Vertical Distributions of Ozone above the San Joaquin Valley Measured by the NOAA TOPAZ lidar during the California Baseline Ozone Transport Study (CABOTS)

A11M-0183

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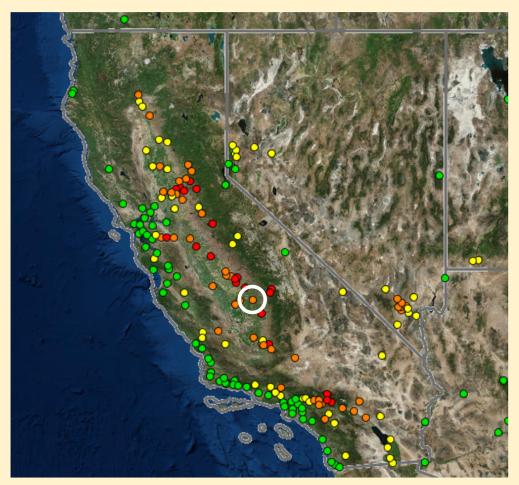
1. Introduction

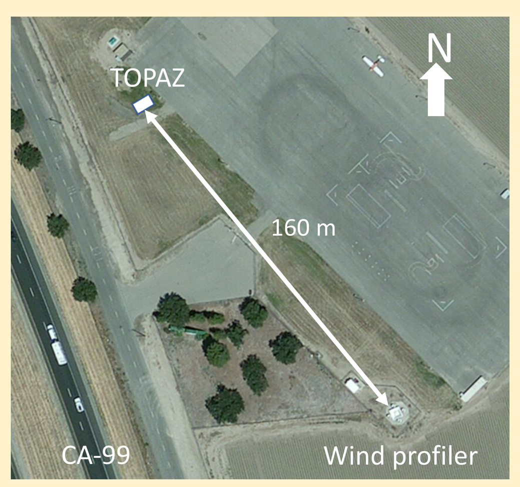
The California Baseline Ozone Transport Study (CABOTS) was conducted in the late spring and summer of 2016 to investigate the influence of trans-boundary ozone (O_3) on the surface concentrations in the San Joaquin Valley (SJV) of California, one of two "extreme" ozone non-attainment areas remaining in the United States.

As part of this study, the NOAA ESRL Chemical Sciences Division (CSD) "Tunable Optical Profiler for Aerosol and oZone" (TOPAZ) truck-based scanning lidar was deployed to the Visalia, CA airport to measure the vertical distribution of ozone during two 3-week intensive operating periods: (May 29 – June 18) and (July 18-August 7). The two IOPs were chosen to contrast different photochemical and transport regimes.

The Visalia Airport was selected because of its location east of the Chews Ridge Observatory (*Faloona A11M-0192*) and its proximity to Sequoia and Kings Canyon National Parks, and to take advantage of the collocated radar wind profiler operated by the San Joaquin Valley Air Pollution Control District (SJVAPCD).



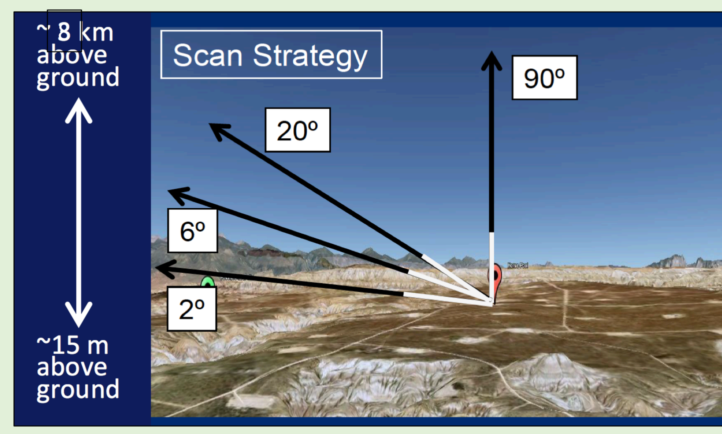
Right, MDA8 O_3 in CA on July 27, 2016. The white circle surrounds Visalia.

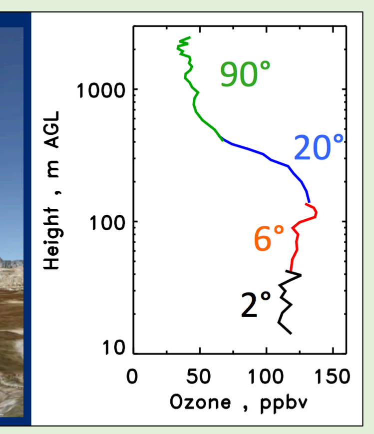


Above left, TOPAZ at the Visalia Airport. Right, aerial view with the SJVAPCD profiler.

2. Methodology

TOPAZ uses the Differential Absorption Lidar (DIAL) technique to measure ozone as a function of distance from the lidar. DIAL works by comparing the backscattered return signals from two laser pulses transmitted into the atmosphere at different ultraviolet wavelengths that are absorbed to different degrees by ozone. TOPAZ couples this technique with a large scanning mirror that sequentially deflects the beams at different angles to measure ozone from 15 m to nearly 6 km above the surface during the day, and 8 km at night. The system is automated, but not autonomous, and requires two real time operators.





Above left, TOPAZ scanning strategy, and right, composite vertical profile.

Above left, NASA/H211 Alpha Jet, and right, Scientific Aviation Mooney.

The CABOTS TOPAZ measurements were coordinated with in situ sampling by the NASA Ames Alpha Jet (AJAX) (*McNamara et al., Poster A11M-0182*) and UC Davis/Scientific Aviation Mooney aircraft (*Trousdell et al., Poster A31I-0183*), and daily ozonesonde launches from Bodega Bay and Half Moon Bay by San Jose State University (*Eiserloh et al., Poster A11M-1080*).

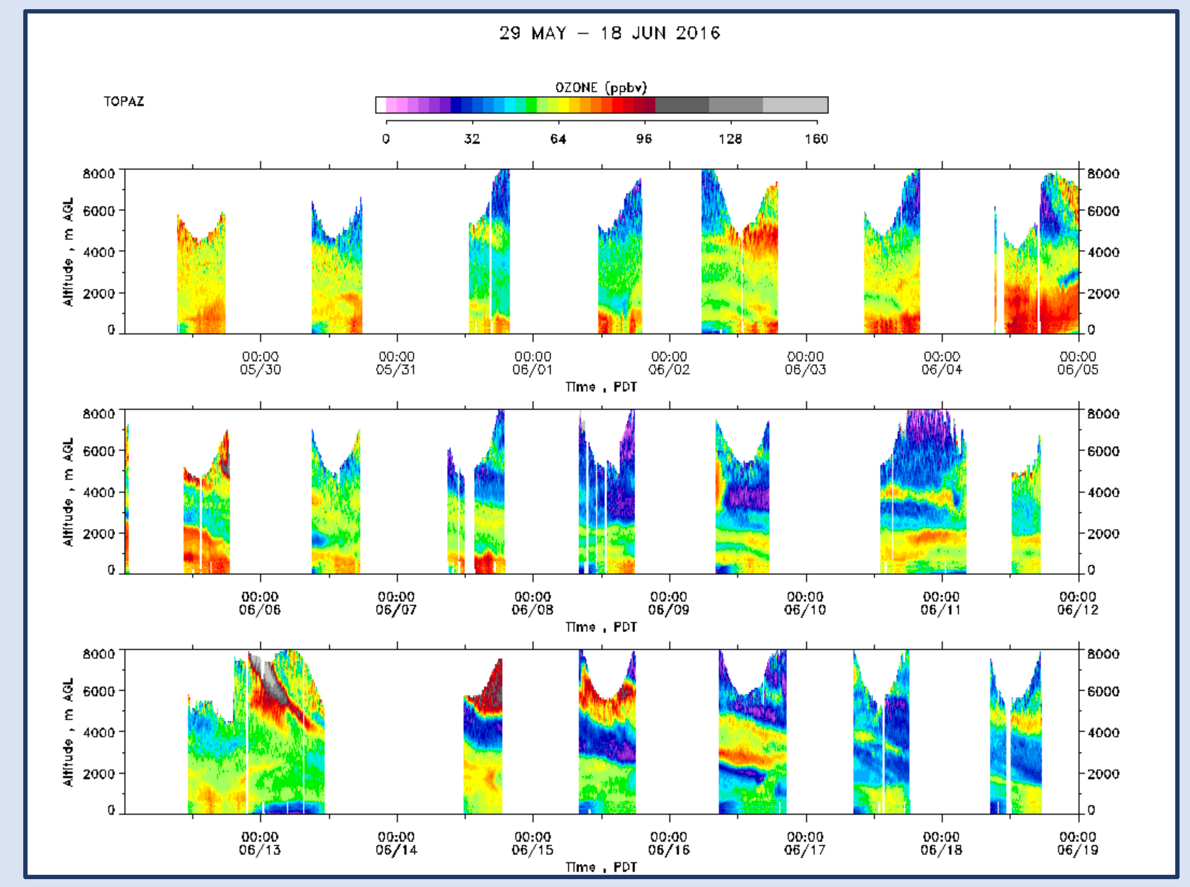
TOPAZ is part of the NASA-sponsored Tropospheric Ozone Lidar Network (TOLNet) (please see posters *A51D-0073, A41A-0005, A31G-0128, A51D-0095*).

3. Preliminary Results

The TOPAZ measurements are summarized below as time-height curtain plots. The system was operated for an average of 10 to 11 hours per day during each of the 3-week IOPS. Both periods were characterized by very shallow (<100 m) nocturnal boundary layers, with frequent destruction of all surface ozone by NOx emissions from the nearby CA-99 in the early morning. The afternoon mixed layers rarely exceeded 1.2 km in depth, and were often overlain by multiple layers of high ozone and aerosol extending to 4 km or more. These layers were maintained in part by differential advection caused by the complex valley and mountain-plains flows in the SJV. The second IOP was dominated by an influx of high ozone and aerosol from the Soberanes Fire near Big Sur, which began July 22.

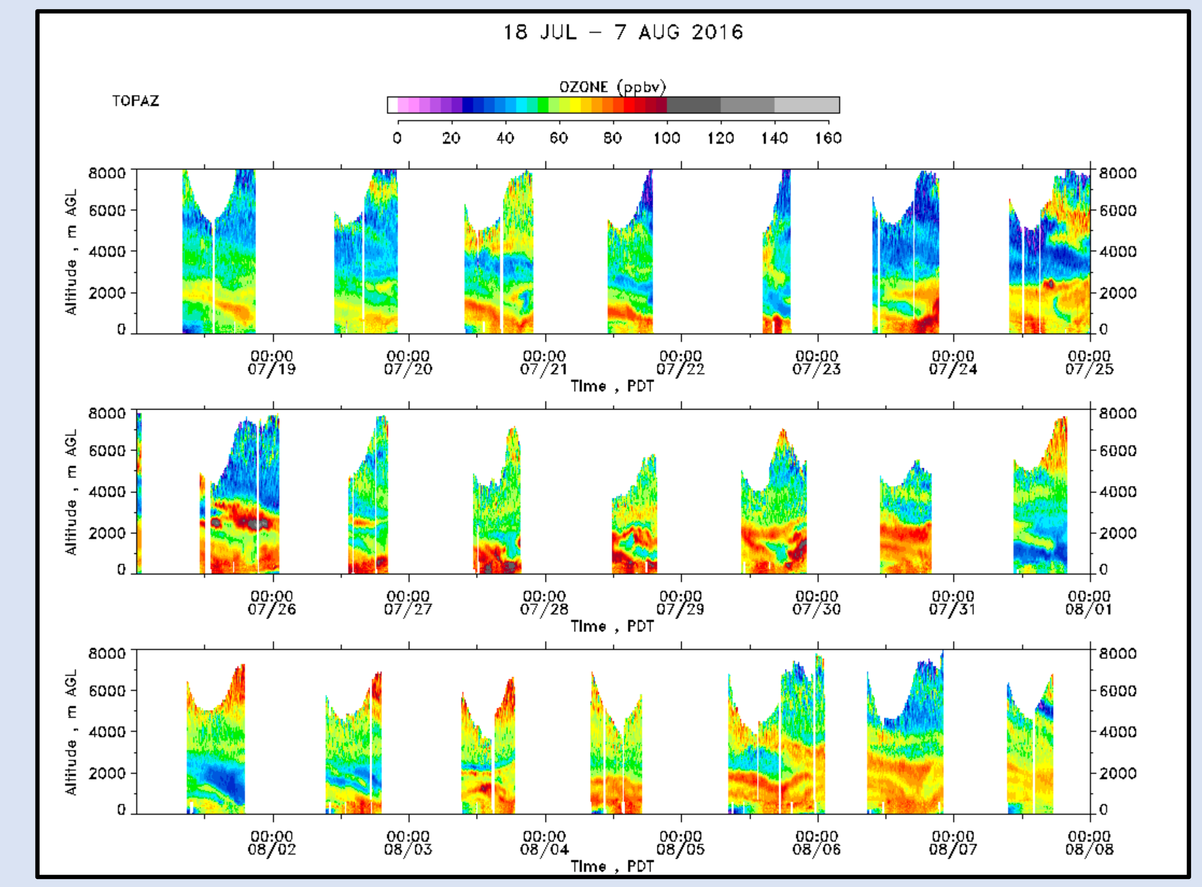
IOP 1 (212 hours)

Ozone mixing ratios

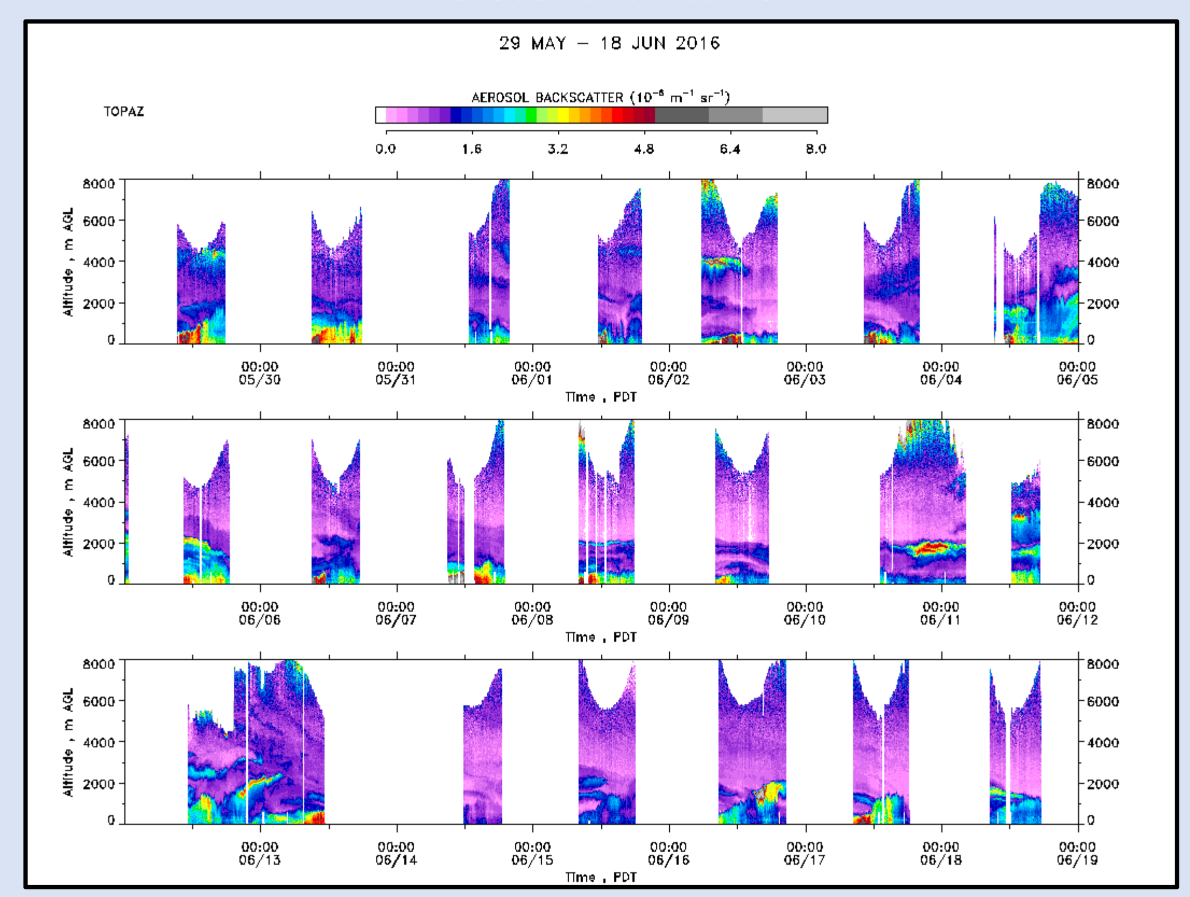


IOP 2 (223 hours)

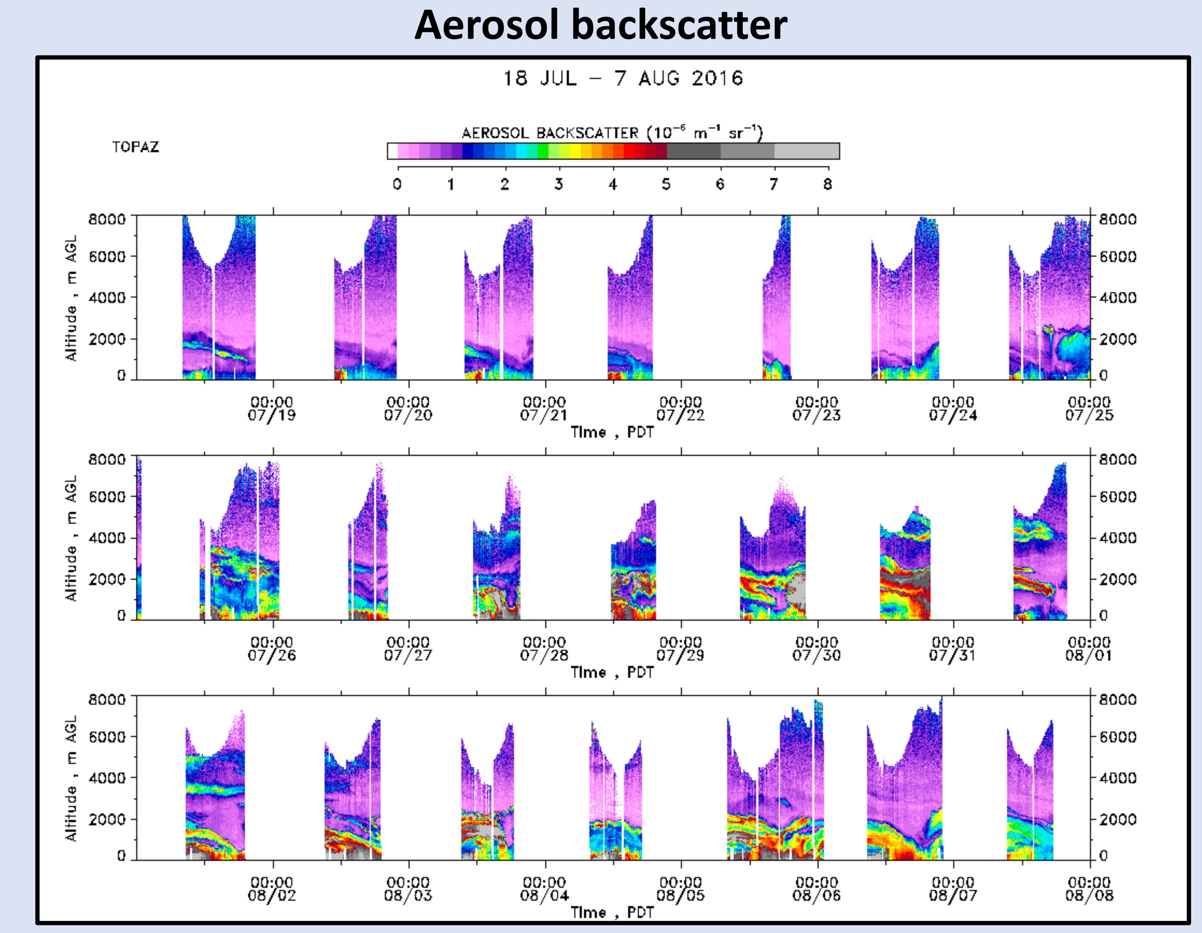
Ozone mixing ratios



Aerosol backscatter

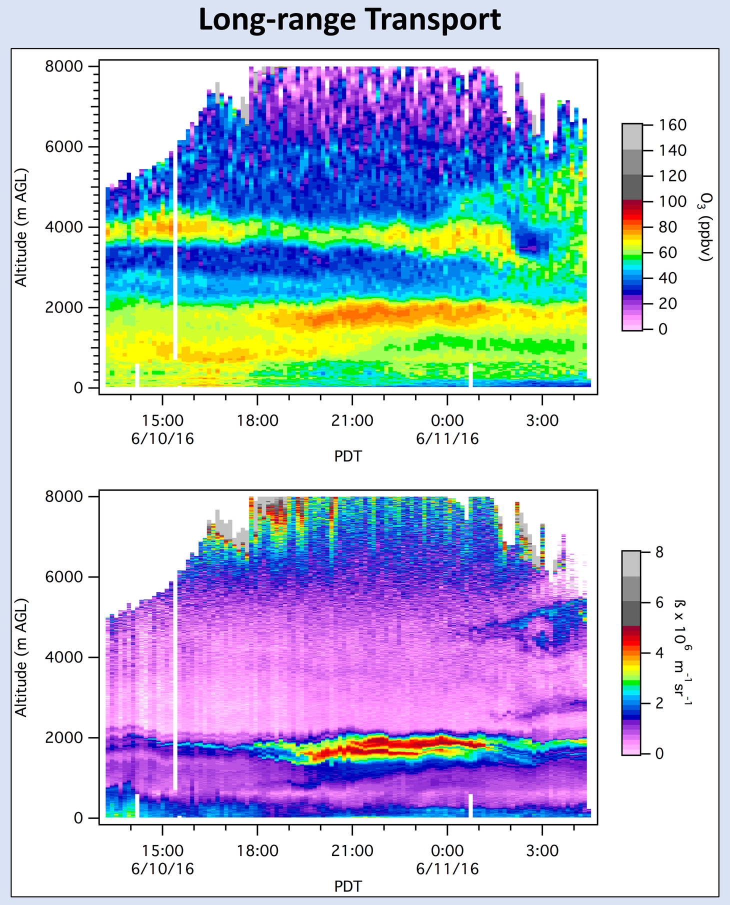


Aerosol backscatter



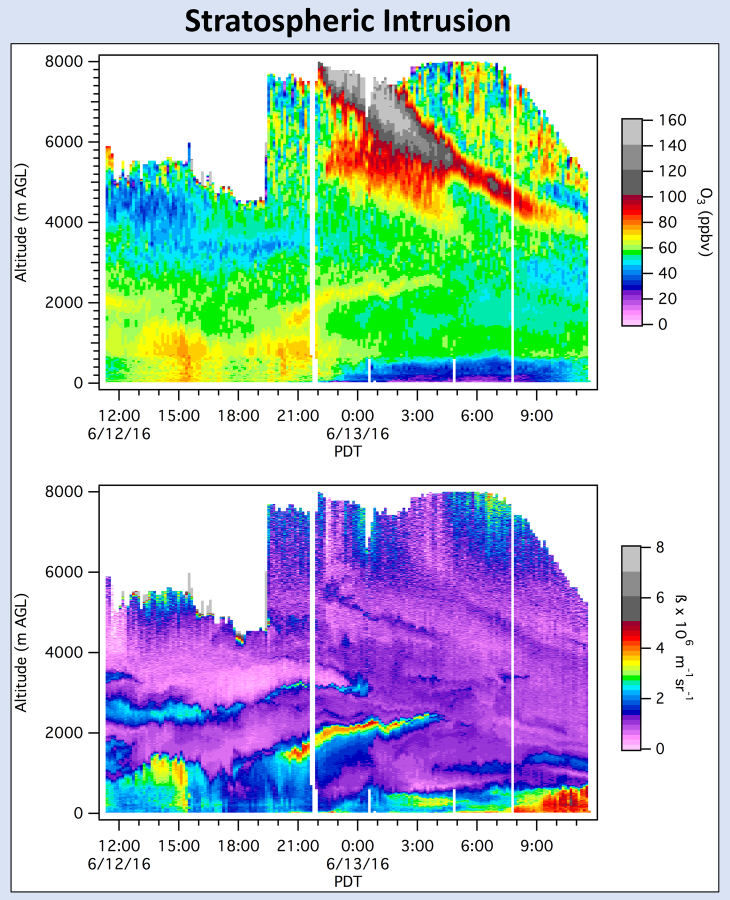
4. Some Examples

Long-range Transport



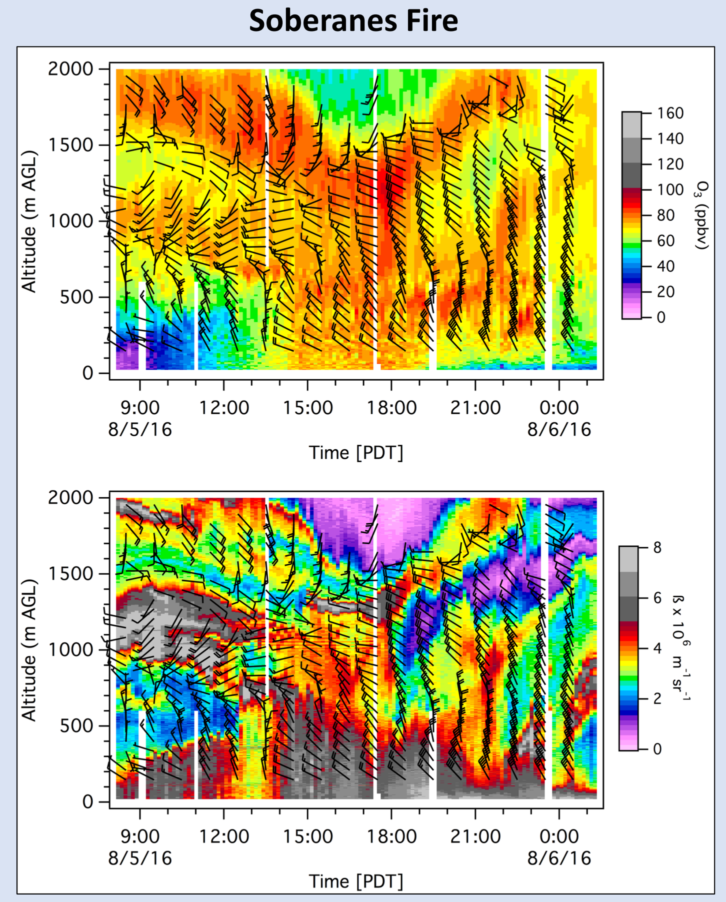
June 10. 15-h time series showing elevated ozone and aerosol layers about 2 km above Visalia attributed to long-range transport of a Siberian fire plume.

Stratospheric Intrusion



June 12-13. 24-h time series showing advection of a stratospheric intrusion over Visalia. The ozone plot appears to show turbulent mixing of the intrusion into the free troposphere. Modest surface enhancements were observed in the Lake Tahoe/Reno area, but not in the SJV.

Soberanes Fire



August 5. 17-h time series overlaid with horizontal winds from the SJVAPCD profiler. The high ozone and aerosol originates from the Soberanes Fire. The winds show that the complex layered structure was created largely by differential advection.

5. Summary and Future Plans

The ozone and aerosol data acquired by the TOPAZ lidar during the 2016 CABOTS campaign have already provided valuable insights into the spatial and temporal variability of ozone in the lower San Joaquin Valley during late spring and summer. Integration of these data with the surface, aircraft, and ozonesonde measurements acquired by other research groups should greatly advance our understanding of the role played by transport in the creation of high surface ozone in the SJV.

Final analyses of the CABOTS TOPAZ data will be completed and the results released in early 2017.

The NOAA ESRL CSD activities during CABOTS were funded in part by the California Air Resources Board (CARB) under contract no. 15RD012, and by the NASA-sponsored Tropospheric Ozone Lidar Network (TOLNet).