THE GeoTASO PROJECT: AN AIRBORNE SPECTROMETER FOR ATMOSPHERIC AND SURFACE MEASUREMENTS SUPPORTING TEMPO

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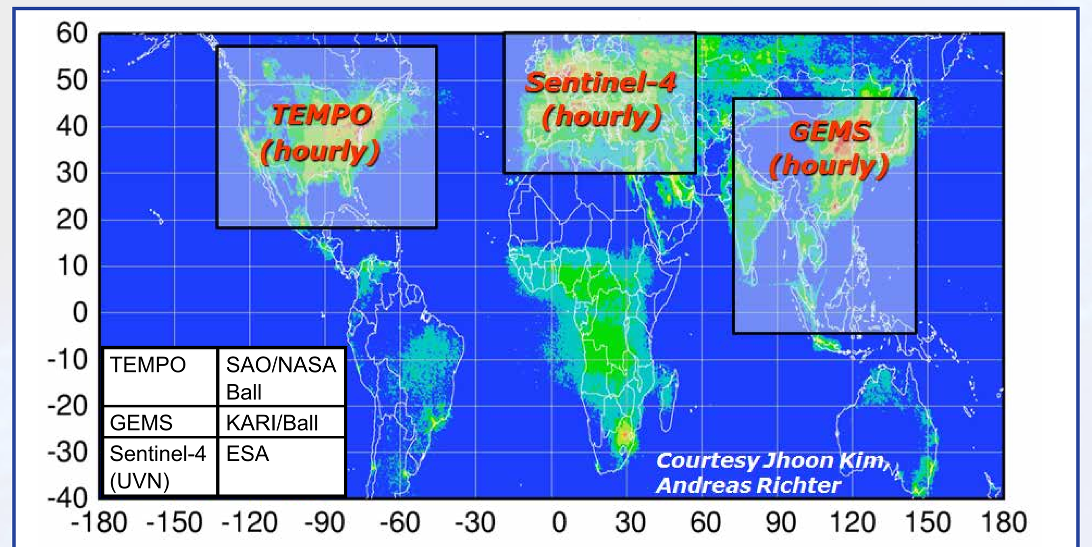
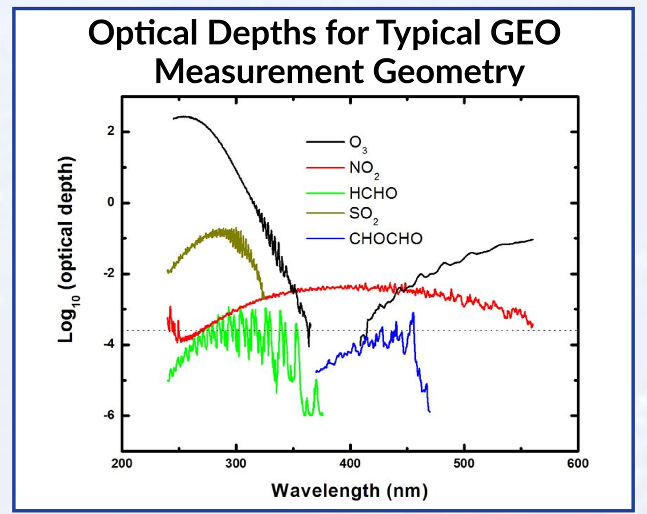
GeoTASO AND TEMPO/GEMS

- GeoTASO: Geostationary Trace gas and Aerosol Sensor Optimization
- Sensor and initial retrievals developed with NASA/ESTO funding
- Flight campaigns, data processing, and ongoing retrieval studies from GeoCAPE, TEMPO, and KORUS-AQ funds
- Supports the TEMPO mission that is:
  - A geostationary spectrometer for air quality monitoring
  - Part of a global constellation for air quality measurements
  - The first Earth Venture Instrument selected
  - Hosted on a commercial telecommunications platform
- The GeoTASO project
  - Advances TEMPO retrieval readiness through testing of trace gas and aerosol retrievals using high spectral and spatial resolution data
  - Fed into development of TEMPO and GEMS concepts and teams and successful proposals

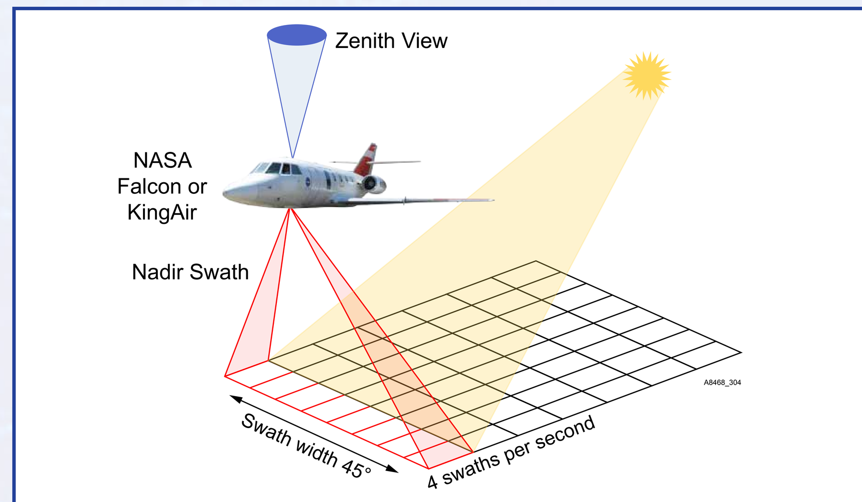


Global Constellation for Air Quality



TEMPO will measure pollutant gases and aerosols from a geostationary platform

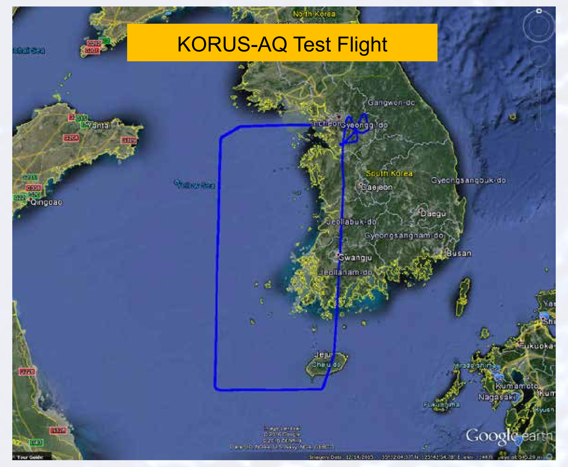
FLIGHT CAMPAIGNS



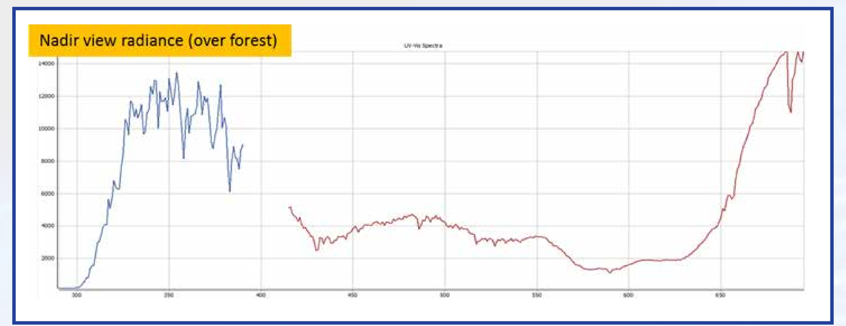
GeoTASO Observations

Parameter	Falcon	KingAir
Altitude	12 km	10 km
Swath width	10 km	8 km
Spatial resolution	40 m x 150 m (xtrack x flt track)	32 m x 80 m
Spatial sampling	10 m x 50 m	8 m x 25 m

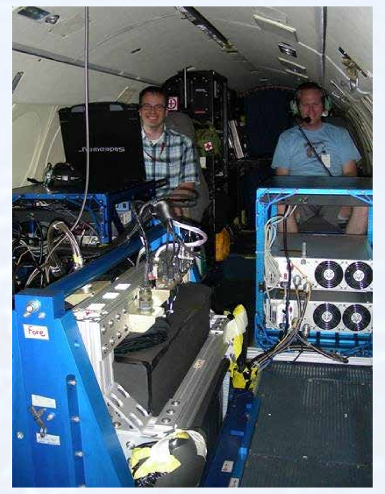
Campaign	Region	Dates	Notes
Test flights	Mid Atlantic coast	2013-2015	Flying out of Langley
Houston	Houston metro area and coast	Sep 2013	With DISCOVER-AQ
Denver	Denver metro area	Jul-Aug 2014	With DISCOVER-AQ
KORUS-AQ	Korean Peninsula	May-June 2016	Air quality and ocean color with Korean scientist



SENSOR FEATURES AND SPECTRAL PARAMETERS



Typical signal from the UV(blue) and Vis (red) channels on GeoTASO. Note that the normally bright middle of the spectrum is attenuated by a wavelength-selective filter to avoid saturation.



Operating features

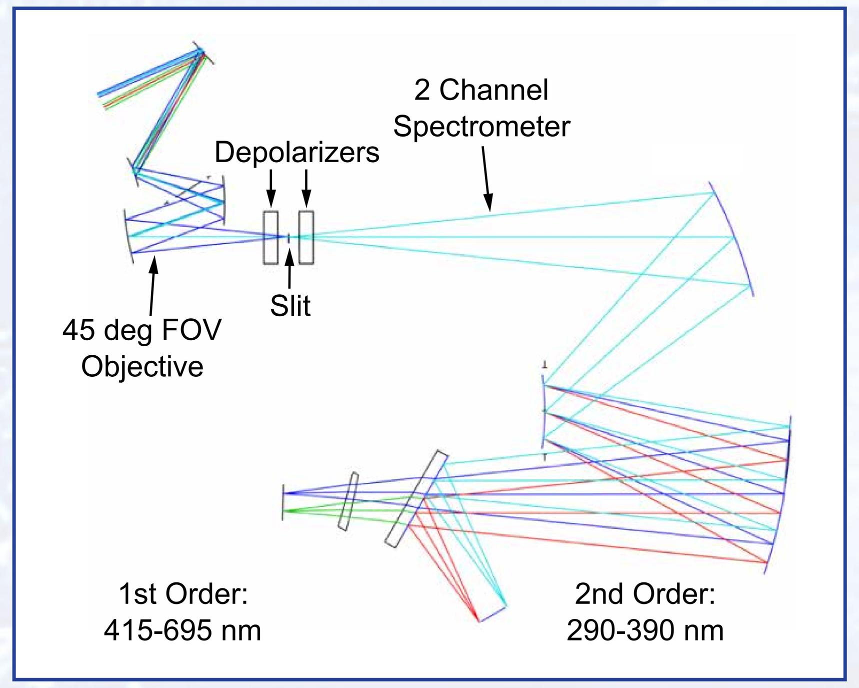
- Mounted inside airplane cabin with nadir view through a window
- Selectable zenith view through fiber optic
- Applanix IMU on bench for geolocation information
- Field-swappable spectrometer entrance slit changes spectral resolution

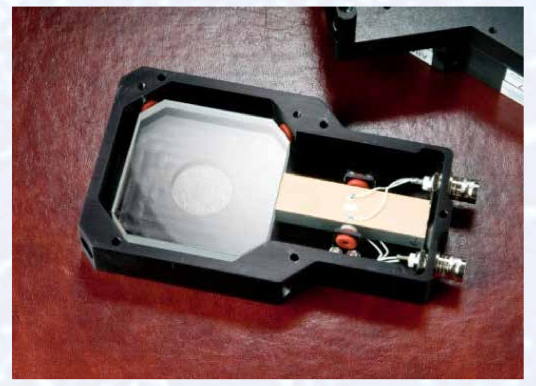
Channel	Spectral Dispersion	Spectral Resolution	Spectral Range
UV	0.14 nm/pixel	0.35 - 0.49	290 - 390 nm
Vis	0.28 nm/pixel	0.7 - 0.98	415 - 695 nm

GeoTASO MULTI-ORDER OFFNER SPECTROMETER

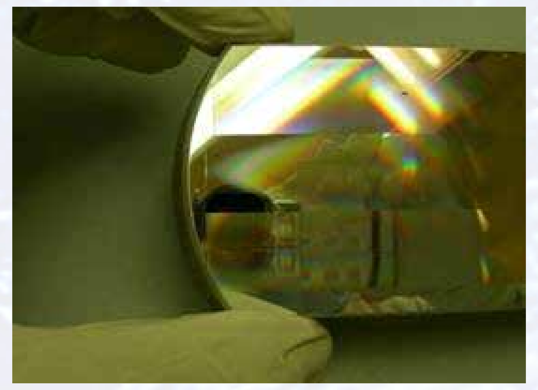
- Instrument
  - Single telescope with Photo-Elastic Modulator based depolarizer (from PolZero ACT)
  - Single spectrometer
  - Cooled full frame transfer CCDs for separate UV and Vis channels
- Spectrometer
  - Multiple diffraction orders from grating
  - Dichroic split of two spectral ranges
- Compact form and spectral separation/filtering are key features

Overlapping Diffraction Orders Keep Spectrometer Small

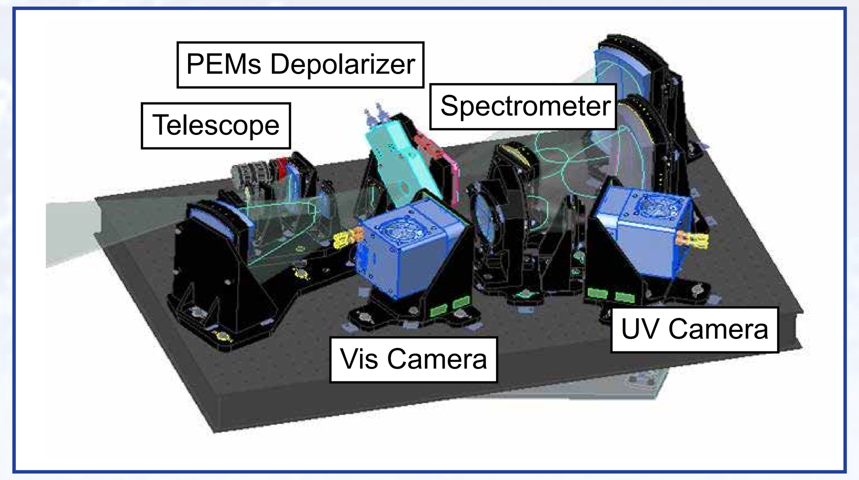




Time-domain depolarizer from PolZero ACT



Ruled convex grating used 4 panels with fixed blaze angles



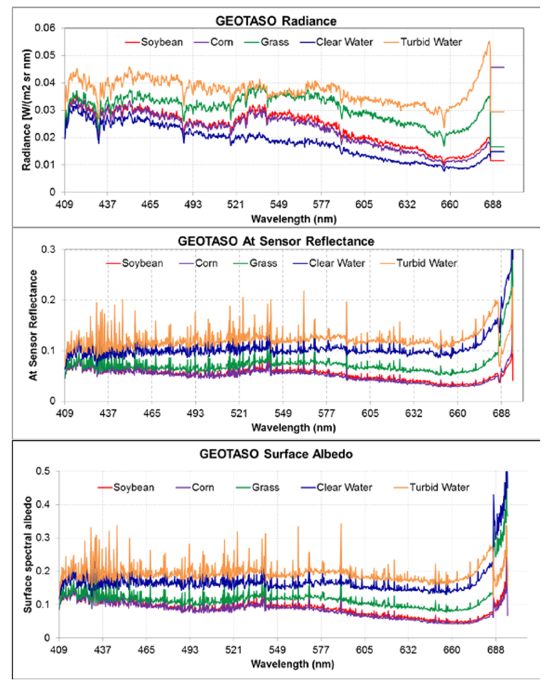
SENSOR CALIBRATION AND L1b DATA PROCESSING

- Calibration:
  - Spectral radiance calibration uses calibrated integrating sphere as radiometric reference
  - Removal of out-of-band stray light from sphere part of calibration process
- All image data processing includes:
  - Conversion to spectral radiance using calibration coefficients
  - Removal of estimated out-of-field and out-of-band stray light
  - Geolocation from timestamped IMU data and simple DEM

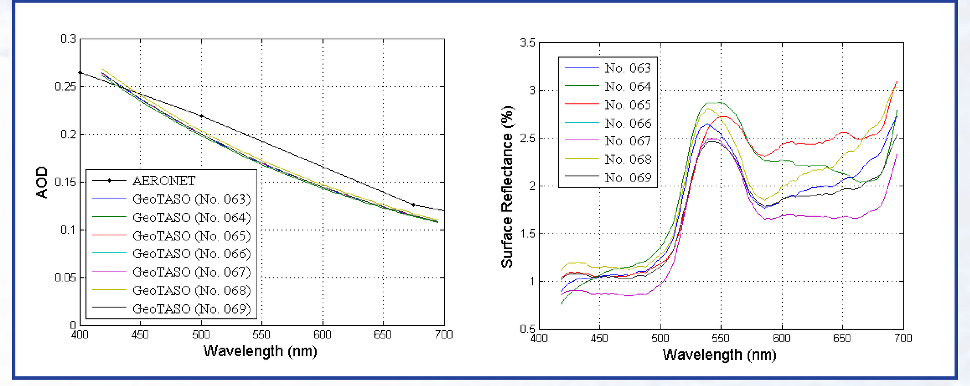
For further information, contact Scott Janz: scott.j.janz@nasa.gov

SURFACE MEASUREMENTS

Wasit Wulamu and Jack Fishman (St. Louis University) study plant spectral signatures, looking for ways to identify and quantify stressed or ozone-damaged plants. Their spectral studies in test fields use GeoTASO data to develop and validate remote sensing techniques to measure these effects from air- or space-based platforms.

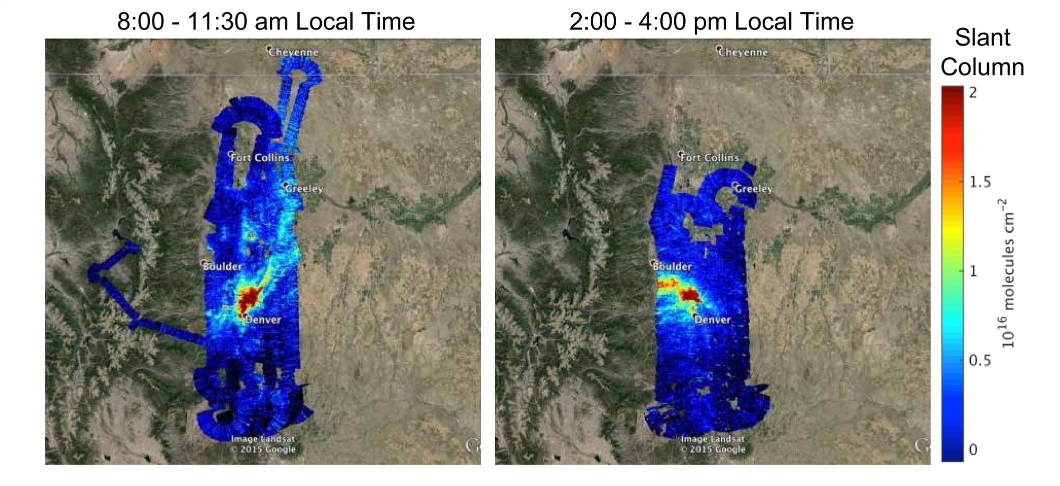


Jun Wang and Weizhen How (U Nebraska) derive surface spectral properties as part of their aerosol retrieval work. Accurate surface characterization is needed to distinguish the aerosol signature from surface reflectance.

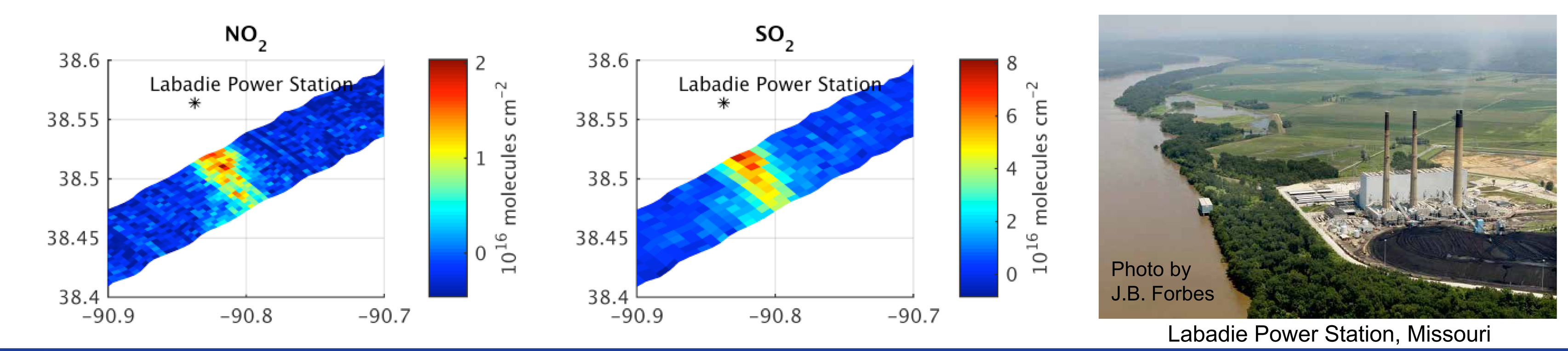


Retrieved AOD and Surface Reflectance

ATMOSPHERIC MEASUREMENTS



Caroline Nowlan (Harvard/SAO) uses GeoTASO Vis channel data in the 420-465 nm spectral window to measure the amount of NO2 in the air. Pollution sources and redistribution by surface flow are seen in the maps of NO2 over the Denver metro area.



GeoTASO UV channel data are used to show SO2 column amounts downwind from a coal-fired power plant in Missouri

DATA ARCHIVE

Level 1B data from all GeoTASO flight campaigns are stored on the NASA Langley Data Archive. The processed flight data are broken into 20 minute "chunks" of about 500 MB size and are in the he5 data format. For access to the data, contact Jay al Saadi at NASA/Langley (j.a.al-saadi@nasa.gov)

GeoTASO Level 1B Data Sets on the NASA/LaRC DAAC

Data Set	Dates	Total Flight Days	Flags/Notes
Houston	9/12/2013 – 9/24/2013	7	UV channel light leak Select sample data
Denver	7/24/2014 – 8/13/2014	13	All flights
Test Flights/Ocean	7/2013 – 7/2015	8	Flights thru 2014
Korea	4/28/2016 – 6/2016	??	Coming soon

References:

Kelly Chance, Xiong Liu, Raid M. Suleiman, David E. Flittner, Jassim Al-Saadi, Scott J. Janz, "Tropospheric emissions: Monitoring of pollution (TEMPO)," Proceedings of SPIE, Vol. 8866, 'Earth Observing Systems XVIII, 88660D (September 23, 2013),' San Diego, CA, USA, Aug. 25, 2013

Jun Wang, Weizhen Hou, Xiaoguang Xu, An algorithm for simultaneous inversion of aerosol properties and surface reflectance from hyperspectral remote sensing data, 2015 HyspIRI Science Workshop, 13-15 Oct 2015, Pasadena, CA.

Wasit Wulamu et al, Characterizing bidirectional reflectance and spectral albedo of various land cover types using GeoTASO data, 2016, to be submitted.

C.R. Nowlan et al., Nitrogen dioxide observations from the GeoTASO airborne instrument: Retrieval algorithm and measurements during DISCOVER-AQ Texas 2013, AMT, accepted for publication.

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