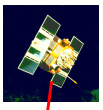
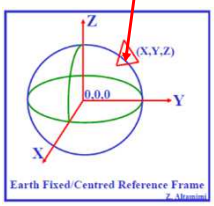


From Global to National Geodetic Reference Frames: how are they connected and why are they needed?

Zuheir ALTAMIMI

Institut National de l'Information Géographique et Forestière, France

Vice-President, International Association of Geodesy



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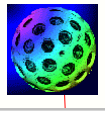
Space — Geodesy



- **Precise positioning on and around the Earth surface**
- **Quantification of changes in space & time of the 3 fundamental properties of the Earth system : its form (i.e. deformations), its gravity field & its rotation in space**

SLR **VLBI** **GNSS/GPS** **DORIS**

Geodetic Instruments

The Global Geodetic reference Frame (GGRF)

- The GGRF includes various components….
- Focus here:
  - The geometric part of the GGRF that allows precise positioning applications
  - Global: The International Terrestrial Reference Frame (ITRF)
  - National : Access to the ITRF using GNSS technology

The ITRF is built on observations of :


SLR

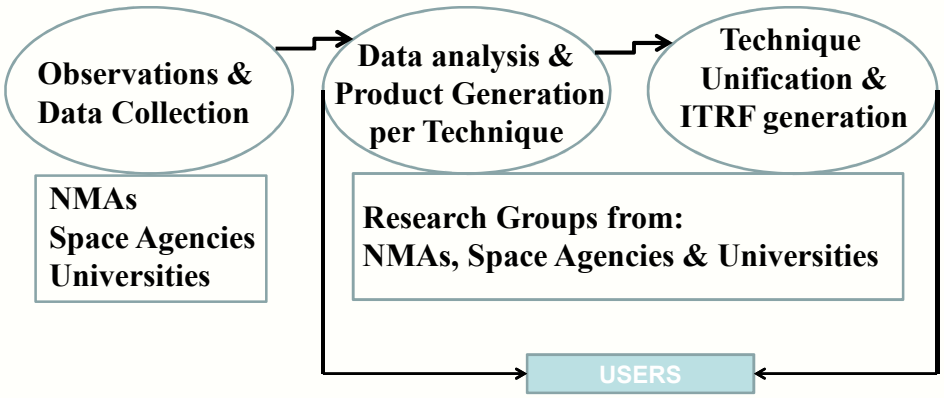

VLBI


GNSS/GPS

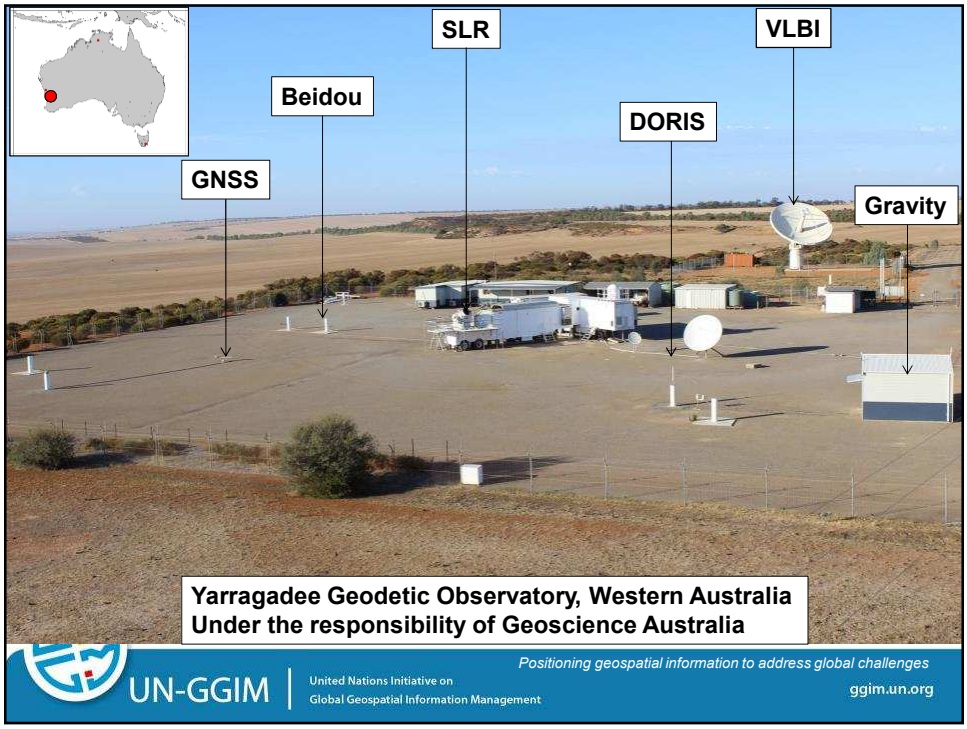

DORIS

and their co-locations…

ITRF: an International Effort, based on the "best effort" principle



Schematic illustration of the chains leading to the ITRF generation


SLR
VLBI
Beidou
DORIS
GNSS
Gravity
Yarragadee Geodetic Observatory, Western Australia
Under the responsibility of Geoscience Australia
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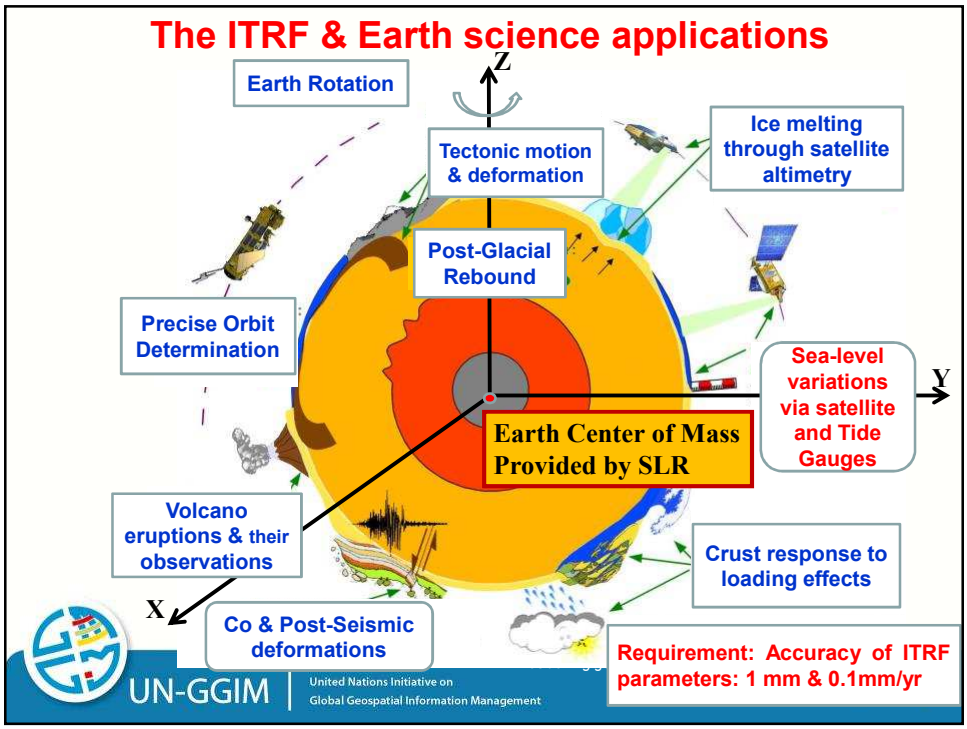
The ITRF & Earth science applications
Earth Rotation
Z
Tectonic motion & deformation
Ice melting through satellite altimetry
Post-Glacial Rebound
Precise Orbit Determination
Sea-level variations via satellite and Tide Gauges
Y
Earth Center of Mass Provided by SLR
Volcano eruptions & their observations
Crust response to loading effects
X
Co & Post-Seismic deformations
Requirement: Accuracy of ITRF parameters: 1 mm & 0.1mm/yr
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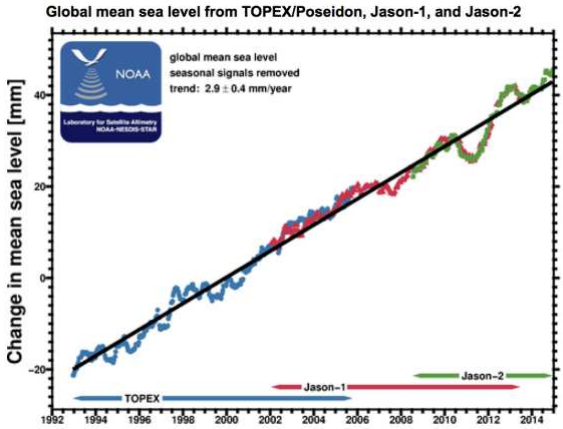
Mean sea level change



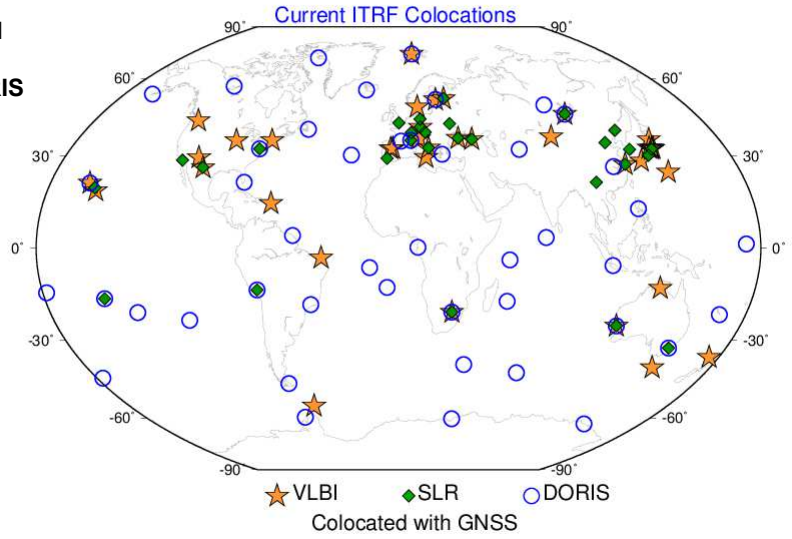
A small drift of 1 mm/yr in the ITRF origin, translates into apparent 0.9 mm/yr in sea level rise at high latitudes

Why Multiple Techniques for the ITRF ?

- **VLBI & SLR:**
  - **Fundamental for an accurate definition of the ITRF physical parameters/ properties**
  - **SLR determines Earth Center of Mass ==> ITRF origin**
  - **VLBI places the Earth in space ==> ITRF orientation**
  - **But their ground networks are poorly distributed and in danger of degradation**
  - **Aging instruments prone to systematic errors**
- **DORIS: disseminates ITRF in satellite orbit determination**
- **GNSS:**
  - **Ensures the link between VLBI & SLR networks**
  - **Is the tool today to access the global ITRF by the regions and nations**

Current colocations

~ 44 VLBI
~ 30 SLR
~ 45 DORIS



Current colocations

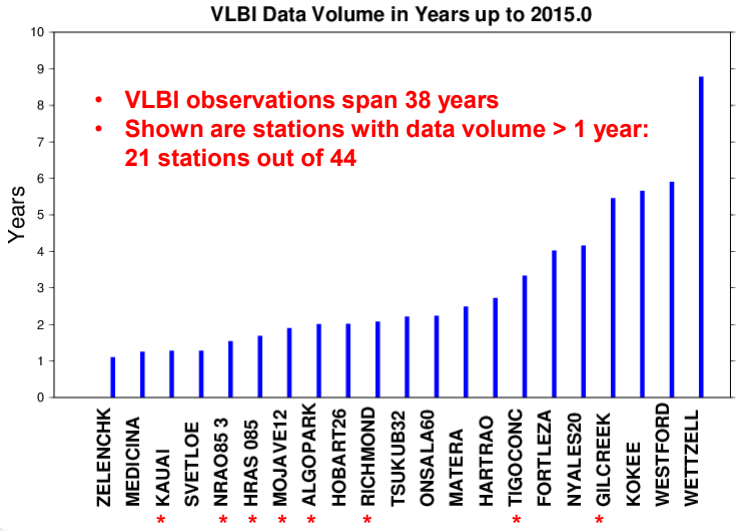
New geodetic Observatory at Ny-Ålesund

~ 44 VLBI
~ 30 SLR

Poor geometry between north and south

"New generation" VLBI antennas

VLBI Data Volume in years up to 2015.0



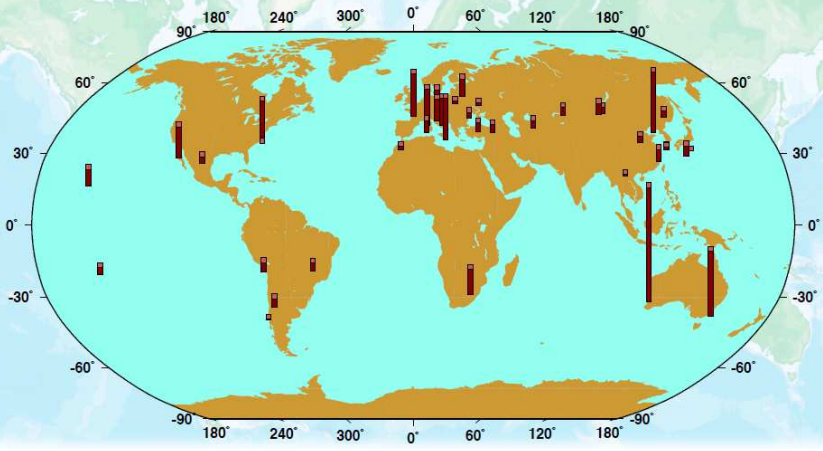
- VLBI observations span 38 years
- Shown are stations with data volume > 1 year: 21 stations out of 44

* No longer in operation

SLR global network data yield

ILRS

- The global SLR data set on the two LAGEOS collected by the ILRS network over 2014-2016 were distributed as shown on this map:



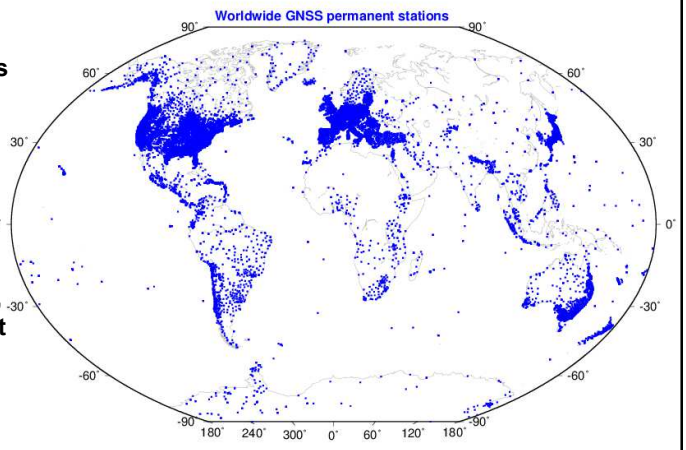
Key points of the UN GA resolution on the GGRF

- *Encourages* Member States and relevant international organizations to enhance global cooperation in providing technical assistance in geodesy for those countries in need
- *Urges* Member States to implement open geodetic data sharing
- *Invites* Member States to commit to improve and maintain national geodetic infrastructure as an essential means to enhance the GGRF
- *Invites* Member States to have multilateral cooperation

Access to the ITRF via GNSS

Key messages:

- **Data Sharing: GNSS data freely available to all users around the world**
- **Backbone link of National Reference Frames to the global ITRF**
- **Note Gaps in Africa, East and South East Asia & South America**



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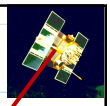
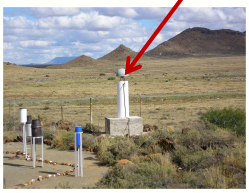
How to connect a National Reference Frame to the ITRF?



- Build geodetic infrastructure using GNSS continuously operating stations, enabling:
  - Modern, more accurate and less costly national reference frame
  - Easy to maintain than old classical geodesy
  - Easy access to the ITRF (see next)
  - inter-operability of geospatial data between countries
  - ==> Economic benefit
- Enhance capacity building & international cooperation in Geodesy for knowledge transfer & know how



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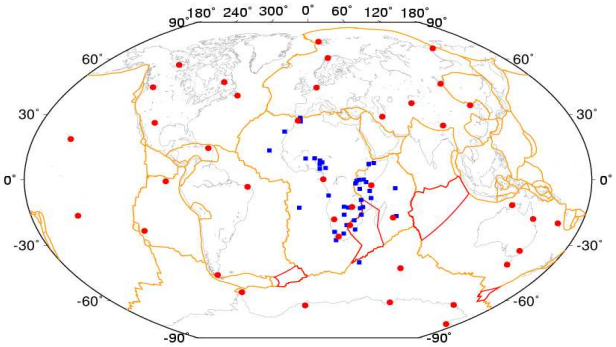
How to connect a National Reference Frame to the ITRF?

AFREF Example



Distribution of processed sites:

- **Red : ITRF/IGS sites used in the alignment to ITRF**
- **Blue : African sites**

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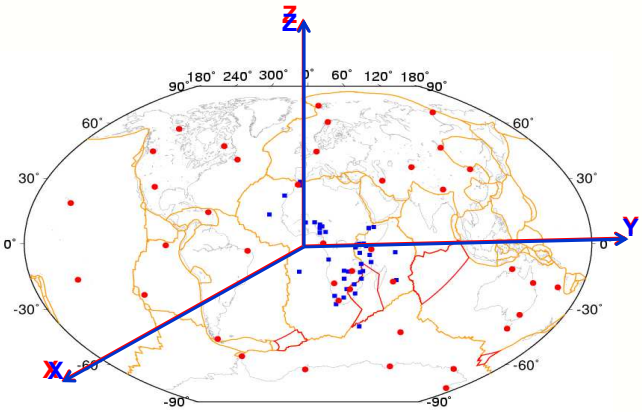
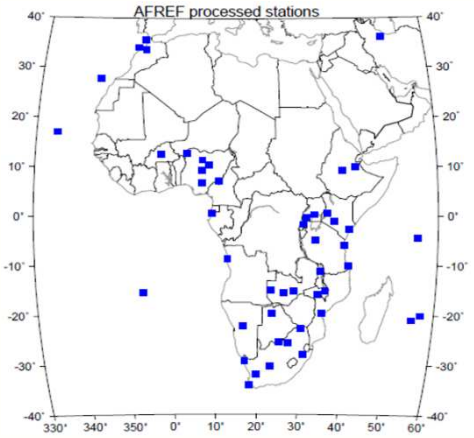
Alignment



AFREF sites processed



Distribution of AFREF sites processed. Note gap from Angola through Congo, Sudan and across North Africa.

Summary

- The UN GA resolution on the GGRF calls for commitments by Member States to improving national geodetic infrastructure as a means to enhance the GGRF
- The current geodetic infrastructure is weak, esp. SLR and VLBI networks that are in danger of degradation over time
- The recent examples of Australia, New Zealand, Norway & other countires in enhancing their geodetic infrastructures are concrete examples to follow by other nations
- There are still gaps in GNSS network to provide effective access to the GGRF/ITRF

Backup

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What is GGRF?

- An authoritative, reliable, highly accurate, and global spatial referencing infrastructure.
- The GGRF includes the celestial and terrestrial reference frame products and Earth Orientation Parameters (EOPs) that connect them, the infrastructure used to create it, and the data, analysis, and product generation systems.
- The GGRF also includes gravimetric observations, products and height systems which underpin measurements of elevation

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ILRS Network Productivity (All targets)