Improving the Geodetic Infrastructure via the UN-GGIM initiative

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Key points

- Introduction
- Why a geodetic/terrestrial reference frame is needed ?
- Current status of the geodetic infrastructure:
  - Gaps and weaknesses
  - The geometric part (ITRF) as an example.

- Response to weaknesses via UN-GGIM initiative
- The GGRF in the context of the UN-GGIM initiative

Introduction

- Since the space era 60 years ago, geodesy became a science in its own right
  - La géodésie est une science à part entière
  - La geodesia es una ciencia por derecho propio
  - A geodésia é uma ciência em si mesma
- Science that quantifies changes of the 3 fundamental properties of the Earth : its shape, its gravity field and its rotation in space

- But that implies the need for, e.g. :
  - A descent infrastructure: geodetic observatories homogenously covering the Earth surface
  - Continuous observations, ideally 24/7
  - Sustainability of the geodetic infrastructure in the long-term
  - …

Why a geodetic reference frame is needed ?

- **Quantification of Earth changes must be expressed in (related to) a geodetic reference frame:**
  - **Sea Level variations in space and time**
  - **Tectonic Motion & crustal deformation**
  - **Dislocations & post-seismic deformation due to earthquakes**
- **Tsunamis and Natural Hazards, rescue and safety of life**
- **Positioning, locations & navigations (ocean, land, air & space)**
- **National territory & land managements, precision agriculture, …**
- **Interoperability of geospatial datasets**
- **Operational geodesy applications: national, regional and global**

The ITRF & Earth science applications

SLR

VLBI

GNSS

DORIS

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

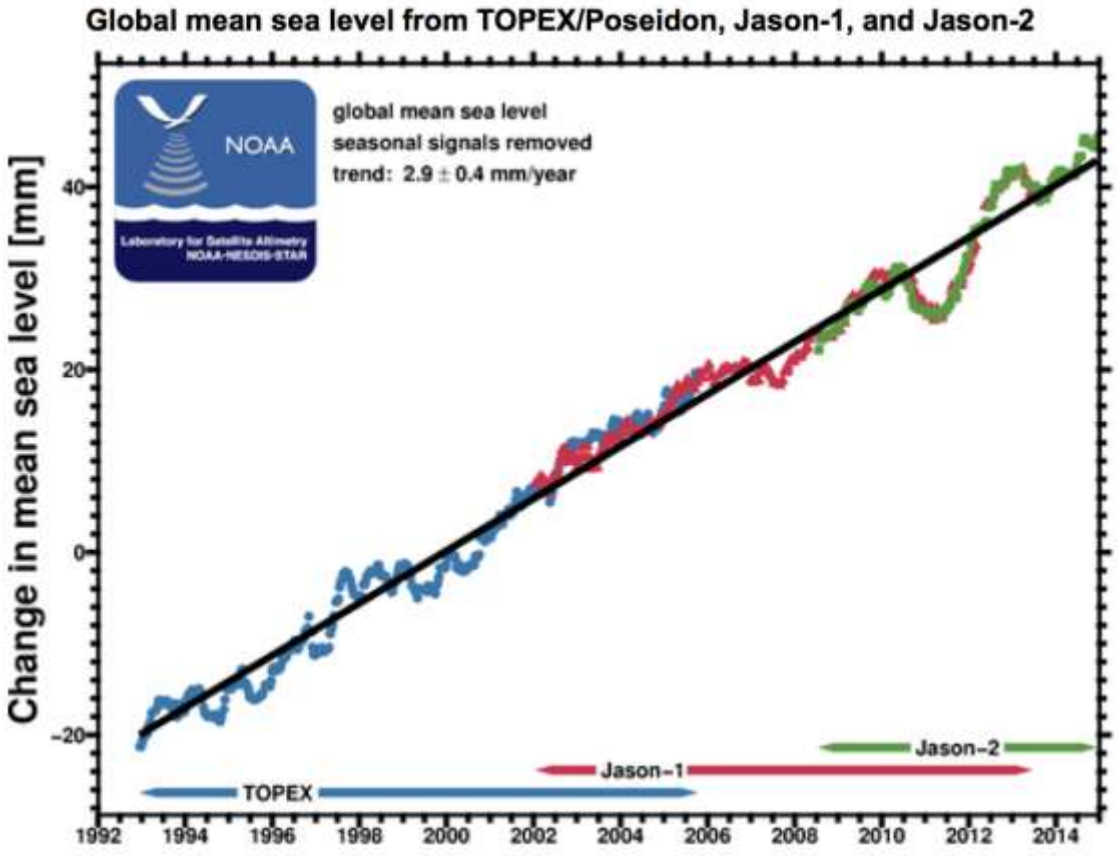
X

Crust response to loading effects

Co & Post-Seismic deformations

Requirement: Accuracy of ITRF parameters: 1 mm & 0.1 mm/yr

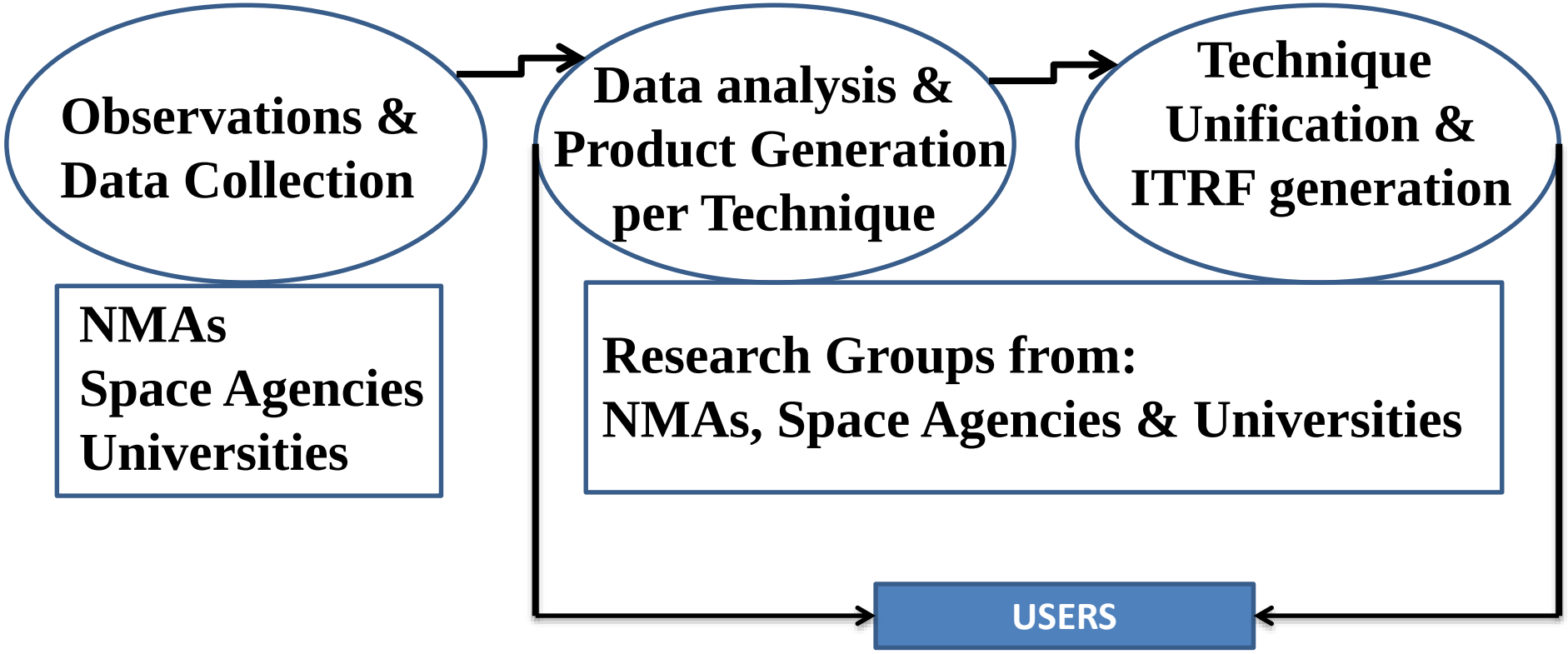
Mean sea level change



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

The ITRF

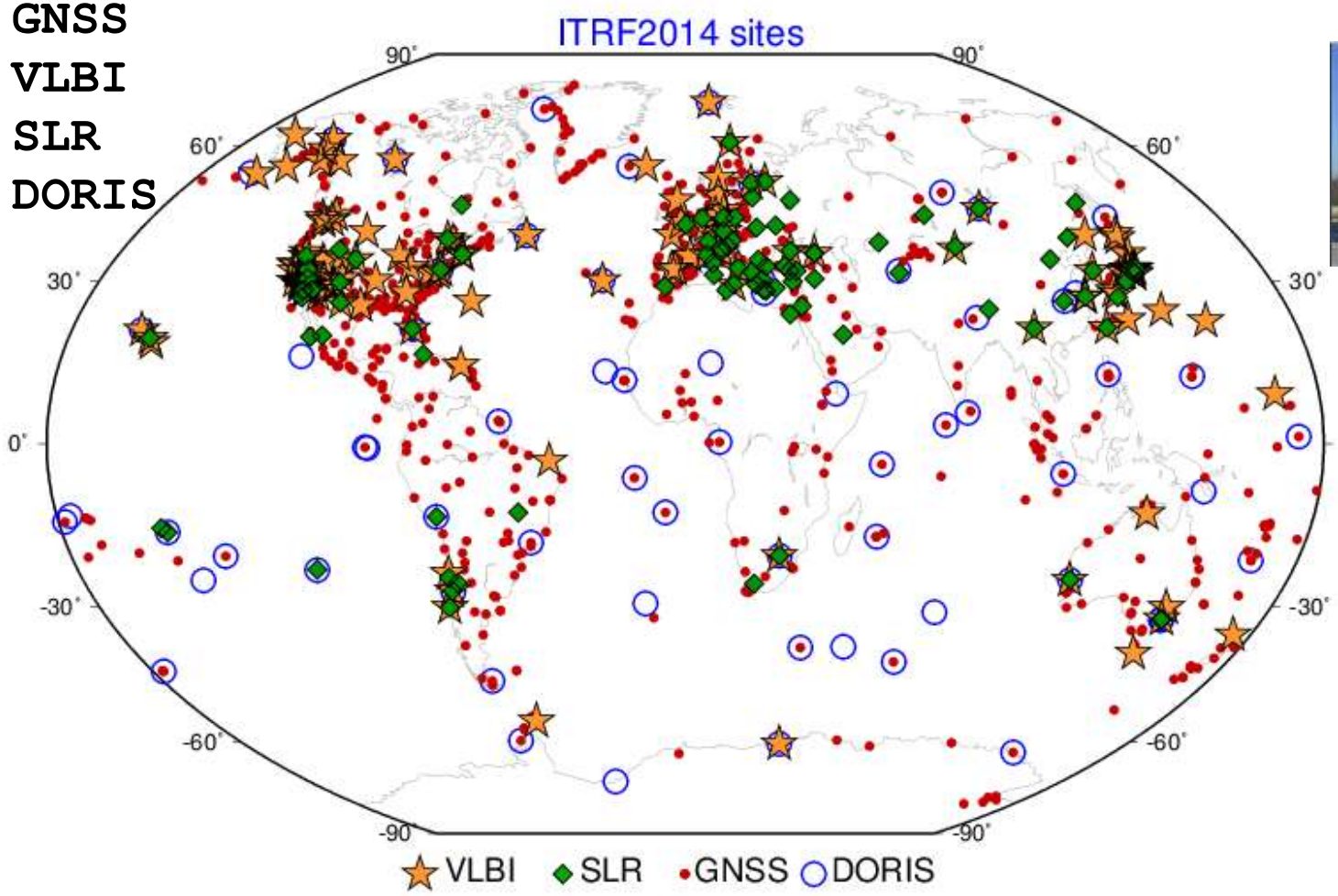
- Three decades of research and development thanks to the IAG Services
- An International effort, based on the "best effort" principle



Schematic illustration of the chains leading to the ITRF generation

Geodetic Infrastructure: our heritage

884 GNSS
124 VLBI
96 SLR
71 DORIS



SLR

VLBI

GNSS

DORIS

BUT: only 35% of VLBI and SLR sites are in operation today
Most of the old decommissioned sites were of poor quality

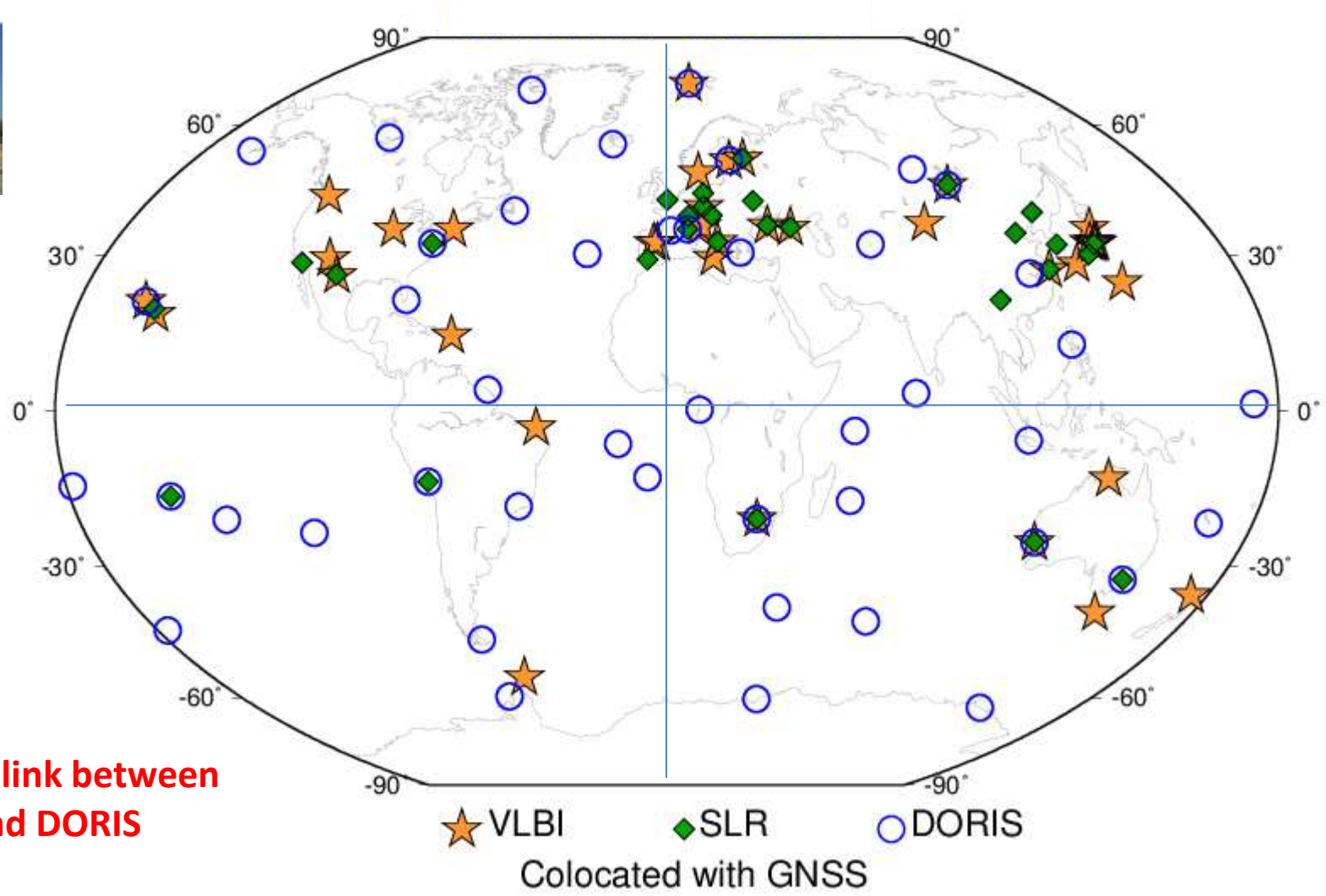
Current co-locations (multiple instruments at the same site)

SLR 38 sites

VLBI 44

DORIS 45

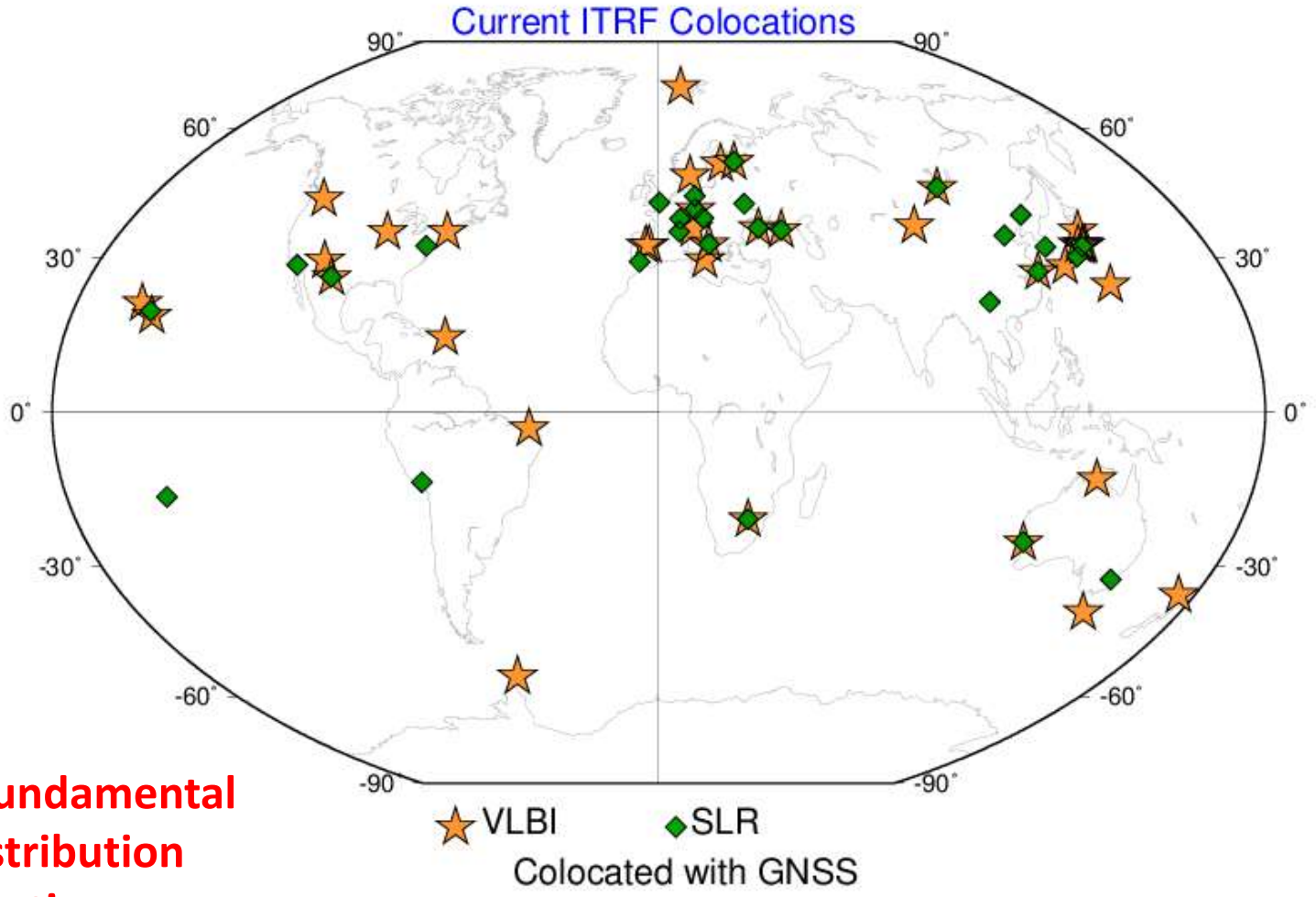
GNSS is the link between SLR, VLBI and DORIS



Risk of degradation

SLR 38 sites

VLBI 44



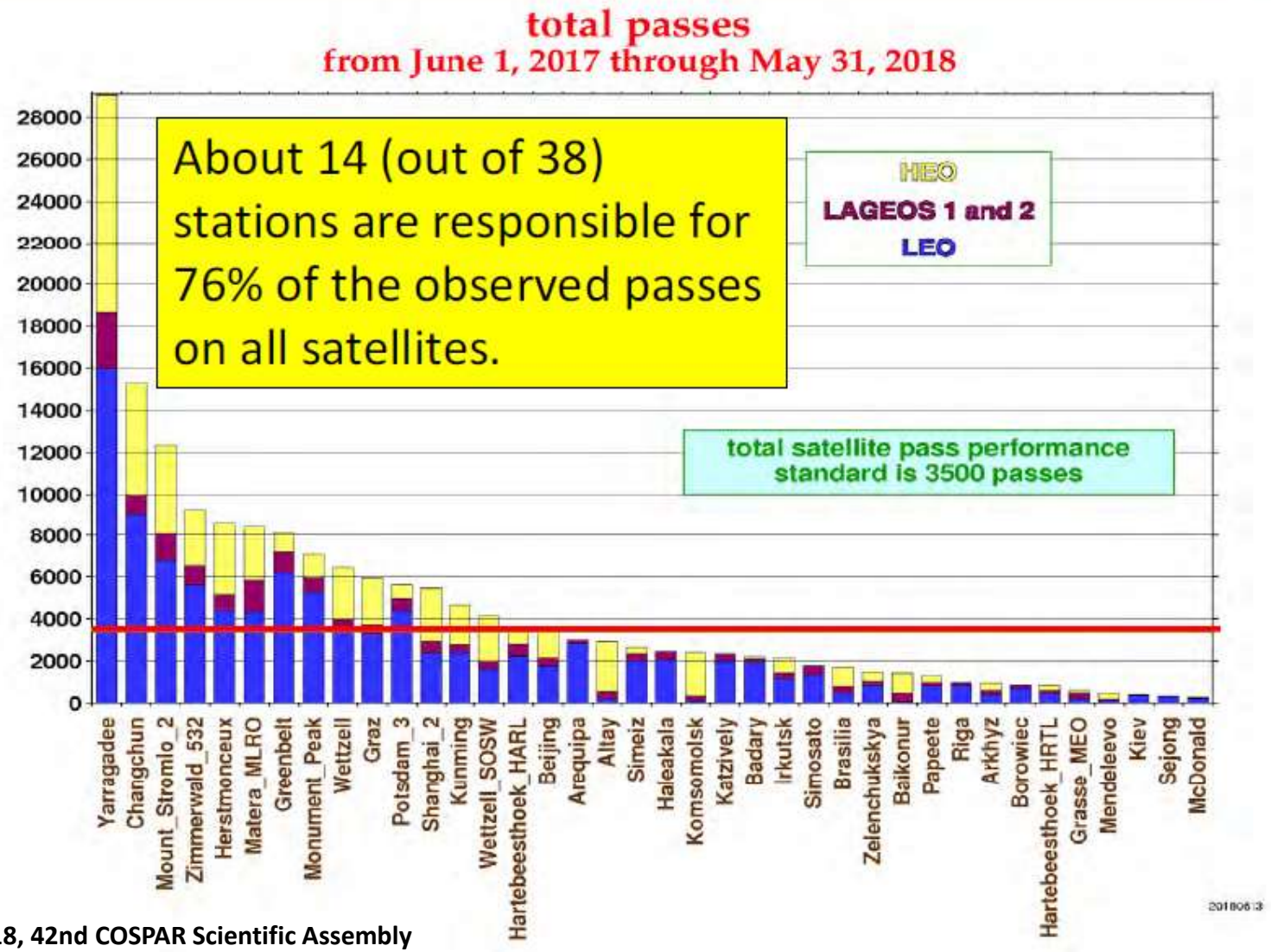
- **SLR & VLBI are fundamental**
- **Poor/uneven distribution**
- **> 50 % old-generation systems**

Current colocations

~ 44 VLBI
~ 38 SLR

New geodetic Observatory at Ny-Ålesund

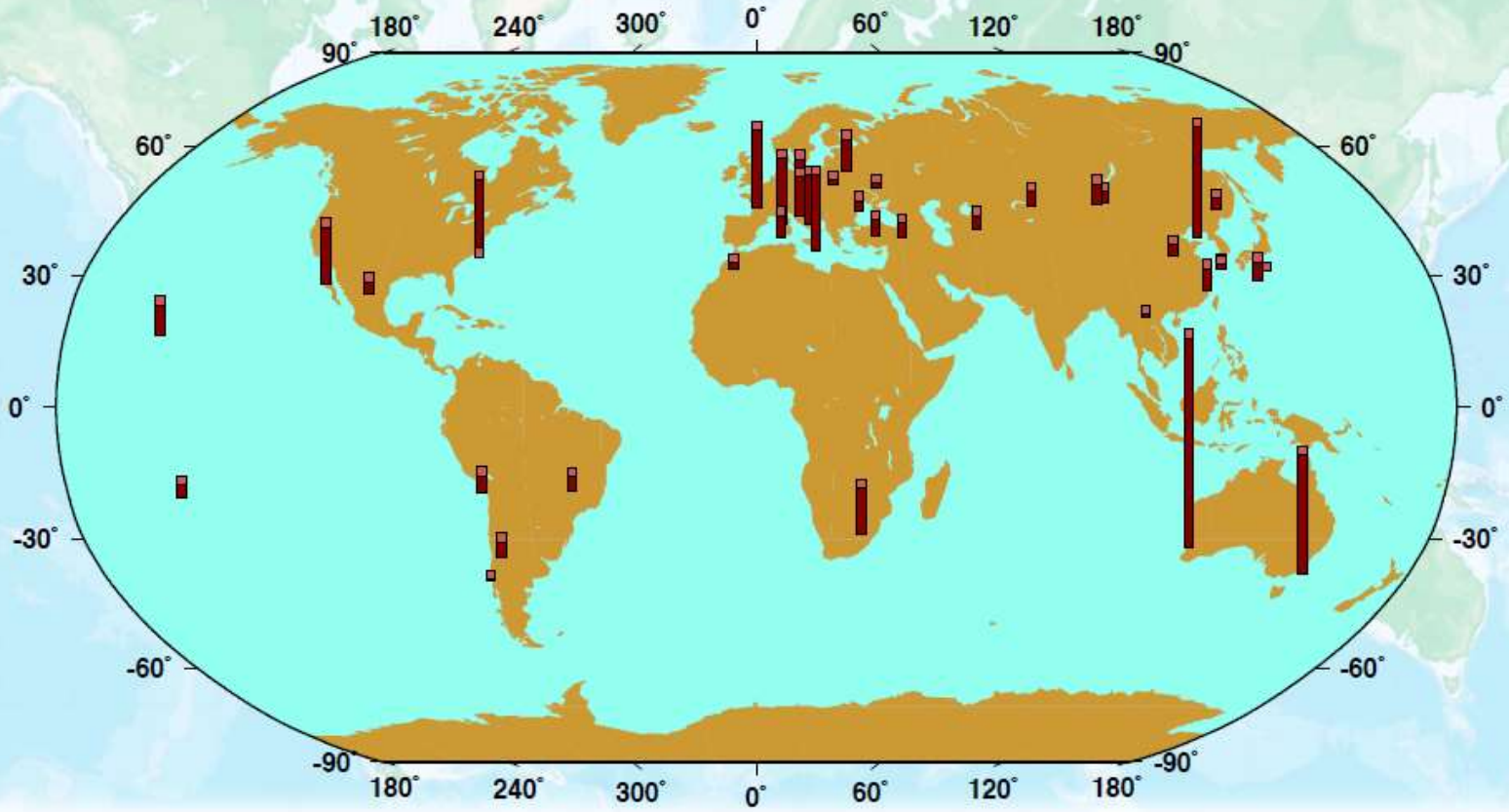
ILRS Network Productivity (All targets)



Pavlis, 2018, 42nd COSPAR Scientific Assembly

The network seen via its data yield

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



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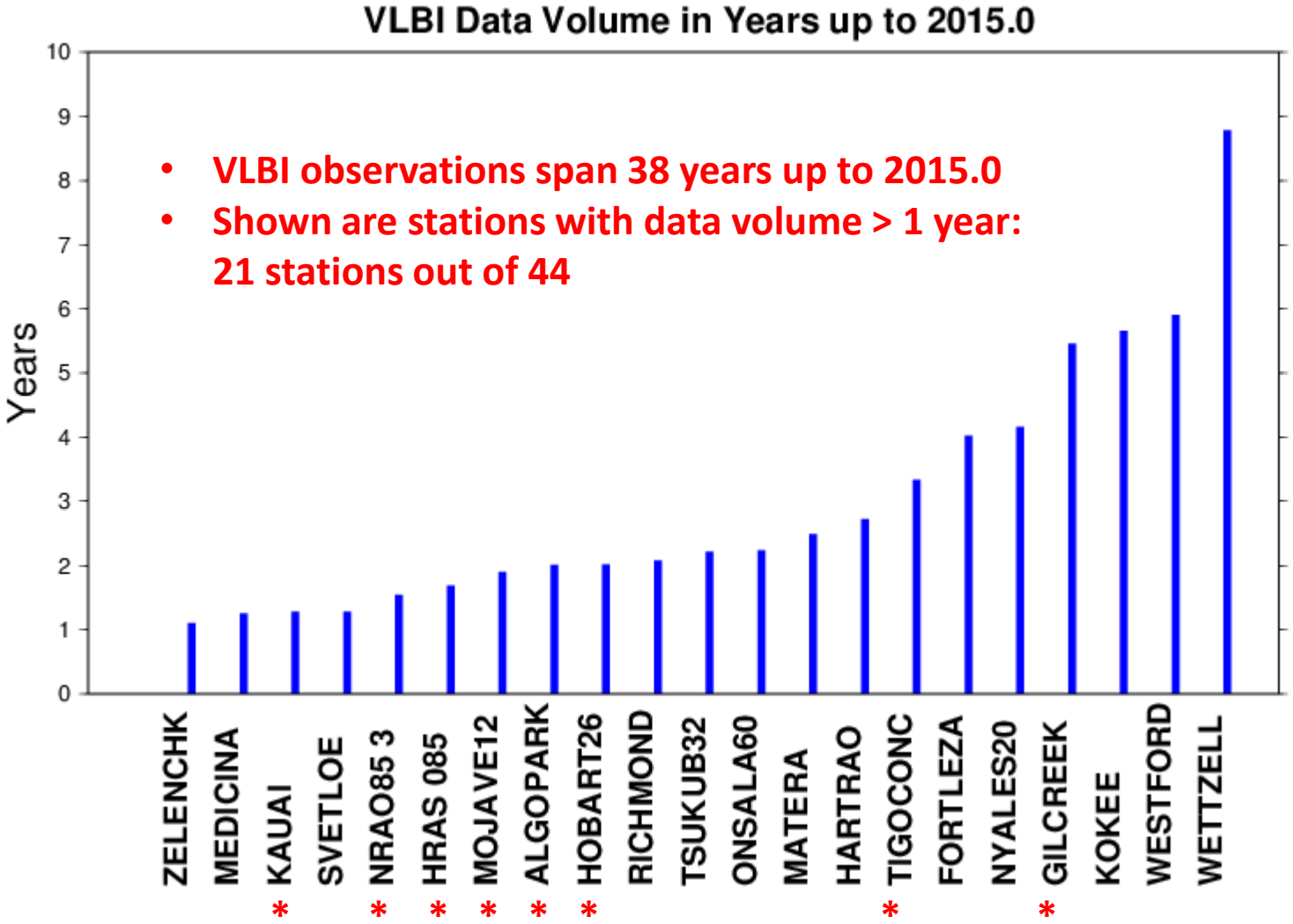
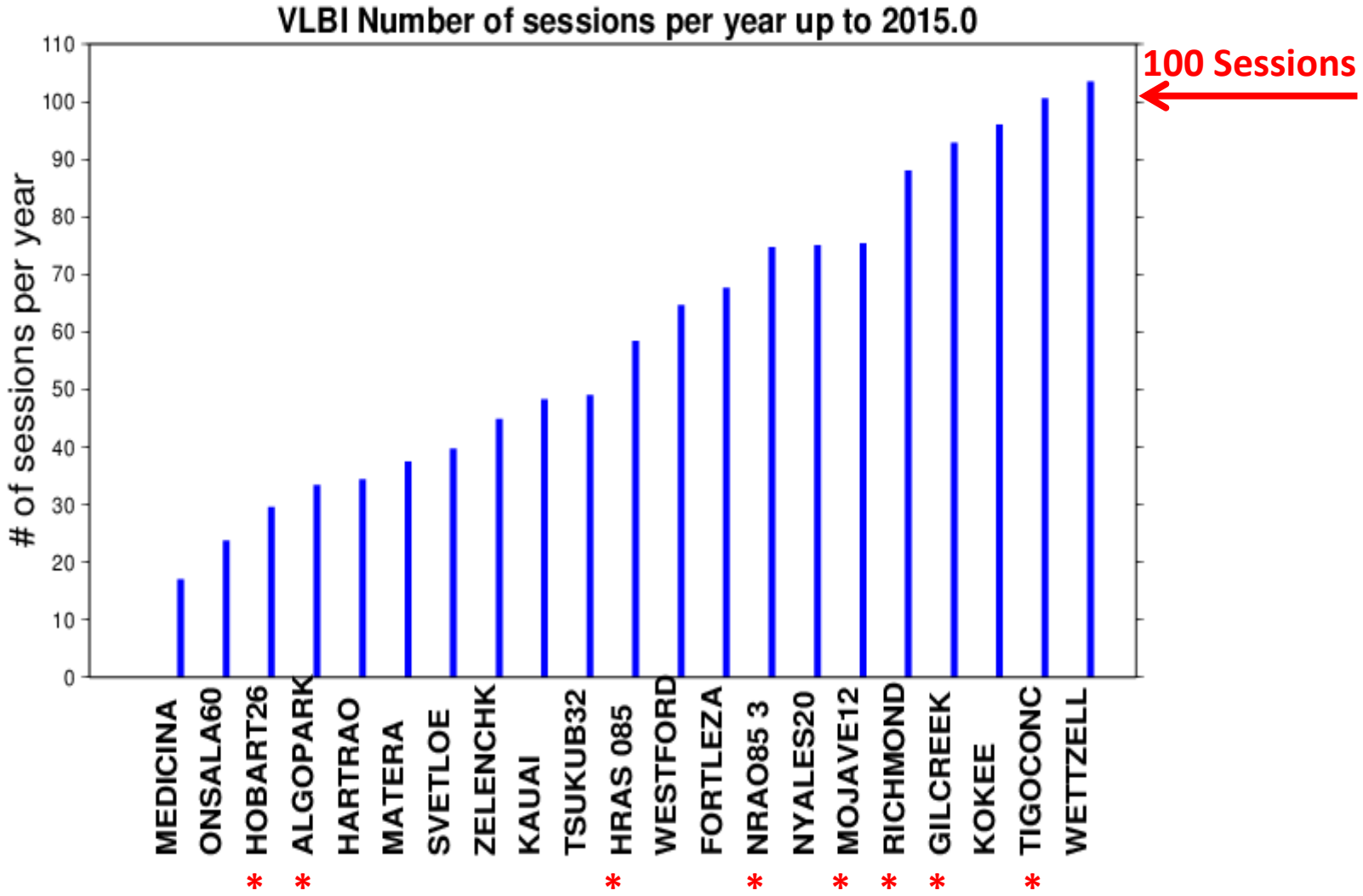
VLBI Data Volume in years up to 2015.0



- VLBI observations span 38 years up to 2015.0
- Shown are stations with data volume > 1 year: 21 stations out of 44

* No longer in operation

VLBI number of sessions per year up to 2015.0



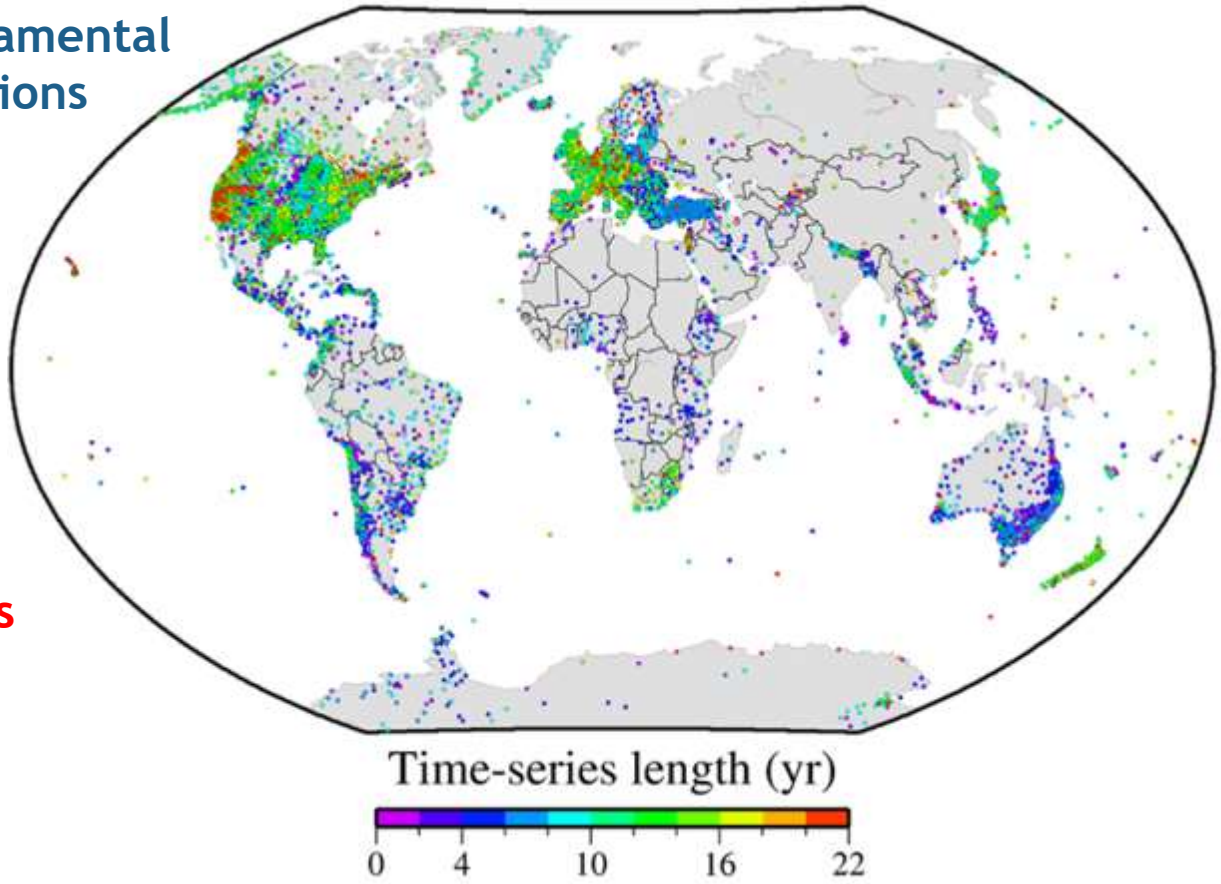
* No longer in operation

VLBI Contribution to ITRF2014

- 5789 daily/session-wise solutions over 38 years
- 407 sessions with two stations (not used)
- 86% of the sessions include a small number of stations between 3 & 9
- 391 (~7%) sessions with 10-19 stations
- 8 sessions with 20 stations
- two sessions exceptionally include 21 and 32 stations
- ==> VLBI observing sessions are not really designed for the TRF, due to limited resources

Access to the GGRF/ITRF via GNSS

- Open Data Sharing is fundamental to enable science applications
- Gaps in Africa, East and South East Asia & South America
- Some empty areas does not mean no GNSS stations But data is not shared



Blewitt, G., W. C. Hammond, and C. Kreemer (2018), Harnessing the GPS data explosion for interdisciplinary science, Eos, 99, https://doi.org/10.1029/2018EO104623

Response to weaknesses

United Nation Global Geospatial Information Management (UN-GGIM)

UN-GGIM and Geodesy

- **Creation of a Working Group on the GGRF in 2013, tasked to formulate:**
  - **A draft text of a UN GA resolution on the importance of the GGRF for sustainable development : Resolution adopted in 2015**
  - **A global geodetic roadmap that describes the current situation & provides recommendations for the long-term GGRF enhancement & sustainability: Roadmap finalized in 2016**

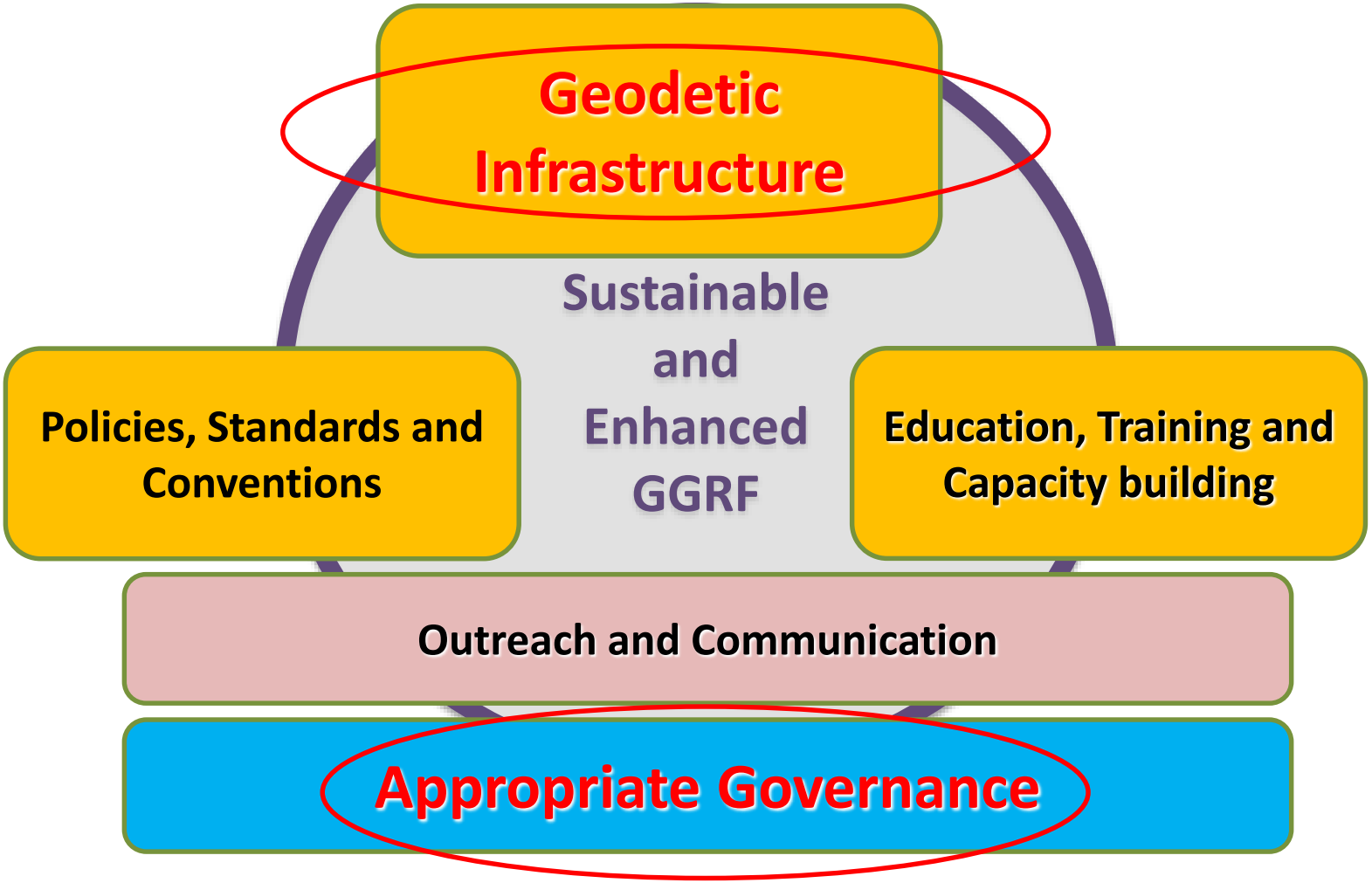
- **Creation of UN-GGIM Subcommittee on Geodesy in 2016**
  Main tasks:
  - **Develop an implementation plan for the long-term:**
  - **Investigate options for a Governance mechanism**

Key points of the UN GA resolution

- *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

VISION of the UN Sub-committee on Geodesy

An accurate, sustainable and accessible Global Geodetic Reference Frame to support science and society



The GGRF as defined in the road map

- **Geodetic framework**

- **It includes:**
  - **Geodetic observatories / Networks**
  - **Data collection, data analysis**
  - **ICRF, ITRF, EOPs & Height systems**
  - **Work forces and product generation systems**
  - **…**
- **The UN-GGIM initiative is about the sustainability of the GGRF on the long-term**

Geodetic Infrastructure: Current situation

- Significant investment in geodetic infrastructure by Member States
- Coordination undertaken by the International association of Geodesy (IAG) and its technique services
- GNSS is the primary means of accessing the ITRF

- Geographical distribution of infrastructure is biased towards North
- Gaps in the networks of infrastructure exist, even in the North
- Many of the legacy infrastructure are aging, difficult to maintain, and of poor performance
- Operating costs for geodetic infrastructure are at risk for sustainable operation
- Coordination across nations, regions and globally is not always fully effective

Geodetic Infrastructure: Recommendations

Recommendations of the GGRF road map: The Member States are urged to:

- establish sufficient geodetic infrastructure to allow an accurate access to the GGRF
- assist those countries with less capacity do so through or multi-lateral agreements
- working within a coordinated science plan developed by the IAG, commit to maintain current investments in the existing Core Observatories
- make efforts to upgrade the current observing systems at geodetic observatories, in particular VLBI and SLR instruments to next generation technologies
- support the IAG's continued efforts to quantify through simulation the global distribution and specification requirements for geodetic observatories
- commit to fill the gaps where Core Observatories are needed

Governance

Recommendations: The Member States are urged to:

- **Note the importance of effective governance to the sustainability and enhancement of the GGRF**
- **The Members States collectively commence the development of an implementation plan for the recommendations in the GGRF road map**

- **==> Towards creation of a Global Geodetic Center of Excellence (GGCE) ?**

- **IAG should have a major role in the GGCE**

Backup

UN-GGIM: Why?

The UN Economic and Social Council (ECOSOC) established in 2011 the:

UN-GGIM Committee of Experts

"To be as the apex of an intergovernmental mechanism for making joint decisions and setting directions with regard to the production, availability and application of geospatial information within national, regional and global policy frameworks."

UN-GGIM Areas of Work

1. Development of the global geodetic reference frame
2. Development of a global map for sustainable development
3. Geospatial information supporting Sustainable Development and the post 2015 development agenda
4. Adoption and implementation of standards by the global geospatial information community
5. Development of a knowledge base for geospatial information
6. Identification of trends in national institutional arrangements in geospatial information management
7. Integrating geospatial statistics and other information
8. Legal and policy frameworks, including critical issues related to authoritative data
9. Development of shared statement of principles on the management of geospatial information
10. Determining fundamental data sets

The GGRF, as defined in the road map

- 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