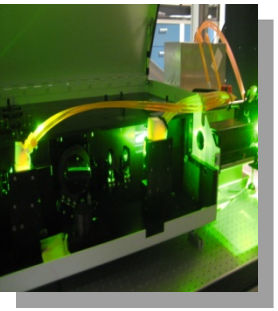
TOLNet

Tropospheric Ozone LIDAR Network



Applying TEMPO and TOLNet to Explore Air-Quality Processes Affecting Health

HAQAST5

January 4, 2019

Michael Newchurch[1], Kelly Chance[2], Susan Alexander[1], Aaron Naeger[1], TEMPO and TOLNet Science Teams

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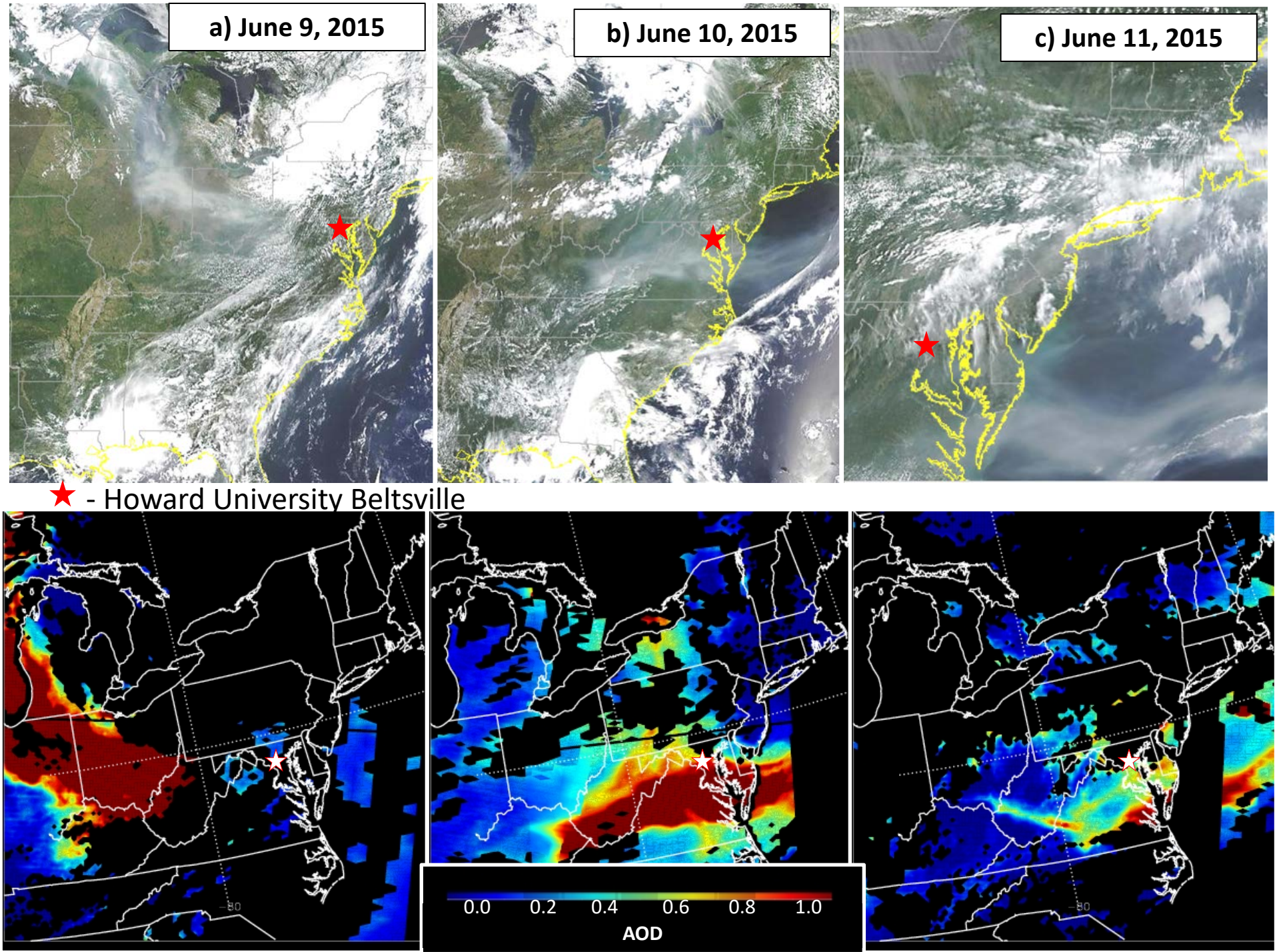
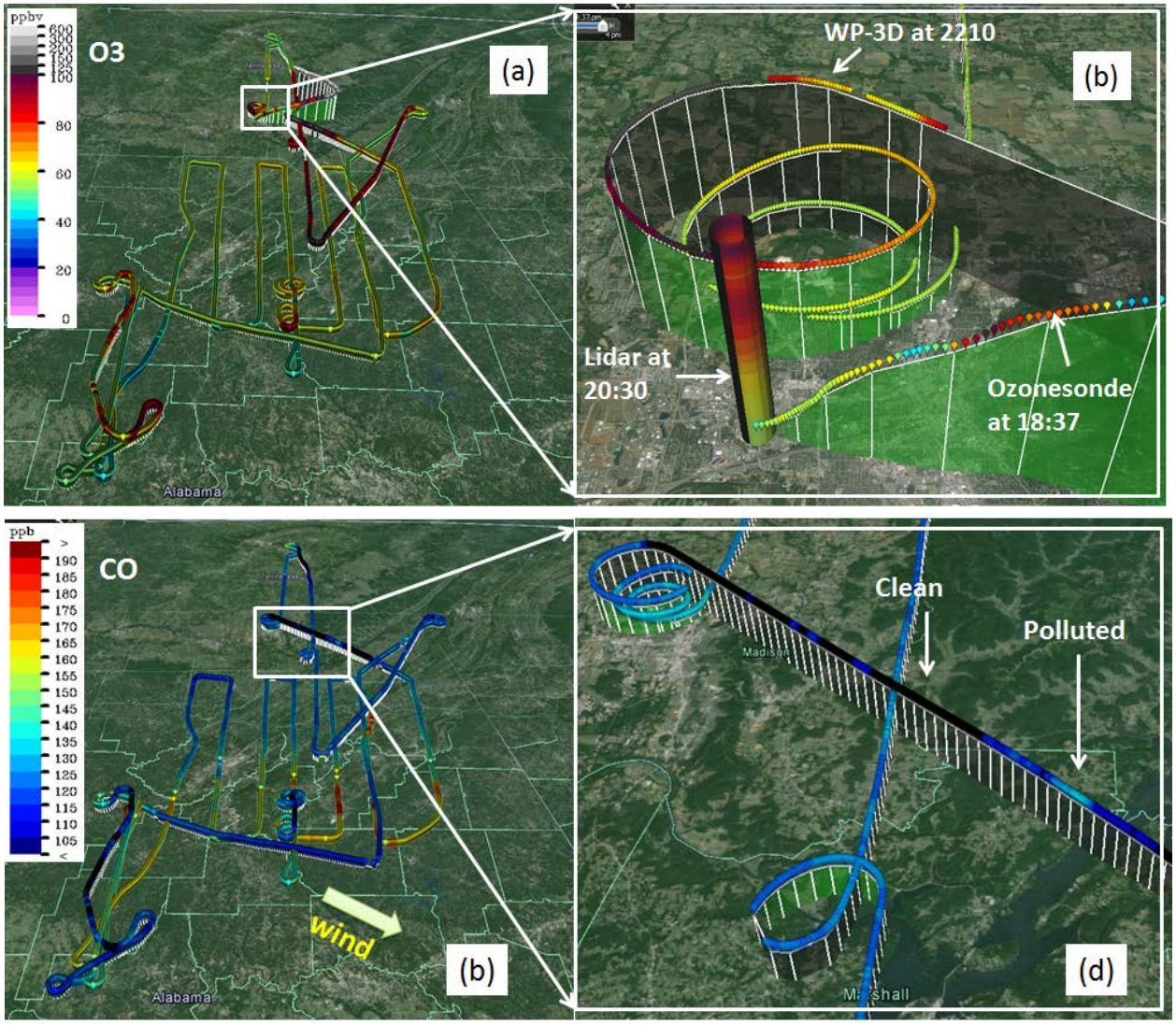
SPORT

NASA NOAA NDACC THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

http://nsstc.uah.edu/atmchem/
http://tempo.si.edu
https://www-air.larc.nasa.gov/missions/TOLNet/


a) June 9, 2015
b) June 10, 2015
c) June 11, 2015
★ - Howard University Beltsville
0.0
0.2
0.4
0.6
0.8
1.0
AOD



O3 provided by Tom Ryerson
CO provided by John Holloway

Figure 8. NOAA P3 airborne ozone and CO measurements during the Birmingham flight on 29 June 2013. (a) Overview of the ozone mixing ratios measured throughout the entire flight; (b) Ozone profiles measured by WP-3D, lidar, and ozonesonde measurements in Huntsville; (c) Overview of the CO mixing ratios measured by WP-3D; (d) CO mixing ratios measured by WP-3D east of Huntsville showing mixing of clean and polluted air at 4.6 km.

TOLNet

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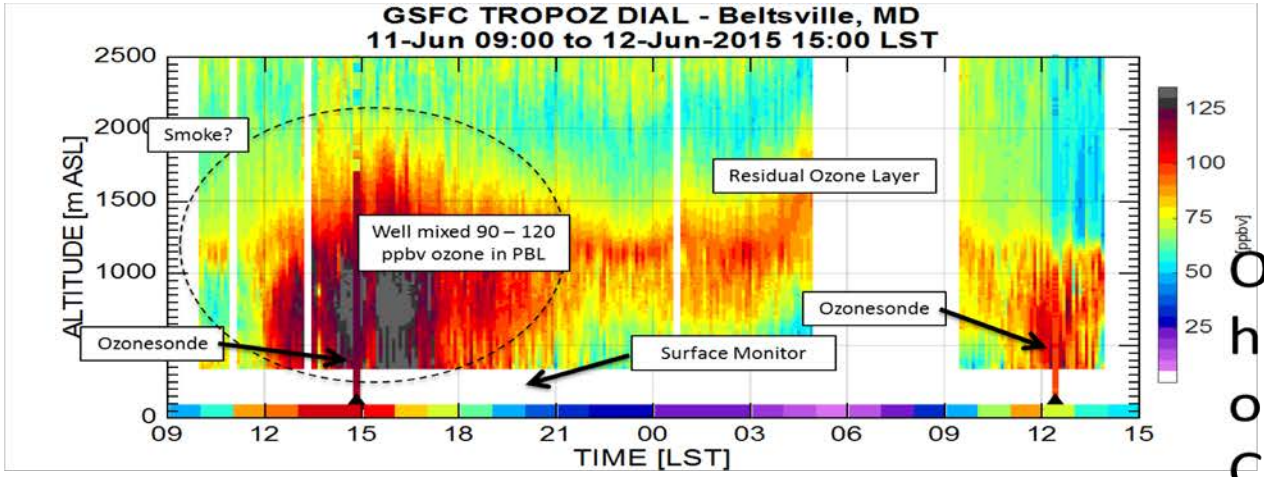
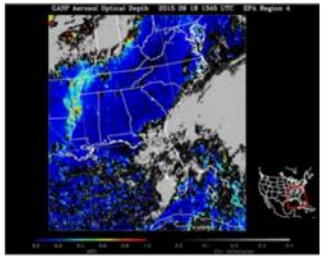


High O3 due to Smoke Transport

On June 10, 2015, heavy smoke originating from Canadian wildfires impacted the boundary layer throughout the Mid-Atlantic region, bringing additional ozone precursors to the region. GSFC TROPOZ lidar (above) measured large ozone enhancement with ozone concentrations reaching 90-120 ppbv (also verified by ozonesonde) at Beltsville, MD, on June 11, 2015. Several sites monitored surface ozone exceeded the NAAQS 8-hr 75 ppbv ozone standard. **This was the worst day for ozone in MD since 2012.** Sullivan et al., 2018

Biomass Burning Transport

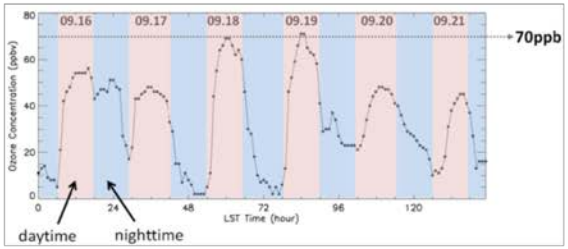
The integrated analyses suggest a causal relationship between the elevated ozone in PBL over Huntsville and the Mississippi Valley wildfire on Sep, 2015.



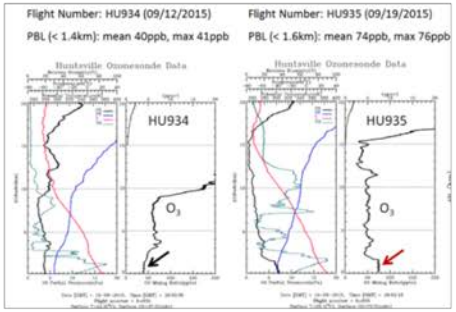
GASP EAST AOD on 2015.09.18 1345 UTC

The smoke plume over the Mississippi Valley is visible.

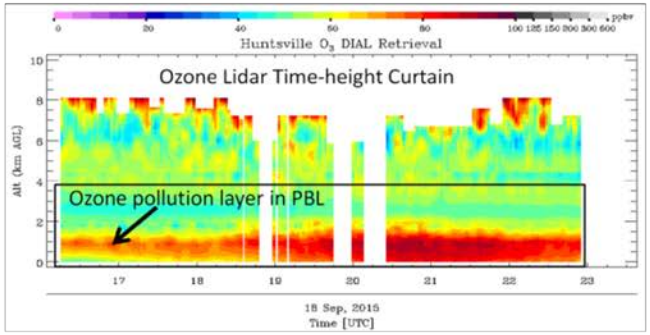
(Figure) Hourly ozone concentration Sep 16-21, 2015 at Huntsville Old Airport Monitoring Site.



The two days with the highest levels of ozone (1day over 70ppb) at the surface, ~~on~~ September 18 and 19, 2015

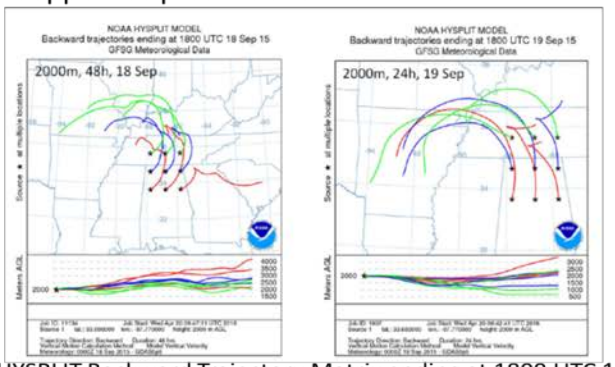


Compared with the last flight, on Sep 19, a~~n~~ PBL ozone enhancement of approximately 30ppb was present over Huntsville.



(Figure) UAH Ozone lidar time-height curtain at 1600-2300 UTC on September 18, 2015.

The lidar profile agrees well with the EPA data (surface) and HU935 ozonesonde (1 day later) on distribution characteristics. An ozone pollution layer and a maximum mixing ratio of approximately 90ppb PBL ozone were observed during the daytime on September 18, 2015.



HYSPLIT Backward Trajectory Matrix ending at 1800 UTC 18 Sep (Left) and at 1800 UTC 19 Sep (Right) at 2000m AGL.

For Sep 18, the air was more stagnant and the pollutant transported to Huntsville from the wildfire area over 48 hours; for Sep 19, along with a cold front moving closer, the air masses transported to

Kuang, S., et al. (2017), Summertime tropospheric ozone enhancement associated with a cold front passage due to stratosphere-to-troposphere transport and biomass burning: Simultaneous ground-based lidar and airborne measurements, *Journal of Geophysical Research: Atmospheres.*

TOLNet Observations Revealing "Next Day" Pollution Episodes

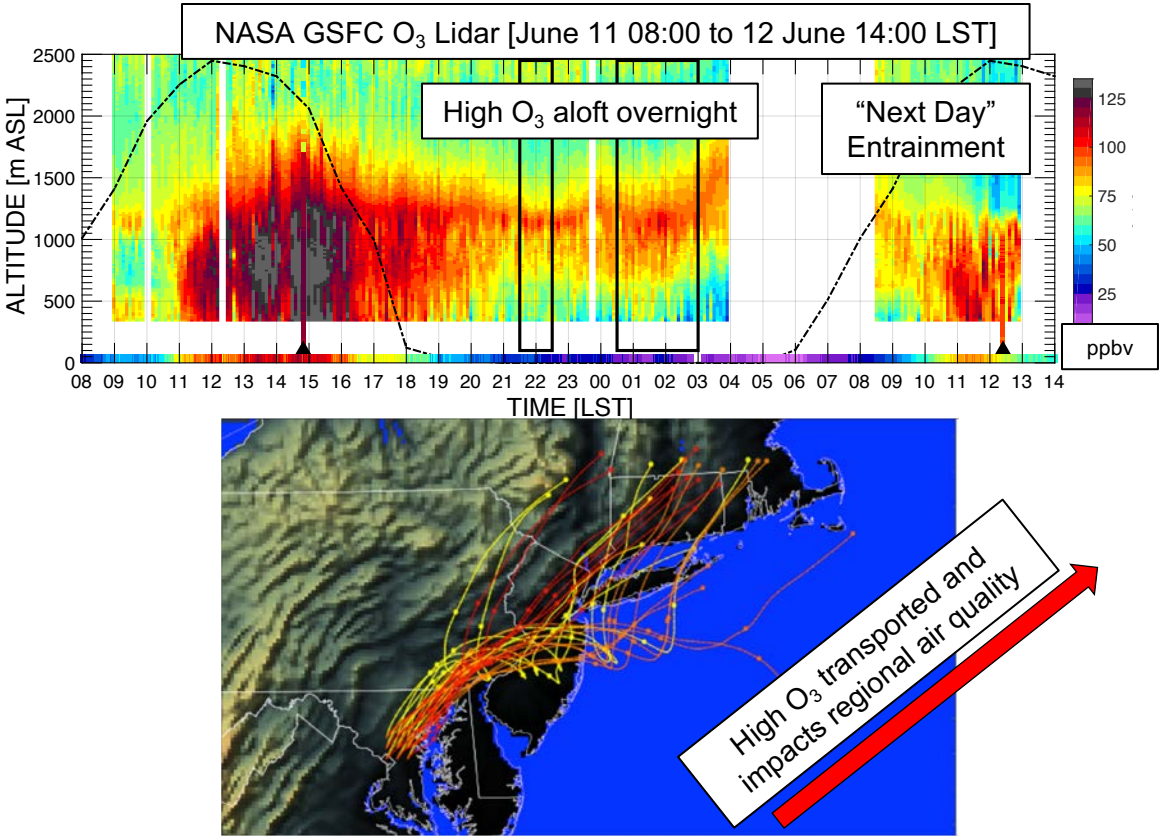
John Sullivan, Thomas McGee et al., Atmos. Env. Vol 158. DOI:10.1016/j.atmosenv.2017.03.039

Background:

- TOLNet (Tropospheric Ozone Lidar Network) comprises 6 lidars dedicated to studying air quality, tropospheric ozone variability, and satellite validation.
- June 2015: The GSFC TOLNet lidar deployed to Beltsville, MD to support regional air-quality forecasts

Analysis:

- Top figure displays nearly 28 continuous hours of lidar and surface data including 2 sondes
- Bottom figure displays trajectories of the ozone profiles measured by the TOLNet/TROPOZ lidar
- Regional surface monitors assessed the potential impacts of this event



TOLNet/GSFC TROPOZ O_3 lidar observes high O_3 aloft (top), which is regionally distributed overnight and entrained on the following morning over a broad region (bottom)

Results:

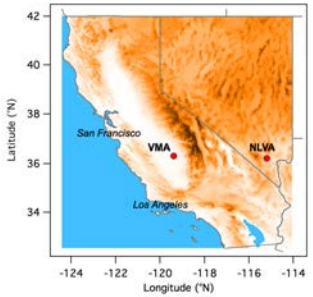
- Trajectories indicate the nocturnal residual layer O_3 and other pollutants affected broad regions down wind
- Lidar and sondes both observed "Next Day" entrainment verified by surface monitors in the locations of high O_3

Significance:

Ozone lidar is the critical measurement platform to identify layers aloft, advection, and vertical mixing of pollutants.

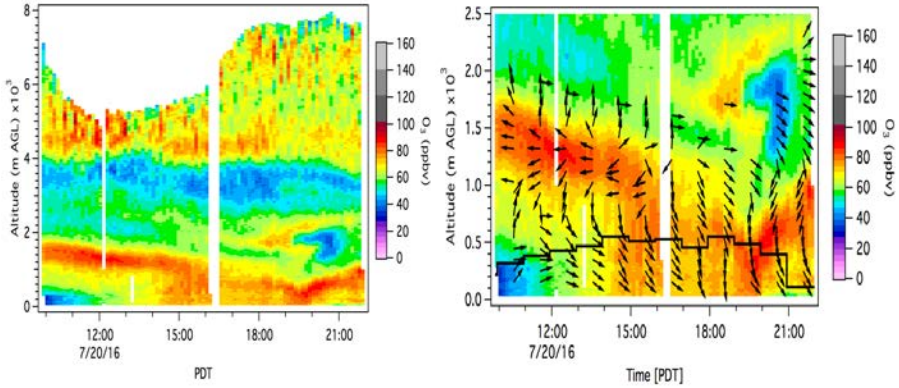
NOAA/ESRL: Boundary layer entrainment of transported O_3 layers

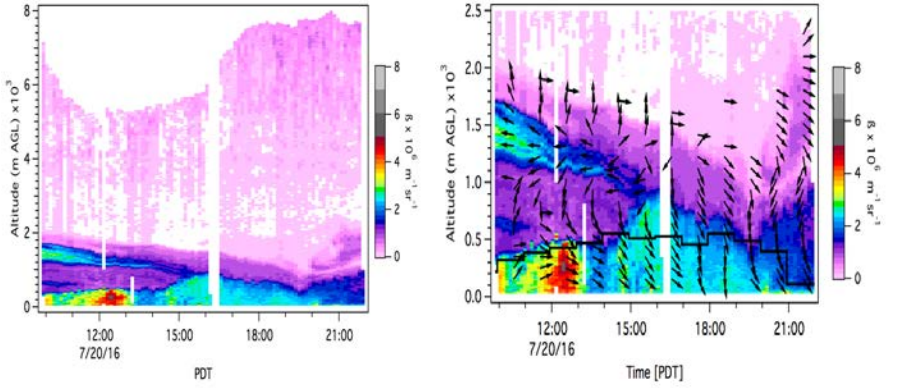
CABOTS: California Baseline Ozone Transport Study (Visalia, CA; May - Aug 2016)



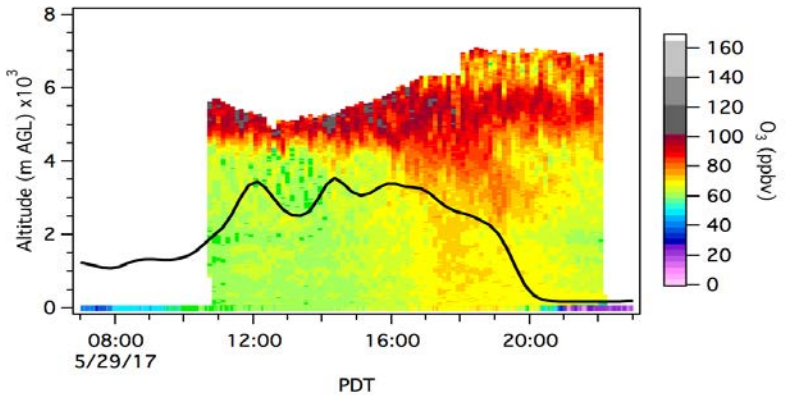
FAST-LVOS: Fires, Asian, and Stratospheric Transport Las Vegas Ozone Study (Las Vegas, NV, May - Jun 2017)

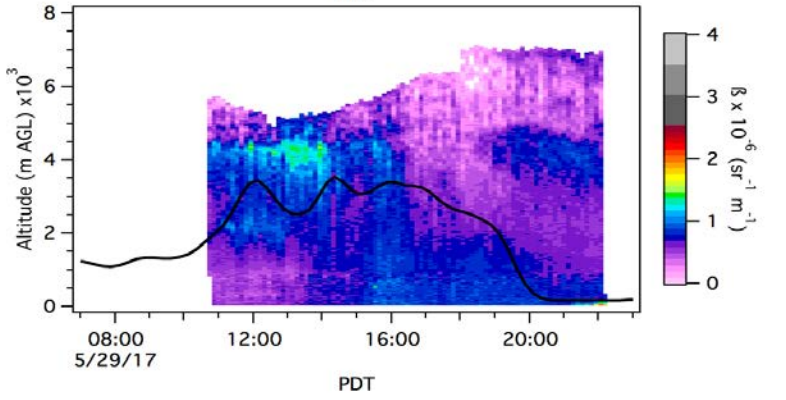
7/20/2016





5/29/2017





Shallow mixed layer over the San Joaquin Valley entrains local pollution plume, but STT/Asian O_3 layer above 4 km AGL is out of reach.

Very deep mixed layer over the Las Vegas Valley partially entrains STT/Asian O_3 layer resulting in an increase in surface O_3.

Synchronized Multi-Day Ozone Lidar Measurements in Support of the Ozone-Water Land Environmental Transition Study-2

John Sullivan, T. Berkoff, G. Gronoff, T. McGee,
G. Sumnicht, L. Twigg, W. Carrion, J. Sparrow

Background:

- **OWLETS-2** is a follow-on study to better understand the behavior of ozone and related trace gases across the water land transition zone in the upper portion of the Chesapeake Bay
  - ***Fig 1: 4 days of continuous TOLNet measurements from Hart Miller Island (HMI) and University of Maryland, Baltimore County (UMBC)***
- At coastal boundaries, significant water-land gradients can occur due to difference in surface deposition, boundary layer height, and cloud coverage from water to land

Science Questions:

- What are the mechanisms (low boundary layer, chemistry, weather) that produce high ozone over the Chesapeake Bay and lead to high ozone at locations on land near the Chesapeake Bay? ***The synergy of TOLNet lidars, balloon-borne, and surface measurements at HMI and UMBC will directly reveal differences in controlling factors related to air quality episodes***
- How can measurements be better utilized (in conjunction with chemical transport models) to connect ground level pollutants to satellites in the upcoming framework of the NASA TEMPO instrument? ***Repeated high-resolution measurements under a variety of atmospheric conditions will help provide the statistics needed to test and optimize satellite retrievals and comparisons.***

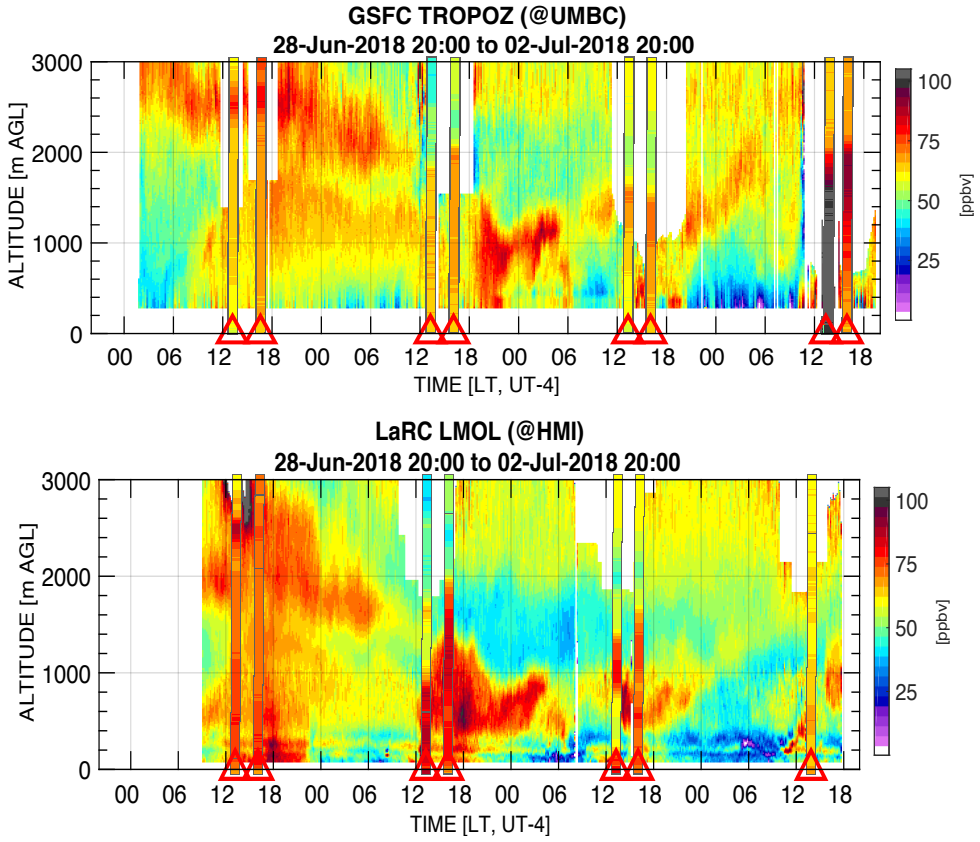


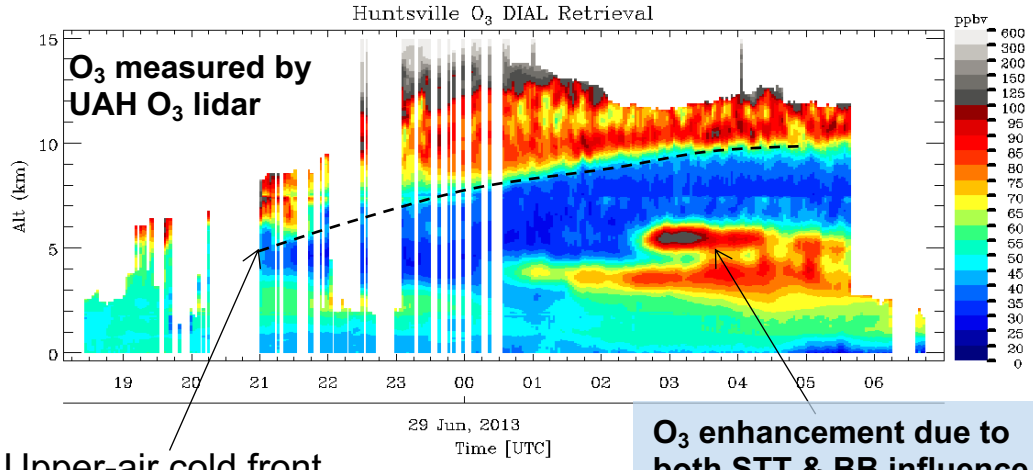
Fig 1: GSFC and LaRC TOLNet lidars operating continuously for 4 days during OWLETS-2 campaign. ***Note: This is preliminary data.***

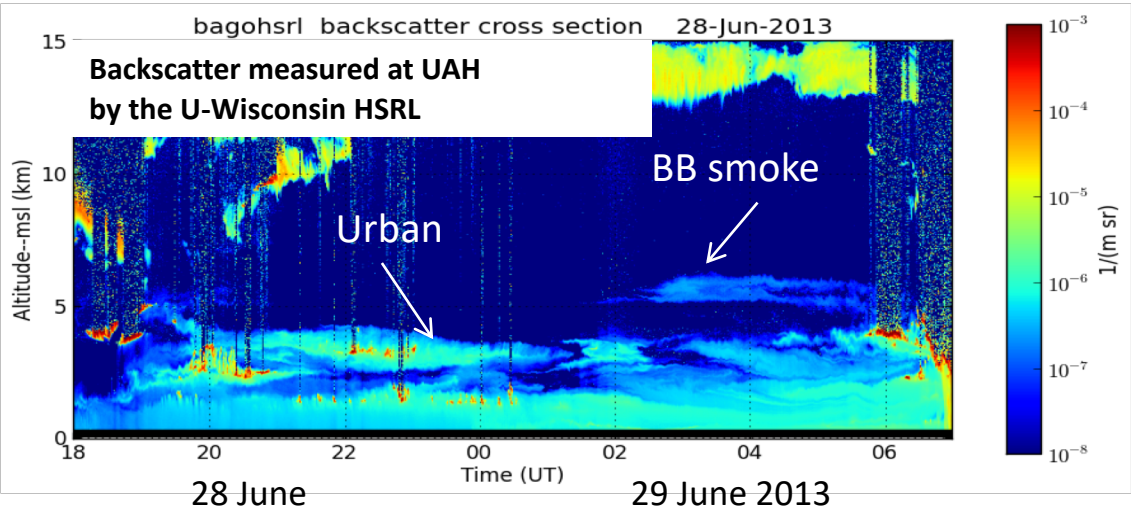
TOLNET

Tropospheric Ozone LIDAR Network

Summertime Tropospheric O_3 Enhancement after a Cold-front Passage Due to Stratosphere-to-Troposphere Transport (STT) and Biomass Burning (BB)

S. Kuang, M. J. Newchurch, J. Burris, E. Eloranta, M. S. Johnson, I. Pollack, T. Ryerson, L. Wang



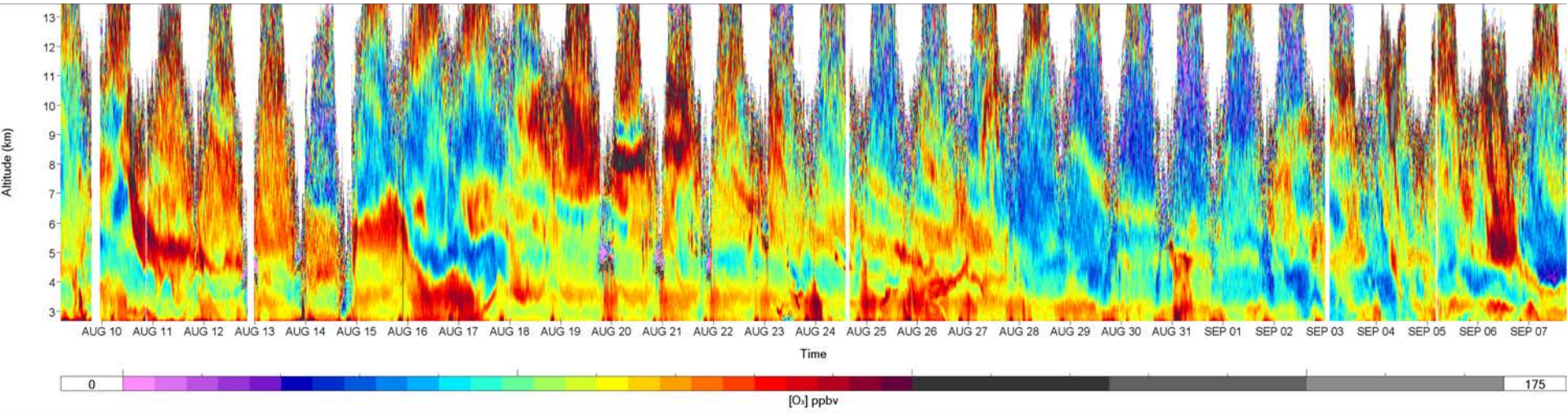


1. Simultaneous ozone and aerosol lidar measurements, rarely available, provide unique information on the sources, interactions, and transport of pollutants.
2. This example reveals the detailed ozone structures associated with a cold-front passage: (1) the large ozone gradients at the upper-air cold front and (2) the large ozone enhancement behind the cold front with mixed sources of STT and BB. The source identification is also confirmed by analysis of simultaneous in-situ, airborne observations.
3. These ozone and aerosol lidar observations provide information to interpret satellite measurements of air pollution in complex environments.

TOLNet

Tropospheric Ozone LIDAR Network

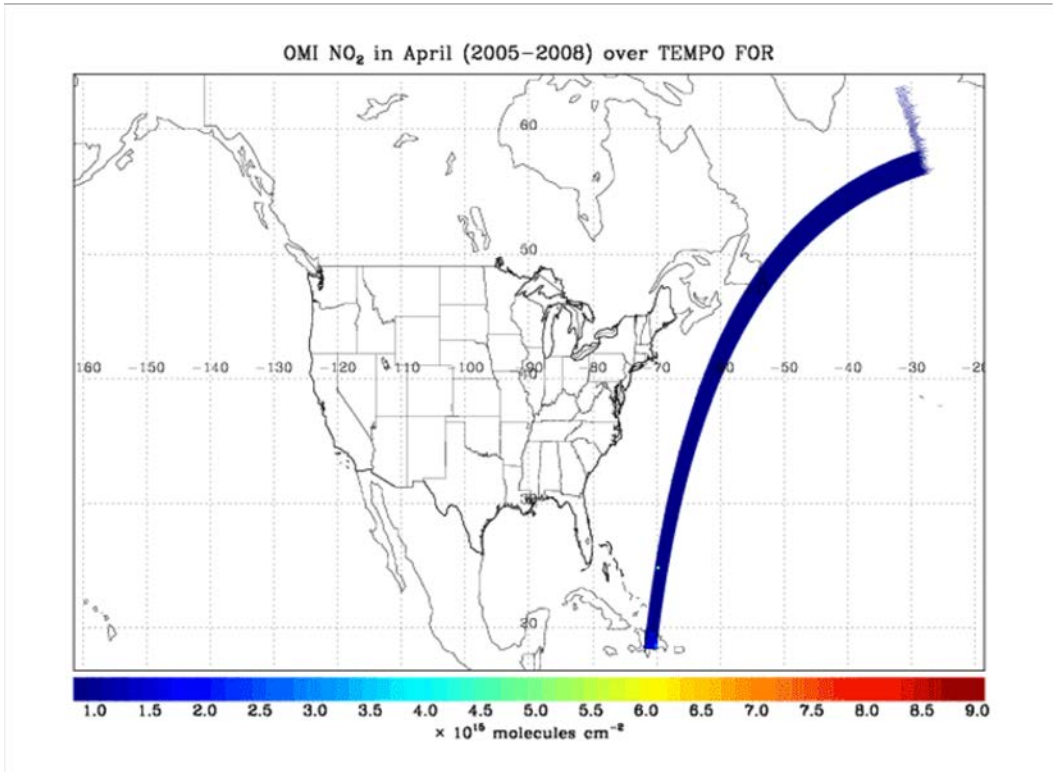
AMOLITE Lidar, 31 days stationed at TMF in 2016 during the SCOOP Campaign



Courtesy of K. Strawbridge/ECCC

TEMPO measurements

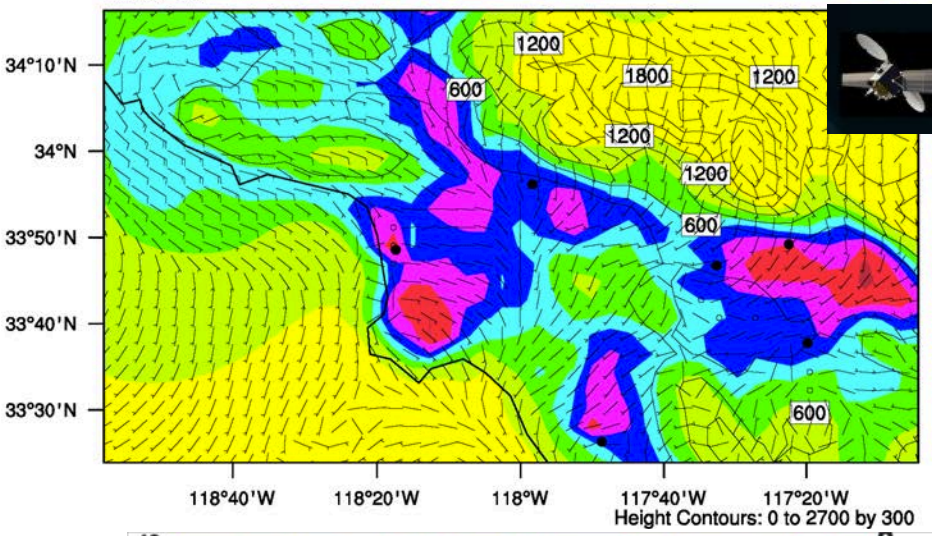
- Hourly daylight measurements from TEMPO will effectively monitor the air quality conditions over North America
- Monitoring will be accomplished at sub-urban scales due to spatial resolution of 2.1 x 4.7 km
- Multi-spectral capabilities (ultraviolet & visible channels) will help distinguish between BL, free tropospheric, and stratospheric O_3

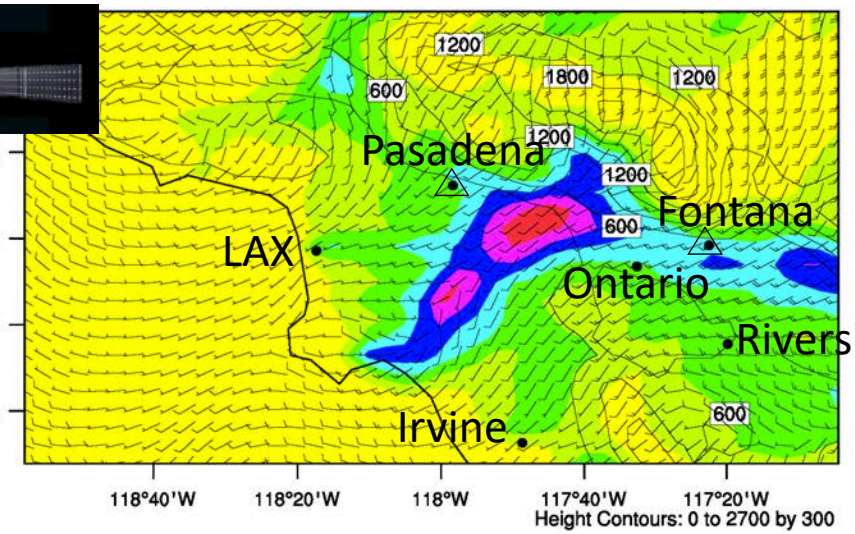


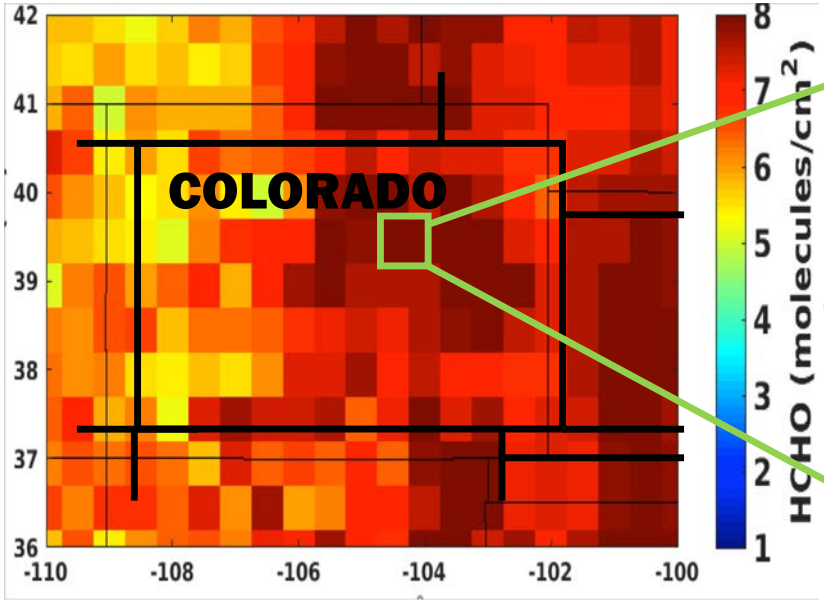
TEMPO synthetic observations

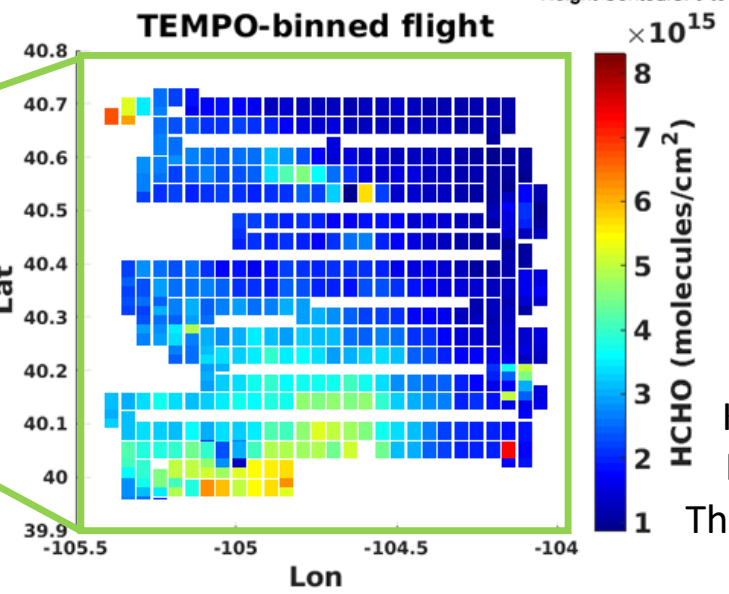
Si-Wan Kim et al.

NO_2 columns modeled at approximate TEMPO resolution





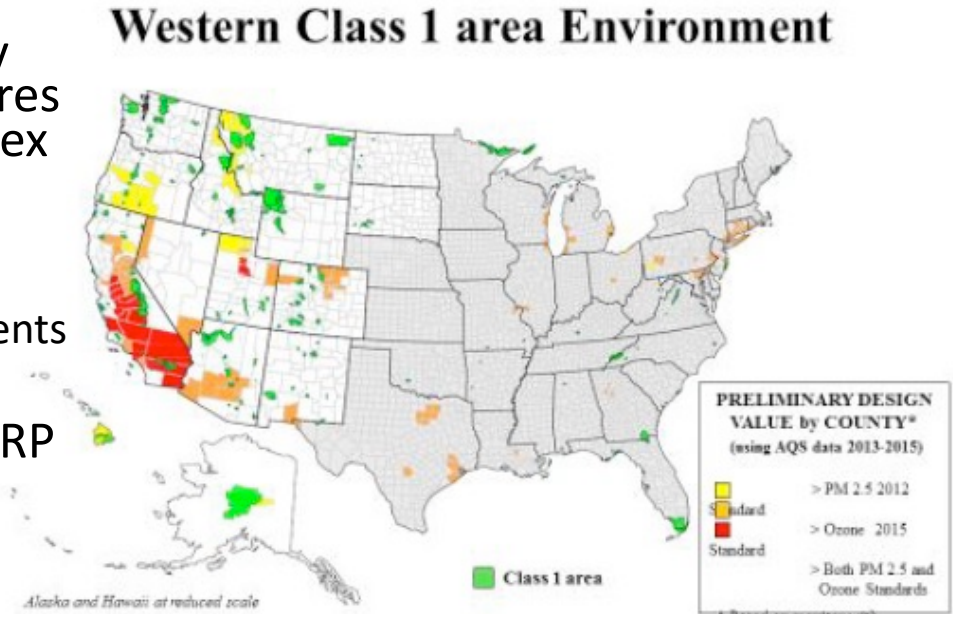




Frank Keutsch, Mitchell Thayer, et al.

Pilot Project: Exceptional Event (Intermountain West)

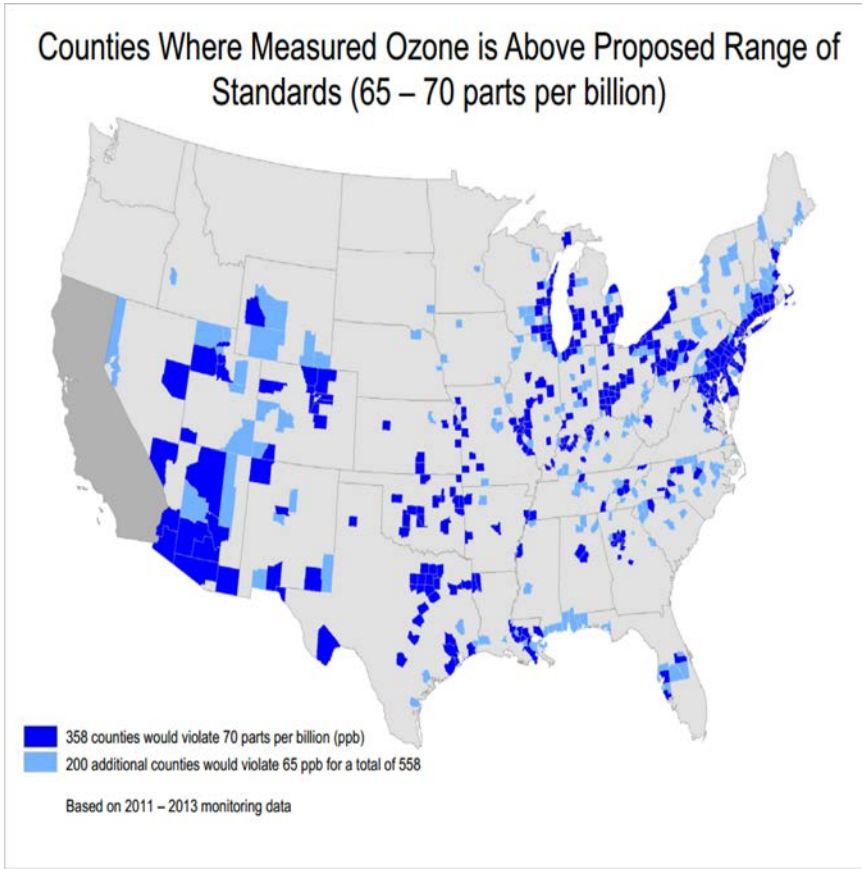
- How can TEMPO be used to identify exceptional events caused by wildfires or stratospheric intrusions in complex terrain?
  - Distinguish between transport and source events
  - Identify frequency of exceptional events
- Focus on complex terrain in collaboration with WESTAR and WARP
- Can incorporation of proxy data improve PM2.5 and O3 precursor emission estimates used in regional modeling analysis to support planning and decision making to protect both human health and visibility?
- Early testing of data processing infrastructure and assimilation of proxy data in regional models will prepare state/federal agencies for use of TEMPO data quickly after launch



Map of western region showing whether PM2.5 and O3 standards were met from 2013-2015 in each county. Orange where PM2.5 standards not met, Yellow where O3 standards not met, and red where both standards not met

Ozone—health impact

- Additive
- Lung function
- Respiratory disorders
- morbidity
- mortality



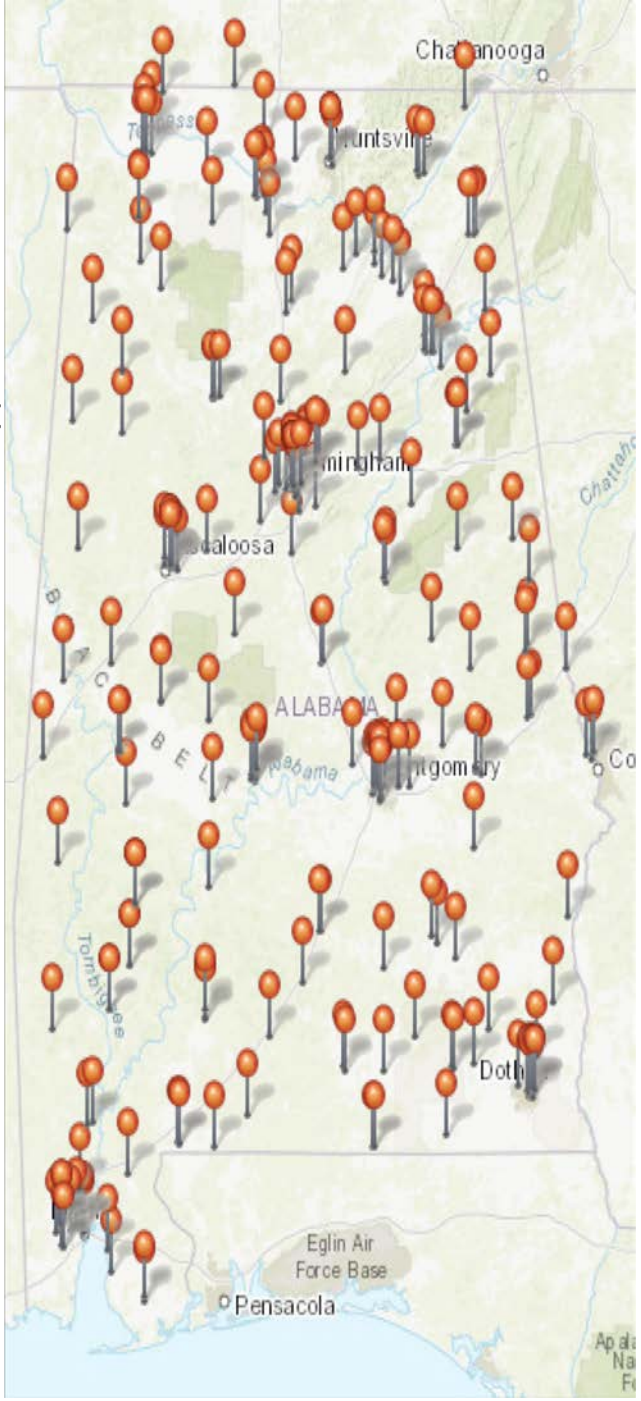
Improved spatial resolution

Reduction in exposure misclassificat

Epidemiological research

Exposure response curve

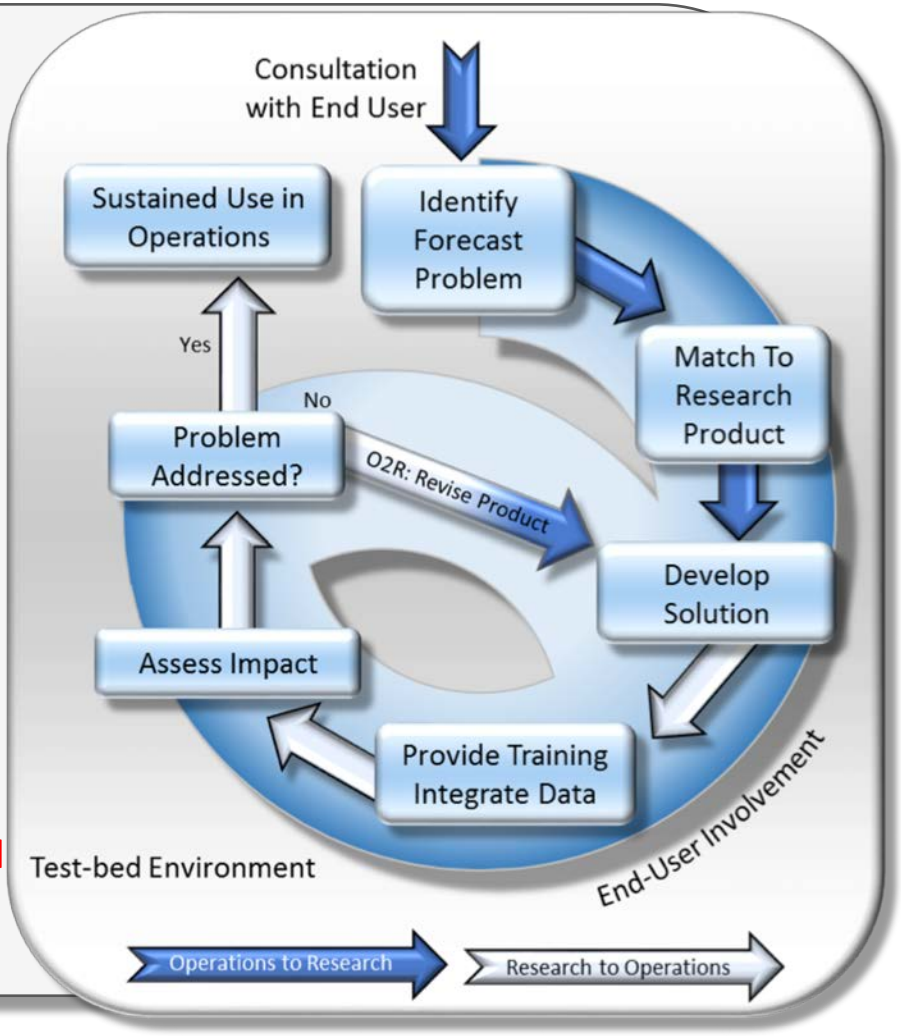
Multiple contaminants



Short-term Prediction Research and Transition (SPoRT)

- **Over the past 15 years, SPoRT has successfully transitioned unique observations from more than 40 satellite datasets to operational end users**
- **Established research-to-operations/operations-to-research paradigm that engages in solving specific forecast problems**
- **SPoRT plans to use this successful approach to prepare the user community for TEMPO data**

See NASA SPoRT talk (Emily Berndt and Aaron Naeger) – SPoRT R2O Paradigm: preparing end users for next-generation satellite missions before day 1 operations



https://weather.msfc.nasa.gov/sport/

TOLNet

Tropospheric Ozone LIDAR Network

TOLNet Science Team

TEMPO Science Team