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A climatology of gravity wave drag for Lindenberg (Germany)

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While the performance in modelling neutral and convective atmospheric boundary layers has significantly improved over the past years, the representation of the stable boundary layer (SBL) and its enclosed processes remains one of the grand challenges in numerical weather prediction and climate modelling. Atmospheric models require artificially enhanced turbulent drag in order to adequately forecast the synoptic flow. The resulting larger than observed turbulent mixing in the SBL leads to significant biases in boundary layer properties. On the way towards more physically based parameterizations of unresolved SBL processes, gravity waves induced by small-scale orography increasingly move into the focus of research. Theoretical as well as numerical approaches show that the drag induced by small-scale gravity waves (< O(10km)) can be of the same or even larger magnitude than turbulent drag. Observational evidence of this finding is difficult and still missing (see Smith, R. B. 1978: A measurement of mountain drag. J. Atmos. Sci, 35, 1644-1654). We address the quantification of gravity wave drag due to small hills by estimating its climatology based on observed profiles of wind and temperature. Meteorological profiles are taken from Lindenberg. The observational site is located at 52.17° N, 14.12° E in Germany and is surrounded by slightly undulating terrain with a mean amplitude of 120m and a peak topographical wave length of around 1.5km. We use the WRF-1D model to forecast vertically high-resolved wind and temperature profiles in 24 hour intervals. These simulations are evaluated against Lindenberg tower measurements. Next, the gravity wave drag is computed by taking into account the 2D Fourier transform of the terrain in a domain of 30kmx30km around Lindenberg. What is unique for the GWD computation is that it includes the non-linear effect of wave breaking. With our results we present a climatology of gravity wave drag for the Lindenberg domain for the period 2010-2015. Frequency and magnitude of GWD events are related with the prevailing synoptic situation. GWD events occur in particular in calm nights with sufficient stratification.