Evaluating Numerical Models to Quantify Cold Air Pool Strength in the Central Valley

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Background

- Air pollution events in the winter in mountainous regions are primarily caused by cold air pools (CAP). CAPs form in mountain valleys mainly in areas of calm weather.
- Temperature inversions that form because of nighttime cooling may persist in calm weather, leading to a persistent CAP (PCAP). This layer of air will not disperse without some outside force, such as a storm.
- Poor air quality during long-lasting CAP events is common, leading to health impacts.
- Cold air pool strength typically qualitatively identified from observations through radiosondes or air quality sensors. These observations are not available everywhere.
- Air quality observations are poor indicators for predicting weak CAPs compared to vertical observations. When vertical observations are unavailable, models could be used, through contain some error.
- Research into model viability for measuring CAP strength specifically is lacking, especially when comparing to observations.

Methodology

- The Central Valley of California has no consistent source of radiosonde measurements.
- Because of a lack of radiosondes, vertically distributed data from NASA's 2013 DISCOVER-AQ field campaign is used. These specific flights are over Fresno and Huron, CA. Surface observations from MESOWEST were appended onto the observed aircraft data.
- Observed data from the aircraft is compared to the North American Mesoscale Forecast System (NAM) model and the Weather Research and Forecasting (WRF) model. Two different planetary boundary layer physics schemes were compared in WRF. (MYNN and YSU).
- CAP Strength quantified through valley heat deficit (VHD) and the bulk Richardson number (R_B).
- VHD measures the energy deficit of an atmospheric layer. Here it is from the surface (~100 m) to the mean elevation of the ridges of the Coast Ranges (1390 m). Higher values indicate greater stability.
- R_B is a ratio of buoyancy to wind shear. Higher values indicate greater stability.

Results

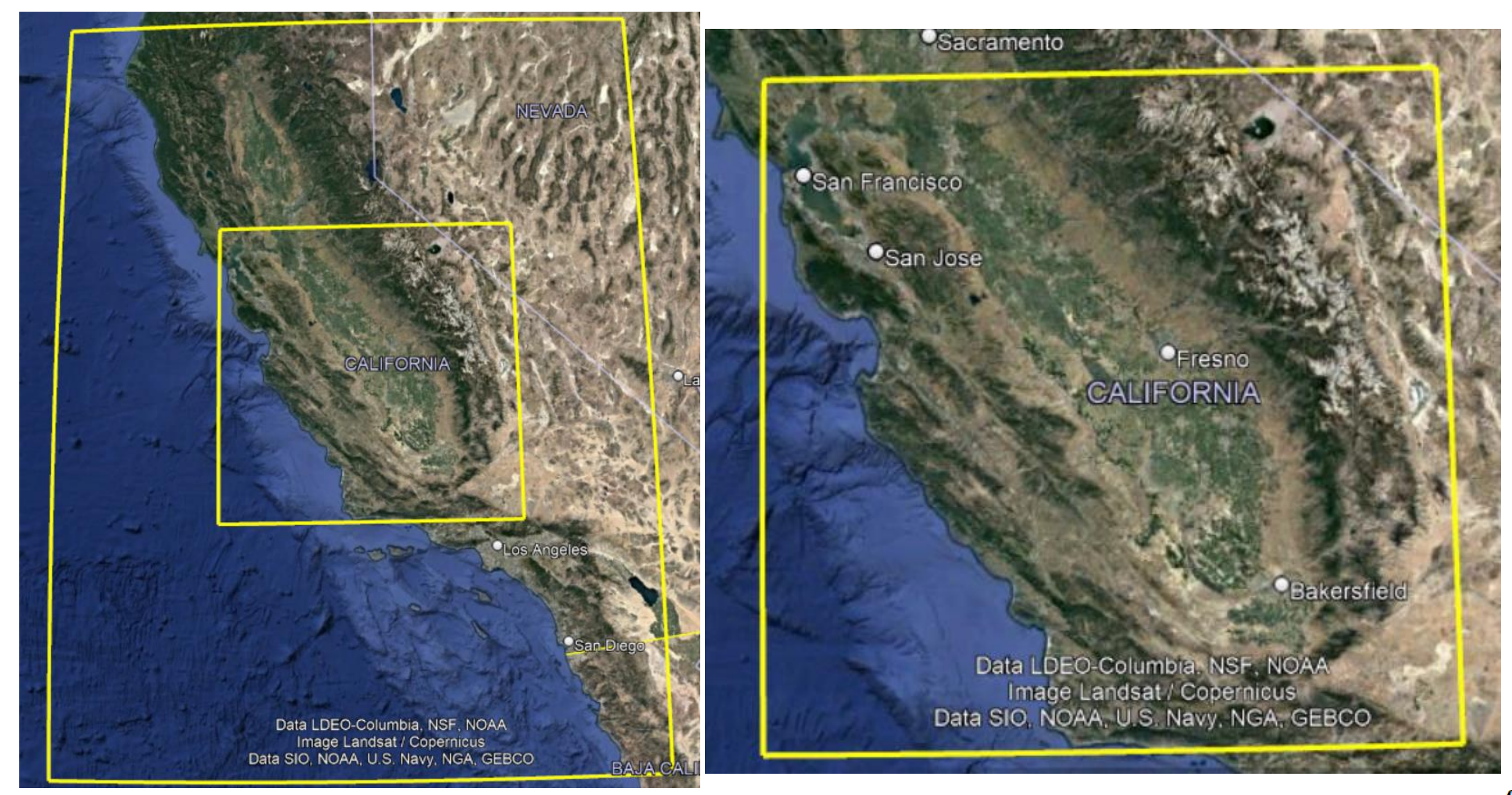

Figure 1. WRF domain for the study, outer box is 12 km resolution, while inner box is 4 km resolution (left) and a zoom in on inner domain (right).

Day	*Observed R_B*	*NAM R_B*	*WRF (MYNN) R_B*	*WRF (YSU) R_B*
January 16	2.20	6.67	0.78	0.79
January 18	1.28	9.44	0.98	0.97
January 20	0.05	5.92	0.77	0.77
January 21	19.9	2.88	1.85	1.54

Day	*Observed VHD*	*NAM VHD*	*WRF (MYNN) VHD*	*WRF (YSU) VHD*
January 16	11.90	11.59	7.98	6.98
January 18	10.58	9.83	8.14	6.64
January 20	11.35	10.38	10.64	8.24
January 21	10.29	10.23	11.04	8.20

Table 1. Model comparison of calculated surface layer R_B values (top) and total VHD (bottom).

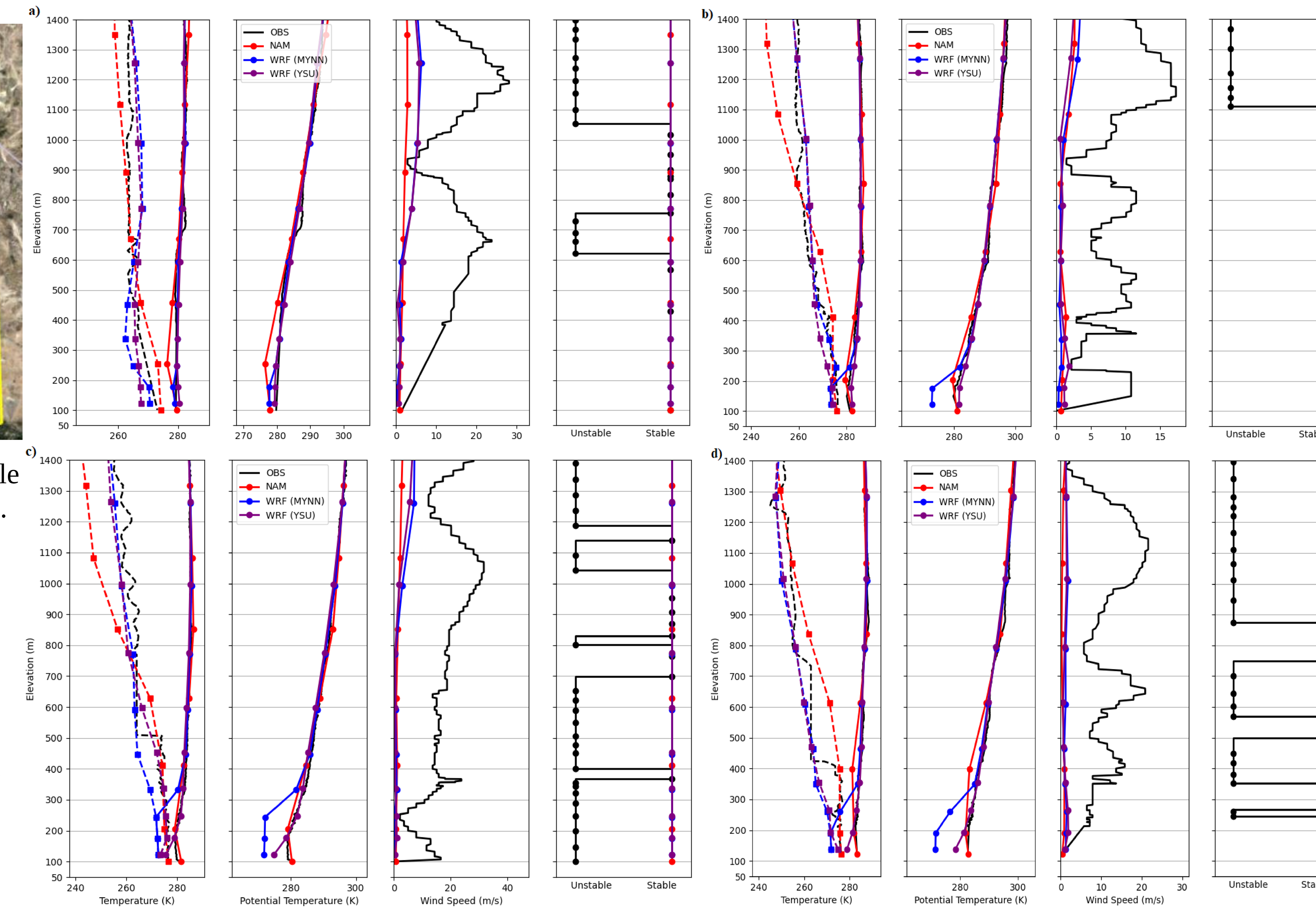

Figure 2. Model comparison of vertical distribution of temperature and dew point temperature (dashed) (left), potential temperature (middle left), wind speed (middle right), and a stability parameter based on R_B (right) on a) January 16, b) January 18, c) January 20, and d) January 21. All models and flight data from10 AM PST (18 UTC).

Conclusions

- Models have poor performance in the lowest parts of the atmosphere compared to those above the surface.
- NAM generally performs the best the most.
- With WRF, MYNN tends to overestimate inversion strength, while YSU tends to underestimates inversion strength.
- Wind speed discrepancies between observations and models lead to discrepancies in observed stable layers in the atmosphere.

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Future Work

- Test models in areas in other cities in the western U.S., mostly involving areas with radiosonde measurements. Model performance in regions with and without consistent radiosondes will be compared here.
- Determine the best preforming metric on predicting a CAP. Though this, determine days of CAPs and PCAPs of (at least) the last decade.
- Data from this project will be used in conjunction with an air quality study examining the relationship between CAPs and health impacts.