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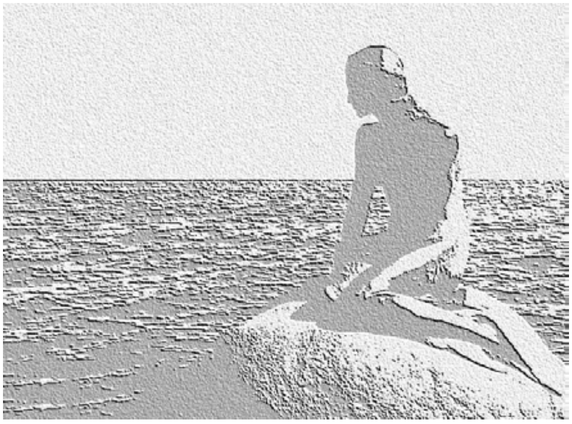
COST-728 / NetFAM workshop on “Integrated systems of meso-meteorological and chemical transport models”

Copenhagen, Denmark
21-23 May 2007



COST-728:
Enhancing Mesoscale Meteorological Modelling Capabilities for Air Pollution and Dispersion Applications

Working Group (WG) 2:
Integrated Systems of MetM and CTM: Strategy, Interfaces and Module Unification

Content:

1. Information Leaflet

COST-728 / NetFAM workshop on "Integrated systems of meso-meteorological and chemical transport models"

Copenhagen, Denmark - 21-23 May 2007

A COST Action 728 / NetFAM workshop on integration/coupling of meso-meteorological (MM) and chemical transport (ACT) models is arranged on May 21-23, 2007 at the Danish Meteorological Institute, DMI (Lyngbyvej 100, Copenhagen, DK-2100, Denmark). The aim of the workshop is to join numerical weather prediction (NWP) and air quality (AQ) modelers to discuss and make recommendations on the best practice and strategy for further developments and applications of integrated/coupled modelling systems "NWP & MesoMeteorology (MM) - Atmospheric Chemical Transport (ACT)". Main emphasis is on the fine-resolution models applied for local chemical weather forecast and considering feedback mechanisms between meteorological and atmospheric pollution (e.g. aerosols) processes.

Organizers of the workshop welcome interested participants from NWP and AQ consortia. Presentations on the following topics are especially welcome:

- Online and offline coupling of meteorological and air quality models;
- Implementation of feedback mechanisms, direct and indirect effects of aerosols;
- Advanced interfaces between NWP and ACT models;
- Model validation studies, including air quality-related episode cases.

Note, the workshop is focusing on the MM and ACT models coupling strategy and does not aim to concentrate on the specific topics of modelling the urban atmosphere nor on those of aerosol dynamics.

A keynote lecture on each of the main topics is planned in addition to contributions of workshop participants. Workshop web site: http://netfam.fmi.fi/Integ07/.

Workshop Programme
The workshop will start on Monday morning, May 21st, and end at midday on Wednesday, May 23rd.

- **Overview lectures** (40 min each),
- **Presentations by participants** (20 min each),
- **HIRLAM-ACT models integration section** (2.5 hours),
- **Discussions / Round Table** to build a joint strategy, recommendations and requirements.

Participation and Deadlines
To participate, please, send an e-mail to the local organizer Alexander Baklanov (alb@dmi.dk), with a title of your (20 minute) presentation till **31 March 2007**. Short abstracts for the workshop are welcome till **30th April, 2007**. An extended abstract for the (printed) workshop report should be provided after the workshop, till **30th June 2007**. It is also possible to participate without making a presentation.
There is no registration fee for the workshop. Information about accommodation in Copenhagen can be found at the page of practical information, contact Bente E. Andersen (bea@dmi.dk). Support for travel expenses is available for NetFAM and COST-728 members upon request: please find the contact info at NetFAM and COST-728 web sites.
Organizers
International organizing committee: Alexander Baklanov and Alexander Mahura (Danish Meteorological Institute), Laura Rontu and Mikhail Sofiev (Finnish Meteorological Institute, FMI), Ranjeet Sokhi (University of Hertfordshire, UK), Barbara Fay (Deutscher Wetterdienst, Germany), Georg Grell (NOAA, USA), Jacek Kaminski (York University, Canada).
The workshop is arranged in the framework of COST action 728 (http://www.cost728.org/) "Enhancing Mesoscale Meteorological Modelling Capabilities for Air Pollution and Dispersion Applications" in cooperation with Nordic Network on Fine-scale Atmospheric Modelling (NetFAM) (http://netfam.fmi.fi/).
The local organizer in Copenhagen is the Danish Meteorological Institute (http://www.dmi.dk).
Contact e-mail for workshop issues: Alexander Baklanov, alb@dmi.dk

2. Work Programme of Working Group 2

Integrated systems of MM and CTM: strategy, interfaces, module unification

Historically, air pollution forecasting and numerical weather predictions (NWP) were developed separately. This was plausible in the previous decades when the resolution of NWP models was too poor for meso-scale air pollution forecasting. Due to modern NWP models approaching meso- and city-scale resolution and using land-use databases with finer resolution, this situation is changing. As a result the conventional concepts of meso- and urban-scale air pollution forecasting need revision along the lines of integration of MetM and CTM. For example, a new Environment Canada conception suggests to switch from the weather forecast to the environment forecast. Some European projects (e.g. FUMAPEX) already work in this direction and will feed into this Action. Within FUMAPEX, for example, Urban Air Quality Information and Forecasting Systems (UAQIFS) will include integration of NWP models to urban air pollution and population exposure models.

The eventual integration strategy will not be focused around any particular model – instead it would possibly be to consider an open integrated system with fixed architecture (module interface structure) and with a possibility of incorporating different MetMs/NWP models and CTMs. Such a strategy would only be realized through jointly agreed specifications of module structure for easy-to-use interfacing and integration. An example of such an integrated approach is that of the PRISM specification for integrated Earth System Models: http://prism.enes.org/.

As pointed out earlier urban/rural transition processes (e.g. recirculation and feedbacks) are important as are interaction of these locally forced features with synoptic scale processes (e.g. fronts and convection). Furthermore, at regional scales the interaction of meteorology (e.g. cloud formation) and pollution transport (e.g. cloud nuclei, precipitation) becomes significant. In this case off-line coupling does not allow the study of feedbacks of atmospheric pollutants on meteorological processes and the access to meteorological fields are limited by the model outputs and a large amount of data exchange. Online coupling, on the other hand, would allow the implementation of 'integrated' physical and chemical parameterization schemes. Additionally, NWP models are not primarily developed for air pollution modelling and their results need to be designed as input to meso-scale air quality models or they have to be integrated into joint modelling systems for air quality forecasting and assessments. For this reason both off-line and on-line coupling of MetMs and CTMs will be considered in WG2. Thus, a timely and innovative field of activity will be to assess the interfaces between MeTMs and CTMs and the MetM-for-CTM models, and to establish the basis for their harmonization and benchmarking.

WG2 will also review practical aspects of running meso-scale models, e.g., gaining access to meteorological and environmental/geographical datasets, running models, accessibility of model codes and data sets. It will consider methods for the aggregation of episodic results, model down-scaling as well as nesting. The activity will also address the formulation of requirements of mesoscale meteorological models suitable as input to air pollution models.

Examination of data assimilation techniques will also form part of WG2 activities as it has been shown that powerful assimilation techniques may be just as critical for achieving accurate forecasts as the comprehensiveness of the model, at least on the short-range (1-2 days). In this respect, the Action will inspect the requirements for assimilation techniques with a view to development of future monitoring networks. Meteorological networks are under a transition phase with many manual stations changing to less numerous automatic stations. The use of remote sensing data is increasing and will be assessed (e.g. through GMES). Pollutant monitoring networks are still very coarse and their resolution cannot generally cope with high-frequency meteorological processes.

Both CTM and NWP meso-scale models require and are dependent on specific input data that may also influence the final outputs: land-use and topographical data, parameters coupled with land-use (e.g., albedo) and emission data. The Action will assess existing datasets and methods in order to propose recommendations for the basic characteristics of datasets required for these models with respect to factors such as spatial and temporal resolution and classes split.

The overall aim of WG2, therefore, will be to identify the requirements for the unification of MetM and CTM modules and to propose recommendations for a European strategy for integrated mesoscale modelling capability. In order to achieve this aim the following activities are planned:

- Overview of existing integrated (off-line and on-line) systems in Europe and outside Europe.
- Identification of the advantages and disadvantages of strategies for integrating of MetMs and CTMs.
- Development of guidance and strategy for on-line coupling of MetMs and CTMs and for their off-line interfacing.
- Overview of existing module structures of MetMs and CTMs, along with recommendations and requirements for module unification.
- Formulation of requirements of mesoscale MetMs suitable as input to air pollution models and improved meteorological pre-processors and model interfaces, including deposition processes, capable of connecting mesoscale MetM results to CTM models.
- Recommended methods for the model down-scaling and nesting, as well as assimilation techniques.
- Identifying requirements (including observation data needs) for an integrated mesoscale modelling capability/strategy for Europe.

Inputs to the Activity:
Inputs to the activity will include data and information on CTM and Met models, used and developed in different countries, their experience of model integration, as well as existing module interface structures. As to data requirements, it would include meteorological data, chemical pollutant data as well as emission inventories for selected pollutants (such as NOx, VOCs and PM10).

***Deliverables**:*
- Overview of existing integrated (off-line and on-line) mesoscale systems.
- Overview of existing module structures of MetMs and CTMs, recommendations and requirements for module unification.
- Requirements of meso-scale MetMs suitable as input to CTMs, assessment of meteorological pre-processors and model interfaces between MetMs and CTMs.
- Recommended methods for the model down-scaling and nesting, as well as assimilation techniques.
- Requirements for an integrated mesoscale modelling capability/strategy for Europe, including data needs.

3. Workshop Programme

Monday, 21 May

Opening and Introduction

10.45 - 11.00 *Registration*

11.00 - 11.10 Opening of the meeting - Peter Aakjaer, director of DMI

11.10 - 11.15 Info about practical arrangements

11.15 - 11.50 Integrated systems: on-line and off-line coupling of meteorological and air quality models, advantages and disadvantages. Alexander Baklanov

On-line and Off-line Coupled Systems

11.55 - 12.30 Online coupled meteorology and chemistry models in the U.S. Yang Zhang

12.35 - 13.40 *Lunch break*

13.40 - 17.15 Afternoon session, chaired by Barbara Fay

13.40 - 14.15 Description, application, and verification of a state-of-the-art fully coupled multi-scale air quality and weather prediction model (WRF/Chem). Georg Grell

14.20 - 14.40 LM-ART – aerosols and reactive trace gases within LM. Heike Vogel

14.45 - 15.20 Integrated modelling systems in Australia, CSIRO. Peter Manins

15.25 - 15.45 *Coffee break*

15.45 - 16.20 Chemical modelling with WRF/Chem and CHASER in Japan. Masayuki Takigawa

16.25 - 16.45 The online coupled mesoscale climate-chemistry model MCCM - a modelling tool for short episodes as well as for climate periods. Peter Suppan

16.50 - 17.10 BOLCHEM, an integrated system for meteorology and atmospheric composition. Alberto Maurizi

Tuesday, 22 May

09.00 - 11.50 Morning session, chaired by Laura Rontu

09.00 - 09.35 Multiscale atmospheric chemistry modelling with GEM-AQ. Jacek Kaminski

09.40 - 10.00 A multiscale modelling approach putting special emphasis on the efficient treatment of urban plumes. John Douros

10.05 - 10.25 Operational ozone forecasts for Austria. Marcus Hirtl

10.30 - 10.50 *Coffee break*

10.50 - 11.10 Coupling of air quality and weather forecasting - progress and plans at met.no. Viel Ødegaard

11.15 - 11.50 ENVIRO-HIRLAM: on-line integrated system. Ulrik Korsholm

11.50 - 12.30 **HIRLAM/HARMONIE-ACT Models Integration Session (Part 1)**

Definition of the discussion topics, start of discussions (Conveners: Alexander Baklanov and Sander Tijm)

12.30 - 13.30 *Lunch break*

13.30 - 15.10 **HIRLAM/HARMONIE-ACT Models Integration Session (PART 2)**

Discussions continue

Included in the session (15 min):
Some experiences using the non-hydrostatic model AROME as driver for the MATCH model. Lennart Robertson

15.10 - 15.30 *Coffee break*

15.30 - 17.25 Afternoon session, chaired by Jacek Kaminski

15.30 - 15.50 Aerosol species in the AQ forecasting system of FMI: possibilities for coupling with NWP models. Mikhail Sofiev

15.55 - 16.15 The online coupled atmospheric-chemistry-aerosol model LM-MUSCAT. Oswald Knoth

16.20 - 16.55 The PRISM support initiative, COSMOS and OASIS4. Rene Redler

17.00 - 17.20 Running the SILAM model comparatively with ECMWF and HIRLAM meteorological fields - a case study in Lapland. Marko Kaasik

Wednesday, 23 May

09.00 - 11.00 Morning session, chaired by Valentin Foltescu

09.00 - 09.35 Coupling global CTMs to ECMWF integrated forecasts system for forecast and data assimilation within GEMS. Johannes Flemming

09.40 - 10.05 Experiences on application of meso-model output for ozone simulation. Bob Bornstein

10.10 - 10.45 Off-line model integration: EU practices, interfaces and possible strategies for harmonisation. Barbara Fay and Sandro Finardi

10.50 - 11.10 *Coffee break*

11.10 - 11.20 New COST Action: Chemical weather forecasting. Mihail Sofiev

11.20 - 12.50 **Discussions / Round Table**
to build a joint strategy recommendations and requirements. Convener: Ranjeet Sokhi

12.50 *Closure of the meeting*

4. Abstracts

A1. Alexander Baklanov: Integrated systems: on-line and off-line coupling of meteorological and air quality models, advantages and disadvantages

Alexander Baklanov

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As strategy of a new generation integrated Meteorology (MetM) and Atmospheric Chemical Transport (CTM) modelling systems for predicting atmospheric composition, meteorology and climate change it is suggested to consider air quality modelling as a combination and integration (at least) of the following factors: air pollution, urban climate/meteorological conditions and population exposure. This combination is reasonable due to the facts that: (i) meteorology is a main source of uncertainty in air pollution and emergency preparedness modelling, (ii) complex and combined effects of meteorological and pollution components on human health (e.g., hot spots in July of 2003 in Paris, France), (iii) effects of pollutants, especially aerosols, on climate forcing and meteorological phenomena (precipitation, thunderstorms, etc.).
In this content several levels of the integration strategy are considered:
1) off-line models:
• separate CTMs are driven by meteorological input data from meteo-pre-processors, measurements or diagnostic models,
• separate CTMs are driven by analysed or forecasted meteodata from Numerical Weather Prediction (NWP) archives/ datasets,
• separate CTMs are read output-files from operational NWP models or specific MetMs with a limited period of time (e.g. 1, 3, 6 hours);
2) on-line models:
• on-line access models, when meteodata is available at each time step (it could be via a model interface as well),
• on-line integration of CTM into MetM, when feedbacks are possible to consider (we will use this definition as on-line coupled modelling).
Main advantages of the on-line and off-line modelling approaches from the first preliminary outlook are the following:
For the on-line coupling:
• Only one grid; no interpolation in space; no time interpolation;
• Physical parameterizations are the same; no inconsistencies; does not need meteo- pre/post-processors;
• All 3D meteorological variables are available at each time step; no restriction in variability of meteorological fields;
• Possibility to consider aerosols and gaseous forcing on atmospheric processes and other feedback mechanisms.
For the off-line coupling:
• Possibility of independent parameterizations;
• Low computational cost (if NWP data - available, no need to run MetM);
• More suitable for ensembles and operational activities;
• Easier to use for the inverse modelling and adjoint problem;
• Independence of atmospheric pollution model runs on MetM computations;
• More flexible grid construction and generation for CTMs, e.g. within the surface and boundary layer;
• Suitable for emission scenarios analysis and air quality management.
The on-line integration of MetM and CTM models gives a possibility to consider feedbacks of air pollution (e.g. aerosols) on meteorological processes and climate forcing, therefore this is a very promising way for future atmospheric simulation systems leading to a new generation of models for environmental and “chemical weather” forecasting. An overview of on-line coupled MetM and CTM model systems already being used in Europe, based on FUMAPEX and COST728 experience (see references), will be presented in the paper. Activities and investigation requirements are multiple but dispersed in Europe. Thus, a COST Action seems to be the best approach to integrate, streamline and harmonize these national efforts towards a leap forward for new breakthroughs beneficial for a wide community of scientists and users. The discussed European joint system strategy does not necessarily include just one model. It could be an open integrated system with fixed architecture (module interface structure) and with a possibility to incorporate different MetMs/NWP models and CTMs.

References:

Baklanov, A., B. Fay, J. Kaminski (editors), 2007: Overview of existing integrated (off-line and on-line) mesoscale systems in Europe. COST 728 D2.1 Report, April 2007, 108 p.
FUMAPEX: Integrated Systems for Forecasting Urban Meteorology, Air Pollution and Population Exposure. EC 5FP project: http://fumapex.dmi.dk/.

A2. Yang Zhang: Online coupled meteorology and chemistry models in the U.S.

Yang Zhang

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The climate- chemistry- aerosol- cloud- radiation feedbacks are important in the context of many areas including global/regional climate modeling, global-through-urban air quality/atmospheric chemistry modeling, numerical weather and air quality forecasting, as well as integrated atmospheric-ocean-land surface modeling. Accurately simulating those feedbacks requires fully-coupled meteorology, climate, and chemistry models and presents significant challenges in terms of both scientific understanding and computational demand.
This review will focus on history and current status of development and application of online models in the U.S. Several representative online coupled meteorology and chemistry models such as GATOR-GCMOM, WRF/Chem, CAM3, and MIRAGE will be included. Major model features, physical/chemical treatments, as well as typical applications will be evaluated with a focus on aerosol microphysics treatments, aerosol feedbacks to planetary boundary layer meteorology, and aerosol-cloud interactions.
Recommendations for future development and improvement will be provided.

A3. Georg Grell: *Description, application, and verification of a state-of-the-art fully coupled multi-scale air quality and weather prediction model (WRF/Chem)*

Georg Grell

National Oceanic and Atmospheric Administration, NOAA / Earth System Research Laboratory, ESRL / Cooperative Institute for Research in Environmental Sciences, CIRES, USA
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We will describe the Weather Research and Forecasting (WRF) model as it is coupled with chemistry. This model is a community effort which now includes many atmospheric chemistry routines covering biogenic emissions, deposition, photolysis, chemical mechanisms. In addition, various atmospheric aerosol routines (modal and sectional approaches) have been added to WRF. The chemistry and aerosol routines are usually solved in an "online," or "fully-coupled" fashion with the meteorological forecast model. In other words, the interaction and transport of meteorological, chemical, and aerosol species are calculated using the same physical parameterizations with no need to interpolate in time and/or space. The most recent version of this modeling system includes the direct and indirect effects of aerosols. An overview of the current status of this modeling system and ongoing as well as future development will be discussed. In addition some evaluation results and scientific applications will be presented.

A4. Heike Vogel: *LM-ART – aerosols and reactive trace gases within LM*

Heike Vogel*, Dominique Bäumer, Max Bangert, Kristina Lundgren, Rayk Rinke, Tanja Stanelle, and Bernhard Vogel*

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Based on the mesoscale model system KAMM/DRAIS/MADEsoot/dust (Riemer et al., 2004, Vogel et al., 2006a) we developed an enhanced model system to simulate the spatial and temporal distribution of reactive gaseous and particulate matter. The meteorological driver of the old model system (KAMM) was replaced by the operational weather forecast model Lokal-Modell (LM, Steppeler et al., 2003) of the German Weather Service. The name of the new model system is LM-ART (ART stands for Aerosols and Reactive Trace gases, Vogel et al., 2006b). The CTM module was online coupled with the operational version of the LM. That means that in addition to the transport of a non reactive tracer the dispersion of chemical reactive species and aerosols can be calculated. Secondary aerosols which are formed from the gas phase, directly emitted components like soot, mineral dust, sea salt and biological material are represented by log normal distributions. Processes as coagulation, condensation and sedimentation are taken into account. The emissions of biogenic VOCs, dust particles, sea salt and pollen are calculated also online, taking into account the dependencies on the meteorological variables. To calculate efficiently the photolysis frequencies a new method was developed using the GRAALS radiation scheme (Geleyn and Ritter, 1992) that is already implemented in LM. To study the interaction of the aerosol and radiation, the so-called direct aerosol effect the climatological aerosol optical properties, which are used in the standard LM version, are replaced by parameterized ones that take into account current modal aerosol mass densities. By comparing different simulation results obtained with parameterized and climatological aerosol optical properties, the impact of the aerosol not only on the radiation, but also on other meteorological variables as the temperature can be quantified.
In this study recent developments of the model system LM-ART will be presented. Examples of simulated distribution of different aerosol particles and their interaction with radiation will be presented.

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Riemer N., H. Vogel, B. Vogel, F. Fiedler, (2003), Modelling aerosols on the mesoscale-μ: Treatment of soot aerosol

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Ritter, B., J.-F. Geleyn, (1992), A comprehensive radiation scheme for numerical weather prediction models with potential applications in climate simulations, Monthly Weather Review, 120, 303-325.
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Vogel, B., C. Hoose, H. Vogel, Ch. Kottmeier (2006a), A model of dust transport applied to the Dead Sea area, Meteorologische Zeitschrift, 14, 611-624.
Vogel, H., B. Vogel, Ch. Kottmeier (2006b), Modelling of pollen dispersion with a weather forecast model system, Proceedings of 28th NATO/CCMS Int. Meeting on Air Pollution Modelling and its Application, Leipzig.

A5. Peter Manins: Integrated modelling systems in Australia, CSIRO

Peter Manins

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CSIRO Australia has been developing and applying integrated complex air pollution prediction models for industry and urban planning purposes. In this presentation I will mention some of the experiences and learning from the past 20 years.
We commenced with a coupled version of the Pielke mesoscale meteorological model and McNider Lagrangian particle model, and applied it in a major power generating region subject to colliding sea breezes. The experiences led to first LADM (Lagrangian Atmospheric Dispersion Model) and then to the in-line PC based system TAPM (The Air Pollution Model) which has gone through almost ten years of development and is up to Version 3. We have 154 active TAPM licenses and it is used in 18 countries.
Joining with the Australian Bureau of Meteorology, by 2000 we developed the off-line operational AAQFS (Australian Air Quality Forecasting System) that predicts hour by hour levels of over 20 species including ozone, to 1 km resolution for our major cities. AAQFS uses the same chemical transport component as TAPM, and optionally a highly complex chemistry (presently Carbon Bond 2005) that we have been using with TAPM for subtle policy support issues such as investigating the air quality benefits of alternative vehicle fuels in urban regions.
Personal exposure and health impacts are major motivators for our work - a novel Lagrangian Wall Model, that runs within the mesoscale models, can resolve air quality impacts of roads down to 10 m.
Presently we are joining with Australian Bureau of Meteorology to develop an Earth System Science unified modelling system based on the Hadley Center's HADGEM - we have our first weather forecasts from this system already, and are working to progress the climate and air quality aspects, along with many other components.

A6. Masayuki Takigawa: Chemical modelling with WRF/Chem and CHASER in Japan

Masayuki Takigawa *(1), Masanori Niwano (1), Hajime Akimoto (1), and Masaaki Takahashi (1,2)*

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Here we would like to briefly introduce our modeling studies with WRF/Chem and CHASER. CHASER (chemical atmospheric general circulation model for study of atmospheric environment and radiative forcing) is a global chemical transport model. (cf. Sudo et al 2002a,2002b, Takigawa 2005). The gaseous and aerosol chemistry module is implemented in the CHASER model in an on–line treatment. CHASER is based on CCSR/FRCGC/NIES AGCM 5.7b, and the meteorology and radiation can be calculated in CHASER itself. The radiative feedback through the distribution of chemical species is taken into account in CHASER. Daily forecasts have been available on a web page since 1 January 2002. This forecasting system was developed for the use of daily flight planning for the PEACE–A (January 2002) and PEACE–B (April–May 2002). I will show you some results by using this global chemical weather forecasting system.
We have been also developing a regional–scale chemical weather forecasting system based on WRF/Chem. The lateral boundary for the chemical species is taken from the 3–hourly output of CHASER. The model–calculated surface ozone by using this model system was compared with the ground–based observations. Vertical profiles of ozone were also compared with ozone DIAL (Differential Absorption Lidar) in Tsukuba, which locates about 60 km away from Tokyo.

A7. Peter Suppan: The online coupled mesoscale climate-chemistry model MCCM - a modelling tool for short episodes as well as for climate periods

Peter Suppan *and Renate Forkel*

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The online coupled regional meteorology-chemistry model MCCM (Mesoscale climate chemistry model, Grell et al. 2000) has been developed at the IMK-IFU. MCCM is based on the non hydrostatic NCAR/Penn State University mesoscale model MM5 (Grell et al., 1994). Similar to MM5 MCCM runs over a range of spatial scale from the regional scale (several thousand kilometers, resolution 30-100 km) to the urban scale (100-200 Km, resolution 1-5 km). It includes several online coupled tropospheric gas phase chemistry modules (RADM, RACM, RACM-MIM [Stockwell et al., 1990, 1997, Geiger et al., 2003]), a photolysis module, and a BVOC emission module. Optional aerosol processes are described with the modal MADE/SORGAM aerosol module (Schell et al., 2001) which considers as single compounds sulfate, nitrate, ammonium, water, and 4 organic compounds. For the Aitken and the accumulation mode the gas phase/particle phase partitioning of the secondary sulphate/nitrate/ammonium/water aerosol compounds is based on equilibrium thermodynamics. The organic chemistry assumes that secondary organic aerosol compounds (SOA) interact with the gas phase and form a quasi-ideal solution.

Anthropogenic emissions of primary pollutants, like NOx, SO2, and hydrocarbons, as well as emissions of primary particulate matter have to be supplied either at hourly intervals or as yearly data from gridded emission inventories. Validation studies with MCCM have shown its ability to reproduce observed meteorological quantities and pollutant concentrations for different conditions and regions of the earth (Forkel and Knoche, 2006; Grell et al., 1998; Grell et al., 2000; Jazcilevich et al., 2003; Forkel et al., 2004; Suppan and Schädler, 2004; Kim and Stockwell, 2007).

Recent applications of MCCM at the IMK-IFU include short term studies such as simulations of high pollutant episodes for Mexico City (Forkel et al., 2004), receptor analysis (Suppan and Schädler, 2004) as well as long term studies such as climate-chemistry simulations (Forkel and Knoche, 2006), simulations of yearly pollution conditions in the Alpine region, and daily real time forecasts of ozone and particulate matter for Germany.

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A8. Alberto Maurizi: BOLCHEM, an integrated system for meteorology and atmospheric composition

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BOLCHEM is the result of an effort to put together different expertises present at ISA-CNR.

BOLAM developed by the "Dynamic Meteorology" group, constitutes the meteorological basis and is known to be well suited for meteorological forecast and studies in complex orography and recorded high scores in various comparison experiments.

The study of transport mechanisms and their representation is the object of the activities of the "Turbulence and Dispersion" group. Careful evaluation of "diffusion" coefficient in different regimes goes together with the study ad the implementation of Lagrangian dispersion models of different levels of complexity.

The contribution of the "Atmospheric Chemistry" group, mainly focused in the past on the gas chemistry, is now concentrated on the introduction of aerosol transport

and dynamics. Starting with the problem of Saharan dust.
Results show that BOLCHEM is a suitable tool for research and air quality monitoring.

A9. Jacek Kaminski: Multiscale Atmospheric Chemistry Modelling with GEM-AQ

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A multiscale atmospheric chemistry model has been developed by the Multiscale Air Quality Modelling Network (MAQNet) – a consortium of seven Canadian universities and government departments. The strategic goal of the project was to develop a modelling platform for tropospheric air quality modelling and chemical data assimilation.
The host meteorological model is the Global Environmental Multiscale (GEM) model developed by the Meteorological Service of Canada for operational weather prediction (Côté et al., 1998). GEM can be configured to simulate atmospheric processes over a broad range of scales, from the global scale down to the meso-gamma scale.
Atmospheric chemistry modules are implemented on-line in the host meteorological model. In this version of GEM-AQ (tropospheric air quality), there are 37 advected and 14 non-advected gas phase species in the model. Transport of the chemically active tracers by the resolved circulation is calculated using the semi-Lagrangian advection scheme native to GEM. The vertical transfer of trace species due to subgrid-scale turbulence is parameterized using eddy diffusion calculated by GEM.
The gas-phase chemistry mechanism currently used in this version of GEM-AQ comprises 51 species, 120 chemical reactions and 16 photolysis reactions representing air quality and free tropospheric chemistry. All species are solved using a mass-conserving implicit time stepping discretization, with the solution obtained using Newton's method.
The modelling system can be used to plan field campaigns, interpret measurements, and provide the capacity for forecasting oxidants, particulate matter and toxics. It will also be able to provide guidance to evaluate exposure studies for people, animals, crops and forests, and possibly for epidemiological studies.
The presentation will focus on the modelling strategy and model applications. Results from a long term global simulation and regional scale episodes will be described. Also, application of the modelling platform to photochemistry on Mars will be presented.

A10. John Douros: A multiscale modelling approach putting special emphasis on the efficient treatment of urban plumes

John Douros *and Nicolas Moussipoulos*

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Multiscale modelling approaches have long been recognized as an important assessment tool when it comes to urban air quality. The OFIS model is a conceptually unique Eulerian urban scale model that fits into a broader modelling scheme that entails regional and street scale models. Most importantly, it allows an adequate description of atmospheric dynamics and photochemical transformation processes in the urban plume at a very low computational effort. Recent improvements in the treatment of vertical stratification have advanced further the concept of the OFIS model and proven the suitability of simpler models for the adequate description of air pollutant dispersion and transformation in the urban environment. As a step towards its further evaluation and development, the OFIS model was applied to various European cities within the framework of intercomparison exercises such as CityDelta, aiming to explore the changes in urban air quality predicted by different atmospheric chemistry-transport dispersion models in response to changes in urban emissions.
This work presents the advantages and limitations of the OFIS modelling approach versus others, highlighting the issues of performance and computational cost, while at the same time it allows the realization of a series of sensitivity analysis tests with respect to various model parameters such as the spatial and temporal resolution of the emissions used, the model cell size and the update frequency of meteorological input. More specifically, model applications confirm the importance, in terms of model performance, of using gridded emissions inventories instead of disaggregated ones as well as of adopting 3-hourly values for the meteorological and boundary conditions input that drives the model, instead of daily ones. Additional improvement was achieved with the use of an appropriate parameterization for wet removal of particulate matter.

A11. Marcus Hirtl: Operational ozone forecasts for Austria

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The operational regional weather forecast model ALADIN-Austria of the central Institute for Meteorology and Geodynamics (ZAMG) is used to implement a forecast system for tropospheric ozone over Europe. The operational ozone forecasts have been run for the summers 2005 and 2006 in cooperation with at the University of Natural Resources and Applied Life Sciences in Vienna (BOKU).
A two grid nesting is used with a coarse grid over Europe and a finer grid for the core area covering Austria where the best possible spatial resolution of 9.6 km is achieved. The meteorological fields have a temporal resolution of 1 hour. ALADIN provides weather forecasts for 48 hours two times a day. The meteorological fields are combined with the results from an emission model and are used as input data for the simulation with the photochemical dispersion model CAMx. The chemistry mechanism SAPRC99 is used.
The ALADIN data is provided on 45 model-levels (only the lower 33 are used in CAMx). Fields of wind, temperature, pressure, convective and large scale precipitation, snow cover, solar radiation and specific humidity are extracted directly out of the ALADIN dataset. The other fields, cloud optical depth, cloud water- and precipitation water content have to be parameterized from the ALADIN output.
The model calculations of the operational runs in 2005 and 2006 as well as for an ozone episode in 2003 are compared to the observations of air quality stations in Austria.

A12. Viel Ødegaard: Coupling of air quality and weather forecasting - progress and plans at met.no

Viel Ødegaard, *Leonor Tarrason and Jerzy Bartnicki*

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Air quality modelling at met.no consists of three different systems, all in off line coupling to our numerical weather prediction models.
For emergency purposes we have the “Severe Nuclear Accident Program” (SNAP) model developed at met.no. This is a Lagrangian particle model transporting gases, noble gases, particles of different size and density. The modeled processes are: advection and diffusion (Random Walk), dry deposition (gravitational settling velocity for particles) and wet deposition (function of size and precipitation for particles). The model is operated by forecasters and run on meteorological input from operational HIRLAM (10 and 20 km horizontal resolution) and from ECMWF.
The urban air quality information system runs operationally at met.no and consists of the chemical dispersion model AirQUIS developed at Norwegian Institute for Air Research and the non-hydrostatic NWP model MM5 in 1km horizontal resolution nested in HIRLAM. During the winter season 2006/2007 the UK Met Office Unified model is introduced to replace MM5, and a new interface to AirQUIS is built.
The Unified EMEP model developed at met.no for simulating atmospheric transport and deposition of acidifying and eutrophying compounds, as well as photooxidans over Europe. The model domain covers Europe and the Atlantic Ocean with the grid size 50×50 km2. In vertical, the model has 20 sigma layers reaching up to 100 hPa. Approximately 10 off these layers are placed below 2 km to obtain high resolution of the boundary layer. Typically, model simulates one year period of the transport and the current results of the model runs are available for the years 19980, 1985, 1990 and each ear from 1995 to 2004. The Unified EMEP models uses 3-hourly resolution meteorological data from PARLAM-PS model, a dedicated version of the HIRLAM model.

A13. Ulrik Korsholm: ENVIRO-HIRLAM: on-line integrated system

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The on-line integration of meso-scale meteorological models and atmospheric aerosol and chemical transport models gives a possibility to utilize all the 3D meteorological fields at each time step and to consider feedbacks between air pollution (e.g. urban aerosols) and meteorological processes. This very promising way for future atmospheric simulation systems will lead to a new generation of models for environmental and "chemical weather" forecasting. ENVIRO-HIRLAM is developing as an on-line integrated system with a possibility of the off-line coupling as well. The system realization includes the following steps:

(i) nesting of models for high resolutions,
(ii) improved resolving boundary and surface layers characteristics and structures,
(ii) 'urbanization' of the model,
(iii) improvement of advection schemes,
(iv) implementation of chemical mechanisms,
(v) implementation of aerosol dynamics,
(vi) realization of feedback mechanisms,
(vii) assimilation of monitoring data.

The model is to be used for operational as well as research purposes and will comprise aerosol and gas transport, dispersion and deposition, aerosol physics and chemistry as well as gas-phase chemistry. The presentation will include current status of the system and evaluation against the ETEX-1 experiment and the Chernobyl accident. Results from two experiments investigating the differences between online and offline models and the importance of feedbacks will also be considered.

A14. Lennart Robertson: Some experiences using the non-hydrostatic model AROME as driver for the MATCH model

Lennart Robertson *and Valentine Foltescu*

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The AROME model is under evaluation at SMHI as part of the work conducted within HIRLAM project. AROME is run on 2.5 km resolution once a day up to 24 hours and for two different areas of Scandinavia.
The benefit of using AROME in contrast to e.g. MM5 is, from a MATCH model perspective, that weather data are provided on hybrid vertical layers, that has been the bases for the MATCH model since its development in the early 90's. The specific challenge has been to use non-hydrostatic data in a model that uses the hydrostatic assumption to determine the vertical discretization and the vertical wind. Moreover, in order to ensure mass conservation we use an initialization of the horizontal winds that restore the wind and mass balance disrupted by internal time interpolation of data (Heimann & Keeling, 1989). The initialization procedure is also based on the hydrostatic assumption.
We are able to use non-hydrostatic input data and still have mass conservation. One of the issues we have to penetrate is to what extent we are "washing out" the non-hydrostatic information by the procedures adopted in the MATCH mode.

A15. Mikhail Sofiev: Aerosol species in the AQ forecasting system of FMI: possibilities for coupling with NWP models

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A new version of the Emergency and Air Quality Modelling System SILAM is presented highlighting the various types of aerosols and their inter-actions represented in the model. Possibilities for 2-way interfacing of the SILAM output with the NWP models are discussed.
The SILAM system v.4 has two dynamic cores – Lagrangian and Eulerian – with corresponding structural elements, such as horizontal and vertical grid compilation, post-processors for the model output, etc. The underlying part of the system consists of meteorological and emission pre-processors, and also includes various supplementary routines.
Since February 2006, the SILAM system is used in operational forecasts of air quality over Europe presented at http://silam.fmi.fi. Presently, the forecasts are generated using the Lagrangian core of SILAM v.3.8.1, while the Eulerian system v.4.0.1 is used for parallel runs and model-model inter-comparison. It is expected that the old system will be phased out providing the successful completion of the parallel runs and model inter-comparison at the end of May.
The species currently included into the Eulerian-system simulations are the following:
- primary EC and OC aerosol, which also includes conservative estimates of direct anthropogenic dust emission. Two size classes are considered after the EMEP emission inventory: PM 2.5 and PM 2.5 – 10.
- sulphur oxides, sulphates representing the fine-size (PM 2.5) secondary inorganic aerosol
- sea salt particles computed for 5 bins: PM 0.01, PM 0.01-0.1, PM 0.1-1, PM 1-2.5, PM 2.5-10
- birch pollen (22 µm particles)
The extended chemical mechanism with NO_x chemistry transformation and nitrates and ammonia completing the secondary inorganic aerosols is currently being tested.
Possibilities for feedback from the SILAM system to NWP models can go along two main lines.
1. Direct aerosol effect on radiation, which can be easily computed via conversion of the 3D aerosol concentration to AOD. Both 2-D (bulk change of radiation at the surface) and 3-D (vertically resolved) impacts can be evaluated with appropriate influence onto temperature profiles. The effect, however, is believed to be limited and small for most of typical conditions, except, possibly, for the largest cities and desert areas during storm episodes.
2. Indirect effect of aerosols via cloud and precipitation formation. Potentially, it has much stronger impact than the direct radiate forcing but it is also much more complicated in implementation because in most NWP systems the cloud microphysics is treated in a simplified manner, which does not easily allow for detailed external information regarding the aerosol forcing.

A16. Oswald Knoth: The online coupled atmospheric-chemistry-aerosol model LM-MUSCAT

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The modelling department of the IfT has developed the state-of-the-art multiscale model system LM-MUSCAT . It is qualified for process studies as well as the operational forecast of pollutants in local and regional areas. The model system consists of two online coupled codes. The operational forecast model LM (Local Model) of the German Weather Service is a non-hydrostatic and compressible meteorological model. Driven by the meteorological model, the chemistry transport model MUSCAT (Multi-Scale Atmospheric Transport Model) treats the atmospheric transport as well as chemical transformations for several gas phase species and particle populations. The transport processes include advection, turbulent diffusion, sedimentation, dry and wet deposition. Due to the online coupling between LM and MUSCAT, the calculations exploit the actual properties of the atmosphere. The implicit-explicit time integration scheme of MUSCAT operates independently from the meteorological model, thus allowing for autonomous time steps and different horizontal grid resolutions in selected regions of the model domain.
The coupler provides MUSCAT with meteorological fields like temperature, humidity, and density from LM. To provide consistent mass fields a projection step is included to fulfill a discrete mass continuity equation. In contrast to other approaches all three components of the wind field are corrected, which leads only to a small correction of the vertical component of the wind field. Moreover, a feedback is implemented whereby the aerosol particle distribution calculated by MUSCAT influences the aerosol optical thickness and, hence, the radiation budget in LM.
In the parallel version of the code each processor is assigned to carry out one partition of the coupled codes alternately. Since the workload of each model code is distributed equally over all processors, imbalances between the model codes are compensated. All processors first calculate the meteorology over one coupling interval. Then the meteorological coupling data are exchanged and all processors continue with the calculation of chemistry-transport over the same interval. Required arrays for feedback are sent from MUSCAT to LM, before the next coupling step is performed.
Two applications with different characteristics are presented. The "Europe" scenario has been utilized to supply boundary values for a scenario in a nested region. The model region comprises central Europe. The "Samum" scenario is used for investigations of the influence of Saharan dust particles on the radiation budget . The emission, transport, and deposition of dust particles without aerosol dynamical processes are considered. A uniform grid of 150 x 150 horizontal cells is used in LM and MUSCAT.

A17. Rene Redler: The PRISM support initiative, COSMOS and OASIS4

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PRISM provides the Earth system modelling community with a forum to promote shared software infrastructure tools. The ever increasing complexity of Earth system models and computing facilities is a heavy technical burden on the research teams developing them. The goal of PRISM is to help share the development, maintenance and support of standards and state-of-the-art software tools to assemble, run, and analyse the results of Earth system models based on component models (ocean, atmosphere, land surface, etc..) developed in the different climate research centres inside and outside of Europe. PRISM is organised as a distributed network of experts who contribute to five "PRISM Areas of Expertise" (PAE): Code coupling and I/O; Integration and modelling environments; Data processing, visualisation and management; Meta-data; and Computing issues. In the first part of the presentation we will briefly introduce the general PRISM concepts and discuss the use of the PRISM infrastructure within the COmmunity earth System MOdelS (COSMOS) project.
In the second part of the presentation we focus on one of the PRISM tools, the OASIS4 coupling and IO software that has emerged from and is further developed within the PRISM initiative. The aim of OASIS4 is to provide a portable, efficient and easy-to-use open source software package. This includes a concise application programmer interface (API) to manage the coupling of arbitrary climate component models as well as the I/O of each individual component. In this presentation we will focus on the way how OASIS4 drives the whole coupled model, ensuring the synchronization of the different component models, the parallel neighborhood search, the exchange and interpolation of coupling fields directly between the components or via an additional coupling process, and the I/O actions from/to files.

A18. Marko Kaasik: Running the SILAM model comparatively with ECMWF and HIRLAM meteorological fields - a case study in Lapland

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This modelling study is based on the aerosol measurement campaign carried out in April-May 2003 in the Värriö monitoring station in Finland, Eastern Lapland, close to the border with Russia. On the generally low aerosol background of Arctic spring a few pollution episodes (up to 30 mg/m3 of PM10) were observed.
First, the SILAM model was applied in adjoint mode to identify the sources of pollution. It was found that the highest peak of aerosol (night of May 2-3) most probably originated from the Nickel metallurgy factory at Kola Peninsula, Russia, about 200 km North from Värriö. Then SILAM was applied in direct mode comparatively with ECMWF and HIRLAM (FMI) meteorological datasets (EMEP emission data on sulphate and PM). The well-tested Lagrangian kernel and new Eulerian kernel (heavily under construction) of SILAM were applied with both datasets, thus producing four comparative runs.
In large scale the concentration patterns produced in all four runs were rather similar, but some differences concerning the May 2-3 peak appeared critical for local measurement-modelling comparison:

- the Lagrangian plume with ECMWF data missed the monitoring station;
- the Lagrangian plume with HIRLAM data matched the monitoring station;
- the Eulerian plume with ECMWF data matched the monitoring station;
- the Eulerian plume with HIRLAM data missed the monitoring station.

In general, the Eulerian scheme produced much wider horizontal spread than the Lagrangian one. Differences were found in vertical spread as well. The reasons of large differences are under research yet. The weather situation during the May 2-3 peak was complicated due to a small high-pressure system with centre located close to the line between the source and the monitoring site. Thus, wind was weak, changing rapidly in space and time. In such conditions small discrepancies in both meteorological fields and ways to treat these in the dispersion model become essential.
We learn from this exercise that both nearly correct and severely wrong predictions for a single-point measurement can be done by several ways. Moreover, interaction between a NWP and an AQ model produces non-linear effects for the accuracy of end results.

A19. Johannes Flemming: Coupling global CTMs to ECMWF integrated forecasts system for forecast and data assimilation within GEMS

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We present the first results of the coupled forecast and assimilation system developed within the GEMS subproject on Global Reactive Gases (GRG). The two-way coupled system consists of ECMWF's integrated forecast system IFS and one of the Chemical Transport Models (CTM) MOZART, TM5 and MOCAGE. In the coupled system, IFS sends meteorological data at high temporal resolution to the CTMs. The CTMs provide concentration tendencies due to emissions and chemical conversion as well as initial tracer conditions to IFS. The application of external tendencies is required in IFS because its 4DVAR data assimilation needs to account for tracer source and sink terms which are not simulated in the IFS model. Moreover, the tracer transport may benefit from ECMWF vertical transport schemes.
The operational forecast and assimilation of satellite observations of NO2, CO, SO2, O3 and CHOH with IFS as well as the provision of boundary conditions for regional air pollution model are the main objectives of GRG.
The coupled system has been applied in forecast mode for several months in 2003 in different configurations in terms of vertical transport and coupling synchronization. Test assimilation runs of CO by MOPITT have been carried out for several weeks. The results have been compared with CO and O3 profiles of the MOZAIC data set.
This presentation focuses on the coupled forecasts, and will cover the following topics:

- Impact of external tendencies on IFS tracer simulations,
- A diagnostic NOx inter-conversion operator to account for fast chemical reaction which cannot be correctly captured by external tendencies,
- Differences in the vertical transport among the CTMs and in comparison with IFS,
- Impact of the 1-hourly meteorological input in comparison to the 6-hourly input in the CTM stand alone runs,
- Practical experiences with the coupling software OASIS4, and performance issues,
- Plans for further developments for pre-operational services within GEMS at ECMWF.

A20. Bob Bornstein: Experiences on application of meso-model output for ozone simulation

Bob Bornstein

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NO ABSTRACT SUBMISSION

A21. Barbara Fay and Sandro Finardi: Off-line model integration: EU practices, interfaces and possible strategies for harmonisation

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In COST728, a survey of the very many and diverse modelling communities in European countries was performed based on COST partner contributions. Thus, the model coverage remains incomplete and somewhat arbitrary although contributions represent a wide spectrum of modelling complexity and effort in 16 European countries and 40 institutions.
The majority of the presented systems are based on mesoscale meteorological models available at the national weather services or in weather forecasting consortia (i.e. HIRLAM, COSMO (Lokalmodell), ALADIN) and on international free community models developed by universities (i.e. MM5, WRF, MC2, RAMS). This approach allows the air quality modelling community to take advantage and benefit from the development, testing, and model validations done for the purpose of weather prediction. At the same time it provides users without large own development capacities or with the need for a standard system to apply model systems supported by a wider community.
The modelling components that deal with transport and transformation of atmospheric pollutants are more diverse than the MetMs, ranging from a simple passive tracer along a trajectory (i.e. CALPUFF) to a complex treatment of reactive gases in an Earth system (i.e. MESSy).
The wide spectrum of model applications ranges from diagnostic or climatologic AQ assessments, episode analysis and source apportionment to forecasting AQ, urban AQ and radioactivity (and environment) emergencies. This large variety of modelling systems can be considered a scientific richness but creates problems of model result inter-comparison and underlines difficulties in model development collaboration in Europe.
The survey also shows quite a surprising number of at least 9 more or less complex on-line coupled MetM and CTM model systems already being used in Europe (and America).
The communication between off-line coupled meteorological and AQ models is a problem of often underestimated importance. The multitude of modelling systems previously introduced give rise to different approaches and methods implemented within interface modules. Tasks covered by interfaces are minimized in coupled systems relying on surface fluxes, turbulence and dispersion parameters (i.e. eddy viscosity) provided by the meteorological driver. Other systems use interface modules implementing surface and boundary layer parameterizations to estimate dispersion parameters. Sometimes these last choices are due to the need to rely on “standard” meteorological products and to guarantee the AQ modelling robustness for practical applications. In other cases interfaces are used to enhance local physiographic data resolution and possibly introduce advanced parameterizations (e.g. urbanization). Atmospheric physics parameterizations, and even default or limit values assumed for some key parameters, can have relevant effects on pollutant concentration fields in critical conditions (e.g. low wind and stable conditions). Moreover, interface modules involve the evaluation of emissions of some relevant species that can be strongly influenced by meteorology, like biogenic VOC, windblown dust and sea salt spray.
In the diverse landscape of European modelling, model harmonisation remains an important issue despite earlier efforts, e.g. COST710 (1994-1998) which are continued in the regular Harmonisation conferences. Modular modelling, flexible IO strategies and adaptable interfaces following agreed guidelines for off-line and on-line integrated modelling, which are applied by all including the large consortia and community models, would greatly facilitate model improvement and applicability for European users.

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44	Yang Xiaohua	Danish Meteorological Institute	Denmark	xx @ dmi.dk
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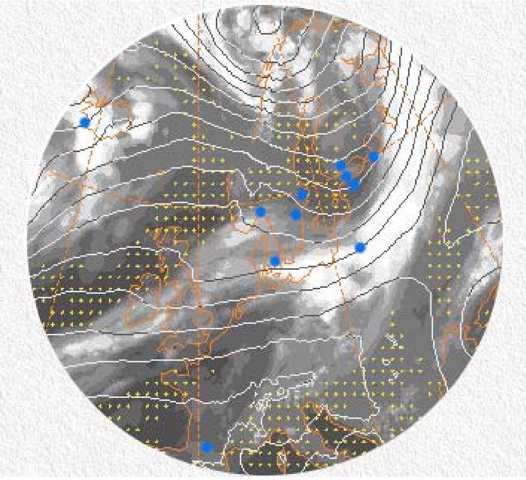
6. Nordic Network on Fine-scale Atmospheric Modelling (NetFAM)



Nordic Network on Fine-scale Atmospheric Modelling NetFAM (http://netfam.fmi.fi/) unites 18 Nordic, Baltic and French meteorological institutes into research and training network funded by

NordForsk

(NordForsk (http://www.nordforsk.org/), former NorFA):

"Nordic Network of Fine-scale Atmospheric Modelling (NetFAM) aims at complex and comprehensive promotion of fine-scale atmospheric modeling of Nordic-Baltic regional weather and climate processes and man--environment interactions, with strong emphasis on specific qualities of Nordic natural environment and the Baltic Sea influence. To achieve these objectives, the network is designed to cover the whole chain from basic research and researcher training towards the application of the models. The network shares modelling tools, observational and physiographic data, computing and educational resources, in order to strengthen the expertise in the area of fine-scale atmospheric modelling in the Nordic countries and adjacent areas around the Baltic Sea. " (from the project plan)

NetFAM national teams : 9 national teams, each representing 2 institutes:

Denmark	Danish Meteorological Institute	http://www.dmi.dk/
	Department for Geophysics, University of Copenhagen	http://www.gfy.ku.dk/ gfy_welcome_eng.html
Estonia	Estonian Meteorological and Hydrological Institute	http://www.emhi.ee/
	Department of Environmental Physics, University of Tartu	http://meteo.physic.ut.ee/kkfi
Finland	Finnish Meteorological Institute	http://www.fmi.fi/en/
	Division of Atmospheric Sciences, University of Helsinki	http://www.atm.helsinki.fi/
France	National Research Center, Meteo France	http://www.cnrm.meteo.fr/
	Department of Aerology, University of Toulouse	http://www.aero.obs-mip.fr/
Iceland	Icelandic Meteorological Office	http://www.vedur.is/
	University of Iceland	http://www.hi.is/
Lithuania	Lithuanian Hydrometeorological Service	http://www.meteo.lt/
	Department of Hydrology & Climatology, University of Vilnius	http://www.vu.lt/
Norway	Norwegian Meteorological Institute	http://www.met.no/
	Department for Geosciences, University of Oslo	http://www.geo.uio.no/
Russia	Russian State Hydrometeorological University	http://eng.rshu.ru/
	Main Geophysical Observatory	http://www.mgo.rssi.ru/
Sweden	Department of Meteorology, University of Stockholm	http://www.misu.su.se/
	Swedish Meteorological and Hydrological Institute	http://www.smhi.se/