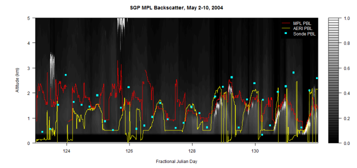
A New Algorithm for Automated Detection of Planetary Boundary Layer Depth

Research Highlight

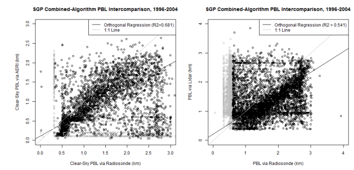
A paper recently accepted by **Atmospheric Environment** presents a new algorithm for detecting the depth of the planetary boundary layer (PBL), or the part of the atmosphere that is affected most directly by surface processes. The thermodynamic properties and aerosol loading of the PBL distinguish it from the free troposphere above it; the PBL depth affects weather, air quality, and climate. The new algorithm is based on two existing methods for PBL depth detection in micropulse lidar (MPL) backscatter profiles. The wavelet covariance transform works well under a wide variety of conditions, requiring little prior information about the data source; iterative curve-fitting by simulated annealing is too dependent on an initial guess to use for long-term data, but is more accurate than wavelet covariance if the profile contains multiple features or if the vertical resolution of the instrument is low. Because these strengths and weaknesses complement one another, the wavelet covariance transform can be used to generate a first-guess PBL depth for iteration, resulting in a combined algorithm that is more robust than either of its components.

As well as MPL backscatter, the algorithm can be modified to work for measurements of virtual potential temperature from radiosonde or atmospheric emitted radiance interferometer (AERI) data. All three measurements were being taken at the Atmospheric Radiation Measurement Climate Research Facility at the Southern Great Plains (SGP) site during the period 1996#2004, and the combined algorithm was used to produce a time series of PBL depth for each of them. Because the instruments operated at the same time and location, the PBL results can be compared to one another to evaluate the algorithm. Over two-thirds of the variance in AERI results and over half of the variance in the MPL results are explained by the radiosonde-derived PBL depths.

The seasonal and diurnal cycles are also compared among the three instruments, revealing that the PBL results are more reliable in winter than in summer. There is greater agreement between instruments during daylight hours than at night, and also at times of day when the PBL is mature rather than collapsing or developing. While the PBL depth cannot be detected from AERI data if clouds are present, or from MPL data if the boundary layer is shallower than 600 m, both instruments have much higher temporal resolutions than radiosonde. The more detailed view of PBL variation over time can capture details of the diurnal cycle, which may be useful for the simulation of the PBL in climate models.



PBL depths detected by MPL, AERI, and radiosonde, overlaid on MPL backscatter during a nine-day period of typical conditions.



Comparison between AERI- and radiosonde-derived PBL depths (left) and MPL- and radiosonde-derived PBL depths (right), with artifact points due to weak signal or lidar overlap limitations (gray) excluded from orthogonal regression.

Reference(s)

Sawyer V and Z Li. 2013. "Detection, variations and intercomparison of the planetary boundary layer depth from radiosonde, lidar, and infrared spectrometer." Atmospheric Environment, 79, 10.1016/j.atmosenv.2013.07.019.

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Cloud-Aerosol-Precipitation Interactions