Airborne Lidar Measurements of Ozone and Aerosol Profiles Over Major US Metropolitan Areas

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TRACER-AQ - NASA LaRC Airborne Science Data for Atmospheric Composition
STAQS - Synergistic TEMPO Air Quality Science

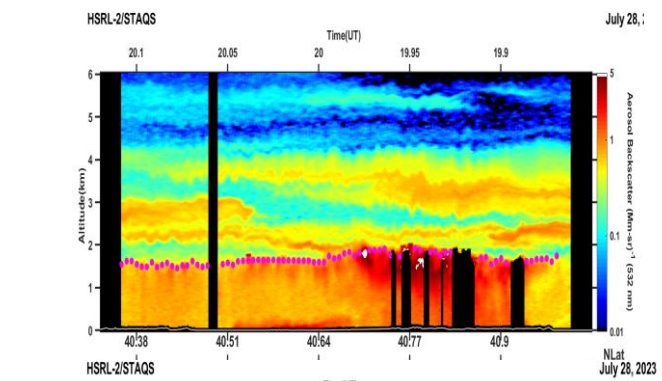
TRACER-AQ 2021/STAQS 2023 Measurement Overview

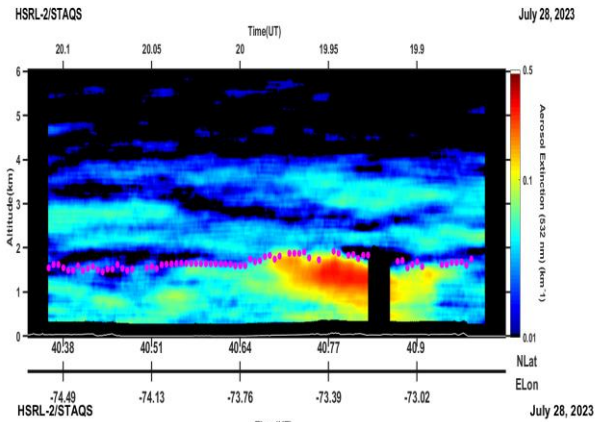
HSRL2–DIAL/NASA G-5

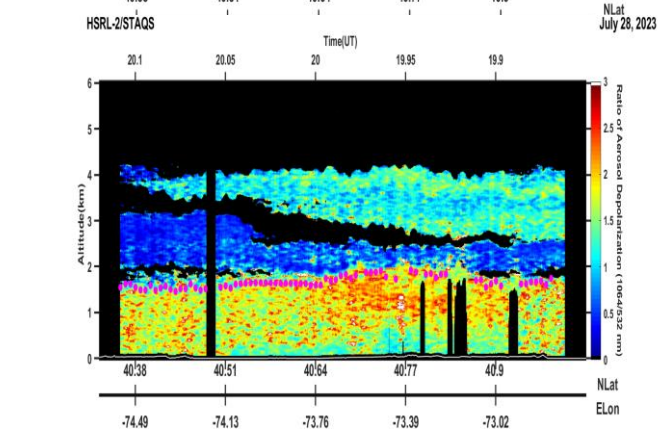
Data Products

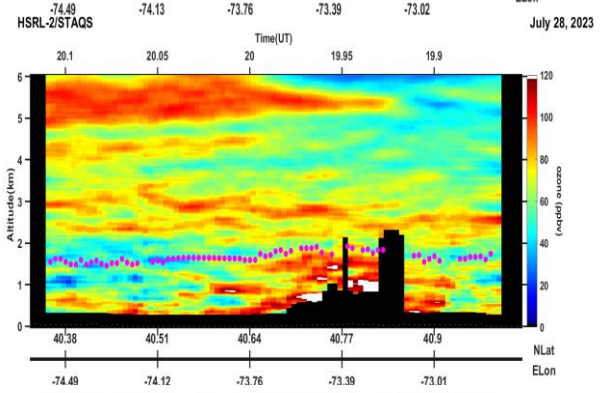
- **Aerosol**
  - *Particulate backscatter profiles (355, 532, 1064 nm)*
  - *Particulate depolarization profiles (355, 532, 1064 nm)*
  - *Aerosol extinction & column AOT profiles (355 & 532 nm)*
  - *Extinction-to-backscatter ("lidar ratio") profiles (355 & 532 nm)*
  - *Aerosol Type (e.g. smoke, dust, urban, marine,…)*
  - ***Mixed Layer Heights***
  - ***Images (both full flight and individual raster patterns)***
- **Ozone**
  - *Ozone profile concentrations*
- **Additional products/resolutions***
  - ***Surface weighted ozone concentrations and aerosol parameters (near surface- 0.5,1 and 2 km) at 10sec (~2km)****

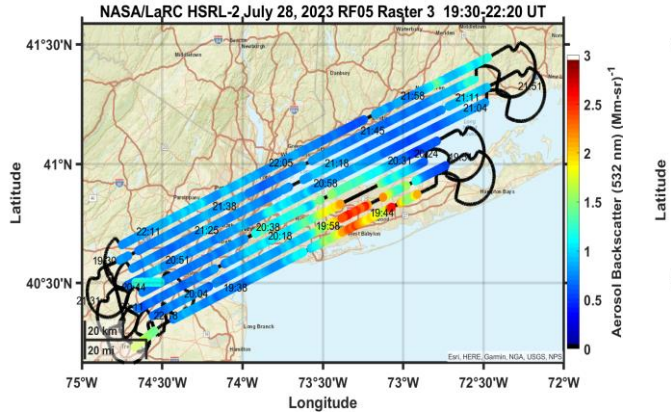
Blue – 10 sec averaged products (~2km), 15m vertical
Green – 1 min. averaged products (~13km), 300m vertical

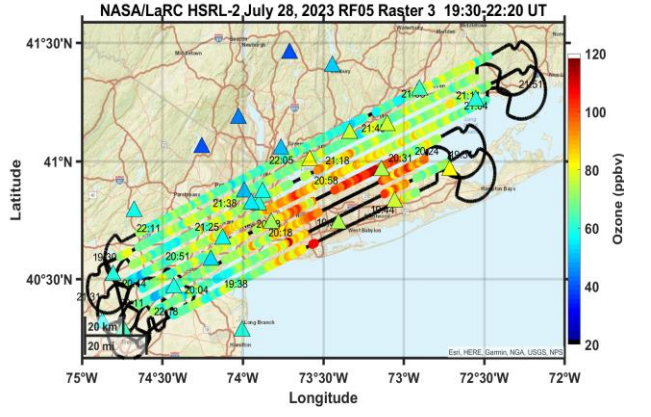












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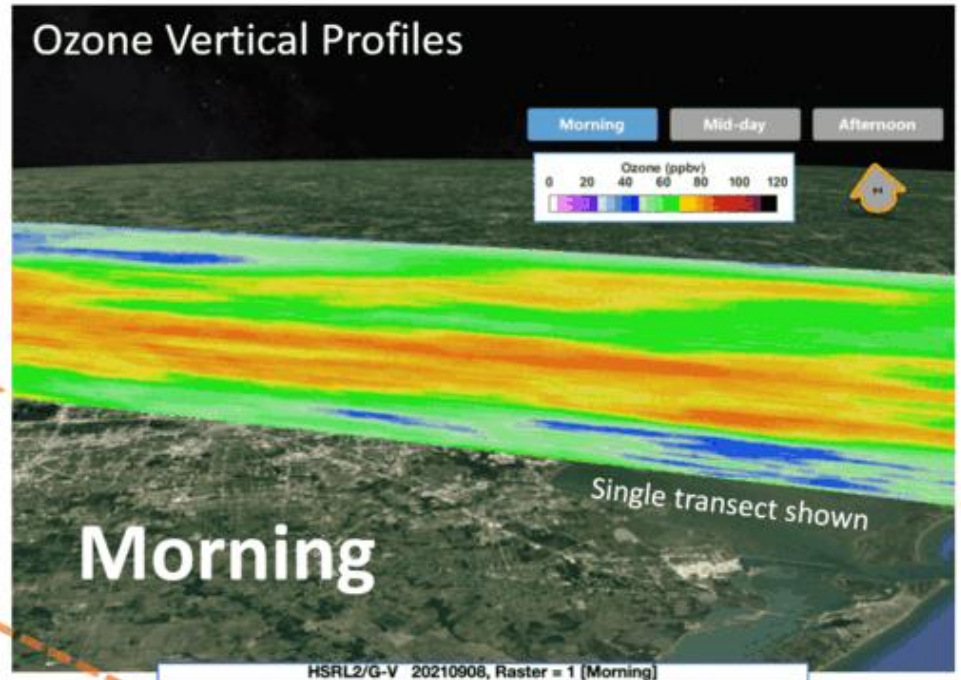
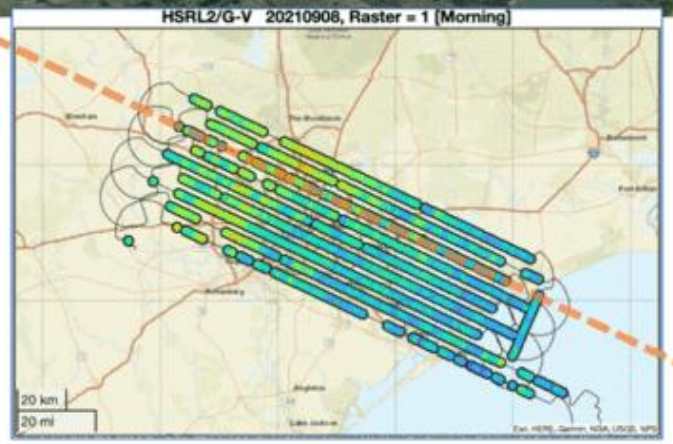
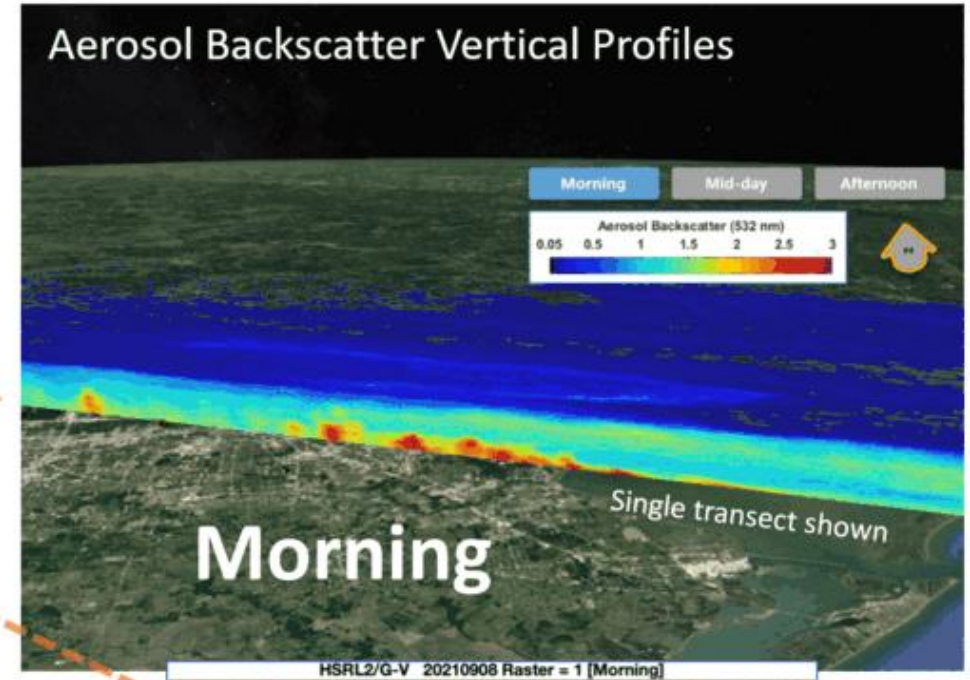
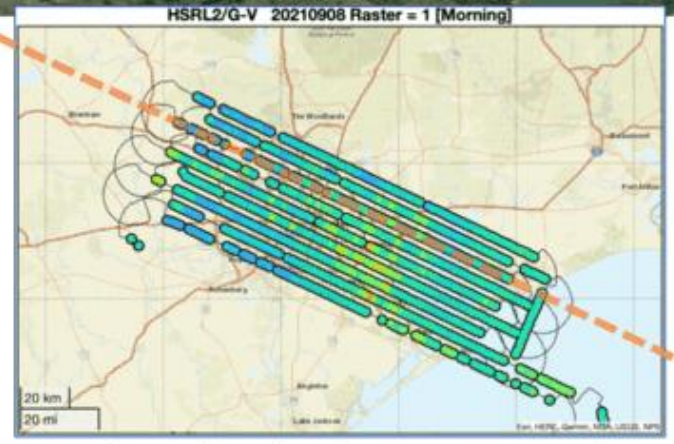
Vertical Profile Products: Connecting to the Surface Diurnal Variations (RF03 – 20210908)





Near-surface (0-1km) Average Ozone

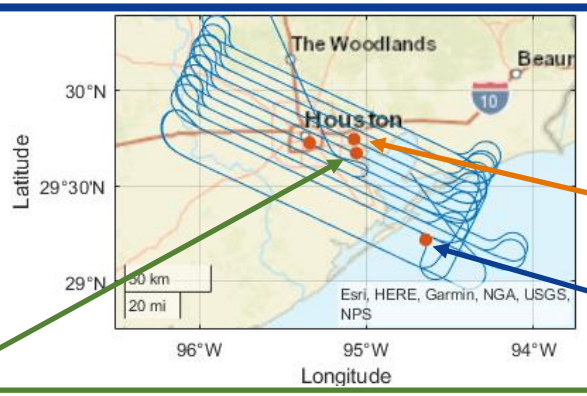


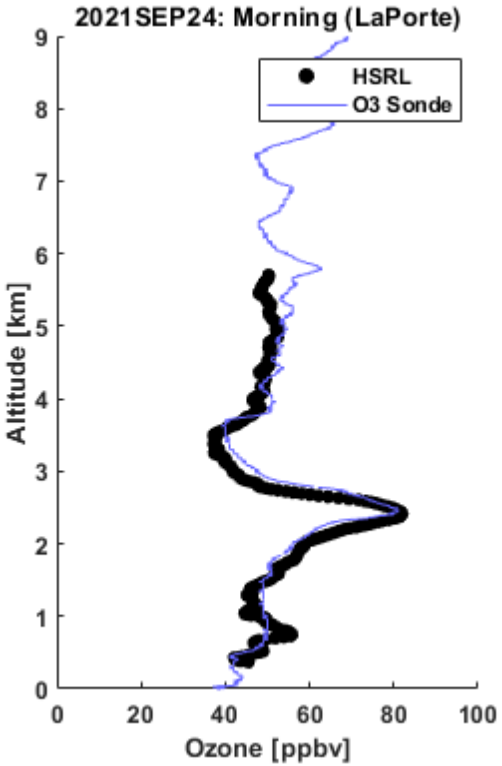


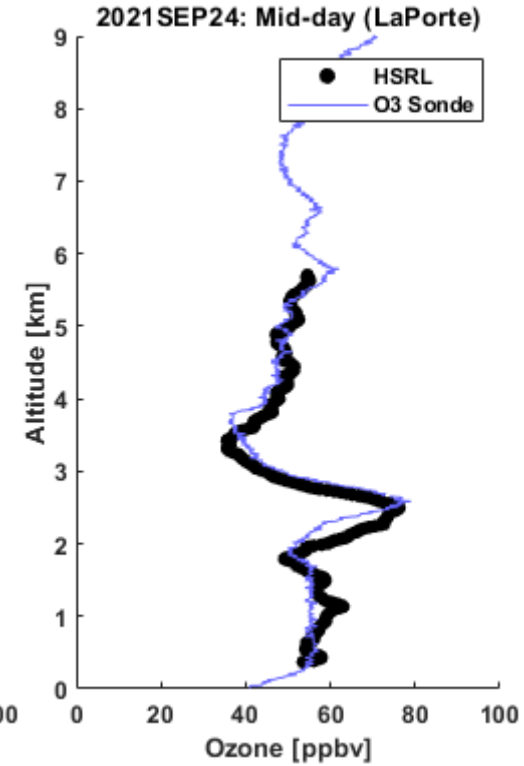
Near-surface (0-1km) Average Backscatter

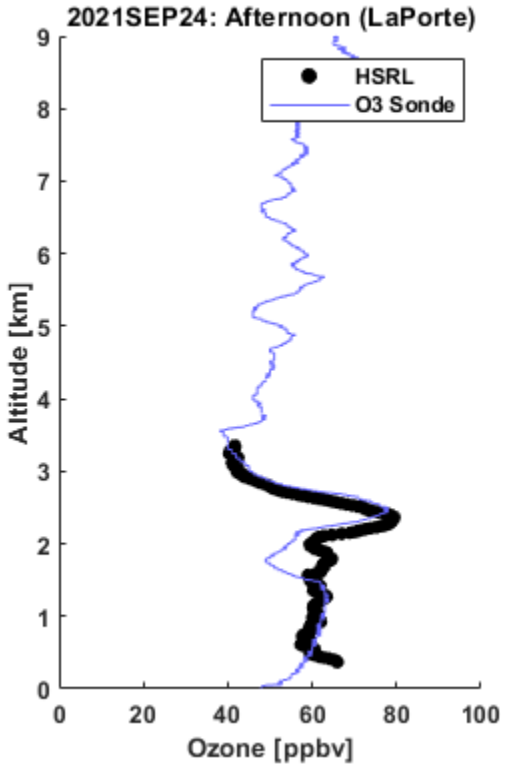
HSRL-2 Ozone Comparison with Ozonesondes
RF08 – 20210924

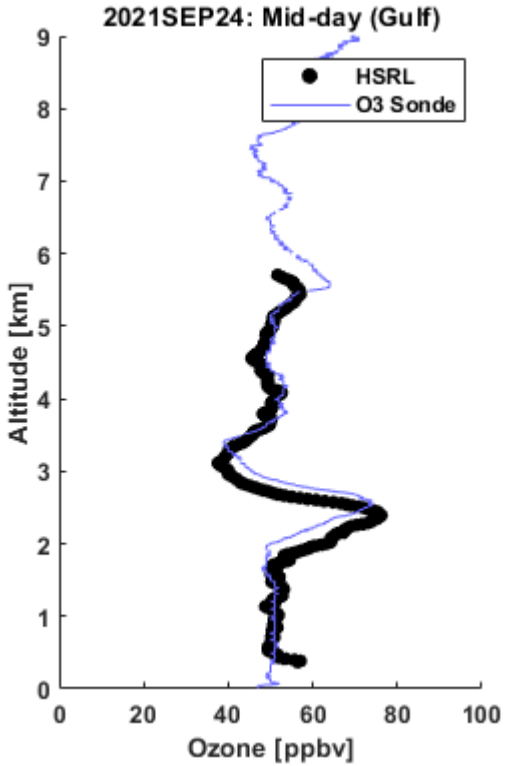
Spatial and temporal requirement
Distance <= 5km
Time < 30 min

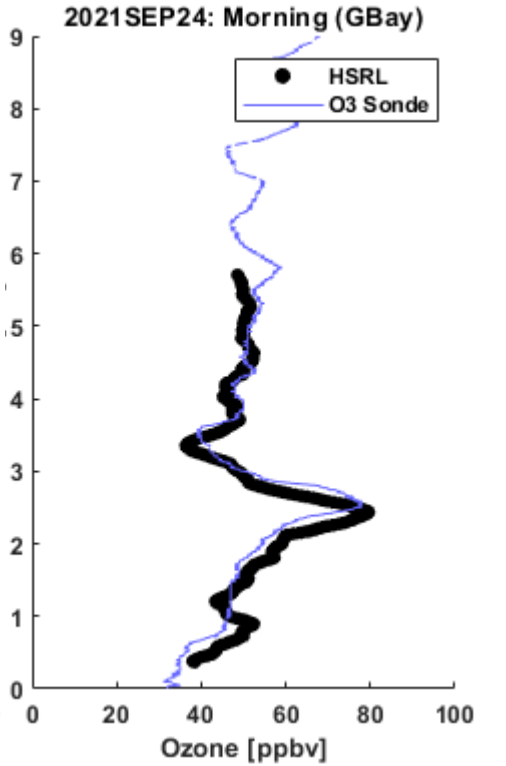




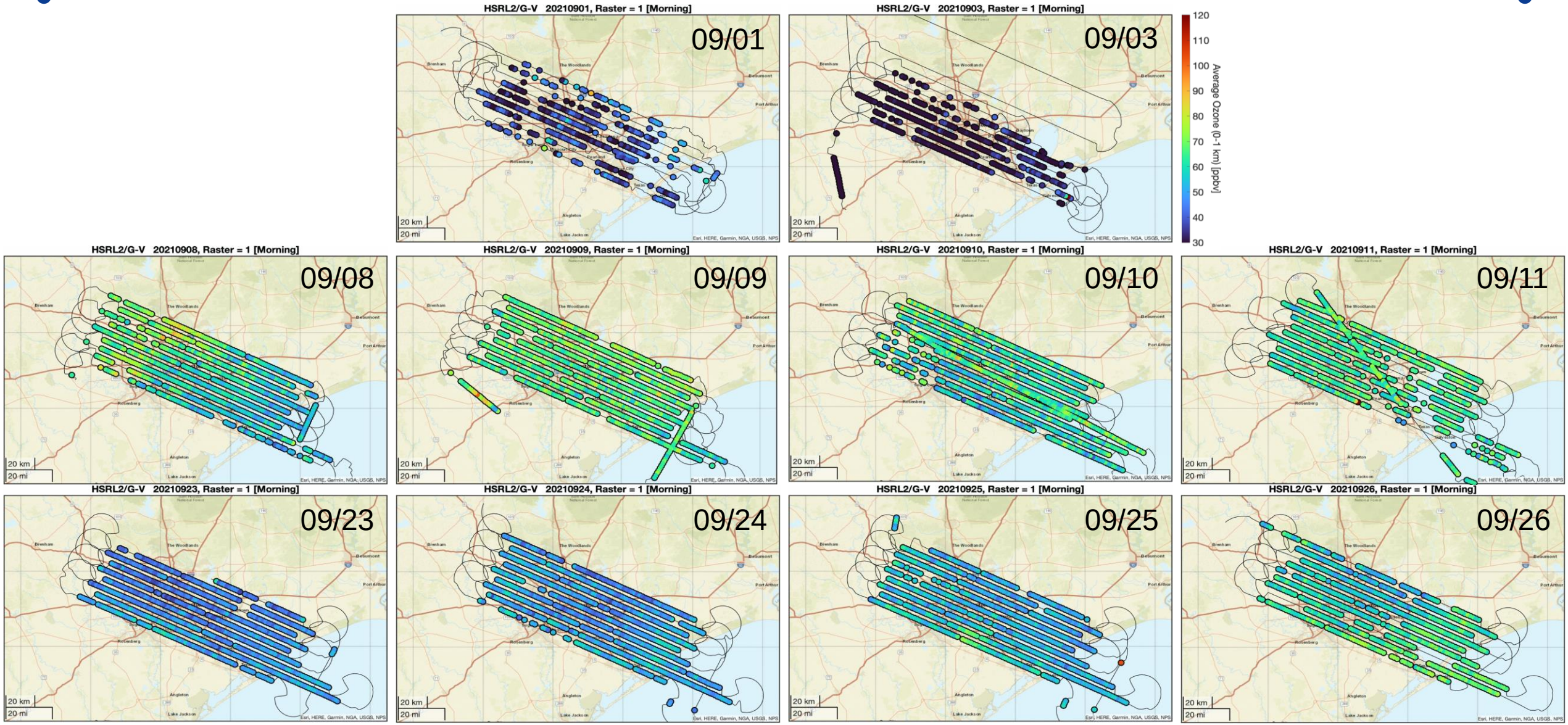




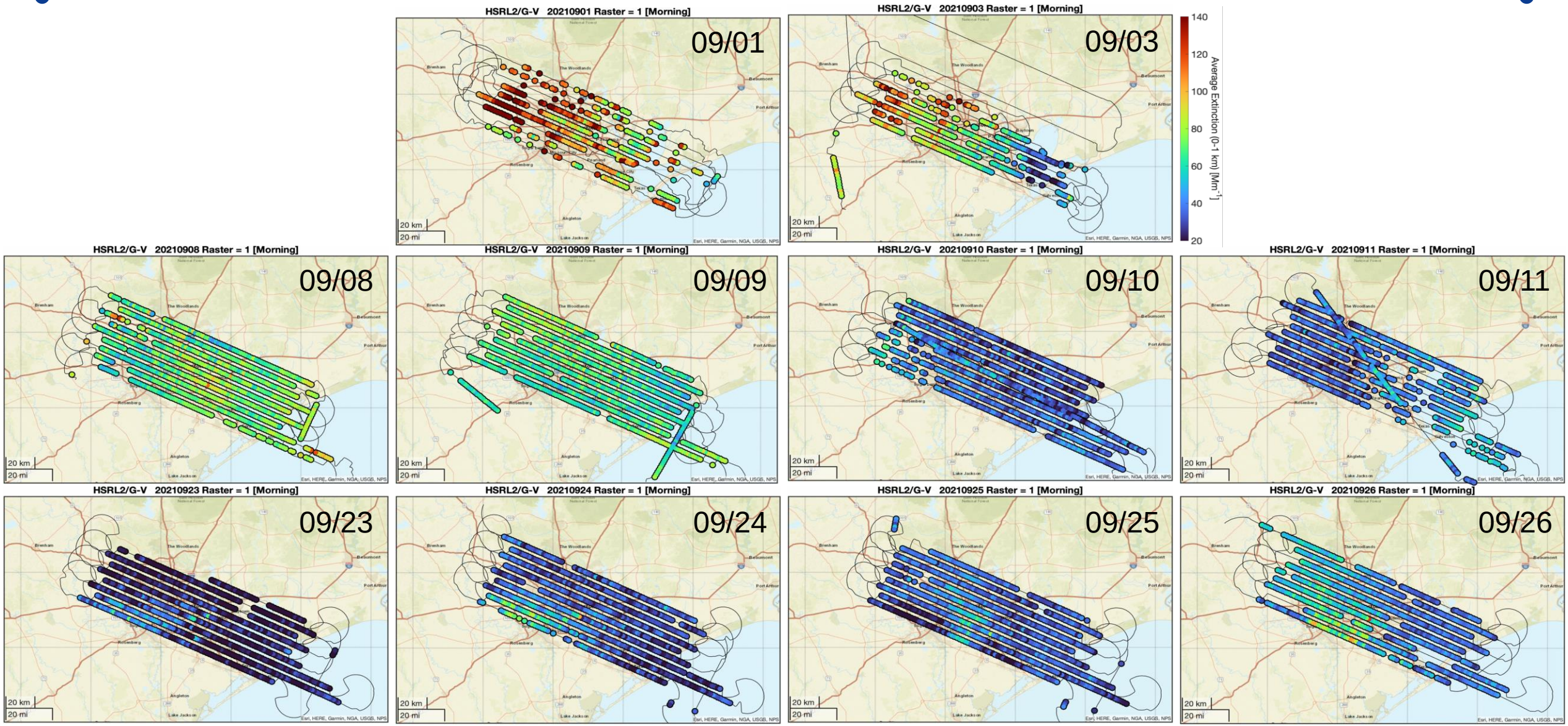




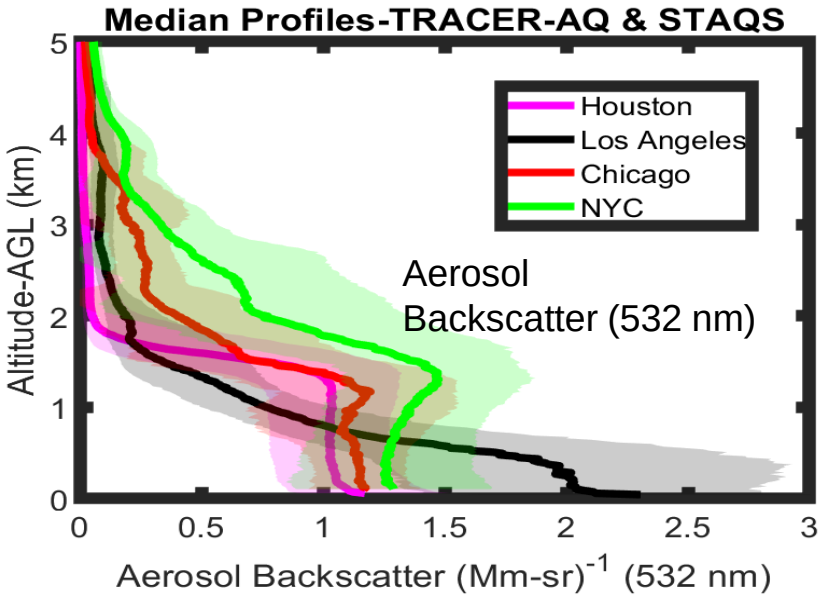
Distribution and evolution of near surface ozone

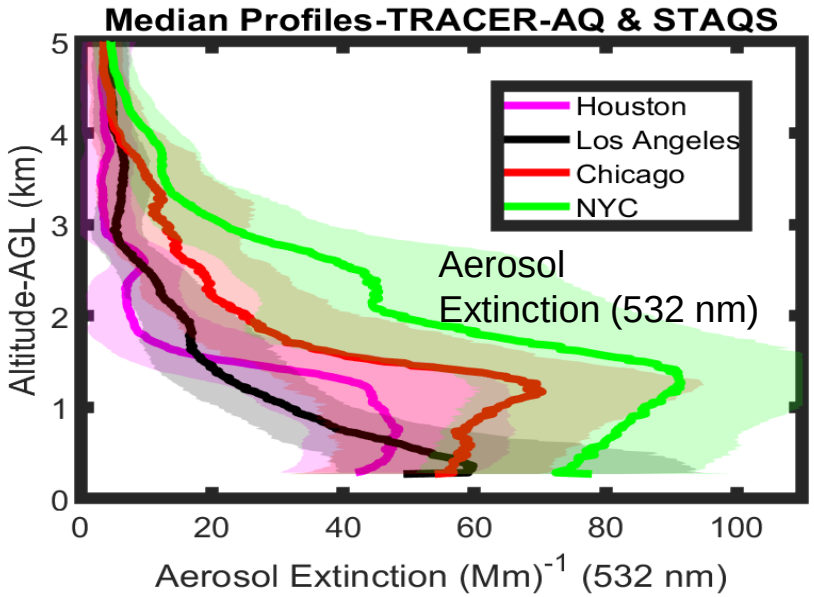


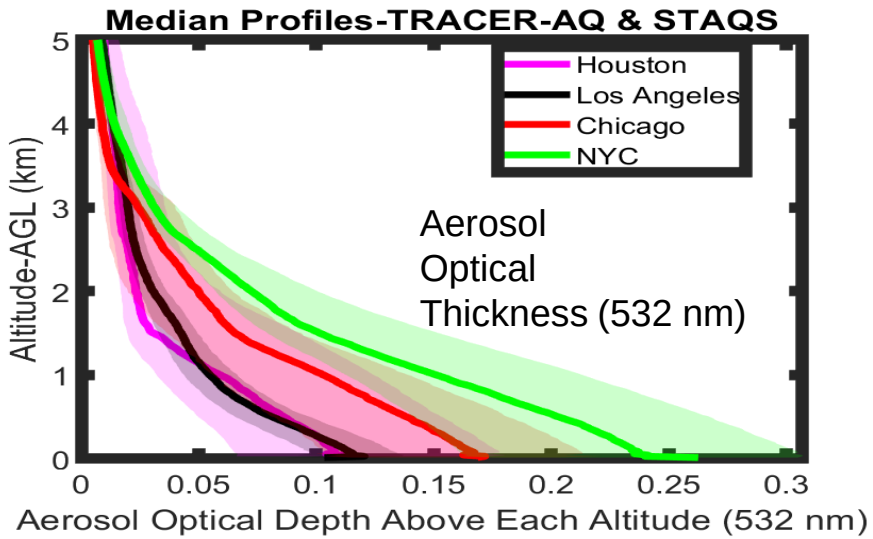
Distribution and evolution of near surface aerosol extinction

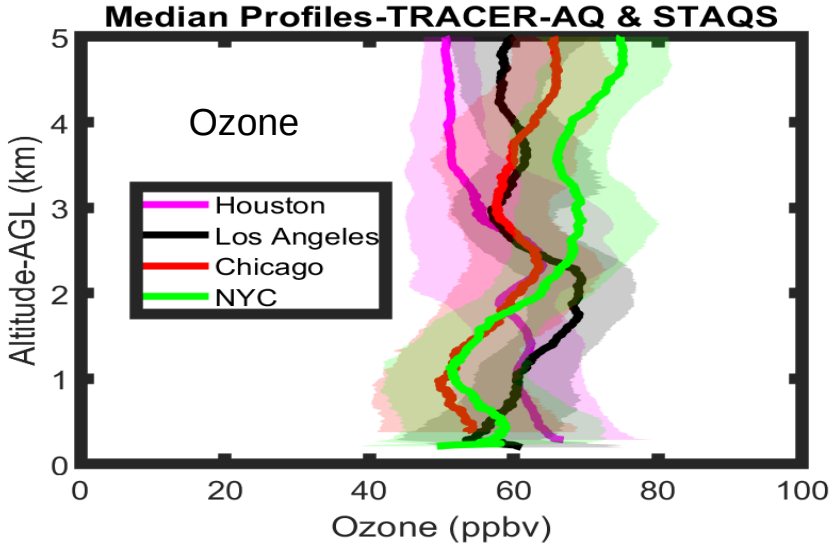


Median Aerosol and Ozone Profiles from TRACER-AQ and STAQS

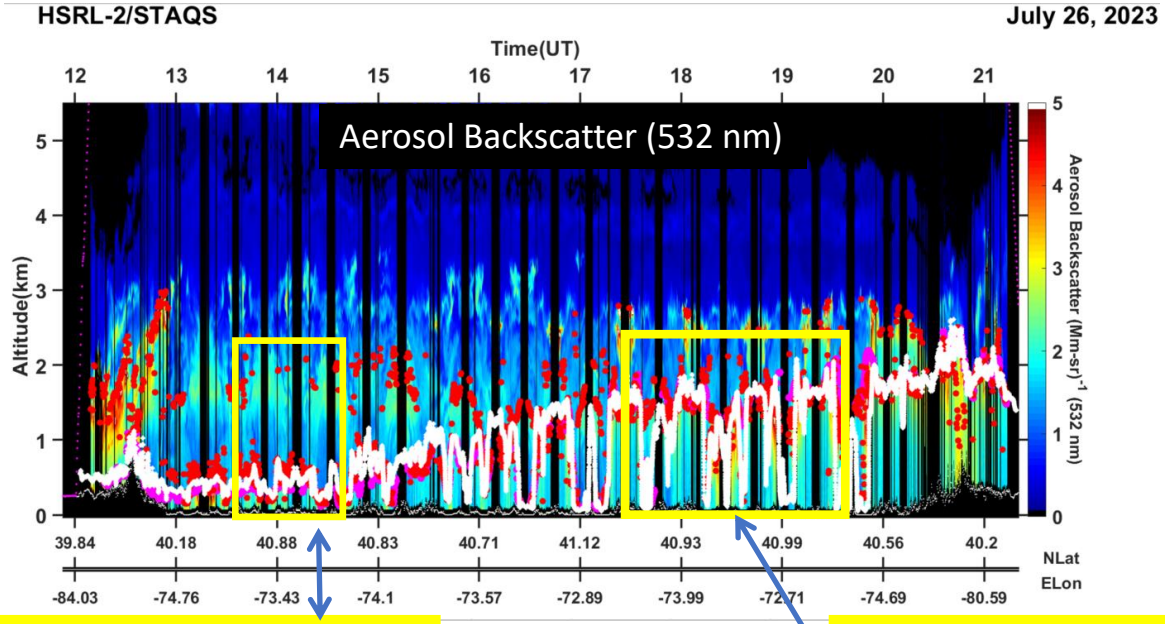






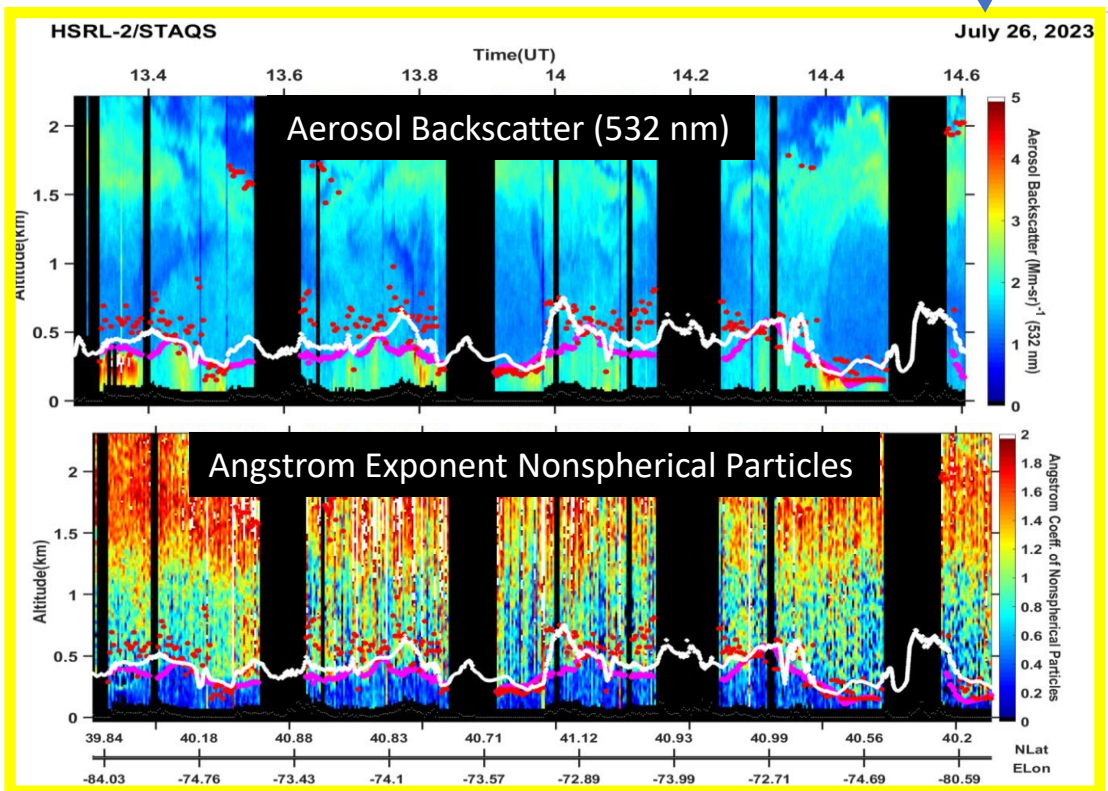


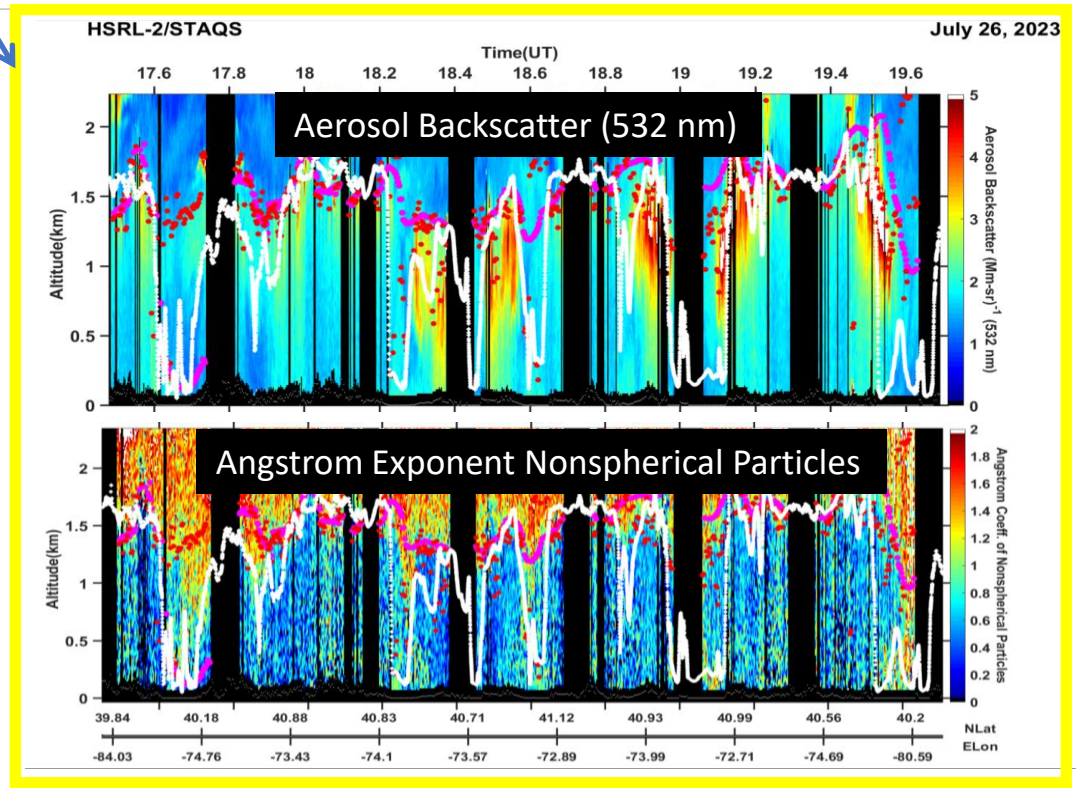
- HSRL-2 retrievals of Mixed Layer Height are based on gradients in aerosol backscatter (Scarino et al., 2014, ACP).
- HRRR model Boundary Layer Height based on based on turbulent kinetic energy when the sensible heat flux is low (stable conditions) and the θv profile when sensible heat flux is larger.
- HSRL-2 MLH and HRRR PBL height are not necessarily the same



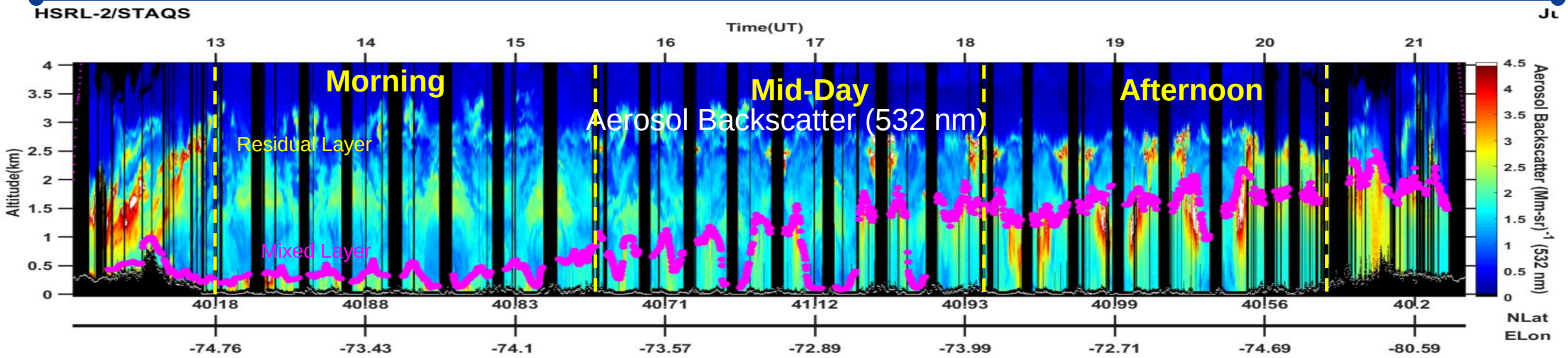
July 26, 2023 New York City

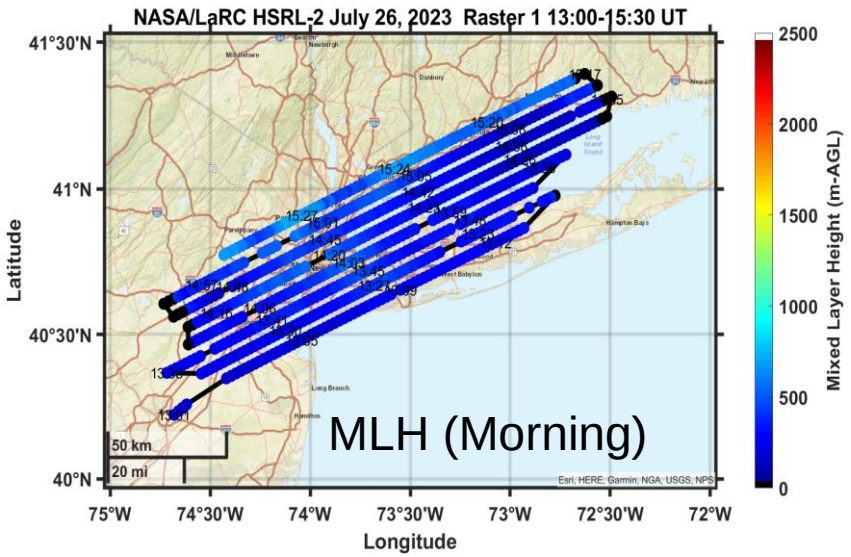
1. MLH from automated algorithm that uses aerosol gradients
2. MLH from automated algorithm and augmented with manual estimate
3. PBL height from HRRR model

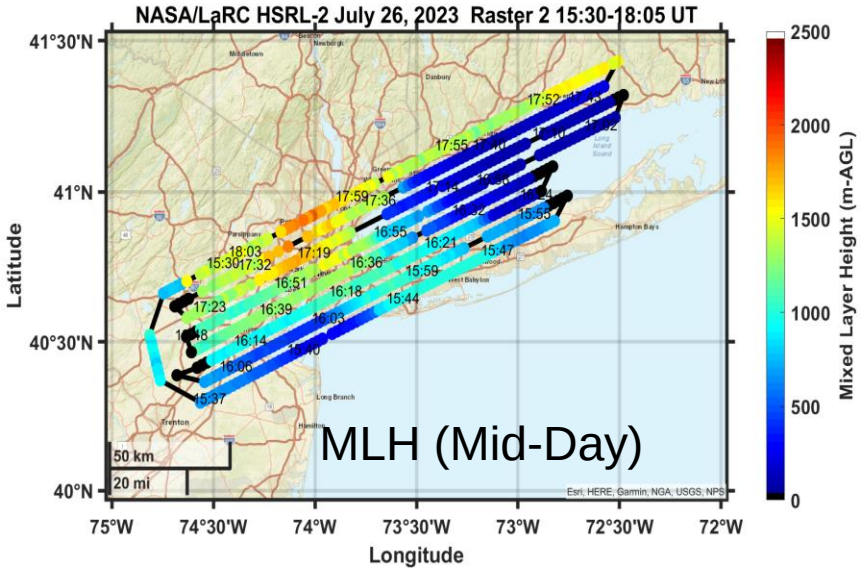


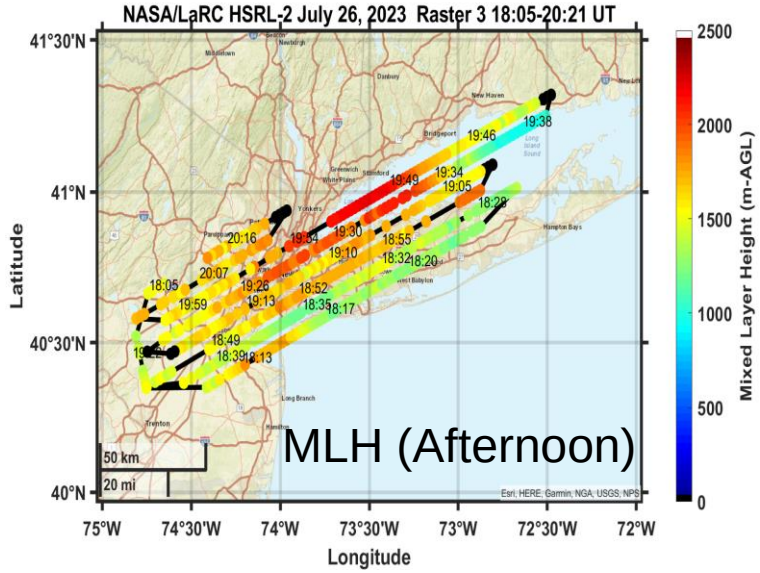


Mixed Layer Heights Derived From HSRL2 – example from July 26, 2023

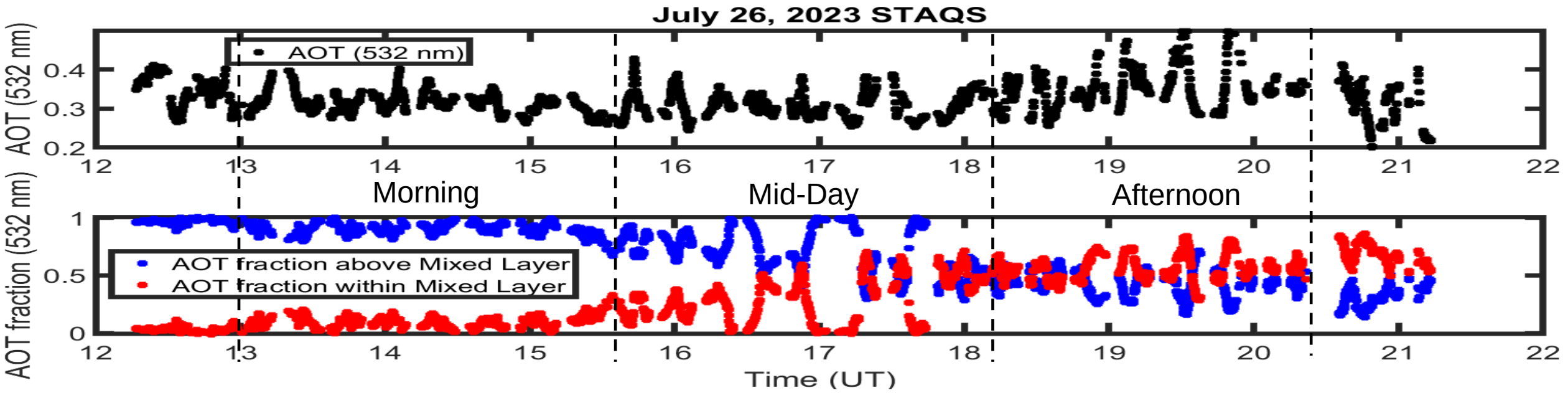


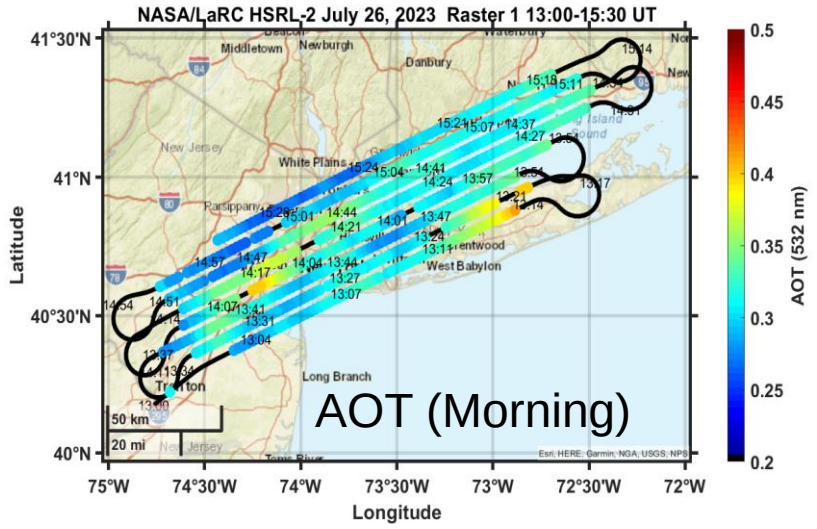


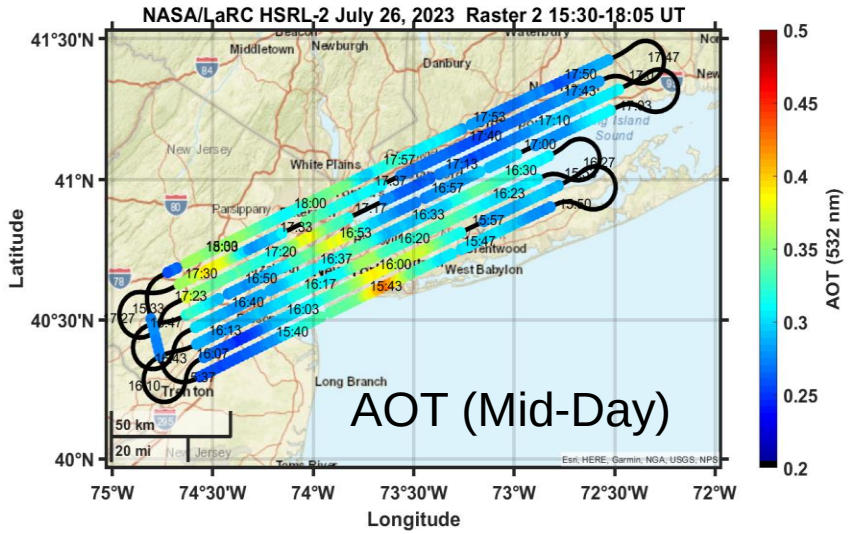


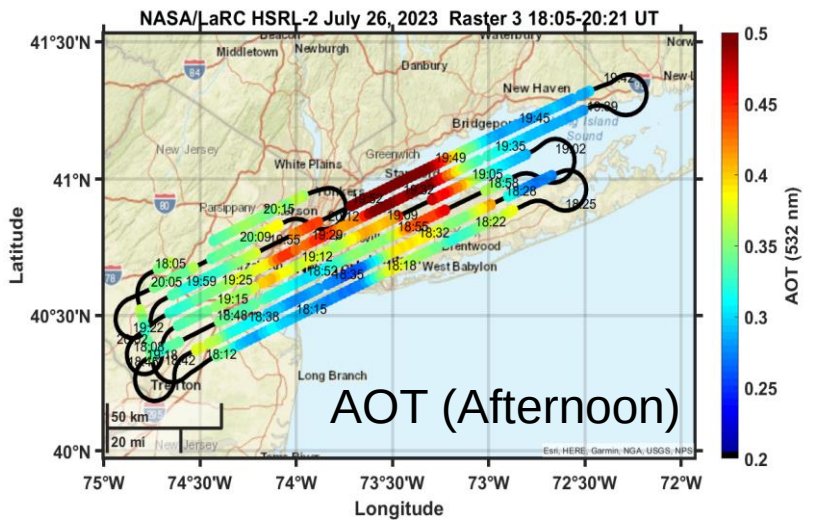


Aerosol Optical Thickness Derived From HSRL2 – Example from July 26, 2023

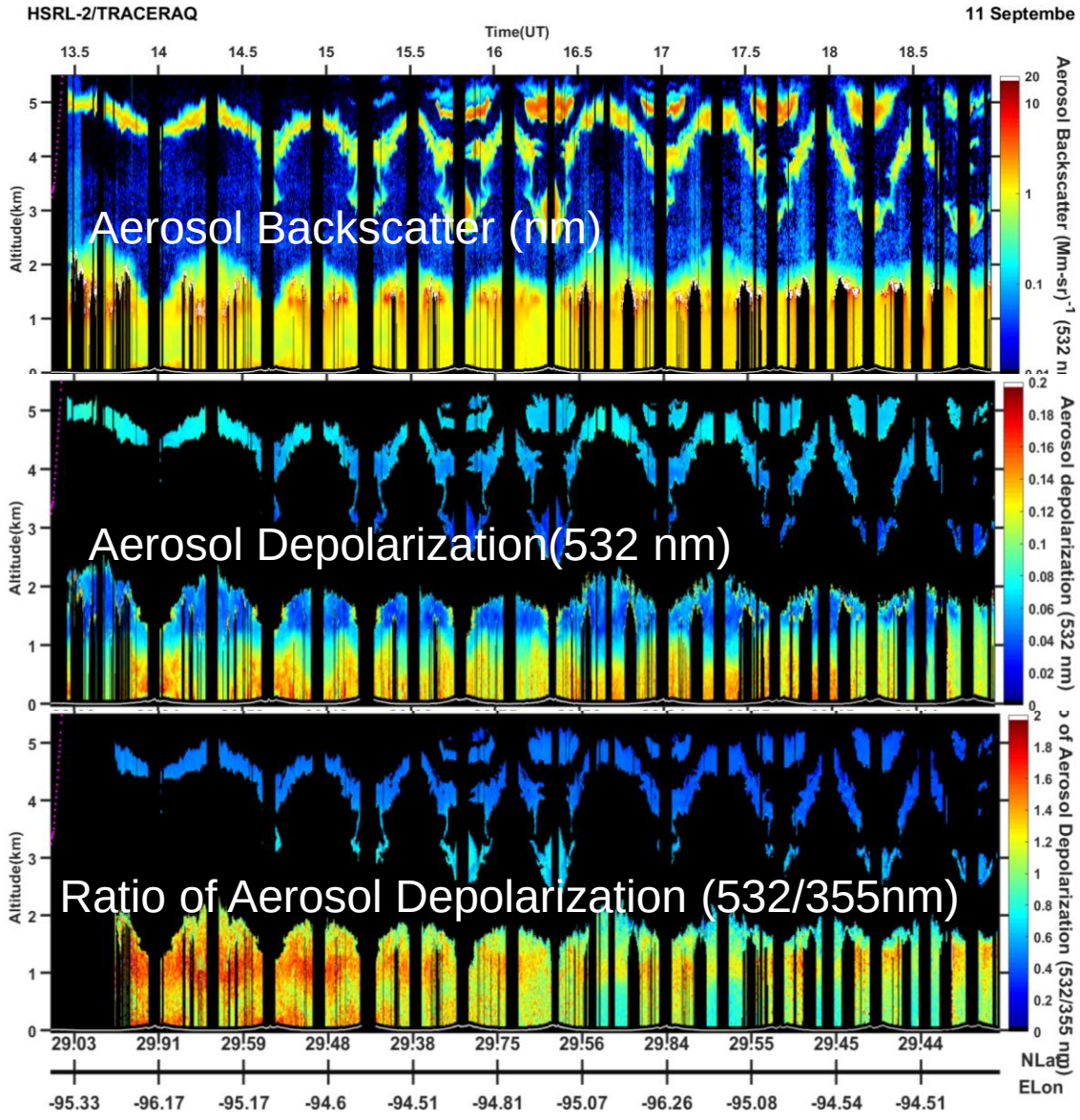


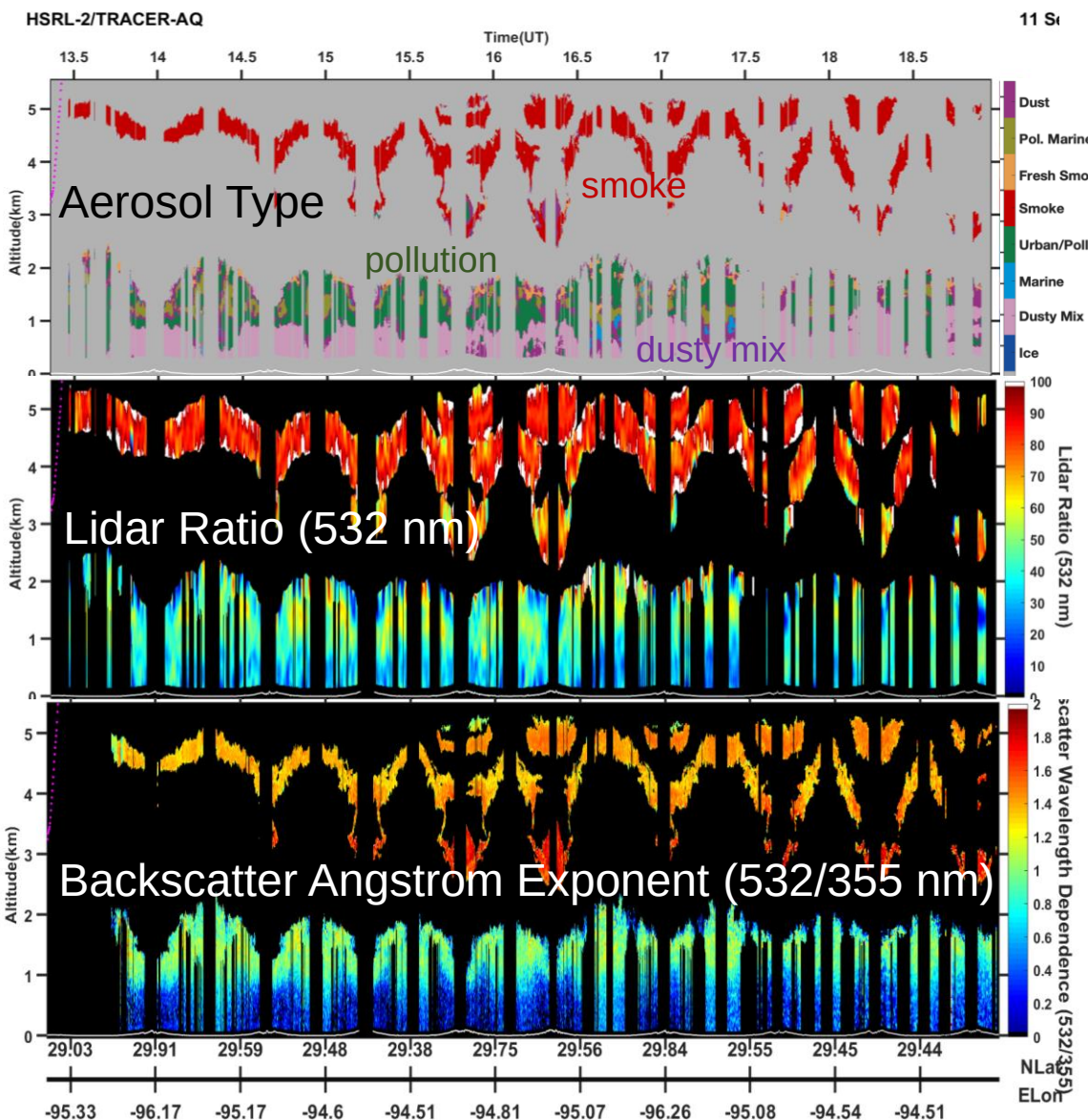




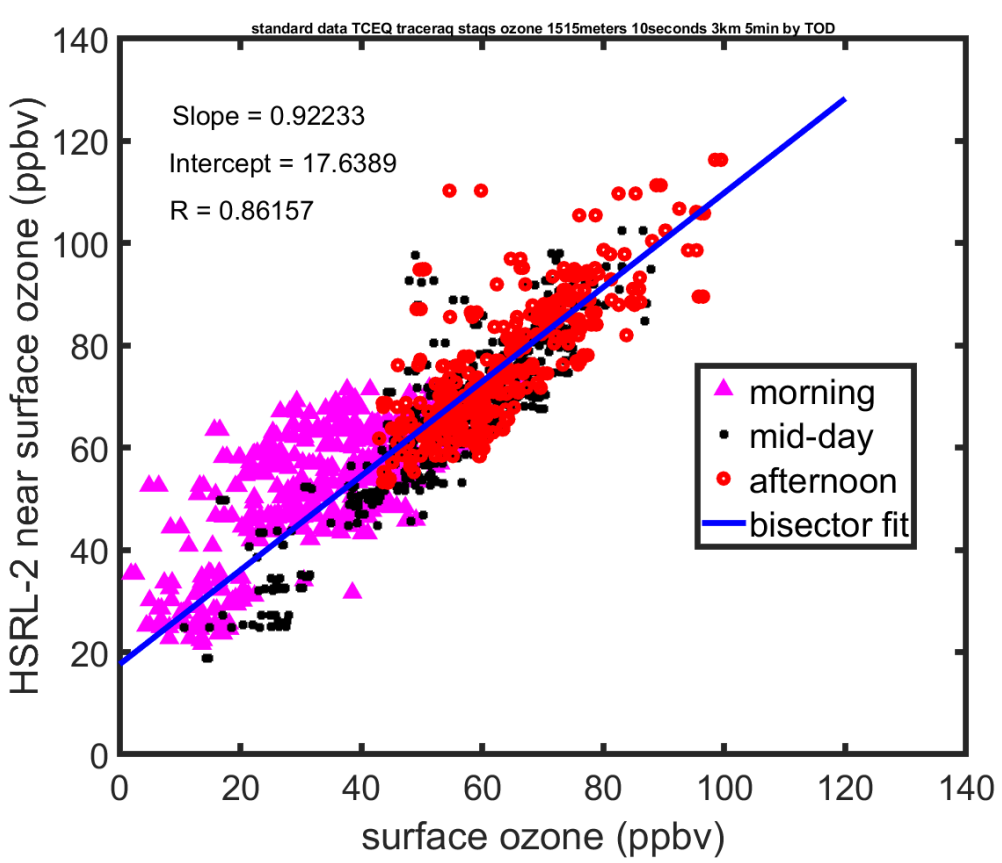


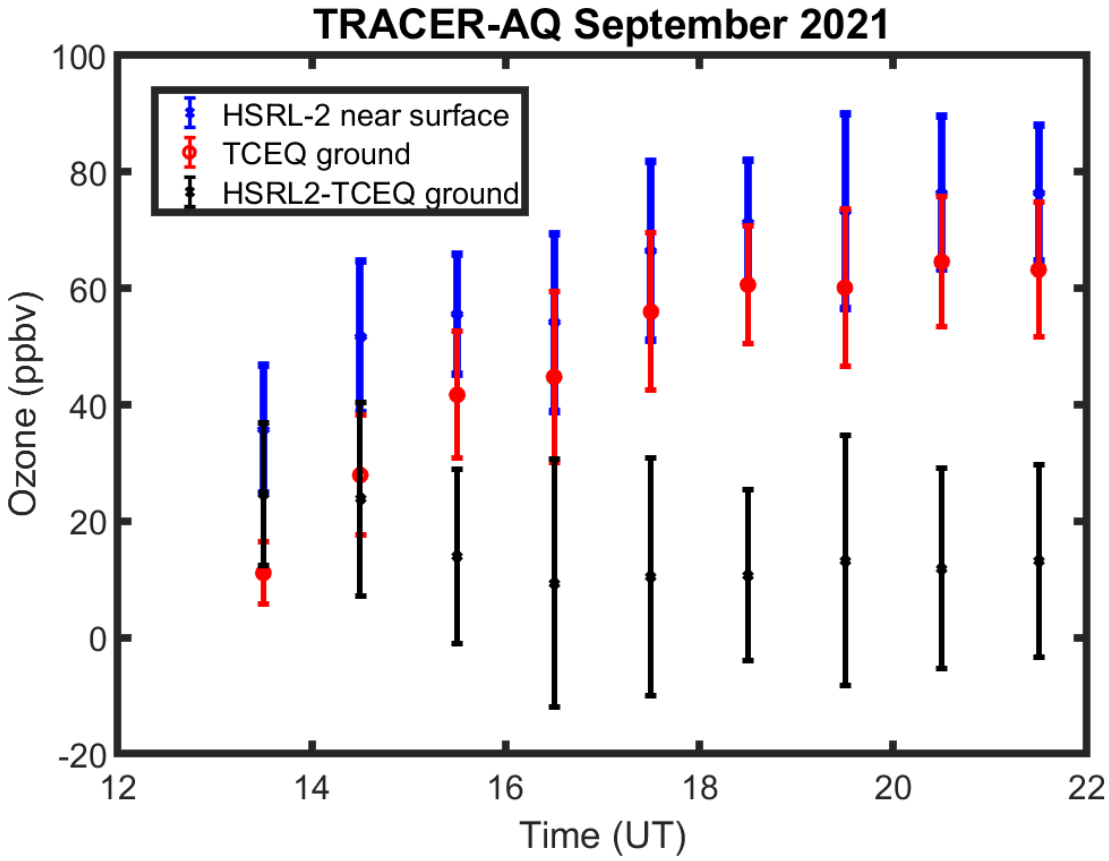
HSRL-2 aerosol measurements on Sept. 11, 2021 show spatial and vertical variability of aerosol optical properties and aerosol type





HSRL-2 Ozone Well Correlated with Surface Data





Summary

- Data collected and standard data products are archived for all research flights (RF1-11) for public use.
- Additional products in progress
  - Mixed Layer Heights, working through challenges with land-water transitions and morning periods where residual layer exists.
  - Surface weighted products produced with same vertical and horizontal averages. These have increased vertical averaging but at higher spatial averages to investigate the distributions and evolution observed the over the Houston Metro. Region.
- HSRL2 provides detailed spatial and temporal aerosol characterization over the region.
  - AOT, aerosol type, lidar ratios, depolarization ratios, backscatter wavelength dependence, and angstrom exponent.
- HSRL-2 near-surface measurements of aerosol extinction could provide good estimation of surface $PM_{2.5}$
- Repeated raster sampling over the entire region should allow for unique analysis.
- Please reach out to our team if you have questions and or need interpretation of the measurements.