The Realization of the Global Geodetic Reference Frame and the IAG Position on GNSS

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The Three Pillars of Geodesy

- Modern geodesy is based on
  - *geometry and kinematics*,
  - *Earth orientation and rotation*, and the
  - *gravity field and its variability*.
- The *terrestrial system reference*, *Earth rotation, and the gravity field* are not stationary.
- Long-term *monitoring* with state-of-the-art techniques therefore is a central issue.

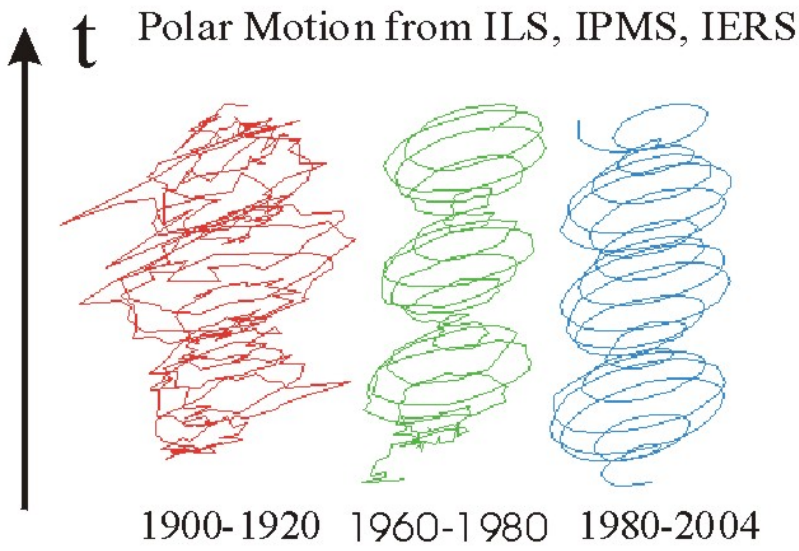
The Modern IAG

- Geodesy went through a (r)evolution in the 2nd half of the 20th century:
  - space age & space geodesy
  - age of computers
  - new understanding of IAG services (IGS, IERS)
- Whenever “permanent” tasks become apparent, the IAG sets up a service.

ILS, IPMS, IERS: A Case Study

- The ILS (Intl. Latitude Service) was founded in 1899 as a service of IAG to monitor polar motion using the astrometric observation technique.
- The IPMS (Intl. Polar Motion Service) used the same technique -- but more stations, better instrumentation, etc.
- The IERS (Intl. Earth Rotation and Reference Systems Service) is based on state-of-the-art Space Geodetic Techniques.

ILS, IPMS, IERS: A Case Study



- The ILS (left) was capable of monitoring PM with about 100mas.
- The IPMS (center) did the same (with the same methods) with an accuracy of few 10mas.
- The IERS does the same with < 0.1 mas accuracy.

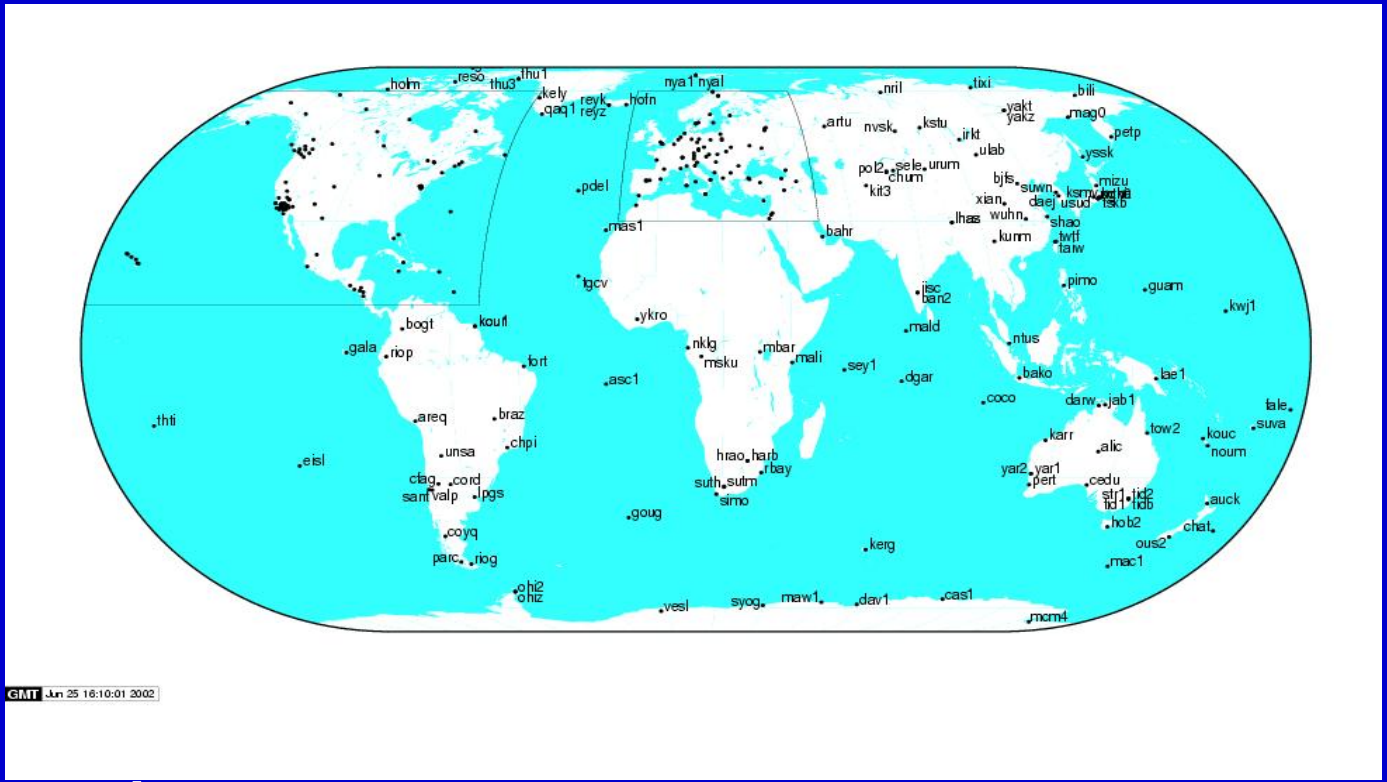
The IGS: Origins and Development

- By the late 80's, the potential of GPS for geodesy and geodynamics was realised by many organisations
  - Announcement of Opportunity 1991
  - Start of 3 month Test Campaign 21 June 1992
  - IGS became an official service of the International Association of Geodesy in January 1994
- Key to approach: sharing investments and operational costs by pooling the limited resources of many (ca. 200) organisations to establish an independent ground segment generating high accuracy products (best efforts basis, reliability through redundancy: importance of standards!)
- 1992-present: faster and more robust products, ever increasing exploitation of the signals

IGS Objectives: Science and Applications

- Provides access to and continually improves the ***International Terrestrial Reference Frame (ITRF)***
  - Station positions, velocities
- Provides ***precise time transfer***
- determines ERPs (polar motion, length of day)
- Monitors solid Earth deformations and sea level variations
- Enables LEO satellite orbit determination on cm-level
- Provides Ionosphere mapping (global, 2h resolution)
- Enables atmospheric applications (ground and space based) for climate research and weather forecasting
- Develops a sub-netork for real-time applications

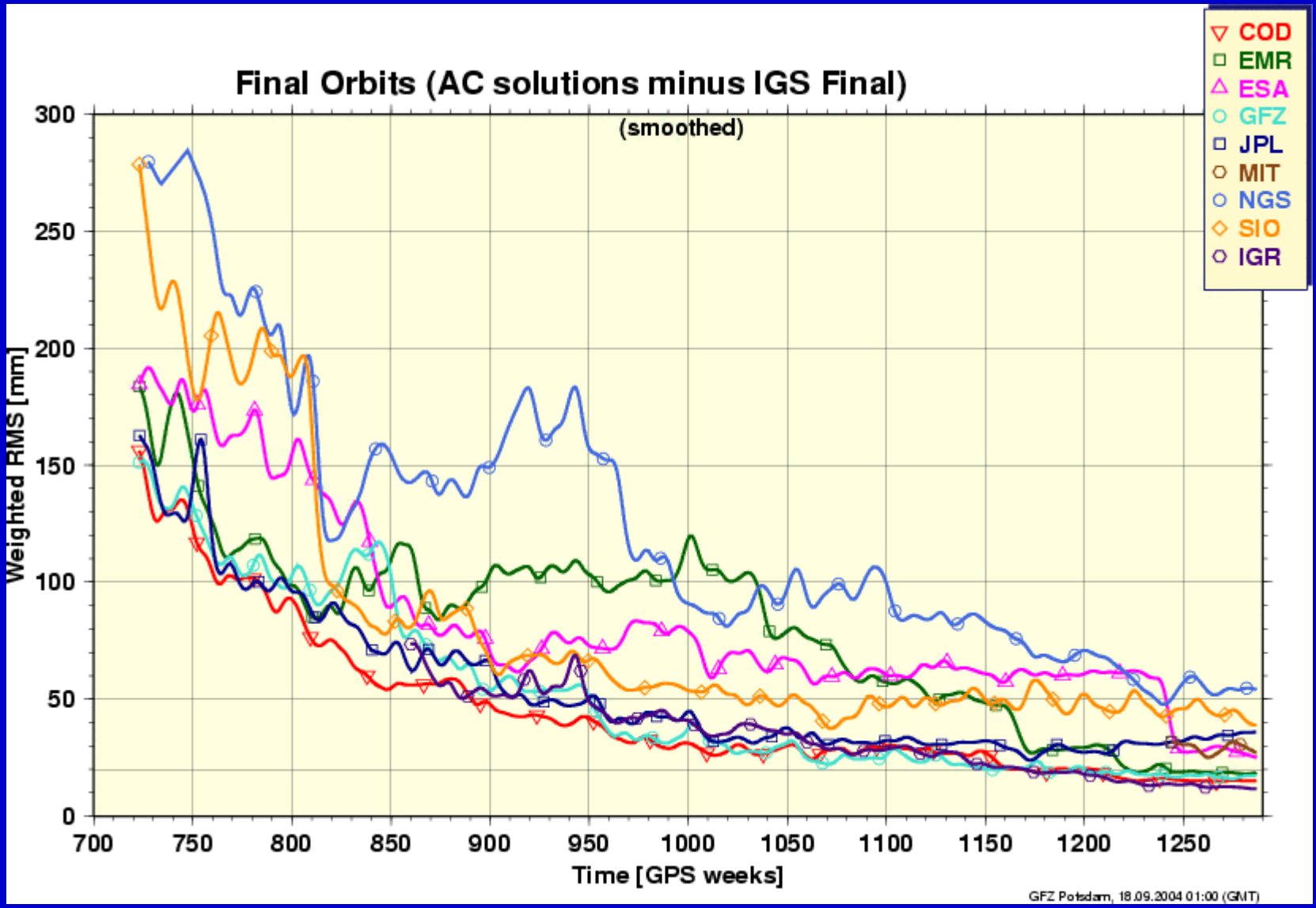
IGS Global Network



- Currently over 350 sites
- New site standards document: http://igscb.jpl.gov/

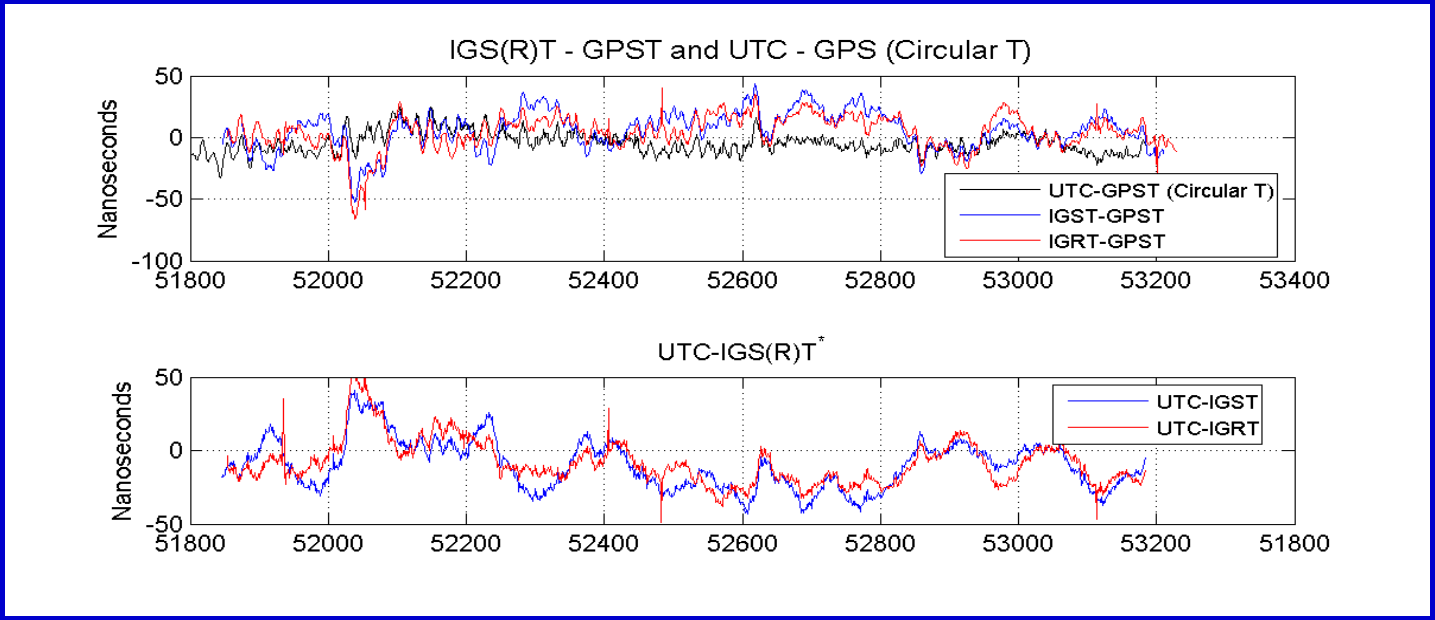
IGS Products

- IGS core products:
  - Precise orbits (<< 5 cm), predictions (10-20 cm)
  - Clock corrections (satellite, ground: sub ns)
  - Ground positioning (sub cm)
  - Consolidated and substantial input to International Terrestrial Reference Frame ITRF
  - Earth rotation parameters with high time resolution.
  - Ionosphere maps, approaching near real time
  - Tropospheric corrections (integrated water vapour)



- IGS orbits are for most applications “free of errors”!

IGS Timescales



- UTC (Universal Time Coordinated) is atomic time (TAI) -- apart from leap seconds.
- Defined and disseminated by time section of ***BIPM***.
- GPS time is the system providers realization of UTC.
- IGS time is the IGS realization of UTC

IGEX, IGLOS

- International GLONASS Experiment (IGEX) 1998, evolving into the International GLONASS Service (IGLOS) under IGS in 2000
- True combination of data from two global navigation satellite systms, namely GPS, GLONASS.
  - Prototype to combining GPS, GLONASS and GALILEO in future
  - Unifies reference frames for GPS and GLONASS
  - Calibration with Satellite Laser Ranging (the S/C have retro-reflectors)
  - Has stimulated the development of multi-system receivers/antennas

IGS 10th Anniversary Symposium & Workshop, Bern 1-5 March 2004

- Workshops: an essential element of the IGS methodology
- WS sessions organised by the WGs, central Symposium day highlighting GNSS developments and achievements
- Proceedings in preparation; see IGS website

The Global Geodetic Observing System (GGOS)

The ***Global Geodetic Observing System (GGOS)*** was installed during the XXIII General Assembly of the Inter-national Union of Geodesy and Geophysics (IUGG) in Sapporo, Japan, July 2003, as the first and presently only Project of the International Association of Geodesy (IAG).

IAG Projects are, according to the bylaws of IAG, ***of broad scope and of highest interest*** for the entire field of geodesy. They serve as the flagships of the Association for a long period (decade or longer).

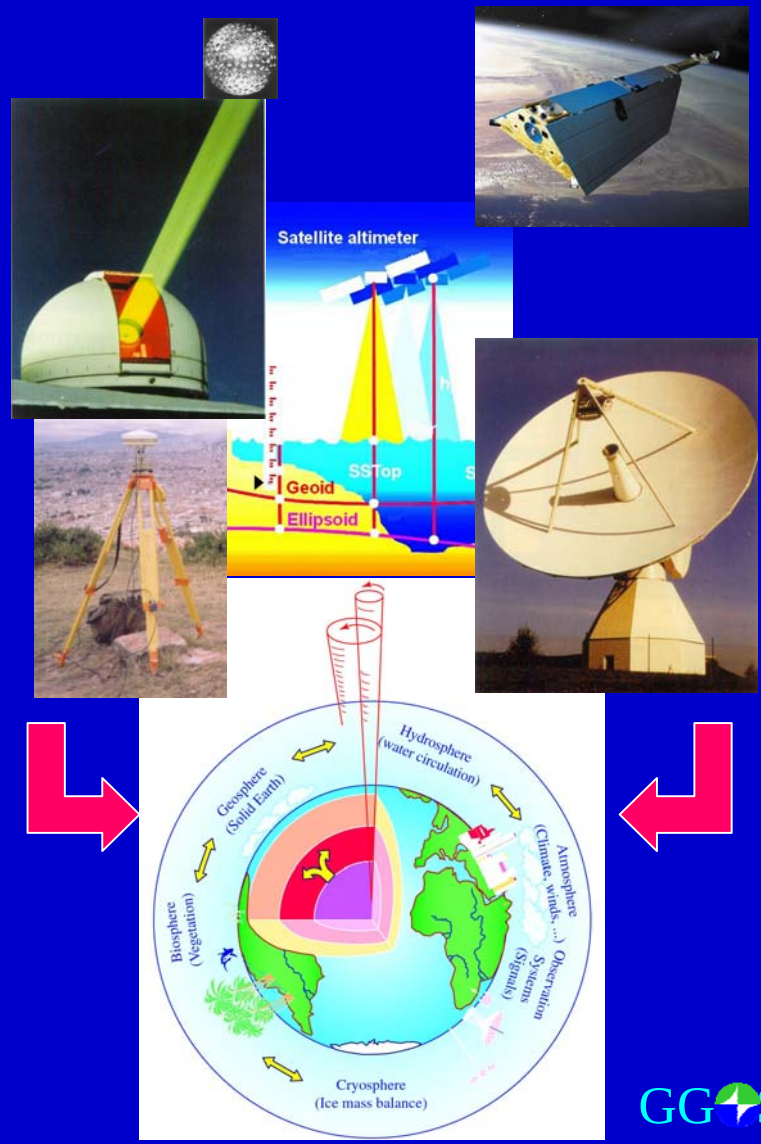
The initial phase of GGOS was set up directly after the Sapporo 2003 meeting. The first meeting of the GGOS Project Board took place before the IAG EC Meeting at the EGU General Assembly, Nice, April 24, 2004.

GGOS

The Vision of GGOS

- GGOS integrates different geo-detic techniques, different models, different approaches in order to achieve better long-term consistency, reliability and understanding of geodetic, geodynamic and global change processes.

- GGOS provides the scientific and infrastructure basis for all global change research in Earth sciences.



GGOS

The Mission of GGOS

- Identification of geodetic products and to establish the requirements concerning its accuracy, time resolution, and consistency
  - What is needed in geodesy, science and society ?
  - Accuracy: 10^{-9} or better for all kinds of GGOS products;
  - Time resolution: hours to decades (depending on products);
  - Use of compatible standards, models, parameters.
- To stimulate close cooperation between IAG services; to identify service gaps and develop strategies to close them;
  - Unified global height reference system (global vertical datum),
  - Vertical deformation models (tectonic, isostatic, loading, ...),
  - Global sea level monitoring (satellite altimetry service),
  - Free availability of terrestrial gravity data.

The Objectives of GGOS (1)

- **GGOS** aims at maintaining the stability of time series of geometric and gravimetric ***reference frames***;
- **GGOS** ensures the consistency between the different geodetic ***standards*** used in the geo-scientific community;
- **GGOS** aims at improving the geodetic ***models*** at the level required by the observations;
- **GGOS** focuses on all aspects to ensure the consistency of geometric and gravimetric ***products***;
- **GGOS** shall be established as an official partner in the United Nations' ***Integrated Global Observing Strategy, IGOS***,
- **GGOS** represents IAG in the inter-governmental ad hoc Group on Earth Observations (GEO).

GGOS

The Objectives of GGOS (2)

IAG‘s GGOS may play an important role within United Nations‘ Integrated Global Observing Strategy (IGOS) because

- It brings together the three Global Observing Systems (G3OS)
  - Global Climate Observing System (GCOS),
  - Global Ocean Observing System (GOOS),
  - Global Terrestrial Observing System (GTOS)
- It is active in various United Nations‘ organizations and in the International Council for Science (ICSU) bodies, e.g.,
  - UN Cartographic Office
  - Scientific Committee on Antarctic Research (SCAR)
  - Committee on Data for Science and Technology (CODATA)
  - Scientific Committee on the Lithosphere (SCL)
  - Committee on Space Research (COSPAR)

GGOS

Summary of IAG Activities and its Position on GNSS

- The IAG provides through its services the following basic information to science and society:
  - Celestial reference frame (IVS and IERS)
  - Terrestrial reference frame (IGS, IVS, ILRS, and IERS)
  - Earth rotation parameters (IERS, IGS, IVS, ILRS)
  - Relevant standards of space geodesy (IERS)
- The IAG provides through the IGS
  - orbits of all GNSS satellites (GPS, GLONASS, ...)
  - unifies the reference frames (geometry, time) of all GNSS (WGS-xy, PZ-90, ...)
  - day-to-day realizations of the ITRF

Agreement of Cooperation between IAG and UN-OOSA

- IAG and its relevant services should be ack-nowledged as provider of the reference frames (geometric, gravitational, time).
- IAG should be recognized as organization to unify ***geometry*** and ***gravity.***
- IGS should be recognized as provider of day-to-day realization of reference systems, GNSS-specific information (e.g., trafo ITRF<—> WGS, PZ90, code biases, etc.

Agreement of Cooperation between IAG and UN-OOSA

- IAG and its services, in particular the IGS, and UN-OOSA should work together to
  - fill gaps in regional geodetic reference system (e.g., AFREF, together with FIG, ICA, ...)
  - promote a global vertical datum (via geoid and GNSS)
  - promote standards of space geodesy, in parti-cular those related to GNSS
  - stimulate discussion with GNSS providers
  - establish seamless “geodetic” reference system in pla-netary system.