



NASA's Future Earth Science Missions for Global Observation

Upendra N. Singh

Chief Technologist, NASA Langley Research Center

February 11, 2010



The NASA Vision

To improve life here,
To extend life to there,
To find life beyond.

The NASA Mission

To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
... as only NASA can.



Study Earth from space to advance scientific understanding and meet societal needs

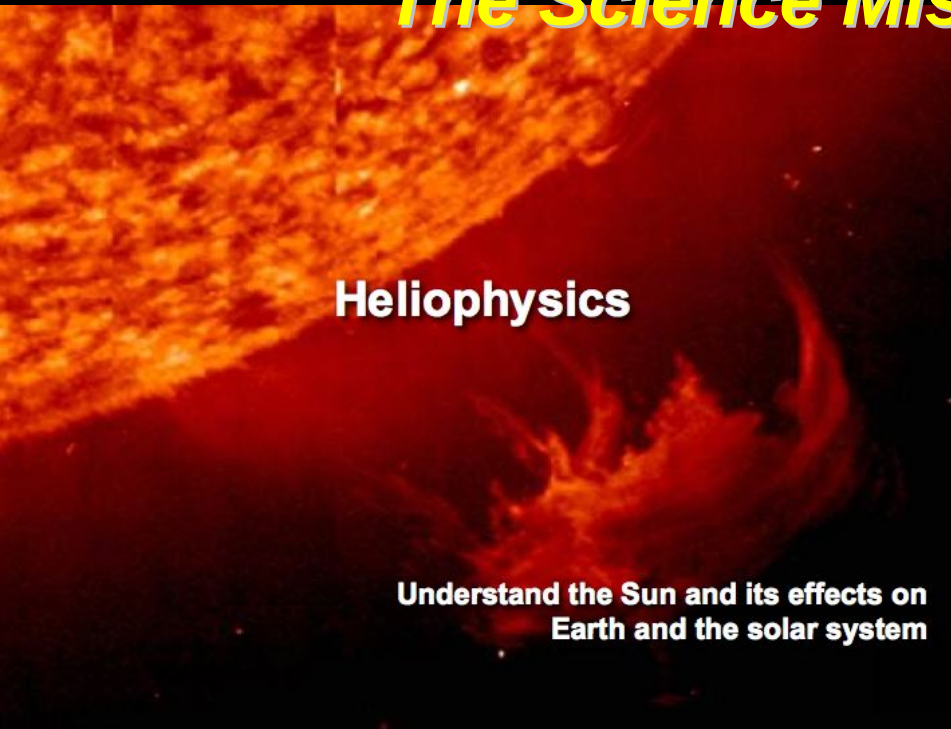
Earth Science



Planetary Science

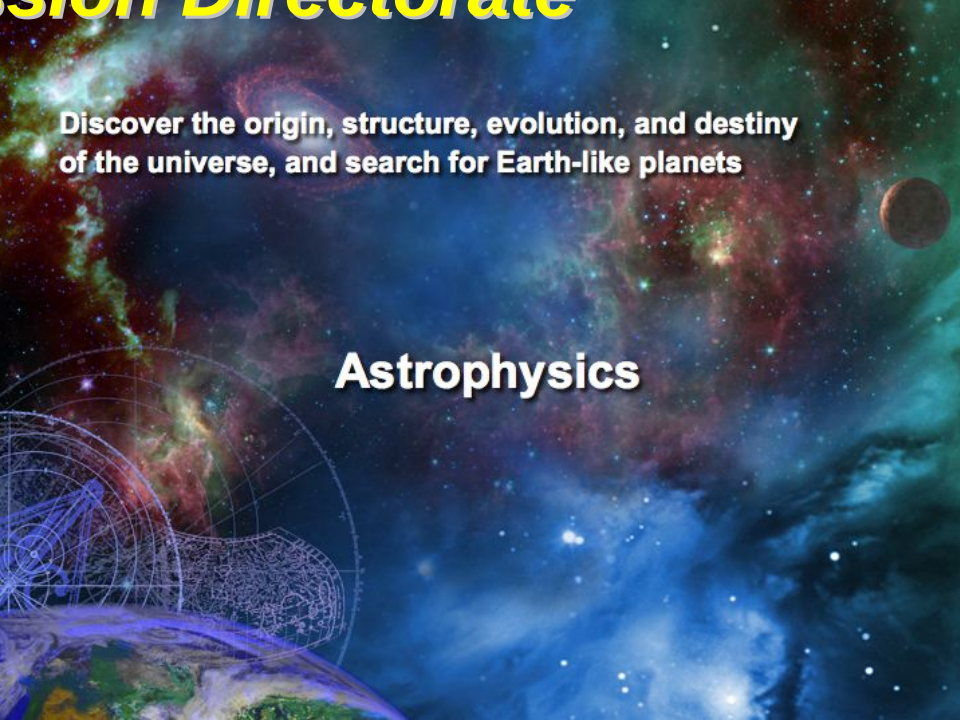
Advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as humans explore space

The Science Mission Directorate



Heliophysics

Understand the Sun and its effects on Earth and the solar system



Astrophysics

Discover the origin, structure, evolution, and destiny of the universe, and search for Earth-like planets



NASA National Objectives Guide

- NASA is implementing five National Objectives. Four of these come directly from the Vision for U.S. Space Exploration. The fifth affirms our continued commitment to understand and protect our home planet.
 - Implement a sustained and affordable human and robotic program to explore the solar system and beyond
 - Extend human presence across the solar system, starting with the Moon by the year 2020, in preparation for human exploration of Mars and other destinations
 - Develop innovative technologies, knowledge, and infrastructure both to explore and to support decisions about the destinations for human exploration
 - Promote international and commercial participation in exploration
 - **Study the Earth System from space and develop new space-based and related capabilities for this purpose**



Earth Science Division Overview

- Overarching goal: to advance Earth System science, including climate studies, through spaceborne data acquisition, research and analysis, and predictive modeling
- Six major activities:
 - Building and operating Earth observing satellite missions, many with international and interagency partners
 - Making high-quality data products available to the broad science community
 - Conducting and sponsoring cutting-edge research in 6 thematic focus areas
 - Field campaigns to complement satellite measurements
 - Modeling
 - Analyses of non-NASA mission data
 - Applied Science
 - Developing technologies to improve Earth observation capabilities
 - Education and Public Outreach

NASA Operating Research Missions



OSTM/Jason 2

Jason-1

QuikSCAT

ACRIMSAT

Landsat 7

NMP/EO-1

Aqua

SORCE

TRMM

Terra

GRACE

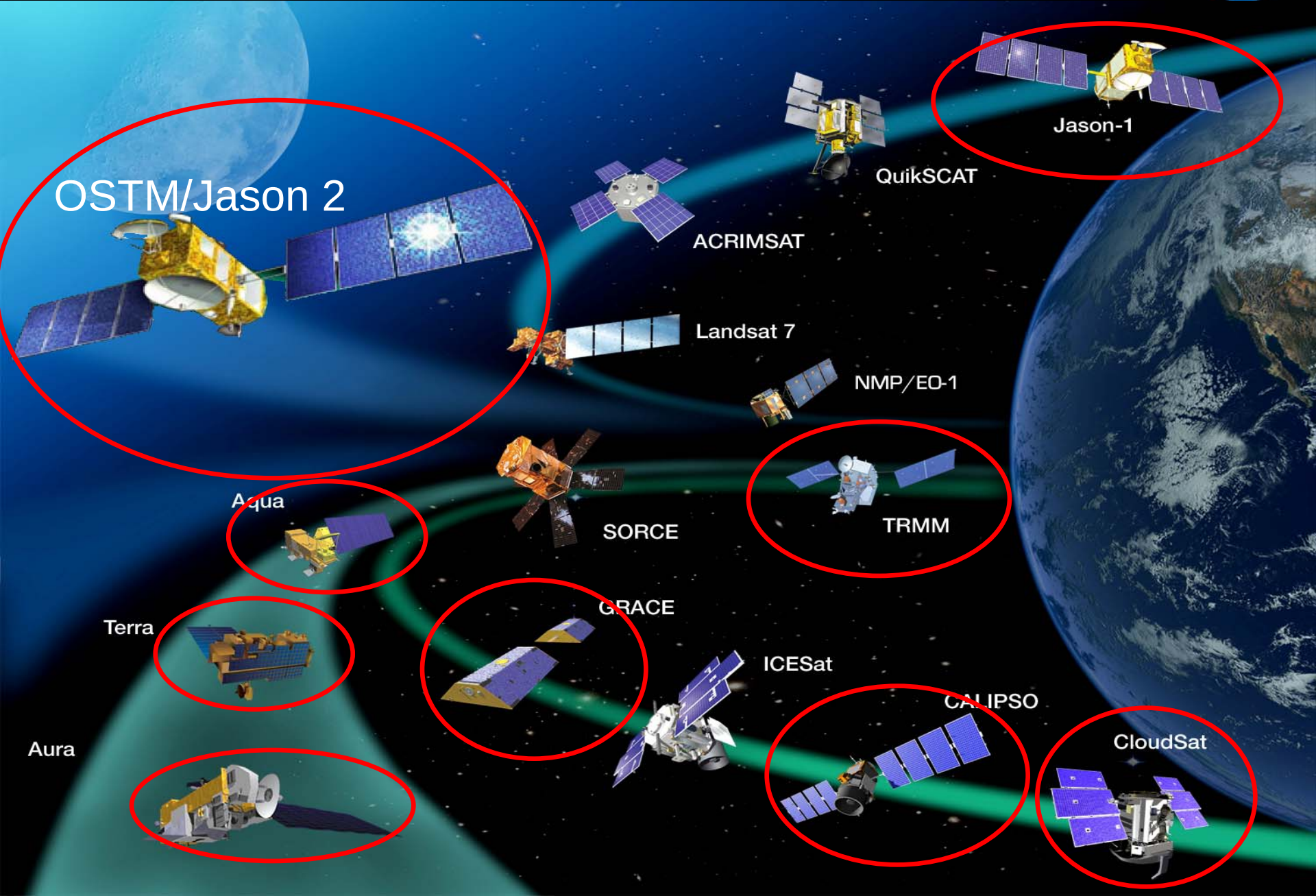
ICESat

CALIPSO

CloudSat

Aura

NASA Operating Missions (International Partnerships)

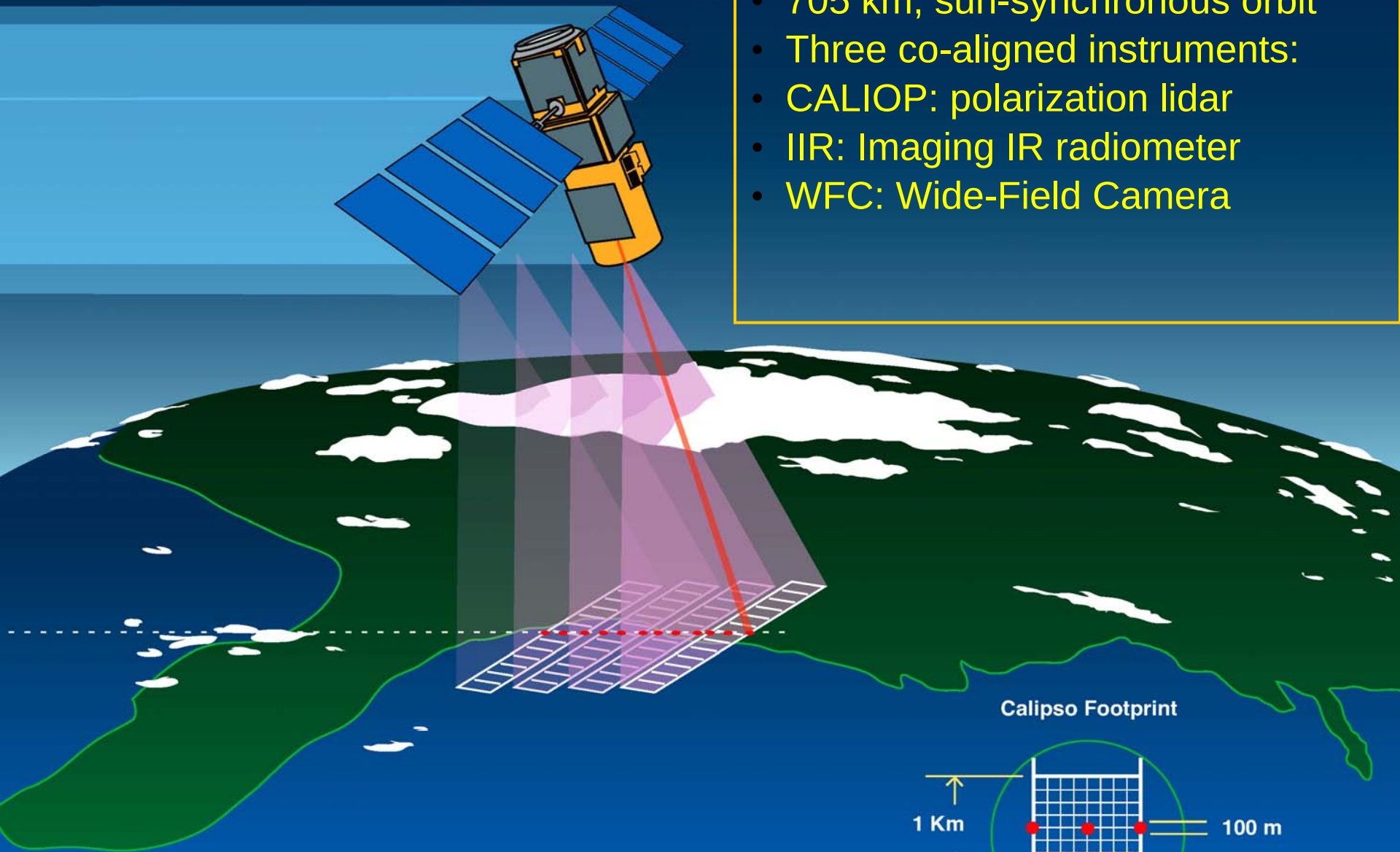


Observing Clouds and Aerosols with CALIPSO

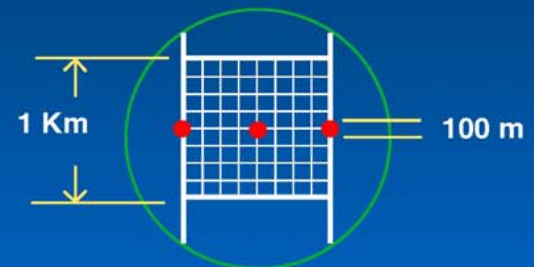


Courtesy: Dave Winker, NASA Langley Research Center

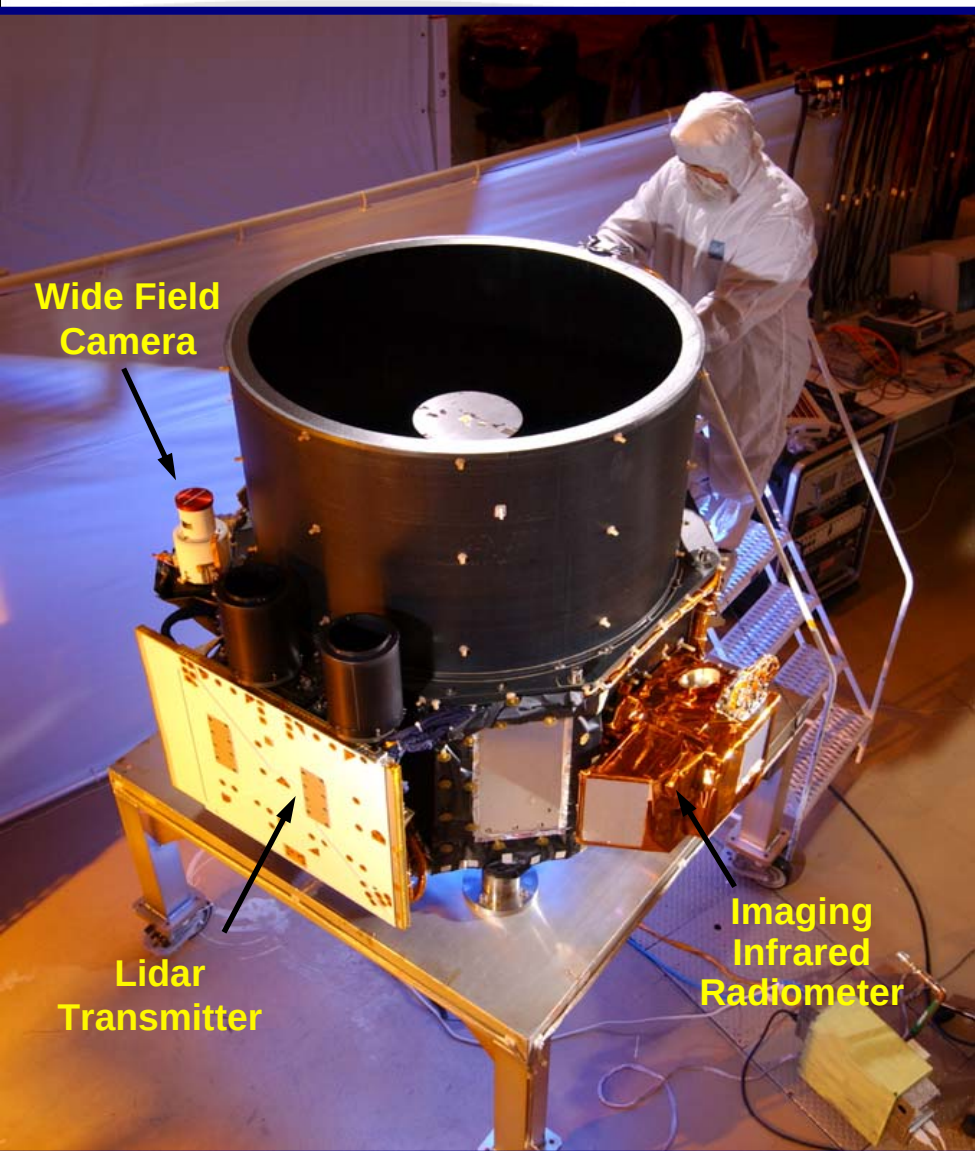
- 705 km, sun-synchronous orbit
- Three co-aligned instruments:
- CALIOP: polarization lidar
- IIR: Imaging IR radiometer
- WFC: Wide-Field Camera



Calipso Footprint



Instrument Specifications



CALIOP

Laser	Nd: YAG, 2x110 mJ
Wavelength	532 nm, 1064 nm
Repetition rate	20.25 Hz
Receiver telescope	1.0 m diameter
Polarization	532 and $\perp$
Footprint/FOV	100 m / 130 μ rad
Vertical resolution	30 - 60 m
Horizontal resolution	333 m
Lin. dynamic range	22 bits

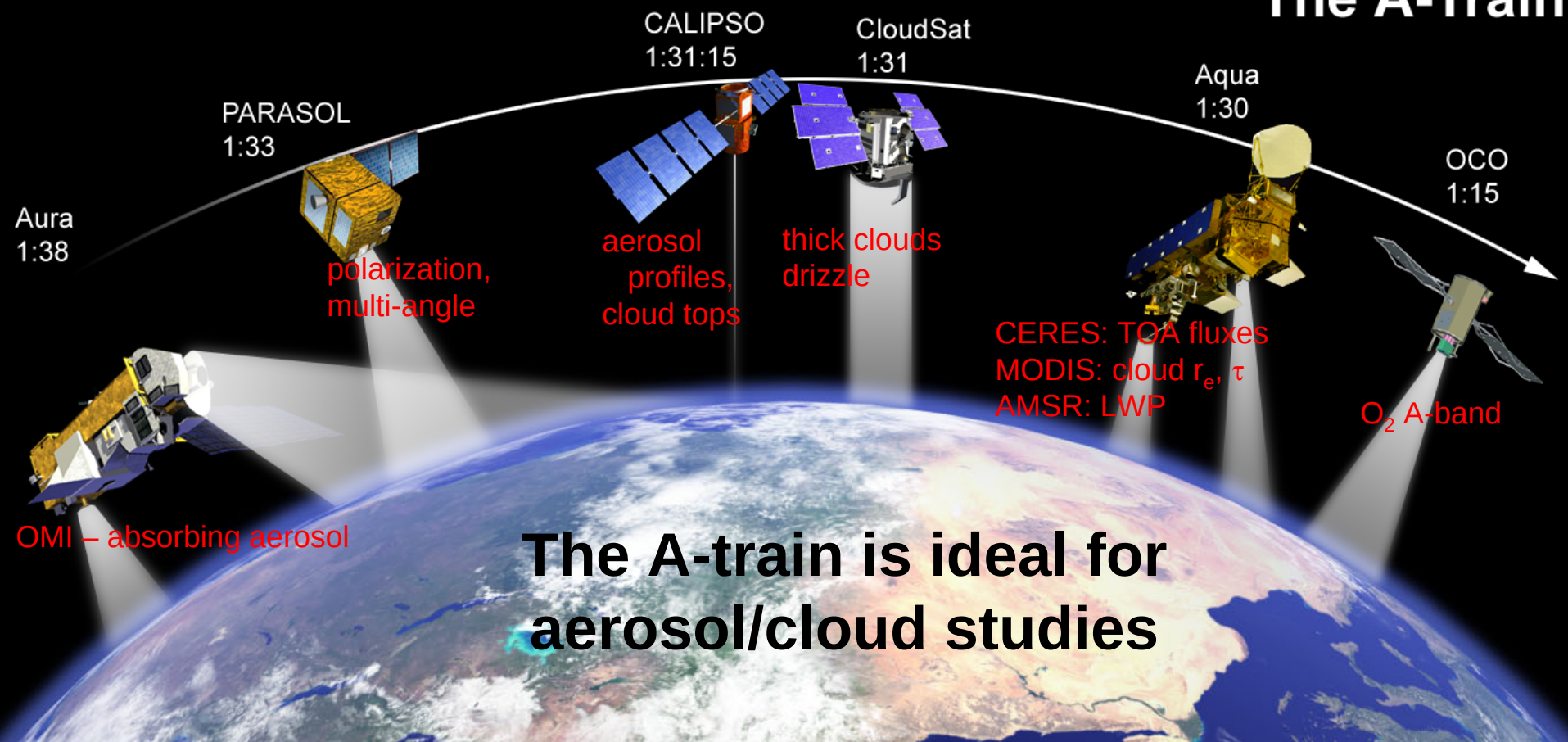
Wide-Field Camera (WFC)

Wavelength	645 nm
Spectral bandwidth	50 nm
IFOV / Swath	125 m / 61 km

Imaging Infrared Radiometer (IIR)

Wavelength	8.65, 10.6, 12.05 μ m
Spectral resolution	0.6-1.0 μ m
IFOV / Swath	1 km / 64 km
NETD @ 210K	0.3 K
Calibration	± 1 K

The A-Train



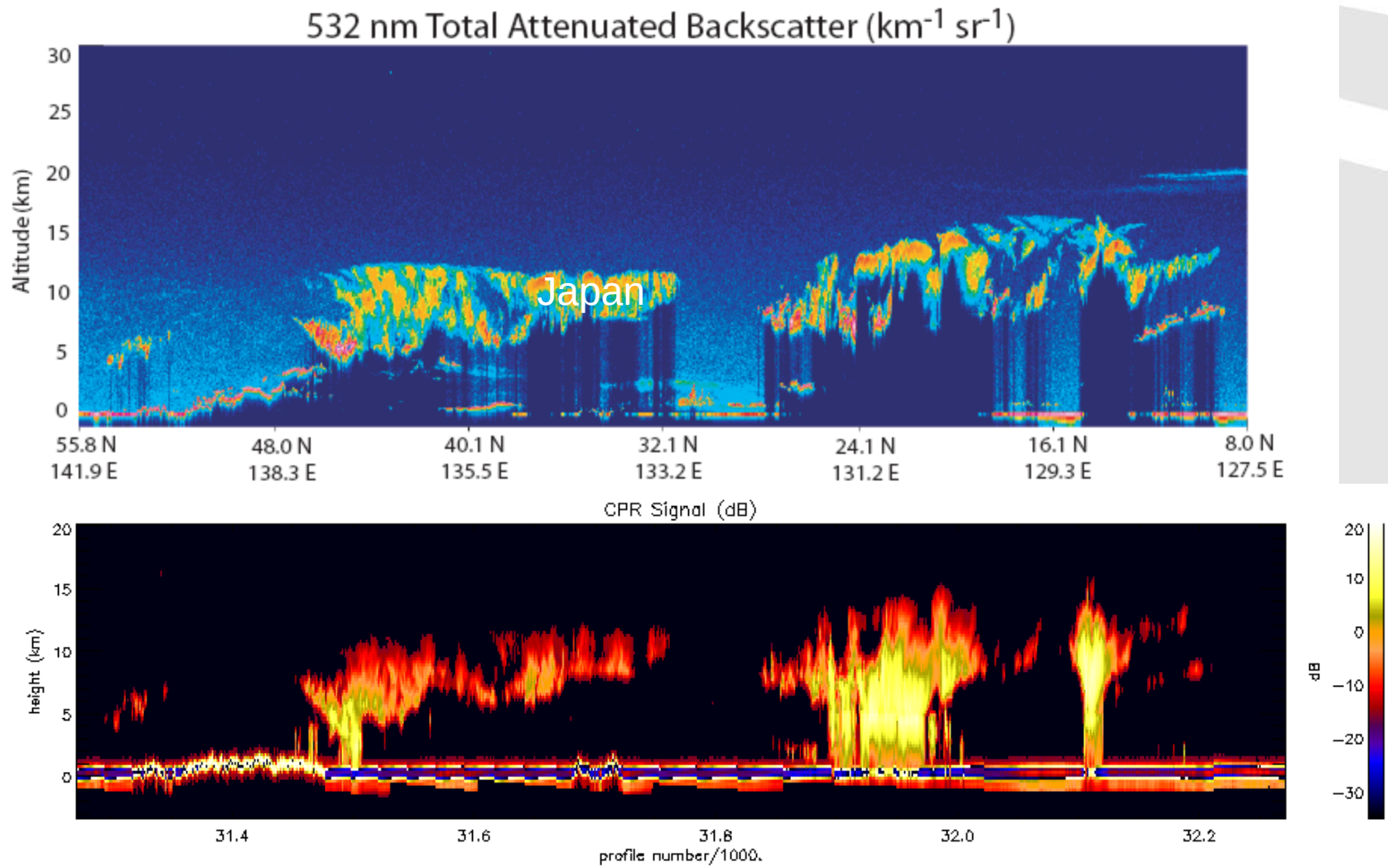
Cloud ice/water mass	CloudSat MLS AMSR
Cloud microphysics	MODIS CloudSat PARASOL
Precipitation	CloudSat AMSR

Aerosol optics	CALIPSO MODIS PARASOL OMI
Cloud optics	CALIPSO, MODIS, and PARASOL
Chemistry	AURA
Radiative Fluxes	CERES

CALIPSO and CloudSat (Western Pacific)



CALIPSO/CloudSat observe the link between the hydrologic cycle and the radiation budget





Aerosol and Cloud Observations over South Asia

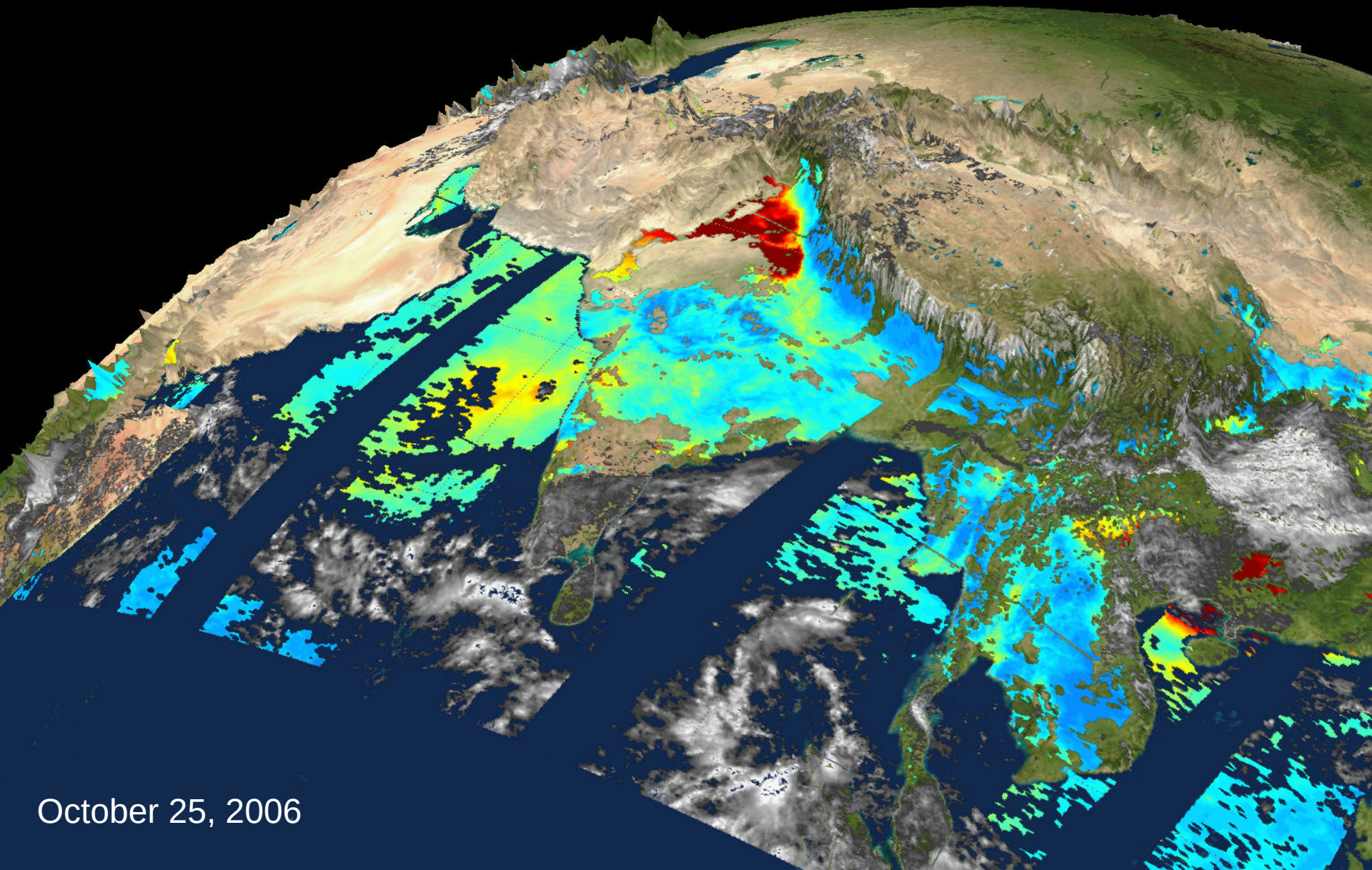


October 25, 2006



Aerosol and Cloud Observations over South Asia

MODIS

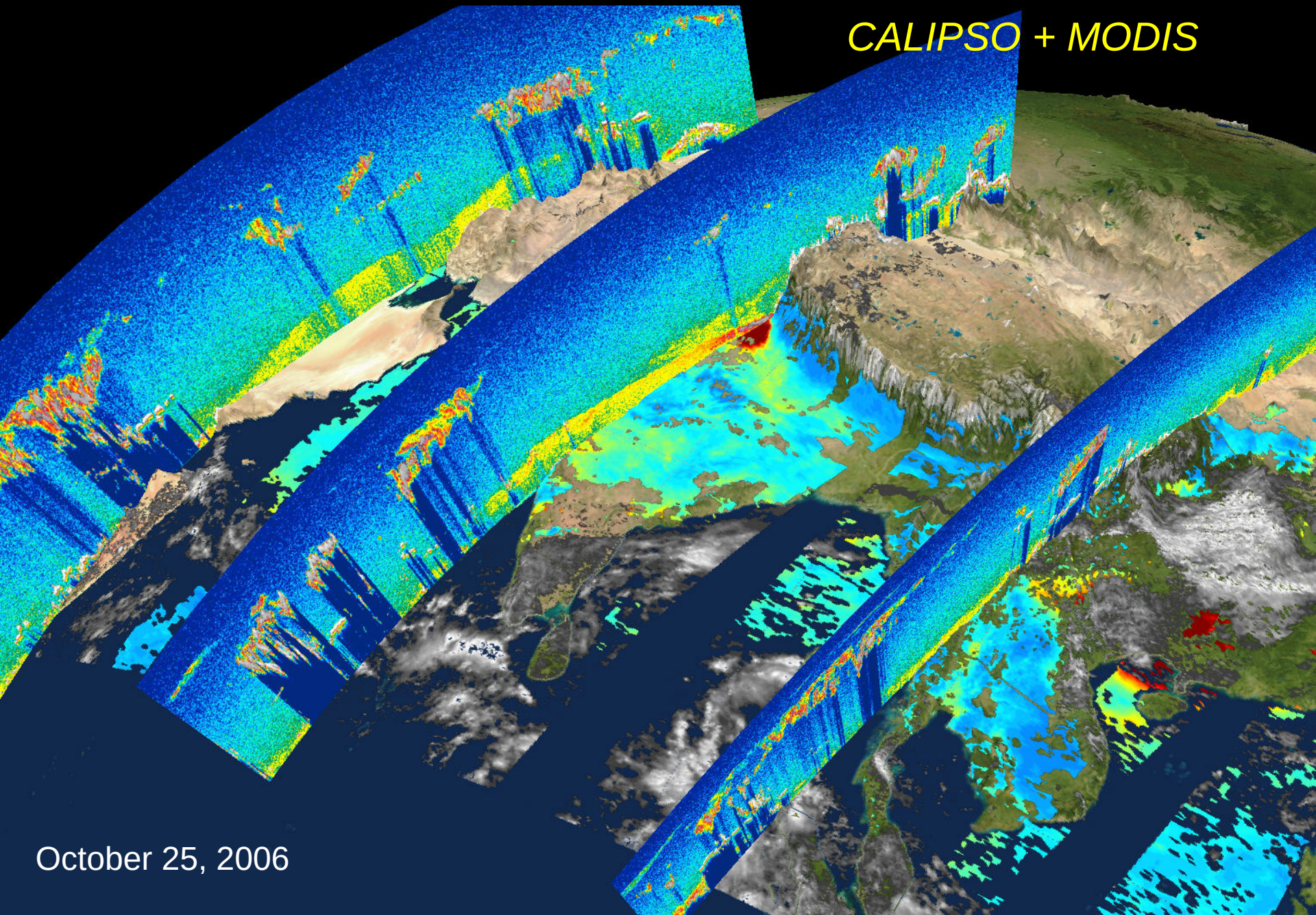


October 25, 2006



Aerosol and Cloud Observations over South Asia

CALIPSO + MODIS

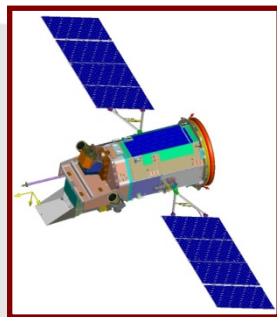


October 25, 2006

Missions in Formulation and Implementation – 1/2010



OCO-reflight
2/2009
2013



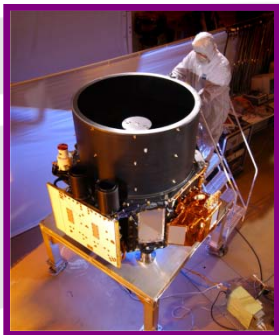
GLORY
6-9/2009
11/2010



AQUARIUS
5/2010
12/2010
(Partner)



NPP
Late 2010?
NET 9/2011
(Partner)



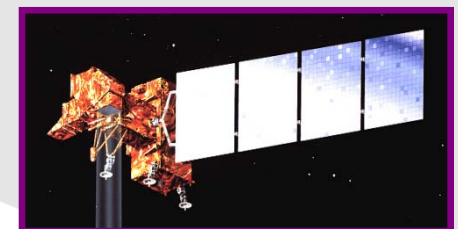
ICESat-II
2014-2015
2015-2016



SMAP
3/2013
2015



GPM
7/2013, 11/2014

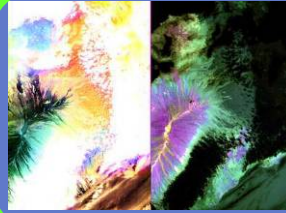
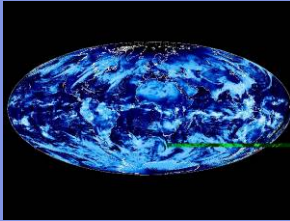


LDCM
12/2012
with TIRS



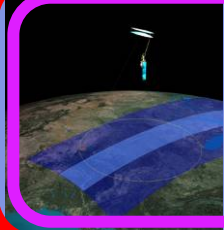
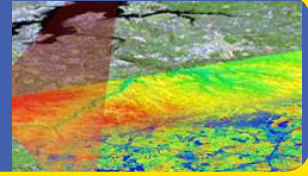
NASA Earth Science Decadal Survey Missions

Climate Absolute
Radiance and
Refractivity
Observatory
(**CLARREO**)



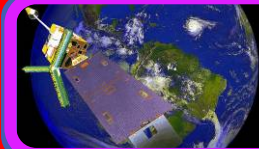
Hyperspectral
Infrared Imager
(**HYSPIRI**)

LIDAR Surface
Topography
(**LIST**)



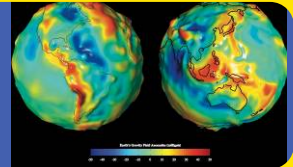
Soil Moisture Active
Passive (**SMAP**)

Active Sensing of
CO2 Emissions
(**ASCENDS**)

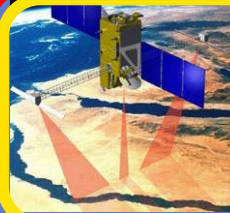
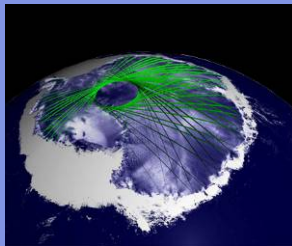


Precipitation and
All-Weather
Temperature and
Humidity (**PATH**)

Gravity Recovery
and Climate
Experiment - II
(**GRACE - II**)



Ice, Cloud, and
Land Elevation
Satellite II
(**ICESat-II**)



Surface Water
and Ocean
Topography
(**SWOT**)



Snow and Cold
Land Processes
(**SCLP**)

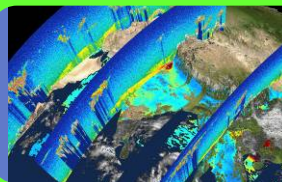
Geostationary
Coastal and Air
Pollution Events
(**GEO-CAPE**)



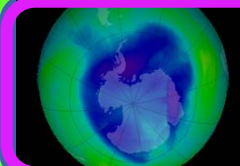
Three-Dimensional
Winds from Space
Lidar (**3D-Winds**)



Deformation,
Ecosystem
Structure and
Dynamics of
Ice (**DESDynI**)



Aerosol - Cloud -
Ecosystems
(**ACE**)



Global Atmospheric
Composition Mission
(**GACM**)

Lasers

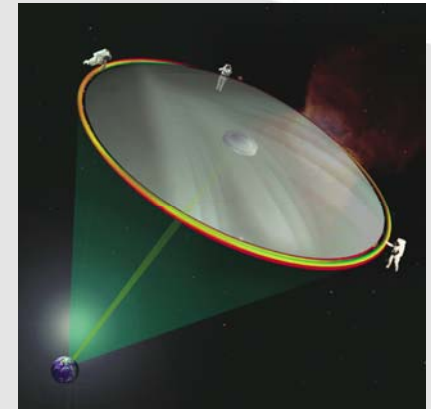
Radars

Passive Optics

Passive Microwave

Earth Science Technology Challenges

- **Active Remote Sensing Technologies** to enable atmospheric, cryospheric and earth surface measurements
- **Large Deployables** to enable future weather/climate/natural hazards measurements
- **Intelligent Distributed Systems** using advanced communication, on-board reprogrammable processors, autonomous network control, data compression, high density storage
- **Information Knowledge Capture** through 3-D visualization, holographic memory and seamlessly linked models.



Challenges Moving Forward



- What we do in Earth Science is recognized by the public and national leaders as **IMPORTANT**, not simply interesting and challenging.
- There is relentless pressure on NASA ESD to expand the scope of our contributions without additional resources
- Preserving a balanced program, completing and launching the missions in development and planned, and developing a realistic, executable future flight program based on the Decadal Survey are the key **programmatic** objectives
- There will be no new research mission launches until the very end of CY 2010 (Glory, Aquarius) – **BUT**
- ***A steady stream of field campaigns, scientific discoveries, applications expansions, and technology developments will carry the program and advance understanding of our planet***

