REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE:	United Kingdom
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Project Title:	Disentangling the local and remote effect of SPPT on seasonal time-scales

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ________________	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2020	
Would you accept support for 1 year only, if necessary?	**YES** ☒	NO ☐

Computer resources required for 2020-2022: (To make changes to an existing project please submit an amended version of the original form.)		**2020**	**2021**	**2022**
High Performance Computing Facility	(SBU)	13 000 000	10 000 000	0
Accumulated data storage (total archive volume)[2]	(GB)	20 000	35 000	0

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.
[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.

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Extended abstract

Model uncertainties stem to a large proportion from unresolved sub-grid scale processes or inadequate physical parametrizations. These model uncertainties can be considered by e.g. multi-model or perturbed parameter ensembles (Weisheimer et al., 2011). In ECMWF's current operational forecast systems, model uncertainties are represented using the Stochastically Perturbed Parametrization Tendency scheme (SPPT) (Palmer et al., 2009; Johnson et al., 2018), for which model uncertainties are assumed to be proportional to the net physics tendency. SPPT has been shown to improve forecast on NWP to seasonal time-scales by increasing their reliability (Fig. 1). Large effects are found in tropical regions, e.g. on tropical precipitation (Subramanian et al., 2017) and the Madden-Julian-Oscillation (Leutbecher et al., 2017). Improvements in tropical regions on seasonal and climate time-scales are found to be closely linked to the impact of SPPT on ENSO (Strømmen et al, 2018, Christensen et al., 2017, Weisheimer et al., 2011).

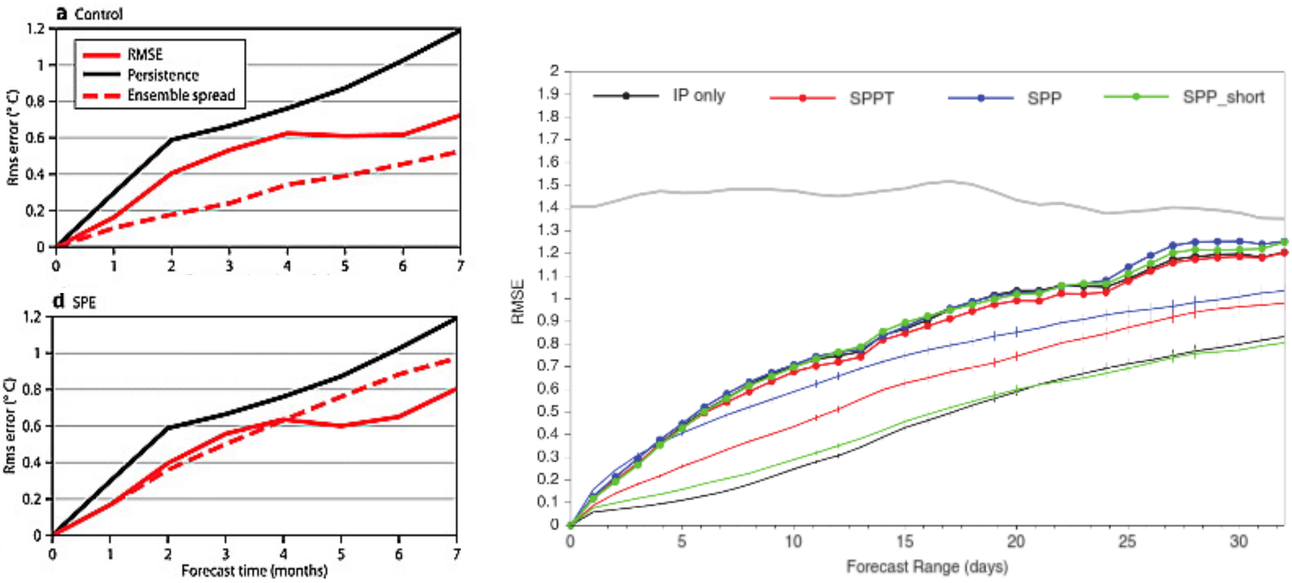

Fig. 1: Left: *"Skill comparison for predicting Niño3 SST anomalies in [...] the stochastic physics ensemble (SPE) and the control simulation for the SPE system (CTRL) showing the ensemble mean RMSE (red solid), the ensemble spread (red dashed) and the RMSE of a simple persistence reference forecast (black dash-dotted) as a function of forecast lead time" (Weisheimer et al., 2011; adapted from their Fig. 3)*
Right: *"Evolution of RMS error (solid lines with dots) and ensemble spread (thin lines) for the leading two MJO PCs. Initial perturbations only (black), SPPT with global conservation fix (red), SPP (blue) and SPP with short correlation scales (green). The grey solid line represents the RMS error of the ERA-Interim climatological mean. The vertical bars represent the 90% level of confidence of the ensemble spread. 32 day reforecasts starting four times a year (1 February, May, August and November) over the period 1989–2014 (104 start dates). The ensemble size is 15 and the horizontal resolution is TCo159 with 91 vertical levels." (Leutbecher et al., 2017; their Fig. 6)*

However, SPPT also positively impacts forecasts in extratropical regions as shown for patterns over the Pacific–North America region (Weisheimer et al., 2014; Fig. 2). SPPT has also been shown to improve the simulation of Euro-Atlantic weather regimes (Dawson and Palmer, 2015). Here, the representation of the spatial patterns is particularly improved whereas improvements w.r.t. the persistence of weather regimes is dependent on resolution and the regime itself (Dawson and Palmer, 2015).

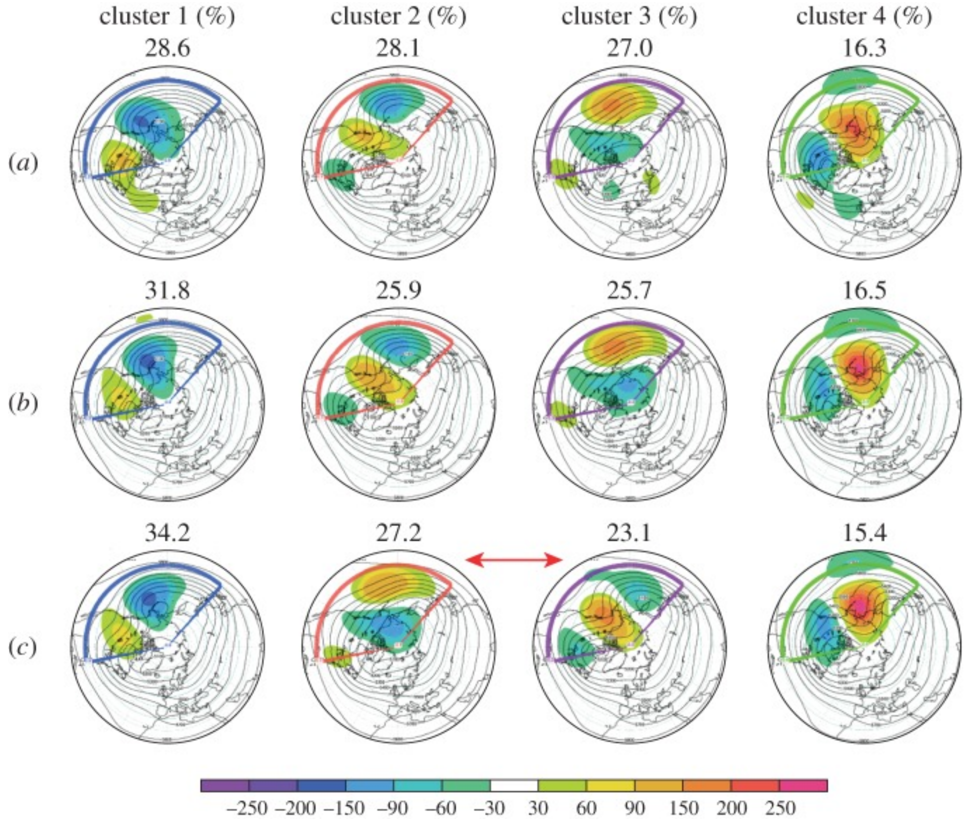

Fig. 2: *"Circulation regimes over the PNA region in ERA-Interim reanalysis data (a), System 4 (b) and in stochphysOFF (c) for anomalies (shades) and full fields (contours) of Z500. The numbers indicate the relative frequency of occurrence of each cluster." (Weisheimer et al., 2014; their Fig. 9)*

Many studies suggest the positive impact of SPPT on seasonal or longer time-scales over both tropical and extratropical regions, however, especially for the latter it is difficult to assess the origin of these improvements. In general, there are two sources for increased skill in the extratropics, being the ***local SPPT effect*** due to adding noise related to sub-grid scale processes over the extratropics itself and the ***remote SPPT effect***, which positively impacts tropical-extratropical teleconnections.

This study is designed to close this knowledge-gap by running targeted simulations. To disentangle the ***local*** and ***remote SPPT effect***, two sets of simulations are planned (Table 1). The first set of simulations (#1 in Table 1) will allow to analyse the ***local SPPT effect*** by only applying SPPT over the extratropics (90°S to 30°S and 30°N to 90°N). The second set of simulations (#2) will allow examination of the ***remote SPPT effect*** on skill over the extratropics by only applying SPPT to the tropical belt (30°S-30°N). All simulations will be carried out in the seasonal framework, initialized each November from 1981 until 2014 (34 start dates) with a total forecast length of 7 months, for 25 ensemble members. The resolution for all simulations will be TCo199 together with a 1-degree ocean, which is generally referred to as the low-resolution version of ECMWF's current operational seasonal forecast system SEAS5 but using IFS cycle 46r1. The choice of this setup is motivated by the fact that two control simulations are currently carried out within the PI's late special project (SPGBDJB - *Assessing the impact of stochastic physics (SPPT) on sub-decadal time-scales*). These control experiments will be available by the start of this project. One of these control simulations is performed without SPPT (global) whereas the other is run with the standard setup (SPPT on). In total, these four simulations will allow to compare the ***global SPPT***, ***local SPPT*** and ***remote SPPT*** effect on extratropical circulation. Analyses are planned to focus on extratropical circulation patterns e.g. NAO or European blocking as well as large-scale teleconnections, e.g. the PNA-ENSO relationship. Further to the existence of the two control simulations, this IFS model version enables a high level of flexibility due to the ability to restart previous model simulations (see Technical Requirements for further information).

From a scientific perspective, these simulations will provide new insights into the drivers of extratropical predictability as well as the relative contributions of ***local*** and ***remote SPPT effects***. This is of direct relevance for seasonal forecasts, but also has potential implications for decadal predictions and climate projections.

List of proposed experiments:

#	Model	Atm. Res.	Ocean Res.	Ini Dates	Length in month [per run]	Years	#Ens. Members	Stochastic Scheme
1	IFS 46r1	TCo199	1 deg	1st Nov	7	1981-2014	25	30N-90N 30S-90S
2	IFS 46r1	TCo199	1 deg	1st Nov	7	1981-2014	25	30S-30N

Table 1: *List of proposed experiments*

Timeline:

Q1-Q4 2020: First 4 months of experiment #1 & #2 **

Q1-Q4 2021: Last 3 months of experiment #1 & #2 **

** This setup of running the first 4 months in 2020 and the remaining 3 months in 2021 will be possible due to the implementation of the ability to continue previous IFS simulations (see Technical Requirements).

Technical Requirements:

The proposed simulations will be conducted using the IFS cycle 46r1 model. Coupled hindcasts with a length of 7 months initialized in November (see Table 1) with 25 ensemble members each, will be performed. Two experiment sets with SPPT (#1 in Table 1) over the extratropics and over the tropics (#2 in Table 1) will allow to analyse the local and remote impact of SPPT on the extratropics. The PI of this special project recently implemented the ability to continue a previous IFS run into cycle 46r1 (given that necessary restart files have been saved at the end of the precious run). This will allow to run the first 4 months of experiment #1 and #2 in 2020 and the remaining 3 months in 2021. Thus, first results comparing **remote** and **local SPPT effect** (based on a forecast length of 4 months) are expected already in 2020.

Costs of proposed experiments:

The costs for one individual model run over one month using IFS cycle 46r1 are:

- **~ 1900 SBU**

Total costs for 34 years * 25 ensemble members * 7 months are:

- **~ 11,305,000 SBU**

Thus, overall costs for all experiments planned are roughly:

- **~ 23,000,000 SBU**

References

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