COST-728/NetFAM workshop on
"Integrated systems of meso-meteorological and chemical transport models"
DMI, Copenhagen, 21-23 May 2007

Notes on 'HIRLAM/HARMONIE-ACT models integration' discussion session arranged on Tuesday 22 May

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Section aim and reasons of the meeting

The main idea of the section is to get together for NWP and ACT modellers, discuss and build our joint strategy for developing integrated system(s) based on HIRLAM. The HIRLAM consortium and ACT modellers in HIRLAM-organisations have some interest and initiatives in such integration, but they work separately and have very low level of coordination and cooperation. There are also several attempts in this direction, including the following.

DMI is actively working with development of the on-line integrated system Enviro-HIRLAM, considering aerosol forcing mechanisms, etc. Most of HIRLAM-members institutes are using national HIRLAM NWP outputs as meteo-drivers for their ACTP modelling and air quality forecasting activities. They already have attempts to build off-line integrations of HIRLAM with own ACT models (CAC, Chimere, DERMA, EMEP, MATCH, SILAM). Such work was also included in the HIRLAM-A development plan (S4.10/4.5 Task: Coupling with atmospheric chemistry). The 'Integration' WG2 in COST 728 involves 5 HIRLAM-member institute representatives (DMI, FMI, Met.no, SMHI, Estonian Tartu Univ.), and they are willing to consolidate and coordinate joint efforts in this work for coupling HIRLAM with ACT models.

Notes from the discussion

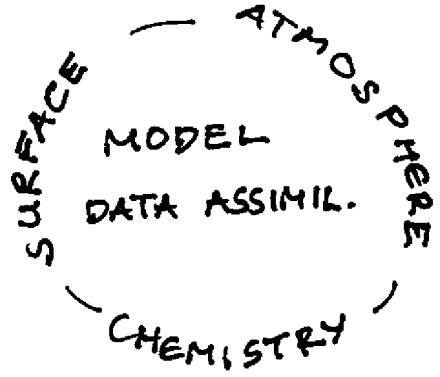
In the discussion session, short presentations by Alexander Baklanov, Sander Tijm, Lennart Robertson and Allan Gross were given (available at the workshop site at http://netfam.fmi.fi/Integ07). The discussion roughly followed a list of items suggested in Sander's presentation: interfaces, NWP output parameters needed by ACT models, species influencing in weather prediction, suggestions for a chemical module of HIRLAM. In the following notes, individual discussion topics are shown in free order, adding also some elements that were touched outside the HIRLAM-HARMONIE session.

Should the NWP model (HARMONIE) produce air quality forecast in addition to the weather forecast?

- No exact answer was agreed for the current stage, however, some steps forward in this direction should be done and an interface allowing both on- and off-line coupling of HARMONIE and air quality models should be built.
- In perspective, the integrated NWP-ACT modelling may be a promising way for future atmospheric simulation systems leading to a new generation of models for improved meteorological, environmental and "chemical weather" forecasting. The online integration of meteorological and ACT models gives a possibility to consider feedbacks of air pollution (e.g. aerosols) on meteorological processes and climate forcing, therefore it could also improve the weather forecasting itself.

Interfaces and coupling methods

- Use universal, well defined and documented software like OASIS4 ?
- Coding standards, interface rules, definition of the coupling parameters
- Coupling of atmospheric model, chemistry and surface scheme both in data assimilation and prognostic regimes:
- Within HARMONIE cooperation, working group on (surface-related) interfaces are working: include chemistry aspects?



What is the importance for ACT and weather models of the good description

- Initial state (data assimilation)
- Surface description (orography, land use, vegetation...)
- Sources and sinks (surface fluxes and emissions)

Use the same physiography data base for surface, atmosphere and chemistry, but applied parameters depending on application?

Importance of data assimilation in the ACT

- In the discussion, the importance of data assimilation was stressed
- Very different amount and character of available meteorological and chemical observations
- Using 4DVAR to include and combine all information

Consistency of numerical algorithms (advection schemes) between ACT and NWP

- possibly different mass conservation requirements in ACT and NWP models,
- improvement and harmonisation of advection schemes is important.

What do the ACT models expect from NWP models (HIRLAM/HARMONIE) - experience of ENVIRO-HIRLAM:

- microphysics, which would allow building of advanced cloud-aerosol interactions (indirect aerosols effects)
- radiation parametrizations, which would allow inclusion of direct and indirect aerosol interactions
- improved 3D output of cloud information for off-line coupling with ACTM
- improved PBL properties, especially PBL height
- modular structure allowing easy modification of needed parametrizations

How would the ACT model utilize improved information if NWP model would produce it?

Boundary layer parameters of NWP and ACT models

Should the ACT models use the (boundary layer) parameters of NWP models as such or use own meteorological preprocessors to calculate them? Which parameters are suitable for common use? Is the consistency more important than differences resulting from different methods of calculation?

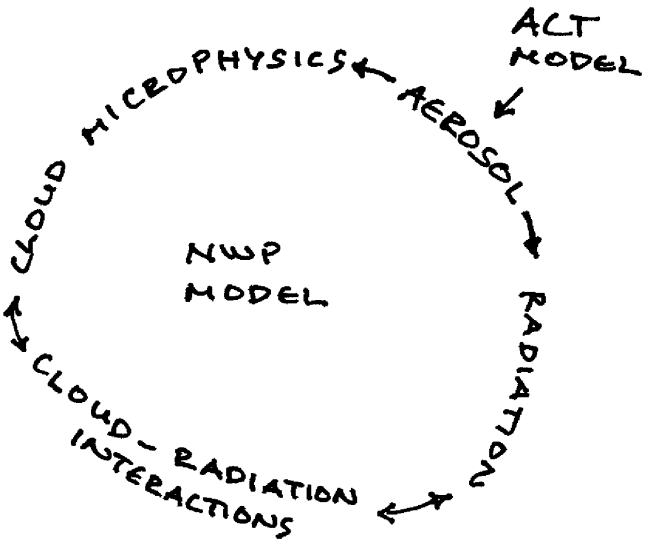
Boundary layer height
- A parameter crucial for ACT models (mixing height), also central in new turbulence parametrizations suggested for NWP (Zilitinkevich et al)
- Not a well defined parameter, sensitive to input data and methods of calculation
- Not observed directly (except new possibilities of satellite-based information, ceilometers, etc.)

What species are expected to influence the weather?

- All greenhouse gases warm near-surface air.
- Aerosols: sea salt, dust, primary and secondary particles of anthropogenic and natural origin.
- Some aerosol particle components warm and others cool the air. Warm the air (by absorbing solar radiation and thermal-IR radiation): black carbon, iron, aluminium, polycyclic and nitrated aromatic compounds. Cool near-surface air (by backscattering incident solar radiation to space): water, sulphate, nitrate, most of organic compounds.
- Different mechanisms of aerosols and other chemical species affect meteorological parameters (direct, indirect effects, …).

Sensitivity studies are needed to understand the relative importance of feedbacks. How to prepare a portfolio of feedbacks? First experience of ENVIRO-HIRLAM indicate some sensitivity to effective droplet size modification in radiation.

ECMWF experience: about five basic aerosol parameters, each with an integrated effective size have been included into the NWP model - sea salt, dust, primary and secondary aerosol species ... Also data assimilation poses limit to the number of variables included.



Urbanization

In ENVIRO-HIRLAM:
- Surface improved description for urban areas: roughness, albedo, urban heat sources.
- Properties of urban aerosol used to modify the albedo characteristics and the effective radius of cloud droplets for the SW radiation (in the HIRLAM radiation scheme).

In FUMAPEX , two other more sophisticated urban schemes: BEP (Martilli) and SM2-U modules were tested. They are more expensive computationally.

Town heat balance module is a part of SURFEX, available in HARMONIE framework.

Handling of the finest-scale details of momentum fluxes in town (forest) canopy could be developed.

Inline chemistry in integrated models

Advantages

- Atmospheric model takes care of the transport (advection, vertical movement)
- Consistency of the numerical algorithms and parameter definitions follows automatically
- Feedbacks may be included with maximum time resolution
- Input-output and data storage can be kept in a minimum level

Disadvantages

- Loss of flexibility in combining different atmosphere-surface-chemistry modelling systems and components

- Possibly heavy and complicated all-purpose-systems, whose application to individual (simple) tasks is not straight-forward

Within HARMONIE, SURFEX has recently *externalized* from the surface parametrizations in inline model environment, to allow greater flexibility.

Candidates for chemical module in HARMONIE

- No need to invent everything from the beginning - use experience of WRF and others
- A WRF initiative, open to all developers: working group on physical and chemical parametrizations in integrated models (e-mail georg.a.grell "at" noaa.gov)
- ENVIRO-HIRLAM with the CAC chemical model could be used as basis for further development

Conclusions, next steps

- Preparation of discussion paper about integration of NWP and ACT models for HIRLAM - HARMONIE management, to form a starting point for further planning.
- Reporting ENVIRO-HIRLAM development progress, strategy and comparative analysis of on-line versus off-line coupling and model runs with versus without aerosol feedbacks.
- Report and further work within WG2: 'Integration' in COST 728 involving 5 HIRLAM-member institute representatives (DMI: A. Baklanov, FMI: M. Sofiev, Met.no: V. Ødegaard, SMHI: V. Foltescu, Tartu Univ.: A. Männik).
- Organisation of an initial working group in HIRLAM-ACTM for further work and a sub-program (not completely inside the HIRLAM-A plan) for the ENVIRO-HIRLAM development cooperation.
- Meeting/training course about fine-scale integration aspects within NetFAM 2009.