NASA Ames TOLNet Group

Tropospheric and stratospheric ozone (O_3) profile observations provided by TOLNet are essential in the evaluation of chemical transport model (CTM) predictions of air quality. Furthermore, applying TOLNet data in modeling studies has led to a wide variety of interesting science results. The TOLNet PI from NASA Ames Research Center (ARC) is working directly with the modeling community to increase the awareness and application of TOLNet data in model evaluation and research studies. Model simulations and TOLNet observations have been used together in studies to evaluate numerous topics such as air quality, stratosphere-troposphere exchange, wildfire O_3 enhancement, seasonality and inter-annual O_3 trends, frontal-range air recirculation, lightning NO_x, source attribution, etc. Additionally, the combination of model and TOLNet data have been vital in multiple recent field campaigns such as DISCOVER-AQ Colorado (http://discover-aq.larc.nasa.gov/), FRAPPÉ (https://www.eol.ucar.edu/field_projects/frappe), and SEAC4RS (http://wwwair.larc.nasa.gov/missions/seac4rs/).

Please contact Matthew Johnson (matthew.s.johnson@nasa.gov) for further information regarding model/TOLNet collaborative efforts. For more information about the Earth Science Division at NASA ARC visit: https://earthscience.arc.nasa.gov/


Tropospheric Ozone LIDAR Network

Pleiades
NASA's fastest supercomputer

1. Summer-time Ozone in the Southeast US

The Environmental Protection Agency recently strengthened National Ambient Air Quality Standards for O_3 to 70 ppb with future standards proposed to be as low as 65 ppb. These lower values emphasize the need to better understand/simulate the transport processes, emission sources, and chemical reactions controlling precursor species (e.g., NO_x, VOCs, and CO) which influence O_3 mixing ratios. During this study we evaluate sources/processes impacting O_3 enhancement events measured by the UAH TOLNet system occurring in the southeast US during summer-time months. High-resolution (0.25° x 0.3125°) North America nested GEOS-Chem simulations were conducted for the month of June 2013 when a variety of large O_3 lamina were measured by TOLNet. Sensitivity studies applying a "brute force" zeroing method allowed for the quantification of source-specific O_3 magnitudes and contribution to total O_3 during two observed O_3 lamina events on June 12 and 29, 2013. The June 12, 2013 lamina was a nocturnal near-surface layer (0-3 km) and the event on June 29, 2013 was a late-evening elevated O_3 layer (3-6 km). Model simulations indicate that wildfire/biomass burning and night-time anthropogenic maximums contributed to the nocturnal near-surface O_3 layer on June 12, 2013. The late-evening elevated O_3 layer on June 29, 2013 was suggested by model simulations to be caused by background and stratospheric O_3 transport. Model-predicted source attribution calculated during this study agrees with in situ measurement data, satellite observations, and other supporting model simulations.

Important figures from this work are in the following slides and the full study is currently in manuscript preparation.
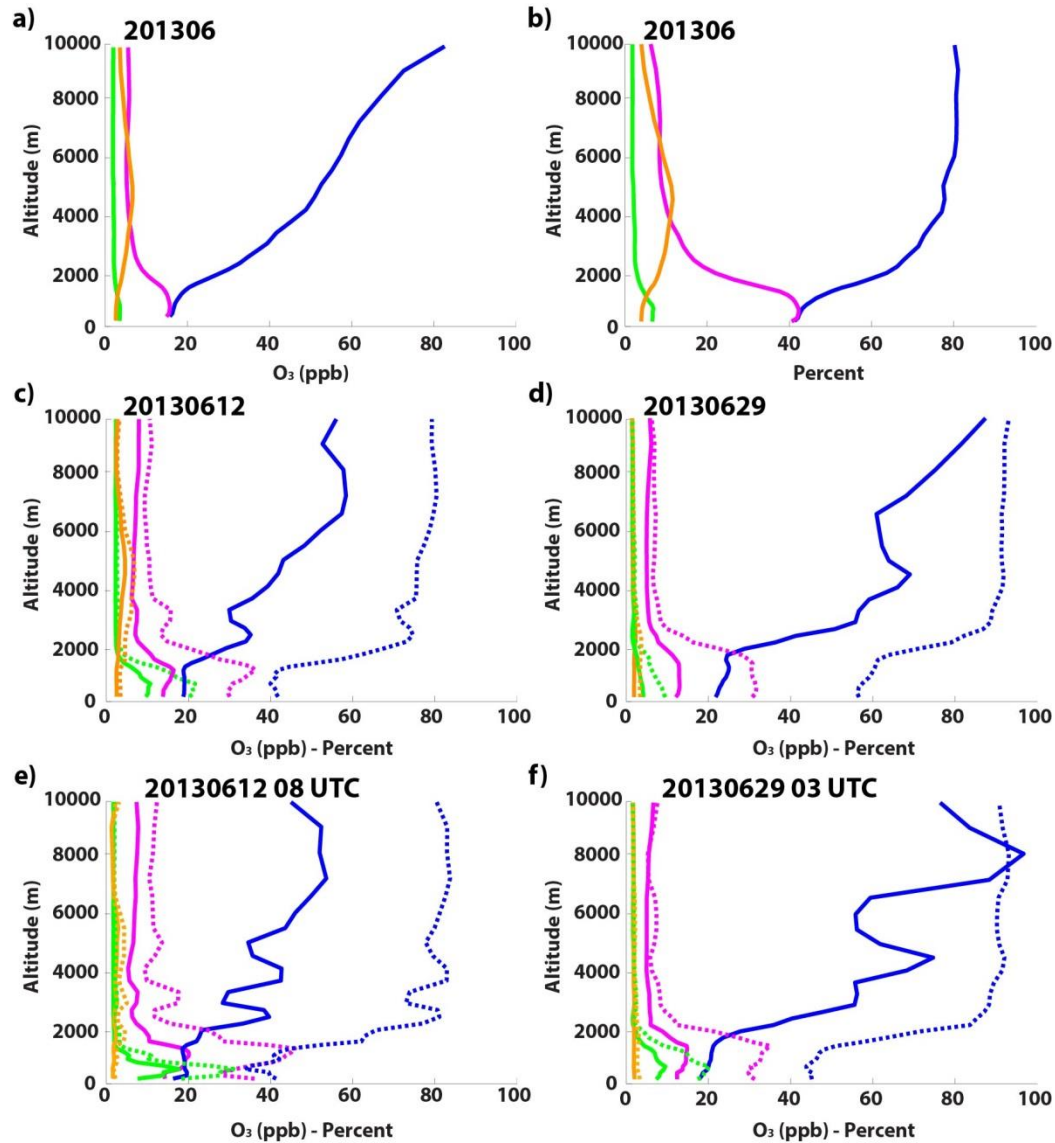
1. Summer-time Ozone in the Southeast US

a) 201306

b) 201306
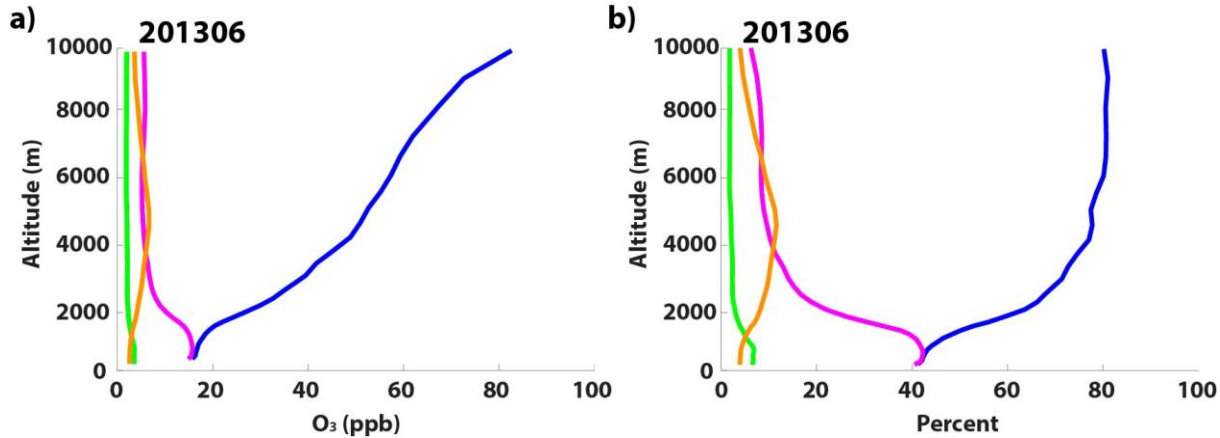
Monthly-averaged a) magnitude and b) percent contribution from **anthropogenic emissions**, **wildfire**, **lightning NO$_x$**, and **background and stratospheric transport** during June 2013

June 12, 2013
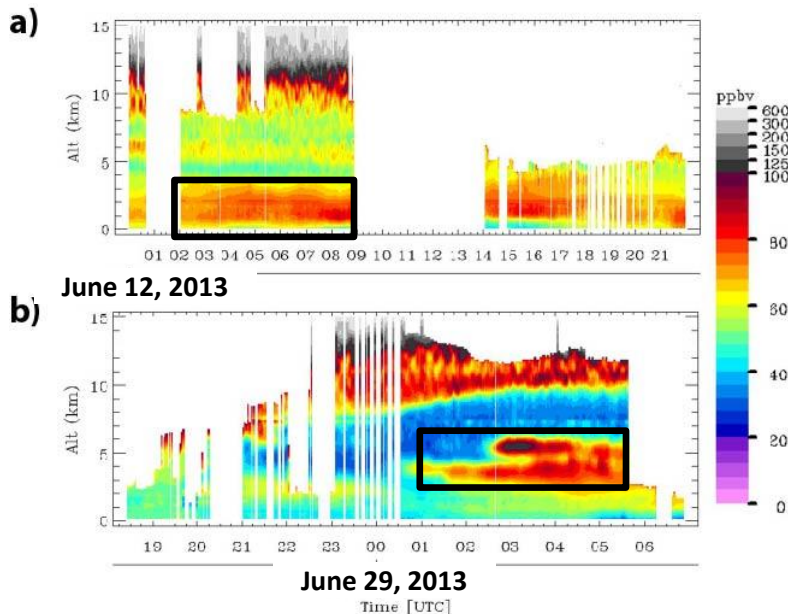
June 29, 2013

Ozone enhancement layers observed by the UAH TOLNet system on a) June 12 and b) June 29, 2013.

- **Monthly-averaged model predicted O$_3$ source contribution over the UAH TOLNet site demonstrated that: 1) near the surface anthropogenic emissions and background/long-range transport contributed the most to total O$_3$ and 2) aloft (>2 km a.g.l.) lightning NO$_x$, anthropogenic emissions, stratospheric air, and background/long-range transport are the main sources.**

- **The UAH TOLNet system measured a nocturnal O$_3$ enhancement on June 12, 2013 which increased from ~65 ppb to ~90 ppb from 01 to 08 UTC. The second large O$_3$ enhancement layer (>100 ppb) occurred ~3-6 km a.g.l. on July 29, 2013 between 01 to 05 UTC.**

1. Summer-time Ozone in the Southeast US

a) 201306

b) 201306

c) 20130612

d) 20130629

e) 20130612 08 UTC

f) 20130629 03 UTC

Magnitude (solid lines) and percent contribution (dashed line) from **anthropogenic emissions**, **wildfire**, **lightning NO$_x$**, and **background/stratospheric transport.**

- On June 12, 2013 (low-level nocturnal O$_3$ enhancement) the model predicts large contribution from wildfires (10 to 20 ppb) and anthropogenic emissions had a nocturnal daily maximum contribution between 01 to 08 UTC.

- On June 29, 2013 (elevated (3-6 km) late-evening O$_3$ enhancement) the model predicts a clear enhancement from background and stratospheric transport (>40 ppb). Additional evaluation suggests that stratospheric transport was largely contributing to this enhancement.

- Supporting evidence from airborne and ground-based in situ data, satellite observations, and corresponding model simulations (e.g., HYSPLIT back-trajectories, WRF-FLEXPART, GFS-FLEXPART) agree with GEOS-Chem model predictions of source attribution determined during this study.

2. Inter-annual and Seasonal Ozone in the Western US

In collaboration with researchers at NASA ARC and JPL, TOLNet lidar measurements from JPL Table Mountain are being used in conjunction with ozone-sondes from Trinidad Head, AJAX airborne in situ measurements, CASTNET surface observations, and modeled data from GEOS-Chem to evaluate seasonality and inter-annual variability of surface-level and vertical O_3 distributions in California and the western US. Overall, the data sources used in this study generally agree in magnitude and vertical distribution and suggest that O_3 mixing ratios are largest during the spring and summer seasons. Furthermore, all data sources suggest an increase in O_3 magnitude and variability in the free troposphere during spring and summer months, likely due to long-range transport and stratospheric intrusions. Additionally, surface-based O_3 measurements in the western US used during this study indicate that larger O_3 concentrations occurred during the spring and summer of 2012 compared to 2013. GEOS-Chem tagged tracer simulation results suggest that upper tropospheric/lower stratospheric (UTLS) sources of O_3 were noticeable larger in the western US during 2012 compared to 2013. These results exemplify, and agree with recent studies, indicating that UTLS sources can have large impacts on surface air quality and O_3 exceedance events in the western US.

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

# 2. Inter-annual and Seasonal Ozone in the Western US
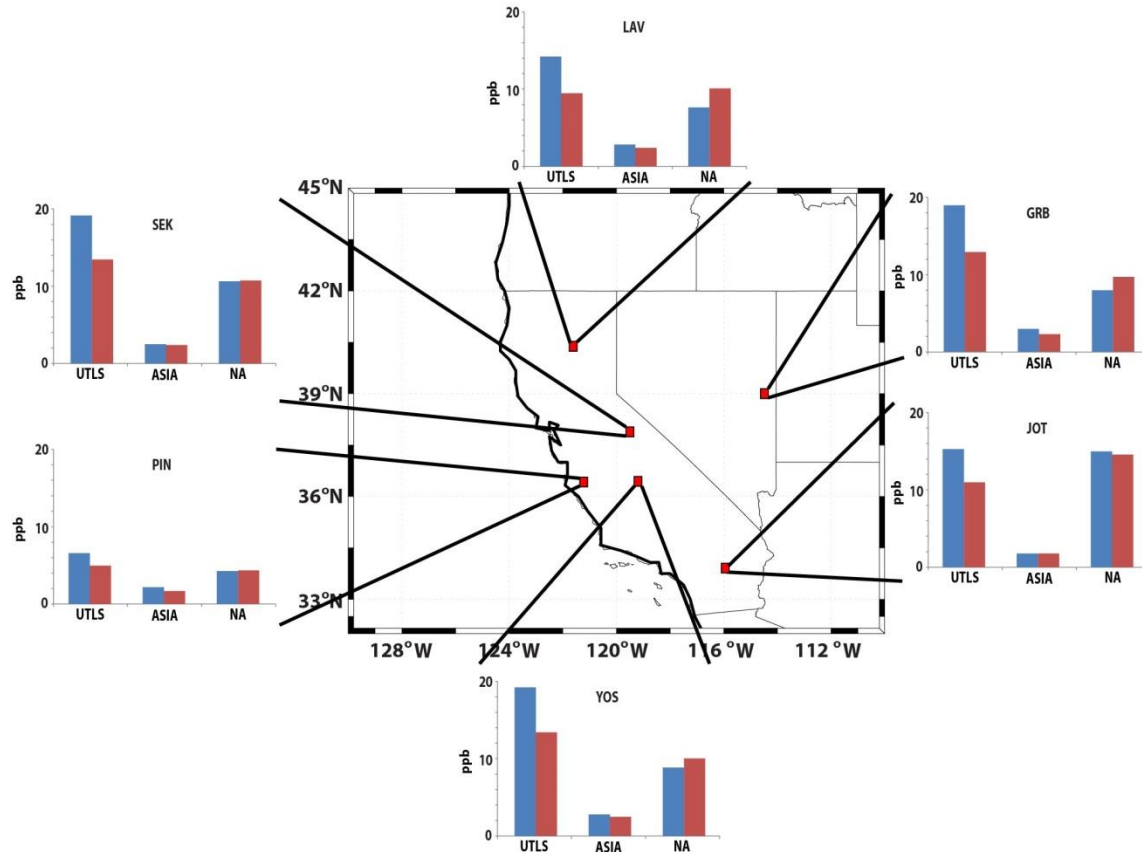
Spring and summer-averaged GEOS-Chem tagged tracer model predictions of surface-level source apportioned O_3 from UTLS, Asian boundary layer, and North American boundary layer at western US CASTNET sites during 2012 (blue) and 2013 (red).

- CASTNET ground-based measurements indicate larger surface O_3 concentrations (leading to an increased number of exceedance days) during 2012 compared to 2013 in the western US.

- Global tagged tracer model simulations conducted with GEOS-Chem during this study indicate that UTLS O_3 magnitudes were much larger during the spring and summer months of 2012 compared to 2013.

3. TOLNet Collaboration with the Modeling Community

One of the main objectives of the TOLNet Science Team is to engage with, and provide data to, the research science community. Thus far, TOLNet observations of O_3 profiles have been applied, in conjunction with model simulations, in numerous research studies. These research studies focused on a wide-variety of topics such as air quality, stratosphere-troposphere exchange, wildfire O_3 enhancement, seasonality and inter-annual O_3 trends, frontal-range air recirculation, lightning NO_x, source attribution, etc. The ARC TOLNet PI has made initial contact in order to develop potential future collaboration with modeling teams (e.g., RAQMS, CMAQ, CAMx, GFDL AM3, WRF-Chem, GEOS-Chem) at numerous universities and government agencies. Please see the TOLNet website (http://www-air.larc.nasa.gov/missions/TOLNet/data.html) to browse and download this O_3 lidar data and please contact the NASA ARC PI Matthew Johnson (matthew.s.johnson@nasa.gov) with any questions.
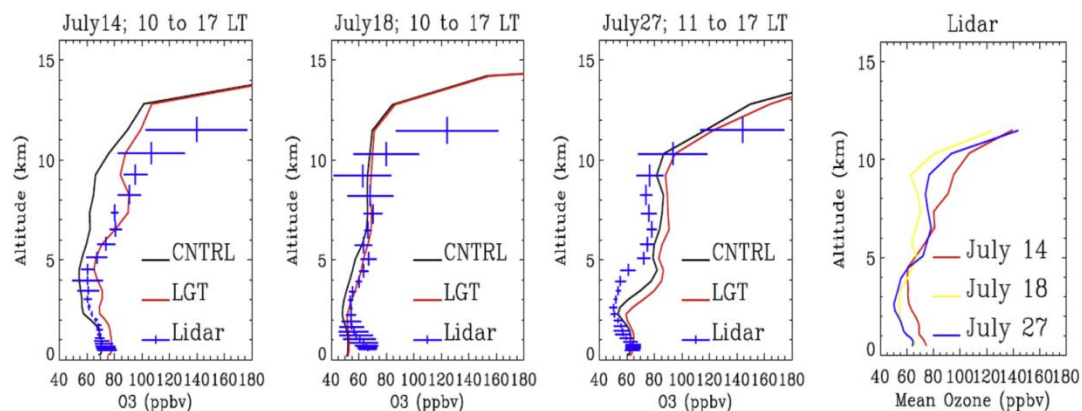
Daily O_3 vertical profiles from WRF-Chem and TOLNet in the study by *Wang et al*. (2015) to evaluate the impact of lightning NO_x on summer-time O_3 mixing ratios in the southeast US.