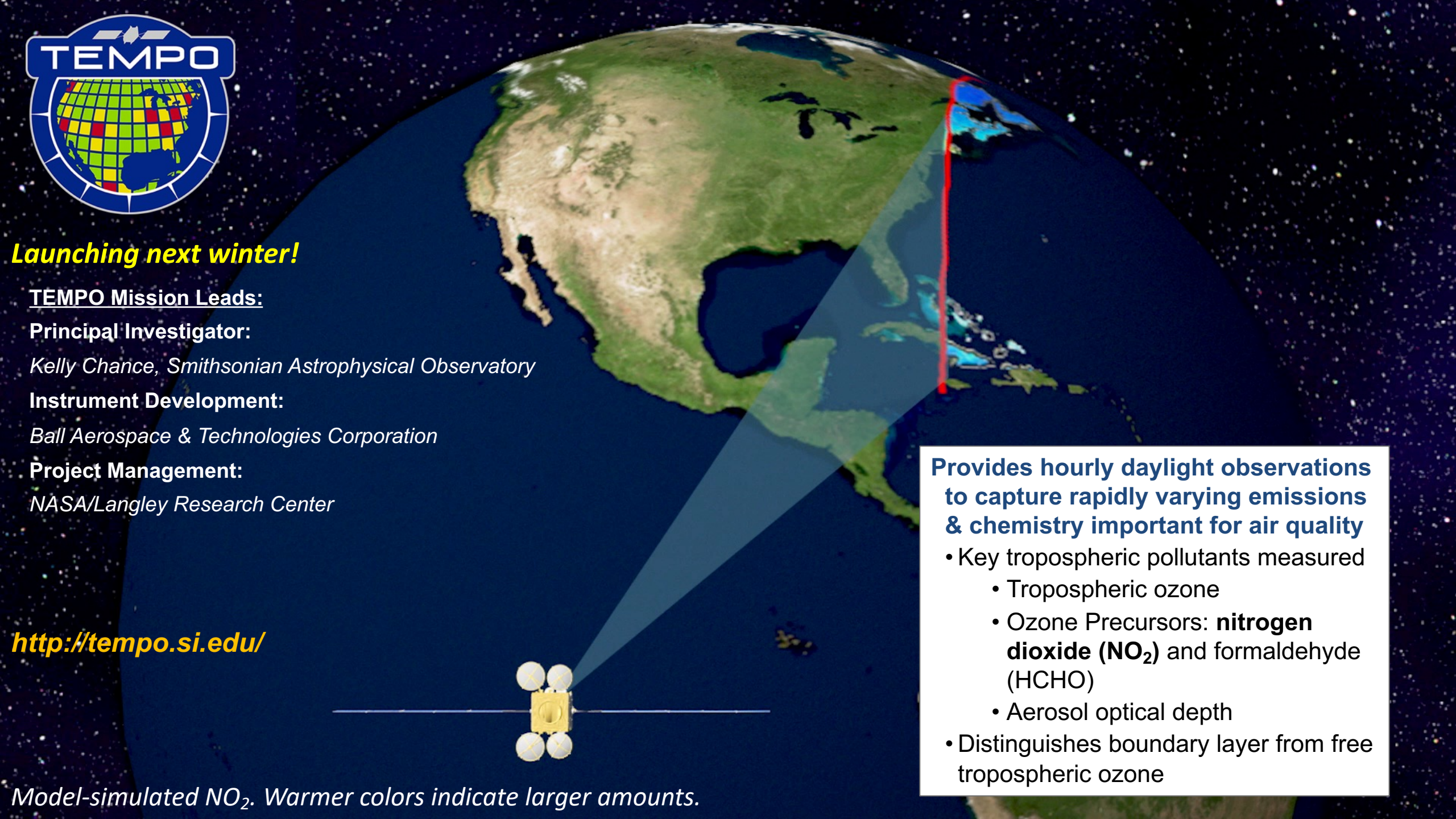


G-V Observations during TRACER-AQ

Laura Judd, John Hair, Taylor Shingler— NASA LaRC

Scott Janz — NASA GSFC





Launching next winter!

TEMPO Mission Leads:

Principal Investigator:

Kelly Chance, Smithsonian Astrophysical Observatory

Instrument Development:

Ball Aerospace & Technologies Corporation

Project Management:

NASA/Langley Research Center

http://tempo.si.edu/

Provides hourly daylight observations to capture rapidly varying emissions & chemistry important for air quality

- Key tropospheric pollutants measured
  - Tropospheric ozone
  - Ozone Precursors: **nitrogen dioxide (NO_2)** and formaldehyde (HCHO)
  - Aerosol optical depth
- Distinguishes boundary layer from free tropospheric ozone

Model-simulated NO_2. Warmer colors indicate larger amounts.

TRACER-AQ 2021 Measurement Overview
GCAS/NASA GV



GCAS Data Products

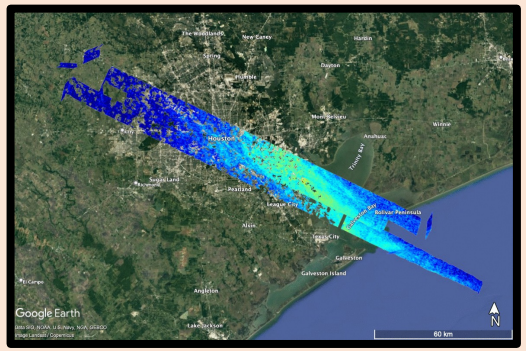
Data product list, number of days, where to find data (is it archived, or do you plan to archive?)

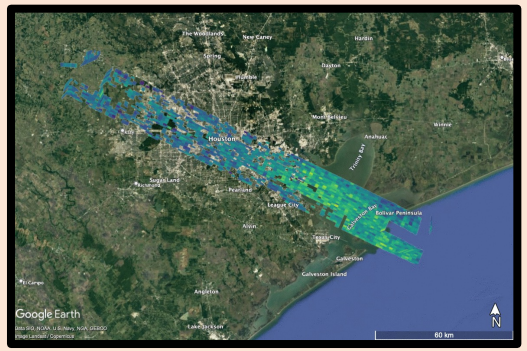
- 10 flights over Houston, 1 over the Gulf of Mexico, 1 test flight
  - NO_2 Slant/Vertical Column densities (archived as of April 13) usually at 250 x 560 m resolution.
  - HCHO Slant/Vertical Column Densities (archived TBD, but soon) at 750 x 1680 m (3x3 of native l1b resolution)

Any other pertinent data-related information (revision info or caveats)

- Retrieval information found in readme file and references within
- Current revision: R0. R1 may include improvements to stratospheric assumptions and any lessons learned during validation with Pandora
- Laura envisions making a level 3 gridded product if there is interest (please let us know any way we can make this data easier to use)

Data Highlight





Relevance to Science Plan

How does your data fit in the broader context of the contributions of the science plan.

Ozone Photochemistry and Meteorology

- *First airborne systematic mapping of ozone from HSRL2 + ozone precursors (HCHO + NO2)*
- *Ambitions to explore the relationship between HCHO and Ozone in this region with high VOC emissions*

Modeling and Satellite Evaluation

- *S5P validation: Judd et al., 2020 https://doi.org/10.5194/amt-13-6113-2020 + TEMPO validation planning*
- *Provides a high-resolution view of column NO2 and HCHO for evaluating spatial/temporal patterns in chemical transport models at an unseen spatial resolution and repeatability in the region.*
- *Can be used to evaluate NOx emissions*

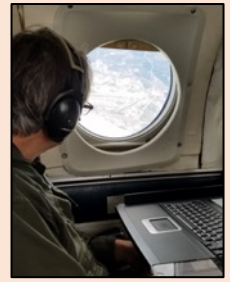
Intersection of Air Quality and Socioeconomic Factors

- *See Demetillo et al., 2020: https://pubs.acs.org/doi/10.1021/acs.est.0c01864*
- *Isabella Dressel's presentation on Day 2*

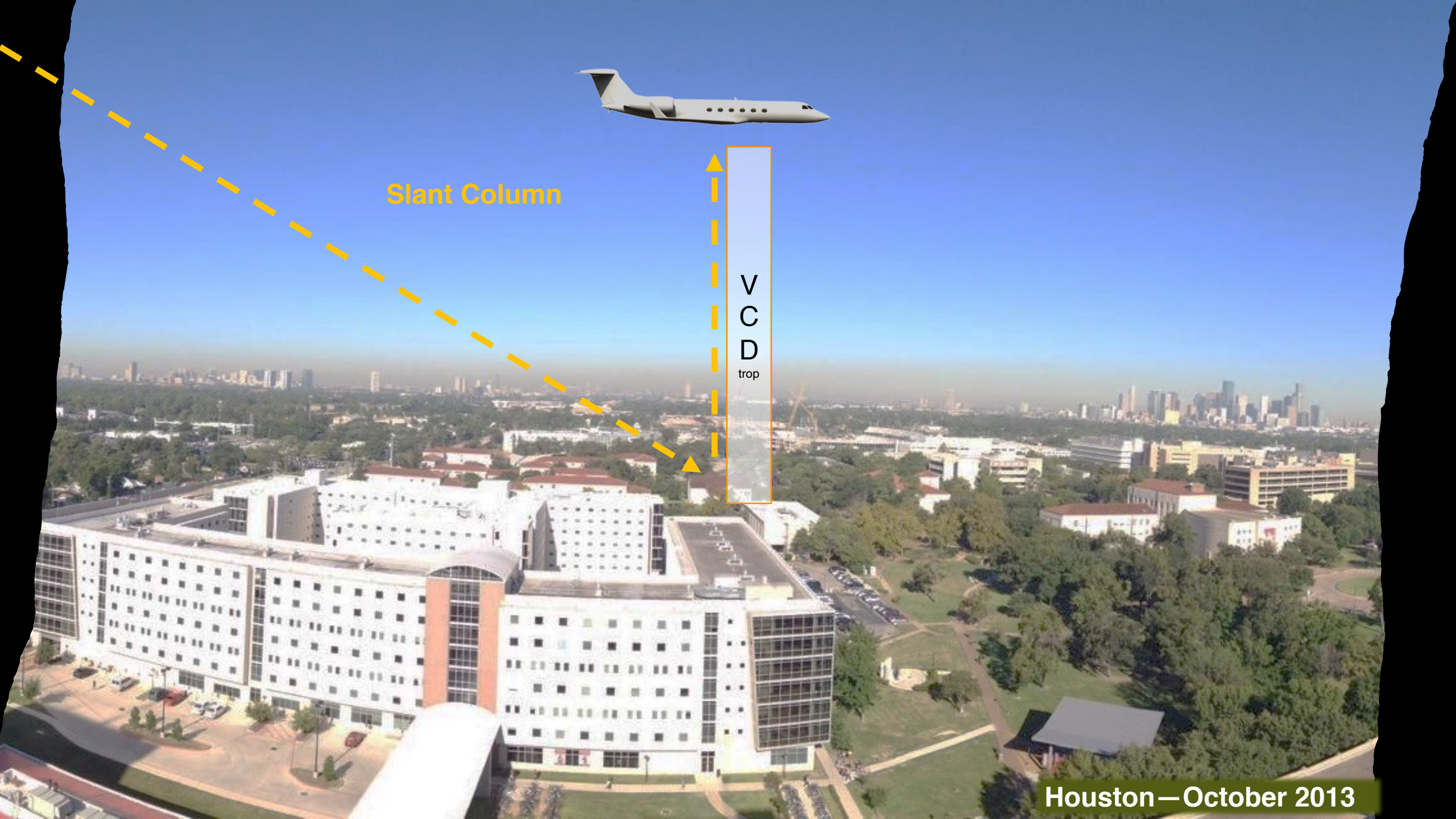
Contact Information

Scott Janz, NASA GSFC
scott.j.janz@nasa.gov

Laura Judd, NASA LaRC
laura.m.judd@nasa.gov






Slant Column
V
C
D
trop
Houston—October 2013

TRACER-AQ 2021 Measurement Overview
HSRL2–DIAL/NASA GV



Data Products (All Research Flights)

- **Aerosol**
  - *Particulate backscatter profiles (355, 532, 1064 nm)*
  - *Particle 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/Classification*
  - *Aerosol Optical Thickness (355, 532 nm)*
  - *Mixed Layer Heights (requires additional analysis/processing)**
  - *Images (both full flight and individual raster patterns)*
- **Ozone**
  - *Ozone concentrations (290,300nm)*
- **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

Contact Information (NASA LaRC)

Johnathan Hair — ***Johnathan.W.Hair@nasa.gov***
Taylor Shingler — ***Taylor.J.Shingler@nasa.gov***
Rich Ferrare — ***Richard.A.Ferrare@nasa.gov***
Marta Fenn — ***Marta.A.Fenn@nasa.gov***

Chris Hostetler, David Harper, Anthony Notari, Shane Seaman, Joe Lee, Amy Jo Scarino, Madison Hetlage (NASA Fellowship, Texas A&M)

Relevance to Science Plan

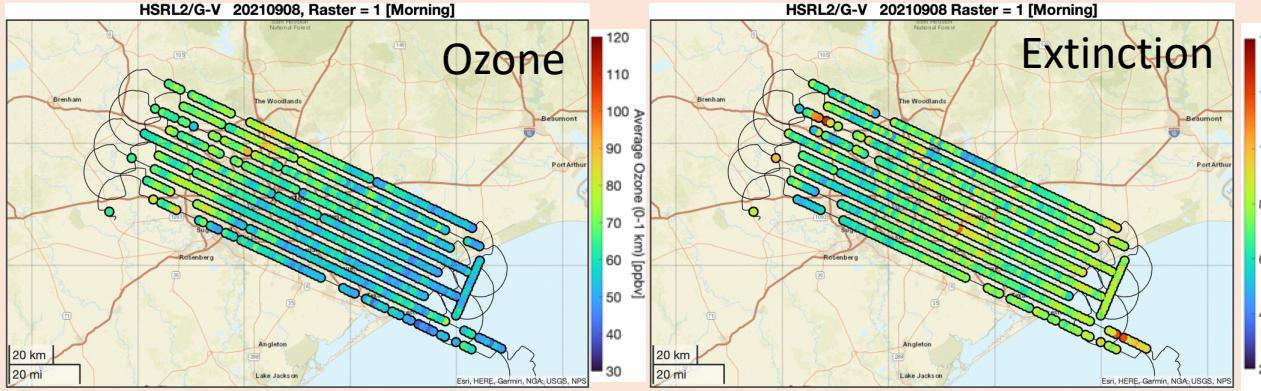
Question 1a-b: Ozone Photochemistry and Meteorology

- *Ozone and Aerosol profiles capture near surface change at the land-to-water transition. Capture the vertical changes both spatially and temporally across the metropolitan Houston region.*
- *Provide evolution of the aerosol mixed layer heights (MLH), based on aerosol gradients.*

Question 2a,c: Modeling and Satellite Evaluation

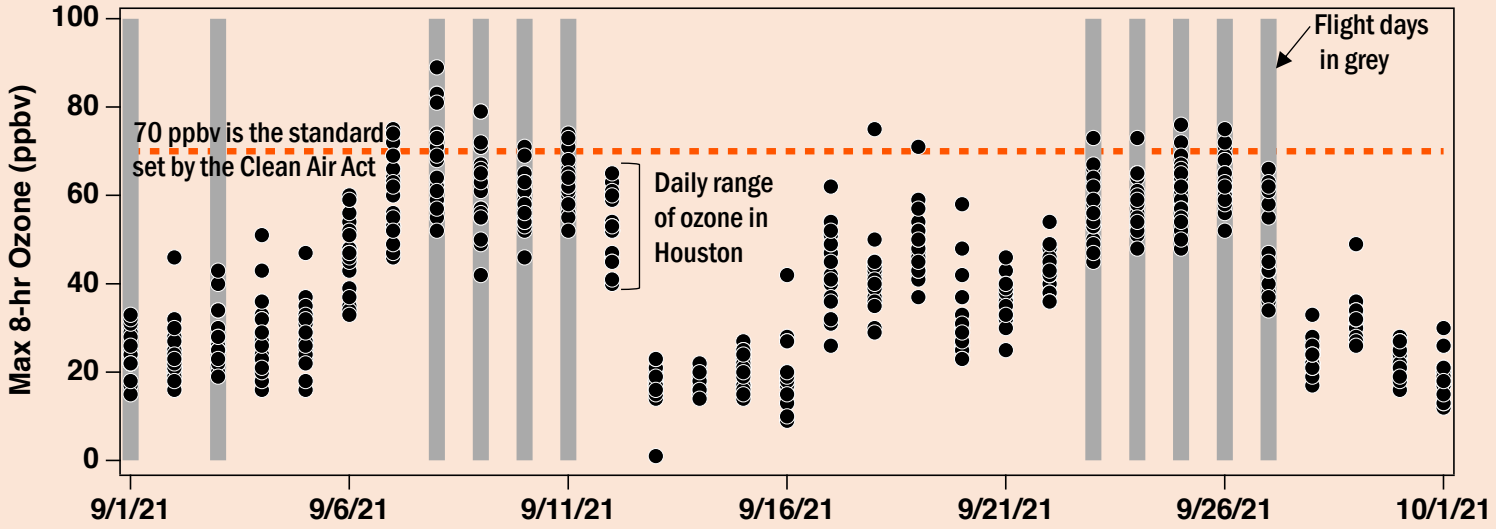
- *Ozone and Aerosol maps can capture the spatial and temporal evolution of ozone and PM2.5 proxies (i.e. extinction) that can be used to assess models.*
- *Aerosol Optical Depth can be compared with current satellites and models.*
- *Provide spatial coverage to better understand the diurnal transport pathways or regions of influence to local sources. Evaluate ozone near the surface and compare these to the ground monitoring sites.*

Data Highlight

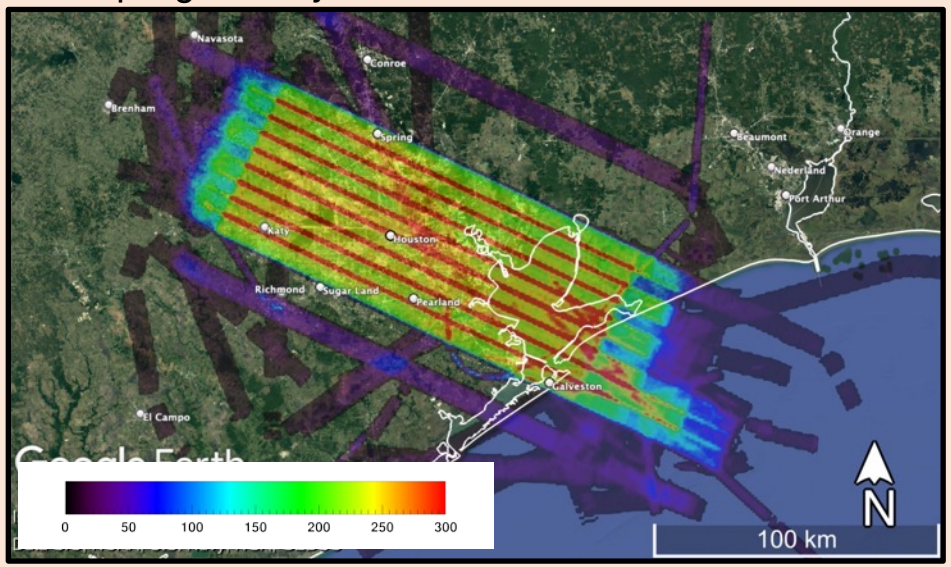


TRACER-AQ G-V Flight Strategy

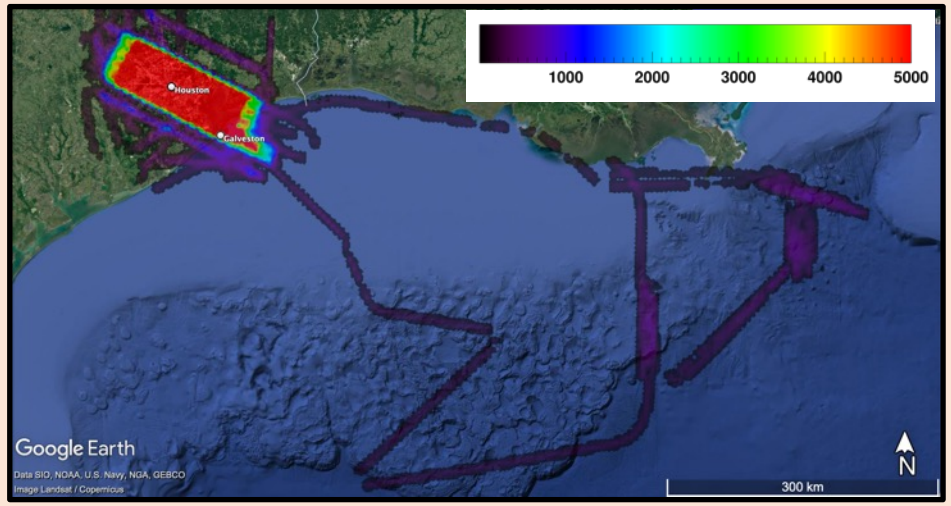
Repeated systematic sampling over the same area up to 3 times in a day to provide a balance of looking over a wide region but being able to better understand day-to-day and time-of-day variance in NO_2 and HCHO (mimicking geostationary)



Sampling Density for GCAS in Houston at 1km scale



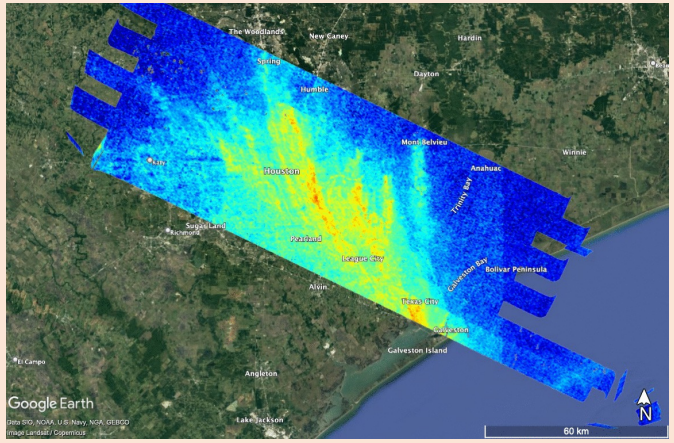
Sampling Density for GCAS in Houston at 5km scale



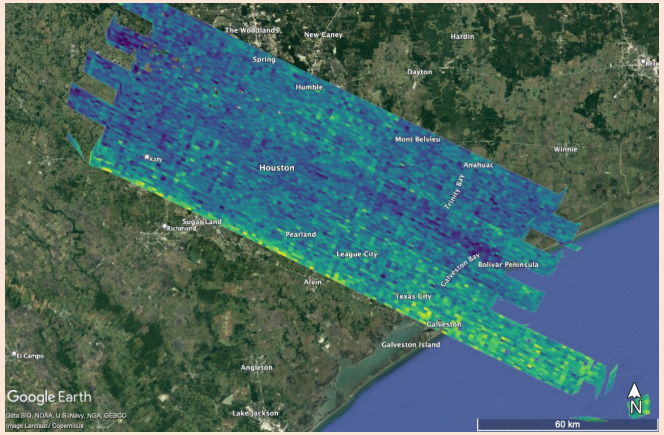
Visualizing chemical weather

GV payload data example from 8 September 2021

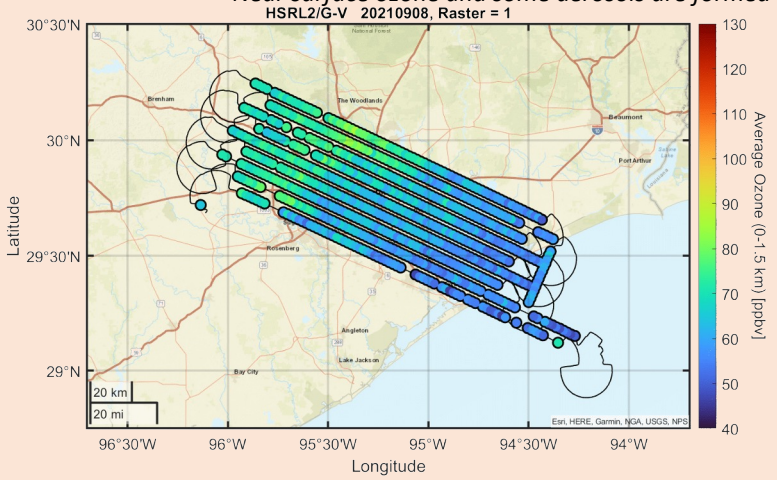
Visualizing emissions (NO2)

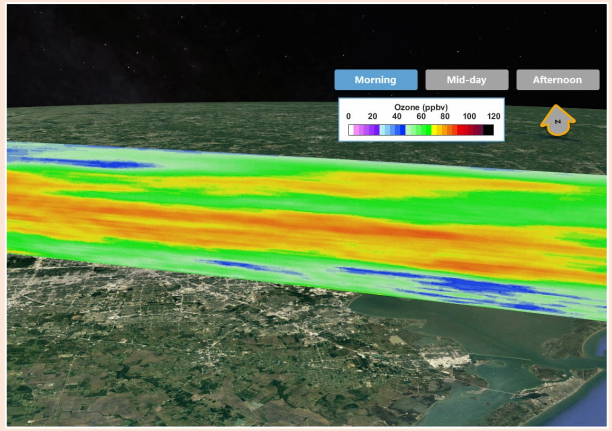


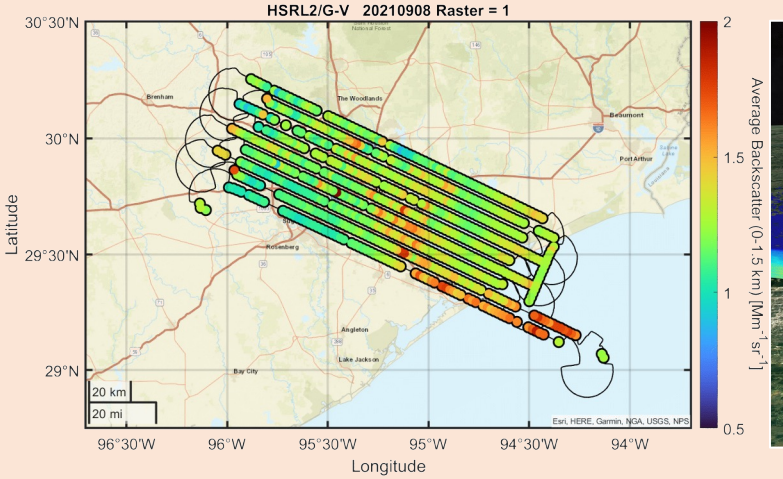
Visualizing the chemical breakdown of VOCs

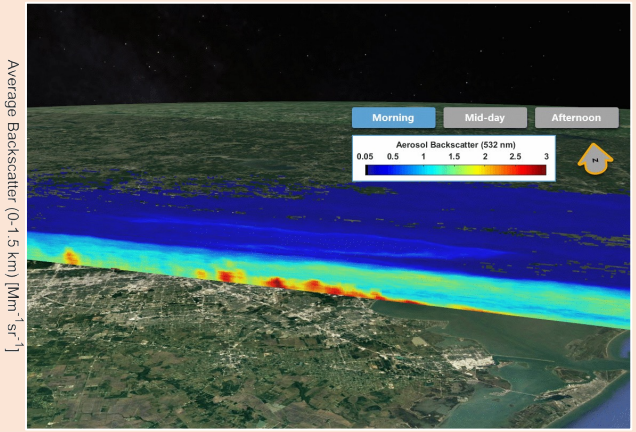


Near surface ozone and some aerosols are formed chemically as emissions move downwind through the day









Additional HSRL2 Products:

- 532 nm Aerosol Depolarization
- Ratio of Aerosol Depolarization (532/355nm)
- Lidar Ratio (532 nm)
- Backscatter Angstrom Exponent (532/355 nm)
- Aerosol Type
- Mixed layer height (future)

⇢ Spatial scales of these measurements reveal information about these pollution that cannot be captured by a satellites.

⇢ The temporal sampling strategies give us a glimpse of the future with hourly view expected from TEMPO.

Data use ideas of GV data (not all inclusive)

- ⇢ How does the top-down temporal evolution of NO_2, HCHO, ozone match with ground-based and modeled measurements during our two 4-day ozone events?
- ⇢ Evaluation on the connections of HCHO column in relation to surface ozone in Houston using Pandora and GCAS
- ⇢ Quantifying emissions using GCAS NO_2 observations
- ⇢ Creation of TEMPO synthetic data to start assessing validation/use strategies during STAQS
- ⇢ Understanding air quality exposure inequality in Houston



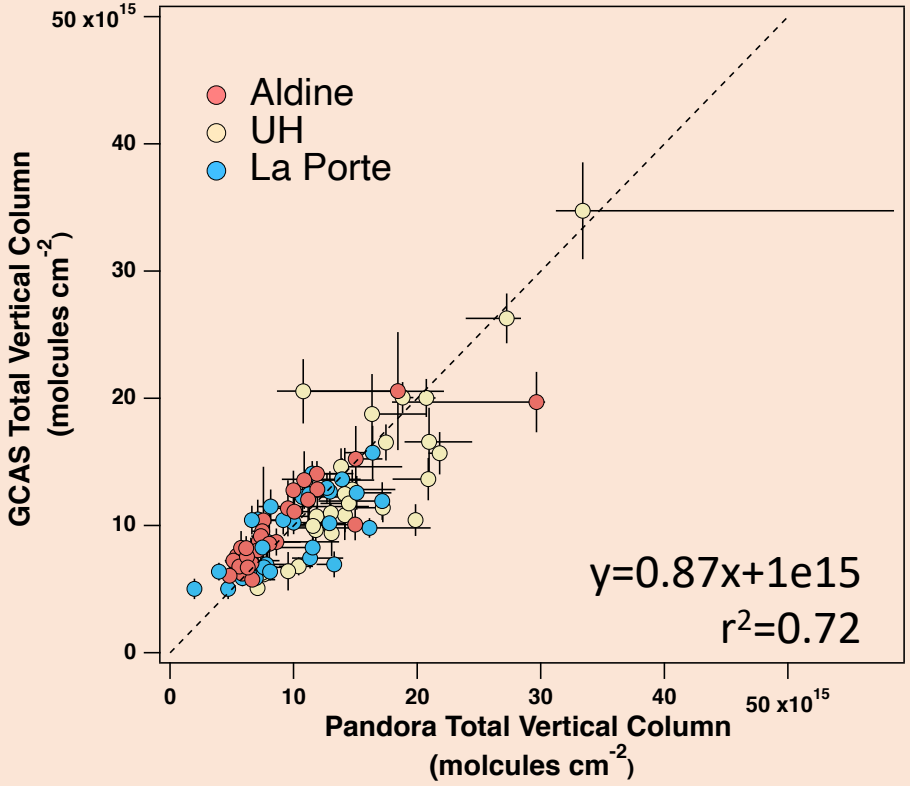
Thanks for you attention!

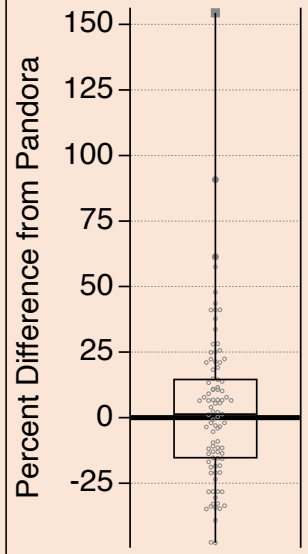


Disclaimer: Trade names and trademarks are used in this report for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by the National Aeronautics and Space Administration.

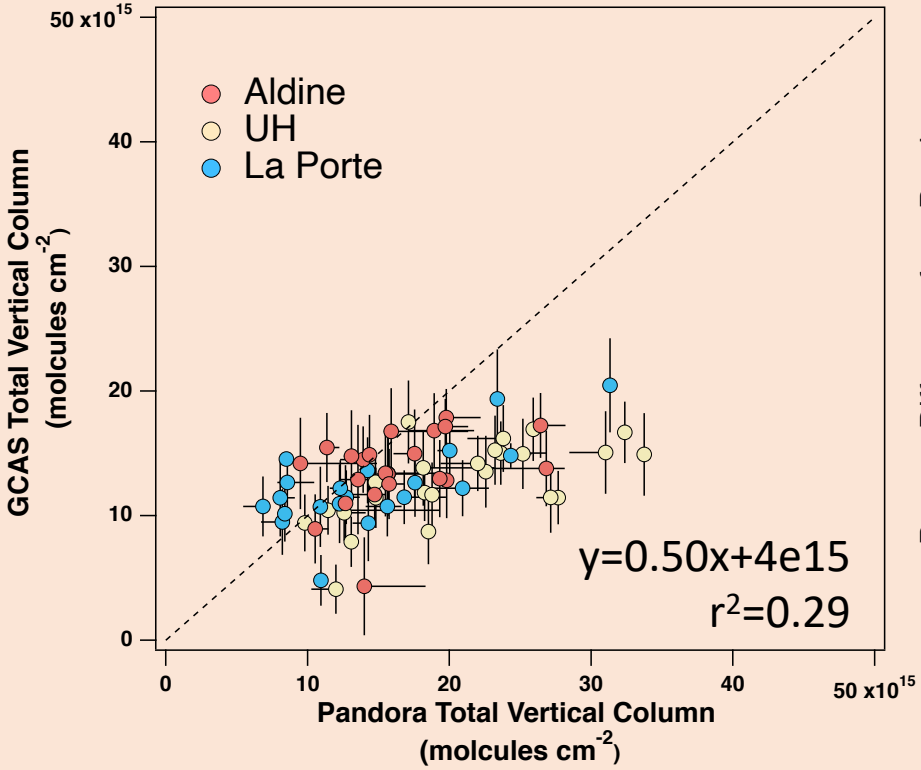
Data Comparisons: GCAS v. Pandora (PRELIMINARY!)

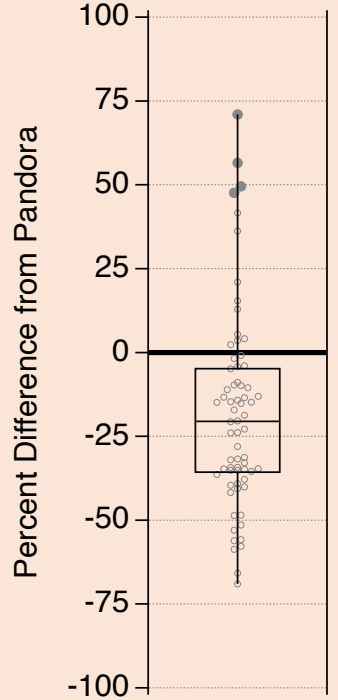
NO_2 Comparisons





HCHO Comparisons





Comparison methodology:

Pandora nearest Pandora valid data point within +/- 15 minutes of GCAS overpass

GCAS mean column within 750 (2250) m +/- stddev for NO_2 (HCHO)

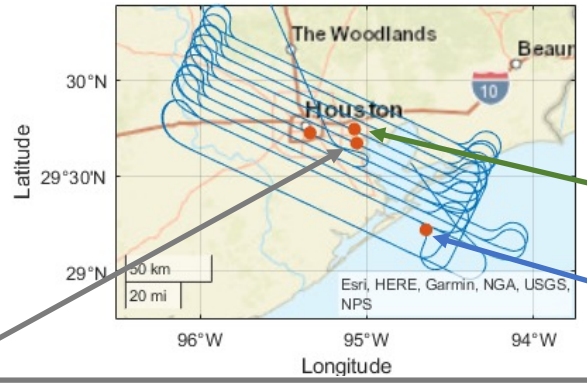
Pandora QA value of 0 or 10

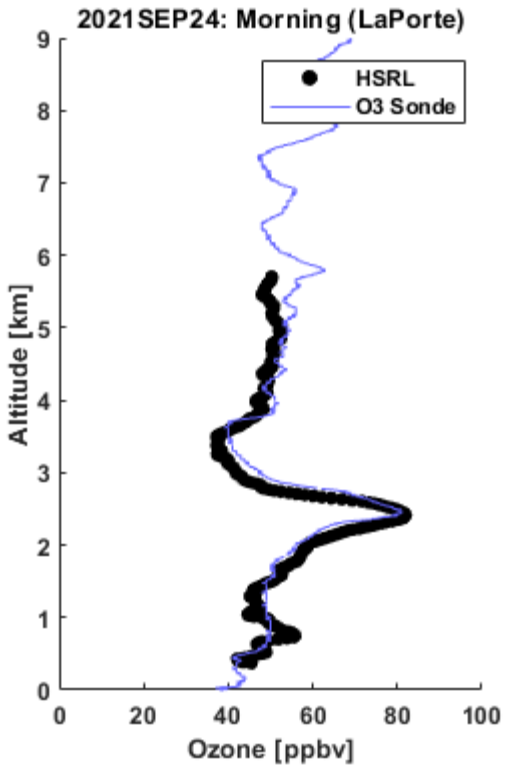
(PRELIMINARY!)

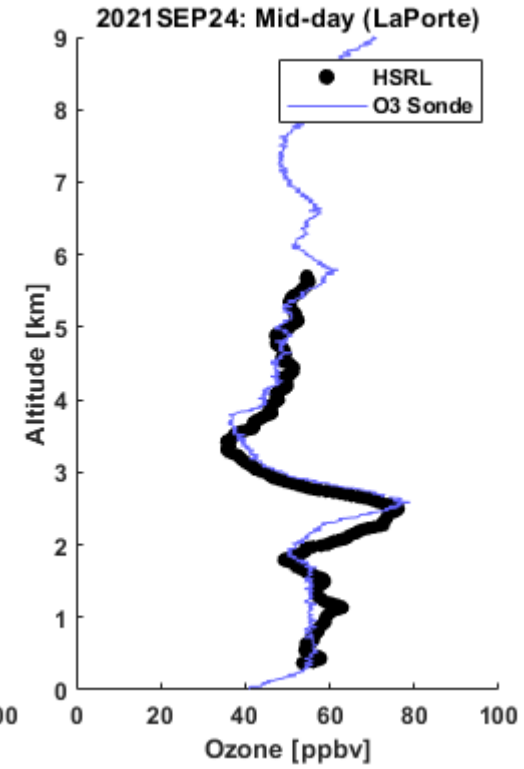
Data Comparisons: HSRL2 Ozone v. Sonde

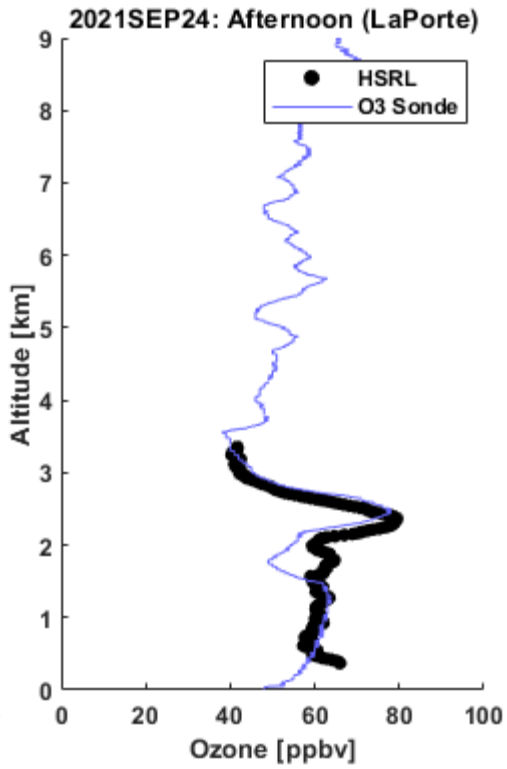
Figures courtesy of HSRL team

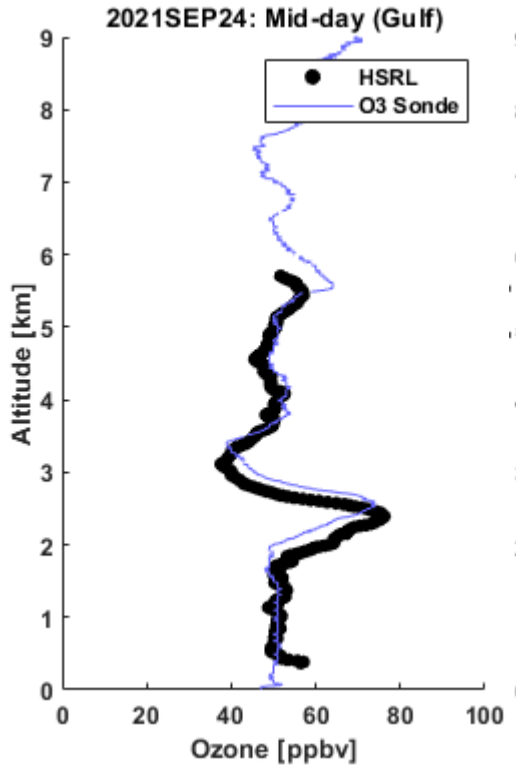
Spatial and temporal requirement
Distance <= 5km
Time < 30 min

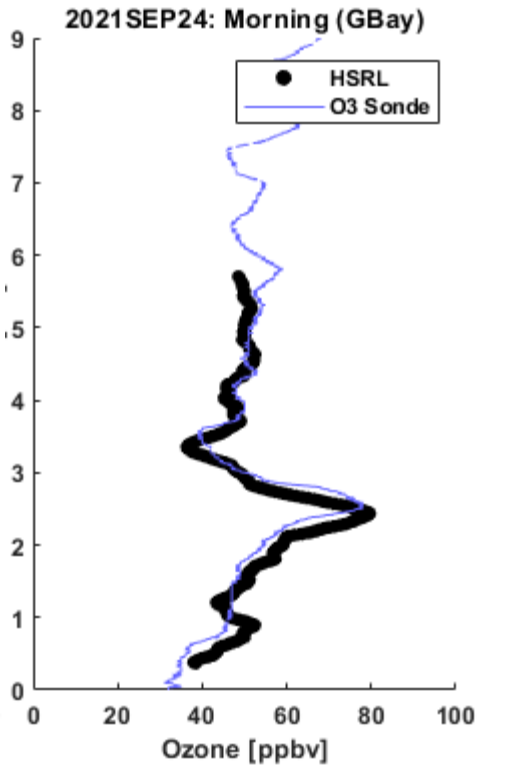












Advice for using data files

Data are in netcdf format in a 30 x n_swaths or 10 x n_swaths size for NO2 and HCHO, respectively

Subset data with raster_flag. Do not lump all flight data into one set! There are easily up to 3 overpasses of a single site separated by hours.

- Each flight has raster flags of 0 (not in raster) or a non-zero number (1,2,3) to indicate which data raster is in

Do not use cloudy data! Processing assumes cloud free skies

- NO_2 product: Only use data where cloud_glint_flag ≠ 1 (cloud free = nan; will be fixed to 0 in R1)
- HCHO product: Set your cloud fraction threshold with cloud_glint_fraction. I use cloud_glint_fraction < 0.3.

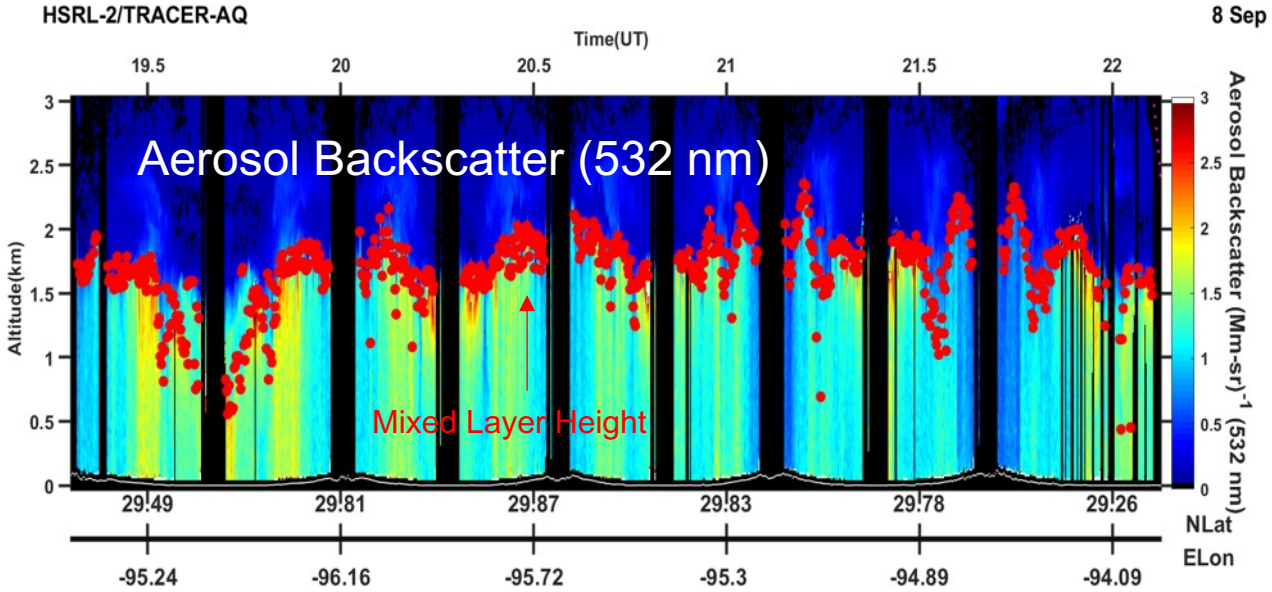
Identified improvements in revisions

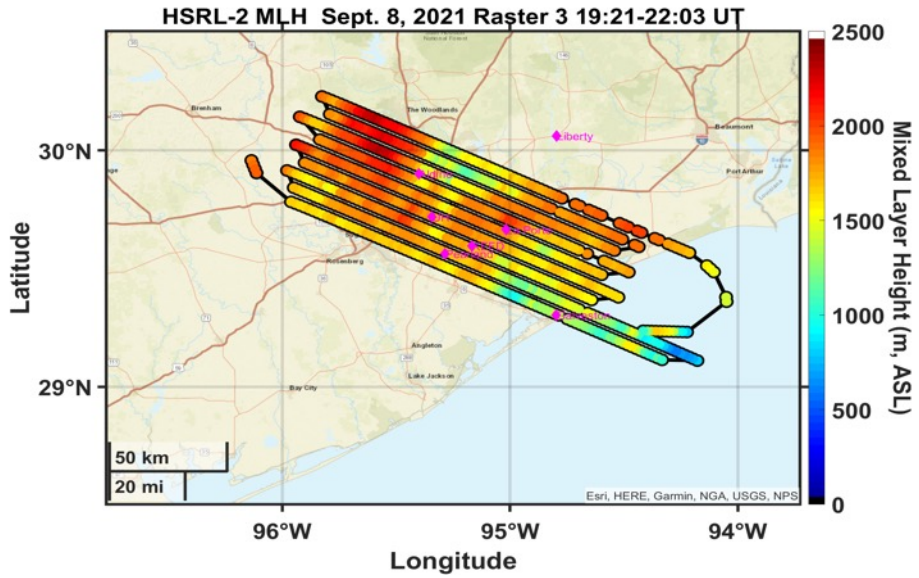
- Measurement corrected stratosphere assumption through TROPOMI correction in NO2. Biggest influence in morning/late day measurements with noticeable impact on Sept 1st and 3rd (I think)
- Plans for a level 3 gridded product of rasters in summer 2022
- Send your ideas for what you want to see to make use of this data easier

Flight	Date/Time UTC	# Rasters	Notes about clouds/conditions (colored by max AQI)
0	08/30 15:34-18:08	0.33	Instrument Check Flight
1	09/01 13:03-17:59	2	Convection
2	09/03 13:08-19:27	2	Convection
3	09/08 13:46-22:20	3	1 red/13 orange
4	09/09 13:16-22:26	3	8 orange
5	09/10 13:16-22:52	3	1 orange
6	09/11 13:15-20:00	2	Undercast sky by midday; 3 orange
7	09/23 13:48-23:00	3	1 orange
8	09/24 13:26-22:44	3	2 orange
9	09/25 13:28-22:46	3	4 orange
10	09/26 13:30-22:48	3	4 orange
11	09/27 15:18-22:00	0	Gulf of Mexico off-shore platform mapping. Quite cloudy.

Mixed Layer Heights Derived From HSRL2 – example from Sept. 8, 2021 - Afternoon

- Mixed Layer (ML) heights derived from cloud-screened aerosol backscatter profiles
- ML heights can be a good proxy for daytime PBL heights
- Technique uses a Haar wavelet covariance transform with multiple wavelet dilations to identify sharp gradients in aerosol backscatter (adapted from Brooks, JAOT, 2003)
- Automated HSRL algorithm chooses ML from among aerosol gradients with input from manual inspection where necessary (Scarino et al., 2014, ACP)
- During afternoon, determining ML heights more straightforward due to single sharp aerosol gradient
- Much lower ML height over water





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

