# Role and importance of the International Terrestrial Reference Frame (ITRF) for science and positioning applications


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# UN-GGIM Objectives

- **The promotion of global geospatial information to address key global challenges & to support improved decision-making;**
- **At the 2nd Session of the Committee of Experts held in New York in August 2012 nine critical issues were identified, including:**
  - **future trends for geospatial information**
  - **development of a knowledge base**
  - **a global geodetic reference system**
  - **a global map for sustainable development**

# Background: need for a global terrestrial reference system (1/2)

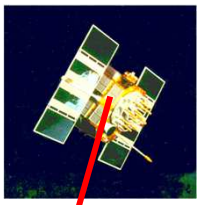
- Positioning (determination of point positions or coordinates) is fundamental for
  - Earth science & Earth observation applications
  - Geospatial activities, navigation, civil engineering, agriculture, …
  - Disaster management & reconstruction (Earthquake, Tsunami…)
- Coordinates are time dependent
  - Plate motion --> up to 10 cm/yr
  - Earthquake dislocation --> up to several meters
- To be truly useful, coordinates are (should be) expressed in a terrestrial reference system

# Background: need for a global terrestrial reference system (2/2)

- Need for a global & unique/standard reference frame --> ensure inter-operability
- GNSS is today's best tool for positioning :
  - To support science and societal applications
  - Low-cost, easy to use, with up to few mm precision
- Need for Continuously Operating GNSS Core Stations, necessary for:
  - Access to the global reference frame
  - Variety of other geodetic & geospatial applications

# What is a Reference Frame in practice?

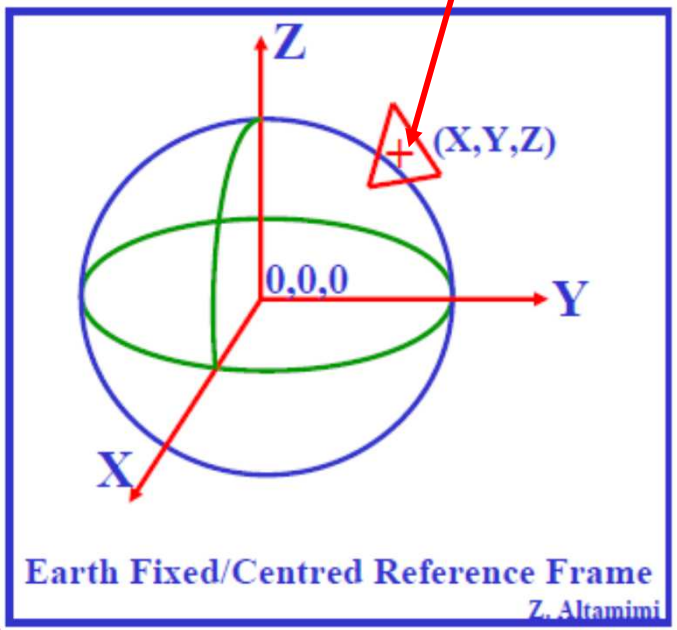
- **Earth fixed/centred RF: allows determination of station location/position as a function of time**



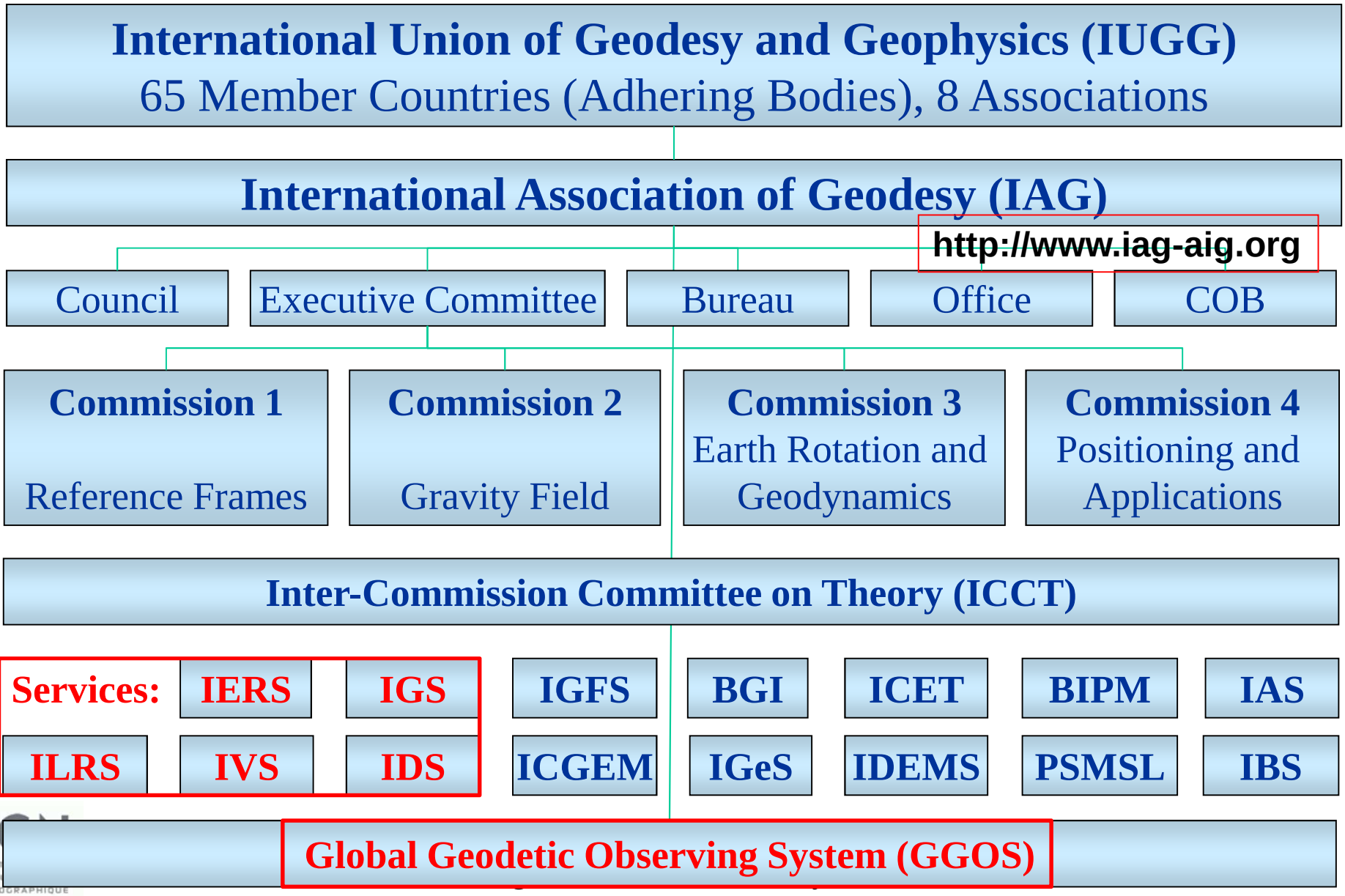
- **It seems simple, but … we have to deal with:**
  - **Relativity theory**
  - **Forces acting on the satellite**
  - **The atmosphere**
  - **Earth rotation**
  - **Solid Earth and ocean tides**
  - **Tectonic motion**
  - **…**

- **Station positions and velocities are now determined with mm and mm/yr precision**

**Origin, Scale & Orientation**



# IAG Structure since 2003



# The International Terrestrial Reference Frame (ITRF)

- Established and maintained by the International Earth Rotation and Reference Systems Service (IERS)
- Numerical realization of the International Terrestrial Reference System (ITRS)
- Adopted by IAG & IUGG in 1991 & 2007 and by CGPM in 2011 for Earth science & timing applications
- Combination of VLBI, SLR, GNSS and DORIS TRFs
- Operated by the ITRS Center, hosted by IGN- France
- Based on co-location sites (see next)
- Updated every 3-5 years: ITRF88,…,2000,2005
- Current Version: ITRF2008

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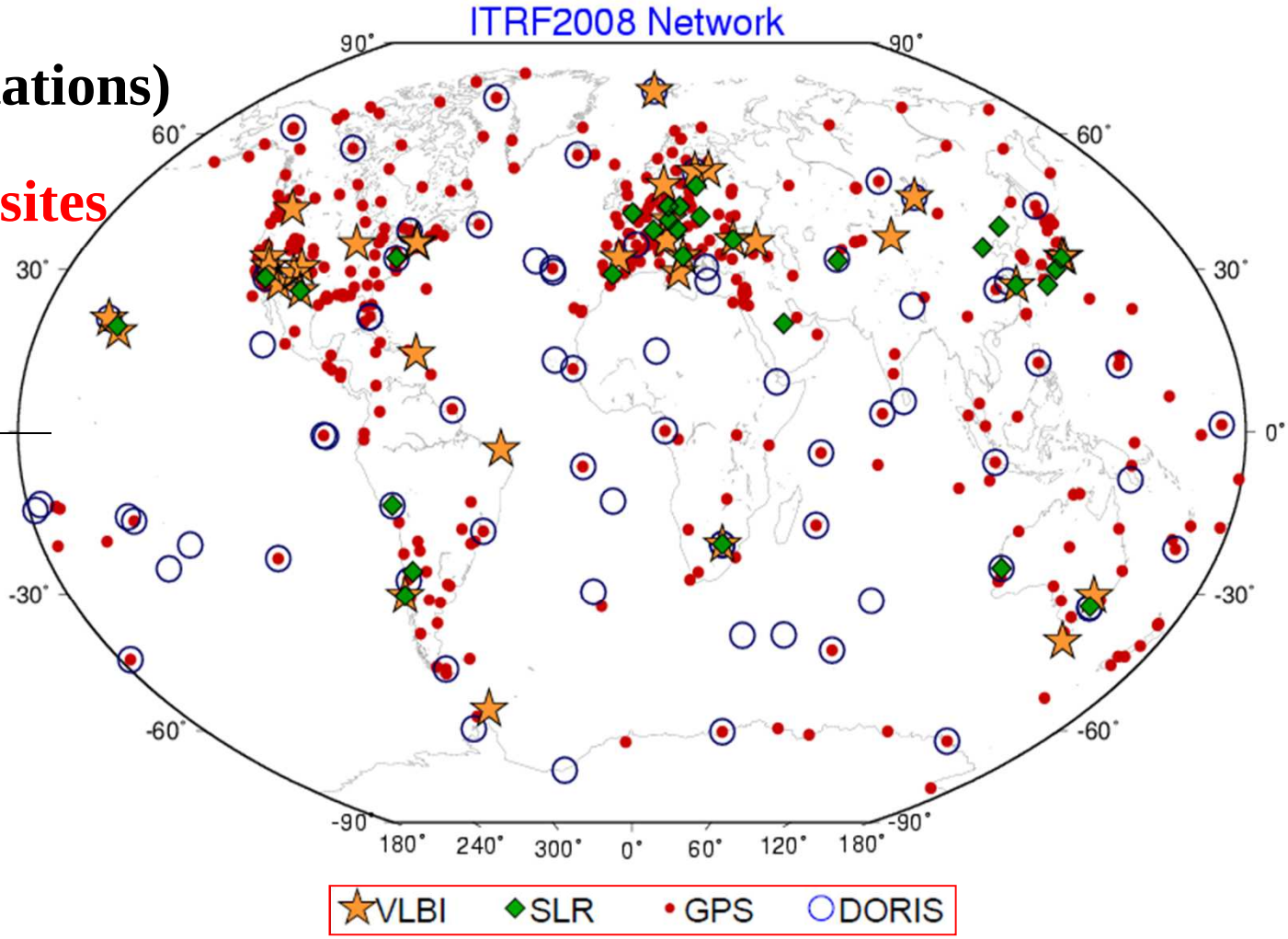
# ITRF2008 Network

**580 sites (920 stations)**

**492 IGS/GNSS sites**

**461 Sites North**

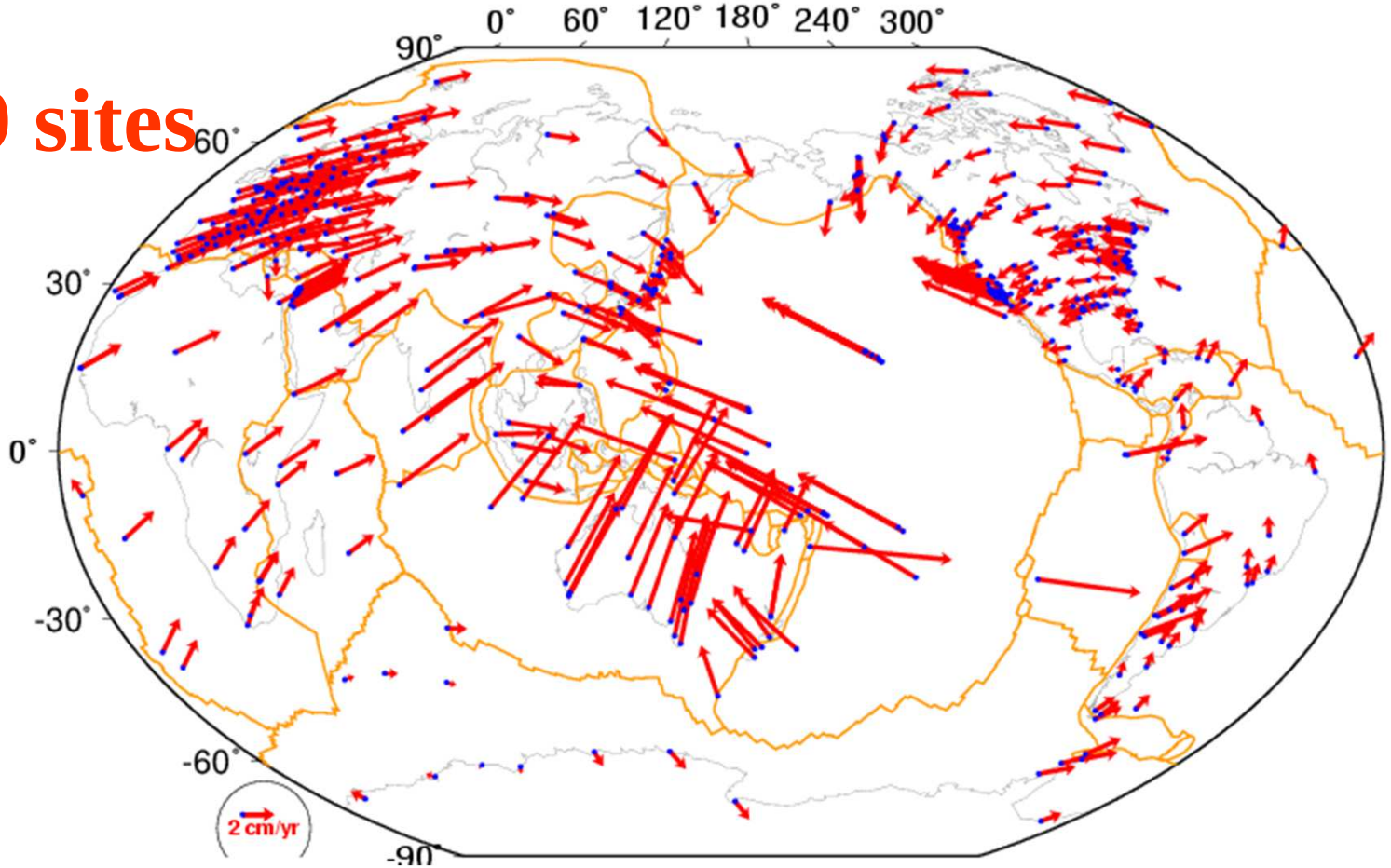
**118 Sites South**



# ITRF2008 Site Velocities:

## time-span > 3 yrs, ($\sigma$ ~ 0.1 – 1 mm/yr)

**509 sites**




$$X(t) = X(t_0) + \dot{X}(t - t_0)$$

# Access to the ITRF and the IGS role

- **Any GNSS network can easily be expressed in the ITRF using IGS products (orbit, clocks, ERP: all expressed in the ITRF)**
- **IGS/GNSS observations (RINEX files) & Products are publicly available**
- **IGS products (Orbits, Clocks and Earth Rotation Prameters) to be fixed in regional processing**
- **Geodetic/mathematical procedure to express a GNSS network in the ITRF is also available**
- **NMAs have access to scientific software packages**

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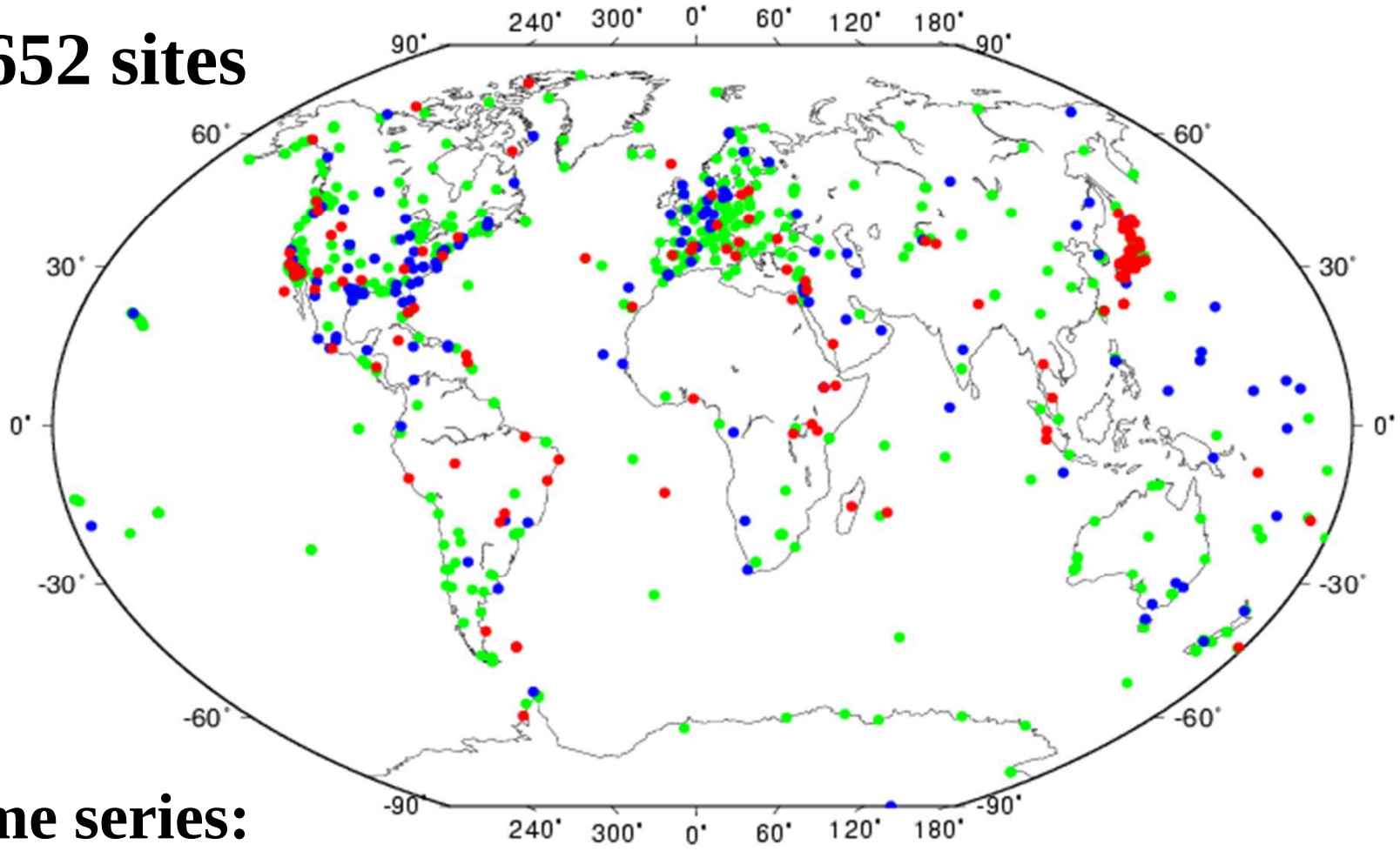
# Processed IGS/GNSS sites, since 1994

**652 sites**




**Time series:**

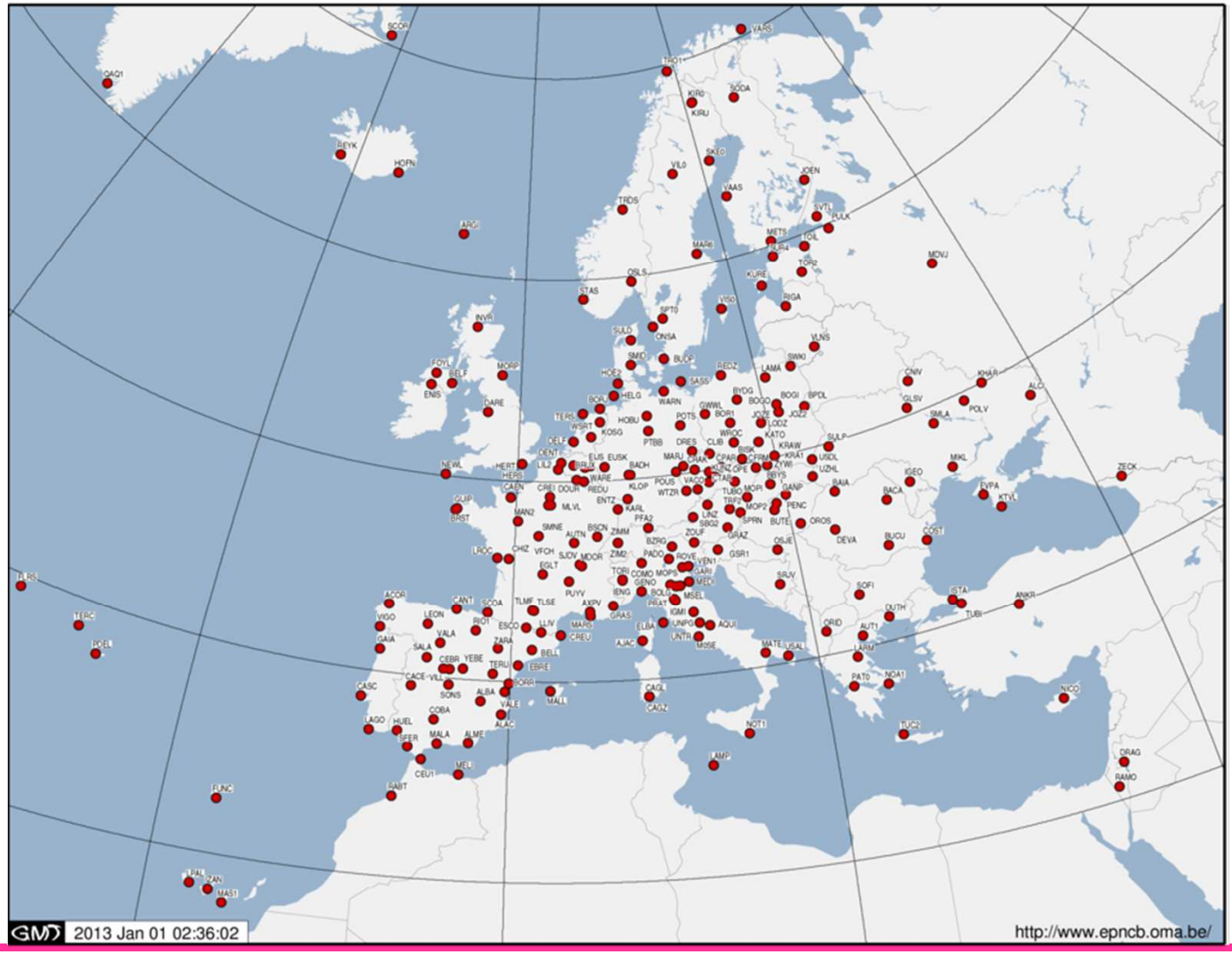
**Red < 5yrs (118), Blue 5-10yrs (138), Green 10-18yrs (396)**

# Regional & National Reference Systems/Frames

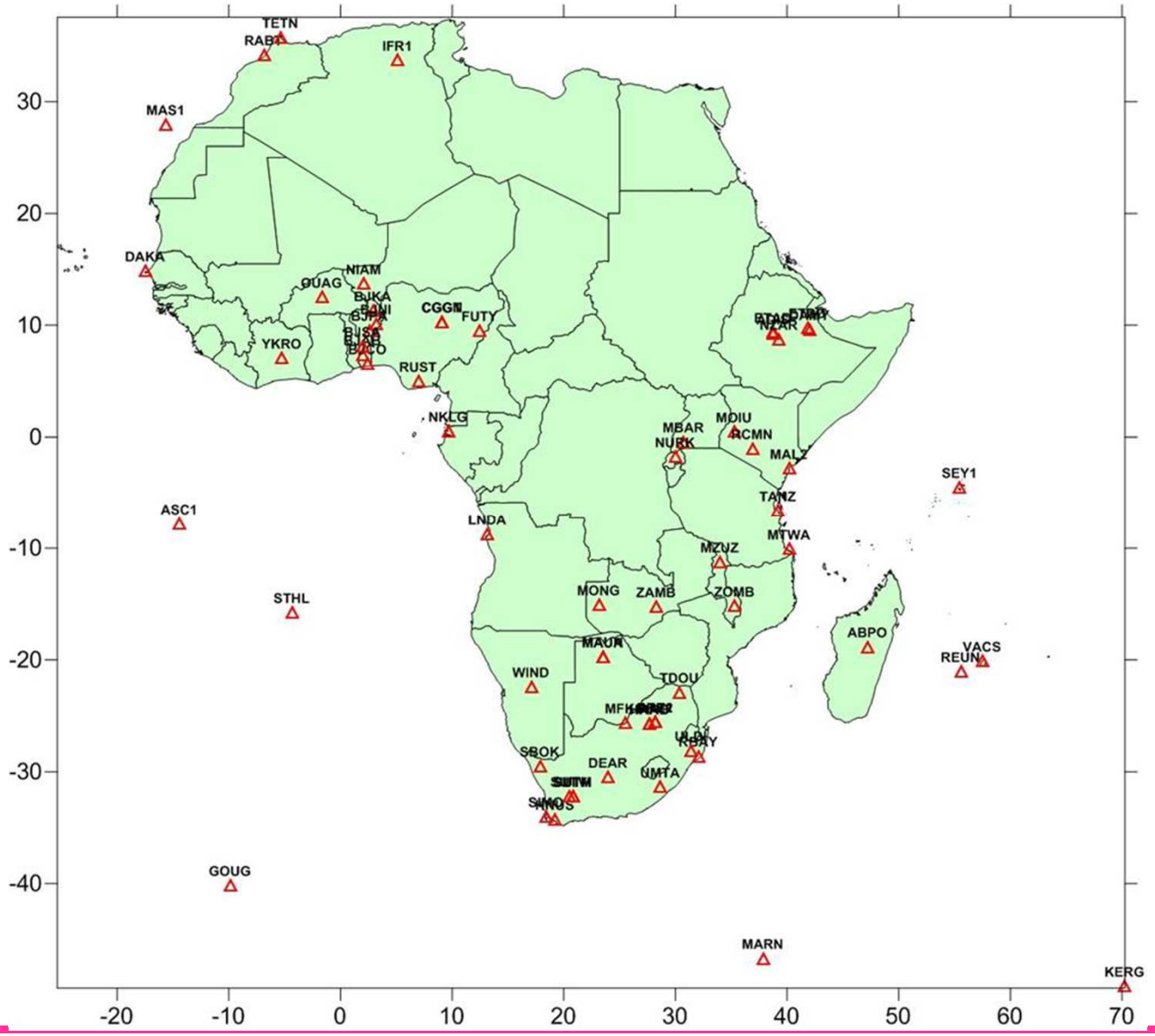
- **IAG Commission 1 (Reference Frames) ==> Sub-Commission 1.3 (Regional Reference Frames):**
  - **EUREF/Europe: ETRS89**
  - **NAREF/North America: NAD83**
  - **SIRGAS/South America: SIRGAS**
  - **AFREF/Africa**
  - **APREF/Asia & Pacific**
  - **SCAR/Antarctica**
- **Regional Reference Frames: rely on the ITRF**
- **Many countries have redefined their geodetic systems to be compatible with/related to ITRF**

# EUREF Permanent Network (EPN)

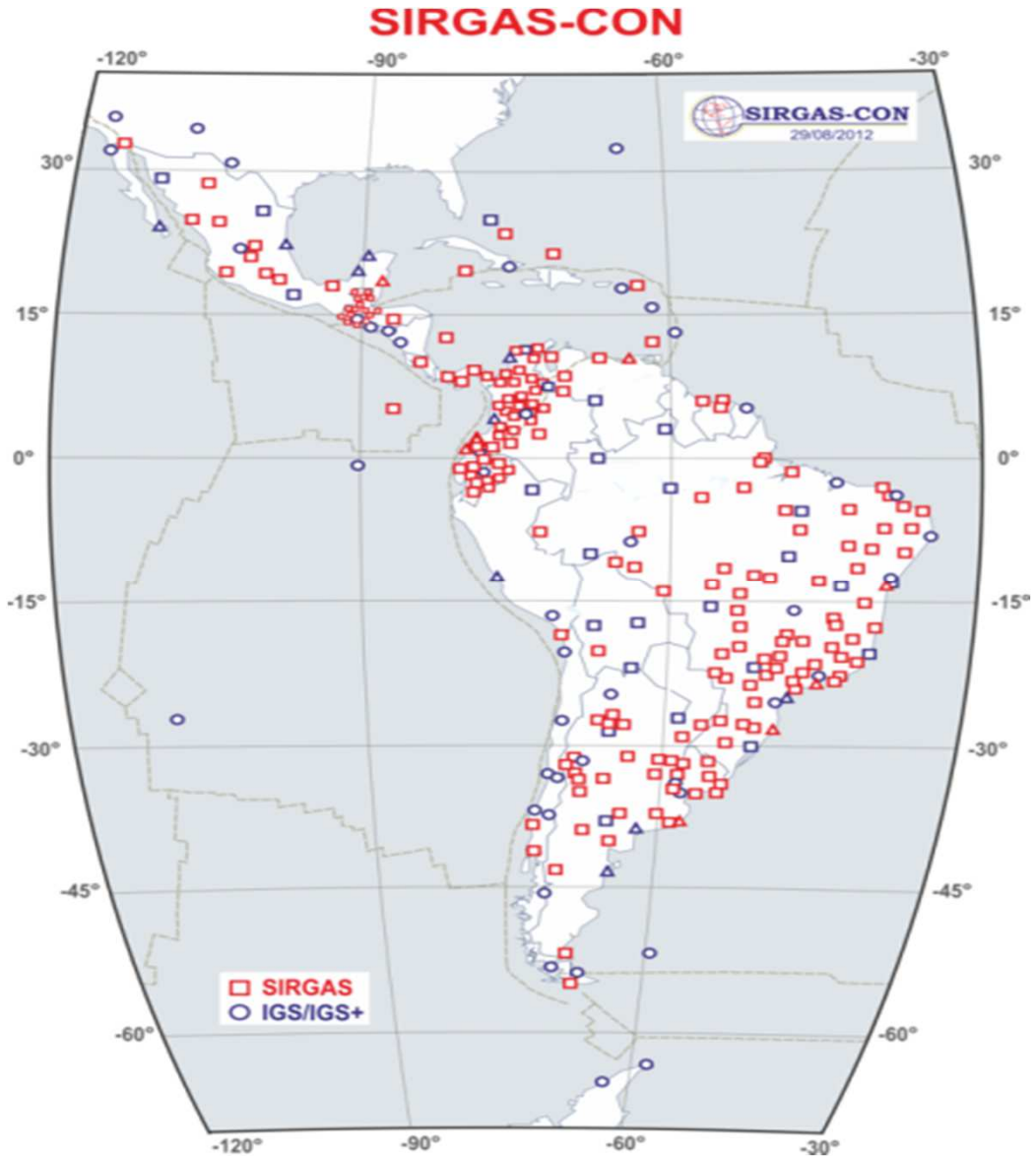
***EUREF Permanent Tracking Network***



# AFREF Network



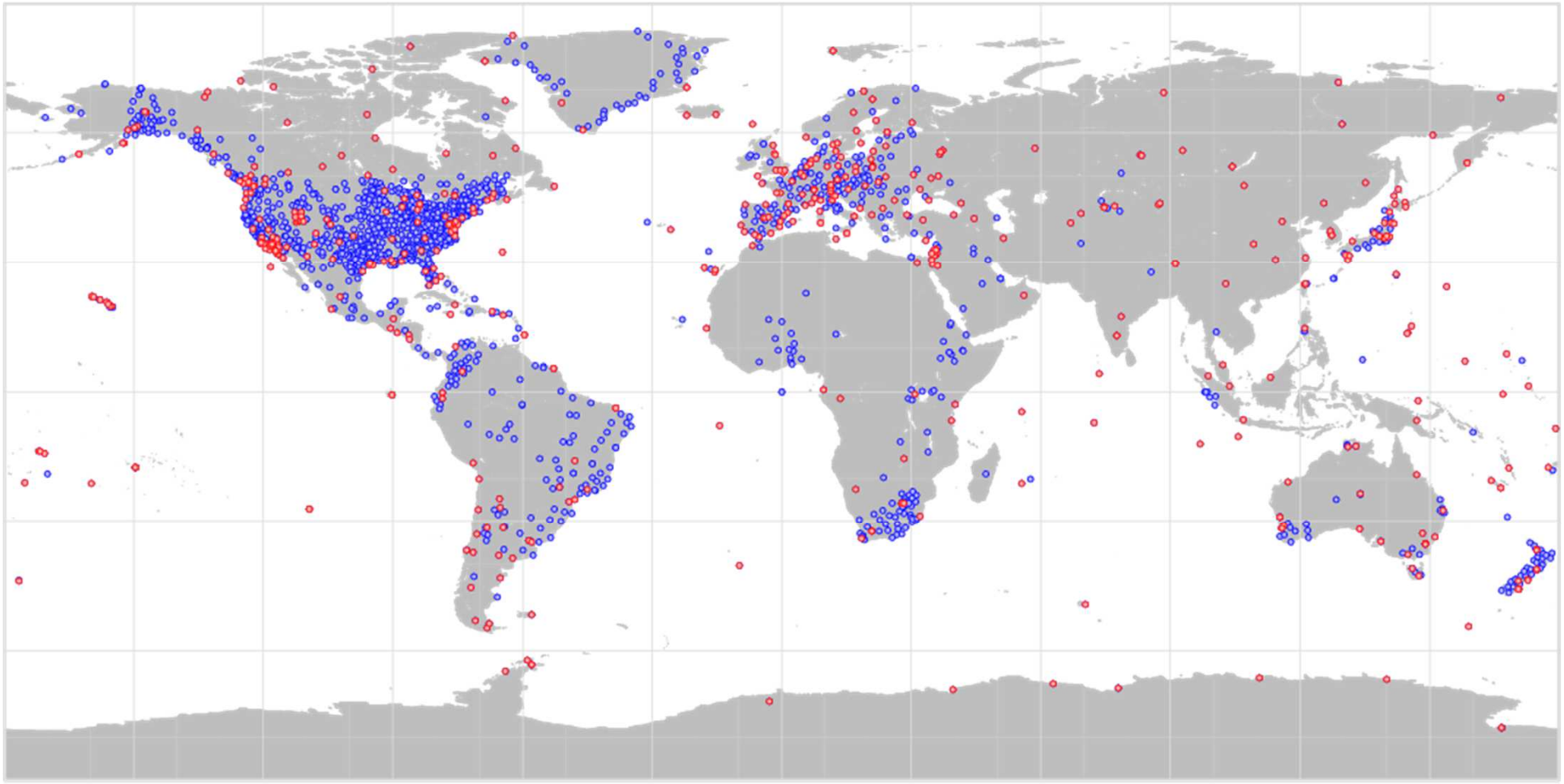
# SIRGAS Network



# ITRF densification

## ITRF2008 GNSS sites

## Densification sites



**Courtesy Juliette Legrand**

# GNSS associated reference systems/frames

| GNSS | Ref. System/Frame |
|---|---|
| • GPS (broadcast orbits) | WGS84 |
| • GPS (precise IGS orbits) | ITRS/ITRF |
| • GLONASS | PZ-90 |
| • GALILEO | ITRS/ITRF/GTRF |
| • COMPASS | CGCS 2000 |
| • QZSS | JGS |

- All are now aligned to the ITRF2008
- WGS84 ≈ ITRF at the decimeter level
- GTRF ≈ ITRF at the mm level
- σ-Position using broadcast ephemerides = 150 cm

# Summary

- **The ITRF**
  - **is more precise and accurate TRF available today**
  - **is the achievement of 30 years of international collaboration and investment of IAG services**
  - **needs to be maintained and improved over time**
- **GNSS and IGS publicly available products are essential in accessing the ITRF**
- **GNSS, regional & national reference frames rely on the availabilty of the ITRF**
- **The ITRF as a common standard ensures inter-operability between geospatial information systems**

- **A UN-mandate for ITRF and its infrastructure ?**