Goals:
1. Summarize the flights and review sampling strategy
2. Talk about retrieval: giving a sense of the uncertainty
3. Data status and potential data uses
Airborne Mapping Spectrometers

GeoTASO
- Geostationary Trace gas and Aerosol Sensor Optimization
- UV-VIS
- Large—300+lbs
- June and October 2018

GCAS
- GEOCAPE Airborne Spectrometer
- UV-VIS-NIR
- Small—~100 lbs
- July-October 2018

Trace gas retrievals:
NO₂ columns at 250 x 250 m
- Current data status: Differential Slant Columns (DSCs) are in the archive
- I have preliminary vertical columns on a subset of flights. I will continue to improve and share this summer!
HCHO columns: Scott Janz will talk this later today

Previous retrieval references: Nowlan et al., 2016; Nowlan et al., 2018

LISTOS Raster Examples 2018
Varied somewhat from day-to-day based on time/meteorology considerations
<table>
<thead>
<tr>
<th>Flight Date (both AM/PM)</th>
<th>Instrument/Platform</th>
<th>Sampling Strategy</th>
<th>Air Quality Conditions (general patterns from AirNow.gov)</th>
<th>Raster Break (approximate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 18</td>
<td>GeoTASO/HU-25</td>
<td>Large Raster 2x</td>
<td>USG up I95 corridor</td>
<td></td>
</tr>
<tr>
<td>June 25</td>
<td>GeoTASO/HU-25</td>
<td>Large Raster 2x</td>
<td>Clean-off shore flow</td>
<td></td>
</tr>
<tr>
<td>June 30</td>
<td>GeoTASO/HU-25</td>
<td>Large Raster 2x</td>
<td>USG NYC: Stagnant to SW flow</td>
<td></td>
</tr>
<tr>
<td>July 2</td>
<td>GCAS/HALO/B200</td>
<td>Large Raster 2x</td>
<td>Very Unhealthy north of NYC</td>
<td></td>
</tr>
<tr>
<td>July 19</td>
<td>GCAS/HALO/B200</td>
<td>Small Raster 4x</td>
<td>Moderate NYC</td>
<td>Flight 1: 13.6 UTC Flight 2: 18.8 UTC</td>
</tr>
<tr>
<td>July 20</td>
<td>GCAS/HALO/B200</td>
<td>Small Raster 4x</td>
<td>Moderate North of NYC/CT Coast</td>
<td>Flight 1: 13.6 UTC Flight 2: 19.0 UTC</td>
</tr>
<tr>
<td>August 5</td>
<td>GCAS/HALO/B200</td>
<td>Small Raster 4x</td>
<td>Moderate throughout domain</td>
<td>Flight 1: 14.9 UTC Flight 2: 19.8 UTC</td>
</tr>
<tr>
<td>August 6</td>
<td>GCAS/HALO/B200</td>
<td>Small Raster 2x</td>
<td>USG through most domain</td>
<td>Flight 1: 14.0 UTC</td>
</tr>
<tr>
<td>August 15</td>
<td>GCAS/HALO/B200</td>
<td>Small Raster 4x</td>
<td>Clean</td>
<td>Flight 1: 13.6 UTC</td>
</tr>
<tr>
<td>August 16</td>
<td>GCAS/HALO/B200</td>
<td>Large Raster 1x</td>
<td>Moderate with some USG on CT Coast</td>
<td>Flight 1: 14.1 UTC Flight 2: 19.1 UTC</td>
</tr>
<tr>
<td>August 24</td>
<td>GCAS/HALO/B200</td>
<td>Small Raster 4x</td>
<td>Moderate in the region</td>
<td>Flight 1: 13.5 UTC Flight 2: 18.4 UTC</td>
</tr>
<tr>
<td>August 28</td>
<td>GCAS/HALO/B200</td>
<td>Large Raster 2x</td>
<td>Classic LIS event: USG levels w/ some unhealthy</td>
<td></td>
</tr>
<tr>
<td>August 29</td>
<td>GCAS/HALO/B200</td>
<td>Large Raster 2x</td>
<td>Classic LIS event: USG levels w/ some unhealthy</td>
<td></td>
</tr>
<tr>
<td>September 6</td>
<td>GCAS/GeoTASO/B200</td>
<td>Large Raster 2x</td>
<td>Classic LIS event: USG levels</td>
<td>Flight 1: 14.9 UTC Flight 2: 20.0 UTC</td>
</tr>
<tr>
<td>October 3</td>
<td>GCAS/GeoTASO/B200</td>
<td>Small Raster 4x</td>
<td>Clean</td>
<td>Flight 1: 14.9 UTC Flight 2: 20.0 UTC</td>
</tr>
<tr>
<td>October 19</td>
<td>GCAS/GeoTASO/B200</td>
<td>Small Raster 3x</td>
<td>Clean</td>
<td>Flight 2: 18.6 UTC</td>
</tr>
</tbody>
</table>
In 2018, we mapped 2-4x per day on 16 days with conditions ranging from clean air to unhealthy ozone events. These images show the early afternoon rasters of NO\textsubscript{2} (satellite overpass time).
NO$_2$ retrieval process:

Differential Slant Column (DSC) = SC - SC$_{\text{reference}}$

DSCs are already in the archive for science team use.

Stratospheric Slant Column (SC). I estimate from the Pratmo climatology (Prather, 1992; McLinden et al. 2000) plus a calculated stratospheric AMF (~ geometric).

Reference would be an offset. The maps shown yesterday and today assume a reference column of 0. (realistically > 0)

Air Mass Factor, or AMF, is the ratio of the mean path length light traveled through the atmosphere and the vertical path length. It is calculated with assistance from a radiative transfer model.

\[
\text{TropVC} = \frac{DSC - \text{stratospheric SC} + \text{reference}}{\text{AMF below}}
\]
AMFs are dependent on:

- Surface reflectivity: averaged MODIS BRDF MCD43A1 daily L3 500m v006 product
- Aerosols: Input from HALO during GCAS flights
- NO$_2$ profiles: relative distribution

Solar and viewing geometry are important! ...easy to calculate

12 km NAM CMAQ
4 km NOAA WRF-CHEM

AMFs $\downarrow$: dark surfaces; AMFs $\uparrow$: bright surfaces

I have a backup slide that shows the influence of model choice

AMFs $\downarrow$: NO$_2$ weighted near surface; AMFs $\uparrow$: less NO$_2$ near surface

Aerosols: Input from HALO during GCAS flights
Comparing Differential Slant Columns to Vertical Columns

Converting DSC to TropVC doesn’t change the spatial distribution of NO₂ but it does change the magnitude.

Red : DSC > TropVC
Blue : DSC < TropVC
GeoTASO/GCAS v. Pandora: Tropospheric Vertical Column Coincidence Criteria:

- Median GeoTASO/GCAS data within 1000 m from the site for each individual overpass (the distance assumption does not significantly alter results at least up to a 1 km radius)
- Closest in time Pandora coincidence (must be within 5 minutes of the overpass)
- Bars indicate the stddev of the data within the spatial/temporal constraints stated above [Spatiotemporal variability!]

Pandora spectrometers are used as a validation standard for airborne spectrometers and future/present satellite products

**Slope=1.13 (1.20)**  
**r^2 = 0.81 (0.87)**  
n= 170 (171)

100x10^{15} 10  
80 8  
60 6  
40 4  
20 2  
0 0  

AirP: Tropospheric Column (molecules cm^{-2})

Westport, CT  
Falk Pond, Long Island  
New Haven, CT  
Rutgers PAMS  
Bradford, CT  
CCNY  
Bronx  
Outer Island

Very well correlated with a 20% slope bias. Excluding the most polluted point still results in a 20% bias. Cause of this bias is still TBD.

Negative offset likely caused by uncertainty in the reference spectrum. Assume a reference amount from NOAA’s 4km WRF-Chem output: 1.4-3.0x10^{15} molecules cm^{-2}. The next round of the retrieval, I will be more strategic in my reference location (hoping for coincident Pandora data)

Using methodology from Judd et al., prepared for submission to AMT

All data shown is preliminary
Beware of Potential Artifacts:

Surface Features:
- Definitely in the DSCs!
- Don’t 100% disappear in this first attempt for a vertical column. Up for a discussion on which ones are real and which are artifact!

Potential Causes:
uncertainty in BRDF or NO\textsubscript{2} column

Sun glint: will need to work to characterize how this changes water albedo
Example from June 18\textsuperscript{th}, 2018 AM Flight

There could be more, but I haven’t stumbled across them yet. Let me know if any of you stumble across anything that looks erroneous after the TropVC release.

Note: these artifacts only show up when there is a decent amount of NO\textsubscript{2} in the column.

All data shown is preliminary
Next Steps:

Data Status

- L1b spectra are currently being processed at GSFC for the first post-campaign iteration.
- I will update DSCs and add preliminary vertical columns this summer for the science team to look at and use with the 12 km NAM-CMAQ a priori.
- Goal would be to have a fully processed vertical column NO$_2$ data public in Fall 2019.
  - Can easily do multiple iterations with different NO$_2$ profile input.

Data use in research

- Overview paper that would include sensitivity studies on a priori assumptions (e.g., model resolution, aerosols).
- TROPOMI Validation:
  - This data was collected in part for our participation in the Sentinel-5 Precursor Validation Team.
    - May be combined with overview paper.
- Integrated observations (ground, aircraft, satellite).
- Potential studies with the need for modeling collaborators:
  - Emission sector studies
  - Testing/Improving model abilities for recreating observed scenarios
  - Data assimilations and emission flux inversions to see influence on modeling air quality events.
- Excited to discuss additional collaborations with science team members.