CDDIS Global Data Center Technical Report 2017

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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) and the Earth Science Information Partners (ESIP).

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 2017 are summarized below; this report also includes any recent changes or enhancements made to the CDDIS.

2 System Description

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. Since December 2016, the CDDIS utilizes a virtual machine (VM) based system configured with 100 Tbytes of unified storage operating within the EOSDIS computer facility and network infrastructure (see Figure 1). This system configuration provides a 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. This system location has addressed a key operational issue CDDIS 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. This system architecture has allowed the CDDIS to achieve an uptime figure of over 99.9 in 2017; some outages were outside CDDIS control, due to issues with EOSDIS facilities.

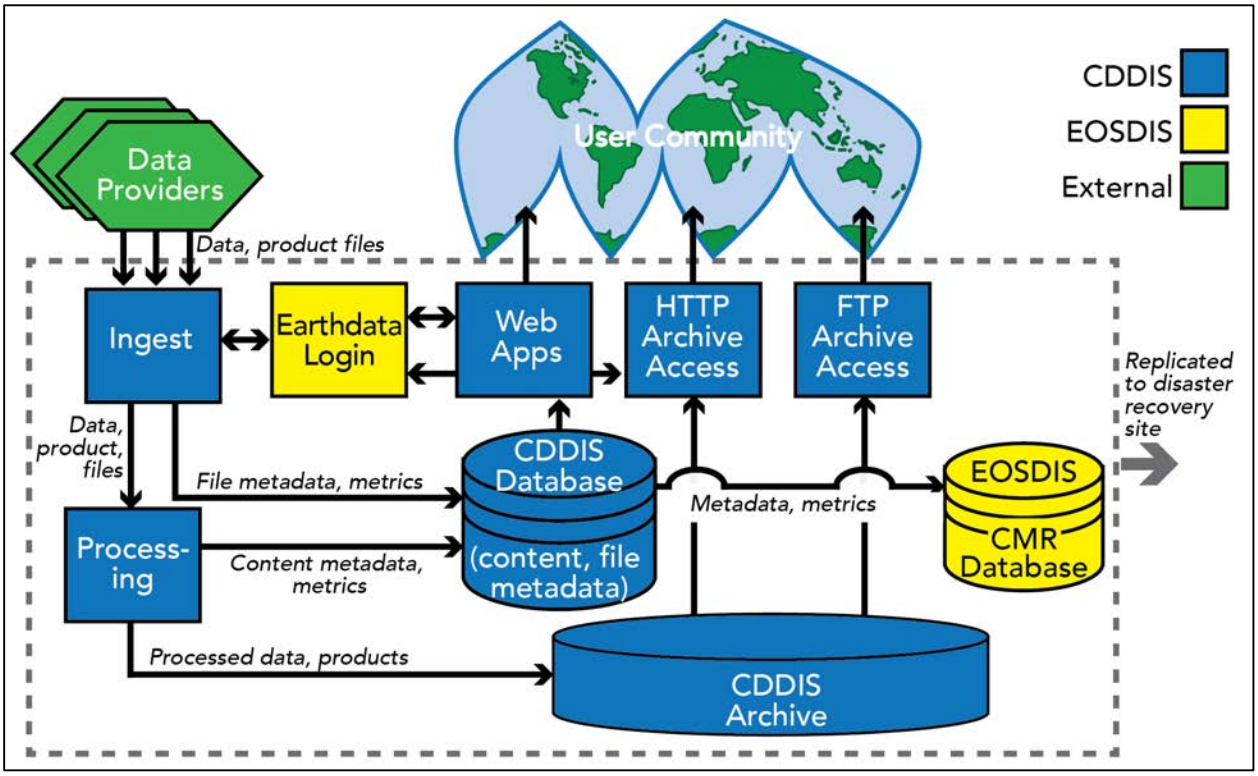

Figure 1: System architecture overview diagram for the CDDIS facility installation within the EOSDIS infrastructure.

As shown in Figure 1, the providers of files for the CDDIS archive push their files (data, derived products, etc.) to the ingest server, utilizing the Earthdata Login system for access. Incoming files are then handled by the processing system which performs file/content validation and metrics extraction. Metadata and metrics (ingest/archive and distribution) information is pushed to the EOSDIS Common Metadata Repository (CMR) system. Content metadata, describing collections and granules are available for access by a broad user community through the CMR. Valid files are then moved to the CDDIS archive for public access through the CDDIS ftp and web servers.

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 21.5 Tbytes in size (over 220 million files) of which over 95% is devoted to GNSS data (19.5 Tbytes) and GNSS products (1.3 Tbytes). All these GNSS 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 30 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 (GDCs),

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.

Table 1: 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	Since 2005
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

The main GNSS data archive (*ftp://cddis.nasa.gov/gnss/data*) at the CDDIS now contain GPS and GPS+GLONASS data in RINEX V2 format and multi-GNSS data in RINEX V3 format. Since January 2016, RINEX V3 data, using the V3 filename specification, have been made available here along with the RINEX V2 data. The availability of RINEX V3 data into the operational, main archives at the IGS GDCs (and detailed in the "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*). Furthermore, the data in RINEX V3 format include all available multi-GNSS signals (e.g., Galileo, QZSS, SBAS, BeiDou, and IRNSS) in addition to GPS and GLONASS. Figure 2 shows the network of IGS sites providing daily data in RINEX V2 and/or V3 formats.

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 1; the network distribution of submitted files is shown in Figure 3. All incoming files for the CDDIS archive are now checked for conformance to basic rules, such as valid file type, non-empty file, uses correct compression, consistency between filename and contents, uses correct file naming conventions, and other logic checks. After incoming files pass these initial checks, content metadata are extracted and the files undergo further processing based on data type and format.

Daily RINEX V2 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. However, this 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. The CDDIS strongly recommends guidance from the IGS on identifying candidates for RINEX V3 QC software that can be used by data centers and users. Over 263K daily station days from 601 distinct GNSS receivers were archived at the CDDIS during 2017; of these sites, 215 sites supplied both RINEX V2 and V3 data (see Table 2). 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 (typically less than 30 seconds), 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. As seen in Table 2, a total of 366 unique hourly sites (over 9.5 million files) were archived during 2017; 152 hourly sites provided data in both RINEX V2 and V3 formats.

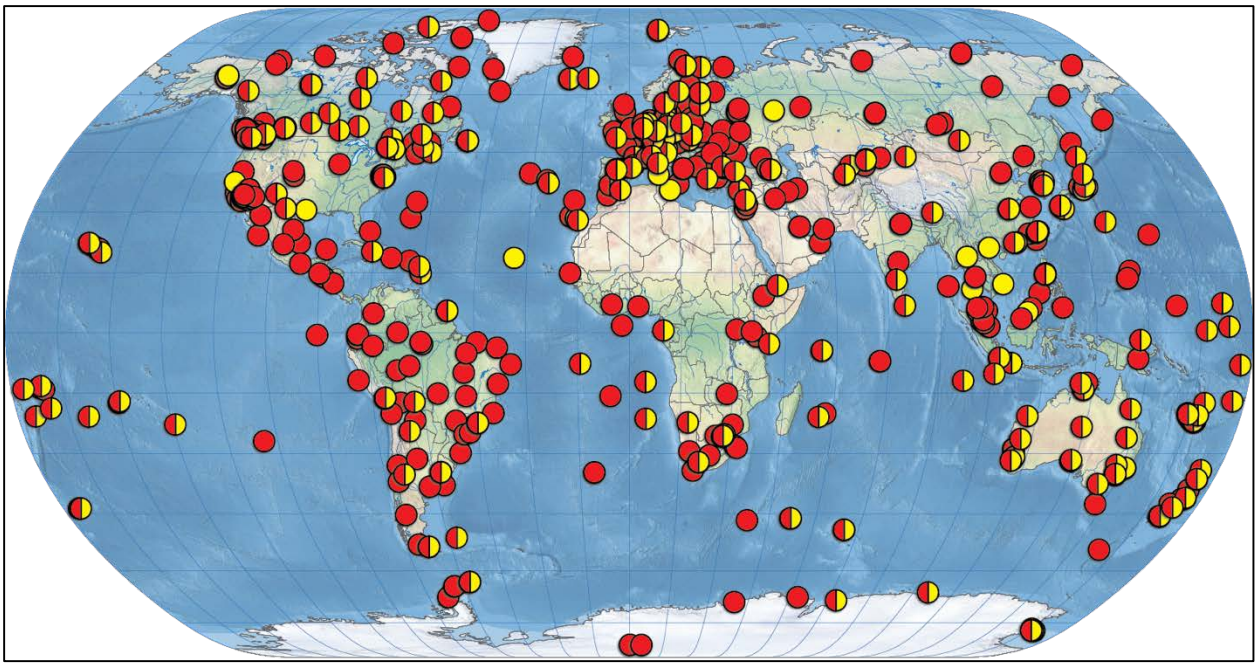

Figure 2: The main, operational archive at CDDIS now includes data in RINEX V2 format using the 8.3.Z filename specification (red) and RINEX V3 format using the V3 filename specification (yellow); sites providing both RINEX V2 and V3 formatted data are shown with the red+yellow icon.

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. As shown in Table 2, data from 295 unique high-rate sites (over 13 million files) were archived in the CDDIS in 2017; 55 high-rate sites provided data in both RINEX V2 and V3 formats.

Table 2: GNSS Data Archive Summary for 2017.

Data Type	Number of Sites				Vol.	# files	Directory
	V2	V3	V2+V3	Unique			
Daily	349	37	215	601	700GB	1.126M	*/gnss/data/daily*
Hourly	205	9	152	366	235GB	9.565M	*/gnss/data/hourly*
High-rate	219	21	55	295	2,100GB	13.530M	*/gnss/data/highrate*

The CDDIS generates global RINEX V2 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 year/day nav file subdirectory as well as the yearly *brdc* subdirectory (*/gnss/data/daily/YYYY/brdc*).

The CDDIS also generates daily RINEX V3 concatenated broadcast ephemeris files. The files are archived in the yearly *brdc* subdirectory (*ftp://cddis.nasa.gov/gnss/data/daily/YYYY/brdc*) with a filename of the form *BRDC00IGS_R_yyyydddhhmm_01D_MN.rnx.gz*. The procedure for generating these files is similar to the V2 procedure in that site-specific, mixed V3 ephemeris data files are merged into to a single file that contains the orbit information for all GNSS satellites for the day. The chair of the IGS Infrastructure Committee provided software that CDDIS staff uses to create these files.

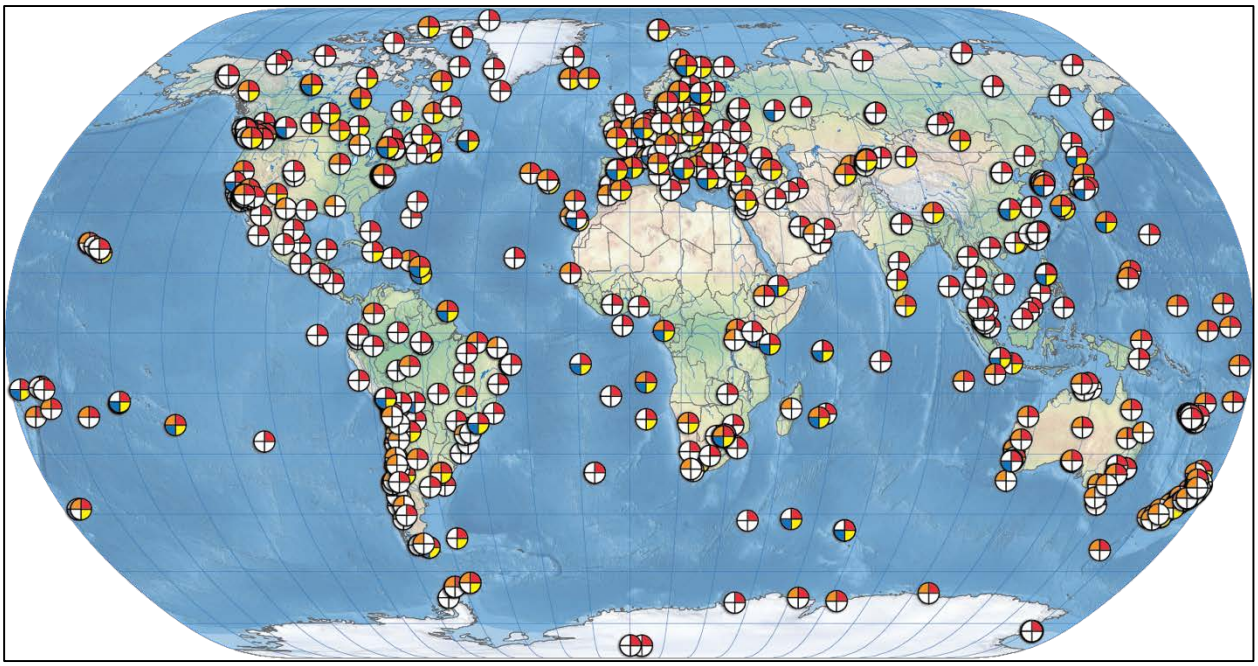

Figure 3: CDDIS GNSS archive includes data in daily (red), hourly (yellow), sub-hourly (blue), and/or real-time (orange) increments. Hourly, sub-hourly, and real-time data allow analysts to generate products for applications needing more frequent updates.

The CDDIS also generates daily RINEX V3 concatenated broadcast ephemeris files. The files are archived in the yearly *brdc* subdirectory (*ftp://cddis.nasa.gov/gnss/data/daily/YYYY/brdc*) with a filename of the form *BRDC00IGS_R_yyyydddhhmm_01D_MN.rnx.gz*. The procedure for generating these files is similar to the V2 procedure in that site-specific, mixed V3 ephemeris data files are merged into to a single file that contains the orbit information for all GNSS satellites for the day. The chair of the IGS Infrastructure Committee provided software that CDDIS staff uses to create these files.

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. These 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 (MGEX) Campaign Archive

During 2017, 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. Any 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*). In 2017, data from only one site

(TWTF) were archived in this manner. All other sites providing RINEX V3 data utilize the RINEX V3 naming convention and are archived in the operational GNSS directories.

The CDDIS continues to archive a merged, multi-GNSS broadcast ephemeris file containing GPS, GLONASS, Galileo, BeiDou, QZSS, and SBAS ephemerides. 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)*.

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, MGEX). 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 2017.

Product Type	Number of ACs/AACs	Volume	Directory
Orbits, clocks, ERP, positions	14+Combinations	3.5 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	7+Combination	5.5 MB/day, 2.0 GB/year	*/gnss/products/ionosphere/YYYY*
Real-time	Combinations	28 MB/week	*/gnss/products/rtpp/WWWW*
MGEX	6	175 MB/week	*/gnss/products/mgex/WWWW*

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.

Six AACs (CODE, GFZ, GRGS, JAXA, TUM, and Wuhan) generated weekly products (orbits, ERP, clocks, and others) in support of MGEX; CODE and JAXA utilize the “long” filename convention for their products. 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 bias (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. By the end of 2017, the CDDIS caster broadcasts nearly 40 product and over 330 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.

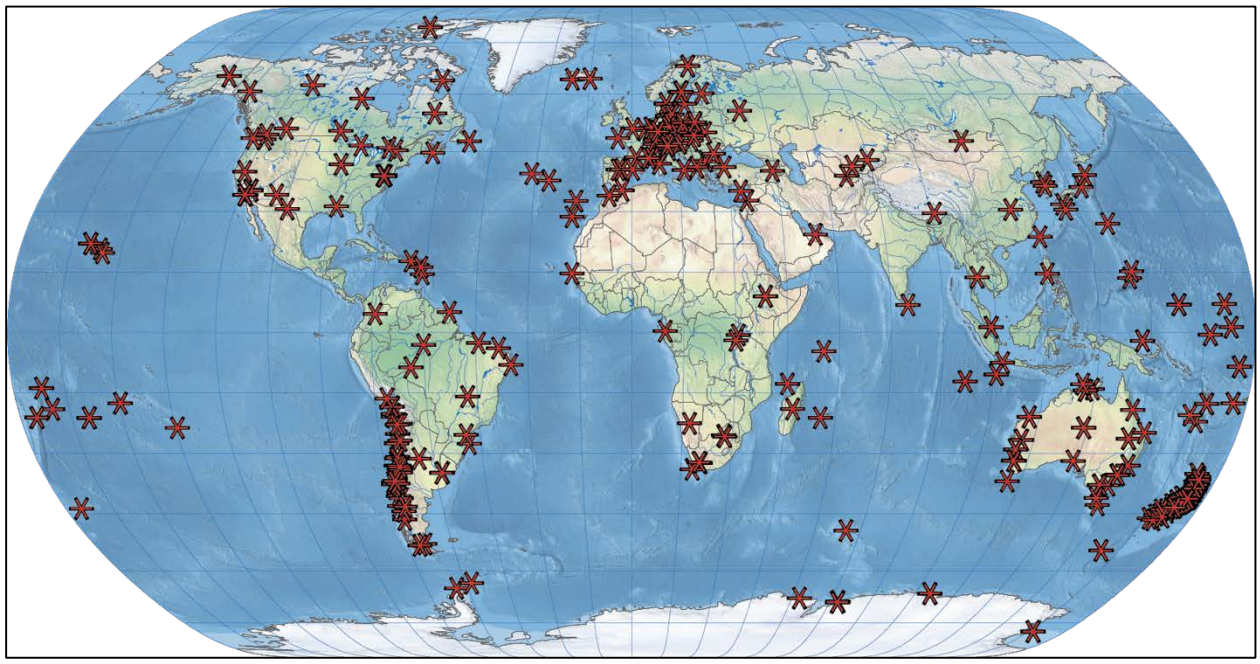

Figure 4: CDDIS is operationally supporting the dissemination of data from over 330 real-time GNSS sites as well as near real-time products derived from these data.

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 367K 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. Several more GDGPS streams were added to the CDDIS caster in 2017.

The CDDIS is participating in tests with the Real-time Earthquake Analysis for Disaster Mitigation (READI) project by streaming GNSS data from a network in Chile. The CDDIS caster also makes streams available from other regional casters (e.g., in Australia and New Zealand)

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/UCAR and BKG are required to register through the CDDIS registration process in order to use the CDDIS caster. By the end of 2017, over 180 users from 32 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.

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 2017. This figure illustrates the number and volume of GNSS files retrieved by the user community during the past year, categorized by type (daily, hourly, high-rate, products). Over 1.3 billion files (nearly 135 Tbytes) were transferred in 2017, with an average of over 100 million files per month. Figure 6 illustrates the profile of users accessing the CDDIS GNSS archive during 2017. The majority of CDDIS users were from hosts in Asia, North America, and Europe.

CDDIS assisted staff at the newest IGS Global Data Center located at ESA/ESAC by generating tar files of GNSS data and products to facilitate the population of their archive.

5 Recent Developments

5.1 Archive Operations

The CDDIS has been operating for over 35 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 consistent processing on all data types. This new software performs routine checksums of and anti-virus scanning on all incoming files, extracts consistent file-level and content-level metadata, and consistently tracks file and content errors. The new operations software was implemented for GNSS data processing prior to the transition to the new hardware system and is now fully operational. In 2017, the software was implemented on other data types uploaded and archived at CDDIS (e.g., SLR and DORIS); testing on incoming VLBI data and product files will continue in 2018.

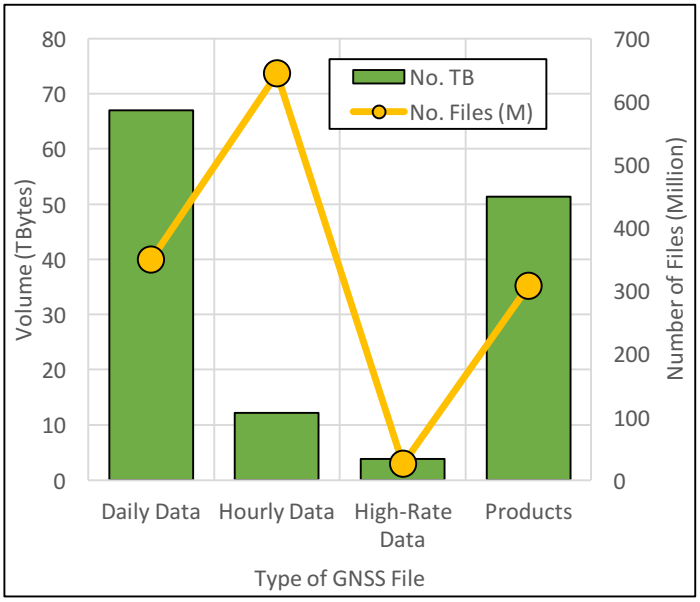

Figure 5: Number and volume of GNSS files transferred from the CDDIS in 2017.

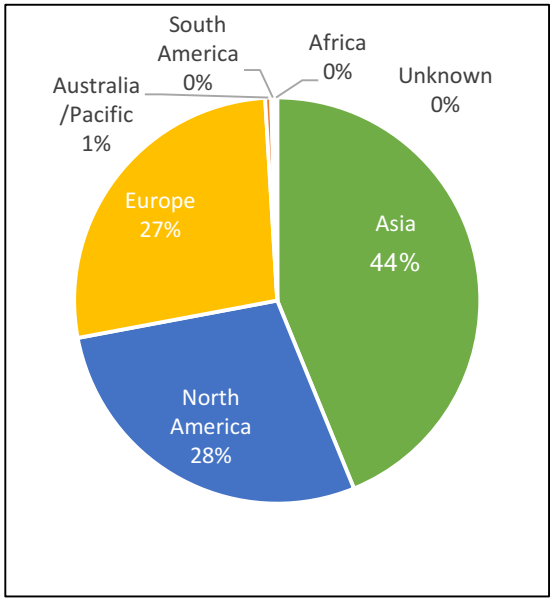

Figure 6: Geographic distribution of IGS users of the CDDIS in 2017.

The software modifications implemented in the new CDDIS processing system allowed staff to check for errors in a more consistent fashion, regardless of data type or file provider. As these checks were automated, the CDDIS has been able to identify new errors, such as problems with file naming, compression, and content. The new software categorizes errors in incoming files as fatal or warning errors; errors are tracked in the CDDIS database allowing staff to more easily monitor data processing. Fatal errors include logic errors (e.g., data with a future date), an empty file, or an unknown file name/structure. Files with fatal errors are not moved to the archive; they are placed in a "quarantine" location for further examination by operations staff. Warning errors are generally auto-corrected/handled and the file is then archived; these errors include a significantly older file, invalid compression, etc.

This improvement in error detection has allowed the CDDIS operations staff to actively work with suppliers to correct a large majority of errors and thus provide users with access to an improved, more reliable CDDIS archive. Furthermore, the number of errors detected have been reduced significantly, mainly due to active communication and cooperation between CDDIS operations staff and file providers. Since GNSS data accounts for a large number of the incoming files to CDDIS, the staff has developed a guidelines document for data providers (*https://cddis.nasa.gov/docs/2017/GNSSDataStandards_v2.pdf*).

5.2 Data Upload System

The CDDIS now utilizes 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. Unfortunately, despite efforts of CDDIS staff to help, some data providers have been unable to update their procedures and software to use the new CDDIS upload system; this deficiency has affected CDDIS data holdings. Although the CDDIS staff continues to work with providers to utilize the upload system, new procedures were needed to retrieve files have been put in place to ensure the archive is as complete as possible. More information on the CDDIS file upload system, including an FAQ, is available at: *https://cddis.nasa.gov/About/CDDIS_File_Upload_Documentation.html.*

5.3 Archive Access

With EOSDIS requesting that EDL should also be used for archive access, the CDDIS has implemented a new method of providing a web-based archive access capability. Since its start, users have accessed the CDDIS archive through anonymous ftp. This protocol allows users to easily automate file downloads but often has problems from a system and user standpoint. Therefore, as many public archives and users continue to move away from using ftp, the CDDIS has implemented https access to its full archive. This https access will continue to use same structure as that provided through ftp and is as efficient as ftp transfer without the firewall/router issues of ftp. For example, since ftp is a two-port protocol, users can have connectivity problems (e.g., with firewall, DNS, etc.). However, http is a one-port protocol and thus has fewer issues with downloads. The CDDIS will eventually utilize the Earthdata Login system for access through https. Even though ftp access to the CDDIS archive will continue; users, however, are encouraged to explore the new https capabilities. As stated previously, users with Earthdata Login credentials have easy access to the broad number of products available through all 12 EOSDIS DAACs. In addition, Earthdata Login will allow CDDIS to know our users better which will then allow staff to improve CDDIS capabilities.

The CDDIS continues to maintain 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 log (currently IGS, ILRS, and IDS). A second application, the CDDIS Archive Explorer (*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 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.

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 2017 and presented, or contributed to, papers on their activities within the IGS, including:

P. Michael and C. Noll. "Supporting GGOS Through NASA's Archive of Space Geodesy Data and Products" (poster), presented at European Geosciences Union General Assembly 2017, Vienna, Austria, April 24-28, 2017, Abstract No. EGU2017-10698.

M. Pearlman, C. Noll, C. Ma, E. Pavlis, R. Neilan, J. Saunier, T. Schoene, R. Barzaghi, D. Thaller, S. Bergstrand, J. Mueller. "The GGOS Bureau of Networks & Observations: An Update on the Space Geodesy Network & the New Implementation Plan for 2017-2018" (poster), presented at European Geosciences Union General Assembly 2017, Vienna, Austria, April 24-28, 2017, Abstract No. EGU2017-10698.

C. Noll and P. Michael. "An Update on the CDDIS IGS Global Data Center" (poster). Presented at IGS Workshop 2017, Paris, France, July 03-07, 2017.

S. Blevins, P. Michael, and C. Noll. "Real-time data and product performance metrics at NASA GSFC CDDIS" (poster). Presented at IGS Workshop 2017, Paris, France, July 03-07, 2017.

J. Woo, R. Limbacher, C. Noll, and P. Michael. "GNSS Quality Control Improvements and Provider Performance Tracking at the Crustal Dynamics Data Information System (CDDIS)" (poster). Presented at IGS Workshop 2017, Paris, France, July 03-07, 2017.

M. Pearlman and C. Noll. "The GGOS Bureau of Networks and Observations" (poster). Presented at the IAG and IASPEI Joint Scientific Assembly, Kobe, Japan, July 30 - August 04, 2017.

C. Noll, P. Michael, J. Woo, R. Limbacher. "NASA CDDIS: Next Generation System" (poster). Presented at the Fall American Geophysical Union meeting, New Orleans, LA, USA, December 11-15, 2017

S. Blevins, L. Hayes, Y. Collado-Vega, P. Michael, C. Noll. "Survey of localized solar flare signatures in the ionosphere with GNSS, VLF, and GOES observations" (poster). Presented at the Fall American Geophysical Union meeting, New Orleans, LA, USA, December 11-15, 2017

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 Archive Access

The https access to the CDDIS archive will become fully operational in 2018. CDDIS staff will work with users to transition their processing to use of https instead of anonymous ftp.

7.2 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.

7.3 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.

8 Contact Information

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

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C. Noll, Y. Bock, H. Habrich and A. Moore, "Development of data infrastructure to support scientific analysis for the International GNSS Service", Journal of Geodesy, Feb 2009, pages 309-325, DOI 10.1007/s00190-008-0245-6.

"IGS RINEX 3 Transition Plan v3.0", IGS website, http://kb.igs.org/hc/en-us/article_attachments/202584007/Rinex_3_transition_plan_v3.0.pdf.

"The Receiver Independent Exchange Format. Version 3.03", IGS website, ftp://igs.org/pub/data/format/rinex303.pdf.