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On the computation of planetary boundary-layer height using the bulk Richardson number method

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Abstract. Experimental data from four field campaigns are used to explore the variability of the bulk Richardson number of the entire planetary boundary layer (PBL), Ri_{bc}, which is a key parameter for calculating the PBL height (PBLH) in numerical weather and climate models with the bulk Richardson number method. First, the PBLHs of three different thermally stratified boundary layers (i.e., strongly stable boundary layers, weakly stable boundary layers, and unstable boundary layers) from the four field campaigns are determined using the turbulence method, the potential temperature gradient method, the low-level jet method, and the modified parcel method. Then for each type of boundary layer, an optimal Ri_{bc} is obtained through linear fitting and statistical error minimization methods so that the bulk Richardson method with this optimal Ri_{bc} yields similar estimates of PBLHs as the methods mentioned above. We find that the optimal Ri_{bc} increases as the PBL becomes more unstable: 0.24 for strongly stable boundary layers, 0.31 for weakly stable boundary layers, and 0.39 for unstable boundary layers. Compared with previous schemes that use a single value of Ri_{bc} in calculating the PBLH for all types of boundary layers, the new values of Ri_{bc} proposed by this study yield more accurate estimates of PBLHs.

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