Role and Evolution of NASA's Earth Science Data Systems

IEEE EDS/CAS Chapter – Camarillo, CA
August 19, 2015

H. K. Ramapriyan
Science Systems and Applications, Inc./ NASA GSFC ESDIS Project
Hampapuram.Ramapriyan@ssaihq.com
Acknowledgement

- This presentation is the result of my long association with the NASA Earth Science Data and Information System Project.
- It has evolved over the years with inputs from several members of the Project and has been used in various forms in many presentations.
- My present work with the ESDIS Project is supported under contract number NNG15HQ01C with NASA Goddard Space Flight Center.
Topics

- NASA’s Earth Science Data Systems
  - Core and Community Capabilities
- Earth Observing System Data and Information System (EOSDIS)
  - Scope and Context
  - System of systems
- Recent Developments
- EOSDIS Evolution - Community inputs
- IEEE GRSS Earth Science Informatics Technical Committee and 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 directly support 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.

- 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 and Community Capabilities

Core Capabilities

- Basic operational capabilities to process, archive, manage and distribute data from NASA missions
  - Earth Observing System Data and Information System (EOSDIS)
  - Precipitation Processing System – NASA GSFC
  - Laboratory for Atmospheric and Space Physics (LASP) Interactive Solar Irradiance Data Center - University of Colorado
  - CloudSat Data Processing Center – Colorado State University

Community Capabilities

- 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)
EOSDIS

- Major core capability in NASA’s Earth Science Data Systems Program.
- 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
Extensive Data Collection

> 8200 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

- **Human Dimensions**
  - Population & Land Use
  - Human & Environmental Health
  - Ecosystems
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 May 15, globally. Credits - Image made by Reto Stockli, NASA's Earth Observatory Team, using data provided by the MODIS Land Science Team
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
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.
National Aeronautics and Space Administration

Earth Science Data Operations

**Mission Operations**

- Data Acquisition
  - Flight Operations, Data Capture, Initial Processing, Backup Archive

**Science Operations**

- Data Transport to Data Centers/SIPSs
  - Science Data Processing, Data Management, Interoperable Data Archive, and Distribution

**Distribution and Data Access**

- Research
- Education
- Value-Added Providers
- Interagency Data Centers
- Earth System Models
- International Partners
- Decision Support Systems

**EOSSpacecraft**

- Tracking and Data Relay Satellite (TDRS)
- White Sands Complex (WSC)
- EOS Polar Ground Stations
- EOS Data Operations System (EDOS) Data Processing
- EOS Operations Center (EOC) Mission Control

**NASA Integrated Services Network (NISN) Mission Services**

**Internet**

- (Search, Order, Distribution)

**EOSDIS Sci. Data Centers**

- Instrument Teams and Science Investigator-led Processing Systems (SIPSs)

**Direct Broadcast (DB)**

- Direct Broadcast/Readout Stations

www.nasa.gov
**EOSDIS – A System of Systems**

- **Instrument and science expertise needed to process data**
  - Most EOS standard products are generated at Science Investigator-led Processing Systems (SIPSSs) under supervision of PIs

- **Earth Science discipline knowledge needed to ensure data stewardship**
  - Processed data are archived and distributed by discipline-specialized EOSDIS Science Data Centers (Distributed Active Archive Centers – DAACs)

- **Expertise in system interoperability needed to provide cross-system (interdisciplinary) data access**
  - EOS Clearing House (ECHO) middleware and associated clients provide search and access to data across all EOSDIS Science Data Centers

- **EOSDIS data collections are diverse:**
  - Primary sources are instruments on-board NASA spacecraft
  - Ancillary, airborne, in-situ and socio-economic data
  - Data from international partners
  - Comprehensive approach to multi-discipline science
  - Feed growing need by models (e.g., climate models)
Data centers, collocated with centers of science discipline expertise, archive and distribute standard data products produced by Science Investigator-led Processing Systems (SIPSs).
### EOSDIS FY2014 Metrics
(Oct. 1, 2013 to Sept. 30, 2014)

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unique Data Sets</td>
<td>8,292</td>
</tr>
<tr>
<td>Distinct Users of EOSDIS Data and Services</td>
<td>2.0 M</td>
</tr>
<tr>
<td>Web Site Visits</td>
<td>2.3 M</td>
</tr>
<tr>
<td>Average Archive Growth</td>
<td>6.4 TB/day</td>
</tr>
<tr>
<td>Total Archive Volume</td>
<td>9.1 PB</td>
</tr>
<tr>
<td>End User Distribution Products</td>
<td>1,028 M</td>
</tr>
<tr>
<td>End User Average Distribution Volume</td>
<td>27.9 TB/day</td>
</tr>
</tbody>
</table>

#### Distribution by Discipline
Product Counts (M)
(Oct 2013 - Sep 2014)

- Atmosphere: 291.8
- Geodesy/Solid Earth: 145.2
- Land: 142.9
- Hydrology: 130.7
- Other: 92.0
- Ocean: 88.3
- Terrestrial Ecology: 61.0
- Radiance/Geolocation: 55.1
- Raw Data: 21.7
- Other: 92.0
- Distribution by Discipline Product Counts (M)

#### Multi-year Total Archive Volume (PBs) Trend

- EOSDIS Science Data Volume Progression

#### Multi-Year Product Distribution Trend

- EOSDIS Science Data Products Distribution FY00 through FY14
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](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 – uniform approach to registration across EOSDIS components
- Global Imagery Browse Services (GIBS)
  - Standards-based, full resolution, interactive browse capability
  - Accessible from [http://earthdata.nasa.gov](http://earthdata.nasa.gov) wiki
Recent and On-Going Developments (2 of 2)

- **Metadata Architecture Study**
  - Initial Study made recommendations on adopting a common approach to metadata to improve user experience and reduce efforts by data providers
  - Phased approach to implementing recommendations

- **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 assignments to datasets in progress
• Building on existing EOSDIS elements provides data from MODIS, OMI, AIRS, MLS, and AMSR 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
  – Homeland Security
Over the four weeks indicated above, >97% of near real-time data requests were satisfied within 3 hours.
What is the Earthdata Website?

- Earthdata was created as a sustainable, evolvable, and reliable Website that represents our community’s needs for NASA Earth science data and information.
- It was designed to support collaboration within and between organizations, and for development and integration of new applications.
- It addresses the need for a 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 more clearly as elements within a larger system of systems.
- Facilitates multidisciplinary research and data integration.
- More quickly responds to emerging technologies
- Provides a platform for demonstration of interoperability throughout all of our systems.
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
Global Image Browse Service (GIBS)

- Goal: “Parameter Visualizations” for all EOSDIS Imagery
- 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
EOSDIS Advisory Panel – aka Data Panel (early to mid-1990’s)
- adhere to a flexible, distributed, portable, evolutionary design;
- distribute data products by appropriate high-bandwidth communication or other media;
- operate prototypes in a changing experimental environment
  ➔ Distributed architecture with DAACs
  ➔ Version 0 working prototype

NRC Review (1995)
- “Responsibility for product generation and publication and for user services should be transferred to a federation of partners selected through a competitive process open to all”
  ➔ Working Prototype Earth Science Information Partners (ESIP) Federation
**EOSDIS Evolution - Community Inputs**

- **EOSDIS Review Group (1997)**
  - Recommended “an adaptive approach which will be less centralized, giving more responsibility to the PIs”
    -> Science Investigator-led Processing System (SIPSs)

  - Six recommendations
    - Clearly define components
    - Employ Infrastructure providing NASA-private sector liaisons
    - Employ competitive processes to select components
    - Empower science investigators for data system development, processing archiving and distribution
    - Apply lessons learned from WP-ESIP Federation
    - Charter transition team

  -> Core and Community Data Systems (Core: EOSDIS with DAACs; Community: REASoN projects -> ACCESS & MEaSUREs)

  -> ESIP Federation

Evolution of EOSDIS Elements Study Team/ Technical Team (2005)

- Developed “EOSDIS 2015 Vision”
  - First step implementation during 2006-2008 – reallocated functions, simplified system, increased automation, improved services, reduced operations costs
  - Vision tenets continue to be used as a checklist to assess progress of on-going improvements

- DAAC User Working Groups (on-going)

- American Customer Satisfaction Index Surveys (annual)
Earth Science Data System Working Groups (ongoing)

- focus on exploration and development of recommendations derived from pertinent community insights
- organized around key technology and information system issues
- Members from ACCESS, MEaSUREs, DAACs, ESDIS
- 2014-2015 Working Groups

- Airborne Data
- ASCII for Science Data
- Cloud Computing
- Data-Intensive Architecture
- Data Preservation Practices
- Data Quality
- Data Recipes
- Dataset Interoperability

- Digital Object Identifiers
- Geospatial
- Innovations Lab
- Open Source
- Provenance for Earth Science (PROV-ES)
- Technology Infusion
- Vision 2020
- Visualization
<table>
<thead>
<tr>
<th>ESDSWG</th>
<th>Earth Science Informatics Technical Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Processing</strong></td>
<td>• Cloud Computing</td>
</tr>
<tr>
<td></td>
<td>• Data-Intensive Architectures</td>
</tr>
<tr>
<td></td>
<td>• Earth system modeling tools</td>
</tr>
<tr>
<td><strong>Archiving/Stewardship</strong></td>
<td>• Data Preservation Practices</td>
</tr>
<tr>
<td></td>
<td>• Data Quality</td>
</tr>
<tr>
<td></td>
<td>• Digital Object Identifiers</td>
</tr>
<tr>
<td></td>
<td>• PROV-ES</td>
</tr>
<tr>
<td><strong>Access</strong></td>
<td>• Recipes</td>
</tr>
<tr>
<td></td>
<td>• Dataset Interoperability</td>
</tr>
<tr>
<td></td>
<td>• Visualization</td>
</tr>
<tr>
<td></td>
<td>• Geospatial</td>
</tr>
<tr>
<td></td>
<td>• Geospatial</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Evolution/Technology</strong></td>
<td>• Innovations Lab</td>
</tr>
<tr>
<td></td>
<td>• Open Source</td>
</tr>
<tr>
<td></td>
<td>• Technology Infusion</td>
</tr>
<tr>
<td></td>
<td>• Vision 2020</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>• Airborne Data</td>
</tr>
<tr>
<td></td>
<td>• ASCII for Science Data</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Vision 2020

#### Discovery and Access
- **Machine Level Discovery and Access** for all data.
- **Seamless Cross-agency Discovery**.
- **Dataset Selection Guidance** based on fitness for purpose.
- **Metadata Naming Conventions** for Variables, Platforms, Instruments, Resolution…
- **Virtual Collections** oriented around science problems.

#### Usage
- **Intelligent Tool Catalogs** suggest tools to work with the data.
- **Publications are linked** to data and tools that allow interactions with the data.
- **Automatic Mobile Data and Processing** to achieve optimal performance.
- **Quantitative Quality** for all data.
- **Reproducibility** of research results with high precision.
- **Documentation** is Concise, Comprehensive and Consistent for all data variables.
- **Capacity Building** mechanisms for people with limited literacy in science, technology, and/or English.
- **Data Analysis at Scale** over any arbitrarily defined area.
- **Dataset Upgrading** for high-value datasets to fully support rich capabilities.

#### Integration
- **NASA data can be combined** with data from other agencies and nations.
- **Combining Tools and Services** within the community is easy.
- **Enable sharing** of any scientific resource.
Common Metadata Repository (CMR)

Goals
- Designed to improve the discovery and access of NASA data, CMR will provide a single source of unified, high-quality, and reliable Earth Science metadata while merging the inventories of ECHO (EOS Clearing House) and GCMD (Global Change Master Directory) / IDN (International Directory Network). CMR will be the authoritative management system for all metadata of EOSDIS data holdings.
- CMR also provides a metadata model that documents vital elements that may be represented across various metadata formats and standards and unify them through core fields useful for data discovery and service invocations.

Current Status
- By the end of CY 2015, CMR will have released the minimal set of functionality that addresses the major goals laid out in a CMR Operations Concept including, sub-second search response, unification of ECHO and GCMD/IDN metadata, enhanced metadata management capabilities, and a unified (and expandable) metadata model representing collections, granules, and services.

Next Steps
- In 2016, CMR will begin to implement enhancements to quality assessment and assurance, search relevancy ranking, science keyword support and ontology and service initiation and chaining.
Background:

- In 2013, the White House Office of Science and Technology Policy (OSTP) kicked off the Big Earth Data Initiative (BEDI) as a multi-agency (NASA, NOAA, USGS) effort to make the collection of Earth Observation (EO) data more readily available and useful to users.
- The data directly supports 12 Societal Benefit Areas (SBAs).
- Funding provided to NASA FY14, FY15

BEDI Objectives:

- Discovery – Make finding of datasets simpler
- Accessibility - Make datasets readily available to users
- Usability – Provide services to use datasets

Task objectives for EOSDIS DAACs:

- Provide metadata to EOSDIS Common Metadata Repository (CMR)
- Maintain persistent identifiers for data collections via Digital Object Identifiers (DOIs)
- Make data available online via OPeNDAP or some other useful service
- Make imagery available in Worldview via GIBS
- Report metrics
NASA is not a “permanent archive” agency
- Must maintain “research archive” for as long as data are used for scientific research and/or transition responsibility to permanent archives
- Research archive responsibilities persist well beyond lives of missions
- NASA works with USGS and NARA for long-term preservation
- NASA has to ensure data and other critical items are preserved and made available to permanent archival agencies

General requirements
- No loss of bits
- Discoverability and accessibility
- Readability
- Understandability
- Usability
- Reproducibility of results

NASA has developed Preservation Content Specifications for Earth Science Data

NASA is participating in Earth Science Information Partners (ESIP) Data Stewardship Committee, on an “emerging” Provenance and Context Content Standard
Categories of Content to be Preserved

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.
Success of EOSDIS has been based on its ability to meet and adapt to needs of diverse Earth science communities

- >20 years of diverse science data centers’ operation to meet the needs of a growing user community
- >16 years of support for EOS missions (starting with TRMM)
- Working with new missions (e.g., EVS-1 aircraft investigations, EV-2 missions, SMAP, ICESat-2, OCO-2)

Some key areas in which improvements are required and incremental progress is being made:

- Ease of discovery and access
- Cross-organizational interoperability
- Data inter-use
- Ease of collaboration
- Ease of citation of datasets
- Preservation of provenance and context and making them conveniently available to users
BACK-UP
EOSDIS ACSI Customer Satisfaction Survey 2014: Relative Rankings

- EOSDIS sponsors an annual independent customer survey in conjunction with the American Customer Satisfaction Index (ACSI)
- EOSDIS consistently exceeds the Federal Government average
- Ratings in the mid to upper 70s are considered “very good” by the rating organization, the CFI Group
- 2014 Survey results based on 4,147 responses
- Comments in surveys help define system improvements
Lessons learned and information technology advances coupled with advice/comments from community supports a continuously evolving data system with growing capabilities.

- **<1990**
  - Discipline/mission specific data systems
  - Community-specific standards only
  - Data inter-use proved cumbersome

- **Mid-1990s**
  - Improved access to heritage data
  - Cross-system search and order access via data interoperability model
  - Common distribution format (HDF); other formats also supported

- **Late 90s +**
  - Support for high data volumes
  - Integrated core plus coupled elements
  - Common data model
  - Expanded software tools and services
  - Options to support or interoperate with external data sources

- **Past decade to near future**
  - Coexistence of heterogeneous, distributed data providers/information partners
  - Minimal set of core standards; support for community-specific standards
  - Preservation – content specifications
  - Reusable software
  - Service Oriented Architecture
  - On-line archives and cross-system service invocation
  - Near Real-Time access
  - Ease of innovation and technology infusion
  - Coherent Web – earthdata.nasa.gov
  - Common Metadata Repository
  - User Registration System
  - Full-Resolution, fast, image browse
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACSI</td>
<td>American Customer Satisfaction Index</td>
</tr>
<tr>
<td>ACRIM</td>
<td>Active Cavity Radiometer Irradiance Monitor</td>
</tr>
<tr>
<td>ARS</td>
<td>Atmospheric Infrared Sounder</td>
</tr>
<tr>
<td>AMSR-E</td>
<td>Advanced Microwave Scanning for EOS</td>
</tr>
<tr>
<td>API</td>
<td>Application programming interface</td>
</tr>
<tr>
<td>ASTER</td>
<td>Advanced Spaceborne Thermal Emission and Reflection Radiometer</td>
</tr>
<tr>
<td>ASDC</td>
<td>Atmospheric Sciences Data Center</td>
</tr>
<tr>
<td>ASF</td>
<td>Alaska Satellite Facility</td>
</tr>
<tr>
<td>AMSU</td>
<td>Advanced Microwave Sounding Unit</td>
</tr>
<tr>
<td>CALIPSO</td>
<td>Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations</td>
</tr>
<tr>
<td>CDDIS</td>
<td>Crustal Dynamics Data Information System</td>
</tr>
<tr>
<td>CERES</td>
<td>Clouds and the Earth's Radiant Energy System</td>
</tr>
<tr>
<td>CEOS</td>
<td>Committee on Earth Observation Satellites</td>
</tr>
<tr>
<td>CFI</td>
<td>Claes Fornell International</td>
</tr>
<tr>
<td>DAAC</td>
<td>Distribute Active Archive Center</td>
</tr>
<tr>
<td>DISC</td>
<td>Data and Information Services Center</td>
</tr>
<tr>
<td>DISC</td>
<td>Data and Information Services Center</td>
</tr>
<tr>
<td>ECHO</td>
<td>EOS ClearingHouse</td>
</tr>
<tr>
<td>ECS</td>
<td>EOSDIS Core System</td>
</tr>
<tr>
<td>EDOS</td>
<td>EOS Data and Operations System</td>
</tr>
<tr>
<td>EOC</td>
<td>EOS Operations Center</td>
</tr>
<tr>
<td>EOS</td>
<td>Earth Observing System</td>
</tr>
<tr>
<td>EOSDIS</td>
<td>EOS Data and Information System</td>
</tr>
<tr>
<td>ESDIS</td>
<td>Earth Science Data and Information System</td>
</tr>
<tr>
<td>ESIP</td>
<td>Federation of Earth Science Information Partners</td>
</tr>
<tr>
<td>ESSI</td>
<td>Earth and Space Science Informatics</td>
</tr>
<tr>
<td>FGDC</td>
<td>Federal Geographic Data Committee</td>
</tr>
<tr>
<td>FRGP</td>
<td>Front Range GigaPOP</td>
</tr>
<tr>
<td>gbps</td>
<td>Giga bits per second</td>
</tr>
<tr>
<td>GCMD</td>
<td>Global Change Master Directory</td>
</tr>
<tr>
<td>GES</td>
<td>Goddard Earth Sciences</td>
</tr>
<tr>
<td>GHRC</td>
<td>Global Hydrology Resource Center</td>
</tr>
<tr>
<td>GLAS</td>
<td>Geoscience Laser Altimeter System</td>
</tr>
<tr>
<td>GMAO</td>
<td>Global Modeling and Assimilation Office</td>
</tr>
<tr>
<td>GMU</td>
<td>George Mason University</td>
</tr>
<tr>
<td>GRACE</td>
<td>Gravity Recovery and Climate Experiment</td>
</tr>
<tr>
<td>GSFC</td>
<td>Goddard Space Flight Center</td>
</tr>
<tr>
<td>HDF</td>
<td>Hierarchical Data Format</td>
</tr>
<tr>
<td>HIRDLS</td>
<td>High Resolution Dynamics Limb Sounder</td>
</tr>
<tr>
<td>HSB</td>
<td>Humidity Sounder for Brazil</td>
</tr>
<tr>
<td>HIRLDS</td>
<td>High Resolution Imaging Sensor</td>
</tr>
<tr>
<td>IAOGA</td>
<td>Interagency Working Group on Digital Data</td>
</tr>
<tr>
<td>IFREMS</td>
<td>Level 1 and Atmosphere Archive and Distribution System</td>
</tr>
<tr>
<td>JPL</td>
<td>Jet Propulsion Laboratory</td>
</tr>
<tr>
<td>LAADS</td>
<td>Level 1 and Atmosphere Archive and Distribution System</td>
</tr>
<tr>
<td>LIS</td>
<td>Lightning Imaging Sensor</td>
</tr>
<tr>
<td>LP DAAC</td>
<td>Land Processes DAAC</td>
</tr>
<tr>
<td>LS</td>
<td>Land, Atmosphere Near-real-time Capability for EOS</td>
</tr>
<tr>
<td>LANCE</td>
<td>Land, Atmosphere Near-real-time Capability for EOS</td>
</tr>
<tr>
<td>MLD</td>
<td>Microwave Limb Sounder</td>
</tr>
<tr>
<td>MODAPS</td>
<td>MODIS Data Processing System</td>
</tr>
<tr>
<td>MODIS</td>
<td>Moderate Resolution Imaging Spectroradiometer</td>
</tr>
<tr>
<td>MOPITT</td>
<td>Measurements of Pollution in the Troposphere</td>
</tr>
<tr>
<td>MSFC</td>
<td>Marshall Space Flight Center</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NGIX</td>
<td>Next Generation Internet Exchange</td>
</tr>
<tr>
<td>NIPR</td>
<td>Next-Generation Polar Radiation Measurements</td>
</tr>
<tr>
<td>NITRD</td>
<td>Networking and Information Technology Research and Development</td>
</tr>
<tr>
<td>NPP</td>
<td>NPOESS Preparatory Project</td>
</tr>
<tr>
<td>NPOESS</td>
<td>National Polar-orbiting Operational Environmental Satellite System</td>
</tr>
<tr>
<td>NSIDC</td>
<td>National Snow and Ice Data Center</td>
</tr>
<tr>
<td>OGC</td>
<td>Open Geospatial Consortium</td>
</tr>
<tr>
<td>OMI</td>
<td>Ozone Monitoring Instrument</td>
</tr>
<tr>
<td>ORNL</td>
<td>Oak Ridge National Laboratory</td>
</tr>
<tr>
<td>PB</td>
<td>Peta Byte</td>
</tr>
<tr>
<td>PO.DAAC</td>
<td>Physical Oceanography DAAC</td>
</tr>
<tr>
<td>RBD</td>
<td>Rate Buffered Data</td>
</tr>
<tr>
<td>SAGE</td>
<td>Stratospheric Aerosol and Gas Experiment</td>
</tr>
<tr>
<td>SAR</td>
<td>Side Aperture Radar</td>
</tr>
<tr>
<td>SEDAC</td>
<td>Socioeconomic Data and Applications Center</td>
</tr>
<tr>
<td>SIM</td>
<td>Spectral Irradiance Monitor</td>
</tr>
<tr>
<td>SIPS</td>
<td>Science Investigator-led Processing Systems</td>
</tr>
<tr>
<td>SNOW-I</td>
<td>Search 'N Order Web Interface</td>
</tr>
<tr>
<td>SOLSTICE</td>
<td>Solar Stellar Comparison Experiment</td>
</tr>
<tr>
<td>SORCE</td>
<td>Solar Radiation and Climate Experiment</td>
</tr>
<tr>
<td>SPORT</td>
<td>Short-term Prediction Research and Transition Center</td>
</tr>
<tr>
<td>TB</td>
<td>Tera Byte</td>
</tr>
<tr>
<td>TES</td>
<td>Tropospheric Emission Spectrometer</td>
</tr>
<tr>
<td>TIM</td>
<td>TRMM Microwave Imager</td>
</tr>
<tr>
<td>TRMM</td>
<td>Tropical Rainfall Measuring Mission</td>
</tr>
<tr>
<td>UMBC</td>
<td>University of Maryland, Baltimore County</td>
</tr>
<tr>
<td>USGS</td>
<td>U.S. Geological Survey</td>
</tr>
<tr>
<td>WGIA</td>
<td>Working Group on Information Systems and Services</td>
</tr>
<tr>
<td>WIST</td>
<td>Warehouse Inventory Search Tool</td>
</tr>
<tr>
<td>XPS</td>
<td>XUV Photometer System</td>
</tr>
</tbody>
</table>