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Normal mode analysis of SPEEDY model and comparison to ERA Interim reanalyses

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Climate models are regularly compared to reanalysis datasets in order to verify their ability to simulate the present-day climate. A successful reproduction of the current climate conditions provides confidence into models' results for future. A critical area of many climate models are the tropics. The tropical circulation can be represented by various motions which are to a large extent unbalanced; i.e. it can be represented as a combination of inertio-gravity motions. Such representation is provided by the 3D normal-mode analysis which is undertaken in this study.
We employ the ICTP AGCM model, simplified climate model, known as SPEEDY, for two 30-year climate simulations (January 1981 to December 2010), one forced by prescribed sea-surface temperature from ERA Interim and another with use of coupled ocean model. The output wind and geopotential from both SPEEDY simulations are projected on three-dimensional orthogonal normal-mode functions in order to evaluate the model energetics. The projection allows us to distinguish between the energy in the balanced state, represented by the quasi-geostrophic motions, and in the unbalanced state, represented by inertio-gravity motions. The energy in different scales and motion types is then compared to ERA Interim data at the same resolution.
The main conclusion of this study is that approximately 10 % of total energy is in unbalanced motions. This result is very robust, with negligible sensitivity to the use of prescribed sea-surface temperature or coupled ocean model. The sensitivity to two different spherical filters applied before normal-mode expansion is also small, with differences up to 1 %. The percentage of energy in balanced and unbalanced motions agrees well with ERA Interim, but ERA Interim contains more energy at smallest SPEEDY scales since the fields used for normal-mode expansion were computed on original ERA Interim resolution and later upscaled to the resolution of SPEEDY.
In physical space the flow is split up between balanced and unbalanced part. Two model levels are studied, one in upper troposphere and one in lower troposphere, averaged over whole 30-year period, over Julies and over Januaries. Most of the balanced flow is found in midlatitudes while a significant amount of flow is projected into inertio-gravity motions in the tropics. Inertio-gravity part of the flow mainly consists of meridional wind component and an interseasonal change of location of ITCZ is evident. In general, circulation is more intense in ERA Interim and in some cases large-scale flow in SPEEDY tends to be more zonal. However SPEEDY is able to capture main features of average flow.