Application and Verification of ECMWF Products 2019

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1. Summary of major highlights

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

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

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

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

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

2. Use and application of products

ECMWF forecasts (HiRes, ENS, seasonal forecasts) are used in DMI for

- production of routine weather forecast
- driving regional weather/ocean/dispersion models as lateral and/or surface boundary conditions

2.1 Direct Use of ECMWF Products

In operational duty, DMI uses 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 weather prediction from 2-7 days, ECMWF is the main model and the forecasters mainly use parameters from the deterministic model and especially the model run from 00 UTC and 12 UTC. The main products are data from the IFS deterministic model on NinJo workstations but also ensembles, plumes, clusters, ENS and ENS-Meteograms from ecCharts. The 06 UTC and 18 UTC model runs is used for boundary conditions to the DMI Storm Surge setup, and in 2019, the forecasters start to follow these model runs to better understand changes in the Storm Surge model.

In situations with severe weather, DMI is using ECMWF products as a second opinion to DMI warnings/DMI risks for the first days. On longer ranges, e.g. 2-5 days ahead, DMI produces a five day 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.

In addition, DMI has special forecasters who produce monthly and seasonal forecasts using several of ECMWF's extended range forecasts such as anomaly charts, large-scale mean flow, MJO index probabilities, etc.

To support military operations, DMI forecasters are working abroad. In these operations, the use of ecCharts with traditional parameters, but also specialized parameters, e.g. sand/dust storms, is very important.

2.2 Other uses of ECMWF output

2.2.1 Post-processing

2.2.2 Derived fields

In summer 2019, DMI will start to calculate Fire Weather Index for day h+72 – h+240 hours for the Danish area.

2.2.3 Modelling

The operational ECMWF HRES, including those from the optional boundary condition (BC) production, are used as lateral boundary conditions for main operational short-range NWP models with high resolution HARMONIE-Arome. Constrained by the delivery time, the ECMWF forecasts are used with time lagging, with a 6 to 9h delay. Apart from upper air parameters, gridded analysis data on sea states are also used by Harmonie-arome as part of the lower boundary condition. Presently, forecasts from HRES from consecutive cycles during the last days are also used in the operational ensemble system DMI-COMEPS (COntinuous Mesoscale Ensemble Prediction System) via the Scale Lagged Average Forecast (SLAF) scheme, although experimentation has been ongoing to test use of the ensemble members from IFENS system.

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. This includes several 3D ocean models as well as the WAM wave model. 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 within the North Atlantic/Arctic Ocean, uses NWP weather data exclusively from ECMWF.

For the ocean models covering the north-western European shelf seas – Baltic Sea area, the ocean models are forced with a blend of DMI's 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. These ocean products are used for Danish national obligations as well as within EU's Copernicus Marine Service.

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.

Furthermore, several ocean regional reanalyses performed or planned for at DMI are using the ERA5 reanalysis products as forcing.

3. Verification of ECMWF products

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 evolution and added values with the LAM products.

3.1 Objective verification

Describe verification activities and show and discuss related scores.

3.1.1 Direct ECMWF model output (both HRES and ENS), and other NWP models

In general, ECMWF short-range forecasts for basic surface parameters continue to perform well and stable, especially during weather situations strongly dominated by large-scale features. For precipitation and cloud cover, DMI forecasters often look at HRES for second opinions, which sometimes are better than the 2.5 km Harmonie-arome for weather situations like those during winter. For Greenland, basic forecast scores with HRES are found to have generally comparable quality to the 2.5 km Harmonie, with the main exception on wind prediction, which tends to be too weak and suffers systematic failure to detect strong wind storms e.g. during cold air outbreak. For several stations in southern Greenland with complex terrain, HRES is found to lack prediction skill for wind speed. As illustrated below, the wind forecast verification for June month of 2019 for station Narsarsuaq in southern Greenland is given in the figure, showing difficulties to represent features associated with strong orographic variability, which requires sufficiently high grid resolution to resolve.

After the recent upgrade, the present version of mesoscale ensemble forecast system DMI-COMEPS is a 19-member EPS on an extended domain with a 1200x1080x65 grid, covering Scandinavia, Iceland and Faroe Islands. COMEPS runs hourly control and perturbed forecasts, assimilating latest observation data. Using the lagged approach, these hourly-produced forecasts are assembled continuously to produce 51h probabilistic forecast. In contrast to the situation with intercomparison between the deterministic Harmonie model and ECMWF ENS, the advantages with high resolution COMEPS over those of IFS ENS remain pronounced in terms of probabilistic scores. IFS ENS continue to be severely under-dispersive for short-range forecast of most key forecast variables. In prediction of small scale convection cases, resolution advantage with Harmonie-arome appears crucial.

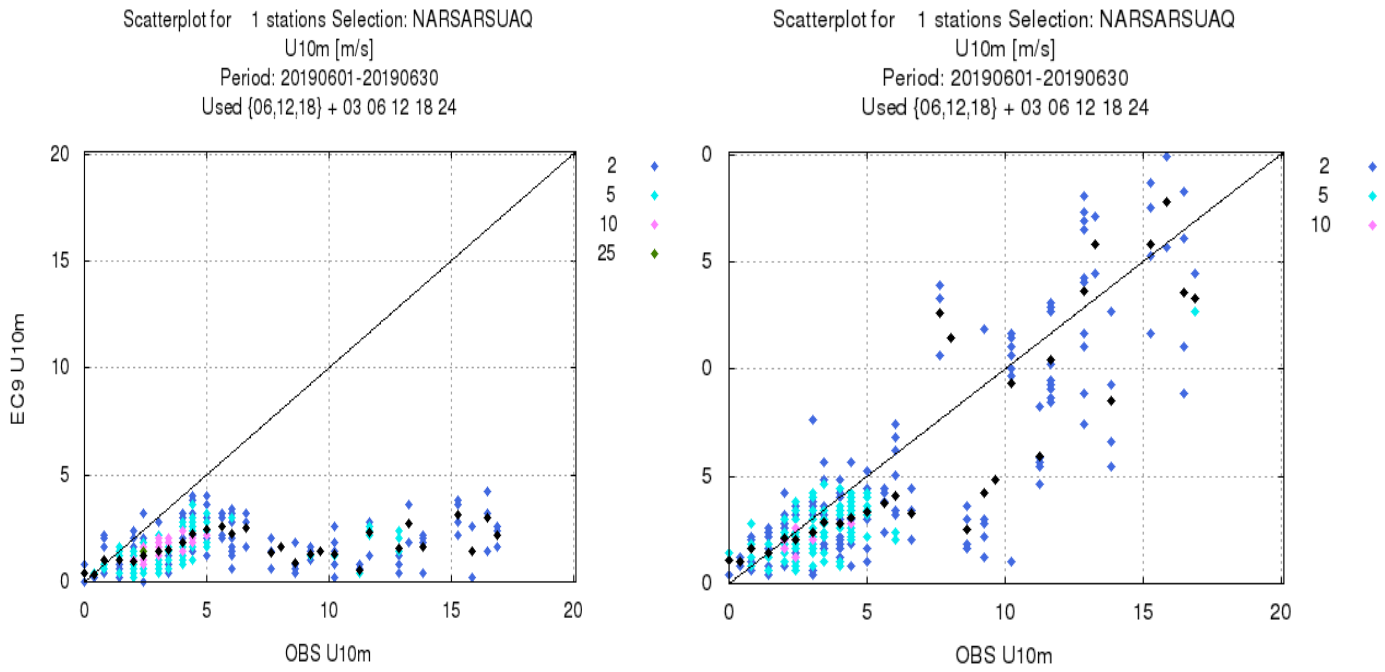

Figure: Scatterplot of 10-m wind forecast verification at station Narsarsuaq with forecast leadtime of up to 24h in, (*left*) HRES and (*right*) Harmonie-IGB for the month of June 2019. X-axis for measurement data and Y-axis for forecast.

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 2018 to June 2019 are for the forecaster 95%, 89%, 78%, and for ECMWF HRES, 91%, 78%, 70%. For DAY 0, the forecasters assessment is based on DMI's own models as well as HRES/ENS, for the next days.

3.1.2 Post-processed products and end products delivered to users

3.1.3 Monthly and Seasonal forecasts

3.2 Subjective verification

3.2.1 Subjective scores (including evaluation of confidence indices when available)

3.2.2 Case studies

4. Requests for additional output

5. Feedback on ECMWF "forecast user" initiatives

6. References to relevant publications

(7. Feedback about suggested template for this report)

DMI support the initiative for ECMWF to request specific opinions from member services around chosen topics.