

3.2 Objectively-determined fair-weather NBL features in the ARW-WRF model and their comparison to the CASES-97 observations

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Heights of nocturnal boundary layer (NBL) features are determined using vertical profiles from the Advanced Research Weather (ARW) Weather Research and Forecasting (WRF) model, and then compared to data for three moderately-windy fair-weather nights during the April-May 1997 Kansas-based Cooperative Atmosphere-Surface Exchange Study (CASES-97) to evaluate the success of four PBL schemes in replicating observations. The schemes are Boujeault-Lacarrere (BouLac), Mellor-Yamada Janjic (MYJ), Quasi-Normal Scale Elimination (QNSE), and Yonsei University (YSU) versions 3.2 and 3.4.1. Our chosen objectively-determined model NBL-height (h) estimate uses a turbulence kinetic energy (TKE) threshold equal to 5%TKE'max, where TKE' is relative to its background (free-atmosphere) value. The YSU- and MYJ determined h could not be improved upon. Observed heights of the virtual temperature maximum h_{Tvmax} and wind-speed maximum, h_{Smax} , and the heights $h_{1wsonde}$ and $h_{2wsonde}$, between which the radiosonde slows from $\sim 5 \text{ m s}^{-1}$ to $\sim 3 \text{ m s}^{-1}$ as it rises from turbulent to non-turbulent air and thus brackets h , were used for comparison to model results. The observations revealed a general pattern: h_{Tvmax} increased through the night; h_{Tvmax} and h_{Smax} converged with time, and the two mostly lay between $h_{1wsonde}$ and $h_{2wsonde}$ after several hours. Clear failure to adhere to this pattern and large excursions from observations or other PBL schemes revealed excess mixing for BouLac and YSU v. 3.2 (but not v. 3.4.1) and excess thermal mixing for QNSE under windy conditions. Observed friction velocity u_* was much smaller than model values, with differences consistent with the observations reflecting local skin drag and the model reflecting regional form drag + skin drag.