Application and verification of ECMWF products 2018

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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)

d) Indirect use, providing surface forcing for regional ocean models

2. Use and application of products

DMI operates several 2.5 km NWP model setups for short range limited area NWP models based on HARMONIE-arome for daily weather forecasts of up to 66h over its service areas centred around Denmark, Greenland and Faroe Islands. Apart from conventional short range forecast at deterministic mode, it also includes a novice **CO**ntinuous **M**esoscale **E**nsemble **P**rediction **S**ystem with 25 member ensemble with hourly refresh through time lagging. In addition, a rapidly refreshing system with 3 km resolution, based on HIRLAM forecast system, is run hourly to cover the needs for nowcasting and for road condition forecast in Denmark and Faroe Islands. As the focus of the LAM forecasts are on short range, the model setups at DMI are typically run with 1 to 3h assimilation interval, with a short (0.5 to 1.5 h) observation data cut-off, enabling a frequent and early delivery. All forecast setup runs with 3D-VAR data assimilation with focus on use of radar, mode-s-EHS/aircraft data as well as synoptic and satellite data.

For all of the operational NWP setups at DMI, the operational HRES forecast at ECMWF, including those by the optional boundary condition (BC) forecasts, are used as lateral boundary conditions through direct coupling, normally with a 6 to 9 h time lagging. For COMEPS ensemble system HRES data from consecutive cycles during the latest days are used through the Scale Lagged Average Forecast (SLAF) scheme. The short range HRES forecasts have also been included in the HARMONIE data assimilation procedure as large scale constraints. In addition, ECMWF HRES and re-analysis data have been used extensively in research activities with DMI involvement, e.g. an adapted version of the HARMONIE-arome is used in the 24-year Copernicus Arctic Regional Reanalysis project with LBC from ERA5.

For verification and quality assurance of the operational NWP models, the HRES and ensemble forecasts (ENS) continue to be used as quality benchmark to assess quality evolution and added value with the LAM products.

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 HRES deterministic forecasts to +144h issued twice a day as atmospheric forcing. Only surface fields are used. This includes ice concentration.

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. 1), 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.

In the short run (up to appx. 48h) DMI mainly uses products DMI-HARMONIE and ECWMF products are used as a second opinion. Beyond 48h (up to 3 months) ECMWF products are the main source and some other global models (e.g. GFS) are used as a second opinion.

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, include surface and upper air pressure, wind, temperature and humidity, sea states (SST and ice fraction), are interpolated to rotated lat-lon grids (at 10 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 HRES products primarily to compare with DMI-HARMONIE.

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 monthly and seasonal forecasts using various ECMWF products such as anomaly charts, probabilities etc.

3. Verification of products

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

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS)

Analysis and short range forecasts from the ECMWF HRES and ENS are routinely extracted for verification and diagnosis purpose, mostly through multi-model inter-comparison. Validation is normally done against observations with radio sonding and surface synoptic data with focus on DMI's main service area centred around Denmark, Greenland and the Faroe Islands. For routine monitoring, surface temperature, wind, precipitation, surface pressure and cloud cover are the key parameters.

3.1.2 ECMWF model output compared to other NWP models

DMI monitors relative skills of short range forecasts by its own LAM suites in relation to those of the ECMWF HRES and ENS forecast, with a goal to monitor evolution of forecast quality and added value with the local NWP products. Overall, ECMWF HRES continues to maintain a general superiority on short range forecast for large scale parameters such as surface pressure and upper air parameters. Such tendency is most obvious in terms of standard deviation error, whereas it is a more for bias trends..

On the other hand, DMI's HARMONIE forecasts continue to show a general advantage in forecast skills for main surface parameters and in general, the prediction skill for summer convection. Especially for prediction of strong wind condition in Greenland as well as Scandinavia, HRES appears to be inferior to LAM models due to model resolution. HRES, e.g., seldom predicts coastal wind storms in Greenland. In general, though, HRES appears to have seen relative improvement in forecast skills (e.g. standard deviations errors) of the surface temperature and wind when compared to the LAM models, thanks, presumably, to improvement in resolution and parameterisation. Prediction of cloud and fog remain a weak link in the HARMONIE forecast for Scandinavia area. As a consequence, duty forecasters at DMI find it useful to also look at the HRES forecast. For Scandinavia winter condition, both ECMWF and HARMONIE models continue to suffer the weakness to model stable boundary layer especially during clear and calm situations, in which model tends to overestimate surface wind and temperature.

As having been found in previous inter-comparisons between ECMWF ENS and LAM EPS, ENS continue to be clearly under-dispersive for short range forecast of most key forecast variables. The figure below illustrate, as example, the averaged RMSE and SPREAD along lead time for 10m wind forecast during the month of March 2018 comparing ECMWF ENS and DMI-COMEPS. The spread in ENS compares clearly less than RMSE although it does grow rather quickly along forecast lead hour, indicating the EPS system being severely under-dispersive for short range. The trend remains clear after de-trending by taking away bias, (not shown here).

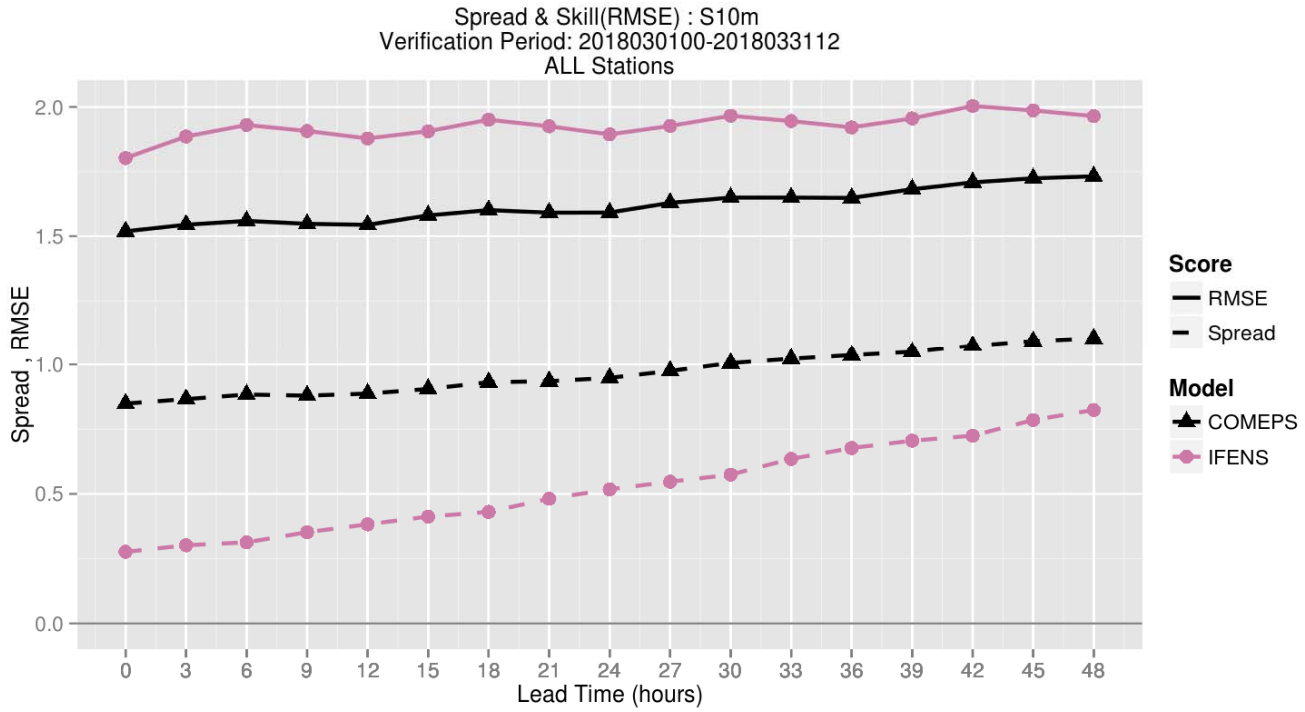

Figure. Averaged Spread (dashed)-RMSE (Solid) along forecast lead time for 10m wind , March 2018, comparing ENS (in magenda) and DMI-COMEPS (in dark) verified against synoptic stations over Scandinavia.

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 2017 to June 2018 are 95%, 86%,75 % respectively for ECMWF HRES and 91%, 83%, 73% for the forecaster.

4. Feedback on ECMWF "forecast user" initiatives

Regarding the use of the "Forecast User Portal" and the "Forecast User Guide".
The knowledge and use of the portal and the guide are, although quite useful, not generally incorporated among the operational forecasters.

5. References