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Analyses of the stratospheric dynamics simulated by a GCM with a stochastic nonorographic gravity wave parameterization

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The effects of the propagation and breaking of atmospheric gravity waves have long been considered crucial for their impact on the circulation, especially in the stratosphere and mesosphere, between heights of 10 and 110 km. These waves, that in the Earth's atmosphere originate from surface orography (OGWs) or from transient (nonorographic) phenomena such as fronts and convective processes (NOGWs), have horizontal wavelengths between 10 and 1000 km, vertical wavelengths of several km, and frequencies spanning from minutes to hours. Orographic and nonorographic GWs must be accounted for in climate models to obtain a realistic simulation of the stratosphere in both hemispheres, since they can have a substantial impact on circulation and temperature, hence an important role in ozone chemistry for chemistry-climate models. Several types of parameterization are currently employed in models, differing in the formulation and for the values assigned to parameters, but the common aim is to quantify the effect of wave breaking on large-scale wind and temperature patterns.
In the last decade, both global observations from satellite-borne instruments and the outputs of very high resolution climate models provided insight on the variability and properties of gravity wave field, and these results can be used to constrain some of the empirical parameters present in most parameterization scheme. A feature of the NOGW forcing that clearly emerges is the intermittency, linked with the nature of the sources: this property is absent in the majority of the models, in which NOGW parameterizations are uncoupled with other atmospheric phenomena, leading to results which display lower variability compared to observations.
In this work, we analyze the climate simulated in AMIP runs of the MAECHAM5 model, which uses the Hines NOGW parameterization and with a fine vertical resolution suitable to capture the effects of wave-mean flow interaction. We compare the results obtained with two version of the model, the default and a new stochastic version, in which the value of the perturbation field at launching level is not constant and uniform, but extracted at each time-step and grid-point from a given PDF. With this approach we are trying to add further variability to the effects given by the deterministic NOGW parameterization: the impact on the simulated climate will be assessed focusing on the Quasi-Biennial Oscillation of the equatorial stratosphere (known to be driven also by gravity waves) and on the variability of the mid-to-high latitudes atmosphere. The different characteristics of the circulation will be compared with recent reanalysis products in order to determine the advantages of the stochastic approach over the traditional deterministic scheme.