SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

Project Title:	Configuration of the Stochastic Pattern Generator for SPPT perturbations in HarmonEPS at High Resolution
Computer Project Account:	spiehall
Start Year - End Year :	2019 - 2019
Principal Investigator(s)	Alan Hally
Affiliation/Address:	Met Éireann 65/67 Glasnevin Hill Dublin 9 Ireland
Other Researchers (Name/Affiliation):	Colm Clancy, Met Éireann Eoin Whelan, Met Éireann Rónán Darcy, Met Éireann Emily Gleeson, Met Éireann

The following should cover the entire project duration.

Summary of project objectives

1. This special project aimed to uncover a suitable configuration of the stochastic pattern generator for SPPT perturbations in the HarmonEPS (HARMONIE-AROME EPS) system.
2. The impact of SPPT perturbations at high resolution (750m) was also a secondary aim of this project

Summary of problems encountered

We encountered no technical problems with the special project account or HPC facility, everything worked the way we expected it would

Experience with the Special Project framework

We found the application and progress reporting procedure to be very easy and user friendly. It was also very easy to switch to using the special project SBUs in our experiments. Our experience with the special project framework was a largely positive one.

Summary of results

Project Introduction

This was a 1 year special project with 2 focused aims. The project in itself was not overly complex, however conducting a meaningful and worthwhile analysis of the results from the project proved to be more complex than was expected. Below is a description of the simulations undertaken in the scope of this project, how these results fed into subsequent simulations and finally a number of project conclusions.

A more detailed description of the project aims can be found in the initial project description: **https://www.ecmwf.int/sites/default/files/special_projects/2019/spiehall-2019-request.pdf**

Description of simulations undertaken

A reference simulation plus 4 configuration simulations were carried out for a winter and a summer period. The winter period covered 5 days from the 13th to the 17th of December, 2018 inclusive. The summer period covered a 5 day period from the 19th to the 23rd of June, 2017. The details of the different experiments are given in the table below:

Exp Name	DTG Start	DTG End	Description	Details	Issues
SPIEHALL_jja_r	2017061900	2017062300	Reference	SPPT not activated	None

ef			Summer experiment for spiehall		
SPIEHALL_djf_ref	2018121300	2018121700	Reference Winter experiment for spiehall	SPPT not activated	None

Table 1: Details of reference experiments for SPIEHALL project

These HarmonEPS experiments were performed over the domain "IRELAND25", an outline of which can be seen below in Fig.1.

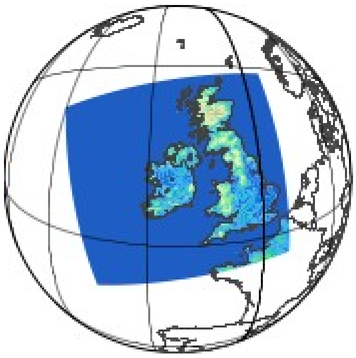

Fig.1: Domain named "IRELAND25"

Four configurations of the SPPT perturbations were chosen to represent the range of possible values for the spatial and temporal coefficients of the stochastic pattern generator (SPG). The details of these configurations are given below:

Exp Name	DTG Start	DTG End	Description	Details	Issues
SPIEHALL_(djf/jja)_config_1	2018121300/2017061900	2018121700/2017062300	1st configuration of SPPT	TAU=32400 XLCOR=800000 SDEV_SDT=0.2 XCLIP_RATIO_SDT=5.0	None
SPIEHALL_(djf/jja)_config_2	""	""	2nd configuration of SPPT	TAU=32400 XLCOR=800000 SDEV_SDT=0.4 XCLIP_RATIO_SDT=2.5	None
SPIEHALL_(djf/jja)_config_3	""	""	3rd configuration of SPPT	TAU=32400 XLCOR=1200000 SDEV_SDT=0.2 and XCLIP_RATIO_SDT=5.0	None
SPIEHALL_(djf/jja)_config_4	""	""	4th configuration of SPPT	TAU=32400 XLCOR=1200000 SDEV_SDT=0.4 XCLIP_RATIO_SDT=2.5	None

Table 2: Configuration of SPIEHALL SPPT simulations

The results of these 8 test simulations (4 per period) were used to inform further experiments which looked at the influence of domain size and grid spacing on the SPPT perturbations. The details of these experiments are given below:

Exp Name	DTG Start	DTG End	Description	Details	Issues
SPIEHALL_(djf/jja)_ref_irl_90	2018121300/2017061900	2018121700/2017062300	Ref experiment for IRELAND25_090 domain	SPPT not activated	None
SPIEHALL_(djf/jja)_config_4_irl90	“”	“”	Configuration of SPPT number 4 over IRELAND25_090 domain	TAU=32400 XLCOR=1200000 SDEV_SDT=0.4 XCLIP_RATIO_SDT=2.5	None
SPIEHALL_jja_ref_750	2017061900	2017062300	Ref experiment for IRL750 domain	SPPT not activated	None
SPIEHALL_jja_750_config_4	2017061900	2017062300	SPPT config 4 for IRL750 domain	TAU=32400 XLCOR=1200000 SDEV_SDT=0.4 XCLIP_RATIO_SDT=2.5	None

Table 3: Configuration of SPIEHALL simulations investigating domain and grid spacing

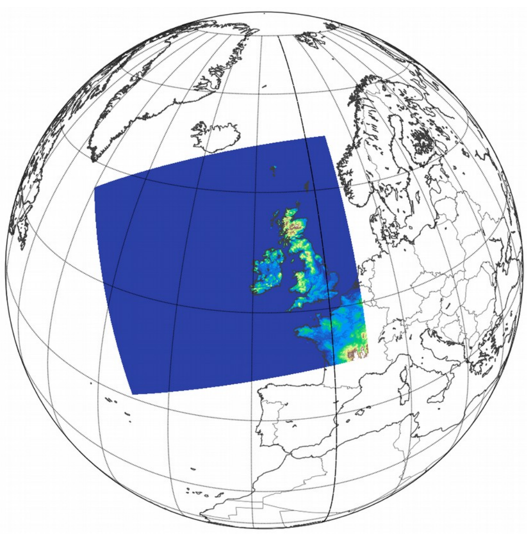

Fig. 2: IRELAND25_090 domain

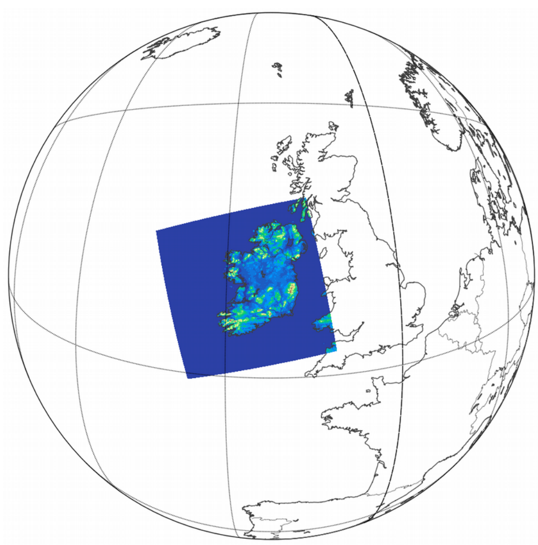

Fig. 3: IRL750 domain

Simulation results

The aim of the simulations was to arrive at a satisfactory configuration for the SPPT perturbations that increased the spread of the HarmonEPS experiments and did not negatively affect the RMSE scores. Other verification metrics were used to gauge the impact of the perturbations including the CRPS and cross-sectional plots of temperature, wind and humidity (as SPPT intervenes directly on the time tendencies of these parameters).

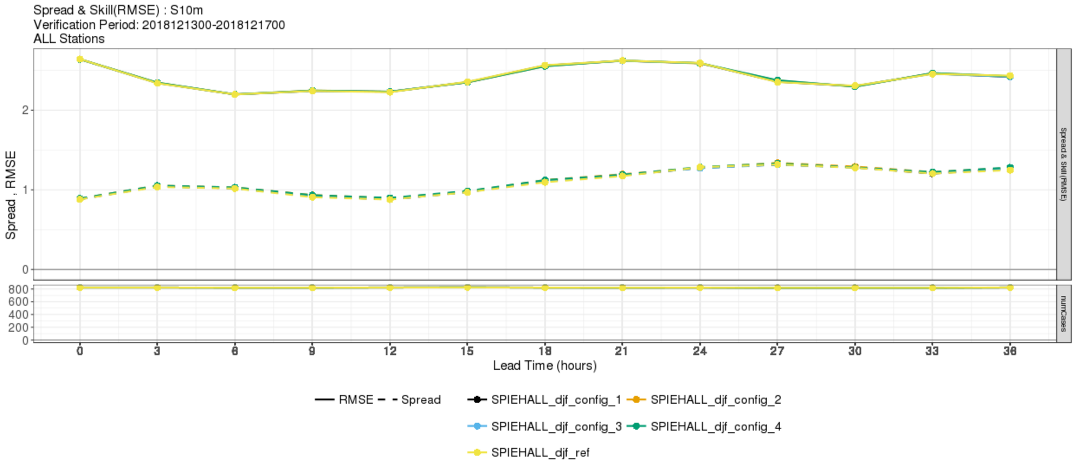

Fig. 4: Spread/Skill scores for 10m wind speed for winter simulations described in Table 2

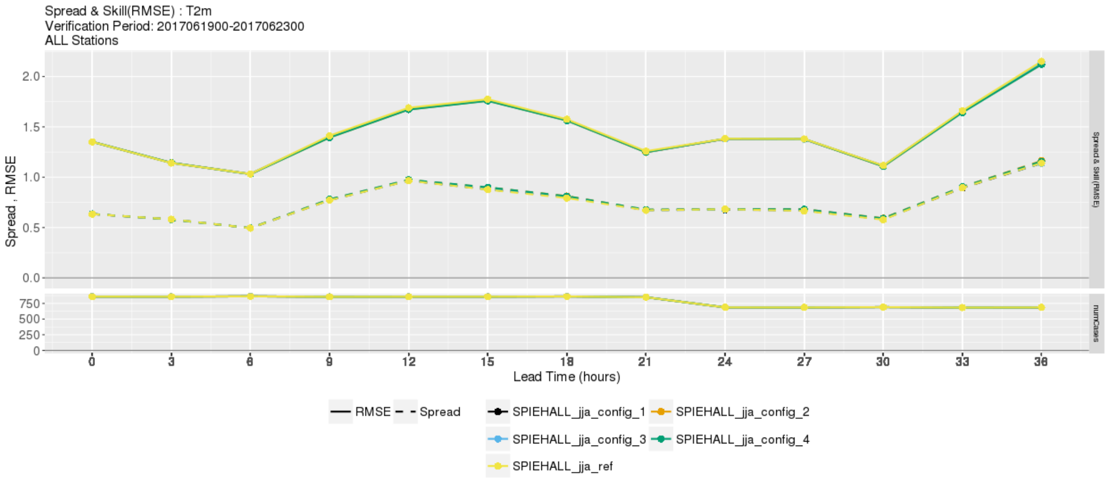

Fig. 5: As for Fig. 4 except for 2m temperature of summer simulations

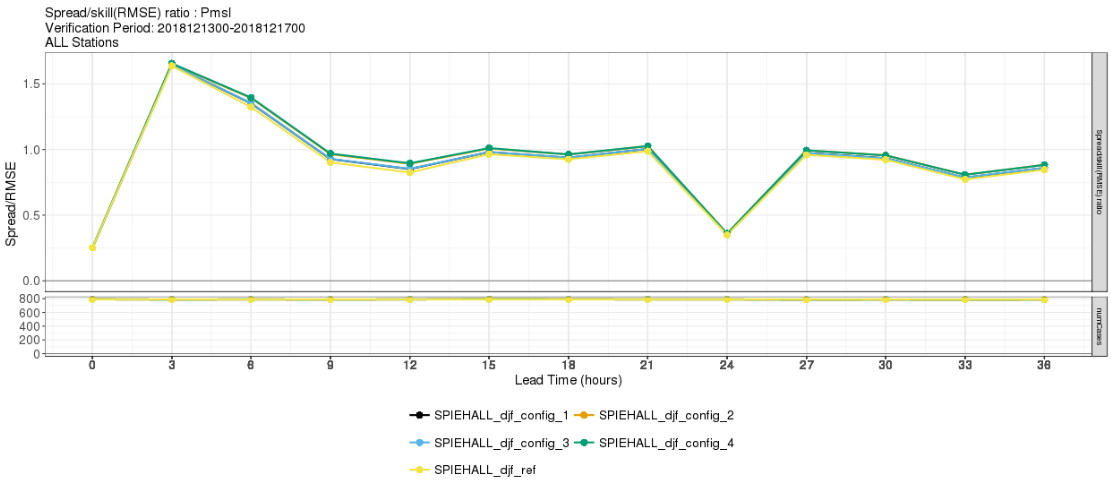

Fig. 6: Spread/skill ratio for MSLP for winter simulations described in Table 2

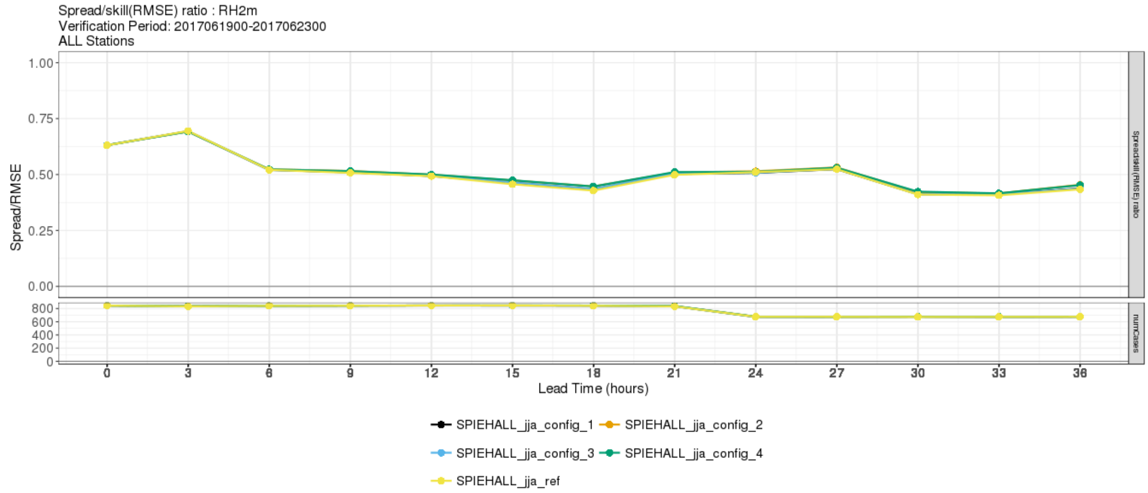

Fig. 7: As for Fig. 6 except for 2m relative humidity of summer simulations

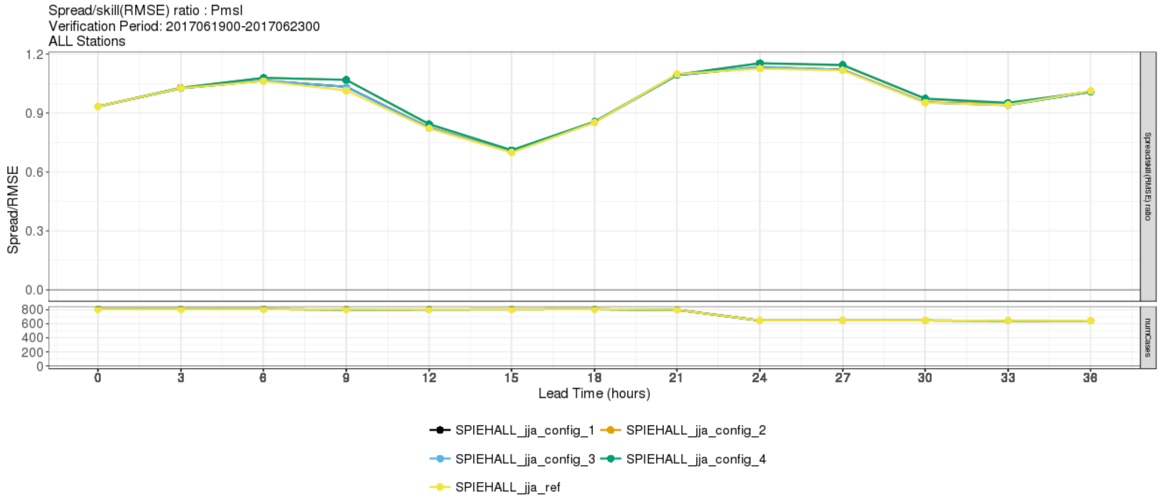

Fig. 8: As for Fig. 7 except for MSLP of summer simulations

In Fig. 4 to Fig. 8 above are plotted spread/skill plots for both simulation periods for various surface parameters. What is clear at first is that there isn't a very large influence of the SPPT perturbations for the two periods concerned. The largest influence is seen for MSLP for both summer and winter periods with Fig. 6 and Fig. 8 both illustrating a spread/skill ratio closer to 1 for the "config_4" experiments. Fig.5 also demonstrates slightly improved scores for 2m temperature during the summer period for the config_4 simulations.

Overall, the four different configurations of the SPG control parameters did not have a very large influence on the surface parameters analysed. The signal was much the same for upper-air parameters (i.e. 925hPa wind speed, not shown). There was a larger influence seen for 850hPa relative humidity, with config_4 giving increased spread (see Fig. 9).

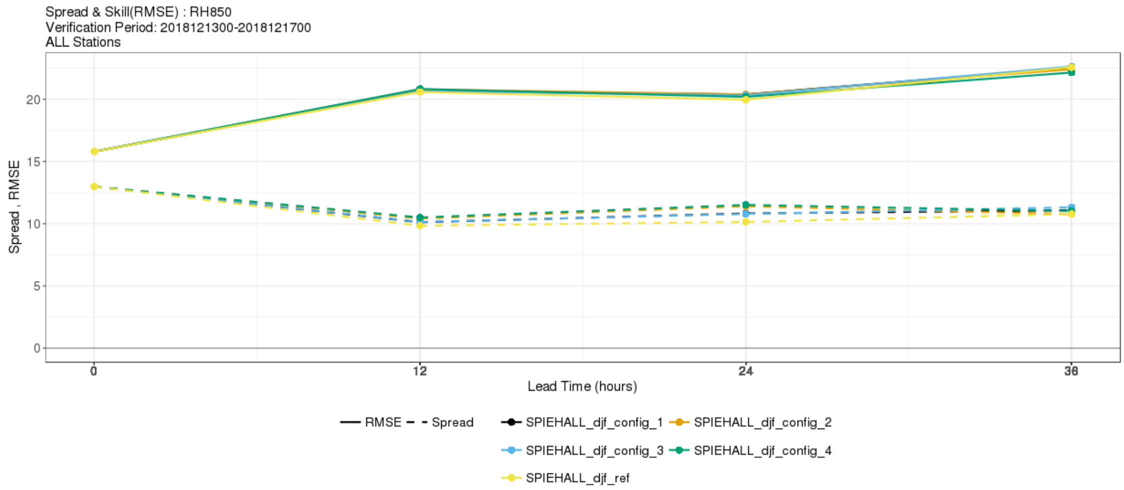

Fig. 9: Spread/skill score for 850hPa relative humidity for winter simulations described in Table 2

Other skill scores (CRPS, not shown) confirmed this tendency of the config_4 setup to give improved verification scores for both periods of interest over the reference experiment and compared to any of the other configurations. Given these scores, configuration_4 was deemed most suitable and was chosen as the configuration for testing domain size and grid spacing.

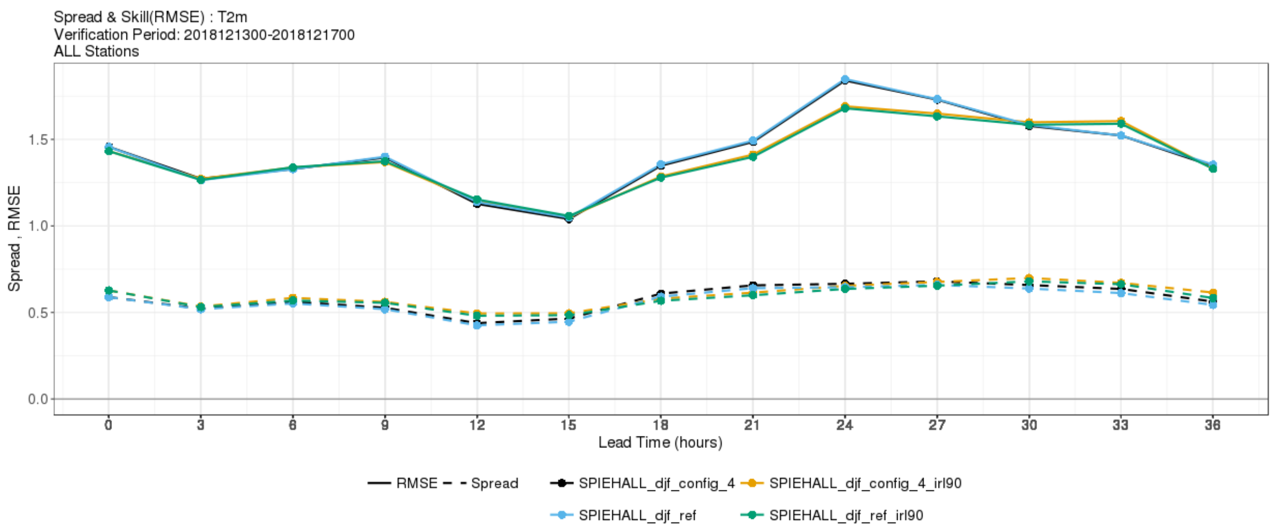

Fig. 10: Spread/skill score for 2m temperature for winter simulations. See Table 2 and Table 3 for experiment details

Fig. 10 illustrates the influence of domain size on the verification scores. The four experiments shown are a reference experiment for each domain and an experiment using the config_4 setup for each domain. The root-mean-squared error (RMSE) for the two experiments over the larger domain are clearly improved compared to the smaller domain for 2m temperature. Fig. 11 below for 10m wind speed does demonstrate that there is a lower spread for the experiments carried out for the larger domain, however the RMSE is much improved.

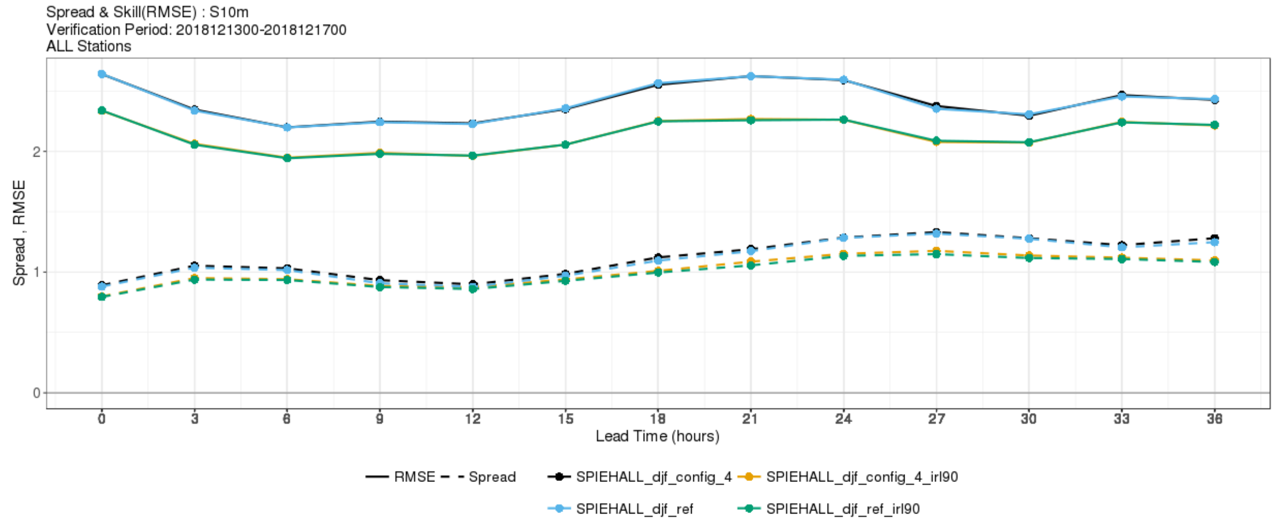

Fig. 11: As Fig. 10 except for 10m wind speed

These results, while needing further clarification through enhanced testing, are promising as they indicate that the operational domain of IREPS (labelled as IRELAND25_090 in Table 3) does have a positive influence on model vs observation verification scores. The impact of the SPPT perturbations over the larger domain is again almost negligible, however Fig.10 does show a slight increase in 2m temperature spread at longer lead times.

The final set of simulations, described in Table 3, were designed to investigate the impact of SPPT perturbations at finer grid spacings (here 750m). A smaller geographical domain centred over the island of Ireland was employed for these experiments.

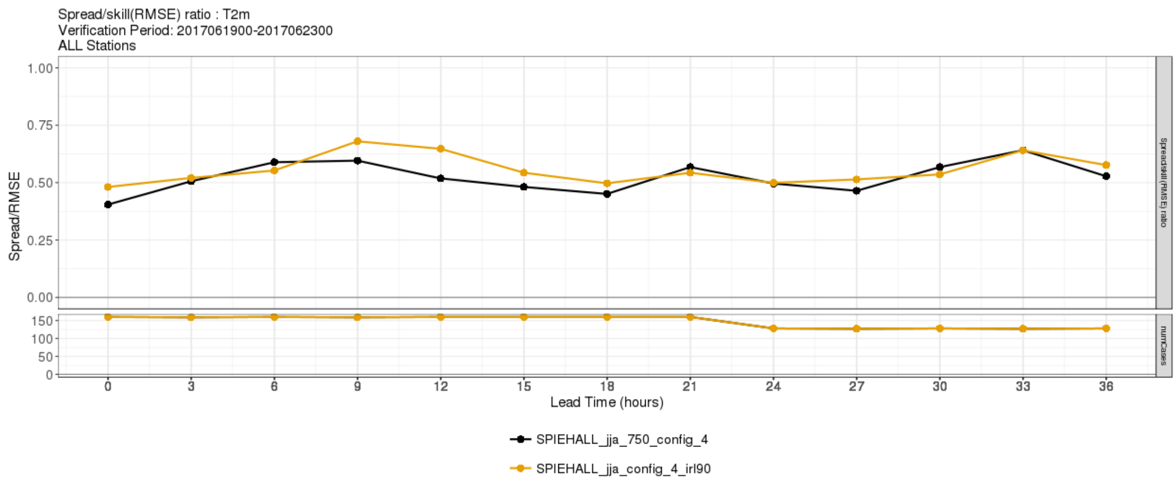

Fig. 11: Spread/skill ratio of 2m temperature for simulation at 750m using config_4 (black) and simulation at 2.5km resolution (orange)

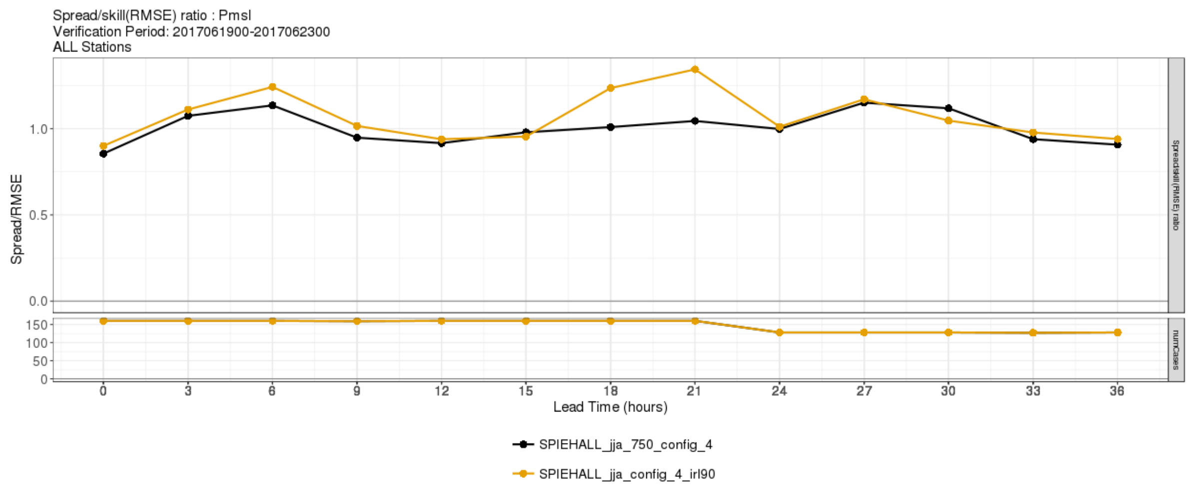

Fig. 12: As in Fig. 11 except for MSLP

It was expected that activating the SPPT perturbations at the finer grid spacing of 750m would yield improved verification scores. However, Fig. 11 above indicates that for 2m temperature, the spread/skill ratio was dis-improved by the 750m simulation. This could be related to faster error growth at 750m compared to 2.5km. For MSLP however, there is a slight improvement, particularly in the 15 to 24 hour time-range.

Discussion and conclusions

The SPPT perturbations, controlled by the stochastic pattern generator, do not have a very strong impact upon the overall evolution of the forecast parameters investigated in this study. Within the HarmonEPS code, as is the case with SPPT in IFS, the perturbations intervene on the time tendencies of U, V, Q and T. Figs. 13 and 14 show the vertical profiles of both U and T and illustrate the SPPT impacts at different levels of the atmosphere. The plots shown below are difference plots for the 750m resolution experiments. The patterns indicate positive or negative differences when compared with a reference experiment without SPPT perturbations.

For temperature, Fig. 13, there is little or no impact near the surface, which coincides with the results from the spread and skill plots shown earlier. The impact is most clear in the middle atmosphere between 400 and 600hPa. Observations of temperature at this pressure level are limited, therefore it was difficult to obtain meaningful verification metrics. Fig. 14 demonstrates that for the U time tendency, the SPPT impact is mostly confined to the area around 850hPa. Spread/skill plots for 925hPa winds (not shown) do demonstrate an increased spread for the simulation with SPPT activated, albeit for a small number of observations. Again the impact of SPPT at the surface for U10 is almost minimal and certainly would not have any noticeable impact on verification metrics.

As shown earlier, MSLP was the only surface parameter investigated that gave a significant signal when SPPT perturbations were activated. The fact that the temperature and wind tendencies show important anomalies from SPPT in the vertical would tend to suggest that the signal in MSLP is being driven by the perturbations applied to these parameters, underlined by the natural link between surface pressure and upper-level temperature/winds.

Of the four configurations (configuration differences were based upon spatial and temporal coefficients as well as the standard deviations of the perturbation sizes), configuration number 4 (config_4 in Tables 2 and 3) was the most satisfactory. As stated, the impact was not as large as expected, however there was a clear signal for MSLP and utilising this configuration gave improvements in the spread/skill ratio, bringing it closer to 1 (the ideal value). Indeed, the small impact of SPPT for these experiments could be related to a number of issues, including the period chosen (only one winter week and one summer week were tested), the geographical domain used or poorly chosen configuration settings for SPG.

This work was however useful as it fed directly into Ireland and HarmonEPS' knowledge of how SPPT works and has given users of HarmonEPS confidence that SPPT-style perturbations do work at finer grid spacings. Work on SPPT continues within the HarmonEPS community.

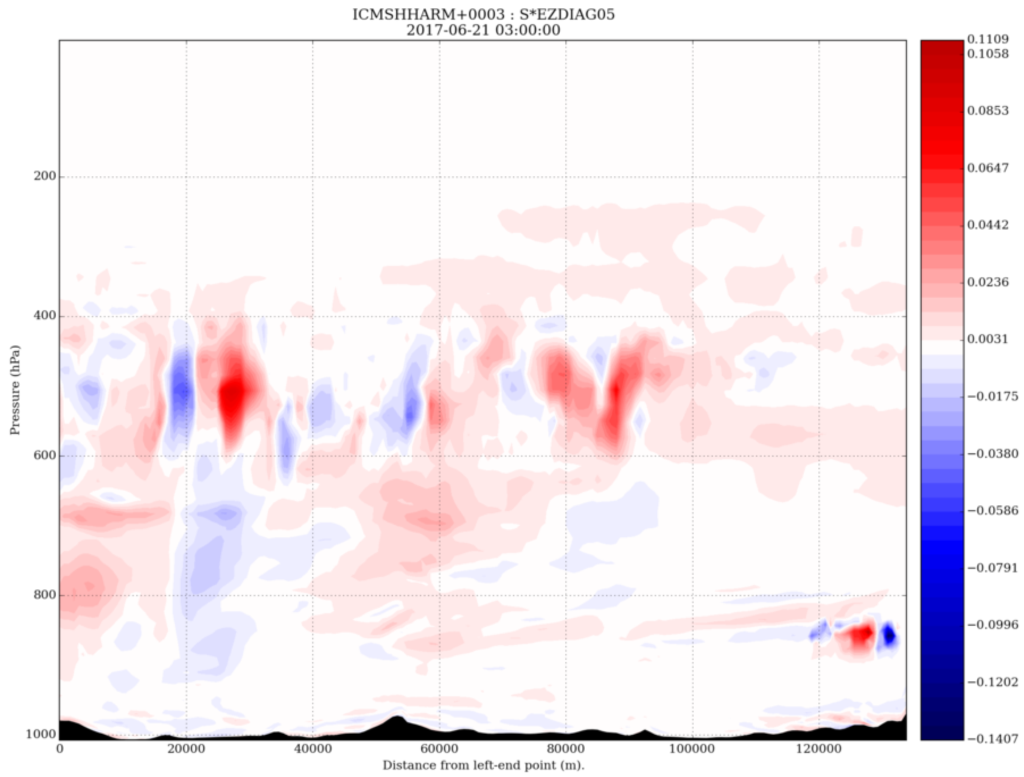

Fig. 13: Cross-section across Ireland showing the influence of the SPPT perturbations on the vertical profile of the temperature tendency. Red colours show positive temperature anomalies from SPPT, blue show negative

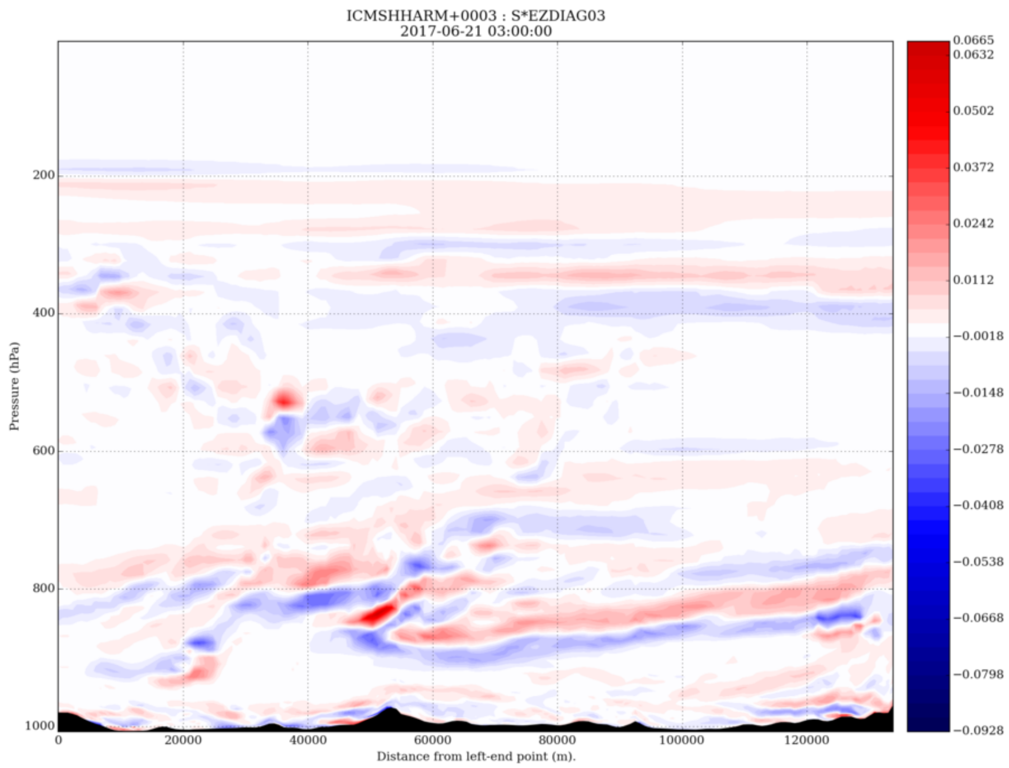

Fig. 14: As for Fig. 13 except for the tendency of the U wind component

List of publications/reports from the project with complete references

For the moment, no publications are planned in relation to this work.

Future plans

Some of the work that was undertaken in this project has fed into work in the HarmonEPS Working Group on EPS, in particular the control settings for the SPPT perturbations.