Variations in pollution concentrations at the mouth of a tributary canyon during persistent cold-air pool conditions in Utah's Salt Lake Valley

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I. Introduction

In winter, the Salt Lake City Valley and other topographic basins in northern Utah frequently experience persistent cold-air pools (PCAPs) under anticyclonic conditions (Baasandorj et al. 2017, Lareau et al. 2013, Whiteman et al. 2014). Stagnation of the stably stratified cold air in the topographic depressions causes fine particulate pollution ($PM_{2.5}$) to accumulate. This often leads to exceedances of the 24-hour average National Ambient Air Quality Standard (NAAQS) for $PM_{2.5}$ of 35 µg m^{-3}.

II. Methods

1. Data from various sites in the Salt Lake Valley (**Figure 1**) during the 2-12 December 2020 pollution episode were compiled, including $PM_{2.5}$ and ozone (O_3) concentrations, temperature, pressure, relative humidity, short- and longwave radiation, and wind speed and direction.
2. A Python code was written to analyze the data and visualize the datasets (**Figure 2 and 3**).
3. The graphs were analyzed to understand the effect of thermally-driven canyon circulations on pollution concentrations under PCAP conditions in the study area.

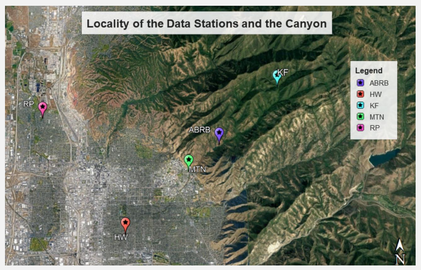

Figure 1. Selected sites in the Salt Lake Valley.

III. Results

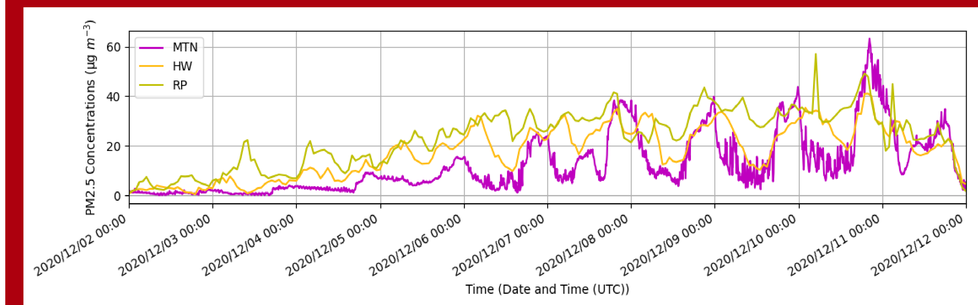

Figure 2. Time series of $PM_{2.5}$ concentrations at three sites in the Salt Lake Valley basin. MTN (purple) is located at the mouth of Red Butte Canyon.

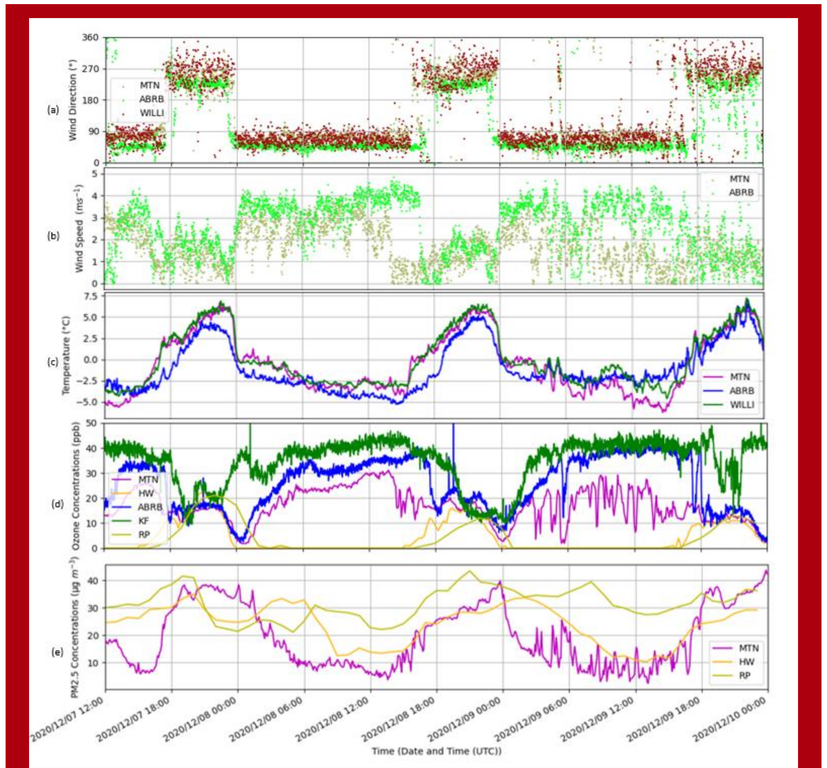

Figure 3. Time series of temperature, wind speed , wind direction, PM2.5, and O3 concentrations at selected sites in the Salt Lake Valley basin for a 2.5 day period during the core of the pollution episode.

- A general increase in $PM_{2.5}$ concentrations is observed as the PCAP evolves.
- Underlying diurnal variations (drops in $PM_{2.5}$ at night) are most pronounced at MTN, a site at the mouth of Red Butte Canyon.
- Diurnal variations in $PM_{2.5}$ and O_3 concentrations at MTN correlate with the wind direction and speed of the thermally-driven canyon flows.
- Night-time down-canyon flows advect lower-$PM_{2.5}$ and higher-O_3, daytime up-canyon flows higher-$PM_{2.5}$ and low-O_3 air to the edge of the PCAP.
- Counter-correlated oscillations of $PM_{2.5}$ and O_3 concentrations are observed as the PCAP pollution layer deepens, indicating periods of sloshing of the particulate pollution layer into the tributary canyon that interrupt the nocturnal down-canyon flow pattern.

IV. Conclusions

- Thermally-driven flows act to modulate pollution concentrations during PCAP conditions, most noticeably at the exits of tributary canyons. They advect higher (lower)-$PM_{2.5}$ and lower (higher)-O_3 air up (down) the canyon during day- (night-) time.
- $PM_{2.5}$ and O_3 observations at the canyon mouth show an inverse relationship. This is especially pronounced when the nighttime polluted stable layer reaches the height of the tributary, and periodically sloshes into the canyon, interrupting the nocturnal down-canyon flow pattern.

V. References

- Baasandorj, M., et al. 2017: Coupling between Chemical and Meteorological Processes under Persistent Cold-Air Pool Conditions: Evolution of Wintertime PM2.5 Pollution Events and N2O5 Observations in Utah's Salt Lake Valley. ES&T, 51 (11), 5941-5950
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