CDDIS UPDATE

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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 GPS, GLONASS, laser ranging, DORIS and VLBI 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 Service (IERS)
- International DORIS Service (IDS)

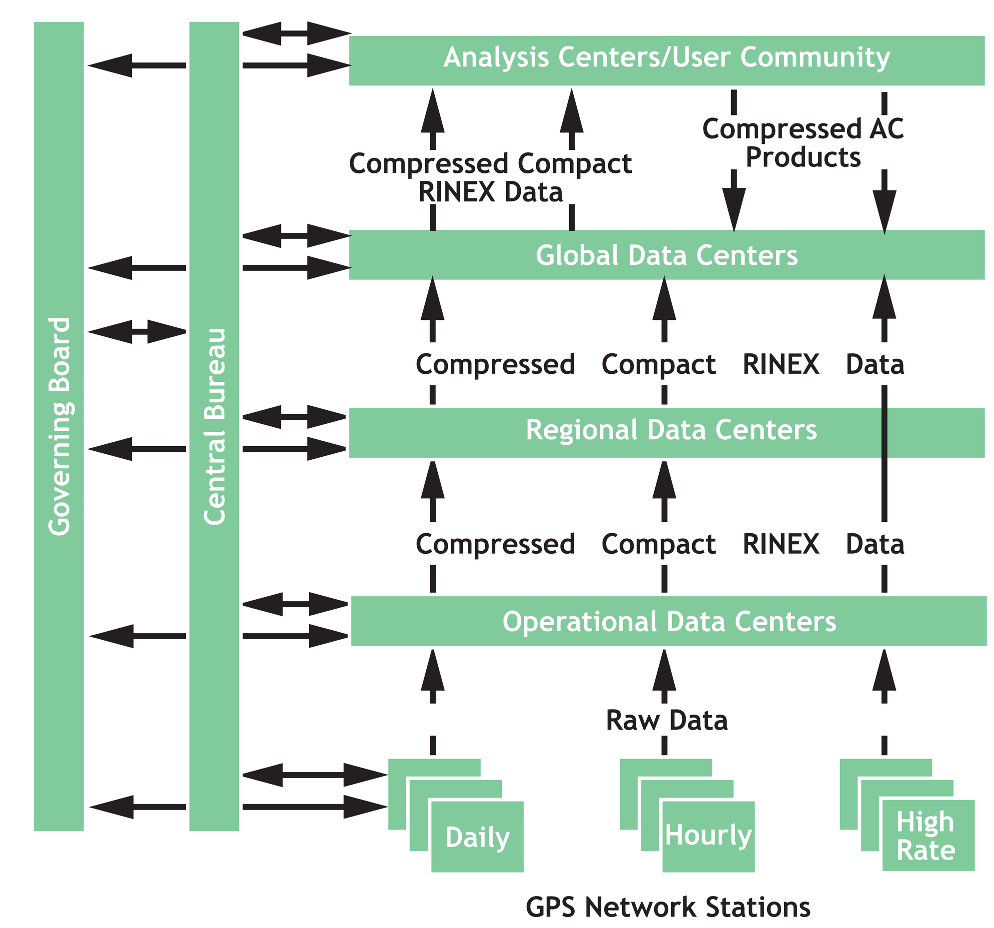
The CDDIS has served as a global data center for the International GPS Service since its start in June 1992, providing on-line access to GPS data from nearly 200 GPS and 50 GLONASS sites on a daily basis as well as the products derived by the IGS Analysis Centers from these data. The CDDIS supports the following working groups and pilot projects within the IGS:

- International GLONASS Service Pilot Project (IGLOS-PP)
- IGS Densification Program
- Ionosphere Working Group
- Troposphere Working Group
- Low-Earth Orbiters Pilot Project (LEO-PP)
- GPS Tide Gauge Benchmark Monitoring Pilot Project (TIGA)

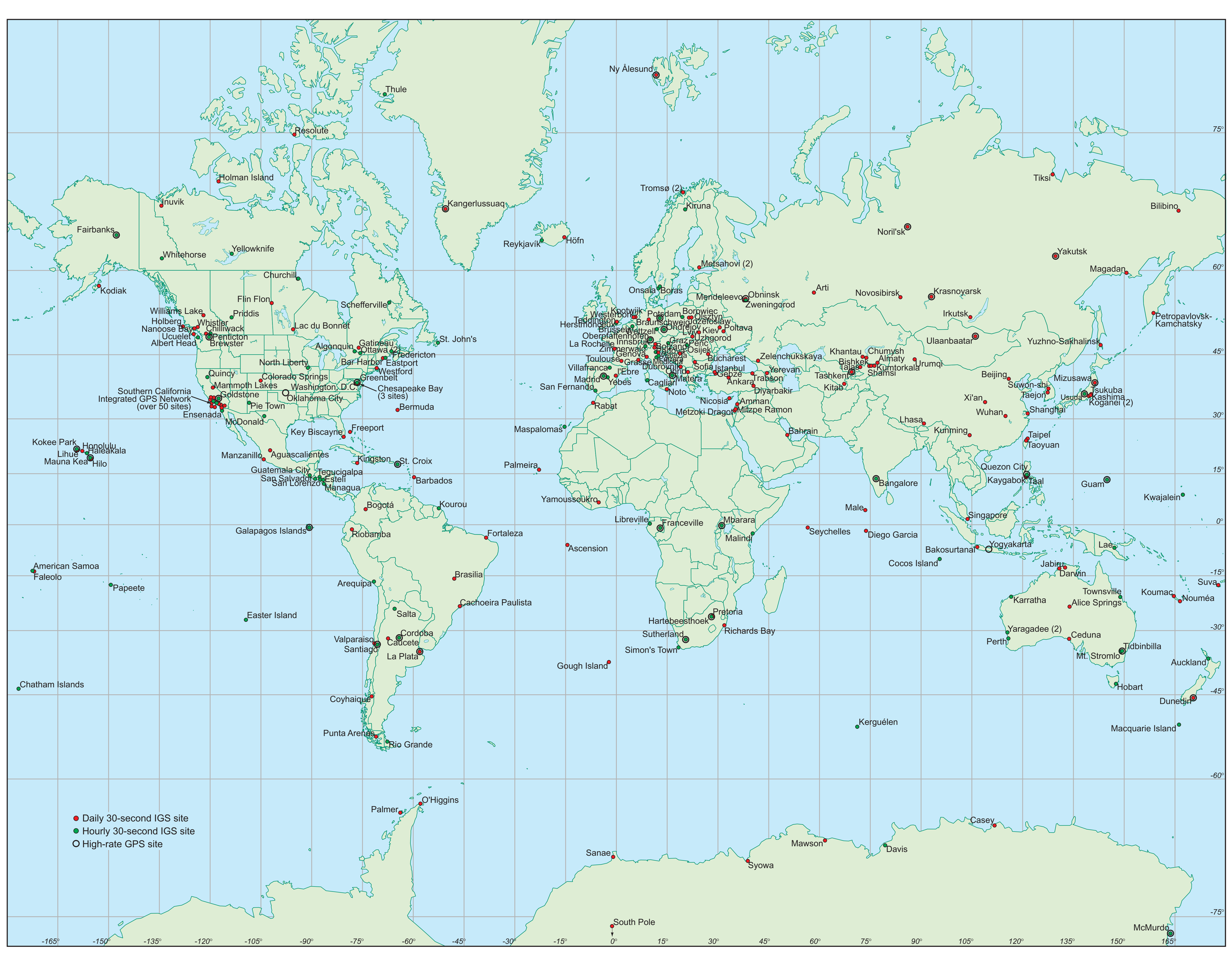
Operational and regional data centers deposit data to individual user accounts on the CDDIS host computer. All data are processed through UNAVCO's TEQC software to ensure data integrity and to extract pertinent metadata from the RINEX headers. These metadata are loaded into an Oracle database for data tracking and query purposes. Daily status files are also generated from the information contained in the RINEX headers.

The CDDIS is operational on a UNIX server with over 550 Gbytes of on-line disk storage. A majority of the archive is devoted to GPS data and products.

DATA FLOW FOR THE IGS



IGS DAILY, HOURLY, AND HIGH-RATE NETWORKS



IGS PRODUCTS AT THE CDDIS

Orbit, clock, ERP products

- Seven ACs
- Since June 1992 (GPS week 0649)
- Weekly precise combination, daily predicted and rapid combinations from AC Coordinator
- *ftp://cddisa.gsfc.nasa.gov/pub/gps/products/WWWW*
  - WWWW is 4-digit GPS week

SINEX products

- Seven ACs, two GNAACs, three RNAACs
- Since February 1996 (GPS week 0840)
- Weekly combination from Reference Frame Coordinator
- *ftp://cddisa.gsfc.nasa.gov/pub/gps/products/WWWW*
  - WWWW is 4-digit GPS week

Ionosphere products

- Working group product
- Global ionosphere maps of total electron content (TEC)
- IONEX format
- Daily files
- Five ACs
- Since June 1998 (GPS week 0960)
- *ftp://cddisa.gsfc.nasa.gov/pub/gps/products/ionex/YYYY/DDD*
  - YYYY is 4-digit year
  - DDD is 3-digit day of year
- *ftp://cddisa.gsfc.nasa.gov/pub/gps/products/ionex/YYYY/DDD/topex*
  - TOPEX ionosphere measurements
  - GPS broadcast ionosphere files
  - CODE Klobuchar model files
- *ftp://cddisa.gsfc.nasa.gov/pub/gps/products/ionex/YYYY/DDD/valid*
  - daily and weekly ionosphere model validation files

Troposphere products

- Working group product
- Combined zenith path delay (ZPD)
- Weekly files
- Weekly combination (from GFZ)
- Since January 1997 (GPS week 0890)
- *ftp://cddisa.gsfc.nasa.gov/pub/gps/products/WWWW/trop*
  - WWWW is 4-digit GPS week

IGS DATA AT THE CDDIS

GPS (and GLONASS) data (daily files):

- 30-second sampling
- ~0.35 Mbytes/site/day in size
- 200+ GPS (+ ~50 GLONASS) stations/day
- Data from 1997 through the present currently on-line
- Approximately 60% of daily data files delivered within three hours
- Data types:
  - O (RINEX observation data)
  - D (RINEX observation data, Hatanaka compression)
  - M (RINEX meteorological data)
  - N (RINEX broadcast ephemeris data)
  - S (output from TEQC)
- Daily combined broadcast ephemeris file created from all hourly nav files
- *ftp://cddisa.gsfc.nasa.gov/pub/gps/gpsdata/YYDDD/YYT*
  - YY is 2-digit year
  - DDD is 3-digit day of year
  - T is file type (O, D, M, N, S)

Near real-time GPS (and GLONASS) data (hourly files):

- 30-second sampling
- ~0.02 Mbytes/site/day in size
- ~116 regularly submitting (16 GPS/GLONASS)
- Approximately 60% of hourly 30-second data files delivered within fifteen minutes
- Retained for three days
- Creation of hourly combined broadcast ephemeris file started mid-2001; updated each hour with new navigation messages
- *ftp://cddisa.gsfc.nasa.gov/pub/gps/nrtdata/YYDDD/HH*
  - YY is 2-digit year
  - DDD is 3-digit day of year
  - HH is hour (00, 01, ... 23)

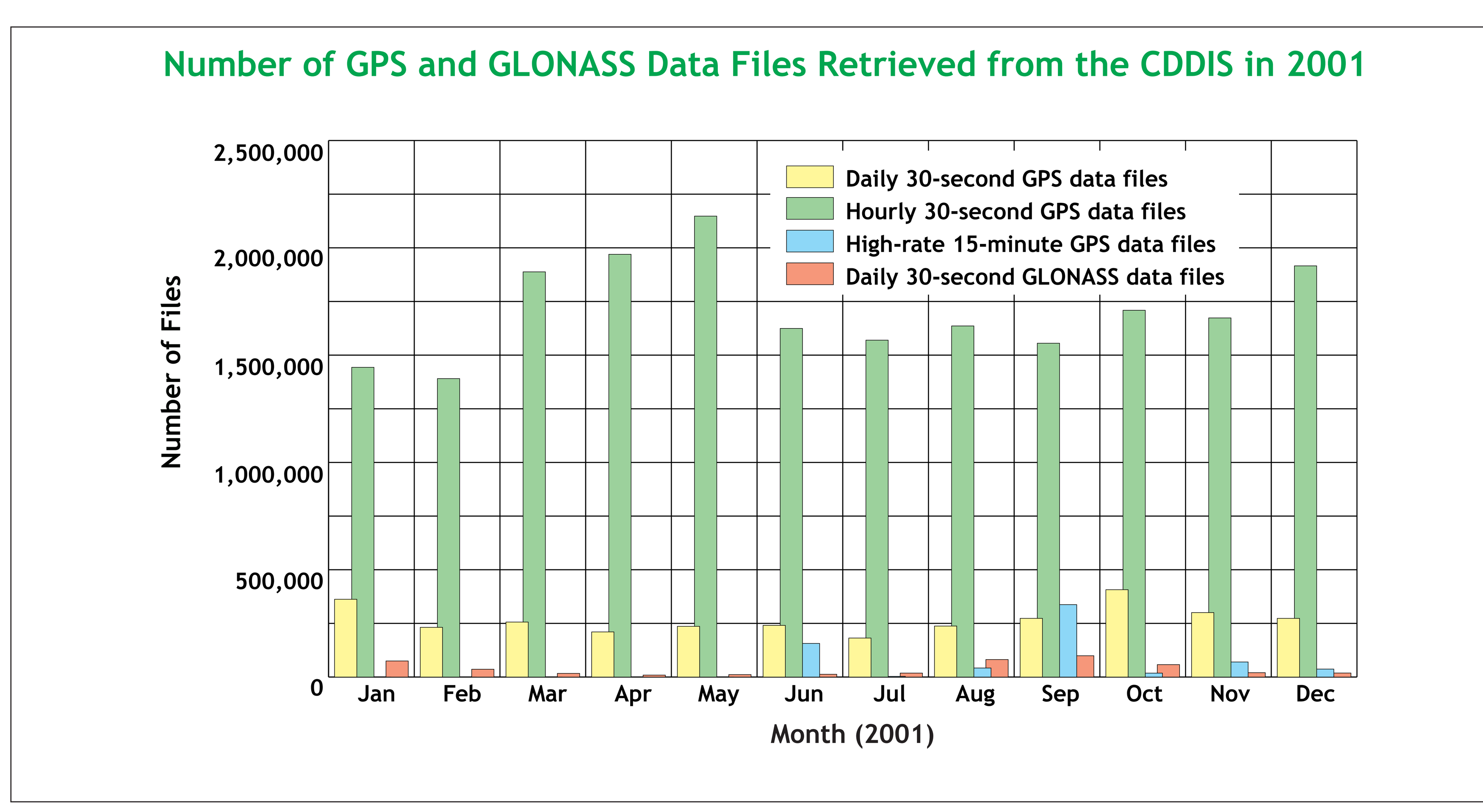
High-rate GPS data:

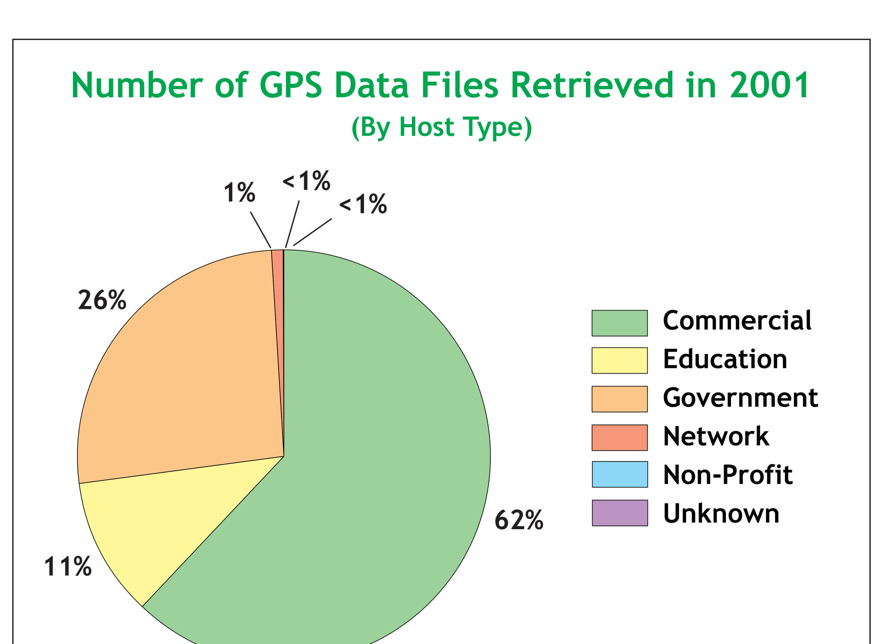
- 1-second sampling (typically)
- ~0.45 Mbytes/site/day in size
- 39 stations currently (from JPL, GFZ, GOPE, and ASI)
- Data in 15-minute files
- Since May 2001
- *ftp://cddisa.gsfc.nasa.gov/pub/gps/hrdata/YYDDD/YYT/HH*
  - YY is 2-digit year
  - DDD is 3-digit day of year
  - T is file type (D, M, N)
  - HH is hour (00, 01, ... 23)

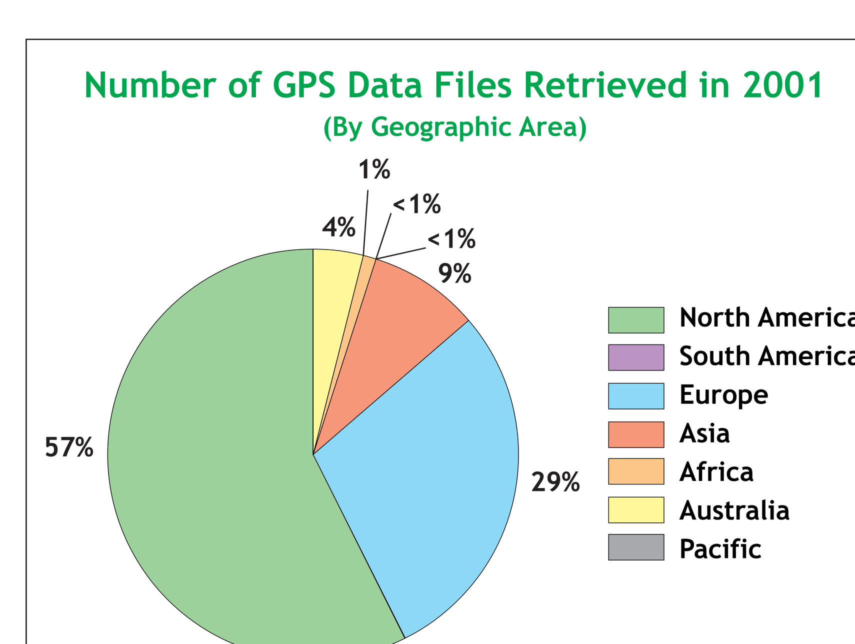
LEO GPS data:

- 10-second sampling
- ~2.5 Mbytes/satellite/day in size
- 3 satellites (SAC-C, CHAMP)
- Data in daily files
- Since January 2002
- *ftp://cddisa.gsfc.nasa.gov/pub/gps/leodata/SATNAME/YYDDD*
  - SATNAME is satellite name
  - YY is 2-digit year
  - DDD is 3-digit day of year

CDDIS ARCHIVE STATISTICS







RECENT DEVELOPMENTS AND FUTURE PLANS

In May 2001, the CDDIS began supporting the IGS Low Earth Orbiter Pilot Project (LEO-PP) by archiving data from a network of approximately forty sites operating at a one-second sampling rate (typically). These data are available in files containing fifteen minutes of data stored in subdirectories by GPS day, hour, and data type. Starting in January 2002, the CDDIS LEO-PP archive expanded to include data from GPS receivers on-board the LEO satellites; currently data from SAC-C and CHAMP are stored in daily files, Hatanaka-compressed RINEX format, in subdirectories by satellite and day. In 2002, this satellite archive will be expanded to include data from ICESat and Jason. The CDDIS is also archiving CHAMP orbit products from associate analysis centers participating in a LEO-PP comparison project; thus far, results from twelve AACs have been received.

The CDDIS supported the Ionosphere Working Group's HIRAC/SolarMax campaign in April 2001. This week-long activity was organized to study the effects of the solar maximum on the Earth's ionosphere using a dense, high-rate GPS tracking network. Data from 104 sites in thirty countries totaling thirteen Gbytes in size were collected and archived.

The CDDIS now creates combined broadcast ephemeris files on an hourly basis from all archived hourly navigation files. This file, available at *ftp://cddisa.gsfc.nasa.gov/pub/gps/nrtdata/YYDDD/hourDDD0.YYn.Z* (DDD is the three-digit day of year, YY is the two-digit year), contains all broadcast messages with the TOE of the day DDD that are available when the file is created at the top of the hour. The file is updated each hour with new navigation messages. At the end of the UTC day, when the final version of the file is generated, the file is copied to the *ftp://cddisa.gsfc.nasa.gov/pub/gps/gpsdata/YYDDD/YYn* and */gps/gpsdata/brdc/YYYY* directories and becomes the "daily" broadcast ephemeris file (denoted as brdcDDD0.YYn.Z).

The CDDIS computer facility was upgraded with a new RAID disk system increasing the on-line disk storage to 470 Gbytes. A second RAID disk array will be purchased in 2002. A dedicated DLT system for system backups and off-line archive storage will also be procured this year.

FOR FURTHER INFORMATION

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CEN 03/14/2002

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CODE - Current Issues Relevant to the IGS

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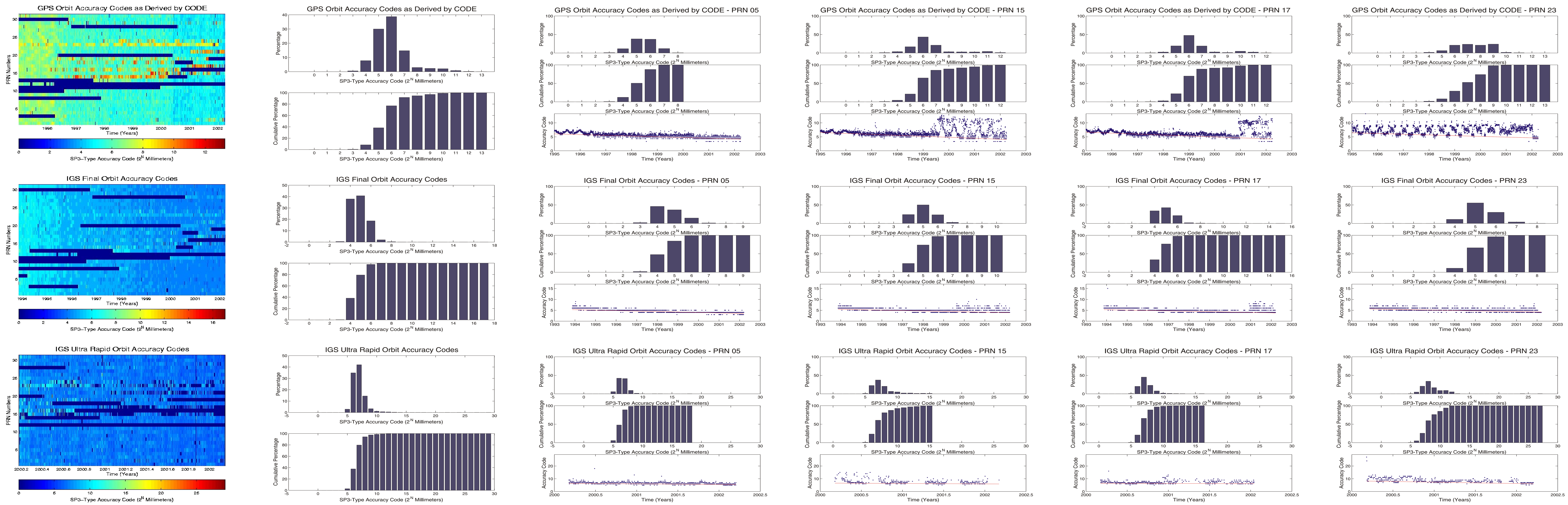
SP3-Type Orbit Accuracy Codes for the GPS Satellite Constellation

The consideration of reasonable orbit accuracy information becomes more and more important, for final, rapid, and in particular for ultra-rapid and predicted IGS orbits. The IGS should aim to provide orbit positions for all active satellites (including badly behaving satellites). In any case, users of IGS orbit products are advised to take the accuracy codes given in the SP3-files into account (especially zero-value codes!).

The plots in the first column give color coded values of different accuracy information for all satellites. Dark blue bars indicate unavailable PRNs. The figures in the second column show overall histograms of accuracy codes, while the plots in columns three to six display histograms and accuracy codes for selected satellites.

The accuracy codes addressed in the first row are derived from the RMS of a 3-day fit to the CODE 1-day final orbits. The accuracy codes in the second and third row are extracted from the IGS final and ultra-rapid SP3-files, respectively.

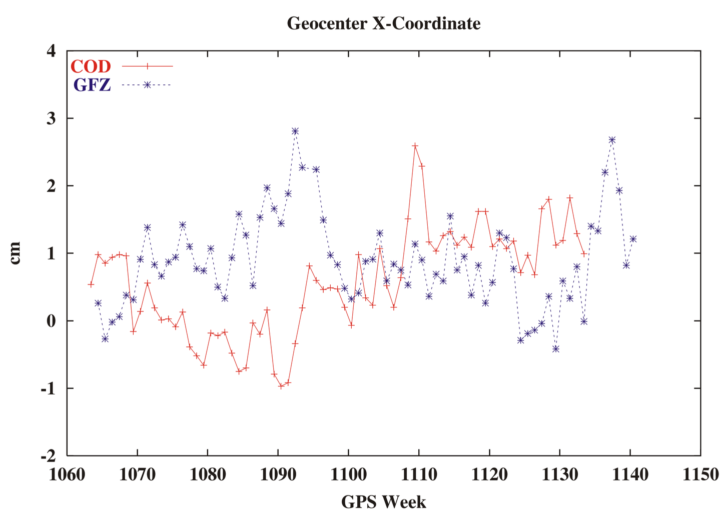
The gradual change of colours in the leftmost figures with time nicely shows the general trend steadily improving GPS orbits. Some satellites show a bad behaviour during certain time periods, e.g. PRNs 15, 17, 23. Seasonal variations indicate problems during eclipsing periods. Interesting to note is that PRN 23 transformed to a nicely behaving satellite around the beginning of 2002.

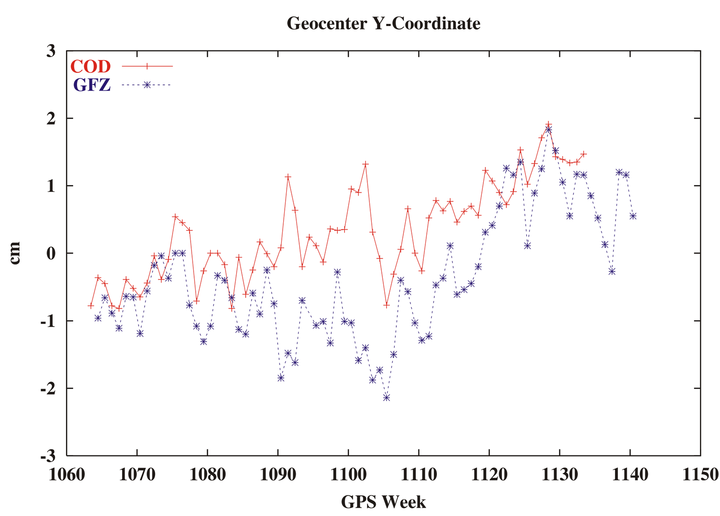


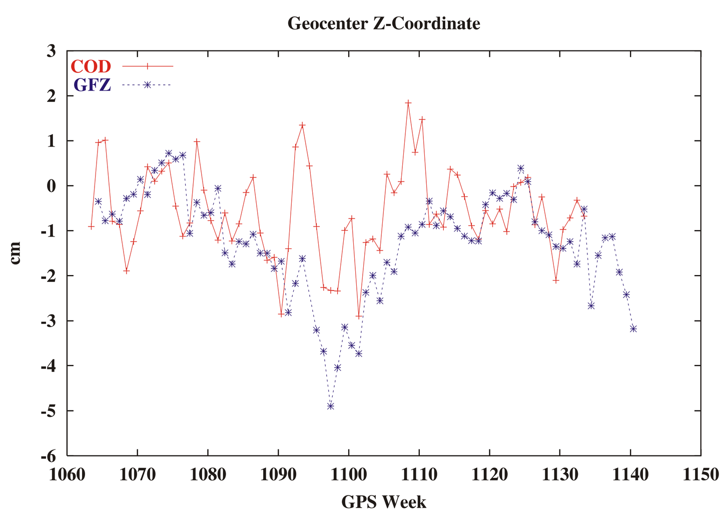
Geocenter Coordinates Derived From IGS Tracking Data

The reconstruction of geocenter coordinate values should be possible with each weekly AC SINEX contribution, independent of the datum definition used by the AC. The plots below show the geocenter coordinate time series as retrieved from weekly IGS SINEX files from CODE and from GFZ (commonly excluded from the IGS geocenter combination).

Both curves follow each other reasonably well.





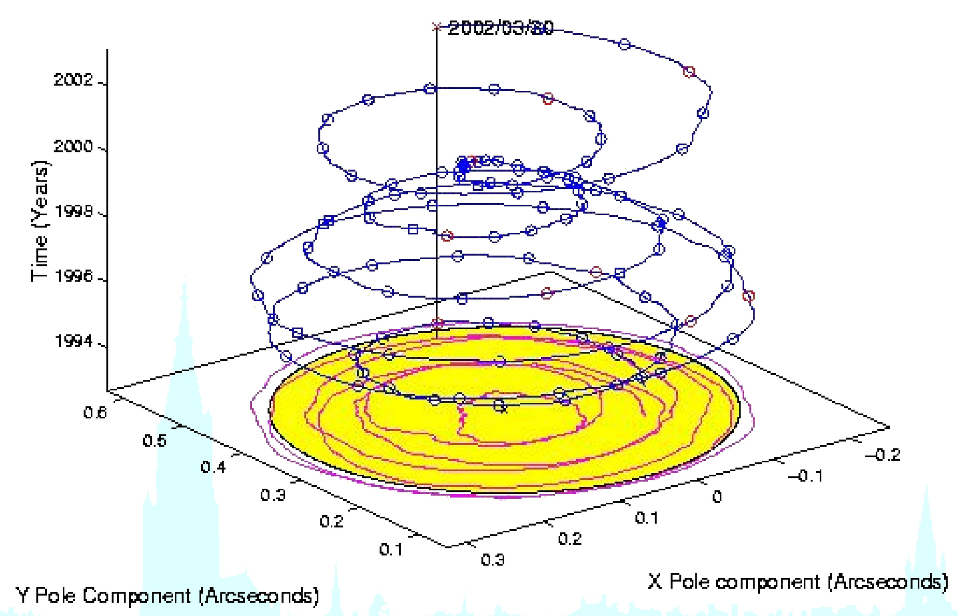


Earth Rotation Axis as Monitored by CODE

Pseudo-3D representation of the motion of the Earth's rotation axis based on a time series starting in July 1993, covering nearly nine years now.

An animated gif file showing the development of the rotation axis at monthly intervals is regularly updated (*http://www.aiub.unibe.ch/code/erp.gif*). The plot nicely shows the beat frequency, with a period of about 6.8 years, between the two major polar motion frequencies (yearly period: 365d, Chandler period: 428d).

High-rate Earth rotation parameters are computed at CODE since the beginning of 1995 (two-hour resolution). Since April 1994, daily drifts in nutation are estimated using 3-day satellite arcs.



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Poster Compiled by Michael Meindl, April 2002

CODE - Current Issues Relevant to the IGS

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Urs Hugentobler, Stefan Schaer, Michael Meindl,
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Pierre Fridez, Gerhard Beutler

Global Ionosphere Mapping

The Earth's ionosphere is still utmost active, as it may be inferred from Figure 1 showing the evolution of the mean vertical total electron content (VTEC) level over a period of more than 7 years. It is unclear whether we already passed the maximum of solar cycle 23.

Figure 2 shows a snapshot taken on 29 March 2002 at 17:00 UT of the global VTEC distribution. About 150 stations of the IGS and other institutions are considered for the global ionosphere mapping. RMS maps giving formal errors with respect to the TEC maps might help to improve the ground station coverage, since a homogeneous ground station coverage would be desireable, in particular for ionosphere mapping. Also, data availability is not unimportant in this context (see also below).

The latest CODE TEC and RMS maps are regularly posted to *http://www.aiub.unibe.ch/ionosphere.html*, recently also in form of animated gif files.

The most recent model change concerns our IONEX (IONosphere map EXchange) results which are no longer results from a 24-hour analysis but results for the middle day of a 72-hour combination analysis (done on the normal equation level). In this way, discontinuities at day boundaries can be minimized. Furthermore, a time-invariant quality level is achieved.

The consideration of TOPEX TEC data is planned. A GPS/TOPEX-combined global ionosphere map (GIM) product may be expected for the near future.

In face of the high ionospheric activity, the remarkable quality level in terms of CODE orbits and station coordinates, and the fact that we use a minimal elevation angle of only 3 degrees, an attempt to model and detect effects due to higher-order ionospheric terms would make sense. It is planned to consider three terms, specifically the related RRE corrections, as part of our classical "ionosphere-free" analysis.

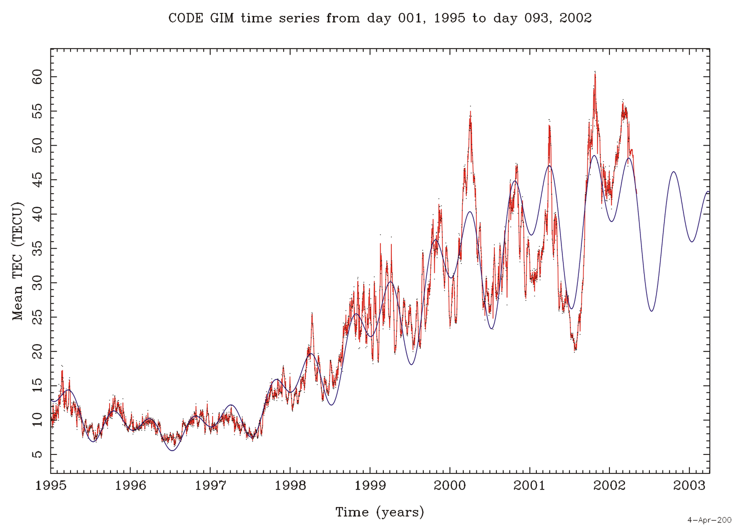

Figure 1: Mean TEC as computed by CODE

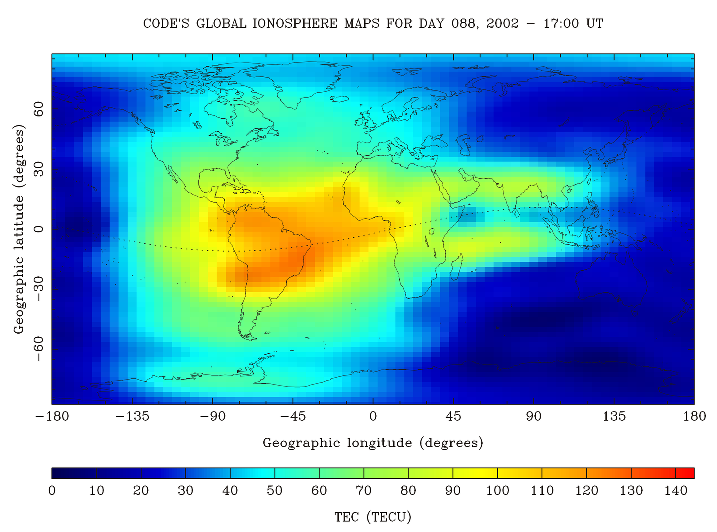

Figure 2: Snapshot of TEC map

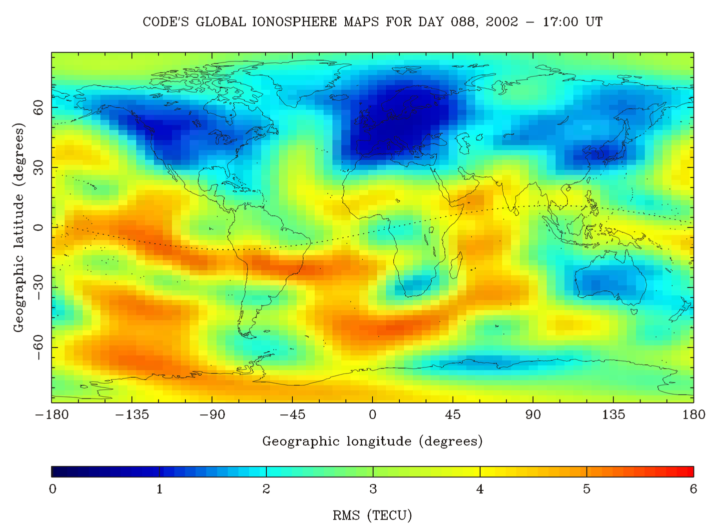

Figure 3: Snapshot of TEC corresponding RMS map

P1-P2 and P1-C1 Code Bias Retrieval

P1-P2 satellite as well as receiver code bias values are estimated in the ionosphere analysis, simultaneously with the parameters used to represent the global VTEC distribution.

P1-C1 satellite code bias parameters are solved for as part of the final clock estimation.

Figures 6 and 7 show corresponding daily differential code bias (DCB) estimates as accumulated over the last 30 days. Time series for both types of DCB are shown in Figures 8 and 9, where a significant jump concerning the bias values may be seen for PRN 11.

P1-C1 DCB values play an essential role for wide-lane ambiguity resolution when relying on precise code measurements. This implies that P1-C1 satellite bias retrieval should be also possible on double-difference level by analyzing the (ambiguity-fixed) "Melbourne-Wuebbena" linear combination of dual-band phase and code measurements. Corresponding procedures are already implemented in the CODE final analysis scheme (but not yet activated).

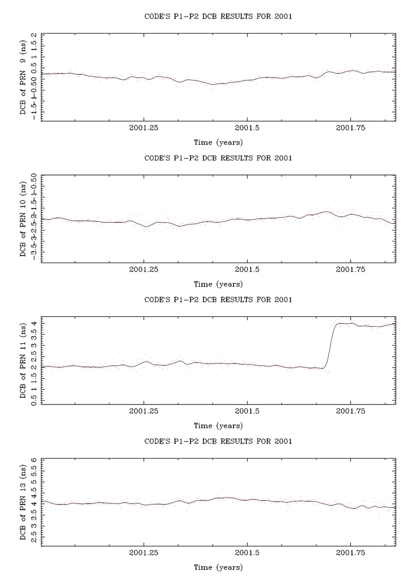

Figure 8: P1-P2 DCB values

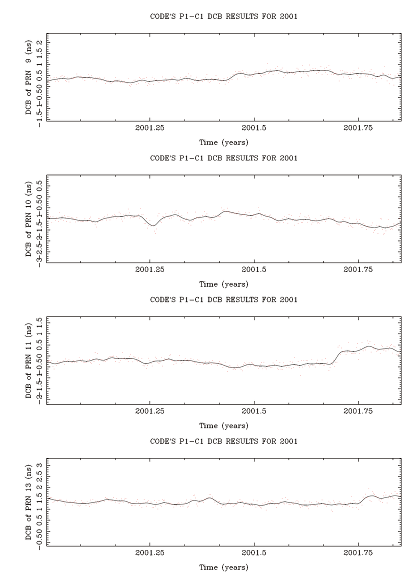

Figure 9: P1-C1 DCB values

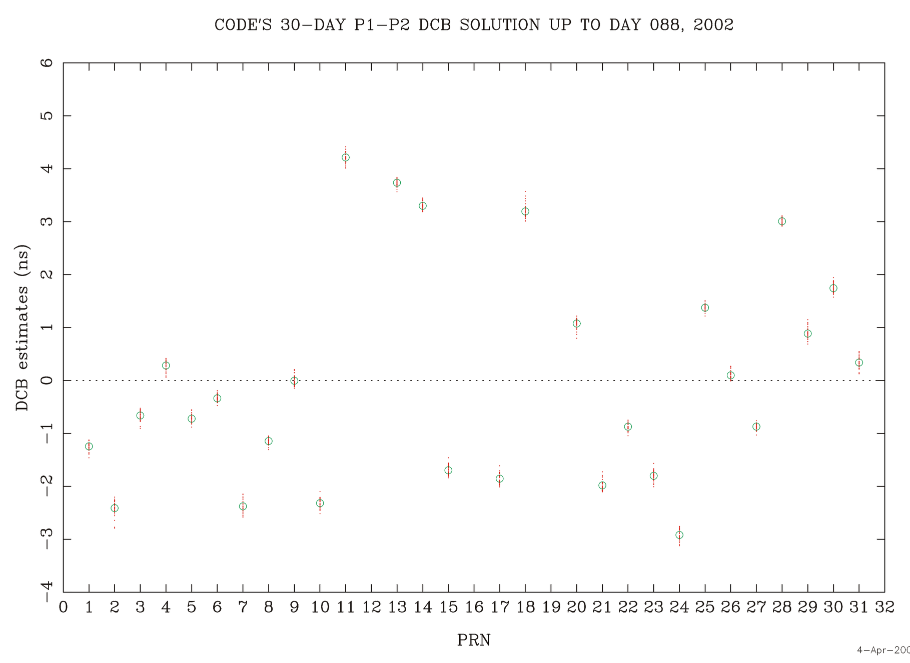

Figure 6: 30-day P1-P2 DCB solution

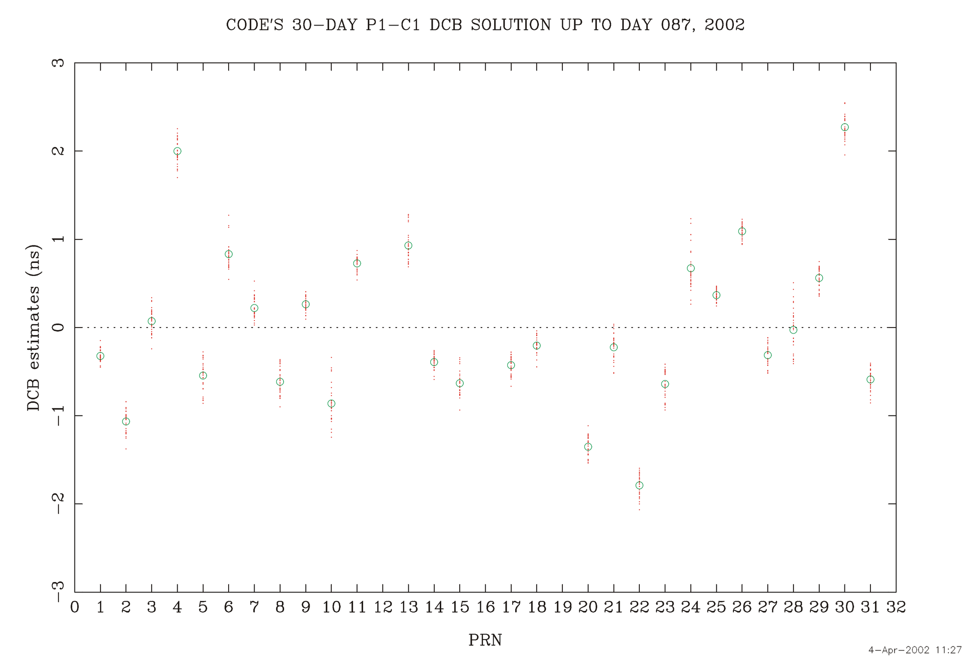

Figure 7: 30-day P1-C1 DCB solution

RINEX Data Availability in the IGS Tracking Network

Adequate availability of RINEX observation data, the primary product of the IGS, is indispensable for high-quality IGS products, in particular for global ionosphere mapping (see also above).

The RINEX observation data availability is visualized in Figure 4 for our final analysis (running with a delay of three days) and in Figure 5 for our rapid analysis (usually started few hours after observation).

Green dots indicate IGS sites where less than 6.6% of data is missing, yellow dots sites with more than 6.6%, dark orange sites with more than 13.2%, red dots sites with more than 19.4%, black dots sites where more than 50% is missing, and finally crux indicate "IGS sites" where no data was available. This statistics was made based on a time span of 365 days.

Corresponding plots (and tables) could be updated and made available on a regular basis.

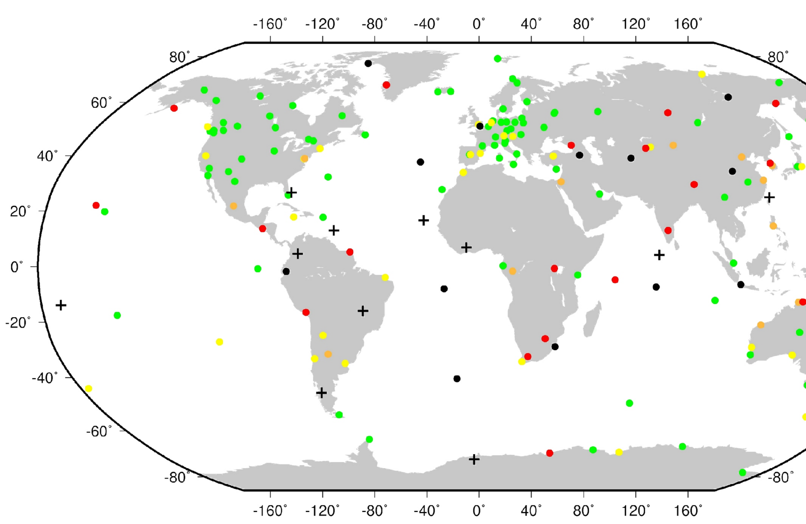

Figure 4: Data availability for CODE final analysis

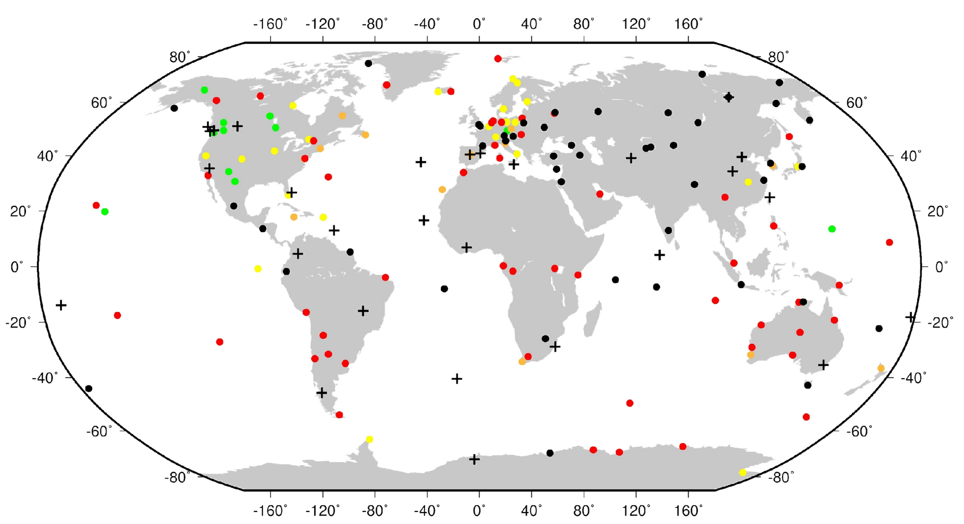

Figure 5: Data availability for CODE rapid analysis

Refined Ambiguity Resolution Scheme at CODE

Resolving initial carrier phase ambiguities seems to be essential also for orbital parameters. This is supported by Figure 10 in an impressive manner. During a short period, ambiguity fixing as part of our rapid analysis was -by mistake- temporarily deactivated (indicated with arrow).

Motivated by this finding, we reviewed and refined our ambiguity resolution scheme in our final as well as rapid analysis. Ambiguity fixing is now attempted for baselines up to 6000 km. Various ambiguity resolution procedures (following different strategies) are executed in a sequential fashion. As part of the final analysis, an additional boot-strapping step is performed, initially considering only baselines up to 3000 km.

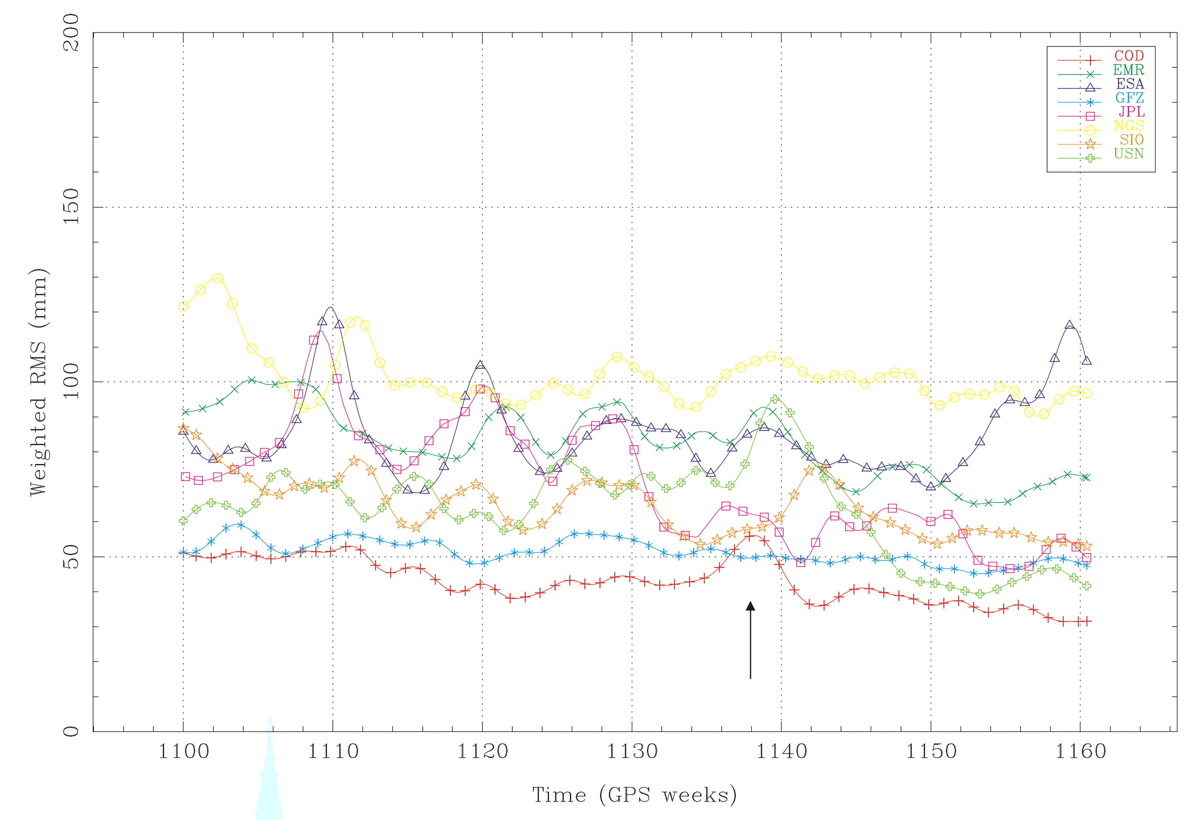

Figure 10: Smoothed weighted RMS for each AC rapid orbit solution with respect to IGS-combined orbit product

Poster Compiled by Michael Meindl, April 2002

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