Contributions of Future SLR Networks to the Development of ITRF

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Global Geodetic Observing System (GGOS)

Official Component (Observing System) of the International Association of Geodesy (IAG) with the objective of:

Ensuring the availability of geodetic science, infrastructure, and products to support global change research in Earth sciences to:

- *extend our knowledge and understanding of system processes;*
- *monitor ongoing changes; and*
- *increase our capability to predict the future behaviour.*

Fundamentals of GGOS

GGOS consists of the following four components:

- Instrumentation - networks of observing stations, ground and space components
- Data infrastructure - communications, data centers, archive and access
- Data analysis and combination - research and analysis algorithms and processes, integrative approach
- Modeling and interpretation - observations improve models, interpretation towards improved understanding

Reference Frame

- Stable coordinate system through which we measure changes and link/ integrate measurements over space (global to regional), time (decades) and rapidly evolving technologies
- Realized by a global array of accurate, well distributed, stable set of station positions and velocities.
- Established and maintained by the global space geodetic networks.
- IAG Services provide the geodetic infrastructure necessary for observing, monitoring and modeling Earth system science and global change research,
- Scientific services form the organizational basis of GGOS

Motivation

- Space techniques are **indispensable** for the development of the terrestrial reference frame and for geodetic metrology
- The current state-of-the-art does not meet science requirements due to **poor area coverage** and **aging equipment**
- To meet the stringent future requirements (e.g. GGOS), we need to **design a new network** and deploy **modern hardware systems**

Future ITRF Accuracy Goal

- Future ITRF* should exhibit consistently and reliably accuracy and stability at the level of:

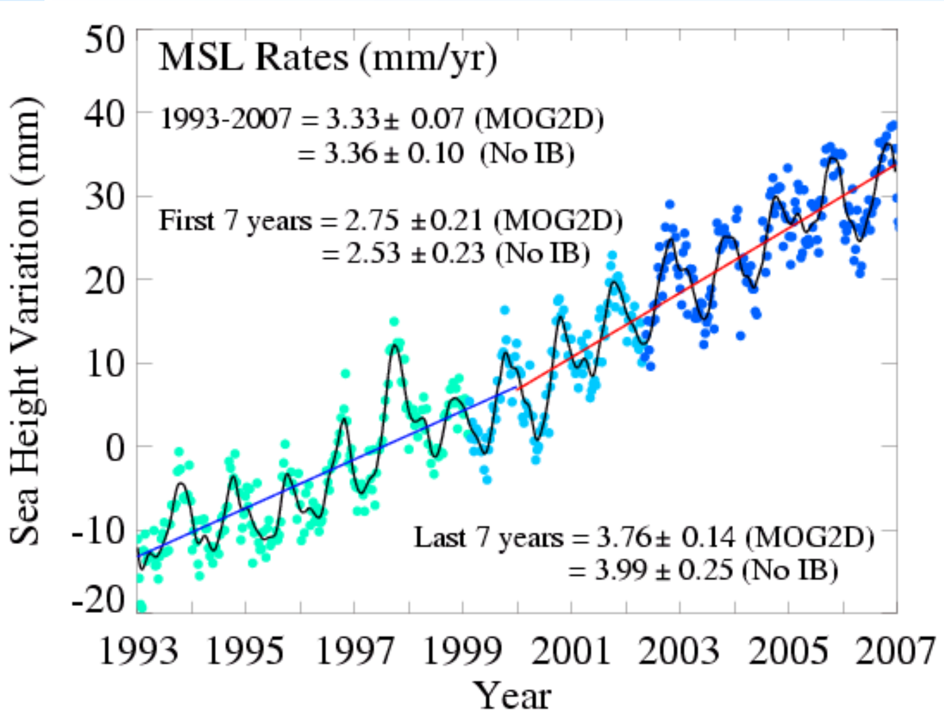
<1 mm in epoch position, and

< 0.1 mm/y in secular change

*Current performance: ~ 10 mm and ~ 1 mm/y

Why 1 mm / 0.1 mm/yr ?

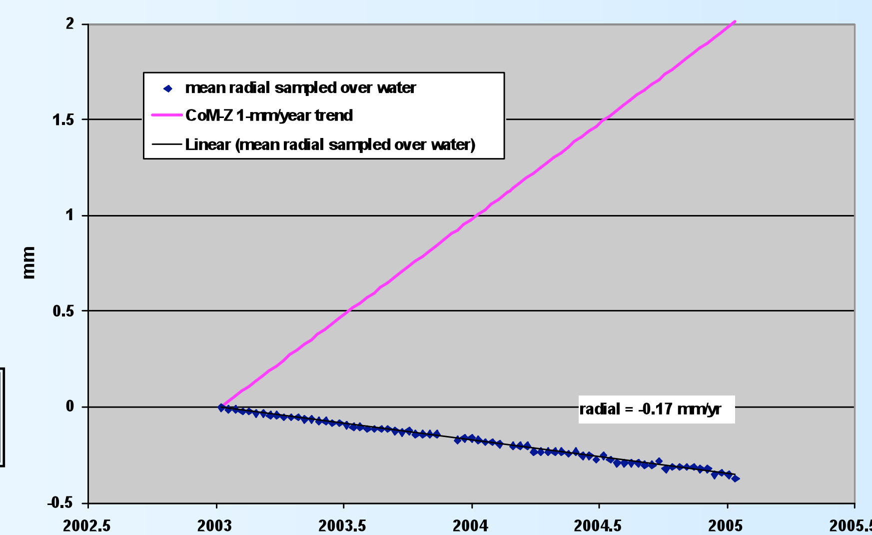
ITRF2005: 3.3 +/- 0.07 mm/yr



Beckley et al. (2007), *GRL, Fig 4*

For every 1 mm/yr Z-trend in the TRF origin, sea-level rates are affected by ~ 0.2 mm/yr

Lemoine et al. (2008),
EGU2008-A-11368



Multiple techniques to solve the puzzle

- High precision geodesy is very challenging
  - 0.1 mm/yr stability required for sea level monitoring
- Fundamentally different observations with unique capabilities
- Together provide redundancy, cross validation and increased accuracy for TRF
- Strength from improvement of techniques and integration of techniques

- Fundamental prerequisite: ***Well-distributed, co-located network with accurate ties***

Technique Signal Source Obs. Type	**VLBI** Microwave Quasars Time difference	**SLR** Optical Satellite Two-way range	**GPS** Microwave Satellites Carrier phase
Celestial Frame UT1	**Yes**	No	No
Scale	**Yes**	**Yes**	Yes
Geocenter	No	**Yes**	Yes
Geographic Density	No	No	**Yes**
Real-time	No	No	**Yes**
Decadal Stability	**Yes**	**Yes**	Yes

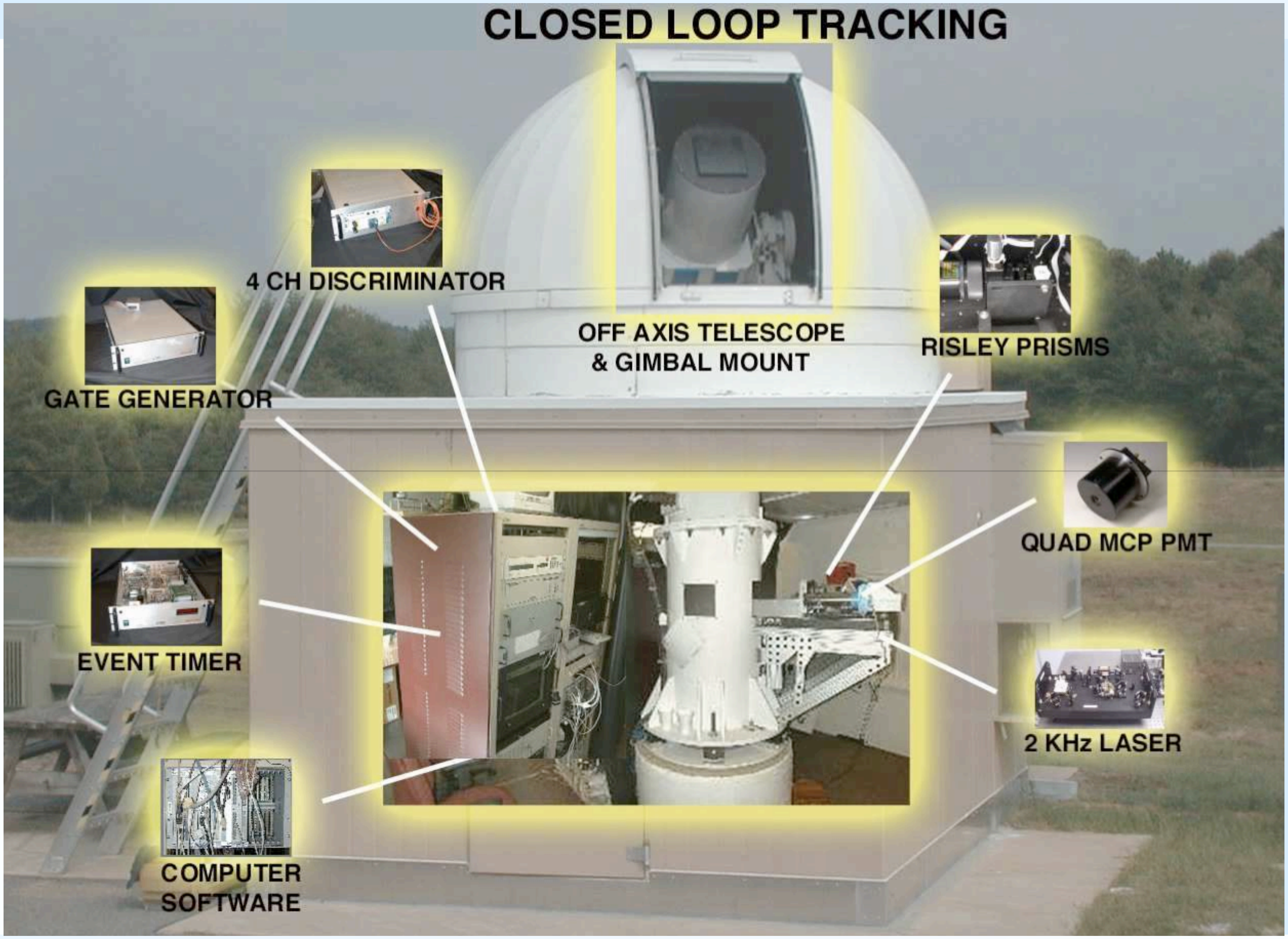
The ILRS Network

ILRS

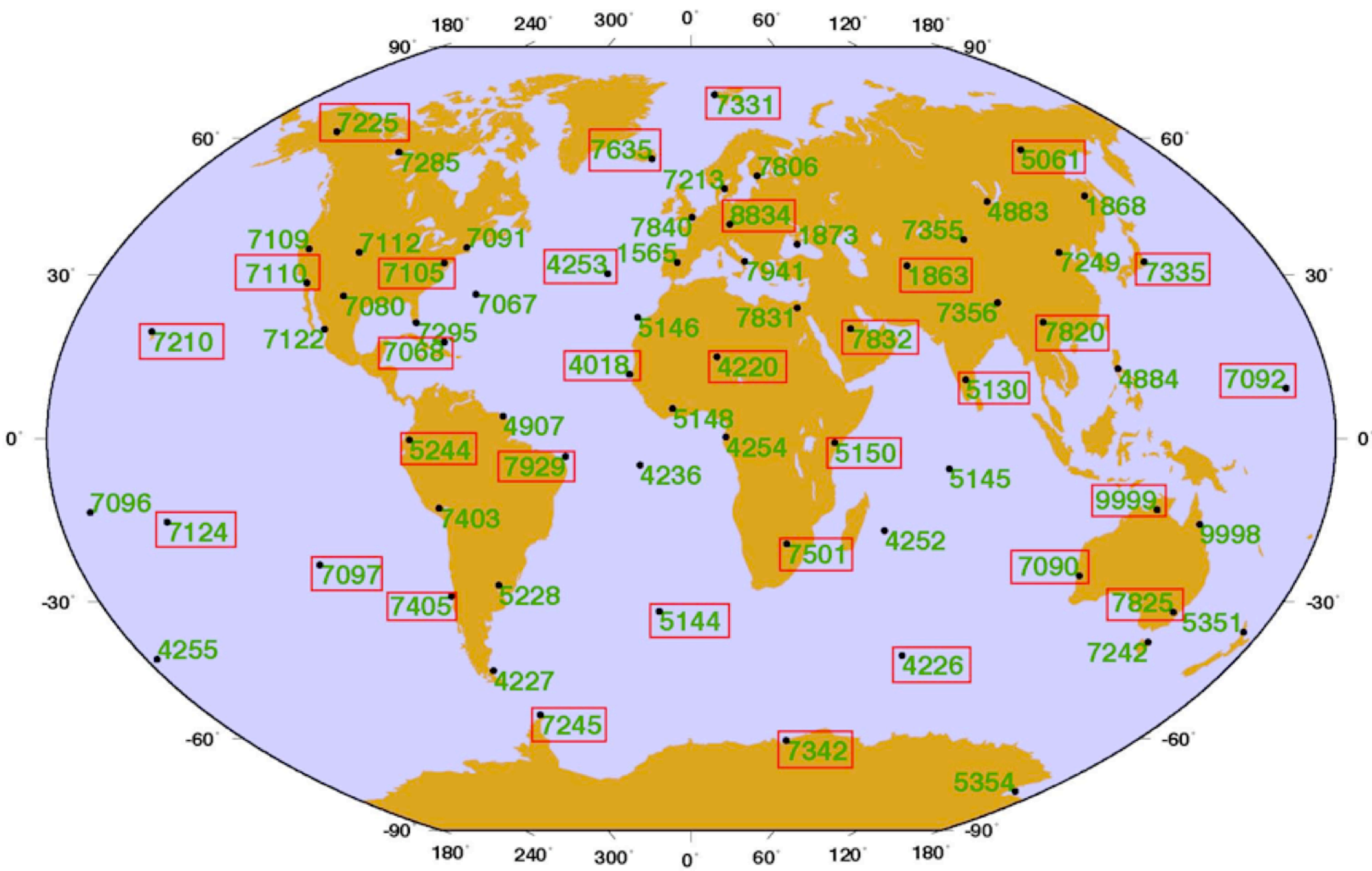
International Laser Ranging Service

Selected SLR Stations Around the World

Future SLR station (NGSLR)

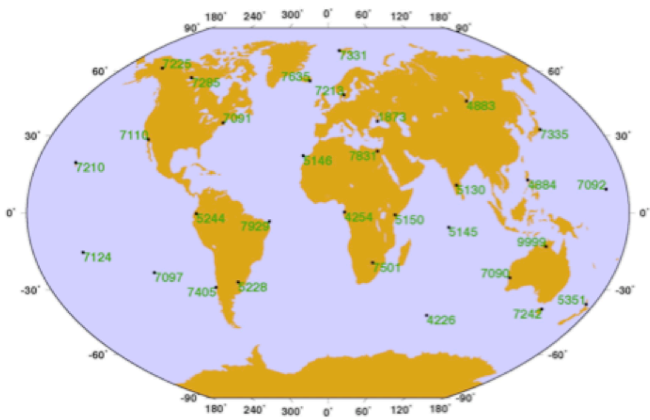


Future Space Geodetic Network

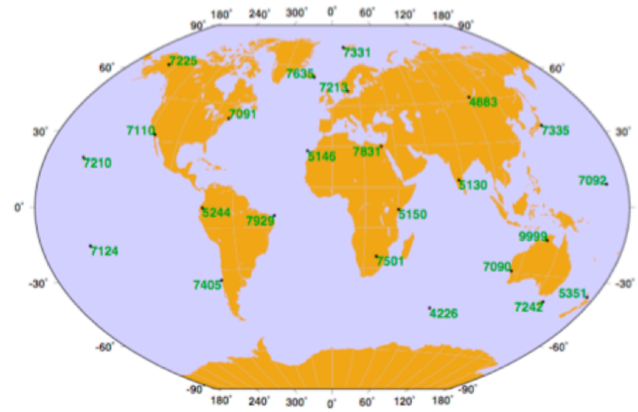


Network variants (32 ⇒ 8)

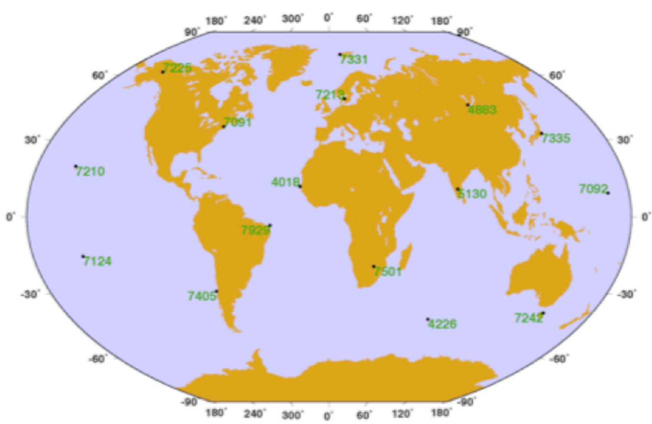
Next Generation NASA Networks 32 sites



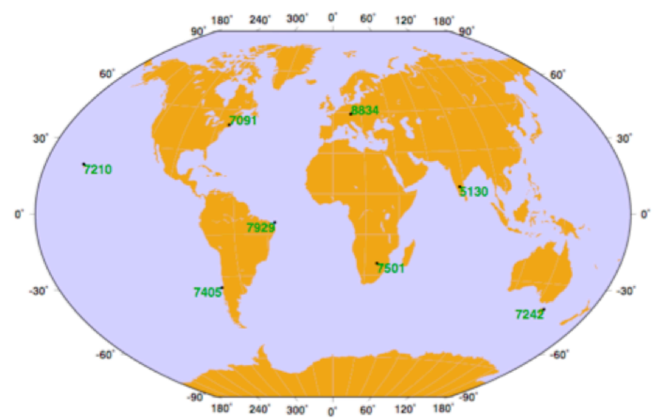
Next Generation NASA Networks 24 sites



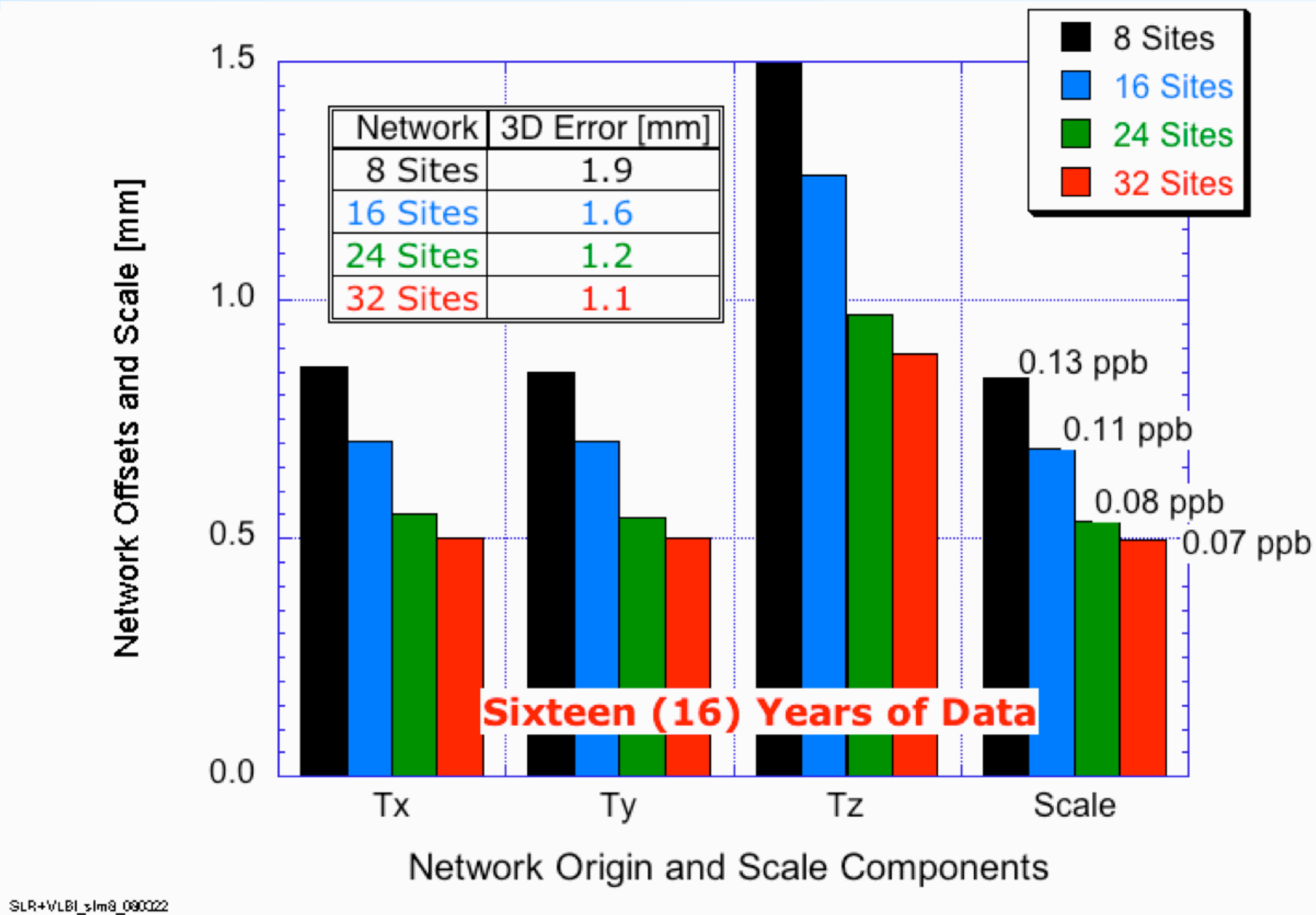
Next Generation NASA Networks 16 sites



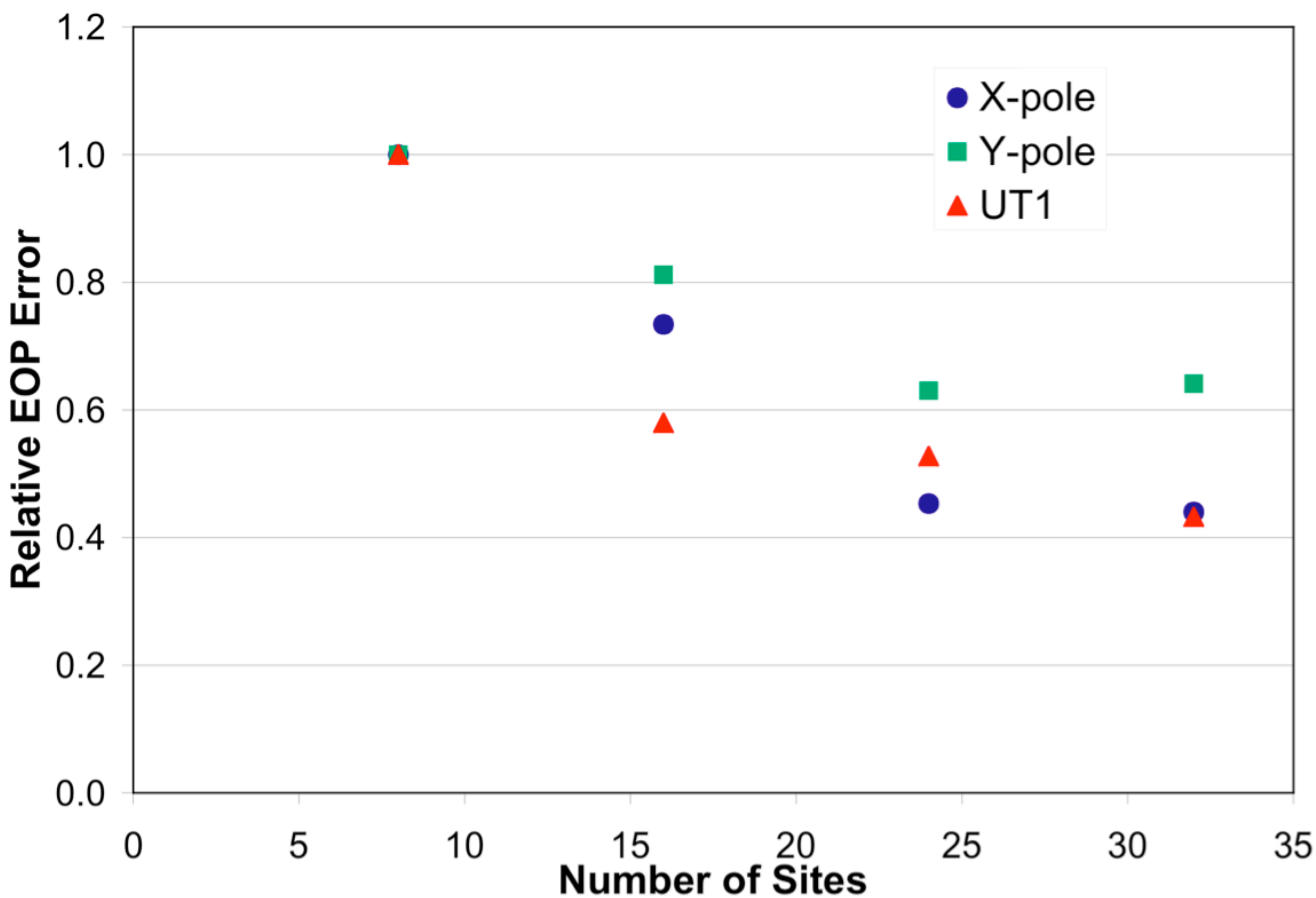
Next Generation NASA Networks 08 sites



Simulation Results



One-year Simulation Results



Summary

- Origin and scale marginally controlled by a 24 site network; when extended to 32 sites, it approaches GGOS goals (1 mm)
- Orientation seems to be less dependent on the size of the network
- The effect of additional techniques on the quality of the TRF remains to be assessed
- Need to develop scenarios of "degradation" and "improvement" of nominal design parameters

Future Work

- We may have to consider *improvement of our models, analysis techniques and our space segment* (e.g. SLR targets) to improve TRF accuracy while keeping a reasonable network size to reach our goal

- Our simulation process now runs on a faster CPU to allow a quicker turn-around of future cases (Columbia grid cluster)

- As we improve our turn-around time we plan to investigate scenarios with additional parameters varied (more satellites, different orbits, systematic errors, operational modes, etc.)