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Computation of balanced and unbalanced kinetic energy spectra in a limited area model

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The kinetic energy spectra based on the aircraft observations describe the upper troposphere and the lower stratosphere and that is why most of studies of the kinetic energy distribution in NWP and climate models have been focused on the same region. The analysis of the energy distribution as a function of horizontal scale has usually been based on global models which describe energy on scales greater than a hundred km. Consequently, little is known about the vertical distribution of kinetic energy below 250 hPa and at scales around and below 100 km. Furthermore, studies have usually dealt with total kinetic energy while at the same time, understanding model dynamics is easier in terms of rotational and divergent energy which correspond to balanced and unbalanced dynamics, respectively.

Our current research deals with kinetic energy spectra from the mesoscale NWP model ALADIN (4.4 km horizontal resolution) split into divergent and rotational components. The discussion is focused on scales below 300 km and the comparison between the rotational and divergent energy contributions at various horizontal scales and vertical levels. It is shown that about 50% of kinetic energy in the free troposphere in ALADIN is divergent energy. The percentage increases towards 70% at the surface and in the upper troposphere towards 100 hPa. The maximal percentage of divergent energy is found at stratospheric levels around 100 hPa and at scales below 100 km which are not represented by the global models. These results call for further studies with high-resolution models and comparisons with observations.

A detailed analysis of the distribution of divergent energy revealed a rather complex vertical structure. The percentage of divergent kinetic energy varies from 80% in the PBL below 20 km scale and in the stratosphere below 100 km to 10% and less above 500 km scales. In two layers, at approximately 900 hPa and between 500 hPa and 400 hPa, rotational energy dominates on all scales larger than the model effective resolution (found to be at about 6 Δx).

Due to existence of several techniques for achieving periodicity of limited area model fields, two sets of results are presented. One uses the standard ALADIN approach for the spectra computation based on the extension zone while the other approach, commonly used in mesoscale models, is based on detrending the velocity components data. In both cases, a very similar vertical distribution of divergent energy is obtained.