Met Éireann High Resolution HARMONIE-AROME Cycle 40 Experiments

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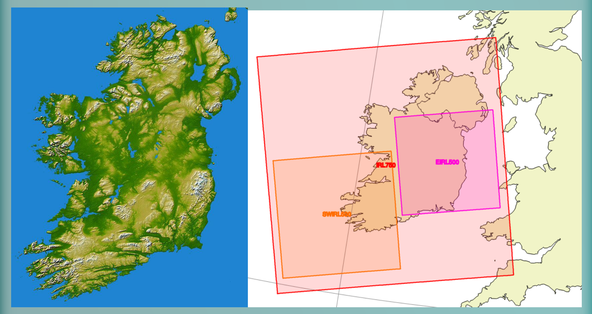
1. Introduction

- Met Éireann's involvement in very fine resolution experiments using HARMONIE-AROME was initiated by Enda O'Brien, ICHEC, over 5 years ago.
- This work involved preparing and testing the ASTER 30 m database and running experiments in the 0.5-1 km grid spacing range.
- Our current aims include:
  - Running a sub-km version in "semi-operational" mode, i.e., on-demand over selected regional domains, on sporadic occasions when the risk of "extreme weather" appears to be high e.g. risks of flooding, convection, strong winds.
  - Creation of stable 750 m and 500 m set-ups for Ireland with optimised run-times and minimal use of diffusion.
- 3 case studies are shown on this poster: 1. convective rainfall over the Northwest of Ireland, 2. Storm Darwin, 3. Gravity wave clouds. HARMONIE-AROME cycle 40 was used.

2. Domains

- We have tested two 500 m domains, one covering the greater Dublin area in the east, the other covering the highest mountains in the southwest.
- We have also tested a 750 m domain covering Ireland – used for most of the results shown on this poster.
- Our experiments involved testing the effect of the following on the stability of the simulations:
  - Time-step (mostly 20-30 seconds)
  - Grid (linear, cubic, quadratic)
  - Time-stepping algorithm (SETTLS and Predictor Corrector (PC))
  - Diffusion (spectral via the RDAMP* coefficients, Semi-Lagrangian Horizontal Diffusion (SLHD)).



3. Case Study - Convective Rainfall

- This rainfall event was a "once in 100 years" intense thunderstorm event in the Northwest of Ireland with 63 mm recorded at Malin Head station on the coast in 2 hours.
- It overwhelmed drainage systems and destroyed old bridges.

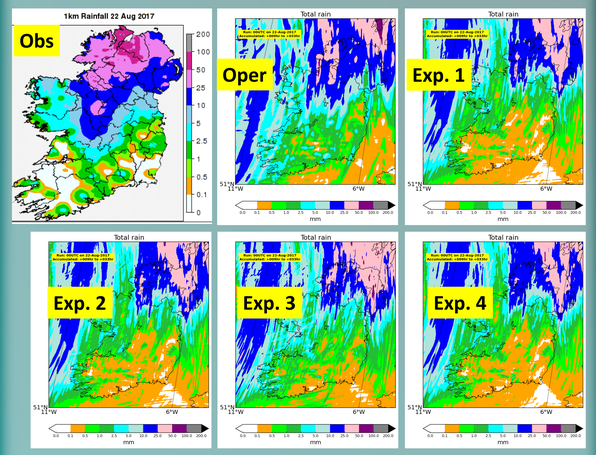
4. Experiment Set-ups

- The table below shows the settings used for each experiment.
- The colour coding on the "Expt." column denotes where an experiment ran successfully (green) or not (red). All 750 m.

Expt.	Time-step (s)	Grid	Time-stepping/Diffusion
Exp. 1	20	Quad.	Defaults used otherwise.
Exp. 2	20	Quad.	RDAMPDIV, RDAMPQ, RDAMPT, RDAMPVD, RDAMPVOR set to 10 (default is 20)
Exp. 3	20	Quad.	LSLHD_OLD = F, RDAMP*=20
Exp. 4	30	Quad.	LPC_FULL=T, LPC_NESC=T, LPC_CHEAP=T, LSETTLST=T, NSITER=1
Exp. 5	20	Quad.	Same as Exp. 4.
Exp. 6	20	Quad.	As Exp. 3 but with LSLHD_T=T, LSLHD_W=T, YQ_NL%LSLHD=T
Exp. 7	20	Quad.	As Exp. 3 but with LSLHD_T=T
Exp. 8	30	Quad.	Same as Exp. 4. but LPC_CHEAP=F

5. Results – Convective Case

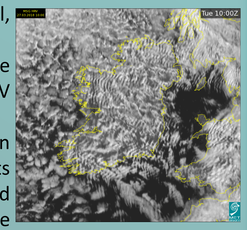
- The following plots show 24-hour accumulations of rainfall for the period 09 Z August 22nd 2017 to 09 Z August 23rd 2017.
- Observations on a 1 km grid and output from the Met Éireann operational run (2.5 km cycle 37h, surface DA and blending) are included for comparison.

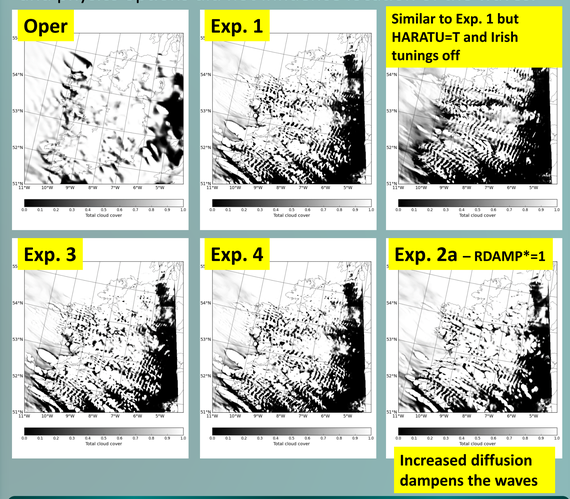


- As well as the above, several cycle 40 tests were run at 2.5 km. Most of these did not produce any accumulations exceeding 50 mm over the north of the country. An exception to this was when OCND2 was turned off.
- Due to cold biases in 2 m temperature in cycle 40, we used a set-up with HARATU=False, ZTINER=2, XCDRAG=0.05 and an LAI modification for grassland. This changes were used in the 750 m convection experiments.
- All bar the SLHD (Exp. 3) show an increase in precipitation over the south compared to cycle 37 @ 2.5 km.
- All of the 750 m runs show highest rainfall in the NE rather than NW. This was not the case in most of the cy40 2.5 km tests.

6. Gravity Waves over Ireland

- March 27th 2018 was a cool, blustery, showery day in Ireland.
- Gravity/mountain waves were clearly visible on the MSG HRV satellite imagery (right).
- These waves could not be seen in our operational cycle 37 forecasts (2.5 km grid) – neither in total cloud cover nor the pseudo-satellite imagery.
- However, these waves are clearly visible in 750 m Exp. 1-5 (details in the table in Section 4) as shown below. Dynamics and physics options did not influence location of the waves.





7. Storm Darwin (February 2014)

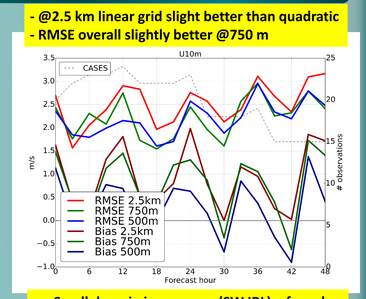
- Storm Darwin caused gusts of up to 159 km/h, mean wind speeds of up to 117 km/h, waves of 25 m and huge destruction in parts of Ireland.
- This "weather bomb" caused the MSLP to drop by 39 hPa in 24-hours – sting jet (comma cloud) can be seen on the satellite image below.
- Our simulations for this test case were done using default cycle 40 (i.e. HARATU on etc.)
- The selection of 750 m and 500 m simulations is summarised in the table in Section 8, using the same traffic light colour system as before but with orange for simulations that ran for a time before failing. In addition to the time-step, time-stepping algorithm and diffusion, linear, cubic and quadratic grids were investigated.

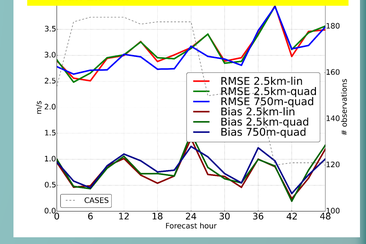
8. Darwin Experiment Set-ups

Expt.	Time-step (s)	Grid	Time-stepping/Diffusion
D. 1	60	Lin. 2.5km	Defaults used otherwise.
D. 2	30	Quad. 750m	Defaults used otherwise.
D. 3	30	Cub. 750m	Defaults used otherwise.
D. 4	20	Quad. 500m	Defaults used otherwise.
D. 5	20	Quad. 500m	RDAMP* =1
D. 6	10	Quad. 500m	RDAMP* =10
D. 7	15	Lin. 500m	Defaults used otherwise.
D. 8	20	Cub. 500m	Defaults used otherwise.
D. 9	20/15	Quad. 500m	RDAMP*=10

9. Results - Storm Darwin

- One of the issues in verifying wind forecasts for Storm Darwin is a lack of wind observations for Ireland.
- There are lots of privately owned wind farms in the country but these data are commercially sensitive and not publically available.
- Nevertheless, the comparisons to the right, done using the Monitor software, include available synoptic observations within the domain.





- The plots below shows 24-h forecasts valid at 12Z on February 12th 2014 at grid spacings of 2.5 km, 750 m and 500 m.
- Two of our southern stations recorded mean wind speeds of over 50 knots at 12 Z - the model runs did not capture the full strength of these extremes. The diffusion applied in the 500 m runs appears to have been detrimental; boundaries may also be an issue in the 750/500 m runs which do not show the core of stronger winds seen in the 2.5 km simulation.