SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

Project Title:	Future Weather: An Investigation of Storm Scenarios for Ireland
Computer Project Account:	spieclan
Start Year - End Year :	2022- 2023
Principal Investigator(s)	Colm Clancy
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Other Researchers (Name/Affiliation):	John Hanley, Tatjana Kokina Met Éireann

Summary of project objectives

The objective of this project is to investigate the effect of a warming climate on extreme post-tropical storms impacting Ireland. The “future weather” framework will be used, employing the high-resolution HARMONIE-AROME NWP model to simulate storm events in hypothetical, but physically plausible, climate settings.

Summary of problems encountered

The main problem encountered was related to the recruitment of a post-doctoral researcher for the project. This unfortunately delayed the start of the work until late 2023.

Experience with the Special Project framework

I had a positive experience with all aspects of the project administration.

Summary of results

Testing of Storm Ophelia with both HARMONIE-AROME (the operational NWP code) and HARMONIE Climate (HCLIM) was carried out. Cycle 43h2.2 of HARMONIE-AROME was used, with experiments focussing on the dynamics options such as off-centring and spectral grid truncation. These options are often used in operations to improve stability and save computational cost. Averaged verification scores generally do not show much effect from these options, but it is important to test their impact on our extreme Ophelia case before deeming them safe to use.

The simulations used the Irish operational domain (red domain on the left of Fig. 1). The reference used all defaults: linear grid with 2.5km horizontal resolution, 65 levels, 75 s time-step. No upper air assimilation was used. To see the effects at different lead-times with different boundaries, three-hour cycling was used from 2017/10/15/00 to 2017/10/16/00, with longer forecasts run at 0000 and 1200 UTC.

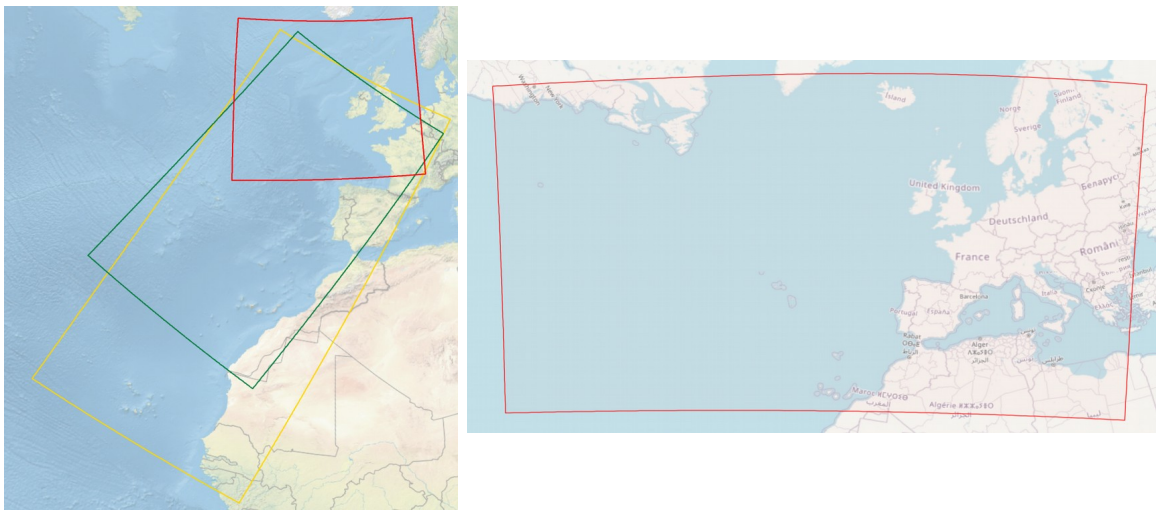

Figure 1: Domains used for HARMONIE-AROME (left) and HCLIM (right) experiments

The changes from the default that were tested were quadratic and cubic grids, off-centring with either XIDT=0.15 or VESL=0.1 (second- and first-order options), and the use of 90 vertical levels. We look first at point values compared with observations. The centre of Ophelia passed quite close to Valentia station in the south-west, providing a useful comparison of the intensity. Figure 2 shows forecasts from the various tests, from three different starting times. In general, we see that results were very similar, with differences due to lead-time/boundaries dominating.

Figure 3 shows similar series for 10 m wind, but at two locations. Roches Point is on the coast and recorded the strongest winds during Storm Ophelia. Moorepark is further inland. Compared to the MSLP results, we see more differences, mainly with the use of the 90 levels, which has more of an effect over land and reduces our peak winds in particular. This is consistent with previous findings, and has been found to be beneficial.

For a more spatial view, we consider forecasts valid at 1200 UTC on the 16th and plot the differences from the default linear experiment. For MSLP, we show those a lead-time of 24 hours in Fig. 4, which includes the original fields overlaid. Differences are very small in magnitude. The 90-level simulation shows the largest differences, due to a very slight shift in the position of the storm.

Figure 5 shows differences in 10 m wind-speed, this time for three lead-times. Most of the largest differences are due to slight positional shifts. The most obvious systematic difference is seen with the 90-level vertical grid (middle row). As discussed above, we see reduced wind-speeds, particularly in areas where we have the strongest winds from the storm. Differences due to the off-centering options (bottom two rows) are smaller, with bigger variations due to lead-times. Longer cycling experiments did not show significant differences in scores when using XIDT, for example.

Finally, some technical testing on the feasibility of much larger computational domains (yellow and green on the left of Fig. 1) was carried out. This required the use of HARMONIE-AROME Cy46h1, which has a parallelised climate generation and so is better suited to simulations of this size.

For the HCLIM testing, Cy43 was used on the domain shown in the right-hand panel of Fig. 1, using a horizontal resolution of 12km. Preliminary simulations of Storm Ophelia were carried out starting from different dates, and using lateral boundaries from ERA5, to examine the sensitivity of the simulated storm track to the starting time. Results of these are shown in Fig. 6.

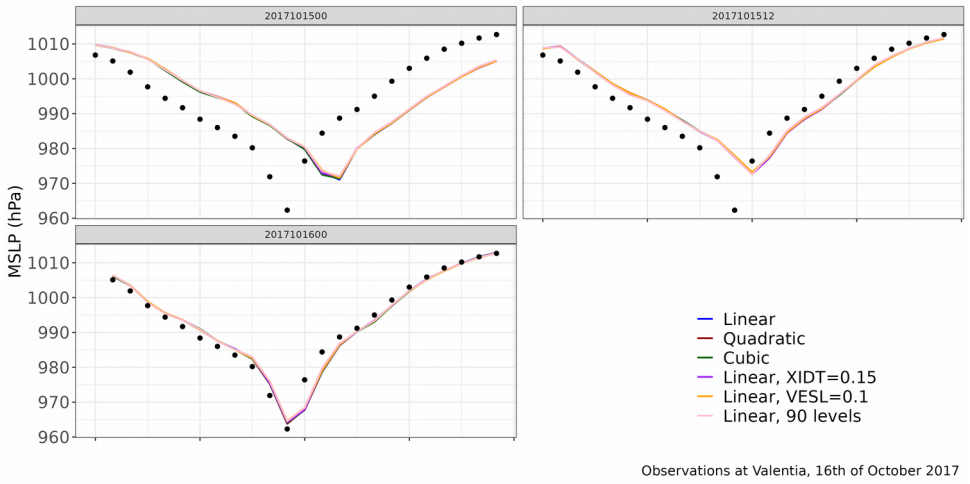

Figure 2: Forecasted MSLP on the 16th October 2017 at Valentia, along with observations (black dots). The forecast start time is given in each panel heading.

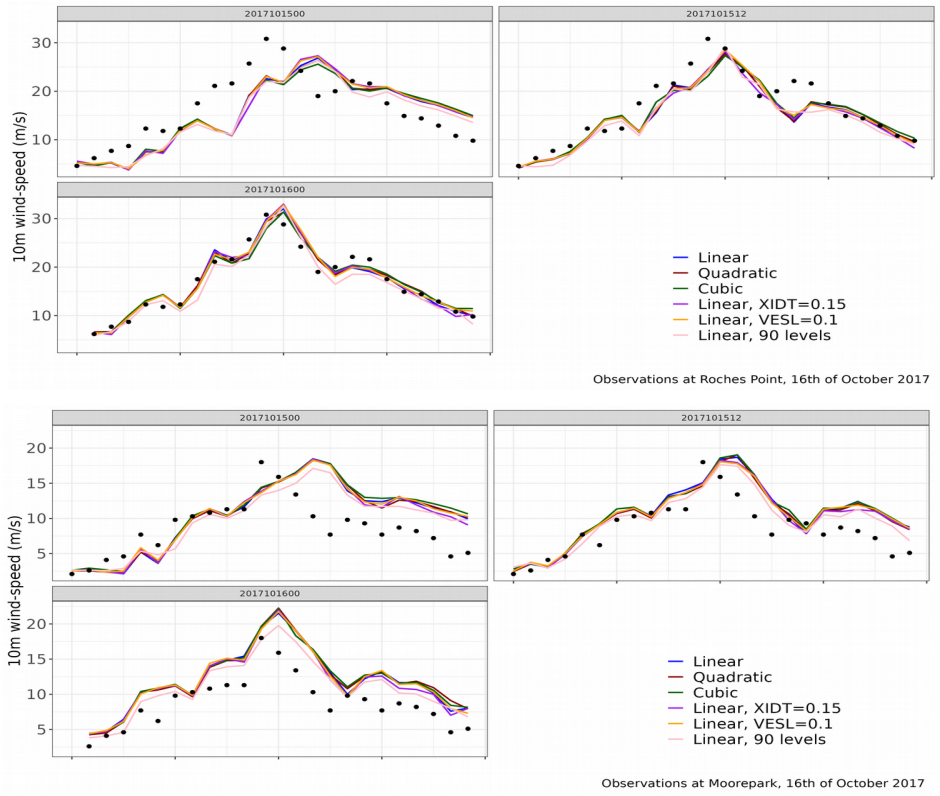

Figure 3: Forecasted 10 m wind-speed on the 16th October 2017 at Roches Point (top) and Moorepark (bottom), along with observations (black dots). The forecast start time is given in each panel heading.

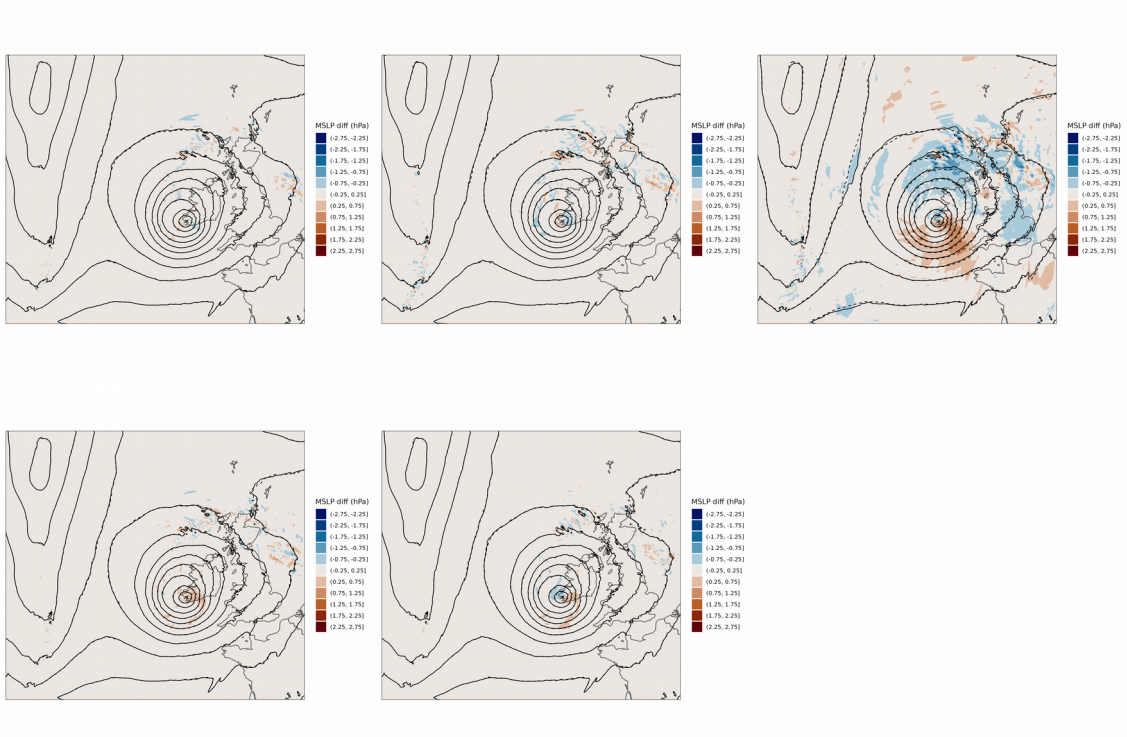

Figure 4: MSLP differences at +24 hours from the default linear experiment valid at 1200 UTC on the 16th of October 2017. For each experiment, the MSLP field is shown (solid isobars) along with the default (dashed). Top, left to right: quadratic grid, cubic grid, MF_90 levels. Bottom, left to right: VESL=0.1, XIDT=0.15

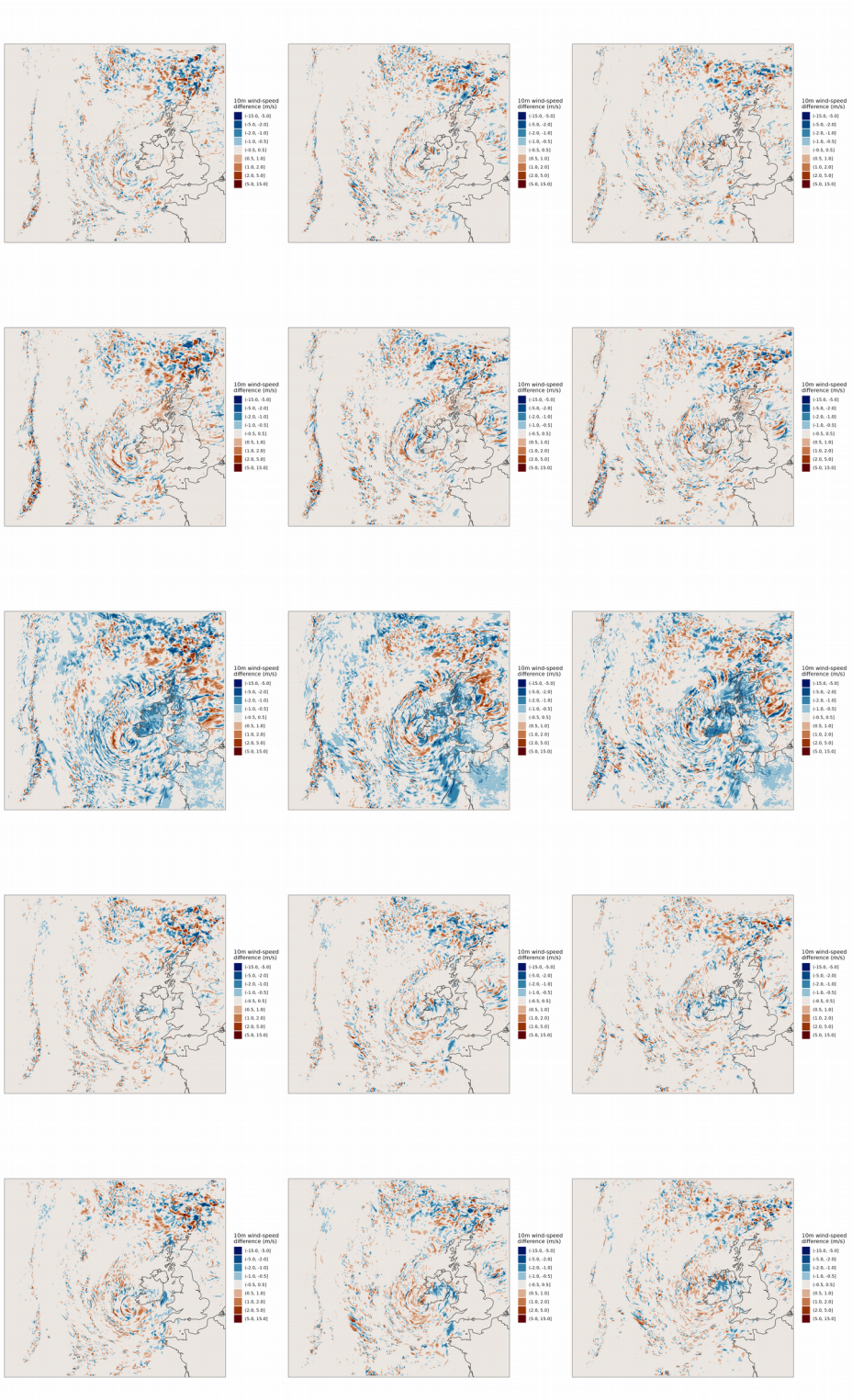

Figure 5: Wind-speed differences from the default linear experiment for forecasts valid at 1200~UTC on the 16th of October 2017. Lead-times are (left to right) 36, 24, and 12 hours. Experiments, top to bottom: quadratic grid, cubic grid, MF_90 levels, VESL=0.1, XIDT=0.15.

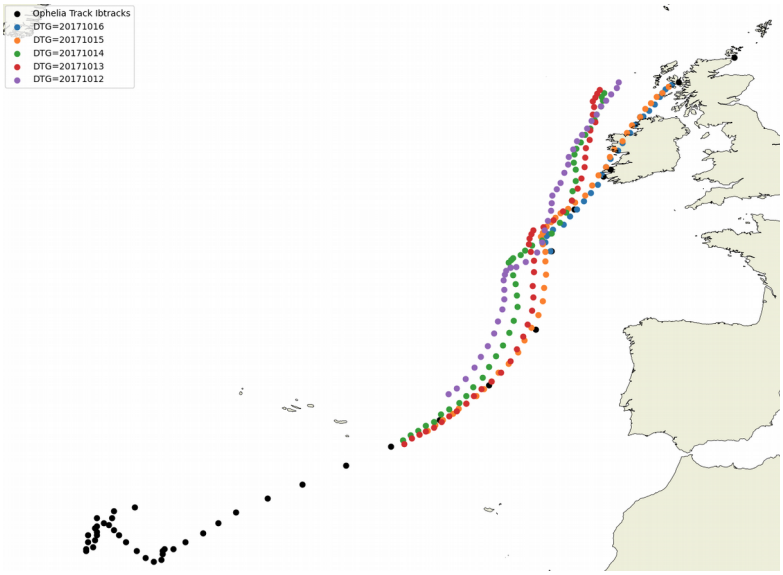

Figure 6: HCLIM simulations of Storm Ophelia track at 12km resolution with different starting times, compared with NOAAS IBTrACS position (black)

List of publications/reports from the project with complete references

The HARMONIE-AROME results described above were included in the following ACCORD newsletter article:

Clancy C, Fannon J, Harney E, Kokina T, Whelan E.
High-resolution and Dynamics Experiments at Met Éireann.
ACCORD Newsletter No. 5, March 2024

Future plans

Due to the delays described, the work reported here represents the beginning of the project. This preliminary technical testing has provided a good basis for the ongoing work, and an application for a Special Project from 2025 will aim to build on this.