Application and Verification of ECMWF Products 2021

Met Éireann, Irish Meteorological Service.
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1.   Summary of major highlights

Met Éireann continue to use ECMWF products as primary guidance for the medium-range (days 2 – 10) weather forecasting and as lateral boundary conditions for operational limited area NWP models. The application and verification of these products is described in more detail in Sections 2 and 3.
The primary users of ECMWF products in Met Éireann are the Forecasting Division, Flood Forecasting Division, and Climate Services, Research & Applications Division.
Seasonal outlooks are now routinely produced using guidance from the C3S multi-model ensemble.

2.   Use and application of products

ECMWF products used by Forecasting Division:
   - All medium range HRES forecasting products for forecasting rainfall, wind, temperature, visibility, snow.
   - All of these products are also used for short range forecasts along with HARMONIE-AROME.
   - ECMWF Wave model is used for forecasting sea states and swell for Sea area forecasts.
   - Ensemble forecasting products including EPS meteograms, plumes etc.
   - Extreme Forecast Index and shift of Tails.
   - Extended range forecast products for forecasts up to 30 days ahead
   - Seasonal forecasting products for seasonal forecasts. (These forecasts are produced by Climate Services, Research & Applications Division)

2.1   Direct Use of ECMWF Products

Forecasting Division:

- The ECMWF forecast products are adapted to be used over Ireland (and Britain in some cases. Eg. Rainfall, wind). Products based on the control / deterministic forecast include max and min temperatures, rainfall amounts, snow and snowfall amounts, wind speeds, wind gusts, warning level gusts, wave heights, swell height, cape, Boyden indices and streamlines for convection.

- As well as using the 'tailored' deterministic products for Ireland, a number of EPS meteograms are used for some of the main towns and cities across Ireland. The meteograms give helpful information on the forecast and also on the uncertainty of the forecast. They also show if the 'control' is in agreement with most other ensemble members or if it is an 'outlier'. This information enables increased / decreased confidence in the 'tailored' deterministic products.

- For severe weather situations, some of 'open charts' are very helpful. The one we use most is the 'Extreme Forecast Index' and 'Shift of Tails'. This product is useful for highlighting the potential for severe weather in the coming days. The EFI charts most used are: 2m Temperature, wind speed, wind gusts, rainfall, snowfall.

- Probability charts are used, especially max wind gust and 24-hour total precipitation.

- Extra-tropical cyclone database (CBD) products are used for forecasting the path/track of cyclones and associated fronts.

- For Monthly forecasts, the charts that are used operationally are: Weekly surface pressure anomalies, weekly surface temperature anomalies, Weekly rainfall anomalies and weekly 500hPa anomalies. Individual forecasters sometimes look at additional products such as 'Weather regime frequency'

Overall the availability of 'Open Charts' is very positive and helpful.
There are many charts now available to forecasters on the ECMWF website. Because there are so many charts, it can sometimes be confusing and difficult for the forecaster to find the chart that he/she is looking for. Perhaps the layout of the open charts site could be examined to see if it can be made a bit more user friendly.

Flood Forecasting Division:
A range of products are used to support Flood Forecasting. Rainfall/precipitation, wind direction and strength, and surface pressure are the principal variables used. Both high resolution (HRES) and ensemble (ENS) products are typically interrogated. The longer lead times of ECMWF products has been particularly useful providing a "heads-up" for significant events. The extreme forecast index (EFI) is a useful product and employed routinely. The Open Charts products are found to be much more responsive and user friendly. The graphics have also improved significantly. For coastal flood forecasting the suite of ECMWF's wave products are used to support real-time decisions.

2.2   Other uses of ECMWF output

2.2.1   Post-processing

HRES forecasts are converted to NetCDF format for ingestion by WDB (Weather DataBase) for the public website/app. Some statistical post-processing is conducted on ENS precipitation and solar radiation to extract quantiles for use by WDB.

2.2.2   Derived fields

N/A

2.2.3   Modelling

ECMWF fields are used are boundary conditions for our limited area model, HARMONIE-AROME, producing 54-hour forecasts eight times per day in a 1+15 ensemble system called IREPS.

ECMWF fields are used as the meteorological input to the Hysplit dispersion model by Met Éireann, an important decision support tool for emergency management in radiation related events. We also generate a blue tongue virus threat product using Hysplit which is disseminated to our Department of Agriculture who in turn pass this information to vets and other interested parties around the country.

For coastal flood forecasting ECMWF forecasts are used as input to the Tide and Storm Surge Forecast (TSSF) model. This is the most important operational tool for surge modelling at a national scale and supports local responses to potential flood events. It is planned that ECMWF forecasts (both HRES and ENS) will be used to run the national fluvial flood forecasting models which are currently in development.

3.   Verification of ECMWF products

3.1   Objective verification

Monthly objective verification is routinely carried out, comparing IFS with our operational limited-area HARMONIE-AROME model using observations from synoptic stations within the domain and other Irish observational networks.
This is done both in a deterministic sense, comparing the control member of our IREPS system with IFS-HRES, and using ensemble metrics to compare the full IREPS with IFS-ENS.

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

Deterministic:

Near-surface parameters (10m winds and 2m temperatures) are of particular interest. In general, IFS-HRES compares favourably with our high-resolution (2.5km) limited area HARMONIE-AROME, but not surprisingly struggles somewhat with more extreme values. An example is shown below for February 2020, when Ireland was impacted by three named storms (Ciara, Dennis and Jorge). Scatterplots of 10m wind-speed forecasts versus observations at Irish synoptic stations are shown for IFS-HRES (left) and HARMONIE-AROME (right). While HRES showed less of a bias at lower values, it was unable to capture the higher extremes. A similar result was found for wind gusts.
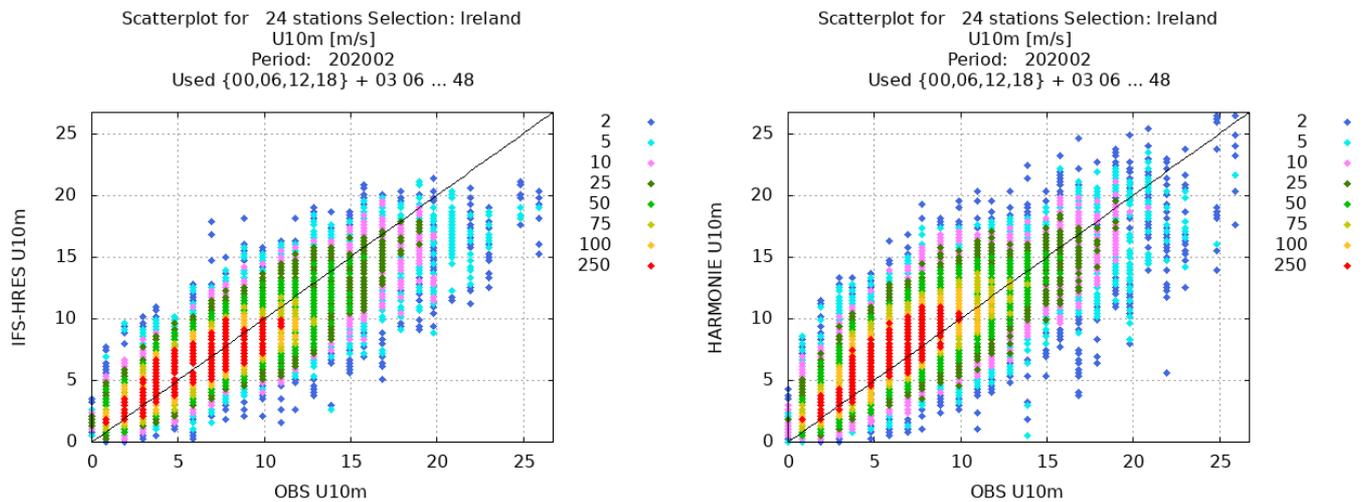
In terms of 2m temperature, feedback from forecasters suggest that HARMONIE-AROME is more reliable for minimum temperatures. An example for June 2020 is shown below.
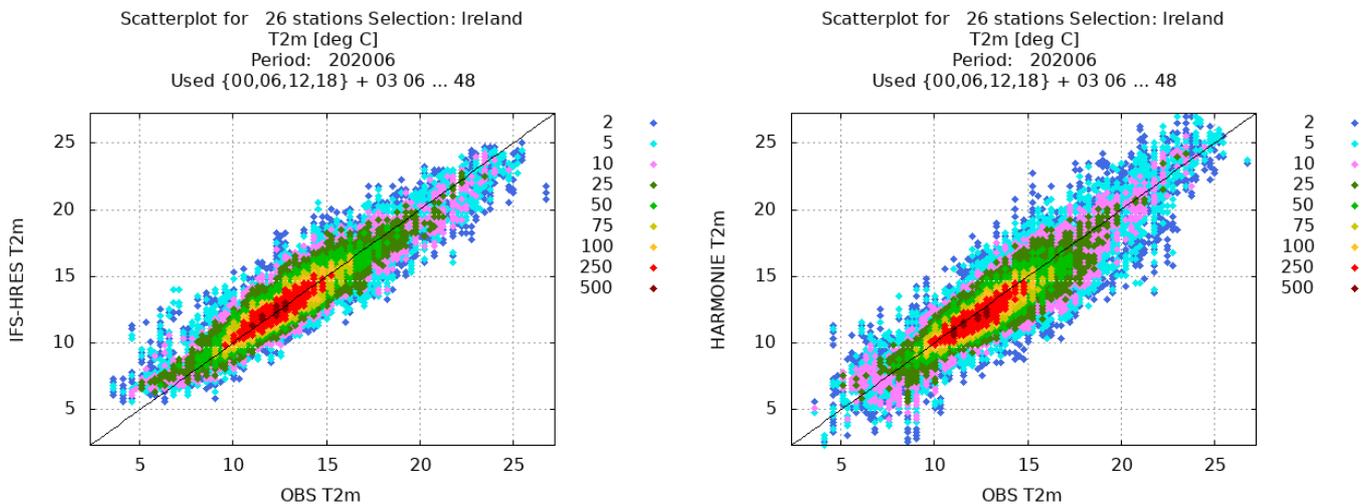
Recently, in April 2021, forecasts of night-time temperatures at Dublin Airport were reported by forecasters to be particularly poor for both IFS-HRES and HARMONIE-AROME. Averaged time-series are shown below (observations in blue), with both models clearly over-estimating the minima on a number of occasions. Investigation into this are ongoing.

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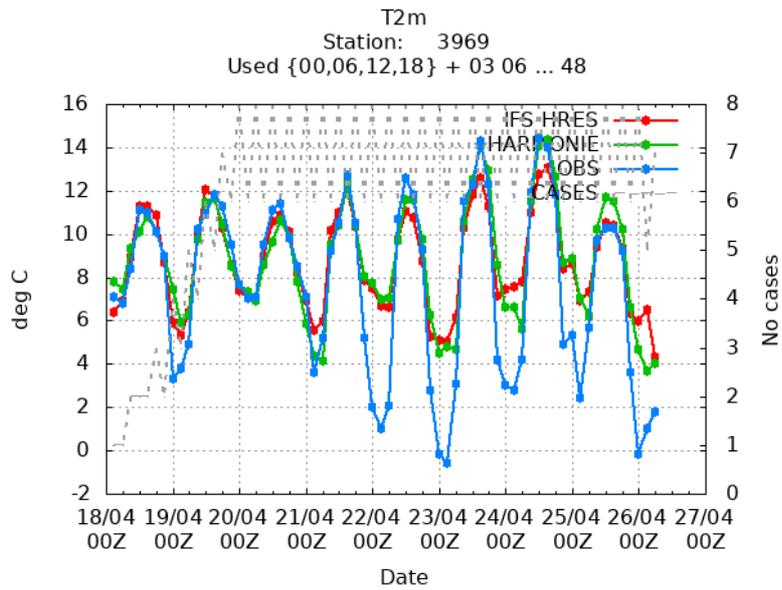
Ensemble:

Near-surface parameters are of most interest in the comparison between Met Éireann's high-resolution EPS (IREPS) and IFS-ENS, in particular parameters related to Met Éireann's weather warnings (wind and rain being the most frequent). IFS-ENS continues to outperform IREPS in MSLP scores, as demonstrated below in a comparison of CRPS scores for the month of May 2021 (left image). IREPS does perform better in terms of 10m wind speed (right image) and 12-hourly accumulated precipitation (centred image). IFSENS appears in orange and IREPS in green in all skill-score plots. These trends hold for the majority of months in the verification archive.
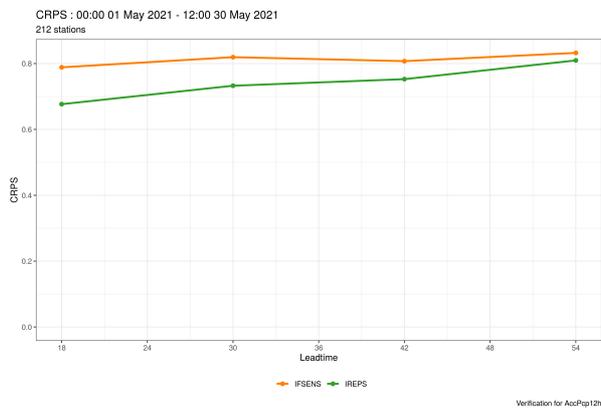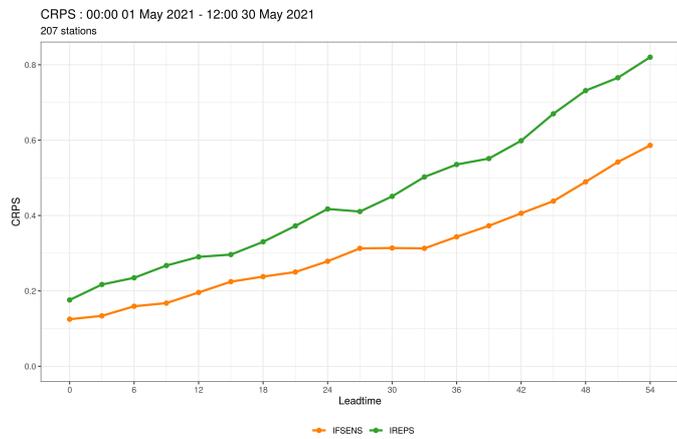
3.1.2   Post-processed products and end products delivered to users

No internal verification

3.1.3   Monthly and Seasonal forecasts

These products are used for guidance within the Forecasting Division, but no internal verification is carried out.

3.2   Subjective verification

3.2.1   Subjective scores

In Forecasting Division, there is no operational verification of ECMWF forecasts. However, for some severe weather events, especially Atlantic storms, verification studies have been done where the performance of ECMWF forecast has been examined.

General Observations regarding ECMWF model performance
- For severe weather events, ECMWF often tends to under-forecast the strength of wind speeds and wind gusts over Ireland and around the coast.
- During the winter forecast minimum temperatures are often too high
- Forecast maximum temperatures are sometimes a degree or two low.
- For rainfall amounts, ECMWF performance is somewhat variable. It can be 'very right', but occasionally, 'very wrong', especially in the medium term (see example mentioned in case studies below).

3.2.2   Case studies

Storm (Ex hurricane) Lorenzo 3rd October 2019. There was a fair degree of uncertainty regarding the track and intensity of the storm in the days leading up to it. As Lorenzo was an ex-hurricane, this storm gathered a significant amount of media attention in Ireland. For forecasters, the uncertainty in the track of the storm, made it challenging to 'manage the message' around the storm and to give a sustain a coherent message to the media. This storm highlighted the importance of consistency from run to run in the days leading up to a severe weather event.

Storm Bella 26th December 2020

ECMWF HRES performed very well for Storm Bella. It forecast the track and depth of the storm depression correctly. It also forecast the maximum winds gusts rainfall totals very well.

Recent forecast for 19th and 20th June 2021.

In Ireland the first half of June was very dry with very little rainfall. The farming community in particular were 'looking' for rain. In the week of 14th to 20th June. ECMWF model runs on 14th, 15th and 16th June and the 00z run of the 17th June predicted that a depression would track close to the south of Ireland and would bring substantial amounts of rain over the country. Amounts of up to 35 mm of rainfall were forecast for many areas corresponding to yellow level warning levels. From 17th 12z run and subsequent ECMWF model runs, the amount of rain forecast for late Saturday 19th and for Sunday 20th, was progressively smaller.

In the end, on Sunday there was very little rainfall over Ireland. The main feature of the forecast was the noticeable change on the 18th from previous days. This meant that the 'forecast message' changed significantly. Many people were under the impression that 'much needed' rainfall was on the way on Sunday 20th and concluded that we got the forecast wrong because it didn't arrive, even though our forecast message closer to the event, mentioned much smaller amounts of rain.

4.   Requests for additional output

It has been suggested by a forecaster that meteograms show Max and Min forecast temperatures rather than (or in addition to) temperatures at 6 hourly intervals.

Last winter and in recent years, much of the 'snowfall' in Ireland has been in the form of 'graupel'. This form of precipitation is catered for in our high resolution HARMONIE-AROME model, but doesn't appear to be catered for in ECMWF HRES. Perhaps ECMWF could produce products for wintry precipitation that distinguish between, sleet, snow, hail and graupel.

5.   References to relevant publications

N/A