The 2016 upgrade of the operational NWP at DMI

Xiaohua Yang, xiaohua@dmi.dk, Danish Meteorological Institute (DMI)

During the past years extensive development has been carried out at DMI to extend its operational short range NWP configuration to kilometer-scale resolution with extended area coverage and with mesoscale probabilistic forecasts, aiming to improve forecast of high impact weather. The efforts are now seeing fruits with operational launch of several mesoscale deterministic and probabilistic forecast systems during late 2016 and early 2017. While these new configurations are mainly based on the nonhydrostatic mesoscale HARMONIE-AROME models (Bengtsson et al 2017) with release 40h1.1, numerous local adaptations and extensions have been implemented, especially with many innovations featured in the mesoscale COMEPS (COntinuous Mesoscale EPS) system.

Operational model domains. The new operational setups, NEA, IGA and COMEPS are all constructed at 2.5 km grid resolution and on spatially rather extensive domains. As illustrated in Figure 1, the model domain of NEA covers North Europe including Faroe Islands. NEA (Yang et al 2017a) is a deterministic suite with a 1280x1080x65 mesh, runs 54-h forecast 8 times a day with 3DVAR data assimilation using numerous observation data including satellite radiance, AMV, radio occultation bending angle. IGA (Yang et al 2017b) is a deterministic model covering Iceland and South Greenland with a 1000x800x65 mesh, offering 54h forecast 4 times a day. Finally, COMEPS is a 24-member time-lagged probabilistic forecast system with capability to produce mesoscale ensemble forecast for regions around Denmark, on a grid-mesh of 800x600x65 (Yang et al 2017c).

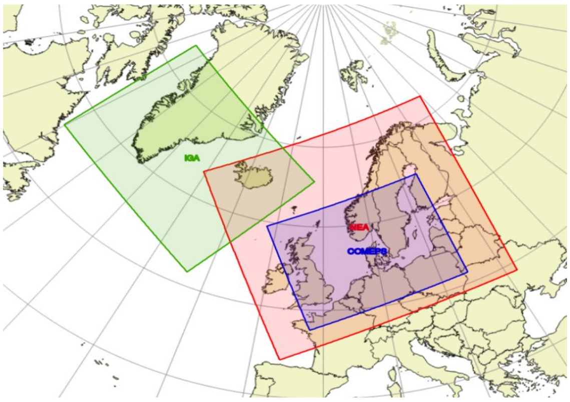

Figure 1: Operational weather forecast suites at DMI with 2.5 km grid spacing. The setup covers North Europe including Faroe Islands (domain NEA, in red), south Greenland and Iceland (domain IGA, in green), and Denmark(with COMEPS EPS, in blue) .

IGA configuration is a joint development between DMI and Icelandic Meteorological Office (IMO) in connection with IMO's hosting of the High Performance Computer (HPC) facility at its headquarter in Reykjavik. IGA brings forward unprecedented high resolution mesoscale forecast capability for Iceland and South Greenland, a region characterised by complex surfaces of high plateaus with glaciers, steep coastal orography, and associated, frequent occurrence of storms and extreme temperature. Significant efforts have been devoted to upgrade and evaluation of database for elevation over Greenland and Iceland, as well as information on glacier extent, soil characteristics, vegetation fractions, albedo and roughness as included in the physiographic database. From observation verification, operational IGA has shown advantages in forecast quality of wind, temperature and precipitation in comparison to other available operational forecasts run at coarser resolution, especially in detection of storms affecting coastal area. Due to an extensive domain coverage, IGA has also been seen to improve forecast of convective precipitation in west of Iceland associated with cold air outbreak, which has been difficult to capture for models with insufficient domain coverage (Yang et al, 2017b).

Construction of COMEPS, a time-lagged mesoscale EPS system with rapid update. For mesoscale EPS forecast system, it is highly desirable to maintain high resolution with adequate spread, good probabilistic forecast skills, with timely delivery and frequent update. Often, many of these virtues are unfortunately associated with high computational cost and hence difficult to achieve. To address such challenges several innovative features have been implemented in constructions of the new operational mesoscale EPS, COMEPS, at DMI. These include use of time lagging method, perturbation with multi-model, multi-physics, and configuration of data assimilation cycling on overlapping windows. The basic design of COMEPS data flow is that, first, rapid refresh data assimilation is performed each hour using latest available observation including synoptic, radar and satellite radiances. With hourly analysis as control, 4 perturbed forecasts are followed. This is repeated each hour around clock. As result, at any given hour of day, a forecast ensemble can be assembled in time lagged mode using all available perturbed forecasts launched during past 6 hour, resulting 4 member/hour x 6 hour = 24 member COMEPS ensemble. Obviously, in comparison to an EPS with conventional construction, a system constructed with COMEPS approach has advantages in terms of an increased temporal spread, frequent update using latest observations, and a more balanced, evenly distributed HPC load.

At present, COMEPS is a two model ensemble using both HARMONIE and HIRLAM forecast systems. Apart from obtaining spread through time lagging and multi-model approaches, COMEPS also utilises several perturbation techniques to enhance representation of uncertainties, such as use of Scaled LAgged Forecasting (SLAF) for lateral boundary perturbation, use of alternative option mix in physical parameterisation. Operational ECMWF forecast is used as lateral boundary condition via SLAF approach. Another novel configuration feature in COMEPS is the data assimilation cycling, which consists of three parallel sets of data assimilation cycles over overlapping time windows, providing additional opportunity to construct perturbation in initial condition. Radar reflectivity from 10 European countries radar network are assimilated.

Acknowledgements: The work reported in this review is result of collective efforts by colleagues at the research department of DMI.

References

Bengtsson, L., Andrae, U., Aspelien, T., Batrak, Y., Calvo, J., de Rooy, W., Gleeson, E., Sass, B. H., Homleid, M., Hortal, M, Ivarsson, K.-I., Lenderink, G., Niemelä, S., Nielsen, K. P., Onvlee, J., Rontu, L., Samuelsson, P., Santos Muñoz, D., Subias, A., Tijm, S., Toll, V., Yang, X., Køltzow, M. Ø., 2017: The HARMONIE-AROME model configuration in the ALADIN-HIRLAM NWP system, MWR, Vol 145, Nr 5.

Yang, X., B. S. Andersen, M. Dahlbom, B. H. Sass, S. Zhuang, B. Amstrup, C. Petersen, K. P. Nielsen, N. W. Nielsen, A. Mahura, 2017a: NEA, Operational implementation of HARMONIE 40h1.1 at DMI, Joint ALADIN-HIRLAM Newsletter 8, 2017.

Yang, X., B. Palmason, B. S. Andersen, B. H. Sass, B. Amstrup, M. Dahlbom, C. Petersen, K. P. Nielsen, R. Mottram, N. W. Nielsen, A. Mahura, S. Thorsteinsson, N. Nawri and G. N. Petersen, 2017b: IGA, Joint Operational HARMONIE by DMI and IMO. Joint ALADIN-HIRLAM Newsletter 8, 2017.

Yang, X., H Feddersen, B H Sass and K Sattler, 2017c: Construction of a continuous mesoscale EPS with time lagging and assimilation on overlapping windows. Joint ALADIN-HIRLAM Newsletter 8, 2017.