ARM Summer Training and Science Applications

Planetary Boundary Layer Height: A Comparison of Estimation Methods and Sites Report

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1.0 Planetary Boundary Layer Height: A Comparison of Estimation Methods and Sites

The structure of the planetary boundary layer (PBL) plays an important role in cloud formation and aerosol transport. Therefore, methods aiming at retrieving PBL heights find applications in several fields of research, ranging from weather forecasting to air quality modeling. PBL height estimation methods have been developed based on data provided by in situ measurements of atmospheric properties, such as those made by Radiosondes and by remote sensing instrumentation such as Doppler Lidars, Ceilometers, and Radar Wind Profilers.

In this study, we assessed these retrieval methods at two ARM sites: Southern Great Plain (SGP), and Manacapuru, Brazil (MAO). Our goals were to (1) compare the quality of retrieval methods at each site and (2) compare retrieved PBL heights between sites and explain the differences/similarities. To achieve these goals, we have used the data collected by several instruments that form part of the ARM facilities, including the Doppler Lidar, Ceilometer, Radar Wind Profiler (RWP), Radiosonde, surface meteorological stations, and the flux tower, during August-September of 2014 at the MAO site and June of 2015 at the SGP site. The PBL height estimates based on the Ceilometer backscatter and the signal-to-noise ratio from the Radar Wind Profiler did not agree well with those from previous studies; hence we have focused on the retrievals from Doppler Lidar and Radiosondes. The results show that PBL height retrieval using Doppler Lidar agrees well with Radiosonde profiles in most instances at SGP while it rarely agrees well at MAO in the afternoon. Agreement at night is better than in the afternoon at both sites, a difference attributable to larger gradients in potential temperature profile near the inversion at night and therefore a better performance of the Radiosonde-based methods. However, the most direct and consistent method, Doppler Lidar-based retrieval, is not valid for PBL height greater than 2 km due to intrinsic instrument limitations. We also used estimations of first cloud base height from Ceilometer and of lifting condensation level (LCL) based on surface measurements of temperature and relative humidity to contextualize the retrieved PBL heights. In several episodes, we observed the formation of clouds when the PBL height exceeded the LCL.

Lastly, we compared the Doppler Lidar-based PBL height estimation for SGP and MAO (Figure 1). The diurnal cycle at both sites shows a low PBL height at night (around 200 m), characteristic of a stable regime. The PBL height increased after sunrise at both locations and peaked in the afternoon to values of up to 2800 m at SGP and up to 1800 m at MAO, consistent with a fully developed convective PBL. Our results agree well with past studies (Chandra et al. 2010; Pearson et al. 2010), highlighting a strong diurnal cycle of PBL in these regions. Our initial results suggest that the greater PBL depth at SGP might be due to the fact that the surface Sensible Heat Flux (SHF) is higher over the SGP site than over the MAO site.

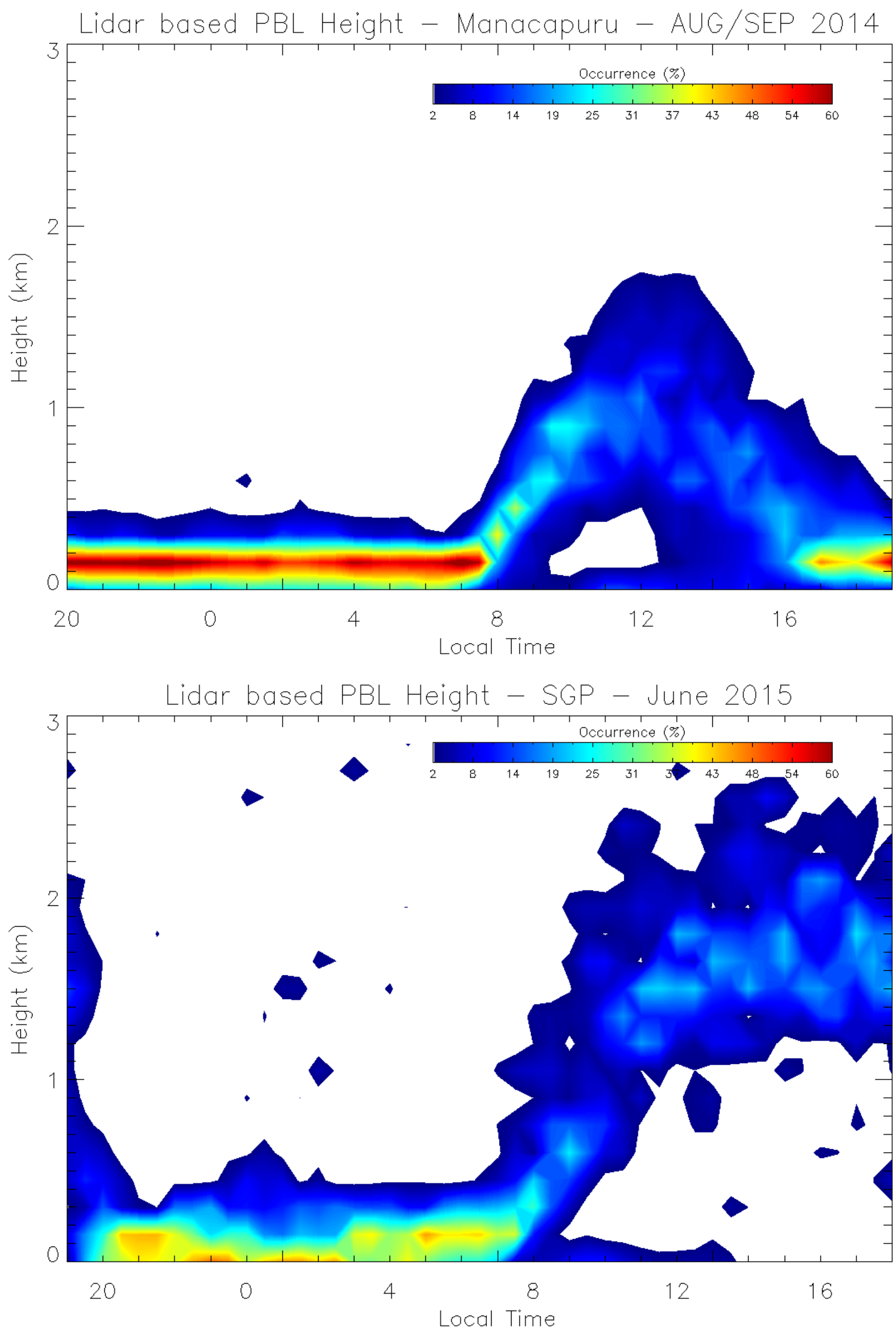

Figure 1. Diel profiles of PBL height weighted by occurrence at MAO (top) SGP and (bottom).

2.0 References

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