då individerna undersöks (lungfunktion, NO i utandningsluft, inflammationsmarkörer i blod m.m.) klassificeras med avseende på ursprunget för den luftmassa individerna andas den aktuella dagen. Även masskoncentrationerna av PM_{10} och $PM_{2.5}$ vid bakgrundstationer tas i beaktande liksom ett stort antal individfaktorer som kan påverka utfallet av de kliniska

undersökningarna. Den hypotes som ska testas är att vissa luftmassor samvarierar med utfallet i ovan nämnda markörer.

Aims and contribution to overall program aims

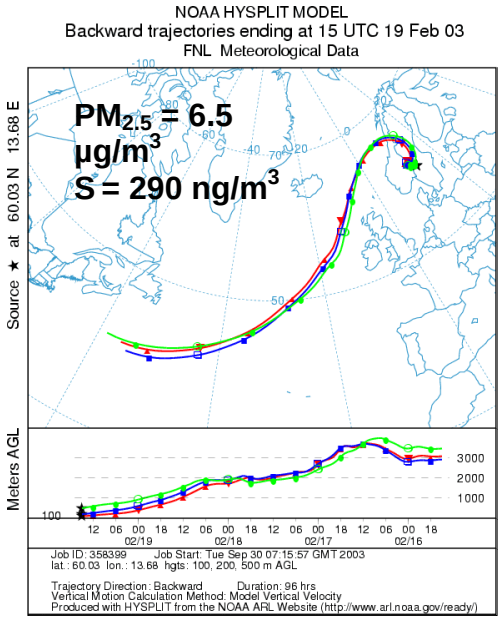
The aim of the project is to test whether certain air masses are associated with markers of pulmonary and/or systemic inflammation.

The project is focussed on issues listed in the program call: Swedish perspective, results within 5 years, relative effects of particles from different sources, effects related to short term variations of exposure

Background, methods and relevance

The present project is only outlined in short, since the application covers a start-up and planning phase only. Running the proposed study will require additional funding from other sources.

Long range transported air pollution (LRT) is important for levels of PM in Sweden. Epidemiologic studies have, however, focussed more on disentangling possible differential effects of various PM size fractions, chemical characteristics of PM, or gaseous components of air pollution. Another approach is to focus on the sources, in particular the origin of air masses. We have recently used this approach in two studies in Hagfors, and Göteborg, se examples below.



$PM_{2.5}$ = 22 µg/m³
S = 3700 ng/m³

The impact of long distance air pollution on health effects will be investigated in a sample from a random population (The APOLLON study) of 10,000 subjects. The subjects will be classified with respect to air mass back trajectories showing paths and

sources of the air (e.g. marine air vs continental air) on the days of examination for those days where a clear classification can be performed. Mass concentrations of PM_{10} and/or $PM_{2.5}$ at background stations will be taken into account, as well as other known factors that could affect the results of the clinical examinations. All subjects are investigated with fraction of exhaled NO, pulmonary function and blood markers of systemic inflammation. Results for days with marine vs. continental air will be compared regarding inflammatory outcomes. The hypothesis to be tested is that certain air masses are associated with markers of pulmonary and/or systemic inflammation. Possible associations will be compared with those found for PM levels alone.

Budget and project group

We apply for funding with 500 000 SEK in the present research programme. This will permit work on design and collecting of some preliminary data. Completion of the study requires, however, additional funding (about 1.5 M SEK).

PI Gerd Sällsten, associate professor, occupational and environmental hygienist. Other senior researchers: Kjell Torén, prof., chief physician, and Anna-Carin Olin, associate professor, physician.

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Regional and national atmospheric models for particulate matter - Sub-program coordinator HC Hansson

Objective: Develop and validate modes for particulate matter (PM), from urban to regional scales for the assessment of effects to human health and climate.

Participating institutions: Stockholm University (HC Hansson, Peter Tunved, Christer Johansson), Swedish Meteorological and Hydrological Institute (Joakim Langner, Valentin Foltescu), Lund Institute of Technology (Erik Swietlicki, Kristina Stenström), Chalmers / Gothenburg University (Mattias Hallqvist) and Norwegian Institute of Meteorology / EMEP (David Simpson). HC Hansson will act as subprogram co-ordinator.

The problem: Today, health effects can only be addressed through PM-concentrations as policy-relevant models (e.g. the EMEP model) are lacking a detailed description of other parameters, e.g. particle size distributions of inorganic components, black and organic carbon (possibly related to health effects, as indicated by the WHO review for CAFE). The EMEP model is presently limited in its ability to provide data for use in health studies.

The concern on how interaction between air quality and climate change is growing as it is recognized that a changing climate influences atmospheric concentrations as well as deposition of air pollutants. Further, it is also recognized that anthropogenic particles might have a considerable climate forcing, at least in the major industrialized parts of the world, including Northern Europe. The EMEP model is not yet prepared to deliver necessary input parameters for such climate forcing calculations.
The research proposed in this program area aims at improving understanding of aerosol particles' importance for health effects by the ability to reproduce both the number and the mass concentration distributions of the multi-component atmospheric aerosol. The project will also enhance the scientific understanding of the source-receptor relationships as a result of including explicit formulation of in-situ particle formation (nucleation) in addition to the direct emission of particulate matter.

The following sub-goals have been identified:
1/ An evaluated robust module describing the chemical (including organic) PM fraction and its relation to natural and anthropogenic sources.
2/ A comprehensive description of particle dynamics ready to be implemented in a 3D Eulerian model
3/ An evaluation of present urban models, concerning their description of particle size distributions and related chemistry.
4/ Methodology on how to develop and construct emission databases for dynamic particle models.

Sub-projects:

The overall aim of the urban and regional scale modelling work is to developed evaluated modules dealing with both dynamics and chemistry, which ca be applied in 3-D models for the prediction of health-related PM data. As a basis for this, we will make use of a comprehensive "reference" modelling system against which to develop

and evaluate computationally efficient models which can be used in 3-D models. The reference scheme will be based upon existing models from e.g. the University of Helsinki or U.S. groups, and modified as necessary. The same reference model will be used in sub-projects (1) and (2), with a focus on chemistry in sub-project (1) and on dynamics in sub-project (2). These two sub-projects will interact continuously, with frequent exchange of routines in order to merge the chemical and dynamical methodologies into one module.

1/ Further develop and validate a model describing the chemistry of aerosols, with a focus on the organic fraction of PM. The final description should be able to use for the calculation of the organic mass fraction in 3D Eulerian models.

The work should focus on development of chemical schemes which can be applied within MATCH and EMEP. Evaluation will be against the the comprehensive reference model and against measurements, e.g. those of the EMEP EC/OC campaign, EU CARBOSOL project. The evaluation will also be done in co-operation with a MISTRA-project on organic aerosols co-ordinated by GU and MET.NO and the recently funded FP6-infrastructure project EUSAAR, which develop and coordinate measurements at 20 super sites in Europe. Additional measurements of 14C to determine the fractionation between fossil and recent carbon might be added. SU and LTH are partners in EUSAAR.

2/ Develop dynamic particle descriptions.

The aim is to describe how the emissions influence the number, mass and chemistry of the atmospheric particles with high spatial and temporal resolution.The work should be conducted in close co-operation with sub-project (1) with the specific objective to develop and evaluate a computationally fast aerosol dynamics module, capable of simulating the aerosol size distribution and composition in the framework of 3D Eulerian models (MATCH and EMEP) on local to regional scale.

Detailed process descriptions are already evaluated in Lagrangian studies, which will be used in the evaluation of suitable parameterizations that can be implemented in the 3D models. The first dynamic formulations have been implemented in the EMEP-model in earlier and ongoing NMR-projects (NORPAC) and in the MATCH-model. The proposed work will focus on tracking the number, mass and composition of particles simultaneously. The main processes involved in aerosol dynamics are nucleation, condensation/evaporation, coagulation, deposition and cloud interactions. The above processes will be coded and validated against the reference modelling system (outlined above) and the available size resolved and chemically resolved aerosol data (same as in sub-project 1).

3/ Construct emission databases for dynamic particle models and validate urban models concerning particle size distribution and chemistry.

The aim is to develop source specific particle-size resolved emission factors for both number and mass. The emission factors will be implemented in an emission database suitable for both urban and regional particle dynamic models that should describe how the particle-size distribution develop and disperse over an urban area. This will be input for larger scale modelling of the urban plume, how it develops on a mesoscale and regional scale. The importance of aerosol dynamic processes for urban scale modelling will also be evaluated and the dispersion model calculations will be validated by comparison with observations.

Relevance

The suggested program aims first at developing an operation model giving a satisfactorily description of the natural and anthropogenic organic particle fractions. This should be done in close co-operation with EMEP / MET-NO. Further shall the program develop a dynamic particle model with suitable emission data base that can be used for evaluation of health effects of single and combinations of different particle components. The model should be useful for calculation of climate forcing by particulate air pollutants.

Budget estimate: 8 million SEK over the program period.

Chemical Modelling of Aerosol Formation - David Simpson

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Summary
Sub-project 1 aims to develop modules for aerosol chemical formation which are appropriate for 3D chemical modelling. In order to develop such models, the "reference" model discussed above will be subject to sensitivity analysis, in realistic European conditions (trajectory modelling), in an effort to assess the most important components and mechanisms. Much simpler models, designed for use in 3-D chemical transport modelling (in particular EMEP and MATCH models), will be developed and tested against the comprehensive model, and against atmospheric observations.

Sammanfattning
Detta subprojekt ämnar utveckla en programmodul för att beskriva bildning, och tillväxt av atmofäriska partiklar, för användning i 3-D Kemiska transport modeller, specifikt EMEP och MATCH modellerna. Modulen skall utvecklas ur och testas mot dels en detaljerad modell och dels mot observationer av partiklarnas kemi och fysik.

Project objectives
The objective of sub-project (1) is to develop aerosol models capable of predicting the chemical composition of aerosols, which can be used in chemical transport modelling (in particular in EMEP and MATCH models) for the purposes of mapping particulate levels across Europe and for emissions control assessments.

The project contribution to the programme objectives
The project will contribute to (1) the understanding of the chemical composition and formation of aerosols by way of a comprehensive chemical model, and (2) development of simplified aerosol models for use in chemical transport modelling, in particular for the MATCH and EMEP models and (3) by way of these models improve the reliability of calculations of aerosol mass, size-distributions, and composition which are used in policy assessments within UNECE and the EU.

The practical relevance

The EMEP model as used within the CAFE programme made use of very simplified schemes for the modelling of aerosols, with only two size ranges (PM2.5 and PM10) and no reactive organic chemistry (i.e. no secondary organic aerosol, SOA). This project aims to ensure that the EMEP model used in forthcoming assessments uses

more realistic treatments of aerosol chemistry, thus ensuring more reliable descriptions of the effects of emissions abatement options.

Work-plan, theories and methods

Development of Comprehensive Model
The available comprehensive models (e.g. Univ. Helsinki, CALTECH group, USA,) will be assessed for their usability and flexibility, in cooperation with sub-project (2). The most-promising candidate will be established in Gothenburg and Norrkjöping. A literature review and discussion with relevant experts will be used to identify where such models could be further improved in terms of chemistry. (Likely areas include the inclusion of the aqueous phase pathways to SOA formation recently highlighted by Warneck, Erviens and co., and the oligomer/polymer formation pathways, e.g. Kalberer, Limbeck, Jiang, which form a rapidly evolving research area)

The reference aerosol module will be implemented in a Lagrangian model, driven by meteorology, emissions and boundary-conditions from the EMEP MSC-W or MATCH CTMs.

Sensitivity analysis of the comprehensive models
The comprehensive model will be thoroughly analysed in order to assess which levels of complexity are really needed in order to capture the main chemical features, e.g. How many size-bins/sections are really needed?; Do we need to model interactions between the aqueous phase-chemistry and the organic-phase chemistry?; Can we assume internally-mixed aerosol, or must we follow separate populations of aerosol particles? Are thermodynamic parameters (e.g activity coefficients for inorganic-organic mixtures) known to a sufficient degree? The aims of these tests will be to identify the processes and complexity level which could be introduced into the simplified models.

X.3 Development and Evaluation of Simplified models
Candidate simplified models include an extended version of the multi-mono scheme with 4 size bins (Univ. Helsinki) which is currently implemented in MATCH and EMEP and as a research code in the EMEP system, and so-called modal models (e.g. Binkowski et al.). These codes both require improvement with regard to at least organic chemistry, and probably with regard to aqueous-phase interactions and number of size-bins or modes. These simplified schemes will be assessed and improved according to the results of the sensitivity analysis discussed above.

The focus will be on the model performance in realistic conditions through the use of paralle runs against a trajectory model version of the reference model, and on comparison with measurements wherever possible. Measurements will include those already available from the Nordic sites (BACCI), EU CARBOSOL project, EMEP EC/OC and EUSAAR, and make use of C14 measurements in Nordic areas from this project and other research programmes. As aerosol chemistry is an active and rapidly-changing field, contact and cooperation with leading aerosol scientists will be actively pursued, e.g. through the ACCENT network.

Investigation of Cloud Chemical Modules

A parameterised cloud scheme will be implemented in the modelling framework by utilizing simplified aerosol activation schemes in conjunction with derived meteorological parameters such as estimated updraft velocities and cloud horizontal and vertical extent. The in-cloud chemistry is treated using a cloud bulk water approach, taking into account the liquid water content (LWC), concentration of surrounding gases and the CCN chemical composition. The approach will allow for main oxidation pathways of gaseous constituents (e.g. pH dependent oxidation of S(IV) by ozone and hydrogen peroxide). The aqueous phase oxidation processes are well know to significantly affect the chemistry and size of the remaining CCN population of dissipating clouds and are thus crucial for an accurate description of the aerosol size and chemical evolution over time. The cloud parameterisation adopted will further be used to estimate in-cloud scavenging of interstitial aerosol, rainout processes as well as effect on vertical distribution of aerosols resulting form cloud cycling. In addition, the cloud model will be used to investigate some of the recent ideas about the possible aqueous uptake and processing of organic molecules as a potentially important source of secondary organic aerosol.

Application
The new schemes will be implemented in the EMEP and MATCH models, and used to investigate the composition of aerosols over Europe and their response to emission controls. e.g. to quantify the role of NOx emissions in the formation of aerosols, through the formation of fine and coarse mode nitrates, and also through the photochemical reactions which lead to SOA formation.

Timescales
Phase I - development of simplified chemical schemes, coordinated with simplified dynamics from sub-project (2). Preliminary investigation of cloud-effects and possible incorporation into 3-D models.

Phase II - Intensive research on cloud-modelling, including more comprehensive evaluations against measurement data and if possible other state-of-the-art models.

Budget

The total estimated cost for this subproject is 3.6 MSEK of which 2.4 MSEK is for the model development and 1.2 MSEK is for 14C measurements.

The sampling, measurements and evaluation of 14C will be done by Kristina Stenström och Erik Swietlicki, Department of Physics, Lund University.

Developing dynamic particle description including formation, growth and deposition - Valentin Foltescu

Project leader
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Summary
The overall goal of this sub-project is to provide an improved understanding of how the natural and anthropogenic emissions influence the number, mass and composition of the atmospheric particles with high spatial and temporal resolution. A suite of objectives have been identified in relation to aerosol dynamics modelling which is considered to be indispensable in order to meet the overall goal.

Sammanfattning
Det övergripande syftet med detta delprojekt är att förbättra vår förståelse av hur naturliga och antropogena utsläpp påverkar de atmosfäriska partiklarnas antal, massa och kemisk sammansättning med hög temporal och spatial upplösning. Flera mål har identifierats i relation till modellering av aerosoldynamiken, som betraktas som nödvändig för att kunna svara mot det övergripande syftet.

Project Objectives
The objective of this project is to develop and evaluate a computationally fast aerosol dynamics module, capable of simulating the aerosol size distribution and composition in the framework of 3-D Eulerian CTM (Chemical Transport Modelling) on local to regional scale.

The project contribution to programme objectives
The research proposed in this project will lead to an improved understanding of aerosol particles' importance for health effects by the ability to reproduce both the number and the mass concentration distributions of the multi-component atmospheric aerosol as a function of particle size. The project will also enhance the scientific understanding of the source-receptor relationships as a result of including explicit formulation of in-situ particle formation (nucleation) in addition to the direct emission of particulate matter.

The practical relevance
The work undertaken in this project will add to the work on modelling the organic aerosol fraction (sub-project 1) and will supply chemical transport models (in particular EMEP and MATCH) with the capability of describing all the major primary and secondary aerosol components. A detailed model-based description of the aerosol concentrations and their composition and mass/number size distribution over Sweden and Europe will serve in promoting awareness of health impacts and solutions aimed at cost-effective control strategies.

Workplan, theories and methods
The basis for the work in this project is the use of the same "reference" modelling system for detailed description of the aerosol chemistry and dynamics employed in sub-project 1. Computationally efficient routines for aerosol dynamics aiming at use in 3-D CTMs will be developed and validated against the reference model. The MATCH model developed at SMHI and the EMEP model will be supplied in this way with a module for merged aerosol dynamics and chemistry. The model requirements on the module input and output will be picked up by enhanced interactions between the MATCH and EMEP modelling groups during the course of the project.

The representation of particle size will be either sectional into discrete sizes or functional, whichever is found to be the most accurate and computationally efficient. Both particle mass and number concentrations will be tracked simultaneously. The module will use state-of-the-art nucleation parameterizations simulating the aerosol size distribution starting at a diameter of 0.8 nm. The interactions between the organic acids and sulphuric acid will be considered in this context as they appear to reduce the nucleation barrier, thereby promoting nucleation. Temperature and humidity control the nucleation process and will be supplied with the meteorological input to the module. Condensation and evaporation of water vapour will be included in the aerosol dynamics module because of their paramount importance in shaping the ambient size-composition distribution. Coagulation will also be included. It is an important sink for the number of the smallest nucleated particles. Deposition is strongly dependent on the actual particle size distribution. The module will allow for descriptions of the size dependent deposition processes. Cloud processes including activation of aerosol particles to form cloud droplets and other aspects of the physical interactions between cloud droplets and aerosol particles will be accounted for. Such processes make changes in the size distribution and can change composition significantly.

Throughout the modelling project, prior to releasing a model version with aerosol dynamics it is necessary to demonstrate that the model represents adequately the important physical and chemical phenomena influencing aerosol particles and their precursors in the study area. If significant bias is exhibited in comparisons with measurements, work will be required to determine the cause of the biases and to rectify shortcomings provided that discrepancies are attributed to the model itself.

The general structure of the work is as follows:
PhaseI:
2:1 Agree with the other sub-projects in Area 2 upon the description of the general modeling structure, including the treatment of size distribution and the choice of the reference model.
2:2 Making an outline of performance evaluation requirements.
2:3 Providing a summary of data requirements in order to perform model evaluation.
2:4 Reviewing the algorithms that are to embody the aerosol dynamics processes and the assumptions that are made to derive these algorithms and the limitations they might impose.
2:5 Coding each of the dynamics processes outlined above and validation against the reference model.
Phase II:

2:6 Evaluating the performance of the aerosol dynamics module in the framework of Lagrangian models and 3-D Eulerian CTM (MATCH and EMEP) using available size resolved and chemically resolved aerosol data (same as in sub-project 1).

2:7 Improving the module descriptions in order to eliminate any significant shortcomings of the model.

2:8 Making an appraisal of further research needs with respect to aerosol dynamics modeling.

Budget:

The estimated budget for this project is 2.4 MSEK over the entire program period.

Construct emission databases for dynamic particle models and validate urban models concerning particle size distribution and chemistry - Christer Johansson

Project leader: Christer Johansson, Department of Applied Environmental Science, Stockholm university, 106 91 Stockholm, Sweden, Phones: 08-6747276; 0709-383086; E-mail: christer.johansson@itm.su.se.

Summary
In this project we will develop source specific particle-size resolved emission factors for both number and mass. The emission factors will be implemented in an emission database suitable for both urban and regional particle dynamic models that should describe how the particle-size distribution develop and disperse over an urban area. This will be input for larger scale modelling of the urban plume, how it develops on a mesoscale and regional scale. The importance of aerosol dynamic processes for urban scale modelling will also be evaluated and the dispersion model calculations will be validated by comparison with observations.

Part of the model development and the measurements in this project depend on additional funding. If additional funding is received the model calculations will be used in health impact assessment studies. These assessments will be made for different particle sizes (and sources). Specifically the health impact of black carbon particle-size distribution will be evaluated on the urban scale.

Sammanfattning
I detta projekt kommer vi att ta fram emissionsfaktorer för partikelantal och massa för olika källor i urban miljö och implementera och testa dessa i en detaljerad emissionsdatabas. Emissionsfaktorerna skall beskriva hela partikelstorleksfördelningen från ca 3 nm – 10 µm och emissionsdatabasen skall appliceras i spridningsmodeller för att bedöma betydelsen av partikeldynamiska processer för partikelhalterna på olika skalor. Resultaten från modellberäkningarna på lokal skala (dvs områden <100 km) utgör sedan input för modellberäkningar på mesoskala (<1000 km) och regional skala (>1000 km).

En del av modellutvecklingsarbetet och modellvalideringen i detta projekt är beroende av tilläggsfinansiering (som kommer att sökas via EMFO). Tilläggsfinansiering kommer dessutom att sökas för att använda modellerade tidsserier i hälsoeffekt analyser. Specifikt kommer (i ett EMFO projekt) emissionsfaktorer avseende storleksfördelningen av fasta sotpartiklar att kvantifieras med en ny mätmetod.

Project objectives
The aims are to
- develop source specific, particle size resolved emission factors for number and mass
- develop a methodology on how to establish emission data bases suitable for both urban and regional particle dynamic models
- describe how the particle size distribution develops and disperses over an urban area, and how the urban plume forms and develop on a regional scale
- quantify the importance of aerosol dynamic processes for urban scale modelling

- validate the dispersion model calculations by comparing with observations

Depending on additional funding the model calculations will be used health impact assessment studies. These assessments will be made for different particle sizes (and sources). Specifically the health impact of black carbon particle-size distribution will be evaluated on the urban scale. Also depending on additional funding, the deposition of particles in the human respiratory tract will be described to give, not only the population exposure to particles, but also the particle dose. The exposure-dose relationships will be validated against direct measurements of lung deposition performed on human subjects.

The project contribution to programme objectives
Several gaps of knowledge become apparent when moving from models that account for particle mass (PM) to those that include also a description of particle number (and surface area) size distributions. First, there is no general consensus regarding size-resolved emission factors from various relevant urban sources, or a methodology on how to deduce these from a combination of mass-based emission factors and existing size-resolved concentration data. Furthermore, it has become evident that the size distributions undergo significant transformations even within the urban air shed, so that the urban plume – as it flows out across the city borders – cannot simply be described as a linear combination of all contributing primary sources plus dispersion. There is also disagreement regarding the extent to which aerosol particle dynamic processes transform the size distribution, and over which temporal and spatial scales they need to be considered.

The outcome of this subproject will enable the population exposure with regard to particle number, surface area and mass to be estimated, taking also into account the importance of the various relevant urban sources. Since the model description will be fully size-resolved, this exposure estimate can be converted to population dose estimates, based on information on the deposition pattern in the human respiratory tract.
The urban plume deteriorates the regional scale air quality. The regional scale models depend on “effective” size-resolved emission factors from urban areas that account for transformations taking place within the urban air shed. The project will describe the urban particle emissions and the characteristics of the urban plume, which is the input to the mesoscale/regional models. Thereby the project will improve the reliability of calculations of aerosol mass, size-distributions, and composition, which are used in policy assessments within UNECE and the EU.

This project can therefore be used to test the efficiency of abatement strategies in urban planning, and assess the importance of different abatement strategies for population health. The results can be used to assess the health effects caused by local versus regional scale pollution. Thereby the importance of primary urban sources can be compared with long-range transported aerosols (both primary and secondary) with regard to mass and number.

The practical relevance
Understanding the relative importance of different airpollutants and air pollutant sources for short and long term variations in morbidity and mortality among the general popolation is fundamental for defining efficicient abamement strategies. The methodology developed in this project can be used for evaluating health effects in

epidemiological studies and to further analyse abatement strategies in local urban planning and in policy assessments within the EU.

Workplan theories and methods

1. Emission factors

Establish a particle size resolved (10 nm – 10 µm) emission factors for the most important sources. This will also include a particle size resolved distribution for soot particles (heavy and light duty vehicles). This emission factor will include both number and mass size distribution.

Emission factors for the following sources/sizes will be included:
- Road wear (studded and non-studded tires), mainly coarse particles (>1 µm)
- Brake linings, mainly coarse particles
- Tailpipe exhausts: Diesel/gasoline, heavy/light duty, mainly nucleation and aitken mode particles
- Wood smoke particles; nucleation and aitken mode
- Ferries; nucleation and aitken mode
- Power plants, district heating etc.; nucleation and aitken mode

Other possible particle fractions that may be of interest from the health point of view:
- Black carbon, mainly diesel vehicles, nucleation and aitken mode
- Volatile, non-absorbing particles from vehicle exhaust, mainly organic, mainly nucleation mode

The first inventory will mainly be based on existing data in Nordic countries or other international data which are representative for Swedish conditions. New data will be available from the ongoing EMFO projects IMPORT, TRAPART, NanoWear and WEAREM.

2. Implementation in emission database and preliminary evaluation

The particle size resolved emission factors will be implemented in the emission database of Stockholm county. A preliminary evaluation of these emission factors will be made by calculating particle concentrations using the air quality dispersion models in the Airviro system of the Stockholm and Uppsala regional air quality management system. Calculated particle mode concentrations will be compared with existing data in Stockholm.

In addition existing particle size-resolved measurements in urban areas Nordic countries will be reviewed in order to compare with the methodology developed in this project. Apart from Stockholm there are measurements in Malmö that started in April 2005 on the roof top station “Rådhuset”.

3. Modelling

The imprtance of particle dynamical processes will be evaluated using the emission data base developed for the Stockholm region. This will be based on the MATCH model and the code developed previously by Gidhagen et al. (2005). This is a three-dimensional dispersion model implemented over the urban area of Stockholm (35x35

km) to assess the spatial distribution of number concentrations of particles in the size range 3 to 400 nm. It includes an aerosol module for calculating the particle number losses due to coagulation and dry deposition. This model treats seven monodisperse particle sizes based on the MONO32 model (Pirjola and Kulmala, 2000) and includes water uptake, coagulation and dry deposition of particle number and mass, for different particle size bins.

Urban area integral emission “factors” for different particle sizes will be calculated in order to be able to extrapolate the concentration in mesoscale and regional modelling. Sensitivity tests will be made in order to simulate emissions in more densely populated cities in central Europe.

4. Model validation and health assessment

So far only limited particle size distribution measurements have been made in Stockholm. In order to validate the model calculations more data is needed. The plans are to seek additional funding (from EMFO) for complementary measurements in the Stockhlm region. Malmö and Stockholm. We will also seek funding for size-resolved measurements of black carbon; both emission factors and ambient concentrations.

Time plan

Phase 1
Emission methodology.
Implementation in emission database and evaluation and characterisation of the urban aerosol paricle size distribution.

Phase 2
Modelling of the urban aerosol.
Model validation (if additional funding is received) and health impact assessment (if additional funding is received).

Budget

The overall budget for the entire program period is 2.4 MSEK.

Sub programme Ecosystem Impacts of Air Pollution - Nitrogen and Acidification - Coordinator John Munthe

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Introduction

The negative environmental impacts of acid rain have decreased greatly in recent years, mainly due to emission reductions of sulphur dioxide in Europe. At present, anthropogenic acidifying deposition is dominated by N-compounds which also contribute to eutrophication. The predicted reductions of N emissions in Europe to 2020 are relatively limited. Together with potential interactions with changes in climate and land use, N-deposition poses a risk for continued acidification, eutrophication and changes in biodiversity in terrestrial and aquatic ecosystems. Scandinavia, and especially the northern parts, is relatively unaffected by high nitrogen deposition and many terrestrial ecosystems have not yet undergone the changes in vegetation type which has taken place in parts of continental Europe, over the last century. These relatively unaffected ecosystems also provide an opportunity to investigate early effects of nitrogen deposition on ground vegetation.

Ecosystem research relies on two primary sources of new information; data from observations (monitoring) and data from experiments at various scales. This sub programme will make use of both. Two major Swedish long term manipulation experiments are involved in several ways (low-dose N addition at Vindeln and NITREX Gårdsjön experiment) and other existing experiments will also be reviewed together with data from national monitoring. Interpretation, conceptualisation and extrapolation of monitoring and experimental data is often best done using mathematical models. This sub programme will focus on development, refining and extensive testing of dynamic models of nitrogen cycling, acidification and changes of vegetation. Model prediction will form the basis of synthesis towards long-term strategies for sustainable ecosystem management.

Relevance

The research described below will be directly relevant to national and international policies to reduce impacts of air pollution and to reach environmental targets. The models employed in this work are directly applicable to the development and refinement of critical load concepts and environmental criteria used for policy assessment. The proposed research will synthesise several earlier and ongoing program activities in Sweden and maintains and develops the Swedish scientific network, as well as the future participation in international networks (e.g. EU research and expert groups in LRTAP). The planned research will also provide arguments for protection of the ecosystems relatively unaffected by human interference with the global biogeochemical N-cycle in northern Scandinavia, on a European level.

There is an increasing international interest in nitrogen and there are several activities started and underway in order to give a more comprehensive picture of the nitrogen fluxes and fate on different scales. In Europe, COST and ESF have both started projects with the aim to prepare assessments of the nitrogen problem. The COST

activity is directed towards a better understanding of atmosphere-biosphere nitrogen fluxes in Europe in relation to the main economic sectors, interactions with the natural environment and current policies, in order to establish a sound scientific basis for strategies to reduce the environmental impacts of nitrogen[1]. The ESF project is directed towards more genuine scientific issues and takes a broader view. Issues of particular importance are links between different media (the cascade effect), interactions with climate change and effects on biodiversity. Several EU projects such as NitroEurope and Eurolimpacs also include important aspects on nitrogen, and activities within SCARP will link up to these projects. There are also plans for a larger EU project on N effects on biodiversity under FP7 and we intend to take part in proposals.

Sub programme Objective

The objective is to improve our understanding of short and long term effects of nitrogen deposition with respect to recovery from acidification, biodiversity and eutrophication and to provide scientific support for measures to reduce negative impacts on the environment.

The following sub-goals have been identified:

- To further clarify the fate of nitrogen deposited to forest ecosystems, and the effects on acidification of soils and surface waters as well as on nitrogen induced vegetation changes
- To evaluate and further develop dynamic models for nitrogen in forest ecosystems including-vegetation interactions and acidification and to apply the modelling results to development of critical loads and other forms of policy support.
- To assess the future status of forest and aquatic ecosystems for different scenarios of deposition, climate change and forestry.

The sub programme is organised in three research projects:

1. Nitrogen cycling in forest ecosystems.

Project Leader Cecilia Akselsson, IVL Swedish Environmental Research Institute
Participants: Annika Nordin SLU Umeå; Lars Högbom, Skogforsk; Filip Moldan, Olle Westling, IVL, Lars Ericsson, UmU.

2. Dynamic model evaluation and development

Project Leader: Salim Belyazid, Department of Chemical Engineering, Lund University
Participants: Filip Moldan, IVL; Harald Sverdrup, Mattias Alveteg, LTH, Lars Ericsson UmU, Annika Nordin SLU.

3. Impacts of deposition, forestry and climate change

Project Leader Filip Moldan, IVL Swedish Environmental Research Institute
Participants: Olle Westling, IVL; Annika Nordin, SLU Umeå; Salim Belyazid, LTH/IVL.

[1] http://www.cost729.org/

Budget for area eco systems

			Budget individual years			
Activities		Total Budget	1	2	3	4-6
	Responsible scientist, participants	7700	1200	1350	1300	3850
1. Coordination and synthesis	John Munthe	600	100	100	100	300
2. Nitrogen cycling in forest soils	Cecilia Akselsson, IVL	2300	800	600	550	350
2.1 Assessment of existing data from e.g. N-addition experiments, etc.	Cecilia Akselsson, IVL	500	400	100		
	Lars Högbom, Skogforsk	300		50	150	100
2.2 Complementary data gathering in field experiments	Filip Moldan, IVL	750	200	225	200	125
	Annika Nordin, SLU	750	200	225	200	125
3. Dynamic model evaluation and development	Salim Belyazid, LTH	1800	300	650	650	200
3.1 Refining and testing of N-dynamics in acidification models	Filip Moldan, IVL	725	125	250	250	100
3.2 Refining and testing of N-dynamics in vegetation response models	Salim Belyazid, LTH	725	125	250	250	100
	Annika Nordin, SLU	350	50	150	150	
4. Impacts of forestry and climate change	Filip Moldan, IVL	3000			0	3000
4.1 Evaluation of climate change impact on ecosystem response	Filip Moldan, IVL	500				500
	Annika Nordin, SLU	300				300
4.2 Scenario development	Olle Westling, IVL	600				600
4.3 Scenario calculations of acidification, nitrogen cycling and vegetation response	Filip Moldan, IVL	800				800
	Salim Belyazid, LTH	800				800

Nitrogen cycling in forest ecosystems - Cecilia Akselsson

Project Leader Cecilia Akselsson, IVL Swedish Environmental Research Institute, PO Box 5302, SE 40014 Gothenburg, Sweden. Ph: +46 31 7256 200; email: cecilia.akselsson@ivl.se
Participants: Annika Nordin SLU Umeå; Lars Högbom, Skogforsk; Filip Moldan, Olle Westling, IVL, Lars Ericsson, UmU.

Summary
This project is focussed on improving our understanding of nitrogen cycling in forest ecosystems, including the role of nitrogen in acidification/recovery and the effects of nitrogen on vegetation composition. The main questions to answer are related to accumulation of N in soils and vegetation, controls on N-leaching to surface waters and controls on vegetation responses. The basis of the work is field experiment and observations including experimental low dose N-addition experiments, forest fertilisation experiments and environmental monitoring. Data from both terminated and on-going experiments will be used. The results will be used for model development and testing in project 2 and will also contribute to the development of empirical critical loads.

Sammanfattning
Projektet är inriktat på att utöka vår förståelse om kväveomsättning i skogsmark. Detta innefattar kvävets roll i försurning/återhämtning och effekter av kväve på vegetationssammansättning. De viktigaste frågorna rör ackumulering av kväve i mark och vegetation, vad som styr läckage av kväve till ytvatten och vad som styr förändringar i vegetationssammansättning. Arbetet baseras på fältexperiment och innefattar försök med lågdos tillförsel av kväve, skogsmarksgödsling och miljöövervakning. Data från såväl avslutade som pågående experiment kommer att användas. Reultaten kommer att användas för modellutveckling och utprovning i projekt 2, och kommer även att bidra till utveckling av empiriska kritiska belastningsgränser.

Project Objectives
To further clarify the fate and impacts of nitrogen in forest ecosystems. This includes the role of nitrogen in acidification and recovery from acidification of forest soils and surface waters, and to correlate soil nitrogen processes to vegetation responses. Also to study ecosystem biodiversity, focusing on the interactions between plants and their natural enemies that contribute to the governing of ecosystem species composition. This particularly in response to low doses of nitrogen input as well as vegetation recovery following decreased nitrogen input.

The Project contribution to programme objectives
The project will contribute by providing data and evaluation results related to nitrogen dynamics in forest soils and vegetation response to nitrogen deposition. This project will focus on results from completed, on-going and planned field experiments and monitoring programmes. Field data will be collected and evaluated with focus on providing input to dynamic biogeochemical models (project 2). Resulting data will be reported to the process of ongoing revision of empirical critical loads of nitrogen recommended for European ecosystems. The results of this project will thus contribute to on-going international and national efforts to reduce impacts of nitrogen deposition.

The Practical Relevance

Nitrogen plays a major role in acidification and eutrophication and affects the biodiversity of ecosystems. An increased understanding of soil nitrogen dynamics and vegetation responses to increased nitrogen supply is necessary for continued cost effective efforts to abate air pollution. Ecosystem nitrogen cycling is also closely linked to the carbon cycling and increased knowledge of nitrogen processes is fundamental to obtain an increased understanding of the capacity of ecosystems to sequester atmospheric carbon. This is of relevance to future assessment of climate change impacts, and thus for the development of policies to reduce impacts of climate change.

In the last decades the role of nitrogen in acidification has increased, as the sulphur deposition has decreased rapidly. There are, however, still knowledge gaps regarding the role of nitrogen in acidification processes and the soil recovery from acidification. Increased availability of nitrogen constitutes a drastic influence on biodiversity of the boreal forest and mire ecosystems characterized by low nitrogen supply that dominate northern Scandinavia. Increased nitrogen supply interferes with the abundance of both rarely occurring endangered species and more trivial species including species responsible for the production of berries and mushrooms in these ecosystems. Experimental research points out that even very low levels of ecosystem nitrogen input can cause considerable vegetation changes as well as alter interactions between different trophic levels. Interactions between climate change and nitrogen are poorly understood, but preliminary results suggest an enhancement of nitrogen impacts at increased temperatures. Moreover, many processes of ecosystem recovery following reduced nitrogen input are largely unknown. The few studies that are available points out that soil chemical parameters can show a relatively fast recovery, whereas biological parameters like plant community species composition tends to recover only slowly.

Due to that south Scandinavia as well as the rest of Europe already receive moderate to high levels of atmospheric nitrogen deposition the effects of low levels of ecosystem nitrogen input can only be investigated and understood in north-Scandinavia where levels of atmospheric nitrogen deposition are still fairly low. In addition processes of ecosystem recovery following decreased nitrogen input can here be studied in long term experiments where nitrogen treatments have been terminated. The knowledge outcome from the planned project will be essential to enhance awareness for the nitrogen issue in the international negotiation work. To develop sound nitrogen management strategies for regions still relatively unaffected by nitrogen pollution, as well as for regions with a long history of nitrogen deposition, it is necessary to increase the understanding of low dose effects and the potential for ecosystem recovery at reduced deposition rates. In addition the issue is highly relevant to assess impacts of large scale commercial forest fertilization employed to increase biomass production on ecosystem biodiversity.

Work plan, theories and methods

This subproject will mainly focus on existing field experiments mainly in Gårdsjön, Bohuslän, and in Vindeln, Västerbotten as well as monitoring programmes and other existing field experiments on N-fertilisation. Within the project the ongoing long-term field experiments in Gårdsjön and Vindeln will be continued and data observations and assessments will be related to soil processes central for soil nitrogen accumulation, leaching and transformations as well as processes directing plant community species composition. The findings in this subproject will be used for model improvements in subproject 2 and 3. Two activities are planned:

1.1 Assessment of existing data from N-addition experiments including low-dose fertilisation and assessment of data from national monitoring and forestry research.

Nitrogen cycling in forest ecosystems is crucial in the acidification, recovery and eutrophication processes. The nitrogen retention processes are, however, not fully known. In this activity an inventory of existing field experiments, monitoring data and forestry research related to nitrogen accumulation, leaching, transformations and interactions with carbon will be made in order to increase the knowledge about nitrogen retention processes and thus be able to improve the nitrogen and vegetation response models. The inventory will also be the basis for a compilation of adequate datasets for model validation.

The first stage of this activity includes identification of critical knowledge gaps that limits the nitrogen and carbon modelling. Results from the ASTA programme will be used for this purpose. It will also partly be based on a critical analysis and evaluation of existing model results. Two retention processes that are already identified as important processes that are not well described in the models are the nitrogen retention in the ground vegetation and in the microbial biomass.

An inventory of field experiments and monitoring data, relevant in the light of the critical knowledge gaps, will then be made and data will be analysed. Potential field experiments include Gårdsjön NITREX, Skogaby and low dose fertilisation experiments as well as terminated N fertilisation experiments in areas with low background N deposition in Vindeln, Västerbotten, and in integrated monitoring areas. The experiments in Gårdsjön and Vindeln are described in section 1.2. Skogaby in Southwest Sweden is a plot experiment in spruce forest conducted in 1988-1997 with increased input of N as ammonium sulphate (Persson & Nilsson 2001). A number of studies describe different effects of the treatments and the fate of added N in above and below ground biomass, soil and soil water. Co-operation and utilisation of results from the project “Where does added nitrogen go in nitrogen rich forests?” (Lars Högbom, SkogForsk, a project financed by FORMAS) is included in the activity 1.1. The experiments with 15N additions will be conducted at four N-rich sites in South Sweden during 2006-2008. Data from the field experiments and monitoring data appropriate for validation purposes will be compiled to validation datasets and used in projects 2 and 3.

1.2 Complementary data gathering in two field experiments

Gårdjön NITREX is a catchment-scale N addition experiment, where a small catchment G2 NITREX has been fertilised with small doses of nitrogen distributed about 20 times a year since 1991. It is an experiment, where a transition from an originally N-poor to eventually N-rich site is experimentally induced at forested catchment typical for many areas of Scandinavia. The experimental site has been extensively investigated through a sweep of national, Scandinavian and European projects. There is a wealth of results, which are to a large extent published in ca 40 peer reviewed articles. The amount of information and the 18 years of monitoring data make the site ideal as a test site for models of N cycling.

In this activity the treatment of the G2 NITREX will continue for additional 3 years and data-set (e.g. deposition, runoff chemistry, soil chemistry, climate, hydrology, microbial processes) for evaluating models of N cycling will be compiled. Additional information on vegetation will be gathered through a vegetation survey. The repeated vegetation survey aims at investigating how the 15 years of enhanced N deposition has changed the composition of vegetation at the site. Results of the survey will be

compared to those from a vegetation survey performed at the beginning of the experiment in 1992. The comparison will provide material for evaluation of models of vegetation change (e.g. ForSAFE VEG) in response to N deposition.
Previous research on low-dose N-additions to boreal ecosystems at Vindeln has shown that changes of key ecosystem components, important to maintain the biodiversity, occurs at lower N deposition than the current empirical critical load of nitrogen for boreal understorey vegetation (e.g. 6 vs. 10 – 15 kg N ha^{-1} yr^{-1}). This research has also shown that vegetation recovery following decreased ecosystem nitrogen input is much slower (i.e. more than 50 years) than soil chemical recovery. Research performed in the ASTA program points out that interactions between plants and their natural enemies (like for example pathogenic fungi and insect herbivores) can be of central importance for these responses. Ecosystem responses to very low nitrogen doses can only be investigated in long-term experiments in areas with low background deposition (*i.e.* for Europe in northern Scandinavia). Internationally, most experiments used to establish the empirical critical loads for nitrogen have been carried out in areas with moderate or high current nitrogen deposition. In the current project, long term low dose experiments established in boreal forests (1996) and mires (1995) in Vindeln, north-Sweden will be employed and continued. Fertilizations with low doses of nitrogen will be performed and the yearly vegetation surveys started in 1996 will be continued. Processes of vegetation recovery will be studied in terminated nitrogen fertilisation experiments. Co-operation and utilization of results from the project “Processes delaying or preventing boreal forest vegetation recovery following decreased nitrogen input” (Annika Nordin, SLU Umeå, a project financed by FORMAS 2006 - 2008) will be included in the activity.

Dynamic nitrogen model development and evaluation - Salim Belyazid

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Summary
This project is focussed on the testing and development of biogeochemical models for nitrogen cycling in forested ecosystems. The work will be based on existing models such as MAGIC, INCA-N and ForSAFE-VEG. Data and results generated in project 1 will form the basis of the development. Main model components to be improved are descriptions of N-accumulation in soils and the role of nitrogen in acidification and recovery of surface waters and interactions between nitrogen species and vegetation including responses and recovery in vegetation species composition. Furthermore, the results will be used to improve and define policy-relevant tools such as critical loads and target loads for nitrogen deposition.

Sammanfattning
Projektet är inriktat på utvärdering och vidareutveckling av biogeokemiska modeller för kväveomsättning i skogsekosystem. Arbetet kommer att baseras på existerande modeller som MAGIC, INCA-N och ForSAFE-VEG. Data och resultat från projekt 1 kommer att utgöra basen för utvecklingsarbetet. Huvudsakliga modellkomponenter för vidareutveckling är: N-ackumulering i mark och kvävets roll i försurning/återhämtning av ytvatten och; samverkan mellan kvävespecier och vegetation inklusive förändringar och återhämtning av vegetationssammansättning. Resultaten kommer även att användas till förbättra och definiera policyverktyg som kritisk belastning av kvävedeposition.

Project Objectives
To evaluate and further develop dynamic models for nitrogen in forest ecosystems including-vegetation interactions, and to develop policy relevant tools such as critical loads to be used in national and international assessment and abatement activities on air pollution.

The Project contribution to programme objectives
In recent years, dynamic models for acidification have been important for explaining the recovery concept i.e. the time lag between reductions of emissions and deposition and measurable improvement in ecosystems. Dynamic modelling results have also become an important part of the scientific basis for policy development in the air pollution sector. Future predictions of acidification and recovery are associated with significant uncertainties mainly caused by uncertainties in nitrogen dynamics. Models describing nitrogen effects on vegetation are currently not part of the scientific basis for policy development. The results of this project will contribute to reducing the uncertainties of nitrogen dynamics in future predictions of acidification and recovery and will also develop and evaluate models describing vegetation effects. This also includes providing policy-relevant tools such as critical loads.

The Practical Relevance
Dynamic models are important for assessment of environmental status of ecosystems. They are becoming increasingly important in the international work on critical loads but need further development and refining. The critical loads of acidification and

nitrogen in areas with high or moderate nitrogen load highly depends on assumptions made about nitrogen retention in forest soils. Different approaches to link nitrogen deposition and accumulation to leaching of nitrogen from forest soils are applied in different models. Large uncertainties remain in descriptions of these processes and relatively coarse assumptions are sometimes necessary. This leads to significant uncertainties in model predictions of nitrogen leaching and thus to uncertainties in predictions of recovery from acidification and important parameters such as aluminium and ANC.

Work-plan, theories and methods

This activity will focus on refining dynamic models for acidification and eutrophication of forest soil and runoff (such as MAGIC, INCA-N, SOILN and ForSAFE (Wallman *et al.,* 2005) with respect to conceptualisation and parameterisation for nitrogen cycling. It also includes extensive testing and evaluation of the ForSAFE-Veg (Belyazid, 2006; Belyazid and Sverdrup 2005) model for vegetation response. This activity will be based to a large extent on the findings of project 1. It will also involve a review of other existing model concepts and data on interactions between biogeochemistry and vegetation.

2.1 Refining and testing of N-dynamics in acidification models

One of major challenges of modelling the long-term effects of N deposition is that the changes caused by the N deposition are usually difficult to observe on a shorter time scale than decades. There are several ways to overcome this problem. Most commonly, a substitution of time for space is used in that sense, that data from a regional survey at one point of time are interpreted as data from one or a few sites at different times. The time is measured by cumulative N deposition. This means that a site A with high N deposition gets interpreted as a future state of site B which has a low N deposition. While this has proven as a successful technique to establish regional relationships between the state of ecosystems and N deposition, it does not answer two other questions: what was the time course at which the ecosystems moved from one state (e.g. N-limited) to another (e.g. N-saturated). Another question is what mechanisms caused this change. The results of regional surveys revealed a strong correlation between C/N ratio in the forest floor and NO3 leaching, which is a commonly used indicator of N-saturation. This, however, does not imply a causal relationship between the two observations and such interpretation or model conceptualisation may not be appropriate.

The Gårdsjön NITREX experiment is one of very few experiments in the world, which has a potential to provide data on gradual changes in an ecosystem subjected to N-deposition (Moldan et al., in press), and is thus useful as a test ground for models. In this activity such a data set will be compiled in project 1 and concepts in models linking the N-deposition with N-cycling between soil and vegetation, N-leaching will be tested. Several models will be applied – MAGIC, FORSAFE and INCA-N applications are planned, other models might also be used. Apart from testing and possibly revising and re-formulating the model concepts, the models applicability will also be the focus of the evaluation. This activity will also make an effort to reach other modelling groups outside Sweden and to invite them to use the same data set for testing other models of N-cycling, acidification and vegetation change used elsewhere (see Brighton report).

2.2 Refining and testing of N-dynamics in vegetation response models

The ForSAFE model (Wallman et al., 2005) for modelling of biogeochemical processes in forest ecosystems, has recently been complemented with the VEG module which simulates the composition of ground vegetation in response to biotic

and abiotic factors (Belyazid, 2006). The ForSAFE-VEG model is the first model incorporating both biogeochemistry in forest soils and responses of ground vegetation. The model has been tested on 16 well investigated sites in Sweden, and the results were promising. Much further work is, however, needed to enhance the model and its parameterization. After the first runs, several specific improvements of the model have been suggested. Nitrogen is in this first version of the model not divided into nitrate, ammonium and organic nitrogen. Since the response of plants differs for the different nitrogen species they should be treated separately in the model. Further, the effect of nitrogen on ground vegetation is included, but not the important feedback, the effect of ground vegetation on nitrogen. Ground vegetation leads to a nitrogen retention which is important for the nitrogen cycling, especially after clear cutting when the uptake by trees in interrupted. The continued work on the model will raise new questions and further improvements will be required. Results from the field experiments in project 1 will be used in the process of improving the model.

The changes in ground vegetation depends on changes is climate, sulphur deposition, nitrogen deposition and management. Thus it is difficult to use the results directly for assessing critical loads of nitrogen for different plants. In this sub programme the effect of nitrogen will be quantified by comparing results from runs with different nitrogen deposition histories but the other data fixed. By doing this, a critical load for nitrogen with respect to different kinds of ground vegetation can be established.

In a lack of time series data the model results are often evaluated by use of measurements at one point of the time. Dynamic models should, however, be evaluated by use of time series which provide possibility to much stronger tests. Field experiments from the project 1 have been running for sufficiently long time to be useful for this.

Future impacts of forestry, deposition and climate change - Filip Moldan

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Participants: Olle Westling, IVL; Annika Nordin, SLU Umeå; Salim Belyazid, LTH/IVL.

Summary
This project will be performed in phase 2 of the programme. The main objective is to assess impacts on terrestrial and aquatic ecosystems of future deposition, climate change and forestry. The results from projects 1 and 2 will form the basis for the assessment together with experiences from on-going projects on climate change impacts and the ASTA programme. An important task is to identify relevant future scenarios for the three main driver's deposition, climate and forestry. Experiences from project such as SWECLIM, ASTA and Eurolimpacs will be used for this purpose. A detailed research plan for this project will be developed towards the end of phase 1.

Sammanfattning
Projektet kommer att utföras inom fas 2 av programmet. Den huvudsakliga målsättningen är att utvärdera effekter på terrestra och akvatiska ekosystem orsakade av framtida deposition, klimat och skogsbruk. Resultat från projekt 1 och 2 kommer att ligga till grund för arbetet tillsammans med erfarenheter och resultat från pågående projekt om klimatpåverkan och t.ex. ASTA programmet. En viktig uppgift är att ta fram relevanta scenarier för de viktigaste framtida påverkansfaktorerna deposition, skogsbruk och klimat. Erfarenheter från projekt som SWECLIM, ASTA och Eurolimpacs kommer att användas för detta syfte. En detaljerad forskningsplan tas fram i slutet av fas 1.

Project Objectives
To assess impacts of climate change, deposition and forestry on leaching of acidifying and eutrophying substances from forest soils.

The Project contribution to programme objectives
This project will be performed in Phase 2 of the programme, i.e. during year 3-6. This project will integrate results from projects 1 and 2 and perform scenario calculations of future ecosystem status. It will form a final synthesis of the project results and achievements in Phase 1.

The Practical Relevance
This project will provide guidance on the future development of ecosystem status in relation to deposition, forestry and climate change. It will thus be of relevance for the development of long-term strategies for sustainable ecosystem management.

Work plan, theories and methods
The major part of this work will be performed in Phase 2 (years 4 – 6) and a more detailed work plan and more detailed objectives will be prepared toward the end of phase 1 based on the outcome of the phase 1.
This activity will combine, interpret and extrapolate in space and time output from projects 1 and 2. The task to evaluate the impacts of deposition, forestry and climate change on ecosystems could be broken down to three steps:

i. summarising by what major mechanisms will the climate change, deposition and land use affect the ecosystems and in which way will these mechanisms act,

ii. to estimate scenarios of how the drivers of ecosystem changes such as temperature, deposition, storm frequency, precipitation, deposition or land use will develop in the future and,
iii. through models evaluate the impact of the changes in drivers on ecosystems.

The structure of this activity follows this concept with 3 sub-activities, one for each of the above-described steps.

3.1 Evaluation of climate change impact on ecosystem response

This activity will draw heavily on the results of projects 1 and 2 as well as results from on-going research projects (e.g. EU project Eurolimpacs, www.eurolimpacs.ucl.ac.uk/). Experimental and field observations of impacts of forestry and climate change on S- and N-cycling in forest soils and runoff will be used to calibrate and test models. The models will then be applied to future scenarios of climate change and forestry. The national ASTA database and data from monitoring and inventories will be used to model future impact of N deposition over regional to national scales. Leakage of inorganic aluminium and possibly mercury will also be included in these activities.

3.2 Scenario development

Based on knowledge of available scenarios for land-use, deposition and climate, integrated scenarios will be developed and selected for assessment using models developed in project 2. The scenarios will be based on an analysis of policies and implementation of policies on use of forest biomass, SWECLIM climate scenarios and deposition currently being developed in the Eurolimpacs project.

3.3 Scenario calculations of acidification, nitrogen cycling and vegetation response

When mechanisms in which the climate and land use change are likely to affect ecosystems are summarised and conceptualised (4.1), when scenarios of future land use are developed and predictions of GCM are downscaled and broken down to actual change of drivers such as temperature or precipitation (4.2) the final step is the actual scenario analysis, evaluation of the model outputs, interpretation and extrapolation. This activity will take place in the final years of the programme and will provide a modelling assessment of several likely scenarios of climate and land use change on ecosystems with respect to acidification, nitrogen cycling, and vegetation.

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Sub programme Integrated Assessment Modelling

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Introduction
Current international air pollution policies are mainly based on results from the application of RAINS. However, the use of the GAINS model, which includes GHG emissions and abatement costs, is expected to increase. In GAINS, the abatement costs are mainly based on technical measures and some energy savings as well as fuel switch measures. However, structural changes and behavioural changes are, despite their importance for emission reductions not taken into account. Another limitation with the model is that on a national level, more detailed and geographically resolved integrated assessment tools are needed. As an example related to ecosystems, the magnitude of impacts from air pollution is very variable and depends on local conditions and external factors such as climate change and land-use. These factors make it difficult to estimate ecosystem effects in the current GAINS.

Objective
The overall objective of this sub program is to provide a basis for optimisation and assessment of future air pollution policies in Sweden and Europe. To fulfil this objective, we propose two work packages. WP1 (project 1 and 2) will focus mainly on the abatement cost estimates including non-technical measures (NTM). This WP will also include adjustment of the cost module to the current GAINS model, which requires a close co-operation with IIASA who has already showed positive response.

WP2 (project 3 and 4) will include a development of a GAINS Sweden. The proposed work does not include the design and development of a completely new model, but rather a version of the GAINS model, in which the cost module, which is already adapted in WP 1, is introduced. GAINS Sweden will thus be adapted and improved to meet requirements and goals with national perspectives regarding cost calculations of abatement measures. We will thus rely heavily on the basic structure of the GAINS model and foresee a close co-operation with the Integrated Assessment Model (IAM) team at IIASA and other European groups. An expected secondary outcome of the project is an establishment of Swedish expertise on IAM.

International collaboration
Since the GAINS model constitutes the base of this sub programme collaboration with IIASA, is essential. It is also valuable to have good contact with other countries having or which are developing their own national IAM, such as the Netherlands (MNP) and Italy (ENEA). An informal network of researchers involved in national IAM has already been suggested.

Participating organisation
Catarina Sternhufvud, is responsible for the communication of the results as well as the co-ordination of the sub programme.

The sub programme is organised in four research projects:

1. Costs of non-technical measures in IAM models – theoretical considerations
   Project leader: Mohammed Belhaj, IVL
   Research scientists: Lena Nerhagen VTI, Stefan Åström, IVL, Catarina Sternhufvud, IVL

2. Inclusion of non-technical measures in the GAINS model
   Project leader: Stefan Åström, IVL
   Research scientists: Salim Belyazid, LTU

3. Development of GAINS Sweden
   Project leader: Salim Belyazid, LTU,
   Research scientists: Stefan Åström, IVL, Catarina Sternhufvud, IVL, Olle Westling, IVL, John Munhe, IVL, Mohammed Belhaj, IVL

4. Integrated assessment modelling at a national scale
   Project leader: Catarina Sternhufvud, IVL
   Research scientists: Mohammed Belhaj, IVL, Lena Nerhagen, VTI, John Munthe, IVL, Olle Westling

Swedish Clean Air Research Programme SCARP						
Projects and budget for Integrated Assessment Modelling						
			Budget individual years (kkr)			
Projects		**Total**	**1**	**2**	**3**	**4-6**
	Project leader and research scientists	**5000**	**850**	**800**	**850**	**2500**
Coordination and communication	**Catarina Sternhufvud**	**600**	100	100	100	300
1 Costs of non-technical measures in IAM models - theoretical considerations	**Mohammed Belhaj, IVL**	**1000**				
1.1 Review of the cost module	Lena Nerhagen, VTI	200	200			
1.2 Theoretical formulation of the cost of non technical measures	Mohammed Belhaj, IVL	600	300	300		
1.3 Method development - Non-technical measures as measures or scenarios	Stefan Åström, IVL	200				200
2. Inclusion of non-technical measures in the GAINS model	**Stefan Åström, IVL**	**1300**				
2.1 Harmonising cost calculation theories with practical modelling	Stefan Åström, IVL	600		150	150	300
2.2 Adjusting the GAINS cost calculations	Salim Belyazid, LTH	700			300	400
3. Development of a GAINS Sweden	**Salim Belyazid, LTH**	**1200**				
3.1 Model adjustments to Swedish settings	Salim Belyazid, LTH	800	150	150	200	300
3.2 Adjustment of background data and cost calculations	Stefan Åström, IVL	400	100	100	100	100
4. Integrated assessment modelling at a national scale	**Catarina Sternhufvud, IVL**	**900**				
	Catarina Sternhufvud, IVL					500
	Mohammed Belhaj, IVL					200
	Lena Nerhagen, VTI					200

Costs of non-technical measures in IAM models – theoretical considerations - Mohammed Belhaj

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Summary
The objectives of this project is to develop the abatement cost theory of an integrated assessment model including both technical and non technical measures taking into account both model assumptions and model formulation. The abatement cost functions should not only be theoretically correct including all costs of interest and the synergies amongst them, these costs should also be possible to estimate and practical to include in an IAM. To fullfil this task, this project will study the cost modules of an integrated assessment model such as GAINS, theoretically formulate the basis for estimating costs of non technical measures and propose methods on how to include these measures in the cost module of the intergrated assessment models.

Sammanfattning
Syftet med projektet är att utveckla åtgärdskostnads teorin för en integrerad bestlutsmodel genom att inkludera både tekniska och icke tekniska åtgärder genom att ta hänsyn till modellens antaganden och modellens formuleringar. Åtgärdskostnads funktionerna ska inte bara vara teoretiskt korrekta och innefatta alla relevanta kostnader samt synergin dem emellan. Dessa kostnader ska också vara möjliga att skatta och praktiska att använda i en integrerad beslutsmodell. Kostnadsmetodiken som används i GAINS kommer att studeras för att möjliggöra framtagande av en teori för kostnader av icke-tekniska åtgärder. I projektet ingår också att diskutera möjliga metoder att inkluderar kostnaderna för icke-tekniska åtgärder i integrerade beslutsmodeller.

Project objectives
The objectives of this sub-project is to evaluate diffetent concepts on how costs could be included in integrated assessment models and to develop a practical theory to be able to use in integrated assessment modelling. Such an approach should take into account the parallel inclusion of both technical and non technical measuresin model formulation and assumptions. The abatement cost functions should not only be theoretically correct including major costs of interest and the synergies amongst them, but these costs should also be possible to estimate and be practical to include in an IAM

The project contribution to programme objectives
This project will supply an updated theoretical abatement cost module including both technical and non-technical measures and adjusting the theoretical basis taking into

account both model formulation and assumptions. The aim of the cost module is to serve the whole programme for estimating reliable cost effective abatement measures.

The practical relevance
The practical relevance of this project include:

- By finding a solution to the cost estimates of non-technicla measures, these measures can be included in the cost module of integrated assessment models, such as GAINS. This will lead to more reliable abatement cost estimates and most probably to more cost efficient solutions as well as realisation of national and international environmental benefits more quickly;
- -A basis for GAINS Sweden;
- -Opportunities to undertake different case studies to find out the most cost efficent solution by including non-technical measures, such as the one related to the Swedish transport sector proposed in projct 4:4.

Workplan theories and methods
The GAINS model addresses emission control strategies that simultaneously address air pollutants and greenhouse gases in order to maximise benefits at all scales. Hence, GAINS is basically the RAINS model including GHG. However, based on the review of the RAINS model, several biases and shortcomings were identified.[2] These include the lack of of non-technical measures as a contol option as well as different uncertainties related to model assumptions and formulations. However, by including non-technical measures, environmental benefits may be realised more quickly. But at the same time, it should be noted that the inclusion of these measures may increase uncertainty.[3] Furthermore, if the costs of some non-technical measures cannot be estimated, we will analyse other possibilities and methods to be used in order to include these measures in the scenarios instead of the cost curves.

1:1 Review of the cost module
The starting point of this task will be to study cost modules in integrated assesment models. This part will rely on excessive collaboration with the IIASA team since access and understanding of the basis of the theoretical background would not be possible otherwise.

1:2 Theoretical formulation of the cost of non-technical measures
The abatement cost for technical measures are often indicated by the investment costs, fixed and variable operating costs. For non-technical measures the control costs may take different forms. It can be direct costs such as in the case of substitution of fuels, but it might also include welfare loss and non-financial costs for the people affected by the measures. Examples of such costs might be additional time spent or experienced reduction in welfare due to inconveniences caused by lower indoor temperature, waste sorting or using a bicycle instead of driving. The discussion on what type of costs that should be considered is of interest since many non-technical measures can have a substantial impact on non-monetary costs for the private consumer. By choosing to ignore these types of costs, non-technical measures might appear more favourable than would be the case if the welfare lost was included. In addition non-technical measures often require behavioural changes, and the measures

[2] http://europa.eu.int/comm/environment/air/cafe/activities/pdf/rain_model.pdf
[3] ibid

need to be accompanied by policy instruments to be realised. The administation cost for these instruments might be substantial in comparison to the control cost usually discussed, especially for non-technical measures. Therefore an analyze has to be carried out how to deal with these kind of costs.

The issue of non-technical measures is a relatively new suggestion, lacking consensus both when it comes to its definition and its theoretical formulation. Due to the difficulties to estimate the total costs of non-technical measures these are often ignored in integrated assessment models. Therefore the main part of this task will be deserved to the theoretical formulation of the cost of non-technical measures. The theroretical development should however not be an obstacle for practical testing and preliminary development of methods for the inclusion of non-technical measures in integrated assessment models.

1:3 Inclusion of non-technical measures as abatement measures or as emission scenarios - method development

This part of the project will work on the adaptation of the non-technical measures into the abatement cost module where emphasis will be put on the theoretical compatibility of these measures. It is estimated that some costs will be very difficult to include in the main cost module, but in those cases the purpose is to develop an alternative method of estimating their implementation costs. This alternative cost estimation method would ideally be included as a "baseline cost" following the scenario in which the considered measure is implemented.

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Time scale and budget

This project will mainly take part during the first phase of the programme and has an estimated budget of 1 000 000 SEK, of which 800 000 is allocated for IVL and 200 000 is allocated for VTI.

Inclusion of non-technical measures in the GAINS model - Stefan Åström

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Summary
Project 2 aims at adapting the current structure of the GAINS model to better suit the requirements regarding policy support and model development in the work on air quality. This objective will be achieved by ensuring that the desired theoretical structure of cost calculations developed within project 1 is adapted to the current GAINS framework, and that the framework itself is adjusted so that introduction of new types of abatement measures is feasible. Two main tasks will be performed. The first task aims at assessing the possibilities to insert the developed cost theory into the GAINS framework. The second task is to expand the current GAINS cost calculations to include additional non-technical measures and "baseline costs".

Sammanfattning
Projekt 2 syftar till att anpassa den nuvarande strukturen av GAINS till de krav som ställs med avseende på politisk support and modellutveckling inom luftkvalitetsarbetet. Detta mål skall uppnås genom att de teoretiska kostnadsfunktioner som utvecklats inom projekt 1 inkluderas i nuvarande GAINS och att själva ramverket anpassas för att möjliggöra att nya typer av åtgärder inkluderas. Två huvuduppgifter kommer att genomföras inom detta projekt. Den första uppgiften är att undersöka hur den utvecklade kostnadsteorin kan inkluderas i GAINS ramverk. Den andra uppgiften är att expandera nuvarande GAINS kostnadsberäkningar så att ytterligare icke tekniska åtgärder samt ”baseline” kostnader kan inkluderas.

Project objectives
The objective of project 2 is to harmonise the cost theory developed in project 1 with the operative features of the cost calculations in GAINS. This requires both the cost theory developed in project 1 to be adjusted to the operational requirements in GAINS as well as it requires the GAINS methodology to be expanded so that new abatement measures can be taken fully into account.

The project contribution to programme objectives
The projects will contribute to the development of integrated assessment models, which are used in international negotiations on air quality. The project will enable cost estimations of non-technical measures in an internationally comparable manner.

The practical relevance
The adjustment of the cost calculations in the GAINS model is desirable since a number of measures to abate air pollution are not included in the current version of

GAINS (Klaassen et al. 2004). Furthermore, this adjustment could be useful in order to illustrate underlying costs of measures that can not directly be taken into account as an abatement measure but are better described in a scenario. The introduction of non-technical measures into the cost calculations or the scenario descriptions is of relevance for a broader perspective on abatement options and their related costs (Sternhufvud & Greenfelt, 2001). The development of these features is also of interest for IIASA since it is in line with their ongoing development of cost calculations and abatement strategies.

Work plan, theories and methods

2.1 Harmonising cost calculation theories with practical modelling

The issue of non-technical measures and structural changes can be treated theoretically without causing an enormous amount of problems. However, the implementation of these theoretical constructions into complex models covering almost every part of society is subject to a number of constraints. These constraints must be taken into account and the main purpose of 2.1 is therefore to assess ways of including the theoretical functions developed in project 1 to be included in the GAINS structure and it's operational features.

This subproject will consist of the following main components:

- Develop a method for introduction of the cost calculations from project 1 into the existing GAINS cost module;
- Investigating GAINS cost module requirements for further introduction of non-technical measures (joint component with project 1);
- Formalising the developed cost theories into operational functions.

2.2 Adjusting the GAINS cost calculations

The task performed within 2.1 serves mainly to ensure appropriate communication possibilities between theory and practice. In addition to this, the GAINS model as it is constructed today will require further adjustments in order to meet the goals of including additional non-technical measures into the cost calculations or scenarios. Today, the NTM included are mainly fuel shifts and some energy efficiency improvements (Klaassen et al. 2004). The main deliverable of 2.2 will be that GAINS is adjusted so as to take into account more features than what is currently modelled in GAINS Europe.

Enhancing the modelling possibilities in the GAINS cost calculations, where the main interest areas are:

- Further introduction of costs for non-technical measures into GAINS;
- Cost calculations of emission removal that can not be included as abatement measures in the model. Efforts will be made to illustrate these costs as "baseline costs";
- Adaptation of scenario development to include the "baseline costs" (or savings) in the cases where scenario emission removals are of interest.

Key references

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Sternhufvud C., Belhaj M., Åström S., (2006) The feature of Non-technical measures and their importance in cost effective air pollutants reduction - applied to two meta-analysis. IVL Report B 1656.

Time scale and budget

This project will take part during both phases of SCARP and has an estimated budget of 1 300 000 SEK, of which 700 000 SEK is allocated to LTH and 600 000 to IVL.

Development of a GAINS Sweden - Salim Belyazid

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Summary
A prominent model for carrying out IAM on a European scale is the GAINS model, which provides a new tool for the evaluation of cost-effective measures for the simultaneous reduction of air pollutants and GHG[4]. In order for Sweden and other countries to participate actively and influentially in the ongoing development process of the GAINS model and the related IAM activities, it is imperative to attempt to endorse and elaborate the model on a national level. The proposed GAINS Sweden version would provide a national tool to implement and test scenarios of measures for the reduction of the air pollutants and green house gases, which are relevant to Sweden. Moreover, there is a national need to elaborate emission and concentration/deposition maps with a higher geographical resolution than currently produced by the GAINS model in order to satisfy the regional and local policy needs within Sweden. Attempting to achieve such a resolution will require structural changes to the model itself and will raise the need to explore and possibly modify the set of satellite models used to build the database necessary for the GAINS simulations. Considering the history and configuration of the GAINS model, any national development has to be based on the original European model and performed in a close collaboration with the IIASA team. However, the anticipated results and experience from the national development and simulations may be the ground for new suggestions for additions in the European GAINS.

Sammanfattning
GAINS modellen, som är en prominent integrerad bedömningsmodell på europeisk nivå, har medfört ett nytt verktyg för att utvärdera kostnadseffektiviteten av åtgärder som simultant reducerar luftföroreningar och GHG. För att Sverige och andra länder skall kunna delta aktivt och påverka utvecklandet av GAINS och närbesläktade aktiviteter, är det viktigt att inneha och utarbeta modellen på nationell nivå. Den föreslagna GAINS Sweden kan bli ett nationellt verktyg för att implementera och testa åtgärdsscenarier för att reducera luftföroreningar och växthusgaser som är relevanta för Sverige. Dessutom finns det ett nationellt behov att utarbeta utsläpps- och koncentration/depositionskartor med högre geografisk upplösning än vad som används i nuvarande GAINS, detta för att tillfredsställa de regionala och lokala politiska behoven i Sverige. Försök att erhålla sådan upplösning kräver strukturförändringar av själva modellen och ökar också behovet av att undersöka och om möjligt förändra de satellit modeller som använts för att bygga den databas som är nödvändig för GAINS simuleringar. En nationell utveckling av GAINS modellen

[4] Klaassen el at., 2004

måste baseras på den europeiska modellen och genomföras i nära samarbete med IIASA. Emellertid kan de resultat som erhålls från den nationella utvecklingen och simuleringarna ligga till grund för förslag till förbättringar av GAINS Europe.

Project objectives
The purpose of this project is to contribute to the construction of a national IAM resource through adjusting the GAINS model developed at IIASA for testing new theories and implementing regional and local simulations on a Swedish, and eventually Nordic level. The result will be a GAINS Sweden, with possible Nordic extension, yet directly based on the European GAINS model and developed in close collaboration with IIASA. The aims are to:[5]:

- Adjust GAINS into a functional version on a Swedish (Nordic) level/resolution;
- Implementing the cost module as developed in project 2 into the current GAINS Europe model or into the GAINS Sweden version;
- Possible structure adjustments of the GAINS model to enable the introduction of alternative scenarios and baseline costs as discussed in subproject 1 and 2.

Additional areas of interest that would be desired in the long run are:
Investigating more detailed effects in the modules related to health and ecosystems effects;

- Being active in the expansion of the existing national efforts by European countries (Italy, Netherlands, Poland) to perform national scenario simulations using the RAINS/GAINS model systems, and contributing in improving and testing the GAINS model on a national as well as European levels;
- Providing Sweden with nationally generated scenario results for the CLRTAP discussions;
- Attempting a higher geographical resolution in the source receptor module;
- In accordance with the higher resolution, adjusting the sector aggregation levels according to the national, regional and local scales in Sweden.

The project contribution to programme objectives
The project will support the realisation of the objectives of the programme related to the areas of integrated assessments, ecosystem effects and human health impacts. The project will provide a national modelling tool and expertise basis for the evaluation of the outcome of the ongoing European policy developments and protocols. As for the future participation of Sweden in the revisions of the current and imminent protocols, the developments in this project will also be a means to have access to the GAINS model structure. This access enables implementation and testing of potential propositions in Sweden before proposing them, if relevant, to IIASA for implementation on a European scale.

Directly relating to the goal in project 4, the development process of GAINS Sweden will also be the opportunity to gather Swedish and international proficiencies and experiences within a Swedish framework to provide a national competence in the field of IAM. By being able to modify the sectorial aggregation levels and the model resolution, the construction of GAINS-Sweden will provide a tool to circumvent the simplifications adopted at the European level and which require sizeable

[5] Sternhufvud C. & Åström S, (2006) Feasability study - a Swedish Integrated Assessment model. IVL Report B 1674. (http://asta.ivl.se/)

simplifications. The results thus achieved may provide scenarios that could be compared with scenarios from GAINS Europe and discussed within the negotiation work within the European air quality directives.

The practical relevance
The results from the national modelling experience proposed here can serve as support to the Swedish participation in EU and CLRTAP discussions and the assessment of different air quality strategies. The outcome of the ongoing and forthcoming European policies (CAFE, CLTRAP) can be evaluated on a national level using nationally modified models in this project with collaboration with other areas of the programme. This project can also reinforce the influence of Sweden, and possibly other Nordic countries, in the following revisions to the existing policies by providing a practical tool to test potential propositions and identify more detailed impacts on human health and ecosystems on a national level.

It can be assumed that GAINS Europe is subject to more constraints regarding aggregation and modelling on a European scale than what the Swedish GAINS should be. It is also plausible that the Swedish GAINS will have more opportunities to function as a tool in which different aspects of pollution abatement can be tested and evaluated. There will be a difference between GAINS Europe and GAINS Sweden, both via the practical differences regarding geographical area and nations included as well as via the fact that GAINS Europe will most probably constitute the scientific base for international negotiations on air quality in the future. As a base for international negotiations, the GAINS Europe would be subject to constraints since only indisputable theoretical features can be included in the model in order for GAINS Europe to keep it's overall political acceptance. GAINS Sweden however, will rather be a tool for national estimations.

Work plan, theories and methods
This project will consist of the following main components:

- Getting access and acquaintance to relevant parts and modules of the GAINS model through the IIASA team. Considering the largeness of GAINS, it is desired at this stage to investigate only the relevant modules related to modifications aspired to in this project, including the cost module and to a more limited degree the definition of the geographical resolution.
- Translating the parts of the model which are relevant to the desired developments into easily readable flowcharts for making the model structure readily available for evaluation and discussions with the other programme projects.
- Incorporating new structural changes in the model for inclusion of:
  The implementation of non-technical measures and related scenarios
  Incorporating new structural changes in the model for future inclusion of:
  The Investigation of the possibility to dynamically define geographical regions in the model.
  A higher resolution of the model to a geographical level relevant to national needs (in comparison, the Italian RAINS project opted for a 20 by 20 km size of the grid cells).
  New sectors relevant for Sweden with lower levels of aggregation and more detailed effects' indicators (such as forestry and vegetation biodiversity).

Throughout the development of this project, a close collaboration will be kept with IIASA and other European efforts to implement national RAINS or GAINS variants. Both the experiences and findings from this project will be made available and shared with the national and European associates.

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Time scale and budget

This project will take part during both phases of the programme and has an estimated budget of 1 200 000 SEK, of which 800 000 is allocated to LTH and 400 000 to IVL.

Integrated assessment modelling at a national scale - Catarina Sternhufvud

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Summary
This project aims to use the results from the other sub programmes to up-date GAINS Sweden with the new findings. The up-date of the Swedish GAINS with the latest results, will make the outcome from the model more reliable. In addition, an alternative scenario for the transport sector will be used and a case study of the transport sector will be carried out. This requires quite a lot of information about different abatement measures, both technical and non-technical as well as knowledge obtained in project 1.

Sammanfattning
Detta projekt syftar till att uppdatera GAINS Sweden med de nya forskningsresultat som framkommit i de andra delprogrammen. Uppdateringen av de senaste resultaten i GAINS Sweden kommer att förbättra de slutgiltiga resultaten från modellen. I detta projekt kommer dessutom ett pilotstudie att genomföras inom transportsektorn baserat på ett alternativt scenario. Detta kommer att kräva mycket information om olika åtgärder, både tekniska och icke tekniska, samt kunskap som erhållits i projekt 1.

Project objectives
To carry out a case study in GAINS Sweden based on national cost estimates, latest dose response relationships as well as alternative scenarios. The focus of the case study will most probably be the transport sector.

The project contribution to programme objectives
The project is closely related to the other sub programmes as well as the additional three projects in the Integrated Assessment Modelling programme. In this project up-dated exposure-response functions both with respect to health effects as well as effects on ecosystems, received from the other sub-programmes, will be included.

The practical relevance
In the GAINS model the abatement measures and their costs are often treated as similar for all countries. However, if specific data and Swedish (Nordic) conditions are considered including not only the technical measures but also the non technical ones that are suitable for implementation, the impacts and the related costs may be different. These aspects would make the potential estimations of costs and impacts more reliable in the case of Sweden. This project will also up-date the Swedish GAINS with the latest results, which will make the outcome from the model more reliable for Swedish conditions.

Work plan, theories and methods
The work plan will be elaborate in close collaboration with the other sub programmes and focus will be directed to the needs of and deliverables from the other projects. As this project will relay on previous sub-projects and will be carried out in phase two of the program no details about the work plan, theories and methods are given at this stage

Time scale and budget
This project will take part during phases two of the program and has an estimated budget of 900 000 SEK, of which 200 000 is allocated to VTI and 700 000 to IVL.

SCARP

Short CVs of the main program participants

10 April 2006

APPENDIX 3

CV for Tom Bellander

500425-0451

Degrees:
Master of Science in Chemistry, Royal Institute of Technology, Stockholm 1976.
PhD in Occupational Mecicine, Lund University, Lund 1987.
Associate Professor in Environmental Epidemiology, Karolinska Institutet (KI), Stockholm 2002

Present employment: Epidemiologist, Department of Occupational and Environmental Health, Stockholm Centre of Public Health, Stockholm County Council, Stockholm 1987- .

Tuition, concluded:
Main tutor, Håkan Westberg, Doctor of Medicine: ”Chemical exposures, biological monitoring and cancer risks in Swedish aluminium foundries and remelting plants”, Linköping University, Örebro 2001-11-15
Main tutor, Mats Rosenlund, Doctor of Medicine: ”Environmental Factors in Cardiovascular Disease” KI, 2005-04-22

Tuition, ongoing:
Assistant tutor, Marie Lewne, Doctor of Medicine, KI, half-time examination 2005-04-08
Main tutor, Niklas Berglind, Doctor of Medicine, KI, registered 2005.
Main tutor, Petter Ljungman, Doctor of Medicine, KI, registered 2005.

Original publications the last five years:
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CV for Bertil Forsberg

Born: 1956-Oct-02
Present position: Associate Professor, Head (enhetschef) of Occupational and Environmental Medicine Unit at the Department of Public Health and Clinical Medicine, Umeå University.
Academic Degrees:
BSc in Environmental Health (Umeå University, 1981)
PhD (med dr) in Epidemiology and Public Health (Umeå University, 1997)
Associate Professor (docent) in Environmental Medicine (Umeå University, 2005)
Previous Jobs:
During 1981-1985 assistant, 1986-1998 lecturer and 1999 senior lecturer at the Department of Environmental Health, Umeå University. From 2000 senior lecturer at Department of Public Health and Clinical Medicine.

Scientific work
I am presently involved in several studies on the associations between air pollution and health in Swedish and international projects such as EU funded *APHEA-2, APHEIS/ENHIS* and *ECRHS*, and the Nordic *NORDAIR*. I am also a partner in the EU projects *PHEWE* on temperature effects on health and the soon starting *HENVINET* on health effects of global environmental change. Current Swedish projects lead by me are funded mainly by Formas (Interactions between particles and ozone), EMFO (Health effects of soot and traffic related particles) and The Swedish EPA/SNAP (Air pollution and adult asthma). These projects are focussing on effects of short-term or long-term exposure to pollutants from traffic, wood burning and long-distance transportation. Methods for environmental health monitoring and health impact assessment in environmental assessments are other research fields. I have together with my research group have been responsible for health assessments of the congestion fee and new north-south road link in Stockholm. I am often contracted as a national or international advisor and member of several expert groups on air pollution and health impact assessment, and co-author of recent WHO reports and books on air pollution. I was the health expert in the EU evaluation group for the integrated modelling of air pollution scenarious for Europe in CAFÉ (Clean Air For Europe).

I am the secretary of the scientific section for Occupational and Environmental Medicine within The Swedish Society of Medicine.

Stakeholder communication
In several of the projects I have been a part of, stakeholder communication has been as important as the scientific analyses, for example in APHEIS www.apheis.net and in AIRNET http://airnet.iras.uu.nl/. I set up a special Swedish reference group for APHEIS, produced popular folders in Swedish and arranged stakeholder meetings. In AIRNET I arranged one of the four European science-policy communication workshops in Sigtuna (as will soon be reported in Environ Health Perspect). I am frequently invited by Swedish authorities (NV, FHI, SOS, STEM) as a speaker, discussant or member of an advisory group. I have also written books, chapters or reports for several of these authorities.

Selected publications in scientific journals from 2004 or later

Gryparis A, **Forsberg B**, Katsouyanni K, Analitis A, Touloumi G, Schwartz J, Samoli E, Medina S, Anderson HR, Niciu EM, Wichmann E, Kriz B, Kosnik M, Skorkovsky J, Vonk JM, Dortbudak Z. Acute Effects of Ozone on Mortality from the "Air Pollution and Health: A European Approach" Project. Am J Respir Crit Care Med 2004;170:1080-1087.

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CV for Anna-Carin Olin

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Degrees

1989 Bachelor of medicine (Med. Kand), University of Gothenburg (GU)
1993 Examination as a medical doctor (leg. läk)
2002 Doctor of Medicine (PhD) (Medicine doctor)
2006 Associate professor in occupational and environmental medicine

Positions

1988	MD, Dept of Rheumatologic Diseases, Sahlgrenska Academy (underläkare)
1989	MD, Childrens Hospital, Gothenburg University (underläkare)
1990-1993	Internship, Alingsås Lasarett (AT-läkare)
1994-2003	Resident, Dept of Infectious Diseases, Borås Lasarett (underläkare) Resident, Dept of Occupational Medicine, Sahlgrenska Academy at Göteborg University (ST-läkare).
2003-	Consultant, Dept. of Occupational and Environmental Medicine, Sahlgrenska University Hospital

Dissertation

2002 Exhaled Nitric Oxide in epidemiological and experimental studies
Sahlgrenska Academy, Gothenburg University

Scientific supervisison

2005 Mona Lärstad

Currently supervising three research fellows;
Lotta Isacsson., MSc, reg 2005
Sophie Svensson, MPharm, reg. 2005
Cecila Alexandersson, MD, reg 2006

Memberships

2006 Member of the Board of the Swedish Society for Occupational and Environmental Medicine (within the Swedish Medical Society)

Publications

25 original papers and one review paper been published or accepted for publication in refereed journals

Grants

Received grants 2003- 2006 from the Swedish Heart and Lung Foundation and Swedish Asthma and Allergy Research Foundation

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Education

1972 University degree Russian, Uppsala University
1980 MD Karolinska Institutet
1982 PhD Karolinska Institutet
1983 Associate professor (docent) Karolinska Institutet

Professional experience

1975-1980 Research assistant, Department of Environmental Hygiene, Karolinska Institutet
1980-1987 Associate professor, Institute of Environmental Medicine
1987– Professor, Institute of Environmental Medicine, Karolinska Institutet
1991– Consultant, Department of Environmental Health, Stockholm County Council
1995– Head, Division of Environmental Epidemiology, Institute of Environmental Medicine
1996-2000 Head, Department of Environmental Health, Stockholm County Council
2000– Chairman, Institute of Environmental Medicine, Karolinska Institutet

Supervision

Supervision of 14 completed PhD theses, including 5 as primary tutor (Christer Svensson 1988, Emma Rylander 1995, Ylva Rodvall 1996, Fredrik Nyberg 1998, Frédéric Lagarde 2001). Currently supervisor of 7 PhD programmes, including 4 as primary tutor.

Committee appointments etc

1993-1997 Member, Scientific Advisory board, WHO, Center for Environmental and Health
1997- Member, Environmental Committee, Royal Swedish Academy of Sciences.
1996-1998 President, International Society for Environmental Epidemiology.

Member of Scientific Review Committees at Swedish Cancer Society and Swedish Environmental Protection Agency.

Repeatedly served as consultant to international organisations, such as IARC, WHO and EU, mainly in relation to environmental health risk assessment. A large number of similar assignments for Swedish authorities, including the Swedish Environmental Protection Agency and the National Board of Health and Welfare.

Member of the Editorial board of Allergy and American Journal of Epidemiology.

Publications

APPENDIX 3

A total of more than 150 scientific publications in international scientific journals. Five major publications:

Pershagen G, Åkerblom G, Axelson O, Clavensjö B, Damber L, Desai G, Enflo A, Lagarde F, Mellander H, Svartengren M et al: Residential radon exposure and lung cancer in Sweden. N Engl J Med 1994;330:159-164.

Alm JS, Lilja G, Pershagen G, Scheynius A: Early BCG vaccination and development of atopy. Lancet 1997;350:400-3.

Alm JS, Swartz J, Lilja G, Scheynius A, Pershagen G: Atopy in children of families with an anthroposophic lifestyle. Lancet 1999;353:1485-8.

Nyberg F, Hou SM, Pershagen G, Lambert B: Dietary fruit and vegetables protect against somatic mutation in vivo, but low or high intake of carotenoids does not. Carcinogenesis 2003;24:689-96.

Melén E, Bruce S, Doekes G, Kabesch M, Laitinen T, Lauener R, Lindgren CM, Riedler J, Scheynius A, van Hage-Hamsten M, Kere J, Pershagen G, Wickman M, Nyberg F: Haplotypes of G-protein-coupled receptor 154 are associated with childhood allergy and asthma. Am J Respir Crit Care Med 2005;171:1089-95.

CV for Thomas Sandström

TS (born in 1957) received his MD in 1983 and presented his PhD thesis on Respiratory effects of the air pollutants sulphur dioxide and nitrogen dioxide at in 1989. Two years later in 1991 he was received an associate professorship at the Medical Faculty at Umeå University and became a specialist in Respiratory Medicine the same year.

In 1992 TS received a Senior Lecturer/ Consultant position and in 1997 he was awarded the first Chair in Respiratory Medicine at Dept of Respiratory Medicine and Allergy at Umeå University Hospital. He has tutored seven research fellows to their PhDs and continues with additional tutorships. Involvement in the educational aspects of science has also included tasks as examiner on ten PhD dissertations.

TS has been a member of the Board of the Medical Faculty at Umeå University, as well as sub-committies. He serves and has served on several Committees, Steering Groups and Boards nationally, in Europe and the US. Additionally TS has acted as expert reviewer on European and US grant and professorship applications.
.
TS co-ordinated the EU FP5 supported project HEPMEAP and arranged together with Prof Viegi in Pisa the AFORDEE meeting, an EU and US sponsored interactive meeting on “Air Pollution Effects in the Elderly”. He has served in the EU sponsored AIRNET air pollution toxicology committee and WHO has repeatedly used his services in air pollution expert groups. In 2001 he was awarded the Royal Skytteanska Research Prize.

TS currently serves as Associate Editor for European Respiratory Journal and has been European representative in the American Thoracic Society (ATS) Environmental-Occupational Health Program Planning Committee. He has served as organiser, chairman and invited speaker at a range of Scandinavian, European and American Respiratory, Allergy and Air pollution meetings.
He has given invited lectures also at US EPA, California Air Pollution Technology and Solutions Management Meeting, Ontario Air Pollution Control Meeting, Canada, and other venues.

TS leads a multidisciplinary scientific group which is focused on respiratory, cardiovascular and systemic responses to a range of oxidative gaseous and particulate air pollutants. The group has extensive experience from controlled chamber exposure experiments with motor engine derived nanoparticles and effects studies in in-vitro and animal systems, as well as human subjects. During the last years much attention has been given to susceptible groups such as asthmatics, elderly, and subjects with COPD and cardio-vascular disease. Evaluation methods range from physiology to immunology, including genetic aspects of responsiveness.

Prof T Sandström has published over 100 original articles and reviews in international peer review journals.

Recent publications relevant for the application

Behndig AF, Mudway IS, Brown JL, Stenfors N, Helleday R, Duggan ST, Wilson SJ, Boman C, Cassee FR, Frew AJ, Kelly FJ, Sandstrom T, Blomberg A. Airway antioxidant and inflammatory responses to diesel exhaust exposure in healthy humans. Eur Respir J. 2006, 27:359-65.

Mills NL, Tornqvist H, Robinson SD, Gonzalez M, Darnley K, MacNee W, Boon NA, Donaldson K, Blomberg A, Sandstrom T, Newby DE. Diesel exhaust inhalation causes vascular dysfunction and impaired endogenous fibrinolysis. Circulation. 2005 Dec 20;112(25):3930-6.

Pourazar J, Mudway IS, Samet JM, Helleday R, Blomberg A, Wilson SJ, Frew AJ, Kelly FJ, Sandstrom T. Diesel exhaust activates redox-sensitive transcription factors and kinases in human airways. Am J Physiol Lung Cell Mol Physiol. 2005 Nov;289(5):L724-30.

Gerlofs-Nijland M, Boere AJF, Leseman DLAC, Dormans JAMA, Sandström T, Salonen RO, van Bree L, Cassee FR. Effects of particulate matter on the pulmonary and vascular system: time course in spontaneously hypertensive rats Part Fibre Toxicol. 2005 24;2(1):2

Hamilton LM, Puddicombe SM, Thornber MD, Steel MD, Dearman RJ, Kimber I, Sandström T, Wallin A, Howarth PH, Holgate ST, Wilson SJ, Davies DE. Altered protein tyrosin phosphorylation in asthmatic bronchial epithelium, Eur Respir J, 2005 Jun;25(6):978-85.

Pourazar J, Frew AJ, Blomberg A, Helleday R, Kelly FJ, Wilson S, Sandstrom T. Diesel exhaust exposure enhances the expression of IL-13 in the bronchial epithelium of healthy subjects. Respir Med. 2004 Sep;98(9):821-5.

Mudway IS, Stenfors N, Duggan ST, Roxborough H, Zielinski H, Marklund SL, Blomberg A, Frew AJ, Sandstrom T, Kelly FJ. An in vitro and in vivo investigation of the effects of diesel exhaust on human airway lining fluid antioxidants. Arch Biochem Biophys. 2004 Mar 1;423(1):200-12.

Stenfors N, Nordenhall C, Salvi SS, Mudway I, Soderberg M, Blomberg A, Helleday R, Levin JO, Holgate ST, Kelly FJ, Frew AJ, Sandstrom T. Different airway inflammatory responses in asthmatic and healthy humans exposed to diesel. Eur Respir J. 2004 Jan;23(1):82-6.

CV for Gerd Sällsten

Born 1952
E-mail gerd.sallsten@amm.gu.se

Current position

Senior occupational- and environmental hygienist, associate professor at the Department of Occupational and Environmental Medicine, Sahlgrenska Academy and University Hospital, Box 414, 405 30 Göteborg.

Academic history

1971-1975	Studies at Chalmers University of Technology, Göteborg, followed by examination as Master of Science (M.Sc.) in Chemical Engineering.
1982-1983	Studies at the National Institute of Occupational Health, Stockholm, followed by examination as Occupational Hygienist.
1994	PhD in occupational medicine, doctoral dissertation at the Medical Faculty, Göteborg University. Title: Occupational exposure to inorganic mercury. Exposure assessment and elimination kinetics. Supervisor: Bengt Järvholm.
1999	Associate Professor **(Docent**) in Occupational Hygiene at the Medical Faculty, Göteborgs Universitity.

My research line is exposure assessment and risk assessment, mainly in the areas of heavy metals and air pollution. During the years 1995-1998 I was responsible for the exposure assessment in a multicentric study on cancer and mortality risk among mercury miners performed by the IARC (International Agency for Research on Cancer, Lyon). In 2000-2004 I was engaged in EMECAP, an EU-programme, investigating low exposure to mercury in the general population. Within the SNAP programme I am PI for one study on fine particulate exposure in the general population, and responsible for exposure assessment in four other projects focussing on air pollution (two on wood smoke). I have been engaged as a member of a scientific committee for a PhD dissertation at KTH, Stockholm and as referee in several scientific journals.

Supervision: Licentiate: Cecilia Johnsson 2004 (fish consumption and mercury levels in biological media). At present main supervisor for three PhD students in the area of air pollution: Peter Molnár, Pernilla Gustafson and Sandra Johannesson. During the last years I have also supervised five graduate students in their 10 or 20 credits theses.

Published nearly 60 papers in peer-reviewed scientific journals, and in addition several Swedish scientific reports.

Recent publications and submitted paper relevant for the present application:

Sällsten G; Gustafson P, Johansson L, Johannesson S, Johannesson S, Molnár P, Strandberg B, Tullin C, Barregard L,. Experimental wood smoke exposure (submitted)

1. Molnár P, Johannesson S, Boman J, Barregard L, Sällsten G. Personal exposures, and indoor, residential outdoor and urban background levels of fine trace elements in the general population. J Environ Monit (accepted)

2. Barregard L, Sällsten G, Gustafson P, Johansson L, Basu S, Andersson L, Stigendal L. Exprimental exposure to wood smoke particles in healthy hunmans: effects on inflammation, coagulation and lipid peroxidation. Inhalation Toxicology (accepted).

3. Strandberg B, Gustafson P, Söderström H, Barregård L, Bergqvist PA, Sällsten G. The use of semipermiable membrane device as samplers to determine persisitent organic compounds in air. J Environ Monit 2006:8:257-262.

4. Strandberg B, Sunesson A-L, Olsson K, Levin J-O, Ljungkvist G, Sundgren M, Sällsten G, Barregård L. Evaluation of two diffusive samplers to determine 1,3-butadiene and benzene levels in air. Atmospheric Environ 2005: 39:4101-4110.

5. Molnar P, Gustafson P, Johannesson S, Boman J, Barregård L, Sällsten G. Domestic wood burning and PM2.5 trace elements: Personal exposure, indoor and outdoor levels. Atmospheric Environ 2005:39:2659-2669.

6. Gustafson P, Barregård L, Lindahl R, Sällsten G. Formaldehyd levels in Sweden – Personal exposure, indoor and outdoor concentrations. J Exp Anal Environ Epidemiology J Expo Anal Environ Epidemiol 2005:15:252-60.

Extensive experience in **communication** to stakeholders. Examples: About ten different projects funded by the Swedish EPA, Swedish Energy Agency, Swedish Social Board of Health and Welfare (SSBHW), which included reports in Swedish as well as oral contributions in seminars for national and regional bodies. Reference: Britta Hedlund, Titus Kyrklund, SEPA, Ann Thuvander, (SSBHW).

APPENDIX 3

CV for Valentin L. Foltescu

Date of birth: 6 June 1967
Nationality: Swedish
Civil Status: Married

Academic degrees:

Associate Professor (Swedish docent) at Chalmers University of Technology	2001
PhD in Environmental Physics, Göteborg University	1995
PhLic (Swedish *"filosofie licentiat"*) in Environmental Physics, Göteborg University	1993
BSc in Physics, Göteborg University	1991

Academic positions:

- Head of The Air Quality Research Unit at SMHI	2004-09-01 – onwards
- Researcher at SMHI	2001-01-01 – 2004-08-31
- University lecturer at Chalmers University of Technology	1999-09-01 – 2000-12-31
- Meteorologist/Analysis expert at SMHI	1997-09-01 – 1999-08-31
- MISTRA Post-doctoral fellowship for research at Environment Institute, Joint Research Centre of the European Commission, Ispra, Italy	1996-08-01 – 1997-08-31
- University lecturer at Chalmers University of Technology	1995-11-01 – 1996-03-31
- Doctorand position at Göteborg University	1991-01-01 – 1995-09-30
- Medical physicist at Borås Hospital, Sweden	summer of 1990

Key qualifications of relevance to the project:

Valentin Foltescu has 15 years experience in research and teaching in environmental physics. He is currently involved in work concerning modelling studies of air pollution dispersion. Previously, he was also engaged in modelling of other atmospheric-related processes, such as biomass growth, and in mesoscale meteorological/climatological analysis. His PhD-thesis (at Göteborg University) and postdoctoral work (at the Joint Research Centre of the European Commission) has dealt with both experimental and theoretical aerosol research. The theoretical part of his work was concerned with stratospheric-tropospheric exchange of particles and ozone and with aerosol modelling. The experimental research, in the framework of several European projects concentrated on terrestrial and in-situ flight experiments, involving systems and methods for measurement and analysis of physical, chemical and meteorological variables and their interplay in the atmosphere. The list of publications includes 38 scientific articles and reports.

CV for Hans-Christen Hansson

Born: December 5, 1951 in Hörby, Sweden
Married to Margareta Hansson, born Källström, Sept 1989.
Children: Erika, born 1991, Annika, born 1993, Mikaela, born 1997.

Exams
Dr of Technology, Department of Nuclear Physics, Lund Institute of Technology, November 24, 1983.
Docent, Jan., 1988

Service since 1994
Professor in Air Pollution, Department of Meteorology, Stockholm University, Feb. 94 – 2004
Head of Air Pollution Laboratory at Department of Applied Environmental Science, Stockholm University, Feb. 94 – present
Professor in Air Pollution, Department of Applied Environmental Science, Stockholm University, 2005 - present
Member of Executive Board of the Department of Applied Environmental Science, Stockholm University, July, 95 – present
Member of the Board of the Department of Applied Environmental Science, Stockholm University, July, 2005 – present
Deputy Head of Department of Applied Environmental Science, 2005 – present
Member of Board of Science Faculty, Stockholm University, 2006- present
Deputy Head of Geo and Environemental Sciences Section, Science Faculty, Stockholm University, 2006-present

Deputy coordinator of EUROTRAC sub-project Groundbased Cloud Experiment, 1991 - 1996
Chairman of the Nordic Society of Aerosol Research, 1992 - 1995
Chairman of Working group for Large Scale Facilities in Environmental Sciences in the TMR-program, Brussels, Apr 94 - Jan 95
Member of the editorial board of Journal of Aerosol Science, 1992 - 1997
Member of the editorial boards of Tellus, 1994 -
Reviewer; International journals: Tellus, JGR, Ambio, J Aerosol Science and several foundations as e.g. NERC and NSF.
Engagement in recently closed EU- commission projects with Environment and Climate:
Coordinator of FREETROPE, 1996 - 1999
Member of scientific steering committee of ACE2, SOAP and HILLCLOUD, 1996 - 1999
Member of scientific steering committee of BIOFORE and PARFORCE, 1998-2000
Partner in EPICA, European program for Ice Cores in Antarctica, 1996-2000
Member of scientific steering committee of PROCLOUD, an EUROTRAC2-subproject, 1996-2000
Co-ordinator of national survey of PM2.5/10 concentrations and their main sources
Chairman for national network on ambient particulate emissions and occurrence, including Swedish Road authorities, Swedish EPA and Swedish Energy Authorities. 1999-2001
Coordinator of Biomass combustion, health and environment (BHM), major program at the Swedish Energy Board.2002-2005
Member of CEN/TC 264/WG15 on standard for ambient particulate mass (PM2.5)
Member of CAFÉ (Clean Air For Europe, within the European Commision) workinggroup on particles, 2003-2005

Present major engagements in larger projects or expert committes;
Subproject coordinator in the MISTRA-program ASTA, 1999 - present

Member of scientific steering committee of Nordic Center of Excellence, BACCI, Biosphere-Atmosphere-Cloud-Climate Interaction, 2002-present
Member of scientific steering committee of FP6 Infrastructure project EUSAAR, European Supersites for Aerosol Research, 2006-present
Member of scientific steering committee of Aerosols, Joint Research Activity within FP6 European network of Excellence ACCENT, 2005- present
Member of the steering committee of SNAP, Swedish National program on Health effects of Air Pollution, 2000- present
Member of EMEP expert group on particles, 2005 - present

Other major projects:
Present work within most of the larger projects is directed towards investigations of the life cycle of the atmospheric particles. The atmospheric particles influence the radiation budget, both directly through scattering of radiation and indirectly through their influence on the clouds and their effect on the radiation balance. The particles as well influence the general chemistry and thus influence deposition patterns of acidifying and eutrophying compounds. Influence on health is a growing concern, which drives our involvement connecting urban research with the regional focused research. A growing substantial effort is now on implementing all achieved knowledge on processes in dynamic transport models giving a possibility describing parameters important to climate and health with high resolution spatially and temporally both on regional as well as urban scale. The major scientific contribution is presently on providing data to and heading the evaluation of the policy relavant EMEP model. For further information, please see www.itm.su.se.

Educational experience:
Advisor or co-advisor of 9 PhD theses and 5 Licenciate theses. Presently advisor or co-advisor of 5 PhD-students. Faculty - Opponent on 4 PhD-thesis.

Publications and reports
H-C Hansson is author or coauthor of about 170 different publications and reports. About 110 are published in peer reviewed international journals. Last year publications given below:

1. Forsberg, B., Hansson, H-C, Johansson, C., Areskoug, H., Persson, K., Järvholm, B., 2005, Comparative Health Impact Assessment of Local and Regional Particulate Air Pollutants, Ambio Vol. 34, No. 1, 11-19
2. Gyula Kiss Etelka Tombácz, Hans-Christen Hansson, Surface tension effects of humic-like substances in the aqueous extract of tropospheric fine aerosol, Journal of Atmospheric Chemistry, Volume 50, Number 3, March 2005, pp. 279-294(16)
3. P. Tunved, E.D. Nilsson, H-C. Hansson, J. Ström, M. Kulmala, P. Aalto, Y., Viisanen, Aerosol characteristics of air masses in Northern Europe – influences of location, transport, sinks and sources, 2005, J. Geophys. Res. (D Atmos.) , vol:110 DOI:10.1029/20
4. P. Tunved, H. Korhonen, J. Ström, H.-C. Hansson, K.E.J. Lehtinen, M. Kulmala , Is nucleation capable of explaining observed aerosol integral number during southerly transport over Scandinavia? 2006, Tellus Vol 58, 129-140
5. Tunved, H-C. Hansson, P., Kerminen, V-M, Ström, J., Dal Maso, M., Lihavainen, H., Viisanen, Y., Aalto, P.P, Komppula M. And , M. Kulmala, High natural aerosol loading over boreal forests, Science, April 14, 2006

CV for Christer Johansson

CJ is an associate professor (Docent) at the department of Applied Environmental Science, Stockholm University. He defended his Ph.D in Chemical Meteorology at Stockholm University, Department of Meteorology, Stockholm in 1988. He is also employed at Environment and Health Protection Administration, City of Stockholm as an Environmental Officer. At the university he is a supervisor of four PhD students and he is the principal inverstigator of several research projects in the field of urban air quality.

List of publications, conference presentations and reports 2003 - 2005

V = Publication in scientific journal with referee procedure
R = Reports of ITM or the EHPA, Stockholm

V * **Johansson, C.** and Johansson, P.Å., 2003. Particulate matter in the underground of Stockholm. Atmospheric Environment, 37, 3-9.

R **Johansson, C.**, Burman, L. & Segerstedt, B., 2003. Trängselavgifter i Stockholm — Effekter på luftkvalitet år 2015 (*Congestion fees in Stockholm — Effect on Air Quality 2015, only in swedish*). Miljöförvaltningen, SLB analys, Box 38 024, 100 64 Stockholm, Rapport LVF 2003:6, Luftvårdsförbundet i Stockholms och Uppsala län.

R Forsberg, B., Segerstedt, B. & **Johansson, C., 2003**. Trängselavgifter i Stockholm — Luftkvalitetsförändrignars beräknade hälsokonsekvenser. Rapportering av forskningsprojekt till Naturvårdsverket och Statens Folkhälsoinstitut. Umeå universitet, Umeå.

R **Johansson, C.**, Mårtensson, M., Nilsson, D. & Buzorious, G., 2003. Emissioner av partiklar till luften i Stockholm. ITM rapport nr. 114. ITM Stockholms universitet, 106 91 Stockholm.

R Lövenheim, B. & **Johansson, C.**, 2003. Nedfall av kväve och svavel år 2001 – Beräkningar för Stockholms stad. Miljöförvaltningen, SLB analys, rapport 3:2003, Box 38 024, 100 64 Stockholm.

V Gidhagen, L., **Johansson, C.**, Langner, J. & Olivares, G., 2003. Simulation of NOx and Ultrafine Particles in a Street Canyon in Stockholm, Sweden. Atmospheric Environment, Atmospheric Environment, 38, 2029-2044

R Johansson, C., Burman, L., Lövenheim, B., Forsberg, B. & Segerstedt, B., 2004. Miljöavgifternas effekt på utsläpp, halter och hälsa i Storstockholmsområdet. LVF 2004:13. Luftvårdsförbundet i Stockholms och Uppsala län. SLB analys Miljöförvaltningen, Box 38 024, 100 64 Stockholm. http://www.slb.nu/slb/rapporter.

R Johansson, C. et al., 2004. Mätningar och beräkningar av vedeldningens påverkan på luftföroreningshalter. Del I. Lycksele. Delredovisning av resultat från programmet Biobränsle hälsa och miljö. ITM rapport 124. ITM Stockholms universitet, 106 91 Stockholm, Sweden. ISSN 1103-341X.

R Johansson, C. et al., 2004. Mätningar och beräkningar av vedeldningens påverkan på luftföroreningshalter. Del II. Växjö. Delredovisning av resultat från programmet Biobränsle hälsa och miljö. ITM rapport 125. ITM Stockholms universitet, 106 91 Stockholm, Sweden. ISSN 1103-341X.

R Omstedt, G. & Johansson, C., 2004. Uppskattning av emissionsfaktor för bensen. SLB analys rapport nr. 2:2004. Miljöförvaltningen, Box 38 024, 100 6 Stockholm.

V Kristensson, A., **Johansson, C.**, Westerholm, R. Swietlicki, E., Gidhagen, L., Wideqvist, U. & Vaclav Vesely, 2003. Real-World Traffic Emission Factors of Gases and Particles Measured in a Road Tunnel in Stockholm, Sweden. Accepted for publication in Atmospheric Envronment, Sept., 2003.

V Gidhagen, L., C. Johansson, G. Omstedt, J. Langner and G. Olivares, 2004. Model simulations of NOx and ultrafine particles close to a Swedish highway. Environmental Science & Technology, 38, 6730-6740.

V Hedberg, E., Gidhagen, L. & **Johansson, C.**, 2005. Source contribution to PM10 and the arsenic concentration in Central Chile using Positive Matrix Factorisation. Atmospheric Environment, 35, 549-561.

R Johansson, C., Norman, M., Omstedt, G., Swietlicki, E., 2004. Partiklar i stadsmiljö – källor, halter och olika åtgärders effekt på halterna mätt som PM10. SLB analys rapport nr. 4:2004. Miljöförvaltningen, Box 38 024, 10064 Stockholm.

R Norman, M. & Johansson, C. Karakterisering av partikelförekomsten vid Mariatorget tunnelbanestation. SLB analys, Miljöförvaltningen, Box 38 024, 100 64 Stockholm.

V Gidhagen, L., **Johansson, C.**, J. Langner and V. Foltescu, 2005. Urban scale modeling of particle number concentration in Stockholm. Atmospheric Environment, 39, 1711-1725.

V Forsberg, B., Hansson, H-C., **Johansson, C.**, Areskoug, H., Persson, K. & Järvholm, B., 2005. Comparative health impact assessment of local and regional particulate air pollutants in Scandinavia, Ambio, 34, 11-19.

R **Johansson, C.**, Norman, M., Omstedt, G., Swietlicki, E., 2004. Partiklar i stadsmiljö – källor, halter och olika åtgärders effekt på halterna mätt som PM10. SLB analys rapport nr. 4:2004. Miljöförvaltningen, Box 38 024, 10064 Stockholm.

R **Johansson, C.**, 2005. Källbidrag till partikelhalterna i tunnelbanan. SLB-analys, preliminär rapport, Miljöförvaltningen, Stockholm, Box 38 024, 100 64 Stockholm..

R Norman, M. & **Johansson, C.**, 2005. Karakteriserng av partikelförekomsten vid Mariatorgets tunnelbanestation. SLB analys, nr 1:2005, Miljöförvaltningen, Stockholm, Box 38 024, 100 64 Stockholm. http://www.slb.nu/slb/rapporter/pdf/partiklar_t_bana_1_2005.pdf.

V **Johansson, C.**, Norman, M., & Gidhagen L., 2005. Characteristics of population exposure to particle mass (PM10) and particle number in a city. To be submitted.

V Norman, M. & **Johansson, C.**, 2005. Evaluation of different measures to reduce road dust emissions in Stockholm. Atmospheric Environment, Submitted.

V Omstedt, G., **Johansson, C.**, & Bringfelt, B., 2005. A Model Induced Non-tailpipe Emissions of Particles Along Swedish Roads. Atmospheric Environment, 39, 6088-6097.

V Hedberg, E., **Johansson, C.**, Johansson, L., Swietlicki, E., & Brorström-Lundén, E. 2005. Receptor model relationships from particle pollution in Lycksele, Sweden, Submitted.

V Forsberg, B., **Johansson, C.**, & Hansson, H-C., 2005. Assessing mortality effects of PM from local traffic emissions. Submitted.

V Mårtensson, E. M., Nilsson, E. D., Bozorius, G., **Johansson, C.**, 2005. Eddy correlation measurements and parameterisation of traffic related particle emissions in an urban environment. Atmospheic Chemistry and Physics, in press.

R Nerhagen, L., Forsberg, B., **Johansson, C.** & Lövenheim, B., 2005. Luftföroreningarnas externa kostnader. Förslag på beräkningsmetod för trafiken utifrån granskning av ExternE-beräkningar för Stockholm och Sverige. VT rapport 517, ISSN 0347-6030. VTI 581 95 Linköping.

CV for David Simpson

Nationality:	British
Born:	20 March 1961, England
Present post:	Senior scientist, EMEP MSC-W, Norwegian Meteorological Institute, Oslo, Norway, (Associated scientist, Radio and Space Science, Chalmers, Göteborg)
Languages:	English (native), Norwegian, Swedish (spoken)
Academics qualifications:	
	Assoc. Prof., Göteborg University, 2003 Dr. Philos, University of Oslo, 2002 B.A. Physics, Oxford University, UK, 1982

Employment

David Simpson has been employed by the EMEP MSC-W group at the Norwegian Meteorological Institute (MET.NO) since 1990, currently with a 'Senior Scientist-1183' position (Prof.-equivalent). He lives and works in Gothenburg, Sweden, however, being located within the Department of Radio and Space Sciences, Chalmers University of Technology.

Previous employments consisted of a parallel 10% position at the Earth Sciences Centre, University of Gothenburg (2002-2003), and seven years working at Warren Spring Laboratory, U.K. (1982-1989).

Professional Experience

1999–2006 : Coordinator of EMEP Eulerian model development.

2005: Contributor to joint WHO/Convention Task Forces on health risks of particulate mater and ozone.

2002-2005 : EU projects MERLIN, CARBOSOL, and NOFRETETE, including extensive work on modelling of particles.

1998–2006 : Development of methods for working with secondary organic aerosol

1996–2000 : Chairman of the "Nature Panel", within the UN-ECE Task Force on Emission Inventories.

1997–2000 : Member of the European Commission's Working Group on Ozone.

1996–1999 : Ozone modelling and optimisation for EU INFOS project.

1994–1995 : Coordinator of the European Commission Auto/Oil I project on local/regional scale photochemical oxidant modelling

1992 : Temporary advisor to World Health Organisation (3-12 September). (Model calculations for SO2 and NOx).

1990–1999 : Development and applications of EMEP MSC-W Lagrangian oxidant model.

1984-1989 : Ozone modelling with trajectory-version of Harwell photochemical model. Modelling of NOx over the UK with dispersion model and EMEP NOx model.

1987 (6 months), 1989 (3 months) : 'contribution-in-kind' to EMEP activities, payed for by the U.K. Dept. of the Environment.

1982-1984 : Development of dispersion models for sulphur and nitrogen, and analysis of observations of NO episodes in London

Publications:

37 Peer-reviewed papers, and 90 other publications. Some selected publications follow:

Y. Andersson-Sköld and D. Simpson. Secondary organic aerosol formation in Northern Europe: a model study. *J. Geophys. Res.*, 106(D7):7357–7374, 2001.

L.D. Emberson, M.R. Ashmore, D. Simpson, J.-P. Tuovinen, and H.M. Cambridge. Modelling and mapping ozone deposition in Europe. Water, Air and Soil Pollution, 130:577–582, 2001.

H.C. Hansson and L- Tarrason (eds.), Long-range transport of particulate matter in Nordic countries, (9 co-authors, inc. D. Simpson), Nordic Council of Ministers Report, 2005

J.E. Jonson, D. Simpson, H. Fagerli, and S. Solberg. Can we explain the trends in European ozone levels? *Atmos. Chem. and Physics*, 6:51–66, 2006. SRef-ID: 1680-7324/acp/2006-6-51.

D. Simpson, J.-P. Tuovinen, L.D. Emberson, and M.R. Ashmore. Characteristics of an ozone deposition module. *Water, Air and Soil Pollution: Focus*, 1:253–262, 2001.

D. Simpson, H. Fagerli, J.E. Jonson, S. Tsyro, P. Wind, and J.-P. Tuovinen. The EMEP Unified Eulerian Model. Model Description. EMEP MSC-W Report 1/2003, The Norwegian Meteorological Institute, Oslo, Norway, 2003.

D. Simpson and P. Makar, Modelling SOA and OC in Europe, EMEP Status Report 4/2004, Norwegian Institute for Air Research, Kjeller, Norway, 2004

D. Simpson, L. Emberson, M.R. Ashmore, and J.P. Tuovinen. A comparison of two different approaches for mapping potential ozone damage to ozone. a model study. *Environmental Pollution*, To be published, 2006.

WHO, Health risks of particulate matter from long-range transboundary air pollution, Joint WHO/Convention Task Force on the Health Aspects of Air Pollution, European Centre for Environment and Health, Bonn Office, (16 co-authors, inc. D. Simpson), 2006

CV for Kristina Stenström

PRIVATE
Name: Ruth Kristina Stenström
Pers no: 6907234204 (Nationality: Swedish)
Gender: Female
Civil status: Single
Children: Daughter, born October 2000
Home address: Clemenstorget 6, SE-222 21 Lund
Work address: Lund University, Department of Physics, Division of Nuclear Physics, Box 118, SE-221 00 Lund

PROFESSIONAL PREPARATION
Undergraduate
Lund University, Bachelor of Science in Physics 1991-08-15
Graduate
Lund University, Div of Nuclear Physics, Ph. D. 1996-04-11
Subject: Applied Nuclear Physics, Accelerator mass spectrometry
Title: New applications of ^{14}C measurements at the Lund AMS facility
Supervisor: Ragnar Hellborg
Post-graduate
Lund University, Div of Nuclear Physics, Ass. Prof. (*docent*) in Nuclear Physics 1999-09-14
Research area: Accelerator mass spectrometry

APPOINTMENTS
Researcher at Lund University/Nuclear Physics/031101-
Research assistant at Lund University/Nuclear Physics/960701-031031
Maternity leave 011201-020131, 020301-020531 (25%)
Maternity leave 010401-011130 (75%)
Maternity leave 001023-010331 (100%)
University lecturer (Atomic Physics, Lund University), 970801-990731 (25%)
Research engineer (nuclear physics, Lund University), 960101-960630 (100%)
Research engineer (radiation physics, Malmö University hospital), 951101-951231 (100%)
Position as PhD student (nuclear physics, Lund University), 910701-950930 (100%)

TUTORING EXPERIENCE
Second supervisor for 3 PhDs, graduated in 2002 (1) and 2003 (2)
Primary supervisor for 1 PhD student (started in 2002)
Supervisor of about 10 master theses

TEACHING
About 20% undergraduate teaching yearly.

OTHER MERITS OF RELEVANCE
Head of the Pelletron accelerator laboratory since 2001-10-01.

Member of the ”Editor Board” for the ”Symposium of North Eastern Accelerator Personnel, SNEAP XXXIV”, Lund University, Sweden, 22-25 October, 2001.
Member of the ”Organizing Committee” for ”International Conference on Applications of High Precision Atomic & Nuclear Methods, HIPAN 2002”, 2-6 September 2002, Neptun, Romania.
Member of examination board for Tekn lic Yanwen Zhang, Nuclear Physics, Lund, 1997.
Member of examination board for Ph D Göran Frank, Nuclear Physics, Lund, 2001.
Member of examination board for Ph D Asad Shariff, Nuclear Physics, Lund, 2004.

Member of examination board for Ph D Jörgen Ekman, Nuclear Physics, Lund, 2004.
Member of the management group of the Division of Nuclear Physics, Lund University since January 2003.
Member of the board of the Nuclear Physics Section of the Swedish Physical Society 2004-2005.
Director of postgraduate studies in physics, Lund University. Lund Universitet 2005-04-01—2006-03-31.

EXAMPLES OF PUBLICATIONS

1. K. Stenström, B. Erlandsson, R. Hellborg, G. Skog, A. Wiebert, R. Vesanen, M. Alpsten and B. Bjurman: *A one-year study of the total air-borne ^{14}C effluents from two Swedish light-water reactors, one boiling water- and one pressurized water reactor.* Journal of Radioanalytical and Nuclear Chemistry 198:1 (1995) 203-213.
2. K. Stenström, B. Erlandsson, R. Hellborg, G. Skog and A. Wiebert: *Environmental Levels of Carbon-14 around a Swedish Nuclear Power Plant Measured with Accelerator Mass Spectrometry.* Nuclear Instruments and Methods B113 (1996) 474-476.
3. K. Stenström, B. Erlandsson, R. Hellborg, G. Skog and A. Wiebert: *Determination of the $^{14}CO_2$ and Total Airborne ^{14}C Releases from Two Swedish Light-Water Reactors Using Accelerator Mass Spectrometry.* Radioactivity and Radiochemistry 7:1 (1996) 32-36.
4. K. Stenström, S. Leide-Svegborn, B. Erlandsson, R. Hellborg, S. Mattsson, L.-E. Nilsson, B. Nosslin, G. Skog and A. Wiebert: *Application of accelerator mass spectrometry (AMS) for high-sensitivity measurements of $^{14}CO_2$ in long-term studies of fat metabolism.* Journal of Applied Radiation and Isotopes 47:4 (1996) 417-422.
5. K. Stenström, S. Leide-Svegborn, B. Erlandsson, R. Hellborg, S. Mattsson, L.-E. Nilsson, B. Nosslin and G. Skog: *A programme for long-term retention studies of ^{14}C-labelled compounds in humans using the Lund AMS facility*. Nucl. Instr. and Meth. B 123 (1997) 245-248.
6. K. Stenström, G. Skog, C. Thornberg, B. Erlandsson, R. Hellborg, S. Mattsson and P. Persson: *^{14}C levels in the vicinity of two Swedish nuclear power plants and from two "clean air" sites in southernmost Sweden.* Radiocarbon 40:1 (1998) 433-438.
7. Å. Magnusson, K. Stenström, G. Skog, D Adliene, G. Adlys, R. Hellborg, A. Olariu, M. Zakaria, C. Rääf and S. Mattsson: *^{14}C levels in the terrestrial environment in the vicinity of two European nuclear power plants.* Radiocarbon 46:2 (2004) 863-868.
8. M.J. Rubel, J.P. Coad, K. Stenström, P. Wienhold, J. Likonen, G.F. Mattews, V. Philipps and JET-EFDA Contributors. *Overview of tracer techniques in studies of material erosion, re-deposition and fuel inventory in Tokamaks.* Journal of Nuclear Materials 329-333 (2004) 795-799.
9. Å. Magnusson, K. Stenström, D. Adliene, G. Adlys, C. Dias, C. Rääf, G. Skog, M. Zakaria and S. Mattsson: *Carbon-14 levels in the vicinity of the Lithuanian nuclear power plant Ignalina.* Submitted to Nucl Instr and Meth B.
10. K. Stenström and Å. Magnusson: *Methods for measuring ^{14}C on spent ion exchange resins – a review.* Presented at "Workshop on C-14 Release and Transport in Repository Environments", Wettingen, Switzerland 27-28 Oct, 2003. NAGRA Interner Bericht 04-03, 2004, p 25-42.
11. Å. Magnusson and K. Stenström: *Determination of organic and inorganic ^{14}C on ion exchange resins – method description.* Internal report LUNFD6/(NFFR-3097)/1-35/(2005).
12. Å Magnusson and K. Stenström: *^{14}C produced in Swedish nuclear power reactors – Measurements on spent ion exchange resins, various process water systems and ejector off-gas.* Final report for SKB project 9808. Internal report LUNFD6/(NFFR-3098)/1-33/(2005).

CV for Erik Swietlicki

1. Personal information

Name: Erik Robert Swietlicki (Gender: Male)
Born: 20 November 1958 in Lund, Sweden (Nationality: Swedish)
Civil status: Married (3 children, born in 1988, 1995 and 1997)

2. Business address

Division of Nuclear Physics, Department of Physics, Lund University/Technical Faculty, P.O. Box 118, S-221 00 Lund, Sweden. (*Avd. för kärnfysik, Fysiska institutionen, Lunds universitet/LTH*), tel: +46-46-222 96 80, +46-709-92 45 12, fax: +46-46-222 44 31. Visiting address: Design Centre, Sölvegatan 26 (room 588). E-mail: Erik.Swietlicki@pixe.lth.se.

3. Present position (2002-)

- Professor in *Aerosol Physics, in particular atmospheric aerosols*, from 1 July 2002, Division of Nuclear Physics, Lund University/LTH (*Befordrad professor*, 70% Research (on external funding only), 20% Graduate teaching, 10% Undergraduate teaching)

4. Previous academic positions (1989-2002)

- Scientific visitor (Post-Doc) during the period 1 November 1989 - 31 October 1990 at the Central Bureau for Nuclear Measurements, Geel, Belgium. This institute is a Joint Research Centre run by the Commission of the European Communities.
- Assistant researcher (*forskningsassistent*) from 1 November 1990 to 31 June 1992 at the Division of Nuclear Physics, Lund University/LTH.
- Junior researcher (*forskarassistent*) from 1 July 1992 to 31 Dec. 1998 at the Division of Nuclear Physics, Lund University/LTH. This position was to a large extent funded by the Swedish Natural Science Research Council (NFR).
- Senior lecturer (*universitetslektor*) from 1 Jan. 1999 to 30 June 2002 at the Div.of Nuclear Physics, Lund Univ./LTH.

5. Education and degrees

- Master of Science in Engineering Physics, May 1983, Lund University/Technical Faculty, Sweden (*Civilingenjör Teknisk Fysik, LTH*)
- Doctor, September 1989, Lund University/Technical Faculty, PhD thesis: European source region identification of long range transported ambient aerosol based on PIXE and related techniques. Supervisor: Prof. Hans-Christen Hansson.
- Docent, June 1994 (*Docent i Fysik, Fysiska institutionen, LU/LTH*)
- Professor, July 2002 (*Aerosolfysik, speciellt atmosfäriska aerosoler, LU/LTH*)

6. Evaluation by the Swedish Research Council 2004

In **March 2004 evaluation** of the area "**Meteorology**", the following **General Judgement** was given: "Erik Swietlicki is a leader in his field and is rated as *excellent* in his scientific achievements related to meteorology, and an *outstanding* organiser of research. The expert panel *strongly recommends* funding at an increased level."

7. PhD student supervisor

Main supervisor for 8 PhD students, so far leading to 5 PhD exams and 1 additional Licentiate exam. **Jingchuan Zhou**, PhD thesis: "Hygroscopic properties of atmospheric particles in various environments", April 2001. **Matthias Ketzel**, PhD thesis: "Dispersion and Transformation of Traffic Exhaust Particles in the Urban Atmosphere", May 2004. **Adam Kristensson**, PhD thesis thesis: "Aerosol particle sources affecting the Swedish air quality at urban and rural level", Sept. 2005. **Jenny Rissler**, PhD thesis: "Hygroscopic properties of aerosols from open-air burning and controlled combustion of biomass", November 2005. **Arash Gharibi**, PhD thesis: "Studies of aerosol particle formation from various sources using ion and electron beam analytical techniques", March 2006. **Olle Berg**, Licentiate thesis: "Measurements and modelling of hygroscopic properties of atmospheric particles", October

1997. At present, I am acting as main supervisor for two PhD student (**Jakob Löndahl** and **Erik Nilsson**). Löndahl started his PhD studies in Sept 2004, and Nilsson in March 2006.

8. The Group

The Aerosol Group at the Division of Nuclear Physics at Lund University (LU) has a 30 years long tradition in aerosol-related atmospheric research. Our group has participated in several EU projects and aerosol-related research programmes at the Nordic and national level. We are currently partners of EU-FP6 EUSAAR, and of the Nordic Centre of Excellence BACCI (Biosphere-Aerosol-Cloud-Climate Interactions). Our group has access to aerosol laboratories and accelerator laboratories for ion beam analysis and ^{14}C analysis of aerosol samples. Areas of interest are: aerosol measurement technology, source-receptor relationships at various spatial and temporal scales, aerosol emissions from various anthropogenic sources, particle hygroscopic growth and aerosol-cloud interactions, particle formation and dynamics in various background and remote environments, long-range transport, population exposure to air pollution.

9. Boards and committees

- Since September 2004, *President of the European Aerosol Assembly* (EAA, http://www.eaa.htm).
- Since March 2005, *Managing Director of the Consortium for Aerosol Science and Technology at Lund University* (CAST, http://www.fysik.lu.se/eriksw/cast/cast.htm).
- Since 1 January 2003, member of the *board of the Lund University Centre for Sustainability Studies*; http://www.lucsus.lu.se/).
- Since November 1998, member of the *board of the Nordic Society for Aerosol Research* (Nordiska Aerosolsällskapet, NOSA; http://www.fysik.lu.se/eriksw/nosa/nosa.htm). *President of NOSA* between October 2000, - November 2004.

10. Duties as opponent and member of examination board

I have served as faculty opponent twice and as a member of the examination board eight times during the defence of PhD theses since 1997.

11. Publications (Number of publications in peer-reviewed journals: 90)

SCARP-relevant selected publications in peer-reviewed journals during 2001-2006:

M. Ketzel, P. Wåhlin, A. Kristensson, E. Swietlicki, R. Berkowicz, O.J. Nielsen and F. Palmgren. Particle size distribution and particle mass measurements at urban, near-city and rural level in the Copenhagen area and Southern Sweden. Atmospheric Chemistry and Physics 4(2004)281-292.

A. Kristensson, C. Johansson, R. Westerholm, E. Swietlicki and L. Gidhagen. Real-World Traffic Emission Factors of Gases and Particulate Matter from Measurements in Stockholm, Sweden. Atm. Env. 38 (2004) 657–673.

M. Kanakidou, J.H. Seinfeld, S.N. Pandis, I. Barnes, F.J. Dentener, M.C. Facchini, R. van Dingenen, B. Ervens, A. Nenes, C.J. Nielsen, E. Swietlicki, J.P. Putaud, Y. Balkanski, S. Fuzzi, J. Horth, G.K. Moortgat, R. Winterhalter, C.E.L. Myhre, K. Tsigaridis, E. Vignati, E.G. Stephanou, and J. Wilson. Organic aerosol and climate modelling: A review. Atmospheric Chemistry and Physics, 5(2005)1053-1123.

J. Rissler, J. Pagels, E. Swietlicki, M. Strand, A. Wierzbicka, L. Lillieblad, M. Bohgard and M. Sanati. Hygroscopic behavior of aerosol particles emitted from biomass fired grate boilers. Accepted for publication in Aerosol Science and Technology.

J. Löndahl, Joakim Pagels, Erik Swietlicki, Jingchuan Zhou, Matthias Ketzel, Andreas Massling and Mats Bohgard. A Set-up for Field Studies of Respiratory Fine and Ultrafine Particle Deposition in Humans. Aerosol Science and Technology, In press (2006).

A. Dahl, A. Gharibi, E. Swietlicki, A. Gudmundsson, M. Bohgard, A. Ljungman, G. Blomqvist and M. Gustafsson. Traffic-generated emissions of ultrafine particles from pavement-tire interface. Atmospheric Environment, 40 (2006) 1314–1323.

CV for John Munthe

***YEAR OF BIRTH*:** 1960
NATIONALITY: Swedish

***POSITION IN FIRM*:**
1999 - Department Manager "Environmental Effects and Atmospheric Chemistry"
1996 to 1999 Section head at IVL. Mercury and acidification.
1992 to 1995 Scientist at IVL

SPECIALISATION:
Mercury biogeochemistry. Environmental cycling and effects of mercury. Environmental assessment of mercury pollution.
General atmospheric chemistry and environmental impacts of air pollutants, international air pollution strategies.

***YEARS WITH FIRM*:** **Since 1992**

***KEY QUALIFICATIONS*:**
More than 15 years experience in environmental research on mercury behaviour, analytical chemistry and environmental assessment. Environmental impacts of air pollutants, atmospheric chemistry, acidification and recovery processes.

EDUCATION:
B.Sc. in Chemistry at University of Göteborg, 1988
Ph.D. in Chemistry at University of Göteborg, 1992

***SELECTED COMMISSIONS*:**
2001: Deputy director of the research programme "International and national strategies for transboundary air pollution (ASTA)"
1998 Swedish representative in Expert group for development of Position paper on mercury within the Air Quality Directive of the EU DG Environment.
1997-1998 Coordinator of EU funded research project Mercury Over Europe (MOE)
1998-2003 Co-ordinator for the EUROTRAC2 subproject MEPOP (Atmospheric Cycling of Mercury and Persistent Organic Pollutants).
1997 Responsible for consultant group in the World Bank "Mercury Clean-Up project" in Azerbaijan.
1998 Project Manager for TACIS Pre-Investment Feasability Study "Assessment of human exposure of methylmercury via fish consumption in the Sumgayit area"
2001, 2004, 2006 Member of the International Steering Committee for the International Conference on Mercury as a Global Pollutant in Minamata, 2001, Ljubljana, 2004 and Madison 2006.
2002, 2005 Guest Editor for special issue in Science of the Total Environment with selected papers from International Conference on Mercury as a Global Pollutant in Minamata, 2001 and Ljubljana, 2004.

PUBLICATIONS (peer - reviewed papers from 2004 - 2005, 48 publications from 1988 to 2002)

Driscoll, C., M. Abbott, R. Bullock, J. Jansen, D. Leonard, S. Lindberg, J. Munthe, N. Pirrone, and M. Nilles. (2005) Airsheds and Watersheds. In: State of the Science for Mercury Effects Assessment for Aquatic and Terrestrial Environments, R. Harris et al. (Eds.), SETAC Press, Pensacola, FL. (in press).

Karlsson, P.-E., Pleijel, H., Belhaj, M., Danielsson, H., Dahlin, B., Andersson, M., Hansson, M., Munthe, J. and Grennfelt, P. 2005. Economic assessment of the negative impact

on ozone on crop yields and forest production: A case study of the estate Östads Säteri in Southwestern Sweden. *Ambio* **34**, 32-40.

Karlsson, P.-E., Pleijel, H., Belhaj, M., Danielsson, H., Dahlin, B., Andersson, M., Hansson, M., **Munthe, J.** and Grennfelt, P. 2005. Economic assessment of the negative impact on ozone on crop yields and forest production: A case study of the estate Östads Säteri in Southwestern Sweden. *Ambio* **34**, 32-40.

Moldan, F., Skeffington, R. A., Mörth, C.-M., Torssander, P., Hultberg, H. and **Munthe, J**. Results from the Covered Catchment Experiment at Gårdsjön, Sweden, after Ten Years of Clean Precipitation Treatment. *Water, Air, and Soil Pollution* **154** (1-4): 371-384, 2004

Munthe, J. and Hultberg, H. 2004. Mercury and methylmercury in run-off from a forested catchment - concentrations, fluxes and their response to manipulations. *Water, Air,Soil Pollution Focus* **4**, 607-618,.

Sommar, J. Wängberg, I., Berg, T., Gårdfeldt, K., **Munthe, J.,** Richter, A., Urba, A., Wittrock, F. and Schroeder, W. Circumpolar transport and air-surface exchange of atmospheric mercury at Ny-Ålesund (79 N), Svalbard, spring 2002. Atmospheric Chemistry and Physics Discussions, Vol. 4, pp 1727-1771, 19-3-2004

Sverdrup, H., Martinson, L., Alveteg, M., Moldan, F., Kronnäs, V. and **Munthe, J.** (2005). Modelling recovery of Swedish ecosystems from acidification. *Ambio* **34**, 25-31.

Wängberg, I., Barregård, L., Sällsten, G., Haeger-Eugensson, M., Munthe, J and Sommar, J. (2005) Emissions, dispersion and human exposure of mercury from a Swedish chlor-alkali plant. Atmospheric Environment 39, 7451-7458, 2005.

Zielonka, U., Hlawiczka, S., Fudala, J., Wängberg, I. and Munthe, J. (2005) Seasonal mercury concentrations measured in rural air in Southern Poland: Contribution from local and regional coal combustion. Atmospheric Environment 39, 7580-7586, 2005

CV for Cecilia Akselsson

Personal data
Cecilia Akselsson, born 7 November 1973, 731107-3949

Office address: IVL Swedish Environmental Research Institute Ltd., Box 5302, SE-400 14 Göteborg, Tel. +46(0)31-7256206, Fax +46(0)31-7256290, E-mail: cecilia.akselsson@ivl.se

Home address: Lagmansgatan 20A, SE-416 53 Göteborg. Tel. +46(0)31-432377.

Education and academic degrees

1997 Master of Science, Earth Sciences, Lund University, Sweden

2005 Doctor of Chemical Engineering, Branch of Studies Biogeochemistry, Department of Chemical Engineering, Lund University, Sweden
Title: Regional nutrient budgets in forest soils in a policy perspective
Supervisor: Professor Harald Sverdrup

Major employments

June 1995-Aug 1995	Assistant geologist at Terra Mining, Björkdalsgruvan, Skellefteå
Jun 1996-Aug 1996	Researcher at the National Board of Forestry, Jönköping, Sweden
Apr 1997-Mar 1998	Researcher at the National Board of Forestry, Jönköping,
Apr 1998-	Researcher at IVL Swedish Environmental Research Institute Ltd., Sweden (Leave of absence Dec 2000-May 2005 for Ph. D. studies at Lund University)
Dec 2000-May 2005	Ph D Student at Lund University

Research orientation

My work the last eight years deals with nutrient budgets in forest soils and how they are affected by atmospheric deposition and forestry. An important part of the work concerns evaluation of data from experiments and environmental monitoring. I have studied effects of lime and ash additions on soil, soil water and trees from several experiments in Sweden. My Ph. D. thesis comprises regional mapping of nutrient and carbon balances with different scenarios of deposition and forestry (e.g. stem harvesting vs. whole-tree harvesting). The nutrients nitrogen, calcium, magnesium and potassium were included. In a special study the amount of nitrogen leaching from clearcuts was estimated on a regional scale.

Presently I am developing the work on nutrient balances to involve more scenarios, e.g. storm effects, the effects of shelterwoods and the effect of nutrient addition. I also develop the methods for calculations of critical loads of acidity. Moreover, the budget calculations will be extended to include phosphorous.

Peer reviewed publications

Akselsson, C., Westling, O. and Örlander, G., 2004: Regional mapping of nitrogen leaching from clearcuts in southern Sweden. Forest Ecology and Management 202: 235-243.

Akselsson, C., Ardö, J. and Sverdrup, H., 2004: Critical loads of acidity for forest soils in the northern Czech Republic. Environmental Monitoring and Assessment 98: 363-379.

Akselsson, C., Holmqvist, J., Alveteg, M., Kurz, D. and Sverdrup, H., 2004: Scaling and mapping regional calculations of soil chemical weathering rates in Sweden. *Water, Air, & Soil Pollution: Focus* **4**: 671-681.

Akselsson, C. & Westling, O., 2005: Regionalized nitrogen budgets in forest soils for different deposition and forestry scenarios in Sweden. *Global Ecology and Biogeography* **14**: 85-95.

Akselsson, C., Berg, B., Meentemeyer, V. and Westling, O., 2005: Scaling up carbon sequestration rates in boreal forest soils - example Sweden. *Global Ecology and Biogeography* **14**: 77-84.

Akselsson, C., Sverdrup, H. and Holmqvist, J., 2006: Estimating weathering rates of Swedish forest soils in different scales using the PROFILE model and affiliated databases. Journal of Sustainable Forestry **21**: 119-131.

Akselsson, C., Westling, O., Sverdrup, H., Holmqvist, J., Thelin, G., Uggla, E. and Malm, G., In Press. Impact of harvest intensity on long-term base cation budgets in Swedish forest soils. Water, Air, and Soil Pollution: Focus.

Ph. D. thesis
Akselsson, C., 2005: Regional nutrient budgets in forest soils in a policy perspective, 2005. Doctoral Thesis, Department of Chemical Engineering, Lund University,
ISSN 1104-2877, ISBN 91-7422-076-4

Presentations on international conferences

Akselsson, C., Westling, O. and Sverdrup, H., 2001: Nitrogen leaching from clearcuts. The 2nd International nitrogen conference N2001, Potomac, Maryland, USA (Oral presentation).

Akselsson, C., Holmqvist, J., Sverdrup, H. and Kurz, D., 2002: New methods for scaling and mapping regional calculations of soil chemical weathering rates in Sweden. BIOGEOMON, Reading, UK (Oral presentation).

Akselsson, C. and Westling, O., 2002: Impact of harvest of biofuels on nitrogen fluxes in forests in Sweden. SUFOR international workshop on Sustainable Forestry in Temperate Regions, Lund, Sweden (Oral presentation).

Akselsson, C., Sverdrup, H., Westling, O., Holmqvist, J., Thelin, G., Uggla, E. and Malm, G., 2005: Impact of harvest intensity on long-term base cation budgets in Swedish forest soils. ACID RAIN, Prague, Czech Republic, 2005. (Oral presentation).

Akselsson, C., Westling, O., Sverdrup, H. and Gundersen, P., 2005. Nutrient and carbon budgets in forest soils as decision support in sustainable forest management. Bridging the gap - Policies and science as tools in implementing sustainable forest management, Alnarp, Sweden, 2005. (Oral presentation).

CV for Filip Moldan

Name of Person:	Filip Moldan
Nationality:	Czech
Year of birth:	1964
Civil status:	Married
Name of Firm:	IVL Swedish Environmental Research Institute
Address:	Box 5302, SE 400 14 Göteborg, Sweden
Phone:	+46 31 7256 231
Fax:	+46 31 7256 290
Email:	filip.moldan@ivl.se

Position in Firm:	Project leader
Years with Firm	15

Education:

1988 BA Hydrogeology and Engineering geology, Charles University, Prague, Czech Republic.

1989 M.Sc. (RNDr) Hydrogeology, Charles University, Prague, Czech Republic.

1999 PhD Forest soil science, Swedish Agricultural University, Faculty of forestry, Umeå, Sweden

Employment record:

1988-1990	Hydrologist, Institute for Hydrodynamics, Czech Academy of Sciences, Prague
1990-present	Hydrologist, geochemist, IVL Swedish Environmental Research Institute, Göteborg
1992-1997	Doctoral student, Swedish University of Agricultural Sciences, Umeå, Sweden

Languages:

	Speaking	Reading	Writing
Czech	excellent	excellent	excellent
Swedish	excellent	excellent	good
English	excellent	excellent	excellent
Russian	poor	poor	poor

Specialisation in Firm: Catchment studies, field experiments, geochemical modelling. An impact of air pollution on surface waters and groundwaters quality. Extensive experience with geochemical models of fresh waters such as MAGIC (Model of Acidification of Groundwaters in Catchments, Cosby et al., 1985).

PUBLICATIONS (peer - reviewed papers, the last 5 yrs)

Moldan, F., Kjønaas, O. J., Stuanes, A., and Wright, R.F., in press. Increased nitrogen in runoff and soil following thirteen years of experimentally-increased nitrogen deposition to a coniferous-forested catchment at Gårdsjön, Sweden. Env. Poll.

Mörth, C-M., Torssander, P., Kjønaas, O. J., Stuanes, A., Moldan, F. and Giesler, R. 2005. Mineralization of Organic Sulphur Delays Recovery from Anthropogenic Acidification. Environ, Sci, Technol, 39, 5234-5240.

Sverdrup, H., Martinson, L., Alveteg, M., Moldan, F., Kronnäs, V., and Munthe, J. 2005. Modeling Recovery of Swedish Ecosustems from Acidification. Ambio, **34**, 1. 25-31.

Wright, R.F., Larssen, Camarero, L., Cosby, B.J., Ferrier, R.C., Helliwell, R., Forsius, M., Jenkins, A., Kopáček, J., Majer, V., Moldan, F., Posch, M., Rogora, M., and Schöpp, W. 2005. Recovery of Acidified European Surface Waters. Environ, Sci, Technol, Feb. 1, 2005, 64-72.

Moldan, F., Kronnäs, V., Wilander, A, Karltun, E., and Cosby, B.J., 2004 Modelling acidification and recovery of Swedish lakes. WASP: Focus, **4**, 2, p.139-160.

Moldan, F., Skeffington, R.A., Mörth, C-M., Torssander, P., Hultberg, H., and Munthe, J., 2004. Results from Covered Catchment Experiment at Gårdsjön, Sweden, After Ten Years of Clean Precipitation Treatment. 2004. WASP, **154**, 1, p. 371-384.

Beier, C., Moldan, F. and Wright, R.F., 2003.Terrestrial Ecosystem Recovery - modelling the Effects of Reduced Acidic Inputs and Increased Inputs of Sea-salts Induced by Global Change. Ambio 32. 4, 275-282.

Moldan, F., Seitzinger, S., Eviner, V.T., Galloway, J.N., Han, X., Keller, M., Nannipieri, P, Smith Jr, W.O., and Tiessen, H. 2003. Potential for Deliberate Management of Element Interactions to Address Major Environmental Issues. in: Melillo, J.M., Field, C.B and Moldan, B., eds., Interactions of major biogeochemical cycles. SCOPE 61, p. 93-114

Jenkins, A., Camarero, L., Cosby, B.J., Ferrier, R.C., Forsius, M., Helliwell, R.C., Kopacek, J., Majer, V., Moldan, F., Posch, M., Rogora, M., Schöpp, W. and Wright, R.F. 2003. A modelling assessment of acidification and recovery of European surface waters. Hydrology &Earth System Sciences 7(4), 447-455.

Hruška, J., Moldan, F. and Krám, P., 2002. Recovery from acidification in central Europe - observed and predicted changes of soil and streamwater chemistry in the Lysina catchment, Czech Republic. Env. Pol. 120 (2002), 261-274.

Evans, C. D., Cullen, J. M, Alewell, C., Kopáček, J., Marchetto, A., Moldan, F., Prechtel, A., Rogora, M., Veselý, J. and Wright, R. F., (2001) Recovery from acidification in European surface waters. Hydrology &Earth System Sciences 5, 3, 283-98.

Grennfelt, P., Moldan, F., Alveteg, M., Warfvinge, P. and Sverdrup, H. 2001. Critical Loads - Is There a Need for a New Concept?. Wat. Air Soil Pol.:Foc. 1: 21-27.

Krám, P., Bishop., K. and Moldan, F., 2001. Modelling Long-term Streamwater Chemistry in the Berg Catchment, Southwestern Sweden. Nordic Hydrology 32 (3), 249-264.

Moldan, F., R. F. Wright, S. Löfgren, M. Forsius, T. Ruoho-Airola and B. L. Skjelkvåle (2001) Long-term changes in acidification and recovery at nine calibrated catchments in Norway, Sweden and Finland. Hydrology &Earth System Sciences 5, 3, 339-50.

Prechtel, A., C. Alewell, M. Armbruster, J. Bittersohl, J. M Cullen, C. D. Evans, R. C. Helliwell, J. Kopacek, A. Marchetto, E. Matzner, H Messenburgh, F. Moldan, K. Moritz, J. Vesely and R. F. Wright (2001) Response of sulphur dynamicsin European Catchmentsto decreasing sulphate deposition. Hydrology &Earth System Sciences 5, 3, 311-26.Grennfelt, P., F. Moldan, M. Alveteg, P. Warfvinge and H. Sverdrup (2001) Critical loads - is there a need for a new concept? Water Air and Soil Pollution Focus 1, 1-7.

Wright, R. F., C. Alewell, J. M Cullen, C. D. Evans, A. Marchetto, F. Moldan, A. Prechtel and M. Rogora (2001) Trends in nitrogen deposition and leaching in acid-sensitive streams in Europe. Hydrology &Earth System Sciences 5, 3, 299-310.

CV for Annika Nordin

Personal: Born May 14, 1968. Married, two children born 2001 and 2004.

Present position: Associate Professor (Docent) in Biology (Forest Plant Physiology), Umeå Plant Science Centre, Department of Forest Genetics and Plant Physiology, Swedish University of Agricultural Sciences, SE-901 83 Umeå, Sweden; phone +46-90-7868537, fax +46-90-7868165, e-mail Annika.Nordin@genfys.slu.se.

Research interest: Mechanisms directing changes in plant species composition of natural ecosystems induced by eutrophication (atmospheric nitrogen deposition as well as forest fertilization). Focus on plant – pathogen and plant – soil interactions.

Editorial assignments: Editorial board of *Ecosystems*. Reviewer for journals such as *Oecologia, Ecology, Functional Ecology, Canadian Journal of Forest Research*. Reviewed proposal to EUROCORES (ESF Collaborative Research Programmes) on EuroDIVERSITY.

Other assignments: Member of the Faculty Board at the Faculty of Forest Sciences, SLU (2004-present).

Member of the board of the Umeå Center for Environmental Studies (Umeå Miljöhögskola) 2002-present.

Member of the steering committee of the MISTRA funded ASTA project (Abatement Strategies for Transboundary Air Pollution) 2003-present.

Main supervisor of 1 PhD student (at the Department of Forest Genetics and Plant Physiology, SLU. Assistant supervisor of 5 PhD students (at the Dep. of Forest Genetics and Plant Physiology SLU (2 students), Dep. of Forest ecology SLU (1 student), Dep. of Forest Vegetation Ecology SLU (1 student) and Dep. of Ecology and Environmental Sciences Umeå University (1 student)).

Current funding from: FORMAS, MISTRA (ASTA-project), Umeå Centre for Environmental Sciences (CMF), The Oscar and Lili Lamm Foundation.

Publications: 11 peer-reviewed publications 1999-present (6 as first author).

Ten recent papers: Forsum, Å., Dahlman, L., Näsholm, T. & **Nordin, A.** 2006. Nitrogen utilization by *Hylocomium splendens* in a boreal forest fertilization experiment. *Functional Ecology.* In press.

Nordin, A., Strengbom, J. & Ericson L. 2006. Responses to ammonium and nitrate addition by boreal forest plants and their natural enemies. *Environmental Pollution* 141: 167 – 174.

Nordin, A., Strengbom, J., Witzell, J., Näsholm, T. & Ericson, L. 2005. Nitrogen deposition and the biodiversity of boreal forests – implications for the nitrogen critical load. *Ambio* 34: 20 – 24.

Strengbom, J., Witzell, J., **Nordin, A.** & Ericson, L. 2005. Do multitrophic interactions override nitrogen fertilization effects on *Operophtera* larvae? *Oecologia* 143: 241 – 250.

Nordin, A., Schmidt, I. K. & Shaver, G. R. 2004. Nitrogen uptake by arctic soil microbes and plants in relation to soil nitrogen supply. *Ecology* 85: 955-962.

Strengbom, J., **Nordin, A.**, Näsholm, T. & Ericson, L. 2002. Parasitic fungus mediates vegetational changes in nitrogen exposed boreal forest. *Journal of Ecology* 90:61-67.

Schmidt, I. K., Jonasson, S., Shaver G.R., Michelsen, A. & **Nordin, A**. 2002. Mineralization and distribution of nutrients by plants and microbes in four tundra ecosystems: responses to warming. *Plant and Soil* 242: 93-106.

Nordin, A., Högberg, P. & Näsholm, T. 2001. Soil N form and plant N uptake along a boreal forest productivity gradient. *Oecologia* 129: 125-132.

Strengbom, J., **Nordin, A.**, Näsholm, T. & Ericson, L. 2001. Slow recovery of boreal forest ecosystem following decreased nitrogen input. Functional Ecology15: 451-457.

Nordin, A., Uggla, C. & Näsholm, T. 2001. Nitrogen forms in bark, wood and foliage of nitrogen fertilized *Pinus sylvestris* L. *Tree Physiology* 21: 59-64.

Nordin, A. & Gunnarsson, U. 2000. Amino acid accumulation and growth of *Sphagnum* under different levels of N deposition. *Ecoscience* 7: 474-480.

CV for Harald Ulrik Sverdrup

Date of Birth: 31-01-1954

Nationality: Norwegian

Education / Professional studies:

Chemical Engineering 1980
PhD Chemical Engineering 1985
Docenture Chemical Engineering 1988 (Habilitation)

Language Skills: (1=notions to 5=excellent, *=mother tongue)

1. Scandinavian
    a. Norwegian* 5
    b. Swedish 4
    c. Danish 4
2. English 5
3. German
    a. High German 4
    b. Swiss German 4
4. Latin
    a. Italian 3
    b. Spanish 2
    c. French 2
5. Tyrrenian
    a. Etruscan 3
    b. Raetic 2
6. Ancient Iberian 2
7. Pictish 1

Membership of Professional/Academic Bodies:
President of the board of directors in

1. KA Rasmussen A/S, Hamar, Norway
2. Gense AB, Eskilstuna, Sweden
3. KAR Sjödings AB, Stockholm, Sweden
4. KAR Guldcentralen AB, Stockholm, Sweden
5. KAR OY, Helsinki, Finland
6. Kultateollisus OY, Åbo, Finland
7. OY, Helsinki, Finland
8. American KA Rasmussen Inc. Washington DC, USA
9. Eternum SA, Gemboux, Belgium

Board Member OU Juwel, Tallinn, Estonia

Founder:

1. Founding father and Director of Lund Universiy Master of Environmental Studies 1996-2001
2. Founding brother and board member of IS&T Inc, Virginia, USA.

Many university boards and committees

Present Position:

1. Professor of Chemical Engineering, Lund University, Sweden
2. President and CEO of KA Rasmussen a/s, Hamar, Norway

Years with the Lund University: Since 1981, 25 years academic experience

Years with KA Rasmussen as: Since 1978, 28 years industrial experience

Key Qualifications:

Integrated mathematical and computer modeller
Engineering skills
Frontline innovations in ecology and geochemistry
Software development

Seasoned teacher and developer of pedagogical methods
Group dynamics and management

Expert in environmental systems and processes
Expert in heterogeneous silicate chemistry and the biogeochemistry of chemical weathering
Expert in precious metal and platinum group metallurgy and refining procfesses

Skills in gold- and silversmith crafts and silverware manufacture
Corporation directorship, strategic business planner

Can teach in Scandinavian, English and German language

12 Professional Experience Record:

- 25 years experience in integrated mathematical and computer numerical modelling in ecosystems, social systems, economic systems. Emphasis on mechanistic differential mathematical model development.
- Active in teaching since 1981 at Lund University. Designed several new courses (Ekoloisk processmodellering, Biogeochemical processes, Biogeochemical models, Systems analysis) and master programmes (LUMES).
- Participated in development of the very first GIS systems in the United States in early 1980's (GeoDex). Developed several software packages (PROFILE, DeACID, KALK, SAFE, ForSAFE, FarmFLOW, Hälge, ForSAFE-VEG, DeCOMP, BigMerk)
- Developed systems analysis education at Lund University (Curriculum plan, pedagogical approach and plan, pedagogical staff training,, pedagogical implementation, Master Programme leadership, Plan for social training with foreign master programme students).
- Carried out distance learning in systems analysis (Argentina)
- Several patents in water neutralization with limestones

13 Publications:

About 250 peer reviewed scientific articles, 150 as first author, 50 as sole author.

CV for Olof Westling

NAME:	HANS OLOF WESTLING	
YEAR OF BIRTH:	1954	
NATIONALITY:	Swedish	
PROFESSION:	Biologist	
SPECIALISATION:	Effects of air pollutants on forests and ground- and surface water, environmental impact of forest management. A total of 25 years of experience of environmental studies of forests, soil, ground water and limnic and marine waters. The experience covers project management of: -Studies of the impact of regional effects of air pollution and land-use in Sweden and other countries.-Integrated monitoring of wet and dry deposition, forest soils, ground-, soil-, and surface water. Pollutants studied are sulphur, nitrogen, heavy metals, and organic species as PCB and PAH. The projects includes both mass flow calculations and effects studies. -Impact of acid deposition including experiments with treatments of acid forest soils and surface waters with liming and fertilisation. -Environmental studies of peat land harvesting and ditching of forest soils and other management methods. -Environmental assessment studies of forest management; e.g. liming, fertilisation and whole tree harvesting in Sweden and the Baltic countries.	
POSITION HELD:	1999-	Assistant Department Manager, Department of Atmospheric Chemistry and Environmental effects at the Swedish Environmental Research Institute (IVL)
	1991-1999	Head of the Regional Environmental Monitoring Department at the Swedish Environmental Research Institute (IVL)
	1985-1990	Head of the Aquatic Environment Department at the Swedish Environmental Research Institute (IVL)
	1972- 1985	Project manager at the Swedish Environmental Research Institute (IVL)
CURRENT COMMISSIONS:	1999-	Responsible for subprogram; “Support to national strategies”, a part of the Swedish MISTRA programme; International and National Abatement Strategies for Transboundary air Pollution (ASTA).
	1996-2005	Responsible for projects; "New Silviculture methods and water quality, a part of the Swedish MISTRA programme; Sustainable Forestry (SUFOR).

1994-1997	Responsible for environmental assessment on large scale treatments with liming and fertilisation of forest soils i Sweden.
1994-	Responsible for programmes for regional monitoring of air pollutants and environmental status in forests in Sweden.
1992-	Responsible for experiments with wood ash treatment of forest soils in Sweden, effects on soil, soilwater and runoff.
1990-	Responsible for effect studies in connection to the Swedish Forestry Board project, large scale liming of forest soils in the south part of Sweden.

PUBLICATIONS (SELECTION)

Peer reviewed publications:

Scaling up carbon sequestration rates in boreal forest soils - example Sweden. 2005. Global Ecology and Biogeography 14: 77-84. Co authors Akselsson, C., Berg, B. and Meentemeyer, V.

Regionalized nitrogen budgets in forest soils for different deposition and forestry scenarios in Sweden. 2005. Global Ecology and Biogeography 14: 85-95. Co author Akselsson, C.

Regional mapping of nitrogen leaching from clearcuts in southern Sweden. 2004. Forest Ecology and Management 202: 235-243. Co authors Akselsson, C. and Örlander, G.

Modelling preindustrial ANC and pH during the spring flood in northern Sweden. 2001. Biochemistry:54 171-195. Co authors Laudon H., Löfgren S. and Bishop K.

Atmospheric deposition of base cations, nitrogen and sulphur in coniferous forests in Sweden-a test of a new surrogate surface. 2000. Boreal Environment Research 5:197-207. Co-authors Ferm M. and Hultberg H.

Leaching of Wood Ash and Lime Products: Laboratory study. 1998. Scand. J. For. Res. Suppl. 2 17-22. Co author Larsson P.-E.

Airborne organic micropollutant concentrations in mosses and humus as indicators for local versus long range sources. 1995. Environmental Monitoring and Assessment 36:75-95. Co-authors Knulst J. and Brorström-Lundén E.

Deposition of acid substances in Sweden. 1995. Ecol. Bull. 44:17-34. Co-authors Lövblad G., Kindbom K., Grennfelt P. and Hultberg H.

Mercury in runoff from drained and undrained peatlands in Sweden. 1991. Water, Air and Soil Pollution 56:419-426.

Liming and fertilisation of acid forest soils - short time effects on runoff from small catchments. Water, Air and Soil Pollution 1991:54. Co-author Hultberg, H.

CV for Lars Ericson

Personal: Born June, 20 1945. Married, 4 children.

Present position and address: Professor in Ecological Botany, Department of Ecology and Environmental Science, Umeå University, SE-901 87 Umeå, Sweden. Fax: +46-90—786 6705, tel.: +46-90-786 5414. E-mail: Lars.Ericson@emg.umu.se

Research interest: Interactions between plants and their natural enemies (parasitic fungi and herbivores), vegetation change, biodiversity, global change.

Commissions of trust: Umeå University: Head of Department (1980-2002), University Board (1998-2003), Faculty of Science and Technology, the Research Committee (1992-98), the Committee for Research Education, chair (1989-2005), Umeå Marine Research Centre (1992-2004), Centre for Environmental Research (1992-).

Outside Umeå University: Swedish Natural Science Research Council, the Biology Committee (1983-89, 91, 92-95), the Energy Committee 1986-89, 92-95), Board (1992-95); Abisko Scientific Research Station (1992-2000, 2004-); National Committee for IGBP&WRCP (2004-); Ammarnäs Research Station (1995-2004); Academy of Finland, Ecology Panel (2000, 2002, 2004).

Honors, elected member of societies: The Royal Swedish Academy of Sciences, Class VI Biology (1992-); The Royal Skytte Society (1995-).

External evaluation of projects for research councils in Austria, Australia, Denmark, Esthonia, Finland, Norway and UK.

Supervision: Supervisor of 21 PhD exams, co-supervisor of four PhD exams. At present supervisor of three PhD students and co-supervisor of four PhD students.

Major research grants: The Swedish Research Council (VR); The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS); Mistra, the ASTA Programme, The Kempe Foundation.

Publications: 129 original papers in international refereed journal, 7 book chapters, about 35 popular scientific papers and reports.

Some recent publications (27 since 2001):

Strengbom, J., Nordin, A., Näsholm, T., and Ericson, L. 2001. Slow recovery of boreal forest ecosystems following decreased nitrogen input. Functional ecology 15:451-457.

Strengbom, J., Näsholm, T., Nordin, A., and Ericson, L. 2002. Parasitic fungus mediates change in nitrogen-exposed boreal forest. Journal of Ecology 90:61-67.

Smith, D.L., Ericson, L., and Burdon, J.J. 2003. Epidemiological patterns at multiple scales: and 11-year study of a Triphragmium ulmariae-Filipendula ulmaria metapopulation. Journal of Ecology 91:890-903.

Strengbom, J., Walheim, M., Näsholm, T, and Ericson, L. 2003. Regional differences in the occurrence of understorey species reflect nitrogen deposition in Swedish forests. Ambio 32:91-97.

Hedenås, H., and Ericson, L. 2003. Response of epiphytic lichens on Populus tremula in a selective cutting experiment. Ecological Applications 13:1124-1134.

Edman, M., Gustafsson, M., Stenlid, J., and Ericson, L. 2004. Abundance and viability of fungal spores along a forestry gradient - responses to habitat loss or isolation? Oikos 104:35-42.

Strengbom, J., Näsholm, T., and Ericson, L. 2004. Light, not nitrogen limits growth of the grass Deschampsia flexuosa in boreal forest. Canadian Journal of Botany 82:430-435.

Nordin, A., Strengbom, J., Witzell, J., Näsholm, T., and Ericson L. 2005. Nitrogen deposition and the biodiversity of boreal forests: Implications for the nitrogen critical load. Ambio 34:20-24.

Berglund, H., Edman, M., and Ericson, L. 2005. Temporal variation of wood-fungi diversity in boreal old-growth forests: Implications for monitoring. Ecological Applications 15:970-982.

Strengbom, J., Witzell, J., Nordin, A., and Ericson, L. 2005. Do multitrophic interactions override fertilization effects of Operophtera larvae. Oecologia 143:241-250.

Strengbom, J., Englund, G., and Ericson, L. 2006. Experimental scale and precipitation modify effects of N-addition on a plant pathogen. Journal of Ecology 94:227-233.

Burdon, J.J., Thrall, P.H., and Ericson, L. 2006. The current and future dynamics of disease in plant communities. Annual Review of Phytopathology 44 (available online).

CV for Lars Gustav Högbom

Born 7/10, 1958, Swedish citizen
Civil status Unmarried
Education PhD in Soil Science (1992); BSc in Biology (1987)
Thesis: Spatial and temporal variability in the use of nitrate by field-layer plants in Swedish forests. (supervisor Prof. Peter Högberg)
Languages Swedish, English
Professional expertise
Eco-physiology, in particular plant/soil interactions
Employment
The Forestry Research Institute of Sweden (Skogforsk)
Uppsala Science Park
SE 751 83 UPPSALA
Tel: 018-18 85 49
Fax: 018-18 86 00
Cell: 0705 – 17 85 46
E-mail: lars.hogbom@skogforsk.se
Present position:
Sept, 1999-, Researcher at SkogForsk, The Forest Research Institute of Sweden.
Previous employment
April, 1996 – August, 1999, Miscellaneous employments.
Sept, 1994 – March, 1996, Post Doc at the Department of Plant and Soil Science, University of Aberdeen, Scotland UK.
May 1987 – Aug 1994, Assistant, PhD-student and from 1993 research assistant at Dept of Forest Ecology, Swedish University of Agricultural Sciences, Umeå, Sweden.
Academic grading committees
Member of the PhD evaluation comities for the thesis of Pål Andersson, SLU, Uppsala.
Academic advisor
Other tasks
3-5 referee tasks per year for various scientific journals.

Refereed publications (published)

Jacobson, S., Högbom, L., Ring, E. and Nohrstedt, H.-Ö. (2004) Effects of wood ash dose and stabilization methods on soil chemistry at two coniferous forest sites. Water, Air, and Soil Pollution 158, 113-125.

Pettersson, F. and Högbom, L. (2004) Long-term effects of forest N fertilization in Pinus sylvestris and *Picea abies* stands in Sweden. Scandinavian Journal of Forest Research 19, 339-347.

Högbom, L., Nilsson, U. and Örlander, G. (2002) Nitrate dynamics after clear felling monitored by in vivo nitrate reductase activity (NRA) and natural ^{15}N abundance of *Deschampsia flexuosa* (L.) Trin. Forest Ecology and Management 260, 273-280.

Ring, E., Högbom, L. and Nohrstedt, H.-Ö. (2001) Effects of brash removal after clear felling on soil and soilsolution chemistry and field-layer biomass in experimental N gradient. In Optimizing Nitrogen Management in Food and and Energy Production and Environmental Protection: Proceedings of the 2nd International Nitrogen Conference on Science and Policy. TheScientificWord S1, 457-466

Högbom, L. and Nohrstedt, H.-Ö. (2001) The fate of ^{137}Cs in coniferous forests following the application of wood-ash. The Science of the Total Environment 280, 133-141.

Högbom, L., Nohrstedt, H.-Ö., Lundström, H. and Nordlund, S. (2001) Soil properties and regeneration success 11 years after clear-felling of a *Pinus sylvestris* L. experimental N gradient in central Sweden. Plant and Soil 233, 241-250.

Högbom, L., Nohrstedt, H.-Ö. and Nordlund, S. (2001) N fertilization and mobility of potentially toxic metal ions in forest soils – implications for stream-water quality. Journal of Environmental Quality 30, 189-193

Bauer, G. A., Gebauer, G., Harrison, A. F., Högberg, P., Högbom, L., Schinkel, H., Taylor, A. F. S., Novak, M., Harkness, D., Persson, T. and Schulze, E.-D. (2000) Biotic and abiotic controls over ecosystem cycling of stable natural nitrogen and sulphur isotopes. In: E-D Schulze (ed.) Carbon and Nitrogen Cycling in European Forest Ecosystems. Ecological Studies 142, 189-216.

Wallenda, T., Stober, C., Högbom, L., Schinkel, H., George, E., Högberg, P. and Read DJ (2000) Nitrogen uptake processes in roots and mycorrhizas. In E-D Shulze (ed.) Carbon and Nitrogen Cycling in European Forest Ecosystems. Ecological Studies 142, 122-143.

Quist, M. E., Näsholm, T., Lindeberg, J., Johannisson, C., Högbom, L. and Högberg, P. (1999) Responses of a nitrogen saturated forest to a sharp decrease in nitrogen input. Journal of Environmental Quality 28, 1970-1977.

Högberg, P., Högbom, L. and Schinkel, H. (1998) Nitrogen-related root variables of trees along an Ndeposition gradient in Europe. Tree Physiology 18, 823-828.

Taylor, A. F. S., Högbom, L., Högberg, M., Lyon, A. J. E, Näsholm, T., Högberg, P. (1997) Natural ^{15}N abundance in fruit bodies of ectomycorrhizal fungi from boreal forests. New Phytologist 136, 713-720.

Högberg, P., Högbom, L., Oecologia Högberg P, Högbom L, Schinkel H, Högberg M, Johannisson C, Wallmark H (1996) ^{15}N abundance of surface soils, roots and mycorrhizas in profiles of European forest soils. *Oecologia*108, 207-214.

Refereed publications (in prep)

Högbom L, Alexander IJ (2005) Variability in plant ä^{15}N and N contents following N and P amendment to High-Arctic tundra ecosystems. Oecologia XX:xxx-xxx

Högbom L, Alexander IJ (2005) Mineralization and nitrification rates following N and P addition to High-Arctic tundra soils. Plant Soil XX:xxx-xxx

Högbom L, Alexander IJ, Högberg M, Högberg P (2005) Variability an ^{15}N in plants ans soils in four High-Arctic environments on Spitzbergen, Svalbard. Arctic, Antarc Alp Res XX:xxx-xxx

Rosenberg O, Jacobson S, Persson T, Grönlund T, Högbom L (2005) Wood ash fertilization in forests – influences on soil chemistry and effects on carbon and nitrogen mineralization. Soil Biol Biochem xxx:xxx-xxx.

CV for Mohammed Belhaj

DATE OF BIRTH	January 3, 1954
NATIONALITY	Swedish
PLACE OF BIRTH	Rabat, Morocco
EDUCATION	PhD in Environmental Economics at Gothenburg University; Title: Energy, Transportation and Urban Environment in Africa: The case of Rabat-Salé, Morocco.
OTHER TRAINING	Econometrics and project valuation studies, University of An arbor, Michigan, USA

LANGUAGES	**Speaking**	**Reading**	**Writing**
Arabic	Mother tongue		
Swedish	Excellent	Excellent	Excellent
English	Excellent	Excellent	Excellent
French	Excellent	Excellent	Excellent

COUNTRIES OF WORK EXPERIENCE

Europe: Sweden, France, Greece, Croatia, Albania, lithuania
Africa: Mainly all African countries south of Sahara, Morocco, Algeria, Tunisia, Egypt,
Middle East: Saudi Arabia, Lebanon
Latin America: Costa Rica and Nicaragua

PRESENT POSITION
ADDRESS

Researcher in Environmental Economics at The
Swedish Environmental Research Institute (IVL)
IVL Swedish Environmental Research Institute
P.O. Box 47086
S-402 58 Gothenburg, Sweden
Phone: 46 31 7256225
+46 31 7256200 (operator)
Fax: +46 31 7256290
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PUBLICATIONS

-A Swedish CBA on acidification abatement -the CAFÉ Baseline scenario, with Åström, S. & Sternhuvud, C. IVL (2005) forthcoming
-Energy Network Green4U, an Environmental Economic Study, with Norrman, J & Arnell, J. IVL, (2005)
- Environmental Economic Analysis of Biogas Investments in Western Sweden, with Norrman, J & Arnell, J. IVL, (2005)
-Does benefit transfer always work? A multi-country comparison (with Abou-Ali), Scandinavian working papers in economics no 158, 2005
-An economic assessment of the negative impacts of ozone on the crop yield and forest production at the Östad Estate in south-west Sweden (with Karlsson P-E, et al) Ambio no1, 2005
-Economic Instruments in the Lithuanian Energy Sector, with Sripple. H., IVL 2004, forthcoming.
-Impacts sanitaires et environnementaux de la qualité de l'eau dans la province de Beni Mellal, Maroc. World Bank 2004, forthcoming.
- Evaluation of environmental damage cost in Morocco; Rapport No 25992-MOR, 2003
-Using stated preference methods to evaluate the impact of water on health: the case of metropolitan Cairo, with Abou-Ali, Land Economic

2005 forthcoming.
-Estimating the benefits of clean air; Contingent valuation and hedonic price methods, International Journal of Global Environmental Issues, 2003: 3,1.
-Developing Desert locust insurance in Eritrea, working paper, Gothenburg University, 2002
-Vehicle and fuel demand in Morocco; Energy Policy, 2002 :30,13.
-The Economics of Desert Locust; the cases of Morocco and Sudan, working paper, Gothenburg University, 1999
-Energy, Transportation and Urban Environment in Africa: The case of Rabat-Salé, Morocco. PhD theses, Gothenburg University, 1998
-The Socioeconomic aspects of the Mediterranean Wetlands, together with Benessaiah Nejib, European Commission, 1998
-Estimating the benefits of clean air; contingent valuation and hedonic prices. World Congress of Environmental and Resource Economists, Venice, Italy, 1998
-Growth and Development in Sub-Saharan Africa, Swedish Development Advisers, 1998
-Gasoline demand and the emission of noxious gases in Africa, International Society of Ecological Economics, San José, Costa Rica, 1994.
-Les prix de l'énergie in Afrique, with Thomas Sterner, Revue de l'Energie no 415. , 1989

ASSIGNMENTS

-Consultant for the World Bank: Evaluation of environmental damage cost in Morocco; Rapport No 25992-MOR, 2003
-The basis to support economic reforms in Benin, Sida (2001)
-Study on Growth and Development in Sub-Saharan Africa, in corporation with Swedish Development Advisers, 1998 (Volvo)
-Responsible for the socioeconomic study in MedWet 2 (Mediterranean Wetland 2) 1997-1998.

CV for Salim Belyazid

Name : Salim Belyazid
Nationality : Moroccan
Occupation : Researcher
Date of Birth : 20 Mai 1977

Current Address: Döbelnsgatan 12
21213 Malmö
Sweden
Telephone : Daytime: +46-46-222-3627 Home: +46-40-185430
E-mail : salim.belyazid@chemeng.lth.se

Academic Background
March 2001-March 2006: Ph.D. candidate at the Department of Chemical Engineering, Lund University.
Field of interest: Forest ecosystem modeling
September 1999 - December 2000: Master of Science in Environmental Sciences, Lund University Masters' program in Environmental Sciences (LUMES).
January 1995 - December 1998: Bachelor of Science In General Engineering, Major in instrumentation, Minor in Mathematics. Al Akhawayn University in Ifrane (AUI), Ifrane, Morocco,
June 1994: Baccalaureate in Mathematical Sciences, Tarik Ibn Zyad High school, Azrou, Morooco.

Scholarships
June - August 2004: Young Scientists Summer Program (YSSP), International Institute for Applied Systems Analysis (IIASA).
March 2001 - March 2006: Ph.D. position financed by SUFOR (Sustainable Forestry in Southern Sweden).

Work Experience
Mars 2001 – present: Forest ecosystem modeling.
Teaching:
February 2005-2004-2002-2001(full time): Systems Analysis & Dynamics. 5 weeks course at LUMES, Lund University, Sweden.
September 2003 (full time): Systems Analysis & Dynamics. 6 days course at Helsingborg Campus, Lund University, Helsingborg, Sweden.
Mars 2002 (full time): Systems Analysis & Dynamics. 2 weeks sourse at the University of Bariloche, Argentina.
March 2005-2003-2001 (part time at 20%): Ecological modeling for engineers within the “Ecological Process Modeling”, Lund University, Sweden.
Mars-August 1999: Software development engineer for database capture and management, Fes, Morocco.
Description: member of a two-engineers' team, I was responsible for developing software for visual aided data capture and supervising the data capture process.

Specific Skills
Systems Analysis, systems dynamics, modeling, scenario analysis.
Computer Programming (Assembly, Fortran & visual Fortran, C++, Visual C++)
Database: Excel, Foxpro.
Simulation (Stella, Consideo, Matlab, Electronic Workbench, Lab View)
Limited experience (3 months) with GIS.
Languages: Arabic (fluent), French (fluent), English (fluent), Swedish (fair), Spanish and Berber (notions)

Projects

2004-2005: Affordnord (Nordic Afforestation). Nordic Cooperation project.
2001-2004: SUFOR (Sustainable Forestry in Southern Sweden). Swedish National Project.
2005: SENSOR (Decision making support related to land use changes in Europe). European Project.
2004-2005: Critical Load Reporting for Sweden. Part of the European program of emission abatement.
2000: Masters' thesis - Sustainability in the Semiarid Region of the Argane Forest in Southern Morocco, study & modeling of the system and variables and qualitative/quantitative modeling.
1998: Bachelor project - Design and construction of an indoor temperature regulation system controlled through computer.

Publications

Belyazid, S. (2006). Dynamic modeling of biogeochemical processes in forest ecosystems, Ph.D. thesis, Lund University.

Belyazid, S., Svenson, M., Sverdrup, H. (2002). Studying a multidimensional problem using system dynamics: The case of sustainability in the semi-arid Argane foorest is Morocco. Proceedings of the System Dynamics Conference.

Belyazid Salim (2004). Evolution of forest cover and soil chemistry at 16 Swedish forest sites following future deposition scenarios. IIASA, YSSP 2004.

Belyazid S., Alveteg M., Sverdrup H. 2004. The biogeochemical models family of the biogeochemistry group at Lund University. Proceedings of the the 6-th Subregional meeting on effect-oriented activities for the UN ECE Convention on Long-Range Transboundary Air Pollution.

Belayzid, S. and Sverdrup H,. (2005). Modelling Changes in Soil Organic Carbon, Nitrogen and Nitrate Leaching at 16 Swedish Coniferous Forest Sites. Submitted for publication.

Belyazid, S. and Sverdrup H.. (2005). FORSAFE-VEG: Modelling integrated effects of air pollution, climate change and forest management on ground vegetation. Submitted for publication.

Belyazid, S., Westling, O., Sverdrup, H. (2005). Evolution of forest cover and soil chemistry at 16 Swedish forest sites following deposition reduction according to the Gothenburg Protocol. Manuscript.

Wallman, P., Belyazid, S., Svensson, M. G. E. and Sverdrup, H. (2004), DECOMP - a semi-mechanistic model of litter decomposition. Submitted for publication.

Belyazid, S. , Sigurdsson, B., Haraldsson, H., Sverdrup, H. (2005). Modeling forest growth and its effects on the ground vegetation composition in Hallormsstadur, Iceland. *Manuscript*.

Wallman, P., Svensson, M. G. E., Sverdrup, H. and Belyazid, S. (2004). ForSAFE - An integrated process-oriented forest model for long-term sustainability assessment. *Forest Ecology & Management* **207**(1-2): 19-36.

Sverdrup, H., Belyazid, S., Nihlgård, B., and Ericson, L. (2005). Modelling change in ground vegetation from effects of nutrients, pollution, climate, grazing and land use. Manuscript.

Haraldsson, H.V., Sverdrup, H, Belyazid, S., Holmquist, J. and Gramstasd, R. (2005). The tyranny of small steps I: Discovery of an archetypal behavior. *Submitter to System Dynamics Review*.

Haraldsson, H. V., Sverdrup, H., Belyazid, S., Sigurdsson B. D. and Halldorsson G. (2005). The System Analysis process preparing for assessment of effects of afforestation in Iceland. *Manuscript*.

CV for Catarina Sternhufvud

YEAR OF BIRTH: 1973

NATIONALITY: Swedish

EMPLOYED BY: Swedish Environmental Research Institute (IVL)

PROFESSION: Environmental Economist

YEARS WITH FIRM: Since 1999

EDUCATION:

Wenell 2005	Project leadership, 4 days course
Högskolan Halmstad 2005	Leadership 5 credits.
Simon-Bolivar, 1999	Two months full-time study of Spanish with private teacher in Quito, Ecuador.
University of Gothenburg 1994-1998	M.Sc. in Environmental Economics.
University of Gothenburg 1994	Four months full-time study of the German language.
Polhemsgymnasiet 1989-1992	Technical programme at upper secondary school.

EXPERIENCE OF IMPORTANCE:

1999-	Employed in the Environmental effects and atmospheric chemistry sector at IVL.
1998-1999	Communicator at Sykes (IT-company) in Edinburgh, Scotland.
1997-1998	MFS in Namibia during three months. I collected data for my master thesis which was about Natural Resource Accounting with emphasis on the ocean fishing sector.
1993-1997	Care assistant for an autistic boy two nights a week.

LANGUAGE:	Speaking	Writing	Reading
Swedish	Mother tongue	Mother tongue	Mother tongue
English	Excellent	Excellent	Excellent
German	Good	Fair	Good
Spanish	Fair	Poor	Fair

RELEVANT PROJECTS:

2005-2006	Connecting regional and global reduction control strategies in Europe, financed by the Nordic Council of Ministers.
2005	Investigation of the possibilities to reduce fossil carbon dioxide from the industry, financed by the Swedish EPA.
2004-2006	The effect on air pollution reduction of non-technical measures, financed by ASTA.
2004-2005	CBA of acidification in Sweden, financed by ASTA.
2002-2004	Investigating possible measures to reduce the emissions form small scale combustion in the Nordic countries, financed my Nordic Council of Ministers.
2001-2004	REKO, construction of a database of emission abatement measures.
2001	Comparison between the cost calculations in RAINS and the estimated costs to reach the Swedish Environmental Quality Objectives, financed by ASTA.
2000-2001	CBA of recovering a eutrophied lake in Inner Mongolia, financed by Sida.
2000	Responsible for the "*Workshop on future needs for regional air pollution strategies"*Saltsjöbaden 10-12 April 2000.

PUBLICATIONS:

Sternhufvud C., Åström S. 2006. *Feasibility study – a Swedish Integrated Assessment Model*. Forthcoming.

Belhaj M., Åström S. and Sternhufvud C. 2005. *A Swedish CBA on acidification abatement – the CAFE Baseline scenario.* Forthcoming.

Sternhufvud C., Belhaj. M and Åström S. 2005. *The feature of Non technical measures and their importance in air pollutants reduction – based on three meta-analysis.* Forthcoming.

Sternhufvud C., Karvosenoja N., Illerup J., Kindbom K., Lükewille A., Johansson M. and Jensen D. 2004. *Particulate matter emissions and abatement options in residential wood burning in the Nordic countries.* Nordic Council of Ministers, Copenhagen, ANP 2004:735.

Sternhufvud C., Grennfelt P. 2001. *A comparison between the cost curves in the RAINS-model and the Swedish environmental quality objectives*. IVL report B 1421.

Grennfelt P., Lindau L. and Sternhufvud C. 2000. *Workshop on future needs for regional air pollution strategies Saltsjöbaden 10-12 April 2000*. Nordic Council of Ministers, Copenhagen, Tema Nord 2000:557.

Ljung E., Sternhufvud C. 1998. *Assessment of the Resource Rent in the Namibian Fisheries; The Case of Hake, Horse mackerel and Pilchard*. Unit for environmental economics, Gothenbrg University.

CV for Stefan Åström

Stefan Åström (Born: 1977) Work: +46 (0) 31 725 62 05
IVL, Swedish Environmental Research Institute Ltd. Mail: Stefan.Astrom@ivl.se
P.O. Box 5302
SE - 400 14 Göteborg

EDUCATION

Sept. –98 – Oct –04	**Swedish Master of Science, Environmental Science**, Göteborgs Universitet. Programme based in chemistry and physics, focus on Life Cycle Assessment.
Sept -02 – Oct -04	**Bachelor degree in Economics**, Göteborgs Universitet. The degree focused on environmental economics, especially Cost Benefit Analysis.

CURRENT EMPLOYMENT

Oct. –04 →	**Environmental Economist at IVL, the Swedish Environmental Research Institute Ltd.** The main assignments are Cost Benefit Analyses and Cost-Effectiveness Analyses.

RELEVANT PROJECTS

Feb -06 → Mar -06	Evaluation of the Dutch request for derogation to Directive 98/69/EC. Performed under the Framework Service Contract No. ENTR/05/18 for EC DG Enterprise, "Economical and technical assistance in relation to the emissions of environmental pollutants from automobiles"
Jan -06 →	Cost-Benefit Analysis on achievement of the Swedish Environmental quality target 'Only Natural Acidification'
June –05 →	Linking Regionally and Globally Motivated Emission Control Strategies in Europe – project for the Nordic Council of Ministers
May –05 →	Cost-Benefit Analysis on heavy metals – project within the ESPREME programme
Dec –04 →	The feature of Non technical measures and their importance in air pollutants reduction – project within the ASTA programme
Oct –04 →	Cost-Benefit Analysis on abatement of acidifying pollutants – project within the ASTA Programme

PREVIOUS WORK EXPERIENCE

June –02 – Aug –02	**Internship at the United Nations Environmental Programme, UNEP, Nairobi.** Prepared background information for the evaluation and preparation of the GEF Climate Change mitigation and adaptation projects under the UNFCCC.

CV for Peringe Grennfelt

Address Swedish Environmental Research Institute - IVL, P.O. Box 5302
Date of birth 31 May 1944

Positions

1969-	Employed at the Swedish Environmental Research Institute (IVL)
1992-	Scientific Director, Swedish Environmental Research Institute
1993-	Associate Professor in "Atmospheric chemistry and air pollution control strategies" at the Department of Inorganic Chemistry, University of Göteborg
1994-	Member of the Royal Academy of Forestry and Agriculture.

Main areas of scientific research and consultant work

My main scientific areas have been research on air pollution, in particular atmospheric emissions, atmospheric chemistry and deposition processes. I have also been involved in reearch in air pollution effects. I have also been deeply involved in development of science-based policy instruments such critical loads and effect-based air pollution strategies. Since many years most of my work has been on leaderships of research programs and large research projects both national and international.

Main appointments and assignments (after 1987)

1987-	Member (from 1989 head of delegation) of the EMEP Steering Body From 1998 member of the Bureau of EMEP.
1987-03	Secretary and co-ordinator of the Nordic research programme on air pollution effects (from 1993 marine and air pollution effects)
1990	Project leader for an assessment study of Sweden's international environmental strategies.
1991-95	Member of the Steering Group of the Eurotrac TOR (Tropospheric Ozone Research)
1991-95	Member of the Scientific Panel on Atmospheric Chemistry under the European Union (EU DG XII)
1991-96	Co-ordinator of the 5th International Conference on Acidic Deposition *Acid Reign 95?,* 26-30 June 1995
1993-99	Chairman in the Programme Committee for Acidification and Tropospheric Ozone Research at the Swedish Environmental Protection Agency
1993-95	Project leader for "Acidification" within the Application Project of the European atmospheric chemistry program EUROTRAC
1994-99	Member of the Scientific Steering Committee of EUROTRAC
1995-96	Member of the Scientific Advisory Group on forest damages at the European Union
1995-99	Member of an expert panel on forest vitality at the Swedish Forest Board
1996-97	Member of the UK photochemical oxidants review group
1997	Governmental expert on emissions from road traffic 1980-95
1998-	Programme director of the Mistra research programme on Abatement Strategies on Transboundary Air Pollution (ASTA)
1999-01	Member of UK National Expert Group on Transboundary Air Pollution (NEGTAP)
1999-00	Secretary of a governmental evaluation and assessment of research on emissions from traffic and off-road vehicles
2002-	Leader for the EU research project NEPAP Network of Experts for the support of European Policies on Air Pollution
2002-2005	Member of the organising Committee of the 7th Conference on Acidic Deposition in Prague in 2005.

2004	Member of the evaluation committee of the Centre for Ecology and Hydrology, United Kingdom.
2004	Leader of the EC review of the RAINS Integrated Assessment Model. (EC Contract)
2004-	Member of the national committee for scientific research at IIASA.
2005-	Deputy chairman of the COST729 on Nitrogen
2005-2006	Leader of the review of the Chalmers Environmental Initiative.
2005-2006	Chairman of the review of the Norwegian Polar Centre, Tomsö.
2006-	Member of the Steering Committee of the ESF project "Nitrogen in Europe"
2006-	Chairman of the External Advisory Board of the EU Nitrogen project NitroEurope

Editor and co-editor of approx. 10 books and special volumes of scientific journals.

Selection of Scientific Publications 1995-

Karlsson, P-E., Örlander., G., Langvall, O., Uddling, J., Hjort, U., Wiklander, K., Areskoug, B and Grennfelt, P. (2006) Negative impact of ozone on the stem basal area increment of mature Norway spruce in south Sweden. Submitted to Forest Ecology and Management.

Grennfelt and Hov, Ø. (2005) Regional air pollution at a turning point. Ambio 34, 2-10.

Karlsson, P-E., Pleijel, H., Belhaj, M. Danielsson, H., Dahlin, B., Andersson, M., Hansson, M., Munthe, J. and Grennfelt, P. (2005). Economic assessment of teh negative impact of ozone on crop yields and forest production. A case study of the Estate Östad Säteri in Southwest Sweden. Ambio 34, 32-40.

Grennfelt, P. (2004) New Directions: Recent research findings may change ozone control policies. Atmospheric Environment 38, 2215–2216.

Erisman, J.W., Grennfelt, P. and Sutton, M. (2001) Nitrogen emission and deposition: The European perspective. TheScientificWorld, 1, 879-896.

Grennfelt, P., Moldan, F., Alveteg, M., Warfvinge, P. and Sverdrup, H. (1999) Critical loads – is there a need for a new concept? Water Air and Soil Pollution: Focus 1, 21-27.

Grennfelt, P., Lindau, L. and Sternhufvud, C. (Eds.) Future needs for regional air pollution strategies. Workshop at Saltsjöbaden 10-12 April 2000. Tema Nord 2000:557 Nordic Council of Ministers, Copenhagen.

Hultberg, H., Iverfeldt, Å., Andersson, B.I., Grennfelt, P. and Skeffington, R.A. (1998) Reversal of Acidification: Policy Implications Derived from the Roof Project In Hultberg, H. and Skeffington, R.A. (Eds.) Experimental Reversal of Acid Rain Effects - The Gårdsjön roof Project pp 447-459, John Wiley and Sons.

Svanberg, P-A., Grennfelt, P. and Lindskog, A. (1998) The Swedish urban air quality network - a cost efficient long term monitoring program. Atmospheric Envionment 32, 1407-1418.

Lövblad, G., Grennfelt, P., Kärenlampi, L., Laurila, T., Mortensen, L., Ojanperä, K., Pleijel, H., Semb, A., Simpson, D., Skärby, L., Tuovinen, J-P. and Tørseth, K. (1996) Ozone exposure mapping in the Nordic countries - A summary of a joint Nordic mapping report. In Kärenlampi, L. and Skärby, L. (Eds.) Critical Levels for Ozone in Europe: Testing and Finalizing the Concepts. UN ECE Workshop Report pp. 264-268.

G. Lövblad, P. Grennfelt, O Westling, H. Sverdrup and P. Grennfelt (1995) The use of critical loads exceedances in abatement strategies. In P. Grennfelt et al (Eds.) Proceedings of the 5th International Conference on Acidic Deposition, 26-30 June 1995, Göteborg, Sweden. J. Water, Air Soil Pollut. 85, 2431-2436.

P Borrell, P. Builtjes, P. Grennfelt and Ø. Hov (1995) Photooxidants, Acidification and Tools: Policy Application of EUROTRAC Results. Springer Verlag.

G. Lövblad, K. Kindbom, P. Grennfelt, H. Hultberg and O Westling (1995) Deposition of acidifying substances in Sweden. Ecol. Bull. 44, 17-34.

K. Kindbom, G. Lövblad, K. Peterson and P. Grennfelt (1995) Concentrations of tropospheric ozone in Sweden. Ecol. Bull. 44, 35-42.