



Earth Science Informatics - Overview

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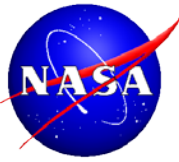
November 27-28, 2017

IEEE GRSS Distinguished Lectures, Hyderabad, India

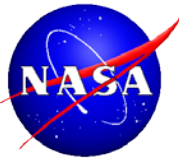


Topics

- Informatics
- Earth Science Informatics (ESI)
- IEEE GRSS
- ESI Technical Committee
- Major “players” in the world
- NASA’s involvement – Earth Observing System Data and Information System (EOSDIS)
- Conclusion



- **“Advance understanding of Earth and develop technologies to improve the quality of life on our home planet.” -- *2014 NASA Strategic Plan***
- **NASA's Earth Science Data Systems Program directly supports this strategic goal by providing end-to-end capabilities to deliver data and information products to users**
- **NASA's Earth Science Data and Information Policy promotes usage of data by the community**
 - In effect since 1990
 - No period of exclusive access - Data are available after initial checkout
 - Data available at no cost to all users on a non-discriminatory basis except where agreed upon with international partners



■ Core Capabilities

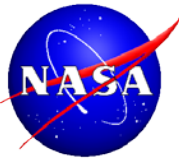
- Basic operational capabilities to process, archive, manage and distribute data from NASA missions
 - ❖ Earth Observing System Data and Information System (EOSDIS)

■ Competitive Programs

- Peer-review-selected projects
- New data products – Making Earth System Data Records for Use in Research Environments (MEaSUREs)
- Research in Earth Science Informatics to feed into the evolution of the core components
 - ❖ Applied Information Systems Technology (AIST)
 - ❖ Advancing Collaborative Connections for Earth System Science (ACCESS)

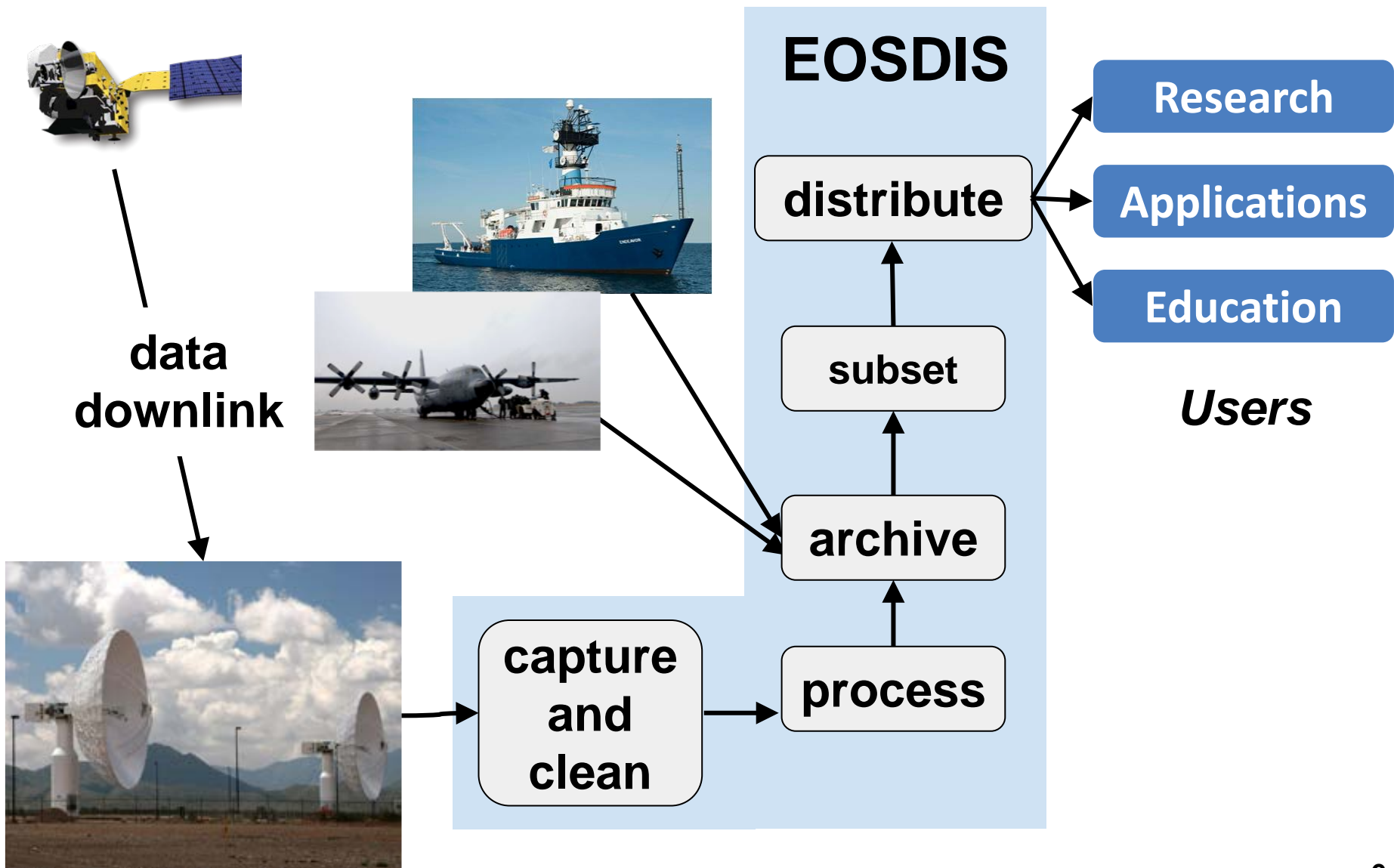
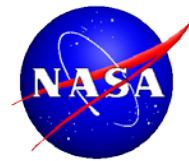
■ Core and Competitive Programs collaborate through Earth Science Data System Working Groups (ESDSWG)

Earth Observing System Data and Information System (EOSDIS)



- **Development and operation by Earth Science Data and Information System (ESDIS) Project – NASA Goddard Space Flight Center**
- **Operating since August 1994**
- **Provides end-to-end capabilities for managing NASA's Earth science data.**
 - **Science Operations**
 - ❖ **Science data processing**
 - ❖ **Data management**
 - ❖ **Interoperable distributed data archives**
 - ❖ **On-line data access services**
 - ❖ **Earth science discipline-oriented user services**
 - **Network Data Transport to distributed system elements**

Earth Observing System Data and Information System (EOSDIS)

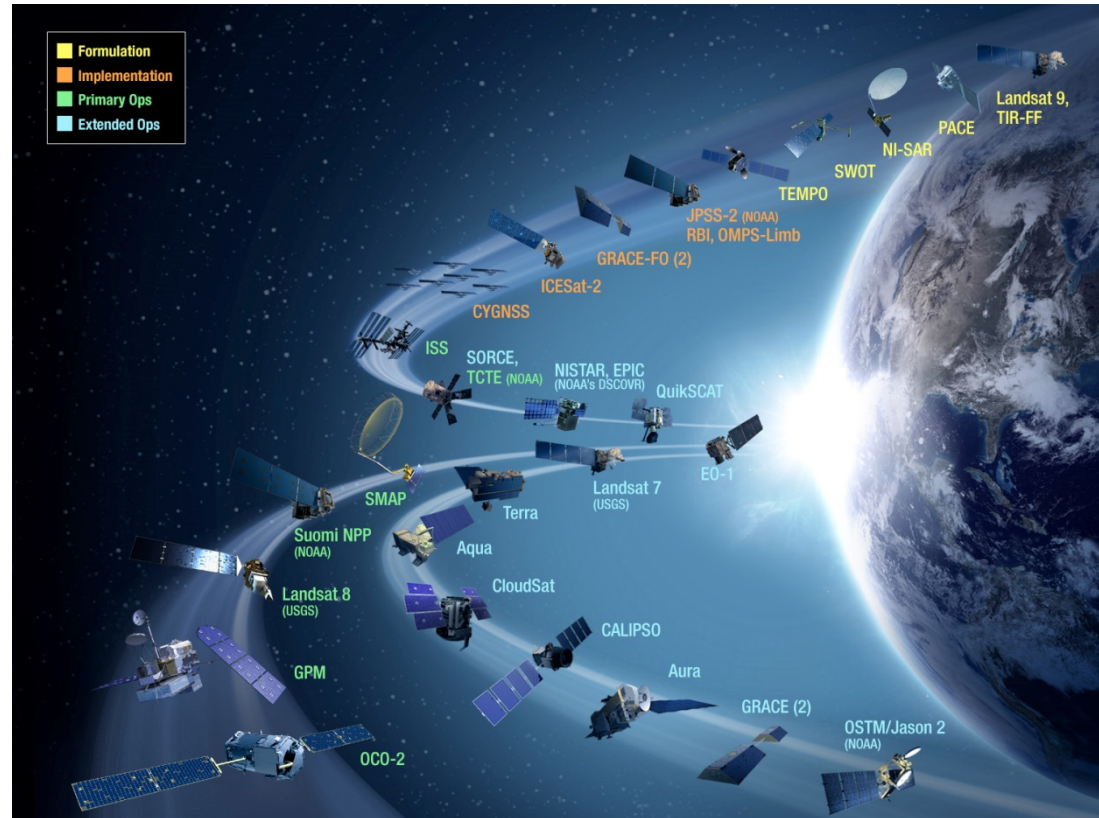


Extensive Data Collection



■ > 11,000 data types (collections)

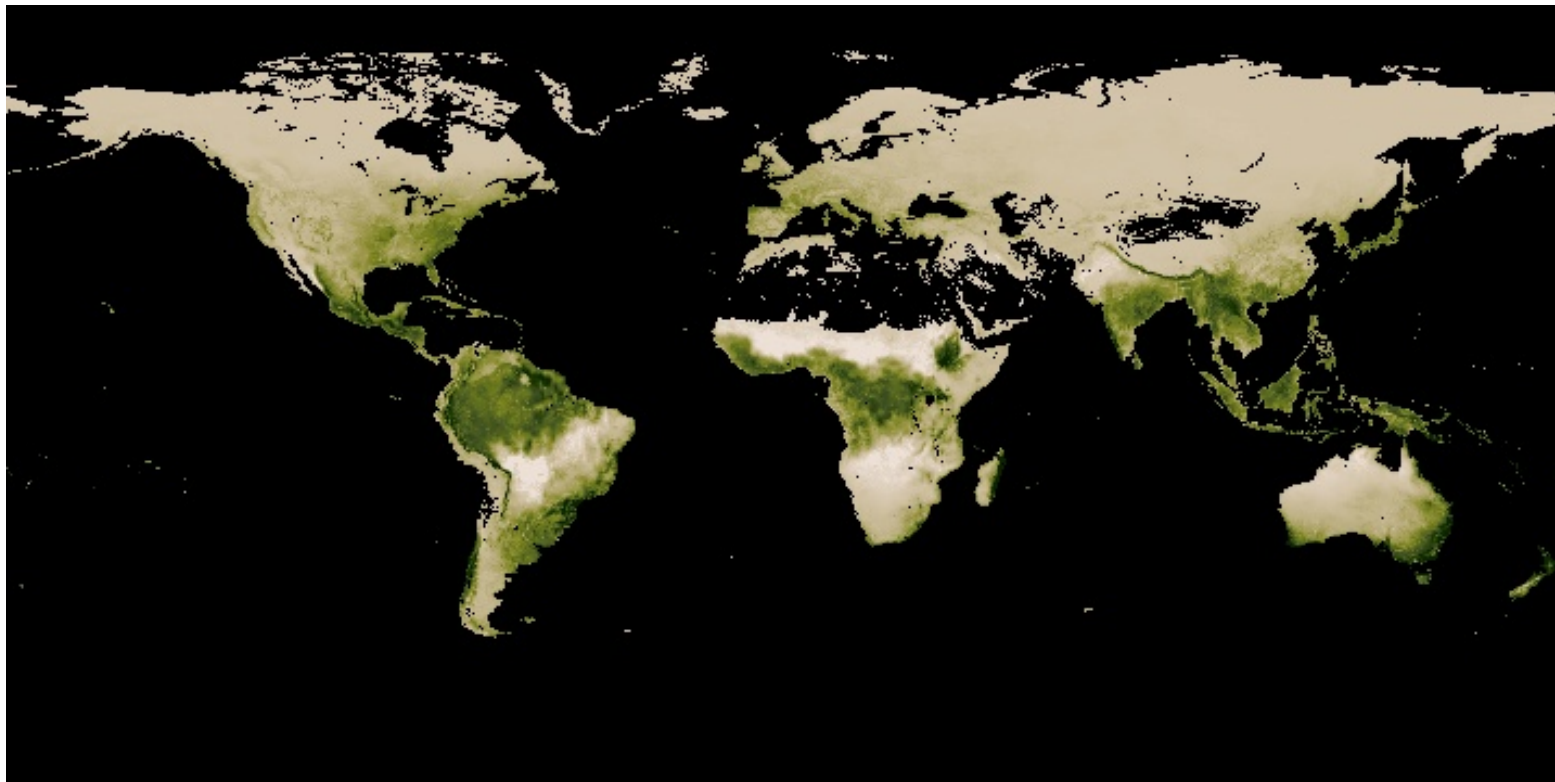
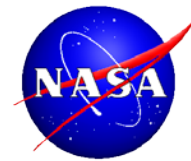
- Land
 - » Cover & Usage
 - » Surface temperature
 - » Soil moisture
 - » Surface topography
- Atmosphere
 - » Winds & Precipitation
 - » Aerosols & Clouds
 - » Temperature & Humidity
 - » Solar radiation
- Ocean
 - » Surface temperature
 - » Surface wind fields & Heat flux
 - » Surface topography
 - » Ocean color
- Cryosphere
 - » Sea/Land Ice & Snow Cover



Credit: NASA Science Mission Directorate

- Human Dimensions
 - » Population & Land Use
 - » Human & Environmental Health
 - » Ecosystems

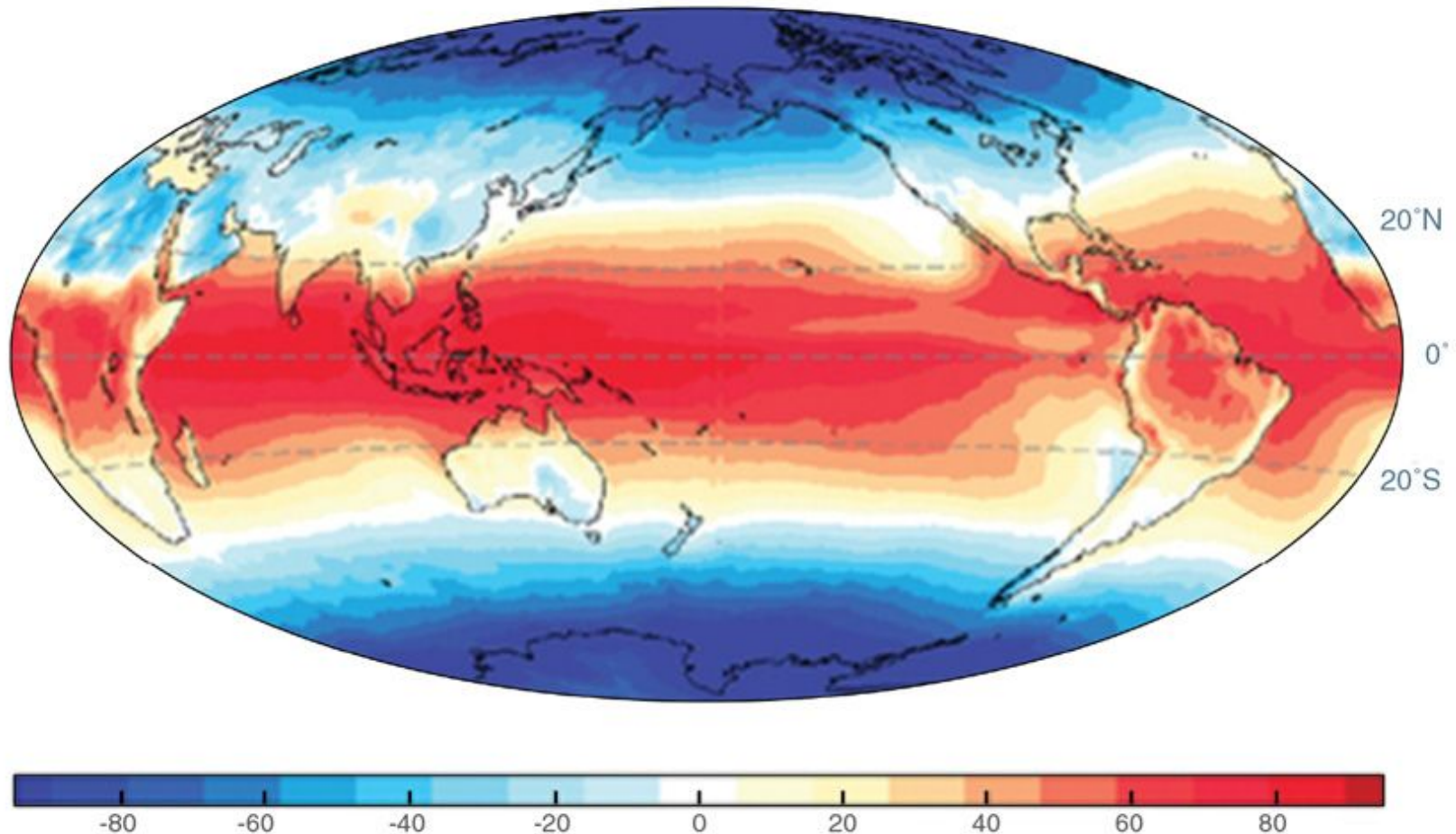
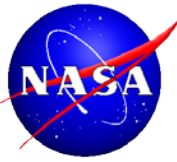
Global Net Primary Productivity



Net Primary Productivity is the amount of carbon absorbed by plants minus carbon released by plants, measured in grams of carbon per square meter per day. Image shows the averages over October 2016, globally. Credits - Image made by Reto Stockli, NASA's Earth Observatory Team, using data provided by the MODIS Land Science Team.

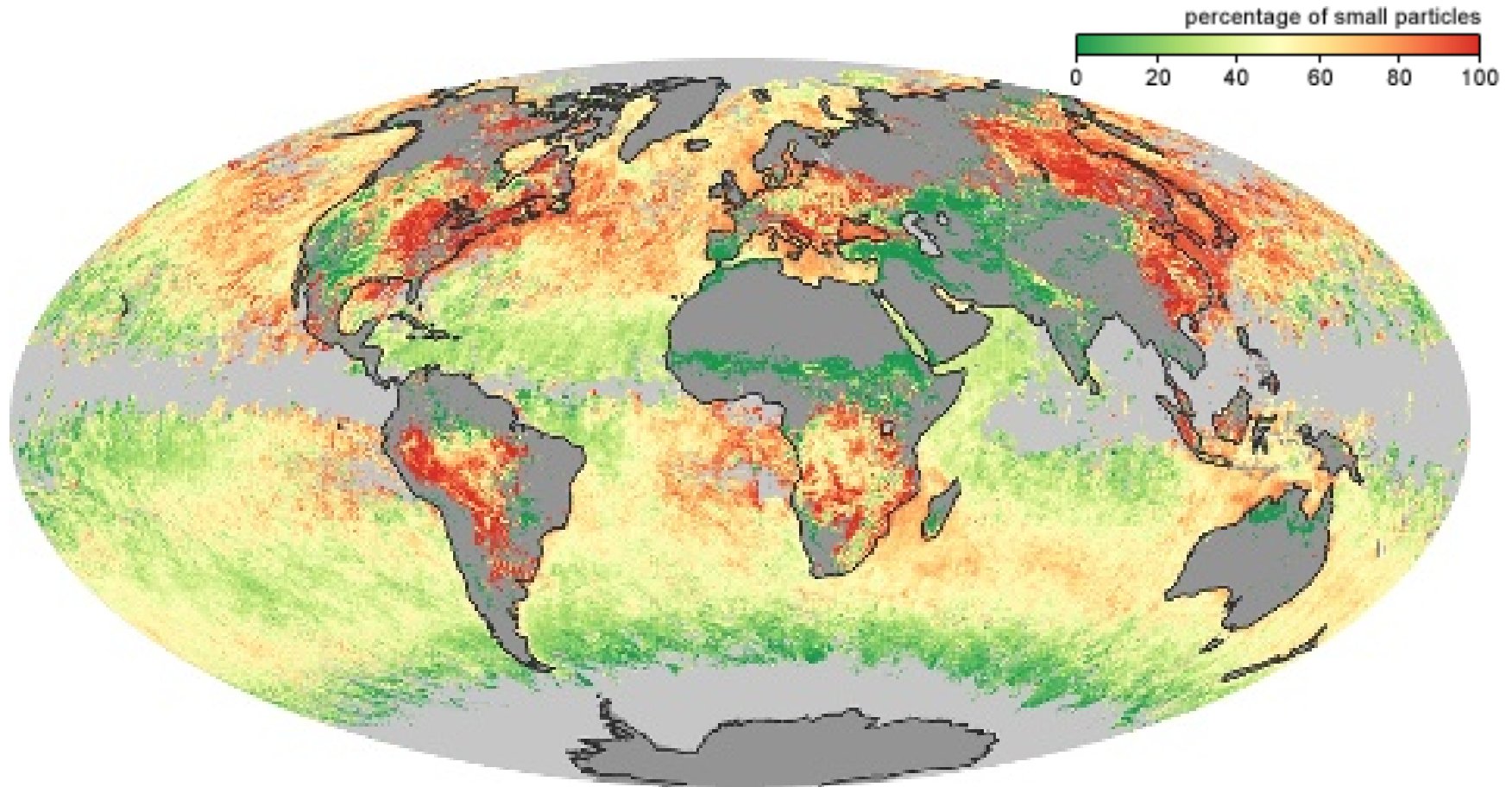
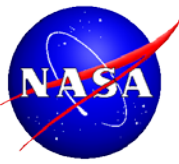
<http://neo.sci.gsfc.nasa.gov/servlet/RenderData?si=1709924&cs=rgb&format=JPEG&width=720&height=360>

Top of Atmosphere Radiation



At the top of the atmosphere (TOA), incoming and outgoing radiation determine Earth's average temperature. This image shows averaged net downward TOA radiation from the Clouds and Earth's Radiant Energy System (CERES) instrument from 2001 to 2010. The Southern Hemisphere receives more net radiation than the Northern Hemisphere. (Courtesy D. Frierson et al., 2013, Nature Geoscience) – accessed through <https://earthdata.nasa.gov/user-resources/sensing-our-planet/rooting-out-rainfall>

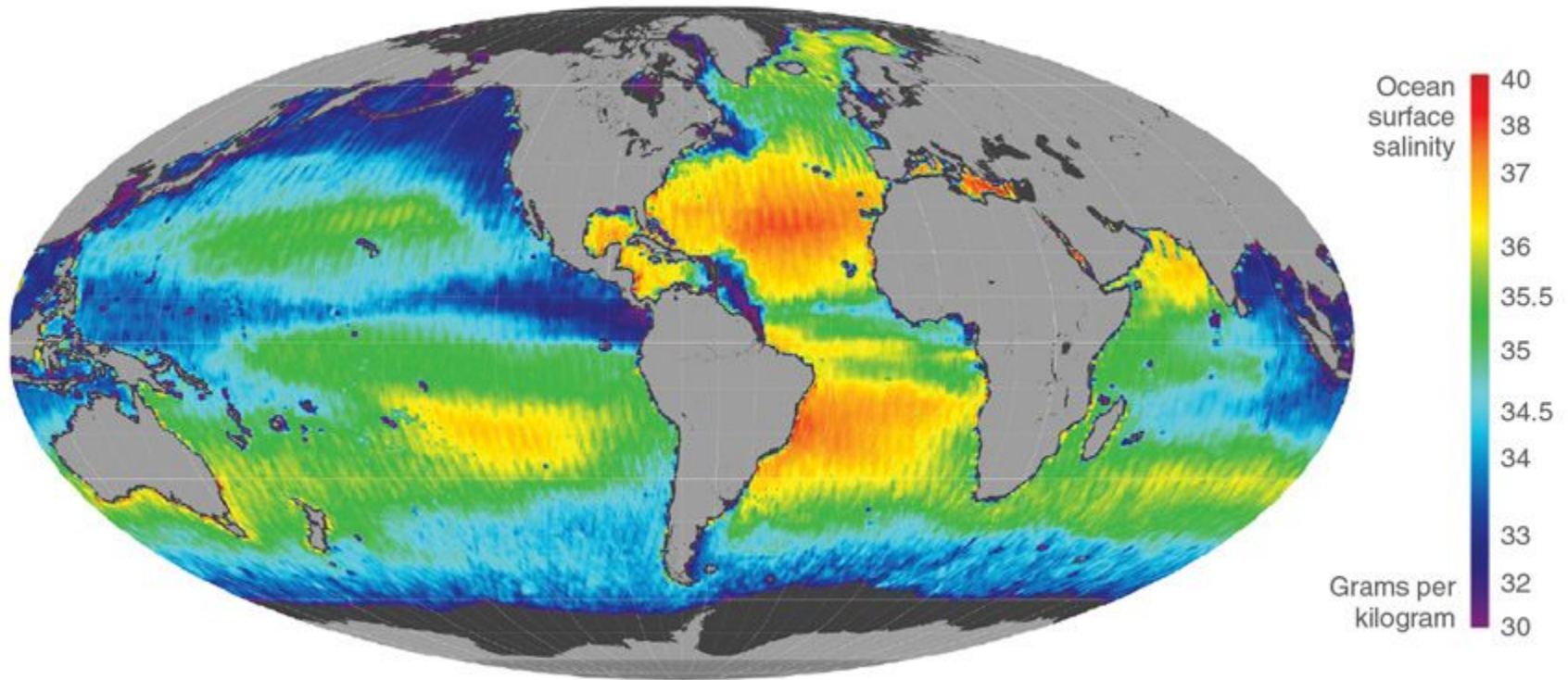
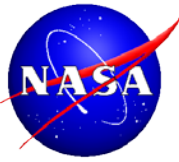
Aerosol Size – August 2015



Aerosol particle sizes – red = small (man made); green = large (natural); yellow = mixed. Map based on data from MODIS instrument on NASA's Terra satellite.

http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MODAL2_M_AER_RA

Sea Surface Salinity



This image of Aquarius sea surface salinity (SSS) measurements averaged for 2012 shows a global color scale of salinity intensity. Warm colors mark stronger salinity values. Values are shown in a range between 30 grams per kilogram (purple) and 40 grams per kilogram (red). (Courtesy N. Kuring/NASA) – accessed through <https://earthdata.nasa.gov/user-resources/sensing-our-planet/salt-of-the-sea>.

Recent Hurricanes

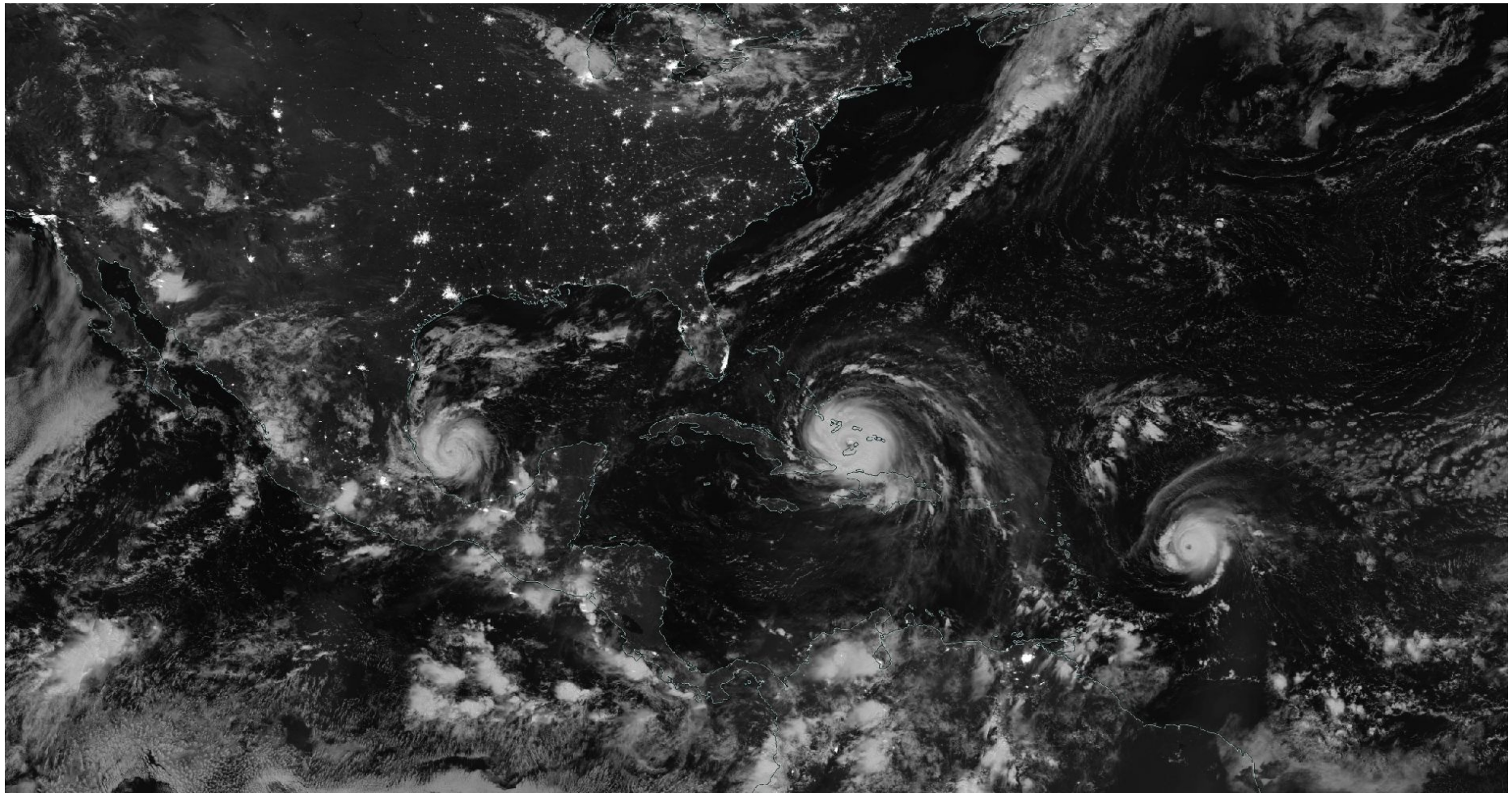
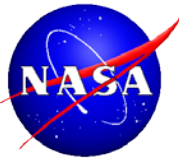
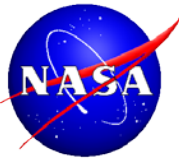
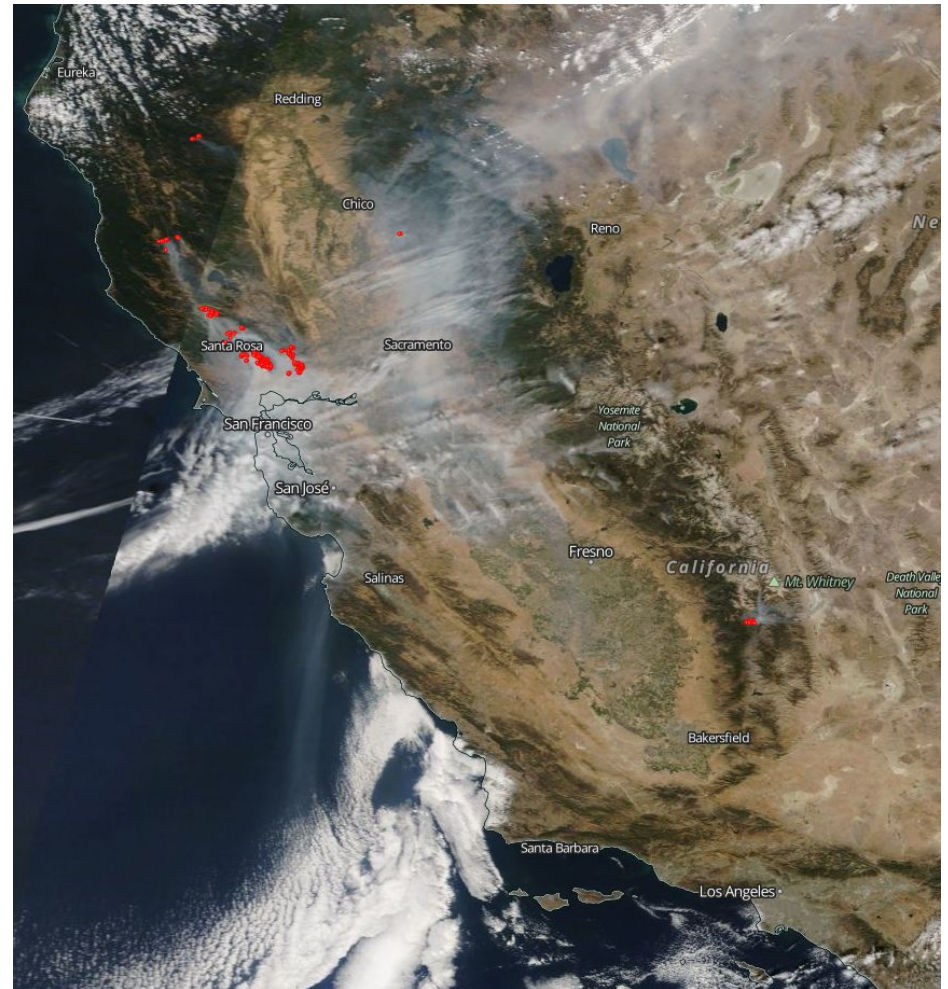


Image of [Hurricanes Katia, Irma, and Jose](#) acquired on 8 September 2017 by the [Visible Infrared Imaging Radiometer Suite \(VIIRS\)](#) instrument, on board the [Suomi National Polar-orbiting Partnership \(Suomi-NPP\)](#) satellite. (Image Credit: NASA WorldView/GIBS)₁₂

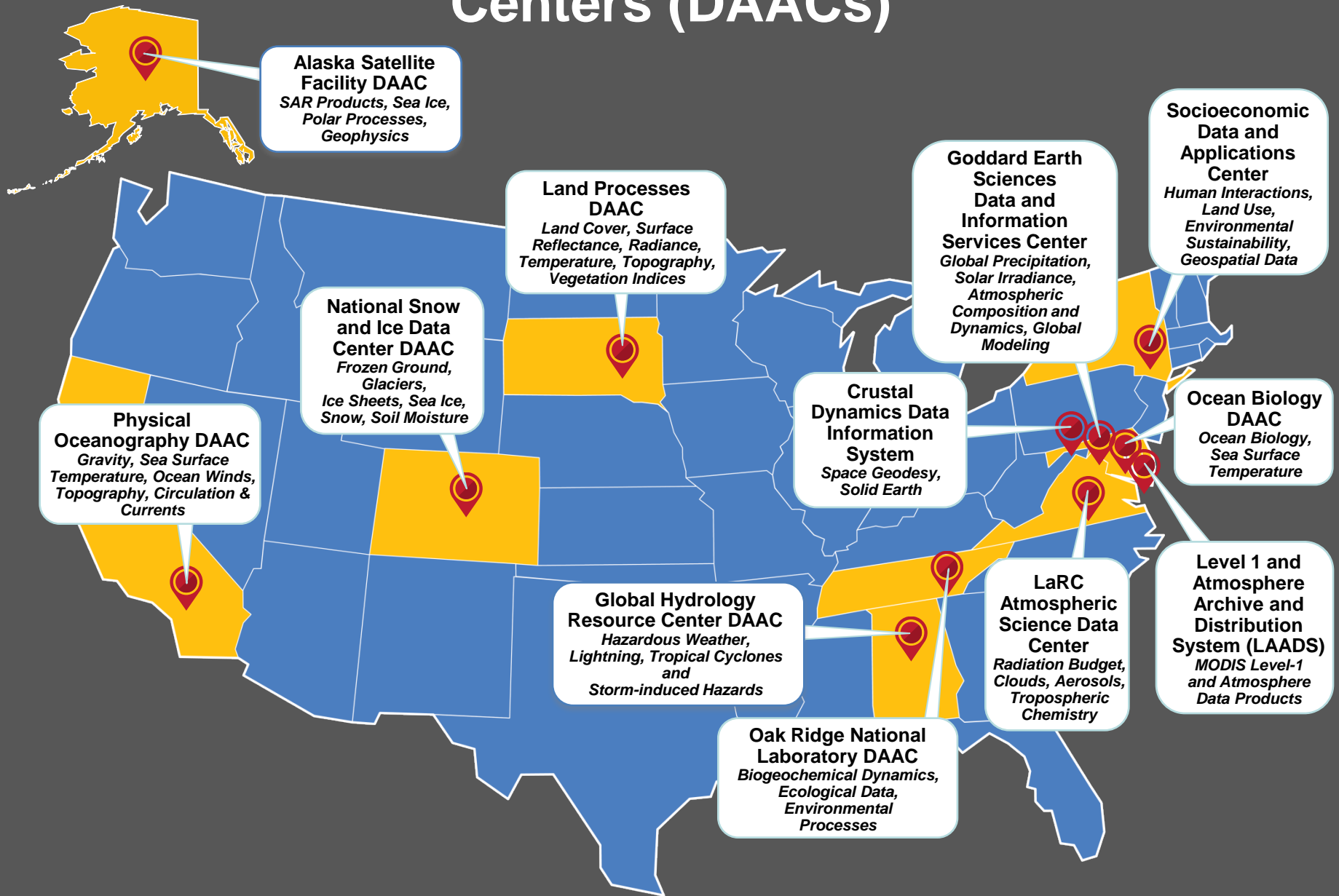
Wild Fires in California



- **Fires in Northern California**
– **October 11, 2017**
- **Image overlays on EOSDIS Worldview**
 - **Fires and Thermal Anomalies (Terra/MODIS)**
 - **Corrected Reflectance (True Color) – Terra/MODIS**
 - **Place Labels (OpenStreetMap)**
 - **Coastlines (OpenStreetMap)**

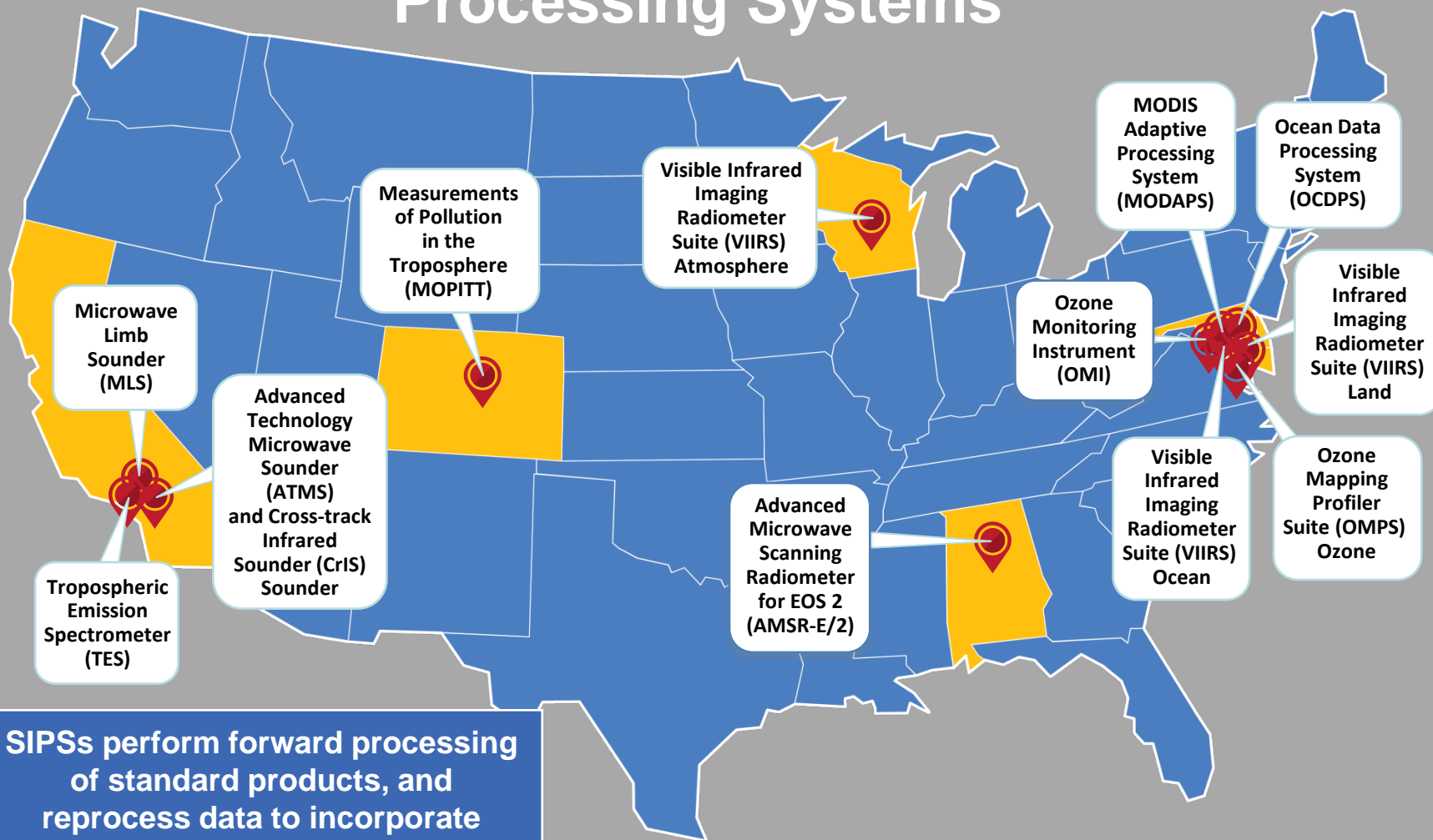


Distributed Active Archive Centers (DAACs)



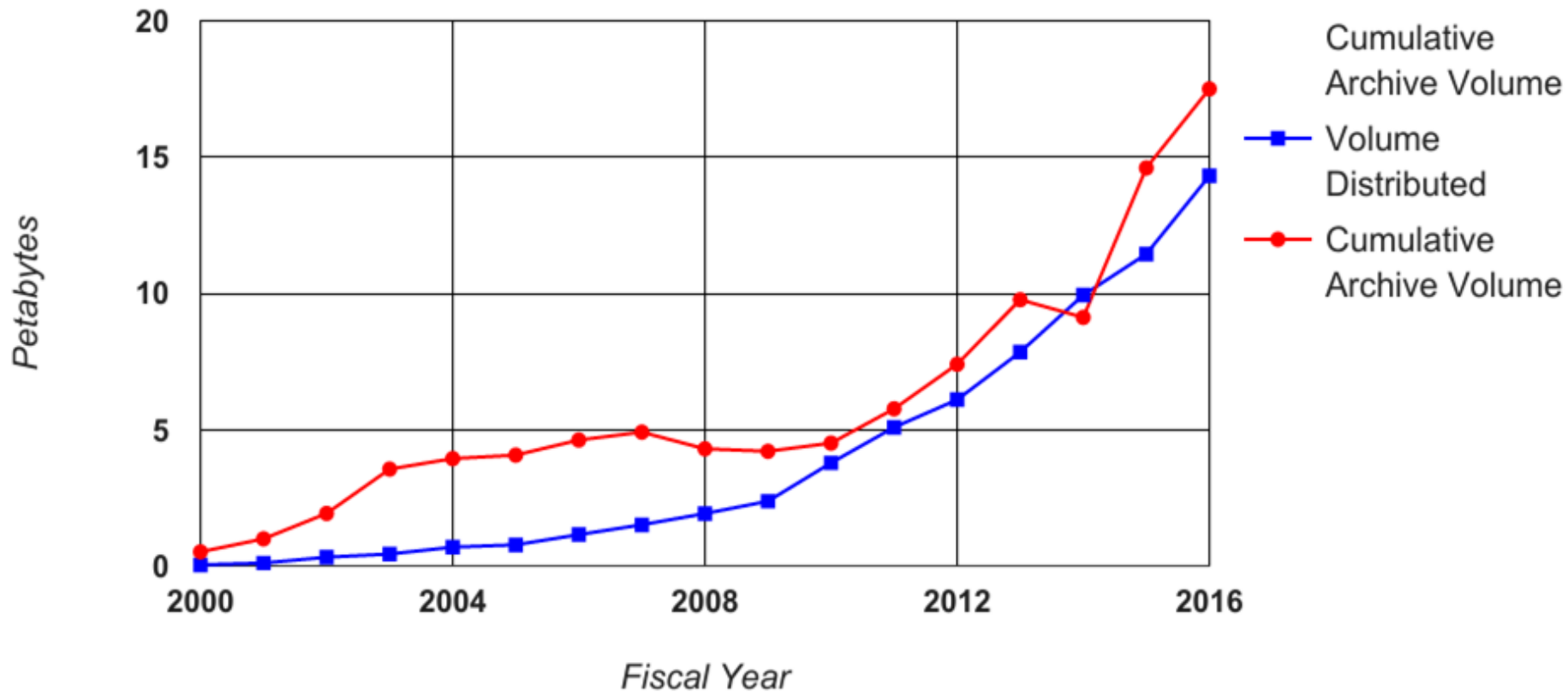
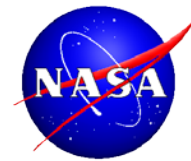


Science Investigator-led Processing Systems

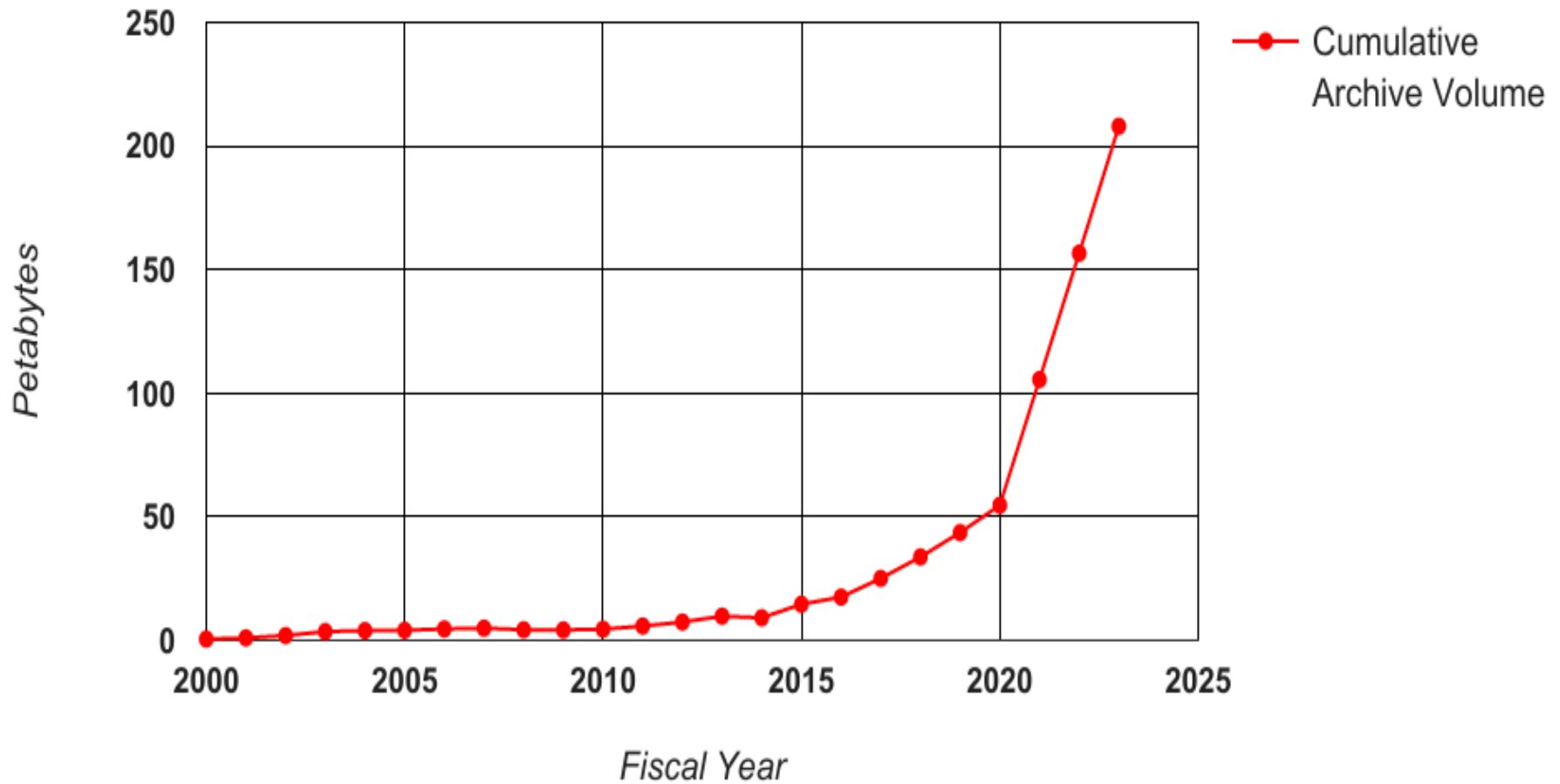
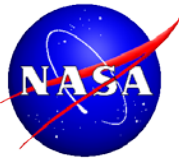


SIPs perform forward processing of standard products, and reprocess data to incorporate algorithm improvements.

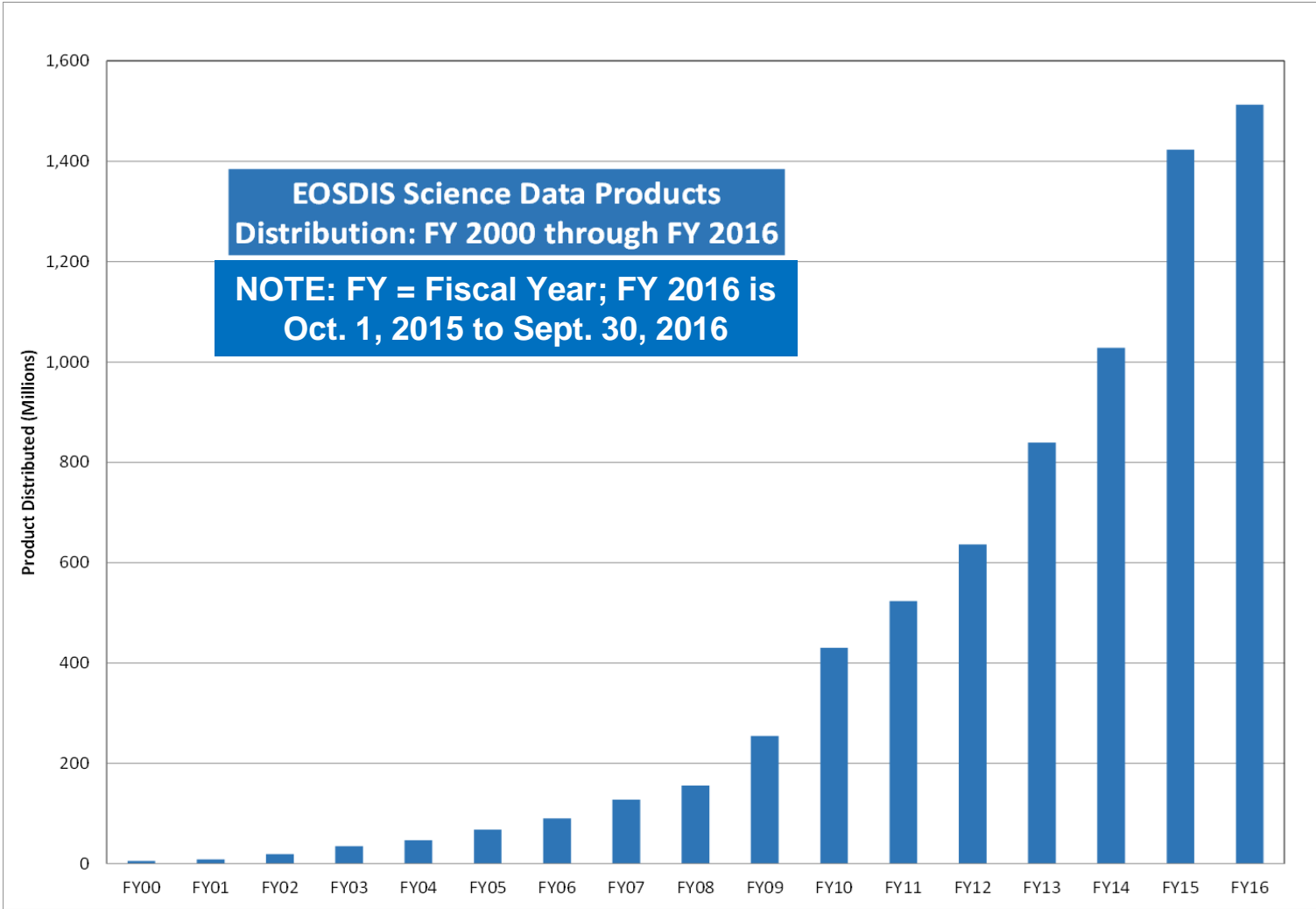
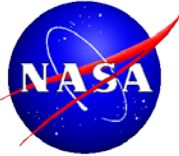
Large & Growing Archive & Distribution Volumes

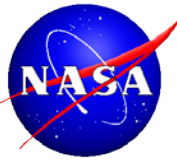


Future Archive Growth

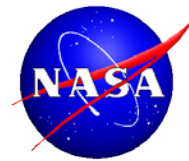


EOSDIS Product files Delivered: FY2000 thru FY2016



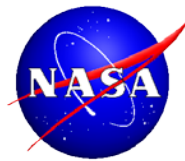


- **Land and Atmosphere Near real-time Capability for EOS (LANCER)**
- **Coherent Web Interface:**
<http://earthdata.nasa.gov> is operational
 - Provides a unified view of NASA Earth science data system resources
 - Consolidates 14 web sites, and provides links to various ways to access data and to related external sites
- **User Registration System & earthdata login – uniform approach to registration across and access to EOSDIS components**



- **Global Imagery Browse Services (GIBS)**
 - Standards-based, full resolution, interactive browse capability
 - Accessible from <http://earthdata.nasa.gov> wiki
- **Unified Metadata Model and Common Metadata Repository**
- **Big Earth Data Initiative (BEDI)**
- **Preservation Content Specification**
- **Digital Object Identifiers**
 - ESDIS Project is a registration authority (prefix 10.5067)
 - DOI's assigned to > 50% of datasets
- **Migration to “Cloud”**

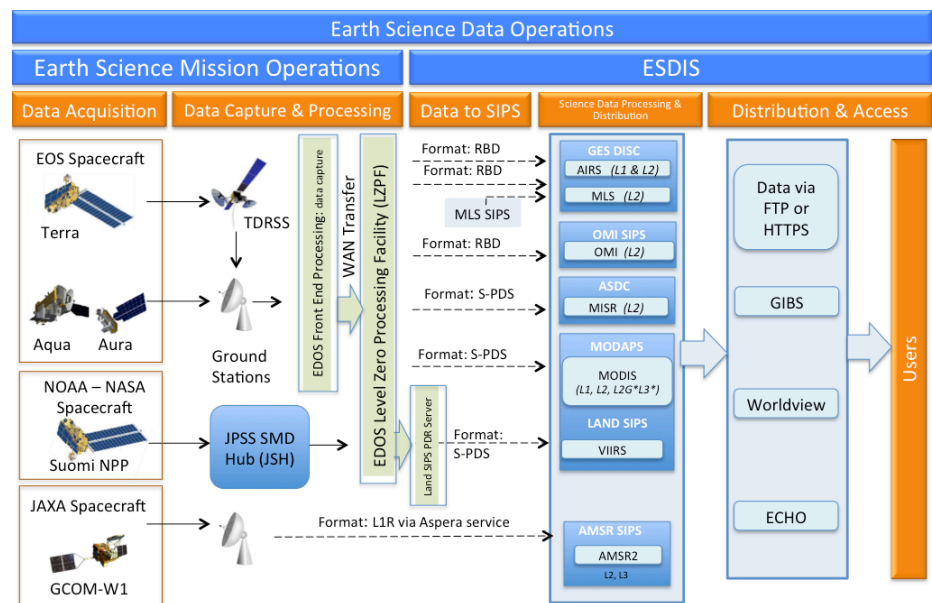
Land, Atmosphere Near-real-time Capability for EOS (LANCE)



- Building on existing EOSDIS elements provides data from AIRS, AMSR, MISR, MLS, MODIS, MOPITT, OMI, and VIIRS instruments in near real-time (< 3 hours from observation)
- Utilizes software for Standard Science Products, but relaxes requirements for ancillary data inputs
- High operational availability

Applications of LANCE data include:

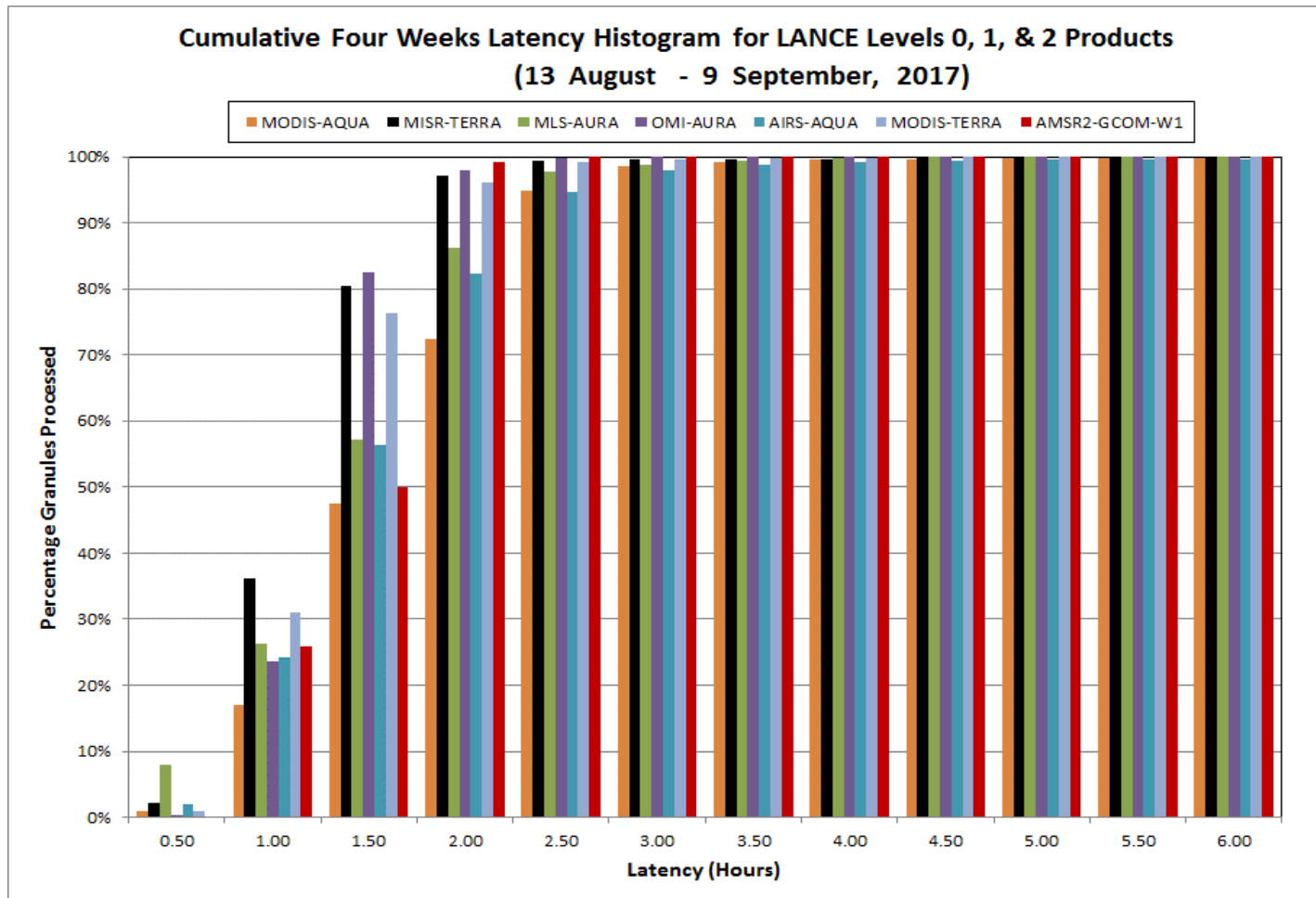
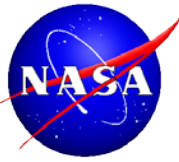
- Numerical weather & climate prediction/forecasting
- Monitoring of Natural Hazards
- Disaster Relief
- Agriculture
- Air quality



RBD: Rate Buffered Data
 S-PDS: Session Based Production Data Set, T-PDS: Time Based Production Data Set
 *L2G and L3 products have a latency of 27 – 48 hours
 SIPS: Science Investigator-led Processing Systems
 TDRSS: Tracking and Data Relay Satellite System

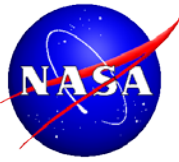
See: <https://earthdata.nasa.gov/earth-observation-data/near-real-time/about-lance>

LANCE Latencies



Over the four weeks indicated above, >98% of near real-time data requests were satisfied within 3 hours.

Earthdata Website



■ What is the Earthdata Website?

- Sustainable, evolvable, and reliable Website representing community needs for NASA Earth science data and information.
- Supports collaboration within and between organizations, and for development and integration of new applications.
- Coherent and comprehensive Web presence of the Earth Science Data Systems Program.
- See Earthdata at <https://earthdata.nasa.gov/>.

■ Benefits of the Earthdata Website:

- Fully represents EOSDIS programmatic investments and capabilities.
- Presents data centers clearly as elements within a larger system of systems.
- Facilitates multidisciplinary research and data integration.
- Quickly responds to emerging technologies
- Changes are made based on usability studies
- Provides a platform for demonstration of interoperability throughout all of our systems.



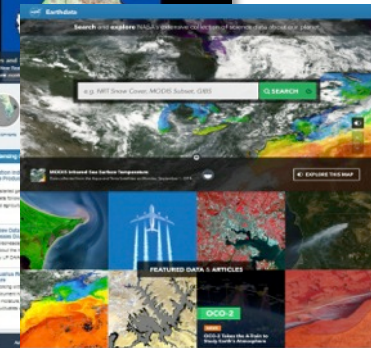
2011



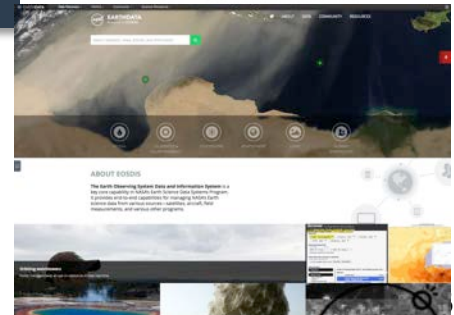
2012



2013

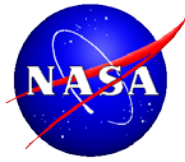


2014



2015

Worldview and Global Browse Imagery Services



GIBS / Worldview Goal:

To transform how users interact with and discover NASA Earth data; make it visual



Approach:

- The Global Imagery Browse Services (GIBS) provide open access to full resolution imagery derived from NASA products to any mapping client and script

<https://earthdata.nasa.gov/gibs>

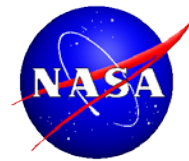
- Worldview is an open source, browser-based client to interactively explore GIBS (and SEDAC) imagery and download the underlying data

<https://worldview.earthdata.nasa.gov>

Open-Access Servers

Client

Global Image Browse Service (GIBS)



- Goal: “Parameter Visualizations” for all EOSDIS Imagery; >400 products available now
- Standardized access via OGC WMTS / TWMS / WMS / KML
- Source code for the GIBS OnEarth server and sample code available at the GIBS GitHub site
- Repository of pre-prepared, hierarchically stored imagery to maximize performance for “full-resolution” browse
- Clients can be built to use and display images in GIBS – WorldView is an example

Worldview: Reference Client for GIBS

<http://earthdata.nasa.gov/worldview>

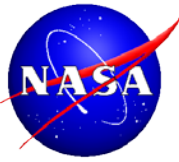
<http://earthdata.nasa.gov/gibs>

The screenshot displays the NASA Worldview web application interface. At the top, the browser title is "EOSDIS Worldview (Alpha) - Mozilla Firefox" and the address bar shows the URL "https://earthdata.nasa.gov/labs/worldview/". The main content area features a global satellite map with numerous red dots indicating fire anomalies, primarily concentrated in Africa and South America. A left-hand sidebar contains a "Layer Control" panel with the following sections:

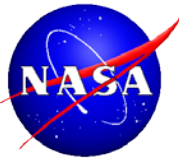
- All** (dropdown menu)
- Search** ("aqua", "fire")
- Base Layers**
 - Corrected Reflectance (True Color) Terra / MODIS
 - Corrected Reflectance (True Color) Aqua / MODIS
 - Land Surface Reflectance (True Color)
- Overlays**
 - Cloud Top Temperature (Night) Aqua / MODIS
 - Fires (Day and Night) Terra/ and Aqua/MODIS Fire and Thermal Anomalies

At the bottom of the sidebar, a date range selector is set to "2014-06-14". Below the map is a timeline navigation bar showing years from 2000 to 2014, with "2014" selected. Underneath the years is a monthly calendar view for June 2014, with the 14th highlighted. The bottom of the screen shows a Windows taskbar with various application icons and a system tray indicating the time as 4:33 PM on 6/20/2014.





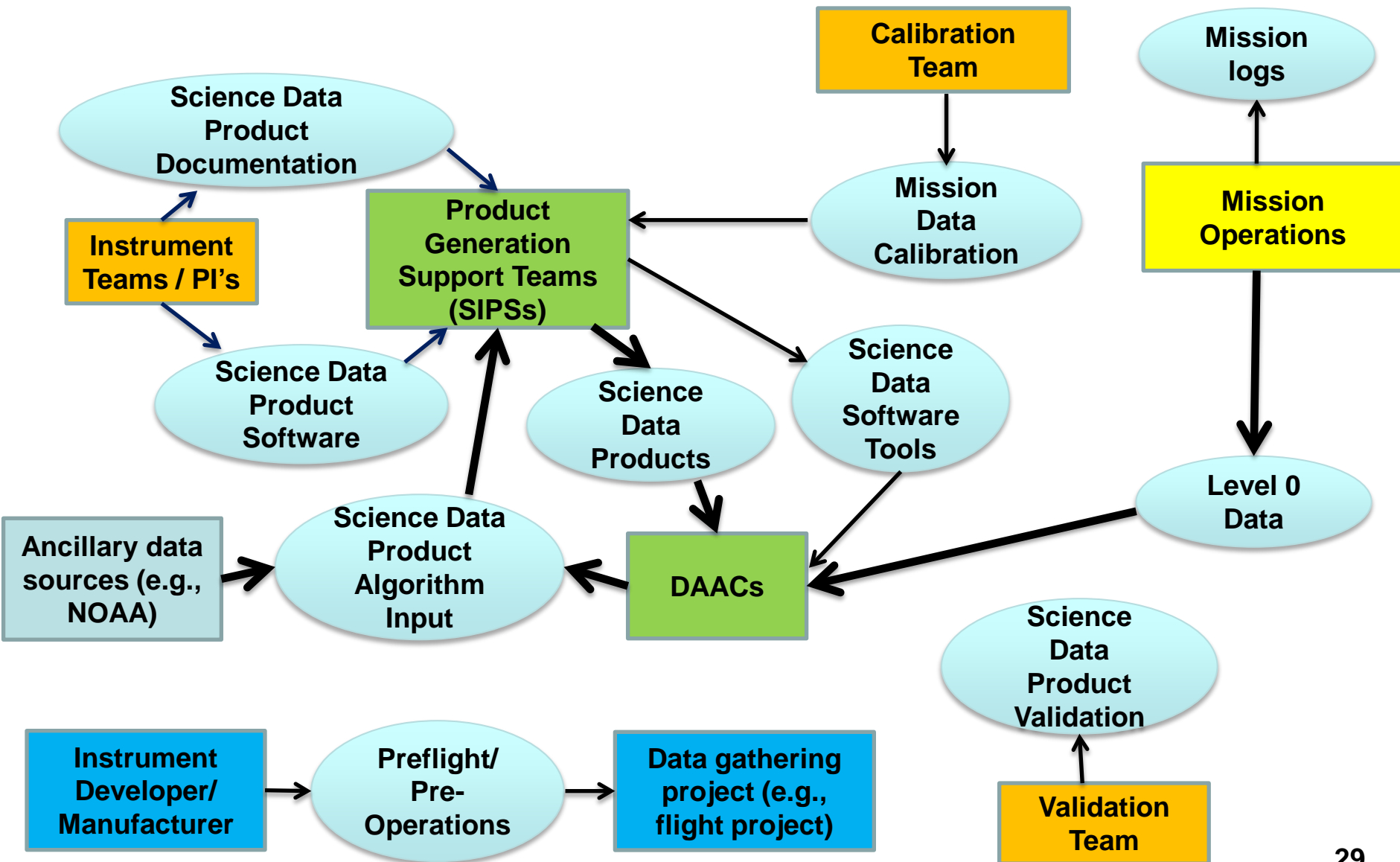
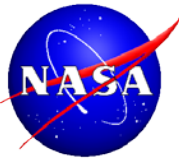
Categories of Content to be Preserved

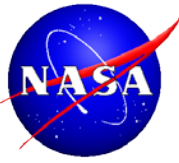


NASA's Preservation Content Specification for Earth Science Data

1. **Preflight/Pre-Operations:** Instrument/Sensor characteristics including pre-flight/pre-operations performance measurements; calibration method; radiometric and spectral response; noise characteristics; detector offsets
2. **Science Data Products:** Raw instrument data, Level 0 through Level 4 data products and associated metadata
3. **Science Data Product Documentation:** Structure and format with definitions of all parameters and metadata fields; algorithm theoretical basis; processing history and product version history; quality assessment information
4. **Mission Data Calibration:** Instrument/sensor calibration method (in operation) and data; calibration software used to generate lookup tables; instrument and platform events and maneuvers
5. **Science Data Product Software:** Product generation software and software documentation
6. **Science Data Product Algorithm Input:** Any ancillary data or other data sets used in generation or calibration of the data or derived product; ancillary data description and documentation
7. **Science Data Product Validation:** Records, publications and data sets
8. **Science Data Software Tools:** product access (reader) tools.

Sources of Content





■ Definition of Cloud Computing (from National Institute of Standards and technology)

- “A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”

■ Motivation

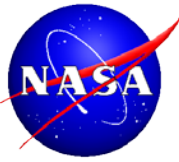
- EOSDIS archive is projected to grow from the current 3.9 petabytes (PB) per year to as much as 47.7 PB per year
- Growth in both data ingest rate and overall archive volume pose new challenges for distributing and analyzing data using current storage approach
- Archive in the Cloud will place data close to computational capabilities, improve scalability, management and data accessibility while expediting science discovery.

Migration to “Cloud” - Status

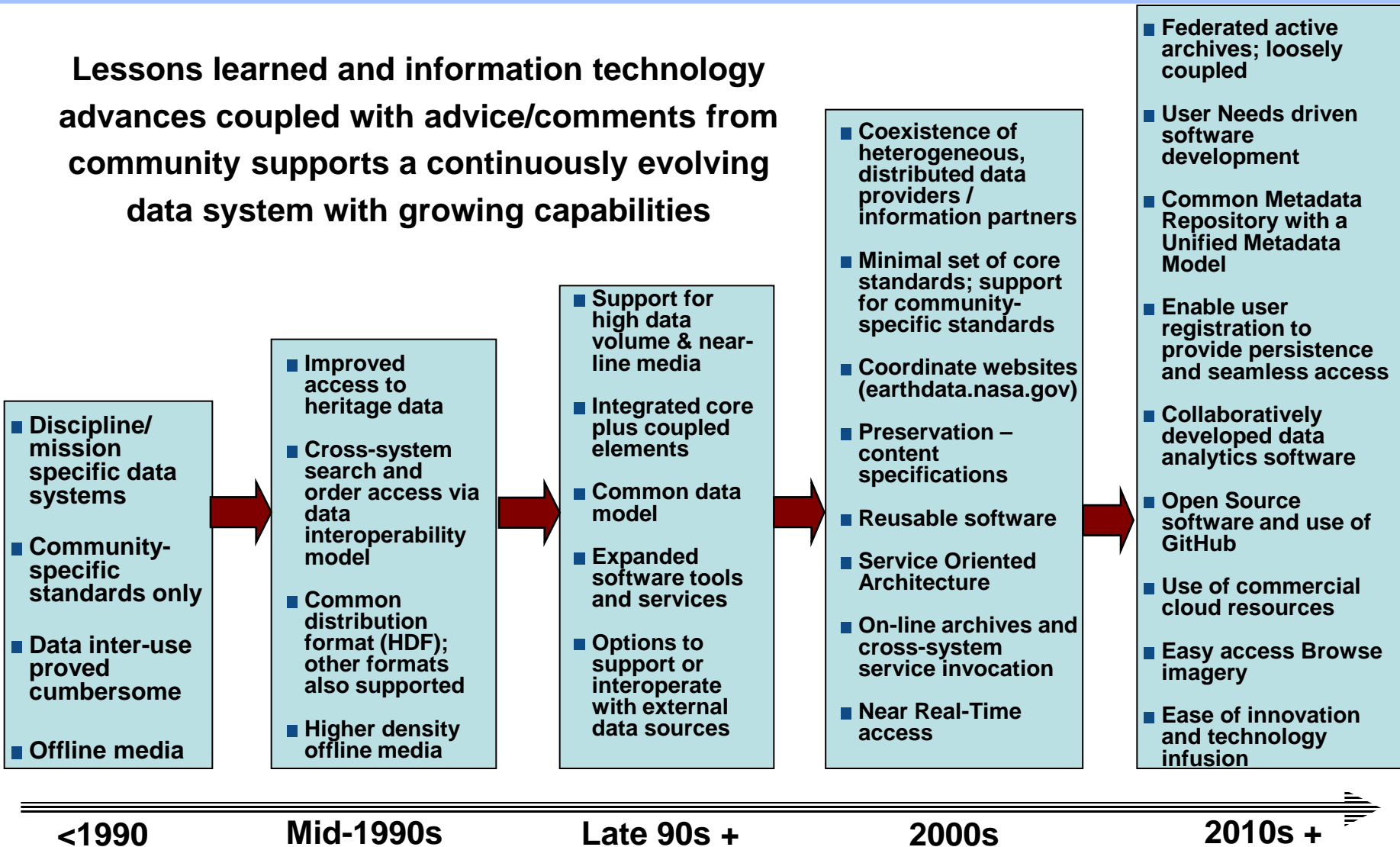


- **Developing new technologies, services, and architectures**
 - **All of them being thoroughly tested and evaluated to ensure that the data can work seamlessly in the cloud environment**
- **Several prototypes have been developed and exercised**
- **Common Metadata Repository and Earth Data Search Client have been migrated**
- **See <https://earthdata.nasa.gov/about/eosdis-cloud-evolution> for details**

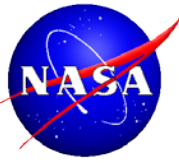
EOSDIS Technology Improvements and System Evolution



Lessons learned and information technology advances coupled with advice/comments from community supports a continuously evolving data system with growing capabilities



EOSDIS Evolution – On-Going with Community Inputs



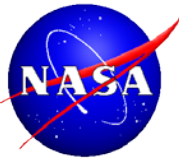
■ Earth Science Data System Working Groups

- Focus on exploration and development of recommendations derived from pertinent community insights**
- Organized around key technology and information system issues**
- Members from NASA-funded core and competed data system activities**

■ Earth Science Information Partners (ESIP)

- Established by NASA in 1998 – now sponsored by NASA, NOAA and USGS**
- > 120 members – government agencies, universities, commercial entities**

Examples of ESIP and NASA ESDSWG Activities



ESIP Collaboration Areas

Cloud Computing

Data Management Training

Documentation

Information Quality

Semantic Technologies

Discovery

Usability

Web Services

Earth Science Data Analytics

VR/AR for Science

Earth Sciences Pre-Prints

Data Stewardship

Observe

Process

Archive

Discover

Access

Analyze/
Visualize

Publish

Preserve

NASA ESDS Working Groups

Cloud Computing

Data Intensive Architectures

Time Series

Map Projections

Data Quality

Airborne Data & Metadata

Search Relevance

Dataset Interoperability

Geospatial Web Services

Data Recipes

Visualization

Users Forum

Digital Object Identifiers & Citations

Provenance

Preservation Practices

Conclusion

- **Earth Science Informatics is a rapidly developing discipline**
- **Many organizations around the world are actively pursuing ESI R & D**
- **Considerable commonality of interests among these organizations**
- **IEEE GRSS ESI TC, ESIP Federation, Research Data Alliance (RDA) are examples of groups promoting collaboration**