The CDDIS: Supporting Scientific Analysis for 25+ Years Using Space Geodesy Data and Products

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- History and background
- System development
- User community

CDDIS & Geodesy

- Crustal Dynamics Data Information System, NASA's active archive of space geodesy data, products, and information
- Geodesy: Measuring the Earth's geometry, gravity field, and rotation; the size and shape of the Earth
- Space Geodesy: Making these measurements between ground-based instruments and objects in space:
  - GNSS
  - Laser ranging
  - VLBI
  - DORIS
- Space geodesy enables research in solid Earth physics, natural hazards, oceanographic, atmospheric, and environmental science
- Accomplished through the creation of a terrestrial reference frame: positions and velocities of a global network of observing stations

Space Geodesy 101

- Space geodetic systems provide the measurements that are needed to define and maintain the International Terrestrial Reference Frame (ITRF)
- Each of the space geodetic techniques has unique properties that bring unique strengths to the determination of this reference frame:
  - Radio verses optical
  - Terrestrial (satellite) verses celestial (quasar) reference
  - Broadcast up verses broadcast down
  - Range verses range difference measurements
  - Geographic coverage

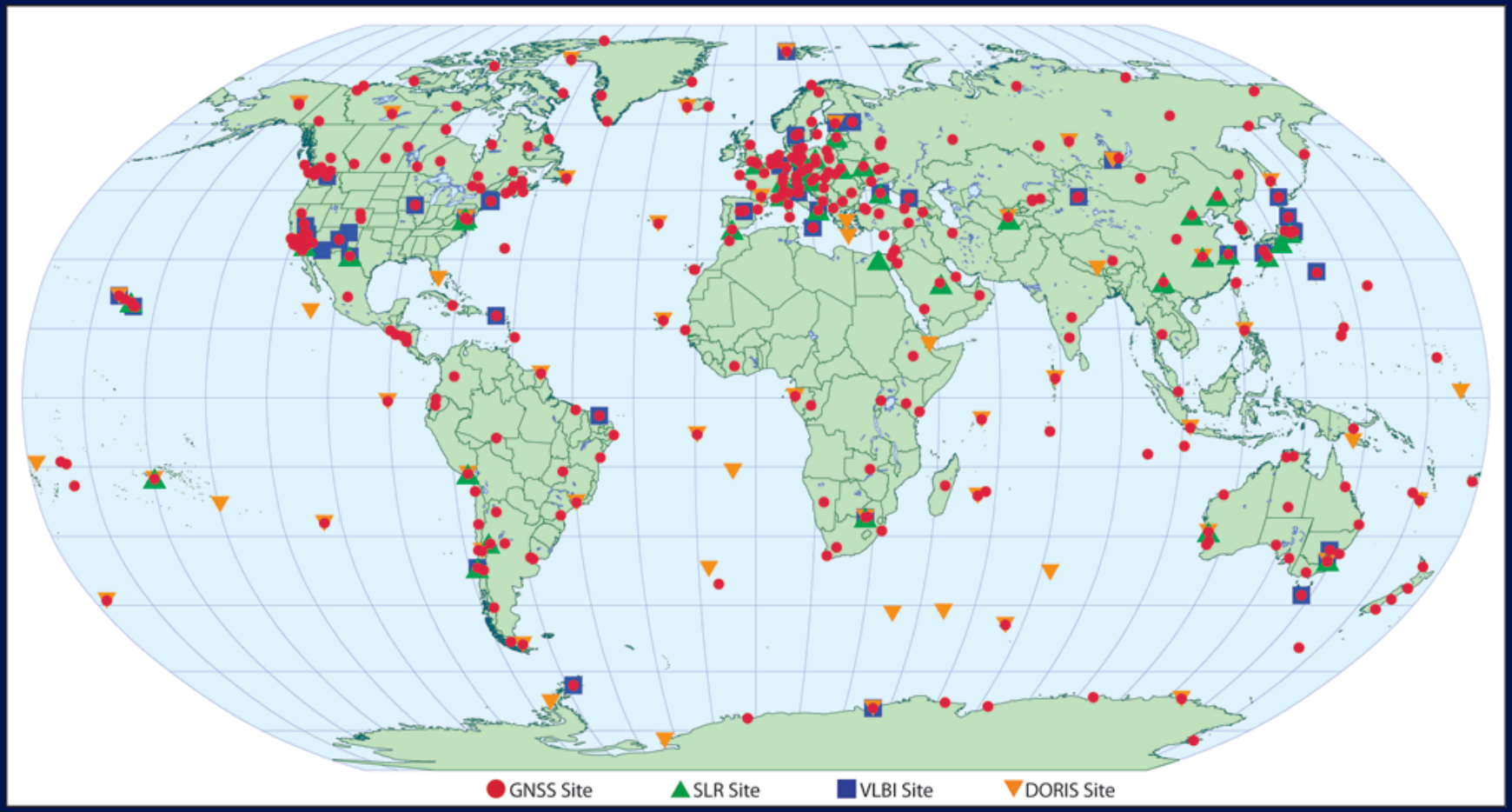
GNSS: Satellites (GPS-U.S., Russia-GLONASS, future EU-Galileo) equipped with precise clocks transmitting messages such as ephemeris, clock offsets, etc. to ground (and spaced-based) receivers to measure station to satellite pseudo-range, phase delay

SLR/LLR: Ground-based short-pulse laser transmitting to satellites (or planetary targets) equipped with corner cubes to measure round-trip pulse time-of-flight to satellite

VLBI: Radio telescopes equipped with X/S wideband receivers record signals from quasars to measure difference in signal arrival times

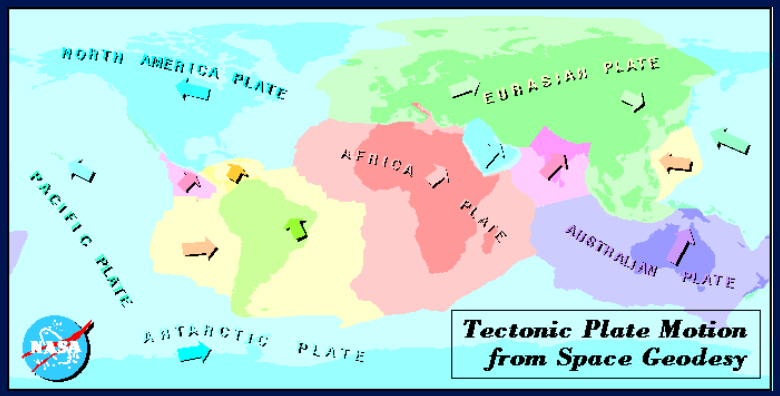
DORIS: Satellites equipped with DORIS receiver and uplink hardware transmit signals to ground beacons to measure Doppler shift on radiofrequency signals

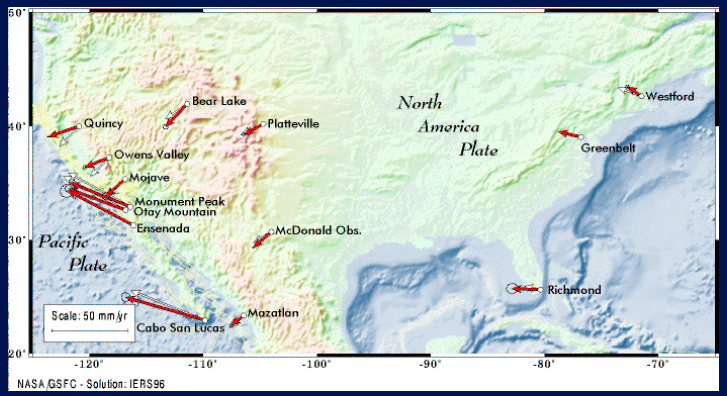
Global Networks: Input to the TRF



Historical Perspective (1/2)

- CDDIS began operations as the data system supporting NASA's Crustal Dynamics Project in 1982
- The CDP used space geodesy to monitor plate motion and the rotational dynamics of the Earth with unprecedented accuracy
- Authorized CDP investigators obtained data from the CDDIS (tapes!) and provided their scientific results to the CDDIS
- The CDP paved the way for cooperative investigation using space geodesy
- Cost high, global coverage low (with SLR and VLBI)





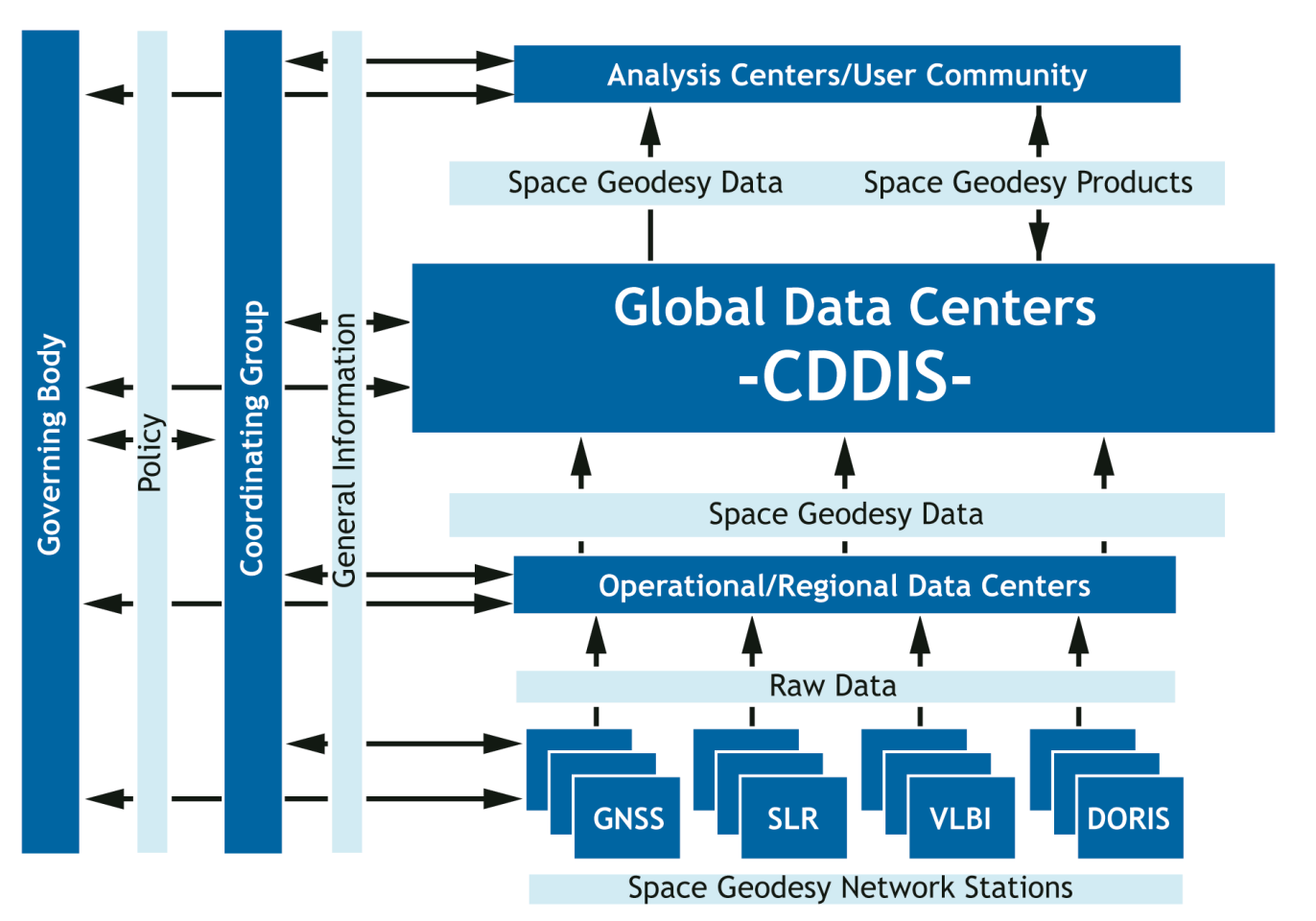
Historical Perspective (2/2)

- By late 1980's, government agencies, universities, etc. began deploying GPS receivers in permanent configurations for scientific study
- Goal: millimeter-level positioning
- Problem: No single government/agency/group could do the job on a global scale
- Solution: international, cooperative partnerships to facilitate research
- Multi-level cooperation: networks, data centers, analysis groups
- The International Association of Geodesy (IAG) began planning for the IGS – The International GPS Service
- IGS has provided precise GNSS observations and products for nearly 20 years
- Today, the International GNSS Service is a voluntary organization of over 200 agencies in over 90 countries

International Geodetic Services

- The IGS served as a model for the creation of other services for space geodesy techniques
- Services function as cooperating federations dedicated to a particular type of data
- Provide data and products on an operational basis to geodesy analysts as well as a broader scientific community
- Examples of a successful model of community management:
  - Develop standards
  - Self-regulating
  - Monitor performance
  - Define and deliver products using pre-determined schedules
- Successful operation through cooperation of many international organizations who leverage their respective limited resources to all levels of service functionality

Data/Products: From Source to User



- CDDIS is THE principle data center supporting services created under the IAG
- Simplicity has been the key to success!

CDDIS Archive

- Archive size: ~6.5 Tb
- Ingest rate: ~60 Gb/1 M files per month
- Distribution rate: ~5.5 Tb/40 M files per month
- File size is typically <2Mb/data “granule”, <10Mb/derived product “granule”
- Easy to add new data types/data sets
- Files:
  - Data, products derived from these data, and information about data and products
  - Multi-day, daily, hourly, sub-hourly
  - Varying latencies (minutes, hours, days)
- Metadata:
  - Non-standard, data type specific
  - Extracted from data (not all products) and loaded into relational database
  - Internal access to database

CDDIS User Community

- Expert Users: scripts for automated, routine file retrieval
  - Science Teams:
    - Analysis Centers supporting IAG services, tasked with providing standard products as per service specifications
    - U.S. and international groups who produce products for use in higher level products (e.g., orbits for GRACE, Jason, etc.; ionosphere/troposphere products for weather models)
    - Require continuous access to data for generation of products on pre-determined schedules
  - Other data centers:
    - Retrieve files from CDDIS to equalize data holdings among other data centers supporting IAG services
- Novice/Occasional Users
  - Need to explore the contents of the archive by spatial, temporal, platform, or parameter specifications
  - Access archive through ftp to:
    - Pick and chose data or products
    - Grab large subsets of data on irregular basis

Supported Groups and Missions (a subset!)

International Services

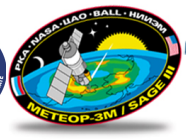


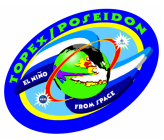
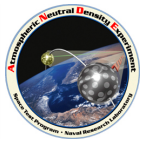



Missions

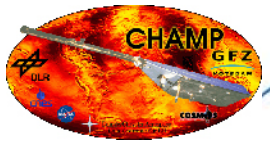
















Agencies and Universities











International Observe the Moon Night

- *http://www.nasa.gov/centers/goddard/visitor/events/observe-the-moon.html*
- GSFC Visitor's Center, September 18th from 6:30-10:00
- Tour and demonstrations of the Goddard Geophysical and Astronomical Observatory (GGAO) laser ranging facilities
- GGAO is home to NASA's Satellite Laser Ranging (SLR) since its development in the early 1960s