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Planetary Boundary Layer Depth in Arizona

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Research Question

How does the planetary boundary layer evolve on hourly time scales across the United States?

Background

The planetary boundary layer (PBL) is the lowest layer of the atmosphere and its depth fluctuates from a few tens of meters at night to several kilometers during the day. The depth of the PBL is affected by the amount of solar radiation absorbed on earth throughout the day. As the Earth's surface receives sunlight during the daytime, the air near the surface warms and becomes buoyant, thus mixes upward and forms the convective boundary layer. During the evening when the Earth doesn't receive any sunlight, the air near the surface becomes colder and is unable to mix upward. This leads to a shallow boundary layer at night. The vertical mixing of air (varying in temperature, moisture and velocity) can cause turbulence in this layer of the atmosphere [1].

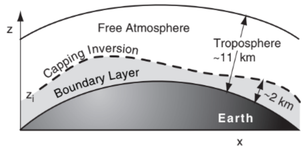
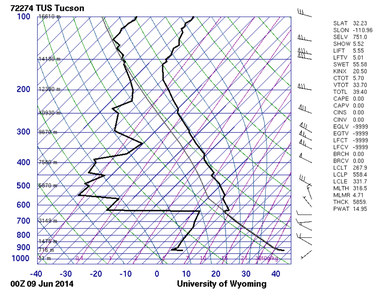


Figure 1. Schematic of the comparison between the PBL and the rest of the atmosphere. The depth of the PBL is typically about 10% of the atmosphere. [1]

Since we as humans interact with this layer of the atmosphere most, it is important that we understand how it is affected and its cycles. Building a better understanding of this layer has application in severe weather prediction, air quality and fire weather.

Figure 2. The PBL is currently observed using radiosonde data collected twice a day and displayed on a Skew T Log P thermodynamic diagram. [2]



Background Cont'd

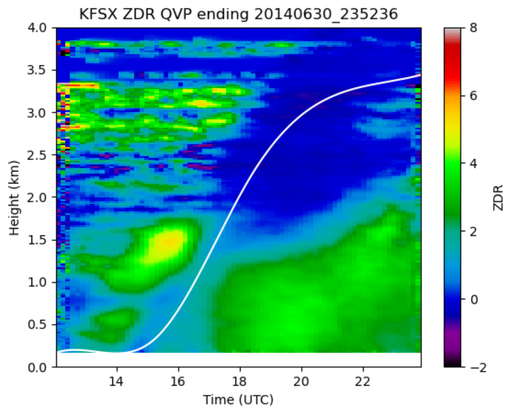


Figure 3. It can also observed using dual polarization radar in which differential reflectivity values (Z_{DR}) are plotted on a quasi-vertical profile (QVP) and can display data on hourly time scales. If it can be proven that radar data is comparable to sounding data, this would result in improved observations and predictions of PBL cycles.

Goals and Objectives

- Calculate dual-polarization radar estimations of PBL depth and compare with forecast model predictions.
- Compare radar data to weather balloon data observations in three cities in Arizona (Queen Creek, Flagstaff and Tucson).

Methodology

In Queen Creek, Flagstaff and Tucson, the following was calculated/obtained for each day in June, 2014:

- Skew T Log P diagram from a database created by the University of Wyoming (soundings provided by NOAA)
- Quasi-vertical profile (QVP)
  - Calculated/generated using MobaXTerm

The Skew T Log P diagrams were compared to the QVPs to determine if the results were comparable.

Results

The PBL top was calculated using radar data and compared to soundings for Flagstaff and Tucson. The table below indicates the average difference between the PBL top calculations.

	Day 1	Day 2	Day 3	Day 4	Day 5	Avg.
Flagstaff	685 m	230 m	158 m	308 m	335 m	343.2 m
Tucson	236 m	907 m	564 m	27 m	769 m	500.6 m

- Skew T Log P diagrams were not available for the Queen Creek location in 2014
- Flagstaff had more consistent data (Flagstaff has a moister climate than Queen Creek and Tucson)
- Not every QVP was reliable
- Queen Creek location did not provide reliable QVPs

Future Research

- Calculate QVPs and collect sounding data for the rest of 2014 in Queen Creek, Tucson and Flagstaff.
- Calculate QVPs and collect sounding data for 2014 in the western United States.
- Explain the differing (narrow vs. wide) PBL gradient.

Acknowledgements

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References

1. Stull, R. B. (1988), An Introduction to Boundary Layer Meteorology, 1 ed., Kluwer Academic Publishers, Dordrecht.
2. University of Wyoming. (2022, June,). *Department of Atmospheric Science*. https://weather.uwyo.edu/upperair/sounding.html

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