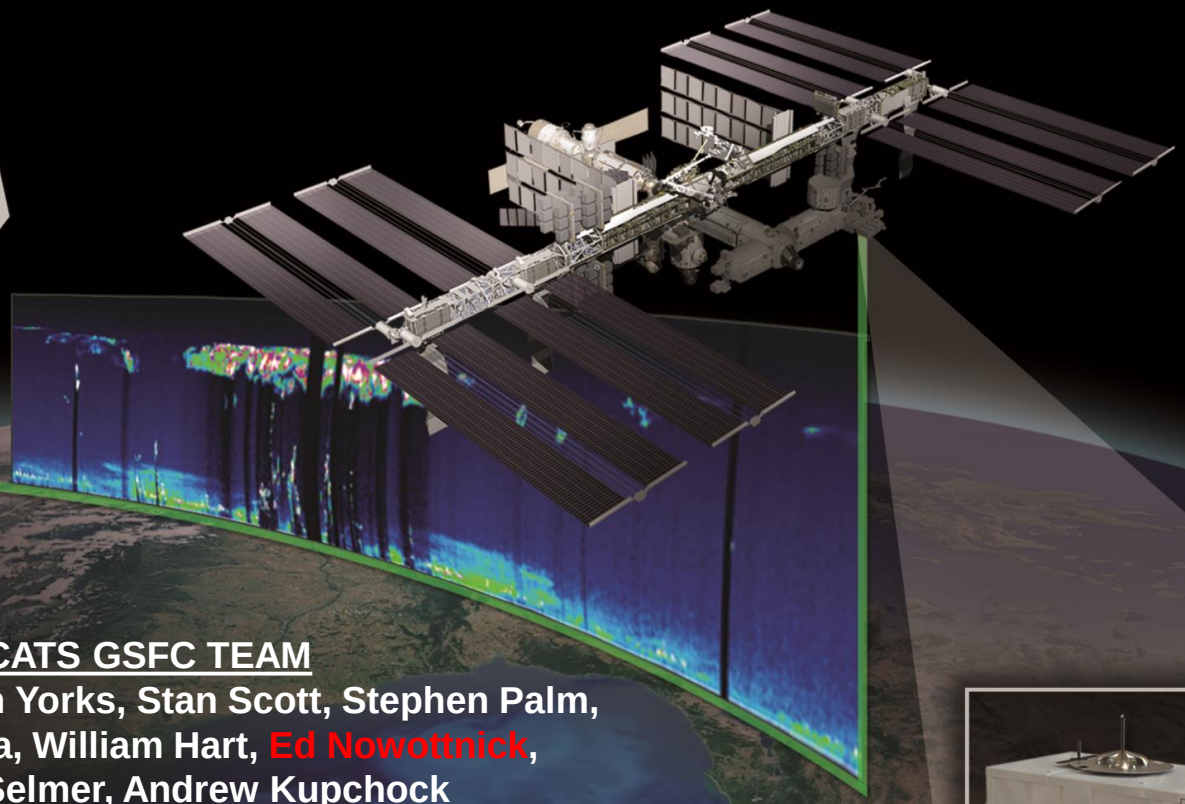
The Cloud-Aerosol Transport System (CATS)



CATS GSFC TEAM

Matt McGill, John Yorks, Stan Scott, Stephen Palm, Dennis Hlavka, William Hart, Ed Nowottnick, Patrick Selmer, Andrew Kupchock

CATS LaRC Team

Chip Trepte, Mark Vaughan, Sharon Rodier, Tim Murray, Mike Jensen

NASA GEOS-5 Collaborators

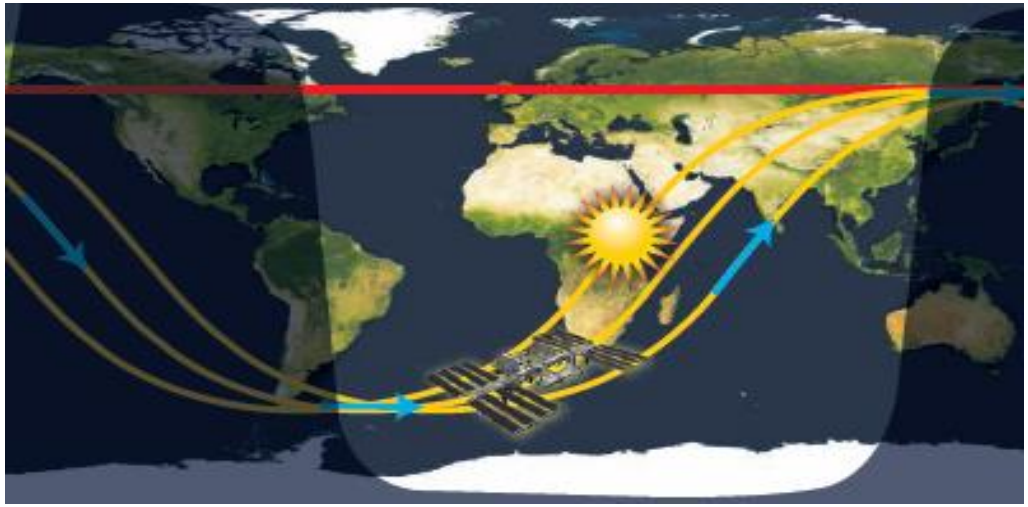
Peter Colarco, Arlindo da Silva, Virginie Buchard-Marchant

What is CATS?

- **CATS is a lidar built at NASA GSFC designed for use on the International Space Station (ISS)**
  - **CATS is not a typical NASA satellite mission**
    - ***NOT*** a flight mission – it is an attached payload launched as cargo
    - ***NOT*** driven by science measurements/requirements
    - Build-to-cost/build-to-schedule
  - **Intended to operate on-orbit for at least 6 months, up to 3 years**
  - **Designed for in-space technology demonstration for future satellite missions and build-to-cost project development**
    - Designed to operate in 1 of 3 main science modes to meet mission goals
      - CALIPSO-like multi-beam mode
      - High Spectral Resolution Lidar (HSRL) mode
      - UV (355 nm) technology demonstration mode

ISS Utilization

- ISS provides a low-cost platform for earth science capabilities
- CATS installed on the Japanese Experiment Module – Exposed Facility (JEM-EF)
- Orbit is a 51º inclination orbit at an altitude of about 405 km
  - Comprehensive coverage of tropics and mid-latitudes
  - Permits study of diurnal changes in clouds/aerosols

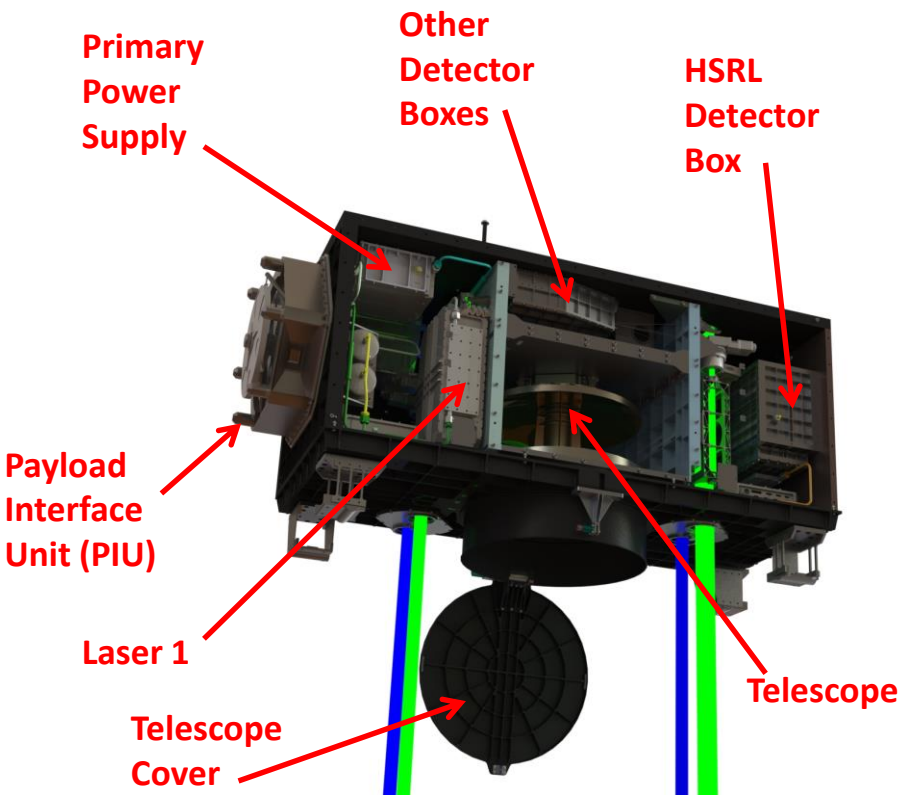


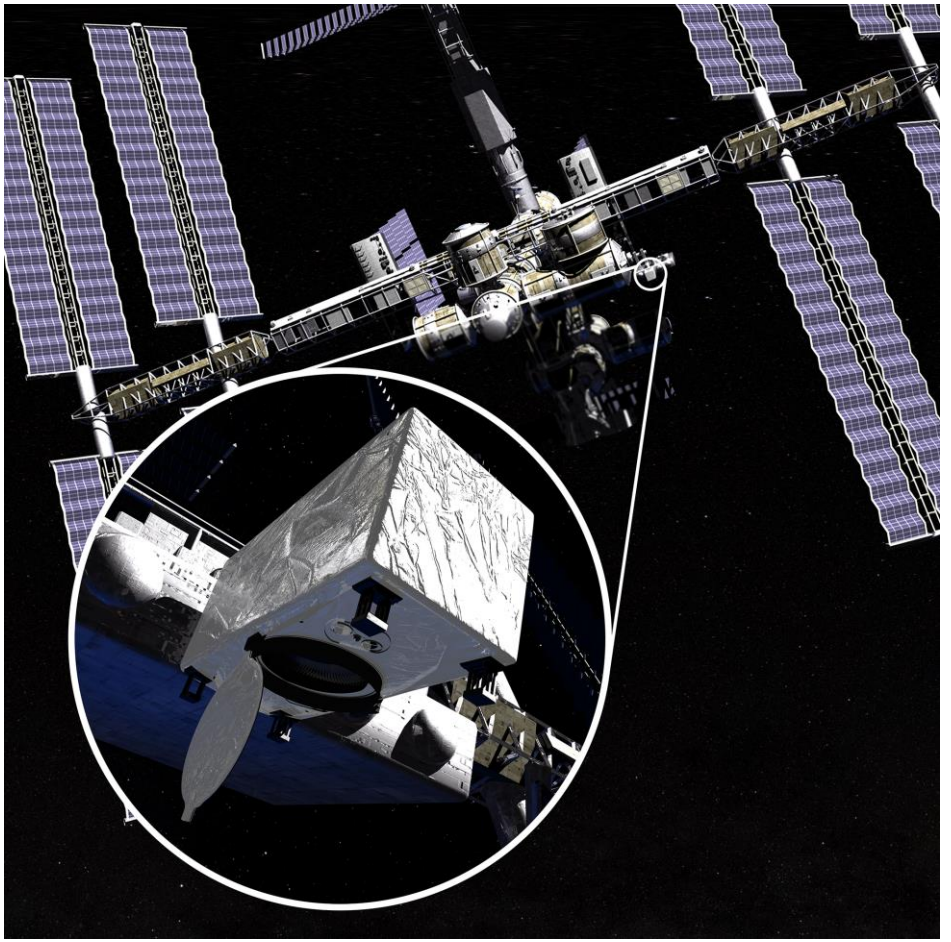
Japanese Experiment Module-Exposed Facility (JEM-EF) on the International Space Station (ISS)

ISS021E030638

CATS Instrument

- CATS employs 2 high repetition rate lasers
  - One operates at 532, 1064 nm
  - Second is seeded to provide narrow linewidth for HSRL measurements and frequency-tripled for use at 355 nm
- CATS has a 60 cm beryllium telescope with narrow field-of-view (FOV)
  - 4 instantaneous fields of view (IFOV)
  - 0.5 degree off-nadir view angle





Science Goals

1. Extend global climate record of lidar data

2006 — 2014 — 2015 — 2020s

2006

CALIPSO

Launched 2006

Using 2nd laser since 2009 (~2.5 year life)

2014

Bridge data gap between CALIPSO/EarthCARE

2015

EARTHCARE

HSRL likely to launch in 2017?

2020s

ACE

Space-based mission launch 2020s

2014

C A T S

Launch early 2015
6 month requirement
3 year goal

Science Goals

2. <u>Technology demonstration for future space-based lidar missions</u>

- Demonstrate HSRL retrievals and 355 nm data for future mission development
- Laser Technology Demo: high repetition rate, injection seeding (HSRL), and wavelength tripling (355 nm)

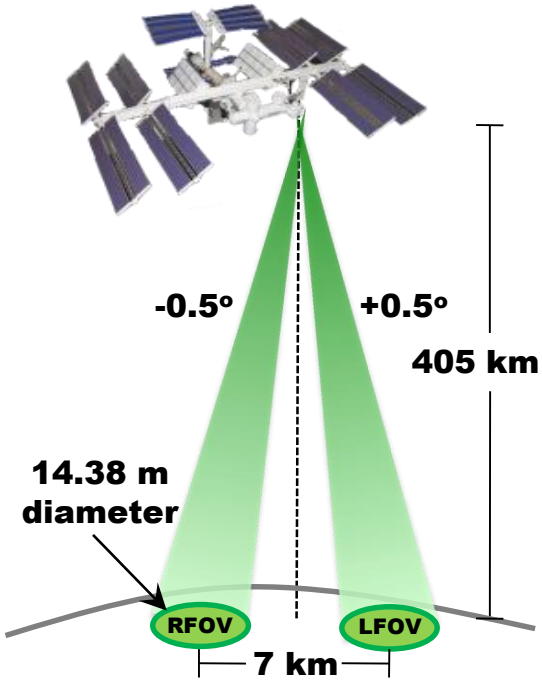
3. <u>Improve operational aerosol forecasting programs and observations of aerosol type</u>

- Provide near-real-time cloud/aerosol data
  - Improve strategic and hazard warning capabilities in near-real-time (dust storms, volcanic eruptions)
  - Data assimilation (within 6 hours)
- Utilize CATS science modes for enhanced aerosol typing

Planned Modes of Operation

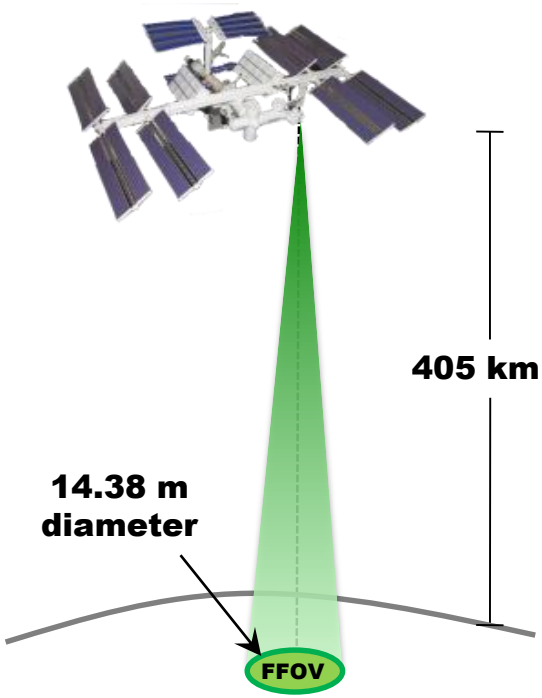
Mode 1: Multi-Beam

Backscatter: 532, 1064 nm
No HSRL
Depolarization: 532, 1064 nm



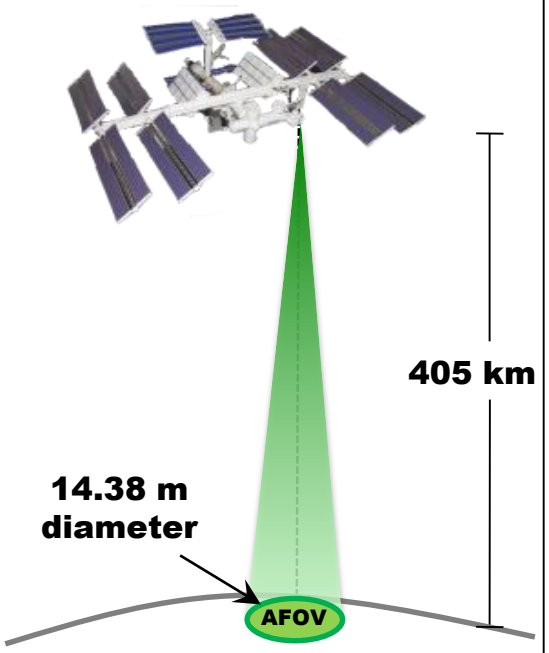
Mode 2: HSRL Demo

Backscatter: 532, 1064 nm
HSRL: 532 nm
Depolarization: 1064 nm

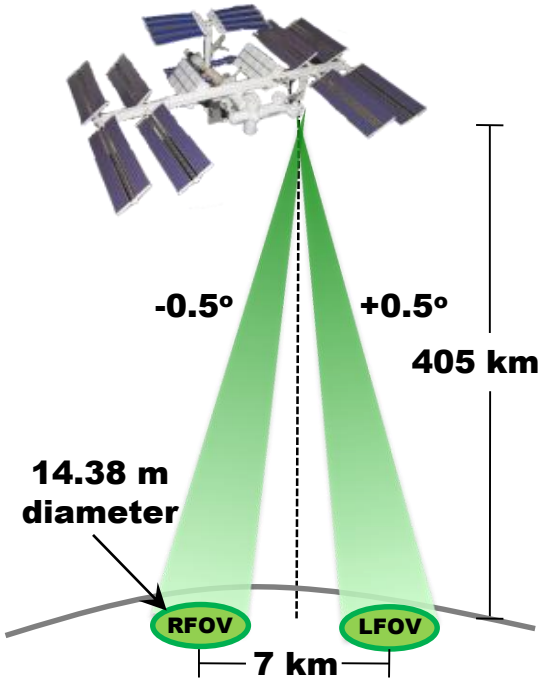
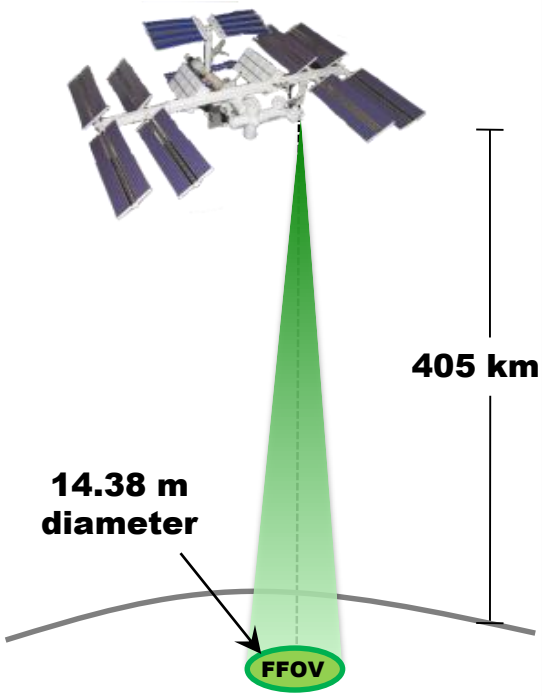
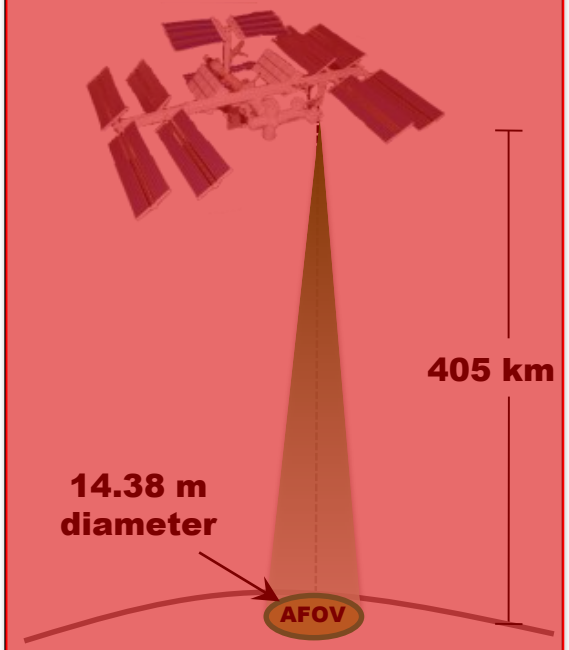


Mode 3: UV Demo

Backscatter: 355, 532, 1064 nm
No HSRL
Depolarization: 532, 1064 nm



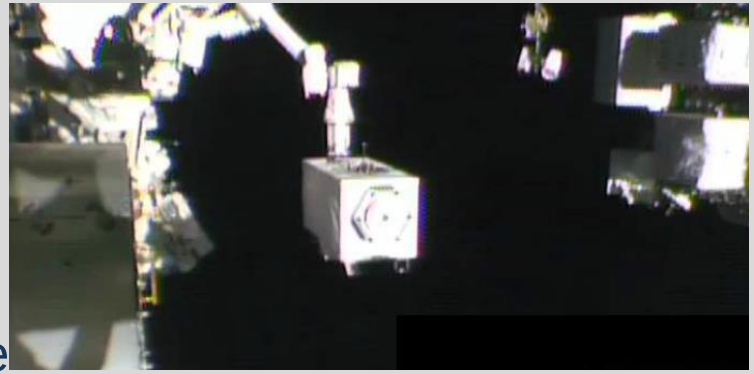
CATS Modes of Operation

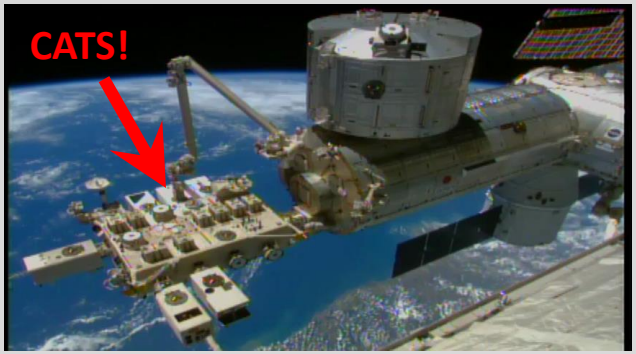
Mode 1: Multi-Beam	Mode 2: HSRL Demo	Mode 3: UV Demo
Backscatter: 532, 1064 nm No HSRL Depolarization: 532, 1064 nm	Backscatter: 532, 1064 nm ~~HSRL: 532 nm~~ Depolarization: 1064 nm	Backscatter: 355, 532, 1064 nm No HSRL Depolarization: 532, 1064 nm
		
Semi-continuous operation: Feb. 10 – Mar. 21 Failure: under investigation	Semi-continuous operation: Mar. 25 – Present Future Mode of Operation	Failure in laser optics No data available

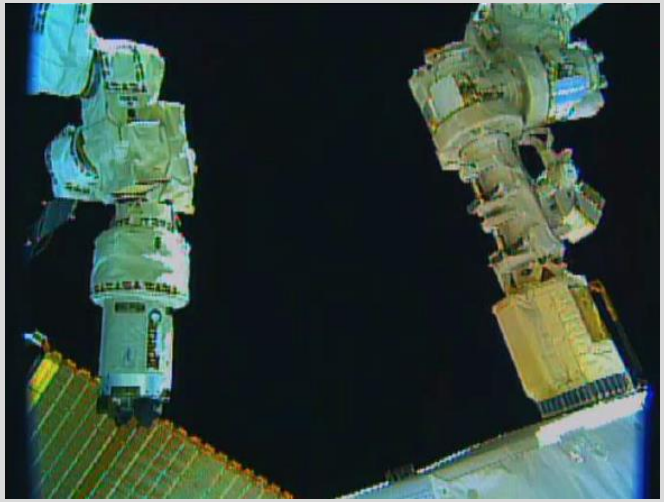
CATS Timeline

What's happened:

Jan 10: CATS launched on SpaceX5
Jan 22: Installed to JEM-EF
Feb 5: "First light" with laser 1
Feb 10: First continuous 24-hr operation
Mar 25: Began laser 2 operations
Jun 12: First browse images on CATS website
Jun 12: First L1B files available (Mode 1)
*Laser 1: over 13 billion shots, 730+ hours
*Laser 2: over 14 billion shots, 800 hours



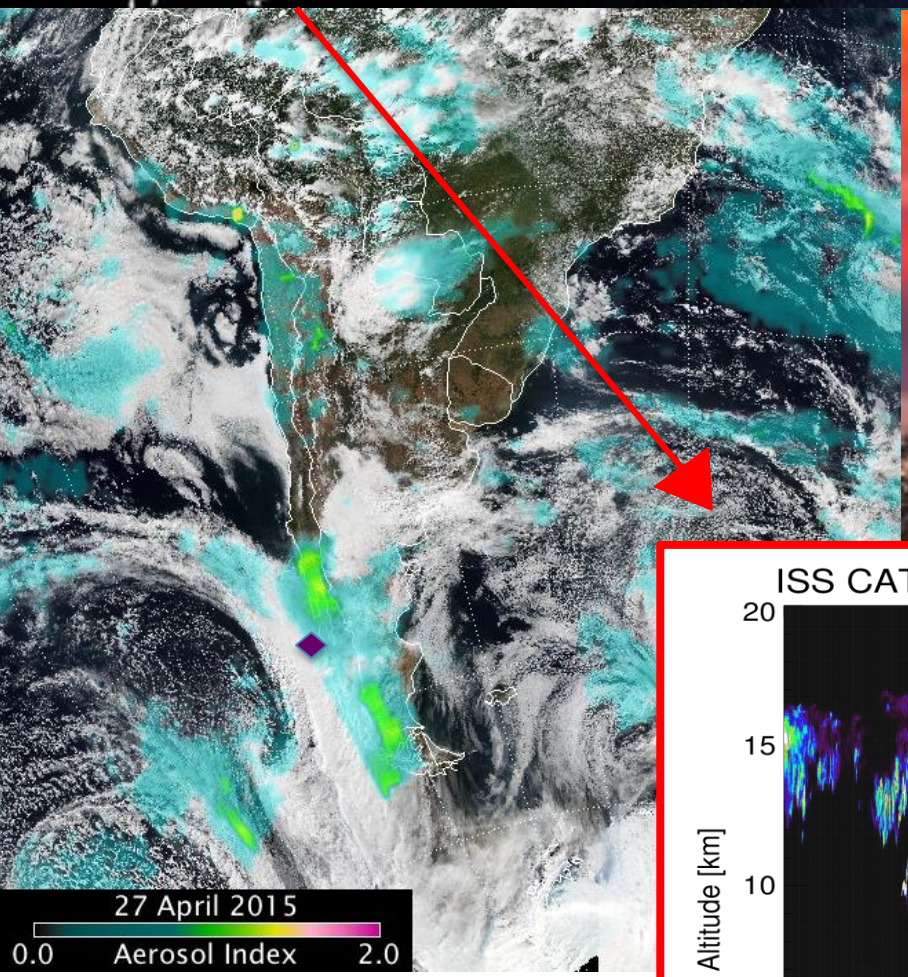


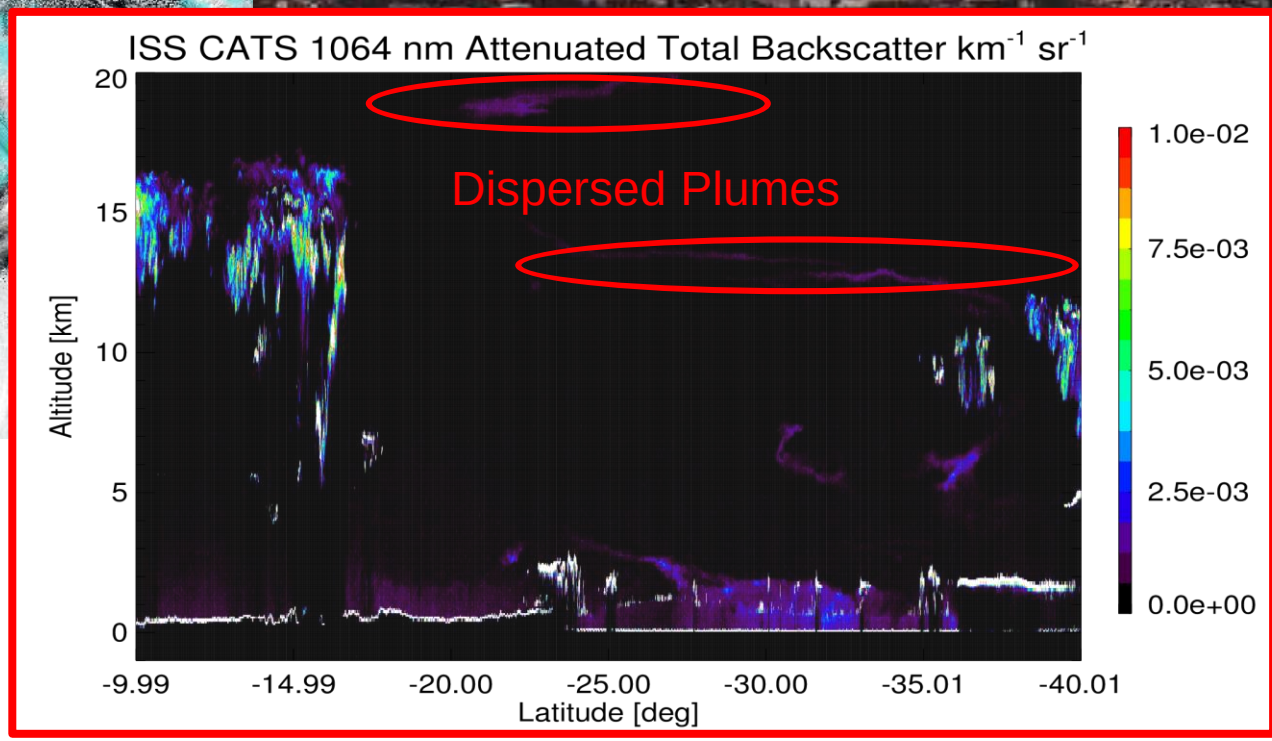


What's next:

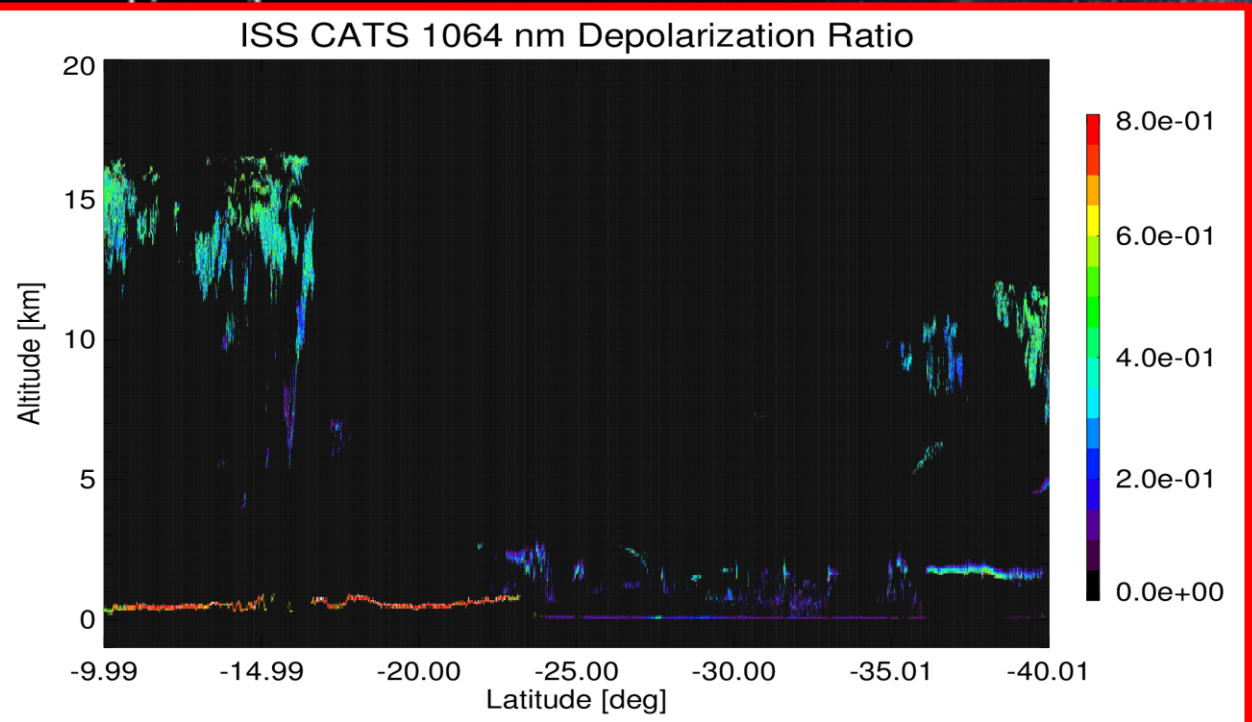
Jul 1: Begin outputting near real time (NRT) files (Mode 2)
Mid Summer: Release Mode 1 Level 2 and Mode 2 L1b data

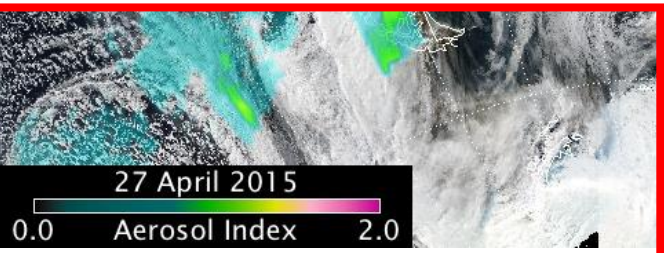
Calbuco Eruption: 22-30 April 2015

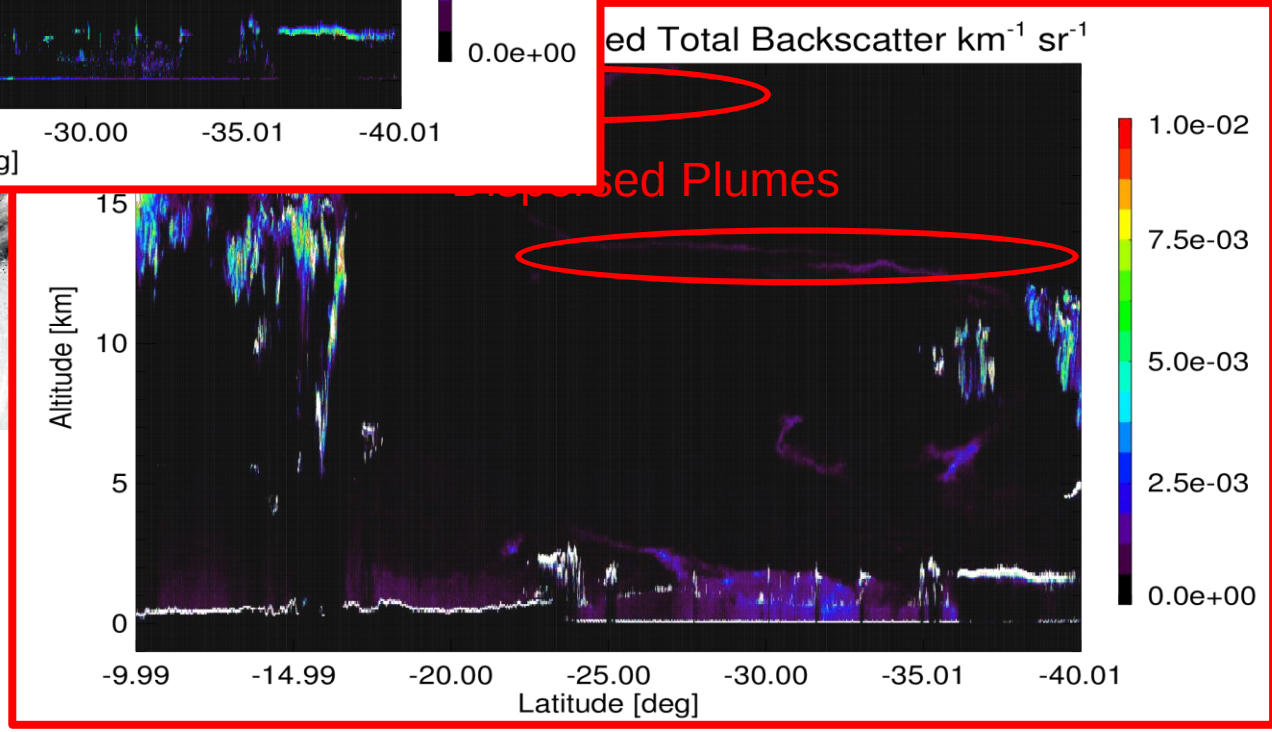




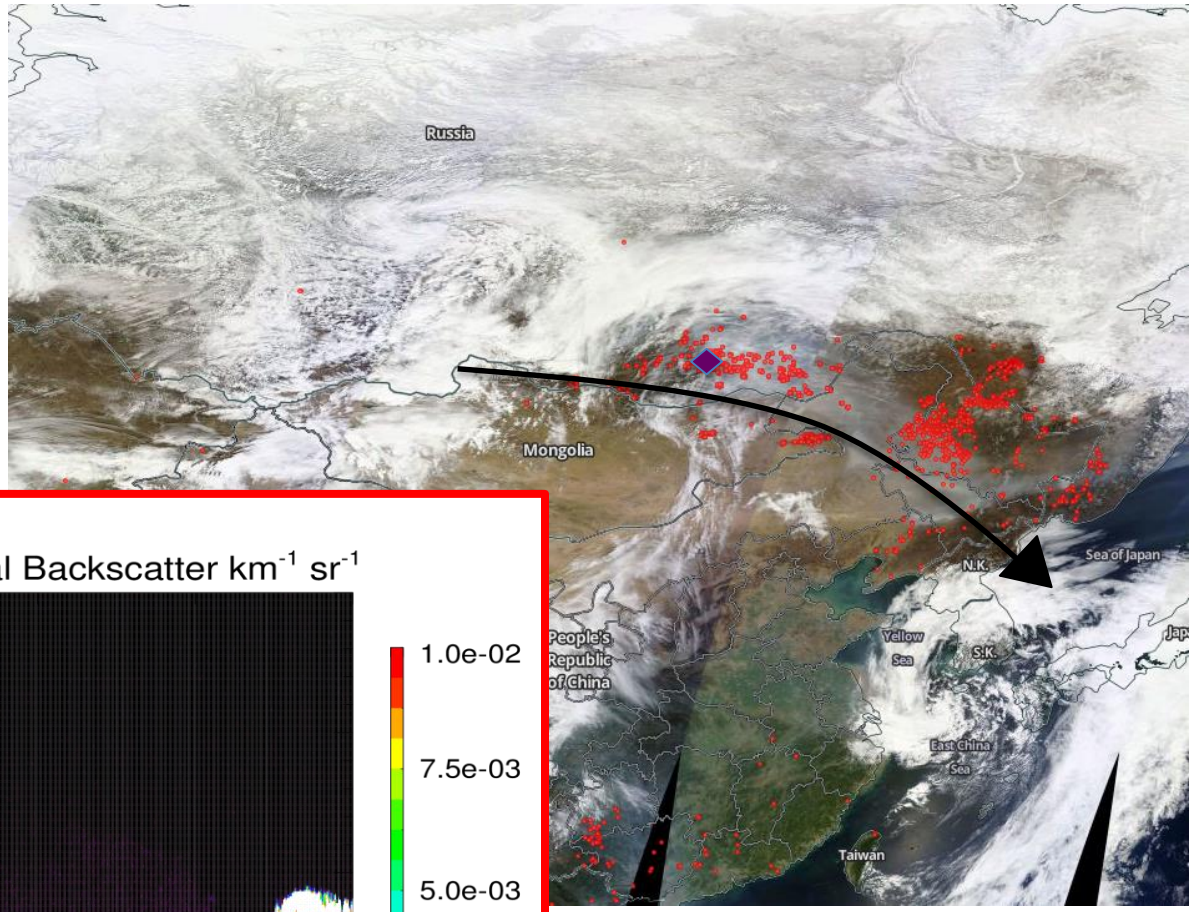
Calbuco Eruption: 22-30 April 2015

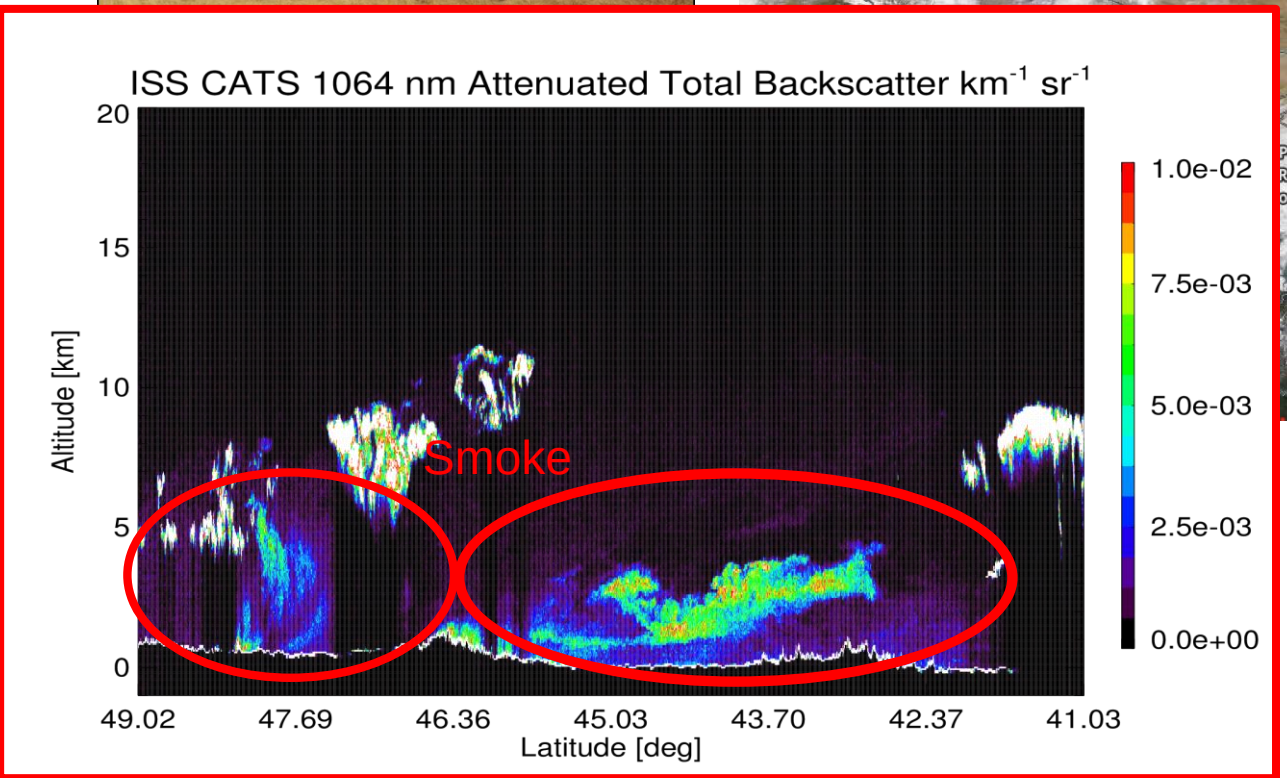




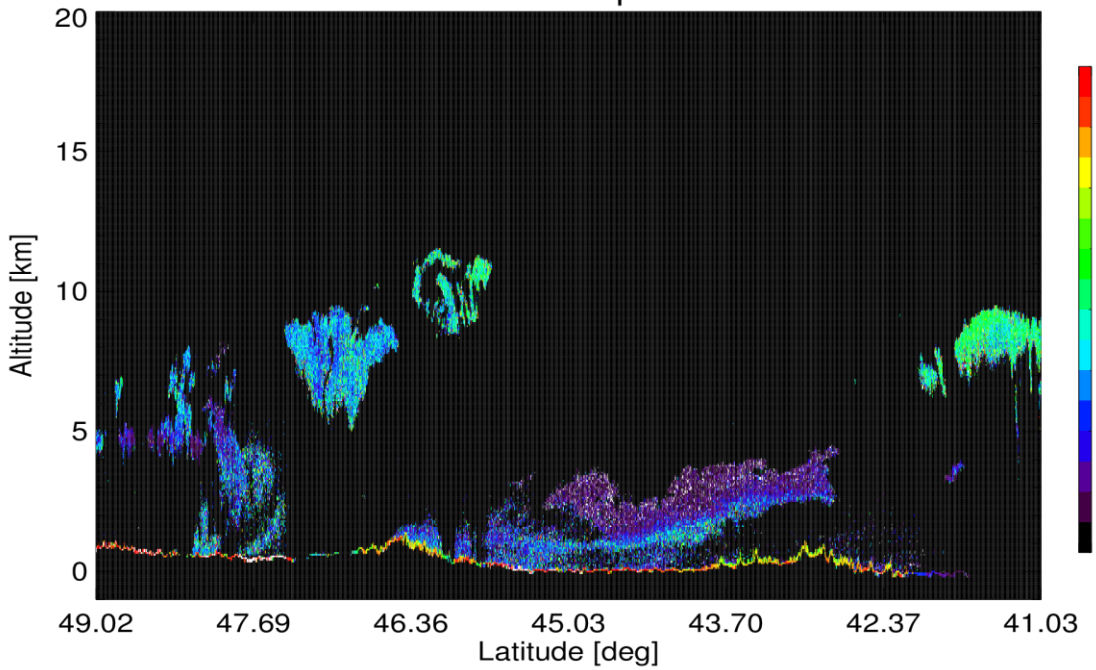


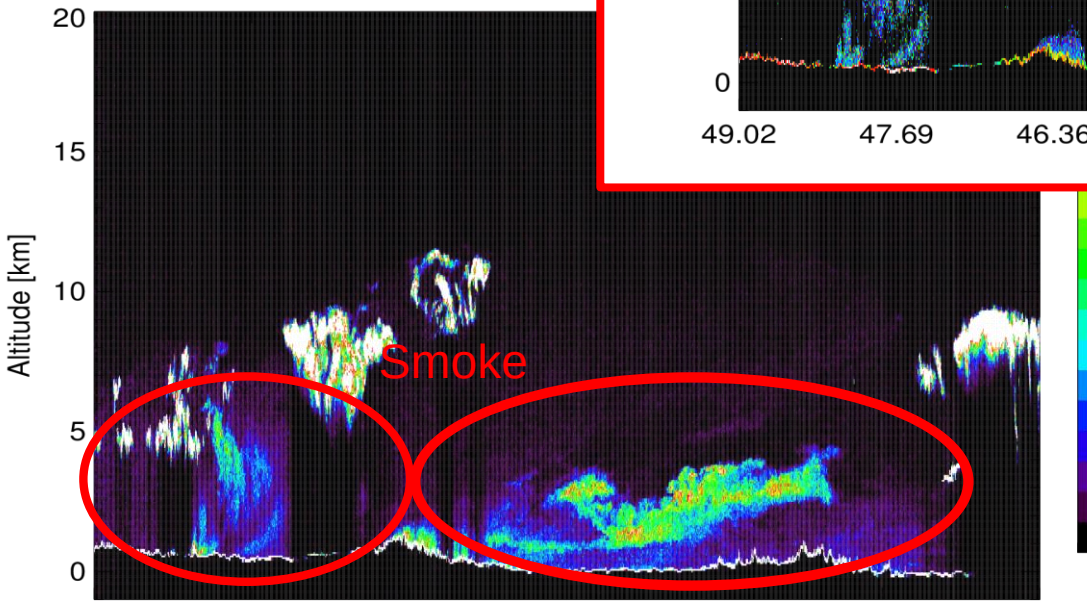
Siberian Fires: 14 April 2015



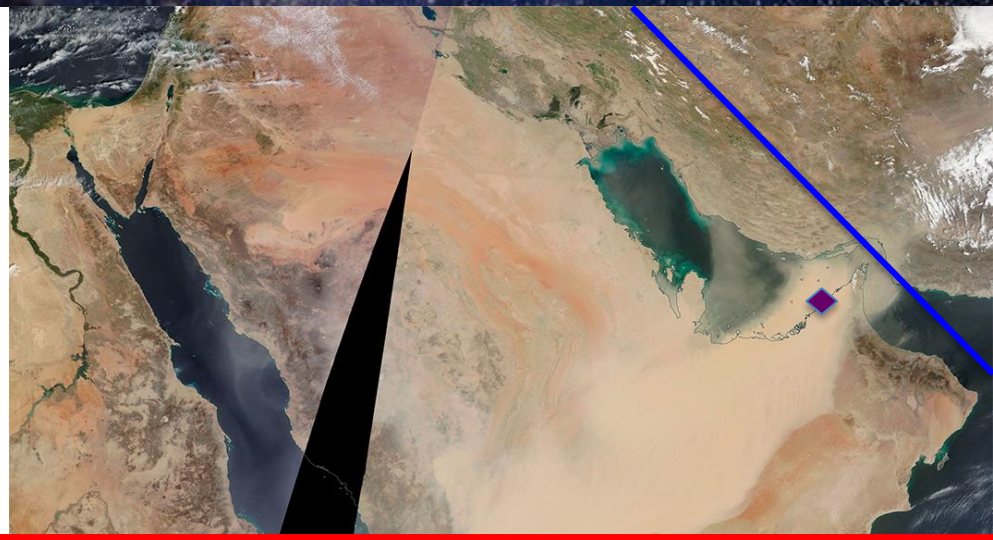


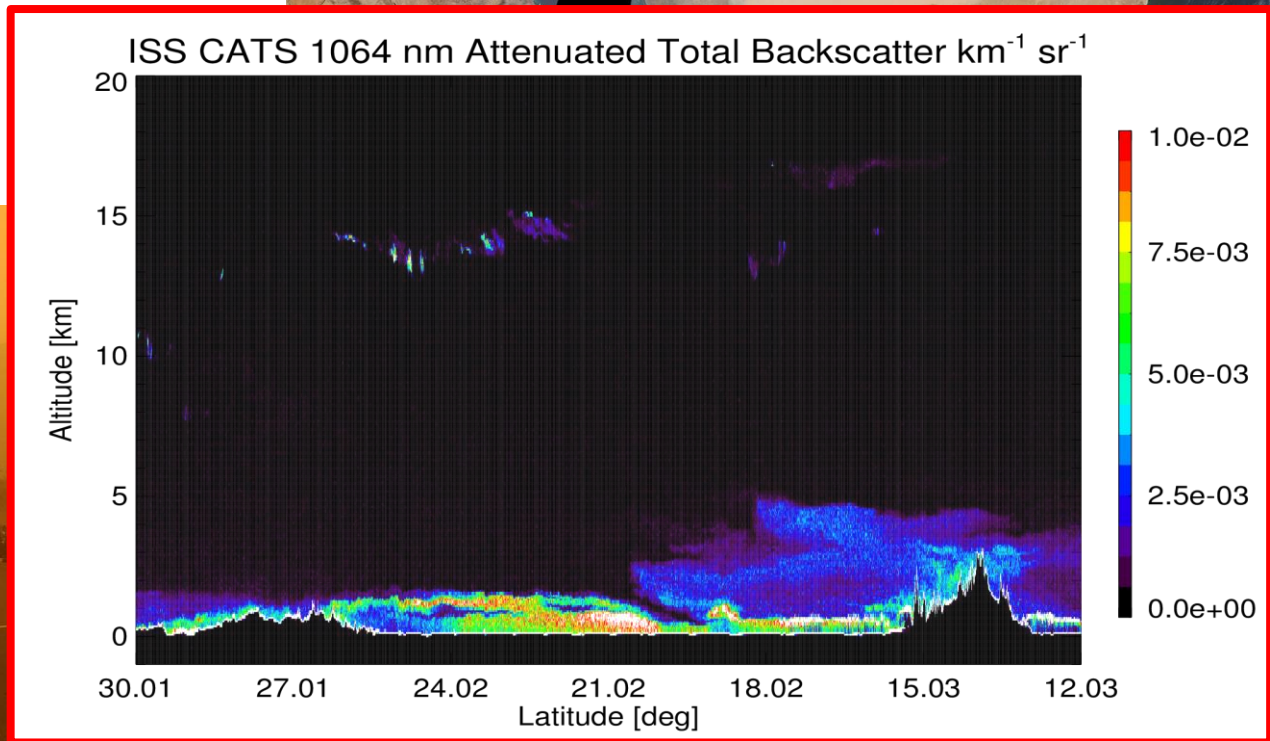
Siberian Fires: 14 April 2015



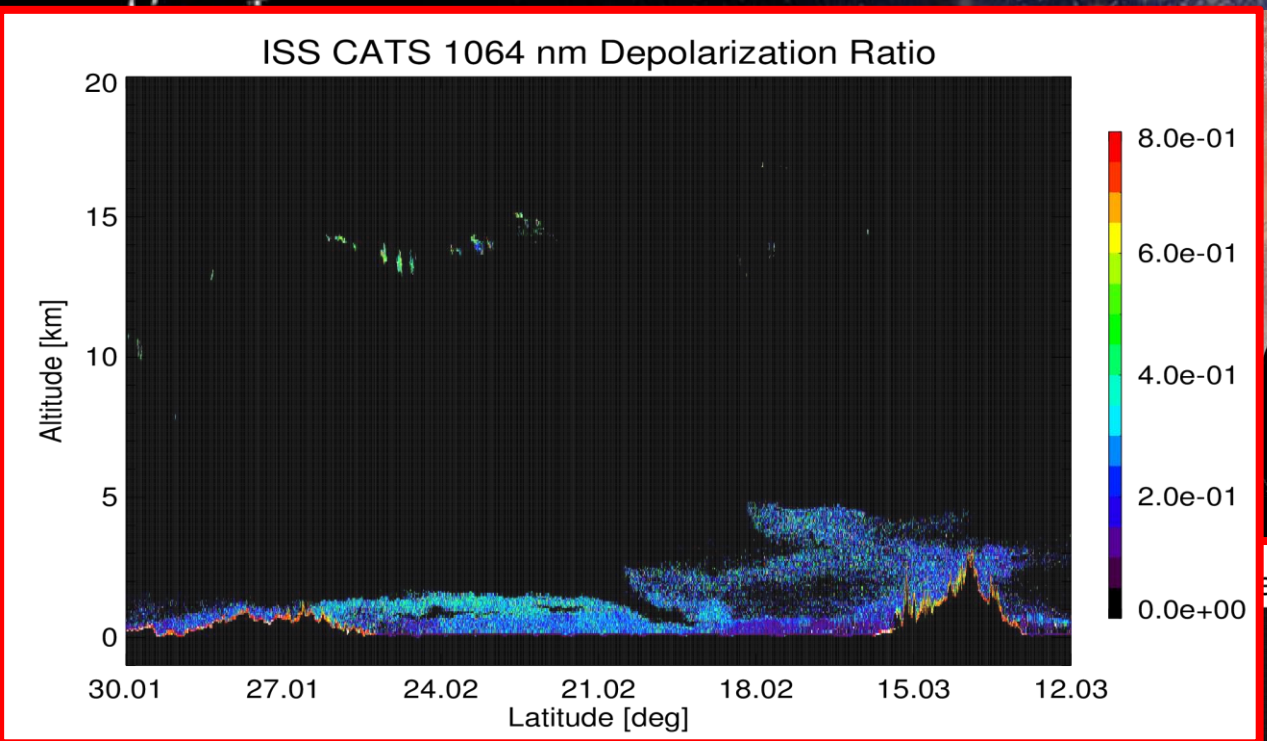


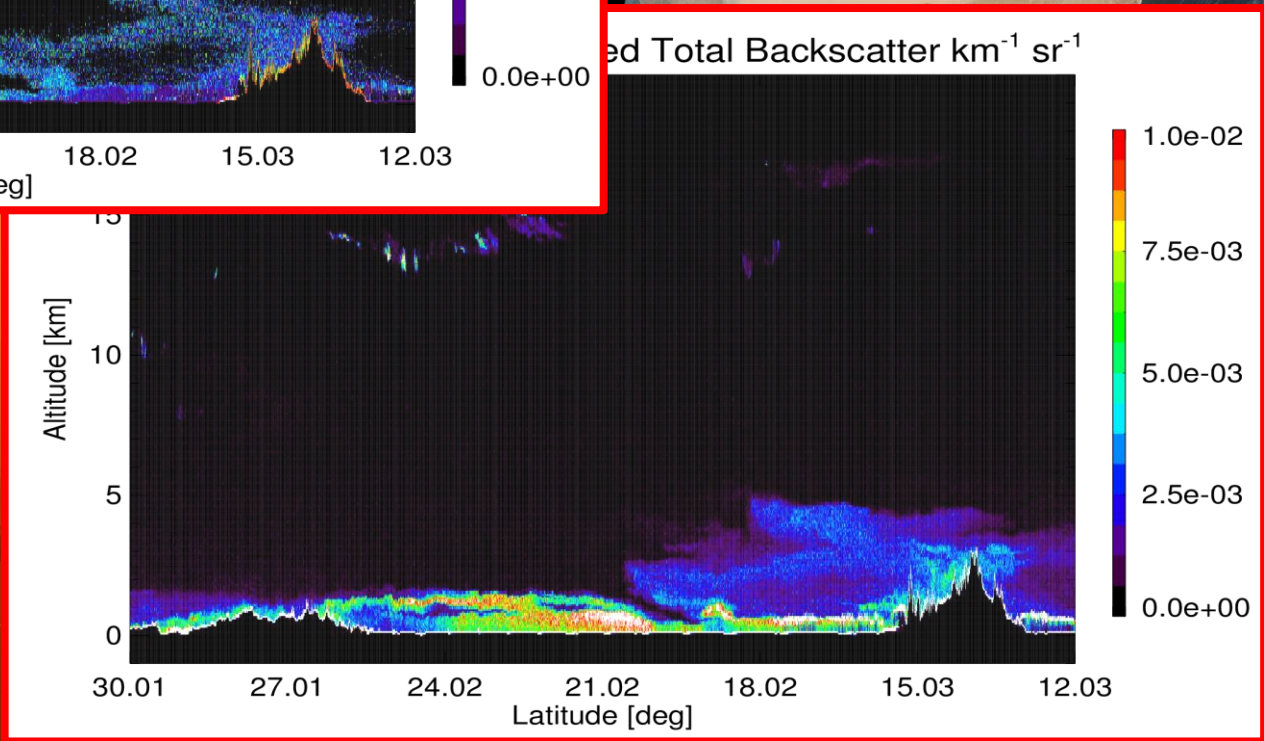
Arabian Dust Storm: 2 April 2015





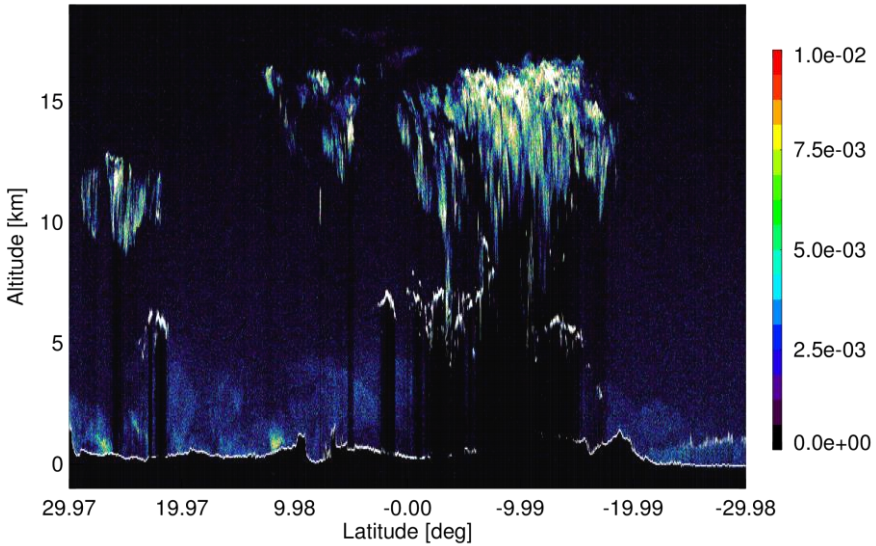
Arabian Dust Storm: 2 April 2015



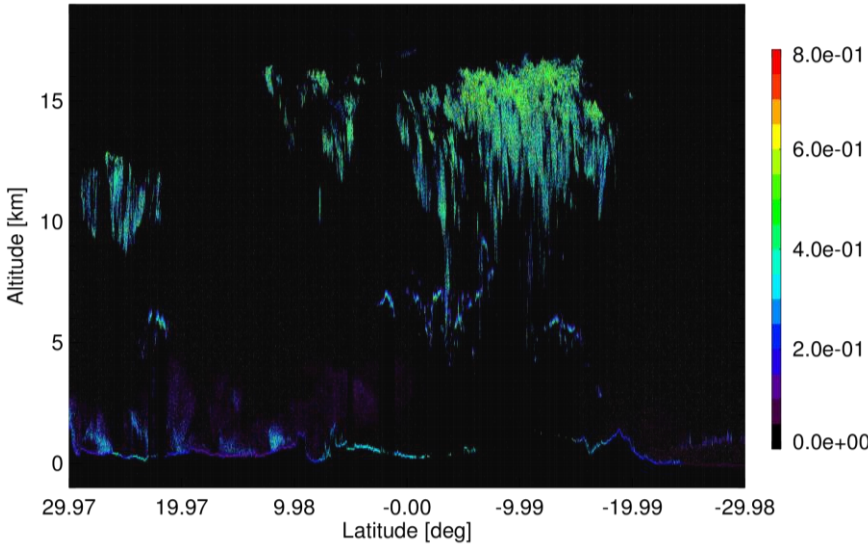


L1B Data Products – Mode 1

L/R FOV 532 nm Attn. Tot. Backscatter km^{-1} sr^{-1}

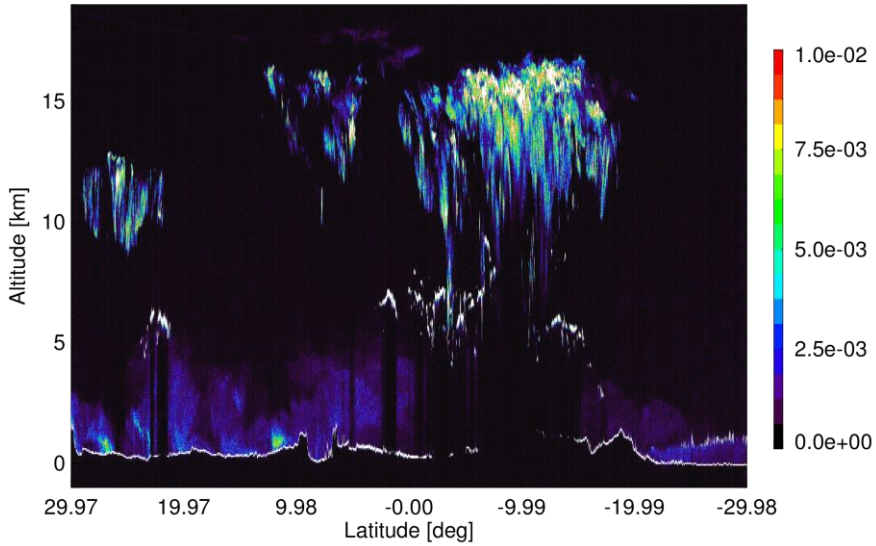


L/R FOV 532 nm Volume Depolarization Ratio

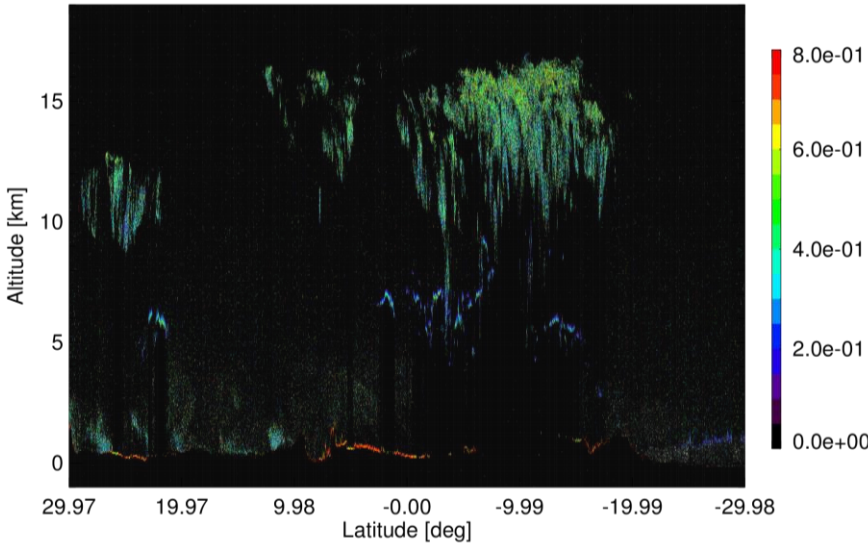


350 meter horizontal, 60 meter vertical resolution

L/R FOV 1064 nm Attn. Tot. Backscatter km^{-1} sr^{-1}

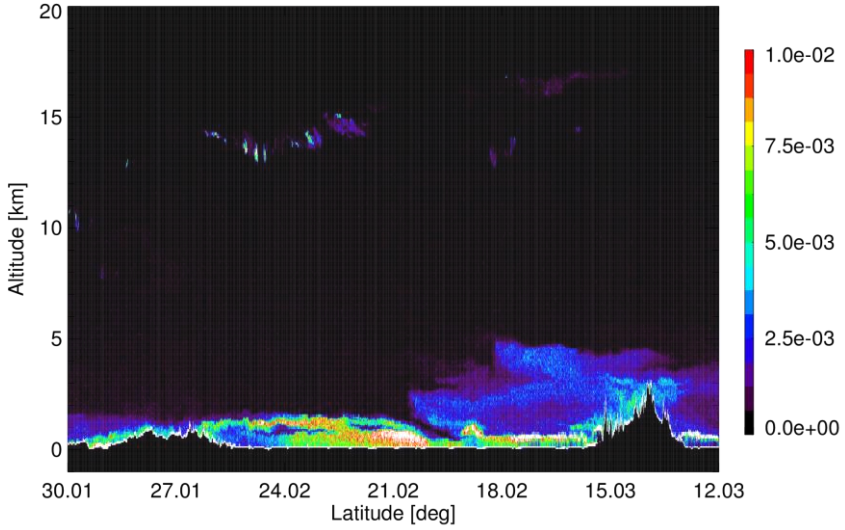


L/R FOV 1064 nm Volume Depolarization Ratio

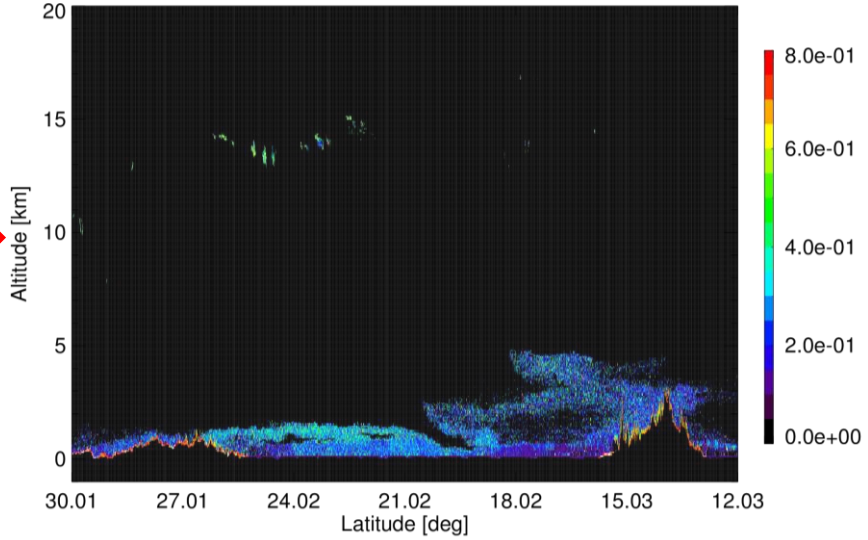


L1B Data Products – Mode 2

FFOV 532/1064 nm Attn. Tot. Backscatter km^{-1} sr^{-1}



1064 nm Volume Depolarization Ratio



350 meter horizontal, 60 meter vertical resolution

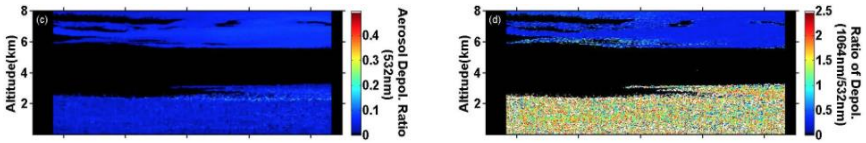
Level 2 Data Products

- Layer location
- Attenuated Total Backscatter (layer & profile)
- Vol. Depolarization Ratio (layer & profile)
- Feature Type
- Feature Type Score
- Vertical Feature Mask
- Lidar Ratio
- Extinction/AOD

Operational VFM

Mode 1 (February 10 – March 21):

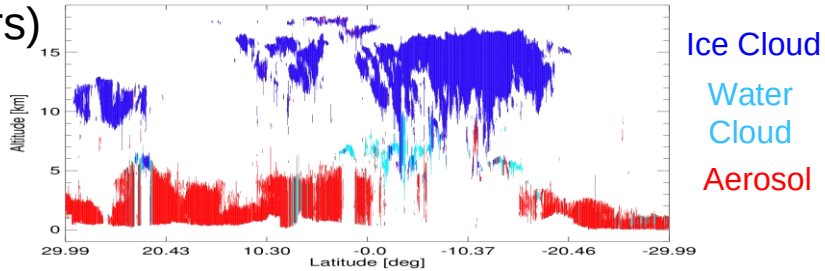
- Expected release in August, 2015
- Enhanced aerosol typing



From Burton et al., 2012

Mode 2 (March 25 – Present):

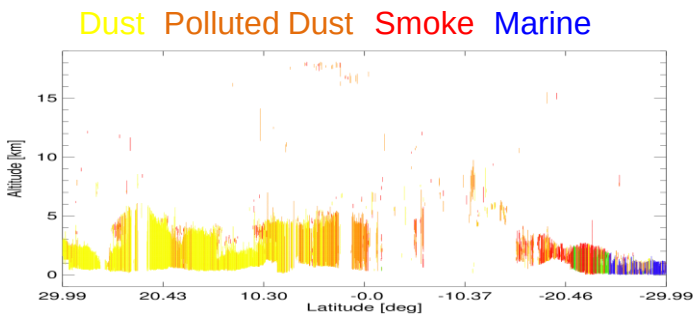
- NRT Cloud/Aerosol Typing (within 6 hours)



- CALIOP – like VFM, but with information from NASA GEOS-5 model (Nowottnick et al., 2015)

Heritage VFM

- CATS L1B data processed through CALIPSO L2 algorithms by LaRC to keep continuity in lidar climate record
- Identical to CALIPSO L2 products
- Release in July 2015
- Only available for Mode 1 data



Getting the Data

Cloud-Aerosol Transport System (CATS)

Home | Mission | Science | Contact

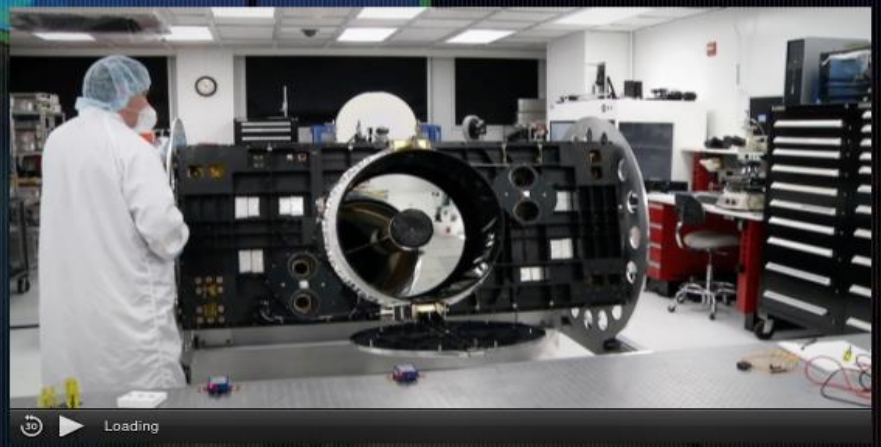
- Goals
- Publications
- Data

http://cats.gsfc.nasa.gov

CATS

The Cloud-Aerosol Transport System (CATS), planned for launch in 2014, is a lidar remote sensing instrument that will provide range-resolved profile measurements of atmospheric aerosols and clouds from the International Space Station (ISS). CATS is intended to operate on-orbit for at least six months, and up to three years.

Mission Overview	Status
CATS Brochure [PDF]	



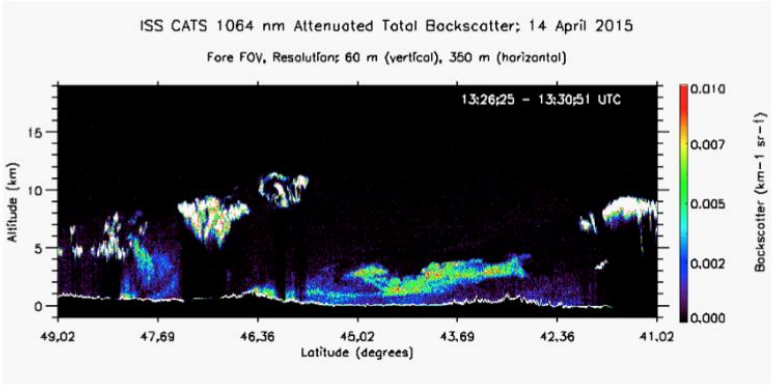
Getting the Data

CATS Products and Data Ordering

CATS produces Level 1 and Level 2 science data products that are listed in detail in the CATS Data Products Catalog. These products are archived and distributed by the Atmospheric Science Data Center. For more information on CATS data products, please see the CATS Algorithm Theoretical Basis Document. Notes for the current data product release can be found here.

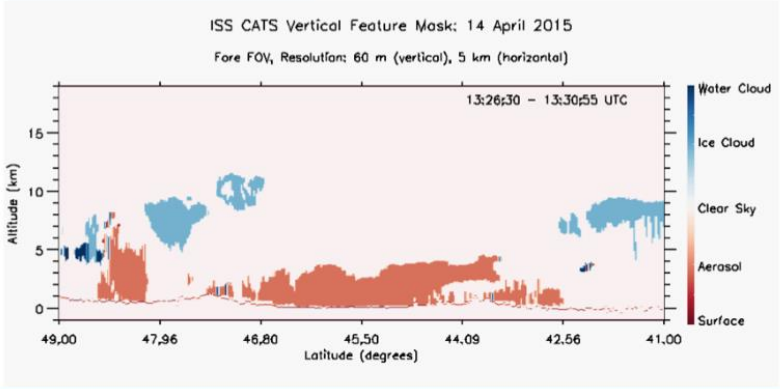
LEVEL 1 DATA:

- Calibrated Backscatter
- Depolarization Ratio
- 60 m vert. resolution
- 350 m hor. resolution



LEVEL 2 DATA:

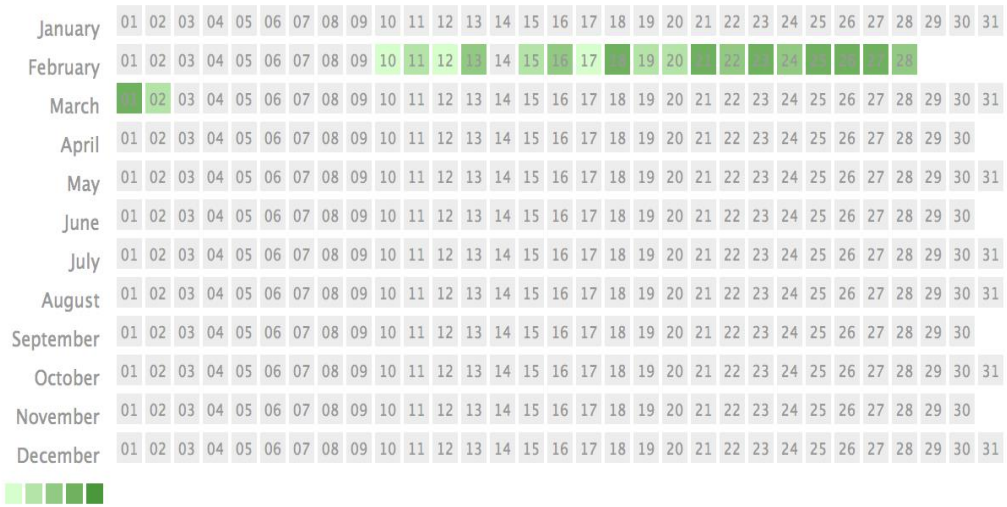
- Cloud & Aerosol identification
- Extinction profiles
- Layer optical thickness
- 60 m vert. resolution
- 5 km hor. resolution



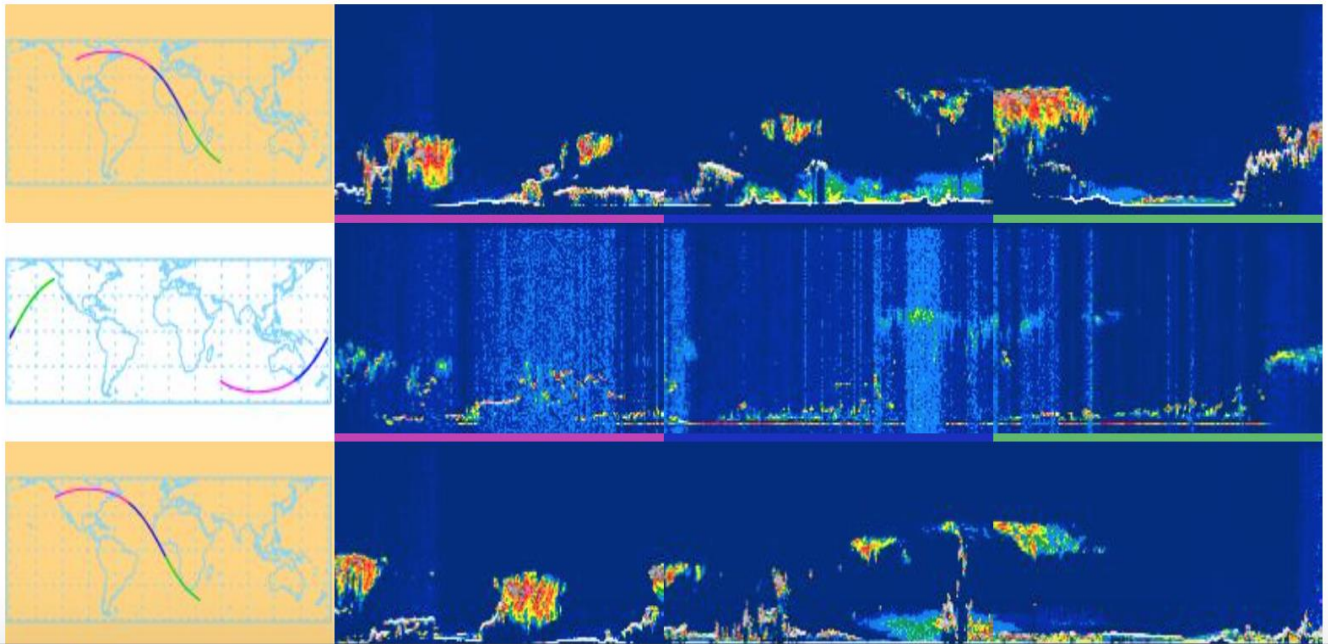
CLICK HERE TO ORDER DATA PRODUCTS OR VIEW BROWSE IMAGES

Getting the Data

Granule Availability 2015



2015-02-11



Getting the Data

Atmospheric Science Data Center

Processing, archiving and distributing Earth science data at the NASA Langley Research Center

Search

Home | Data Descriptions | Order Data | Citing ASDC Data | Help & Resources

Home » CATS Data and Information Page

Cloud-Aerosol Transport System (CATS) Data and Information

The Cloud-Aerosol Transport System (CATS), is a lidar remote sensing instrument that will provide range-resolved profile measurements of atmospheric aerosols and clouds from the International Space Station (ISS).

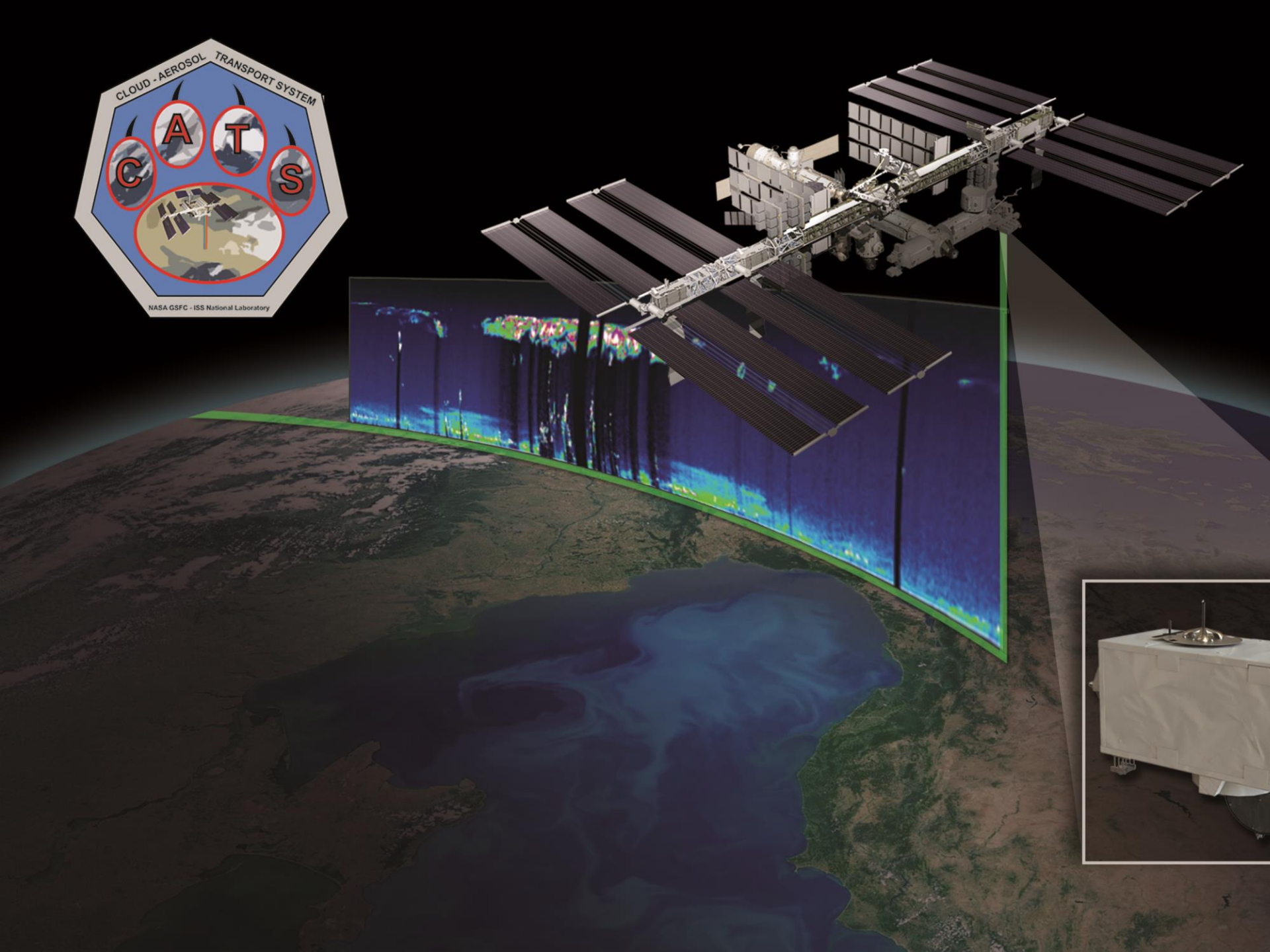
CATS will provide vertical profiles at three wavelengths, orbiting between ~230 and ~270 miles above the Earth's surface at a 51-degree inclination with nearly a three-day repeat cycle. For the first time, it will allow scientist to study diurnal (day-to-night) changes in cloud and aerosol effects from space by observing the same spot on Earth at different times each day.

Products | Parameters

Product Level	Description
Level 2	L1B files that are run through the new operational CATS L2 algorithm, which will include new capabilities. Includes geophysical parameters, such as the vertical feature mask, profiles of cloud and aerosol properties and layer-integrated parameters.
Level 1B	L1A data that have been calibrated, annotated with ancillary meteorological data, and processed to sensor units.

Conclusions & Future

- **Despite many challenges, CATS has demonstrated the utilization of ISS for earth science measurements by providing lidar observations from space.**
- **CATS will continue to demonstrate high-rep rate, photon counting detection for future missions and can be used to fill in diurnal gaps of CALIOP measurements.**
- **Mode 1 L1b data was recently released (6/12/2015) and is now on the web (http://cats.gsfc.nasa.gov)**
- **Coming later this summer:**
  - **Mode 2 NRT (within 6 hours) data available through FTP by the end of the month**
  - **Mode 2 L1b data (7/2015)**
  - **Mode 1 Level 2 data (8/2015)**

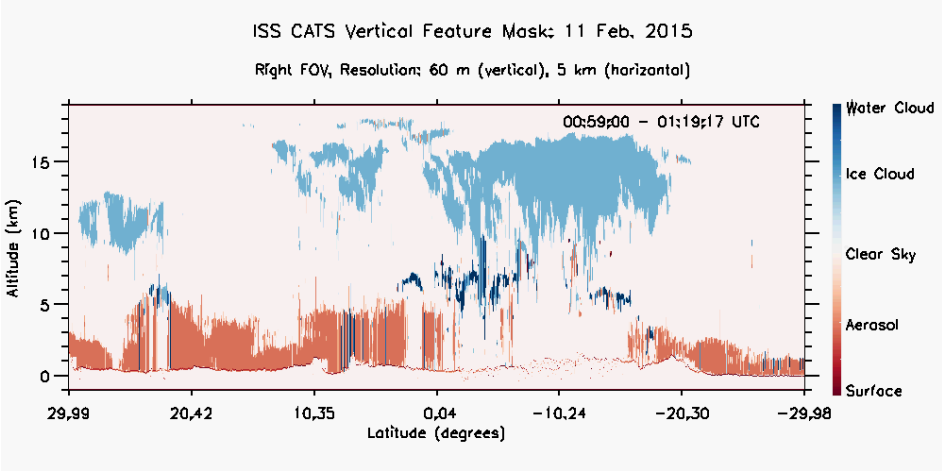

CLOUD - AEROSOL TRANSPORT SYSTEM
C A T S
NASA GSFC - ISS National Laboratory

Processing Update: Level 2

Level 2: Vertical Feature Mask and Optical Properties

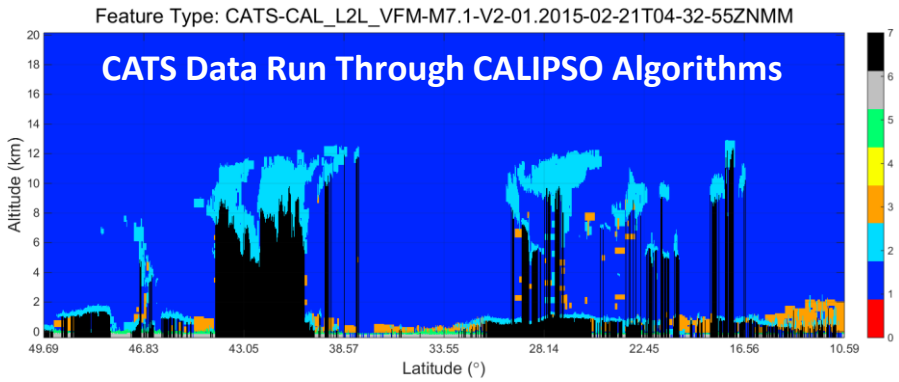
Operational:

- Developed by GSFC with new features spectral depolarization
- 1064 nm layer finder
- Combined cloud/aerosol files
- 2 types: layer and profile
- Resolution: 5 km horizontal, 60 m vertical
- Release in Aug. 2015



Heritage:

- CATS L1B data processed through CALIPSO L2 algorithms by LaRC to keep continuity in lidar climate record
- Identical to CALIPSO L2 products
- Release in July 2015
- Only available for Mode 1 data



CATS vs. CALIPSO

- **Development:**
  - CATS is ***NOT*** a flight mission – it is an experiment
  - Intended as a pathfinder for low-cost Class D payloads and NASA-developed science payloads for ISS
  - ***NOT*** driven by science measurements/requirements (Build-to-cost/schedule)
- **Performance:**
  - 1064 nm - CATS has better SNR and MDB than CALIOP
  - 532 nm - CATS and CALIOP have similar signals at night (CALIOP better during daytime)

CATS-CALIOP Minimum Detectable Backscatter

Simulation	Type	Backscatter (km-1 sr-1)
CATS	532 - Night	1.00E-3 ± 0.54E-3
CATS	1064 – Night*	5.00E-5 ± 0.77E-5
CALIOP	532 - Night	8.00E-4 ± 1.00E-4
CATS	532 - Day	2.20E-2 ± 0.35E-2
CATS	1064 – Day*	1.30E-3 ± 0.24E-3
CALIOP	532 - Day	1.70E-3 ± 0.30E-3

*Mode 2 data, since 1064 nm is the better wavelength

CATS vs. CALIPSO

- **GSFC-LaRC Collaboration:**
  - CATS data products will be similar to CALIPSO
  - Level 1B: Calibrated Backscatter, Depolarization
    - Similar resolutions
      - 60 m vertical (all altitudes)
      - 350 m horizontal (20 Hz)
    - Similar 532 calibration technique (normalize to Rayleigh)
  - Notable differences:
    - Depolarization at both 532 and 1064 nm (Mode 1)
    - Multi-beam in Mode 1
    - High rep-rate, photon counting
    - CATS 1064 nm data has higher SNR
      - Calibrate by normalizing to Rayleigh signal instead of color ratio technique used by CALIPSO

CATS – CPL Comparisons

- Conducted successful underflights with CPL on ER-2: Feb 10, 17, 20, 21 (CalWater-2)
- Feb 21-22 ISS underflight: cirrus over Pacific during local nighttime hours (03:49 UTC)
- CPL underflight data used to assess calibration and polarization gain ratios at 532 & 1064