NOAA ESRL TOLNet Lidar

The Tunable Optical Profiler for Aerosols and oZone (TOPAZ) 3-wavelength mobile differential absorption lidar (DIAL) system can profile O_3 and aerosol layers from near the surface to about 6 to 8 km a.g.l. The TOPAZ system is based at the NOAA Earth System Research Laboratory (ESRL) in Boulder, CO. but is mobile and has traveled numerous times to participate in field campaigns. This lidar has been used to examine scientific topics such as stratosphere-troposphere O_3 exchange, long-range transport of Asian pollution, local O_3 chemistry processes, and evaluating satellite-derived surface O_3. Furthermore, the TOPAZ system has been relocated to support multiple field campaigns such as DISCOVER-AQ Colorado (http://discover-aq.larc.nasa.gov/) and FRAPPÉ (https://www.eol.ucar.edu/field_projects/frappe).

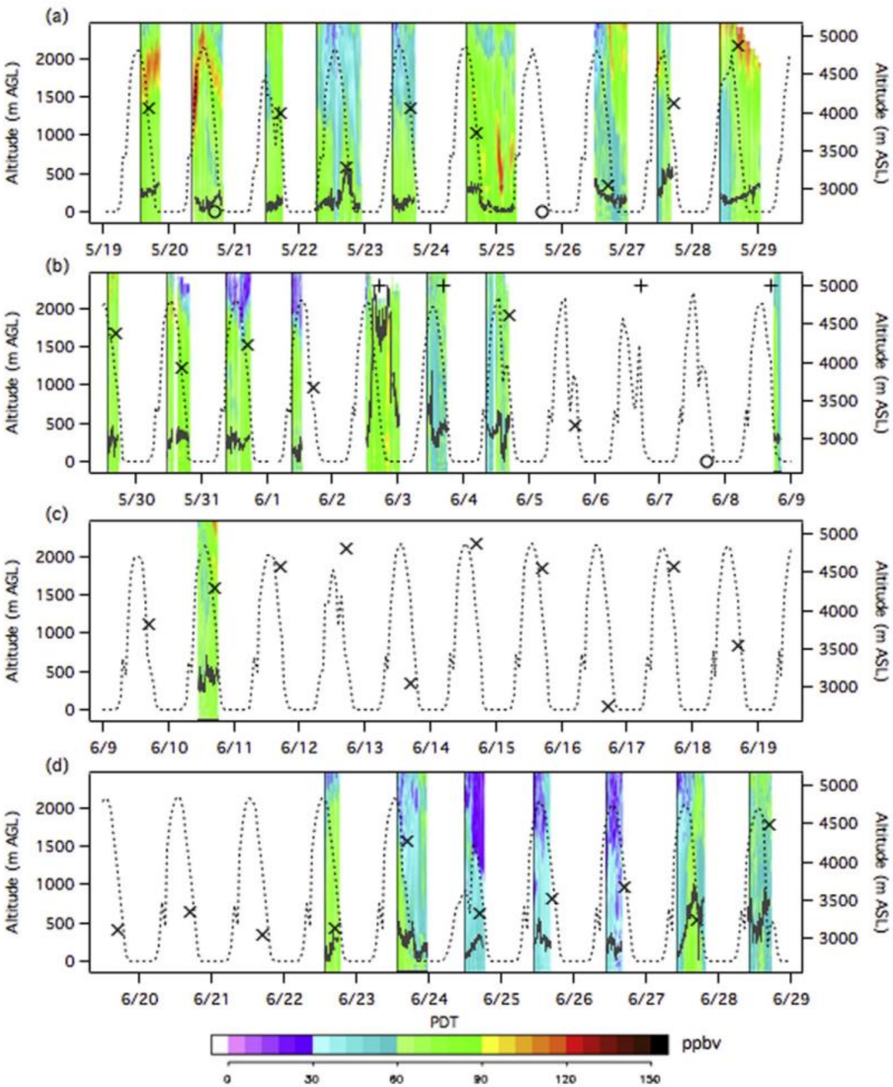
Please contact Andy Langford (andrew.o.langford@noaa.gov) or Chris Senff (christoph.senff@noaa.gov) for further information regarding these research topics. For more information about the Chemical Science Division at NOAA ESRL please visit: http://www.esrl.noaa.gov/csd/

1. 2013 Las Vegas Ozone Study (LVOS)

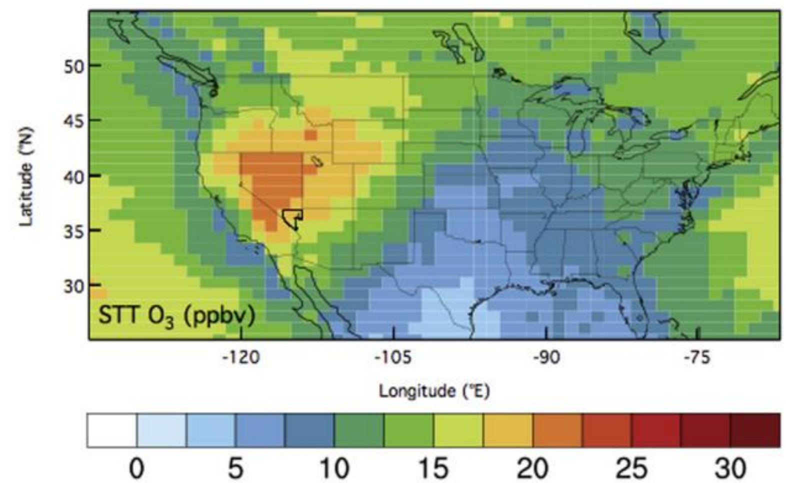
The 2013 Las Vegas Ozone Study (LVOS) was conducted in the late spring and early summer of 2013 to assess the seasonal contribution of stratosphere-to-troposphere transport (STT) and long-range transport to surface O_3 in Clark County, Nevada and determine if these processes directly contribute to exceedances of the National Ambient Air Quality Standard (NAAQS). Secondary goals included the characterization of local O_3 production, regional transport from the Los Angeles Basin, and impacts from wildfires. The study consisted of two extended periods (May 19 - June 4 and June 22 - 28, 2013) with near daily 5-min averaged TOPAZ measurements of O_3 and backscatter profiles from the surface to ~2.5 km, and in situ measurements (May 20 - June 28) of O_3, CO, and meteorological parameters at the surface. These activities were guided by forecasts and analyses from the FLEXPART dispersion model, RAQMS, and the NOAA GFDL AM3 chemistry-climate model. The combined measurements and model analyses show that STT directly contributed to each of the three O_3 exceedances that occurred during LVOS, with O_3 contributions in excess of 30 ppbv. The analyses show that long-range transport from Asia made smaller contributions (<10 ppbv) to surface O_3 during two of those exceedances. The contribution of regional wildfires to surface O_3 during the three LVOS exceedance events was found to be negligible.

Important figures from this work are in the following slide and the full study can be found at: Langford, A. O., et al. (2015), An overview of the 2013 Las Vegas Ozone Study (LVOS): Impact of stratospheric intrusions and long-range transport on surface air quality, Atmospheric Environment, 109, 305-322, doi:10.1016/J.Atmosenv.2014.08.040.

1. 2013 Las Vegas Ozone Study (LVOS)



TOPAZ measured O_3 concentrations during LVOS



NOAA GFDL AM3 average STT contribution to surface O_3.

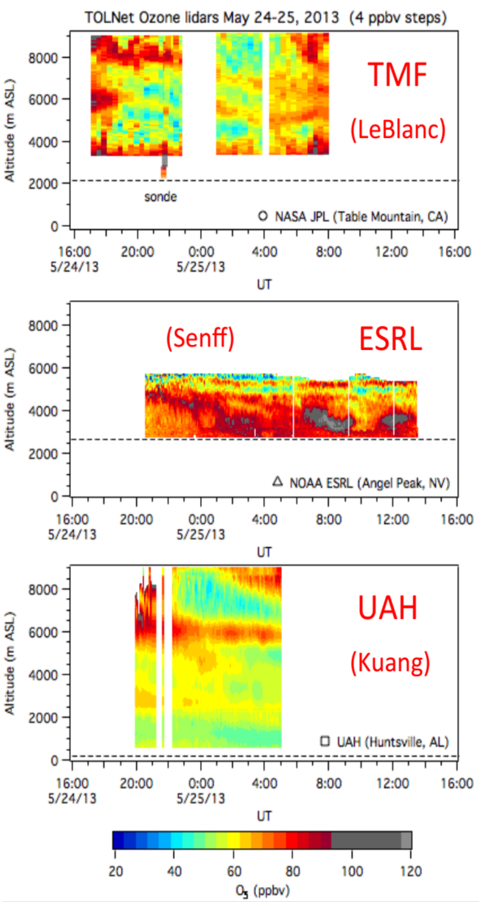
- The TOPAZ lidar measured frequent layers with O_3 values greater than 100 ppbv within a few km of the surface.
- The layers of enhanced O_3 were associated with clear-sky conditions and low aerosol loading suggesting Upper Tropospheric and Stratospheric influence.
- The NOAA GFDL AM3 model predicted average stratospheric O_3 values at the surface exceeding 20 ppbv during LVOS.

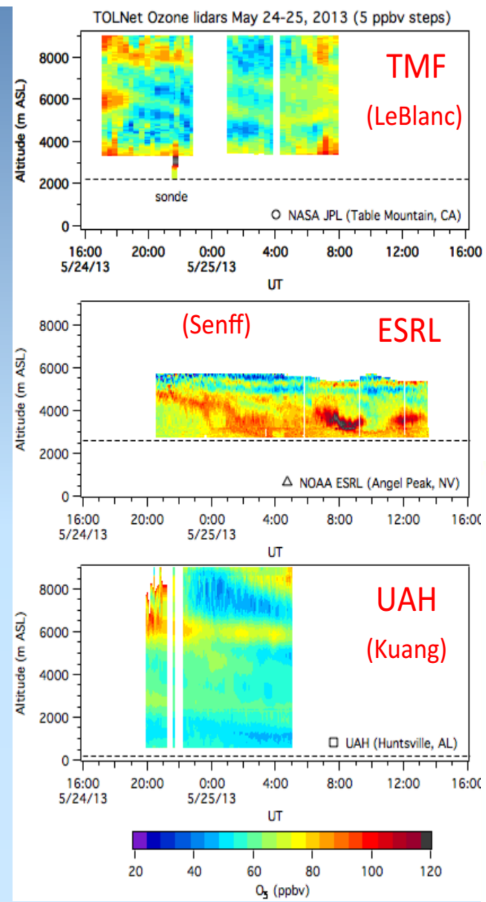
2. Observations of Simultaneous Stratospheric Intrusions

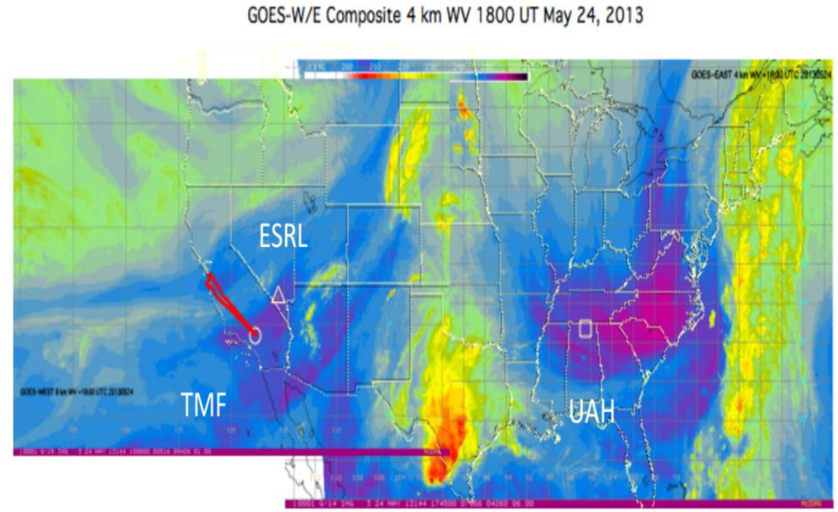
This preliminary research applies measurements from multiple TOLNet lidars (ESRL TOPAZ, UAH, and TMF) in California, Nevada, and Alabama which observed two large simultaneous stratospheric intrusions impacting the western and eastern US on May 24-25, 2013. Coinciding with the TOLNet observations on May 24, 2013, data obtained from GOES satellite derived water vapor in the lower troposphere clearly displayed two very dry air masses (associated with stratospheric air) over the locations of the TOLNet lidars. Additionally, chemical transport model simulations using the RAQMS model reproduces the simultaneous stratospheric intrusions observed by TOLNet lidar observations. During the stratospheric intrusions, all three TOLNet lidars observed lower tropospheric O_3 lamina with mixing ratios > 80 ppb. The ESRL TOPAZ and TMF lidar observations showed that O_3 mixing ratios were > 100 ppb less than 2 km above the surface. The large mixing ratios of O_3 measured by the TMF lidar system on May 24, 2013 were validated by airborne observations and O_3-sondes. This synergistic study emphasizes the valuable science which can be conducted applying multiple O_3 TOLNet lidar systems, satellite observations, in situ ground-based and airborne data, and model simulations.

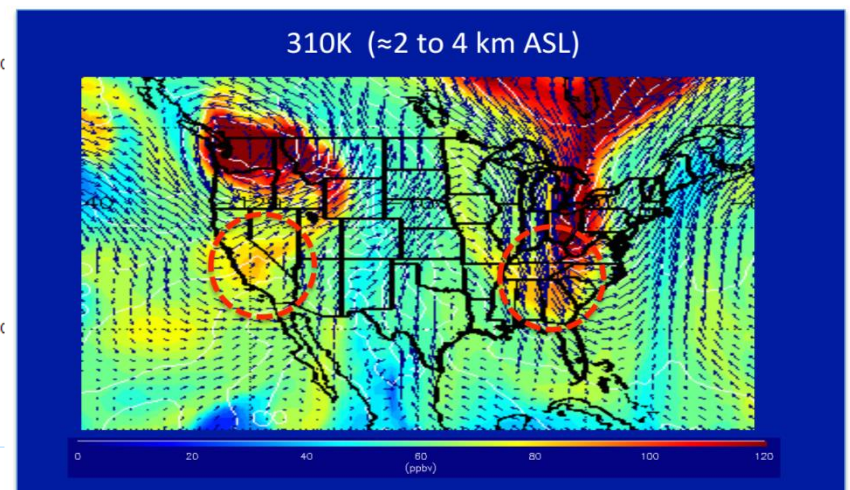
Important figures from this work are in the following slide and the full study is currently in manuscript preparation.

2. Observations of Simultaneous Stratospheric Intrusions









- **On May 24-25, 2013 multiple TOLNet lidars (ESRL TOPAZ, UAH, and TMF) observed two simultaneous stratospheric intrusions impacting the western and eastern US (left).**
- **The stratospheric intrusions were also indicated by GOES water vapor observations (top right) and RAQMS model simulations (bottom right).**

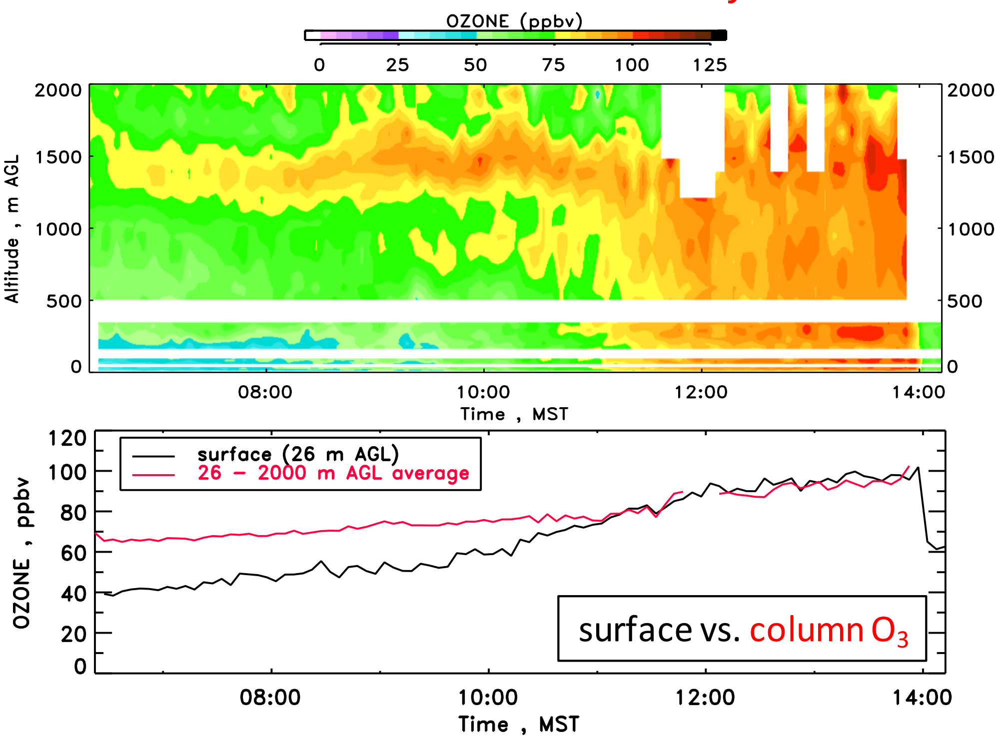
3. Evaluating the Uncertainty of Satellite-derived Surface Ozone

This preliminary study is being conducted to investigate the ability of lower-atmosphere column satellite observations to infer surface level O_3 concentrations. This research is important as NASA moves forward with future satellite missions to monitor air quality such as the Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument. These space-borne sensors plan to monitor surface air quality with observations which are sensitive to the lower most ~2 km of the troposphere. Applying high vertical resolution TOPAZ lidar observations from near the surface to 2.0 km from four different field campaigns conducted at different locations and different times of year, this study evaluates how lower-tropospheric column averaged space-borne observations would compare to surface measurements. Furthermore, applying lidar observations of O_3 allows for the evaluation of atmospheric conditions in which column averaged space-borne observations can and can not replicate surface O_3 mixing ratios. Results from this preliminary study demonstrate that theoretical satellite-derived surface O_3 values would typically agree with lidar measurements at the surface from mid-day through the afternoon, when the boundary layer is usually well mixed. However, biases between surface and column-average O_3 concentrations occur when significant O_3 vertical gradients are present in the boundary layer and lower troposphere, which is often the case during morning hours, when the lower atmosphere tends to be stably stratified.

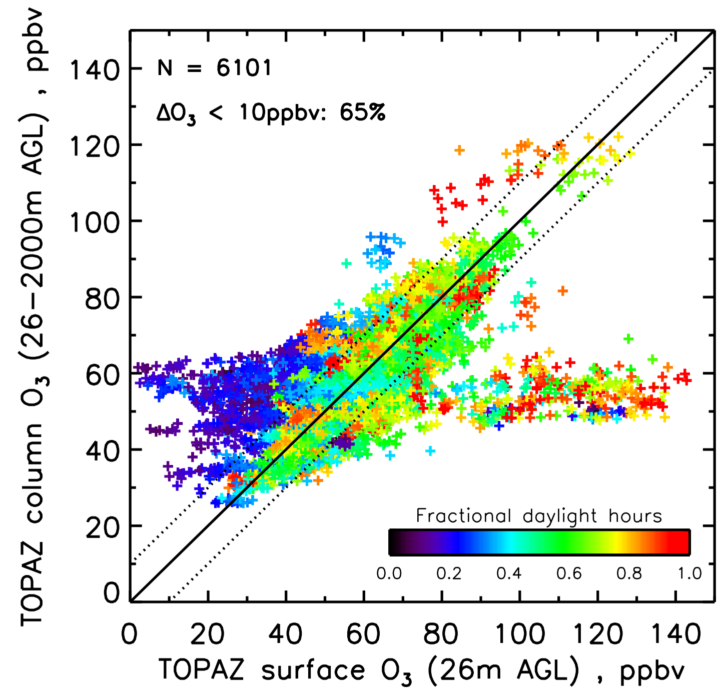
Important figures from this work are in the following slide and the full study is currently in progress.

3. Evaluating the Uncertainty of Satellite-derived Surface Ozone

29 Jul 2014: Residual Layer

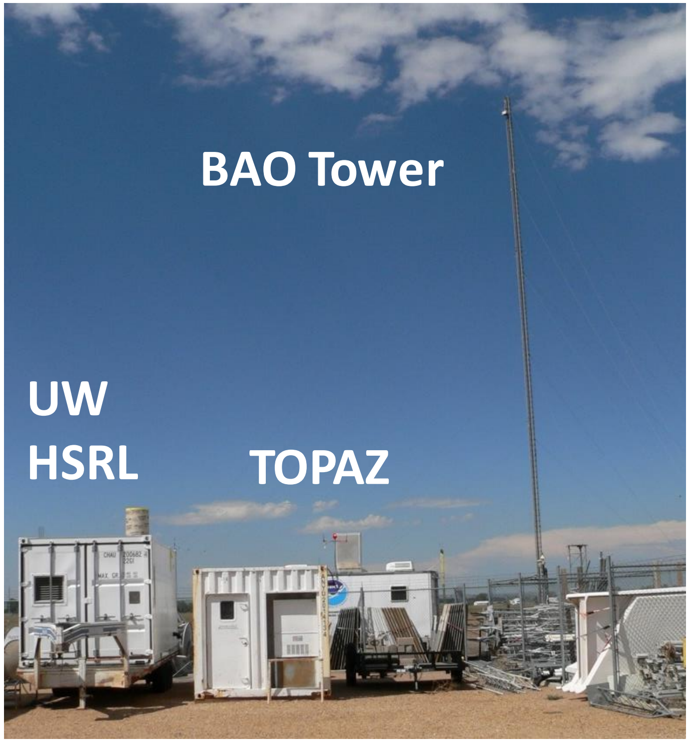


Surface vs column O_3: 4 field studies

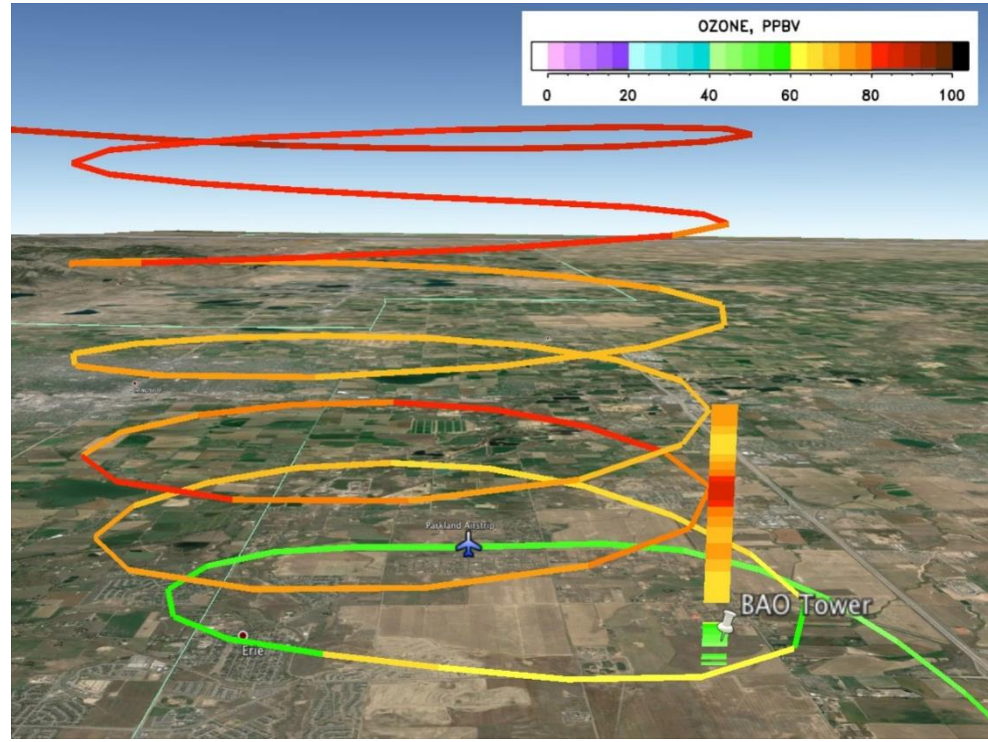


- **TOPAZ lidar measurements close to the surface and surface-to-2km lidar O_3 column averages from four different field studies were compared to assess the ability of future satellites to measure surface O_3 by way of lower-atmosphere column observations.**
- **Column and surface O_3 observations typically agree from mid-day through the afternoon, when the boundary layer is usually well mixed. Biases occur when significant O_3 gradients are present in the lower troposphere, due to, e.g., a shallow mixed layer or low-level advection of different air masses by thunderstorm outflows or the sea breeze.**

4. Lidar Observations in Support of Discover-AQ and FRAPPÉ



TOPAZ O_3 lidar at BAO during Discover-AQ.



NASA-P3 and TOPAZ O_3 observations at BAO on 29 July at 09:20 MDT.

In support of the DISCOVER AQ and FRAPPÉ field campaign the NOAA TOPAZ lidar took multiple days of O_3 observations during the summer of 2014. During this time, the system observed numerous processes controlling O_3 spatio-temporal variability, such as transport and mixing, and chemical processes. The NOAA TOPAZ lidar provided critical observations of O_3 vertical profiles which were inter-compared with numerous measurement platforms and chemical transport models and have assisted in studies of varying processes impacting tropospheric O_3.