On the Excess Mixing in NWP Models in Stable Boundary Layers: the Possible Role of Orographic generated Sub-grid Gravity Wave Drag

G.J. Steeneveld (1), A.A.M. Holtslag(1), C. J. Nappo(2) and L. Mahrt(3)

(1) Wageningen University, Wageningen, The Netherlands, (2) Air Resources Laboratory, Atmospheric Turbulence and Diffusion Laboratory, NOAA, Oak Ridge, U.S.A, (3) College of Oceanic & Atmospheric Sciences, Oregon State University, Corvallis, OR, U.S.A.

Our ability to model the atmospheric boundary layer on a large spatial scale during stable stratification is rather poor at the moment. The functional form of the so-called flux-profile relationships found from local field observations and Large-Eddy Simulation ("short tail") does not match the functional form of the flux-profile relationships needed in large scale global models ("long tail"). The latter needs more boundary-layer drag to obtain good skill scores, but because all this additional drag is added in the form of turbulence, the boundary-layer structure is violated and generally too deep. This contradiction exists now for a long period. To bridge the gap between these two drag formulations, we may need to parameterize a process in addition to turbulence. The objective of this paper is to investigate the possible role of gravity wave drag on the total drag in the stable boundary layer. Using the linear gravity wave theory and focusing on small wind speeds, we estimate the amount of (non-turbulent!) drag by gravity waves from observed stratification and wind speed for the CASES-99 experiment and recalculate the effective flux-gradient relationships. Surprisingly, the resulting effective flux-gradient relationship for momentum corresponds fairly well with the mixing function that is currently in use in large-scale NWP models. As such, the gravity wave drag may act as the bridge between "short tail" and "long tail" mixing functions