Application and verification of ECMWF products 2017

Danish Meteorological Institute (DMI)

Department of Forecasts and Warnings (Michael S. Kamp, msn@dmi.dk or Henning Gisselø hg@dmi.dk)
Research and Development, Weather Models (Contact: Bent H. Sass, bhs@dmi.dk)
Research and Development, Oceanographic models (Contact: Kristine Skovgaard Madsen, kma@dmi.dk)

1. Summary of major highlights

From DMI perspectives, ECMWF products have been used primarily for the following purposes:

a) Source of lateral boundary condition (LBC) for both operational and non-operational LAM activities.

b) Quality benchmarking in terms of short range forecast verification inter-comparison

c) Direct use in the Weather Operations Centre (Forecasts & Warnings)

2. Use and application of products

DMI operates several short range limited area NWP models based on HARMONIE-AROME (ref. (1), (3)) and HIRLAM forecast systems (www.hirlam.org) to provide weather forecasts of 0 to 60 h over Danish and Greenland domains. Also an advanced Limited area ensemble prediction system (COMEPS ~ **CO**ntinuous **M**esoscale **E**nsemble **P**rediction **S**ystem, ref. (4)) is operated, with rapid updates: 4 perturbed runs are launched every hour. Adequate verification systems have been implemented (ref. (2) and (4)) in order to compare forecast quality of LAM systems with that of ECMWF models.

For most of these LAM setups ECMWF forecast, including those of operational HRES, ensemble (ENS) and optional boundary condition (BC) forecasts, are used as LBC. In several applications ECMWF analyses or short range forecasts have also been included in the data assimilation and initialisation procedure as large scale constraints. In addition, ECMWF HRES and ERA-interim data have been used in research activities providing LBC data for HARMONIE and HIRLAM models.

In addition DMI operates a range of short- to medium range limited area ocean models, covering the North Atlantic ocean, the Arctic estuary, and north-western European shelf seas. These models use ECMWF NWP deterministic (HRES) forecasts to +144h issued twice a day as atmospheric forcing. Only surface fields are used.

For the Arctic and Atlantic Ocean, an operational ocean- and sea-ice model (HYCOM-CICE), with fine scale nesting's within the North Atlantic/Arctic Ocean (ref. 5), uses NWP weather data exclusively from ECMWF.

For the north-western European shelf seas, ocean model forcing is a blend of DMIs own NWP products and ECMWF NWP products. Ocean forecasts beyond 60 hours, and ocean forecasts for parts of the water body outside DMI-Hirlam or DMI-Harmonie model domains, rely on ECMWF weather forcing.

Ocean- and sea-ice model output is afterwards – if requested - used as input for an oil drift and particle drift model. The NWP surface wind is transferred in the process.

2.1 Post-processing of ECMWF model output

2.1.1 Statistical adaptation

So far DMI does not perform statistical corrections of the ECMWF forecasts.

2.1.2 Physical adaptation

Hourly ECMWF forecasts from HRES and BC suites are interpolated to rotated lat-lon grids (at 15 km grid resolution) to provide LBC for the LAM setups at DMI, including those of the HARMONIE, HIRLAM, nowcasting and dispersion models.

2.1.3 Derived fields

No derived products are made from ECMWF forecasts.

2.2 Use of ECMWF products

2.2.1 Use of Products

In operational duty DMI use ECMWF products for a wide range of forecasts. For the short term, up to 2 days, we use ECMWF products primarily to compare with our two main models HARMONIE-AROME and HIRLAM.

For forecasts from 2-7 days ECMWF is our main tool using the deterministic model, Ensembles, eccharts, plumes, clusters, ENS, ENS-Meteogram. In situations with severe weather DMI is using ECMWF fields as a second opinion to DMI warning/DMI risk for the first days. On longer ranges , e.g. 2-5 days ahead, DMI produces a five days forecast for severe weather and is using ECMWF HRES/ENS and on the web pages EFI-index, Extra-Tropical-Cyclones, and on eccharts also ENS with the special Danish criteria.

Besides DMI has special forecasters who produce 1-3 month trends using the tools that are available for monthly and seasonal forecasts, such as various anomaly charts, probabilities etc.

3. Verification of products

DMI performs regular quality monitoring of locally produced NWP forecasts, and includes ECMWF short range forecasts for verification inter-comparisons.

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS)

So far the verification procedure involving ECMWF HRES data have mainly been associated with validation against surface synoptic observations with a focus on inter-comparison of extracted forecast data (up to 54h) from ECMWF HRES and local NWP forecast for stations over Denmark, Greenland and the Faroe Islands. For routine monitoring, surface temperature, wind, precipitation, surface pressure and cloud cover are the key parameters. ENS forecasts have been regularly monitored in connection with the development of COMEPS system, primarily as a quality reference.

3.1.2 ECMWF model output compared to other NWP models

DMI monitors relative skills of short range forecast by its own LAM suites in relation to those of the ECMWF HRES forecast. While HRES continue to demonstrate an advantage on forecast of large scale parameters such as surface pressure and some upper air parameters (especially in winter half year), the gap appears to reduce in recent years, presumably due to higher LAM resolution and an improved data assimilation capability with the latter.

On the other hand, while LAM systems have traditional advantages in forecast skills for surface parameters such as T2m, W10m, in recent years a trend has been seen of improved standard deviation errors with HRES for such parameters in comparison to the LAM models, presumably due to improved resolution and parameterisation with HRES.

However, The LAM systems operated at DMI has still clear advantages, e.g. related with high model resolution:

a) Near surface wind diagnosed for Greenland and Iceland weather stations

An example of underpredicted 10m winds with ECMWF HRES is given in Fig. 1. This applies to an average of a large number of stations (252) and over 5½ months of the Iceland/Greenland domain. It is seen that wind speeds of storm (24 m/s) is very rarely produced as output from HRES. The regression line shown clearly indicates the under prediction of diagnosed 10m winds. The HARMONIE-AROME for Greenland domain has the potential to produce much higher extreme winds in the fiords of Greenland.

b) Small scale convection in Danish COMEPS model domain

Also the high resolution COMEPS ensemble prediction setup shows clear benefit compared with ECMWF counterparts. This is due to both increased horizontal resolution (2.5 km HARMONIE-AROME grid) and the frequent update of model runs (four perturbed runs per hour). The benefits are demonstrated by the operational ensemble prediction verification, e.g. in scores such as Continuous Rank Probability Score.

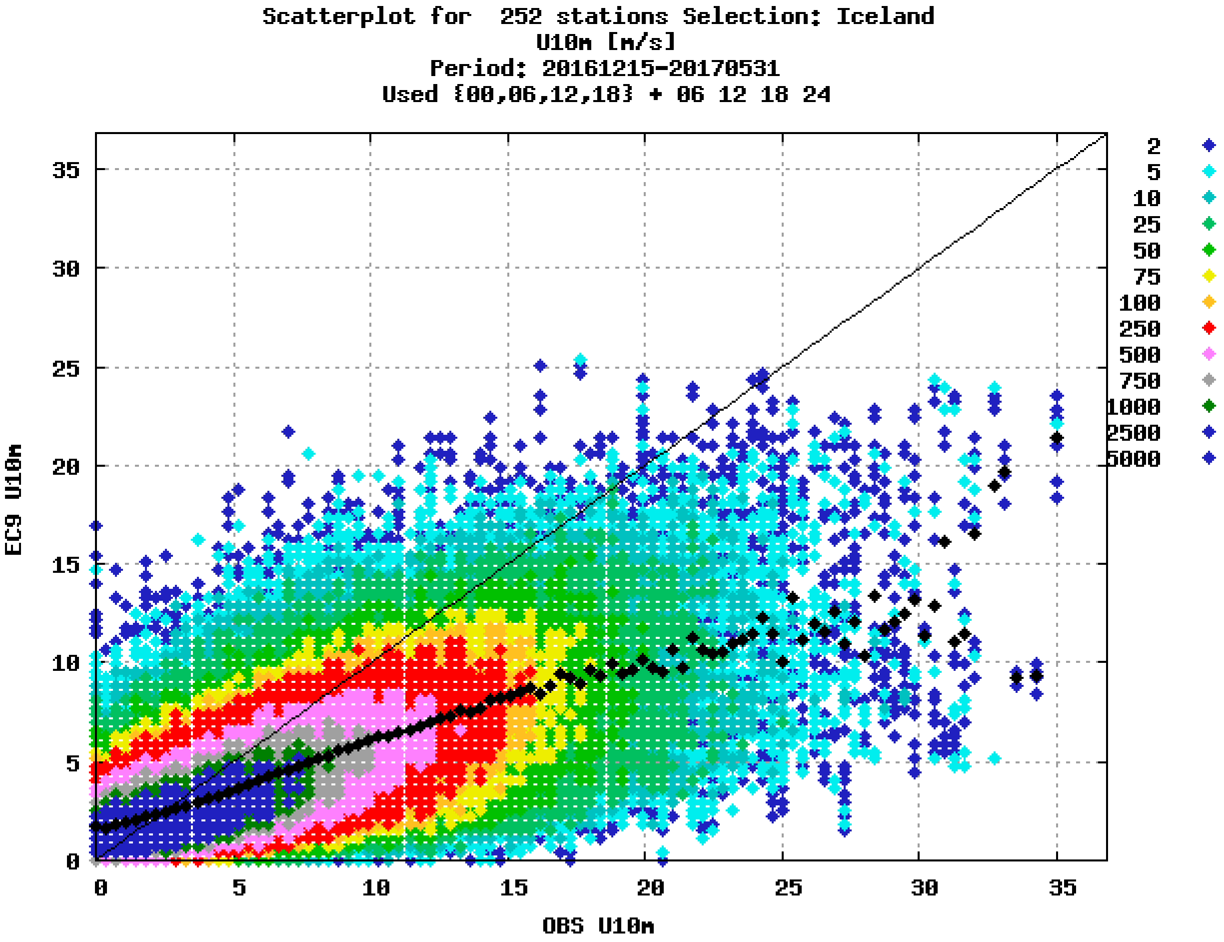

Fig1: Under-prediction of 10m winds by ECMWF model over Iceland/Greenland

3.1.3 Post-processed products

No verification is made on post-processed products form ECMWF

3.1.4 End Products delivered to users

The Weather Operations Centre produces daily a forecast 7 days ahead on basis of HRES/ENS. DMI makes an objective verification of temperature for DAY 0, DAY 3 and DAY 5. The scores for temperature ± 2° for the period from July 2016 to June 2017 are 92%, 87%,73 % respectively for ECMWF HRES and 94%, 90%, 77% for the forecaster.

4. Feedback on ECMWF “forecast user” initiatives

Regarding the pages: https://software.ecmwf.int/wiki/display/FCST/Known+IFS+forecasting+issues)
and the “severe event catalogue” (see: https://software.ecmwf.int/wiki/display/FCST/Severe+Event+Catalogue).

Both pages mentioned are not generally known except for the forecasters who have recently been to one of the courses. The severe event catalogue is a great page, but the duty forecasters are normally on a tight schedule, so there is no time to go into this.

5. References

(1) Bengtsson, Lisa, Andrae, U., Aspelien,T., Batrak, Y., Calvo, J., Wim de Rooy, Gleeson, E., Sass, B.H., Homleid, M., Hortal, M. , Ivarsson, K-I., Lenderink, G., Niemela, S., Nielsen, K.P., Onvlee, J., Rontu, L., Samuelsson, P., Muñoz, D.S., Subias, A.,Tijm, S., Toll, V., Yang, X., and M. Ø. Køltzow: The HARMONIE–AROME Model Configuration in the ALADIN–HIRLAM NWP System. *Monthly Weather Review*, 145(5):1919–1935, 2017.

(2) Sass, Bent Hansen and X. Yang, 2012: A verification score for High resolution NWP: Idealized and preoperational tests. HIRLAM Technical Report 69

(3) Yang, Xiaohua, Andersen, B.S., Dahlbom,M., Sass, B.H., Zhuang,S., Amstrup,B., Petersen, C., Nielsen, K.P., Nielsen, N.W. and A. Mahura: NEA, the Operational Implementation of HARMONIE 40h1.1 at DMI: *ALADIN-HIRLAM Newsletter No. 8, January 2017, p 104 -111*

(4) Yang, Xiaohua, Feddersen, F., Sass, B.H. and K. Sattler: Construction of a continuous mesoscale EPS with time lagging and assimilation on overlapping windows*: ALADIN-HIRLAM Newsletter No.8, January 2017, p 112-118*

(5) Madsen, K.S., Rasmussen, T.A.S., Ribergaard, M.H., and I.M. Ringgaard, 2015: High resolution sea ice modelling and validation of the Arctic with focus on south Greenland waters, 2004-2013. *Polarforschung*, 85 (2), 101-105, doi:10.2312/polfor.2016.006