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

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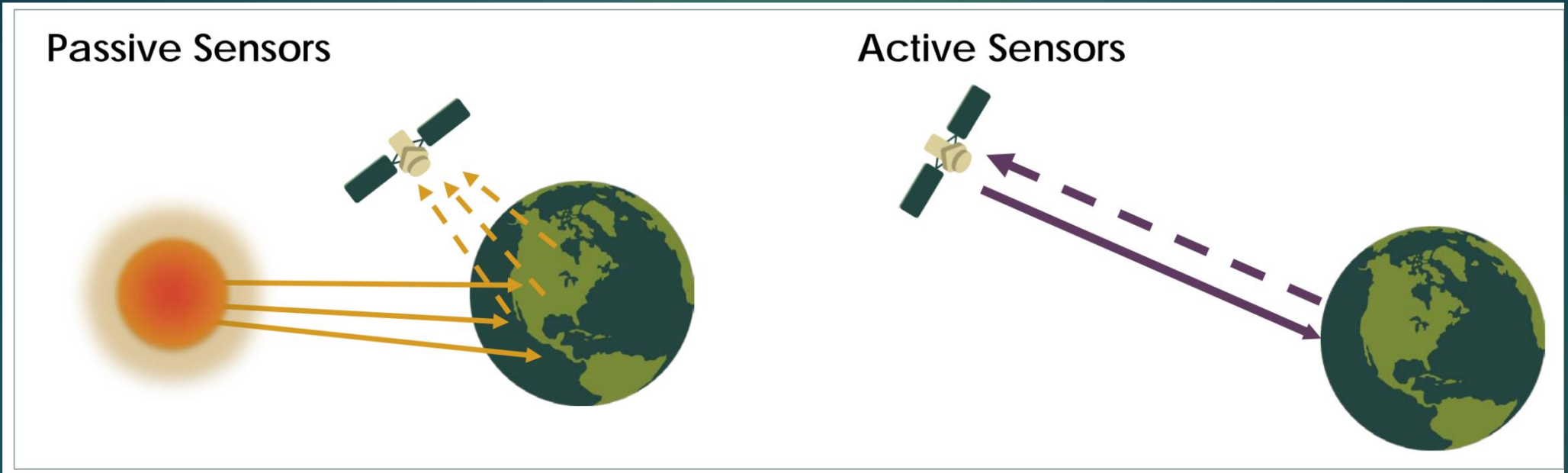
CogSIMA 2022

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

Platforms and Sensors

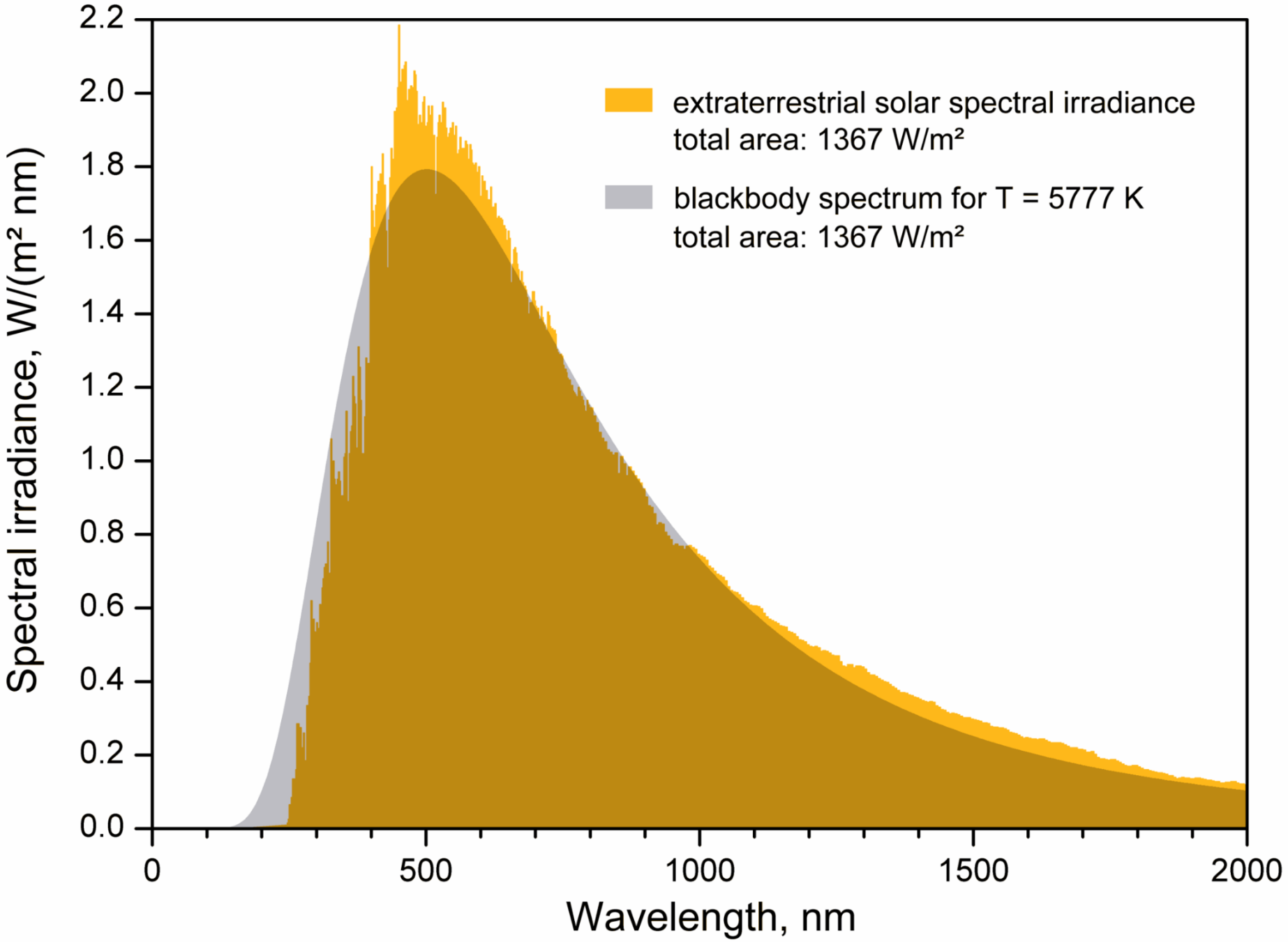
- Platforms
  - Ground –Ocean
  - Aerial - Aircraft and Drones
  - Satellite(s) – constellations or formations

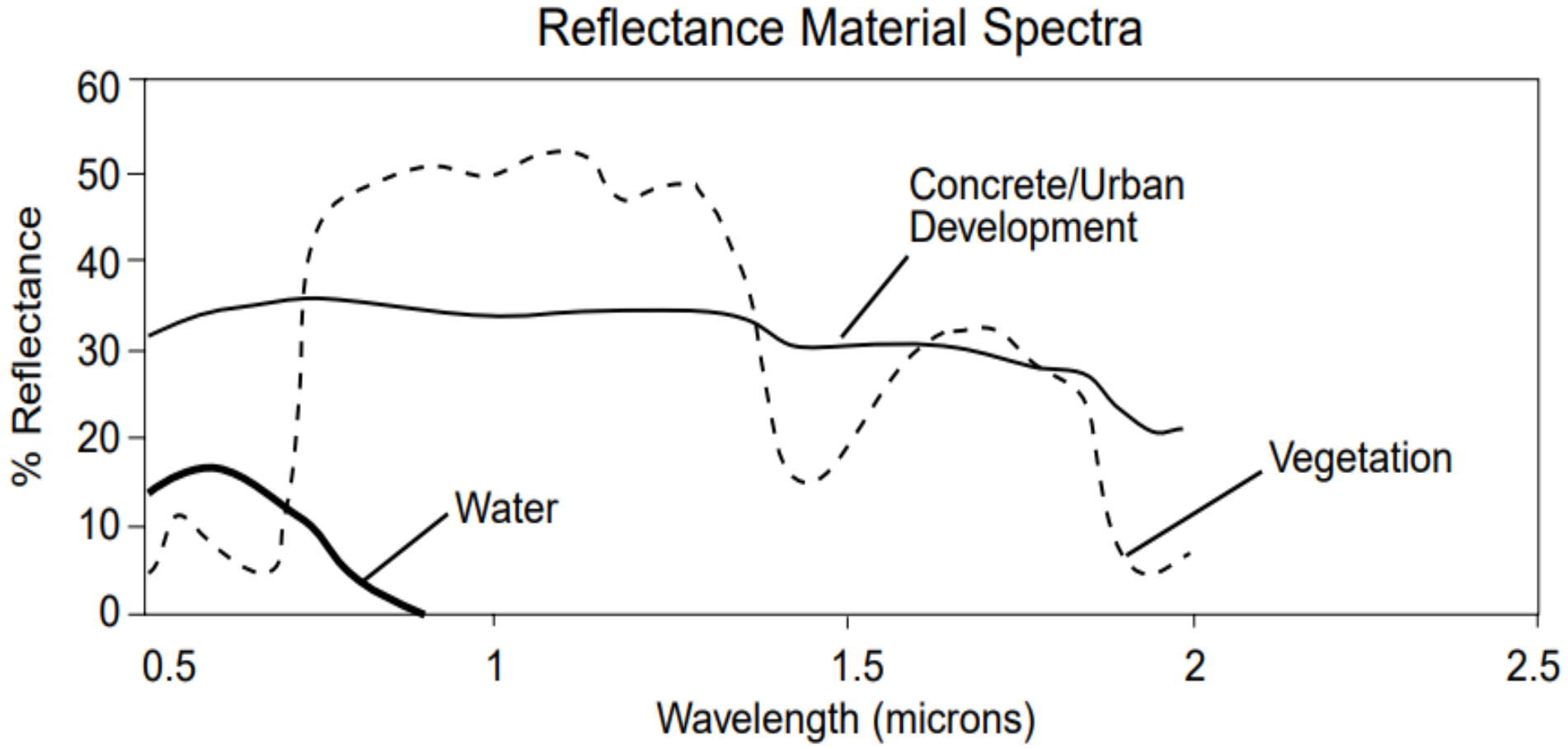
- Sensors
  - Multispectral (0.3-100 micrometers) and > 30 bands (MODIS, VIIRS)
  - Radiometers (IR and Microwave) 1-100 micrometers and 2GHZ to 200 GHZ
  - Active: Radars, Lidars


Passive Sensors
Active Sensors

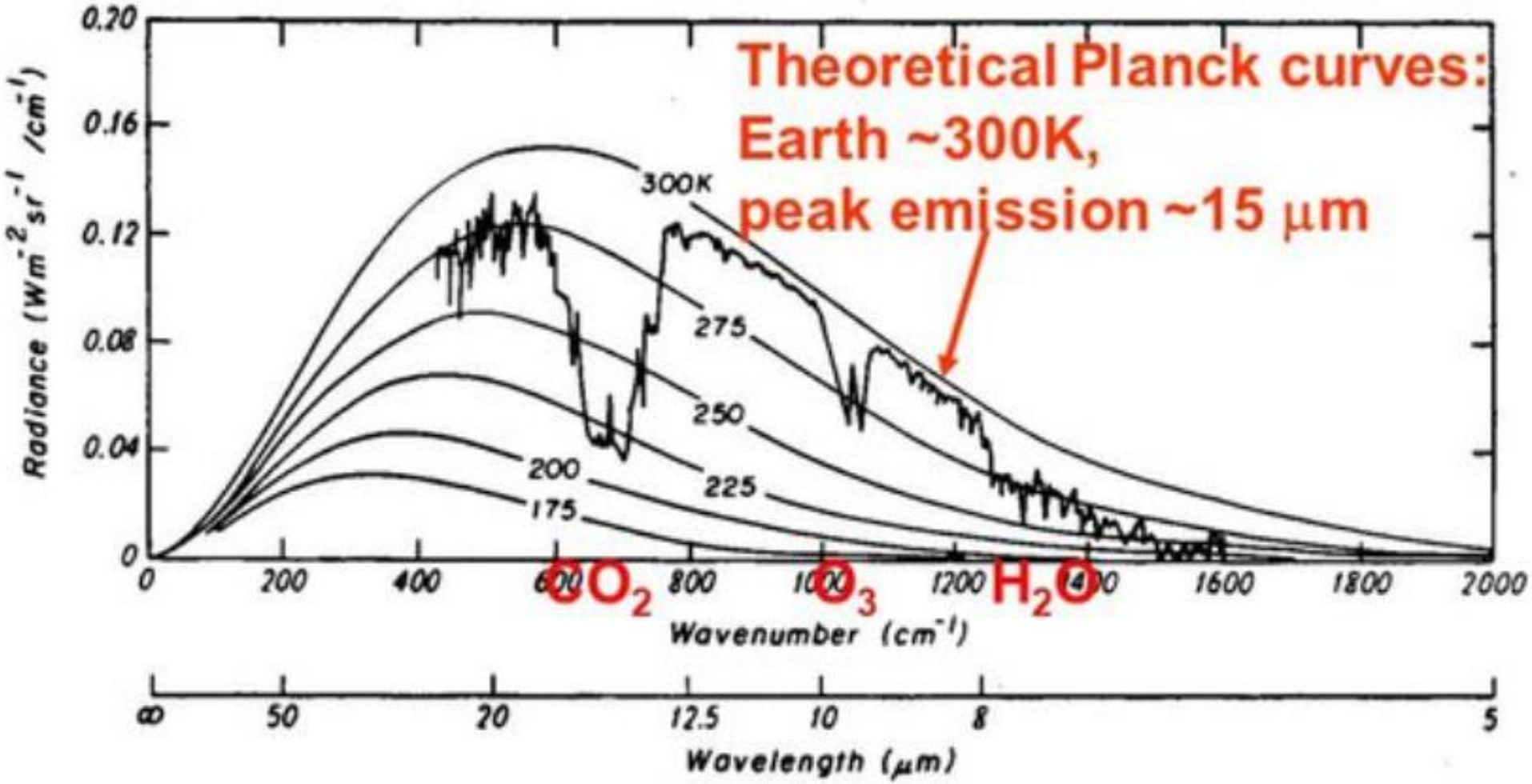
EM Radiation and Active Sensors

- 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.


extraterrestrial solar spectral irradiance
total area: 1367 W/m²
blackbody spectrum for T = 5777 K
total area: 1367 W/m²
Spectral irradiance, W/(m² nm)
Wavelength, nm
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
0
500
1000
1500
2000


Reflectance Material Spectra
% Reflectance
60
50
40
30
20
10
0
0.5
1
1.5
2
2.5
Wavelength (microns)
Concrete/Urban
Development
Vegetation
Water

Sahara Desert on Nimbus 4 Satellite



Dr. Ravi Sharma, Chair Ontology Summit 2022
07/08/2022

Environmental Science Enablers

- 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)

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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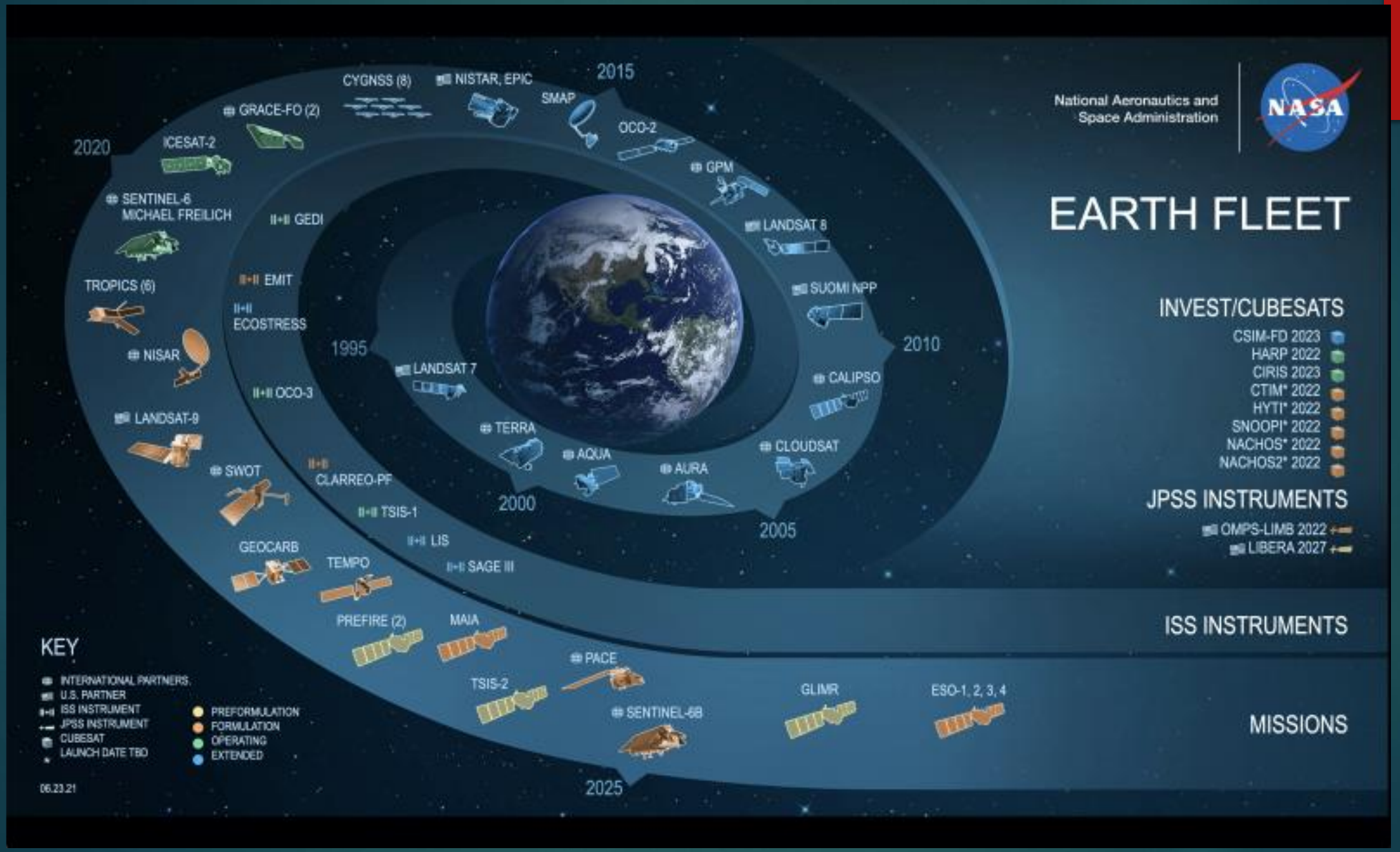
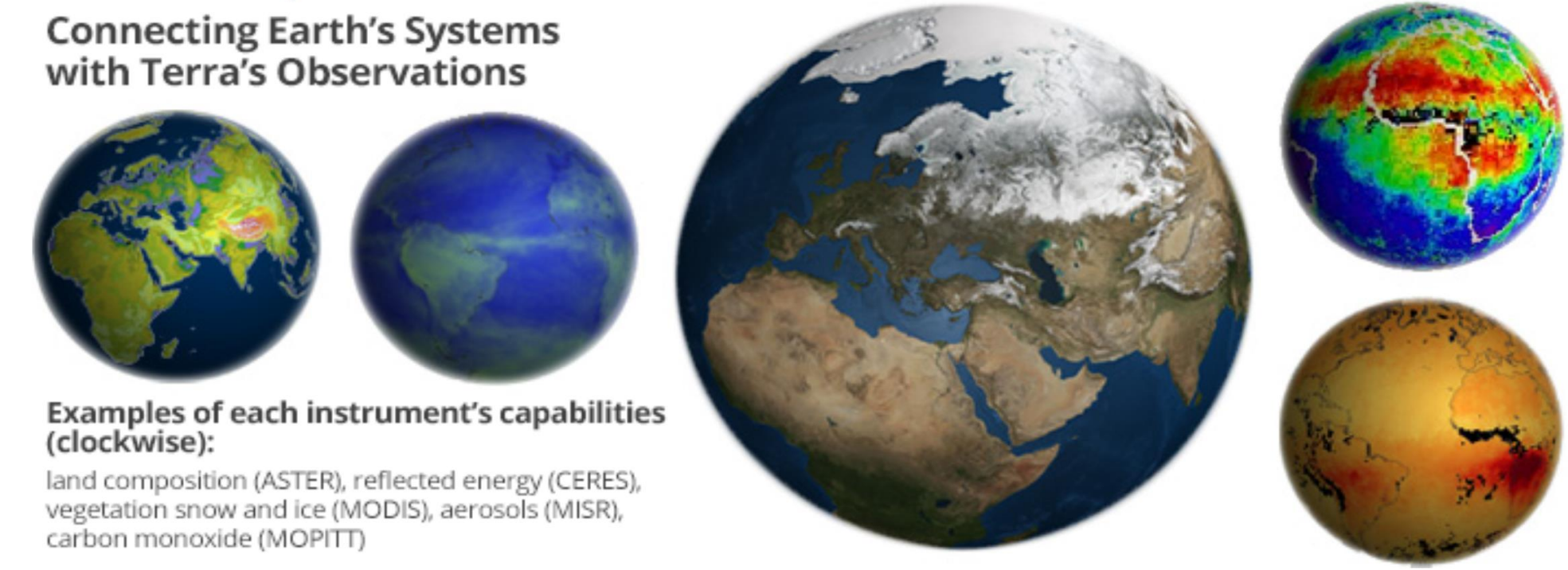

National Aeronautics and Space Administration
NASA
EARTH FLEET
2015
CYGNSS (8)
NISTAR, EPIC
SMAP
OCO-2
GPM
2020
GRACE-FO (2)
ICESAT-2
SENTINEL-6 MICHAEL FREILICH
GEDI
LANDSAT 8
TROPICS (6)
EMIT
SUOMI NPP
ECOSTRESS
NISAR
1995
LANDSAT 7
2010
CALIPSO
OCO-3
LANDSAT-9
TERRA
AQUA
AURA
CLOUDSAT
SWOT
CLARREO-PF
2000
2005
TSIS-1
LIS
GEOCARB
TEMPO
SAGE III
PREFIRE (2)
MAIA
PACE
TSIS-2
GLIMR
ESO-1, 2, 3, 4
SENTINEL-6B
2025
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.

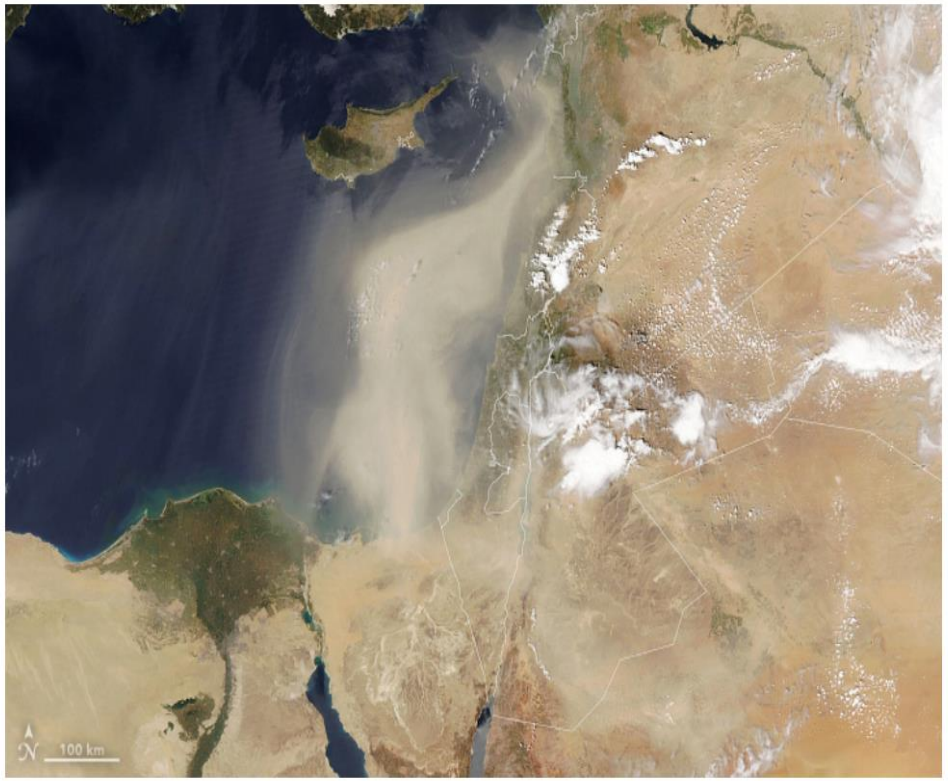


Key Aqua Facts

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

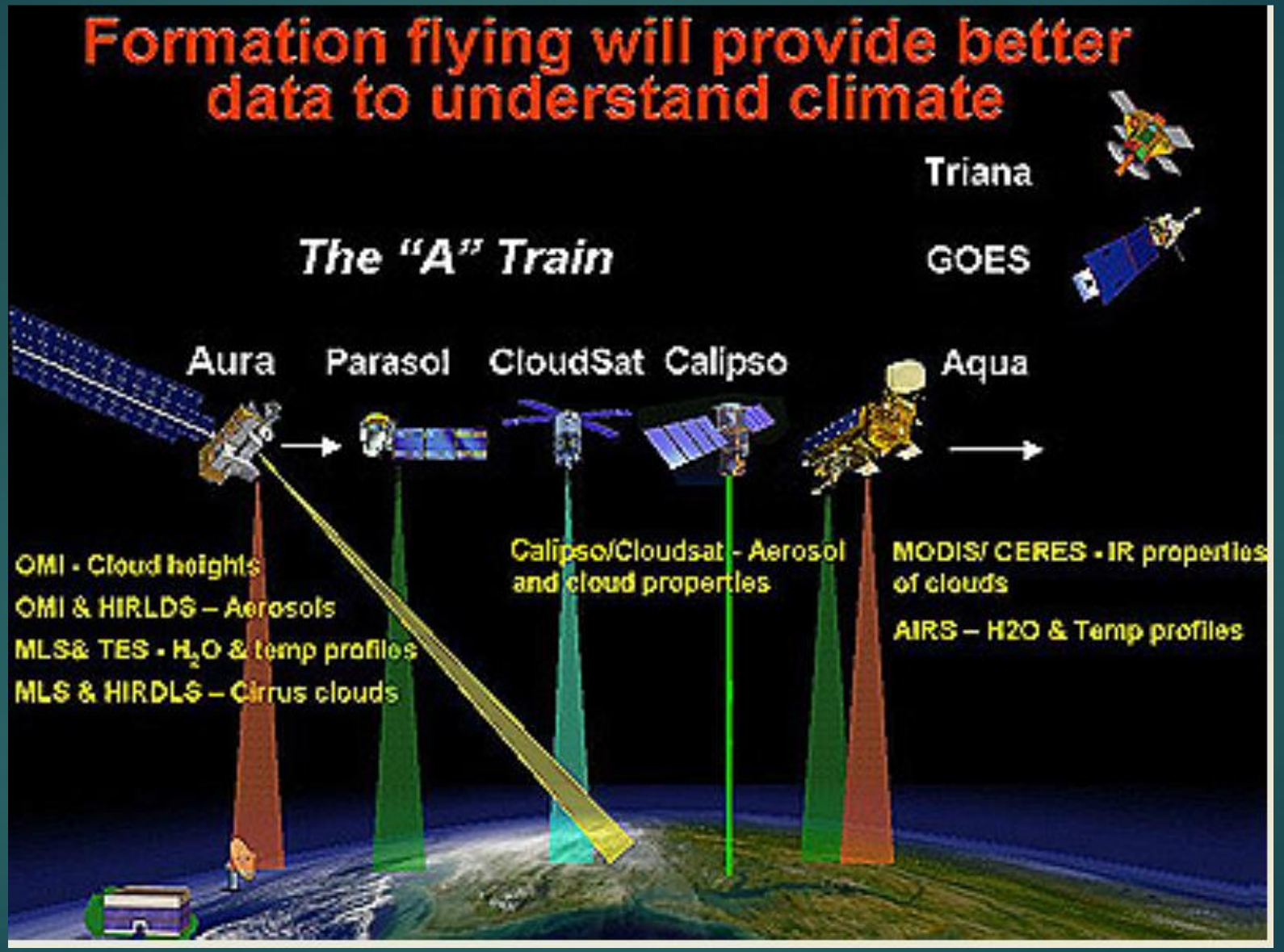
Published on Friday April 29, 2022

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

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
Triana
The "A" Train
GOES
Aura
Parasol
CloudSat
Calipso
Aqua
OMI - Cloud heights
OMI & HIRLDS – Aerosols
MLS& TES - H2O & temp profiles
MLS & HIRDLS – Cirrus clouds
Calipso/Cloudsat - Aerosol and cloud properties
MODIS/ CERES - IR properties of clouds
AIRS – H2O & Temp profiles

POESS Aerosol Polarimeter Sensor (APS)

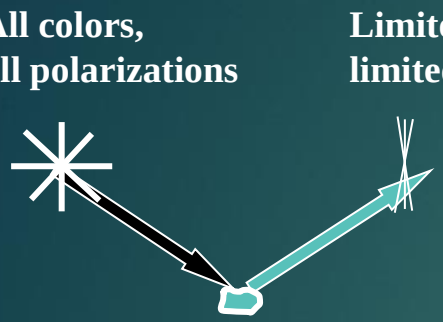


Figure 1

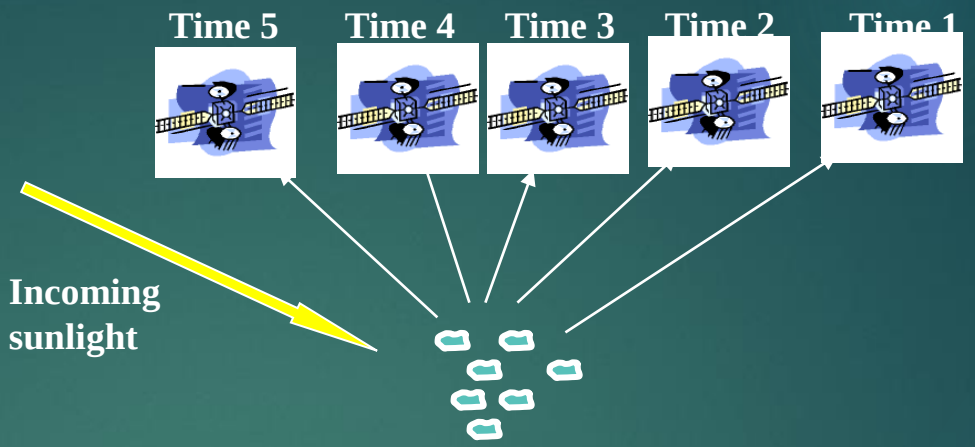


Figure 2

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

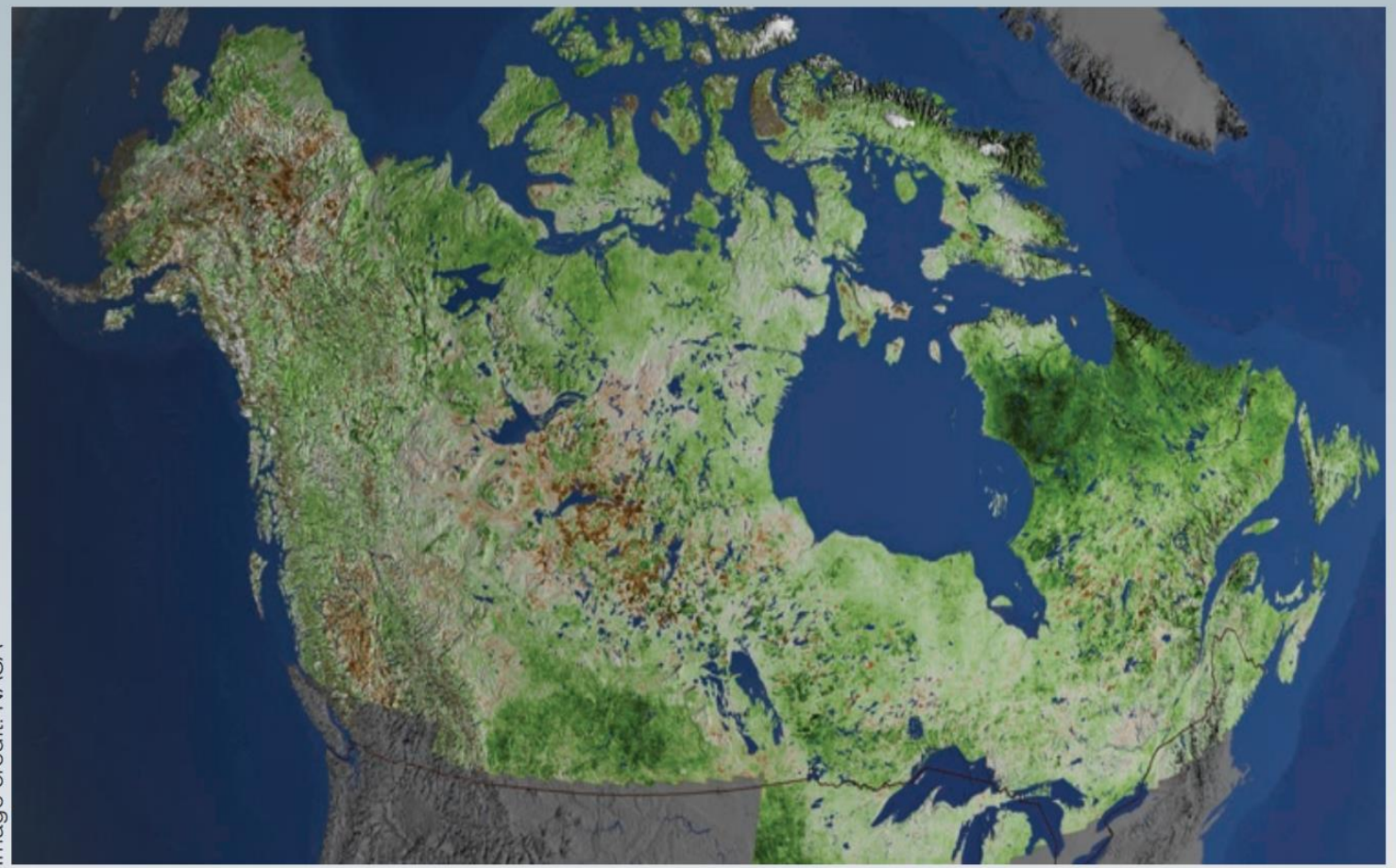
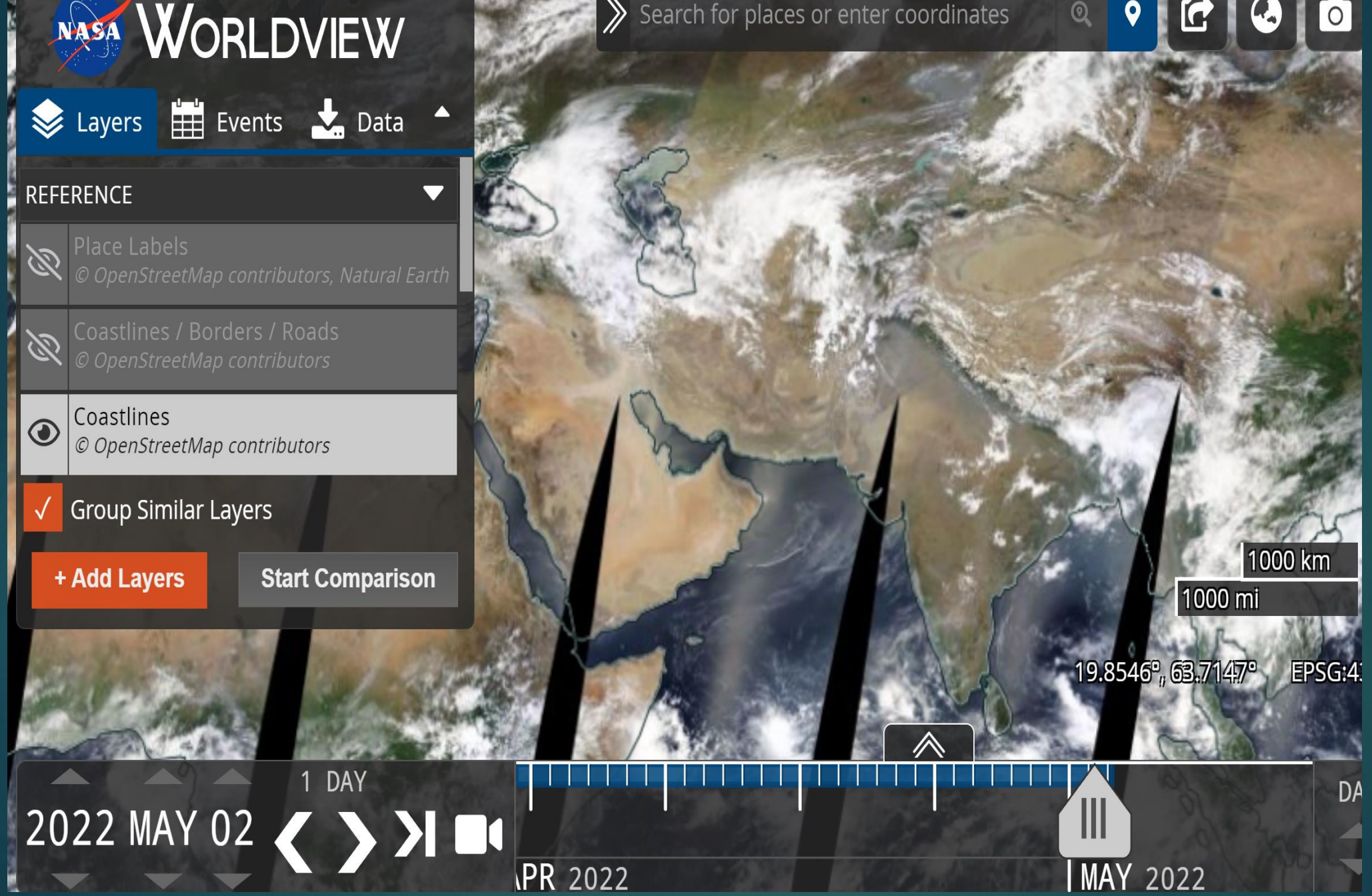
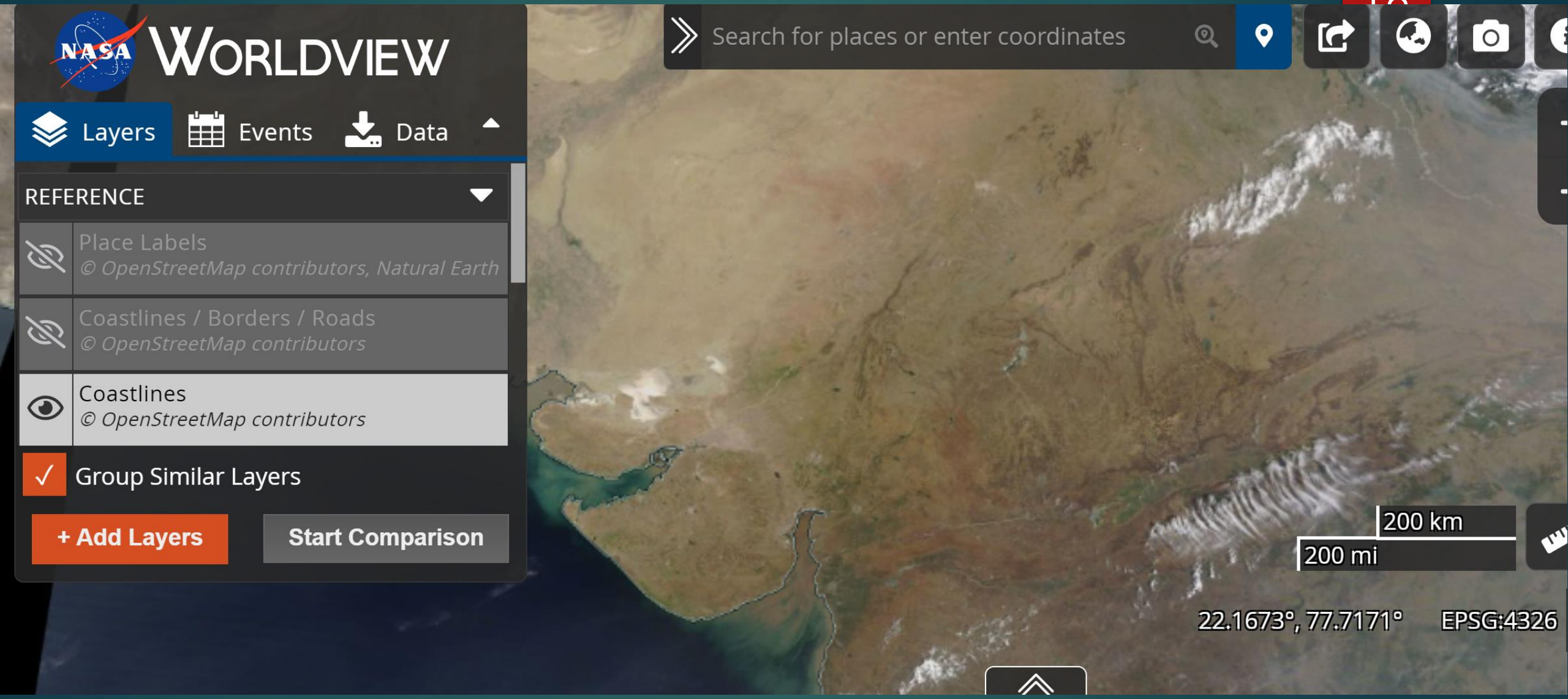


Image credit: NASA

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


NASA
WORLDVIEW
Search for places or enter coordinates
Layers
Events
Data
REFERENCE
Place Labels
© OpenStreetMap contributors, Natural Earth
Coastlines / Borders / Roads
© OpenStreetMap contributors
Coastlines
© OpenStreetMap contributors
Group Similar Layers
+ Add Layers
Start Comparison
1000 km
1000 mi
19.8546°, 63.7147°
EPSG:4
1 DAY
2022 MAY 02
APR 2022
MAY 2022


NASA WORLDVIEW
Layers
Events
Data
REFERENCE
Place Labels
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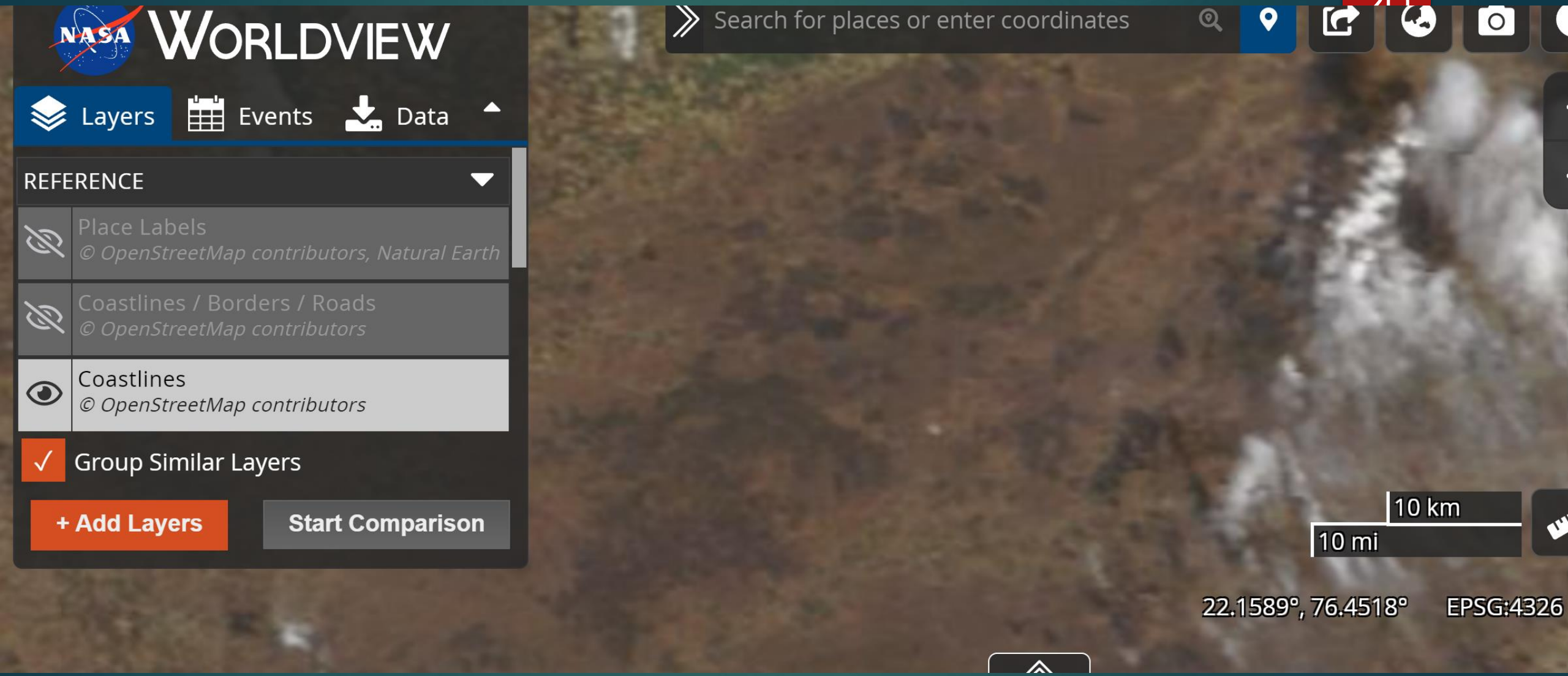
Coastlines / Borders / Roads
© OpenStreetMap contributors
Coastlines
© OpenStreetMap contributors
Group Similar Layers
+ Add Layers
Start Comparison
Search for places or enter coordinates
200 km
200 mi
22.1673°, 77.7171°
EPSG:4326


WORLDVIEW
Search for places or enter coordinates
Layers
Events
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REFERENCE
Place Labels
© OpenStreetMap contributors, Natural Earth
Coastlines / Borders / Roads
© OpenStreetMap contributors
Coastlines
© OpenStreetMap contributors
Group Similar Layers
+ Add Layers
Start Comparison
10 km
10 mi
22.1589°, 76.4518°
EPSG:4326

Knowledge – Earth Science examples

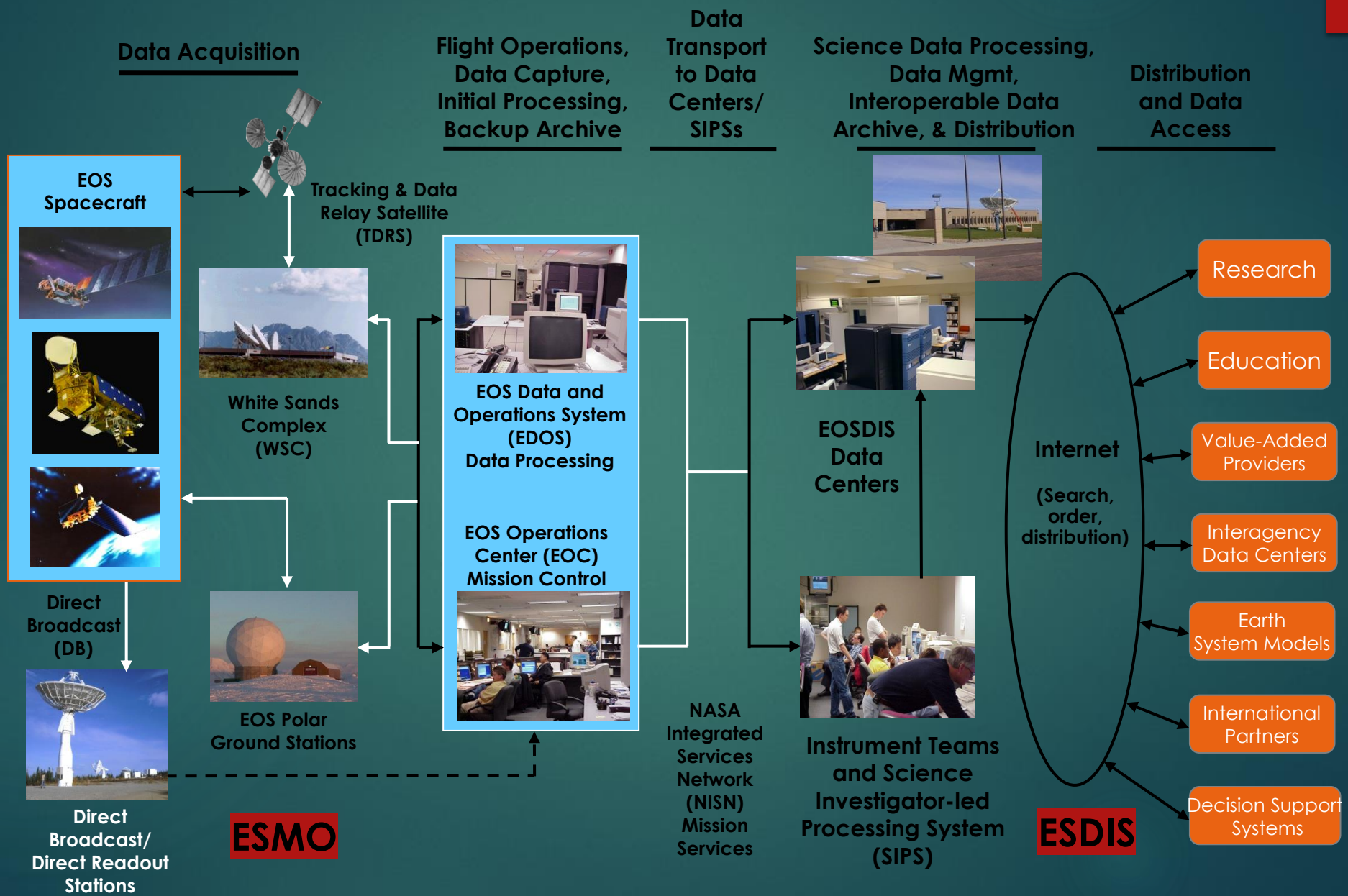
Oceans & atmospheres

- 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

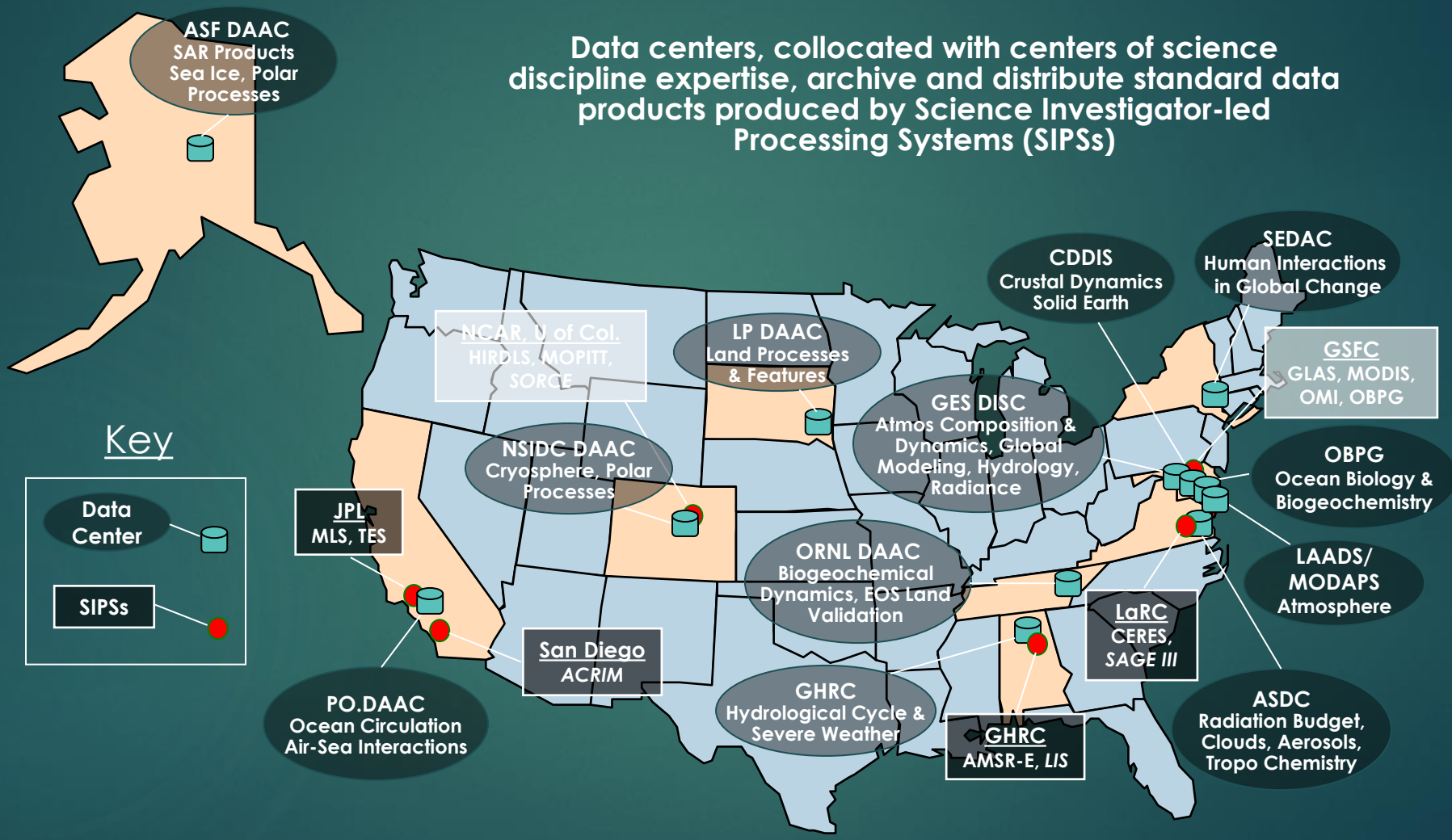
Solid earth

- 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

EOSDIS Context – NASA CREDITS



EOSDIS Facilities – NASA CREDITS



Overview of HDF and HDF-EOS

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

Accuracy of Data Products

- 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.

Explore Links

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

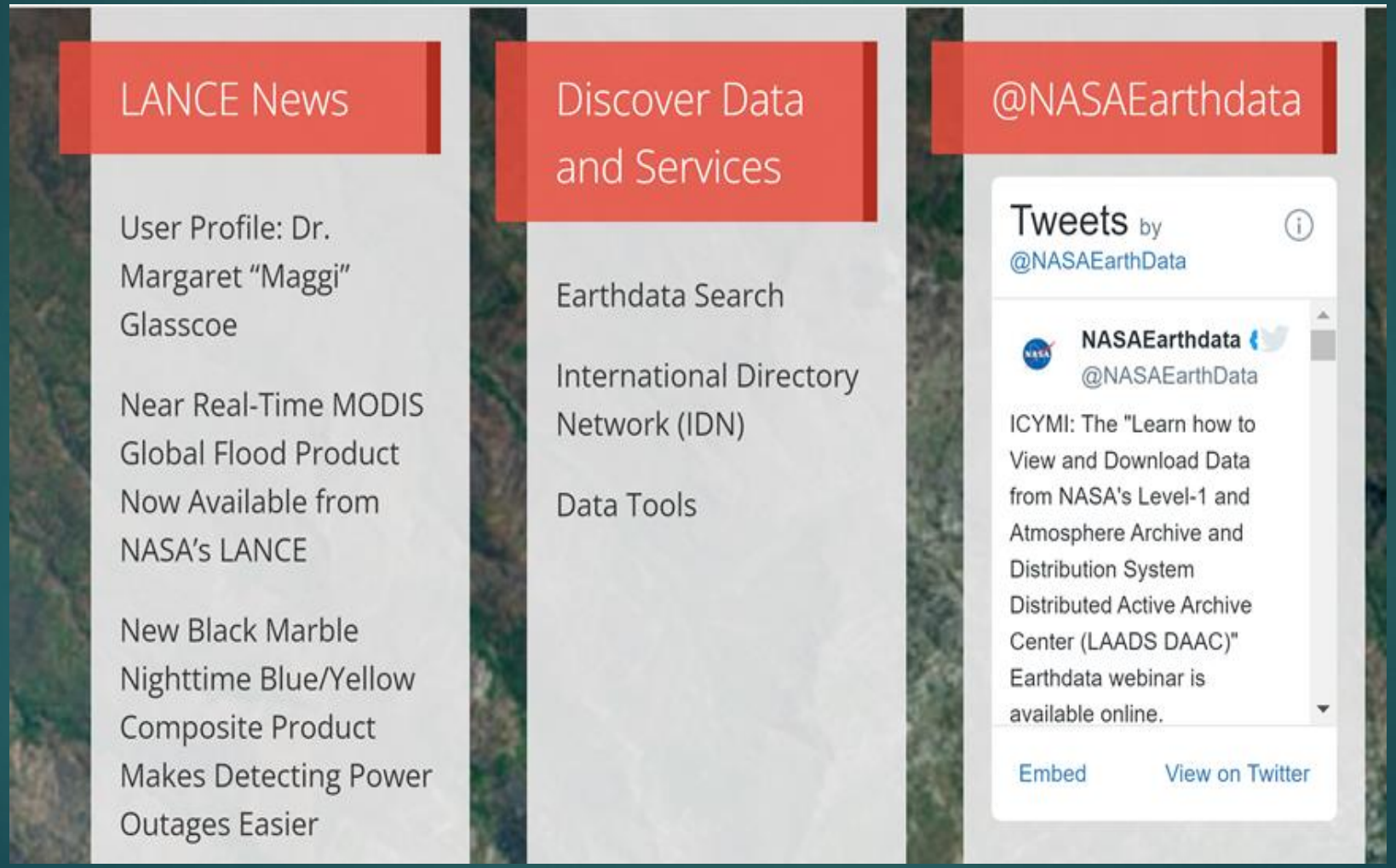
  Human Dimensions

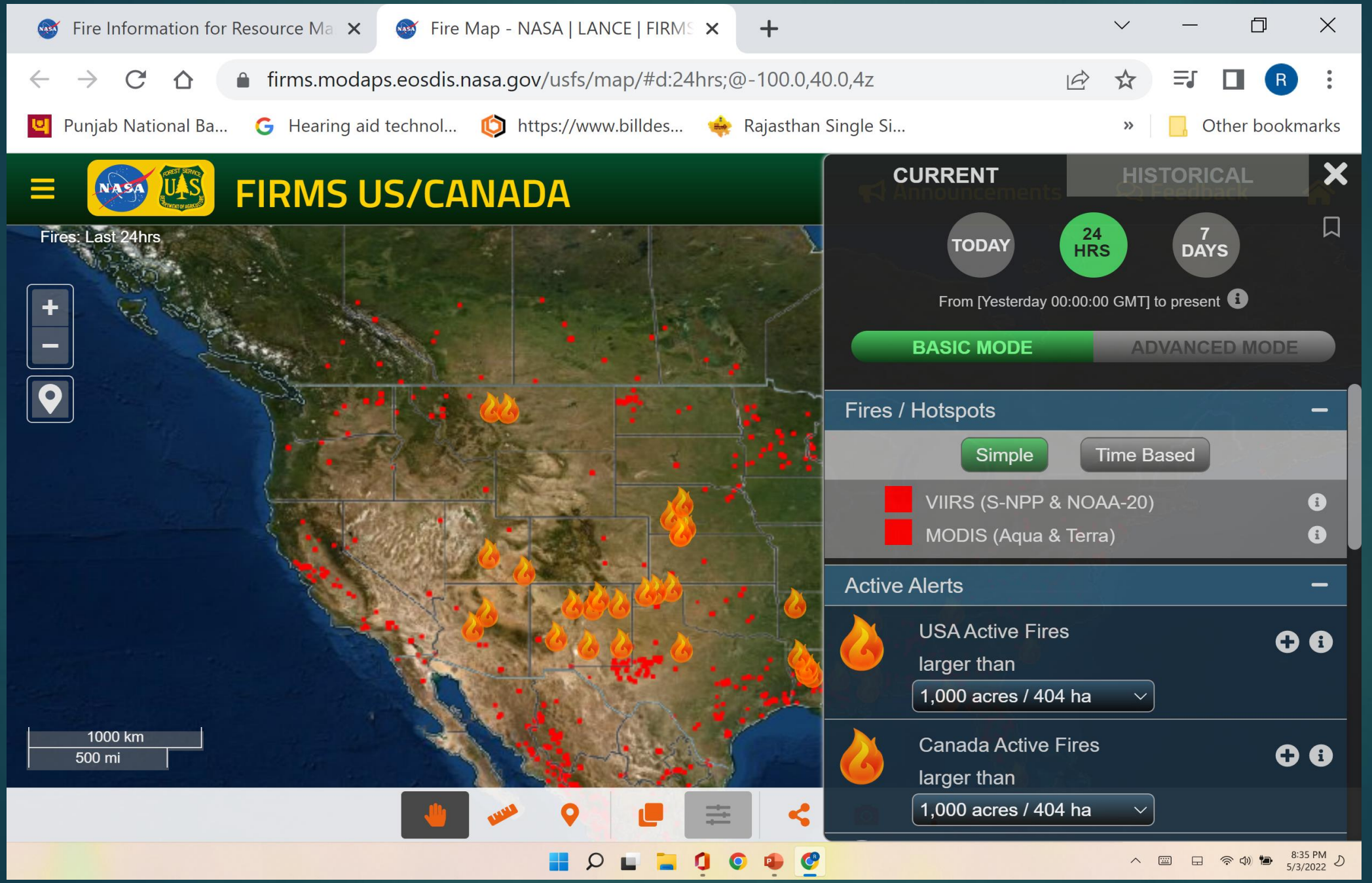
  Land

  Ocean

  Radiance
- https://earthdata.nasa.gov/learn/user-resources/glossary

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




Fire Information for Resource Ma
Fire Map - NASA | LANCE | FIRMS
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
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
8:35 PM
5/3/2022

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

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.

Designed with a predicted life of six years, Terra (left) and Aqua (right) have continued to perform beyond expectations. However, recent maneuvers by NASA in February 2020 and March 2021 have revealed that these aging satellites will be retired in the coming years. Credit: NASA

Topics

Atmosphere

Aerosols

Ocean

Ocean Color | Ocean Optics

Land Surface

Geomorphic Landforms/processes

Sensors

AIRS | AMSU | ASTER | CERES | MISR | MODIS | MOPITT | VIIRS

HLS Processing

Sentinel-2 Processing

Landsat 8 Processing

Data Inputs

Sentinel-2 MSI data

Landsat 8 OLI data

Processing Steps

Atmospheric Correction and Cloud Masking

Geometric Resampling and Geographic Registration

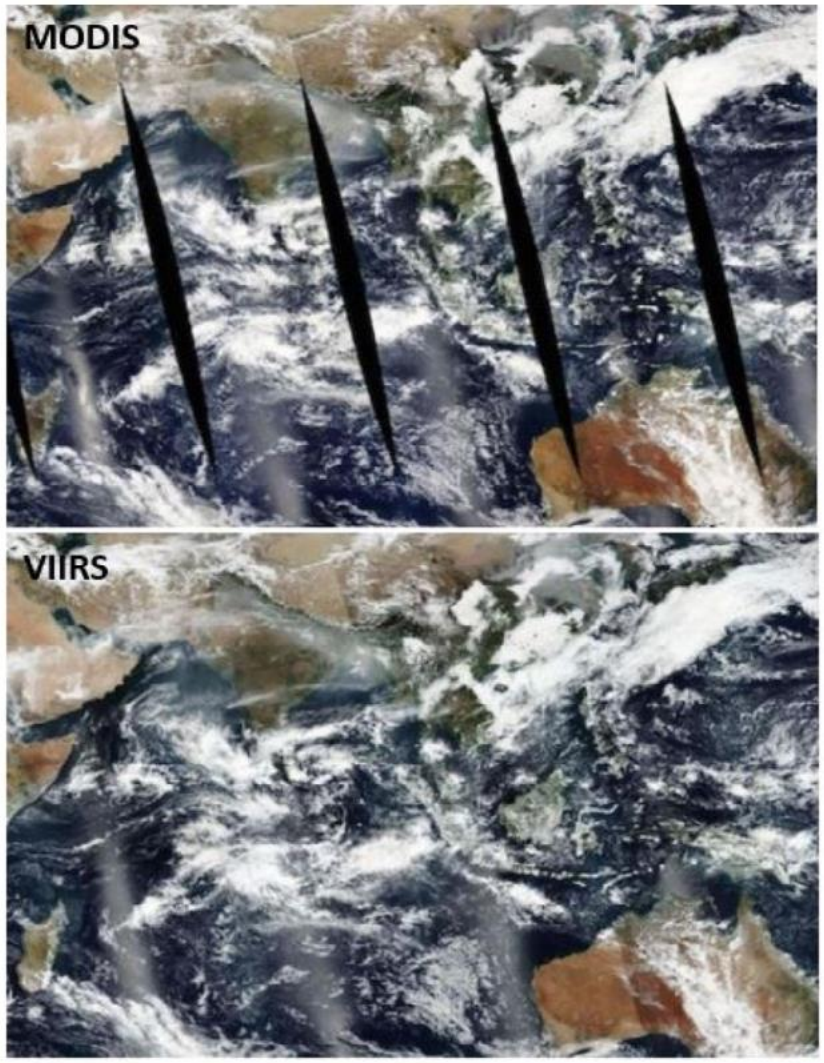
BRDF Normalization

Band Pass Adjustment

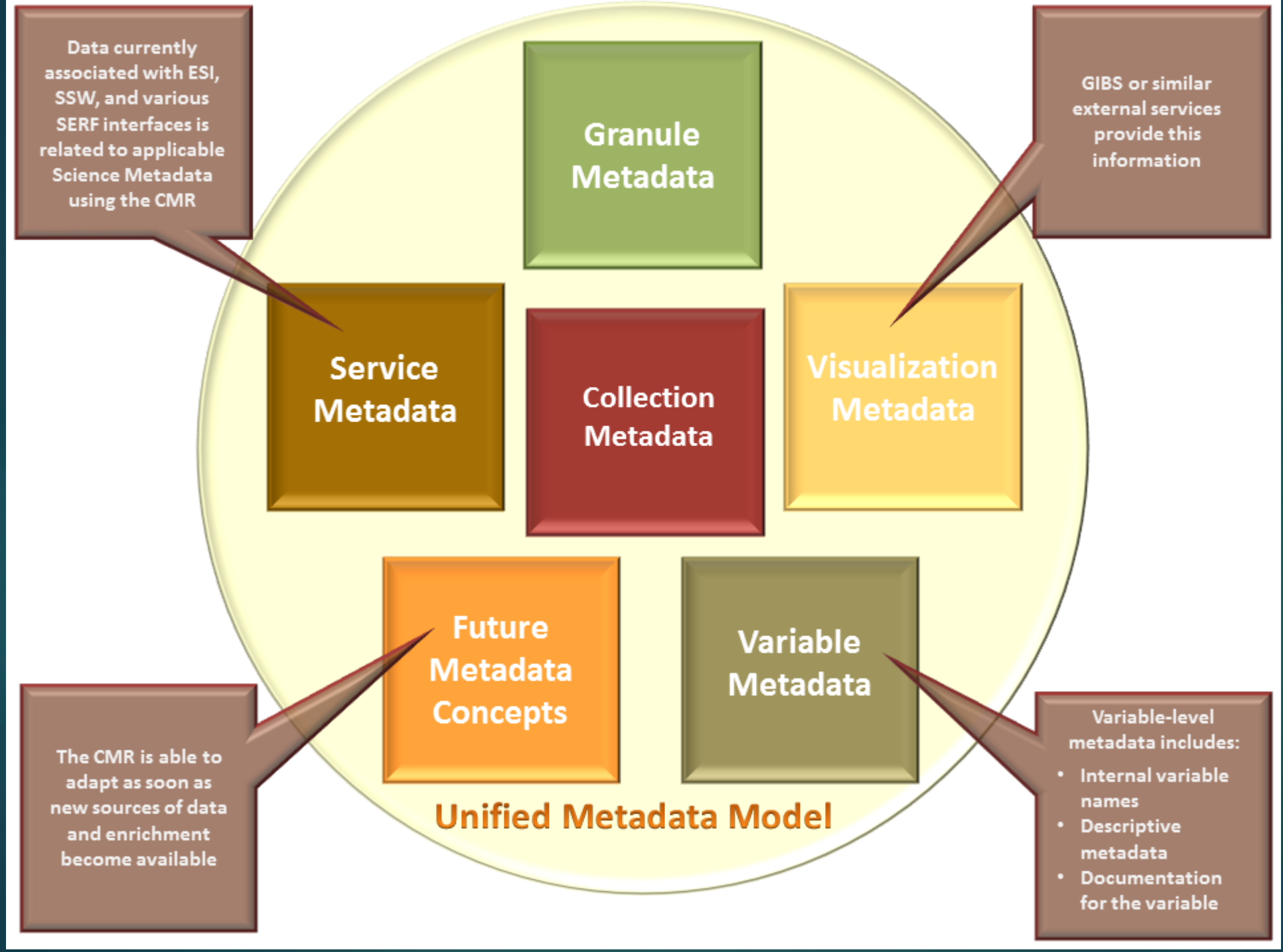
Outputs

S30 Product

L30 Product



As seen in this comparison of true-color imagery from Aqua/MODIS and Suomi-NPP/VIIRS captured on December 7, 2015, one of the most visually striking differences between the two instruments is that VIIRS has a wider swath


Data currently associated with ESI, SSW, and various SERF interfaces is related to applicable Science Metadata using the CMR
GIBS or similar external services provide this information
Granule Metadata
Service Metadata
Collection Metadata
Visualization Metadata
Future Metadata Concepts
Variable Metadata
The CMR is able to adapt as soon as new sources of data and enrichment become available
Variable-level metadata includes:
• Internal variable names
• Descriptive metadata
• Documentation for the variable
Unified Metadata Model

From where is Ontology to be extracted

- 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

Interoperability for Situation Management and Decision-Making

- Interoperation is enabled by
  - Establishing and following Standards (e.g. HDF EOS
  - Same or translatable Languages used for Operations (Systems and Humans),
  - Common Vocabularies ,Terms ,Ontologies
  - Harmonization among above as well as among Sensors, platforms, and orbit and goniometry parameters
  - Data, Image Data And Data Products
  - Metadata as shown in types earlier
- Situation Management is knowledge everywhere and Know when - Where!
- Domain and Interdomain awareness
- Depending on Emergency - Fuzzy knowledge-based decisions may be required.