Earth Science Informatics - Overview

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September 28, 2017 IEEE GRSS Distinguished Lecture, Melbourne, FL

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

NASA's Earth Science Data Systems

- "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

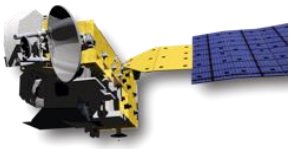
Core Capabilities and Competed Programs

- **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)



data downlink

EOSDIS

capture and clean

process

archive

subset

distribute

Research

Applications

Education

Users

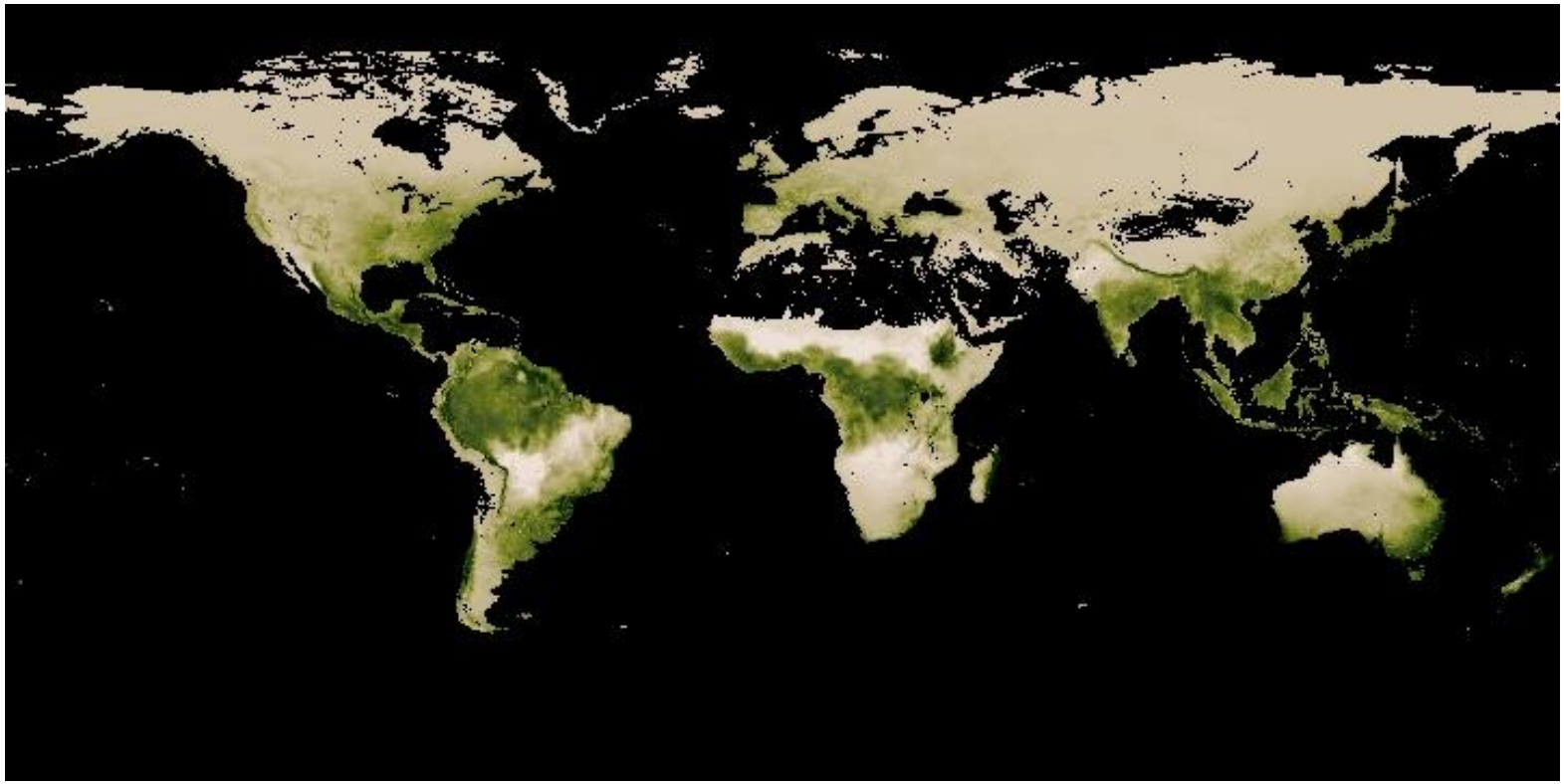
Extensive Data Collection

- **> 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

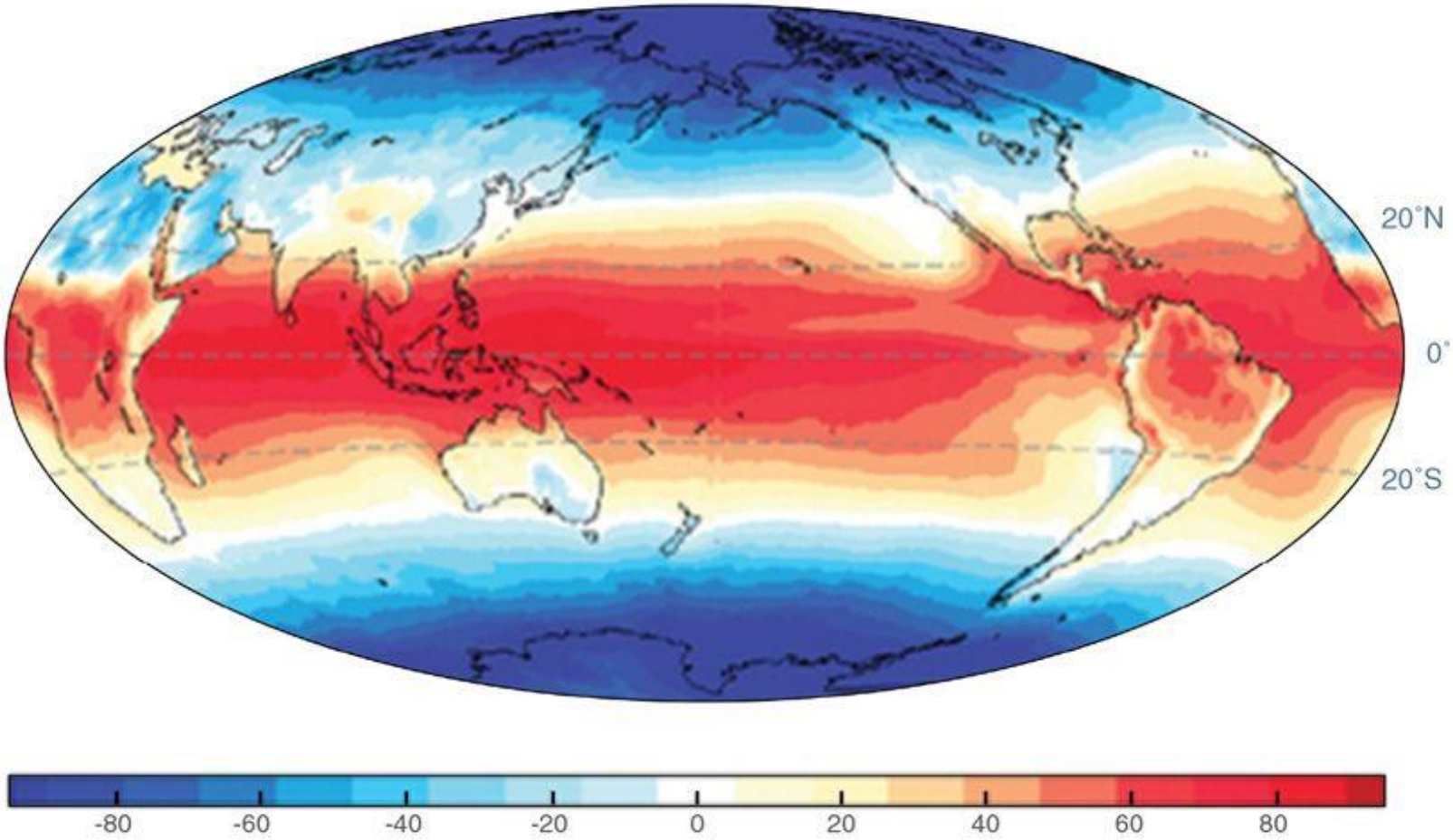
- Human Dimensions
  - » Population & Land Use
  - » Human & Environmental Health
  - » Ecosystems

Global Net Primary Productivity



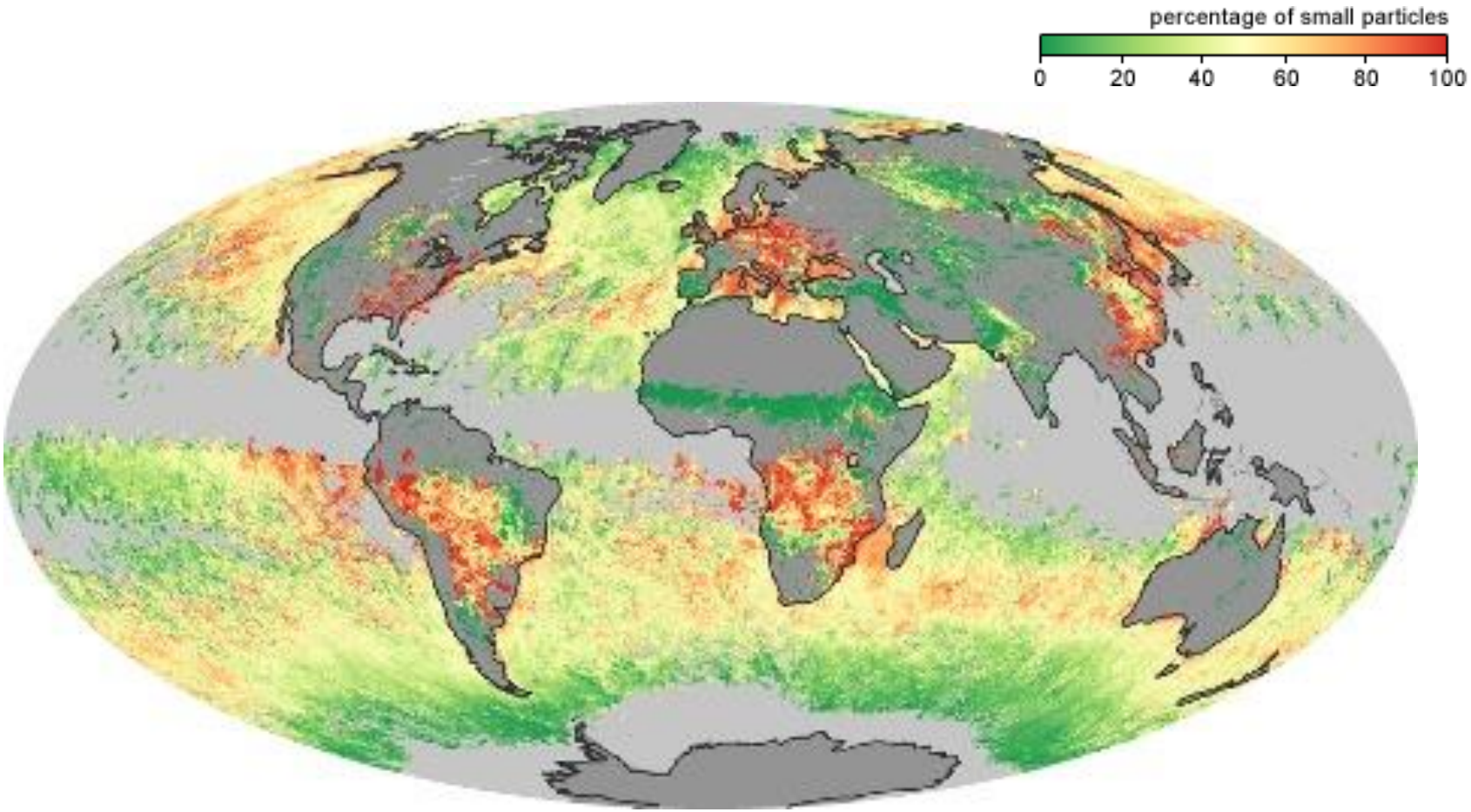
Net Primary Productivity is the amount of carbon absorbed by plants minus carbon released by plants, measured in grams of carbon per square meter per day. Image shows the averages over October 2016, globally. Credits - Image made by Reto Stockli, NASA's Earth Observatory Team, using data provided by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



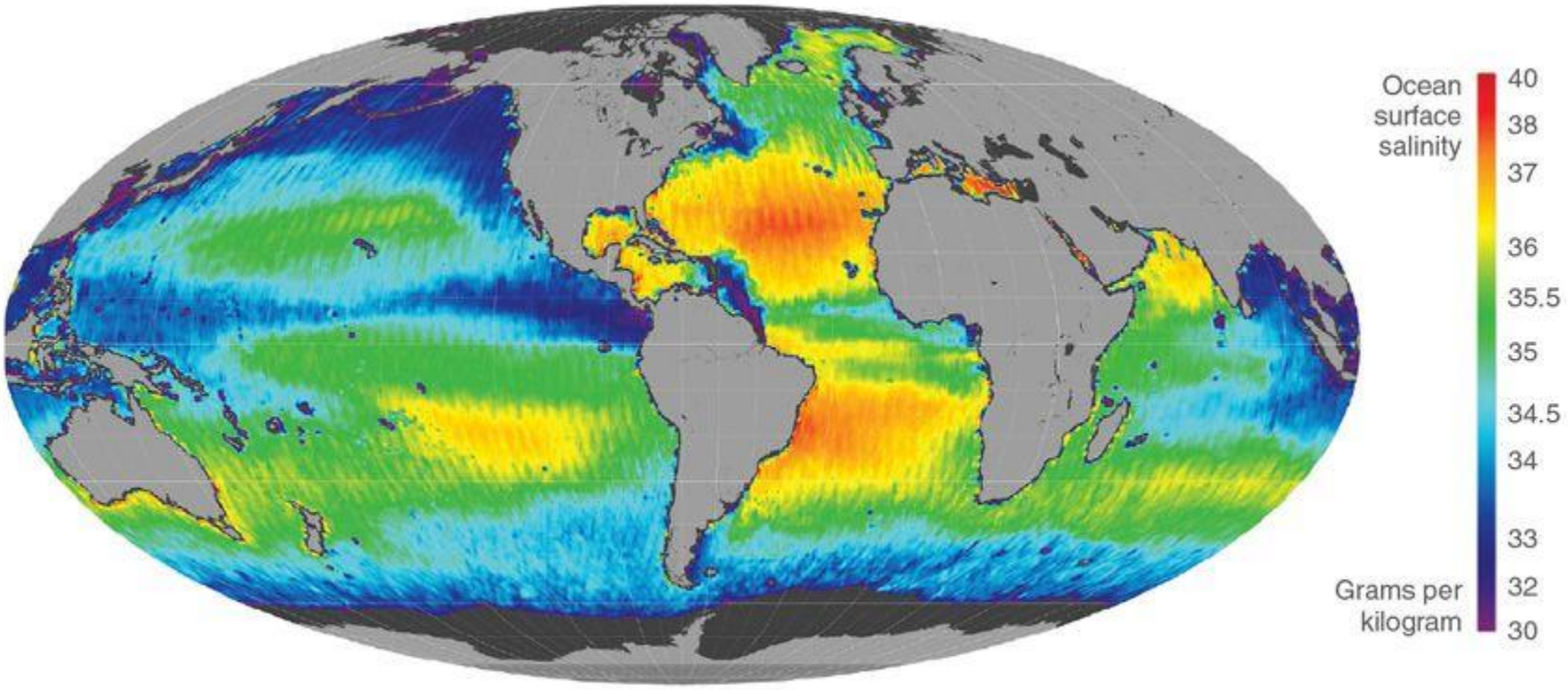
At the top of the atmosphere (TOA), incoming and outgoing radiation determine Earth's average temperature. This image shows averaged net downward TOA radiation from the Clouds and Earth's Radiant Energy System (CERES) instrument from 2001 to 2010. The Southern Hemisphere receives more net radiation than 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 – September 2016



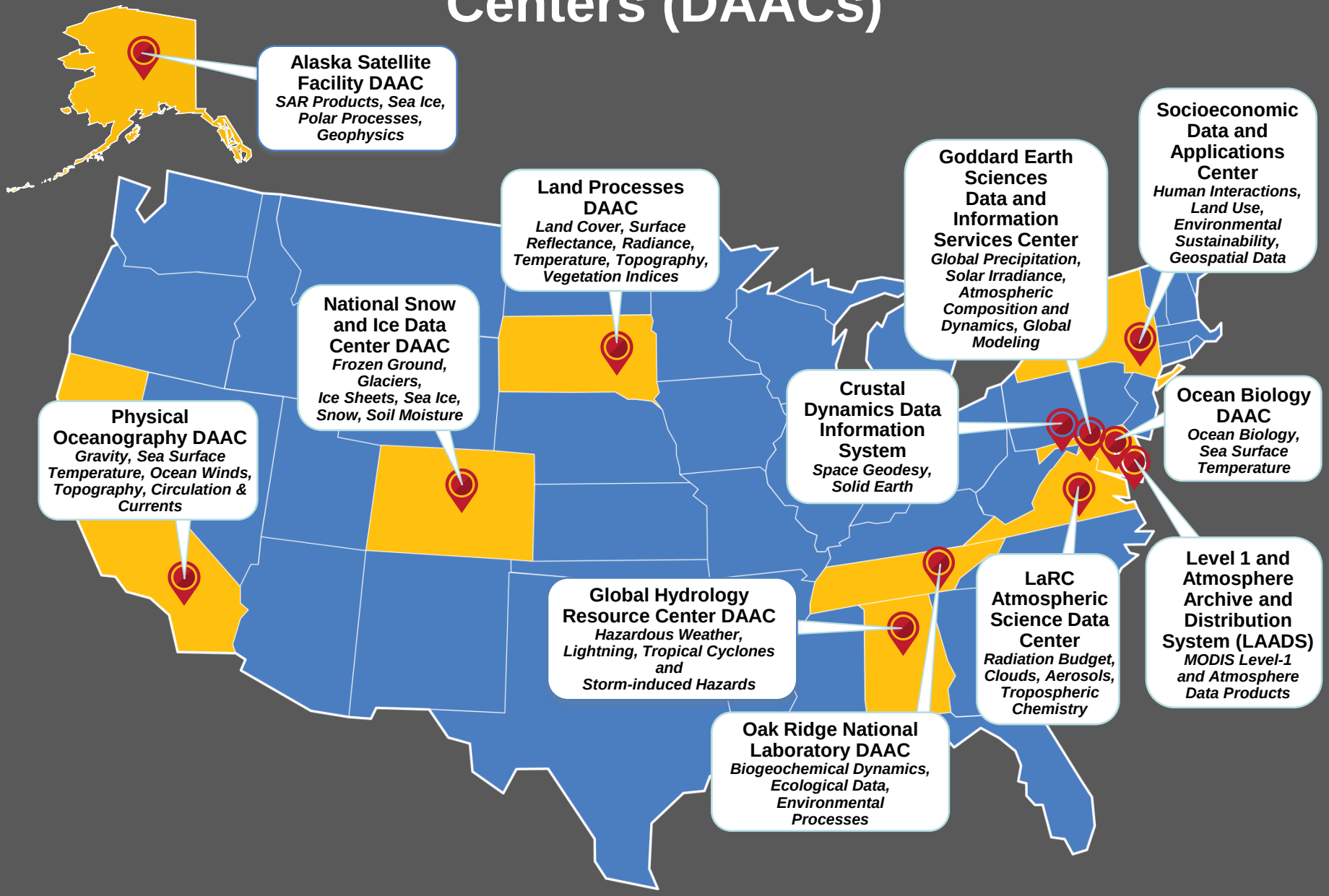
Aerosol particle sizes – red = small (man made); green = large (natural); yellow = mixed.
Map based on data from MODIS instrument on NASA's Terra satellite.
http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MODAL2_M_AER_RA

Sea Surface Salinity



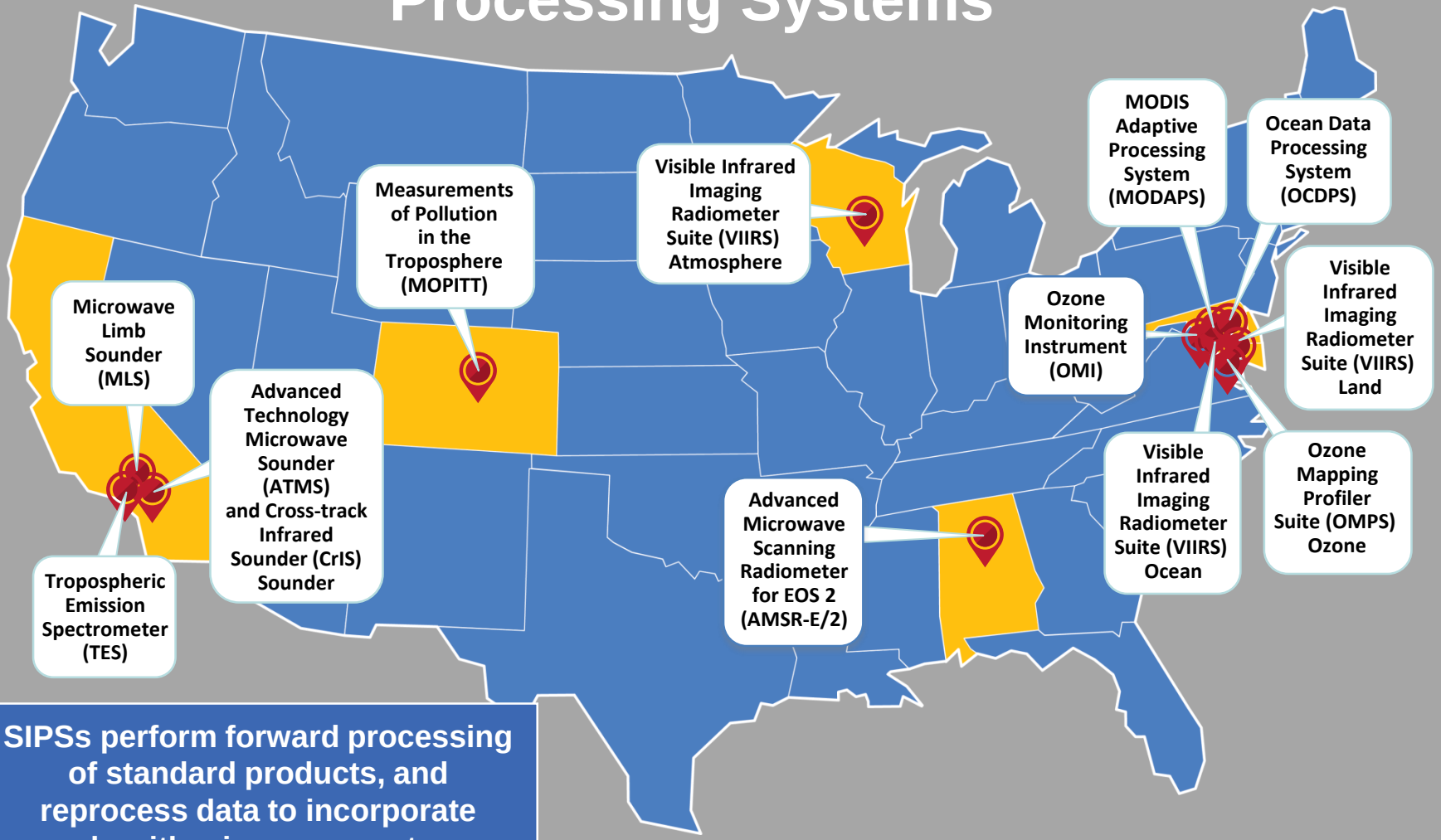
This image of Aquarius sea surface salinity (SSS) measurements averaged for 2012 shows a global color scale of salinity intensity. Warm colors mark stronger salinity values. Values are shown in a range between 30 grams per kilogram (purple) and 40 grams per kilogram (red). (Courtesy N. Kuring/NASA) –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

Distributed Active Archive Centers (DAACs)



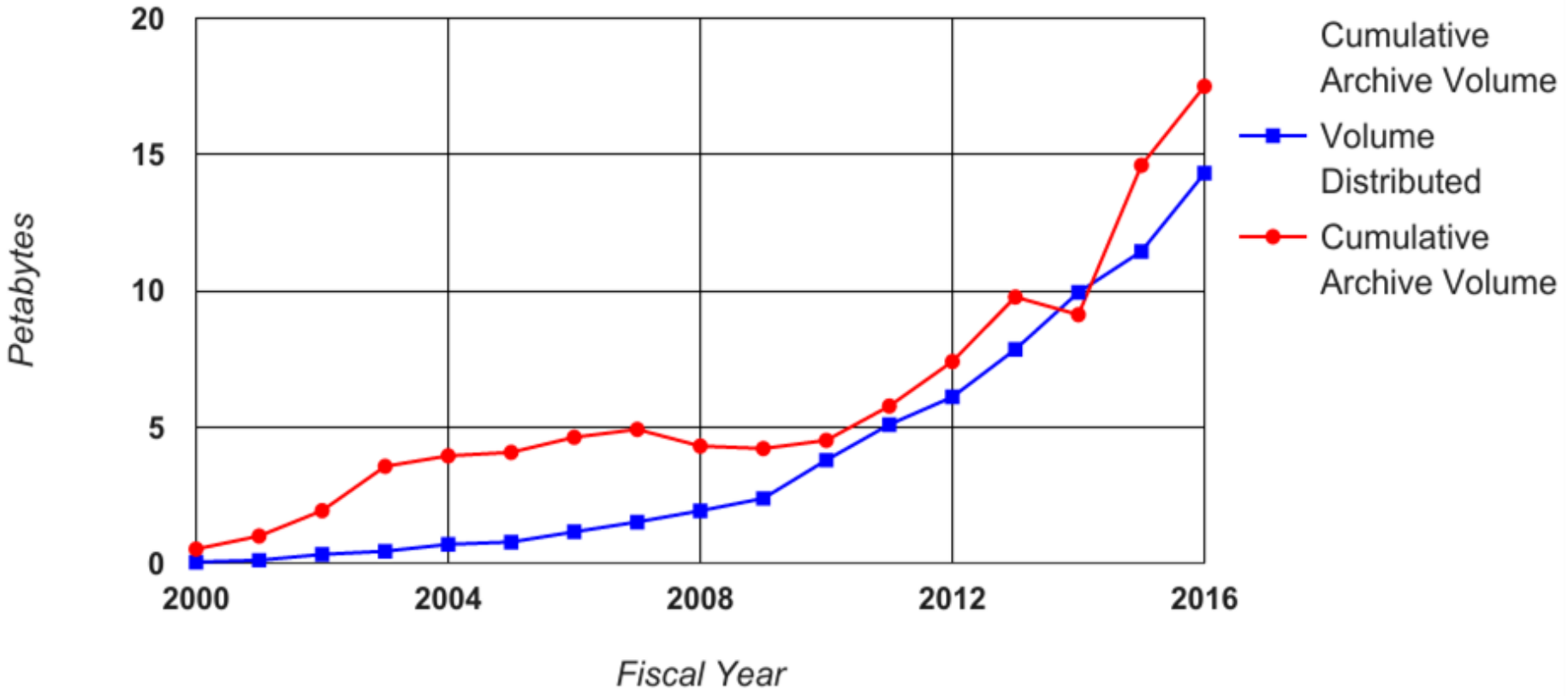
National Aeronautics and Space Administration

Science Investigator-led Processing Systems

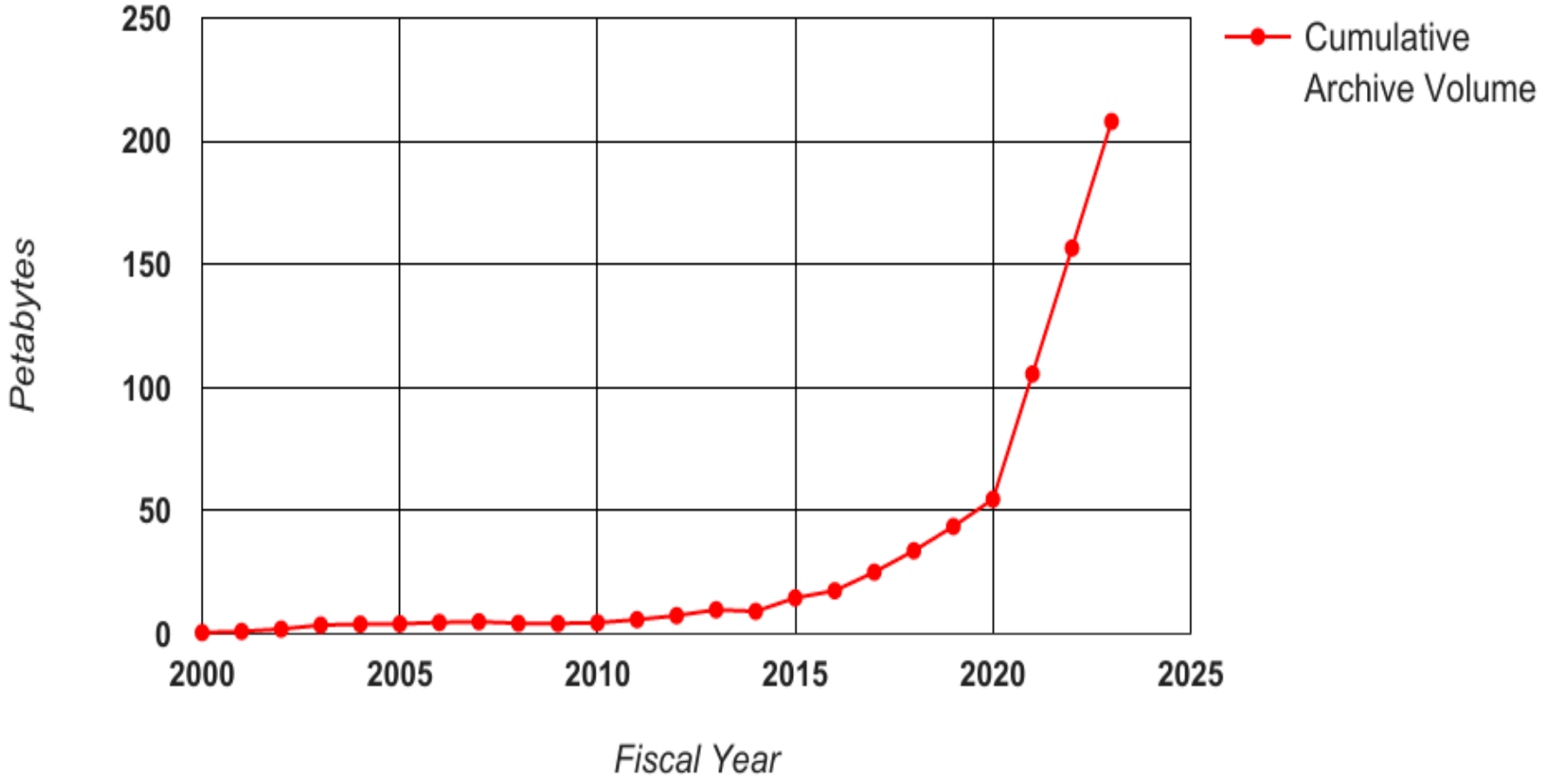


SIPSs perform forward processing of standard products, and reprocess data to incorporate algorithm improvements.

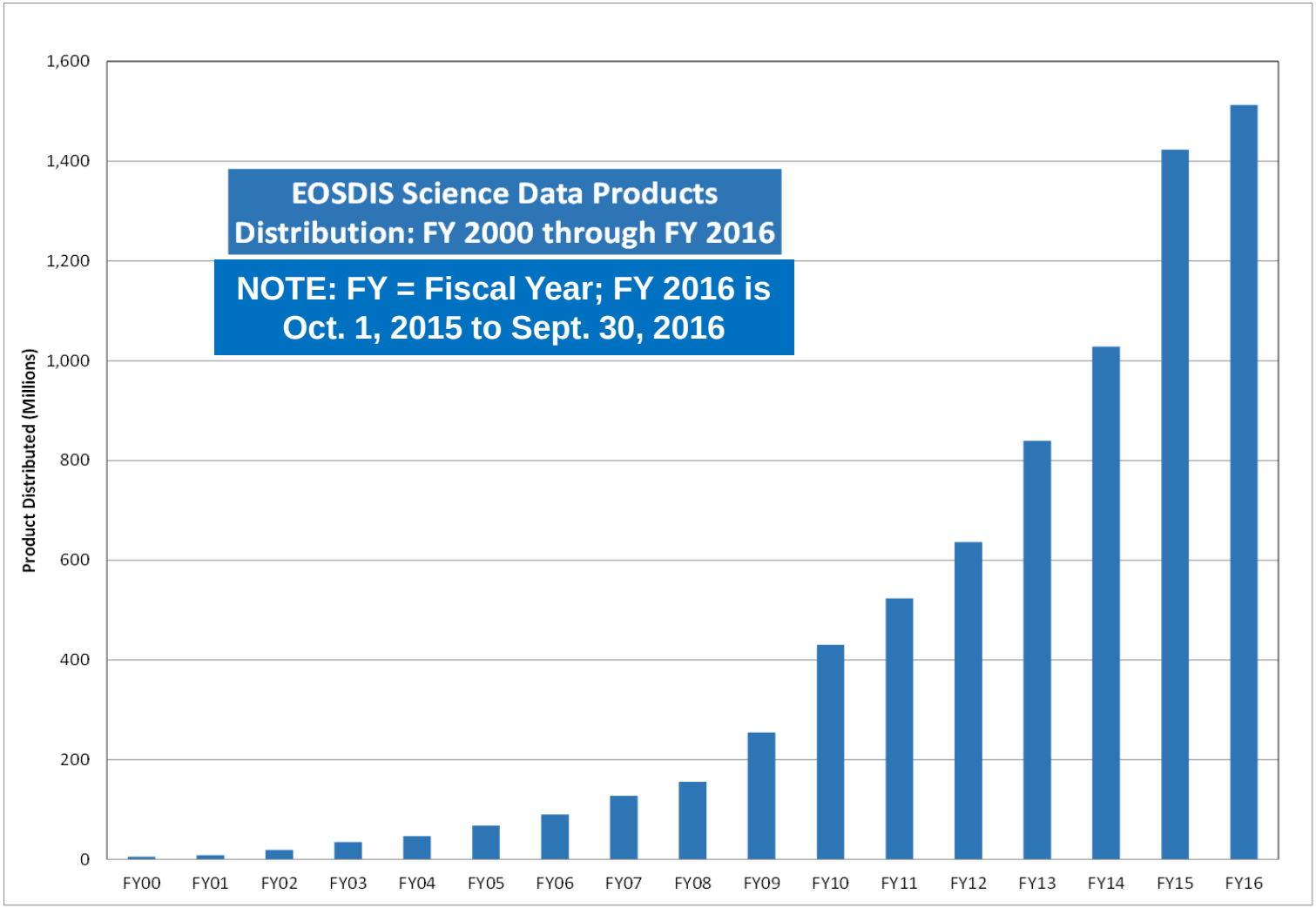
Large & Growing Archive & Distribution Volumes



Future Archive Growth



EOSDIS Product files Delivered: FY2000 thru FY2016



Recent and On-Going Developments (1 of 2)

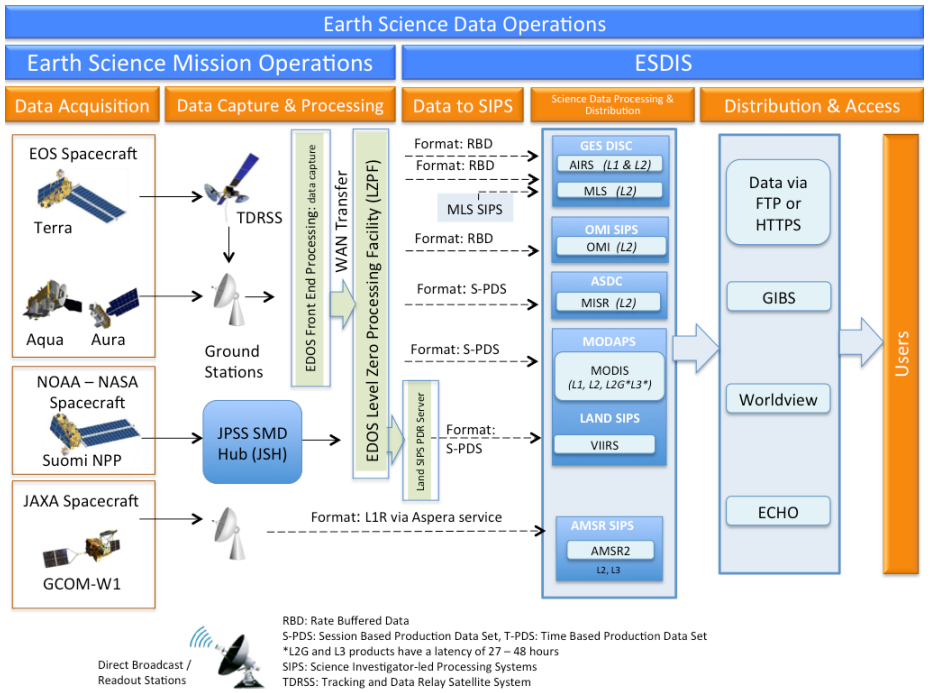
- **Land and Atmosphere Near real-time Capability for EOS (LANCE)**
- **Coherent Web Interface: http://earthdata.nasa.gov is operational**
  - **Provides a unified view of NASA Earth science data system resources**
  - **Consolidates 14 web sites, and provides links to various ways to access data and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

Recent and On-Going Developments (2 of 2)

- **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

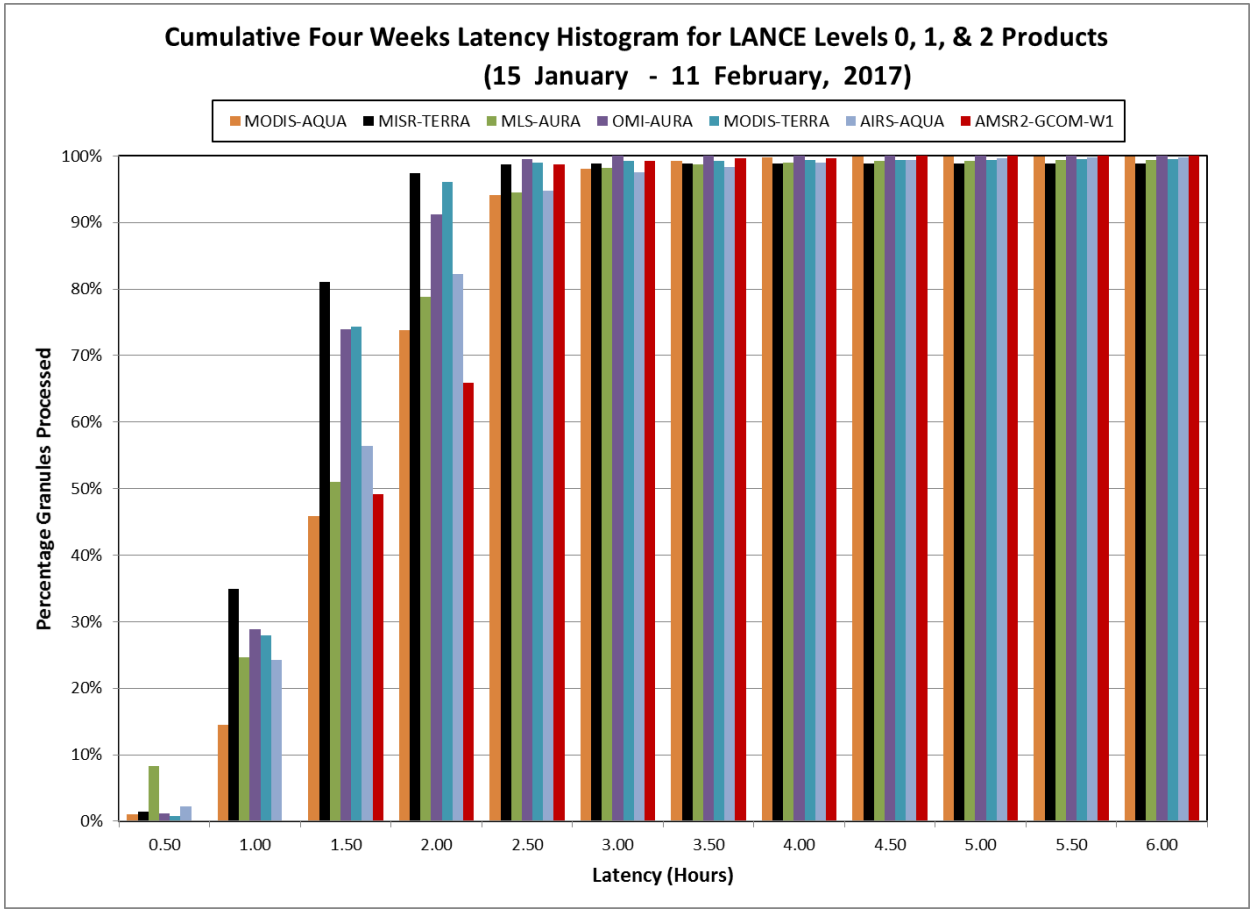
Land, Atmosphere Near-real-time Capability for EOS (LANCE)

- **Building on existing EOSDIS elements provides data from AIRS, AMSR, MISR, MLS, MODIS, 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**



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.

EOSDIS Evolution: 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:**
  - Better 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
  - Provides a platform for demonstration of interoperability throughout all of our systems.

EOSDIS Evolution: 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

Open-Access Servers

– **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

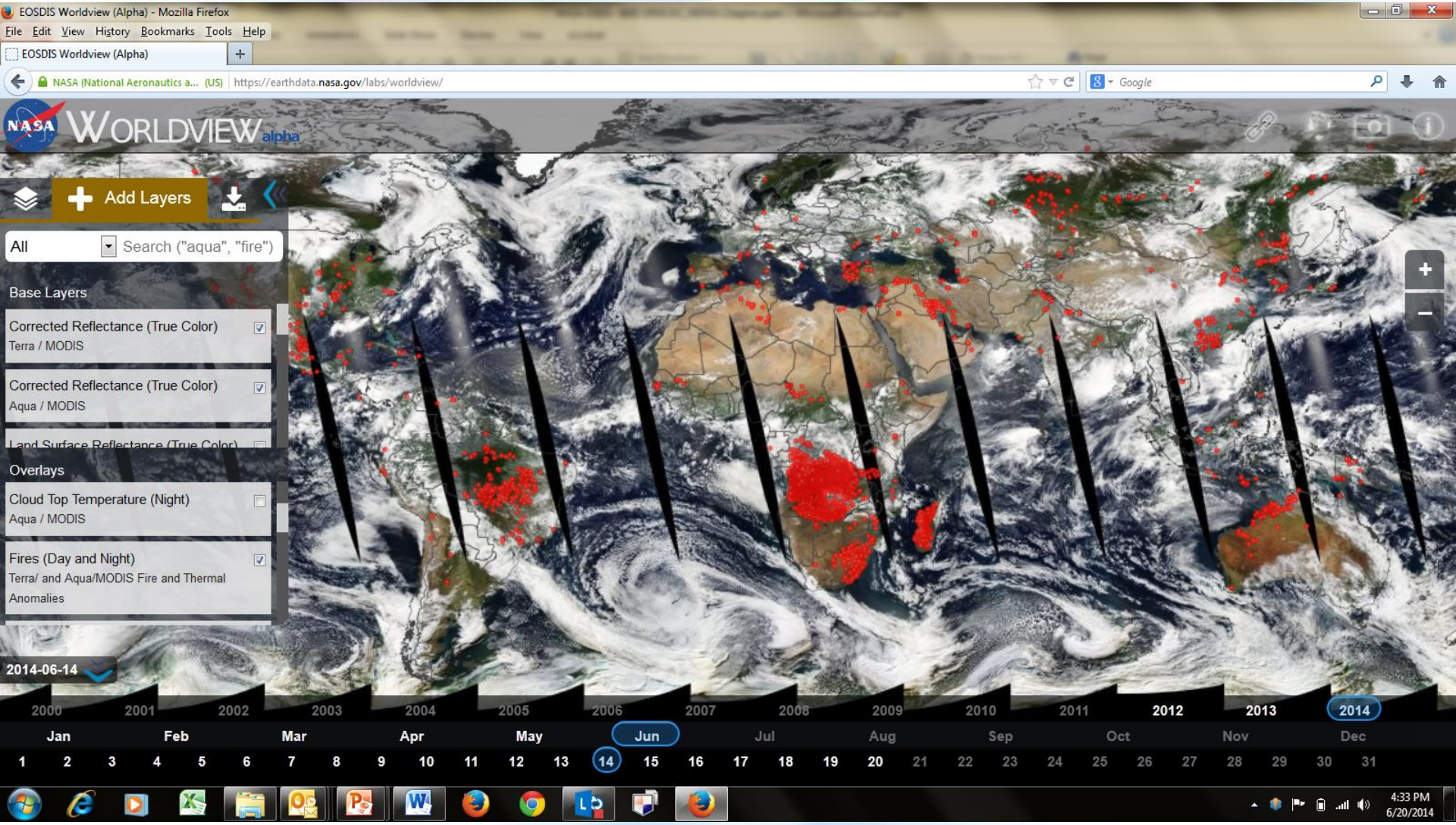
Client

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



Data Tools

- Search and Order Tools (45)
- Data Handling (Read/Ingest, Format Conversion, Data Manipulation) (31)
- Subsetting and Filtering Tools (Temporal, Spatial, Parameter, Channel) (34)
- Geolocation, Reprojection, and Mapping Tools (28)
- Data Visualization & Analysis Tools (31)

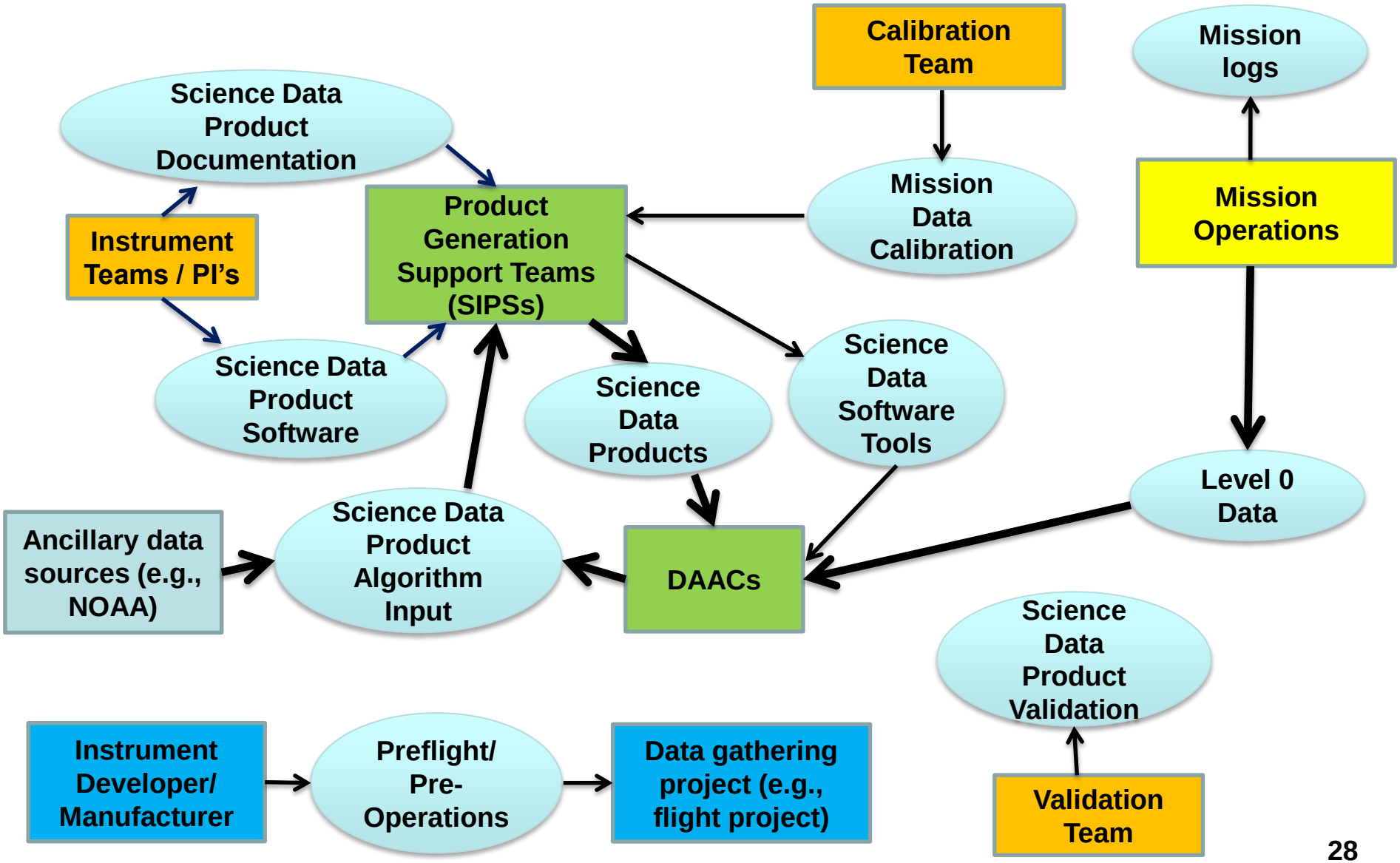
Preserving NASA Earth Science Data

Categories of Content to be Preserved

NASA's Preservation Content Specification for Earth Science Data

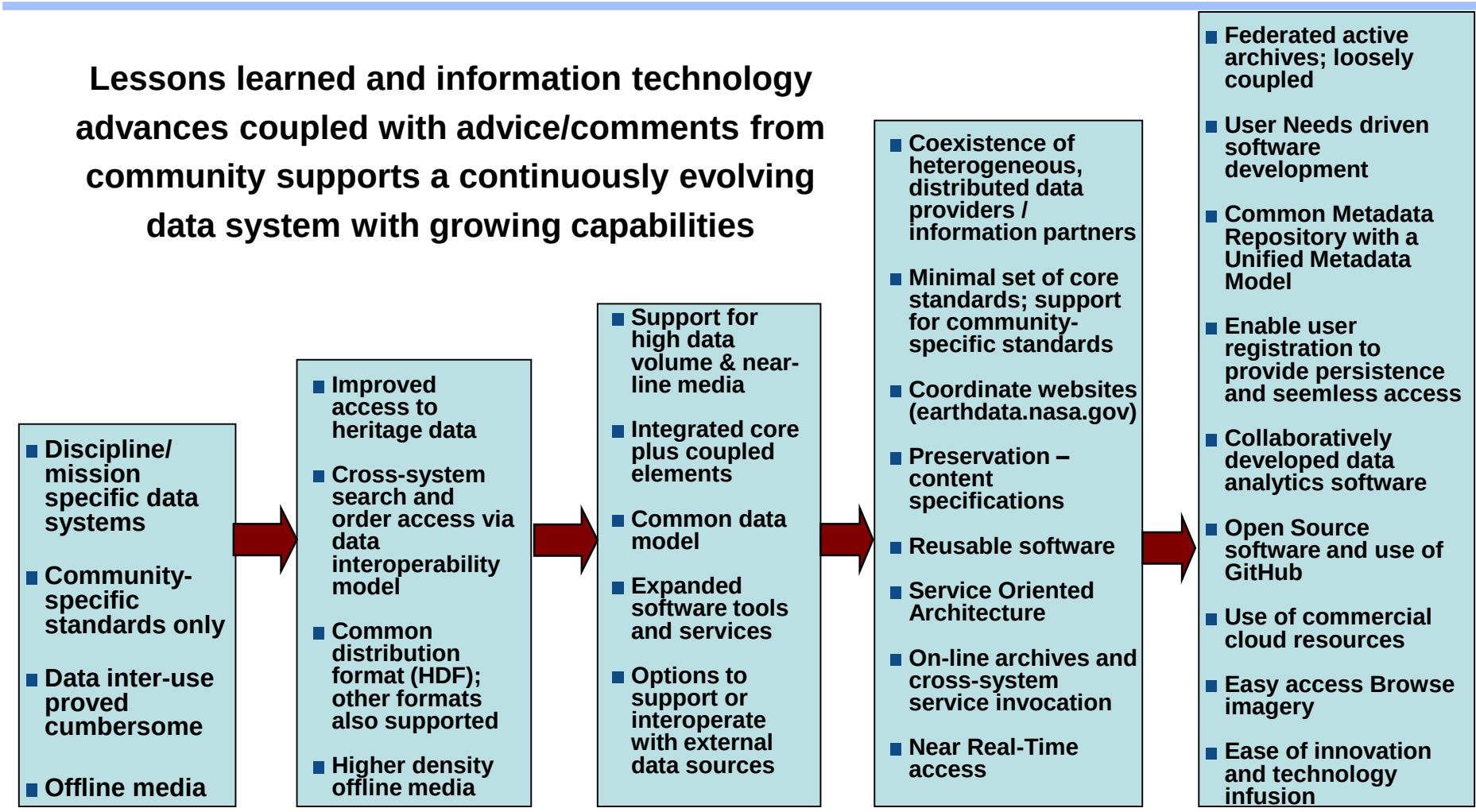
1. **Preflight/Pre-Operations:** Instrument/Sensor characteristics including pre-flight/pre-operations performance measurements; calibration method; radiometric and spectral response; noise characteristics; detector offsets
2. **Science Data Products:** Raw instrument data, Level 0 through Level 4 data 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



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
- Documentation
- Data Management Training
- Information Quality
- Semantic Technologies
- Discovery
- Web Services
- Usability
- 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