# Sampling the next large volcanic cloud


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ATOC

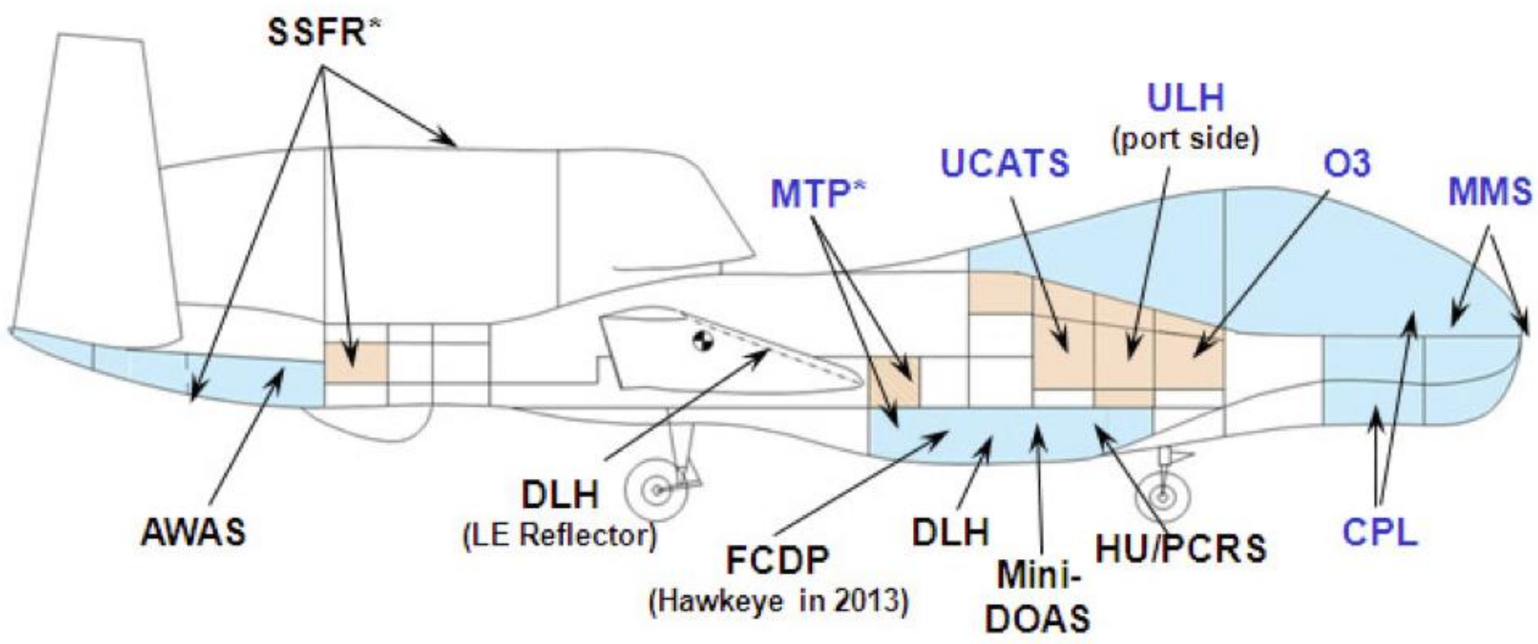
# Three platforms

- Global hawk
- Space station lidar
- Constellation of limb sounder satellites

# Global Hawk

- Plus-
  - Very long range 11,000 km, 25 hours duration, can get into Southern Hemisphere, go almost to North Pole from Dryden.
  - Rapidly developing payloads, many suitable for volcanic cloud studies.
- Minus-
  - All NASA aircraft heavily committed
  - Altitude maximum near 20 km

# ATTREX Global Hawk payload: Strong overlap with volcanic cloud issues




*Instruments in blue font have previously flown on the Global Hawk.
*Instruments in black font have not flown on the Global Hawk.

ISS021E030638

Japanese Experiment Module-Exposed Facility (JEM-EF) attached payload for the International Space Station (ISS)

# CATS-ISS

## (Cloud-Aerosol Transport System for ISS)

Matthew McGill

**Directed Opportunity**

**Payload Delivery Date: April 2013**

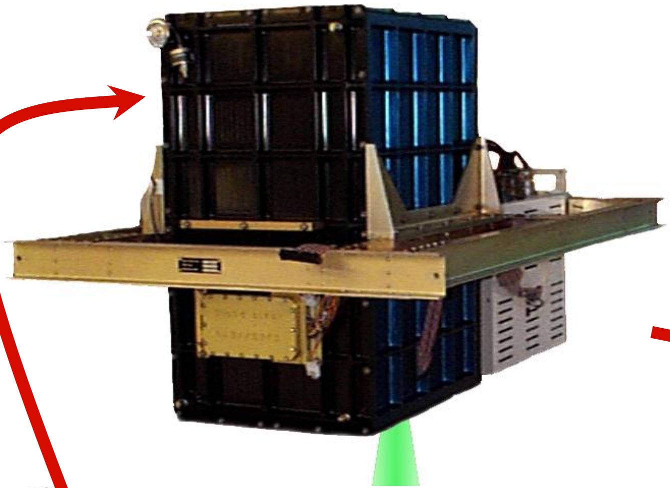
**Planned Launch Readiness Date: mid-2013**

# Mission Concept/Design

- Target Launch Date:  mid-2013
- Orbit parameters:  ISS orbit, 405 km, approx. 51∨ inclination.
- Instrument
  - Lidar, multi-wavelength (1064, 532, 355 nm)
  - Mass:  < 500 kg
  - Power:  1200W
  - Data rate:  ~ 2 Mbits/second via HRDL
- Launch vehicle options:  TBD by JSC, either HTV or Space-X
- Mission Margins:
  - ISS allotment for JEM-EF attached payloads are 500 kg, <3 kW, and HRDL FDDI data downlink option.

# Heritage:  the Cloud Physics Lidar

**CPL is a self-contained, autonomous backscatter lidar**



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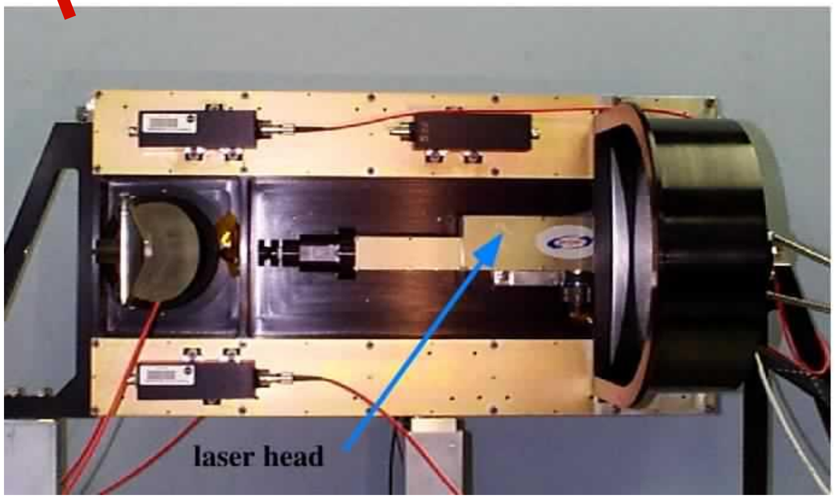


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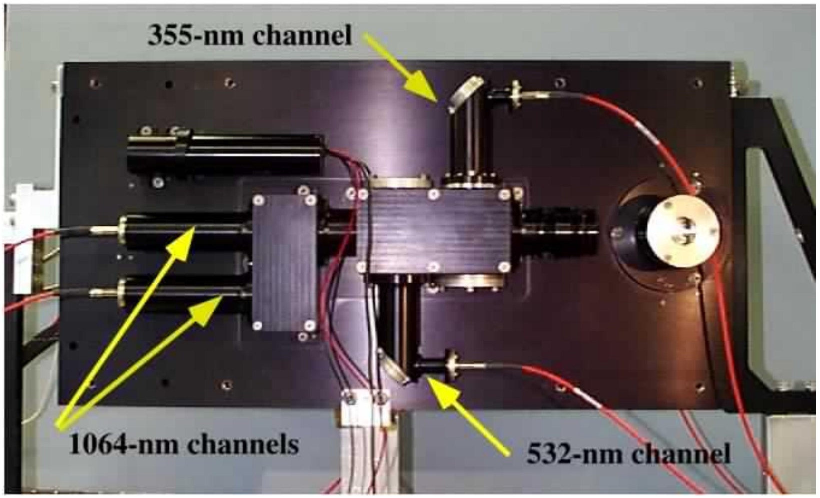


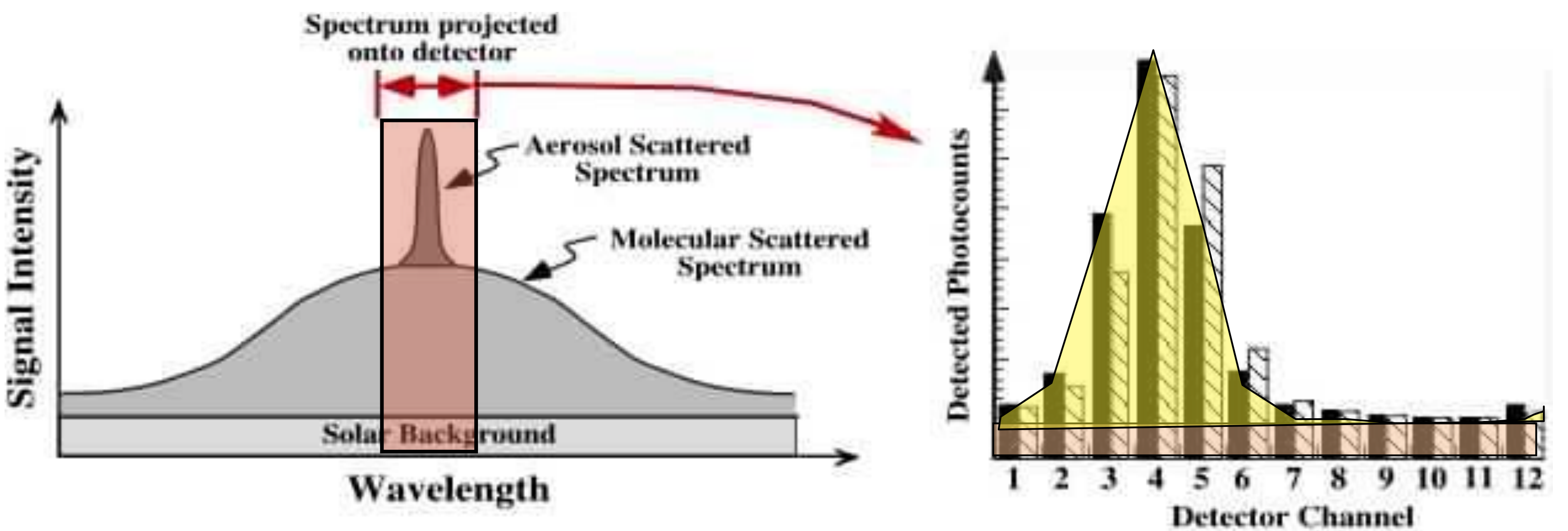

**The CPL web site is:  http://cpl.gsfc.nasa.gov**

# Lidar (HSRL) Concept

High Spectral Resolution Lidar (HSRL) is a method used to isolate aerosol-scattered light from molecular-scattered light, thereby permitting unambiguous determination of aerosol extinction.

Requires high-fidelity laser performance, more complex optical receiver.

Our approach uses a Fabry-Perot interferometer to reject most of the molecular-scattered light. Using a multi-element detector, the measured signal can be decomposed into aerosol and molecular components.




**HSRL has not been done in space before. The CATS instrument provides tech demo and risk reduction for future Earth Science missions.**

# Solar Occultation Constellation for Retrieving Aerosols and TracE-gaseS SOCRATES

# Mission Overview
# November 16, 2011

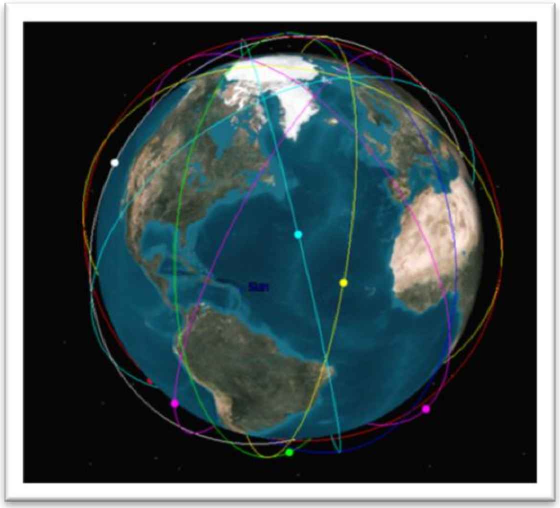
# What is SOCRATES?

## Our Science Goal:

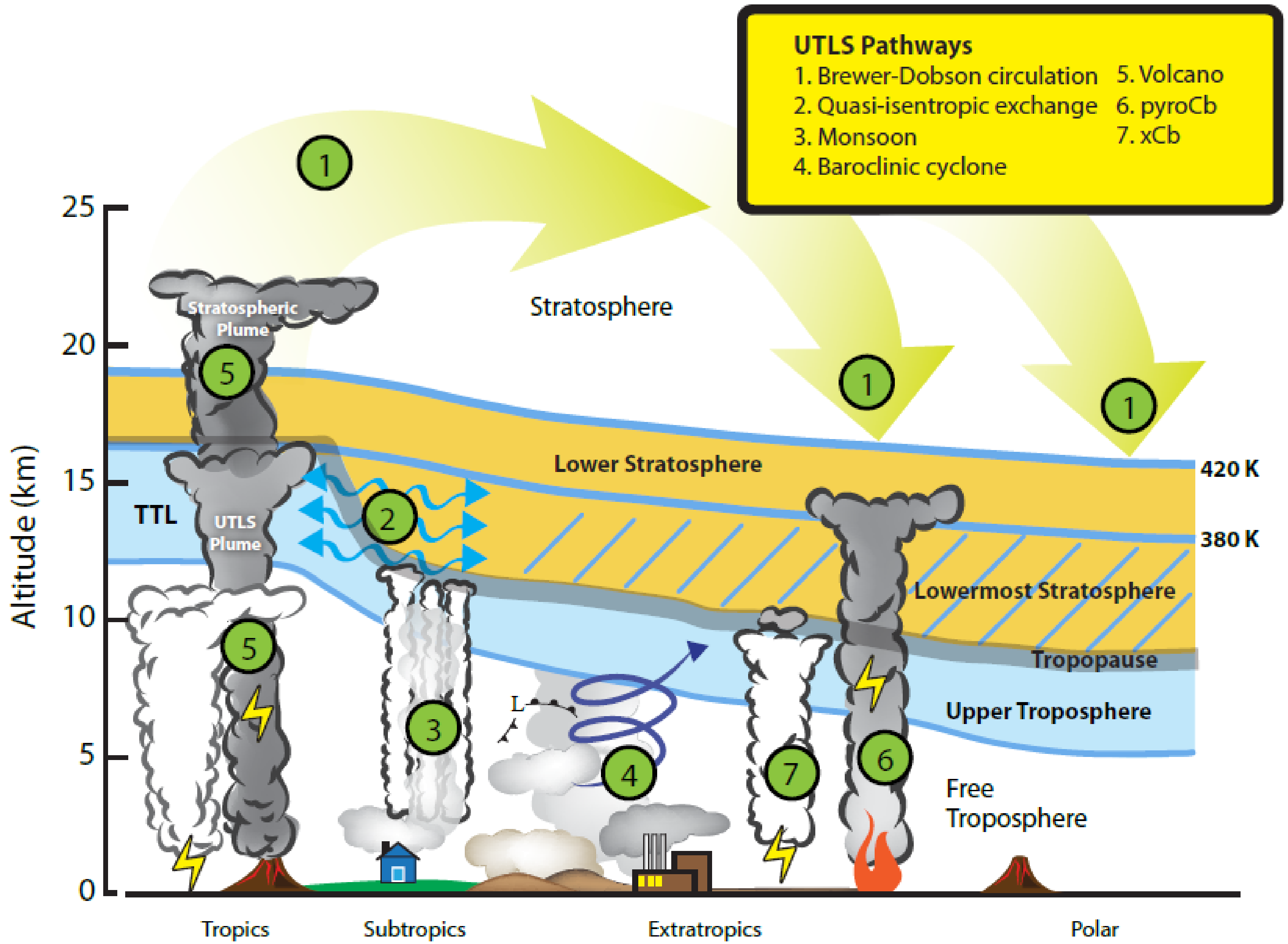
The goal of SOCRATES is to—for the first time—clearly quantify the role of the UTLS in the climate system through measurements of aerosols and trace gases, and to extend the global climate record of ozone-controlling stratospheric constituents.

## Our Implementation:

We will fly a constellation of 8 mico-satellites each carrying identical solar occultation instruments to measure UTLS Aerosols, $H_2O$, $O_3$, CO, $CO_2$, $CH_4$, HCN, HDO, $N_2O$, HCl, HF, and Temperature at 1km vertical resolution. The constellation will be launched from a single rocket. Two years of observations covering tropical and midlatitudes will be obtained.



# SOCRATES Will Investigate Transport into the UTLS Via Exchange Pathways and Determine the Impacts of These Pathways on Global Climate Forcing



# SOCRATES Top Level Science Questions

1. What are the global distribution and variability of key radiatively active gases, aerosols, and transport tracers in the UTLS?

2. What are the amount and composition of material transported into the UTLS via different exchange pathways?

3. What are the impacts of these transport pathways on global climate forcing?

4. What are the abundance of stratospheric ozone and related constituents and how are they changing?

| Pathways Under Consideration | Description |
|---|---|
| Brewer Dobson circulation | Stratospheric circulation in which air rises in the tropics and then moves polewardand downward. |
| Quasi-isentropic exchange | Cross-tropopause transport primarily via Rossby Wave breaking |
| Asian Monsoon | Synoptic-scale summer convection/circulation system |
| Baroclinic cyclone | Synoptic-scale extratropical storm circulation |
| Volcano | Eruptive/convective injection into the UTLS |
| PyroCb | Eruptive/convective thunderstorm caused by wild fire. |
| xCb | Thunderstorm generating a plume above the tropopause |

# The SOCRATES Team

Principal Investigator: *Scott Bailey, Virginia Tech*

Deputy Principal Investigator: *Richard Bevilacqua, Naval Research Lab*

Project Scientist: *Mike Fromm, Naval Research Lab*

Project Manager / Mission Scientist: *Chad Fish, Space Dynamics Lab, Utah State U.*

Instrument Scientist: *Larry Gordley, GATS Inc.*

Spacecraft Provider: Commtech Aero Astro – Patricia Stroh, Jay Joblinske

Launch Provider: *Orbital Sciences Corp. – Warren Frick, Bryan Baldwin*

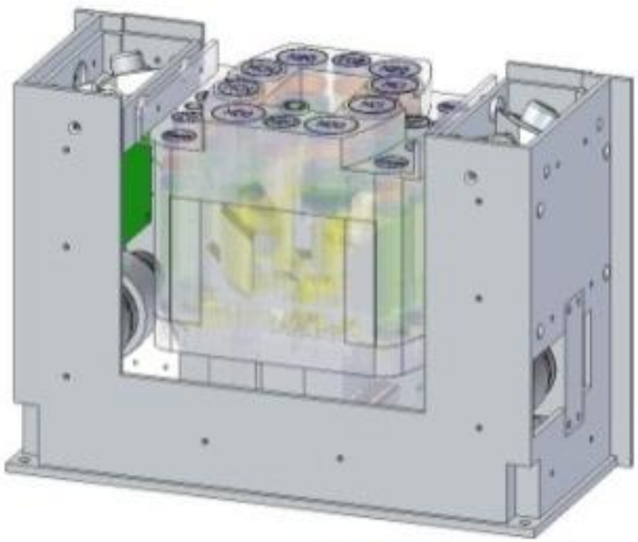
Ejection System Provider: *Planetary Systems Corp. – Walter Holemans*

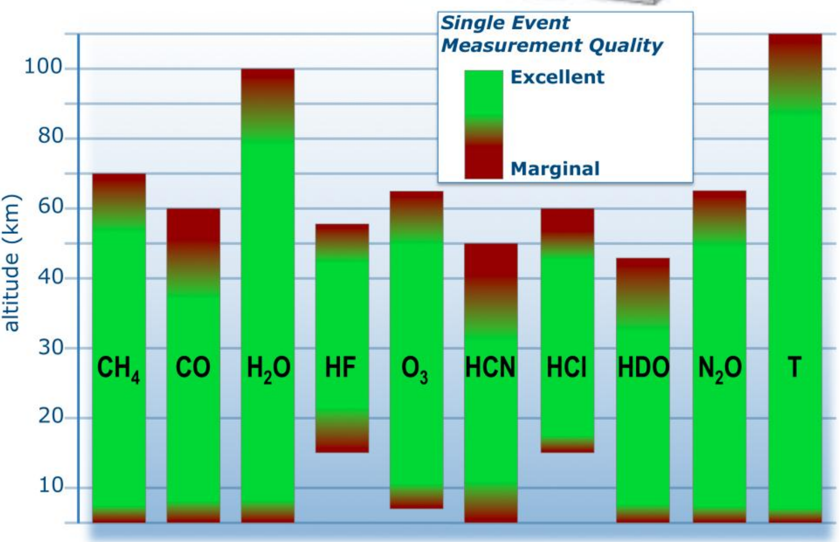
Mission Operations: *LASP, U. Colorado – Mike Packard*

**Science Team:**

*Doug Allen, Pete Colarco, Andy Dessler, Troy Henderson, Lynn Harvey, Mark Hervig, Karl Hoppel, Gourihar Kulkarni, Tom Marshall, Marty McHugh, Gerald Nedoluha, Cora Randall, Phil Rasch, Karen Rosenlof, Dave Siskind, Mike Summers, Brian Toon, and Rahul Zaveri*

# SOCRATES Measurements Will Be Made By the GFCR Limb Occultation (GLO) Instrument, Building on HALOE and SOFIE Heritage



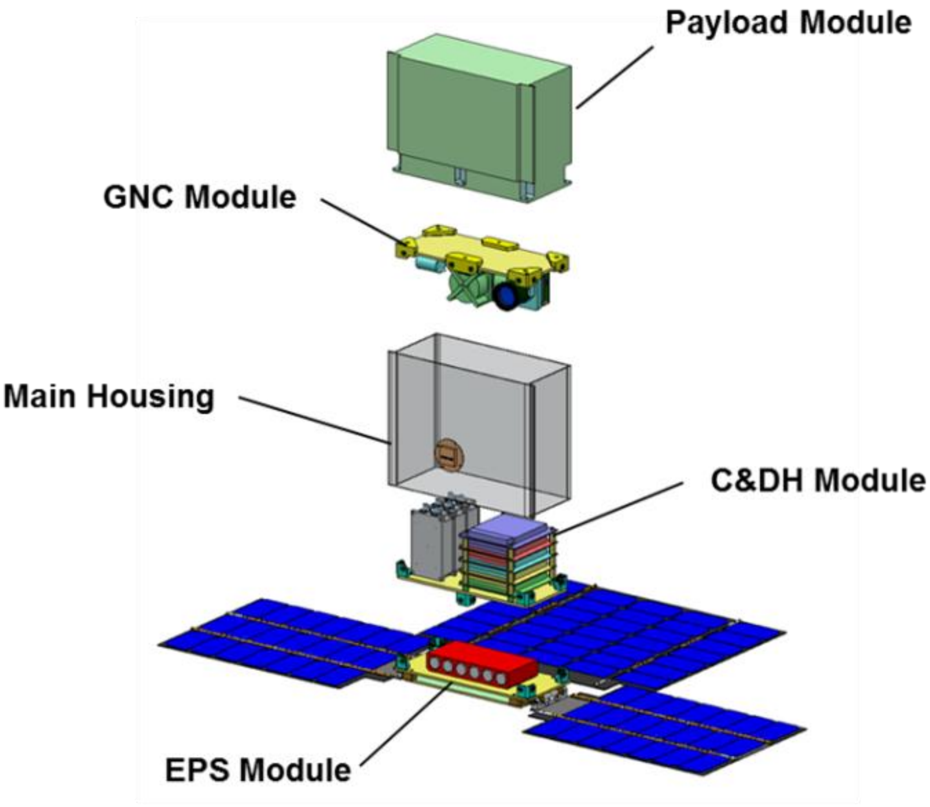



GLO Measurement Range. Assumes clear air. Cloud tops will usually dictate lower limit.

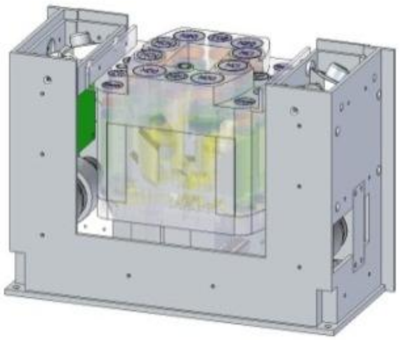
| Channel # Type | Species | λ(μ) | Object-ives | Applications |
|---|---|---|---|---|
| 1 B | Aerosol | 0.45 | 1,2,3 | Radiation, STE analysis, chemistry |
| 2 B | Aerosol | 1.0 | 1,2,3 | See #1 |
| 3 B | Aerosol | 1.6 | 1,2,3 | See #1 |
| 4 G | $CH_4$ | 2.31 | 1,2,3,4 | Radiation, used to close H budget, BDC |
| 5 G | CO | 2.33 | 1,2 | Tropospheric air tracer, sensitive to pollution sources |
| 6 G | $H_2O$ | 2.44 | 1,2,3,4 | Radiation, aerosol microphysics, tropospheric air tracer |
| 7 G | HF | 2.46 | 2,4 | F budget, CFC trends, BDC |
| 8 G | $O_3$ | 2.49 | 1,2,3,4 | Radiation, chemistry, stratospheric air tracer |
| 9 B | $H_2O$ | 2.6 | 1,2,3,4 | See #6 |
| 10 B | $CO_2$ | 2.8 | | T above 50km |
| 11 G | HCN | 3.02 | 1,2 | Tropospheric air tracer, biomass burning emission |
| 12 G | HCl | 3.52 | 2,4 | Cl budget, CFC trends, stratospheric chemistry |
| 13 G | HDO | 3.74 | 1,2 | Tracer of transport, convective history |
| 14 G | $N_2O$ | 3.88 | 1,2,3,4 | Radiation, tropospheric air tracer, BDC |
| T | Diffraction of solar images. | | 1,2,3,4 | Radiation, tropopause identification |

# Modern Technology Allows for High Performance in Small Packages
# A Complete SOCRATES Observatory Fits into a 30x20x10 cm Form Factor

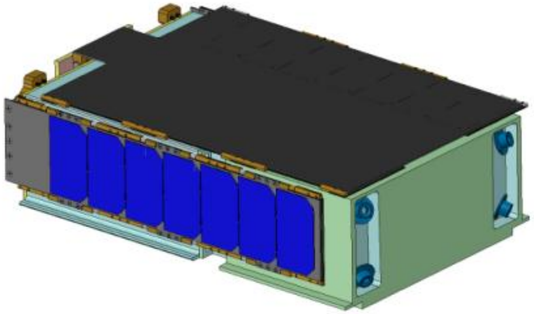
## Modular Observatory Integration



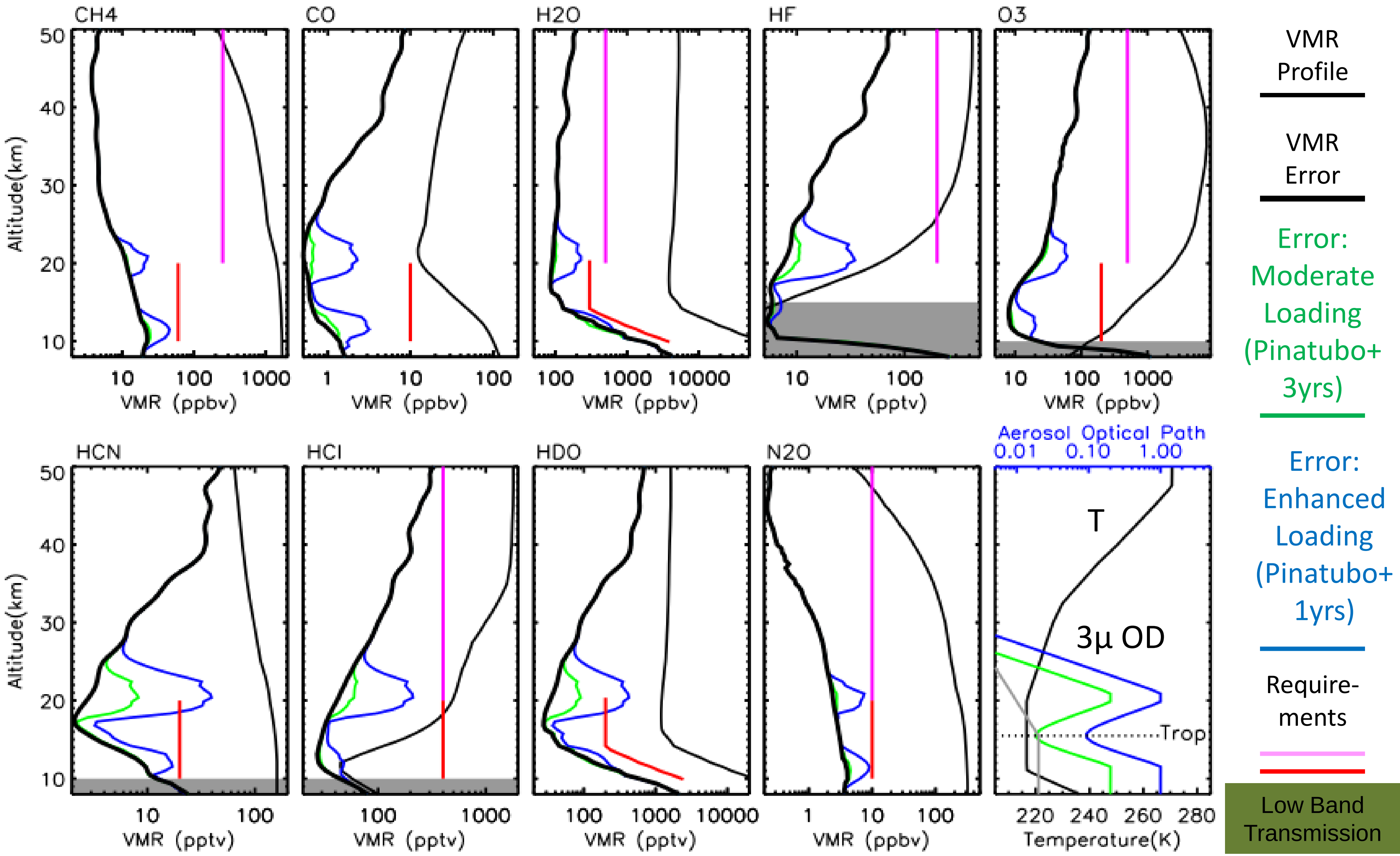

## GLO Instrument (20 x 15 x 10 cm)



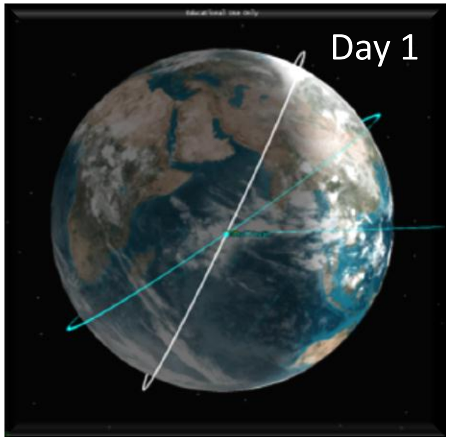
## Stowed Observatory (30 x 20 x 10 cm)

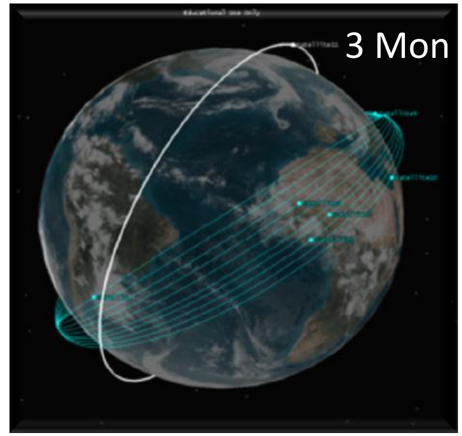


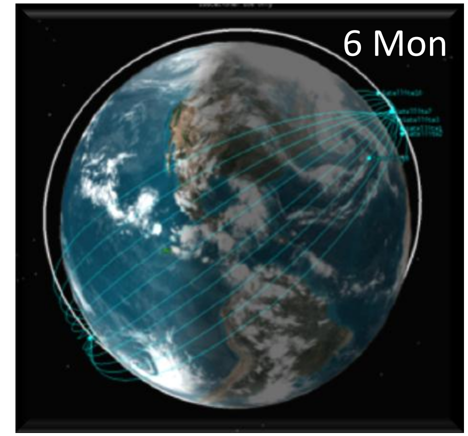
# GLO Retrievals Have Been Simulated Including Aerosol Effects and Show Improved Precision Over HALOE and Other Previous Instruments

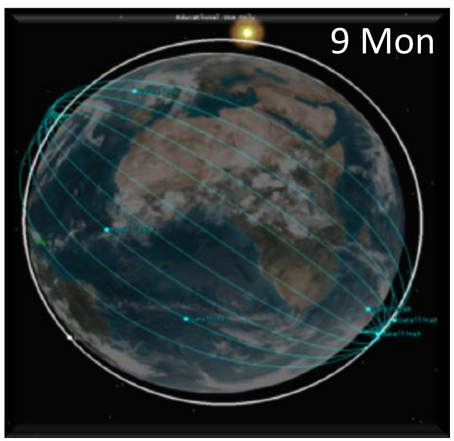


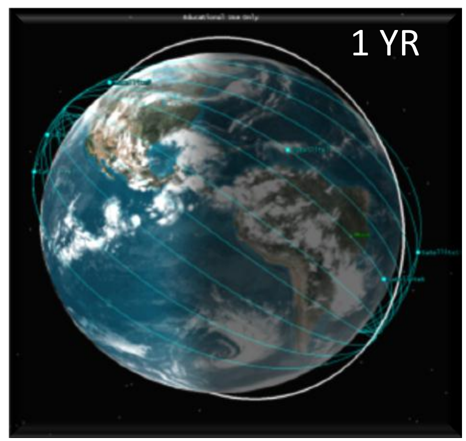
# The SOCRATES Satellites are Launched From a Single Launch Vehicle and the Orbits Evolve to Achieve Near-Global Coverage

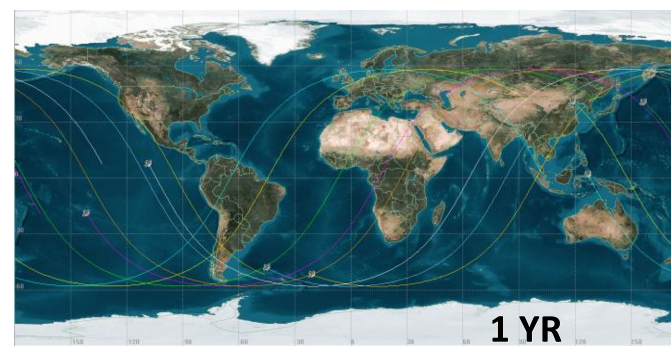


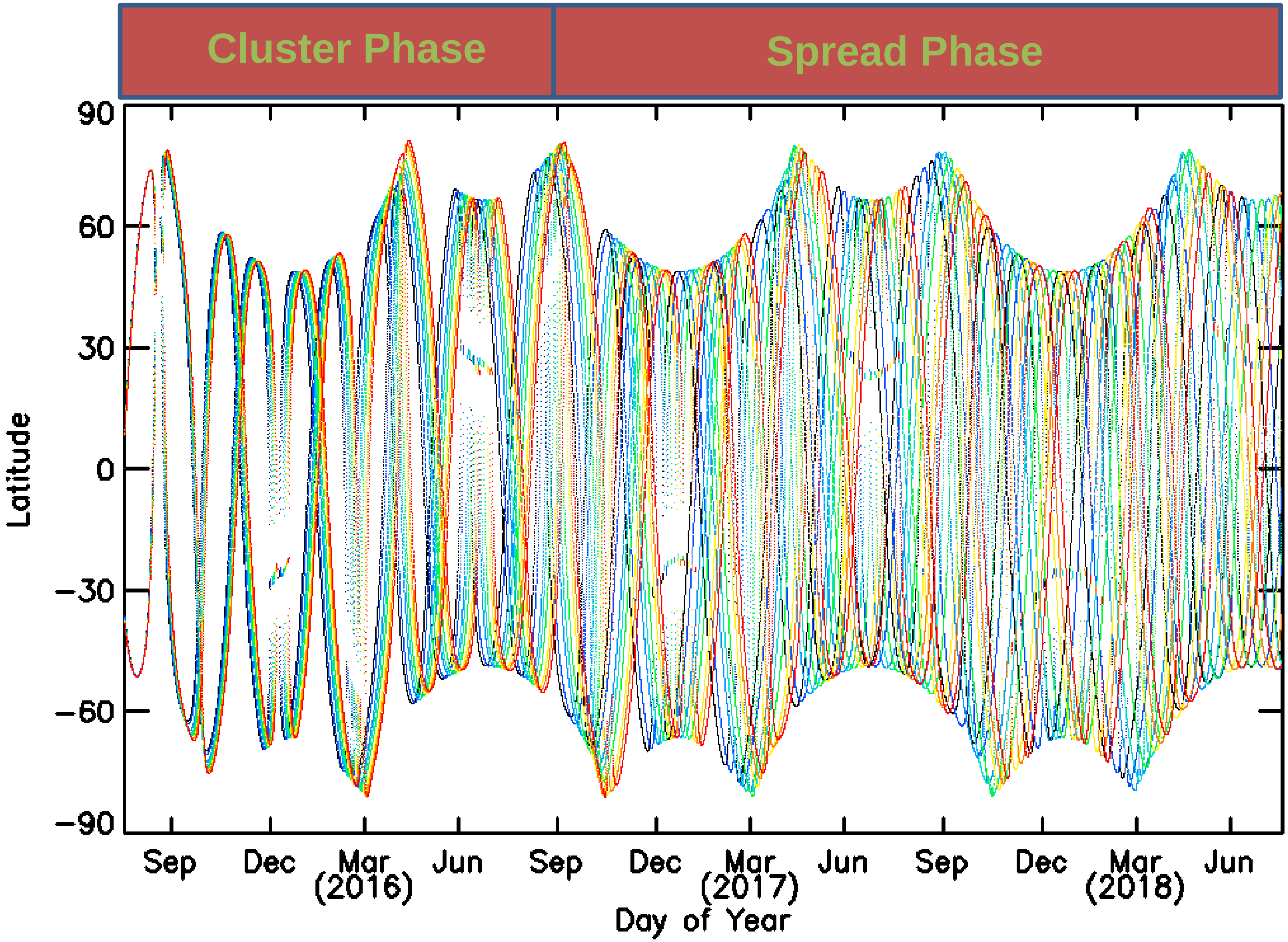



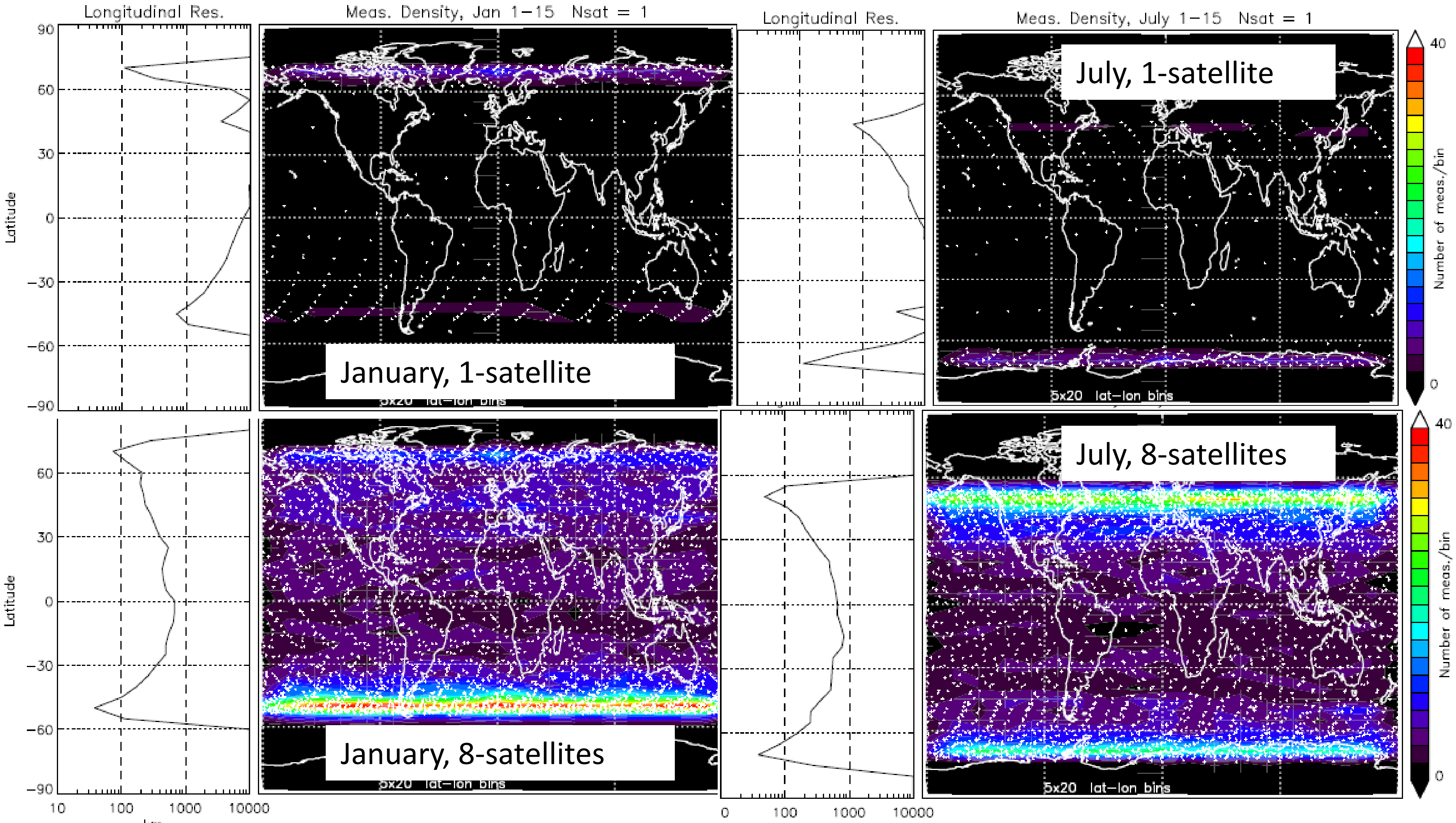

Immediately after launch, all satellites (blue lines) are in the same orbit plane. Due to slightly different precession rates (due mostly to different satellite altitudes), the satellite orbits spread over time such that within a year they are spread equally over the globe.

# The SOCRATES Satellites are Launched From a Single Launch Vehicle and the Orbits Evolve to Achieve Near-Global Coverage




Each color represents a different SOCRATES Satellite. Each point represents an occultation profile. There are eight satellites in the SOCRATES Constellation.

# The SOCRATES Constellation Approach Enables Near Global Coverage, With Excellent Spatial Resolution.




Color images reflect number of observations in a 5° lat by 5° lon 14 day bin. Line plots show mean distance between individual profiles as a function of latitude.

*SOCRATES provides a novel approach to obtaining atmospheric measurements through solar occultation, yet it requires no new technology development, employs robust proven designs, and will be run by an experienced team. SOCRATES is a low risk mission with high scientific payoff.*