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	2021
Project Title:	Sensitivity experiments on decadal prediction
Computer Project Account:	SPITMECC
Principal Investigator(s):	Virna Loana Meccia
Affiliation:	Institute of Atmospheric Sciences and Climate, National Research Council (ISAC-CNR), Italy.
Name of ECMWF scientist(s) collaborating to the project (if applicable)	-
Start date of the project:	01-01-2019
Expected end date:	31-12-2021

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)	9,500,000	9,500,000	9,500,000	1,039,102
Data storage capacity	(Gbytes)	30,000	30,000	45,000	30,000

Summary of project objectives (10 lines max)

The original special project had the aim of exploring the role of ocean decadal variability on global climate. The original plan was to apply EC-Earth version v3.2.2. to a series of experiments designed following the Decadal Climate Prediction Project.

Summary of problems encountered (10 lines max)

As already reported in the previous periods, we have considered it of utmost importance to deviate from the original plan to study the impacts of including stochastic physics schemes (SPS) in the atmospheric component of EC-Earth on the predicted climate. Based on our previous results, we have started a collaboration with colleagues from the University of Oxford to address the remaining open questions regarding the impacts of including SPS in the atmospheric component of EC-Earth, on climate sensitivity.

Summary of plans for the continuation of the project (10 lines max)

Together with others colleagues, we could apply the SPS on the CMIP6-generation EC-Earth for running a *spin-up*, *piControl* and *abrupt4xCO2* simulations. We are currently analysing those experiments in comparison with the already existing CMIP6 simulations in which the SPS is not activated. Depending on the results we get, we might plan a new set of experiments.

List of publications/reports from the project with complete references

There are no publications regarding this special project during the period July 2020-June 2021.

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

During the reported period, (July 2020 – June 2021), some of the experiments proposed in the previous report were run with the core hours of this special project. In particular, we have run about 170 years of the *abrupt4xCO2* experiment with EC-Earth3 and the stochastic physics schemes activated in the atmospheric component (EC-Earth3S). This run, together with the *piControl* experiment (also with the SPS activated) allows us to compute the Equilibrium Climate Sensitivity (ECS) and to compare the result with the ECS obtained for the equivalent CMIP6 experiments with the standard EC-Earth3, that is, when SPS is not activated (EC-Earth3). Climate sensitivity is typically defined as the global temperature rise following a doubling of CO2 concentration in the atmosphere compared to pre-industrial levels. The ECS is, therefore, the temperature increase that would eventually occur (after hundreds or even thousands of years) when the climate system fully adjusts to a sustained doubling of CO2.

The timeseries of global air surface temperature (TAS) for 4 experiments (*piControl* and *abrupt4xCO2*, both with EC-Earth3 and EC-Earth3S) are plotted in Figure 1.

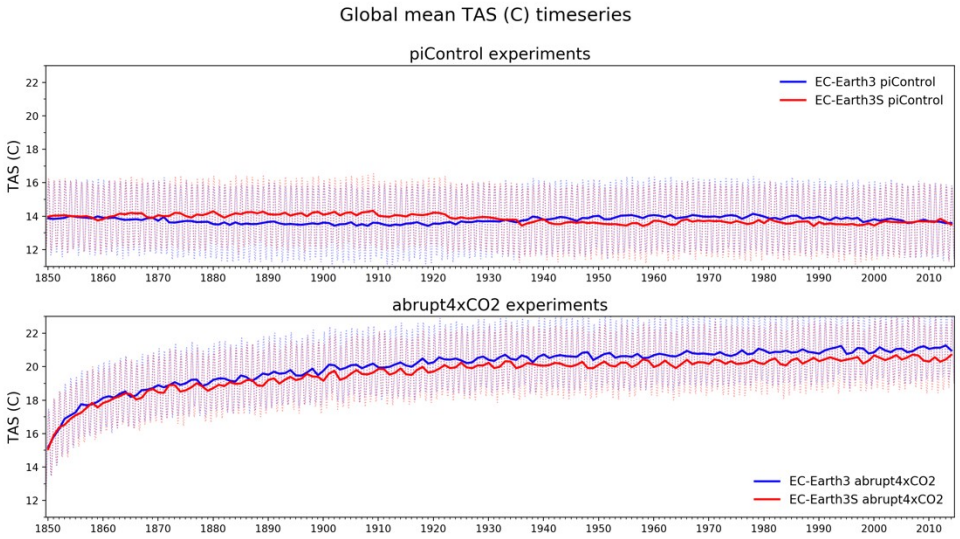

Figure 1. Timeseries of monthly and annual TAS (C) for the piControl (upper panel) and abrupt4xCO2 (lower panel). Blue (red) lines correspond to the runs without (with) the stochastic physics scheme activated in the atmospheric component.

The ECS was computed by applying the method of Gregory et al. (2004). As models may present an energy balance that is not perfectly closed, resulting in a nonzero equilibrium at the Top of the Atmosphere (TOA) net flux (Qnet), the *piControl* equilibrium values are typically removed from the *abrupt4xCO2* values before proceeding with the computation of ECS. To do so, we subtracted from the *abrupt4xCO2* experiment values, the mean values of both, Qnet and TAS of the corresponding *piControl* experiment. Only the last 50 years of simulation from the *piControl* were considered to compute the mean values. We plotted the increments in Qnet versus the increments in TAS with respect to the equilibrium *piControl* and we fitted a line to the scatterplots (Figure 2). The fitted line gives us information about the ECS (intercept of the linear fit with the abscissa divided by 2), the radiative feedback parameter (slope) and the effective radiative forcing (ERF; intercept with the ordinate divided by 2) as shown in Table 1.

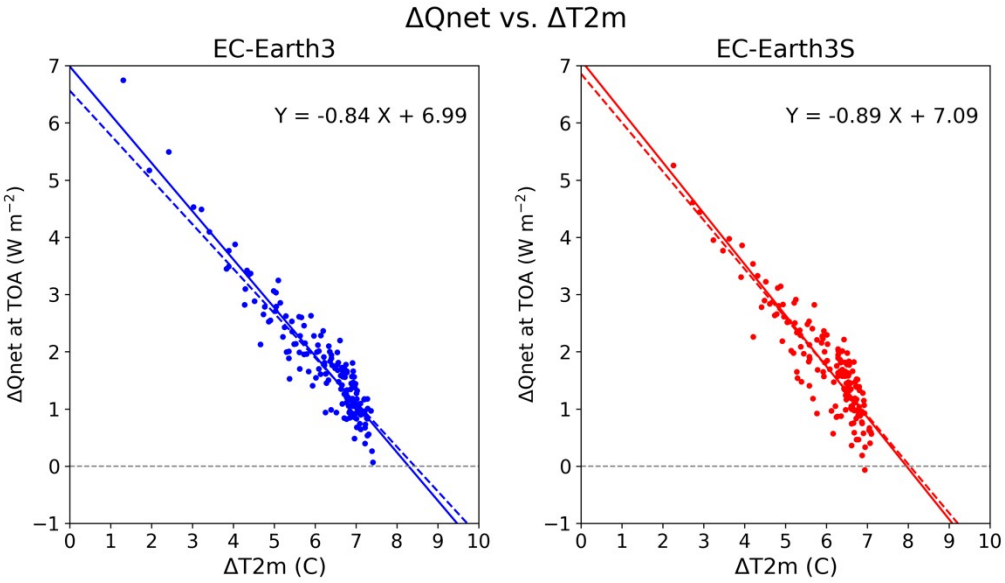

Figure 2: Gregory plots from the abrupt4xCO2 experiment of EC-Earth3 without (left) and with (right) the SPS activated in the atmospheric component after subtracting the corresponding piControl equilibrium value. A regression line considering all the data (solid line) and the last 155 years (dashed line) is fitted.

MODEL	ECS	λ	ERF
EC-Earth3	4.14	-0.84	3.49
EC-Earth3S	3.98	-0.89	3.54

Table 1. Equilibrium climate sensitivity (ECS, in C), net feedback parameter (λ, in W m^{-2} K^{-1}) and effective radiative forcing (ERF, in W m^{-2}) in EC-Earth3 and EC-Earth3S.

Although previous studies show that the inclusion of SPS affects the transient climate sensitivity (Strommen et al, 2019; Meccia et al., 2020), the ECS is similar in both cases, EC-Earth3 and EC-Earth3S. Based on these results, we will continue investigating the impacts of SPS on transient climate sensitivity based on new experiments of the *1pctCO2*.

References

Gregory, J. M., Ingram, W. J., Palmer, M. A., Jones, G. S., Stott, P. A., Thorpe, R. B., Lowe, J. A., Johns, T. C., and Williams, K. D. (2004). A new method for diagnosing radiative forcing and climate sensitivity. Geophysical Research Letters, 31, L03205. https://doi.org/10.1029/2003GL018747

Meccia V.L, Fabiano F., Davini P and Corti S. (2020). Stochastic parameterizations and the climate response to external forcing: An experiment with EC-Earth. Geophysical Research Letters, 47, e2019GL085951. https://doi.org/10.1029/2019GL085951.

Strommen, K., Watson, P. A. G., and Palmer, T. N. (2019). The impact of a stochastic parameterization scheme on climate sensitivity in EC-Earth. Journal of Geophysical Research-Atmosphere, 124. https://doi.org/10.1029/2019JD030732