The HIRLAM physics towards meso-scale

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1 Vision for Hirlam

The vision of the Hirlam Programme is to provide the best available meso-scale (1-3 km) modelling system to be operational in the member countries 2010. The reasons for this are

- Necessary to resolve weather in mountaineous areas
- Needed for very short-range prediction of severe weather of precipitation and particularly connected with convection
- More detailed and higher resolution forecast for many applications such as air pollution dispersion modelling, wind energy, disastrous releases of dangerous agents, etc.

To provide such a model requires:

- Non-hydrostatic and efficient dynamics
- Meso-scale advanced physical parameterisation
- Advanced meso-scale data assimilation with many new data sources
- Probabilistic forecasting
- Transparent Boundary conditions

Most of these items are additional to the previous Hirlam Projects of synoptic scale modelling at resolutions that used to be around 50-20 km, although some of the physical parameterisation and data assimilation have common components or framework with the synoptic modelling.

At the same time, Hirlam will also continue to provide a synoptic scale system for regional (Atlantic) scales and of resolutions of around 10 km. The reasons for this are

- To provide the meso-scale forecasting system with the most recent boundary conditions, with high resolution in space and **time** and with certain consistensies in the physics
- To provide members with a high quality regional forecasting system that is at least of eaual quality as available alternatives but is run more frequently (as demanded) with short cut-off after observations have been made
- To provide members with a high resolution (in space **and** in time) comprehensive set of forecast variables to be used for a wide range of forecasting applications and also to drive other models

2 How to achieve the goals

Hirlam is not going to develop a new meso-scale model of its own. It is a large effort and takes several years. The Project does on have enough dynamics staff currently, even though a pressure coordinate anelastic non-hydrostatic dynamical core was developed by Tartu University, outside of the Project. The time and resources are crucial and besides to embark on a new model would mean a lot of duplication in Europe.

In order to re-gain lost time and to get critical mass in all areas, the Project has concluded that it is necessary to collaborate with other partners. Hirlam has a long established collaboration with Météo-France (it is member of Hirlam since 1992) and there is good experience of this collaboration and it should be increased whenever possible. There have been large advances in the non-hydrostatic dynamics of the ALADIN model, developed in partnership with ALADIN members. By using parts of the physics from Méso-NH in France, Météo-France has an advanced project aiming for operational meso-scale forecasting, called AROME. This coincides very much with the ambitions and needs in Hirlam and the Project sees several opportunities for mutual benefits and contributions. Furthermore, ALADIN is using the main part of the ECMWF IFS code and is syncronised with this, and this brings benefits from ECMWF as well. ALADIN and Hirlam models and data assimilation have several common components and ALADIN was developed with ideas from Hirlam.

To achieve all the benefits of collaboration, the Project has decided for a **code** collaboration with ALADIN. This will ensure that also future developments on both/all sides will go into the common system and is a vehicle to actually share the work. The price to pay is that one needs to be committed to syncronise-phase the code at regular intervals and this requires quite a lot of work. The benefits are however expected to be much larger than the extra efforts. The research plans in the areas of collaboration (first the meso-scale activities) are to be coordinated. For the next Hirlam and ALADIN projects the MoUs of the organisations need to include the collaboration and details will be regulated. Cross steering mechanisms need to be established.

It is evident that, even though the synoptic Hirlam model is thriving and used operationally and is undergoing development, in the long run it will be to much to maintain two modelling systems. The synoptic Hirlam model should be merged into the collaboration as well, and particularly the physics need to be interfaced. The dynamics are rather equivalent for the hydrostatic part, particularly if one compares with the spectral Hirlam model.

3 Hirlam model components and strategy

The Hirlam physics is quite state of the art for the synoptic scale (currently around 20 km grid resolution). The radiation is relatively simple but efficient and relatively good, the turbulence is a TKE scheme and has been the focus of much attention and development, the surface scheme is ISBA and is being enhanced with an explicit snow scheme. The condensation is of Sundqvist type and the convection scheme is a regularised Kuo scheme although a mass-flux Kain-Fritsch scheme is available and used by some. Meso-scale and sub-grid scale orography parametrisation has been developed. A number of these schemes have been developed in collaboration with Météo-France and also indirectly with Méso-NH.

The Hirlam strategy is not to try to model in the no-man's land between 8-4 km or thereabouts. Even though there are at least partially successful Hirlam applications in this range too, there are compelling reasons when dealing with resolved or parameterised convection that makes this range very difficult to model. Furthermore, the user requirements make it necessary to achieve as high resolution as possible.

There are several Hirlam components that should be suitable also in the meso-scale. The surface ISBA scheme is also designed for high resolution and the tiling is probably relevant even below 1 km resolution, due to nature. The TKE turbulence scheme is 1D and probably this is OK down to about 1 km but not lower. The Hirlam radiation scheme has been enhanced to include sloping surfaces and may be used still for some time. The cloud physics is not so advanced and in this area much more is needed. The sub-grid scale orography still needs parametrisation at 1 km. At the same time, there are the already mentioned similarities in the Méso-NH and AROME physics. The turbulence schemes have the same origins. The ISBA scheme is not tiled at Météo-France and is being externalised. There is significantly more advanced microphysical treatment in Méso-NH and this needs to be used in Hirlam too.

While Hirlam will continue to support and improve its synoptic physics, work is going on to integrate and interface it with ALADIN. The aim is to compare with AROME physics and integrate some AROME options or some Hirlam options with AROME. Options will be switchable and a Hirlam configuration will be defined.

There are several more challenges for the meso-scale forecasting system. The meso-scale data assimilation needs to be developed, even though there are many building blocks available. It is necessary to carry out probabalistic forecasting and modelling of uncertainties. Verification aspects will also require new methods in the meso-scale.

4 Recent work in Hirlam

The Hirlam group has acquired the ALADIN model set it up at ECMWF for compilation and exectution, to run some cases in a test period. This has been an extensive learning exercise but also some initial results could be seen, that seemed very reasonable. Work is ongoing to interface Hirlam boundaries and parts of the Hirlam physics has been interfaced.

During the recent years there has been a lot of activity to improve the Hirlam synoptic physics, in the areas of turbulence, surface parameterisation and surface fluxes mainly. It has been very important for the model to increase the surface drag and fill cyclones correctly, but without deteriorating the vertical wind profiles. Recently some good compromises, with a certain mixing also in stable stratification (but not excessive), increased orographic and vegetational roughness and a turning of the surface stress, have in combination with different roughness lengths for heat/moisture and momentum, resulted in large and important forecast improvements. The systematic errors of too moist and cold summer 2m forecasts have been much reduced and also the cold and moist spring problem are reduced. For further documentation, see Järvenoja (2005) and Eerola (2005) (from which some material was shown at the meeting and in the ppt presentation).

References

Eerola, Kalle, 2005: Verification of Hirlam version 6.3.5 against RCR in autumn conditions *HIRLAM Newsletter*, **47**.

Järvenoja, Simo, 2005: Experimentation with a modified surface stress. some earlier versions and RCR. *HIRLAM Newsletter*, **47**.