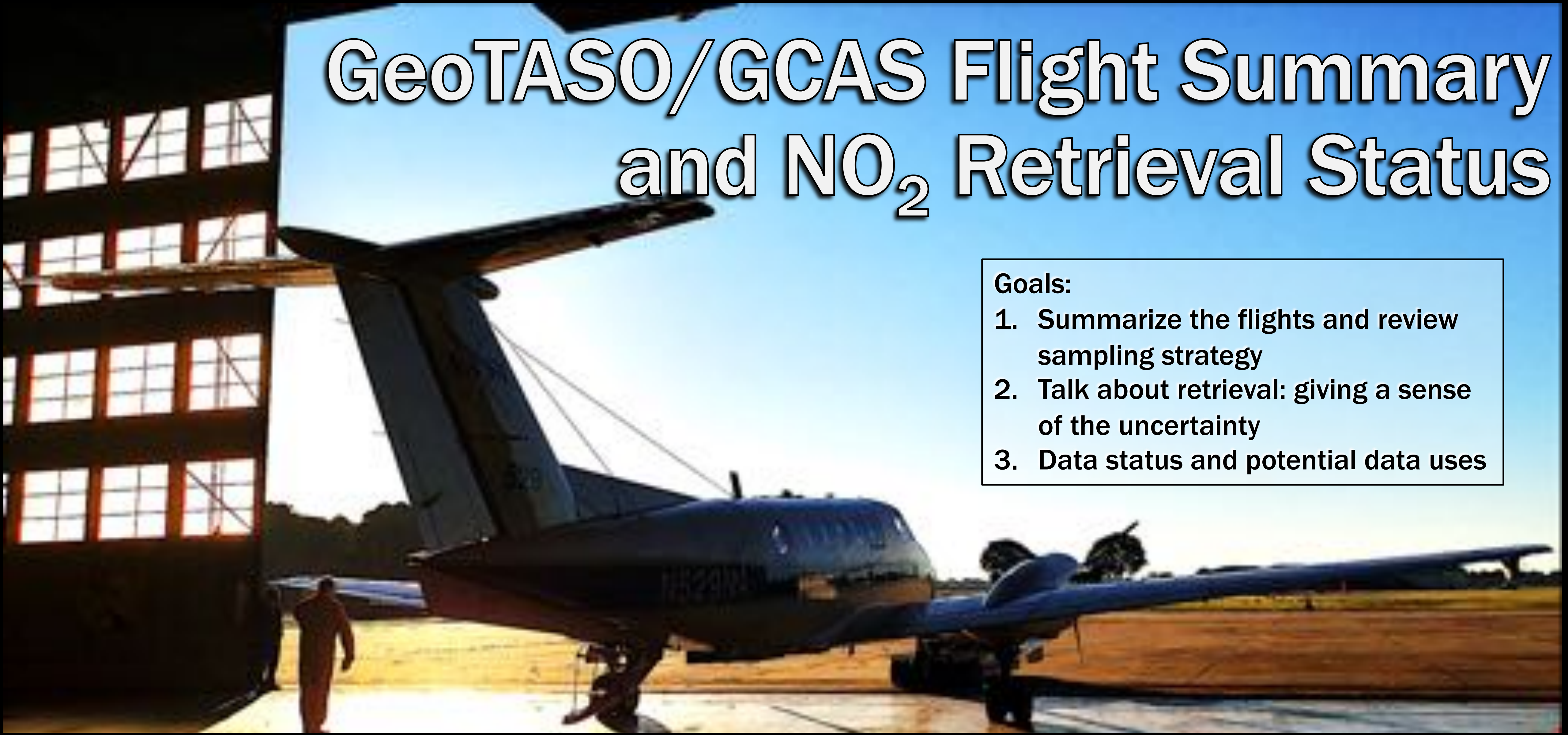
GeoTASO/GCAS Flight Summary and NO_2 Retrieval Status



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

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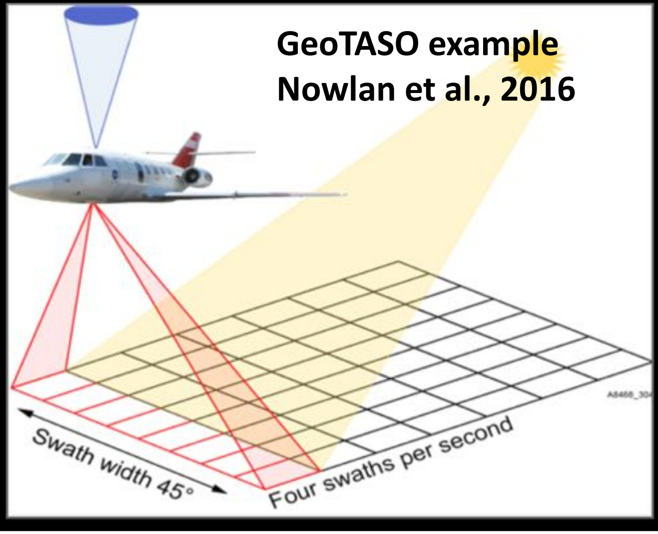
Airborne Mapping Spectrometers

GeoTASO

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

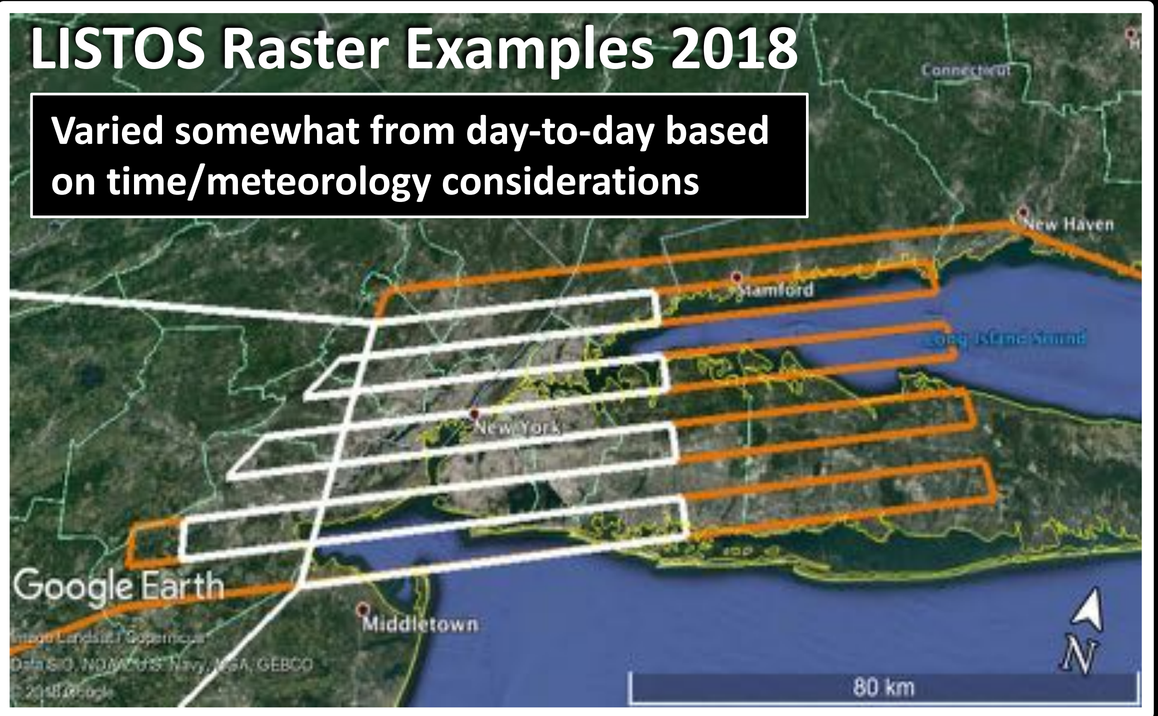
GCAS

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



Trace gas retrievals:
NO_2 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!

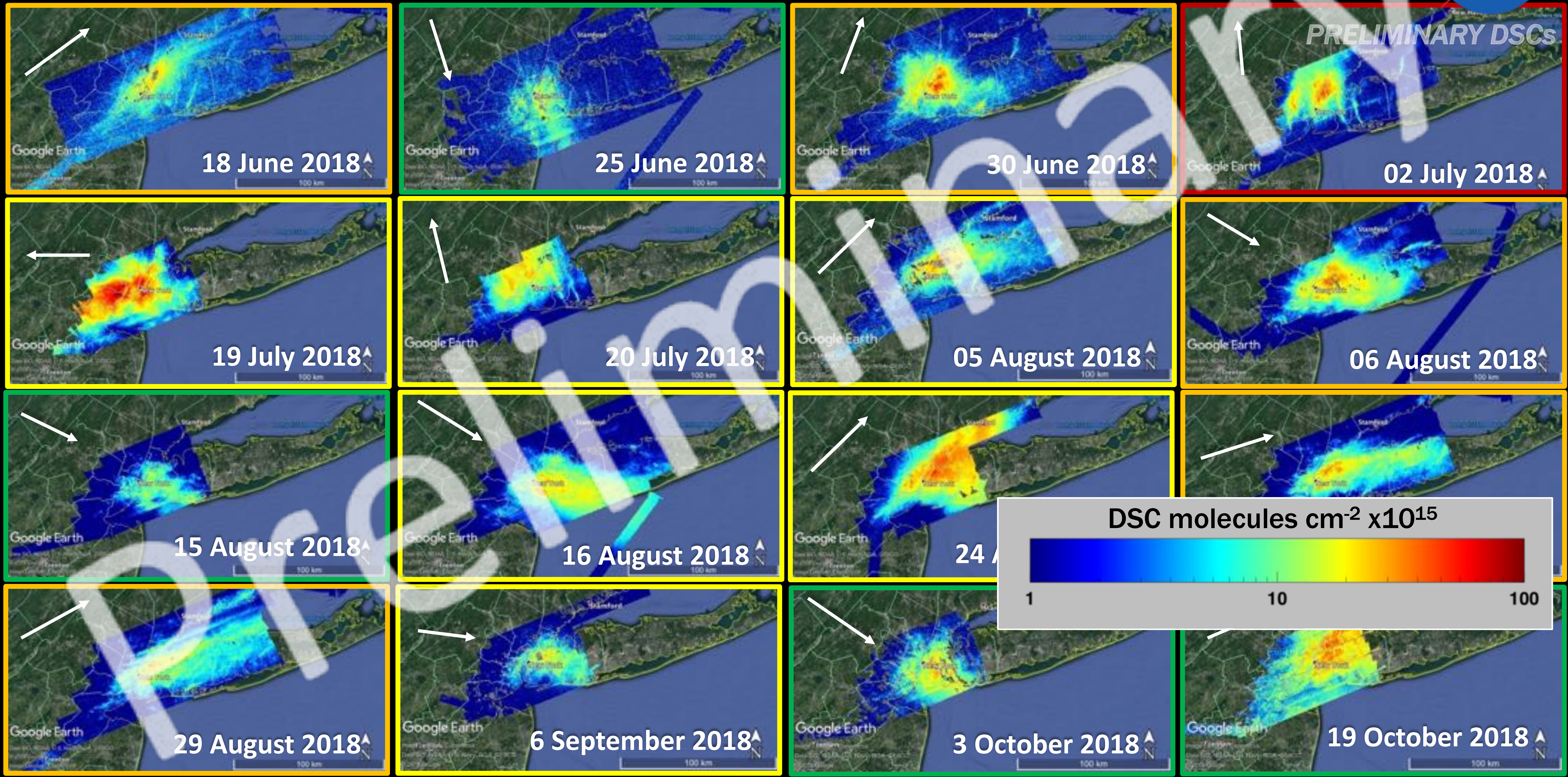
HCHO columns: Scott Janz will talk this later today



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

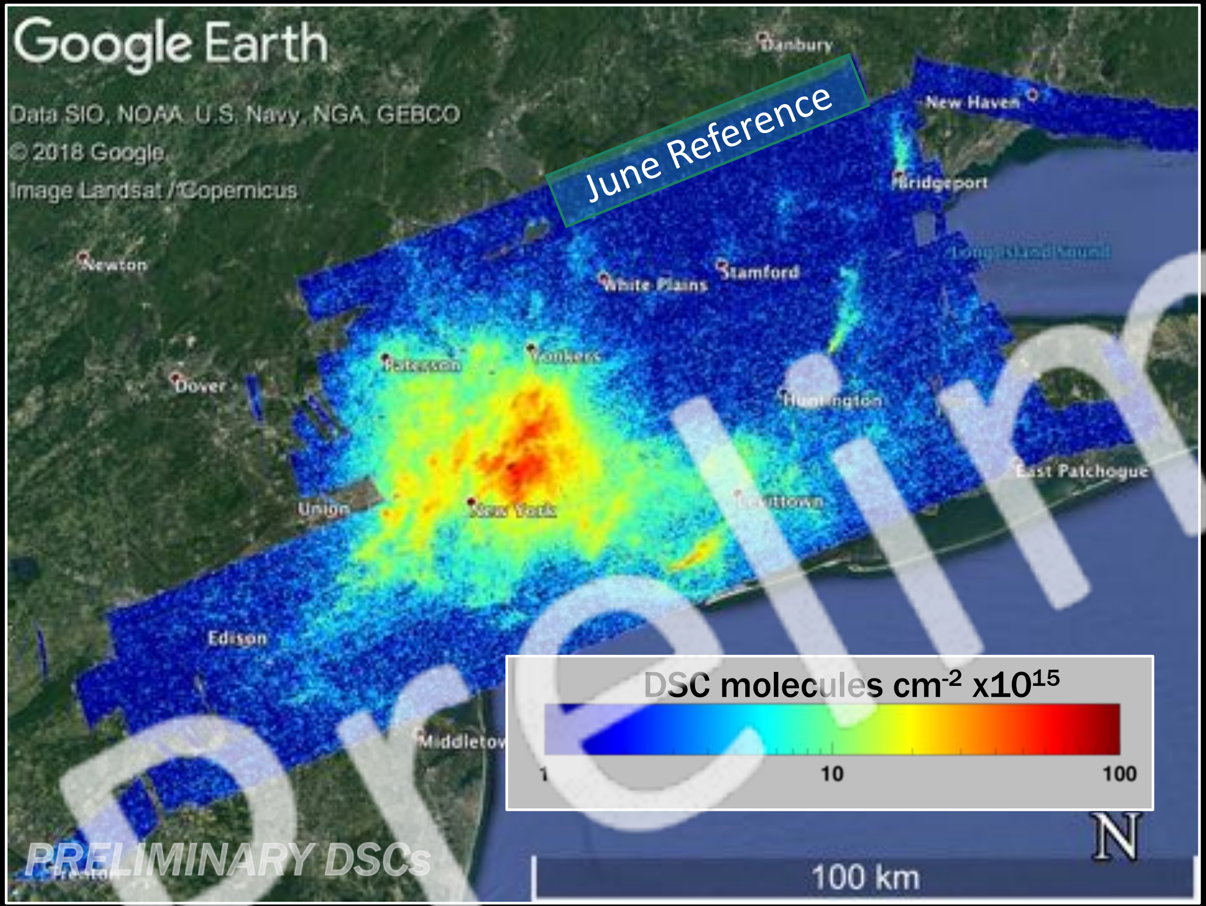
Flight Date (both AM/PM)	Instrument/Platform	Sampling Strategy	Air Quality Conditions (general patterns from AirNow.gov)	Raster Break (approximate)
June 18	GeoTASO/HU-25	Large Raster 2x	USG up I95 corridor	
June 25	GeoTASO/HU-25	Large Raster 2x	Clean-off shore flow	
June 30	GeoTASO/HU-25	Large Raster 2x	USG NYC: Stagnant to SW flow	
July 2	GCAS/HALO/B200	Large Raster 2x	Very Unhealthy north of NYC	
July 19	GCAS/HALO/B200	Small Raster 4x	Moderate NYC	Flight 1: 13.6 UTC Flight 2: 18.8 UTC
July 20	GCAS/HALO/B200	Small Raster 4x	Moderate North of NYC/CT Coast	Flight 1: 13.6 UTC Flight 2: 19.0 UTC
August 5	GCAS/HALO/B200	Small Raster 4x	Moderate throughout domain	Flight 1: 14.9 UTC Flight 2: 19.8 UTC
August 6	GCAS/HALO/B200	Small Raster 2x Large Raster 1x	USG through most domain	Flight 1: 14.0 UTC
August 15	GCAS/HALO/B200	Small Raster 4x	Clean	Flight 1: 13.6 UTC Flight 2: 19.1 UTC
August 16	GCAS/HALO/B200	Large Raster 1x	Moderate with some USG on CT Coast	
August 24	GCAS/HALO/B200	Small Raster 4x	Moderate in the region	Flight 1: 13.5 UTC Flight 2: 18.4 UTC
August 28	GCAS/HALO/B200	Large Raster 2x	Classic LIS event: USG levels w/ some unhealthy	
August 29	GCAS/HALO/B200	Large Raster 2x	Classic LIS event: USG levels w/ some unhealthy	
September 6	GCAS/HALO/B200	Large Raster 2x	Classic LIS event: USG levels	
October 3	GCAS/GeoTASO/B200	Small Raster 4x	Clean	Flight 1: 14.9 UTC Flight 2: 20.0 UTC
October 19	GCAS/GeoTASO/B200	Small Raster 3x	Clean	Flight 2: 18.6 UTC

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_2 (satellite overpass time).

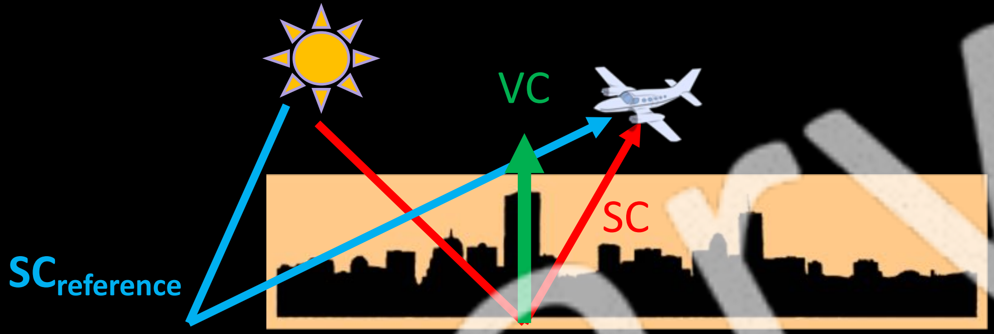


NO_2 retrieval process:

Differential Slant Column (DSC)= SC-$SC_{reference}$



June 30th, 2018 Saturday Afternoon: GeoTASO



$$TropVC = \frac{DSC - stratospheric\ SC + reference}{AMF\ below}$$

DSCs are already in the archive for science team use

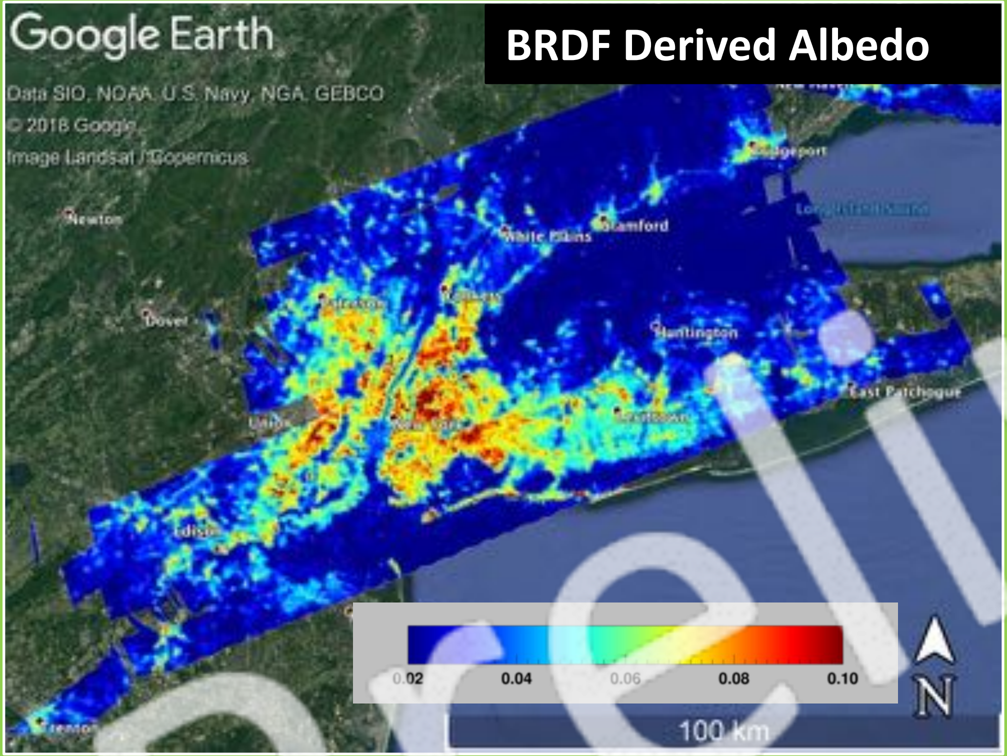
Stratospheric Slant Column (SC). I estimate from the Pratmo climatology (Prather, 1992; McLinden et al. 2000) plus a calculated stratospheric AMF (~ geometric)

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.

AMFs are dependent on:

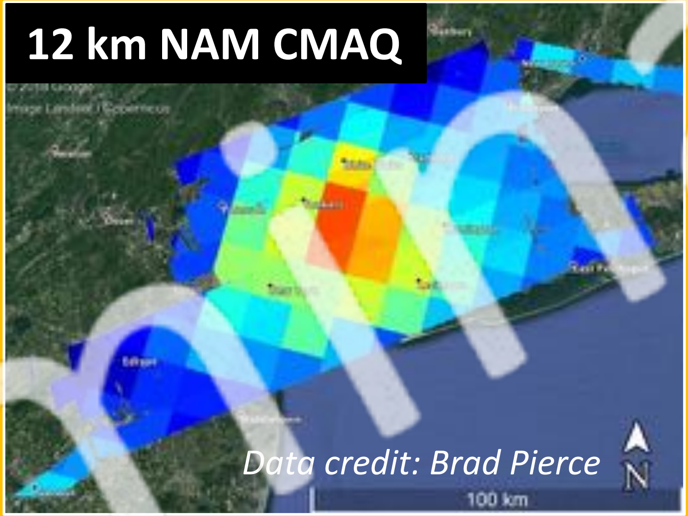
Surface reflectivity: averaged MODIS BRDF MCD43A1 daily L3 500m v006 product

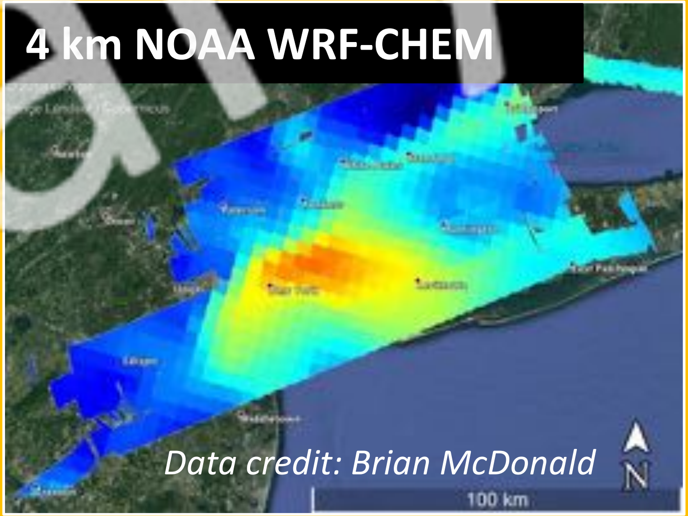


AMFs ↓: dark surfaces; AMFs ↑: bright surfaces

NO_2 profiles: relative distribution

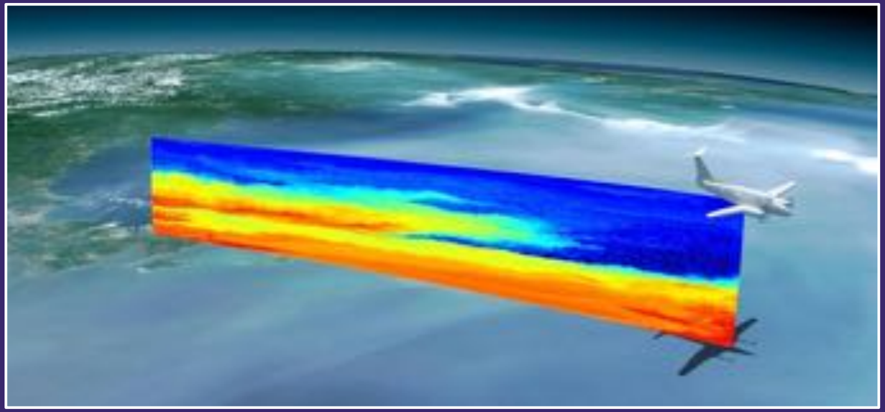
I have a backup slide that shows the influence of model choice





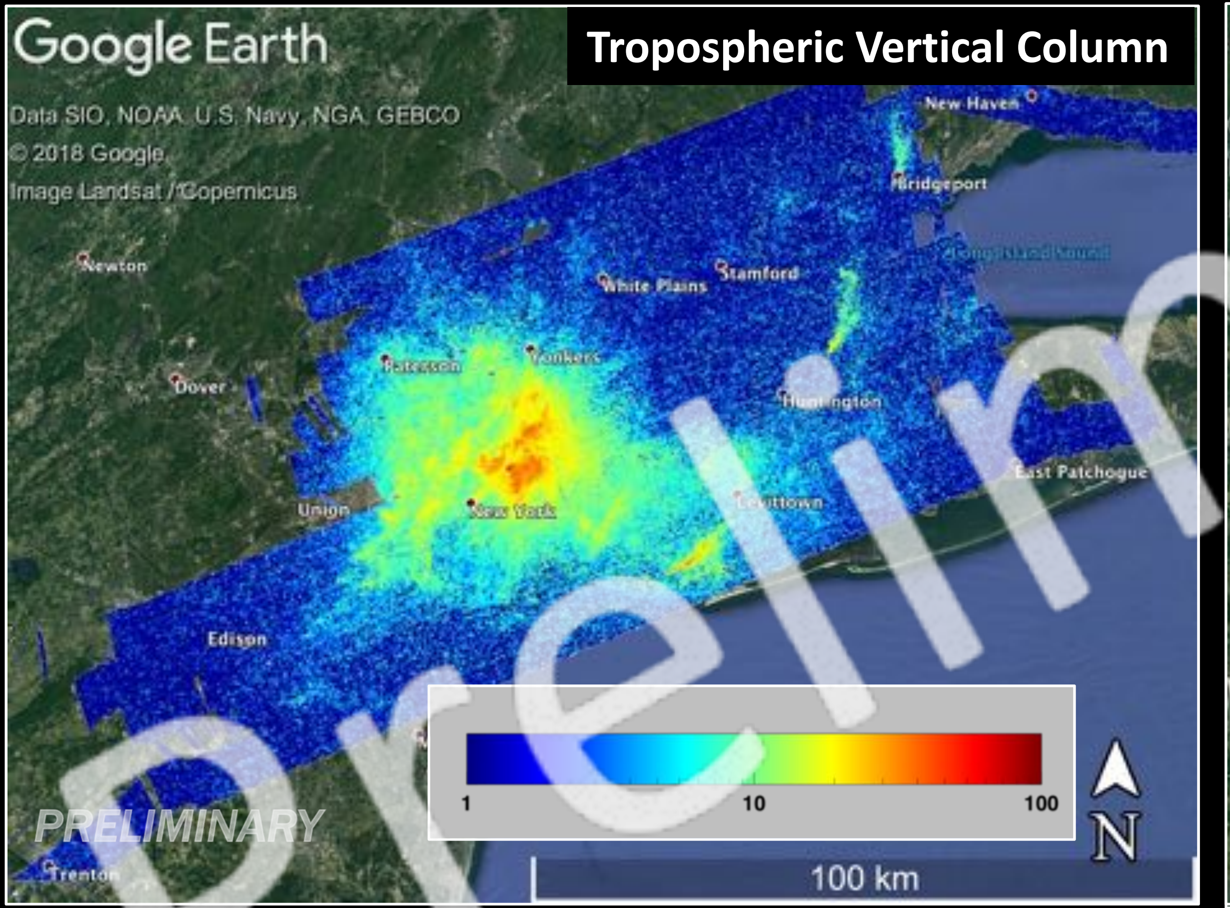
AMFs ↓: NO_2 weighted near surface; AMFs ↑: less NO_2 near surface

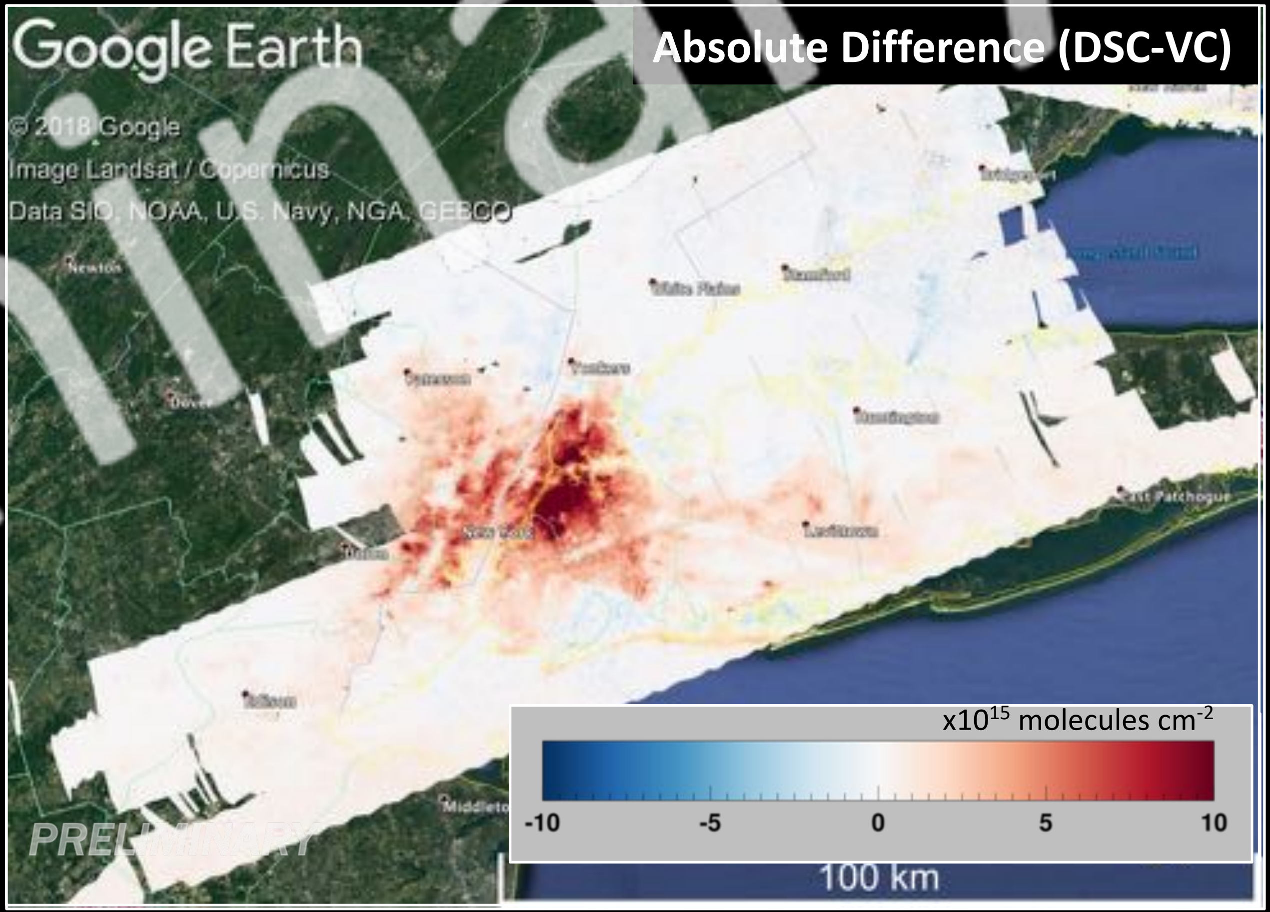
Aerosols: Input from HALO during GCAS flights



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

Comparing Differential Slant Columns to Vertical Columns



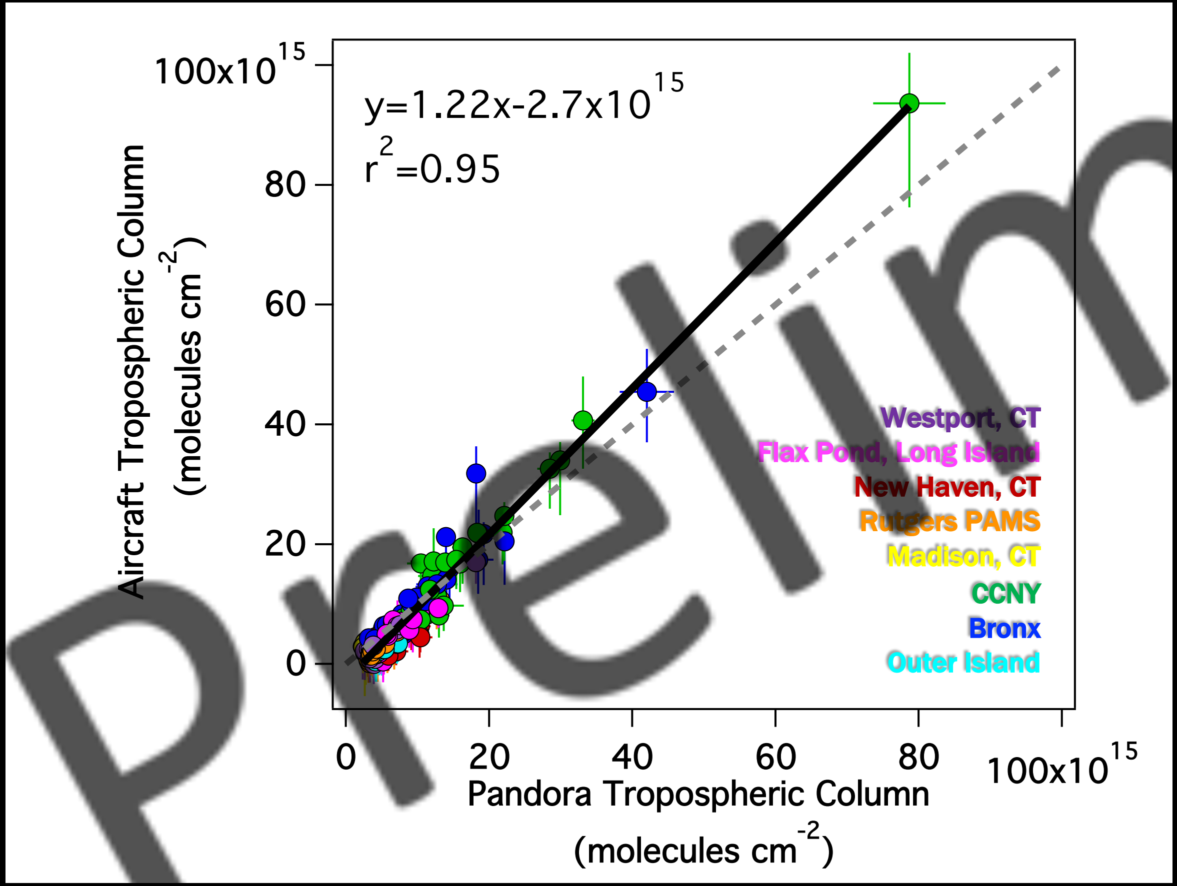


Converting DSC to TropVC doesn't change the spatial distribution of NO_2 but it does change the magnitude

Red : DSC > TropVC
Blue : DSC < TropVC

GeoTASO/GCAS v. Pandora: Tropospheric Vertical Column

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



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

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!]***

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: $1.4\text{-}3.0 \times 10^{15}$ molecules cm^{-2}. The next round of the retrievel, I will be more strategic in my reference location (hoping for coincident Pandora data)

All data shown is preliminary

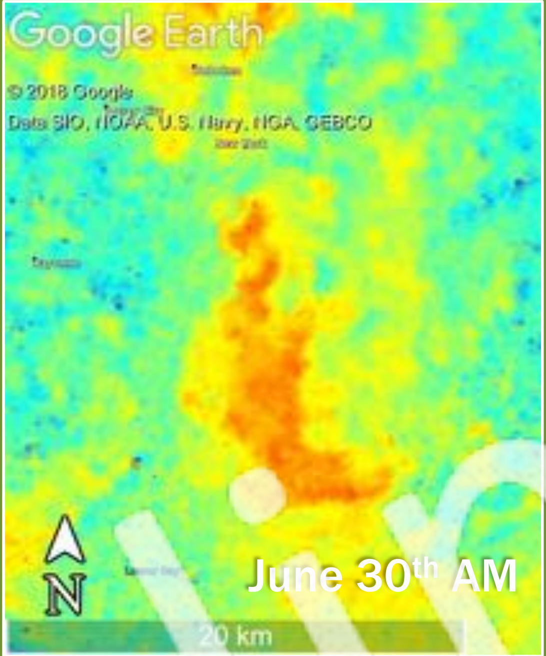
Beware of Potential Artifacts:

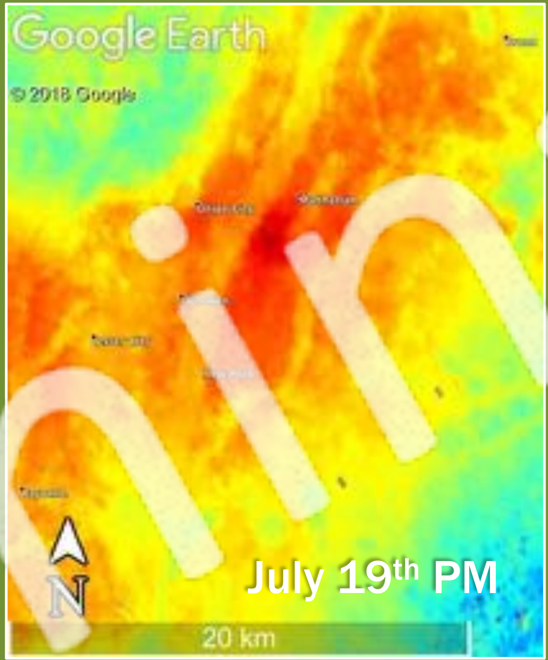
Note: these artifacts only show up when there is a decent amount of NO_2 in the column

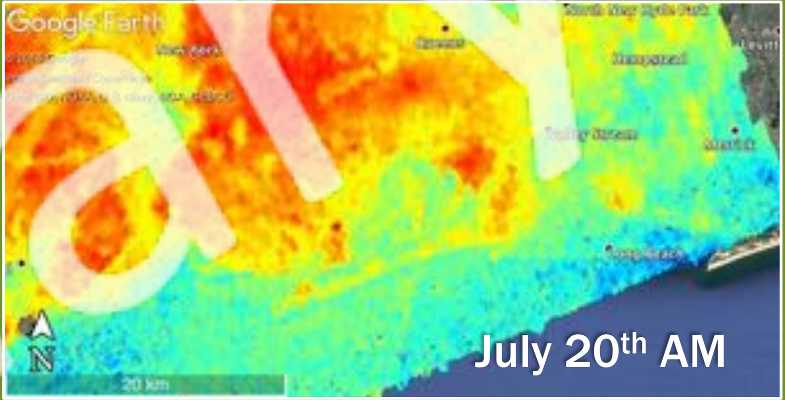
Surface Features:

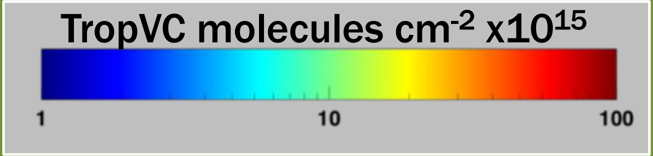
- Definitely in the DSCs!
- Don't 100% disappear in this first attempt for a vertical column. Up for a discussion on which ones are real and which are artifact!

Potential Causes: uncertainty in BRDF or NO_2 column



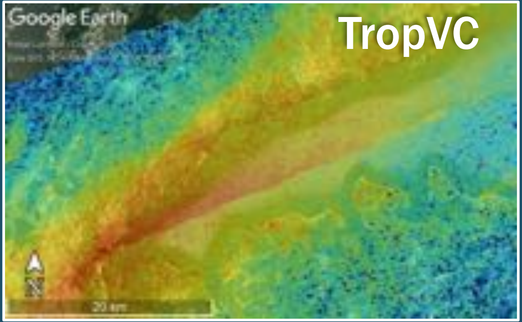






Sun glint: will need to work to characterize how this changes water albedo

Example from June 18th, 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.

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