Met Éireann Updates

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1 Introduction

Met Éireann’s operational Numerical Weather Prediction (NWP) activities during 2017 were mainly focussed on the porting of our operational NWP suite to run at ECMWF’s High Performance Computing Facility (Section 2) and the testing for a planned upgrade to cycle 40 of the shared ALADIN-HIRLAM NWP System (Section 3). Preliminary work was also carried out on the introduction of a regional ensemble system (Section 4) and the use of ECMWF’s SAPP system for observation pre-processing (Section 5). In Section 6 we discuss recent research in the ongoing regional reanalysis project, MÉRA.

2 Operational NWP in 2017

This section provides details of Met Éireann’s operational NWP suite. The HARMONIE-AROME configuration of the shared ALADIN-HIRLAM NWP system, hereafter HARMONIE-AROME, is the main model used for operational short-range forecasts and additionally as a research tool for Met Éireann scientists. The HIRLAM model also continues to be run as part of the NWP suite. Table 1 below provides a summary of the configurations of both models.

The 1200 UTC cycle on the 15th of August 2017 produced the first set of forecasts at ECMWF used operationally by Met Éireann. This followed the porting work carried out in 2016 and 2017 and an upgrade to the Irish RMDCN connection to ECMWF. The operational suite is monitored and running successfully under the “Framework for Member State time-critical applications - option 2” (ECMWF, 2015) using the ecFlow scheduler.

On the 16th of October, Ireland was hit by the extra-tropical extension of Hurricane Ophelia which resulted in three fatalities. Mean 10 m wind speeds of 31 ms\(^{-1}\) were recorded at Roches Point station in the south of the country; see Fig. 1(a). The accuracy of the HARMONIE-AROME forecasts leading up to this event was praised by the operational forecasters, particularly in relation to wind speeds.

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<th>Table 1: HARMONIE-AROME and HIRLAM operational configurations</th>
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Some stability issues arose, however, resulting in two forecast model crashes. Firstly, the 0000 UTC forecast on the 15th of October destabilised at a forecast time of approximately 34 hours, when the storm was due to have entered the southwest of the domain; see Fig. 1(b). The model time-step was reduced from a default of 60 s to 45 s and the subsequent cycles ran without incident at this value. However, the 00 Z forecast on the 16th crashed again, necessitating an unprecedented reduction of the time-step to 30 s.

Figure 1: Ex-hurricane Ophelia on the 16th of October: (a) shows the operational 10 m wind forecasts from the 0000 UTC forecast on the 16th, at Roches Point station on the southern coast of Ireland; (b) shows the forecast at +34 hours from 0000 UTC on the 15th. HARMONIE-AROME encountered instabilities around this time.

3 Cycle 40 upgrade

We plan to upgrade from our current operational cycle 37h1.1 to 40h1.2 of HARMONIE-AROME. As part of this upgrade, we intend to increase the domain size and to implement upper-air data assimilation (3D-Var) using conventional observations with a 3-hour cycle. Extensive testing of 40h1.2 was carried out in 2017 and results were compared with past operational cycle 37h1.1 forecasts. Although cycle 40h1.2 shows a general improvement in verification scores, especially for 10 m wind speeds, there was a significant degradation in the 2 m temperature forecasts and this has delayed the implementation of our HARMONIE-AROME upgrade. We have observed a consistent cold bias of up to 1 °C using the default HARMONIE-AROME settings; see Fig. 2.

A number of changes to the physics parametrizations have been investigated; see Fig. 3. Switching off HARATU showed an improvement in the temperature bias, but this degraded the quality of 10 m wind forecasts. We have also experimented with lowering the default value of the heat capacity of vegetation in SURFEX (PCV in the code) and this has improved the temperature biases. However, the physical basis for any such changes needs to be investigated further. This work will continue in 2018.

4 Ensemble System, IREPS

We plan to implement a version of HarmonEPS based on cycle 40h1.2 of HARMONIE-AROME. This implementation will be based on the Scaled Lagged Average Forecasting (SLAF) technique which has already been made operational at a number of other HIRLAM centres. Initial testing has been carried out with the default set-up available in cycle 40h1.2, along with some tests using the official HarmonEPS branch of the code. We plan to have an 11-member ensemble (10+1 control) running twice daily (0600 and 1800 UTC) out to +36 hours.

We aim to improve the short-range forecasting of high-impact weather events over Ireland with the introduction of IREPS (Irish Regional EPS). As such, our initial testing has focused on simulating a number of these types of
Figure 2: Comparing cycle 40h1.2 with the operational cycle 37h1.1 for December 2015: point verification of 2 m temperature forecasts starting at (a) 0000 UTC and (b) 1200 UTC.

Figure 3: Comparing cycle 40h1.2 with the operational cycle 37h1.1 for December 2014: point verification of (a) 2 m temperature and (b) 10 m wind forecasts. The cycle 40 experiments run with default physics (met40dflt), HARATU turned off (met40dflt_noharatu) and HARATU on but with a reduced value for the PCV parameter (met40_pcv8).

events which occurred in 2017. The most unprecedented of these was the passing of the extra-tropical extension of Hurricane Ophelia on the 16th of October 2017. At the time, the track was somewhat uncertain. Fig. 4 (a) demonstrates the projected track of the central pressure of Ophelia using our operational HARMONIE-AROME run from 0000 UTC on the 16th of October, while Fig. 4 (b) shows the track simulated by each of the 11 ensemble members in our initial IREPS set-up. The narrow geographical spread of the projected tracks illustrates the high model-confidence in Ophelia’s path. Such an ensemble product would have been very useful for our forecasters to have on the morning of the 16th October.

5 SAPP evaluation

SAPP (Scalable Acquisition and Pre-processing) was introduced into operations at ECMWF in 2014, replacing the previous observation pre-processing system which ran for 20 years (Fucile et al., 2014). In Met Éireann we have tested this system as a possible replacement for our current operational pre-processing system called the ADE (Automatic Data Extraction), which has been used to process observational data for assimilation in our NWP models since the 1990s. The function of the SAPP processing chain is to:

- Acquire observations from multiple sources
Figure 4: (a) Projected track of the central low pressure of Ophelia over a 24-hour period from the operational run of HARMONIE-AROME at 0000 UTC on the 16th of October. (b) Projected track of the central low pressure of Ophelia over the same period for each of the 11 ensemble members of IREPS.

- Decode these formats (for example, BUFR, GRIB, HDF, netCDF, ASCII)
- Apply QC to the process
- Convert to a consolidated format (ECMWF BUFR), before ingestion in data assimilation

SAPP was provided by ECMWF pre-installed on a virtual machine. The set-up, configuration and familiarisation of the system can be achieved within a short time-frame. A working version can conceivably be installed and begin processing GTS data in a matter of hours. The SAPP system was reliable and robust during the test period of six months. The preliminary evaluation of SAPP for use by Met Éireann would suggest that the SAPP system would be suitable for operational use by any institute.

6 Regional Reanalysis, MÉRA

Met Éireann has completed a regional reanalysis, called MÉRA, in 2017 which spans the period 1981 to 2017 and will be continued in close to real time as ERA-Interim boundaries become available. We used cycle 38h1.2 for this project which covers the same domain as we use operationally. We currently have approximately 100 users in Ireland, the UK, the Netherlands, Germany, the USA and Canada. Details on MÉRA can be found in Gleeson et al., 2017.

Here we focus on the monthly accumulations of precipitation compared to observations and coarser resolution datasets including ERA-Interim (79 km) and HARMONIE-ALARO from UERRA (11 km). Precipitation forecasts produced by these datasets were compared with observations of 24-hour accumulations of precipitation recorded by Met Éireann’s network of (approximately 400) voluntary rainfall stations (0900 UTC to 0900 UTC). Fig. 6 shows areal comparisons of monthly precipitation (for winter, DJF) averaged over the period 1981-2015. ERA-Interim mainly underpredicts monthly precipitation, particularly over mountainous areas. Both UERRA and MÉRA also underpredict the precipitation over mountains, due to mismatches in orography; the 2.5 km and 11 km grid spacings cannot resolve all mountain peaks contained within a grid box. UERRA underpredicts precipitation over most of the country whereas MÉRA overpredicts except over high ground. As expected, the higher resolution MÉRA shows an improvement over the coarser resolution ERA-Interim and UERRA, which underestimate precipitation at the Irish rainfall stations. MÉRA shows similar bias patterns for each season (not shown) i.e. negative biases over high ground and positive elsewhere.
7 Summary and Outlook

The past year has seen some significant NWP developments at Met Éireann. The move of our operational suite to ECMWF followed 11 successful years using ICHEC HPC platforms. Significant work in the area of NWP during 2017, including the preparation for the upgrade to cycle 40, the development of an ensemble prediction system and the evaluation of SAPP, should put Met Éireann on a good footing for the coming years.

The operational version of HARMONIE-AROME will be upgraded from cycle 37h1.1 to 40h1.2 in the second quarter of 2018. The implementation of HarmonEPS for Ireland, IREPS, will be made operational in the second half of the year. Other planned NWP developments include further local development of SAPP, the assimilation of radiance data and the evaluation of locally received Mode-S observations.

8 References

