Miljöforskningsnämnden
Ansökan om projektbidrag inom Naturvårdsverkets forskningsprogram

Forskningsprogram ☐ **SNAP** X **REPROSAFE** **FLIPP** Inriktning: Ekonomiska styrmedel Inriktning: Informationssystem och indikatorer I				
Projekttitel (svensk): Exponering för luftföroreningar och hälsoeffekter– en fallstudie i Skåne				
Projekttitel (engelsk): Exposure and Health effects due to environmental air pollution - a case study in Scania, Southern Sweden				
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Sammanfattning på **svenska** strukturerad enligt följande: 1) Projektets betydelse för programmet
2) Miljörelevans och förväntad betydelse för miljöpolitiken 3) Mål och hypotes 4) Metodik och genomförande
5) Kommunikationsinsatser i relation till programmet:

För att utvärdera miljömålsarbetet behövs goda verktyg för monitorering av befolkningens exponering för luftföroreningar och därtill relaterad ohälsa. Goda verktyg behövs också för riskbedömning, för att utvärdera insatser för förbättrad luftkvalitet, samt för planerings- och övervakningsändamål. Två principiellt olika metoder används i dag – registerdata och skattade exponeringsnivåer från mätningar och modelleringar, eller folkhälsoenkäter med självupplevd grad av störning och egenrapporterad ohälsa. Ökad kunskap om dessa metoders användbarhet och jämförbarhet är angelägen.

Mål för det sökta projektet är för det första att vidareutveckla verktyg baserade på GIS-metodik för statiska och dynamiska populationer, att öka kunskapen om hur val av spridningsmodeller påverkar resultat och att relatera beräknade exponeringar till hälsoutfall. Ett annat mål är att utvärdera hur uppgifter om exponering och sjukdom som erhålls i folkhälsoenkäter kan svara mot exponerings- och sjukdomsdata från register och modelleringar. Detta utgör en indirekt validering av de två principiellt olika metoderna för hälsorelaterad miljöövervakning .

Beroende på tillgängliga emissionsdata, val av spridningsmodell och rumslig upplösning kan modellerade halter skilja sig markant. I detta projekt kommer vi att kombinera olika modeller och detaljnivåer för att optimera en heltäckande skattning av luftföroreningar i Skåne. Vi kommer också att komplettera och utarbeta standardiserade former för emissionsdatabaser. Genom utveckling av kända GIS-verktyg för skattning av exponering för statisk befolkning (baserad på bostadskoordinater) kommer vi även att kunna skatta exponering för rörliga objekt (personer) över tid. Ett sådant verktyg kommer att utvecklas och resulterande exponeringsskattningar kommer att jämföras med statiska skattningar. För befolkningens rörelsemönster kommer befintliga data (hem och arbetsplats) att kombineras med enkätdata. Kända samband mellan utomhus- och inomhusluft kommer också att testas.

En populationsbaserad folkhälsoenkät till 15000 personer i Skåne år 2004 kompletteras med en utvidgad enkät för en fall-referentstudie avseende luftvägssjukdom. Registerdata, GIS-skattad exponering och egenrapportering jämförs och samband mellan exponering och hälsa studeras. Särskild vikt läggs vid inverkan av socioekonomiska faktorer, boendeförhållanden och rökning.

Projektet föreslås som en del i SNAP programmet och resultaten kommer att rapporteras vid vetenskapliga konferenser och i vetenskaplig litteratur. Resultat rapporteras också vid seminarier i nära samarbete mellan universitet, sjukvården, länsstyrelsen och kommunernas miljö- och hälsoskyddsförvaltningar och det lokala folkhälsoarbetet.

	År 2004	År 2005
Summa sökta med per år i kr:	822 000	712 800

Miljöforskningsnämnden
Ansökan om projektbidrag inom Naturvårdsverkets forskningsprogram

Sökta projektmedel fördelade på kostnadsslag	År 2004 (k	År 2005 (k
Personalkostnad inkl. soc. avgifter * *Namn och tjänster specificeras i Bilagan*	605 000	544 000
Övriga omkostn exkl moms (förbrukningsmtrl, analyser, resor etc)** Modellering SMHI Registerdata, utskick,porto, enkätkostnad	80 000	 50 000
Delsumma av ovanstående poster:	685 000	594 000
Förvaltningspåslag: 20%	137 000	118 800
Totalsumma per år: (införs sid. 1):	822 000	712 800

*) Specificera namn, tjänst **) Specificera

Samtliga övriga miljörelaterade projekt för vilka de sökande har beviljats anslag eller söker anslag för 2004-2006. OBS Även EU-finansiering.

Projekttitel	Finansiär	Tidsperiod	Sökt kr	Beviljat kr
Exponering för cancerframkallande ämnen i tätortsluft (HT)	NVV	2003-2004		1 000 000
Att skatta exponering – jämförelse mellan mätningar och beräkningar baserade på spridningsmodellering (medsökande HT)	NVV	2004-2005	2 800 000	
A European health and environment information system for exposure and disease mapping and risk assessment, EUROHEIS II (medsökande KJ)	EU	2004-2006	2 500000	
SNAP (Hans Welinder, PP från 2004	NVV	2002-2004		1 100 000

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Miljörelaterade projekt för vilka sökande har beviljats anslag för 2000-2003
OBS Även EU-finansiering

Projekttitel	Finansiär	Tidsperiod	Beviljat Kr
GIS för analys för av hälsopåverkan av luftföroreningar (PP)	Statens energimyndighet	2000-2003	800 000
Regional miljöövervakning	Länsstyrelsen i Skåne Län /NVV	2002-2003	380 000
Regional miljöövervakning	Länsstyrelsen i Skåne /NVV	2003	200 000

Lund 031014

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Proposal of an activity as part of the SNAP programme

Exposure and Health effects due to environmental air pollution - a case study in Scania, Southern Sweden

Keywords: NO2, PM2.5, PM10, dispersion modelling, GIS, health impact assessment

1 Background – importance for the SNAP programme

Lund University is presently running the SNAP project "A population based tool for risk assessment of exposure to environmental air pollution". In the project we study the interaction between air pollutants and health effects of population, by using dynamic models for air pollution and as well as GIS solutions for interaction with population data. The project aim is to make a risk assessment of the exposure to different air pollutants (in first place particular matter – PM10 and nitrogen dioxide – NO_2) among the population of southern Sweden (Scania).

Quantification of population exposure to various air pollutants is essential for understanding the associations between health and air pollution. The ongoing project has highlighted the differences in estimated air pollution related to spatial resolution and model assumptions This is also described by e.g. Langner et al., 2000 and Jönsson et al., 2003. Another important factor that has been stressed is the need for a tool that makes it possible to estimate exposure for "moving" objects (i.e. a dynamic population). Such a tool could be used to perform different scenario studies, where changes in emissions as well as in population density and/or population number can be simulated. In combination with reliable estimations of exposure and knowledge about the possible relation between health and exposure it would also benefit planning within the environmental and health sectors.

Other issues that have to be stressed in exposure – health studies are e.g. that

1. The estimates of human population exposure relies heavily on outdoor exposure, although as much as 90% of the time is spent indoors. There is a need to develop models that incorporate relevant "indoor" factors affecting exposures.
2. Postal enquiries to a general population random sample are frequently used for monitoring of environmental exposures and health status. There is a need for better understanding of such exposure data, and its relation to measured and modeled exposure. For calculation of health effects of pollution hospital discharge data are frequently used, while there is less knowledge of less severe disease entities like diagnoses in primary health care, due to a lack of such registry data. Moreover, there is a need for more data on the prevalence of respiratory troubles in a general population, and its relation to well-defined exposure.

2 Aims and hypothesis

The aims of the proposed project are:

1. to optimize modelling in time and space of air pollutants (primarily particles, and NO_x),
2. to develop a GIS based tool that makes it possible to estimate exposure of air pollution (based on the result of the modelling) for objects that change geographical position over time.
3. to compare estimated exposures for a stationary and a "moving" population respectively,

4. to make adjusted estimations of (mainly indoor) exposure by the use of “additional” data about e.g. smoking, gas stoves, number of persons in household, living area and ventilation system
5. to compare “indoor”-adjusted and non-adjusted exposure estimates
6. to compare self-reported exposures from postal population enquiries and estimated exposures from the GIS systems
7. to investigate possible relationships between exposure and health effects in the adult population in Scania, southern Sweden (0.8 million people) by the use of
   a. health care registry information (hospital discharge data, primary health care data)
   b. a 1% population sample for self-reported health (postal enquiry)
   c. a case-referent study within sample b.

Research hypotheses related to the specific aims stated above are that:
1. the modelling can be optimized according to available emission data, scale/resolution and the type of population data to be used. By combining a number of dispersion models the results can be improved.
2. estimated exposure can differ significantly depending on how population “movements” are treated. This is most obvious for groups like e.g. commuters and employees in the transport sector.
3. see hypothesis 2 above.
4. estimated exposure differs significantly if we include additional factors like smoking, gas stoves and ventilation system in the estimation.
5. see hypothesis 4 above.
6. self-reported exposure reflects estimated exposures to a certain extent
7. there are statistically significant relationships between environmental exposure to air pollution and health effects for different population groups in Scania.

3 Materials and methods

In this project, experts on GIS-systems, environmental hygiene, epidemiology and medicine are cooperating with regional authorities (Länsstyrelsen i Skåne län, Region Skåne).

3.1 Exposure data

3.1.1 Emission data

A newly constructed emission database, located at the GIS Centre, will be essential in the execution and testing of different dispersion models in different scales for different time periods. The database, which covers the Öresund region (southern Sweden and parts of Denmark), is the most comprehensive in Sweden today and includes approximately 24 000 emission sources in Scania, Sealand and the Baltic Sea. Emissions stored are NO_x, particles (PM10), SO_2, CO, VOC and CO_2. Most of the sources are lines, like roads (23 300) and boat traffic (200), but the database also includes approximately 500 point sources (e.g. industries and energy plants), 200 area sources and 50 grid sources. These are all separated in layers depending on land of origin, municipality and branch. The resolution in space varies depending on source type, but is generally between 25 and 50 meters.

Even if the present database is unique, it needs to be updated and extended. Among other things, the resolution of some of the grid sources can be improved if the emission data are linked to more detailed geometrical information (i.e. location of sources). The database also

has to be complemented by particles (PM 2.5) since emission estimations and health effects of these will be included in the project.

3.1.2 Population data

If we want to estimate human exposure spatially distributed population data is a necessity. The better data we can get, in terms of spatial resolution and precision, the better estimations. If we are working with a “non-stationary” population, which we are, the positions of persons vary in space over time. Then, in order to estimate accumulated exposure we need data for these movements.

In this study, the population data will consist of individual addresses (x and y coordinates) for the total population in Scania, complemented by information on workplace and individual movements for a sample (approx. 9 000) of these (see below). With knowledge about home address, work place, mode and time spent on travels to work it will be possible to make an estimation of individuals movements in space over time. By the use of this knowledge “dynamic” expose can then be estimated.

3.1.3 Self-reported exposure

Region Skåne in cooperation with Skåne läns allmänna försäkringskassa and other organizations or authorities is planning for a population-based postal enquiry, “Folkhälsa i Skåne”, to be performed in September 2004. The target population will be approximately 15 000 adults aged 18-80 (possibly extended up to 25 000; but we assume 15 000). A similar enquiry performed in 1999 with a target population of 25 000 had a response rate of 60%. Data from this survey has been used for estimation of health effects of exposure to radon (Jakobsson et al., 2003) and noise (Albin et al., 2003).

The enquiry will consist of information on sickness and health, socioeconomic conditions, housing conditions and smoking habits. Also there will be a short section on environmental exposures (respiratory irritants, noise), and mode and time spent on travels to the workplace. Thus, self-reported exposure for around 9000 persons, i.e. approximately 1% of the adult Scanian population will be available by the end of 2004.

A nationwide population based postal enquiry on environmental health (Barnmiljöhälsoenkäten) was sent to children aged 8 months, 4 years and 12 years in 2003. The Scanian sample size was 1700 children. Thus, information on environmental exposures is also available for children. The questions on environmental items are identical or near identical in these two enquiries. All respondents are geo-coded, enabling comparison of self-reported exposure data and exposure data within the GIS system.

The present study is adding a case-referent study within the adult responding population, using an extended postal questionnaire for in-depth exposure information (see below). Cases are persons with reported airway complaints (approximately 1200-1400), and persons with diagnosed asthma (approximately 500-600). Referents are non-diseased persons within the responding population.

3.2 Health outcomes

The prevalence of airway symptoms, diagnosed asthma and use of medication for respiratory conditions in the Scanian population can be estimated using data from the population surveys. Hospital discharge data will be available for the respondents in the population survey.

The registration of diagnoses in outpatients in primary care has hitherto been centrally available only from two of the five health care districts in Scania (covering 1/3 of the Scanian population). Here, approximately 80% of all visits to physicians have been coded according to ICD-10. Starting from January 2004, the central registration will cover all districts, however not visits to private physicians. Hence, it will also be possible to obtain outpatient diagnoses for the respondents in the population survey from 2004 an on from all districts, and retrospective information from two districts.

3.3 Methods

The methods in this project can be divided into three groups. The first part of the study (aim 1) includes distributed modelling of air pollutants; the second part treats estimation of exposure for different population categories that are treated in different ways (i.e. stationary or dynamically) according to aims 2-6, and the last part of the study investigates possible relations between exposure and health (aim 7).

3.3.1 Modelling of air pollutants

The project will mainly use a gaussian dispersion model (ENVIMAN) in the estimations of air pollutants. The model can be run both with a generalized meteorology and with climatologically captured data (e.g. every hour) for a specified period of time. The desired resolution in the modelling will vary depending on the purpose of the modelling. The two extremes will probably be a courser estimation for the whole region (Scania + Sealand, 150 x 150 km) with a resolution of 1 by 1 km, and more detailed street canyon estimations in city environments with a resolution of less than 10 metres. Models like the MATCH model from SMHI will we used to estimate “long distance” pollution from northern Sweden and other countries. A detailed street canyon model (OSPM), design for city environments, will be also be used. Additionally, a simple model to adjust outdoor pollution to indoor values (see above) will be implemented.

When estimating exposure for a dynamic population a combination of the models mentioned above will be used. The different steps in the estimation will probably be as follows:

- Background pollutant levels will be estimated by the use of the MATCH model for sources further away than 100 km from Scania, with a spatial resolution of 5 x 5 km.
- Background pollutant levels will be estimated by the use of the ENVIMAN model for sources closer than 100 km from Scania, with a spatial resolution of 1 x 1 km.
- Spatial distribution of pollutants within Scania will be estimated by the use of ENVIMAN with a resolution of 500 x 500 metres.
- Pollutant levels within cities will be estimated by the use of ENVIMAN with a resolution of 50 x 50 and/or 100 x 100 metres.
- Pollutant levels in street canyons will be estimated by the use of OSPM with a resolution of 5-10 metres.
- Pollutants will be adjusted to indoor levels by the use of known relationships.

The estimations will then be analysed in an integrative model by the use of GIS.

3.3.2 Estimation of human exposure

In order to estimate exposure the results from the dispersion models will be analyses together with population data. By the use of overlay analyses in a GIS environment it is possible to estimate exposure for a static as well as for a dynamic population. For the analyses of the dynamic population addresses in combination with workplace, mode and time spent on travel will be used to trace individual movements in space over time. These movements can then be analyzed together with the results of the dispersion models, where the pollutant levels in space at different times (probably mean values every hour) are estimated. If exposure is integrated over time an estimation of the total exposure for a certain period of time can be performed. These estimations will then be compared to the “static ones” for corresponding test persons.

Based on known relations between outdoor and indoor levels of pollutants it is also possible to test differences between these estimations. Even if this part of the study is simplified, we expect that differenced will be revealed if we include data about smoking, gas stoves, ventilation etc. Additionally, a comparison between self-reported and estimated exposure will be carried out.

3.3.3 Self-reported exposure and attributed exposure from a GIS system

Self-reported exposure data from the 2004 survey in adults (approximately 9000 responders) and the 2003 survey in children (approximately 900 responders) is used for a comparison with exposure estimates obtained within the GIS system. Linking of exposure data on individual level is possible as all subjects are geocoded. The subsample from a case-referent study with an extended enquiry is similarly investigated (approximately 3000 responders).

3.3.4 Health effects related to air pollutant exposure

Environmental risk factors for self-reported respiratory troubles and diagnosed asthma are assessed in the respondents from the population samples of adults (i.e. approximately 1% of the Scanian population) and children. Self-reported exposures and exposure information from the GIS system is used. Socioeconomic factors, living conditions and smoking habits are taken into account. In adults, information on disease from registries (hospital discharges, primary health care) are linked to the subjects, and similarly investigated. Non-respondents cannot be investigated; however a representativity study is possible, using registry information (including socioeconomic variables on grid level) for the total Scanian population.

A case-referent study within the adult responding population will be performed, using an extended postal questionnaire for in-depth exposure information. Exposure information from the GIS system is also linked to the subjects . Thus, two-stage models for selection of cases and controls can be used (Strömberg et al 2003). Cases are persons with reported airway complaints (approximately 1200-14 00 persons) and persons with diagnosed asthma (approximately 500-600 persons). Referents are non-diseased persons within the responding population. Altogether around 3000 cases and referents will be investigated. We consider a two-stage case-referent study, where the investigator first draws a case-referent sample from the study population to estimate the exposure needed for stratification. The individual exposures are estimated by a geographical information system (GIS). At stage two, random subsamples of the first-stage cases and referents are drawn on the basis of the (first-stage) exposure estimates, which can be categorized into relevant exposure strata. The second-stage cases and controls are investigated, in order to provide information on important confounders and more detailed exposure data.

4 Implementation

4.1 Time plan

The database construction, the integration of dispersion models, and the development of a tool for exposure estimation for a dynamic population will continue during 2004. Standards will be documented, results compared, and different solutions for integrating exposure over time will be tested. An intermediate report is planned to be available January 1, 2004. In early 2005 results from different approaches (static-dynamic and outdoor-indoor) will be tested. A methodology to test different scenarios (in terms of emissions, models, population behaviour, and population distribution) will also be implemented.

The planning of the population survey Folkhälsa i Skåne 2004 has started, and questions are elaborated. The enquiery will be sent to the subjects in September 2004. Thus, data for analysis, and for selection of cases and referents cannot be available until the beginning of 2005. The in-depth exposure enquiries will be sent to cases and referents during spring 2005. The analysis of health data, and the report of results will take place during the autumn 2005.

4.2 Personnel, and scientific cooperation

4.2.1 GIS-centre at Lund university

Petter Pilesjö, Ph D, Associate professor. Exposure modelling and geo-statistics
Susanna Gustavsson, PhD-student. Dispersion modelling.
Emilie Stroh, PhD student. Exposure modelling and geo-statistics
Karin Larsson, PhD student. Exposure/GIS modelling and database management.

4.2.2 Department of Occupational and Environmental Medicine

Håkan Tinnerberg, PhD. Exposure assessment.
Kristina Jakobsson , MD, PhD. Environmental medicine
Ulf Strömberg, PhD. Epidemiology and biostatistics

4.2.3 Region Skånes Kompetenscentrum för klinisk forskning

Jonas Björk, Dr Med Sci. Epidemiology and biostatistics
Håkan Löfqvist, Data management and biostatistics

4.2.4 Scientific cooperation

Exposure data and modelling
Joakim Langner, The Swedish Meteorological and Hydrological Institute
Erik Swietlicki, Dpt of Nuclear Physics, Lund university
Anders Åkesson, the Scanian Air Quality Management Association
Registry data
Åke Boalt, the GIS-unit, Region Skåne
Folkhälsoenkät i Skåne 2004
Per-Olof Östergren, professor, Department of Community Medicine, Lund university

5 National and international cooperation

The present project is performed in close cooperation with other parts of the SNAP programme. Especially, the validation of modelled exposure with exposure measurements (Stockholm, Göteborg and Lund/Malmö cooperation) is essential.

We (KJ) are co-applicants in an EU-project (EUROHEIS II), headed by Lars Järup, Imperial college, London, with participants from Denmark, Finland Ireland, Spain, Italy, and UK. The project is aiming at the development and implementation of an integrated health and environment information system initiated in a previous project (EUROHEIS). This system at present uses point source investigations, and incorporates socioeconomic covariates. Our contribution will be aimed at further development and integration of GIS-data for exposure.

6 Project costs

Year	2004	2005	Total
GIS-centre			
Post graduate student (ES)			
(30 000 kr/month, incl social taxes)	180 000	90 000	270 000
Applied from Euroheis			
Post graduate student (ES)			
(30 000 kr/month, incl social taxes)	*(180 000*	*90 000*	*270 000)*
Post graduate student (SG)			
(40 000 kr/month, incl social taxes)	240 000	120 000	360 000
Senior scientist (PP)			
(50 000 kr/month, incl social taxes)	80 000	40 000	120 000
External analyses (modelling at SMHI)	80 000		80 000
YMM and Region Skånes kompetenscentrum för klinisk forskning			
Epidemiology assistant			
(30000 kr/month, incl social taxes)	60 000	150 000	210 000
Data manager (HL)			
(45 000 kr/month, incl social taxes)	45 000	-	45000
Statistician (JB)			
(48 000 kr/month, incl social taxes)	-	144 000	144 000
Registry data costs, postal enquiries	-	50 000	50 000
Total	685 000	594 000	1 279 000
Overhead 20%	137 000	118 800	255 800
TOTAL	822 000	712 000	1 534 800

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CV of Kristina Jakobsson

Kristina Jakobsson is consultant (överläkare), and associate professor (docent) in the Department of occupational and environmental medicine at Lund university Hospital and Lund University. She got her PhD 1993. Her thesis was focused on asbestos –related diseases. Her main research field has been occupational epidemiology (mainly cancer and respiratory diseases). She is also involved in studies of exposure to persistent organic compounds, and in studies using GIS for environmental health studies. She co-supervises a PhD student, and is the main supervisor for another research student. She has co-authored more than 20 original scientific papers.

CV of Petter Pilesjö

Petter Pilesjö is the director of Lund University GIS centre and associate professor in physical geography, lund University. He got his PhD in 1992, and has been active in the field of GIS and modelling since then. His specialities are distributed modelling and spatial statistics. Since the late 90íes he has been involved in projects related to the implementation of GIS in social sciences and medicine. He is the main supervisor for four PhD students, and has produced over 15 refereed articles and books in GIS and modelling. Professor Pilesjö and the staff at the GIS centre have a multidisciplinary view of GIS and modelling, with the aim to develop sustainable solutions for practical use.

CV of Håkan Tinnerberg

Håkan Tinnerberg was born in 1965, obtained MSc in 1991 and PhD in 1997. His research has mainly been focusing on developing chemical analytical methods for monitoring isocyanates exposure. In his thesis and in later publication he has performed and validated exposure assessments in occupational epidemiology studies. He is now involved in a study regarding the exposure to air pollution for a randomised selected population in Malmö. Håkan Tinnerberg is working as occupational and environmental hygienist and is the head of the occupational and environmental hygiene section at the Department of Occupational and Environmental Medicine at Lund University. He has co-authored more than 20 original scientific papers.

CV of Jonas Björk

Jonas BJörk was born in 1966, obtained a BSc in Economics in 1991, and Dr med vet in 2001. His research has been focused on the methodological development of case-control studies, especially the use of individual and group level data for exposure assessment, using leukaemia as a case model. His present affiliation is as a consultant for clinical researchers. Previously, he was employed at the department of occupational and environmental medicine, Lund. He has co-authored over more than 20 original scientific papers.

BILAGA CV