

Sensors, Platforms, Image-Data from Earth Observations applicable to Disasters

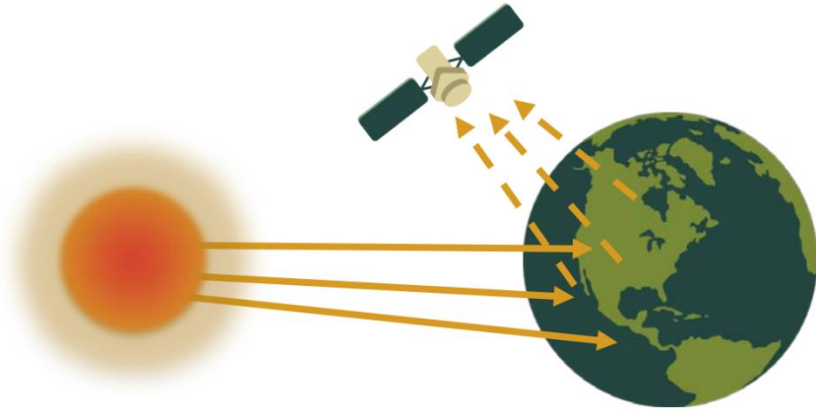
(Dr. Ravi Sharma, Ph.D. USA)
Chair, Ontology Summit 2022
Senior Enterprise Architect
Particle and Space Physicist
Elk Grove CA
drravisharma@gmail.com

Credits to NASA and Other organizations for their materials where used.

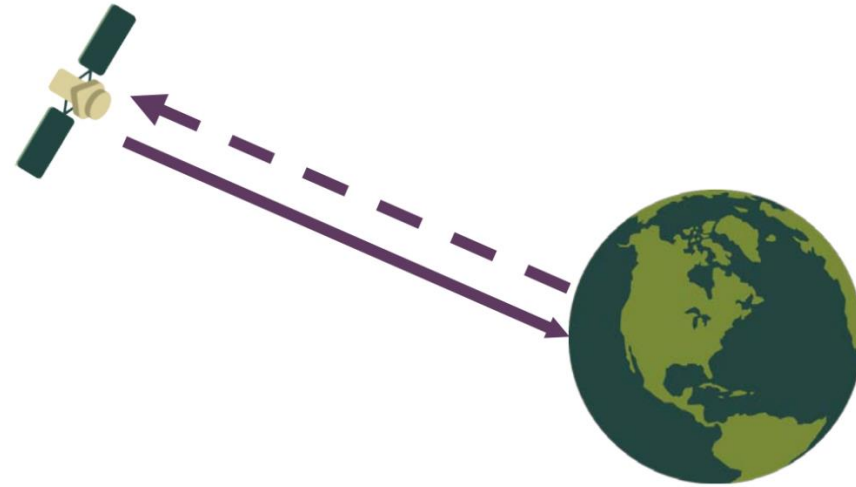
Platforms and Sensors

- ▶ Platforms
 - ▶ Ground –Ocean
 - ▶ Aerial - Aircraft and Drones
 - ▶ Satellite(s) – constellations or formations
- ▶ Sensors
 - ▶ Multispectral (0.3-100 micrometers) and > 30 bands (MODIS, VIIRS)
 - ▶ Radiometers (IR and Microwave) 1-100 micrometers and 2GHZ to 200 GHZ
 - ▶ Active: Radars, Lidars

Passive Sensors

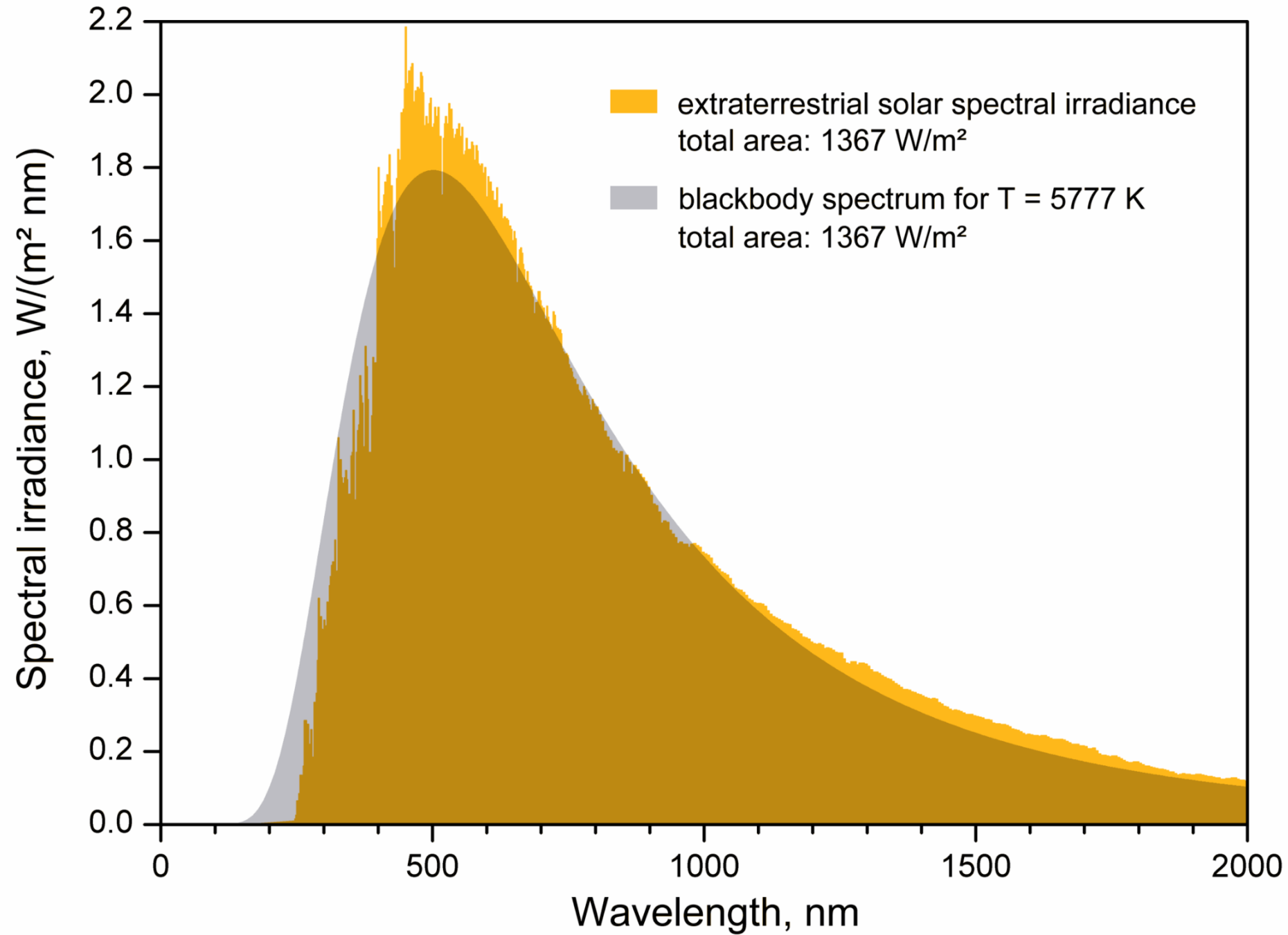


Active Sensors

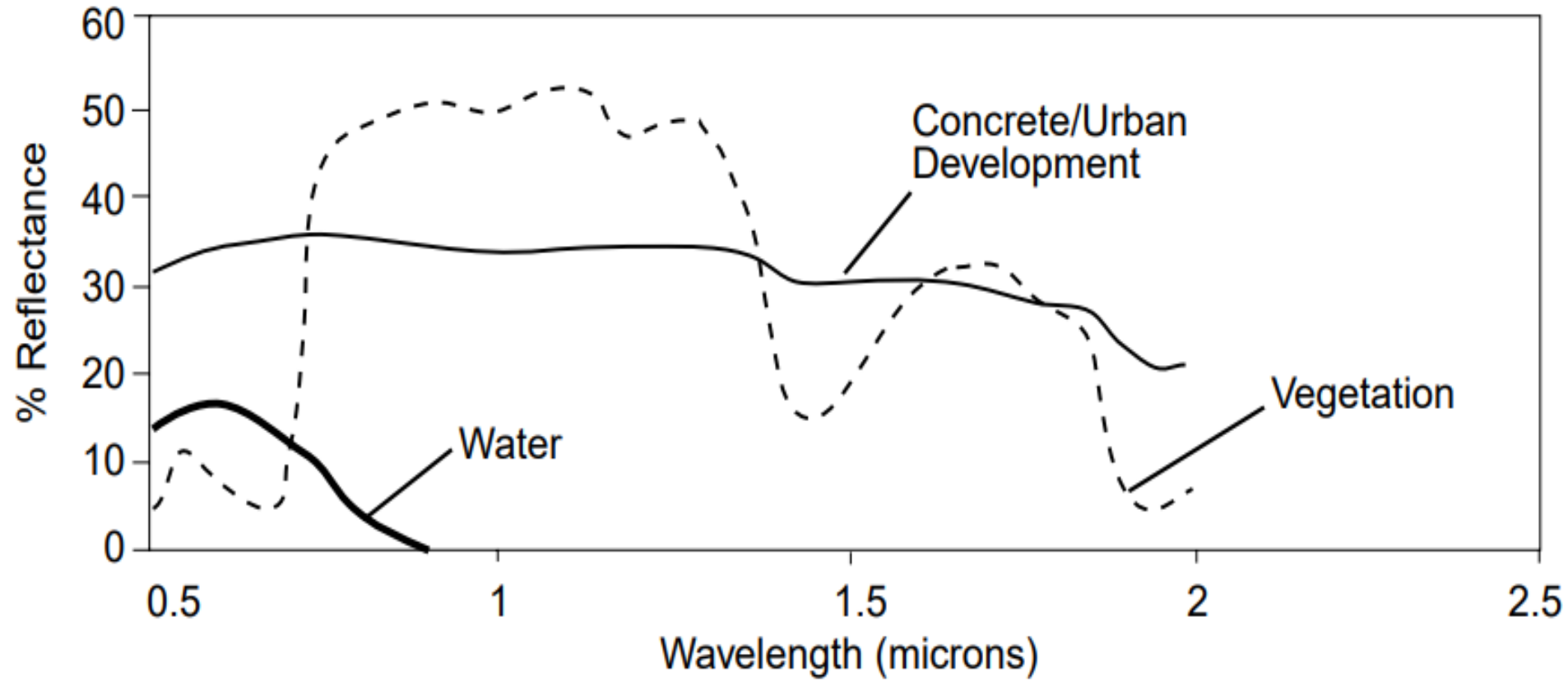


EM Radiation and Active Sensors

- ▶ EM Spectrum and transmission absorption bands (Examples solar radiance and water absorption and vegetation chlorophyll bands)
- ▶ Specular, Diffuse (Lambertian – white bulb), Rayleigh - molecular and Mie – Particulate scattering (used for measuring Aerosols – We are all familiar with pollution measurement – PPM above sizes 0.25-10-100 micrometers or microns.
- ▶ Knowledge or discovery of phenomena that affect incidence at detectors.

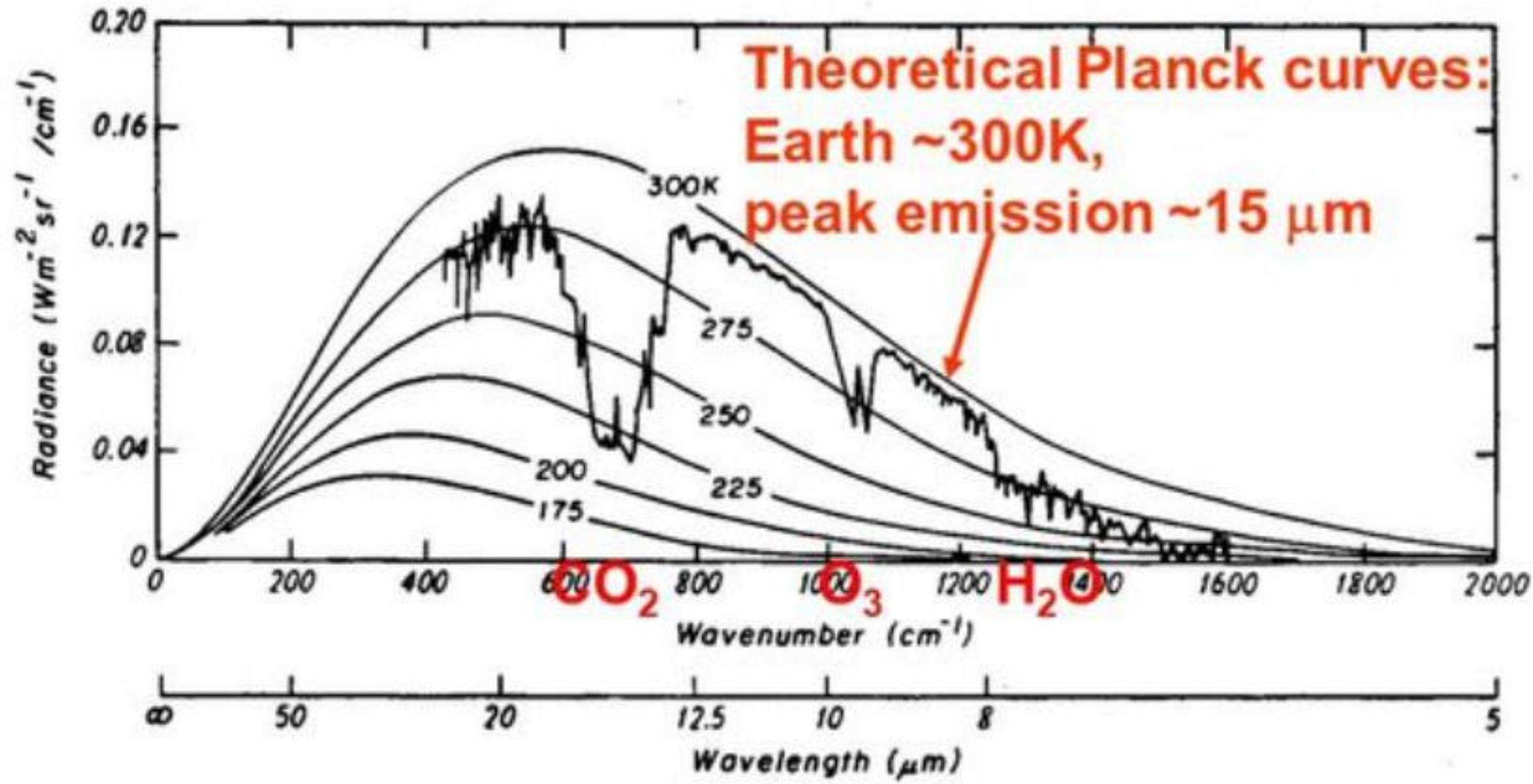


Reflectance Material Spectra



Sahara Desert on Nimbus 4 Satellite

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Environmental Science Enablers

8

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- ▶ Goniometry
- ▶ Spectral Irradiance
- ▶ Passive – Electromagnetic Spectrum (Sun, Earth, Atmosphere), Microwave and IR radiometry
- ▶ Active – Visible/IR LIDAR. Microwave/Radio RADAR (Scatterometer, Phased array)
- ▶ Data Sources (platforms, natural phenomena – fires/volcanoes, sensors, floods)
- ▶ Ground Truth (in-situ, IoT, Buoys, physical measurements)
- ▶ Metadata (including standards for interoperability)
- ▶ Image-Data Products and Electronic Data Records (EDR)

National Aeronautics and
Space Administration

EARTH FLEET

INVEST/CUBESATS

CSIM-FD 2023
HARP 2022
CIRIS 2023
CTIM* 2022
HYTI* 2022
SNOOPI* 2022
NACHOS* 2022
NACHOS2* 2022

JPSS INSTRUMENTS

OMPS-LIMB 2022
LIBERA 2027

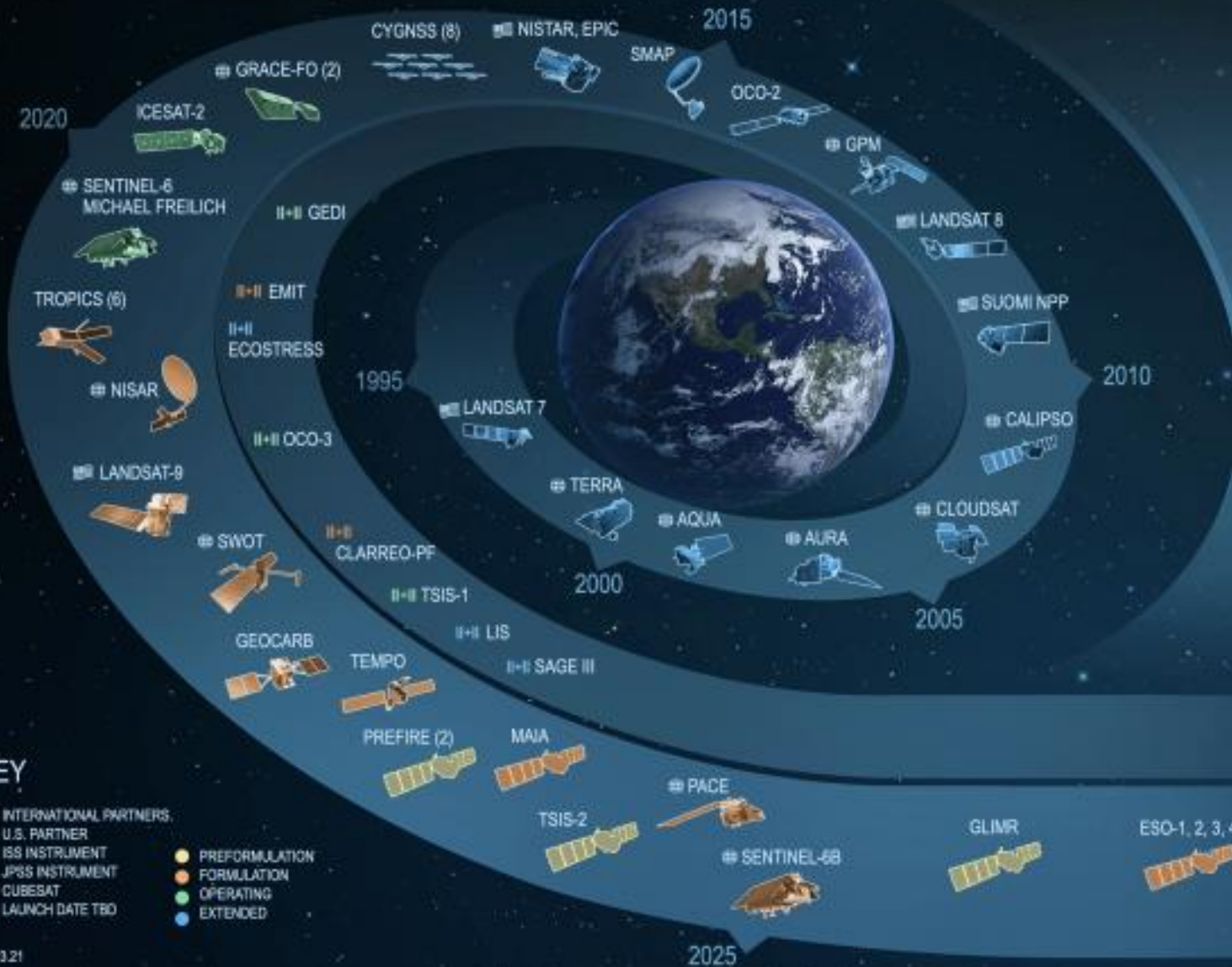
ISS INSTRUMENTS

MISSIONS

KEY

- INTERNATIONAL PARTNERS
- U.S. PARTNER
- ISS INSTRUMENT
- JPSS INSTRUMENT
- CUBESAT
- LAUNCH DATE TBD
- PREFORMULATION
- FORMULATION
- OPERATING
- EXTENDED

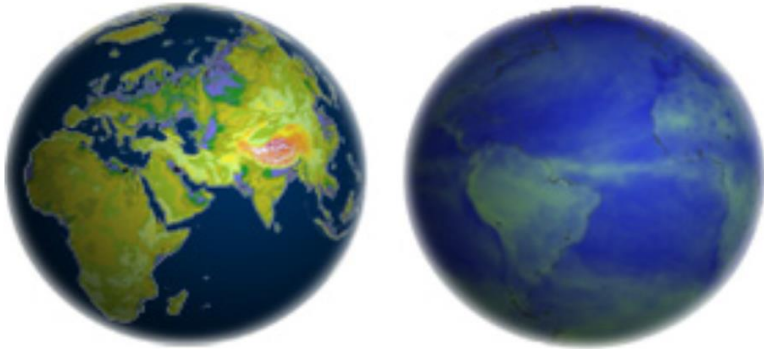
06.23.21



Terra: the EOS Flagship

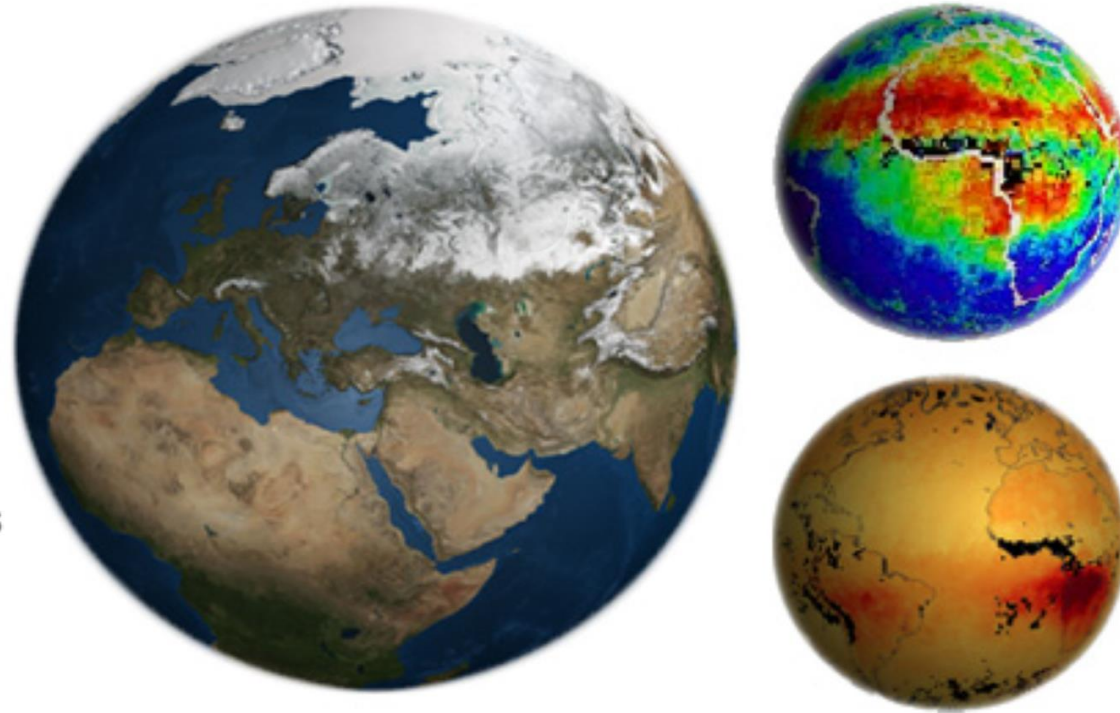
Terra explores the connections between Earth's atmosphere, land, snow and ice, ocean, and energy balance to understand Earth's climate and climate change and to map the impact of human activity and natural disasters on communities and ecosystems.

Connecting Earth's Systems with Terra's Observations



Examples of each instrument's capabilities (clockwise):

land composition (ASTER), reflected energy (CERES), vegetation snow and ice (MODIS), aerosols (MISR), carbon monoxide (MOPITT)

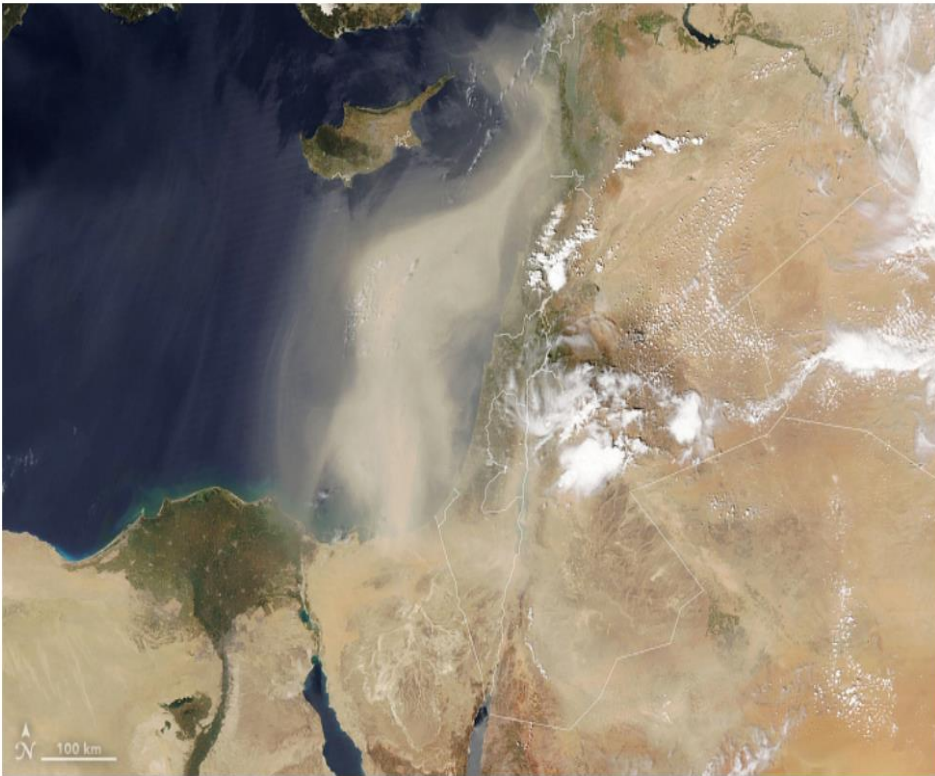


Key Aqua Facts

Mission/Portal Page:	http://science.nasa.gov/missions/aqua
Reference Handbook:	 Aqua.pdf
Data Links:	earthdata.nasa.gov
Launch Vehicle:	Delta II 7920-10L rocket
Altitude:	705km
Inclination:	98.2°
Local Node:	1:30 p.m.
Origination:	Joint with Japan and Brazil
Instruments:	AIRS (Atmospheric Infrared Sounder) AMSR-E (Advanced Microwave Scanning Radiometer for the Earth Observing System) AMSU-A (Advanced Microwave Sounding Unit-A) CERES (Clouds and the Earth's Radiant Energy System) HSB (Humidity Sounder for Brazil) MODIS (Moderate-Resolution Imaging Spectroradiometer)

fuel limitations, Aqua completed the last of its drag makeup maneuvers in December 2021 and is now in a free-drift mode, slowly descending below the A-Train and drifting to later equatorial crossing times. Its AIRS, AMSU, CERES, and MODIS instruments all continue to collect and transmit science-quality data.

Recent Imagery Incorporating Aqua Data



Mediterranean Dust Storm

Published on Friday April 29, 2022

Aqua Status

- Operating instruments: AIRS, AMSU, CERES, MODIS, and AMSR-E, the latter at a reduced rotation rate appropriate for cross-calibration purposes rather than for science.
- Current life expectancy: Aqua has a strong chance of operating successfully into the early 2020s.
- Current systems issues: None.
- Data access: The processed Aqua data are available through several NASA data centers identified on the [images and data page](#).
- The Aqua data are also transmitted via direct broadcast, from which they can be processed for real-time applications using technologies and algorithms available from the [NASA Direct](#)

Aura Sensors and Acronyms for Atmospheric Chemistry

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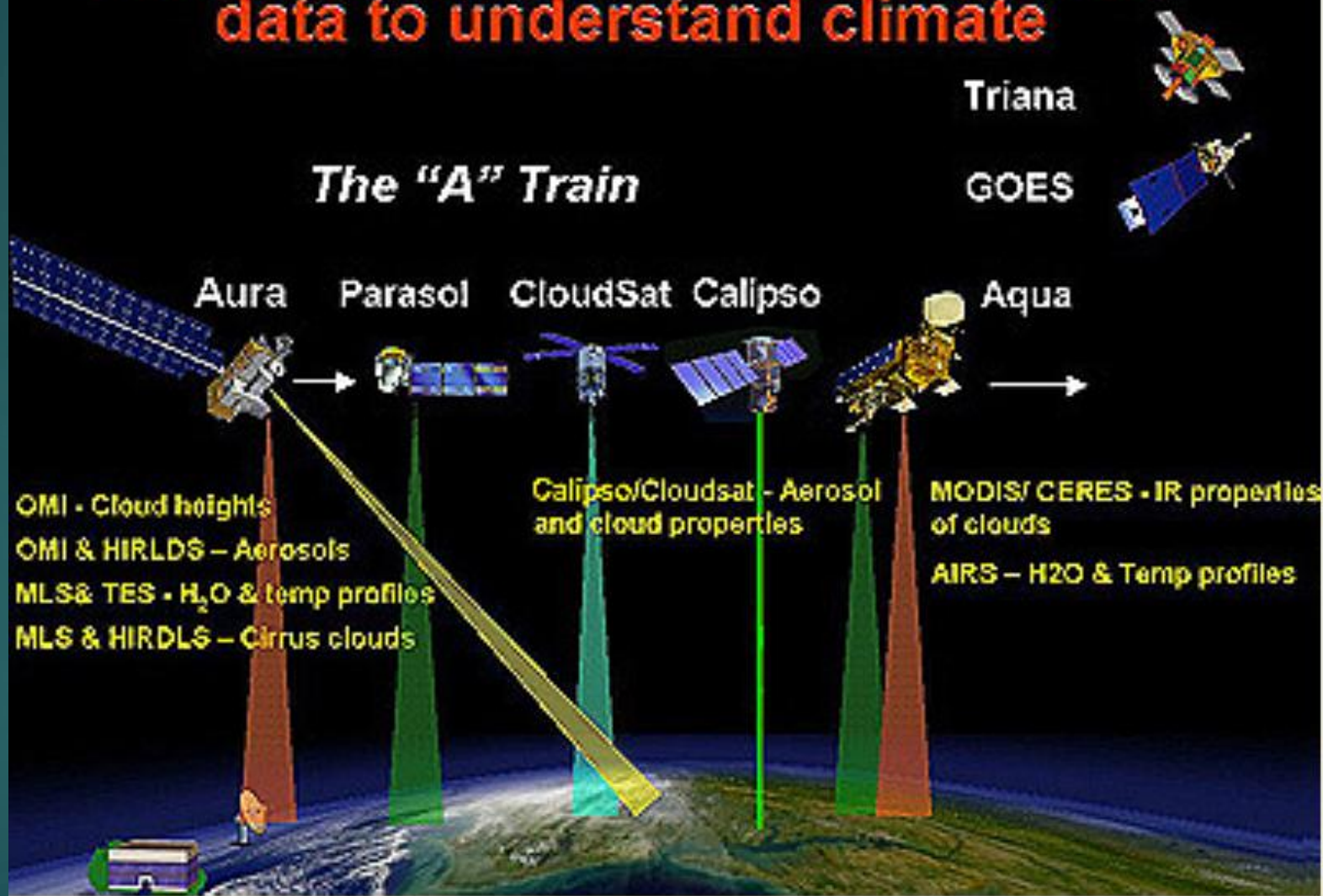
- ▶ HDF Hierarchical Data Format
- ▶ HDF5 Hierarchical Data Format Version 5.X
- ▶ HDF-EOS Hierarchical Data Format for the EOS mission
- ▶ HDF-EOS5 Hierarchical Data Format for the EOS mission Version 5.X
- ▶ **HIRDLS High Resolution Dynamics Limb Sounder**
- ▶ MCF Metadata Configuration File
- ▶ **MLS Microwave Limb Sounder**
- ▶ NASA National Aeronautics and Space Administration
- ▶ **OMI Ozone Monitoring Instrument**
- ▶ **TES Tropospheric Emission Spectrometer**

Key Aura Facts

Mission/Portal Page:	http://science.nasa.gov/missions/aura/
Reference Handbook:	 Aura.pdf
Launch Vehicle:	Delta II 7920 rocket
Altitude:	705km
Inclination:	98.2°
Local Node:	1:45 p.m.
Origination:	Joint with Netherlands, Finland, and the U.K.
Instruments:	HIRDLS (High-Resolution Dynamics Limb Sounder) MLS (Microwave Limb Sounder) OMI (Ozone Monitoring Instrument) TES (Tropospheric Emission Spectrometer)
Project Scientist(s):	Bryan Duncan
Deputy Project Scientist(s):	Joanna Joiner

Formation flying will provide better data to understand climate

The "A" Train



POESS Aerosol Polarimeter Sensor (APS)

All colors,
all polarizations

Limited colors,
limited polarizations

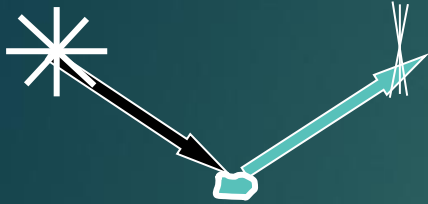


Figure 1

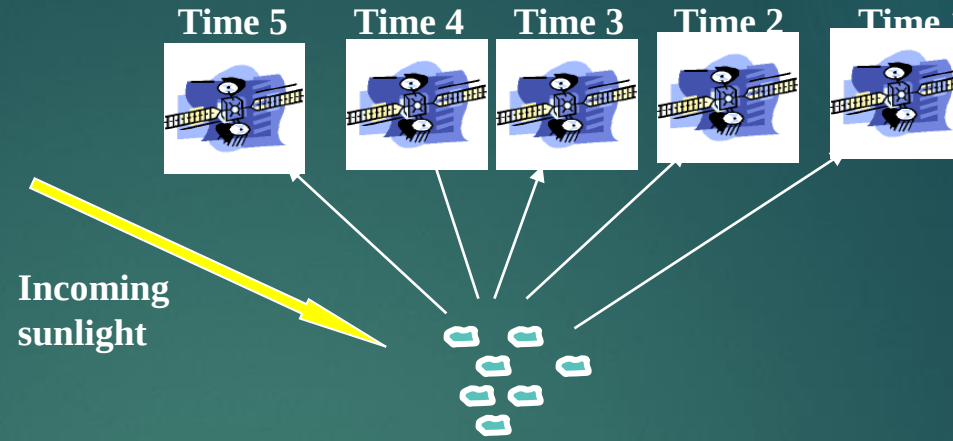


Figure 2

The reflected energy may have a specific polarization – only sine waves going at a specific angle are reflected. See Figure 1. This is the principle used by the aerosol polarimeter sensor (APS).

By looking at aerosols in the air with multiple different colors, it is possible to discern the aerosol. By looking at it with polarizing filters, it is possible to determine the surface properties

By comparing the results, scientists can determine:

- how much energy is absorbed and reflected
- the shape of the particle
- the probably origin of the particle

Continuing the Legacy of Tracking Climate Change Impacts



Image credit: NASA

Arctic Greening Trend

Landsat Reveals Greening Across North America's Arctic.

The northern reaches of North America are getting greener, according to a NASA study that examined plant life across Alaska and Canada. In a changing climate, almost a third of the land cover—much of it Arctic tundra—is looking more like landscapes found in warmer ecosystems. With 87,000 images taken from Landsat satellites between 1984 and 2012, converted into data that reflects the amount of healthy vegetation on the ground, the researchers found that western Alaska, Quebec and other regions became greener over three decades. Rapidly warming temperatures in the Arctic have led to longer growing seasons for plants and changes to the soils. Grassy tundra changes to shrubland, and shrubs grow bigger and denser—changes that could impact regional water, energy and carbon cycles.



WORLDVIEW



Layers



Events



Data

REFERENCE



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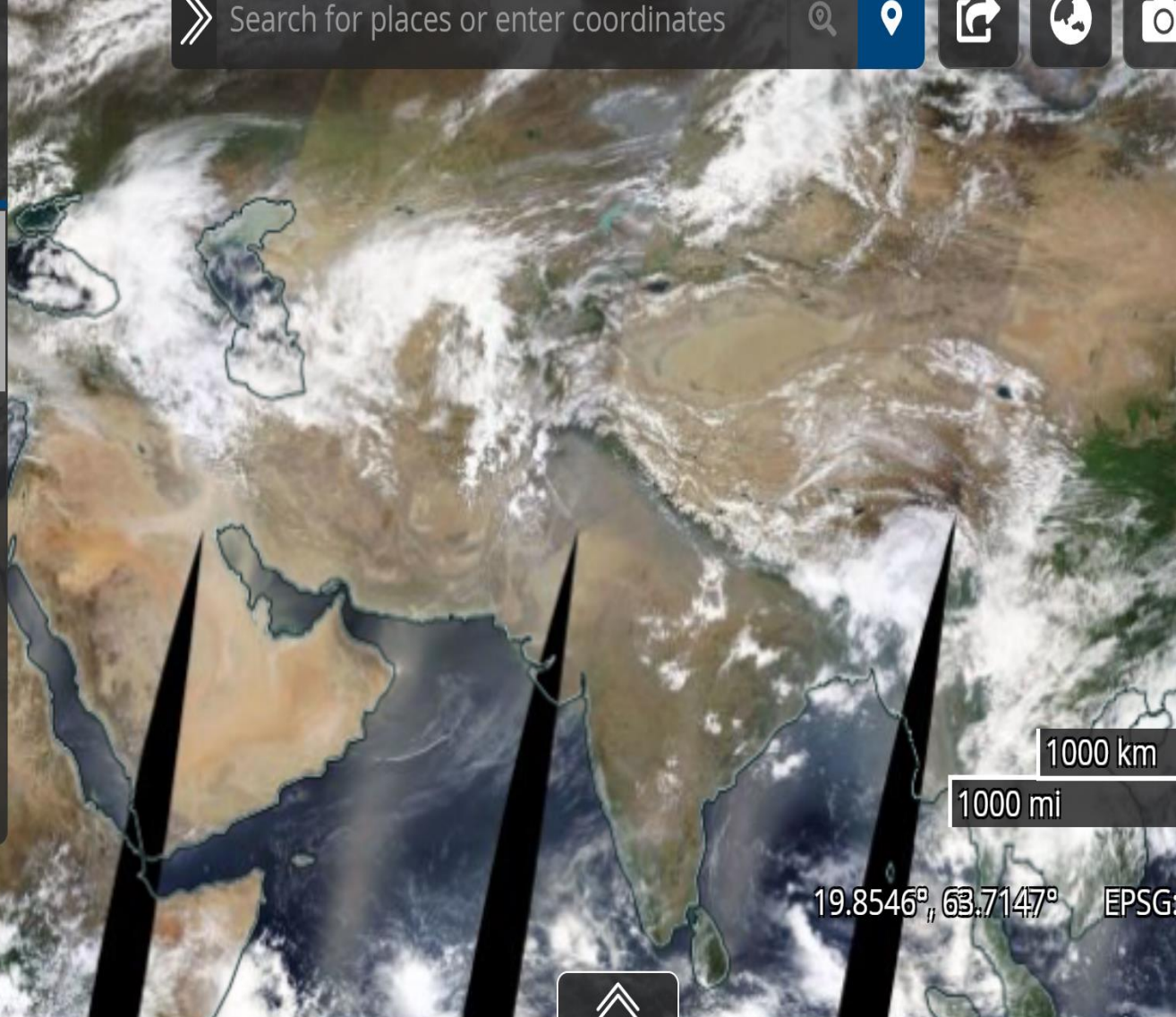
Start Comparison

Search for places or enter coordinates



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2022 MAY 02



1 DAY



APR 2022



MAY 2022



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Layers



Events



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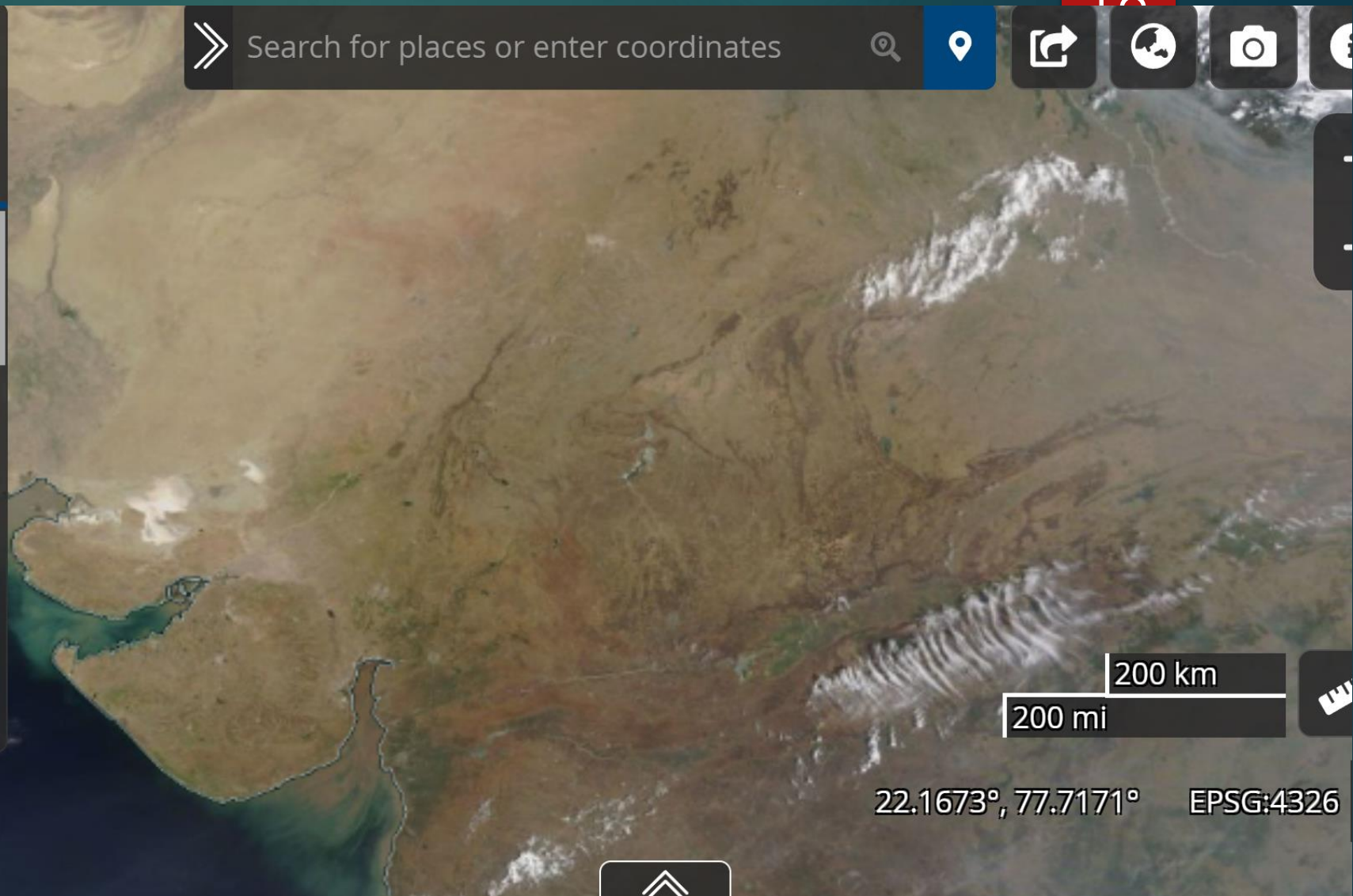
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Start Comparison



Search for places or enter coordinates



200 km

200 mi

22.1673°, 77.7171°

EPSG:4326

 Layers  Events  Data 

REFERENCE

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 Coastlines
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 Group Similar Layers

+ Add Layers

Start Comparison

 Search for places or enter coordinates



10 km
10 mi

22.1589°, 76.4518° EPSG:4326

MODIS Terra
Date: 2007/06/3 - 03/04

[Go back to the main page](#)

MODIS Terra
721

MODIS Terra
NDVI



el size:
[100m](#) | [250m](#)



size:
[1km](#) | [250m](#)



[100m](#) | [250m](#)

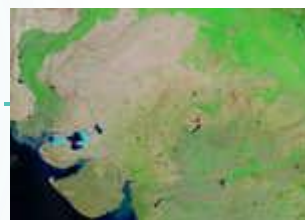
MODIS Aqua
True color

MODIS Aqua
721

MODIS Aqua
NDVI



el size:
[1km](#) | [500m](#) | [250m](#)



size:
[1km](#) | [500m](#) | [250m](#)



[1km](#) | [500m](#) | [250m](#)

Algorithm Theoretical Basis Documents

Algorithm Theoretical Basis Documents (ATBDs) have been developed for EOS instrument products, although some ATBDs address more than one product, and some products are addressed by more than one ATBD. ATBDs typically provide the theoretical basis, both the physical theory and the mathematical procedures and possible assumptions being applied, for the calculations that have to be made to convert the radiances received by the instruments to geophysical quantities. The geophysical quantities are then available to the scientific community for studies of the various characteristics of the Earth system.

NOTE: All ATBDs accessible through these links are subject to revision. These are the latest versions we are aware of. Please help us keep this list current by sending updates or other corrections to the web editor.

[ACRIM](#) Active Cavity Radiometer Irradiance Monitoring

[AIRS](#) Atmospheric Infrared Sounder

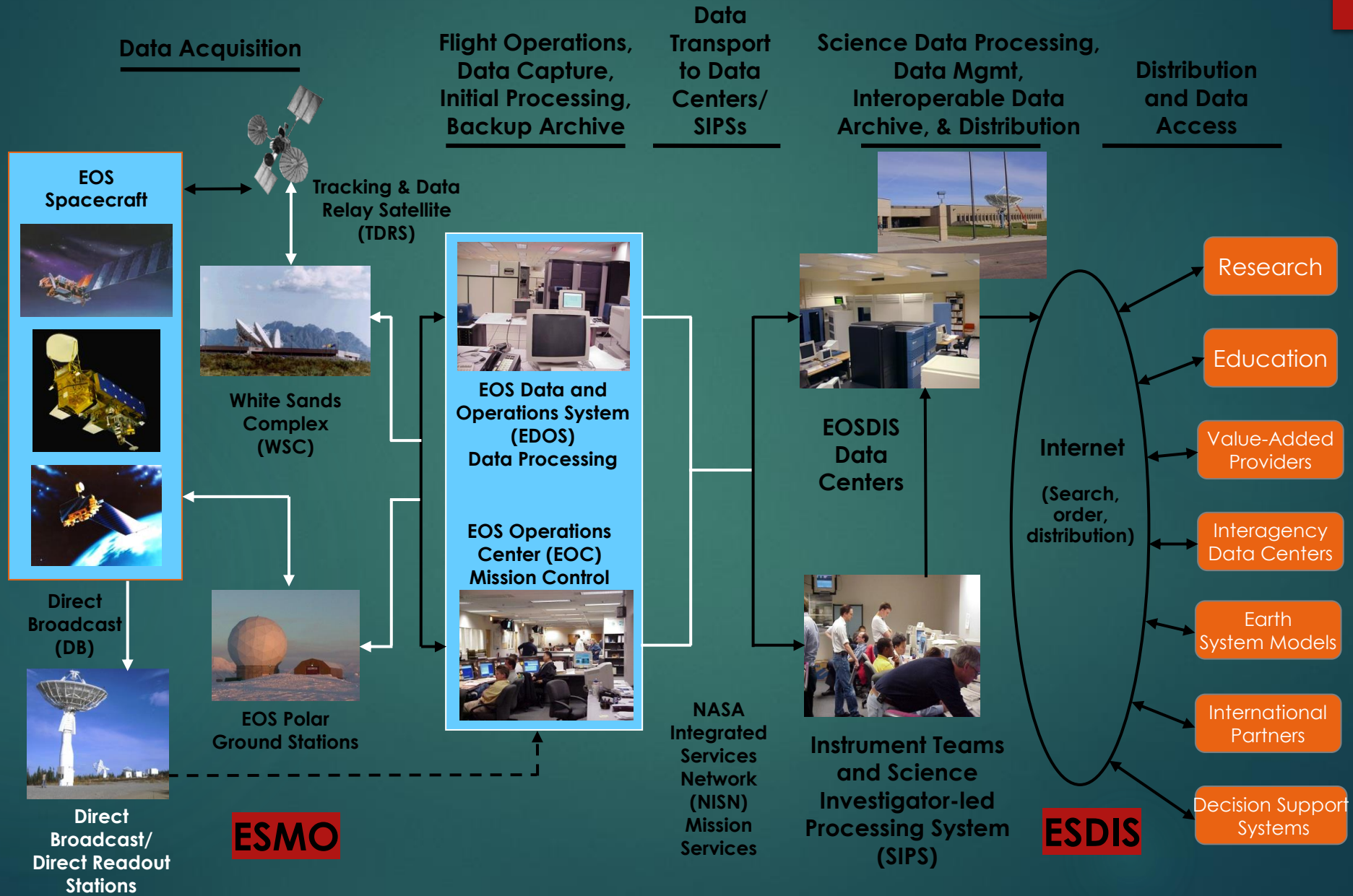
[AMSR-E](#) Advanced Microwave Scanning Radiometer for the Earth Observing System

[ASTER](#) Advanced Spaceborne Thermal Emission and Reflection Radiometer

[CERES](#) Clouds and Earth's Radiant Energy System

[DAO](#) Data Assimilation Office

EOSDIS Context – NASA CREDITS

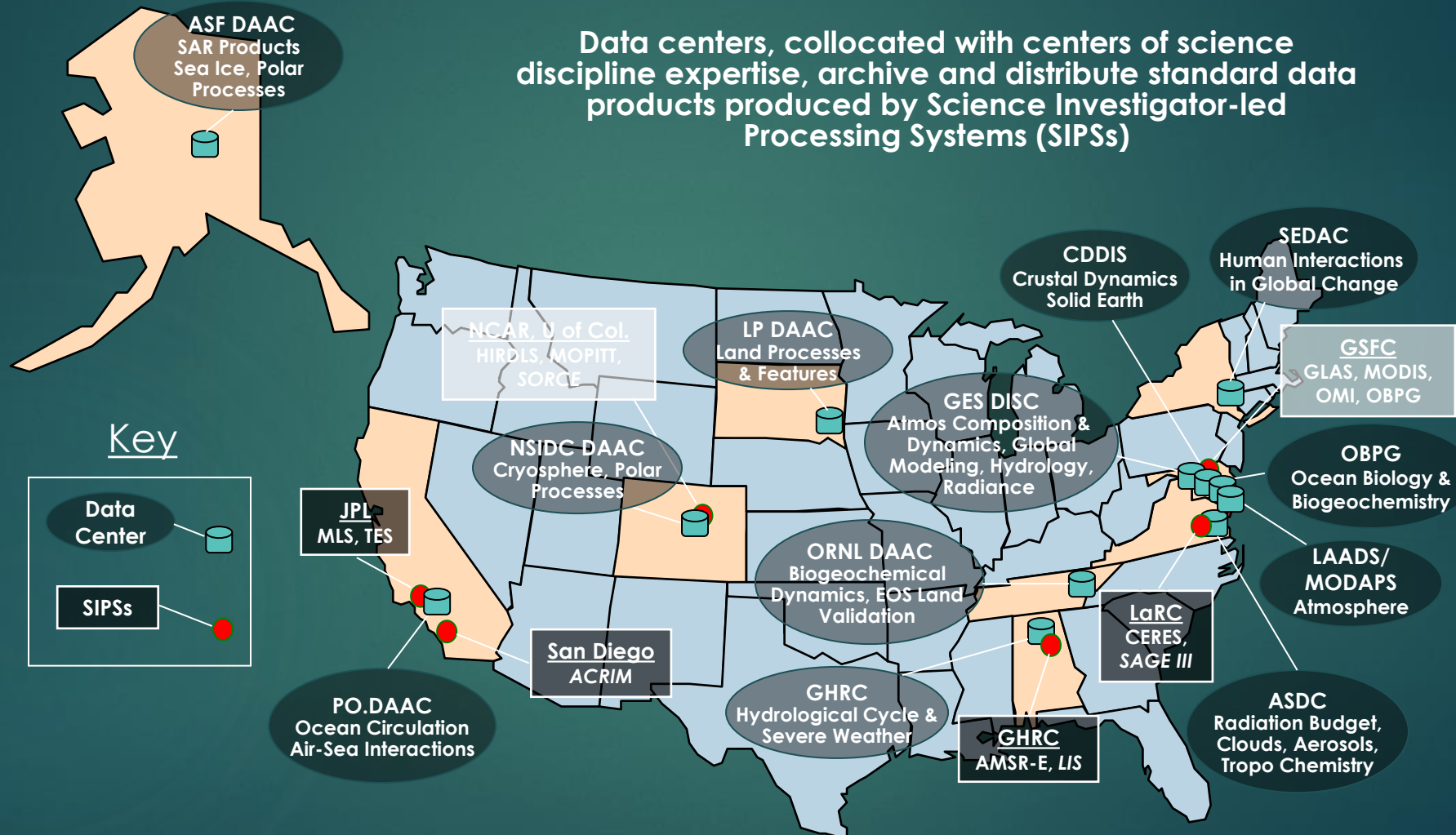


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EOSDIS Facilities – NASA CREDITS

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Overview of HDF and HDF-EOS

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HDF (Hierarchical Data Format) is a data format library which provides self-describing, machine-transparent data storage for scientific data. Data are written and read with HDF library calls and can be accessed via C, Fortran and Java code. Numerous tools are available to allow viewing of HDF-based files. In addition, third party packages such as IDL,

Mathematica and Matlab are able to manipulate HDF files.

A few of the benefits of this data format are:

- Data files are easily transferable between machine platforms (ranging from PCs to high performance computers)
- Files are much more compact than equivalent ASCII files
- Information about the data can be stored along with the data (via HDF attributes)
- Files are self-describing and applications can determine the structure from data contained within the file

Etc.

- Data files are easily sub-settable

<i>HDF-EOS Name</i>	<i>Dimension</i>	<i>Data Type</i>	<i>Units⁽¹⁾</i>	<i>H</i>	<i>M</i>	<i>O</i>	<i>T</i>	<i>Notes</i>
Temperature	(nLevels,nTimes)	REAL - 32 BIT	K	X	X		X	
TemperaturePrecision	(nLevels,nTimes)	REAL - 32 BIT	K	X	X		X	
TemperatureNormChiSq	(nTimes)	REAL - 32 BIT	NoUnits	X				
TemperatureQuality	(nTimes)	INTEGER - 8 BIT	NoUnits	X				
O3	(nLevels,nTimes)	REAL - 32 BIT	vmr	X	X		X	
O3	(nLayers,nXtrack,nTimes)	REAL - 32 BIT	vmr			X		
O3Precision	(nLevels,nTimes)	REAL - 32 BIT	vmr	X	X		X	
O3NormChiSq	(nTimes)	REAL - 32 BIT	NoUnits	X				
O3Quality	(nTimes)	INTEGER - 8 BIT	NoUnits	X				
H2O	(nLevels,nTimes)	REAL - 32 BIT	vmr	X	X		X	
H2OPrecision	(nLevels,nTimes)	REAL - 32 BIT	vmr	X	X		X	
H2ONormChiSq	(nTimes)	REAL - 32 BIT	NoUnits	X				
H2OQuality	(nTimes)	INTEGER - 8 BIT	NoUnits	X				
ClONO2	(nLevels,nTimes)	REAL - 32 BIT	vmr	X				
ClONO2Precision	(nLevels,nTimes)	REAL - 32 BIT	vmr	X				
ClONO2NormChiSq	(nTimes)	REAL - 32 BIT	NoUnits	X				
ClONO2Quality	(nTimes)	INTEGER - 8 BIT	NoUnits	X				
N2O5	(nLevels,nTimes)	REAL - 32 BIT	vmr	X				
N2O5Precision	(nLevels,nTimes)	REAL - 32 BIT	vmr	X				
N2O5NormChiSq	(nTimes)	REAL - 32 BIT	NoUnits	X				
N2O5Quality	(nTimes)	INTEGER - 8 BIT	NoUnits	X				
N2O	(nLevels,nTimes)	REAL - 32 BIT	vmr	X	X			
N2OPrecision	(nLevels,nTimes)	REAL - 32 BIT	vmr	X	X			
N2ONormChiSq	(nTimes)	REAL - 32 BIT	NoUnits	X				
N2OQuality	(nTimes)	INTEGER - 8 BIT	NoUnits	X				
NO2	(nLevels,nTimes)	REAL - 32 BIT	vmr	X			X	TES limb only
NO2Precision	(nLevels,nTimes)	REAL - 32 BIT	vmr	X			X	TES limb only

Image Data – accuracy levels

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- ▶ L0 Level 0 (zero)
- ▶ L0R Level 0 Release
- ▶ L1 Level 1
- ▶ L1G Level 1 Geometrically Corrected
- ▶ L1R Level 1 Radiometrically Corrected
- ▶ L2 Level 2
- ▶ L2TP Layer 2 Tunneling Protocol
- ▶ L3 Level 3
- ▶ L4 Level 4
- ▶ LAADS DAAC Level 1 and Atmosphere Archive and Distribution System DAAC

Accuracy of Data Products

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- ▶ Level 0 (L0): reconstructed, unprocessed instrument or platform data at full resolution.
- ▶ Level 1A (L1A): reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters, e.g., platform ephemeris, computed and appended but not applied to the Level 0 data.
- ▶ Level 1B (L1B): Level 1A data that have been processed to sensor units.
- ▶ Level 2 (L2): Derived geophysical variables at the same resolution and location as the Level 1 source data.
- ▶ Level 3 (L3): Level 3 data products are variables mapped on uniform space-time grid scales.
- ▶ Level 4 (L4): Level 4 data products are model output or results from analyses of lower level data, e.g., variables derived from multiple measurements.

Knowledge – Earth Science examples

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Oceans & atmospheres

- ▶ Science of ocean atmosphere interaction developed
- ▶ Careful partitioning can generate sub-domain ontologies
- ▶ Knowledge use for Risk Management, Recovery, resilience (Dikes), etc.
- ▶ Complex changes – difficult to model natural environment factors combined with human caused impacts

Solid earth

- ▶ Seismic, volcanic, landslides, less coupled or understood
- ▶ Short term- Earthquake
- ▶ Long term- desertification
- ▶ Difficult challenges
 - ▶ Nuclear waste management
 - ▶ Plastics in oceans
 - ▶ Chemicals in water and air
 - ▶ Erosion and land recovery

Explore Links

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Fire Information for Resource Management System (FIRMS)

▶ <https://earthdata.nasa.gov/earth-observation-data/near-real-time>

▶ <https://earthdata.nasa.gov/learn/discipline>

Atmosphere

Cryosphere

Human Dimensions

Land

Ocean

Radiance

▶ <https://earthdata.nasa.gov/learn/user-resources/glossary>

NASA's Land, Atmosphere Near real-time Capability for EOS (LANCE).

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The image shows a screenshot of the LANCE website and a tweet from @NASAEarthdata. The website is divided into three main sections: LANCE News, Discover Data and Services, and @NASAEarthdata. The LANCE News section features a user profile for Dr. Margaret "Maggi" Glasscoe and two news items: "Near Real-Time MODIS Global Flood Product Now Available from NASA's LANCE" and "New Black Marble Nighttime Blue/Yellow Composite Product Makes Detecting Power Outages Easier". The Discover Data and Services section includes links for "Earthdata Search", "International Directory Network (IDN)", and "Data Tools". The @NASAEarthdata section displays a tweet from @NASAEarthData with the text: "ICYMI: The 'Learn how to View and Download Data from NASA's Level-1 and Atmosphere Archive and Distribution System Distributed Active Archive Center (LAADS DAAC)' Earthdata webinar is available online." Below the tweet are links for "Embed" and "View on Twitter".

LANCE News

User Profile: Dr. Margaret "Maggi" Glasscoe

Near Real-Time MODIS Global Flood Product Now Available from NASA's LANCE

New Black Marble Nighttime Blue/Yellow Composite Product Makes Detecting Power Outages Easier

Discover Data and Services

Earthdata Search

International Directory Network (IDN)

Data Tools

@NASAEarthdata

Tweets by @NASAEarthData

NASAEarthdata @NASAEarthData

ICYMI: The "Learn how to View and Download Data from NASA's Level-1 and Atmosphere Archive and Distribution System Distributed Active Archive Center (LAADS DAAC)" Earthdata webinar is available online.

[Embed](#) [View on Twitter](#)

Fire Information for Resource Ma x Fire Map - NASA | LANCE | FIRMS x

firms.modaps.eosdis.nasa.gov/usfs/map/#d:24hrs;@-100.0,40.0,4z

Punjab National Ba... Hearing aid technol... https://www.billdes... Rajasthan Single Si... Other bookmarks

FIRMS US/CANADA

Fires: Last 24hrs

1000 km
500 mi

CURRENT HISTORICAL

Announcements Feedback

TODAY 24 HRS 7 DAYS

From [Yesterday 00:00:00 GMT] to present

BASIC MODE ADVANCED MODE

Fires / Hotspots

Simple Time Based

VIIRS (S-NPP & NOAA-20)
MODIS (Aqua & Terra)

Active Alerts

USA Active Fires
larger than
1,000 acres / 404 ha

Canada Active Fires
larger than
1,000 acres / 404 ha

Windows taskbar: 8:35 PM 5/3/2022

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Download Data

- [AIRS](#) - Atmospheric Infrared Sounder
- [AMSR2](#) - Advanced Microwave Scanning Radiometer 2
- [LIS ISS](#) - Lightning Imaging Sensor on the International Space Station
- [ICESat-2](#) - Advanced Topographic Altimeter System (ATLAS) on the Ice, Cloud and land Elevation Satellite-2 (ICESat-2)
- [MISR](#) - Multi-angle Imaging SpectroRadiometer
- [MLS](#) - Microwave Limb Sounder
- [MODIS](#) - Moderate Resolution Imaging Spectroradiometer
- [MOPITT](#) - Measurements of Pollution in the Troposphere
- [OMI](#) - Ozone Monitoring Instrument
- [OMPS](#) - Ozone Mapping and Profiler Suite
- [VIIRS-Atmosphere](#) - Visible Infrared Imaging Radiometer Suite
- [VIIRS-Land](#) - Visible Infrared Imaging Radiometer Suite

Hazards and Disasters

FIRMS: [Active fire/hotspot data, maps and alerts](#)

Aqua	Sounding Instruments	Atmospheric Infrared Sounder (AIRS)	Sounder (Passive Sensor)	GES DISC	Provides spatial resolution of ~13.5 km in the IR channels and ~2.3 km in the visible. Swath retrieval products are at 50 km resolution.
Aqua	Sounding Instruments	Advanced Microwave Sounding Unit (AMSU)	Sounder (Passive Sensor)	GES DISC, GHRC DAAC	The instrument has 15 channels. Measures temperature profiles in the upper atmosphere. Has a cloud filtering capability for tropospheric temperature observations. Provides spatial resolution of 40 km at nadir.
Aqua	Sounding Instruments	Humidity Sounder for Brazil (HSB)	Sounder (Passive Sensor)	GES DISC	The Humidity Sounder for Brazil (HSB) is primarily a humidity sounder providing supplementary water vapor and liquid data to be used in the cloud clearing process. HSB is a near identical copy of AMSU-B. Due to budget constraints, it implements only four passive moisture sounding channels of the five AMSU-B channels.
Aura	Sounding Instruments	High Resolution Dynamics Limb Sounder (HIRDLS)	Sounder (Passive Sensor)	GES DISC	Measures infrared emissions at the Earth's limb in 21 channels to obtain profiles of temperature, O ₃ , CFCs, various other gases affecting ozone chemistry, and aerosols at 1 km vertical resolution. In addition, HIRDLS

Harmonization of Goniometric data

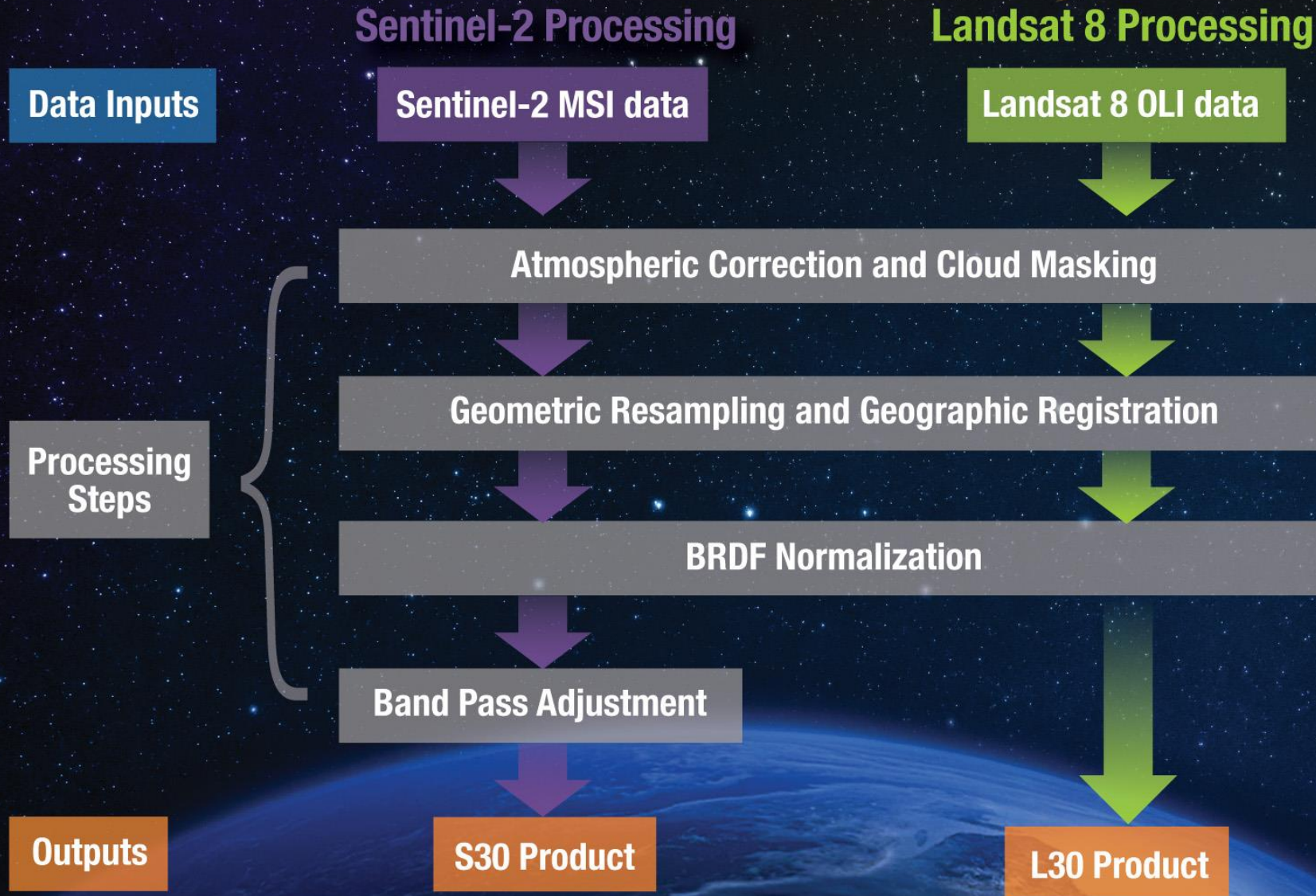
- ▶ The Harmonized Landsat Sentinel-2 (HLS) project is an extension of research conducted at NASA's Goddard Space Flight Center in Greenbelt, MD, that takes input data from the joint NASA/USGS Landsat 8 and the ESA (European Space Agency) Sentinel-2A and Sentinel-2B satellites to generate a harmonized, analysis-ready surface reflectance data product with observations every two to three days.
- ▶ HLS processing workflow. Bidirectional Reflectance Distribution Function (BRDF) Normalization accounts for changes in solar and view angles for the same ground target, which vary between MSI and OLI. MSI Band Pass Adjustment accounts for small differences between the equivalent MSI and OLI spectral bands. Image courtesy of the HLS Science Team.

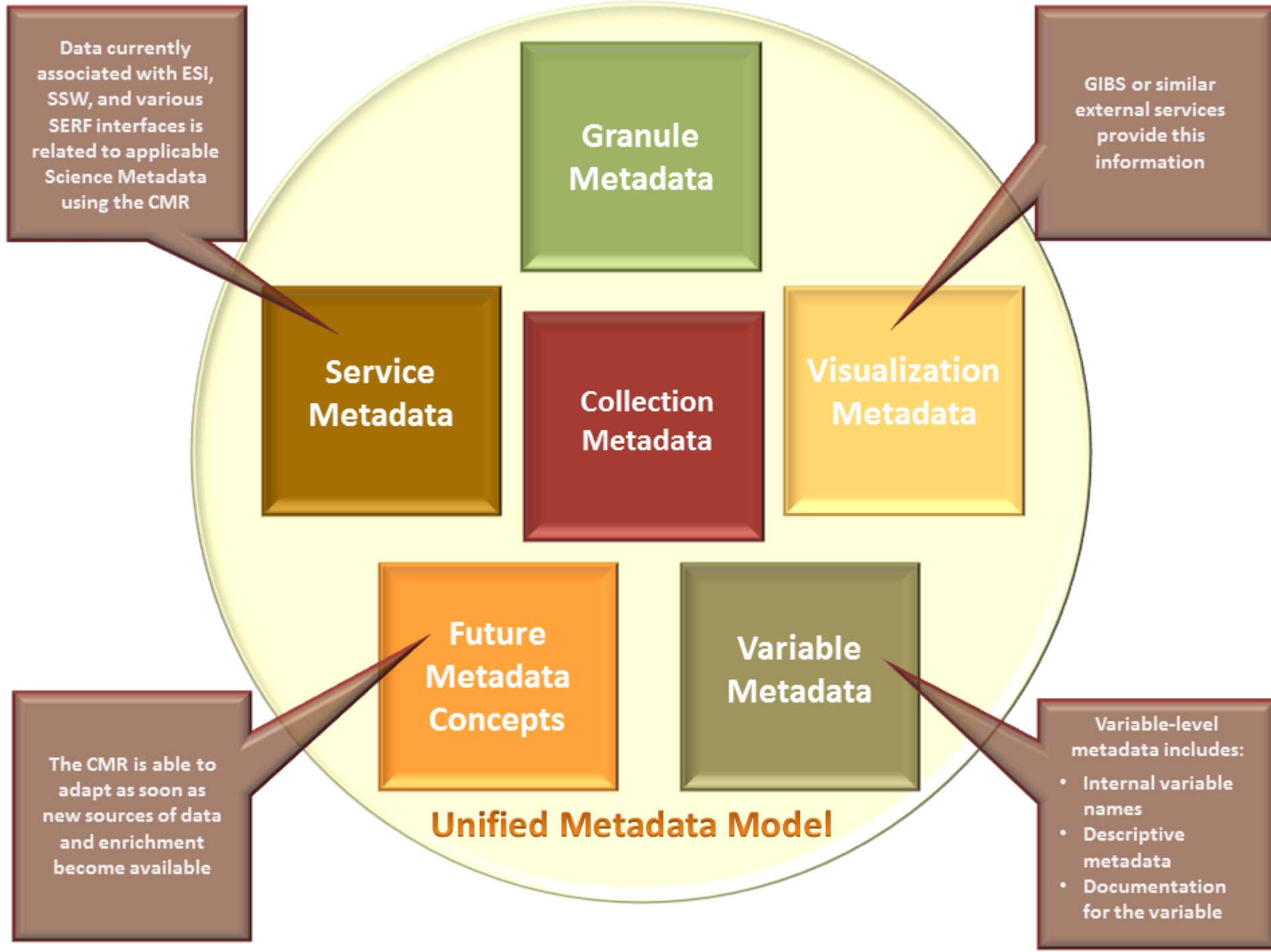


HLS Processing



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Ontology to be extracted - Maintained dynamically from

- ▶ DAAC Data Archives architecture
- ▶ Structure of HDF-EOS standards, definitions, Parameters and EDRs as well as ATBD
- ▶ Metadata
- ▶ Glossaries, Terms, Vocabularies,
- ▶ Domain Applications
- ▶ Integration with Disaster Applications and Emergency services
- ▶ Need based push of required info
- ▶ Knowledge Graphs and updates
- ▶ Unfolding CDM, LDM, PDM, and non- relational databases

Dr. Ravi Sharma - 50 Years Experience

- Earth Observation Systems - Data and Information Systems

Dozens of papers and reports

- ▶ 1968-72 NASA HQ
- ▶ Apollo Space cryogen and water dumps (Relevance to Space debris and planetary / interstellar Environment)
- ▶ ERTS / Landsat Spectral Band Selection, Radiative transfer for Atmospheric Corrections
- ▶ Skylab Multispectral Scanner and IR Spectrometer Experiments. Oversight
- ▶ Space Shuttle Sorties for Day / Night Earth viewings (PI) NASA HQ
- ▶ 1973-79 India's Satellite Bhaskara - Concept to implementation and establishing national remote sensing agency and IRS and INSAT (Met) satellites
- ▶ 1996-2000 NASA GSFC on Terra, Aqua, Aura (Chem), Polar Satellites And Data and Info Systems, Image data, NASA Petabyte Active Archives
- ▶ Constellations with radiation ATMOSPHERIC data records / NOAA
- ▶ FGDC Metadata, with vocabularies

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