The future Hirlam at KNMI.

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Introduction

Within the Hirlam community there is a strong push towards the development of a non-hydrostatic model. This is partly caused by demands from users of meteorological data, but also partly because of the fear of losing the race with the centra running global models. This strong emphasis on the development on a very high resolution model may however pose a threat for the Hirlam project. In this contribution I will look at the pros and cons of non-hydrostatic model development and maybe point at a few alternatives that can enable a project such as the Hirlam project to survive without too much emphasis on the development of a non-hydrostatic model. This alternative can also be a possible road that KNMI will follow with respect to the future operational implementations of limited area models (LAM).

The push towards an ever increasing resolution

Global models, such as the ECMWF model, are running at an ever increasing resolution. The current resolution is about 40 km, next year they plan to run at a resolution of approximately 25 to 30 km. The members of the Hirlam community now run at resolutions of 5 to 25 km, which means that they are one to three steps ahead of ECMWF concerning the resolution of the model. One way of justifying the running of limited area models such as Hirlam is pointing at this higher resolution of the LAM.

In the Netherlands, however, we feel that this is not the only or dominant reason that can justify the running of a limited area model. Another, and probably more important, reason is the shorter cutoff time for the analysis that can be used in a limited area model, enabling these models to deliver the forecasts up to 6 to 9 hours before the global models. A second reason is the possibility for a higher update (analysis) frequency that can be used in limited area models. The third reason is the possibility to include more local observations in a locally run LAM while a fourth reason is the availability of much more model output from a model that is run locally, plus the knowledge about models (and what its output is worth) being available at the local institute. All these reasons justify the running of a local LAM.

It is therefore dangerous to justify the running of a LAM only by pointing at the resolution of a LAM. For most parameters postprocessing of a global model may result in equally good forecasts (or maybe even better because of the smoother nature of global models) as running a LAM. The extra value of a LAM therefore must come from the small scale features that can be resolved in LAMs and not in global models. The problem, however, with these features is that they are very difficult to analyse and predict, even in a LAM. The higher the resolution of a model, the more difficult it will probably become to analyse and forecast the smaller details at the right place and with the correct intensity. The credibility of a deterministic model with the users strongly depends on the meteorological structures being forecasted at the right place and time and with the correct intensity. We may therefore make it more difficult and dangerous than necessary by pushing for a resolution of e.g. 2 kilometer for a LAM.

The use for a NH-model in the Netherlands is very limited, because of the absence of steep orography. This does not mean that we do not see the importance of developing a NH-model. Such a model is very important for the correct modelling of the flow in areas with complex orography. Other situations where a NH-model is capable of forecasting the meteorological conditions better than a hydrostatic model are the impact of mountains on the precipitation distribution, also under severe convective conditions, and the dynamics of severe convection itself. A fourth application area of a NH-model is model development and research. This last application probably will be the initial role of a NH-model at KNMI.

Running a NH-model at a resolution of 1 to 3 km will require 25 to 1000 times more computer power than the institutes have available at the moment. To reduce the computational costs one could also think of a NH-model over a relatively small area, that follows the feature, e.g. a mesoscale complex, that is interesting to forecast. Such a small, flexible, rapid deployment model may be capable of representing strong, transient convection at a reasonable cost. What remains, however, is the problem of introducing such a weather system in a NH-model through the analysis.

Other options

Other options for the Hirlam community to pursue lie in the area of the analysis and ensembles and, still, the synoptic scale model. High resolution and high frequency analyses are necessary to make an optimum (cost effective) use of local observation systems. The high resolution high frequency analysis can aid the (automated) nowcasting where the model is used to integrate all different observations into a complete description of the atmosphere. It will however take development in the analysis as well as in the initialisation to enable the model to make an optimum use of the high resolution observations.

At the allstaff meeting in Madrid it was noted that the 3D-Var analysis is not capable of extracting more high resolution information from e.g. radar radial winds than the model can get from VAD or VPP radar wind profiles. This is caused by the rather broad structure functions that smooth the smaller details that are available in the radar radial winds. Development in the area of the analysis will therefore be necessary to enable a high resolution analysis, even at 10 km, let alone at 2 km in a NH-model.

The second area where development is necessary to enable high frequency analyses is the initialization. 4D-Var analyses will probably be too expensive in the near future to run at a high resolution so 3D-Var is the most probable analysis system to make a high resolution, high frequency analysis. This analysis will need an initialisation to remove the imbalances from the analysis. Up till now, however, the initialisation has given rise to spinup in the forecast. Launching digital filtering initialisation (DFL) and incremental digital filtering (IDFI) reduce the spinup to almost zero, but may have negative effects due to the averaging effect (DFL) or the impact on the analysis increments (IDFI).

Short range ensembles are also an avenue to pursue, and an area where there is demand from the users of short range forecasts. At the allstaff meeting results were shown from experiments with multi-model, multi-analysis, multi boundary and targeted ensembles. All these methods aim at producing ensemble forecasts with reliable probabilities, but they are computationally very expensive. Further it is not very clear if the multi-model, multi-analysis, multi boundary ensembles result in the correct probability distributions as you do not know exactly what differences are introduced at the starting point of all ensemble members and if you change the parameters that you are interested in.

Another and much cheaper way of arriving at probability forecasts may be the use of model output statistics (MOS). MOS can be used to derive probabilities from deterministic forecasts, but they may also be used to derive reliable probabilities from a small set of ensemble runs. Especially for the on/off features such as convection, MOS may be a reliable and cheap alternative for the expensive, brute force method of large ensembles. The strength of MOS was shown last year in a case over the Netherlands where all models, including Hirlam, did not forecast thunderstorms (or any showers at all). MOS forecasted a probability of around 50 to 60 percent of thunderstorms, based on deterministic output of Hirlam and ECMWF. Vertical motions at higher levels triggered this high probability in the MOS-forecast. Thunderstorms did materialize in this case, starting off as small showers at a height of a few km, that locally grew into weak thunderstorms with precipitation reaching the ground. Based on this example we think that MOS may be a good addition to the ensembles to create the correct probabilities.

Ensembles, high frequency analyses and in a few cases a rapid deployment, feature tracking, non hydrostatic model, are the future of Hirlam at KNMI. Putting too much emphasis on these developments, however, poses a threat that the larger scale model, that will always be necessary if only to create boundaries for a NH-model, will be neglected, while recent developments like the turning of the surface stress vector show (see the contribution of Bent Hansen Sass and others in this newsletter?) that a lot of progress still is possible for Hirlam at the larger scales. We therefore have to take care that the already thinly spread resources for the Hirlam development are not being directed too much towards the new areas.

Conclusions

Short range forecasts at KNMI will probably be produced by three different LAM-systems. For the first system the emphasis will lie on the rapid updates with analyses every hour. This system will be based on the current synoptic scale Hirlam. The second system will produce ensembles, but how the probabilities are achieved is not yet clear at the moment. The Spanish and Norwegian developments are followed with interest, but we also see a role for probabilities generated through MOS, possibly based on a small ensemble of short range forecasts. The third system is a NH-model, fed at the boundaries by the synoptic scale Hirlam, which may be feature tracking to reduce the computational cost.

From all the presentations at the allstaff meeting it is clear that there are many developments within the Hirlam community. The addition of a strong focus on the development of a NH-model may spread our resources too thin, which may result in the synoptic Hirlam receiving too little attention, while still much progress can be made in that area.