Mixed Layer Evolution Observed by Radiosondes, Profilers, and LIDAR during MILAGRO

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Introduction

Pacific Northwest National Laboratory (PNNL) and Argonne National Laboratory (ANL) operated atmospheric profiling systems at Veracruz and at two locations on the Central Mexican Plateau. We here describe a comparison of measurements of mixed layer depth as determined independently from collocated radiosonde, radar wind profiling, and lidar systems during the campaign and the structure and evolution of the boundary layer at T1 and T2.

Comparison of ML Depths

All of the ML depths were extracted from data using a GUI written in MATLAB. Values from each system were extracted without *a prior* reference to the others. For radiosondes, selecting between values was sometimes difficult. We thus made additional alternative selections for some of the soundings.

Figure 4. Comparison of ML depths derived from the profiler and from radiosonde ascents. Colored symbols are primary choices, which were sometimes below profiler values. In those cases, second values were usually in better agreement.

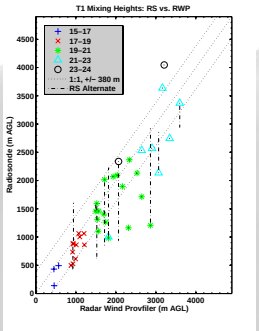
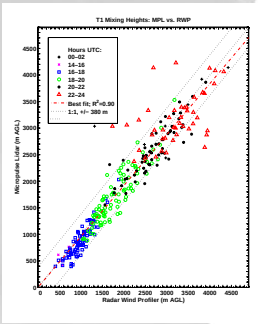


Figure 5. Lidar/profiler ML depth comparison. Agreement is very good. Outliers occurred mostly in late afternoon, when convection or the cessation of surface heating complicate the interpretation of the measurements.



Summary

• Comparisons show overall reasonable agreement between radiosonde, lidar, and radar estimates of ML depth during MILAGRO.

•The morning ML growth was comparable to previous field programs on days with and without deep convection.

• The maximum afternoon depth of the ML at T2 tended to be less that T1 by about the elevation difference between the two sites, suggesting a limited influence of terrain on the inversion in the afternoon.

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Boundary Layer Depth

Depth of the mixing layer (ML) is determined from radiosondes, profilers, and lidar using varying criteria that are subject to ambiguities. For radiosondes we used jumps in conserved variables. For lidar and radar, we subjectively followed an appropriate layer of backscattered signal.

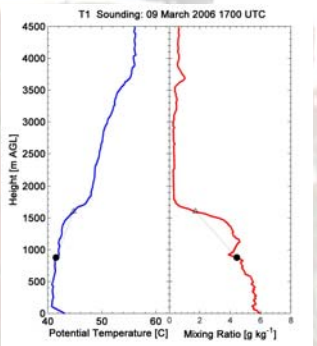

Figure 1. Example sounding illustrating ambiguity in mixing layer depth. Bullet indicates preferred height of mixing layer, triangle the second choice.

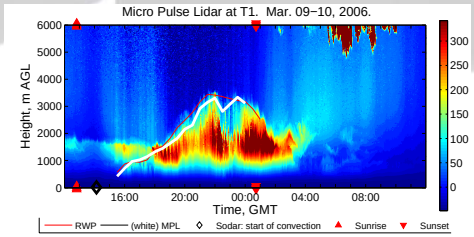

Figure 2. Lidar backscatter (not fully corrected). White line is maximum selected ML depth. Red triangles are sunrise and sunset. Mixing was typically not detected by the sodar until about an hour after sunrise.

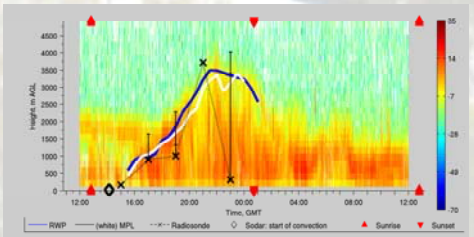

Figure 3. Profiler signal-to-noise ratio (SNR). Depth of mixing layer is red line. Radiosonde and lidar estimates are also shown.

Boundary Layer Evolution

The morning growth of the boundary layer was quite consistent from day to day (and with previous field campaigns). There was little difference in growth rate between days with some deep convection and days with none, although maximum ML depth varied more on the convective days. The maximum ML depth at T2 was typically 400m less than at T1, which corresponds to the elevation difference between the sites. Thus, the ML did not strongly follow terrain by mid-afternoon.

Figure 6. ML depths from the profiler at T1 as a function time for all days of MILAGRO. Red indicates days with some deep convection, blue with none reported. Curves are median values.

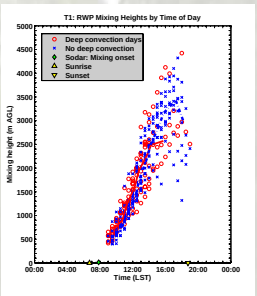

Figure 7. ML depths from the profilers at T1 and T2 during MILAGRO. Colors indicate hour of the day. Dashed lines indicate offsets of two range gates.