Background and Motivation

- A new 20-year record of Planetary Boundary Layer (PBL) heights was developed using backscatter data from Wind Profilers (WP) located over the US Great Plains, but the observational record does not contain enough information to explain PBL behavior.

- PBL heights from the Modern Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) are model-based and have been shown to be biased high, but observational constraints in MERRA-2 provide reliable meteorology that can be used to explain PBL behavior.

- A combination of WP PBL heights and MERRA-2 fields is used to understand the behavior in the region.

**Monthly Mean Behavior**

Examination of WP PBL mean annual cycles at all the stations revealed several categories of behavior, that we name ‘canonical’, ‘early peak’, ‘double peak’, and ‘late peak’.

- The ‘canonical’ PBL height annual cycle is shown in Figure 2 (black circles in Figure 1). As seen in Figure 2a, the PBL height is low in the spring, rises to its maximum in June and July, and descends again in the fall, following the solar insolation. Figures 2b, c, and d show that the PBL height annual cycle is dictated by the surface temperature and surface sensible heat flux, and that the soil moisture, latent heat and precipitation exert little influence on the behavior of the monthly mean PBL height.

- The ‘double peak’ PBL height annual cycle is shown in Figure 3 (blue circles in Figure 1). Figure 3a shows a clear rise of PBL height in May, a drop in June-July and a subsequent rise in August. Figures 3b, c, and d show that the PBL height annual cycle is dictated by the surface temperature and surface sensible heat flux, and that the soil moisture, latent heat and precipitation exert little influence on the behavior of the monthly mean PBL height.

- The ‘early peak’ and ‘late peak’ PBL height annual cycles (purple and red circles in Figure 1, respectively, not shown here) are governed by the same physics as for the ‘double peak’. In both of these the timing of the maxima in precipitation and latent heat flux and so the PBL heights differ from the ‘double peak’.

**Variations About the Monthly Mean**

To examine the processes related to variations about the monthly mean PBL heights we performed an analysis of variance (ANOVA) using several different statistical models based on relevant fields. Results are presented from empirical models using three pairs of predictors: latent heat flux and 2-meter temperature, latent heat flux and sensible heat flux, and evaporative fraction and net radiation at the surface.

The variability of PBL height during the peak mean PBL height months at the ‘canonical’ stations was divided into two general behavior regimes: (i) a drier regime in the stations in the western geographical sector characterized by small amounts of vegetation and dry soils (see Figure 1) and (ii) a wetter regime in the stations further to the east that are more vegetated and have wetter soils. The behavior in the drier regime is shown in Figures 4a,b. These figures show the small contribution of latent heat flux and evaporative fraction to the total PBL height variability relative to the contributions of the 2-meter temperature and net radiation. Figures 4c,d show the behavior in the wetter regime, where the latent heat flux and evaporative fraction determine as much or more of the variability of PBL height as the temperature and net radiation.

The stations in the ‘late peak’ category are located in the wetter areas of the geographical domain. ANOVA results from July (the peak month of monthly mean PBL height) are shown in Figure 6. The figure shows that up to 80% of the PBL variations are explained by evaporative fraction.

**Summary**

- MERRA-2 can be used to understand the behavior of the monthly mean and variability of the observed PBL heights.

- WP PBL height mean annual cycles were grouped into four general categories of behavior, ‘canonical’, ‘double peak’, ‘early peak’ and ‘late peak’ categories, each named for the month relative to July at which the PBL height reached its maximum. These cycles are governed by the annual cycles of sensible and latent heat fluxes, which are controlled by small amounts of vegetation and dry soils.

- ANOVA determined that the role of latent heat in determining the PBL height variations was found to be large (explaining up to 40% of PBL height variability) even in the ‘canonical’ category for which latent heat played no role in setting the monthly mean, and for other stations the latent heat explained up to 80% of the PBL height variations.