Archiving Space Geodesy Data for 20+ Years at the CDDIS

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Abstract

Since 1982, the Crustal Dynamics Data Information System (CDDIS) has supported the archive and distribution of geodetic data products acquired by NASA programs. These data include GPS (Global Positioning System), GLONASS (GLObal NAvigation Satellite System), SLR (Satellite Laser Ranging), VLBI (Very Long Baseline Interferometry), and DORIS (Doppler Orbitography and Radiolocation Integrated by Satellite). The data archive supports NASA's space geodesy activities through the Solid Earth and Natural Hazards (SENH) program. The CDDIS data system and its archive have become increasingly important to many national and international programs, particularly several of the operational services within the International Association of Geodesy (IAG), including the International GPS Service (IGS), the International Laser Ranging Service (ILRS), the International VLBI Service for Geodesy and Astrometry (IVS), the International DORIS Service (IDS), and the International Earth Rotation and Reference Systems Service (IERS). The CDDIS provides easy and ready access to a variety of data sets, products, and information about these data. The specialized nature of the CDDIS lends itself well to enhancement and thus can accommodate diverse data sets and user requirements. All data sets and metadata extracted from these data sets are accessible to scientists through ftp and the web; general information about each data set is accessible via the web. The CDDIS, including background information about the system and its user communities, the computer architecture, archive contents, available metadata, and future plans will be discussed.

CDDIS Overview

The Crustal Dynamics Data Information System (CDDIS) is a dedicated data center supporting the international space geodesy community, providing easy and ready access to a variety of data sets, products, and information about these data. The data center was established in 1982 as a dedicated data bank to archive and distribute all Crustal Dynamics Project-acquired data and information about these data. Today, the CDDIS continues to serve as the NASA archive and distribution center for space geodesy data, particularly Global Navigation Satellite System (GNSS, currently GPS and GLONASS), laser ranging, Very Long Baseline Interferometry (VLBI), and Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) data. The specialized nature of the CDDIS lends itself well to enhancement to accommodate diverse data sets and user requirements.

The CDDIS serves as one of the primary data centers for the following International Association of Geodesy (IAG) services:
- International GPS Service (IGS)
- International Laser Ranging Service (ILRS)
- International VLBI Service for Geodesy and Astrometry (IVS)
- International Earth Rotation and Reference Systems Service (IERS)
- International DORIS Service (IDS)

Operational data centers deposit data to incoming ftp dropoff areas on the CDDIS host computer. All data are processed to ensure data integrity and to extract pertinent metadata. Data are then copied to public directories and made available to the user community through anonymous ftp and the web. The metadata (primarily temporal and spatial parameters) are loaded into a relational database for data tracking and query purposes. Users can query this information to learn more about the CDDIS data holdings by location and time period. The metadata are also utilized by the CDDIS staff to monitor data holdings and data integrity.

The CDDIS is operational on a dedicated server with over three Tbytes of on-line RAID disk storage. A tape subsystem is utilized for system backups. In 2003, over five million files totaling over 450 Gbytes in size were downloaded each month from the CDDIS on-line archive. More than 2,000 distinct hosts in 100 countries accessed and downloaded data from the CDDIS last year. Over 130 institutions in over sixty countries supply data to the CDDIS on a daily basis for archival and distribution to the international user community.

CDDIS Metadata Query

Several forms have been created in the CDDIS website that allow users to query the metadata stored in the CDDIS relational database. One such set of queries, shown here in the first screen shot, displays any GNSS sites for a specified geographic region. The result of the first query is a list of GNSS sites in South America whose data were archived in the CDDIS since 1992. After selecting a site, as shown in the second screen shot, a list of data holdings by year are displayed. The final results, shown in the third screen shot, show more specific station location information as well as a list of any collocated space geodetic techniques (such as SLR, VLBI, or DORIS).

IGS Data and Products

The main mission of the International GPS Service (IGS) is to provide a service to support geodetic and geophysical research activities through GPS data and products. This service has been operational since 1994. The current network consists of nearly 400 permanently occupied, globally distributed sites that provide GPS (and GLONASS) data to IGS data centers on a daily, hourly, and near-real-time basis. These GNSS data are used by the IGS analysis centers to generate products such as precise satellite ephemerides and satellite and station clock information.

GNSS (GPS and GLONASS) Data at the CDDIS:
- Daily files containing 30-second sampled GPS data in RINEX format
  - 280+ GNSS stations/day
  - Approximately 0.35 Mbytes/site/day in size (compressed)
  - Data since January 1992 on-line
- Hourly files of 30-second sampled GPS data in RINEX format
  - 140+ GNSS stations/day
  - Approximately 0.02 Mbytes/site/hour in size (compressed)
  - Data retained for five days (replaced by daily files)
- Fifteen-minute files of one-second sampled GPS data in RINEX format
  - 40+ GPS stations/day
  - Approximately 0.45 Mbytes/site/hour in size (compressed)
  - Data since May 2001 on-line
- Daily files of ten-second sampled satellite-borne GPS receiver data in RINEX format
  - Two satellites (SAC-C, CHAMP); Jason, GRACE, ICESat in future
  - Approximate 2.5 Mbytes/satellite/day in size (compressed)
  - Data since January 2002 on-line

IGS Products:
- Precise GNSS satellite ephemerides (<5 cm accuracy)
  - Weekly
  - Rapid and ultra-rapid (sub-daily)
- IGS station and GPS satellite clocks
  - Weekly (<0.1 ns accuracy)
  - Rapid (~0.1 ns accuracy) and ultra-rapid (~0.2 ns accuracy)
- Earth rotation parameters
- IGS tracking station coordinates and velocities
- Global ionosphere maps of total electron content (TEC)
- Troposphere product consisting of combined zenith path delay (ZPD)
- All IGS products since June 1992 on-line

IGS Website: *http://igscb.jpl.nasa.gov*

*GODE GPS antenna at Greenbelt, MD
CDDIS photograph*

*MCM4 GPS antenna at McMurdo station Antarctica
IGS web site photograph*

*GPS satellite
Smithsonian Institution photograph*

IVS Data and Products

Products generated by International VLBI Service for Geodesy and Astrometry (IVS) contribute to research in many areas, including solid Earth, tides, studies of the vertical, and VLBI technique improvement. The objectives of IVS are to provide a service to support geodetic, geophysical, and astrometric research and operational activities, to promote research and development for VLBI, to integrate VLBI into a global Earth observing system, and to interact with users of VLBI products.

VLBI Data:
- VLBI data bases in DBH and NGS card formats
- Auxiliary files (e.g., log, met data, schedule, cable info, etc.)
- Currently, over 40 antennas participate in the IVS
- Approximately 2-3 Mbyte/data base file (compressed)
- CDDIS VLBI data archive: 1979 through present; most data holdings available on-line
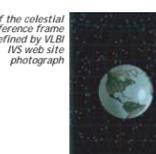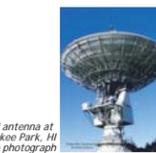
IVS Products:
- Intensive and session Earth orientation parameter series (EOP-I and EOP-S)
- Daily station position solutions
- Terrestrial Reference System
- Celestial Reference System
- Combined zenith path delay (ZPD)

IVS Website: *http://ivscc.gsfc.nasa.gov*

*VLBI antenna at Kokee Park, HI
IVS web site photograph*

*Part of the celestial reference frame defined by VLBI
IVS web site photograph*

ILRS Data and Products

Satellite (and lunar) laser ranging uses lasers to measure ranges from ground stations to satellite-borne (and moon-based) retroreflectors to the millimeter level. The International Laser Ranging Service (ILRS), operational since 1998, provides global satellite and lunar laser ranging data and their related products to support geodetic and geophysical research activities as well as IERS products important to the maintenance of an accurate International Terrestrial Reference Frame (ITRF). The service develops the necessary global standards/specifications and encourages international adherence to its conventions. The ILRS collects, merges, archives and distributes Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR) observation data sets of sufficient accuracy to satisfy the objectives of a wide range of scientific, engineering, and operational applications and experimentation.

Laser Data:
- Daily and monthly files containing on-site normal points, sorted by satellite, in ILRS normal point format
- Hourly files containing on-site normal points from all satellites, in ILRS normal point format retained for five days
- Daily and monthly full-rate data files from a subset of the global network, sorted by satellite, in ILRS full-rate format
- Currently, 29 satellites and four sites on the moon are tracked on a routine basis by 40 SLR and LLR stations
- Approximately 1 Mbyte/day on-site normal point data (uncompressed): 2 Mbytes/day full-rate data (compressed)
- CDDIS laser data archive: 1976 through present

ILRS Products:
- Precise satellite ephemerides (future)
- Site positions and velocities, utilized for maintaining the International Terrestrial Reference Frame (ITRF)
- Earth rotation parameters

ILRS Website: *http://ilrs.gsfc.nasa.gov*

*Retroreflector array on Jason, GFO-1, ICESat, and ADEOS-II
ILRS web site photograph*

*LAGEOS satellite
ILRS web site photograph*

*Three SLR systems operating in Grasse, France
ILRS web site photograph*

IDS Data and Products

The DORIS system, developed by CNES and IGN in France, is based on the measurement of Doppler shifts in radio signals, transmitted by ground beacons to a DORIS receiver on-board the satellite. This uplink system does not require network connectivity for data transmission and allows the network to be remotely monitored. Like GPS and SLR, precise satellite orbits, positions of and distances between observing stations, and Earth rotation, orientation, and polar motion values can be derived from DORIS measurements. The primary objective of the International DORIS Service (IDS), operational since 2003, is to foster the DORIS technique to support international geodetic, geophysical, and other research and operational activities.

DORIS Data:
- Files containing one "cycle" (~ten days) of data (computed range measurements), sorted by satellite, in DORIS-specific format
- Seven satellites (TOPEX, Jason, Envisat, and SPOT series) have on-board DORIS receivers that receive transmitted signals from a network of nearly 60 beacons
- Approximately 5 Mbyte/satellite/cycle (compressed)
- CDDIS DORIS data archive: 1992 through present

IDS Products:
- Precise satellite ephemerides
- Site coordinates and velocities; position time series
- Earth rotation parameters
- Special products
  - Ionosphere information
  - Time varying geocenter coordinates
  - Static and time-varying coefficients of the Earth's gravity field

IDS Website: *http://ids.cls.fr*

*DORIS on-board receiver
IDS web site photograph*

*DORIS antenna located in Hartebeesthoek, South Africa
IGN web site photograph*

*DORIS satellite antenna
AVISIO web site photograph*

Data Flow for International Services
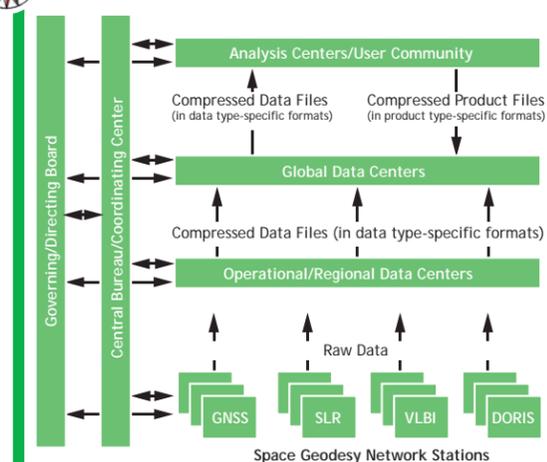
Network Stations
Continuously operational
Timely flow of data

Data Centers
Interface to network stations
Perform QC and data conversion activities
Archive data for access to analysis centers and users

Analysis Centers
Provide products to users (e.g., station coordinates, precise satellite orbits, Earth orientation parameters, atmospheric products, etc.)

Central Bureau/Coordinating Center
Management of service
Facilitate communications
Coordinate activities

Governing Body
General oversight of service
Future direction

Global GNSS, Laser, VLBI and DORIS Networks
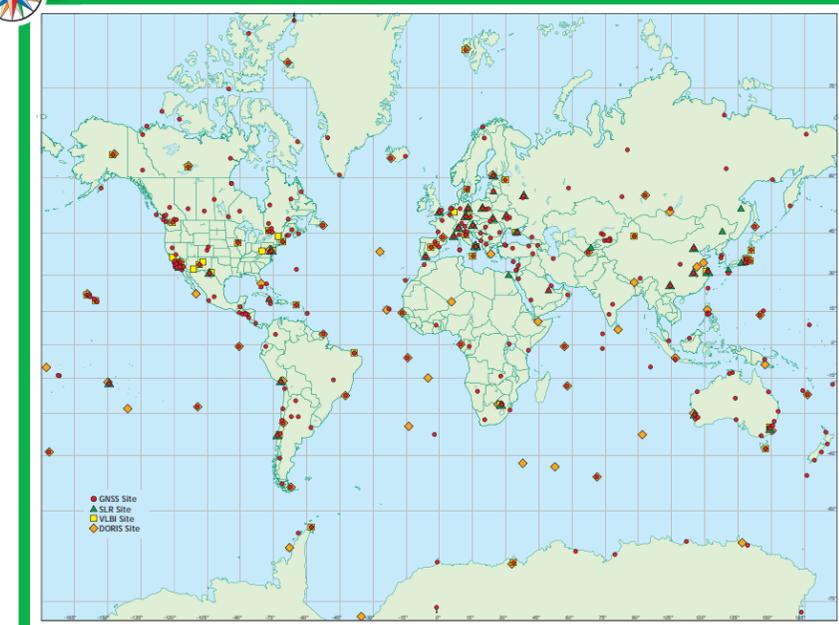
Future Plans

A new Linux-based computer system and backup server were purchased in 2003 to replace the current CDDIS UNIX server. The new system has been configured with nearly three Tbytes of RAID disk space. This increased disk space will permit on-line availability of daily, 30-second GPS data since 1992. A dedicated tape backup system was also procured. Plans are to have this system operational as the main CDDIS on-line server by the end of 2004.

The CDDIS web site has also been redesigned in 2004 to reflect the "NASA Look-and Feel". The new version of the CDDIS home page is shown at right.

For More Information

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