REQUEST FOR A SPECIAL PROJECT 2016–2018

MEMBER STATE: …………………ITALY……...……………………………………

Principal Investigator[1]**:** ………Chiara Cagnazzo…………………………………………..……

Affiliation: …………ISAC_CNR……………………………..……

Address: ……………Via Fosso del Cavaliere 100, 00100 Rome, Italy
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E-mail: …c.cagnazzo@isac.cnr.it…………………………………………
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Other researchers: …Federico Serva, Gloria Rea, Riccardo Biondi.……

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Project Title: … Effects of a stochastic gravity wave parameterization on the simulation of stratospheric dynamics
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If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ________________	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2016	
Would you accept support for 1 year only, if necessary?	**YES X**	NO ☐

Computer resources required for 2016-2018: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2018.)	**2016**	**2017**	**2018**
High Performance Computing Facility (units)	1.0 million	2.0 million	2.0 million
Data storage capacity (total archive volume) (gigabytes)	25000	30000	30000

An electronic copy of this form ***must be sent*** *via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date):
………30 June 2015……………

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

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Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

Current state-of-the-art Atmospheric General Circulation Models (AGCM) do not explicitly resolve small-scale waves and use parameterizations to take into account the momentum deposition associated with upward propagating gravity waves (GWs).

Specifically, the orographically excited GWs, which are stationary, having an important role in the extratropics Northern Hemisphere (NH) middle atmosphere in winter and GWs with non zero phase speed relative to the surface, having a predominant contribution to the momentum budget of the NH extratropics during summer and in the tropics and Sothern Hemisphere (SH) during all time of the year.

In GCMs, contributions to the forcing by subgridscale (unresolved) flows are generally represented, if at all, by deterministic parameterizations. A deterministic parameterization is based on the assumption that subgrid-scale flows are in some form of statistical equilibrium with the resolved fields and that such a statistical equilibrium can be adequately represented by the mean of their distribution alone. Some studies have suggested that representing higher-order moments in parameterizations of subgrid-scale flows may improve GCMs.

For example Buizza et al. (1999) showed how the forecasting skill in the European Center for Medium-Range Weather Forecast Ensemble Prediction System (ECMWF EPS) could be improved simply by adding an arbitrary amount of variance to the total parameterized forcings. Palmer (2001) used a low-order simple dynamical system to show that using a deterministic parameterization for one of the independent variables fails entirely to reproduce the expected features of the system. He also showed that adding a simple stochastic term to the parameterized variable improved the system behavior greatly and suggested that some of the remaining errors in climate prediction may have their origin in the neglect of subgrid-scale variance. Piani (2003) extended these results and showed that a further improvements could be made by constraining the stochastic parameterized variable to follow the probability density function observed in the original system.

Therefore, if the distribution of a stochastic parameter is known, that should be used to constrain the stochastic parameter in the GCM. In our case, we will use the analysis of Piani et al 2013 that used observations of the flow at the subgrid-scale to define a distribution for the root mean square GW winds. The model in use is the ECHAM5 GCM that already includes a Doppler-spread Hines scheme.

The purpose of the work will be to include a stochastic component in the already existing parameterization to represent the intermittent nature of the convective generating processes. The sensitivity of the tropical and polar stratosphere to changes in the gravity wave scheme will then be examined.

Particular attention will be given to how the Quasi Biennial Oscillation (QBO) and the winter stratosperic polar vortices respond to changes in the introduction of a stochastic source strength with varying distributions into the gravity wave parameterization.

The QBO of equatorial zonal winds is a prominent feature of stratospheric dynamics. That is driven downward by waves which originating in the troposphere and travelling upwards into the stratosphere. The waves break, deposit momentum and cause a downward propagation of the wind max ima. Those waves include large scale Kelvin and Rossby-gravity waves as well as smaller scale gravity waves with shorter horizontal wavelength. Dunkerton (1997) show that the contribution of intermediate inertia-GWs and mesoscale GWs is necessary to produce a QBO with realistic period and amplitude. For a more detailed description on the forcing and the physical mechanisms of the QBO (see the review paper by Baldwin et al. 2001). The QBO has also impact on other parts of the atmosphere, in both the stratosphere and the troposphere. Holton and Tan (1980) show that the easterly phase of the QBO is associated with weakening of the northern wintertime stratospheric polar vortex. In the troposphere, the QBO influences tropical cyclone tracks (Ho et al. 2009), the boreal summer monsoon (Giorgetta et al. 1999) and tropical deep convection (Collimore et al. 2003).

Experimental details:

We will make make use of the MA-ECHAM5 model (Roeckener et al., 2006) with top at 0.01 hPa and 95 vertical layers, T63 horizontal resolution (about 1.9 degrees) and with the shortwave radiation scheme implemented by Cagnazzo et al. (2007). This version of ECHAM5 includes a well-resolved stratosphere in the sense that stratospheric planetary wave–mean flow interaction, possibly leading to SSW events, is explicitly resolved and the effects of both orographic and non-orographic gravity waves on the stratospheric and mesospheric large-scale flows are parameterized (Manzini et al., 2006; Charlton et al., 2007; Cagnazzo and Manzini, 2009). It also includes a spontaneously occurring QBO (Giorgetta et al., 2006). The standard model version employs the GW scheme after Hines which is based on the Doppler spread theory (Hines 1997a, b). The schemes launches a broad band spectrum of waves at 600 hPa with constant amplitude in time and longitude. The strength of the source is determined by the RMSCON (root mean square of the wind variability) parameter. At each time step, four pulses of upward propagating gravity waves are released. The waves propagate in the four cardinal directions and are characterized by the same initial vertical wave number spectrum.

In the first year we will realize a first set of simulations (50 years long each) by changing the RMSCON parameter in the deterministic model configuration over all the globe and study the sensitivity of the atmospheric circulation to the chosen parameter. The simulations will be atmosphere-only with imposed observed SSTs. Another set of simulations will be realized by changing the RMSCON parameter differently in the tropics and in the extra-tropics. A stochastic parameterization of the RMSCON will then be realized and implemented in the model, with different the gravity wave source strength constrained to follow different probability distributions. A set of test simulations will be realized. The analysis of stratospheric and tropospheric dynamics will focus in the Tropical regions and in the polar vortex part of the atmosphere in the two hemispheres.

In the second and third year, the atmospheric model will be run in its coupled atmosphere-ocean-seaice version. The ocean-sea-ice component is OPA-LIM, with 31 levels and horizontal resolution of 2°x2° with refinements around the Equator (Madec et al., 1999; Timmermann et al., 2005). The physical and technical coupling interface is described by Fogli et al. (2009). A set of long term simulations will be realized. The simulations in the case should be ~ 300 years long, after a further ~ 500 years oceanic model spin-up.

The simulated stratosphere will also be compared with the one simulated by the EC-EARTH model.

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