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Towards a climatology of orographic induced wave drag in the stable boundary layer over real terrain

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The stable boundary layer (SBL) plays a vital role in the current understanding of climate and climate change. SBL is of particular interest for numerous environmental issues such as air quality, aviation, fog forecasting and wind energy engineering. The multiplicity of small-scale processes which may occur at the same time in the SBL are causing relatively poor understanding of the SBL. One of processes involved in stable boundary layer is generation of orographically induced gravity waves.
During night-time stable conditions undulating orography in the landscape may trigger gravity wave propagation. Until now the quantitative role of orographic induced gravity wave drag to the total momentum budget of the SBL is rather limited. It solely originates from high resolution numerical studies over idealized terrain and for idealized forcing. At the same time it is realized that large-scale weather forecast models encounter problems with forecasting winds and temperatures in the stable boundary layer.
This study extends earlier results from Steeneveld et al (2009) for a broader range of weather conditions and time frame to further investigate the role of gravity wave drag on the SBL in a climatological sense. In order to do so, we run the high resolution WRF single column model in for the Great Plains (USA) area, which is characterized by small scale orography (amplitude $\sim$10 m, wave length <5 km). The forecasted wind and temperature fields are forwarded to a linear wave model which estimates near surface wave drag. In this module, the contributions of the individual Fourier modes of the terrain to the wave drag are considered for each wind sector. Also it allows for analyzing critical levels, and wave stress divergence, which might trigger flow acceleration, and turbulence.
It appears that the estimated surface wave drag is substantial and of comparable magnitude as the turbulent drag, in particular for relatively calm nights. The simulations suggest that wave drag can be important and need to be parameterized in large-scale models.