

Global & National Geodesy, GNSS Surveying & CORS Infrastructure

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FIG Working Week, Marrakech, Morocco
18-22 May 2011



International
Association of
Geodesy

A Constituent Association of the IUGG

... advancing geodesy ...

FIG Working Week, Marrakech, Morocco, 18-22 May 2011

The Dual Nature of Geodesy...

- Geodesy is the *foundation* for the **representation of horizontal & vertical position** (& its variation) in global or national reference frames, primarily to support societal needs of **Spatial Data Infrastructure** (mapping, etc.)... *tasks often referred to as **Operational Geodesy**.*
- Geodesy is also a *fundamental **Geoscience*** that uses a wide range of **earth observation & space technologies** (deployed across different platforms... satellite, aerial, vehicle, terrestrial) that contribute to our **understanding of the "System Earth"**, *and in particular its dynamics and geometry/ gravity interactions.*



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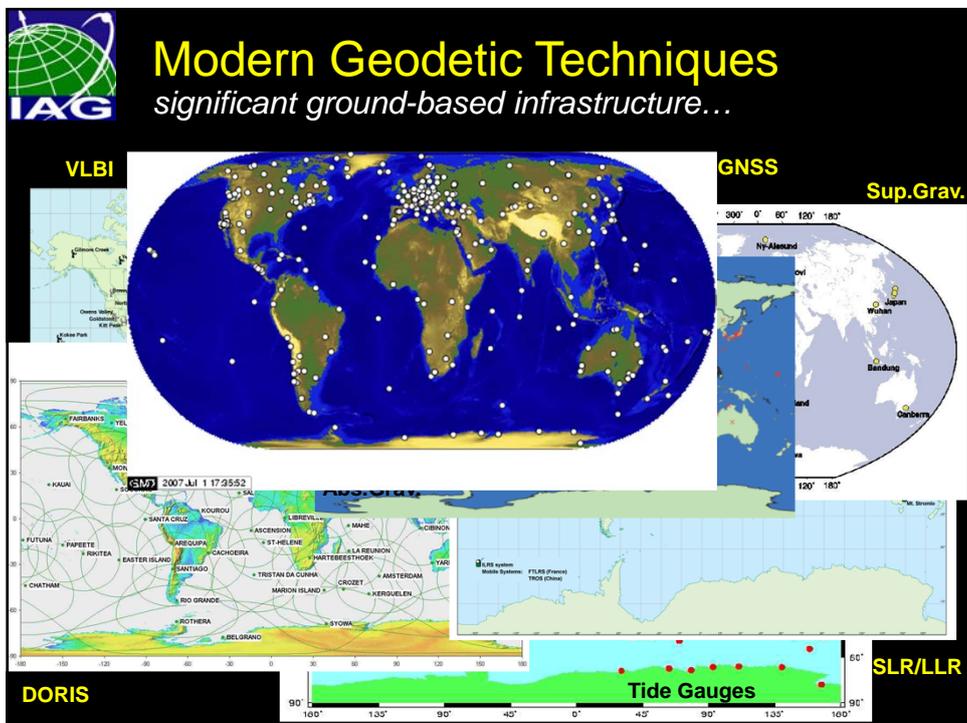
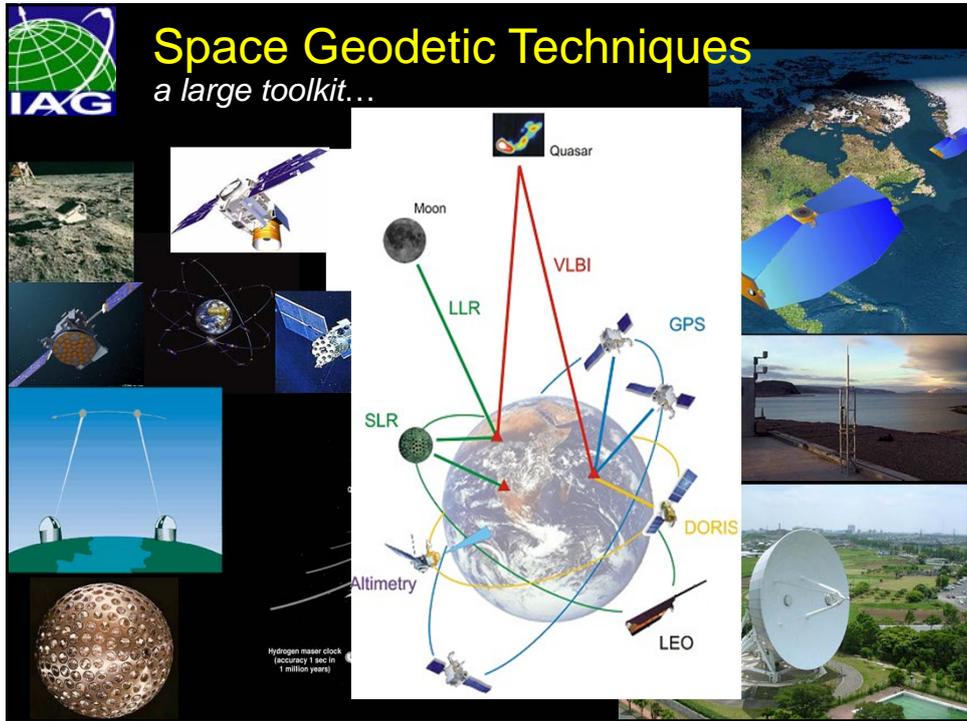
“Defining, maintaining & providing access to the most accurate Reference Frames remains a core responsibility of Geodesy.”

“However, the challenge for Modern Geodesy is to improve the technology, infrastructure & services to also address the increasingly stringent requirements of its geoscientific mission.”



From Classical to Modern Geodesy

- From 3-D points and terrain, to 4-D mapping of land, sea & ice surfaces.
- Increasing time resolution of geodetic measurements & outputs, from 0.1s position, to sub-daily EOP, to monthly gravity field models.
- Increasing spatial resolution of geodetic products, from GNSS points, to 1m for SAR pixels, to 100km for gravity features.
- Increasing accuracy, on both short-term and long-term time scales.
- Increasing reliance on infrastructure and services.
- Increasing variety of satellite missions that ‘sense’ faint Earth dynamic effects that have 4-D geometric and gravimetric signatures.





“The International Association of Geodesy (IAG) is the oldest of the international scientific bodies, having its origins in the late 19thC... it is part of the IUGG... and a sister association of the ISPRS, FIG, etc.

Geodesy makes an important contribution to science and society through its IAG Services & a variety of EOS techniques.”

EOS Satellite Missions used in Modern Geodesy

Gravity Field
CHAMP GRACE-1/2 GOCE ...

Satellite Tracking
SLR sats DORIS sats

Ocean Altimetry
Topex/Pos. JASON-1 JASON-2 ...

Earth Surface
TerraSAR-X TanDEM-X ...

Atmosphere
CHAMP COSMIC-1/2 MetOp ...

Ice Altimetry
IceSat-1 Cryosat-2 IceSat-2 ...

Positioning
GPS GLONASS GALILEO COMPASS

... and other mission concepts



IAG Services

<div style="border: 1px solid black; padding: 2px; text-align: center; width: 50px; margin-bottom: 10px;">Geometry</div> <div style="border: 1px solid black; padding: 2px; text-align: center; width: 50px; margin-bottom: 10px;">Gravimetry</div> <div style="border: 1px solid black; padding: 2px; text-align: center; width: 50px; margin-bottom: 10px;">Ocean</div> <div style="border: 1px solid black; padding: 2px; text-align: center; width: 50px;">Std</div>	<p>IERS: International Earth Rotation and Reference Systems Service</p> <p>IGS: International GNSS Service (1994)</p> <p>IVS: International VLBI Service (1993)</p> <p>ILRS: International Laser Ranging Service (1993)</p> <p>IDS: International DORIS Service (2002)</p> <p>IGFS: International Gravity Field Service (2008)</p> <p>BGI: Bureau Gravimetric International</p> <p>IGeS: International Geoid Service</p> <p>ICET: International Centre for Earth Tides</p> <p>ICGEM: International Centre for Global Earth Models</p> <p>IDEMS: International Digital Elevation Models Service</p> <p>PSMSL: Permanent Service for Mean Sea Level (1933)</p> <p>IAS: International Altimetry Service (in planning)</p> <p>BIPM: Bureau International des Poids et Mesures (Time 1875)</p> <p>IBS: IAG Bibliographic Service</p>
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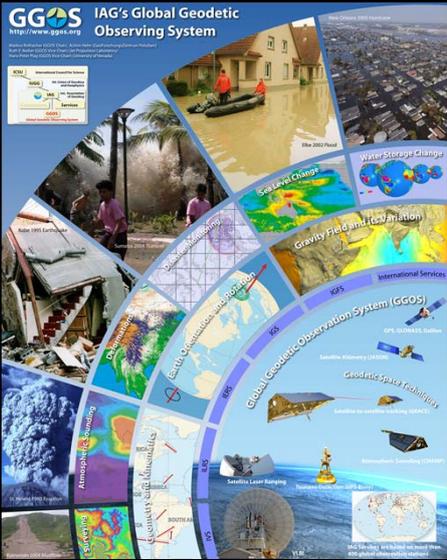
GGOS binds them together

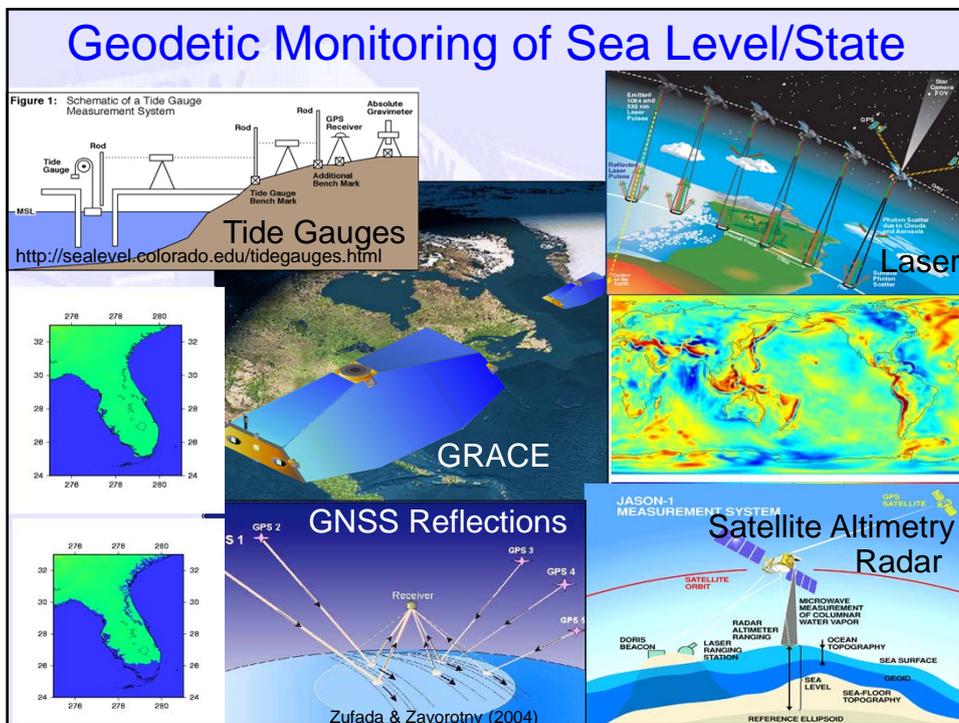
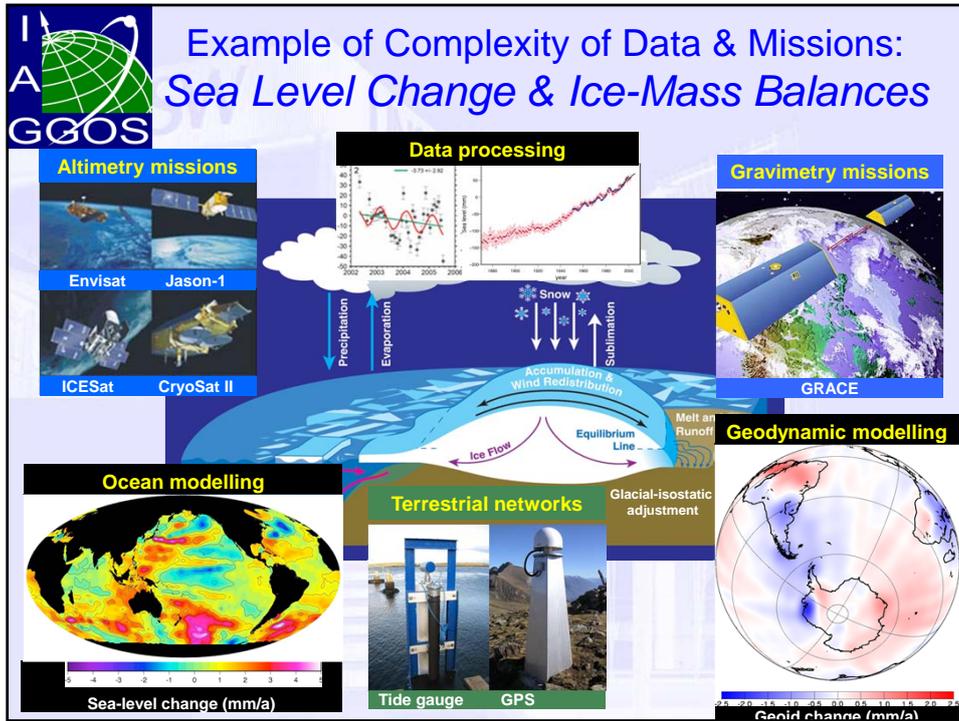


The International Association of Geodesy's Global Geodetic Observing System

... a continuous,
synoptic, high
accuracy Earth
Observing System
that can detect the
"fingerprints" of
Global Change...

<http://www.ggos.org>







*“The challenges of GGOS can be summarised very simply: **improve the accuracy, resolution, reliability & timeliness of geodetic products by an order of magnitude in the coming decade...** **by operationalising ‘millimetre-geodesy’ so as to monitor the faint System Earth dynamic effects...** This will require a significant upgrade of all geodetic infrastructure.”*



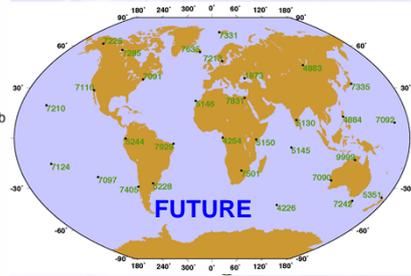
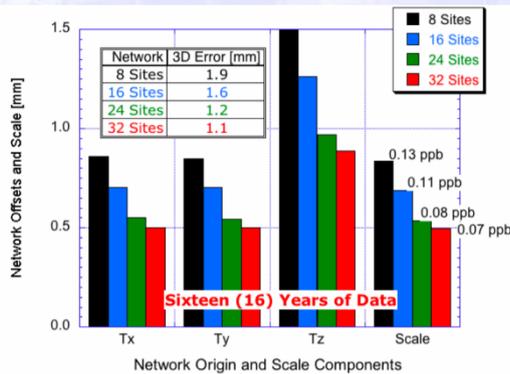
GGOS needs more & better infrastructure

- Upgraded ground infrastructure, well distributed globally as well as densified in areas of interest
- Global collaboration
- “Core network” of “super sites”, *with co-located geodetic observatories*
- Space missions to support GGOS
- Continuous, long-term observations
- “Operationalisation” of geodetic infrastructure & missions
- Integrated analysis & interpretation
- Reliable products & services of the highest quality
- Delivered to geoscientific users in a form capable of assimilation into sophisticated System Earth models



Future SLR/VLBI Network Design

- Simulations show that starting from the current network, will need to approximately **quadruple** the number of co-located SLR and VLBI sites in order to meet GGOS requirements: 1 mm & 0.1 mm/yr for the origin and 0.1 ppb & 0.01 ppb/yr for the scale.



“However, densifying & upgrading the GNSS network is a very achievable goal for the coming decade that ALL nations can contribute to.”

“This shared CORS geodetic infrastructure requires investment by national & international agencies.”

“AND can also support national &/or regional GNSS-based National Positioning Infrastructure.”

GNSS: The Versatile Geodetic Tool

- GNSS has progressively taken on ever-increasing importance for Modern Geodesy.
- Current applications: **POD, point kinematics, atmospheric remote sensing, deformation monitoring...**
- These roles (& more) will increase with multi-constellation GNSS and improvements in CORS infrastructure.
- *The International GNSS Service (IGS) is evolving in order to address the increased demands of GGOS...*
- *The GNSS CORS network infrastructure is a critical IGS component...*



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The IGS: IAG's First Operational Service

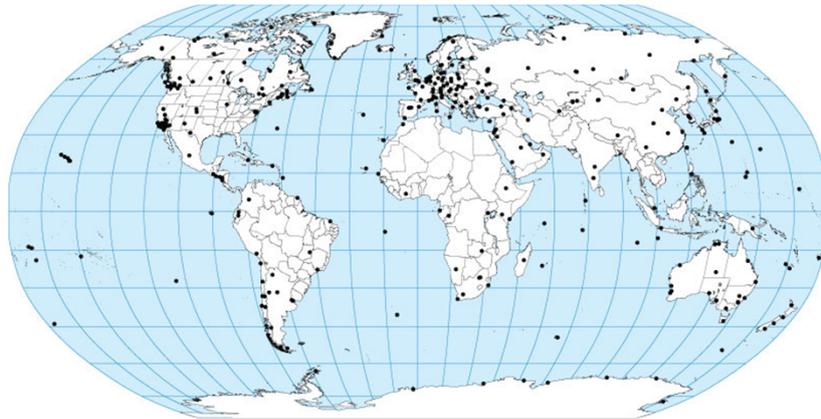
- By the late 1980's, the potential of GPS for geodesy & geodynamics was realised by many organisations:
 - AO 1991: *International GPS Service for Geodynamics* (until 1999, then simply IGS)
 - Start of 3 month Test Campaign 21 June 1992
 - IGS became an official IAG service in January 1994
 - Became the **International GNSS Service** in March 2005
- Key to approach: sharing investments and operational costs by pooling the resources of many (> 200) organisations to establish an independent ground CORS segment and generate high accuracy products ... **"best efforts" basis, reliability through redundancy, data & products freely available to all users.**

<http://igs.org>



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IGS Geodetic CORS Network



Many countries & organisations contribute to the IGS, and many more benefit from this collective investment... free raw GNSS data, derived products & connection to the ITRF.

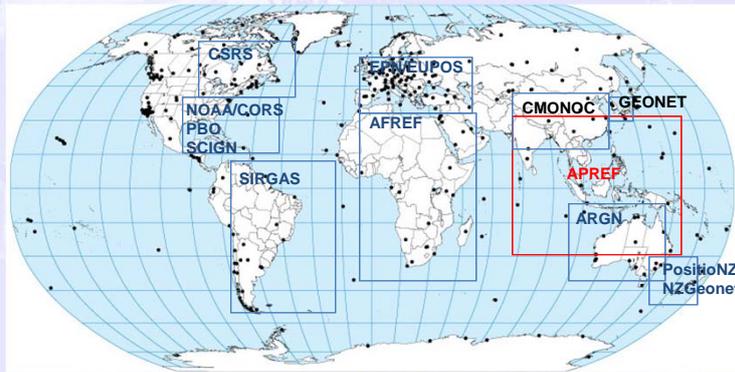


“GNSS is an operational geodetic tool supported by ground CORS networks coordinated by IGS... but the infrastructure is uneven & must be upgraded... more stations, multi-GNSS-capable, real-time products, etc...”

“GGOS is fortunate to have IGS as a component service, but... can not take GI for granted.”



IGS and Regional CORS



- IGS network relies heavily on regional scientific and national reference frame networks.
- Regional reference frame activities help to fill in gaps in global network coverage of stations that can be used in the generation of IGS products.



The Value of Geodesy & GNSS to Society

- **Fundamental geoscience...** *solid earth geophysics, atmospheric, cryospheric & oceanographic processes, hydrology.*
- **Global Change studies...** *climate change (causes & effects), water cycle & mass transport changes, sea level rise, mesoscale circulation, GIA, polar studies... long-term monitoring.*
- **Geohazard research...** *seismic, volcanic, landslip, storms, sea state, flooding, tsunami, space weather... early warning systems.*
- **Geodetic reference frames...** *ITRF, national datums/SDI, gravity, timing.*
- **Engineering...** *RT precise positioning/navigation, atmospheric sounding, georeferencing platforms (satellite & ground-based, POD), operational geodesy, radar & laser imaging, engineering geodesy.*
- **Disaster management & decision-making...** *imaging & positioning satellites.*

Concluding Remarks (1)...

- *Modern Geodesy* is an EO science that uses sophisticated geodetic infrastructure for studying “the System Earth”.
- Improved accuracy, resolution, & reliability of future geodetic “products” will support the geosciences...*through GGOS*.
- All GI must be upgraded to meet the requirements of geodesy’s (GGOS’s) more challenging role.
- GI includes space missions (space agencies), ground infrastructure (national geodetic agencies), and collaborative frameworks (international & regional institutions, e.g. IAG, FIG).
- GNSS is a versatile precise positioning tool...*hence it forms both core GI and National Positioning Infrastructure*.



Concluding Remarks (2)...

- Need to determine *balance* of GNSS geodesy (Tier 1/2) and GNSS surveying (Tier 3) CORS.
- Need increased national & regional cooperation...*esp. provision of GNSS CORS data to IGS (and others)*.
- Leadership is needed to ensure the future multi-GNSS signals, real-time services, and CORS networks, continue to address core needs of GI and NPIs...*at international & national levels*.
- The IGS will soon launch multi-GNSS “pilot project”, and real-time IGS services.
- The IAG seeks to work closely with sister associations such as the FIG...*to realise the GGOS goals, and to deliver Services that support NPIs*.





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www.iugg2011.com

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