EGU22-9270
https://doi.org/10.5194/egusphere-egu22-9270
EGU General Assembly 2022
© Author(s) 2022. This work is distributed under
the Creative Commons Attribution 4.0 License.

Macro-Turbulent Energy Cascades in UpperTropospheric-Lower Stratospheric Mesoscales

Serhat Can
Leibniz Institute of Atmospheric Physics, Theory and Modeling, Rostock, Germany (can@iap-kborn.de)

In recent years a consensus has been reached regarding the direction of the energy cascade in the mesoscales in the Upper Tropospheric-Lower Stratospheric (UTLS) altitudes. Numerous measurements and model results confirm the existence of a predominantly forward spectral energy flux from low to high horizontal wavenumbers. However, the details to explain the observed -5/3 power law for Kinetic and Available Potential Energy (KE and APE) are still being debated.

In this study we performed simulations using the dry version of the Kühlungsborn Mechanistic general Circulation Model (KMCM) with high horizontal and vertical resolution for permanent January conditions. Horizontal diffusion schemes for horizontal momentum and sensible heat satisfy the Scale Invariance Criterion (SIC) using the Dynamic Smagorinsky Model (DSM). We investigated the simulated KE and APE spectra with regard to the scaling laws of Stratified Macro-Turbulence (SMT). Zonally and temporally averaged dissipation rates for KE & APE and SMT statistics correlate highly in subtropical mid-latitudes and the UTLS levels. Particularly the characteristic dimensionless numbers of Buoyancy Reynolds Number and turbulent-Rossby Number are pronounced in the regions, where the maximum of the forward spectral fluxes of nonlinear interactions are also found. During this process the spectral contribution of the negative buoyancy production term plays an important role by converting KE to APE. These findings are entirely in line with the spectral and statistical predictions of idealized Stratified Turbulence (ST) and confirms that the energy cascades that give rise to the simulated mesoscale shallowing are strongly nonlinear.

Furthermore level by level analyses of the horizontally averaged spectral tendencies and fluxes of both KE and APE reservoirs in this specific region revealed that there is a non-negligible spectral contribution by the energy deposition term of upward propagating Gravity Waves (GW). Further investigation indicate the dynamics of these resolved GWs look like a superposition of westward Inertia GWs that are subject to a Lindzen-type saturation condition. Their vertical propagation in UTLS heights is non-conservative above their generation level. These results associate directly for the first time ST and GW dynamics, which were thought to be distinct in character. Finally we present simulations with different diffusion schemes and show that the previously mentioned energy deposition contribution was only identified if both horizontal momentum and sensible heat diffusion schemes fulfill the SIC.