CDDIS Global Data Center Technical Report 2016

C. Noll

NASA Goddard Space Flight Center, Code 61A
Greenbelt, MD 20771 USA
Carey.Noll@nasa.gov

1 Introduction

The Crustal Dynamics Data Information System (CDDIS) is NASA's data archive and information service supporting the international space geodesy community. For over 35 years, the CDDIS has provided continuous, long term, public access to the data (mainly GNSS-Global Navigation Satellite System, SLR-Satellite Laser Ranging, VLBI-Very Long Baseline Interferometry, and DORIS-Doppler Orbitography and Radiopositioning Integrated by Satellite) and products derived from these data required for a variety of science observations, including the determination of a global terrestrial reference frame and geodetic studies in plate tectonics, earthquake displacements, volcano monitoring, Earth orientation, and atmospheric angular momentum, among others. The specialized nature of the CDDIS lends itself well to enhancement to accommodate diverse data sets and user requirements. The CDDIS is one of NASA's Earth Observing System Data and Information System (EOSDIS) Distributed Active Archive Centers (DAACs); EOSDIS data centers serve a diverse user community and are tasked to provide facilities to search and access science data and products. The CDDIS is also a regular member of the International Council for Science (ICSU) World Data System (WDS).

The CDDIS serves as one of the primary data centers and core components for the geometric services established under the International Association of Geodesy (IAG), an organization that promotes scientific cooperation and research in geodesy on a global scale. The system has supported the International GNSS Service (IGS) as a global data center since 1992. The CDDIS activities within the IGS during 2016 are summarized below; this report also includes any recent changes or enhancements made to the CDDIS.

2 System Description

2.1 Computer Infrastructure

The CDDIS archive of IGS data and products are accessible worldwide through anonymous ftp (*ftp://cddis.nasa.gov*). The CDDIS has also implemented web-based access to the archive (*https://cddis.nasa.gov/archive*). The CDDIS is located at NASA's Goddard Space Flight Center (GSFC) and is available to users 24 hours per day, seven days per week.

The CDDIS computer facility is fully redundant with primary and secondary/failover systems. Until December 2016, the CDDIS server configuration consisted of multiple incoming and outgoing servers dedicated to specific functions and was equipped with 32 Tbytes of online storage. Throughout early 2016, a new virtual machine (VM) based system configured with 100 Tbytes of unified storage was tested within the EOSDIS computer facility and network infrastructure. The new CDDIS computer system, shown in Figure 1, became operational on December 01, 2016. This new system configuration provides a more reliable/redundant environment (power, HVAC, 24-hour on-site emergency personnel, etc.) and network connectivity; a disaster recovery system is installed in a different location on the GSFC campus for rapid failover when required. The new system location addresses a key operational issue CDDIS has experienced over the past several years: the lack of consistent and redundant power and cooling in its computer facility. Furthermore, multiple, redundant 40G network switches are available to take full advantage of a high-performance network infrastructure by utilizing fully redundant network paths for all

outgoing and incoming files along with dedicated 10G network connections between its primary operations and its backup operations. The use of the virtual machine technology provides multiple instance services for a load balancing configuration and allows for VM instances to be increased or decreased due to demand. Furthermore, the VM technology allows for system maintenance (patching, upgrades, etc.) to proceed without any downtime or interruption to user access. The large, unified storage system will easily accommodate future growth of the archive and facilitate near real-time replication between its production and disaster recovery sites. The entire archive is also mirrored to traditional storage arrays for additional complete copies of the archive.

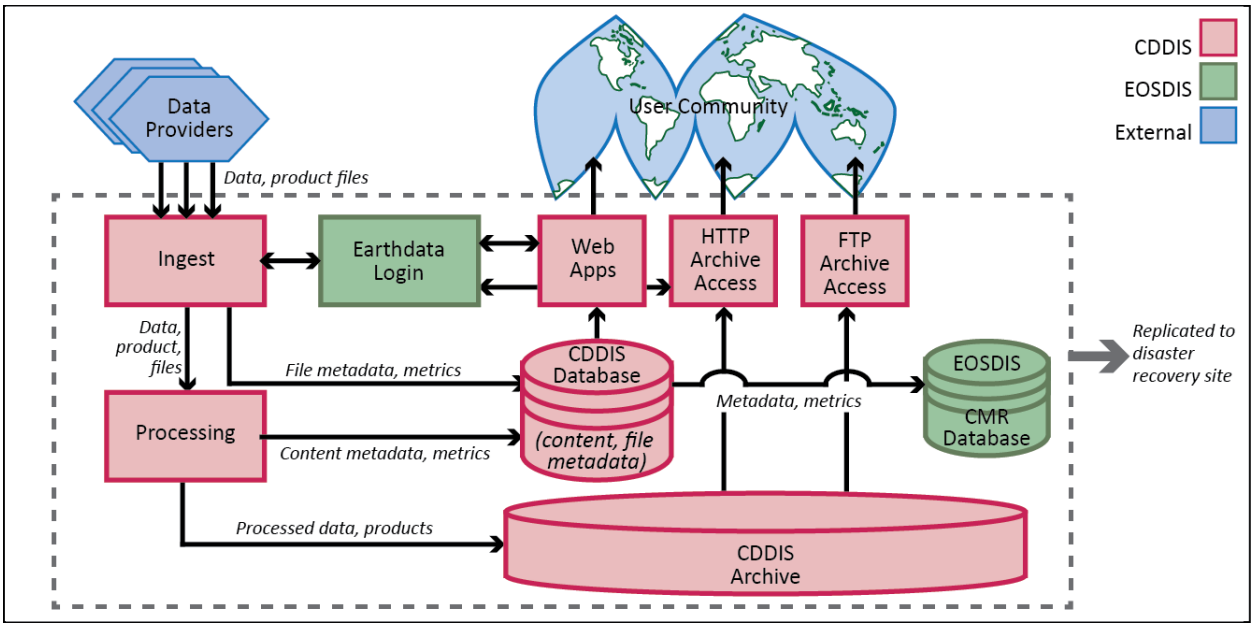

Figure 1: System architecture overview diagram for the new CDDIS facility installation within the EOSDIS infrastructure.

2.2 Web Applications

The CDDIS maintains two applications for querying site information or archive contents. The Site Log Viewer (*https://cddis.nasa.gov/Data_and_Derived_Products/SiteLogViewer/index.html*) is an application for the enhanced display and comparison of the contents IAG service site logs; currently the IGS, ILRS, and IDS site logs are viewable through this application. Through the Site Log Viewer application, users can display a complete site log, section by section, display contents of one section for all site logs, and search the contents of one section of a site log for a specified parameter value. Thus, users can survey the entire collection of site logs for systems having particular equipment or characteristics. Access to IVS/VLBI site logs will be provided in a future release of the application.

A second application, the CDDIS Archive Explorer accessible at *https://cddis.nasa.gov/Data_and_Derived_Products/CddisArchiveExplorer.html* allows users to discover what data are available through the CDDIS. The application provides users, particularly those new to the CDDIS, the ability to specify search criteria based on temporal, spatial, target, site designation, and/or observation parameter in order to identify data and products of interest for download. Results of these queries include a listing of sites and additional metadata satisfying the user input specifications. Such a user interface also aids CDDIS staff in managing the contents of the archive. Future plans for the application include adding a list of data holdings/URLs satisfying the search criteria.

3 Archive Contents

As a global data center for the IGS, the CDDIS is responsible for archiving and providing access to GNSS data from the global IGS network as well as the products derived from the analyses of these data in support of both operational and working group/pilot project activities. The CDDIS archive is approximately 17.5 Tbytes in size (over 190 million files) of which 16.5 Tbytes (95%) is devoted to GNSS data (15.4 Tbytes), products (1.1 Tbytes), and ancillary information. All data and products are accessible through subdirectories of *ftp://cddis.nasa.gov/gnss*.

3.1 GNSS Data

3.1.1 Main Data Archive

The user community has access to GNSS data available through the on-line global data center archives of the IGS. Over 70 operational and regional IGS data centers and station operators make data (observation, navigation, and meteorological) available in RINEX format to the CDDIS from receivers on a daily, hourly, and sub-hourly basis. The CDDIS also accesses the archives of other IGS global data centers, Scripps Institution of Oceanography (SIO) in California, the Institut Géographique National (IGN) in France, and the Korea Astronomy and Space Science Institute (KASI) to retrieve (or receive) data holdings not routinely transmitted to the CDDIS by an operational or regional data center. Table 1 below summarizes the types of IGS GNSS data sets available in the CDDIS in the operational, non-campaign directories of the GNSS archive.

Data, in RINEX V2.10 or V2.11 format, from GPS and GPS+GLONASS receivers are archived within the main GNSS directory structure */gnss/data*. Since January 2016, RINEX V3 data, using the V3 filename specification, are archived with the RINEX V2 data (see section 3.1.2 for more information).

Table 1a: GNSS Data Type Summary.

Data Type	Sample Rate	Data Format	Available On-line
Daily GNSS	30 sec.	RINEX V2	Since 1992
Daily GNSS	30 sec.	RINEX V3	Since 2016
Hourly GNSS	30 sec.	RINEX V2	12+ years
Hourly GNSS	30 sec.	RINEX V3	Since 2016
High-rate GNSS	1 sec.	RINEX V2	Since 2001
High-rate GNSS	1 sec.	RINEX V3	Since 2016
Satellite GPS	10 sec.	RINEX V2	2002-2012

Table 1b: GNSS Data Archive Summary for 2016.

Data Type	Avg. No. Sites/Day	No. Unique Sites	Avg. Volume/Day	Total Volume/Year	No. Files	Directory Location
Daily GNSS (V2 filename)	495	545	1,570 MB	580 GB	828K	*/gnss/data/daily*
Daily GNSS (V3 filename)	210	111	215 MB	80 GB	121K	*/gnss/data/daily*
Hourly GNSS (V2 filename)	385	344	680 MB	250 GB	7,455K	*/gnss/data/hourly*
Hourly GNSS (V3 filename)	119	55	160 MB	60 GB	1,627K	*/gnss/data/hourly*
High-rate GNSS (V2 filename)	335	204	4,110 MB	1,500 GB	12,518K	*/gnss/data/highrate*
High-rate GNSS (V3 filename)	36	22	935 MB	345 GB	891K	*/gnss/data/highrate*

The CDDIS archives three major types/formats of GNSS data, daily, hourly, and high-rate sub-hourly, all in RINEX format, as described in Table 1a; the network distribution of submitted files is shown in Figure 2. Daily RINEX data are quality-checked, summarized (using UNAVCO's teqc software), and archived to public disk areas in subdirectories by year, day, and file type; the summary and inventory information are also loaded into an on-line database. Over 177K daily station days from 545 distinct GNSS receivers were archived at the CDDIS during 2016; 209 RINEX V3 sites (including 46 RINEX V3-only) supplied RINEX V3 data. A complete list of daily, hourly, and high-rate sites archived in the CDDIS can be found in the yearly summary reports at URL *ftp://cddis.nasa.gov/reports/gnss/*.

Within minutes of receipt, the hourly GNSS files are archived to subdirectories by year, day, and hour. Although these data are retained on-line, the daily files delivered at the end of the UTC day contain all data from these hourly files and thus can be used in lieu of the individual hourly files. A total of 385 unique hourly sites (over 7.4 million files) were archived during 2016; 119 hourly sites provided data in RINEX V3 format (12 RINEX V3-only).

High-rate (one-second sampling rate) GNSS data are made available in files containing fifteen minutes of data and in subdirectories by year, day, file type, and hour. Many of these data files are created from real-time streams. Data from 335 unique high-rate sites (over 12 million files) were archived in the CDDIS in 2016; 36 high-rate sites provided data in RINEX V3 format (20 RINEX V3-only).

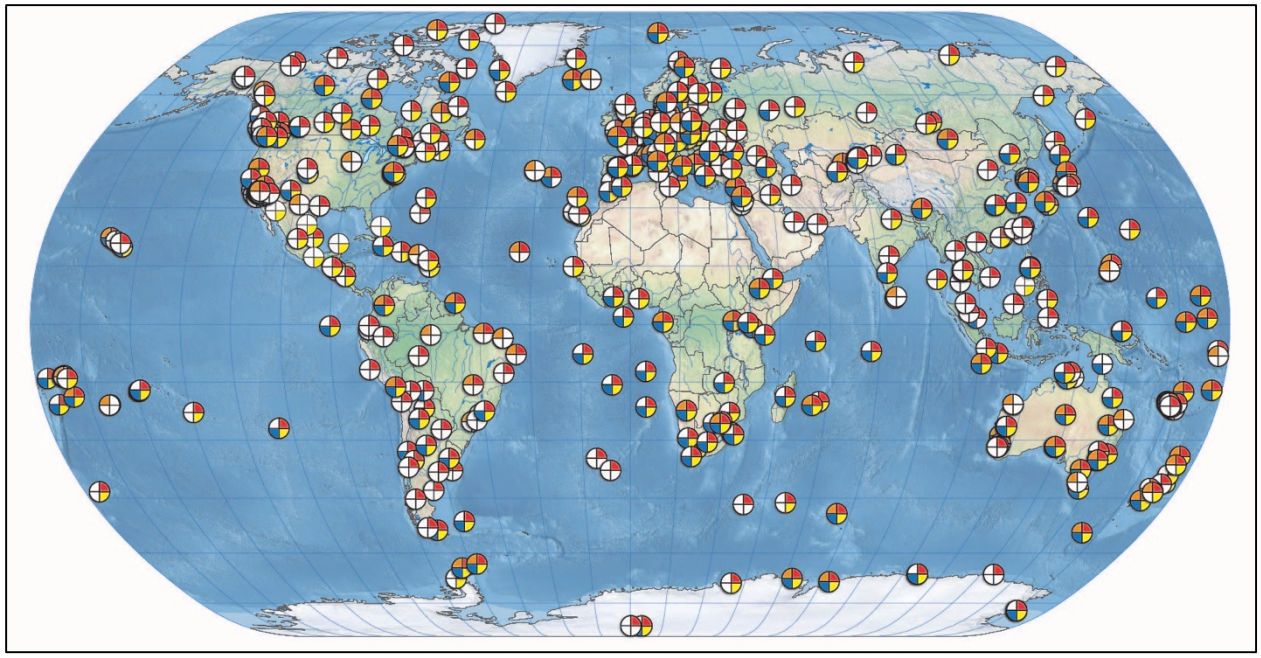

Figure 2: CDDIS GNSS archive includes data in daily (red), hourly (yellow), sub-hourly (blue), and/or real-time (orange) increments. Hourly, sub-hourly, and real-time data allow analysts to generate products for applications needing more frequent updates.

The CDDIS generates global broadcast ephemeris files (for both GPS and GLONASS) on a daily and hourly basis. The hourly concatenated broadcast ephemeris files are derived from the site-specific ephemeris data files for each hour and are appended to a single file that contains the orbit information for all GPS and GLONASS satellites for the day up through that hour. The merged ephemeris data files, named *hourDDD0.YYn.Z*, are then copied to the day's subdirectory within the hourly data file system. Within 1-2 hours after the end of the UTC day, after sufficient station-specific navigation files have been submitted, this concatenation procedure is repeated to create the daily broadcast ephemeris files (both GPS and GLONASS), using daily site-specific navigation files as input. These daily broadcast files, named *brdcDDD0.YYn.Z* and *brdcDDD0.YYg.Z*, are then copied to the corresponding subdirectory under the daily file system. Users can thus download this single, daily (or hourly) file to obtain the unique navigation messages rather than downloading multiple broadcast ephemeris files from the individual stations.

The CDDIS generates and updates "status" files, (*/gnss/data/daily/YYYY/DDD/YYDDD.status* for RINEX V2 data and *YYDDD.V3status* for RINEX V3 data) that summarize the holdings of daily GNSS data. The archive status files of CDDIS GNSS data holdings reflect timeliness of the data delivered as well as statistics on number of data points, cycle slips, and multipath (for RINEX V2 data). The user community can thus view a snapshot of data availability and quality by checking the contents of such a summary file.

3.1.2 RINEX V3 Integration

The CDDIS worked with the IGS Infrastructure Committee (IC) to integrate data in RINEX V3 format into the operational, main archives at the IGS Global Data Centers. The resulting "RINEX V3 Transition Plan" addressed a key recommendation from the IGS 2014 Workshop: "one network one archive" and provided for the better integration of multi-GNSS data into the entire IGS infrastructure. Starting in 2015, stations began submitting RINEX V3 data using the format's "long" filename specification. The transition plan specified that RINEX V3 data from IGS network sites using the V3 filename structure should be archived in the same directory structure as the operational RINEX V2 data. Therefore, starting on January 01, 2016, all daily, hourly, and high-rate data submitted to the CDDIS in RINEX V3 format and using the long, V3 filename specification have been archived in the same directories as the RINEX V2 data (which use the 8.3.Z filename for daily and hourly files and the 10.3.Z filename format for high-rate files). In addition, these RINEX V3 files are compressed in gzip (.gz) format; files in RINEX V2 format continue to use UNIX compression (*.Z*). Figure 3 shows the network of IGS sites providing daily data in RINEX V2 and/or V3 formats.

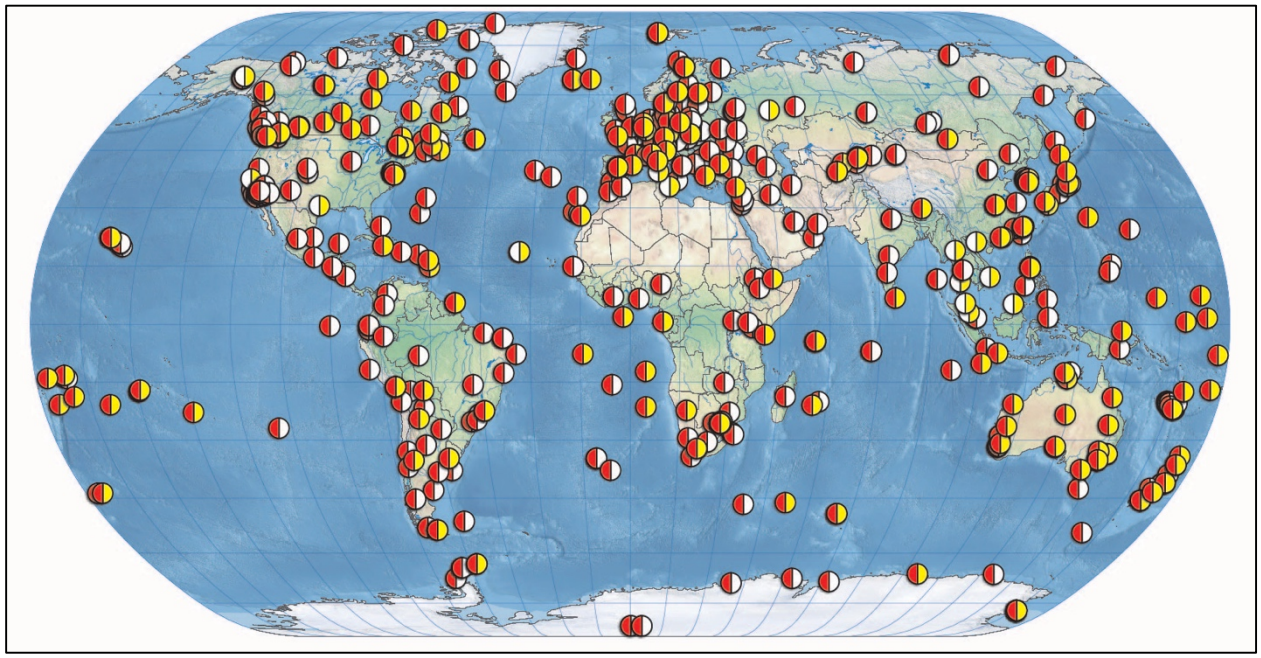

Figure 3: The main, operational archive at CDDIS now includes data in RINEX V2 format using the 8.3.Z filename specification (red) and RINEX V3 format using the V3 filename specification (yellow).

3.1.3 RINEX V3 (MGEX) Archive

During 2016, the CDDIS continued the archiving of data in RINEX V3 format from multi-GNSS receivers participating in the Multi-GNSS Experiment (MGEX) as well as products derived from the analysis of these data. The data include all available multi-GNSS signals (e.g., Galileo, QZSS, SBAS, BeiDou, and IRNSS) in addition to GPS and GLONASS. These data, in RINEX V3 format but using the 8.3.Z filename specification, continue to be archived in a campaign directory structure at CDDIS *(/gnss/campaign/mgex/data*). The summary of the MGEX data holdings at the CDDIS is shown in Table 2 below. Daily status files are also provided that summarize the MGEX data holdings; however, data quality information, generated for data holdings in RINEX V2 format, is not available through the software used by CDDIS to summarize data in RINEX V3 format. CDDIS continues to investigate and evaluate software capable of providing data summary/QC information for RINEX V3 data. As station operators converted RINEX V3 data to the long, RINEX V3 filename specification (see section 3.1.2), the amount of data archived in the campaign directories has decreased.

The CDDIS also added a merged, multi-GNSS broadcast ephemeris file containing GPS, GLONASS, Galileo, BeiDou, QZSS, and SBAS ephemerides from MGEX stations. This file, generate by colleagues at the Technical University in Munich (TUM) and Deutsches Zentrum f˙ur Luft- und Raumfahrt (DLR), is similar to the daily and hourly concatenated broadcast message files in RINEX V2 format provided by the CDDIS for the operational GPS+GLONASS data sets; it contains all the unique broadcast navigation messages for the day. The file, named *brdmDDD0.YYp.Z*, is stored in daily subdirectories within the MGEX campaign archive at CDDIS (*/gnss/data/campaign/mgex/daily/rinex3/YYYY/DDD/YYp*) and in a yearly top level subdirectory (*/gnss/data/campaign/mgex/daily/rinex3/YYYY/brdm)*.

Table 2: GNSS MGEX Data Archive Summary for 2016.

Data Type	Avg. No. Sites/Day	No. Unique Sites	No. Files	Avg. Volume/Day	Total Volume/Year	Directory Location
Daily GNSS	111	210	121K	375 MB	136 GB	*/gnss/data/campaign/mgex/daily*
Hourly GNSS	55	120	1,630K	80 MB	29 GB	*/gnss/campaign/mgex/data/hourly*
High-rate GNSS	22	36	890K	2,300 MB	740 GB	*/gnss/campaign/mgex/data/highrate*

Colleagues at TUM and DLR are also providing GPS and QZSS CNAV (civilian navigation) data on an operational basis within MGEX. These messages are collected from a sub-network of MGEX stations and are provided in a merged daily file in a format similar to RINEX. These files are named *brdxDDD0.YYx.Z* and stored in a daily subdirectory within the MGEX archive at CDDIS (*/gnss/data/campaign/mgex/daily/rinex3/YYYY/cnav*).

3.2 IGS Products

The CDDIS routinely archives IGS operational products (daily, rapid, and ultra-rapid orbits and clocks, ERP, and station positions) as well as products generated by IGS working groups and pilot projects (ionosphere, troposphere, real-time). Table 3 below summarizes the GNSS products available through the CDDIS. The CDDIS currently provides on-line access through anonymous ftp to all IGS products generated since the start of the IGS Test Campaign in June 1992 in the file system */gnss/products*; products from GPS+GLONASS products are available through this filesystem. Products derived from GLONASS data only continue to be archived at the CDDIS in a directory structure within the file system */glonass/products*.

Table 3: GNSS Product Summary for 2016.

Product Type	Number of ACs/AACs	Volume	Directory
Orbits, clocks, ERP, positions	14+Combinations	1.4 GB/week	*/gnss/products/WWWW (GPS, GPS+GLONASS)* */glonass/products/WWWW (GLONASS only)*
Troposphere	Combination	3 MB/day, 1.1 GB/year	*/gnss/products/troposphere/YYYY*
Ionosphere	6+Combination	4 MB/day, 1.5 GB/year	*/gnss/products/ionosphere/YYYY*
Real-time	Combinations	28 MB/week	*/gnss/products/rtpp/YYYY*
Repro2	10+Combinations	850 MB/week	*/gnss/products/WWWW/repro2*

Note: *WWWW*=4-digit GPS week number; *YYYY*=4-digit year

The CDDIS also continues to archive combined troposphere estimates in directories by year and day of year. Global ionosphere maps of total electron content (TEC) from the IONEX AACs are also archived in subdirectories by year and day of year. Real-time clock comparison products have been archived at the CDDIS in support of the IGS Real-Time Pilot Project, and current IGS Real-Time Service, since 2009.

In 2015, the IGS analysis centers completed the upload of products for the second IGS reprocessing campaign (repro2). The CDDIS provided support through upload of files from the ACs and online archive of these products (*/gnss/products/WWWW/repro2*); additional files were submitted in 2016.

Six AACs (CODE, GFZ, GRGS, JAXA, TUM, and Wuhan) generated weekly products (orbits, ERP, clocks, and others) in support of MGEX. These files are archived at the CDDIS in the MGEX campaign subdirectory by GPS week (*/gnss/products/mgex/WWWW*).

Colleagues at DLR and the Chinese Academy of Sciences (CAS) provide a differential code biase (DCB) products for the MGEX campaign. This product is derived from GPS, GLONASS, Galileo, and BeiDou ionosphere-corrected pseudorange differences and is available in the bias SINEX format. DLR has provided two files per year, daily satellite and daily satellite and station biases since 2013 in CDDIS directory */gnss/products/mgex/dcb*; CAS provides daily files. Additional details on the DCB product are available in IGSMail message 6868 sent in February 2015 and message 7173 sent in October 2015. Both products use the new RINEX V3 file naming convention.

3.3 Real-Time Activities

In 2013, the CDDIS staff configured a server and began testing a caster to provide a real-time streaming capability at GSFC and support the IGS Real-Time Service (IGS RTS). The CDDIS successfully tested obtaining product streams from the BKG and IGS casters and providing access to these streams to authorized users; additional streams from Natural Resources Canada (NRCan) and Geoscience Australia (GA) were later added to the caster. Work was completed in spring 2015 and the CDDIS caster became fully operational, broadcasting nearly 40 product and 165+ data streams in real-time. The caster runs the NTRIP (Network Transport of RTCM via internet Protocol) format. Figure 4 shows the distribution of stations providing real-time streams to the CDDIS caster.

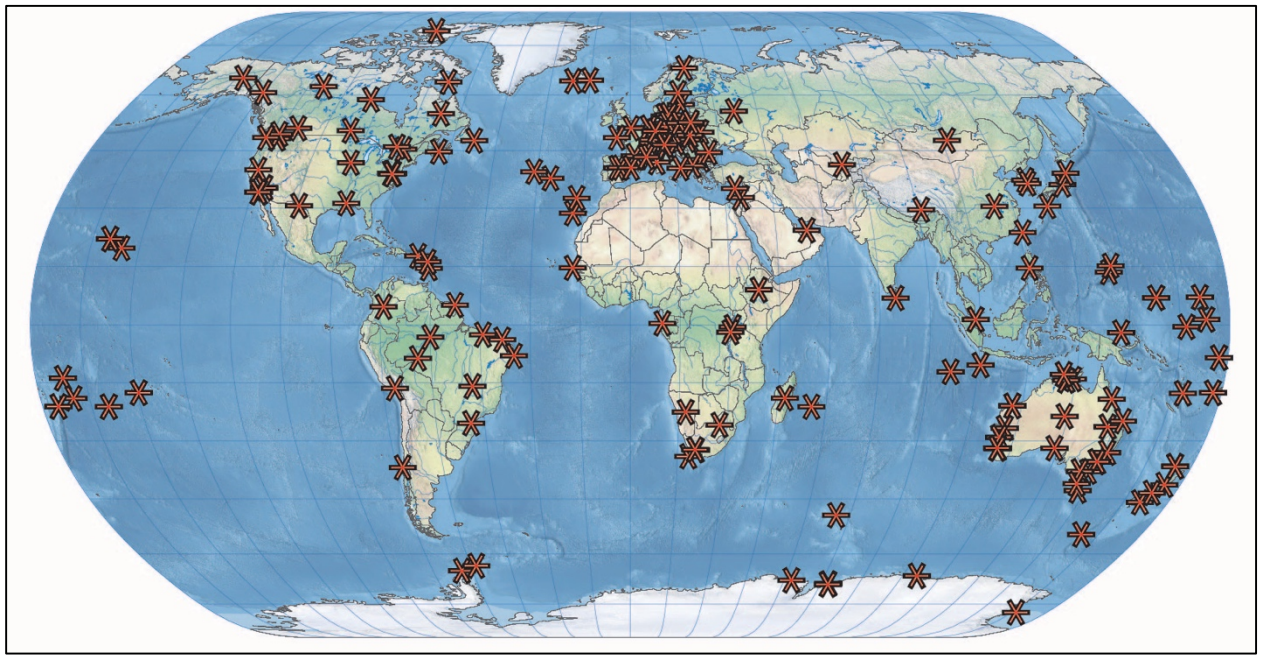

Figure 4: CDDIS is operationally supporting the dissemination of data from over 225 real-time GNSS sites as well as near real-time products derived from these data.

As stated previously, the CDDIS is one of NASA's EOSDIS DAACs and through EOSDIS, has access to a world-class user registration process, the EOSDIS Earthdata Login (EDL, formerly User Registration System, URS), with over 255K users in its system. Since the NTRIP-native registration/access software was not compatible with NASA policies, the CDDIS developed software to interface the caster and the EDL within a generic Lightweight Directory Access Protocol (LDAP) framework. The module was specifically developed to easily interface with multiple user verification systems and was given back to the NTRIP community for possible inclusion in future releases. New users complete a registration form available on the CDDIS website; once completed, the data are passed to the EDL, which generates an email to the user with a validation link. The user accesses the link and the EDL validates the form's data; this process is accomplished within a minute or less. The user's validated access request is submitted to CDDIS staff for access authorization to the CDDIS caster. This second step is not yet automated and can

take several hours to configure depending on the time of day. In addition, users registering in this system have access to the entire suite of EOSDIS products across all 12 EOSDIS DAACs.

Initially, the CDDIS caster provided access to data and product streams from several regional real-time casters. Data streams have also been provided through JPL for receivers in NASA's Global GPS Network. In 2016, an additional set of stations from JPL's Global Differential GPS (GDGPS) network were added to the CDDIS caster. This network of globally distributed, geodetic quality, dual frequency receivers, provides additional 1 Hz data streams to those current available from the IGS RTS. The CDDIS caster was augmented with new real-time streams as they became available from IGS network sites.

The CDDIS caster serves as the third primary caster for the IGS RTS, thus providing a more robust topology with redundancy and increased reliability for the service. User registration, however, for all three casters is unique; therefore, current users of the casters located at the IGS and BKG are required to register through the CDDIS registration process in order to use the CDDIS caster. By the end of 2016, over 100 users from 28 countries have registered to use the CDDIS caster. More information about the CDDIS caster is available at *https://cddis-casterreg.gsfc.nasa.gov/index.html*.

The CDDIS has also developed software to capture real-time data streams into fifteen-minute high-rate files. This capability requires further testing and coordination with the IGS Central Bureau and Infrastructure Committee before it is put into operational use.

3.4 Supporting Information

Daily status files of GNSS data holdings, reflecting timeliness of the data delivered as well as statistics on number of data points, cycle slips, and multipath, continue to be generated by the CDDIS for RINEX V2 data; status files, with limited information, summarizing RINEX V3 data holdings are also available. By accessing these files, the user community can receive a quick look at a day's data availability and quality by viewing a single file. The daily status files are available through the web at URL *ftp://cddis.nasa.gov/reports/gnss/status*. The daily status files are also archived in the daily GNSS data directories.

In preparation for the analysis center's reprocessing campaigns, the CDDIS developed site-specific reports detailing missing data. Station operators and operational data centers can consult these lists (*ftp://cddis.nasa.gov/gnss/data/daily/reports/missing*) and if available, supply missing files to the CDDIS for inclusion in the global data center archives.

Ancillary information to aid in the use of GNSS data and products are also accessible through the CDDIS. Daily, weekly, and yearly summaries of IGS tracking data (daily, hourly, and high-rate) archived at the CDDIS are generated on a routine basis. These summaries are accessible through the web at URL *ftp://cddis.nasa.gov/reports/gnss.* The CDDIS also maintains an archive of and indices to IGS Mail, Report, Station, and other IGS-related messages.

4 System Usage

Figure 5 summarizes the usage of the CDDIS for the retrieval of GNSS data and products in 2016. This figure illustrates the number and volume of GNSS files retrieved by the user community during 2016, categorized by type (daily, hourly, high-rate, products). Nearly 930 million files (nearly 140 Tbytes) were transferred in 2016, with an average of nearly 80 million files per month. Figure 6 illustrates the profile of users accessing the CDDIS IGS archive during 2016. The majority of CDDIS users were once again from hosts in North America, Asia, and Europe.

5 Recent Developments

5.1 Next Generation Hardware

As detailed in the system hardware section above, the CDDIS transferred operations to the new virtual-machine based architecture on December 01, 2016. The transition to the new system was accomplished with less than 30 hours of downtime to the user community.

5.2 Archive Operations

The CDDIS has been operating for over 30 years. During that time procedures and processes have grown to meet both existing data archive needs and new requirements, which over time had become unwieldy and hard to support. Therefore, CDDIS conducted a complete review of the entire data ingest operations system in early 2016 to identify and correct process inefficiencies in and improve the QC of incoming files. Software development included the addition of more automation capabilities, better redundancy, easier supportability, and common code sharing. The staff developed and integrated new software to perform routine checksums of and anti-virus scanning on all incoming files. The new operations software was implemented for GNSS data processing prior to the transition to the new hardware system and is now fully operational on this new system. Testing on other data types (e.g., SLR and DORIS) will start in early 2017.

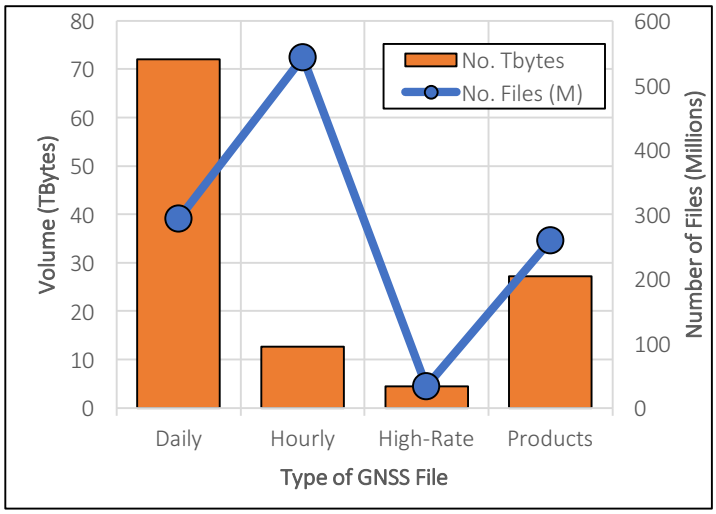

Figure 5: Number and volume of GNSS files transferred from the CDDIS in 2016.

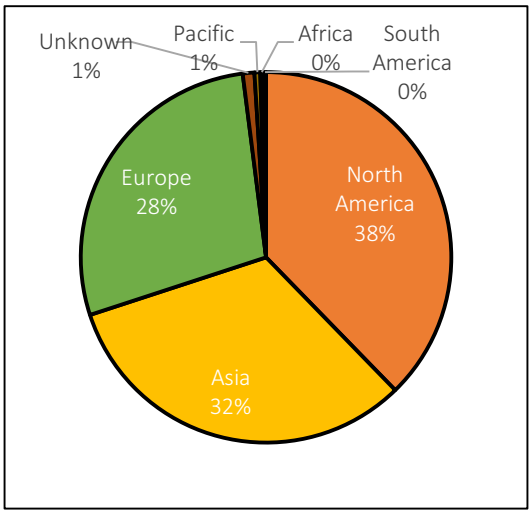

Figure 6: Geographic distribution of IGS users of the CDDIS in 2016.

5.3 Data Upload System

CDDIS has traditionally used ftp (with a username/password) for delivery of files from the data and product suppliers. The underlying user accounts to receive these contributions had limited privileges, allowing data and product providers to deposit files but not retrieve files from these disk areas. However, with the installation of the CDDIS servers within the new computer facility, the CDDIS needed to move to a better-supported protocol and at the same time use a single sign-on system to perform authentication. The CDDIS staff developed an https-based protocol method for delivery of files from suppliers of data and products. The authentication is performed through the EOSDIS Earthdata Login (EDL) system, the same system used for access to the CDDIS real-time caster. The file uploads can be performed through a webpage interface or a command line application that can perform an http "post" operation, which is more commonly used for scripting. This process allows data suppliers to authenticate through the EDL system and provide their files through https to CDDIS for ingest into the archive. For several months, suppliers performed significant testing on the new upload system. By late summer, all data and product suppliers were contacted and full testing began. This new delivery method was fully implemented for all

suppliers as the CDDIS transitioned operations to the new servers. Unfortunately, some data providers have had difficulty adapting their software to use the new CDDIS upload system which has affected CDDIS data holdings. The CDDIS staff continues to work with these providers to help answer any questions during their transition to the new system. More information on the CDDIS file upload system is available at: *https://cddis.nasa.gov/About/CDDIS_File_Upload_Documentation.html.*

5.4 Metadata Developments

The CDDIS continues to make modifications to the metadata extracted from incoming data and product files pushed to its archive and implemented these changes in the new operations software system. These enhancements have facilitated cross discipline data discovery by providing information about CDDIS archive holdings to other data portals such as Earth Observing System search client and future integration into the GGOS portal. The staff continues work on a metadata evolution effort, re-designing the metadata extracted from incoming data and adding information that will better support EOSDIS applications such as its search client and the metrics collection effort. The CDDIS is also participating in GGOS metadata efforts within the Bureau of Networks and Observations.

The CDDIS continues to implement Digital Object Identifiers (DOIs) to select IGS data sets (GNSS data and products). DOIs can provide easier access to CDDIS data holdings and allow researchers to cite these data holdings in publications. Landing pages are available for each of the DOIs created for CDDIS data products and linked to description pages on the CDDIS website; an example of a typical DOI description (or landing) page, for daily Hatanaka-compressed GNSS data files, can be viewed at: *https:/cddis.nasa.gov/Data_and_Derived_Products/GNSS/daily_gnss_d.html*. DOIs will be assigned to additional GNSS data and product sets in the near future.

6 Publications

The CDDIS staff attended several conferences during 2016 and presented papers on or conducted demos of their activities within the IGS, including:

C. Noll, P. Michael, “Developments at CDDIS to Support Real-Time and RINEX V3” (poster), presented at IGS Workshop “GNSS Futures”, Sydney, NSW, Australia, February 08–12, 2016

P. Michael, C. Noll, “Important Upcoming Architecture and User Changes at the CDDIS” (poster), IGS Workshop “GNSS Futures”, Sydney, NSW, Australia, February 08–12, 2016

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Electronic versions of these and other publications can be accessed through the CDDIS on-line documentation page on the web at URL *https:/cddis.nasa.gov/Publications/Presentations.html*.

7 Future Plans

7.1 RINEX V3 Data

The CDDIS will continue to coordinate with the Infrastructure Committee, the Data Center Working Group, and other IGS data centers to implement steps outlined in the RINEX V3 transition plan to complete the incorporation of RINEX V3 data into the operational GNSS data directory structure. The CDDIS began this process with multi-GNSS, RINEX V3 data from January 2016 onwards; the CDDIS will continue these efforts by integrating RINEX V3 multi-GNSS data from years prior to 2016 into the IGS operational archives. MGEX campaign directories will continue to be maintained during this transition to the operational directory archive. Furthermore, the CDDIS staff will continue to test software to copy RINEX V3 data (using the older filename format) into files with RINEX V3 filenames as well as QC RINEX V3 data and files and incorporate the software into operational procedures.

7.2 Real-Time Activities

The CDDIS will continue to add real-time data and product streams to its operational caster in support of the IGS Real-Time Service. Future activities in the real-time area include capturing the streams for generation of 15-minute high-rate files for archive. This capability requires further testing and coordination with the IC. The staff is also developing software to provide metrics on usage of the CDDIS caster. The staff will also investigate automating the process of adding users to the CDDIS caster configuration files.

7.3 Web-Based User Access

With EOSDIS requesting that EDL should be used for all data delivery to users, CDDIS is investigating possible methods of providing a web-based capability. Over 95% of CDDIS users retrieve files using automated scripts; these scripts will not work with a web-based approach as http does not support globbing. The EOSDIS EDL group has recently developed an Apache-based module to emulate ftp globbing functionality. This module is currently in testing with both CDDIS and EOSDIS. This new module will make the transition between ftp and http easier and CDDIS is investigating implementing EDL within an https download option. CDDIS staff will continue to study possible solutions and best methods for allowing users to retrieve data through https while still maintaining the ability to use scripts. During this development, CDDIS staff will incorporate the lessons learned from their data upload system into the https access capability.

8 Contact Information

To obtain more information about the CDDIS IGS archive of data and products, contact:

Ms. Carey E. Noll	Phone:	(301) 614-6542
Manager, CDDIS	Fax:	(301) 614-6015
Code 61A	E-mail:	*Carey.Noll@nasa.gov*
NASA GSFC	WWW:	*http://cddis.nasa.gov*
Greenbelt, MD 20771		

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