SEMINAIRE CNRM / GAME

N°2012_21

mercredi 26 septembre 2012 à 11h

FORMULATION DU BILAN ENERGETIQUE SPECTRAL DE L'ATMOSPHERE ET ANALYSE DE DEUX GCMS. DIFFERENCES EN TERME DE LA SIMULATION D'UNE CASCADE DIRECTE D'ENERGIE AUX MESO-ECHELLES

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Résumé :

Nastrom and Gage [1985] showed that the atmospheric kinetic energy and potential temperature spectra measured in the upper troposphere and lower stratosphere present two inertial ranges. At the mesoscales, the spectra have a $k_h^{-5/3}$ power law dependence and at larger scales there is a narrow range where the spectra show a k_h^{-3} dependence. Recently, there has been considerable progress in simulating the observed spectra with some high resolution General Circulation Models (GCMs) [e.g. Hamilton et al., 2008].

In order to investigate the energetic of the mesoscales and how well different GCMs simulate these scales, we have developed a formulation of the spectral energy budget using the concept of available potential energy [APE, Lorenz, 1955] and the spherical harmonics decomposition. Results from two GCMs are analyzed, the T639L24 AFES model and the T1279L91 ECMWF Integrated Forecast System.

The ratio of the total APE over the total kinetic energy is large, of the order of 3. This is due to a larger magnitude of the APE spectrum at the very large scales of the atmosphere (total wavenumber $l < 4$). At the other scales, APE and KE spectra are of the same order of magnitude. For the IFS and at the synoptic scales, the APE spectrum is half the KE spectrum as predicted by Charney [1971].

The main terms of the spectral energy budget are computed which allows us to present a spectral representation of the Lorenz energy cycle. The spectral fluxes show that the AFES, which reproduces realistic spectra with a $k_h^{-5/3}$ inertial range at the mesoscales, simulates a strong downscale energy cascade. Moreover, we have shown that the $k_h^{-5/3}$ spectra are due to this downscale energy cascade. In contrast, neither the $k_h^{-5/3}$ spectra nor the downscale energy cascade are produced by the ECMWF GCM.

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