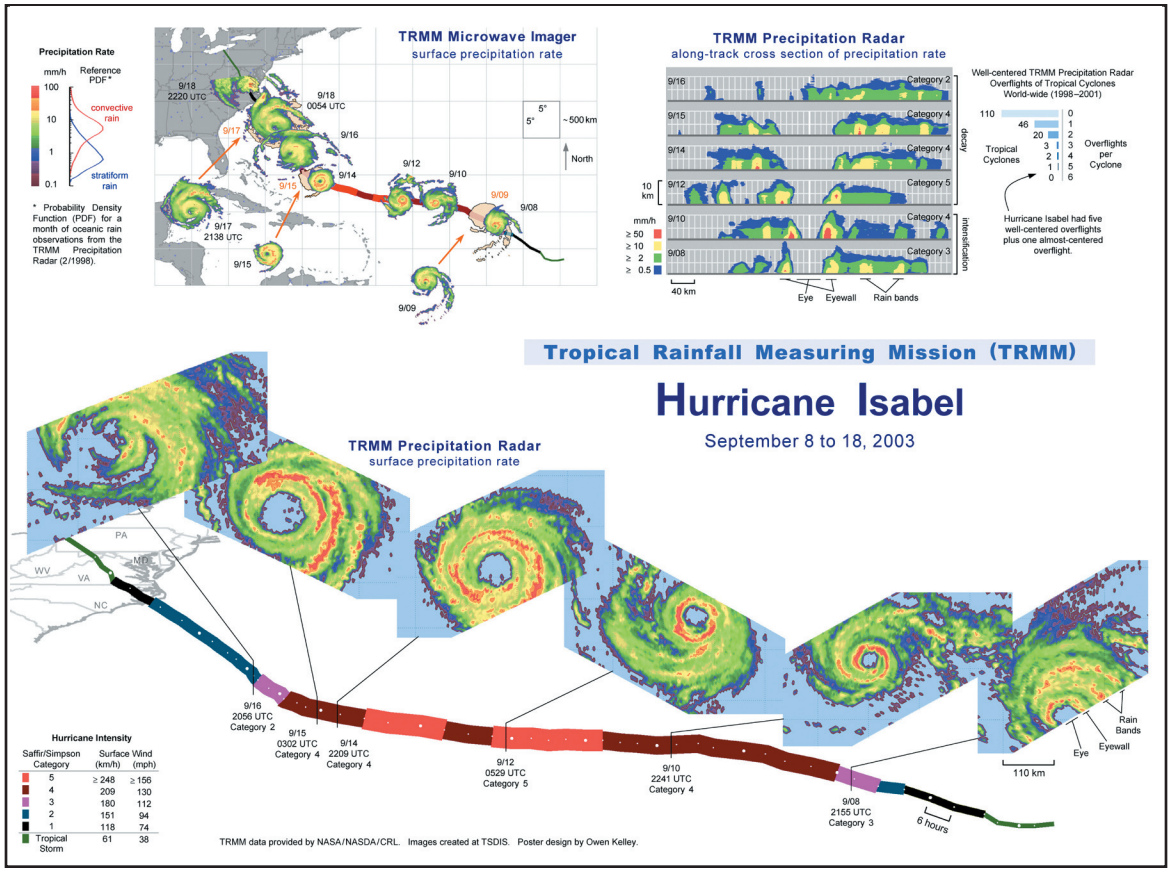
NASA/TM–2004–212753

GLOBAL CHANGE DATA CENTER

Mission, Organization, Major Activities, and 2003 Highlights

June 2004

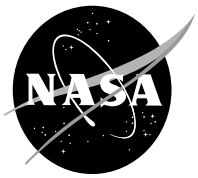


National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

The cover image shows Hurricane Isabel as it approached the Mid-Atlantic States in September 2003; the Tropical Rainfall Measuring Mission (TRMM) satellite overflew the storm an unusually large number of times in the storm's life cycle. The TRMM Precipitation Radar (PR) observed Hurricane Isabel six times, which is more times than the PR has seen with any other individual hurricane. What was especially significant was that the PR swath was effectively centered on the eye of the storm in each instance. In the future, this unique set of observations may help scientists understand how the heavy rain in a hurricane's eyewall evolves during the hurricane's lifetime. The composite image also shows the wider field of view of the TRMM Microwave Imager (TMI). The TMI collects passive microwave data that are similar to, but at a higher resolution than, the data of existing Special Sensor Microwave/Imager (SSM/I) instruments. Even after Hurricane Isabel struck the U.S. East Coast and forced the evacuation of NASA Goddard, the TRMM Science Data and Information System (TSDIS) continued to provide near-real time monitoring of the heavy rain associated with Hurricane Isabel.

NASA/TM–2004–212753



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Available from:

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Springfield, VA 22161
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1. INTRODUCTION

Rapid, efficient access to Earth sciences data from satellites and ground validation stations is fundamental to the nation's efforts to understand the effects of global environmental changes and their implications for public policy. It becomes a bigger challenge in the future when data volumes increase from current levels to terabytes per day. Demands on data storage, data access, network throughput, processing power, and database and information management are increased by orders of magnitude, while budgets remain constant and even shrink.

The Global Change Data Center's (GCDC) mission is to develop and operate data systems, generate science products, and provide archival and distribution services for Earth science data in support of the U.S. Global Change Program and NASA's Earth Sciences Enterprise. The ultimate product of the GCDC activities is access to data to support research, education, and public policy.

2. PHILOSOPHY

The GCDC is an office in the Earth Sciences Directorate of the Goddard Space Flight Center (GSFC). The GCDC encompasses the design, development, and management of data and information systems; the development of processing algorithms, the production of data products, the management of Earth science data archives; and the management of information system projects.

To carry out its mission and to meet the organizational objectives, GCDC has adopted a management strategy that builds on four major strategic parameters: quality, productivity, efficiency, and partnerships. Within this context, GCDC has adopted the following core management concepts.

Customer Driven Quality: The ultimate success of the GCDC organization depends on its ability to deliver quality products and services to a diverse user community on time and with minimum cost. All GCDC projects stress a customer focus based on an analysis of the total information system from a customer's perspective. This analysis starts with the establishment of performance-oriented requirements and ends only after delivery of a product (system, services, algorithm, data products, etc.) that satisfies the customer.

Leadership: Strong, resourceful leaders establish the direction and focus of the individual GCDC project teams. A GCDC leader is expected to be a coach, a trainer, a team builder, and a role model for the project teams. Each leader must constantly assess what to change, what to change to, and how to change so that their project achieves the quality, productivity, and efficiency measures needed for success.

Continuous Process Improvement: Most of the projects managed by GCDC are in a competitive environment where the customer has a choice and increasingly high expectations for services. Moreover, staff and budget constraints are a way of life and are unlikely to change in the foreseeable future. For these reasons, the continuous review and improvement of critical processes is vital to the efficient and effective delivery of quality products that meet the customer's needs.

Employee Participation and Development: Organizational success depends on the effective use of all the individual skills, abilities, and expertise of the limited government and contractor staff. GCDC projects are conducted in a cross-functional team environment that emphasizes individual accountability and creativity, encourages participation in the decision making process, and provides rewards based on the successful achievement of project objectives. GCDC stresses the importance of employee development through training, experience, career enrichment, and recognition.

Distributed Management: The GCDC uses the strength of its leaders and employees by providing a great deal of autonomy to each project. The responsibility and accountability for decisions is delegated to the lowest level possible. The GCDC provides an overall management framework for integrated strategic planning, budgeting, scheduling, resource allocation, and project assessment. Project leaders are responsible for achieving individual project goals within this overall framework.

Organizational Responsiveness: Responsiveness to ever changing and evolving customer requirements requires that information systems and services be flexible and adaptable and that new systems be developed rapidly. Product cycle time is an important factor in meeting customer expectation and achieving project objectives with minimum cost. GCDC uses a variety of techniques to facilitate short development cycles including rapid application development and prototyping.

Design Quality: The often conflicting demands of delivering the right products with high quality, on time, and with shrinking budgets, emphasizes the need to build it right the first time. This is accomplished by using a

team that encompass all the processes inherent in delivering an information system (design, development, test, deployment, maintenance, and operations) throughout the entire development.

Strategic Outlook: In order to effectively plan and manage its organizational resources, the GCDC must maintain a strategic perspective that anticipates evolving needs, and provides an orderly process for meeting those needs. This perspective is needed to provide a road map for the organization and a framework for decisions involving new business.

Objective Management: To ensure that management decisions are based on facts and are timely and appropriate, projects require a flow of accurate, objective information. Open communications, objective metrics, and well understood plans and schedules are critical to this process. It is important that, whenever possible, decisions be made rationally, and not in response to the crises.

Partnership Development: Partnerships with our customers are fundamental to success. The clear establishment of mutually understood requirements, the ability to meet those requirements, and the flexibility to respond to changing requirements and development problems cannot be done without close working relationships between all parties. This is particularly important in the current environment where expectations grow and budgets shrink.

Business Rules: The GCDC attempts to adhere to the following rules in conducting its day-to-day business:

- Anchor strategic planning to customer needs and organizational goals
- Anticipate and be responsive to customer needs
- Develop cost-effective systems and solutions
- Use open and extensible system architecture
- Provide value-added systems, services, and skills
- Reward leadership, innovation, creativity, and personal responsibility
- Minimize and simplify interfaces
- Emphasize flexibility, modularity, and reusability in system design
- Maximize electronic access to information and services

3. ORGANIZATION AND FACILITIES

The GCDC is organized by projects. The ongoing projects include the Global Modeling and Assimilation Office (GMAO) Computer System Group (CSG), Global Change Master Directory (GCMD), Goddard Earth Sciences Data Information Systems Center, Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Data System, and the Tropical Rainfall Measuring Mission (TRMM) Science Data and Information System (TSDIS). The Global Precipitation Mission data system is in a study phase, mainly conducted within the TSDIS Project.

There are 25 civil servants within GCDC. The composition of the GCDC Division Office and each project are as follows.

Global Change Data Center

Stephen Wharton	Chief, GCDC
Richard Kiang	Group Leader
Michelle Renaud (Code 903)	
Gary Wolford	

Earth Science Data System Working Groups

Catherine Corlan	
Kathleen Fontaine	

Global Change Master Directory

Lola Olsen	Manager
Janine Pollack	

Goddard Earth Science Data and Information Systems (ESDIS) Center

Steven Kempler (Code 586)	Manager
Gary Alcott (Code 581)	
Stephen Berrick	
Eunice Eng (Code 586)	
Gregory Leptoukh	
Christopher Lynnes	
Long Pham	
Peter Smith	
Darnell Tabb	
Bruce Vollmer	
Gail Wade	

Goddard Modeling and Assimilation Office Computer System

Gi-Kong Kim	Manager

SeaWiFS Data System

Gene Feldman	Manager, also SeaWiFS Project Manager
Norman Kuring	

TRMM Science Data and Information System

Erich Stocker	Manager
Michael McCumber	Deputy Manager
Charles Cosner, Jr.	

Aside from civil servants, the GCDC work activities are supported by a staff from George Mason University's Center for Earth Observing and Space Research and a number of supporting contractors. The majority of the GCDC personnel are located in Building 32. SeaWiFS Data System personnel are located in Building 28.

4. OUR WORK AND ITS PLACE IN NASA'S MISSION

The Global Change Data Center provides an essential interface to the scientific community and to the public through its data service, publications, presentations, Web pages, collaborations, and conferences. The data, data products, and associated services provided by the GCDC's various data systems directly support NASA's mission: to understand and protect our home planet; to explore the universe and search for life; to inspire the next generation of explorers, ...as only NASA can. We help understand and protect our home planet by providing the data and data services necessary to understanding the Earth's system and its response to natural and human-induced changes. Our computing technologies and collaborations listed later in this document help our users improve the quality of life and create a more secure world. In addition, we are helping to inspire the next generation of explorers by providing educational material to help motivate students, inspire teachers, and improve our Nation's scientific literacy.

The mission of the Earth Science Enterprise (ESE) takes a three-pronged approach. With a science strategy, an applications strategy, and a technology strategy, the ESE seeks to develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations. This approach provides data and information necessary to answer a fundamental question: How is the Earth changing and what are the consequences for life on Earth? The many examples that follow illustrate the GCDC's commitment to do data collection, processing, dissemination, and modeling as only NASA can.

5. MAJOR ACTIVITIES AND HIGHLIGHTS IN 2002

5.1 Earth Science Data System Working Groups

5.1.1 ORGANIZATION

The Earth Science Data System Working Groups (ES DSWG) stemmed from recommendations outlined in the Strategic Evolution of Earth Science Enterprise Data Systems (SEEDS) Study. The SEEDS Study examined the vital issues surrounding distributed, heterogeneous data systems, as outlined in the concept paper, "NewDISS:A 6- to 10-year Approach to Data Systems and Services for NASA's Earth Science Enterprise." To perform the study, the team identified seven major areas of interest: near-term standards, long-term standards process, data life-cycle issues, reuse and reference architectures, metrics planning and reporting, levels of service and cost modeling, and technology infusion. For each area, a study team was formed to identify the state of the Enterprise efforts in those areas, identify the future needs of the Enterprise, determine the community needs, and recommend a way forward. Over the course of roughly two years, the team held three public workshops; many, many smaller meetings and teleconferences; and countless one-on-one discussions with members of other Federal agencies, commercial organizations, universities, data providers, and other users of the ESE data systems. The result, the final recommendations, is available at http://lennier.gsfc.nasa.gov/seeds/SFormHome.html.

The working groups established as a result of the SEEDS study are now known collectively as the ES DSWG. The first set of working groups are Metrics Planning and Reporting, Technology Infusion, Reuse and Reuse Frameworks, and Standards. These four groups held a kick-off meeting in January 2004 in Orlando, Florida. Web sites have been established for all groups, and are located at http://lennier.gsfc.nasa.gov/seeds/WG/.

5.1.2 MAJOR ACTIVITIES

Each working group is currently completing its initial set of activities. These include finalizing their charters, establishing rules of operation, and identifying items of high priority to the Enterprise. When fully established, each group will prioritize its work, and then make a series of recommendations to the ESE regarding their area of expertise. Initially, each working group is composed of the winners of a recent ESE data system solicitation, as well as other interested parties. It is expected that as the working groups become more established, interest and membership will expand.

Current activities include the following four key areas:

1. Metrics Planning and Reporting
   - Finalizing a set of metrics for use by the ESE
   - Finalizing a tool for reporting those metrics by smaller data providers
   - Identifying or combining current metrics collection tools for use by larger data providers

2. Technology Infusion
   - Finalizing the process by which data system technology gaps are identified
   - Finalizing the technology drivers in use by the ESE which feed into the above process

3. Reuse and Reuse Frameworks
   - Finalizing their charter
   - Finalizing the process for identifying reuse candidates and evaluating their potential
   - Identifying such policy issues as intellectual property rights and studying their effect on reuse

4. Standards
   - Finalizing their initial set of Request for Comments (RFCs) which outline how the identification and adoption of ESE standards will work

For more information on any of the above groups or the SEEDS study, please contact Kathy Fontaine at kathy.fontaine@nasa.gov or 301-614-5582.

5.2 Global Change Master Directory

5.2.1 Mission

The mission of the GCMD is to assist the scientific community in the discovery of, and linkage to, Earth science data and related services, as well as to provide data holders a means of advertising their data to the Earth science community. The GCMD leads the search to data, offers links to data providers, and often leads directly to the data itself.

5.2.2 Science User Working Group

Representing the broad range of Earth science disciplines including life sciences, oceanography, geophysics, and atmospheric science is an active Science User Working Group (UWG). Members are chosen for their interest in NASA's directory effort, and for their understanding of the importance of high quality data management. The composition of the group for the upcoming UWG meeting in May 2004 includes Acting Chairperson, Mr. Martin Ruzek of the University Space Research Association (USRA); Dr. Walter R. Hoegy, NASA/Goddard representative from Code 910; Dr. Erick Chiang, National Science Foundation/Office of Polar Programs; Dr. Glenn Rutledge, National Oceanic and Atmospheric Association (NOAA)/National Climatic Data Center (NCDC); Dr. Benno Blumenthal, Lamont-Doherty Earth Observatory at Columbia University; Dr. Wendell Brown, University of Massachusetts-Dartmouth; Dr. Hubert Staudigel, Scripps Institution of Oceanography; Ms. Andrea Buffam from the Canadian Centre for Remote Sensing (CCRS), representing the Committee on Earth Observation Satellites' International Directory Network (CEOS IDN); and Dr. Doug Beard, United Staes Geological Service (USGS)/Biological Resources Division (BRD). The GCMD Science User Working Group works under the UWG Terms of Reference. Recommendations from previous UWG meetings have helped to guide the progress of the directory.

5.2.3 Organization

The directory is staffed by three software developers, a systems administrator, a database administrator, and four Earth science coordinators (one coordinator is supported by the USGS BRD), the contract task lead, and the project manager, Lola Olsen. The science coordinators are responsible for the data sets related to the biosphere and land surface; oceans and the hydrosphere; solid Earth and the cryosphere; solar-terrestrial interactions; spectral/engineering data; agriculture and human dimensions; the atmosphere and climate indicators; and paleoclimate. The software developers collectively hold skills in database management, programming languages such as Python, Java, Perl, and C++, user interface design, and configuration management.

5.2.4 Highlights

Following are the top five highlights for 2003 that have had the greatest positive impact on the GCMD work:

1. Improved configuration management, with expanded testing through a set-up of "sand-box" machines. Extensive test plans to complete functional end-to-end testing of all major system components on a variety of platforms were designed for quality assurance.

2. There has been recognition of the value of the "portals" by an increasing number of interested groups. Virtual subsets of the directory can be created for special events and/or for groups wishing to host a directory of only their contributions. During 2003, 11 new portals were created.

3. The addition of an "Update" option within the authoring tools, permits updates to be made quickly and easily by external participants. This important advancement provides an important key to maintaining current information in the directory.

4. There has been a 47.7% rise in content for Earth science tools and services. This created increased interest in fruitful searches and the impetus to add new content.

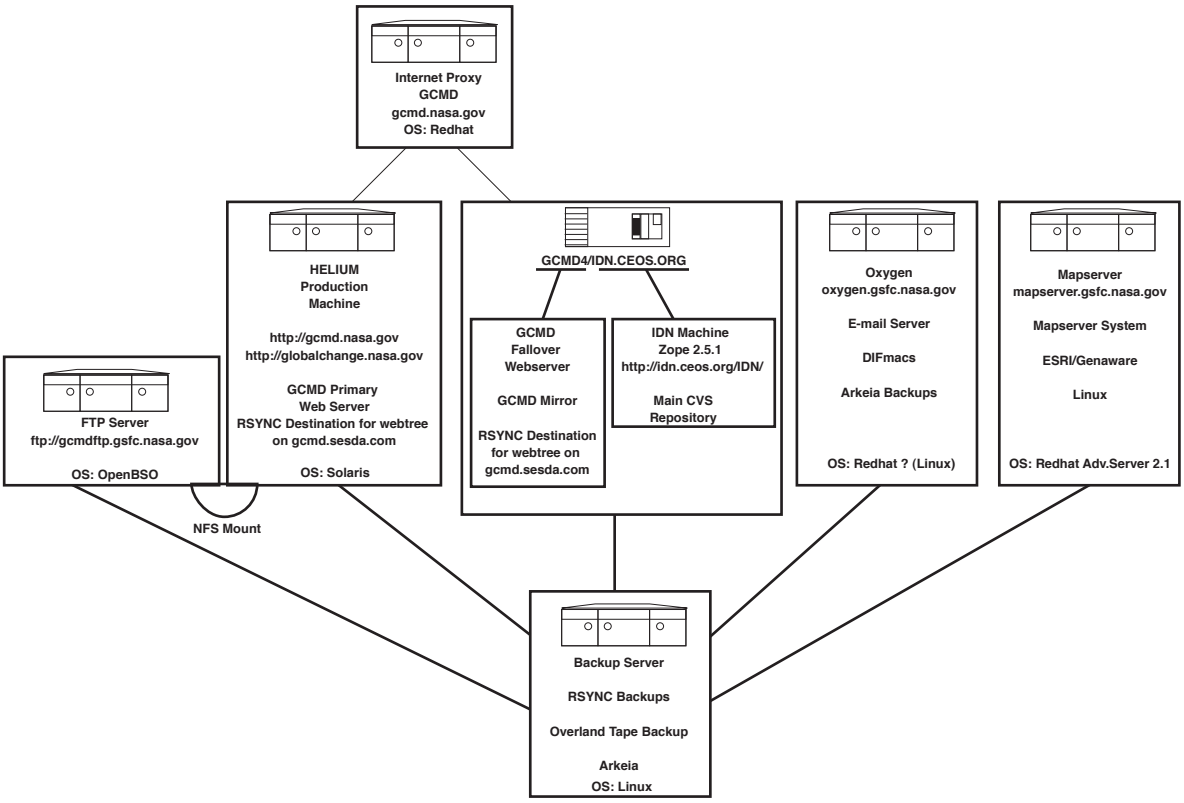
5. The addition of a new topic keyword category, "Climate Indicators," is now the most frequently searched of the 13 topics.

5.2.5 FACILITY FOR OPERATIONS AND MAINTENANCE

The GCMD facility is located at GSFC. The primary operational computing resources consist of a "proxy" computer and a backup for the proxy-accessible as http://globalchange.nasa.gov. These computers route users to one of two operational computers, so that one is always available for user access when the other needs maintenance or requires the installation of upgrades. To ease the network burden for off-site contractors, a "development platform" is available at the contractor's facility. New this year are a series of testing platforms (several acquired through Goddard's equipment "excess") to perform cross-platform testing, and quality assurance (see the following diagrams).

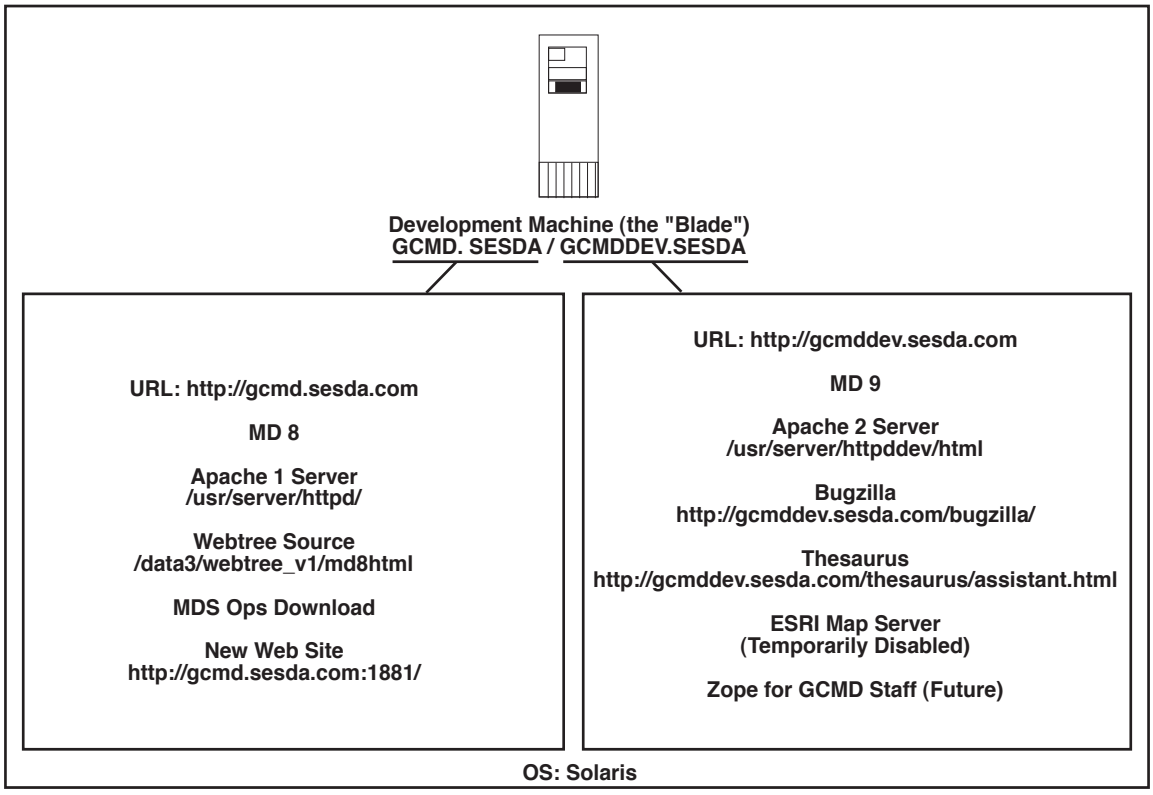
GCMD Production Servers

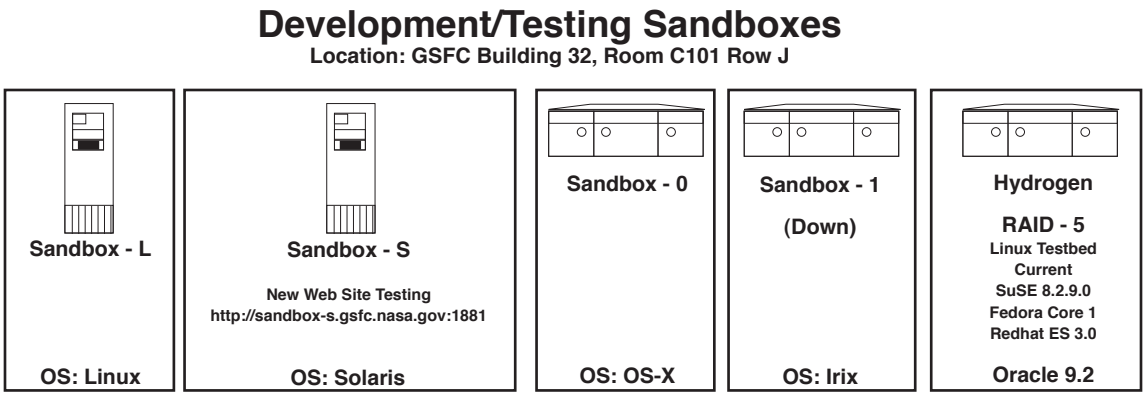
Location: GSFC Building 32, Room C101 Row N



GCMD Development Server

Location: Aerospace Building 5th floor, Room 564





5.2.6 SYSTEM DEVELOPMENT

To make electronic and information technology accessible to people with disabilities, Congress amended the Rehabilitation Act. The law is known as "508," and the GCMD's MD8 software is fully "508" compliant.

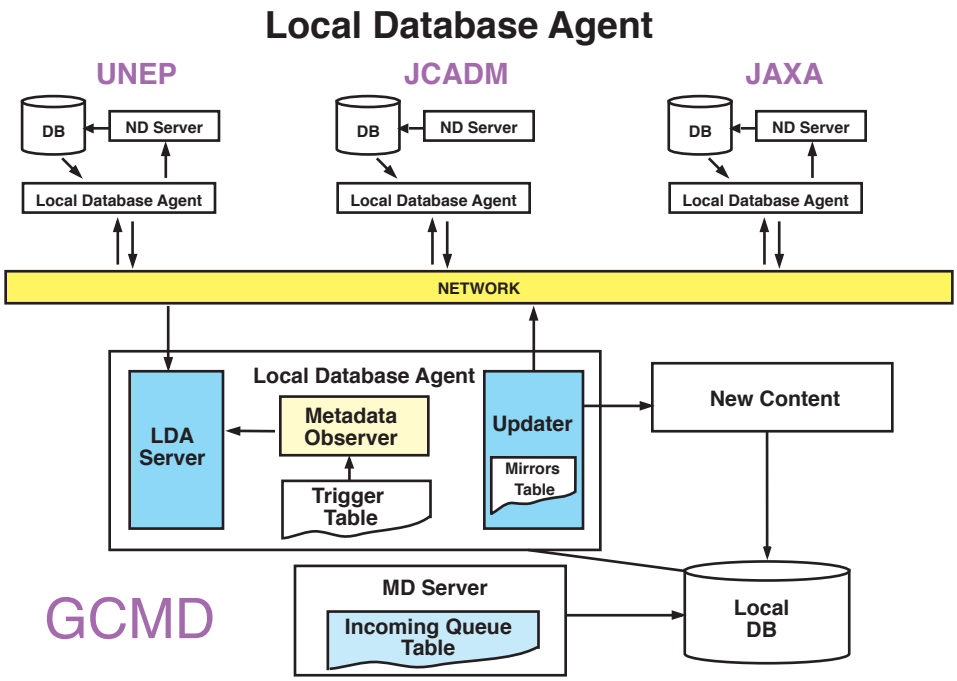
Software upgrades were integrated (transparently to the users) during the year-as the code was reconfigured "behind the scenes" into a better-organized, more reusable package in preparation for the ISO-19115 implementation. Users may note visible upgrades:

- A new capability to refine the current query to include global, global land, and global ocean data sets;
- An upgraded parent–child functionality which allows users to refine by children only, parents only, and navigate more easily between the two; and
- More direct access to data such as from the Moderate Resolution Imaging Spectroradiometer (MODIS) through links located next to the titles' display.

For the first time last year, the Operations Facility (OPS) was made available to all the science coordinators to interact directly with the database. The facility performed well in 2003. Changes were also made within the Local Database Agent (LDA) software for improved functionality of the distributed aspect of the system (see the revised diagram).

In addition, the Geospatial One-Stop was completed, permitting users to access information easily by project. This search for NASA projects (missions) was based on the development of a free-text search through the open-source search engine, Lucene (see http://gcmd.gsfc.nasa.gov/md/lucene/luceneSearch.html).

The work was done in response to OMB A-11 Guidance regarding posting information on geospatial data acquisitions and on compliance with Federal Geographic Data Committee (FGDC) standards. A-11, Section 51 Basic Justification Materials: In February 2003, agencies must post information on all geospatial data acquisitions in excess of $1M planned for FY 2004 on the FGDC Clearinghouse, characterized using the FGDC metadata standard, taking care to specify the geographic area and scale to which the data layer is proposed to be collected. Exhibit 300 Section II.A.2 Data C. If this initiative processes spatial data, identify planned investments for spatial data and demonstrate how the agency ensures compliance with FGDC standards required by OMB Circular A-16. See the Web site, http://www.geo-one-stop.gov/.

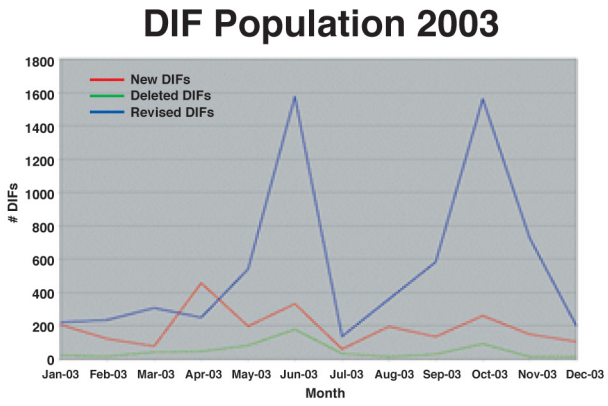


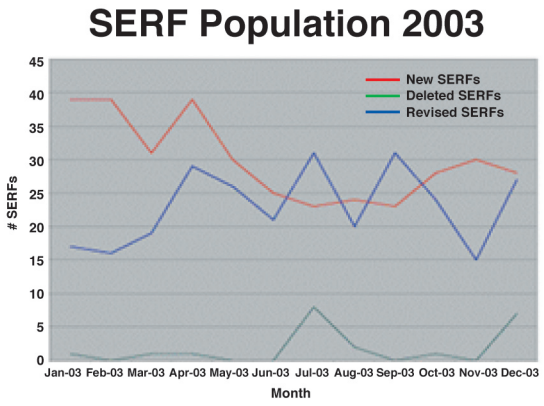
5.2.7 METRICS FOR CONTENT, USAGE, AND USER FEEDBACK AND SUPPORT

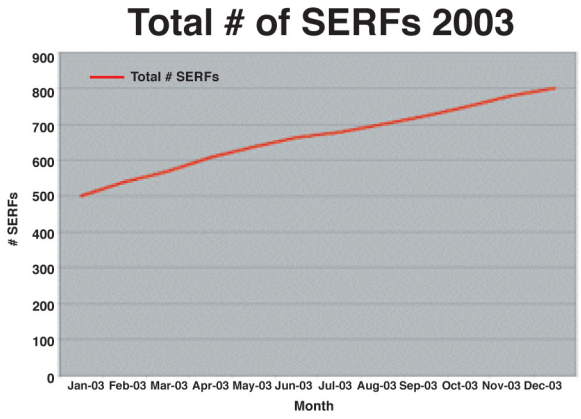
5.2.7.1 Content

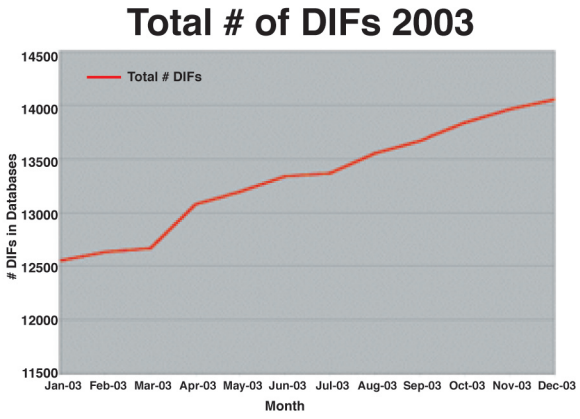
The population of the directory's data sets reached 14,049 at the end of December 2003, which is up from 12,343 the previous year. The number of new data set descriptions decreased from 2,503 in CY02, to 2293 in CY03; however, the number of revised data set descriptions increased 4.9% from 6,376 in CY02, to 6,691 in CY03. The distribution of Directory Interchange Formats (DIFs) among Earth science topics can be viewed in the chart below (where SERF is defined as the Services Entry Resource File):

GCMD Population	2002	2003	Change in 2003 Input [%]
New DIFs	2503	2293	–8.3
Revised DIFs	6375	6691	4.9
New SERFs	243	359	47.7
Revised SERFs	213	276	29.6
New Data Centers	42	333	692.8
Revised Data Centers	27	21	–22.2
New Sources	52	144	176.9
Revised Sources	12	69	475.0
New Sensors	5	519	10,280.0
Revised Sensors	23	56	143.5
New Projects	401	84	–79.0
Revised Projects	37	32	–13.5





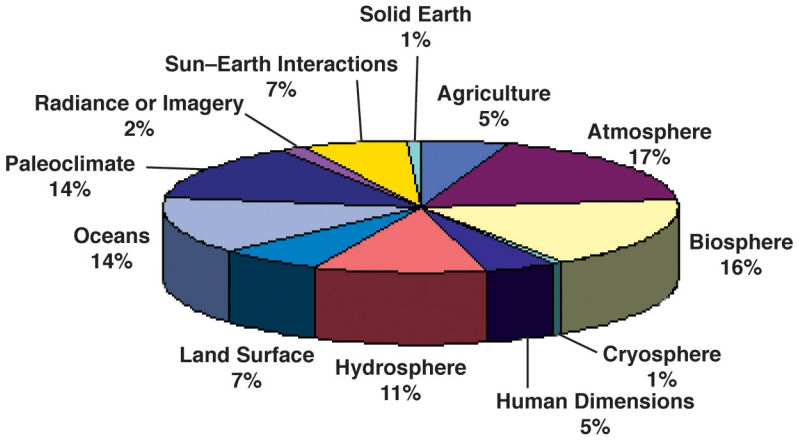




Population of DIFs by Earth Science Topic:

Topic	2002	2003	Change [%]
Agriculture	168	139	–17.3
Atmosphere	565	617	9.2
Biosphere	696	798	14.6
Climate Indicators	N/A	21	N/A
Cryosphere	336	218	–35.1
Human Dimensions	629	398	–36.7
Hydrosphere	245	332	35.5
Land Surface	722	553	–23.45
Oceans	415	702	69.1
Paleoclimate	48	93	93.7
Radiance/Imagery	255	160	–37.2
Sun–Earth Interactions	6	13	116.7
Solid Earth	340	322	–5.3

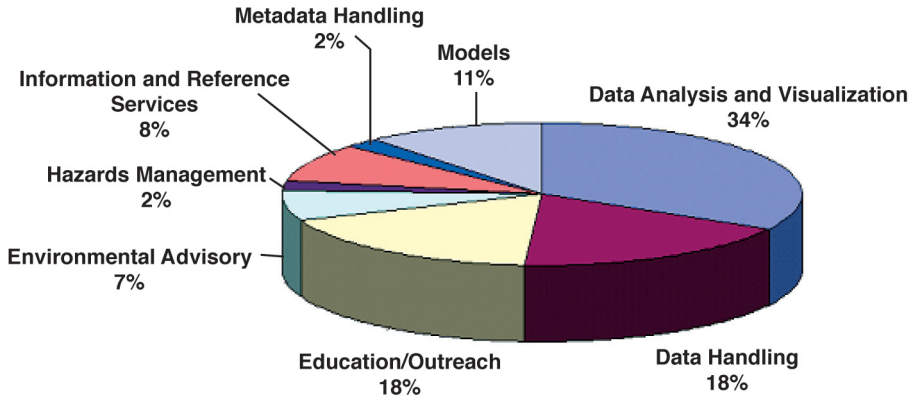
GCMD Population by Topic 2003



Population of SERFs by Earth Science Service Topic:

Topic	2002	2003	Change [%]
Data Analysis and Visualization	199	374	87.94
Data Handling	114	206	80.70
Education/Outreach	139	199	43.17
Environmental Advisory	46	78	69.57
Hazards Management	11	28	154.55
Information and Reference Services	51	96	88.24
Metadata Handling	7	25	257.14
Models	51	126	147.06

GCMD Service Population by Topic 2003



The GCMD continues to offer a variety of metadata authoring tools for the creation and modification of DIFs and SERFs. The DIF writing tools are widely used among the Earth Observing System Data and Information System (EOSDIS) Distributed Active Archive Centers (DAACs). Langley Research Center/ Atmospheric Sciences Data Center (LaRC/ASDC), the National Snow and Ice Data Center (NSIDC), Goddard Earth Sciences (GES), Marshall Space Flight Center/Global Hydrology Resource Center (MSFC/GHRC), the Socioeconomic Data and Applications Center (SEDAC), and Physical Oceanography DAAC (PODAAC) regularly send all their new and modified DIFs using the DIF authoring and modification tools. The DAACs have also contributed new and revised SERFs using the online tools. In total, the DAACs contributed 431 DIFs and 17 SERFs to the GCMD in 2003. Development of new, Extended Markup Language (XML)-based and Java-based metadata authoring tools (docBUILDER) is well underway, with the release scheduled for early 2004.

Several of the Federation's Earth Science Information Partners (ESIPs) have provided DIFs and SERFs using the metadata authoring tools. The University of New Hampshire (EOS-WEBSTER), Distributed Oceanographic Data System/Open-Source Project for a Network Data Access Protocol (DODS/OPeNDAP), and the Museums Teaching Planet Earth (MuTPE) were the most active contributors during the year. In total, the non-DAAC Type 1, Type 2, and 3 ESIPs contributed 254 new DIFs and 25 new SERFs.

1. A critical aspect of the GCMD mission is that of providing links to data sets. At the end of CY03, the GCMD provided 70,535 links to data sets and information within the DIF and SERF metadata - up from 52,539 in CY02, and an additional 4,327 links from within supplemental descriptions (instruments, platforms, projects, data centers) and 1,430 links to web resources on the Earth Science pointers page.

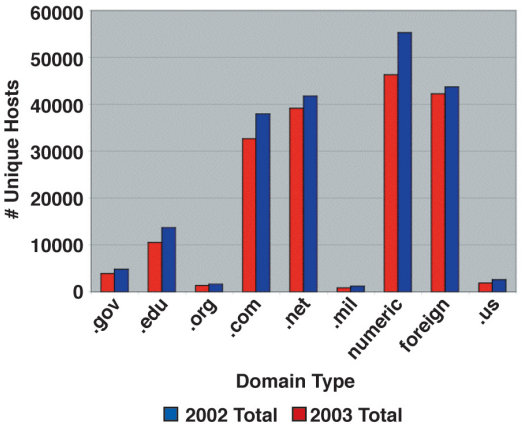
2. The Global Change Conference Calendar now contains 1007 conference listings. During 2003, 202 new conferences were added and 17 were revised.

5.2.7.2 GCMD Web Usage

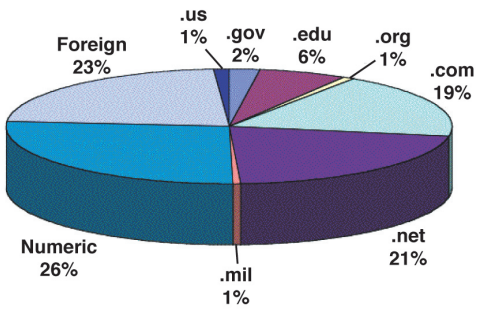
Usage, as measured by the number of unique hosts, for CY03 was down by 11.7% from 202,518 to 178,730 unique hosts-reflecting the inability of the metrics software to determine unique users among the collapsed ".com" addresses. The number of "hits" on the GCMD Web site continued to climb from 6,463,527 in CY02, to 7,569,397 in CY03 (+17.1%). User Web sessions show a remarkable "academic year"-like pattern of low activity during the summer and winter holidays.

U.S. Unique Hosts	2002	2003	Change [%]
.gov	4,774	3,925	–17.8
.edu	13,637	10,469	–23.2
.org	1,625	1,332	–18.1
.com	37,921	32,613	–14.0
.net	41,793	39,135	–6.4
.mil	1,207	831	–31.1
.us	2,566	1,849	–27.9
Numerical	55,263	46,351	–16.1
Hits (GCMD Site)	6,463,527	7,569,397	17.1

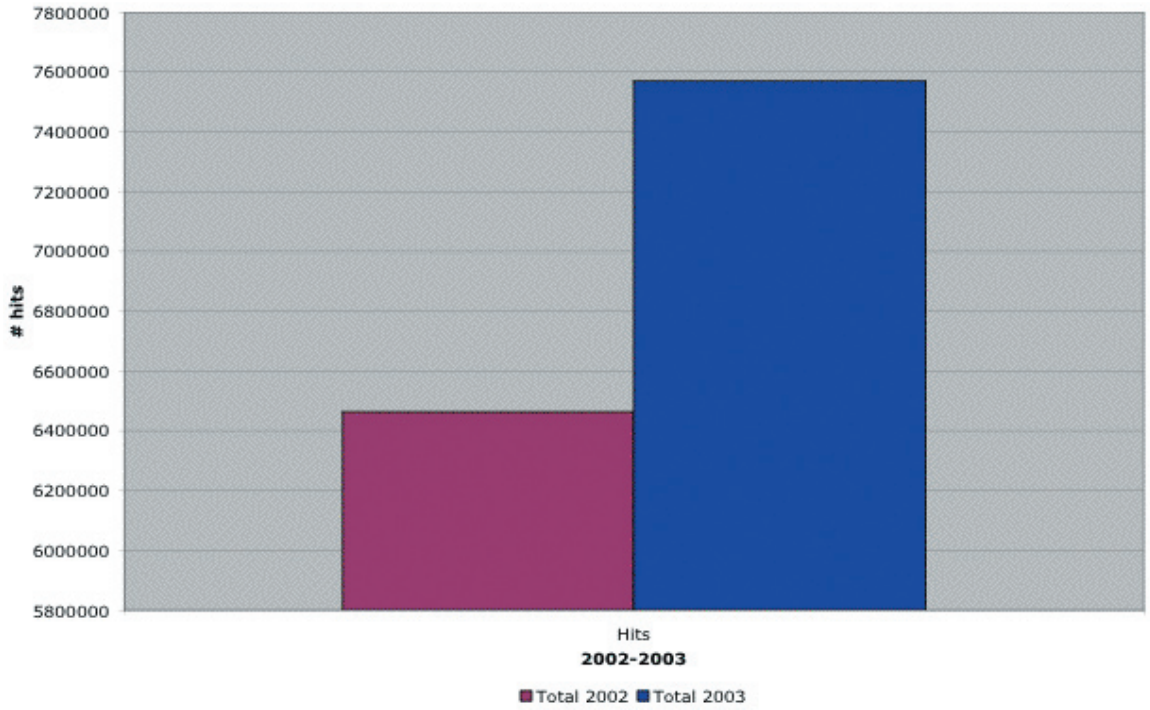
2002-2003 Web Usage by Domain

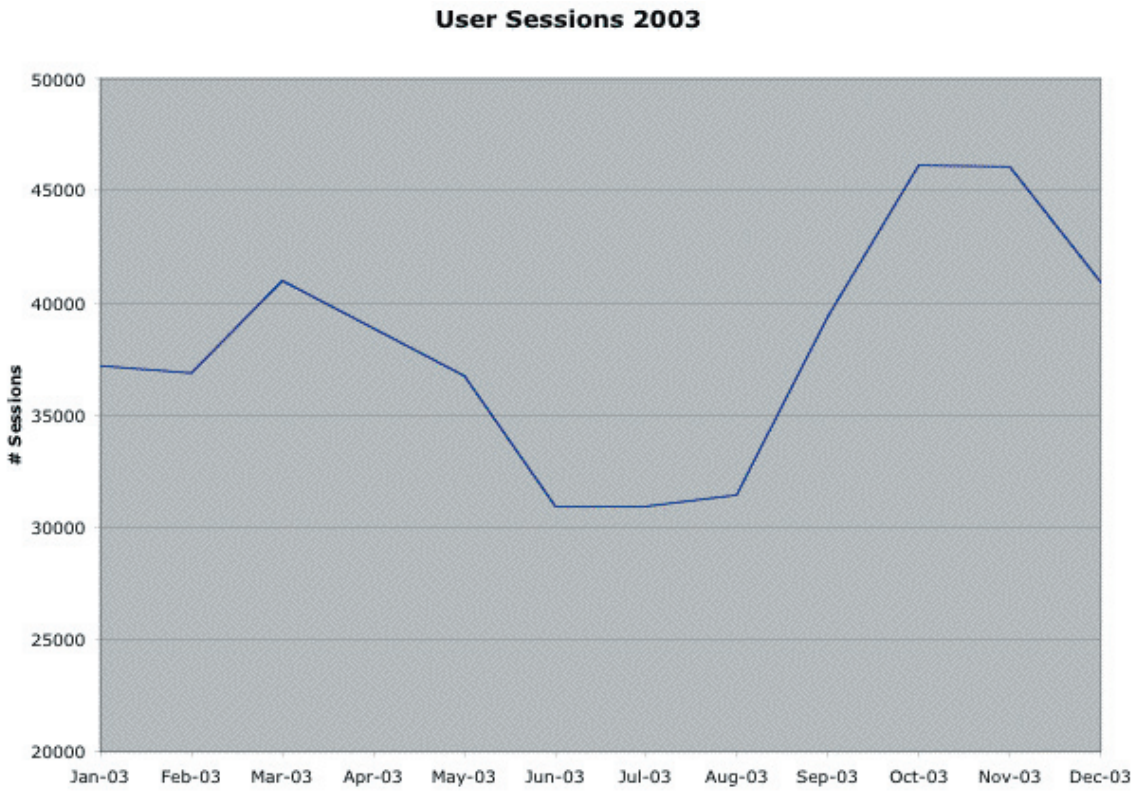


GCMD Usage by Domain Type 2003

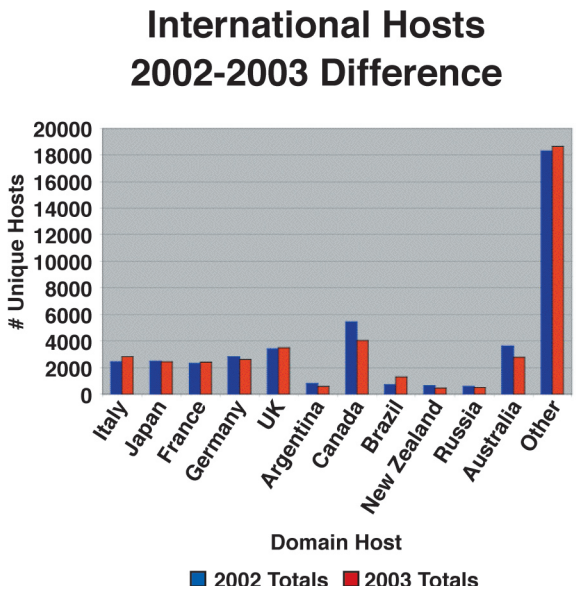


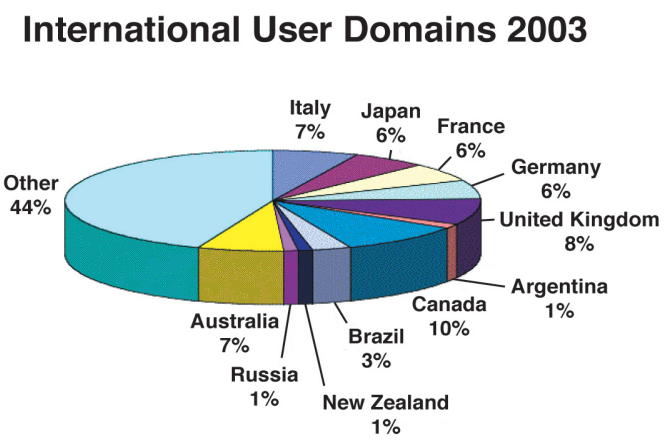
GCMD Web Hits 2002-2003





International Hosts	2002	2003	Change [%]
All International hosts	43,732	42,225	–3.4
.it (Italy)	2,450	2,841	15.9
.jp (Japan)	2,508	2,451	–2.3
.fr (France)	2,306	2,405	4.3
.de (Germany)	2,845	2,618	–8.0
.uk (United Kingdom)	3,431	3,499	2.0
.ar (Argentina)	808	612	–24.0
.ca (Canada)	5,446	4,063	–25.4
.br (Brazil)	735	1,304	77.4
.nz (New Zealand)	653	469	–28.2
.ru (Russia)	598	512	–14.4
.au (Australia)	3,634	2,795	–23.1
Other International	18,318	18,656	1.8
All Unique HOSTS	202,518	178,730	–11.7





Search and retrieval from free-text interfaces:

Interface	2002	2003	Change [%]
Search: Free-Text	51,559	57,730	11.9
Retrieval: Free-Text	26,138	25,912	–0.9
Search: ZServer	50,261	204,216	306.3
Retrieval: ZServer	115,755	133,540	15.3
Retrieval: Supplemental	528,961	195,709	–63.0

Search and retrieval from keyword interfaces:

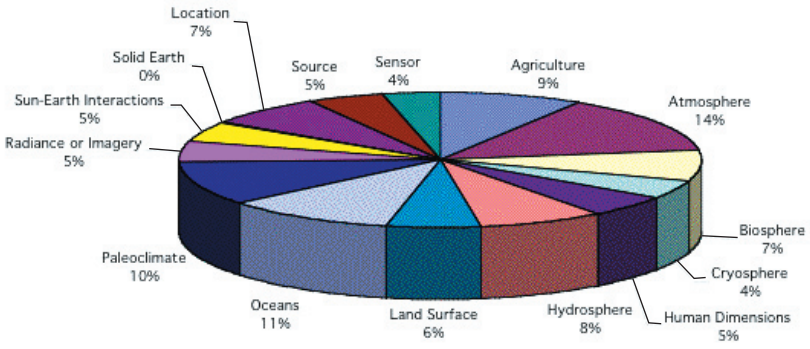
Keyword	2002	2003	Change [%]
Search: Keyword	124,427	80,839	–35.0
Retrieval: Keyword	66,644	257,211	285.9
Search: Portal Keywords	33,150	12,123	–63.4
Retrieval: Portal Keywords	27,994	24,772	–11.5

* Global Land Information System is no longer available.

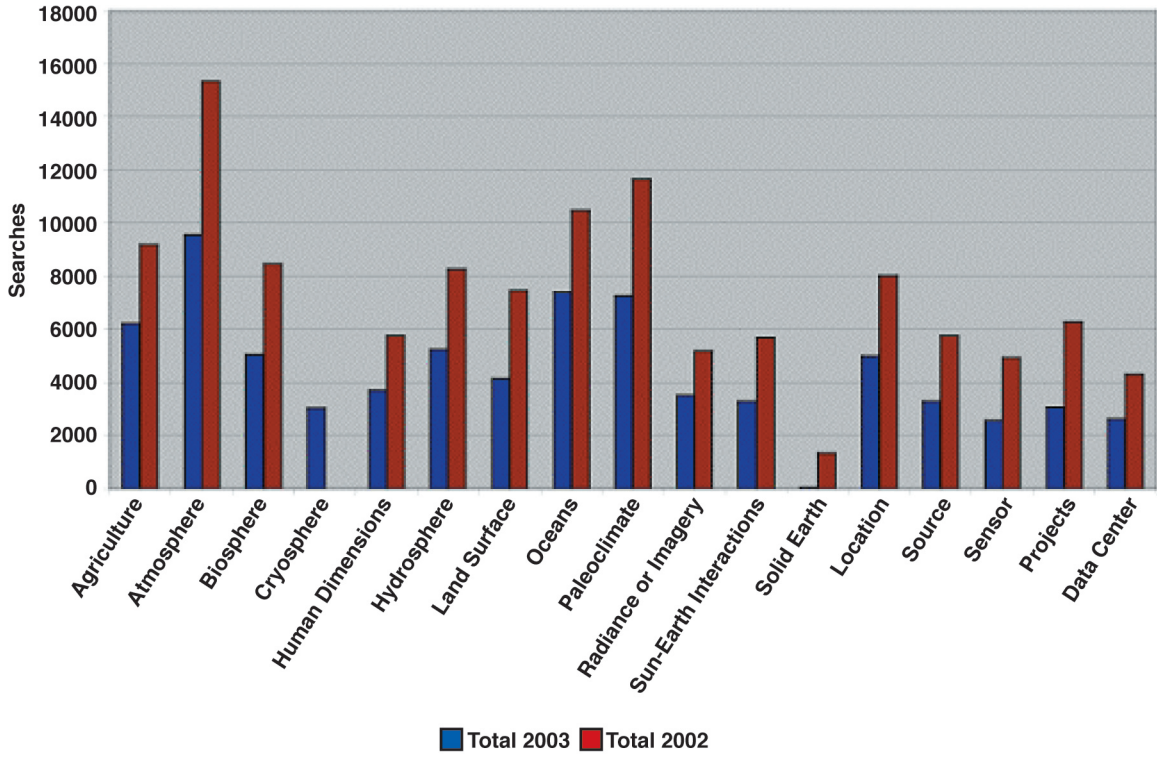
Total Retrievals	2002	2003	Change [%]
Retrievals: All Sources	540,471	690,685	27.8

Parameter Searches	Searches Conducted	Total Searches [%]
Agriculture	6,203	7.7
Atmosphere	9,565	11.8
Biosphere	5,029	6.2
Climate Indicators	3,031	3.7
Cryosphere	3,695	4.6
Human Dimensions	5,244	6.5
Hydrosphere	4,118	5.1
Land Surface	7,731	9.1
Oceans	7,244	9.0
Paleoclimate	3,503	4.3
Radiance/Imagery	3,281	4.1
Sun-Earth Interactions	26	0.03
Solid Earth	4,987	6.2
Locations	3,290	4.1
Platforms	2,558	3.2
Instruments	3,064	3.8
Projects	2,612	3.2
Data Centers	6,018	7.4

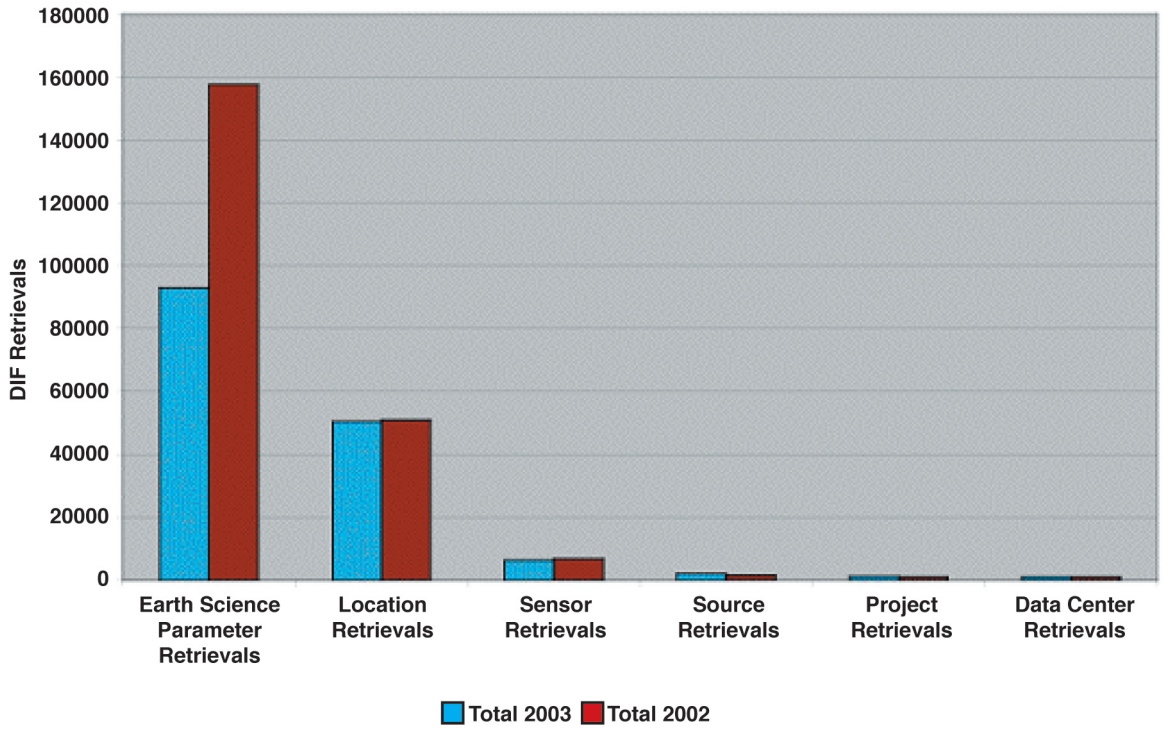
Searches by Earth Science Topic

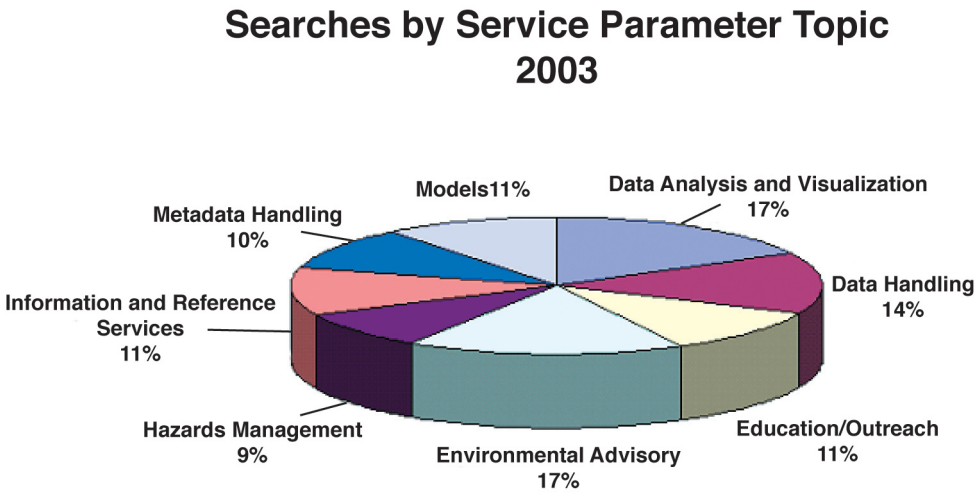


2002-2003 Keyword Searches



2002-2003 Retrievals by Keyword





5.2.7.3 User Feedback and User Support

There were 101 user support questions received during 2003. Users typically ask questions about locating maps and images, climate data, and sources of information on various science topics. Below are some examples of user support questions received:

"I am writing a term paper about the Northwest Passage. I want to write about three major points: 1. The climate change, the melting of the ice, the lengthening of the melting periods; 2. The legal status of the route, legal character; and 3. This route as a navigable route. My question to you: can you help me in finding information or could you provide me information?"

"I am looking for an aerial or satellite photograph of my father-in-law's land in British Columbia, Canada."

"Could you please tell me the national map projection parameters for Bolivia?"

"I have EndNote6 (ISI) a software which allows downloading of records for reference purposes (scientific papers) if the service is Z39.50 compliant. I imagine that your server is. I do need information to set up a connection file for downloading. Can you help me?"

"I'm looking for raw data on global temperatures over the last say 200 years and CO_2 readings so that pupils can graph the results and draw conclusions."

"My teacher asked that before the next class I find the location of our school in degrees, minutes, and seconds, but I really don't know how to get it. Please help me."

"How can I obtain recent global land clearing statistics?"

"I am looking for data on the Marianas Trench. Has it been changing in any way?"

"I'd like to know about atmospheric conditions (ex. Great Northern Lights) and be alerted as to when they are."

"Hi. My name is ___. I'm a senior and I'm working on a science project. My topic is the North Atlantic Oscillation and how it affects the weather in Europe. One of my friends has been talking to you and you sent her some very helpful data sets and I was hoping maybe you could do the same for me! If not its OK, but anything you think you could do to help me would be greatly appreciated!! Thank you so much!"

Some of the types of user feedback is evident in the following:

Liam O'Reilly (Student) in search of rainforest destruction information for a report. "Thank you very much for the helpful information. I will write back to you and tell you what I get on it."

Professor Don Hyndman was in search of a weather map and jet stream information. He wrote, "Thanks for the Web links. The NOAA one is the best. Although I had browsed various NOAA sites I had not seen this one. It has some good images and explanations. One of them is actually a nice, concise explanation of the Jet Streams: http://www.srh.weather.gov/jetstream/global/jet.htm".

Mariana Castillo in search of national map projection parameters for Bolivia. "It's amazing, thanks a lot!"

Arindam Ghosh in search of climate data links for the Indian stations and the Indian Ocean. "Thanks a lot for the information. These links are really very useful. Thanks again!"

Charles T. Robinson had many questions pertaining to the GCMD parameter keywords. "Thanks for the quick response, this is exactly what I needed."

Carol Kreis (a freelance writer) developing an educational map for Newsweek about human impacts on climate change. She wanted to know how to obtain permission to reproduce the graph, "The increase of atmospheric CO_2 over time." After receiving assistance, she wrote, "Thanks for your prompt reply".

Liesbeth Van Iseghem (a student) needed assistance on researching the Northwest Passage. She replied "It has been a while but you sent me information and you supported me in writing my term paper about the Northwest Passage. I want to thank you very much for your help. It was not an easy subject but it was so interesting. I learned so much and really felt a discoverer. At school there were people who supported me and were interested. There were, unfortunately, also 'non-believers', who thought it was a stupid subject. But I made it, yesterday I graduated with distinction!! I will always, from now on, follow a little bit the evolution in the Arctic sea-ice and all related subjects! Thank you so much for your help and support, without you I could never succeed in doing this."

Antje Dun (Australian Conservation Foundation Representative) requested assistance with land clearing statistics for 2002 and 2003. After receiving assistance, the user responded, "Thank you so much for your help. You are wonderful! I look forward to hearing from you if you find any more information about 2003."

Mathew Koelz was in search of an algorithm for distance between a pair of latitude and longitude coordinates. The user responded, "Much appreciated... and thanks for taking the time to look... my calculator uses the cosine method, with a small addition for the radius for the

average height amsl [Above Mean Sea Level], but my problem was the distance for the minute of arc. With the information in the document, I hope to improve my calculator accuracy somewhat, which is only used for distances of 10000' or less."

Helen Pan was in search of satellite and space photographs of China. She responded, "Thanks a million. It is powerful. I can't get these pictures in China."

Hailie Cook was in search of global warming information. The user replied, "Thank you so much for the websites you sent."

Mallory Guerin was in search of ultraviolet-B radiation and rainforest information. The user responded, "Thank you so much Gene for taking time out to help me. I think that I will be able to use this information in my paper."

Danna Smith was in search of North Atlantic Oscillation data and responded, "Wow!!! Thank you so much!! This is a huge help! You have no idea how much I appreciate this!! Once again thank you sooooo much!!"

5.2.8 COLLABORATIONS

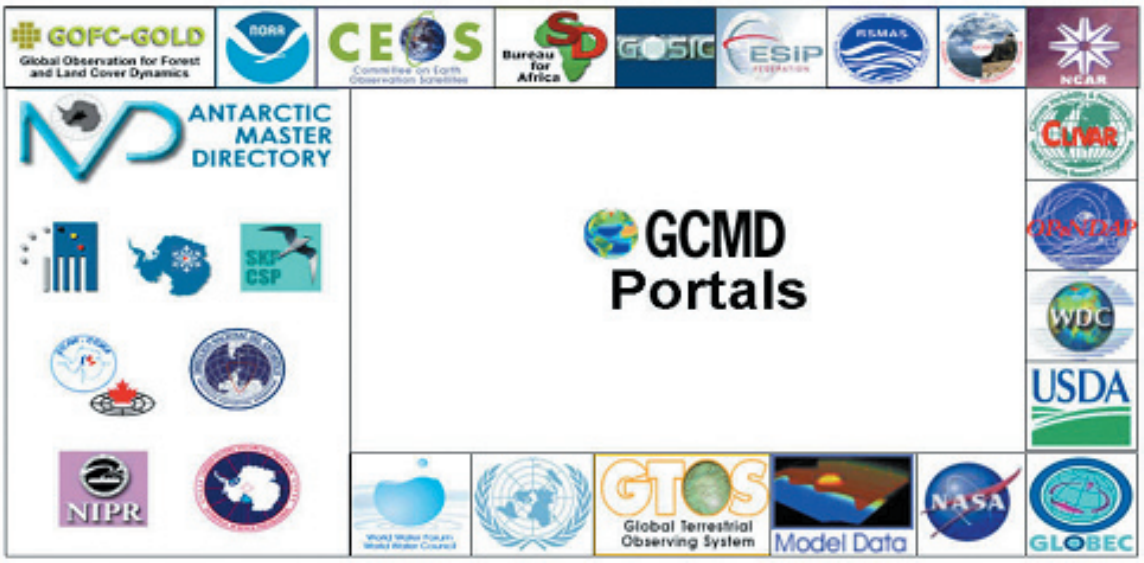
5.2.8.1 Portals

Many organizations acknowledge the importance of metadata related to their area of interest, but do not have the resources required to manage their content. Portals allow organizations to maintain and document their data without duplicating the effort in creating another online directory. By hosting metadata through a GCMD portal, users can view the virtual subset of interest. Portals help provide science, or application-specific foci for other agencies, science focus groups, consortia, etc., and may be trademarked with the logo of an organization.

Using a portal to search a virtual subset is advantageous in that as metadata is added to the subset, it is also freely available from the GCMD's general search pages for scientists in other disciplines to access and use. Maintenance and creation of customized free-text and keyword search portals for the science community continued in 2003 with 11 new portals added. Usage statistics are also regularly tracked and available (see http://gcmd.nasa.gov/Data/portal_index.html).

Maintenance and creation of customized free-text and keyword search portals for the science community continued in 2003. Additional portals for the Antarctic Master Directory, the Japan Aerospace eXploration Agency (JAXA), and other organizations will be added during 2004 (see http://gcmd.nasa.gov/Data/portal_index.html).

GCMD Access to Community-focused Data



Current portals include:

- U.S. Department of Agriculture, created October 1999
- Global Observation System Information Center (GOSIC) including the Global Climate Observing System (GCOS)
- Global Terrestrial Observing System, and Global Ocean Observing Systems (GTOS and GOOS, respectively), created March 2000
- Joint Committee on Antarctic Data Management/Antarctic Master Directory (JCADM/AMD), created August 2000
- DODS, created August 2000
- Global Observation of Forest Cover (GOFC), a CEOS project, created September 2000
- ESIP, created December 2000
- Global Ocean Ecosystems Dynamics (GLOBEC), an International Geosphere-Biosphere Programme (IGBP) project, created May 2001
- CEOS, created June 2001
- World Data Centers (WDC), created June 2001
- Rosenstiel School of Marine and Atmospheric Science (RSMAS) [University of Miami], created July 2001
- Climate Variability and Predictability (CLIVAR), a World Climate Research Programme (WCRP) project, created January 2002
- Geographic Information for Sustainable Development (GISD), a CEOS project, created June 2002
- Model Output Data portal, created September 2002
- NOAA, created July 2002

Created in 2003:

- Argentina Antarctic Center, created August 2003
- Belgian Antarctic Program, created January 2003
- Canadian Polar Commission/Canadian Committee for Antarctic Research, created October 2003

- Finnish Antarctic Program, created January 2003
- Swiss Committee on Polar Research, created November 2003
- NASA Geospatial Framework, created September 2003
- NASA GSFC GES Distributed Active Archive Center, created June 2003
- National Center for Atmospheric Research (NCAR), created September 2003
- Remote Sensing for Conservation, created May 2003
- United Nations (UN) Earth Science Data, created April 2003
- World Water Forum (WWF), created January 2003

5.2.8.2 Collaboration Updates for 2003

DODS/OPeNDAP:

DODS/OPeNDAP currently promotes the GCMD through the portal on their Web site and through presentations at scientific conferences. The GCMD continues to serve as a locator for all of the DODS data sets. Statistics for this portal are presented to DODS each month. As of December 31, 2003, an average of 304 visitors accessed the portal each month. The GCMD has also worked closely with DODS to provide direct access to the Live Access Server (LAS) data sets and to provide a direct link through GCMD's Open-Applications Programming Interface (OpenAPI). DODS recently introduced the OPeNDAP Data Connector (ODC), a stand-alone Java program, which allows the search and retrieval of datasets published by OPeNDAP data servers. The ODC allows one to find OPeNDAP related data sets and import them into client applications such as Interactive Data Language (IDL), Matlab, (Statistical Package for the Social Sciences (SPSS), Excel, or into databases such as Access and Oracle, and plot them with advanced graphics capabilities. The ODC Search Frame provides interfaces to the GCMD and the DODS data set list. For additional information about the ODC, please see http://dodsdev.gso.uri.edu/ODC/.

USGS/Biological Resources Division:

The following new metadata (182 records) were provided to the USGS/BRD National Biological Information Infrastructure (NBII):

- Risk Assessment, Management, and Audit Systems (RAMAS) Ecological software system, 3
- Biota of Virginia (BOVA) database, 10
- Biologically Integrated Geospatial Salmonoid data Access and Management (BIGSAM), 13
- University of Tennessee, 16
- Patuxent Wildlife Research Center (PWRC) software, 9
- PWRC data, 4
- Brooklyn Botanic Garden Herbarium Catalog
- New York Metropolitan Plant Occurrence
- Patuxent Software metadata, 9
- Leetown Science Center, 19
- Southern Appalachian Information Node, 94
- Amphibian Research Monitoring Initiative, 3

ESIP/FIND:

The Federation of ESIP brings together government agencies, universities, nonprofit organizations, and businesses in an effort to make Earth Science information available to a broader community. Members of the Federation continue to provide DIFs and SERFs to the GCMD, which the GCMD also makes available through the Federation of Information for Networked Discovery (FIND) on the Federation home page. The Federation added 685 new DIFs and 53 new SERFs for a total of 3,817 DIFs and 156 SERFs in the GCMD.

The GCMD is represented on the information and technology committee, e-journal committee, and the products and services committee. The GCMD staff members have also presented posters and given technical workshops at Federation meetings.

JCADM/AMD:

The Antarctic Master Directory (AMD) is an effort coordinated with the Joint Committee Antarctic Data Management (JCADM) to offer Antarctic data collected by researchers from 15 of the Antarctic Treaty countries. Data may be searched through the AMD portal, which was created in 2001, and is located at http://gcmd.nasa.gov/Data/portals/amd/. In 2003, portals were added for the following AMD nodes: Argentina, Belgium, Finland, Canada, Switzerland, Japan, and the United States. These portals are available at http://gcmd.nasa.gov/Data/portal_index.html. Over 593 additional new DIFs were received from the following nodes: Australia, United States, Argentina, Spain, United Kingdom, Estonia, and New Zealand. In addition, the Australian Node from the Australian Antarctic Data Centre (AADC) has installed the final MD8 software and tools.

IODE:

Representatives from the GCMD coordinated with International Oceanographic Data and Information Exchange (IODE) for the release of the MEDI metadata tool to the IODE community. The Marine Environmental Data Information (MEDI) tool is available online from the IODE Web site. GCMD continues to actively participate in IODE technical and scientific meetings. Meeting notes and proceedings are available online at http://iode.org/. As a part of the outreach effort of the IODE community, the GCMD is currently featured within the Ocean Portal (http://www.oceanportal.org), a high-level directory of ocean data and information related Web sites. The objective of the ocean portal is to assist scientists and other ocean experts in locating data and information.

NOAA:

Collaborations continued with NOAA during 2003. The entire NCDC metadata content was retrieved from the NOAA Server, translated from the FGDC/Content Standard for Digital Geospatial Metadata (CSDGM) to DIF, and loaded into the GCMD (completed April 2003). An effort was also initiated to replace outdated NOAA metadata content from other NOAA centers with updated information. A NOAA portal (http://gcmd.nasa.gov/Data/portals/noaa/) was created to feature over 1,586 NOAA data sets referenced in the GCMD. The "model output" portal, created in 2002 as a result of collaborations with the NOAA NOMADS project, exceeded 600 metadata records, (see http://gcmd.nasa.gov/Data/portals/models/).

NCAR:

Collaborations continued with the National Center for Atmospheric Research (NCAR). A portal was created (http://gcmd.nasa.gov/Data/portals/ncar/) to feature data offered by NCAR. The GCMD staff also began working with NCAR's Community Data Portal (CDP). The CDP staff created an XSL Style Sheet to convert their XML metadata to DIF XML. As a result, 34 new DIFs were contributed to the GCMD from CDP. The total NCAR metadata collection in the GCMD reached 472 DIFs in 2003. Additional DIFs are expected in 2004, as NCAR's Data Support Section (DSS) is expected to archive almost the entire archive of European Centre for Medium-Range Weather Forecast (ECMWF) ERA-40 Model Data.

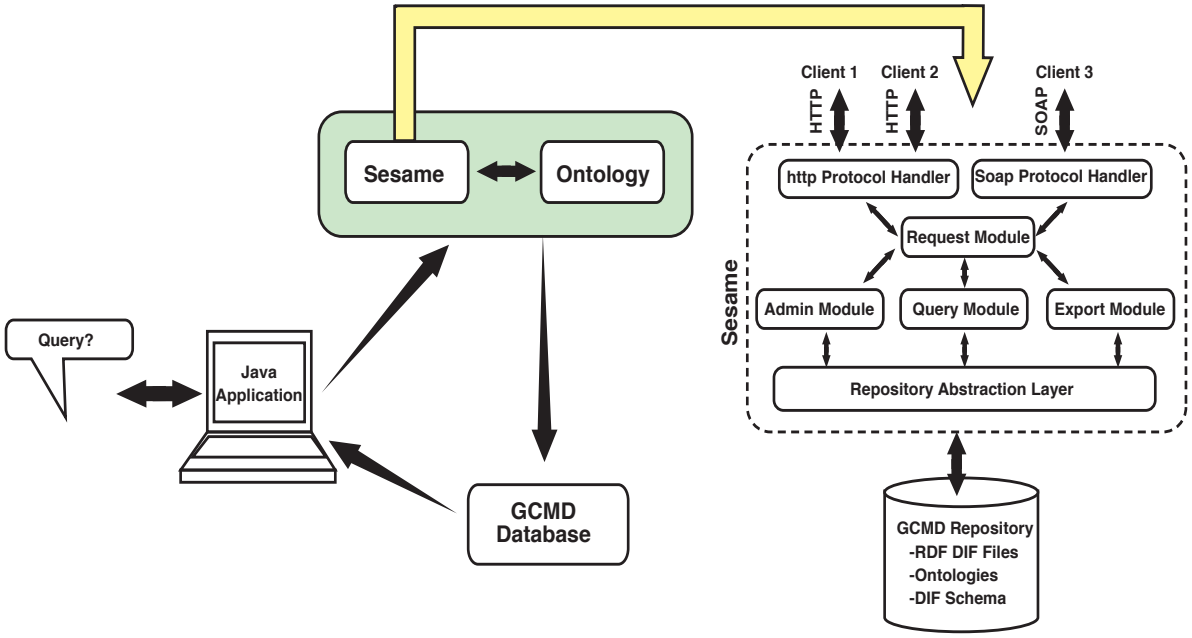
GLOBEC:

Collaborations with the GLOBEC community have continued. GLOBEC has continued to contribute to the GLOBEC portal by creating records from data collected in the Georges Bank and the Southern Ocean.

The project has continued to promote their portal by featuring the GCMD within their Web site (GLOBEC Metadata Inventory and Information (http://www.pml.ac.uk/globec/Data/metadata.htm).

Graduate Summer Student Program:

Through the work of a student in the Graduate Summer Student Program (GSSP) at GSFC, the GCMD experimented with database structures in machine parsable format, which are associated with the semantic Web. The semantic Web provides the ability to search for semantic relationships among any DIF terms within an ontology, without the need to change the database structure when new classes and relationships are added. The real advantages occur when an ontology is enriched. The diagram above illustrates "Sesame" (an open source, Resource Description Framework [RDF] schema-based repository and query facility) middleware and its flexibility as a graphical user interface (GUI) or application programming interface (API), using alternative databases.



UNEP/GRID:

Mr. Viktor Pusztai from the United Nations Environmental Programme/Global Resource Information Database (UNEP/GRID) of Budapest (Hungary) has been working to integrate the PostgreSQL database into the MD software. His valuable contribution through the CEOS IDN community will provide an open-source alternative to the Oracle database. Mr. Pusztai has taken the current Structured Query Language (SQL) scripts to create the tables, indexes, views, triggers, etc., and is rewriting them in order to set up the same database structure in PostgreSQL. He is also making modifications to the MD software necessary to interact with this database.

University of Virginia:

The University of Virginia group, led by Dr. Worthy Martin, presented the final report on their thesaurus work as part of an Earth Science Technology Office (ESTO) award. The thesaurus is currently running on a development machine at GCMD. It has the ability to query the Oracle database for terms and allows users to edit the terms already in the database. The thesaurus, however, is not able to accept new terms to be added to the database.

GOSIC/GTOS:

GOSIC at the University of Delaware (in Lewes, Delaware), coordinates the data activities of the Global Observing System (GOS), which consists of the Global Terrestrial Observing System (GTOS), the Global Ocean Observing System (GOOS), and the Global Climate Observing System (GCOS). The GCMD, in collaboration with GOSIC and GTOS representatives, identified new science keywords and added them to the GCMD database. Scripts were created to allow the direct query of DIFs from GOSIC interfaces. In October 2003, the GCMD presented a status report on the GCMD-GOSIC collaboration to the GOSIC Science User Working Group.

IOOS/DMAC:

The Data Management and Communications (DMAC) subsystem will combine all of the global and coastal components of the sustained Integrated Ocean Observing System (IOOS), and link every part of the observing system from the instruments to the users. Representatives from the GCMD, in collaboration with the IOOS/DMAC Metadata Working Group, contributed to the metadata section and reviewed other sections of the IOOS/ DMAC Implementation Plan.

U.S. Office of Management and Budget:

As requested by the U.S. Office of Management and Budget (OMB), the GCMD developed a NASA Geospatial framework portal, highlighting geospatial data investments consisting of framework data layers. These framework layers include cadastral, digital ortho-imagery, elevation bathymetric, elevation terrestrial, government units, transportation, hydrography, and geodetic controls (see http://gcmd.gsfc.nasa.gov/Data/portals/nasa_geo/).

5.2.9 STANDARDS

5.2.9.1 GCMD Controlled Keywords

Although it is unclear how many groups use the GCMD keywords, 12 additional organizations that use them were identified in 2003, bringing the known total to 23. The GCMD's Earth science parameter and services controlled keywords are available at http://gcmd.gsfc.nasa.gov/Resources/valids/ and are currently used by the following organizations:

CEOS Interoperability Protocol (CIP)

EOSDIS Data Gateway (EDG)

EOSDIS Core System (ECS)

NASA's Visible Earth

NASA Taxonomy

Federal Geographic Data Clearinghouse (FGDC)

Canada Centre for Remote Sensing (CCRS)/GeoConnections

Mercury/Beja Flor, Oak Ridge National Laboratory (ORNL)

NASA Visible Earth/Earth Observatory

DODS (also known as OPeNDAP)

NOAA (used in NOAA FGDC records as the thesauri keywords)

Metadata Enterprise Resource Management Aid (MERMAid), formally the Coral Reef Information System (CORIS)

University of California Natural Reserve System

Semantic Web for Earth and Environmental Technology (SWEET) at the Jet Propulsion Laboratory (JPL)

Digital Library for Earth system Education (DLESE) (not explicitly using them but acknowledges GCMD as a resource when constructing high-level DLESE controlled vocabulary)

American Geophysical Union (AGU) Cryosphere keywords (Larry Hinzman)

Global Change Data and Information System (GCDIS)

Global Observing System Information System (GOSIC)

Marine Environmental Data Inventory (MEDI)

Benguela Environment Fisheries Interaction and Training (BENEFIT)-this is the Marine Fisheries system in South Africa

Neptune, Australia National Oceans Office (see http://neptune.oceans.gov.au/)

Scalable Agent-based Information Retrieval Engine (SAIRE) at NASA/ Ames Research Center (ARC) (see http://saire.arc.nasa.gov/GCMD-Final/key.html)

GCMD vocabulary considered during the Monterey Bay Aquarium Research Institute (MBARI) metadata workshop, October 2003.

During the year, the following additions and modifications were made:

New or Modified Science Keywords

- Added new TOPIC: Climate Indicators
- Added 23 new Variables and 7 new Terms
- Currently (2003): 13 Topics, 117 Terms and 1219 Science Variables

New or Modified Services Keywords

- Added 1 new Variable
- Currently (2003): 8 Topics, 43 Terms and 57 Services Variables

5.2.9.2 Data Set Content Description Standard

The Directory Interchange Format (DIF), see http://gcmd.nasa.gov/User/difguide/write-a-dif_v8.html.

5.2.9.3 Analytical Resources Content Description Standard

The Services Entry Resources Format (SERF), see http://gcmd.nasa.gov/Services/write_a_serf.htm.

5.2.9.4 International Standards Organization (ISO)

For the ISO 9001 standards for configuration control, see http://gcmd.nasa.gov/Aboutus/software_docs/config.html.

5.2.9.5. ISO Geospatial Metadata Standard, 19115/TC 211

GCMD representatives monitored and responded through the international community during the ISO standard process. In preparation for compliance with this standard, a cross-mapping was completed between DIF and ISO19115/TC211, and additions will be made to the DIF for compatibility. Mappings were also made between the ISO Topic and GCMD keywords. Proposals were sent to the CEOS Interoperability Forum, documenting the changes necessary for ISO compatibility.

5.2.9.6 FGDC and the New Geospatial One Stop

The explicit decision to retain the DIF format for internal use, while making all DIF metadata available as FGDC compliant records, has proven to be an excellent one. It has provided the distinct advantage of preserving the validation of metadata through the database—a property not available through the Clearinghouse. It has also allowed NASA to maintain fields critical for the GCMD that are not available in FGDC. These fields are considered to be absolutely essential to the NASA mission. They help prevent duplicative entries and assist in the discovery of data sets and include the following:

- Entry ID (unique identifier for every data set);
- Entry Title;
- Parameters (science keywords essential for "normalization" of the database);
- Sensor (Instrument);
- Source (Platform, e.g., a satellite);
- Minimum/Maximum Altitude and Depth;
- Temporal Resolution;
- Project;
- Data Set Language;
- Originating Center;
- Data Center Name (variant);
- Data Center URL;
- Multimedia Sample URL;
- Multimedia Caption;
- Related URL; and
- IDN Node.

The GCMD's controlled keyword vocabulary may be selected for use by the FGDC. Because FGDC has no formal keyword vocabulary, the keywords may be used as thematic keywords in Section 1.6.1.1 of the FGDC's standard, where the Theme Keyword Thesaurus allows participants to specify a keyword framework.

NASA has met the requirements for the Geospatial One-Stop Initiative by providing information on geospatial acquisitions (see http://gcmd.gsfc.nasa.gov/md/lucene/luceneSearch.html).

5.2.9.7 ISO Geospatial Metadata Standard 19115/TC 211

The release of MD9-ISO in May 2004 will bring the DIF into compliance with this ISO standard.

5.2.9.8 National Biological Information Infrastructure (NBII)

Work on the NBII continues through a formal, interagency agreement with the USGS Biological Resource Division (BRD).

5.2.9.9 Crosswalk or Mapping with Other Standards

These standards can be accessed at http://gcmd.nasa.gov/Aboutus/standards/.

- Dublin Core
- FGDC
- NBII
- ISO 19115

5.2.9.10 Concurrent Versioning System (CVS)

The Concurrent Versioning System is used within the project for software configuration control.

5.2.9.11 The Zen of Object Publishing Enterprise (ZOPE)

ZOPE, which is written in Python (a highly-productive, object-oriented scripting language), is used for internal document management and for the CEOS IDN interactions.

5.3 Goddard Earth Sciences Data and Information Systems Center/DAAC

5.3.1 ORGANIZATION, MISSION, AND STRATEGY

The Goddard Earth Sciences (GES) Data and Information Systems Center (DISC) is a part of the Global Change Data Center (GCDC), GSFC Code 902. The DISC provides data and services for global change research and education.

The GES DISC mission is to maximize the investment of NASA's Earth Science Enterprise by providing data and services that enable people to realize the scientific, educational, and application potential of global climate data.
As a source of information for atmospheric, hydrologic, land biosphere and ocean color data, the GES DISC facilitates the study of natural and human processes that influence Earth's climate, by processing, archiving, distributing, and providing user and value added data management services.

The DISC is divided into two groups:

1. The DAAC is responsible for the execution of heritage DAAC data management functions: data ingest, archive, production, distribution, management, and user services; system engineering; data support; science software integration; and the development of DAAC Unique Extensions.

The DAAC is composed of the following versions:

- Version 0 (V0)—Developed and operated by GES DAAC personnel to support data originating prior to 1998.
- Version 1 (V1)—Developed and operated by GES DAAC personnel to support data originating from TRMM, starting November 1997.

- Version 2 (V2, also known as ECS)—Developed by the ESDIS Project and operated by the GES DAAC to support Terra, launched December, 1999, Aqua, launched May 2002; and the Solar Radiation and Climate Experiment (SORCE), launched January 2003.

The GES DAAC's goal is to efficiently and cost effectively ingest, produce, archive, and distribute Earth Science data and information, related to hydrology, ocean biology, atmospheric dynamics and chemistry, and land biosphere, and to perform the data management functions and services that maximize the use and usefulness of this data and information.

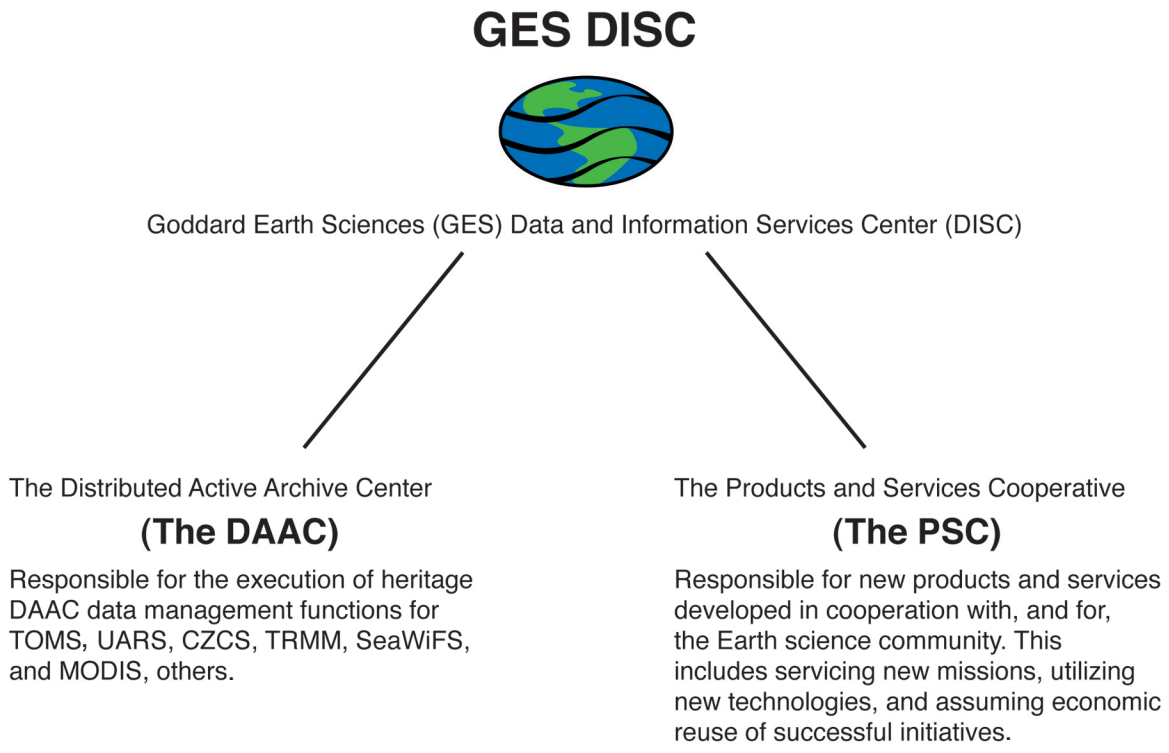
2. The Products and Services Cooperative (PSC) is responsible for new products and services in cooperation with, and support of, the Earth science data community including the development and deployment of products and data management services for new projects, development of value added products such as data management and manipulation tools that can be reused; new technology development, new project initiatives, and product reuse.

The GES PSC uses the following criteria to take on new work:

- The new work must be useful to a group of users.
- The new work must facilitate science (e.g., add value to existing products or services).
- The new work must provide a means to improve DISC and other data center data management facilities, on the individual and data center levels.

The GES PSC goal is to develop, in complete collaboration with individuals being served, keep inventory, and provide data management products and services in response to the changing data management requirements of the Earth science community, and the development of new applications.

The figure that follows illustrates the two GES DISC organizations, i.e., the DAAC and the Products and Services Cooperative (PSC).

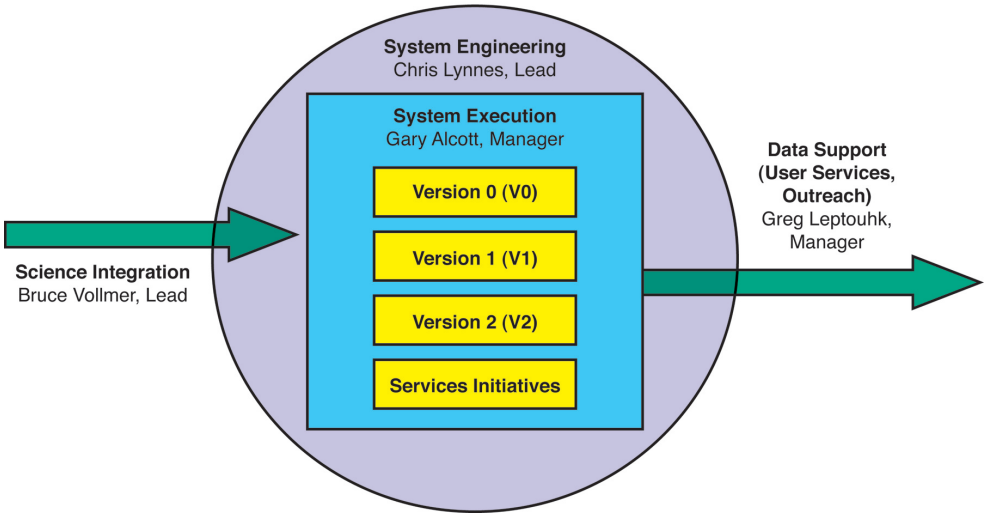


Within the GES DISC organization, four highly dependent components exist, each addressing a vital part of the GES DISC:

1. Engineering and system development
2. System Execution
3. Data Support
4. Science Integration

The following figure depicts the relationship between the DISC groups.

GES DISC ORGANIZATION



The GES DISC strategy is built upon balancing two opposing drivers: maintaining a high level of customer services, and performing appropriate functions within budgetary constraints. The GES DISC, therefore, uses the following strategies to strive toward this balance:

Engage scientists

- Communications must be frequent
- Dedicated points of contact to gather and provide information are identified

Build economically

- Look for reuse, ways to save funds
- Willing to take calculated risks; otherwise low risk
- Build to integrate new technologies

Engage employees

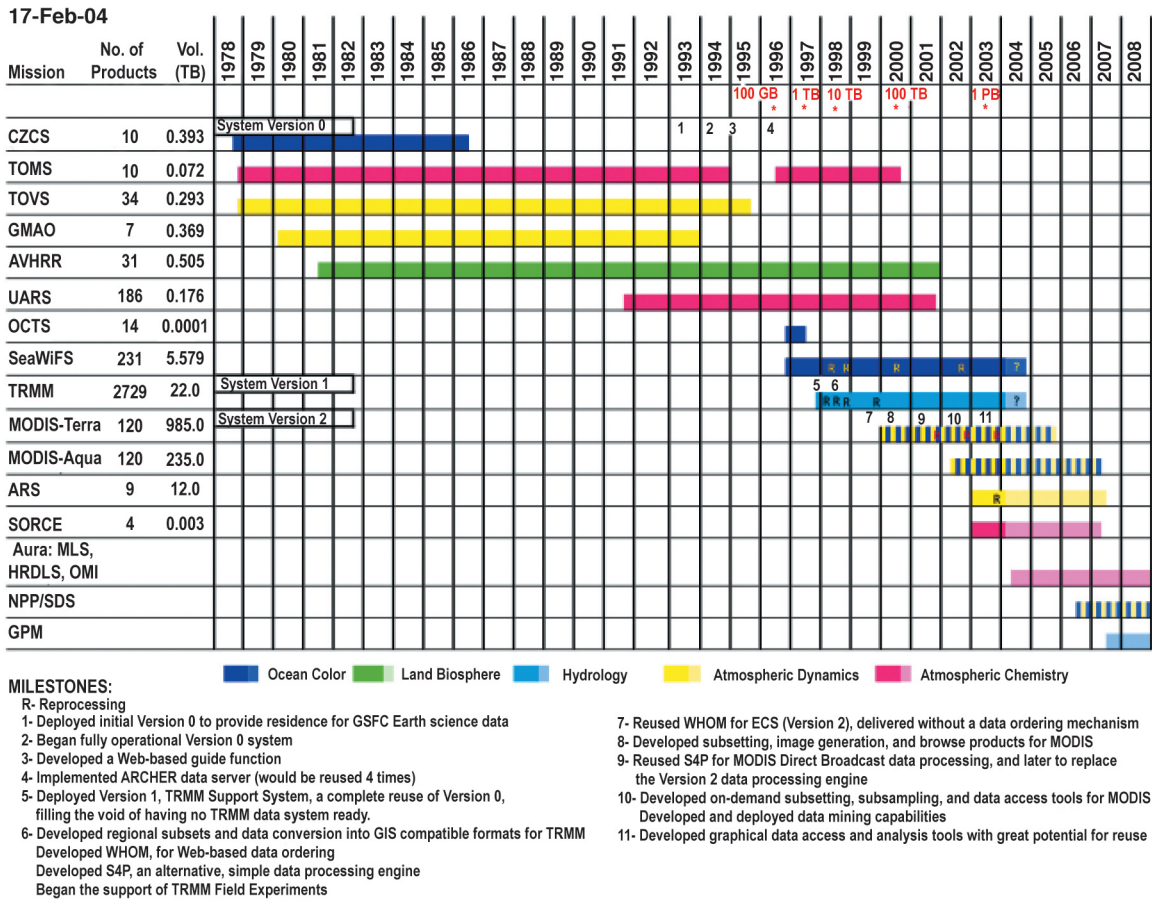
- Ensure that employees realize the value of their contributions
- Treat all employees equally; maintain a badgeless environment; work around distracting contractual issues

5.3.2 DATA SET HOLDINGS

The GES DISC holds remote sensing data for the following Earth Science disciplines:

- Atmospheric Chemistry
- Atmospheric Dynamics
- Hydrology
- Interdisciplinary Studies
- Ocean Color
- Land Biosphere

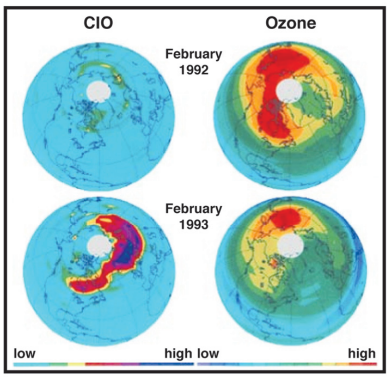
The timeline shown below shows all mission-oriented data sets currently residing at the GES DISC. The bars are color coded to reflect similar continuous discipline-oriented data sets. This is a helpful view of GES DISC holdings, as NASA ESE moves from mission data sets, to measurement data sets to facilitate science.



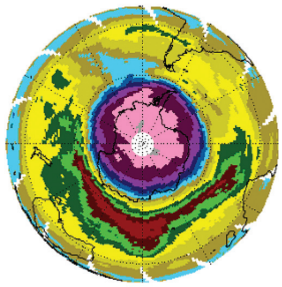
MILESTONES:
R- Reprocessing
1- Deployed initial Version 0 to provide residence for GSFC Earth science data
2- Began fully operational Version 0 system
3- Developed a Web-based guide function
4- Implemented ARCHER data server (would be reused 4 times)
5- Deployed Version 1, TRMM Support System, a complete reuse of Version 0, filling the void of having no TRMM data system ready.
6- Developed regional subsets and data conversion into GIS compatible formats for TRMM
Developed WHOM, for Web-based data ordering
Developed S4P, an alternative, simple data processing engine
Began the support of TRMM Field Experiments
7- Reused WHOM for ECS (Version 2), delivered without a data ordering mechanism
8- Developed subsetting, image generation, and browse products for MODIS
9- Reused S4P for MODIS Direct Broadcast data processing, and later to replace the Version 2 data processing engine
10- Developed on-demand subsetting, subsampling, and data access tools for MODIS
Developed and deployed data mining capabilities
11- Developed graphical data access and analysis tools with great potential for reuse

The following figures illustrate discipline-specific imagery and data sources that are accessible from the GES DISC data holdings.

GES DAAC Science Disciplines



Relationship between stratospheric Cholrine Monoxide and Ozone



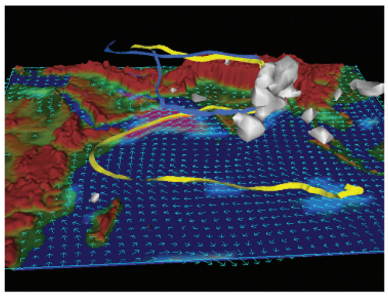
Antarctic Ozone Hole 9/25/99 as seen by TOMS

Atmospheric Chemistry

Heritage TOMS
Heritage SBUV
UARS
EP-TOMS
SORCE
HIRDLS (AURA)
MLS (AURA)
OMI (AURA)

Blue - Future Missions
Red - Current Missions
Black - Closed Data Set

GES DAAC Science Disciplines

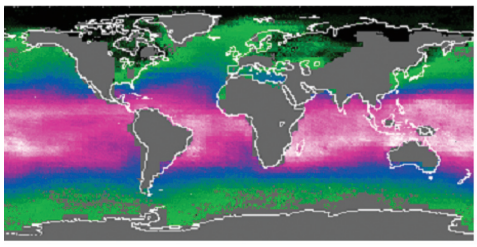


Air Parcel Trajectories computed using Data Assimilation

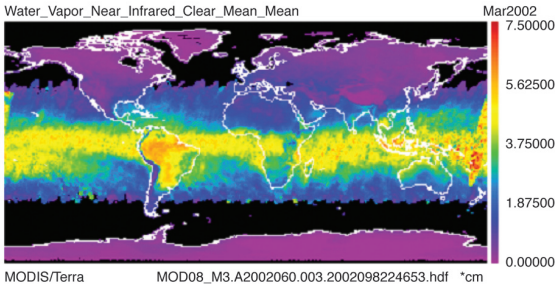
Atmospheric Dynamics

TOVS Pathfinder
Data Assimilation
MODIS
AIRS

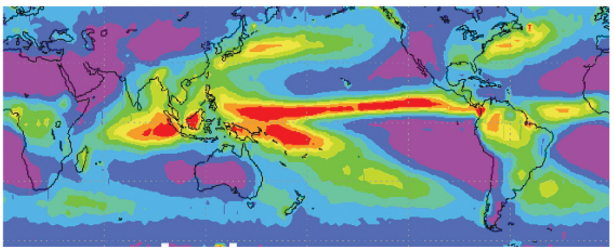
Red - Current Mission
Black - Closed Data Set



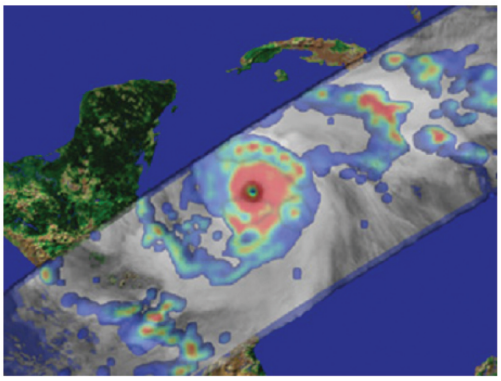
TOVS 1000 MB Monthly Mean Specific Humidity



GES DAAC Science Disciplines



GPCP Annual Mean Precipitation 1988-1998



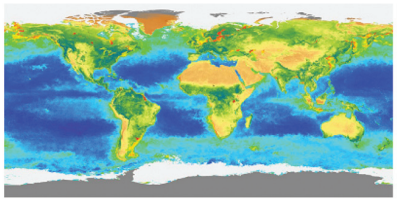
Hurricane Mitch as seen by TRMM

Hydrology

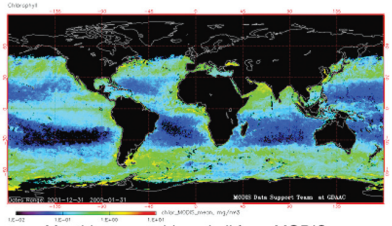
Rainfall Climatologies
Combined Satellite/ Gauge Rainfall
TRMM
TRMM Field Experiments
GPM

Blue - Future Missions
Red - Current Missions
Black - Closed Data Set

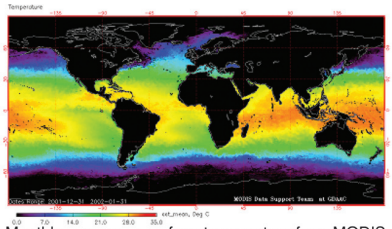
GES DAAC Science Disciplines



Monthly ocean chlorophyll and NDVI from SeaWiFS



Monthly ocean chlorophyll from MODIS



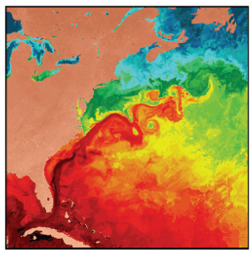
Monthly ocean sea surface temperature from MODIS

Global Biosphere

Ocean Color
- **CZCS**
- **SeaWiFS**
- **MODIS**

Land Biosphere
- **AVHRR Pathfinder**

Red - Current Missions
Black - Closed Data Set



Gulf Stream as seen by CZCS sensor

5.3.3 DATA SYSTEMS AND TOOL HOLDINGS

The GES DISC is not only the archive for the Earth Science data just described, but it provides the kinds of services and tools that further facilitate the usability and accessibility of this data. The following systems and tools (described below) were implemented by the GES DISC, often enabling EOSDIS functionality, which would otherwise not be available:

- The Version 0, Version 1, and Version 2 (ECS) data management systems
- Simple Scalable Script-based Science Processor (S4P) data production system
- Web-based Hierarchical Ordering Mechanism (WHOM) interface
- Subsetting and subsampling, and format conversion tools
- Near Archive Data Mining (NADM)
- DISC Online Visualization and Analysis System (DOVAS)

5.3.4 MAJOR ACTIVITIES AND HIGHLIGHTS

The GES DISC major activities and highlights center around the organizations' central operations and efforts to improve data system operability, efficiency, data accessibility, and data usability. These activities range from exploring and implementing new data management technologies, to developing value added products and tools, to exploring advanced data center paradigms for providing user services for the sake of facilitating data usage for research and applications. In addition, much time was spent in redefining the GES DISC business model to ensure that all customers were being serviced in accordance with new ESE strategies. Most noteworthy of all is that, GES DISC strategies have evolved to focus further on discipline based data archives, distribution, and support. In particular, the GES DISC Web presence has been revamped, specific measurements have been accentuated (based on science collaborations and in-house expertise), and data analysis, access, and usability tools have been developed that were able to be reused for different science measurements

In January 2003, the SORCE mission was launched and from the beginning, has faultlessly provided data to the GES DISC for archiving. The addition of this data for receiving and processing two flows of MODIS data, plus a flow of AIRS data, has been met with great success.

GES DISC highlights in 2003 and their impacts, organized by DISC groups, are described in the following subsections.

5.3.4.1 GES DISC System Engineering

The GES DISC Engineering staff is primarily responsible for maintaining the integrity, currency, and usability of GES DISC operational systems, as well as taking on many new innovative activities that add very worthwhile functions to the GES DISC arsenal of data management capabilities.

Expanded Use of the S4P System: S4P was self initiated and developed by the GES DISC as an alternative data processing engine for new missions needing a simple way to execute data-driven science algorithms. S4P lends itself to be easily portable to the DISC's main processing system, as well as scientist site data processing environments. S4P's success is reflected in the fact that it has been reused four times, including integration into ECS, and has provided a capability previously unavailable to various projects. This year, S4P replaced the ECS Planning and Data Processing System (PDPS) as the sole data production engine for these instruments: MODIS (Terra, processing and reprocessing); MODIS (Aqua, processing and reprocessing,

when it starts); and AIRS. This 'simpler' processing engine has been almost maintenance free, drastically reducing the ESDIS Project's custom software maintenance costs.

NADM Environment: The success of last year's Data Mining activities associated with TRMM data, lead to the development of the NADM environment. Given that the first operation scientists often perform on newly acquired data is extract subsets of the data based on their research interests, the NADM environment affords scientists the opportunity to have their first data reduction operations done in a secure environment at the GES DAAC. This provides the advantage of only having to transmit, receive, and store a much smaller data set at the scientist's site, and frees up the scientist's computer for more analytical processes. By cleverly marrying this environment to the GES DAAC Data Pool (a Redundant Array of Inexpensive Disks [RAID] archive that cycles the latest data produced for MODIS and AIRS on- and off-line, providing quick and easy data access), large volumes of the most current data are being reduced in size, and immediately captured by scientists. For global data researchers, this (and the subsampled data generated by the GES DAAC) is the only way to acquire MODIS data in a meaningful way.

Advanced Technology Research for Data Management Applications: GES DAAC made great strides in researching, analyzing, and in some cases, prototyping promising advanced technologies for the ultimate purpose of enhancing the usefulness of Earth science data systems in retrieving specific desirable data-in short, to bring data management systems to the next level of maturity in serving increasingly more sophisticated users. Three areas were studied:

1. Conceptual architectures for intelligent archives that would enable users to extract derived information from data holdings;

2. Neural networks that can help identify and classify significant events captured in remote sensing data; and

3. Machine learning techniques for decision support in intelligent data management.

5.3.4.2 GES DISC System Execution

The System Execution team is responsible for the operations of the GES DISC active archive systems, ensuring that the system produces, archives, and distributes data properly, and the system is operating optimally.

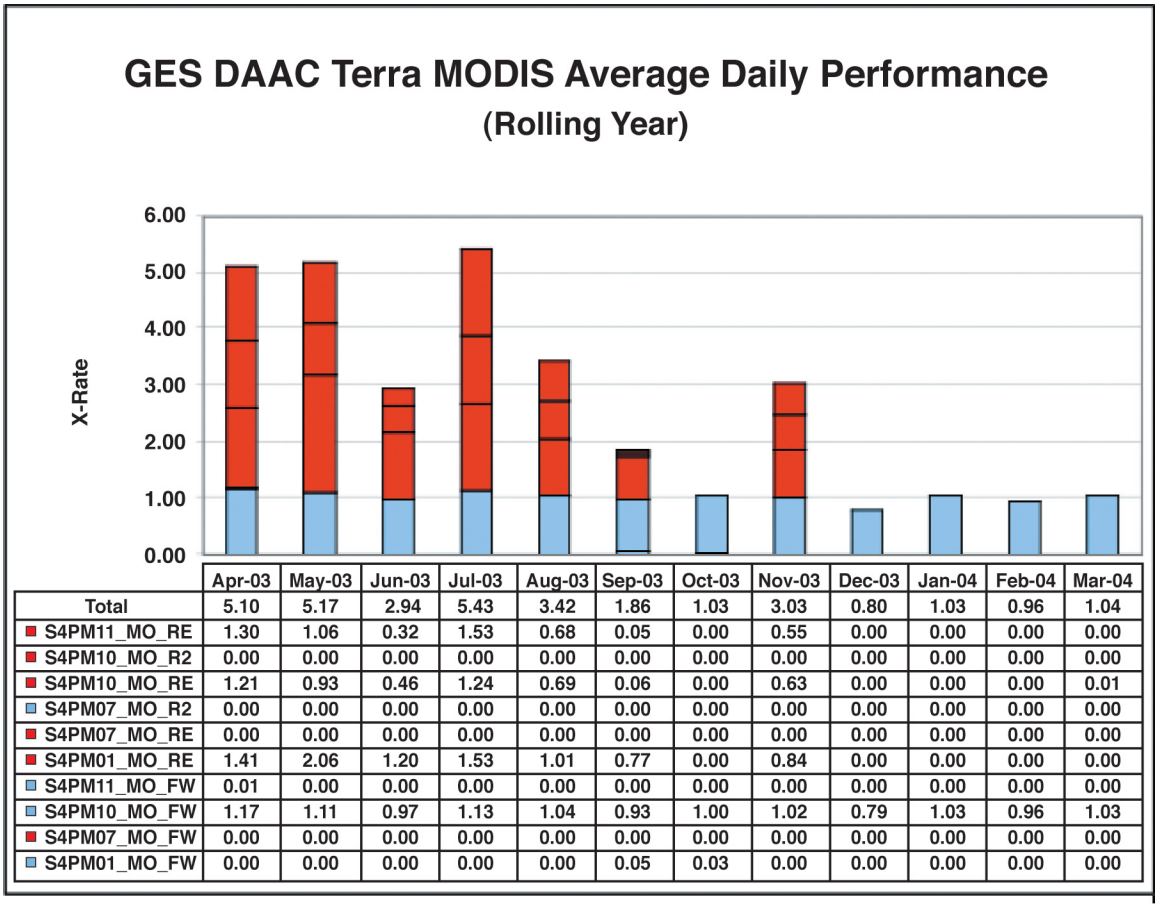
Procedural Accomplishments: In conjunction with the MODIS Science Team, the GES DISC began, and successfully completed, the MODIS data reprocessing for each MODIS mission data set, resulting in fully validated level-1 data (and counting) produced and archived. In addition, the GES DAAC operations staff, operate the data management system continuously, and are now very knowledgeable about the behavior of the system, was able to take advantage of increasing throughput rates. With the system being tuned to maximize data throughput, rates of greater than 4X (4 times the amount of data moving through the system than is being ingested from the instrument, e.g., 24 hours of level-0 data being processed to level-1b in 6 hours) and data processing requests exceeding 10,000 per 24 hours, became common place-well over system requirements.

All known ECS procedures (planned and unplanned) have been documented during this period, allowing the operations staff to perform more efficiently, more independently, and with greater responsibility.

Data Archive Accomplishments: In archiving over 1 PB of data in ECS, and 40 TB of data in the Version 0/1 systems, the GES DISC had a number of accomplishments:

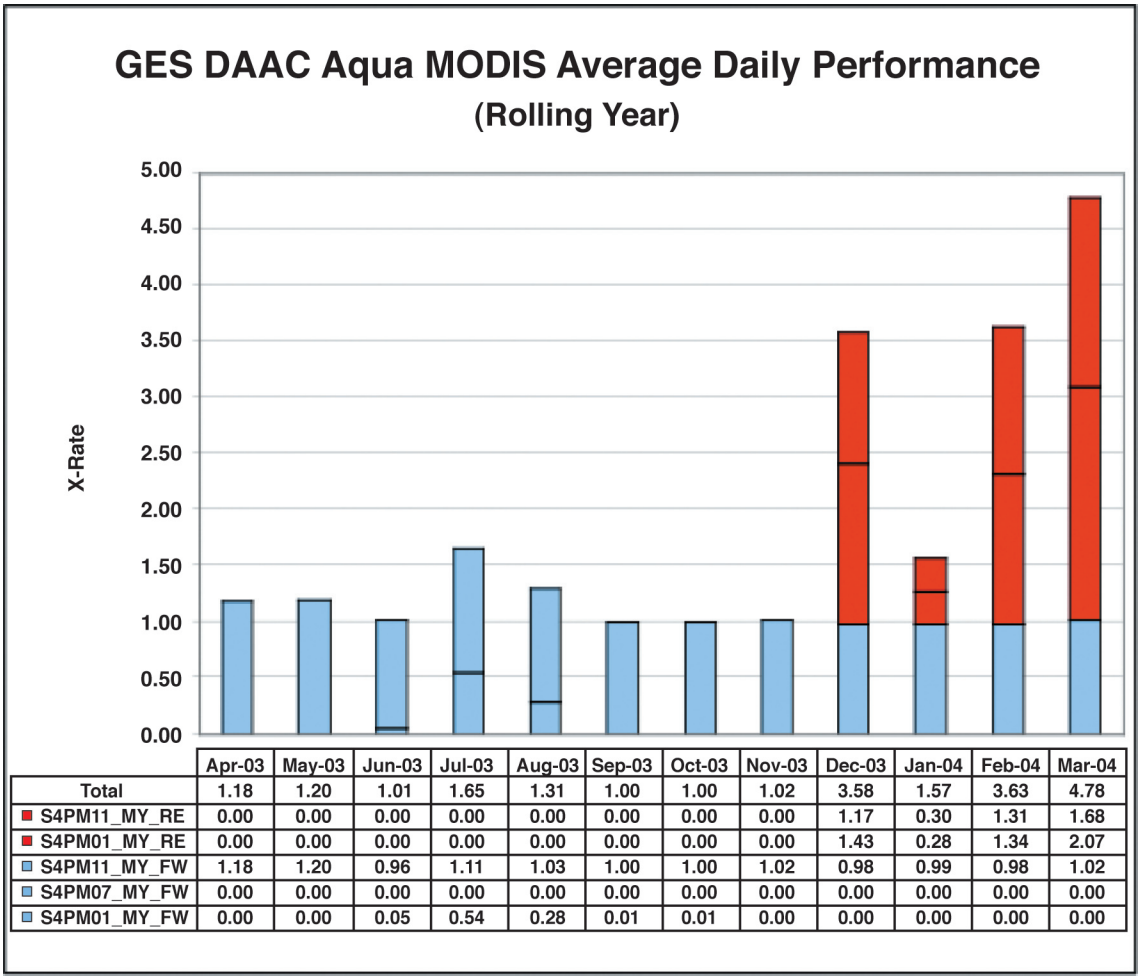
- Routinely ingested data from the MODIS Processing System (MODAPS).
- Processed and distributed special requests of data in support of major field campaigns.
- During the MODIS Collection 4 Reprocessing, and MODIS Terra and Aqua processing, over 3 TB of MODIS data were archived per day.
- From instrument turn on, all AIRS data was processed with no major glitches.
- Entertained over 2500 requests for MODIS data per month, consistently, as well as over 2000 users of heritage data.
- Added hardware to enhance ECS processing.

The following figures illustrate the production, archive, and distribution metrics at the GES DAAC:

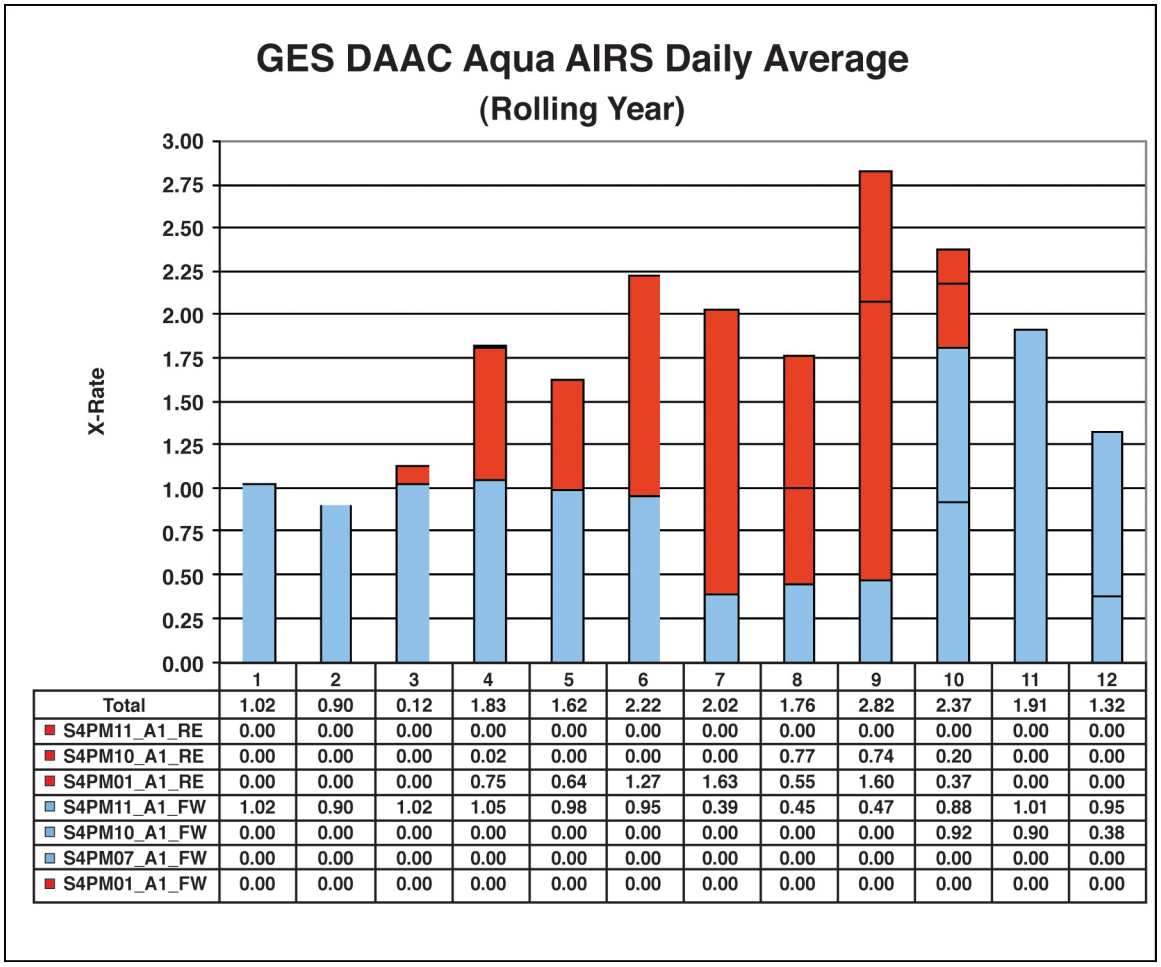


	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04
Total	5.10	5.17	2.94	5.43	3.42	1.86	1.03	3.03	0.80	1.03	0.96	1.04
S4PM11_MO_RE	1.30	1.06	0.32	1.53	0.68	0.05	0.00	0.55	0.00	0.00	0.00	0.00
S4PM10_MO_R2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S4PM10_MO_RE	1.21	0.93	0.46	1.24	0.69	0.06	0.00	0.63	0.00	0.00	0.00	0.01
S4PM07_MO_R2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S4PM07_MO_RE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S4PM01_MO_RE	1.41	2.06	1.20	1.53	1.01	0.77	0.00	0.84	0.00	0.00	0.00	0.00
S4PM11_MO_FW	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S4PM10_MO_FW	1.17	1.11	0.97	1.13	1.04	0.93	1.00	1.02	0.79	1.03	0.96	1.03
S4PM07_MO_FW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S4PM01_MO_FW	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.00

MODIS PRODUCTION: 1X = ~ 460 GB/day



	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04
Total	1.18	1.20	1.01	1.65	1.31	1.00	1.00	1.02	3.58	1.57	3.63	4.78
S4PM11_MY_RE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.30	1.31	1.68
S4PM01_MY_RE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.43	0.28	1.34	2.07
S4PM11_MY_FW	1.18	1.20	0.96	1.11	1.03	1.00	1.00	1.02	0.98	0.99	0.98	1.02
S4PM07_MY_FW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S4PM01_MY_FW	0.00	0.00	0.05	0.54	0.28	0.01	0.01	0.00	0.00	0.00	0.00	0.00

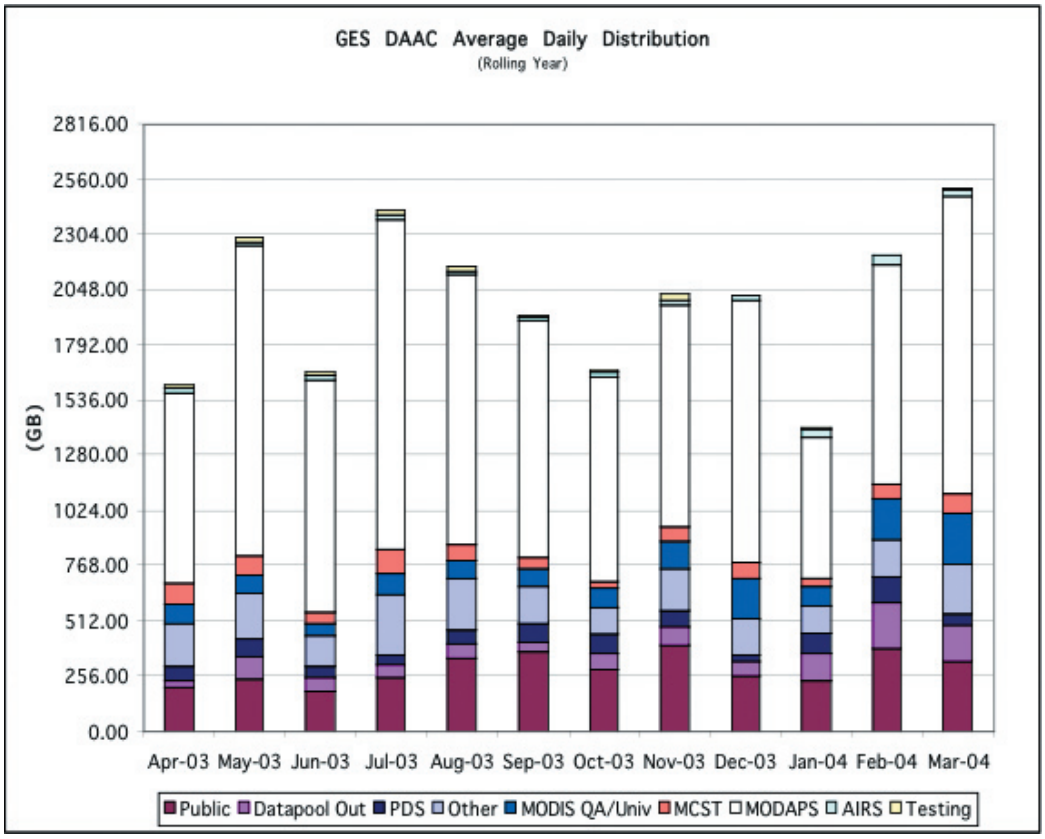


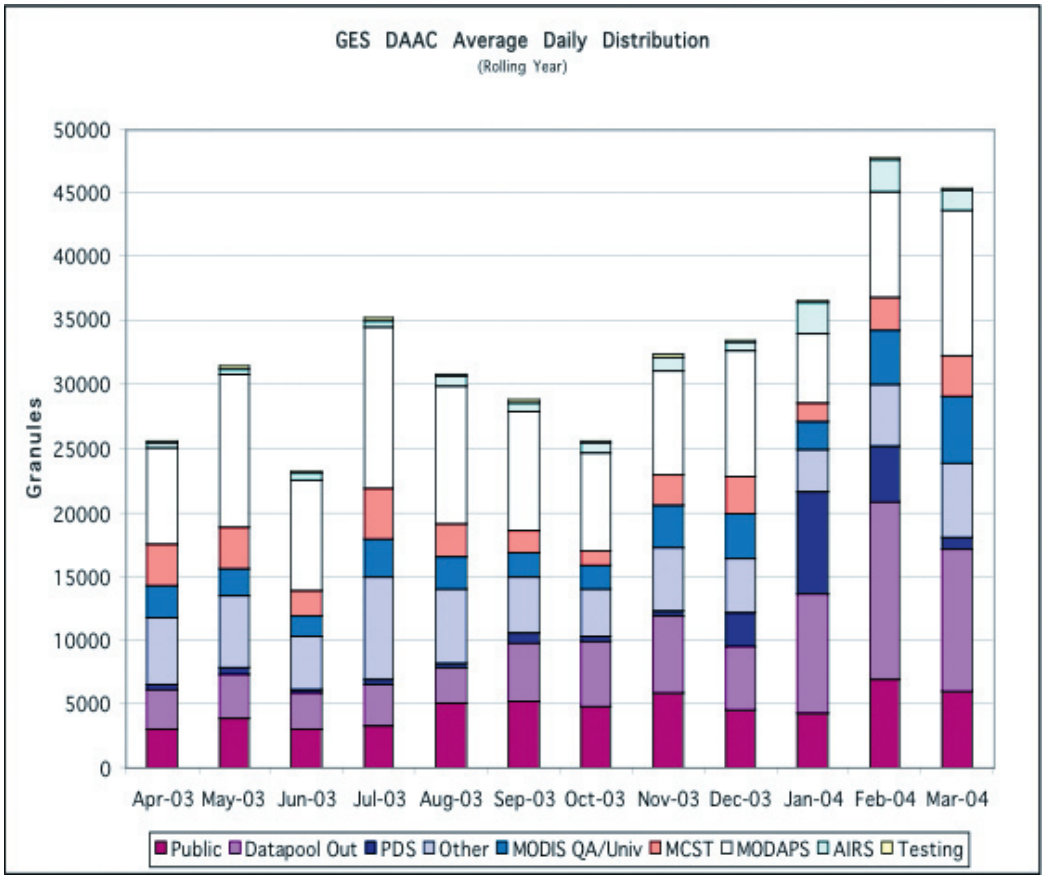
	1	2	3	4	5	6	7	8	9	10	11	12
Total	1.02	0.90	0.12	1.83	1.62	2.22	2.02	1.76	2.82	2.37	1.91	1.32
S4PM11_A1_RE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S4PM10_A1_RE	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.77	0.74	0.20	0.00	0.00
S4PM01_A1_RE	0.00	0.00	0.00	0.75	0.64	1.27	1.63	0.55	1.60	0.37	0.00	0.00
S4PM11_A1_FW	1.02	0.90	1.02	1.05	0.98	0.95	0.39	0.45	0.47	0.88	1.01	0.95
S4PM10_A1_FW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.90	0.38
S4PM07_A1_FW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S4PM01_A1_FW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Archive Summary of MODIS/AIRS Data

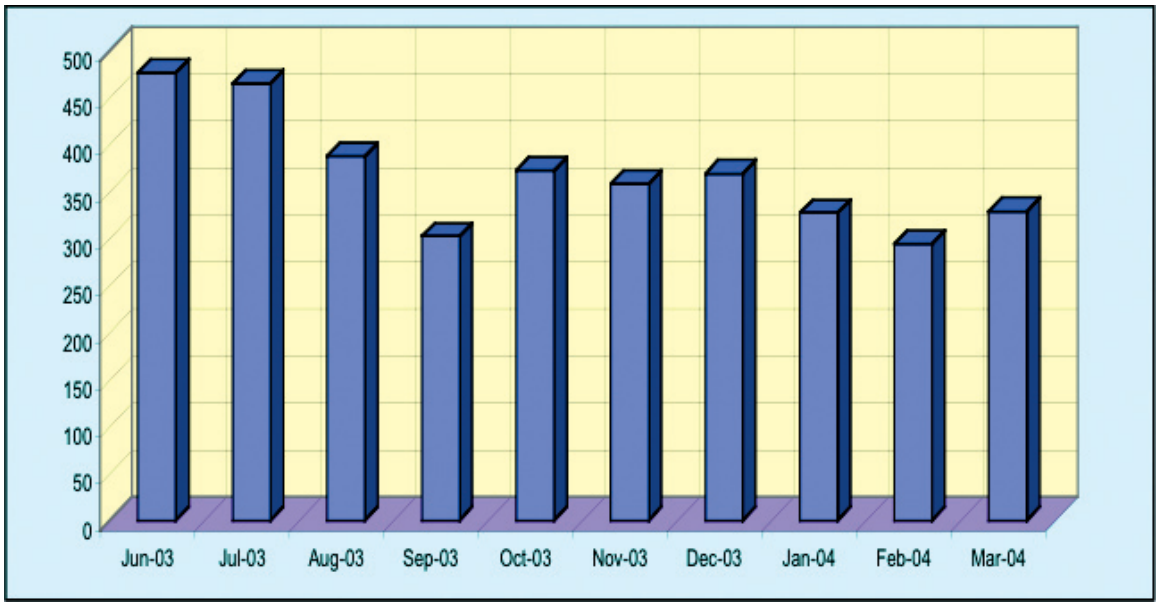
	Amount per Month [TB] Sustained*	Total Amount to Date [PB]	"On the Floor" Currently [PB]
GSFC	82	1.3	~1.1

*November 2003 to January 2004 averaged

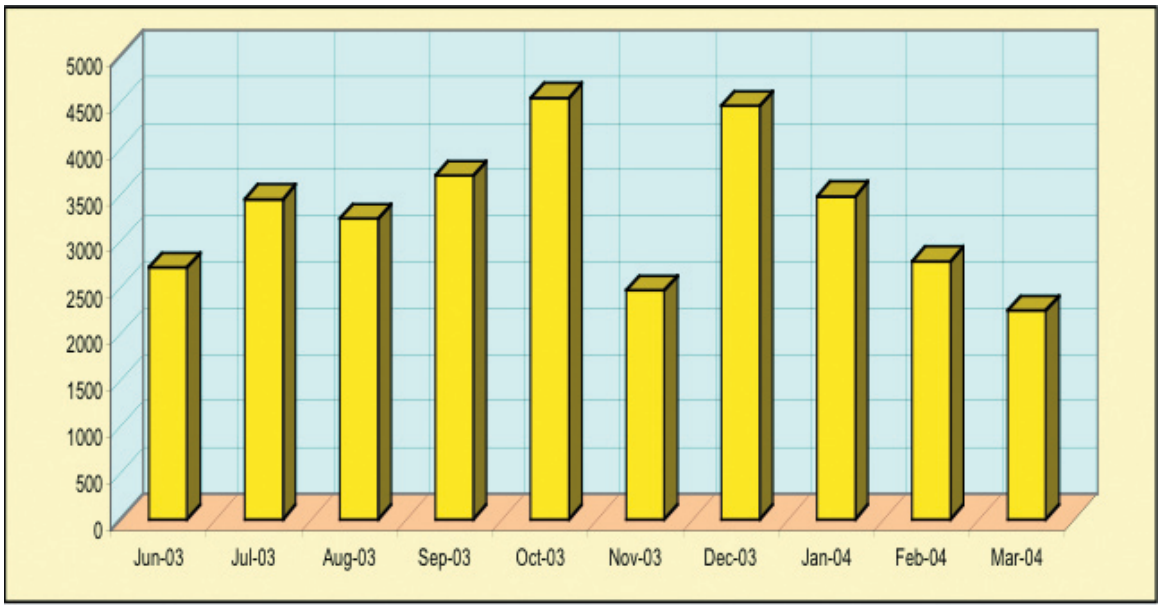

GES DAAC Average Daily Distribution
(Rolling Year)
(GB)
2816.00
2560.00
2304.00
2048.00
1792.00
1536.00
1280.00
1024.00
768.00
512.00
256.00
0.00
Apr-03 May-03 Jun-03 Jul-03 Aug-03 Sep-03 Oct-03 Nov-03 Dec-03 Jan-04 Feb-04 Mar-04
Public Datapool Out PDS Other MODIS QA/Univ MCST MODAPS AIRS Testing


GES DAAC Average Daily Distribution
(Rolling Year)
Granules
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Apr-03 May-03 Jun-03 Jul-03 Aug-03 Sep-03 Oct-03 Nov-03 Dec-03 Jan-04 Feb-04 Mar-04
Public Datapool Out PDS Other MODIS QA/Univ MCST MODAPS AIRS Testing

June 2003- March 2004
Ingest and Archive
VERSION 0/VERSION 1 DATA SETS



June 2003- March 2004
Distribution
VERSION 0/VERSION 1 DATA SETS



5.3.4.3 GES DISC Data Support

The Data Support Team (DST) consists of science-trained and engineer-trained people who support GES DISC data. Each member of the DST specializes in GES DISC discipline-specific (listed below) data holdings. DST members not only provide user and data support, but they also are tasked to develop value-added products, requiring small efforts, are often pursued by the DSTs. Another major task of the DST is to acquire and make available NOAA National Centers for Environmental Prediction (NCEP) ancillary data products to all ESE DAACs:

Developing Value Added Products, Tools, and Documentation: The GES DISC DST developed additional extensions to the EOSDIS Core System (ECS) to enhance operability (e.g., metrics tools, data manipulation tools, user requested interfaces), essential for reporting progress and system efficiency. In addition, the team developed software to create value added products for TRMM, MODIS, and AIRS, such as regional subsetting, on-demand channel subsetting, subsampling, multiple data ordering tool, data conversion to GIS and binary formats, and data mining. These tools address two user specified data access issues: the large minimum volume that can be shipped, and the need to provide data in alternative formats.

The release of MODIS products, now accessible and being used by the public, is greatly aided by extensive search-and-guide documentation prepared by the GES DISC DST, meeting the standards of EOSDIS and satisfaction of the users.

Recognizing the diversity of data access protocols (again, one size does not fit all) and in response to user requests, the GES DISC is addressing the needs of its users by developing the Universal Data Reduction Server to serve data using various protocols.

Many new value added data products are available through the GES DISC:

- All post-boot TRMM Precipitation Radar (PR) products;
- Six new TRMM ground validation (GV) data products processed by the University of Washington and delivered regularly to TSDIS;
- MODIS subsetted products for the CloudSat Project;
- Special subsets of the Data Assimilation data in support of the Compact Disk-Read Only Memory (CD-ROM) assembled for the Southern African Regional Science Initiative (SAFARI) campaign; and
- Various data sets, which can be viewed through the Web-based Geographic Information Systems (WebGIS) client as GIS levels.

In addition, GES DAAC subsetting software was modified to support the new Goddard Earth Observing System (GEOS-4) Assimilation data products provided by the GMAO.

Science Support and Collaboration: The GES DAAC began a mutually beneficial relationship with the United Nation's World Food Programme in which the GES DAAC provides remote sensing imagery and captures to support articles relating climate with food production. With this new application for NASA data comes popularity, as additional organizations are learning the usefulness of NASA Earth science data for applications research.

Responding to Data Support Needs: GES DAAC personnel, with the objective of providing a better understanding of GES DAAC data and services to selected communities, initiated and/or participated in several workshops:

- Initiation of the data support workshop for AIRS science team members to further enhance and describe the GES DAAC services that will (at the time) soon support AIRS,
- Initiation of the MODIS Oceans Products Workshop at the 2003 Ocean Sciences Meeting, and
- Initiation of an ocean color data seminar at the College of Marine Sciences at the University of South Florida.

Prior to the delivery of the ECS user interface, the GES DISC successfully adapted and reused the Version 0/Version 1 Web-based Hierarchical Ordering Mechanism (WHOM) as an interface to accessing MODIS data. The WHOM reuse has proven not only to be a user friendly alternative for accessing MODIS data, but

a reliable backup to the EOSDIS interface (EOSDIS Data Gateway or EDG), and currently a more popular means to access MODIS data at the GES DISC.

The GES DISC provides a full suite of user services, from telephone and e-mail support to the recently implemented MODIS Frequently Asked Questions Web page. The GES DISC fully understands the various levels of service that may be provided, and strives for the highest affordable level. In fact, a preliminary version of a Data Center Levels of Service model had been circulated by the GES DISC.

GES DAAC personnel gave papers or presentations at several notable conferences and workshops throughout 2003 to promote the use of GES DISC data and services:

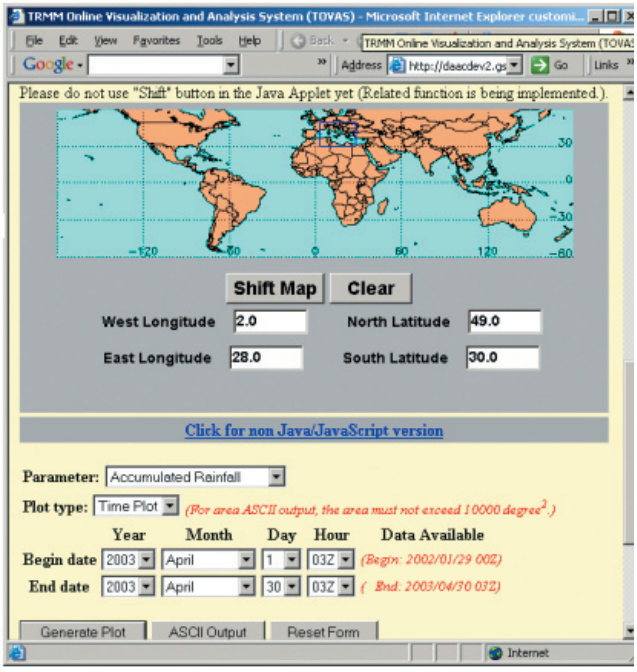
- Fall AGU—Presented poster papers and hosted the GES DAAC booth;
- International Geoscience and Remote Sensing Symposium (IGARRS)—Presented poster papers and one presentation paper;
- ESE Federation—Presented papers; and
- American Society for Photogrammetry and Remote Sensing (ASPRS)—Presented poster papers and hosted the DAAC-wide booth.

DISC On-Line Visualization and Analysis System (DOVAS): The GES DISC has developed this tool to quickly serve up online data and allows the user to visualize specific spatial areas, create plots and histograms of the selected data, and provides ASCII lists of the data. The tool has been modified so that it can be easily reused by simply specifying different online data products. Thus far, DOVAS has been used for TRMM data products (hydrology), MODIS (aerosol data), and agricultural applications data. (See Sect. 5.3.4.5, below, for a discussion on the Cooperative Agreement Notice [CAN].) Additional instantiations are planned. DOVAS lends itself nicely as a measurement based science analysis tool. The following exemplifies the top-level user interface for DOVAS.

Web-Based Online Analysis Tool

Instead of ordering large files, users select geophysical parameter(s), area, and time interval, and get results in seconds.

Output:
-Numerical (ASCII)
-2D plots
-Correlations
-Animation



5.3.4.4 GES DISC Science Integration

The GES DISCs Science Integration group ensures that science software and associated documentation is integrated into the DISC data systems.

Taking science software from one development environment and integrating and testing it into the GES DISC has proven to be an important, and precise effort. GES DAAC personnel now integrate MODIS level-1 science software for two MODIS processes, as well as a full suite of AIRS data processing software. The GES DISC Science Integration group has improved the efficiency of the MODIS Science Software Integration and Test (SSIT) process, thereby more easily accommodating new and sudden changes to science software (also known as Product Generation Executables [PGEs]) resulting from instrumentation changes and necessary calibration Look-up Tables (LUTs) changes, with little effect to the science team.

The Science Integration group was also involved with two major activities:

- Active involvement in the MODIS Data Processing Review. Personnel not only provided much information to the MODIS Team Leader regarding MODIS level-1 processing and data archive, but also wrote major sections of the Review Preparation White Paper, and presented at the review. This exercise resulted in much greater coordination between the principal investigator (PI) processing system and the GES DAAC.
- A self initiative to better understand the issues related to ordering and receiving data from ECS. The Data Order and Delivery Group (DODGr) uncovered many inefficiencies and system bugs as it stepped through the data ordering process. As the study proceeded, finding were addressed immediately and system improvements were realized quickly. The final reports came later.

5.3.4.5 GES DISC-Wide Highlights

There were a number of GES DISC-wide activities.

The GES DISC was very active in proposing relevant work to the NASA CAN, Earth Science Research, Education, and Applications Solutions Network (Earth Science REASoN). The GES DISC was very successful on the following winning proposals:

a. PI—Integrating NASA ESE Data into Global Agricultural Decision Support Systems (Steve Kempler)
b. Co-I—Development and Maintenance of An Ocean Color Time Series (Watson Greg, PI)
c. Provided letters of support—
    - A Thematic Data Portal to Satellite-Derived Ocean Surface Properties: Discovery and Access (Peter Cornillon, PI)
    - GENESIS-II: Data Fusion and Analysis for Multi-Sensor Earth System Science (Thomas Yunck, PI)
    - The Invasive Species Data Service: Towards Operational Use of ESE Data in the USGS Invasive Species Decision Support System (John Schnase, PI)
d. SEEDS—The GES DAAC provided much informational experience to the very important ESE Data Management initiative regarding the evolution of Earth science data management systems. In light of decreasing computing prices, advancing computer technologies, and the community desire to maximize the availability of Earth science data, the GES DAAC supported several of the SEEDS areas of study, including cost of data center modeling, science data levels of service, governance of distributed data management systems, and data life cycle preparations for long term data stewardship.

e. ESE Federation—The GES DAAC continued to participate in key activities that lead to further maturing the Federation.
f. Global Precipitation Mission (GPM)—The GES DISC participated in the GPM Planning Workshop and submitted a technical and cost proposal for the data system.

5.4 GMAO Computer System Group

Gi-Kong Kim of Code 902 is leading the Computing Systems Group (CSG) of 900.3/GMAO. The GMAO develops and uses models and assimilation systems to conduct research that advances understanding of climate variability and changes. The CSG is responsible for the following functional areas of GMAO.

Systems engineering:
- Information and configuration management
- GEOS system testing and verification
- GEOS system operations
- GEOS operational software development and maintenance
- GEOS data user support

The current GMAO Data Assimilation System (DAS) in use for routine DAS data production is the GEOS-4 system. The GEOS-4 system consists of the atmospheric general circulation model (GCM) called the finite volume GCM (fvGCM), and the statistical analysis system called the Physical-Space Statistical Analysis (PSAS). The GEOS-4 system operation generates 8 first-look and 13 late-look DAS products daily in support of the EOS instrument teams and also generates near-real time forecasts twice a day to support field experiment missions.

5.4.1 System Development and Maintenance

Since October 2002, when the GEOS-3 system was replaced with the GEOS-4 DAS system, the GEOS-4 system underwent two major system upgrades. The first upgrade was implemented in April 2003. This system release produced improved quality of skin temperature and humidity at near surface resulting in reduction of noise manifested in the spatial distribution of the data in high latitude regions.

The second GEOS-4 system release, which was implemented operationally in October 2003, made significant improvements in various data quality, particularly those parameters that are to be used by the EOS Clouds and Earth's Radiant Energy System (CERES) instrument team. The land surface model (LSM) was replaced with a new model called the Community Land Model (CLM) in the second system release. The CSG successfully implemented the two system releases. The CSG led the interaction with external interface elements such as ECS, DAAC, and EOS instrument teams to coordinate the planning for the GEOS-4 system upgrades and tests.

The migration of GMAO high-end computing from ARC to the GSFC NASA Center for Computational Sciences (NCCS) was successfully completed in early September 2003, which was ahead of schedule. The CSG led the initial planning activities involving the GSFC NCCS and ARC. The migration was performed in phases such that computing workload that was less dependent on data was moved first. The GEOS operation was moved in the last phase to mitigate risks due to inherent instability in the NCCS system in the early period. The CSG played a critical role by providing system engineering-related consultation to the NCCS. The CSG also took the initiative to form a technical working group to plan and implement the porting of the GEOS-4 system to the Compaq architecture as part of the migration. This system porting was completed in time so that the production and system development could use the large Compaq computer at NCCS in

addition to the Silicon Graphics Inc. (SGI) platforms. The CSG provided close assistance to NCCS in relocating more than 150 TB of data. The migration of GEOS-4 system operation was carefully planned including sufficient system testing to ensure the smooth operation at NCCS before the computing systems at Ames for GMAO were turned off.

In preparation for the EOS Aura satellite launch in 2004, the GMAO has been collaborating with the Aura instrument teams and also with the atmospheric chemical transport modeling community, to define the GEOS data products requirements for the users. The CSG led the feasibility study to understand the system development effort required and to estimate cost and implementation schedule. The GMAO presented the result of the study and proposal for the operational production of eta-level DAS data products in a Aura science team meeting. The CSG led the development of the eta-level DAS products file specification and coordinated the document review by the users. It is expected that the production of the eta-level DAS products will start in time to support the Aura instrument teams.

5.4.2 GEOS System Operations

The GEOS-4 operations have produced all the First-Look and Late-Look data products in the forward processing stream without any serious anomalies. In addition to the forward processing, the CSG production team successfully completed the GEOS-4 reprocessing using the v4.0.2 for the MODIS instrument team in mid-August 2003, as planned. The reprocessed GEOS-4 data products for January 2000 through April 2003 were successfully archived at ECS/GSFC DAAC.

The production of DAS data for the TRMM period—called the TRMM reanalysis using the GEOS-3 system with a new capability to assimilate the precipitation observations—was successfully completed in March 2004. The analysis was done for the time period spanning December 1997 through December 2001. This was the first time that the spaceborn precipitation observations were assimilated in a reanalysis project.

The GEOS-4 data production operation successfully completed the near-real time support for the pre-Aura Validation Experiment (PAVE) conducted in January 2004. The PAVE used GEOS-4 5-day forecasts generated twice a day in the mission planning for flights from Houston to Costa Rica.

The GEOS operations team in the CSG completed the production of the GEOS-4 reanalysis for the CERES team for the period from February 2000 through March 2004, according to the agreement between the GMAO and CERES signed in October 2004. The CERES reanalysis using the frozen GEOS-4 system will cover the time period spanning from 1978 through March 2004, while the forward processing will continue to produce two late-look type data until 2007.

More details on the GEOS production operations can be obtained at the following URL: http://gmao.gsfc.nasa.gov/operations/.

5.5 SeaWiFS Data System

Two Global Change Data Center civil servants support the SeaWiFS Project, as well as the development and operations of the SeaWiFS Data System. For details of SeaWiFS Data System and its operations, refer to the NASA GSFC Laboratory for Hydrospheric Processes Annual Report.

5.6 TRMM Science Data and Information System

5.6.1 ORGANIZATION

TSDIS is the data and information processing facility for TRMM. TSDIS processes data from the three TRMM satellite instruments: the Visible and Infrared Scanner (VIRS), the TRMM Microwave Imager (TMI), and the Precipitation Radar (PR). TSDIS also ingests ground validation radar data from TRMM investigators and from the TRMM Office and catalogs associated metadata information in its database. All TRMM data products are sent to the GSFC DAAC for long-term archive. TSDIS provides data product browse and ordering support to a select group of investigators (e.g., TRMM algorithm developers, the TRMM instrument scientists, and TRMM data quality scientists). The general public accesses TRMM data through the Goddard DAAC.

TSDIS also provides science support to the TRMM algorithm developers. This support includes evaluation of algorithms in the TSDIS Integration and Test Environment (ITE) and development of data display tools.

5.6.2 FACILITY

The main computing resources consist of a distributed array of SGI computing platforms, which are partitioned into processing streams. These streams are aligned with particular TRMM instruments and with the type of processing (i.e., initial processing or reprocessing). The system is sized to ensure that satellite data can be processed well within 24 hours of receipt for initial processing. For reprocessing, the system was originally sized to generate data products at a rate of 2 data days per day. Upgrades have significantly enhanced this capability to beyond 6 data days per day.

Hewlett Packard (HP) computers are used to house the database, the automated scheduler, and Openview (task monitoring software). Data Direct Networks (DDN) RAID, NetApp, and Unitree storage devices provide large online and near-line storage capabilities. These large storage capabilities are especially helpful to speed reprocessing and algorithm testing, because the starter files are resident at TSDIS and they do not have to be retrieved through the DAAC pipeline.

A personal computer (PC) provides a link to the Science Data Processing Facility (SDPF), which supplies level-0 data and ephemeris files to TSDIS. Because the SDPF is now highly automated (known as Packet Processor-Automated, or Pacor-A), this link is essential for TSDIS operators to access needed files when problems occur with the SDPF server when that facility is not staffed. Upon request, TSDIS also can access files for retransmission to JAXA under these circumstances. JAXA (formerly the National Space Development Agency, or NASDA) is NASA's partner in the TRMM mission.

TSDIS also serves as an intermediary for sending instrument command requests and Quick Look data requests from the TRMM instrument scientists to the Mission Operations Center (MOC).

5.6.3 MAJOR ACTIVITIES

5.6.3.1 Science Support

TRMM Fire Product: The fire data were reprocessed at the request of users. There were discussions with several investigators who used the TRMM fire data in scientific papers that they published in the Journal of Geophysical Research (JGR) and Atmospheric Chemistry and Physics (ACP). The TRMM Fire Product generation is part of an ongoing effort. For more information, contact Dr. Yimin Ji (yji@tsdis.gsfc.nasa.gov).

Merged Rainfall Products: Intercomparisons were produced among rain gauge, TRMM satellite, and NOAA/Advanced Microwave Sounding Unit (AMSU) satellite rain estimates in support of science algorithm improvements and microwave rain product merging activities. Network connections were established between TSDIS and NOAA to acquire NOAA real-time infrared (IR) and microwave rain products for the ongoing merged product work. For more information, contact Dr. Yimin Ji (yji@tsdis.gsfc.nasa.gov).

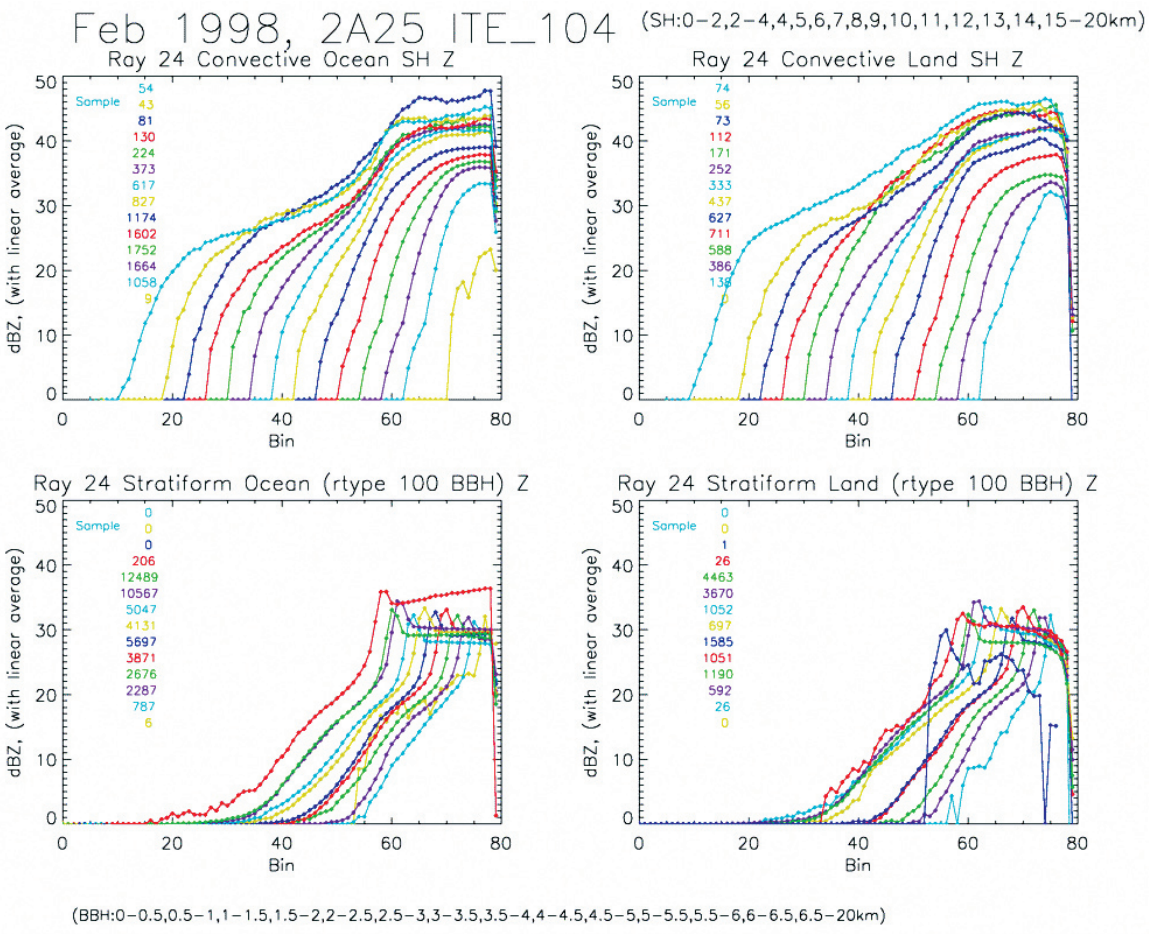
Preparation for TRMM Version 6 Data Reprocessing: Whereas the commencement of reprocessing was delayed until April 2004, much advance work was still needed to test and prepare revised science algorithms. TSDIS performed integration and testing for new versions of most of the science algorithms. The analyses of the tests included generation of statistics on individual granules, and the creation of time series, zonal analyses, joint probability distributions between algorithms, and profiles of reflectivity data.

The tests of each successive candidate Version 6 algorithm showed the incremental change of that version and revealed that the 2A25 and 2B31 algorithms were producing illegal values (Institute of Electrical and Electronic Engineers (IEEE) NaN or "Not a Number"). The algorithm developers fixed their algorithms so as to not write the illegal values.

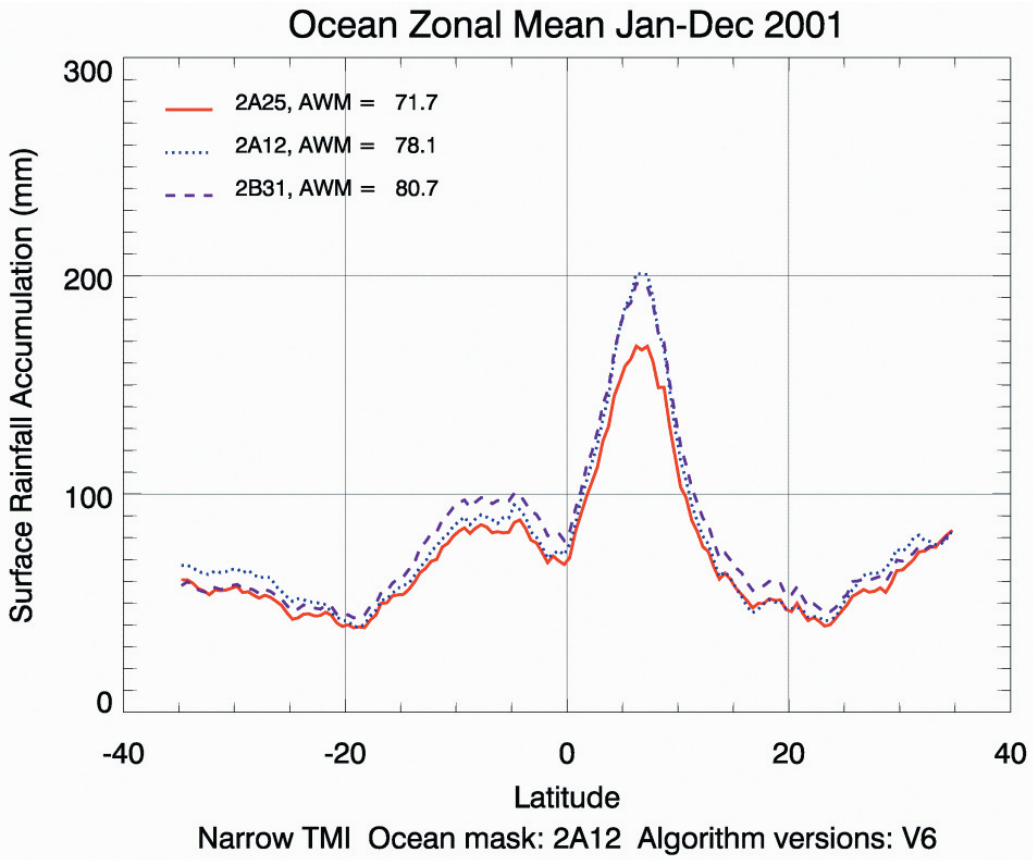
Previous testing for Version 5 and earlier versions of the algorithms used one month of test data. For Version 6, TRMM scientists requested more extensive testing. Tests that were four months in duration were run repeatedly in the Integration and Testing Environment (ITE). In addition, longer tests of 16 months, which included the TRMM satellite altitude boost month of August 2001, were run in the ITE. In order to accommodate the 20 times larger test data set, TSDIS made the analysis procedures more efficient. Additionally, analyses were developed that included distributions of each of the 20 Rain Types as defined by algorithm 2A23, profiles of algorithm 2A25 radar reflectivity data, zonal averages for the Pacific Ocean only, and zonal averages of level-2 data using algorithm 3G68. Of particular interest to the PR Science Team has been the behavior of the PR reflectivity and rainfall rate profiles as a function of storm height. Statistics of the profiles were generated to assist the PR Science Team in evaluating the improvement in rainfall estimates by the 2A25 algorithm (see the first figure below).

The first long test was run starting in July 2003. The test results showed that the algorithms, as of July 2003, had significant differences in their rainfall estimates. The second figure below shows the zonal mean surface rain rate of each level-2 rain algorithm for the year 2001. TRMM scientists presented and discussed these results at the Precipitation Science Team Meeting in October 2003. At that meeting, they decided to delay the start of Version 6 reprocessing until the algorithms could be improved even more to reduce the disagreement in rainfall estimates. After further modifications to the algorithms, a second long test commenced in December 2003 and continued into 2004.

The following figure shows vertical profiles of mean reflectivity from the nadir ray of the PR instrument for convective and stratiform (with bright band) rain types. The profiles are further split into land and ocean cases. Bin 0 is closest to the spacecraft while bin 79 is defined as the Ellipsoid Bin. The different profiles in each graph are separated by storm height or, in the case of stratiform rain, the height of the bright band.


Feb 1998, 2A25 ITE_104
(SH:0-2,2-4,4,5,6,7,8,9,10,11,12,13,14,15-20km)
Ray 24 Convective Ocean SH Z
Sample
54
43
81
130
224
373
617
827
1174
1602
1752
1664
1058
9
Ray 24 Convective Land SH Z
Sample
74
56
73
112
171
252
333
437
627
711
588
386
138
0
Ray 24 Stratiform Ocean (rtype 100 BBH) Z
Sample
0
0
0
206
12489
10567
5047
4131
5697
3871
2676
2287
787
6
Ray 24 Stratiform Land (rtype 100 BBH) Z
Sample
0
0
1
26
4463
3670
1052
697
1585
1051
1190
592
26
0
dBZ, (with linear average)
Bin
(BBH:0-0.5,0.5-1,1-1.5,1.5-2,2-2.5,2.5-3,3-3.5,3.5-4,4-4.5,4.5-5,5-5.5,5.5-6,6-6.5,6.5-20km)

The figure shown below is the zonal mean surface rainfall rates for the TRMM level-2 rain algorithms for the year 2001. Zonal mean rainfall rates were calculated from the first long test of candidate Version 6 algorithms, which were run in July 2003.



For more information, contact Dr. John Kwiatkowski (johnk@tsdis.gsfc.nasa.gov) regarding the PR algorithms, Dr. Yimin Ji (yji@tsdis.gsfc.nasa.gov) regarding the VIRS and TMI algorithms, and Mr. John Stout (stout@tsdis.gsfc.nasa.gov) regarding the combined algorithms.

5.6.3.2 Data and Information Processing

TRMM data products were generated for the satellite instruments. In 2003, 68,878 data products were created for initial processing. Each product represents a granule (i.e., 1 orbit) of data. The data products include level-1a through level-3b. Browse images (i.e., low resolution images used for product ordering) and Coincident Subsetted Intermediate (CSI) products between ground sites and TRMM overpasses were also created. A total of 6,107 browse images and 171,257 CSI products were generated.

No reprocessing was done in 2003. The TRMM Science Team scheduled the Version 6 reprocessing to begin in April 2004. In addition, no GV data products were received in 2003. Transfers from the TRMM Office are expected to resume in 2004.

Availability of the processing system continued to be high. Total system availability for the year was 98.3%. Of the 1.7% downtime experienced, 0.8% was unplanned. The remaining downtime, 0.9%, was scheduled, including system upgrades and routine maintenance.

5.6.4 HIGHLIGHTS

TRMM PR Sensitivity Studies: Sensitivity studies were performed for the 2A25 PR rainfall algorithm. These studies were coordinated with the JAXA/Earth Observing Research Center (EORC) in Japan. The studies made use of previously measured drop size distribution data and new techniques for retrieving path-integrated attenuation. Work in this area focused on the use of the Surface Reference Technique and its use in the 2A25 retrieval algorithm. This is an on-going study. For more information, contact Dr. John Kwiatkowski (johnk@tsdis.gsfc.nasa.gov).

Disdrometer Drop Size Distribution (DSD) Study: A technique has been developed to incorporate drop size distributions obtained from disdrometer measurements into the TRMM PR rain retrieval algorithm. This is being done in coordination with U.S. TRMM science team members. The primary goal of this work is to facilitate the inclusion of field campaign data into the TRMM satellite rain retrieval algorithms. Work was performed in collaboration with JPL and the 2B31 algorithm developer to assess retrieval differences between the combined and radar-only algorithm. This is an ongoing study. For more information, contact Dr. John Kwiatkowski (johnk@tsdis.gsfc.nasa.gov).

Determination of TRMM Spacecraft Attitude Using PR Data: A study continued in 2003 for developing and implementing a method for estimating the TRMM spacecraft attitude using data directly measured by the PR. Specifically, the interest was in the spacecraft roll in the across-track plane. The method turned out to be very reliable and it is independent of onboard attitude errors. This technique was used extensively during and after the TRMM altitude boost for attitude monitoring when the TRMM Earth Sensors failed and alternate means of attitude control were implemented. Work in 2003 concentrated on using the technique to estimate pre-boost attitude errors (back to mission launch in 1997) for use during the Version 6 reprocessing cycle. For more information, contact Dr. John Kwiatkowski (johnk@tsdis.gsfc.nasa.gov).

PR Ocean Retrieval Validation: Collaboration was initiated with Dr. Sandra Yuter (Univ. of Washington) regarding the PR satellite rainfall retrievals off the Eastern coast of South America. This area is of particular interest to Dr. Yuter because it is relatively dry with very low storm heights. The purpose of this work is to isolate possible satellite algorithm inconsistencies with ship-borne radar data. For more information, contact Dr. John Kwiatkowski (johnk@tsdis.gsfc.nasa.gov).

Data Format Activities: The TSDIS prototype data format system was used to create example formats for a hypothetical "Chinese Radiometer" and the radiometer on Megha-Tropiques. The resulting formats were presented at a GPM Data Working Group meeting in February in College Park, Maryland. For more information, contact Mr. John Stout (stout@tsdis.gsfc.nasa.gov).

Upgrades to the Data Processing System: An additional 16 TB of storage was ordered to enhance TSDIS capacity. In addition, wireless networking equipment was ordered to enhance TSDIS networking capability. Both of these upgrades will be installed in 2004. Finally, changes are being made to the facility operating systems, moving away from proprietary systems to Linux. For more information, contact Mr. Charles Cosner (Charles.M.Cosner@nasa.gov).

Hurricane Isabel Study: As Hurricane Isabel approached the Mid-Atlantic States in September 2003, the TRMM satellite overflew the storm an unusually large number of times in the storm's life cycle. The TRMM PR observed Hurricane Isabel six times, which is more times than the PR has seen with any other individual hurricane. What was especially significant was that the PR swath was effectively centered on the eye of the storm in each instance. In the future, this unique set of observations may help scientists understand how the heavy rain in a hurricane's eyewall evolves during the hurricane's lifetime. The composite image shown on

the cover (of this report) also shows the wider field of view of the TRMM Microwave Imager (TMI). The TMI collects passive microwave data that are similar to, but at a higher resolution than, the data of existing SSM/I instruments. Even after Hurricane Isabel struck the U.S. East Coast and forced the evacuation of NASA GSFC, TSDIS continued to provide near-real time monitoring of the heavy rain associated with Hurricane Isabel.

6. EDUCATION AND PUBLIC OUTREACH

GCMD

January 8: Interviewed by Janet Ormes and Gail Hodge for a chapter on Ontologies and Knowledge Codification being written for a book on Knowledge Management Technologies and Applications at NASA at the request of Dr. Jay Liebowitz, Code 300.

May 6–8: THematic Real-time Environmental Distributed Data Services (THREDDS) in Boulder, Colorado. Presented summary of GCMD activities as they relate to THREDDS data discovery efforts.

May 15–17: ESIP Federation Meeting at the University of Maryland. Gave presentation and demo of GCMD activities related to the Federation Interactive Network for Discovery (FIND) during the Federation Technical Workshop and participated in the Federation Showcase Demo and Poster session.

June 4–7: EDG/EOSDIS Clearinghouse (ECHO) meeting at GSFC, with keyword presentation.

TSDIS

TSDIS continued to answer researchers' questions about how to visualize TRMM data using the Orbit Viewer and to take suggestions for future enhancements to the Orbit Viewer. In 2002, contacts in the United States include researchers at the University of New Mexico, Hofstra University in New York, Earth Science Information Partner-3 (ESIP-3) in California, Massachusetts Institute of Technology (MIT), University of Iowa, and George Mason University in Virginia. In addition, TSDIS responded to questions about the Orbit Viewer from researchers in the following countries: Brazil, Canada, China, Germany, India, and Japan. For more information, contact Owen Kelley (okelley@tsdis.gsfc.nasa.gov).

APPENDIX 1. PRESENTATIONS AND PUBLICATIONS

GCMD:

Koken, P., W.T. Piver, F. Ye, A. Elishauser, L.M. Olsen, and C.J. Portier, 2003: "Temperature, Air Pollution, and Hospitalization for Cardiovascular Diseases Among Elderly People in Denver," *Environ. Health Perspectives,* **111,** 1,312–1,317.

Northcutt, T., and L. Olsen, June 2003: "Protecting Goddard Network Resources Via Transparent Network Bridges and Port Knocking Techniques," *Director's Discretionary Fund Presentation,* NASA Goddard Space Flight Center, Greenbelt, Maryland.

Olsen, L., 2003a: "CEOS International Directory Network Newsletter," **#16,** http://gcmd.gsfc.nasa.gov/pipermail/interop/2003-August/000013.html.

——, 2003b: "Overview and Demonstration of the Global Change Master Directory. Existing and Emerging Capabilities of the Global Change Master Directory," ESSAC Subcommittee on Information Systems and Services (ESISS), Washington, D.C.

Olsen, L.M., 2003a: "CEOS International Directory Network Newsletter," **#15,** http://gcmd.gsfc.nasa.gov/pipermail/interop/2003-April000011.html.

——, 2003b: "International Standards for Scientific Data and Open Source Products—An Analogy," presented at *Science Data Centers Symposium,* University of Maryland, College Park, Maryland.

——, G. Major, S. Leicester, K. Shein, J. Scialdone, H. Weir, S. Ritz, C. Solomon, M. Holland, R. Bilodeau, T. Northcutt, and R. Vogel, 2003: NASA/Global Change Master Directory, *Earth Science Keywords,* Version 4.2.2, http://gcmd.nasa.gov/Resources/valids/keyword_list.html.

Reitsma, F., and L. Olsen, 2004: "Spatial Data Accessibility and the Semantic Web." *SCISW2003,* (submitted).

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APPENDIX 2. ACRONYMS

AADC	Australian Antarctic Data Centre
ACP	Atmospheric Chemistry and Physics
AGU	American Geophysical Union
AIRS	Atmospheric Infrared Sounder
AMD	Antarctic Master Directory
AMSU	Advanced Microwave Sounding Unit
API	Application Programming Interface
ASDC	Atmospheric Sciences Data Center
ASPRS	American Society for Photogrammetry and Remote Sensing
BENEFIT	Benguela Environment Fisheries Interaction and Training
BIGSAM	Biologically Integrated Geospatial Salmonoid data Access and Management
BOVA	Biota of Virginia
BRD	Biological Resources Division
CAN	Cooperative Agreement Notice
CCRS	Canada Centre for Remote Sensing
CCRS	Canadian Centre for Remote Sensing
CDP	Community Data Portal
CD-ROM	Compact Disk-Read Only Memory
CEOS IDN	Committee on Earth Observation Satellites' International Directory Network
CERES	Clouds and Earth's Radiant Energy System
CIP	CEOS Interoperability Protocol
CLIVAR	Climate Variability and Predictability
CLM	Community Land Model
CORIS	Coral Reef Information System
CSDGM	Content Standard for Digital Geospatial Metadata
CSG	Computing Systems Group
CSI	Coincident Subsetted Intermediate
CVS	Concurrent Versioning System
DAAC	Distributed Active Archive Center
DAO	Data Assimilation Office
DAS	Data Assimilation System
DDN	Data Direct Networks
DF	Hierarchical Data Format
DIF	Directory Interchange Format
DISC	Data and Information Systems Center
DLESE	Digital Library for Earth System Education
DMAC	Data Management and Communications
DODGr	Data Order and Delivery Group
DODS	Distributed Oceanographic Data System
DOVAS	DISC Online Visualization and Analysis System
DSD	Drop Size Distribution
DSS	Data Support Section
DST	Data Support Team
DSWG	Data System Working Groups

ECHO	EOSDIS Clearinghouse
ECMWF	European Centre for Medium-Range Weather Forecast
ECS	EOSDIS Core System
EDG	EOSDIS Data Gateway
EORC	Earth Observation Research Center (Japan)
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
ES	Earth Science
ESDIS	Earth Science Data and Information Systems
ESE	Earth Sciences Enterprise
ESIP	Earth Science Information Partner
ESTO	Earth Science Technology Office
FGDC	Federal Geographic Data Committee
FIND	Federation of Information for Networked Discovery
FvDAS	Finite Volume Data Assimilation System
FvGCM	Finite Volume General Circulation Model
GB	Gigabyte
GCDC	Global Change Data Center
GCDIS	Global Change Data and Information System
GCM	General Circulation System
GCMD	Global Change Master Directory
GCOS	Global Climate Observing System
GEOS	Goddard Earth Observing System
GES	Goddard Earth Sciences
GHRC	Global Hydrology Resource Center
GIS	Geographic Information Systems
GISD	Geographic Information for Sustainable Development
GLOBEC	Global Ocean Ecosystems Dynamics program
GMAO	Global Modeling and Assimilation Office
GOFC	Global Observation of Forest Cover
GOOS	Global Ocean Observing System
GOSIC	Global Observing System Information Center
GPM	Global Precipitation Mission
GRID	Global Resource Information Database
GSFC	Goddard Space Flight Center
GSSP	Graduate Summer Student Program
GTOS	Global Terrestrial Observing System
GUI	Graphical User Interface
GV	Ground Validation
HP	Hewlett Packard
IDL	Interactive Data Language
IEEE	Institute of Electrical and Electronic Engineers
IGARSS	International Geoscience and Remote Sensing Symposium
IODE	International Oceanographic Data and Information Exchange
IOOS	Integrated Ocean Observing System
IR	Infrared

ISO	International Standards Organization
IT	Information Technology
ITE	Integration and Test Environment
JAXA	Japan Aerospace Exploration Agency
JCADM	Joint Committee on Antarctic Data Management
JGR	Journal of Geophysical Research
JPL	Jet Propulsion Laboratory
LAS	Live Access Server
LDA	Local Database Agent
LSM	Land Surface Model
LUT	Look Up Table
MBARI	Monterey Bay Aquarium Research Institute
MD	Not an acronym, but the name of software.
MEDI	Marine Environmental Data Information
MERMAiD	Metadata Enterprise Resource Management Aid
MIT	Massachusetts Institute of Technology
MOC	Mission Operations Center
MODAPS	MODIS Adaptive Processing System
MODIS	Moderate Resolution Imaging Spectroradiometer
MSFC	Marshall Space Flight Center
MuTPE	Museums Teaching Planet Earth
NADM	Near Archive Data Mining
NaN	Not a Number
NASDA	National Space Development Agency (Japan)
NBII	National Biological Information Infrastructure
NCAR	National Center for Atmospheric Research
NCCS	NASA Center for Computational Sciences
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Prediction
NetApp	Network Appliance
NOAA	National Oceanic and Atmospheric Administration
NSIDC	National Snow and Ice Data Center
ODC	OPeNDAP Data Connector
OMB	Office of Management and Budget
OpenAPI	Open-Applications Programming Interface
OPeNDAP	Open-source Project for a Network Data Access Protocol
OPS	Operations Facility
ORNL	Oak Ridge National Laboratory
Pacor-A	Packet Processor-Automated (part of the SDPF)
PAVE	Pre-Aura Validation Experiment
PC	Personal Computer
PDPS	Planning and Data Processing System
PGE	Product Generation Executable
PR	Precipitation Radar
PSAS	Physical-space Statistical Analysis System

PSC	Products and Services Cooperative
PWRC	Patuxent Wildlife Research Center
RAID	Redundant Array of Inexpensive Disks
RAMAS	Risk Assessment, Management, and Audit Systems
RDF	Resource Description Framework
RFC	Request for Comments
RSMAS	Rosenstiel School of Marine and Atmospheric Science
S4P	Simple Scalable Script-based Science Processor
SAFARI	Southern African Regional Science Initiative
SAIRE	Scalable Agent-based Information Retrieval Engine
SDPF	Sensor Data Processing Facility
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SEDAC	Socioeconomic Data and Applications Center
SEEDS	Strategic Evolution of Earth Science Enterprise Data Systems
SERF	Services Entry Resource File
SGI	Silicon Graphics Incorporated
SORCE	Solar Radiation and Climate Experiment
SPSS	Statistical Package for the Social Sciences
SQL	Structured Query Language
SSIT	Science Software Integration and Test
SSM/I	Special Sensor Microwave/Imager
SWEET	Semantic Web for Earth and Environmental Technology
TB	Terabyte
THREDDS	Thematic Real-time Environmental Distributed Data Services
TMI	TRMM Microwave Imager
TRMM	Tropical Rainfall Measuring Mission
TSDIS	TRMM Science Data and Information System
UNEP	United Nations Environmental Programme
USGS	United States Geological Service
USRA	University Space Research Association
UWG	User Working Group
V0	Version 0
V1	Version 1
V2	Version 2
VIRS	Visible and Infrared Scanner
WCRP	World Climate Research Programme
WDCs	World Data Centers
WebGIS	Web-based Geographic Information Systems
WHOM	Web-based Hierarchical Ordering Mechanism
WWF	World Water Forum
XML	Extended Mark-up Language
ZOPE	Zen of Object Publishing Enterprise

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Rapid, efficient access to Earth sciences data from satellites and ground validation stations is fundamental to the nation's efforts to understand the effects of global environmental changes and their implications for public policy. It becomes a bigger challenge in the future when data volumes increase from current levels to terabytes per day. Demands on data storage, data access, network throughput, processing power, and database and information management are increased by orders of magnitude, while budgets remain constant and even shrink.

The Global Change Data Center's (GCDC) mission is to develop and operate data systems, generate science products, and provide archival and distribution services for Earth science data in support of the U.S. Global Change Program and NASA's Earth Sciences Enterprise. The ultimate product of the GCDC activities is access to data to support research, education, and public policy.

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