SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2020
Project Title:	The Impact of Stochastic Parametrisations in Climate Models: EC-EARTH System Development and Application
Computer Project Account:	spgbtpsp
Principal Investigator(s):	T. N. Palmer K. J. Strommen H. M. Christensen S. Juricke D. MacLeod A. Weisheimer
Affiliation:	University of Oxford
Name of ECMWF scientist(s) collaborating to the project	Antje Weisheimer.
Start date of the project:	1st of January 2018
Expected end date:	31st of December 2020

Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	17000000	16046253	13000000	792304
Data storage capacity	(Gbytes)	10 Tb	~8 Tb	10 Tb	~1 Tb

Summary of project objectives

The central aim of the project is to implement stochastic parametrisation schemes in multi-year integrations of the EC-Earth climate model and investigate their impacts on the modelled climate. Stochastic schemes are developed for all components of the EC-Earth model (atmosphere, ocean, sea-ice and land) and tested in different combinations. Model evaluation is focused both on basic mean state biases, long-term climate dynamics (e.g. ENSO), response to forcing (i.e. climate sensitivity) and the representation of key regional phenomena crucial for modulating local climate (e.g. Euro-Atlantic weather regimes, the Indian summer monsoon etc.)

Summary of problems encountered (10 lines max)

No serious problems were encountered during the reporting period. The main problem that had been posed in previous years was dealing with the large volume of raw model data, which needed to be kept in temporary storage for a limited amount of time to allow for robust post-processing. This was more problematic because of the need to run multiple ensemble members in parallel, which was frequently necessary to meet project deadlines. This was adequately handled in collaboration with ECMWF support and there have been no further issues.

Summary of plans for the continuation of the project

The remaining units of the project will be devoted to two main objectives. The first is to undertake a first ever abrupt4xCO2 experiment with the SPPT scheme turned on. The spin-up and pre-industrial control are already in progress, in collaboration with colleagues using units on a separate ECMWF Special Project. The goal is to compare this with the existing abrupt4xCO2 of the deterministic EC-Earth (generated for CMIP6) and understand how SPPT changes the equilibrium climate sensitivity as well as individual feedbacks (using a radiative kernel method). This is to resolve outstanding questions posed from existing results using transient forcing scenarios which showed non-linearities in the response.

The second main objective is to implement a new humidity fix for SPPT and test it in short climate simulations.

List of publications/reports from the project with complete references

- Deliverable D4.1 Report, PRIMAVERA Horizon 2020.
- Deliverable D4.4 Report, PRIMAVERA Horizon 2020.

Both reports are awaiting publication following approval from the EU H2020 Coordinators. Once approved, they will be publicly available at https://www.primavera-h2020.eu/output/project-deliverables/

- Impact of stochastic physics and model resolution on the simulation of Tropical Cyclones in climate GCMs, P.L. Vidale et al., 2020; in preparation.

Summary of results

This reporting period was devoted firstly to the completion of our suite of EC-Earth ensembles, as part of our contribution to the PRIMAVERA Project. This consisted of 3 ensemble members for each of the following configurations of EC-Earth3 v3.2: CTRL (default, deterministic), SPPT (with SPPT turned on), OCE (with stochastic ocean and sea-ice schemes turned on in NEMO and LIM), FESM (SPPT, stochastic ocean and sea-ice and a stochastic land scheme in H-Tessel), and PESM (as for FESM but using Independent SPPT instead of SPPT). Each member covers 1950-2015 with historical forcing, running at T255L91 resolution coupled to a 1 degree NEMO. For each configuration, 1 ensemble members was extended out to 2050 using RCP8.5 forcings. Each member was post-processed and CMOR-ized, with the CMOR-ized data then transferred to local storage servers in Oxford.

As discussed in the previous progress report, most of this ensemble was completed in the previous period. The outstanding simulations completed in this reporting period were the ensemble members of the FESM configuration. These were completed in autumn 2019.

The remainder of the reporting period consisted in an extensive analysis on the stochastic ensembles. A comprehensive summary of this analysis was written up and submitted as our contribution to Deliverable D4.1 in the PRIMAVERA H2020 Project. It included an assessment of changes in mean state and variance biases of global fields, Arctic sea-ice variability and evolution, precipitation and wind-speed extremes, atmosphere-ocean coupling, the AMOC, tropical cyclones, teleconnections to mid-latitude circulation from ENSO and the Arctic, and a preliminary assessment of the impact on Euro-Atlantic weather regimes. Broad improvements were found in many of these, in many cases comparable in magnitude to improvements found with increased horizonal resolution. The results on teleconnections, tropical cyclones and weather regimes are in the process of being written up into research papers. The D4.1 report itself is awaiting publication following approval from the EU H2020 coordinators.

A second PRIMAVERA Deliverable, D4.4, was also completed in the reporting period. This assessed changes to the diurnal cycle with stochastic physics compared to increased resolution, and how such changes may evolve in the future under an RCP8.5 forcing scenario. The report is awaiting publication following approval from the EU H2020 coordinators.

Our contribution to both reports can be forwarded to ECMWF upon request, in case their evaluation is required prior to their official publication later this summer. As a `highlight' example, we found that the inclusion of the stochastic sea-ice and ocean schemes not only notably improved mean-state and variance biases of Arctic sea-ice concentration, but also resulted in the appearance in the model of a teleconnection between November sea-ice and the December-January-February North Atlantic Oscillation. Such a teleconnection is a robust presence in reanalysis data, but was not represented in either the low or high-resolution deterministic EC-Earth. See Figures 1 to 3 below.

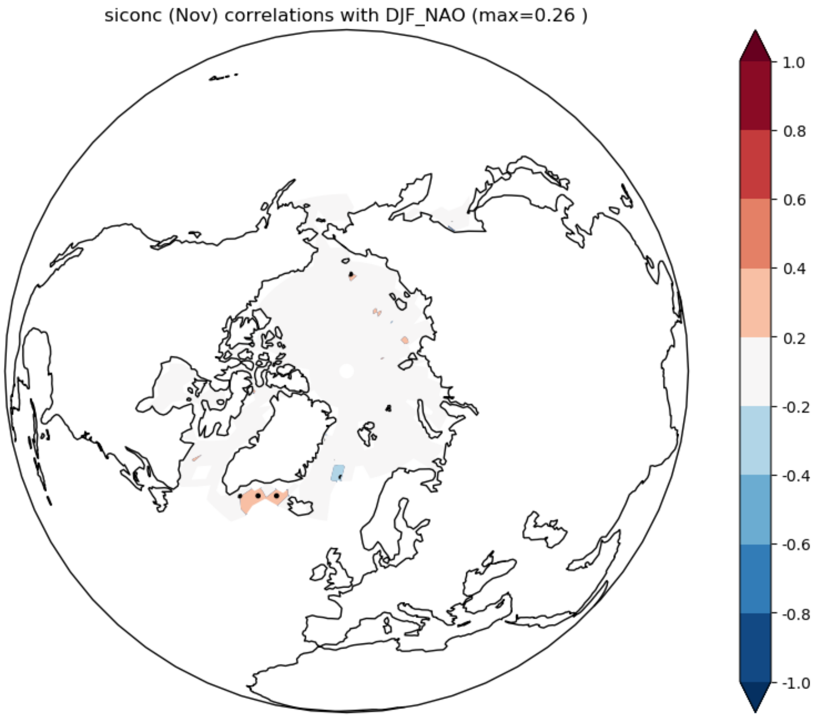

Figure 1: Correlations between November gridpoint sea-ice concentration and the subsequent DJF NAO index, across the period 1980-2015. Using the deterministic EC-Earth3P at T255L91 resolution, coupled to a 1 degree NEMO/LIM.

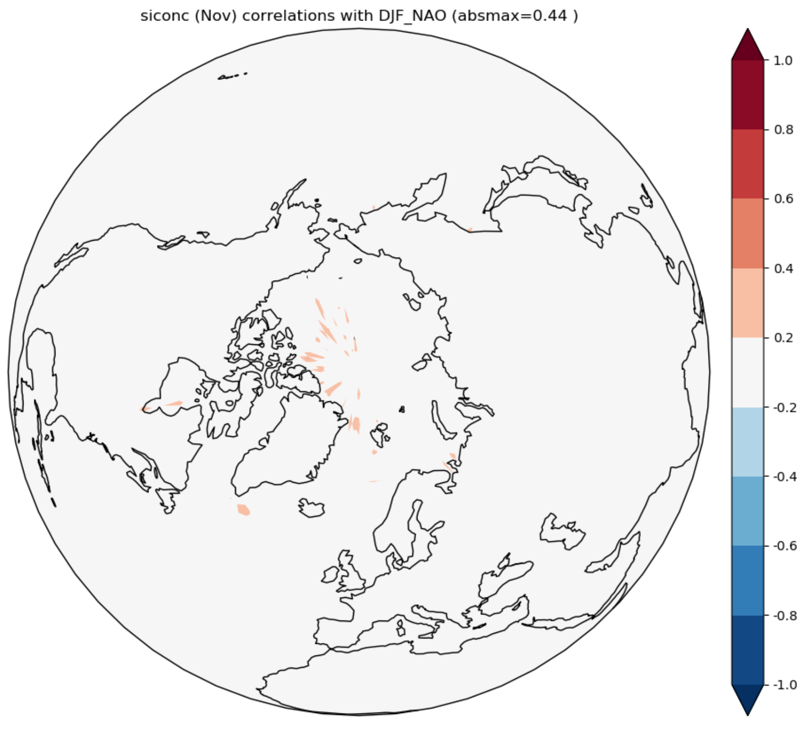

Figure 2: As above but using a deterministic EC-Earth3P at T511L91 resolution, coupled to a 0.25 degree NEMO/LIM.

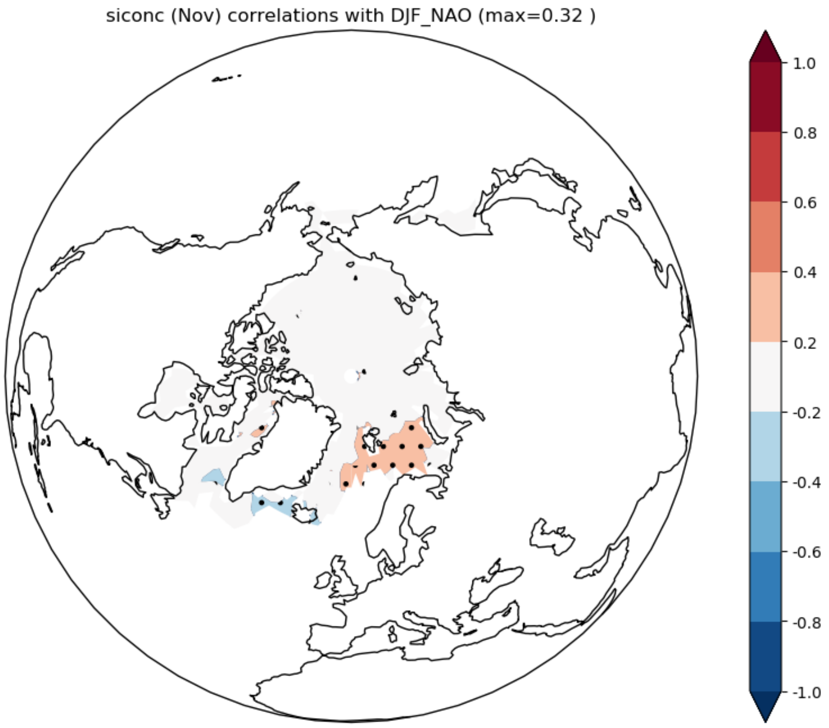

Figure 3: As in Figure 1 but now activating a stochastic sea-ice and ocean scheme.