Comparison of Atmospheric Boundary Layer Structures over Land and Ocean as Observed by ACRF Ground-based and Space-based Lidar Measurements

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Boundary layer processes are important in climate, weather and air quality. With ACRF MPL and radiosonde measurements, we developed and evaluated a lidar-based method to determine the height of the boundary layer and mixing layer. The diurnal and season cycles of atmospheric boundary layer depth and vertical structure over land and ocean are compared based on measurements at the three TWP sites and the SGP site. The new method is also applied to satellite Lidar measurements to derive a global atmospheric boundary layer structure database.

1. Data

Ground-base data: Micropulse Lidar (MPL) data and Balloon-Borne Sounding System (SONDE) data from three TWP sites and the SGP site were used in this study.

Sattelite data: Multiple A-train satellite datasets during the period of 2006 to 2010 are used.

2. Methodology and Validation

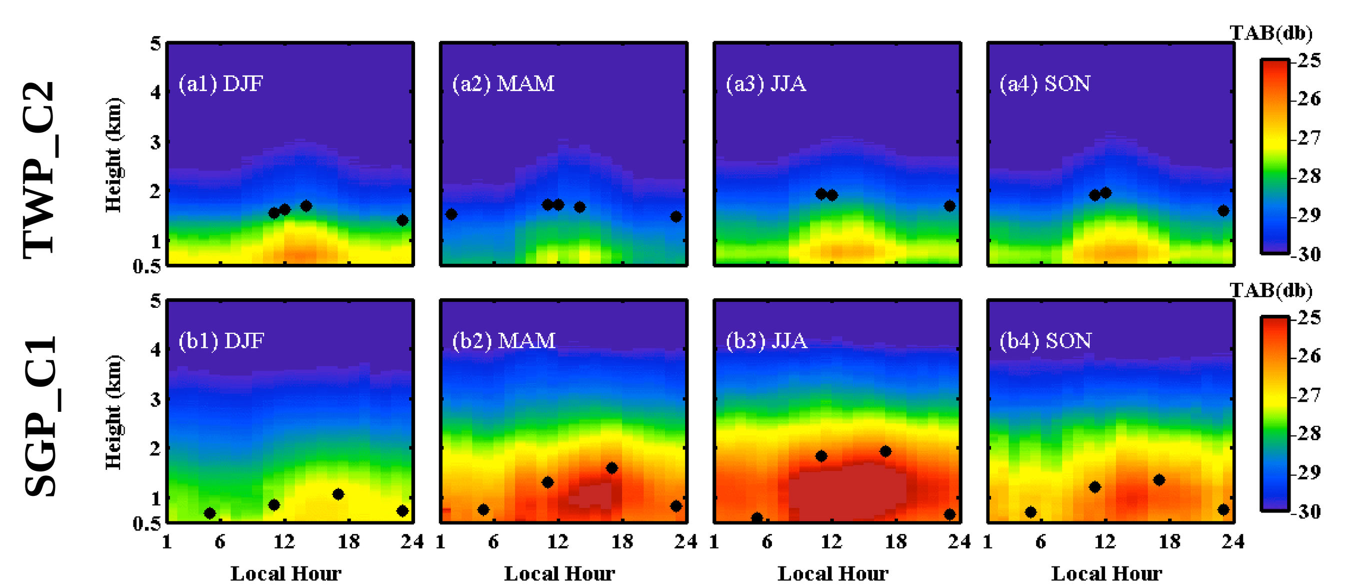


Figure 2. Diurnal cycle of boundary layer aerosol structure at different cites. The black dot in each figure represents the BLH obtained from SONDE profiles with the Richardson number method.

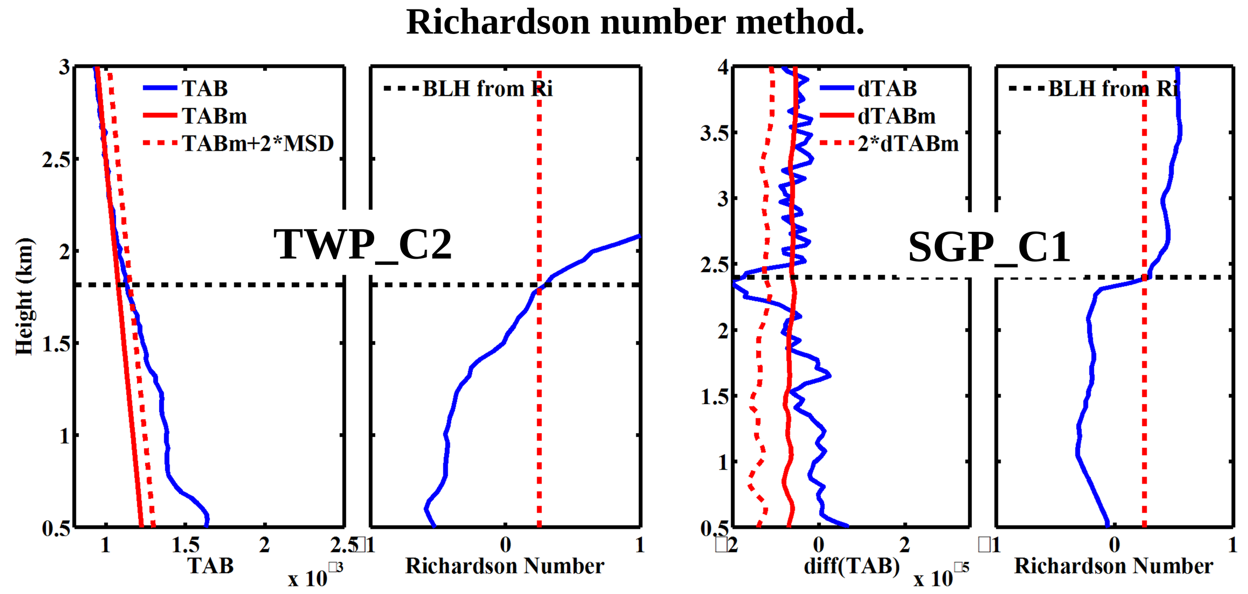
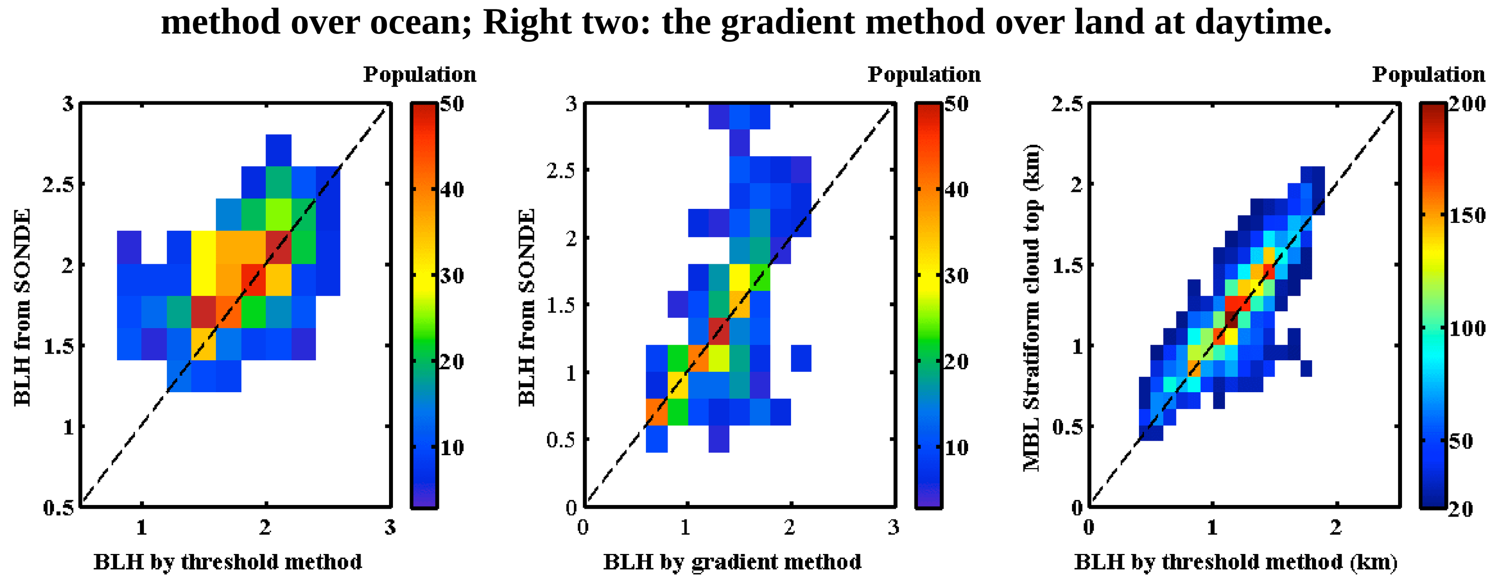


Figure 3. Illustration of MPL BLH identification methods. Left two: the threshold method over ocean; Right two: the gradient method over land at daytime.



Comparing to observations over ocean, total attenuated backscattering (TAB) over land shows higher aerosol loading above the boundary layer top. This may be resulted from background aerosols or elevated aerosol layer, which are usually not controlled by boundary layer processes.

Thus, different methodologies are needed for identifying boundary layer depth (BLH) over ocean (the threshold method) and land (the gradient method, daytime only) These two approaches are illustrated in Figure 3 and compared with with the Richardson number method. The threshold method were also applied to CALIPSO data over ocean. The comparisons of BLH between different methods show good agreements.

Figure 4. Comparison of BLHs between SONDE derived and MPL derived (a) with the threshold method at TWP_C2 cite and (b) with the gradient method at the SGP_C1 cite; Comparison between marine BLH derived with the threshold method and marine boundary layer stratiform cloud top from CALIPSO measurements (c) .

3. Diurnal and Seasonal Cycles of BLH

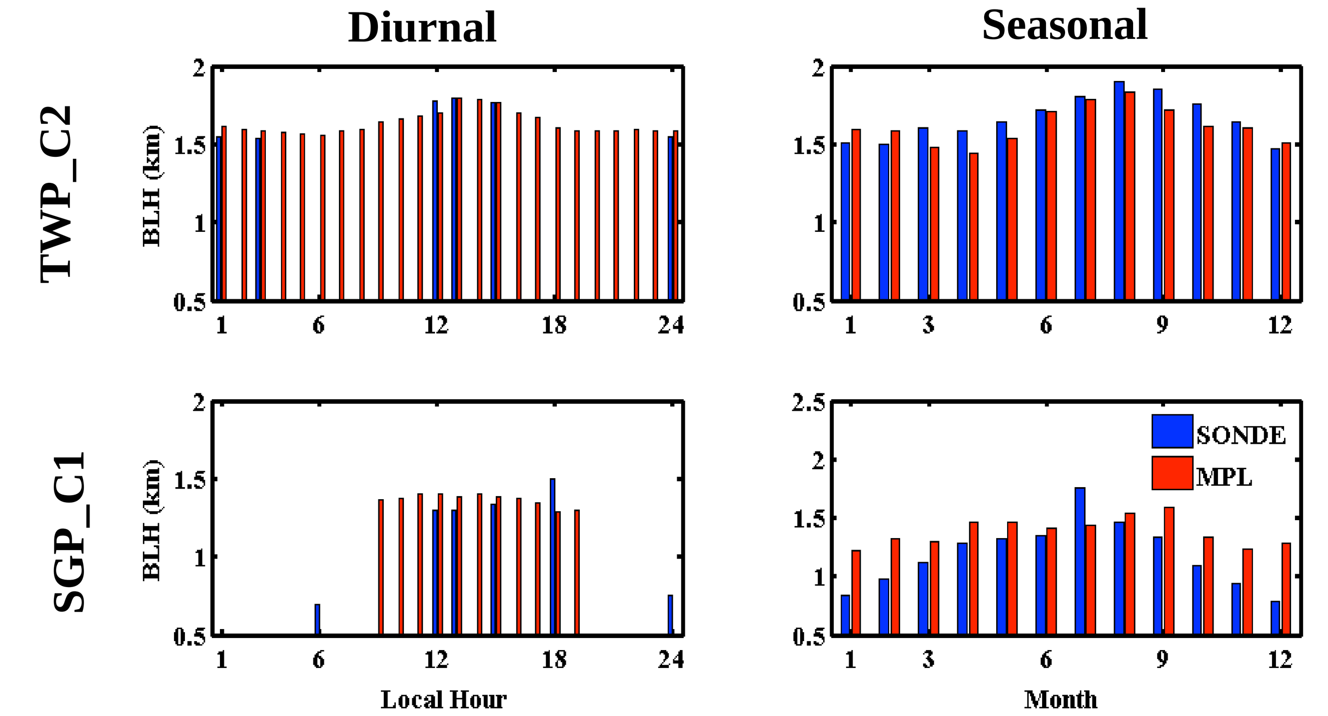


Figure 5. Diurnal and seasonal cycles of boundary layer depth over ocean (top panel) and land (bottom panel) .

The diurnal and seasonal cycles of BLH from MPL shows good agreement with those from SONDE, especially over ocean. The BLH identification over land needs further improvements, especially during nighttime.

4. Boundary Layer Structure over Ocean

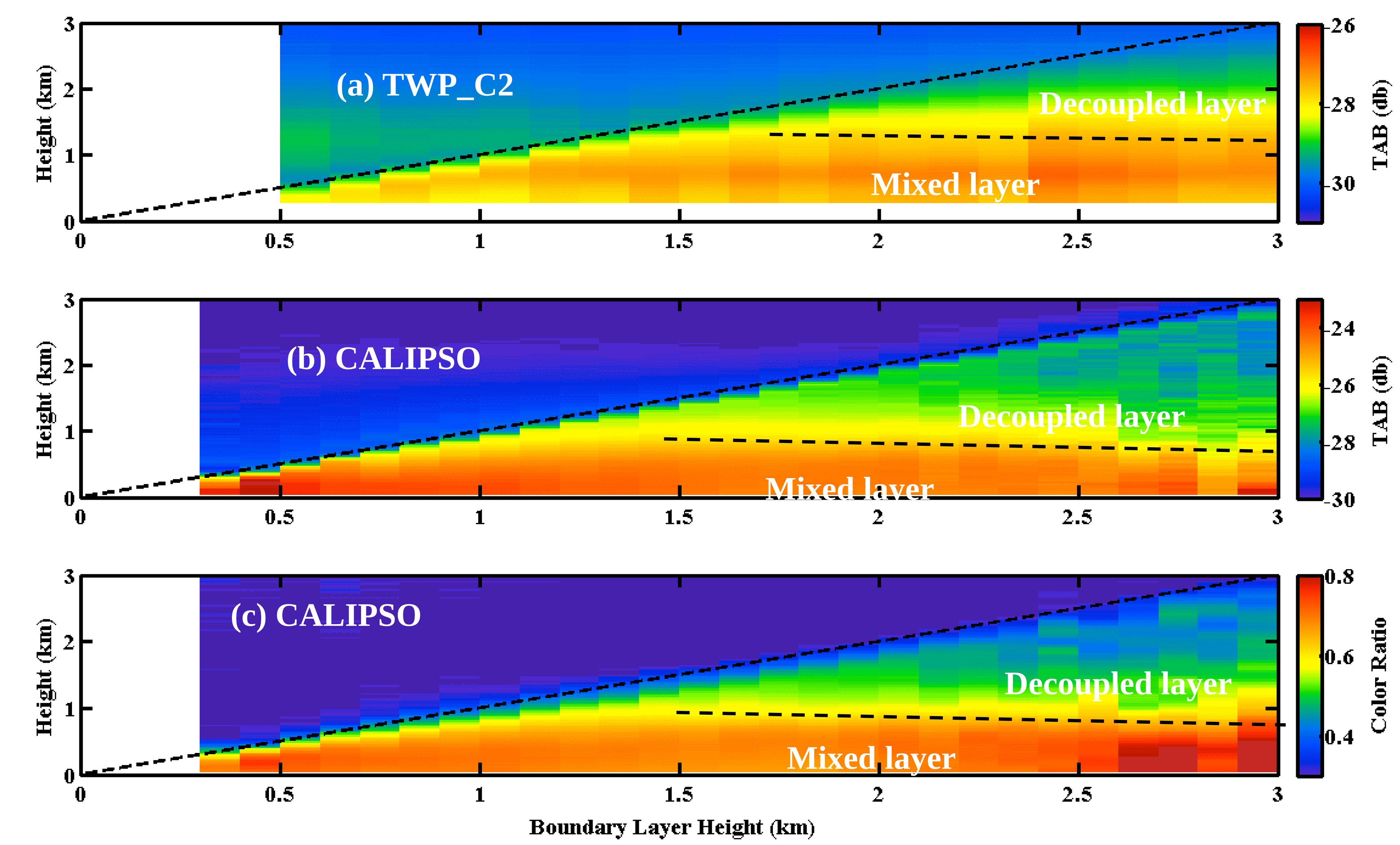


Figure 6. Boundary layer aerosol structure as a function of BLH : at the TWP_c2 cite (a-TAB) and over global ocean when surface wind speed is between 10-12m/s (b-TAB; c-color ratio).

The threshold method is applied to CALIPSO data and a new marine boundary layer (MBL) database is derived. The MBL structure in terms of aerosol properties is shown in figure 6. A well-mixed layer near surface and an upper decoupled layer within the MBL can be easily identified when MBL deepening. Comparing with the decoupled layer, the well-mixed layer has higher aerosol loading and larger aerosol size.

These results illustrated that combined ground and satellite measurements offer a more complete view of the temporal and spatial variations of atmospheric boundary layer.