Appendix 1. Plan 2005-2007.

Nordic Network on Fine-scale Atmospheric Modelling (NetFAM)

The Nordic environment with its extreme and specific variability in time and space is unique in the world. However, these specific features are a real challenge for atmospheric modelling since it requires high temporal and spatial resolution. For instance in winter, hydrostatic stable conditions with low surface temperatures and strong shallow inversions over snow-covered ground and ice may prevail over extensive periods. The thermal contrast between the cold/warm sea and lakes, and the warming/cooling land surface creates specific opposite stability conditions influencing the local weather and mixing conditions. The long and complicated coast line and archipelagoes also demand increased resolution for predictions of, e.g., local weather, pollution dispersion, sea currents and waves and algal blooming.

All these special features and conditions must be properly taken into account in most environmental and safety applications. For instance, ensuring safety of the increasing maritime traffic over the sensitive Baltic Sea and fisheries at the western Scandinavian coast poses special requirements for environmental monitoring and prediction. Wave and ice prediction models require input wind data from fine-scale atmospheric models. Understanding and predicting air quality in cities requires the coupling of fine-scale numerical weather prediction (NWP) and air quality models. Ecological models for marine or terrestrial ecosystems also require high-resolution atmospheric deposition data in order to be in phase with biological cycles. Predicting regional impacts of climate changes will require advance physical parametrisations.

Thus, understanding, describing and properly predicting the Baltic and Nordic atmospheric variability (and downstream that of the sea, lakes and ecosystems) is possible only using fine-scale models, with new capacities in simulating interacting physical processes of the atmosphere and the underlying surface specificities. On the other hand, this unique Nordic environment offers an excellent test bench for these fine-scale models. Thus, the Nordic expertise in atmospheric modelling would make a valuable contribution to the understanding and prediction of global change processes and their impacts in specific and sensitive environmental conditions.

This Nordic Network of Fine-scale Atmospheric Modelling (NetFAM) aims at the promotion and development of a suite of complementary key aspects for comprehensive fine-scale atmospheric modelling of the complex Nordic-Baltic regional weather and climate processes and man-environment interactions, with a strong emphasis on the specificities of the Nordic natural environment and on the Baltic Sea feedbacks. To achieve these goals, the project is designed to cover the whole chain from basic research and researcher training towards the application of the models. The network will share modelling tools, observational and physiographic data, computing and educational resources, in order to strengthen the expertise on fine-scale atmospheric modelling in the Nordic countries and adjacent areas around the Baltic Sea. Individual training will be monitored.

The proposed network includes all leading research groups dealing with the fine-scale atmospheric modelling in the Nordic countries and adjacent areas. Nine united research teams were formed to represent the fine-scale atmospheric modellers of each country.

(a) Current status of research and research training in the fine-scale atmospheric modelling in the Nordic countries and adjacent areas

Fine-scale atmospheric models are used for basic atmospheric research, local NWP, climate studies and simulation of air quality and deposition to ecosystems. Recent developments in computing power offer new possibilities for a clear increase in spatial resolution of high-resolution model in the near-future down to the kilometre-scale, with a typical forecast range of one day. The development of such models requires expertise in 4 main areas: (1) Adaptation of observational information to the model (data assimilation), (2) Numerical methods for solving the hydrodynamic equations (model dynamics), (3) Parameterisation of subgrid-scale and microphysical processes and (4) Coupling the NWP-model with marine, hydrological and air chemistry models. However, the fine-scale resolution

poses special requirements in all these areas. For instance, it is necessary to relax the hydrostatic assumption used in larger-scale atmospheric models and thus to reformulate the basic equations of the models. For data-assimilation, new types of observation like radar information become essential. For physical parameterisations, models architecture must be developed to enable the full 3-dimensional description of turbulence, cloud-radiation interactions, etc. Thus, it is timely to combine expertise, synergize resources and form the basis for a future pole of excellence in this domain in the Nordic countries at this early stage of far-reaching new developments.

The proposed network includes all leading research groups dealing with fine-scale atmospheric modelling in the Nordic countries and adjacent areas. The participating national weather services (NWS) will develop, use and maintain the atmospheric research, weather prediction and regional climate model HIRLAM[1], while the atmospheric science departments of the participating universities will contribute to the model development and to researcher training in the critical areas of required expertise. All these universities have strong traditions of research and education in dynamical meteorology, which forms the basis for atmospheric modelling. This NWS-university cooperation will ensure effective and coordinated training.

All partners in NetFAM pursue research aimed at developing different aspects of fine-scale atmospheric models, but in a scattered manner and lacking critical mass for effective advances in the required areas of expertise, e.g.: expertise on non-hydrostatic dynamics is concentrated at UTa and MF, while DMI, FMI, met.no and SMHI have a key role in the development of data assimilation methods. There is a bias with most researchers and research students working on modelling of physical processes (particularly boundary layer (BL) physics and convection). Air quality modelling is addressed in most of the participating institutes but without concertation. Some institutes (e.g., LHMS and EMHI) are just starting work in atmospheric modelling and thus need support from the more experienced partners. The number of students and researchers in atmospheric physics in each university departments (except RSHU) is relatively small, with only a few specializing in (fine-scale) modelling, while research training in this field is often not possible at all. Moreover, ongoing training is not coordinated in any way, in spite of its societal relevance and the need for modellers in atmospheric science and other related fields such as oceanography, hydrology and environmental science.

The proposed NetFAM is an extension of the pilot project Baltic-HIRLAM (http://hirlam.fmi.fi/Baltic), which was funded during the academic year 2003-2004 by the Nordic Grant Scheme of the Nordic Council of Ministers. However, NetFAM will be a major stepwise advance in order to foster the deepening and extension of this Baltic cooperation, through a stronger integrated academic and research emphasis and a wider participation basis. A summary of the achievements of the Baltic-HIRLAM project is attached (Appendix 6).

(b) Prospects and need for Nordic co-operation in the fine-scale atmospheric modelling

The NetFAM-partners have so far concentrated on some aspects and applications of fine-scale modelling, but they all would benefit from strong research training and sharing of resources and expertise. Key areas where the strong expertise of some partners could be extended to the whole network are model dynamics and related numerical methods, fine-scale data assimilation, BL modelling and parameterisation. A critical component of any modelling development is the diagnosis and validation of model results, so that the network will put special emphasis in providing data and developing methods for validation.

The NetFAM partners will share important basic resources, including:

Models. The international HIRLAM project and Meteo-France will provide the network mem-

[1]Historically, HIRLAM (**H**igh **R**esolution **L**imited **A**rea **M**odel) is a genuinely Nordic initiative. Its development was started in 1984 as a cooperation of the meteorological institutes of the five Nordic countries. Till today, HIRLAM has grown to one of the main European limited area atmospheric models, consolidating into the international HIRLAM consortium nine national meteorological institutes and maintaining research cooperation with tens of research institutes and universities. The development of non-hydrostatic fine-scale HIRLAM takes place in close cooperation with Meteo France.

bers with the possibility to use the HIRLAM code and participate in the AROME[2] mesoscale NWP development. UTa will provide and maintain the Tartu non-hydrostatic HIRLAM code. In addition, other fine-scale modelling tools (MM5, the Unified Model from the UK MetOffice, the Canadian MC2 model) are used in some participating institutes.

Observational data. In addition to conventional meteorological observations, the partners of the network will share radar and satellite data, data from special observation campaigns (e.g. BALTEX, WINTEX, Icelandic SNEX) and micrometeorological data (e.g. Sodankylä mast and observatory).

High-resolution physiography data. These data describe the different properties of the underlying surface, including digital elevation maps and land-use data. In general they are freely available, but special methods are needed in order to apply them into fine-scale models. Data and methods will be shared within the network.

Computing resources. Fine-scale atmospheric modelling is computationally very demanding, some of the operations requiring supercomputing resources that are not widely accessible. These resources are available to the participating NWSs, and will be shared within the network during research visits.

Educational resources. A host of various educational and training materials related to atmospheric dynamics and numerical modelling is used in each country. A dedicated effort will be undertaken to make them available to all network members by using internet tools and resources.

Coupled models and components. Various systems for coupling NWP, air quality, hydrological, marine and land-surface models are applied within the network. Experience with each solution will be assessed and exchanged in order to produce optimized and advanced tools for all partners.

International contacts. Many members of the network are active partners in several international scientific programmes or projects involving atmospheric modelling. This will ensure strong links and exchanges between NetFAM and the international community, enable access to other data and raise awareness of model applications among the younger researchers. Relevant international research programmes and networks include: BALTEX (Baltic Sea Experiment), CEOP (Coordinated Enhanced Observing Period), and GABLS (Global Atmospheric Boundary Layer Study), COST-728 ("Enhancing Meso-scale Meteorological Modelling Capabilities for Air Pollution and Dispersion Applications"), the EUMeTNet programme SRNWP (Short Range Numerical Weather Prediction) for benchmarking and sharing joint model runs, and the EU FUMAPEX-project (Integrated Systems for Forecasting Urban Meteorology, Air Pollution and Population Exposure) to improve meteorological forecasts in urban areas through NWP and air pollution models coupling and feasibility studies in various cities (incl. Oslo and Helsinki).

(c) Detailed plan of collaborative activities during three first years

Most of the collaborative activities will be organized to support the identified key aspects of fine-scale modelling (cf. Section (a)) through dedicated training workshops but taking into account local needs through individual visits. The visits will be assessed and monitored by the Coordinating Group, though aiming at a fair distribution. The trainees will be asked to present their work at the network workshops, thus improving their communication/dissemination skills. The network partners can provide top class teachers and courses for the training and workshops, but whenever possible, experts from outside the Network will be invited. The team leaders in NetFAM will also aim at advising, supporting and monitoring research students in the planning of their curricula, mobility and research activities, in order to enhance their career profile. This will be organized through periodic meetings and using the web site.

Exchange visits

The resources of the network will be mainly used for one-three week's research visits between the institutes. Visits with a total length of approximately 30-35 weeks per year are planned. A detailed

[2]Fine-scale atmospheric model system "**A**pplications of **R**esearch to **O**perations in **ME**soscale" initiated by Meteo France

schedule of exchange will be prepared at the beginning of each year. A preliminary plan for the first year includes visits to study non-hydrostatic model system, boundary layer physics, radiation parametrizations, convection and microphysics, mountain effects, fine-scale data assimilation. Visits from nine groups directed to five groups are planned during the first year, see the budget for a preliminary plan of visits.

Workshops and summer schools to be arranged

Workshop on convection Helsinki, January-February 2005. For a state of the art description and discussion on improved representations of convection processes in NWP and air quality models since they critically influence the development of precipitation systems or the transfer of pollutants to the global atmosphere.

Participation in the **Sodankylä-2005 summer school and training campaign "Planetary boundary layers over complex and vegetated land surfaces"** arranged by FMI and UH in the framework of an ongoing EU project (Marie Curie Excellence Grants allocated to Prof. Sergei Zilitinkevich). For a broad approach to the BL theoretical and modelling aspects together with measuring techniques and data analysis on surface-atmosphere exchange over Nordic and Boreal ecosystems (e.g., lakes, forests, peat bogs).

Workshop on uncertainty in high-resolution atmospheric models, 2006. Fine-scale atmospheric models will provide deterministic and probabilistic forecasts of high impact weather (e.g. heavy precipitation), which may lead to severe floods and avalanches. However, as the resolution is improved the impact of uncertainties in model formulations becomes more significant. Thus new approaches and advanced methods of validation are required. The workshop aims at summarizing the state of the art and main lines of development in the field.

Summer school on "Non-hydrostatic dynamics and advanced data-assimilation methods for fine-scale models", St. Petersburg, summer 2006. To remove the paradox that this hard core topic of atmospheric modelling is poorly covered by current NetFAM's university curricula though NetFAM countries have world class experts. It will provide top-level lectures, practical exercises and training material, provided by the leading specialists within the network.

Workshop on cloudy boundary layer, Toulouse, 2007. Description of BL convection and its interactions with turbulent processes is a challenge for the fine-scale models. The workshop aims at a review, discussion and further planning of efforts in the area.

If resources will be remaining, NetFAM may support key researchers from the network to participate in the regular workshops of SRNWP on fine scale data assimilation, non-hydrostatic modelling, surface processes and verification.

Extended researcher training

During the three years, NetFAM plans to apply for separate mobility scholarships of 2-12 months for 1-3 young researchers from UTa and RSHU to the institutes with which they already cooperate.

The "Numlab-2005" course of UH, the MISU HIRLAM course and courses of dynamical meteorology and numerical modelling of RSHU are open for participants from NetFAM. The network will support LHMS/UV and EMHI who plan to send research students to attend these regular local courses. This will help enrolling research-oriented last-year students into fine-scale atmospheric modelling research already within their diploma projects.

Creation of a web page of NetFAM

A web page will be created for exchange and dissemination of information within the network as well as to promote the Nordic networking activities. The following services are planned: 1) Basic network information and documents (responsible: coordinating group); 2) educational resources and links (responsible: RSHU); 3) a simple discussion forum (responsible: UTa); 4) ftp server for data exchange (responsible: FMI).

(d) Targets to be achieved during the operating period of the network

The general objectives are:
1. To improve and support postgraduate research training and education on all aspects of fine-scale atmospheric modelling in Nordic countries and around the Baltic Sea.
2. To extend and deepen research and expertise in key areas of atmospheric fine-scale modelling in the region.
3. To establish long-lasting collaboration between the universities and meteorological institutes across the region in order to strengthen the chain from basic research to applications in fine-scale modelling.
4. To support the interactions and cooperation between fine-scale atmospheric modelling and researchers in marine, hydrological, aerosol and atmospheric chemistry modelling.
5. To promote the exchange of information and best practices on curricula and training on atmospheric simulation, fine-scale modelling and surface-atmosphere exchange.

Within the network, it is planned to create and make available to all participants
1. A non-hydrostatic research version of HIRLAM, suitable for application at the kilometre-scale. Knowledge and software for running alternative non-hydrostatic models will be exchanged.
2. Data sets applicable for model validation in stable atmospheric conditions (based on Sodankylä observations) and in convective cases.
3. Common definitions, tools and protocols for extended diagnostics and verification to be used in model comparison studies.

A system of extended visits, workshops and summer schools will be built in a coordinated way. Existing educational resources will be made available to all participants. Curricula and training will be also addressed during Workshops in a separate session. Scientific results obtained and presented during training and research visits will be published in appropriate scientific report series and peer-reviewed journals, whereby younger scientists will benefit from the insight of longer established scientists. The network activities will enhance the abilities of young researchers to be active in an international environment.

(e) Visions for continued co-operation after the grant period

The proposed network will help nurturing new common research projects and seeking external funding for joint activities, e.g. in the framework of EU and national science programmes. At present, NetFAM partners are already taking part in several international research programmes, which will last beyond the NetFAM grant period. This will enable continuation of cooperation and offer an opportunity to export the expertise acquired during NetFAM outside of the Nordic area but also to establish suitable grounds for implementing developments achieved elsewhere. Direct bilateral and multilateral collaboration between the partners will continue in different forms and guarantee the availability of resources also after the NetFAM period,

(f) Increasing of equal participation and equality of women and men

The percentage of women of the members of the research teams of NetFAM is 26 %. For historical and other reasons women and men are unevenly distributed in the different institutes of the network, as it is elsewhere in Europe in scientific discipline. Both men and women are guaranteed equal rights and conditions in participating in all network activities. In case of insufficient resources for visits and travelling we will aim at giving priority to the representatives of the minority.

(g) Estimated number of research students participating in the network

At present, the number of research student members in the national teams is about 40 or almost half of the total amount of researchers involved (see the project application for the distribution of students by groups). The number of research students estimated to participate in the network during these three years is 40-45.