

# The Global Geodetic Observing System (GGOS) - its Role and its Activities

Michael Pearlman <sup>1</sup>, Harald Schuh <sup>2</sup>, Detlef Angermann <sup>3</sup>  
and Carey Noll <sup>4</sup>

<sup>1</sup> Center for Astrophysics, Cambridge USA

<sup>2</sup> GeoForschungsZentrum, Potsdam Germany

<sup>3</sup> Technische Universität München, Munich Germany

<sup>4</sup> NASA Goddard Space Flight Center, Greenbelt USA



JpGU-AGU Joint Assembly  
May 24, 2017

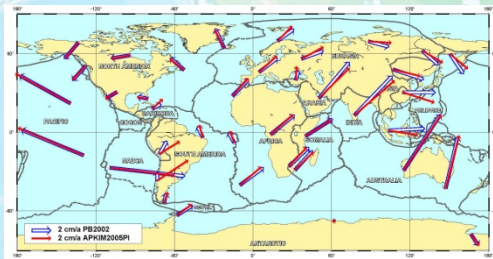




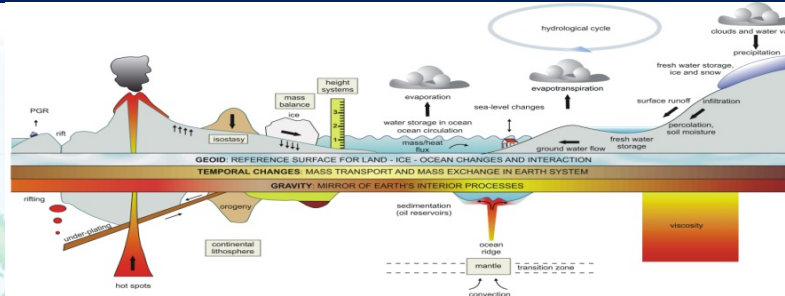
# International Association of Geodesy (IAG) Central Objective Geodetic Observation of Earth Processes

Processes in the solid Earth:  
geodynamics  
(deformation)

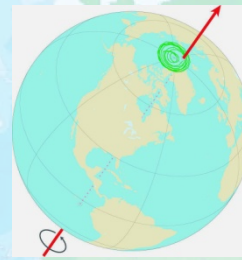
deformations



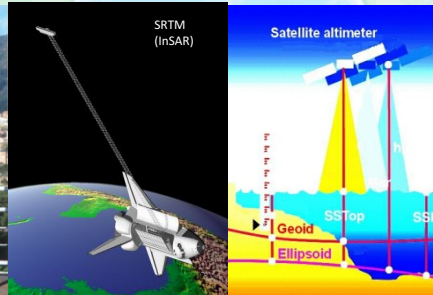
point positioning



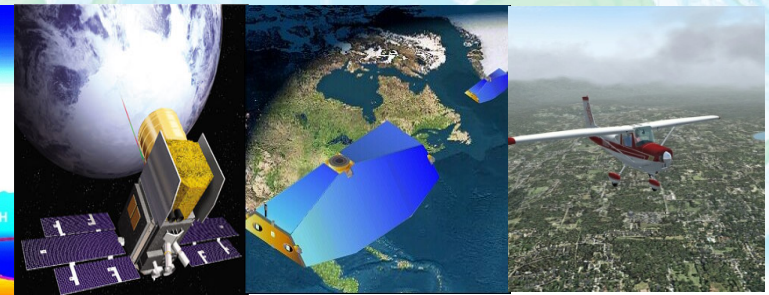
variations of the rotation and the gravity field



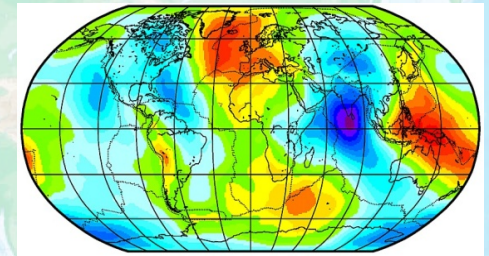
surface scanning



gravity measurement



Processes in the  
atmosphere and  
hydrosphere:  
water cycle

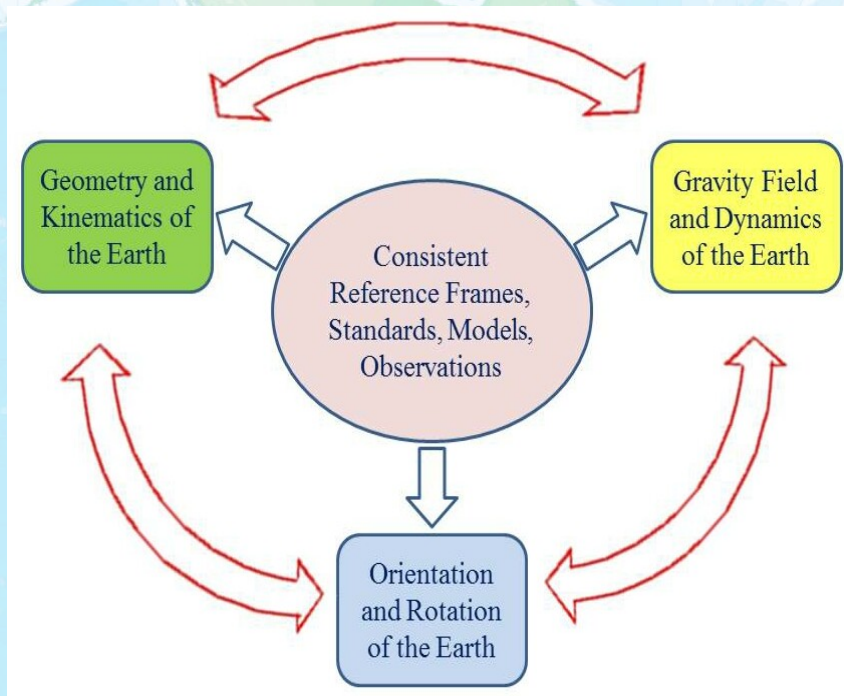




# Fundamental Requirement for Monitoring Global Change

The study, understanding and modelling of the effects of global change require:

- precise, consistent and stable reference frames,
- standards and models for the three geodetic parameter groups:
  - Earth geometry and kinematics,
  - Earth gravity field and dynamics,
  - Earth orientation and rotation.



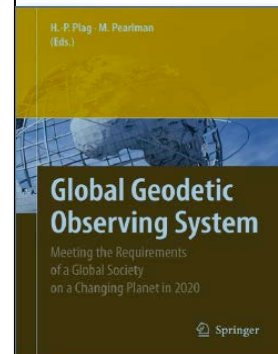
**The reference frame is the basis upon which we measure change over space, time, and evolving technology.**

It must fulfill the following conditions:

- One order more precise than the magnitude of the phenomena to be analysed;
- Globally consistent and reliable (high precision at any place of the Earth's surface);
- Stable over long periods (high precision at any time).

# Global Geodetic Observing System (GGOS)

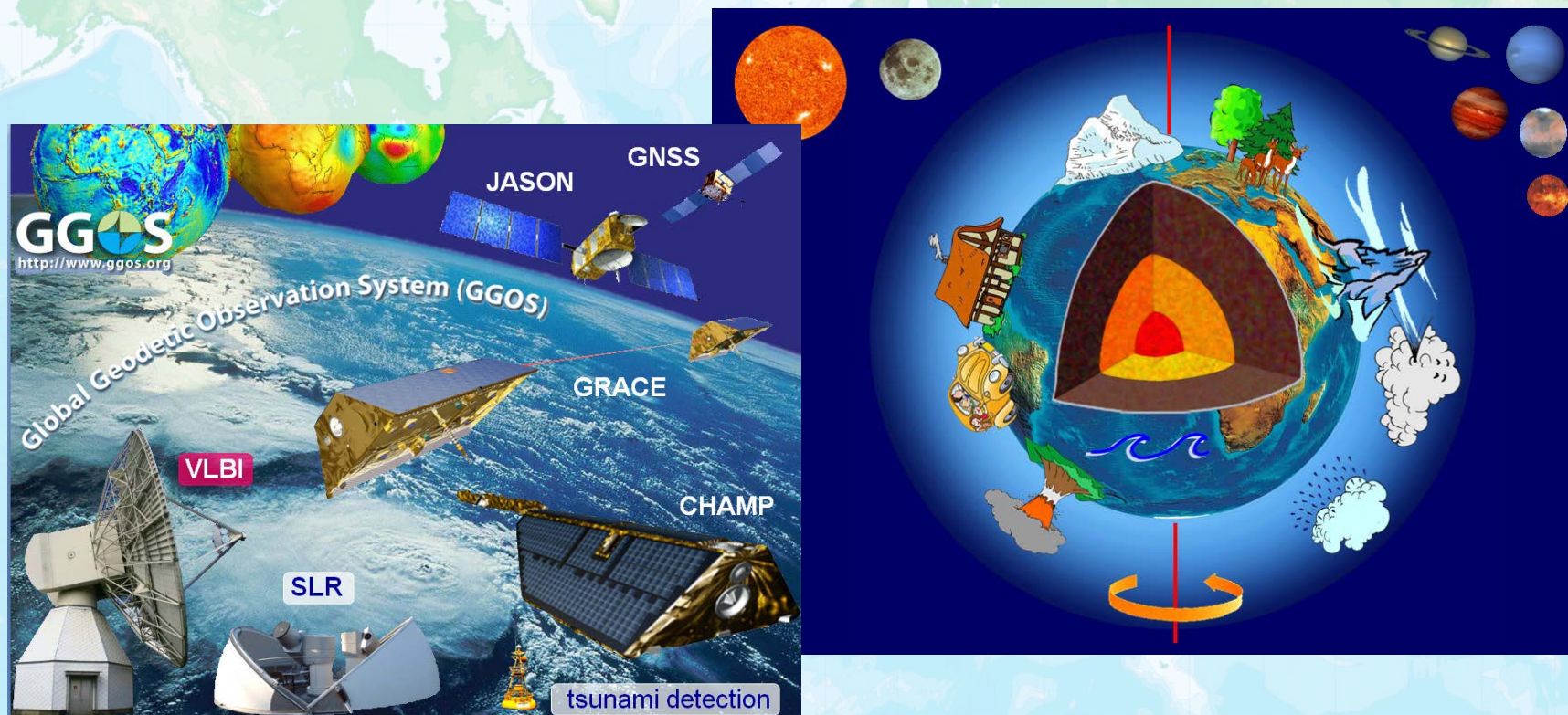
- Established by the IAG in 2004 to be its Observing System
- Vision: Advancing our understanding of the dynamic Earth system by quantifying our planet's changes in space and time to:
  - Advance Earth Science (Earth, oceans, ice, atmosphere, etc)
  - Help us better understand the processes
  - Help us make intelligent societal decisions
- Mode of Operation: Works with the IAG components (IGS, ILRS, IVS, IDS, IGFS, IERS, IAG commissions, etc.) to provide the geodetic infrastructure necessary for monitoring the Earth System and Global Change:
  - observations needed to monitor, map, and understand changes in the Earth's shape, rotation, and mass distribution;
  - the TERRESTRIAL REFERENCE FRAME and CELESTIAL REFERENCE FRAME for measuring and consistently interpreting key global change processes;
  - Other data products that require integration among measuring techniques: Unified height systems, Unified sea level model, Natural hazard warning tools, etc





# Approaches of GGOS

- Combination and integration of all available observations, methods, ...
- Combine physical measurements and geometric techniques
- Improve our understanding of the interactions in "System Earth"



# Geodesy is an essential input to several of the areas of focus of the Global Earth Observation System of Systems (GEOSS)

GGOS should benefit science and society by providing the foundations upon which advances in Earth science and applications are built.

## THE GLOBAL EARTH OBSERVATION SYSTEM OF SYSTEMS





# GGOS today

## IAG Bylaws 1(d)

*“The Global Geodetic Observing System works with the IAG components to provide the geodetic infrastructure necessary for monitoring the Earth system and global change research.”*

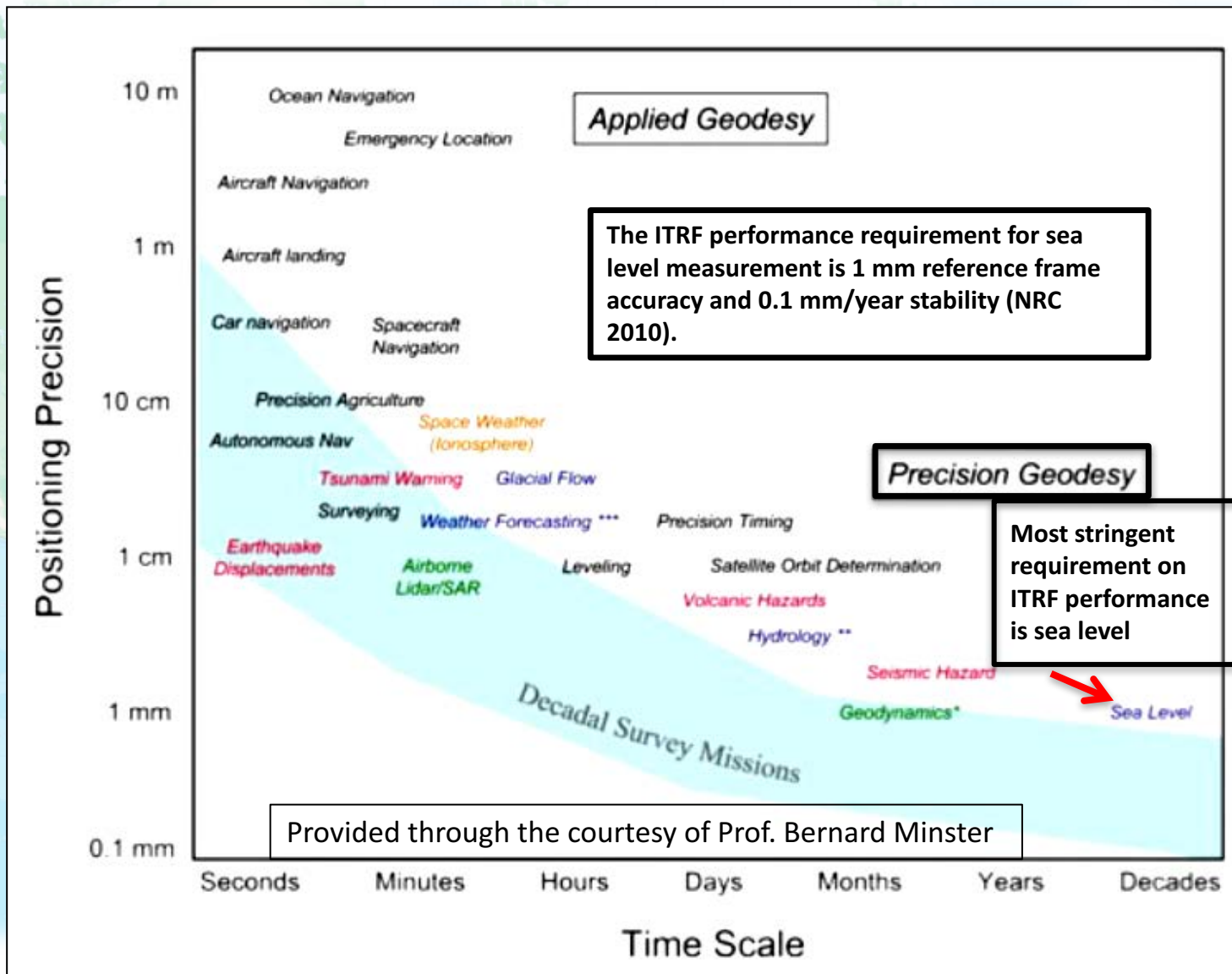
## The vision of GGOS is

*“Advancing our understanding of the dynamic Earth system by **quantifying** our planet’s changes in space and time.”*

# Practical Applications of Space Geodesy

## US National Research Council Study


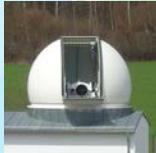



- **Geodesy** is the science of the Earth's shape, gravity and rotation, including their evolution in time.
- **Techniques** used to observe the geodetic properties of the Earth **provide the basis for the International Terrestrial Reference Frame (ITRF)**
- The **ITRF** is the foundation for virtually all **airborne, space-based, and ground-based Earth observations**, and is fundamentally important for **interplanetary spacecraft tracking and navigation**.





# GLOBAL Reference Frame (Terrestrial and Celestial)

- Basis on which we measure changes over time, space, and evolving technology
- Most stringent requirement from sea level rise, but other applications are close behind
  - “accuracy of 1 mm, and stability at 0.1 mm/yr” (a factor of 5 - 10 improvement)
- Accessibility: 24 hours/day; worldwide
  - Users anywhere on Earth can position their measurements in the reference frame
- Space Segment:
  - LAGEOS, LARES, Etalon, GNSS, DORIS to define the reference frame
- Ground Segment (Core and Co-located ground sites):
  - Global distributed network of “modern technology”, co-located SLR, VLBI, GNSS, DORIS stations locally tied together with accurate site ties
  - Dense GNSS ground station network to distribute the frame globally to the users
- Reference Frame Formulation provided by the IERS from data provided by the IAG Services: IGS, IVS, ILRS, and IDS

VLBI	SLR	GNSS	DORIS	Vector Tie
				

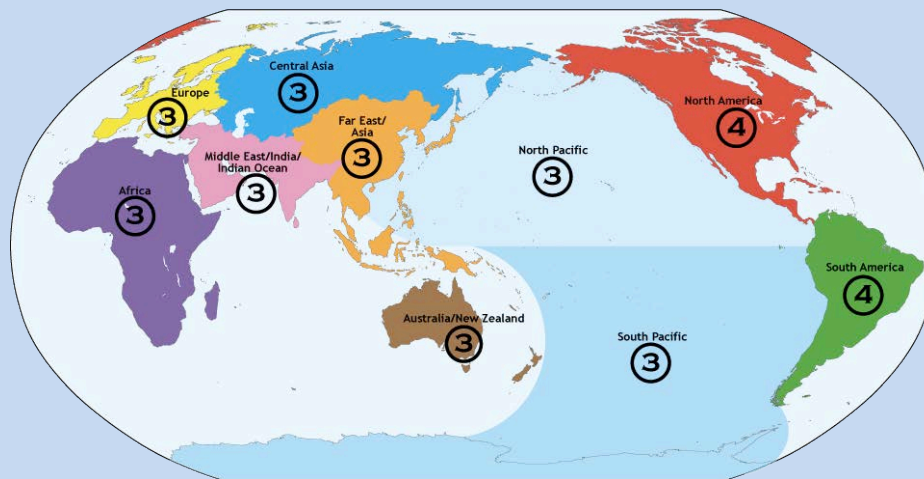
# Early Simulation Studies to Scope the Network

(impact on the Reference Frame)

(Erricos Pavlis)

Early simulation studies showed the we needed:

- ~32 globally distributed, well positioned, new technology, co-location sites will be required to define and maintain the reference frame;
- ~16 of these co-location stations must track GNSS satellites with SLR to calibrate the GNSS orbits which are used to distribute the reference frame.

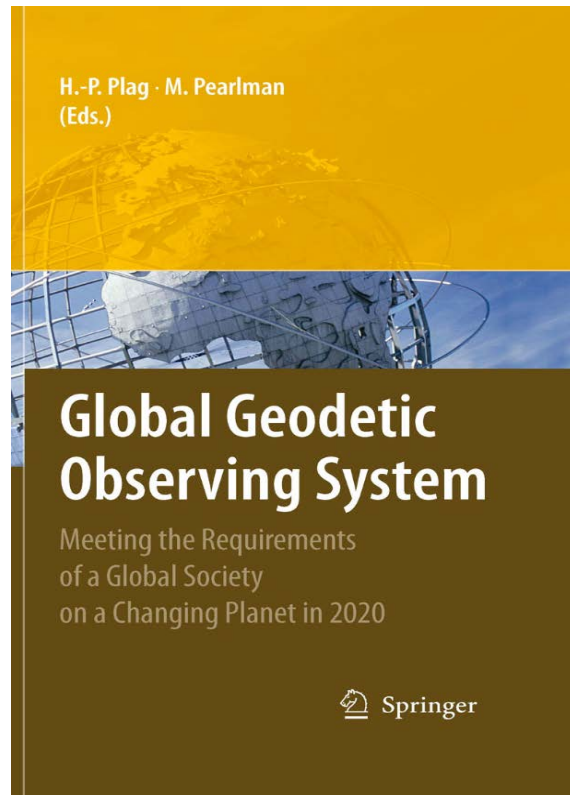


- **Design Initiative, but it a major Challenge**
- **Will require time, significant resources, and strong international participation**
- **Now we recognize that it will be a combination of core and colocation sites with apple geographic distribution.**



# GGOS 2020 Book (2009)

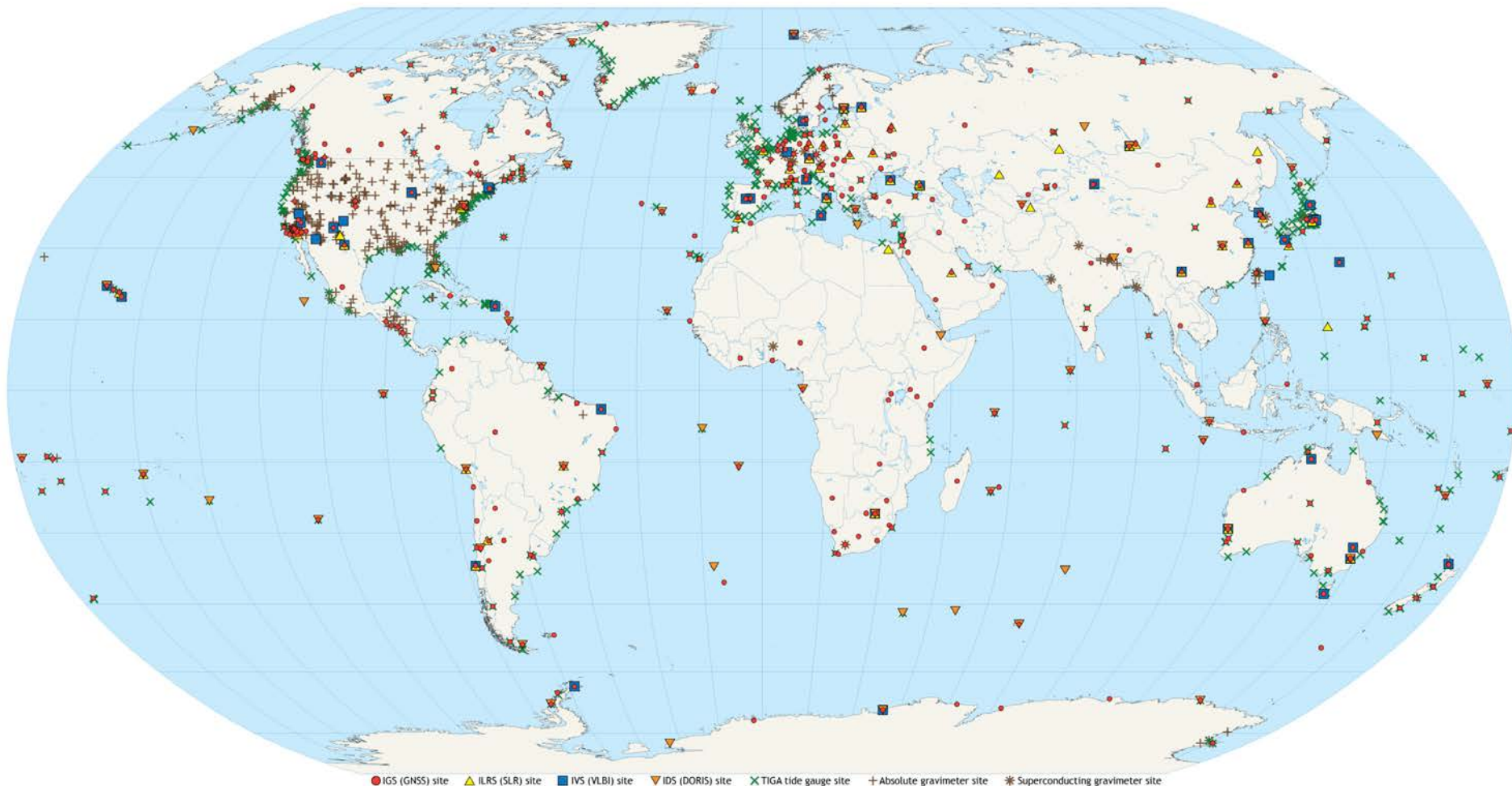
GGOS: Meeting the Requirements of a Global Society on a Changing Planet in 2020. Eds. H.-P. Plag and M. Pearlman. Springer 2009. p. 332



## Content: main arguments for GGOS

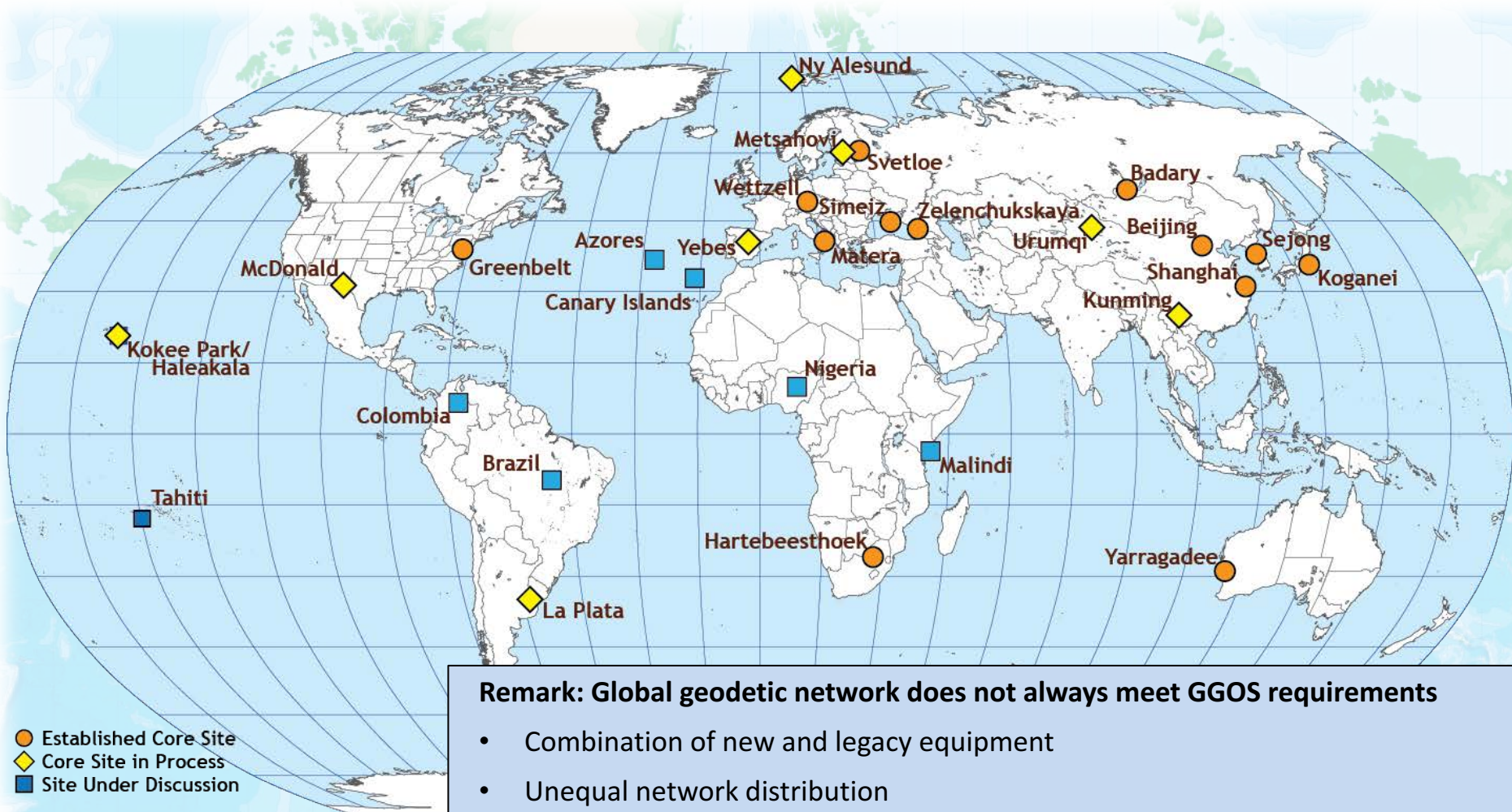
- Goals, achievements and tools of modern geodesy
- Earth science requirements for geodesy
- Maintaining a modern society (9 societal benefit areas)
- Future geodetic reference frames
- Future Global Geodetic Observing System (GGOS)
- GGOS 2020

# Stations Participating in the GGOS Affiliated Network (Call for Participation)





# Present and Projected CORE Network (all 4 techniques)



## Remark: Global geodetic network does not always meet GGOS requirements

- Combination of new and legacy equipment
- Unequal network distribution
- Local ties of techniques
- Still systematic observational errors
- Need for ~10 times improvement in measurement accuracy

# GGOS Site Requirements Document

([http://cddis.gsfc.nasa.gov/docs/GGOS\\_SiteReqDoc.pdf](http://cddis.gsfc.nasa.gov/docs/GGOS_SiteReqDoc.pdf))



- Introduction and Justification
  - What is a Fundamental Station?
  - Why do we need the Reference Frame?
  - Why do we need a global network?
  - What is the current situation?
  - What do we need?
- Site Conditions
  - Global consideration for the location
  - Geology
  - Site area
  - Weather and sky conditions
  - Radio frequency and optical Interference
  - Horizon conditions
  - Air traffic and aircraft Protection
  - Communications
  - Land ownership
  - Local ground geodetic networks
  - Site Accessibility
  - Local infrastructure and accommodations
  - Electric power
  - Site security and safety
  - Local commitment



# UN Adopted its first Geospatial UN Resolution

- **Global Geodetic Reference Frame (ITRF and ICRF combination) for Sustainable Development (GGRF) resolution - No. A/69/L.53 -**
- **adopted by the United Nations General Assembly on 26<sup>th</sup> of Feb, 2015**
- **co-sponsored by 52 Member States including Japan**
- ... first resolution recognizing the importance of a globally coordinated approach to geodesy – the discipline focused on accurately measuring the shape, rotation and gravitational field of planet Earth.
- The General Assembly resolution, *A Global Geodetic Reference Frame for Sustainable Development*, outlines the value of ground-based observations and remote satellite sensing when tracking changes in populations, ice caps, oceans and the atmosphere over time.



# Summary

- Challenging program with very important science and societal benefits
- Technologies are maturing; new technologies are on the horizon
- Global distribution is essential; success needs the enhanced networks that will depend on partnerships
- Very large opportunity for participation in analysis and scientific research
- Need to engage young scientists and students





**150th  
Anniversary**

**1862-2012**

**Thank you for your attention!**

**[mpearlman@cfa.harvard.edu](mailto:mpearlman@cfa.harvard.edu)**