Investigation of Mesoscale Energy Cascades with a Scale Invariant GCM

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Atmosphere modeled as a forced dissipative system composed of a strongly stratified fluid under the effect of gravity arises quite challenging problems for simulating it. Especially the lack of thoroughly rigorous theory explaining the direction of energy flow and which pathways it follows is a key issue residing in the formulation of Equations of Motion. In a general sense several energy reservoirs are defined and to prescribe the dynamics their exchange among each other is considered. One such reservoir would be the Kinetic Energy (KE), which is crucial in keeping the circulation quasi-steady. With this regard the investigation of the spectral distribution of KE and its budget would allow to quantify various processes.

Attempts to explain the different parts of observed tropospheric KE spectra historically focused on different driving mechanisms. Although the synoptic and larger scales could be explained with Geostrophic turbulence, leading to an inverse energy cascade for planetary scales and a forward enstrophy cascade in the synoptic regime, theories for the mesoscales are largely exempt from such a consensus.

In the present study, we review the dynamics for the high wavenumber regime of a GCM from the perspective of Stratified Macro Turbulence (SMT), and we look for conditions for the existence of SMT via analyzing the spectral budget of KE. We argue that a net forward energy cascade for wavenumbers beyond the kink seen in spectral slopes is governed by SMT. Analysis is carried out on a 12 day time series from a January simulation performed with Kühlungsborn Mechanistic Circulation Model with idealized differential heating. Different contributions to the KE budget are compared between runs having different diffusion schemes in the momentum equation.