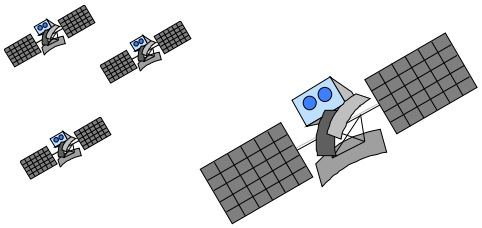
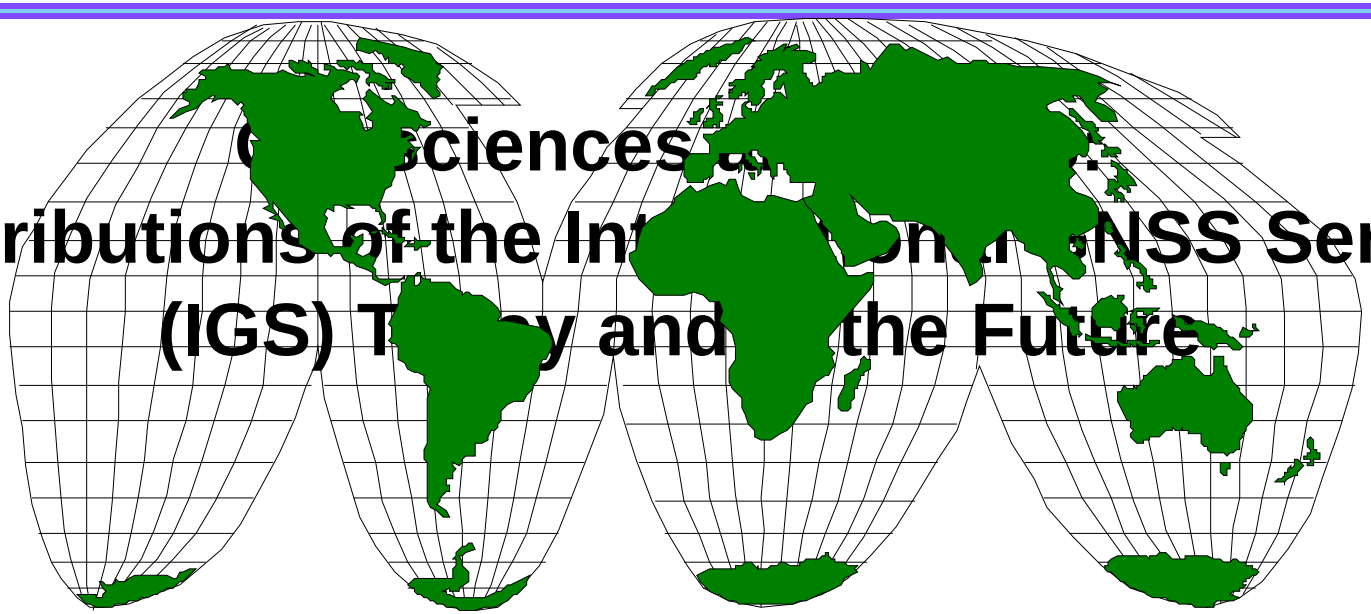


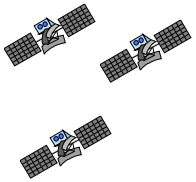


Geosciences and the International GNSS Service (IGS): Today and the Future

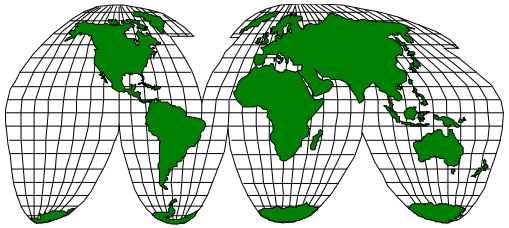
R. Neilan [1], J. Dow [2], R. Ferland [3], G. Gendt [4], A. Moore [1], M. Hernandez-Pajares [5], H.P. Plag [6], M. Rothacher [4], T. Schoene [4], R. Weber [7], R. Wonnacott [8]

[1] Jet Propulsion Laboratory, Caltech, IGS Central Bureau, California, USA, [2] ESA/European Space Operations Center, Darmstadt,Germany, [3] Natural Resources Canada, Ottawa,
[4] GeoForschungsZentrum Potsdam, Germany, [5] Universitat Politecnica de Catalunya, Spain,
[6] University of Nevada at Reno, USA, [7] Technical University of Vienna, Austria, [8] Chief Directorat Surveys and Mapping, South Africa

EGU Geodesy Session
Vienna, April 4, 2006



Overview



- IGS & Directions
  - Today, products and directions (see IGS exhibit here)
- Challenges for GNSS
  - Keeping pace with technology evolution, multiple GNSS
- GGOS and GNSS
  - Contributions to the Global Geodetic Observing System in support of Geosciences

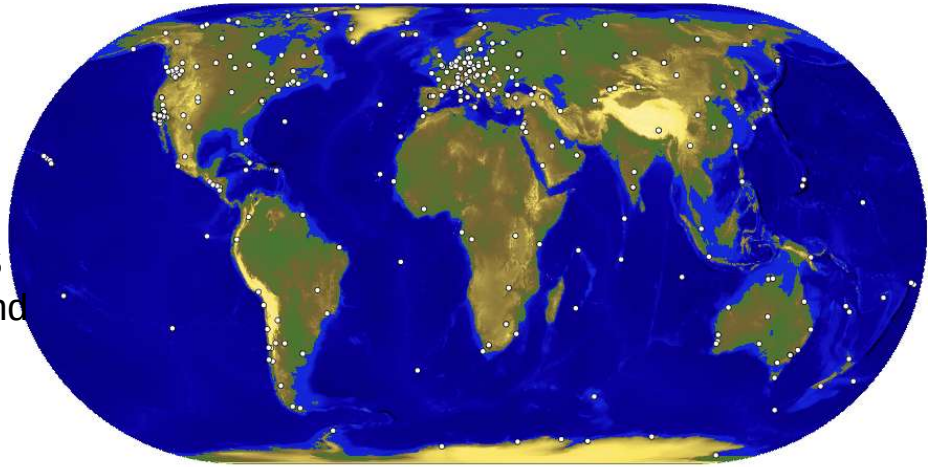
International GNSS Service

Formerly the International GPS Service

GNSS: Global Navigation Satellite System

The IGS is a voluntary federation of more than 200 worldwide agencies that pool resources and permanent GNSS station data to generate precise GNSS products.

Over 350 permanent, geodetic GNSS stations operated by more than 100 worldwide agencies comprise the IGS network. Currently the IGS supports two GNSS: GPS and the Russian GLONASS.

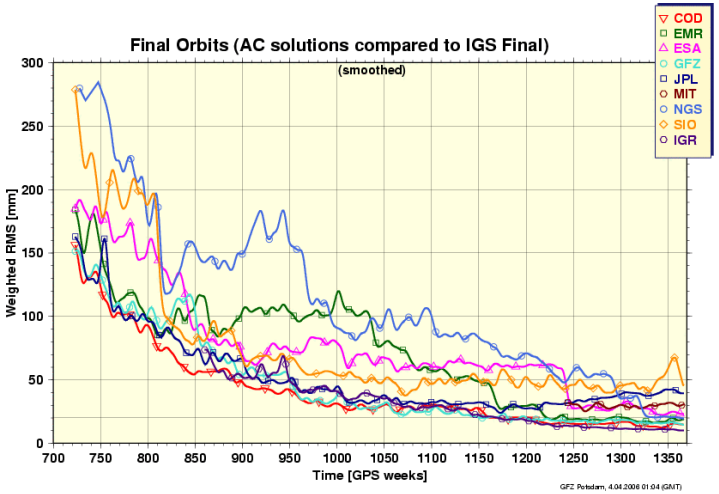


IGS products are formed by combining independent results from each of several Analysis Centers. Improvements in signals and computations have brought the centers' consistency in the Final GPS satellite orbit calculation to ~ 2cm.

IGS is a key component contributing to the ITRF and enabling its densification. IGS fosters unique application projects and working groups.

IGS Projects & Working Groups

IGS Reference Frame
Precise Time & Frequency Transfer
GLONASS Pilot Service Project
Low Earth Orbiters Project
Ionosphere WG
Atmosphere WG
Sea Level - TIGA Project
Real-Time WG
Data Center WG
GNSS WG

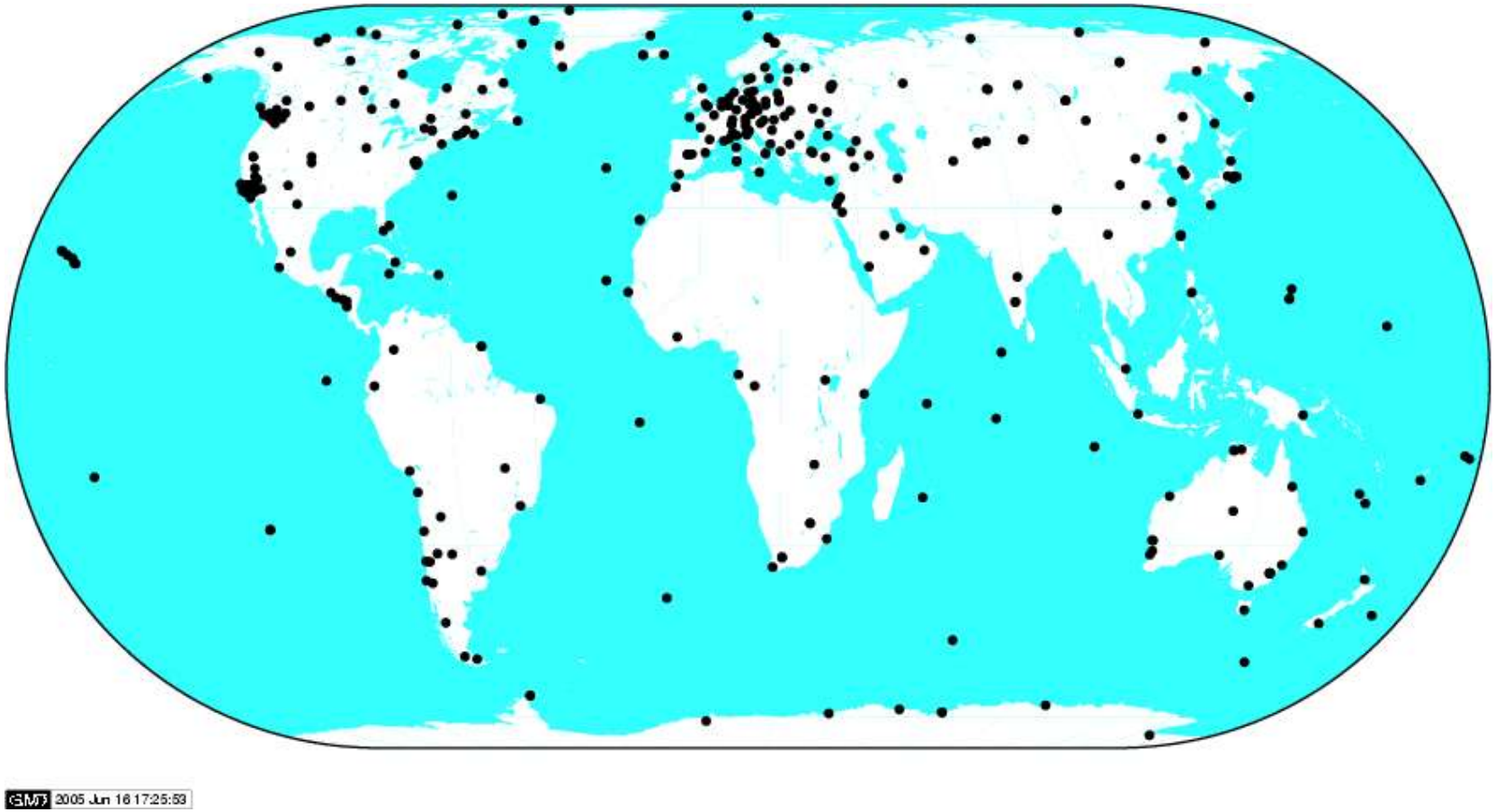


Graph courtesy Analysis Coordinator

G. Gendt, GFZ Potsdam

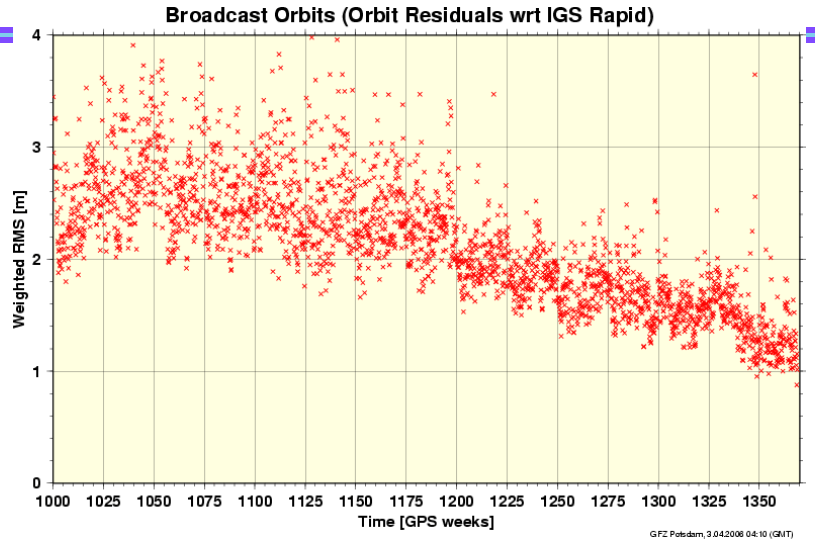
IGS Tracking Network 2006

GPS + GLONASS

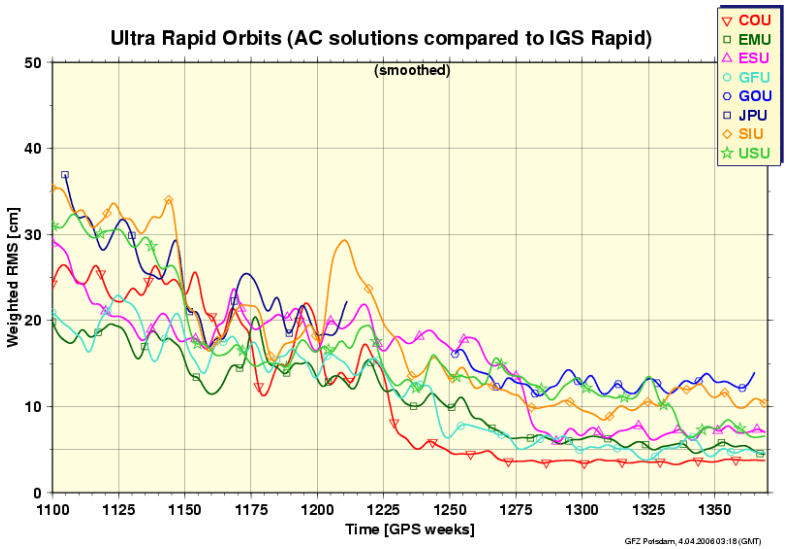


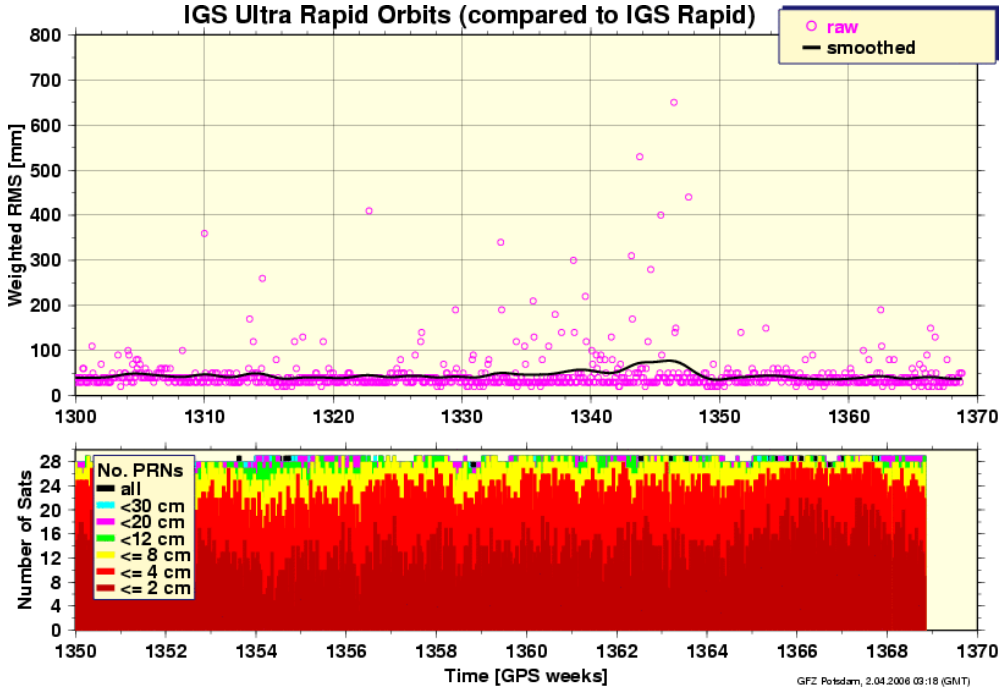
http://igscb.jpl.nasa.gov/network/netindex.html

Towards Real-time: IGS Ultra-Rapid Products



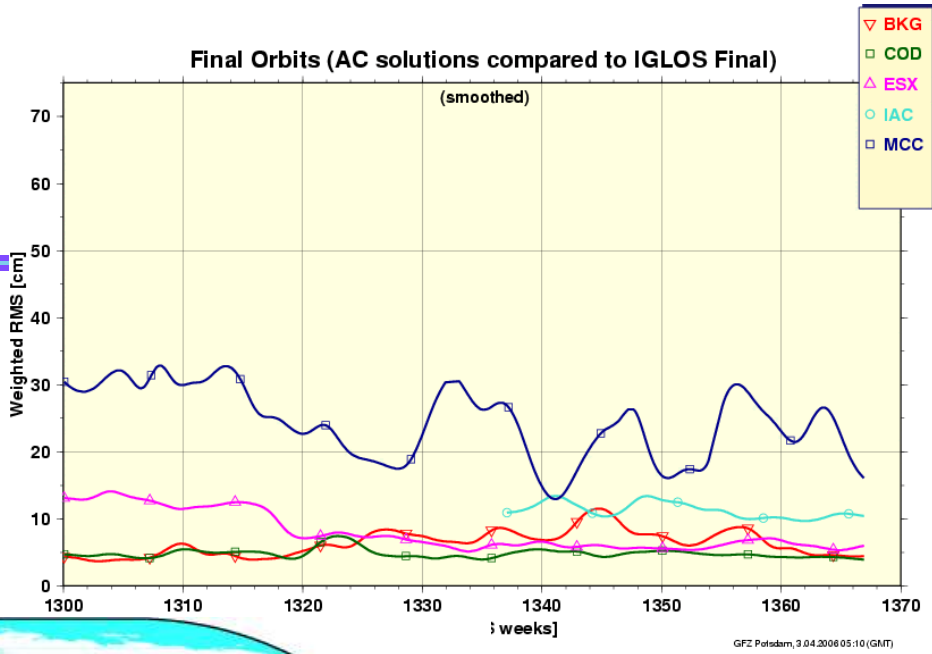
- GPS Broadcast orbits - significant and steady improvements
- IGS Ultra-rapid delivered every 6 hours
- Combination of real and predicted
- Real-time - integrity monitoring for analyses, future products developing





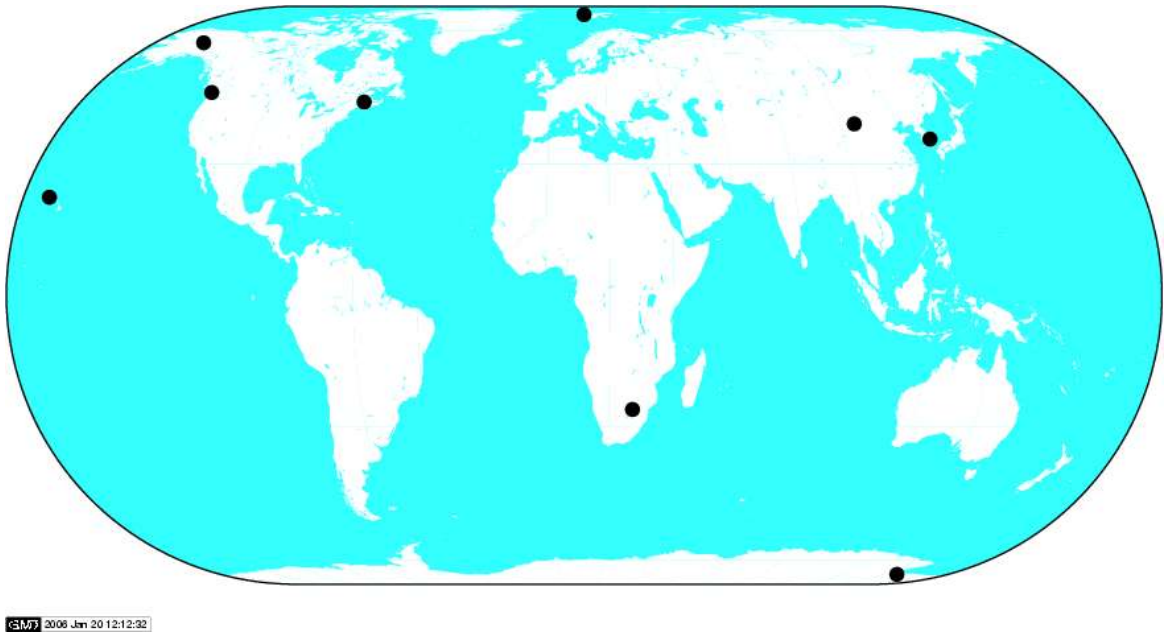
GLONASS Network

GLONASS/GPS Receivers



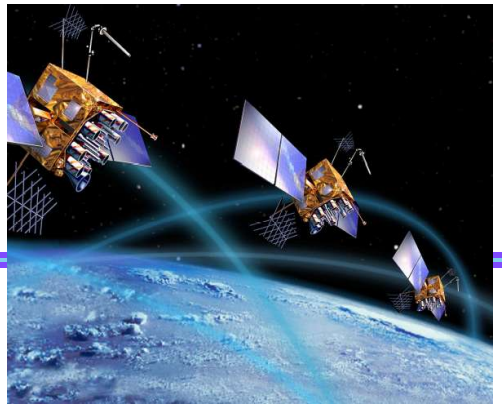
New GPS Signal - L2C Tracking Demo

- GPS2RM-1, PRN 17, Launch 24 October 2005
- IGS Sub-Network deployed with L2C capable, JPL & IGS Partners
- JPL Blackjack space receiver modified to track signal
- Civil interest clear
  - New signal to be exploited
  - Look forward to Galileo
- Data at IGS Global Data Center - CDDIS



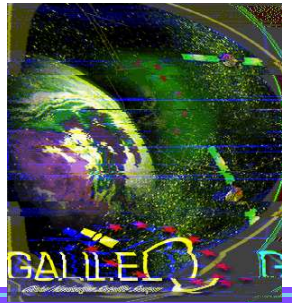
L2C Tracking Demonstration Network

IGS - New Signal Strategies

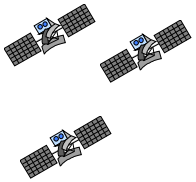


- Careful inclusion of new signals
  - IGS target observations of new GNSS at sites with well understood time series, to characterize and evaluate new signals
  - IGS will enable a sub-network for utilizing new capabilities with subsequent careful analyses
    - » Provide a bridge to reference frame
    - » New instrumentation, use *immediately*, healthy curiousity, results will need to be relatable to previous ones and to other projects *seamless geo-referencing*
  - Long overlap period with old and new equipment and analyses
- IGS the long-term steward of the GNSS reference frame

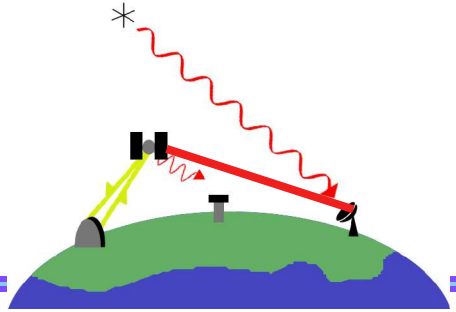
Directions



- Natural **densification** of the ITRF via GNSS - grows at exponential rate
  - GNSS enables users access to the ITRF, anytime, anywhere
- Multiple GNSS over the coming decade will be exciting and ***challenging***, particularly for IGS and reference frame
  - **Consistency** of long-time series, minimizing discontinuities, 3-D precise reference including vertical, importance of gravity/geoid, real-time access,…
- IGS recognizes vital importance of Reference Frame issues
  - See EGU session here
  - Continual improvement effort and keen attention to details
- IGS approach ***influences GNSS providers***
  - Convergence of ITRF and GPS WGS84 over past decade
  - GPS and GLONASS --> IGS realization of ITRF and Contributions to IERS
  - Transformation of GLONASS PZ90 & GPS WGS84
  - EU IGS/IERS consortium developing the Galileo Geodetic Reference Frame (GGRF)
- IGS participating in International Committee on GNSS (ICG), established Dec ‘05 by United Nations Office of Outer Space Affairs (UN-OOSA)

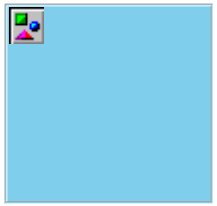


GGOS & IGS Coordinated Approach

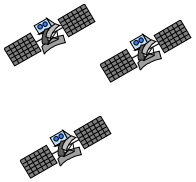


- Closely coordinated ***collocation long-term multi-technique, geodetic observations and analysis***
- Global Geodetic Observing System (GGOS) objective - supported by IGS
  - Session Friday AM
  - Consider strategies toward future of multiple techniques that guide technical development over the coming decade
    - ***Simultaneous integrated observations*** of multi-techniques
    - SLR, VLBI capability to observe GNSSs should improve understanding: retro-reflectors on GNSS, VLBI capable to observe GNSSs as radio source per VLBI2010 report
    - Could greatly improve inter-technique calibration/validation
    - New approach to conventional ‘site ties’
  - Timing integral part of collocation
    - characteristics to improve stability and precision
  - Applications requiring utmost accuracies of the reference frame need **order of magnitude improvement** - towards scale stability and 0.1 mm/yr geocenter
    - sea level change,tide gauges and benchmarks, altimeter calibration sites

IGS, GGOS & Geosciences

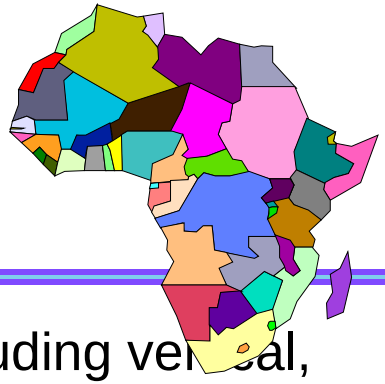


- Key Challenge - reference frame, *long-term observations, analysis and smooth, seamless incorporation of new technology*
- GGOS/IAG - developing and strengthening links with Geoscience
  - Collective voice for IAG's geodetic science, and broad geoscience community
  - Active participant in Group of Earth Observation (GEO) System of Systems (GEOSS)
  - Focus attention on consistency of data and products within IGS,other services
  - Support and stability of the IAG service's components
- Resources: a *persistent* global issue, national entities affected
- Developing compelling justifications for decision makers, need supporting voice of geo-scientific partners
  - Unfortunately, politics and programmatics, short term views persist
- Sea-level, driving requirement and social issue for geohazards:
  - World Climate Research Program workshop on 'Understanding Sea-level Estimation and Variability', June 2006
  - Includes dedicated geodetic session - increasing interdependence realized



AFREF

Unification of African Reference Frames



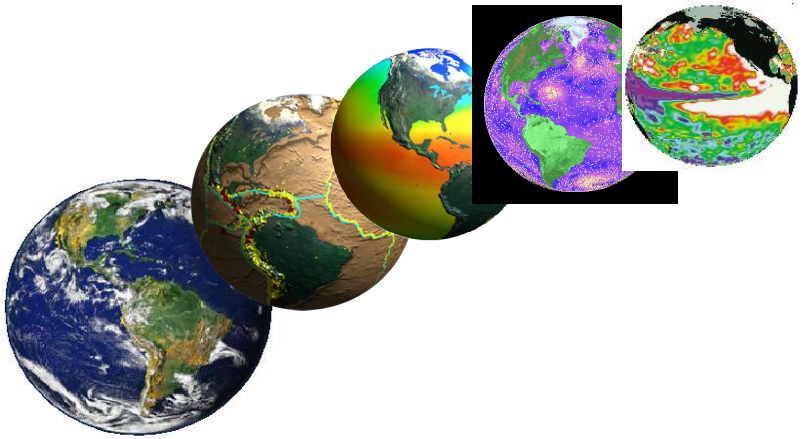
- Establish a continental reference system for Africa including vertical, fully consistent within the ITRF framework through an international project
- Basis for all geoscience applications and all developments requiring geo-referencing, e.g., GIS, SDI, also climate, weather, GNSS apps.
  - » Leap-frog development, equal access to technology benefits
- Use GPS/GNSS as primary tool
  - » Standardize and modernize 50+ national datums to utilize GNSS across Africa - commonly developed & accepted continental grid
  - » Adopt the internationally accepted conventions, standards and procedures of the IGS and ITRF
- NEEDED: International assistance, sponsors and partnerships especially for the developing nations
- Technical workshop July'06 University of Cape Town, South Africa

Space Geodetic Stations In Africa

Summary

- GNSS is the simplest and most effective tool for reference frame access and densification, economics enable wide use
  - Critical to on-going geoscience research and investigations
- IGS will lead the realization of this, keeping pace with numerous exciting developments in the coming decade
- IGS Workshop in May, Darmstadt hosted by ESA/ESOC Prof John Dow (IGS Governing Board Chair) and his team
  - Initiates IGS Strategic Planning Process for 2007-2012
  - Will identify IGS key contribution to GGOS
- IGS is committed to carefully incorporating and exploiting all GNSS

Reference frame is of fundamental importance to all that IGS accomplishes and is key to further developing understanding of Earth System Science within GGOS



15 Years later…….

From GIG'91:

"Finally, the resources available for acquisition of space geodetic systems and for their deployment, even with broad international participation, are increasingly becoming limited. Consequently, it behooves us to develop an overall rationale for the optimal use of these systems, taking into account their unique range of applications as well as their relative strengths and weaknesses, particularly in connection with Earth Rotation monitoring and terrestrial reference frame maintenance."

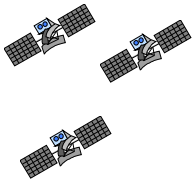
Melbourne, et. al., The first GPS IERS and Geodynamics Experiment - 1991, in "Permanent Satellite Tracking Networks for Geodesy and Geodynamics," IAG Symp. vol. 109, edited by G. L. Mader, pp. 65-80, Springer-Verlag, New York, 1993.

Acknowledgments

IGS is a federation with no central funding authority, each contributor is currently self-funded

It is important to recognize the significant contributions of all organizations worldwide who support and sponsor IGS activities

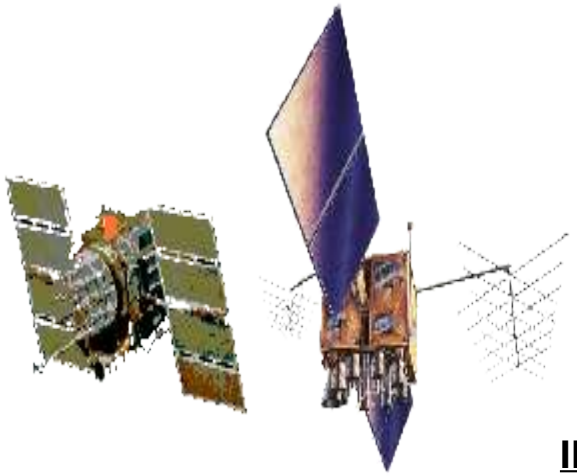
Collective vision and dedication prove to be successful and beneficial for all



Backup Slides

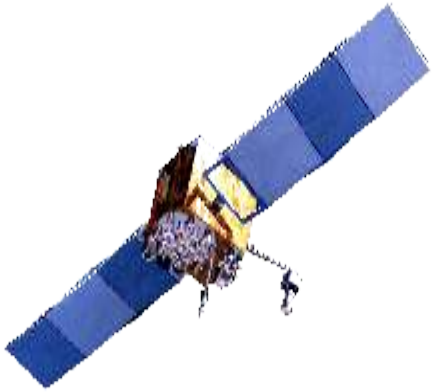
Next Decade of GNSS Signals - GPS

1989-2010



- C/A civil signal L1C/A
- Std Service, 16-24m SEP
- Precise Service, 16m SEP
  - L1 & L2 PY nav
- First Launch: 1989
- 24 Satellites: 1995

2005-2018
Block IIR-M, IIF



IIR-M:

- Adds 2nd civil signal L2C
- Adds new military code
- First launch: Sep 2005
- 24 Satellites: 2012

IIF: above capability plus

- Adds 3rd civil signal L5
- First launch: 2007
- 24 Satellites: 2015

2013-2030
Block III

- Adds improved civil signal L1C
- Increased accuracy 4.8 to 1.2m
- Evaluating integrity improvements
- Navigation surety
  - Increased A/J power +20 dB
- First launch: 2013
- 24 Satellites: 2021

Galileo - 2010 and beyond