SPECIAL PROJECT
PROGRESS REPORT

Progress Reports should be 2 to 10 pages
in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year ………July 2017 – June 2018……………….……

Project Title: ………Effects of a stochastic gravity wave parameterization on the simulation of stratospheric dynamics……………………………………….……

Computer Project Account: ……SPITCHCG……………………………….……

Principal Investigator(s): ……Chiara Cagnazzo ………………………….……

……Federico Serva…………………………….……

Affiliation: ……ISAC/CNR……………………………………….……

Name of ECMWF scientist(s) collaborating to the project (if applicable) …………………………………………………………….……

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Start date of the project: ……2016…………………………………………….……

Expected end date: ……2019…………………………………………….……

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)	2’000’000	2’000’000	2’000’000	75’000
Data storage capacity	(Gbytes)	30’000	15’000	30’000	100

Summary of project objectives

(10 lines max)

The main objective of this Special Project is to study the dynamics of the stratosphere using climate model simulations. This is pursued using a custom version of a stratosphere-resolving model (ECHAM5), in which the parameterization of nonorographic gravity waves (NOGWs) is made stochastic. The stochastic approach is motivated by the intermittent nature of NOGWs, which is not represented in the default model version. The purpose is also to contribute to international coordinated initiatives related to the modeling of stratospheric processes (more details below).

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Summary of problems encountered (if any)

(20 lines max)

No particular problems encountered, but prompt and effective assistance from ECMWF support staff is acknowledged over minor technical issues.

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Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

During this period, two main activities have been carried out in the frame of the Special Project.

On the one hand, as stated in the Special Project proposal, we started using the EC-EARTH global climate model [Hazeleger et al., 2010], which will be used by the consortium for participating in the upcoming Coupled Model Intercomparison Project – Phase 6 (CMIP6) [Eyring et al., 2016]. The atmospheric component of the model, the Integrated Forecasting System (IFS), is simulating the stratosphere and the lower mesosphere in the standard configuration of the model (T255L91), with the model top at around 80 km.

Therefore the model is well suited for the DynVarMIP [Gerber and Manzini, 2016], a MIP dedicated to the simulation of the stratosphere and its implication for the circulation and surface climate. However, some technical work on the model is necessary to have the required output in the desired format. This is being achieved by modifying the model code – particularly for the gravity waves related quantities – in the main routine and several modules.

Given that some testing is necessary, we also performed some sensitivity tests for the parameterized NOGW forcing. In the IFS, the scheme of [Scinocca et al., 2002] is used for representing the interaction of small scale waves with the mean flow in the middle atmosphere. A key parameter, which remains not well constrained, is the momentum flux at the launching level (GFXLAUN parameter).

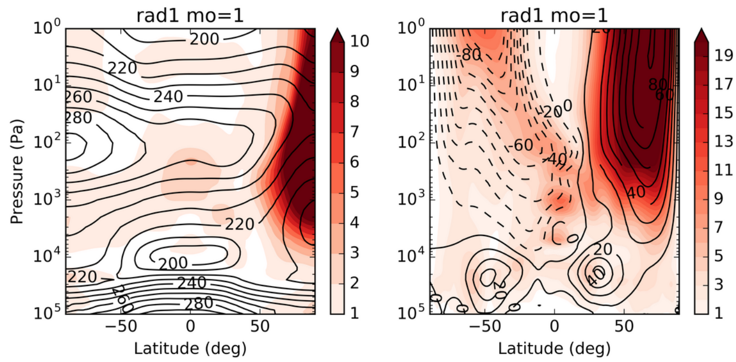

Figure 1: the zonal mean temperature (left) and zonal mean zonal wind (right) for a simulation with reduced NOGW momentum flux. Mean over 10 years (lines) and interannual variability (red shadings).

A smaller NOGW flux at launching level (Figure 1) strongly affects the stratospheric dynamics at high latitudes. The vortex is in fact overly strong, and the observed weakening of the zonal wind is absent. Significant changes are also present at low latitudes, as substantial forcing of the Quasi-Biennial Oscillation comes from parameterized NOGW. As it is evident from Figure 2, reducing the momentum flux at launch leads to the disappearence of the QBO. Clearly this circumstance is problematic, as e.g. projected changes of the QBO are strongly dependent on the NOGW scheme.

Another part of the resources has been dedicated to the activities related to the Quasi-Biennial Oscillation Initiative (QBOi, [Butchart et al., 2018]). Thanks to the allocated resources, we can participate with our modified version of the ECHAM5 model to some of the new experiments. In particular, some new experiments have been added to the initial protocol, in order to study the sensitivity of the modelled QBO to the El Niño – Southern Oscillation (ENSO) phenomenon. These simulations are recently started, after the definition and finalization of the common input files for the simulations.

References

[Butchart et al., 2018] Geosci. Model Dev., 11, 1009-1032, 2018, 10.5194/gmd-11-1009-2018
[Eyring et al., 2016] Geosci. Model Dev., 9, 1937-1958, 2016, 10.5194/gmd-9-1937-2016
[Gerber and Manzini, 2016] Geosci. Model Dev., 9, 3413-3425, 2016, 10.5194/gmd-9-3413-2016
[Hazeleger et al., 2010] BAMS, 10.1175/2010BAMS2877.1

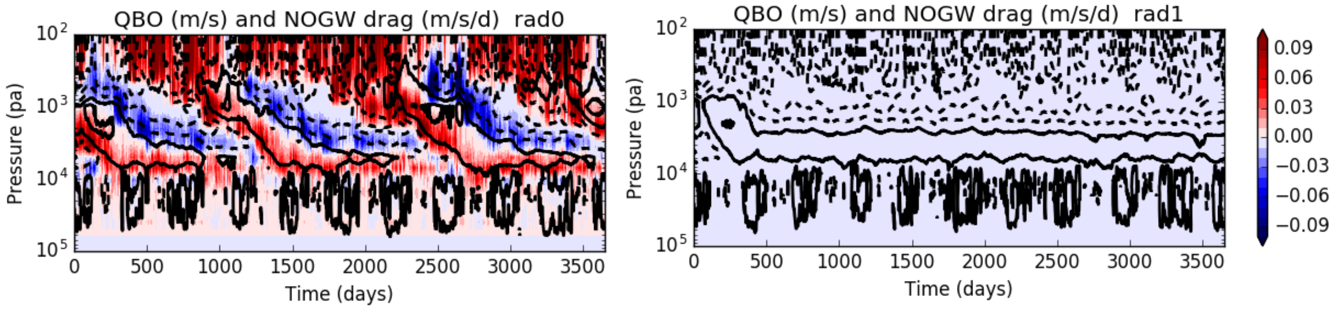

Figure 2: The QBO sensitivity to a reduction of the momentum flux at the launching level. Averaged zonal mean zonal wind in the +/- 5 degree channel (lines) and the acceleration from NOGWD (shadings). The oscillation is suppressed in the stratosphere when the forcing at the launching level is too small.

List of publications/reports from the project with complete references

Serva, F., Cagnazzo, C., Riccio, A. and Manzini, E., Impact of a stochastic nonorographic gravity wave parameterization on the stratospheric dynamics of a General Circulation Model, JAMES, Under Review, 2018

Butchart et al., Overview of experiment design and comparison of models participating in phase 1 of the SPARC Quasi-Biennial Oscillation initiative (QBOi), Geosci. Model Dev., 11, 1009-1032, 2018, doi:10.5194/gmd-11-1009-2018

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Summary of plans for the continuation of the project

(10 lines max)

We plan to employ a consistent portion of the allocated resources for the experiments related to the QBOi activities. Other resources could be used for shorter simulations with the EC-EARTH model (in the atmosphere only configuration), in support of the DynVarMIP exercise.

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