DESIGNING THE
NEXT GENERATION GLOBAL GEODETIC NETWORKS
TO SUPPORT GGOS

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NG^3N

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European Space Agency

NG^{3}N for GGOS

- GGOS relies on Space Geodetic networks for accurate products (IAG's contribution to GEO)
- Current networks, originally designed in the early 80s, had a *cm*-level accuracy goal
- Deployment of the new hardware (*e.g. NGSLR, VLBI2010, GNSS receivers, etc.*) dictates new design to meet new accuracy goals:

<1 mm position and < 0.1 mm/y variations in time.

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…NG^{3}N for GGOS

- Optimized design for future networks is long overdue

- NG^{3}Ns will comprise of a core network of fiducial observatories with the maximum number of space geodetic techniques co-located and,

- An extended (interpolating) network which will be dominated by relative positioning techniques (e.g. GNSS) to provide users direct access to the ITRFyy and to control regional deformations not captured by the core network

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…NG^{3}N Simulations

- SLR and VLBI optimal combination (first step):
  - ✓ Simulation of SLR and VLBI data for the past 13 years (to develop a calibrated error model based on real data)
  - ✓ Covariance analysis of several variants of ~ 70 globally distributed sites in various size sub-networks
  - ≈ **Simulation of a 1-year period with SLR and VLBI data (<u>eventually to be extended to ~ 6 years</u>)**
    - GSFC VLBI group developed an efficient procedure to generate multi-year schedules in a simplified way
  - – Inclusion of GNSS, etc. later, in a future step

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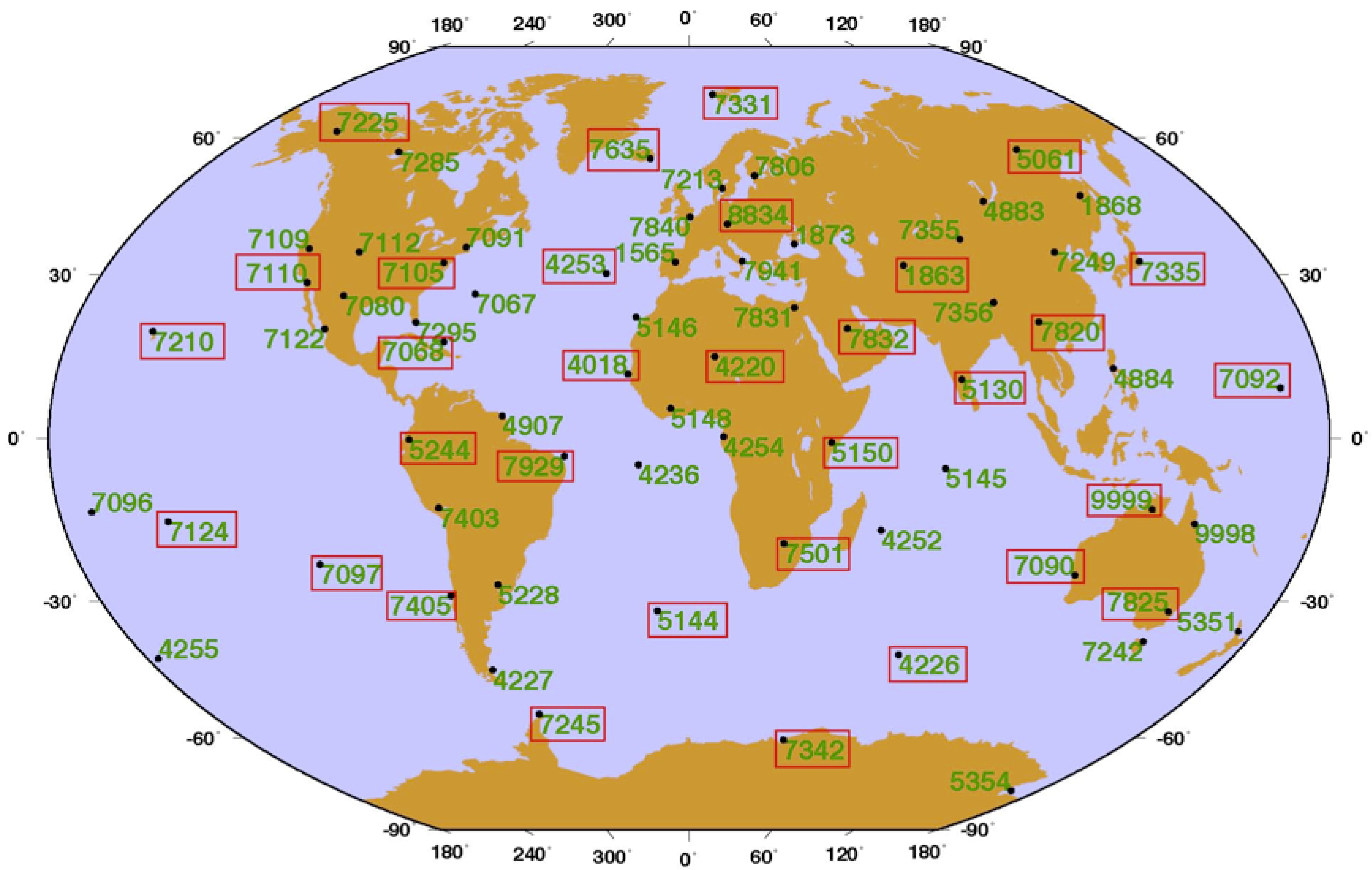
Maximal Overlapping SLR-VLBI Network (**32**)

Next Generation NASA Networks ~70 sites



Covariance Predictions for Sub-networks

- The covariance of the 14-parameter similarity transformation is computed for progressively smaller networks, and the degradation in the accuracy of these estimates is noted as the network size decreases or the site distribution degrades
  - Covariance studies with Monte-Carlo runs
  - Simulation of SLR and VLBI data for ~6 years for a few, selected networks identified from the above process as key configurations, will follow

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VLBI Simulation Parameters

- Specify VLBI2010 antenna sensitivities, slew rates, SNR requirements

- Design global network of co-located VLBI and SLR sites using a combination of current VLBI, SLR and GPS site locations

- Make observation schedules for each 24-hour VLBI experiment session with the VLBI *SKED* program

- Generate simulated delays for each observation, where the dominant VLBI errors are ***atmosphere*** and ***"clock-like" (maser + instrumental)*** delay errors

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SLR Simulation Parameters

- Specify NGSLR sensitivities, ranging rates, SNR performance

- Design global network of co-located VLBI and SLR sites using a combination of current VLBI, SLR and GPS site locations (*mutually agreed upon with VLBI*)

- Make observation schedules for each site using weather statistics from past 13-year period and the GEODYN program

- Generate simulated errors for each observation, where the dominant SLR errors are ***<u>described through a site-dependent random-walk model</u>***

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SLR & VLBI Error Model

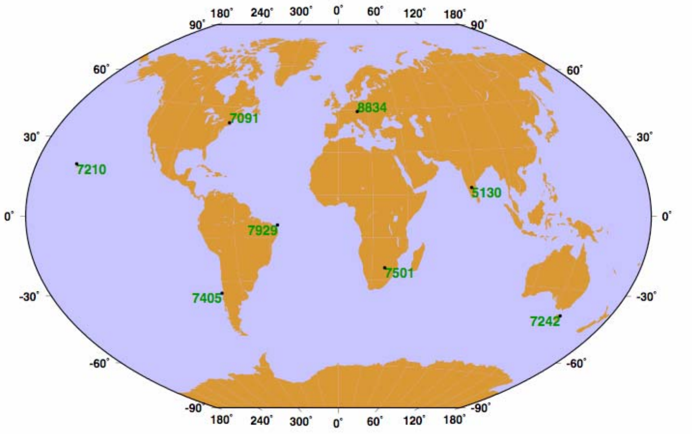
- Geophysical parameters common to both techniques were assigned "commission errors"

- As a general rule, the simulated data were generated with agreed upon geophysical models (where applicable), e.g. gravity-- static and temporal, tides, loading, atmosphere, etc.

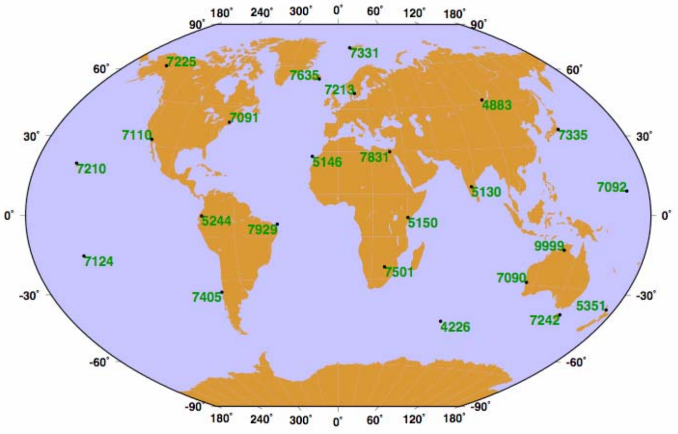
- The recovery of the parameters of interest is done with models which are different from those used in generating the data, the difference being commensurate with the expected errors in these models (to our best guess)

Network variants (8 ⇒ 32)

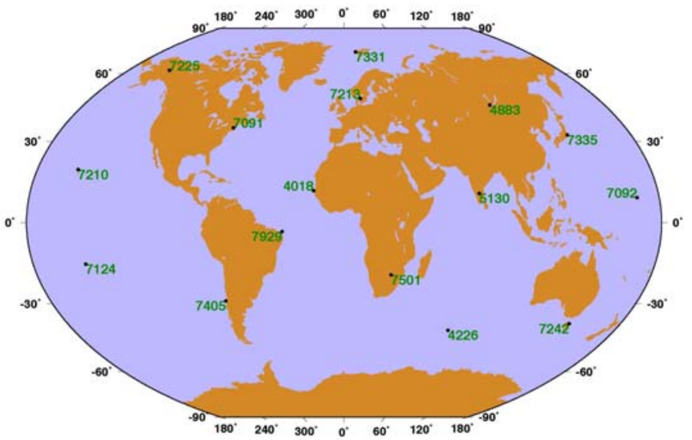
Next Generation NASA Networks 08 sites



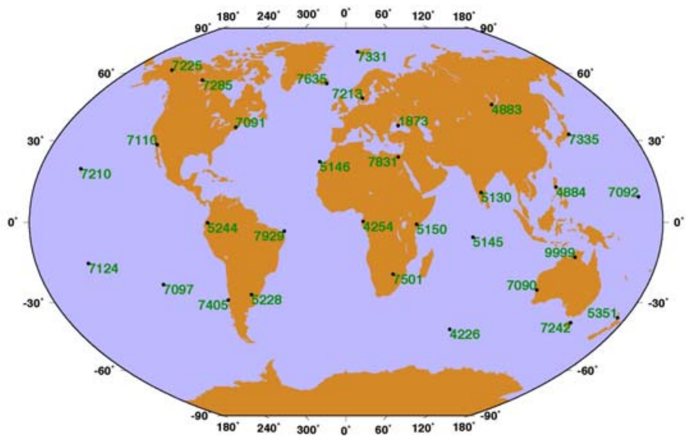
Next Generation NASA Networks 24 sites



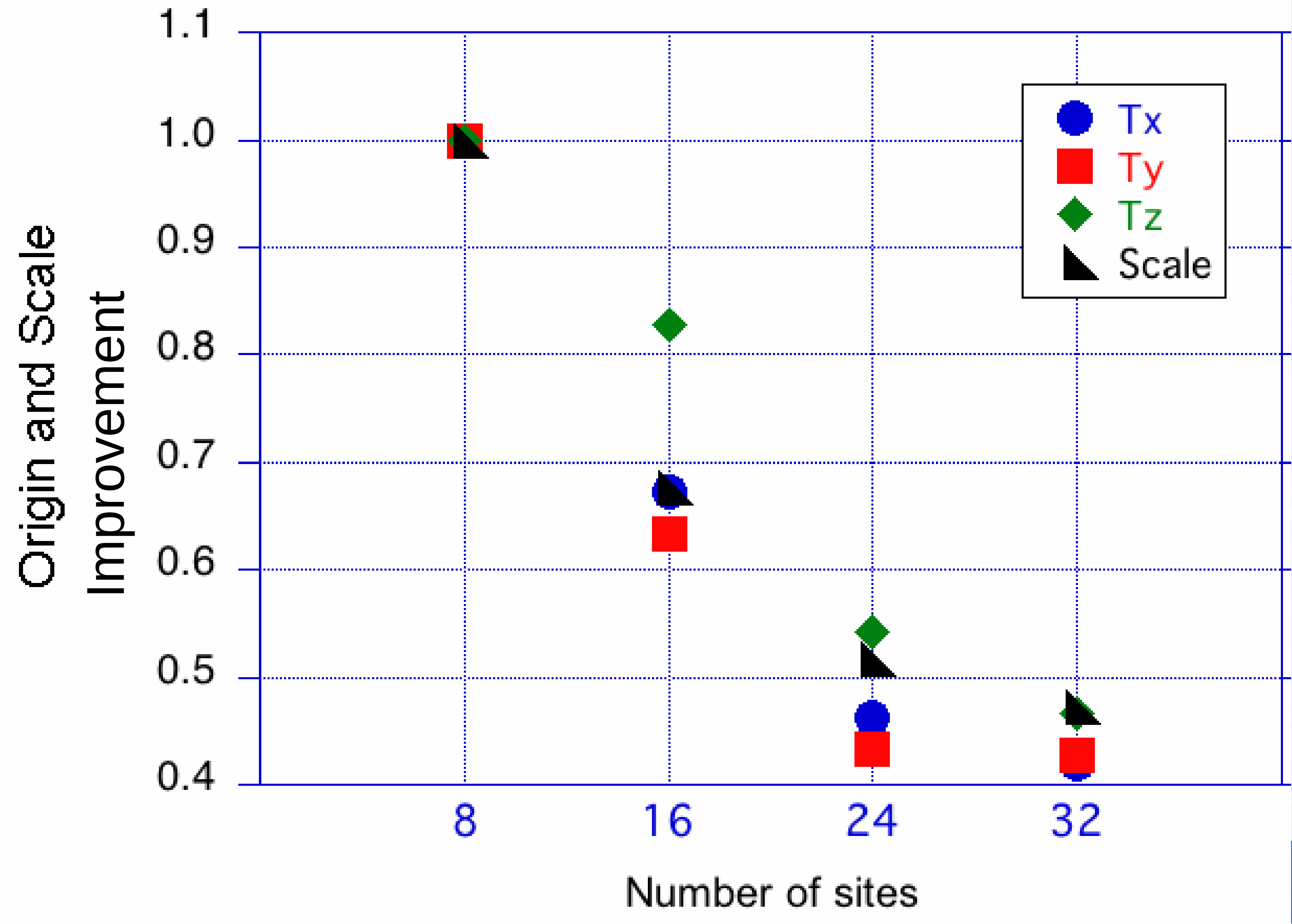
Next Generation NASA Networks 16 sites



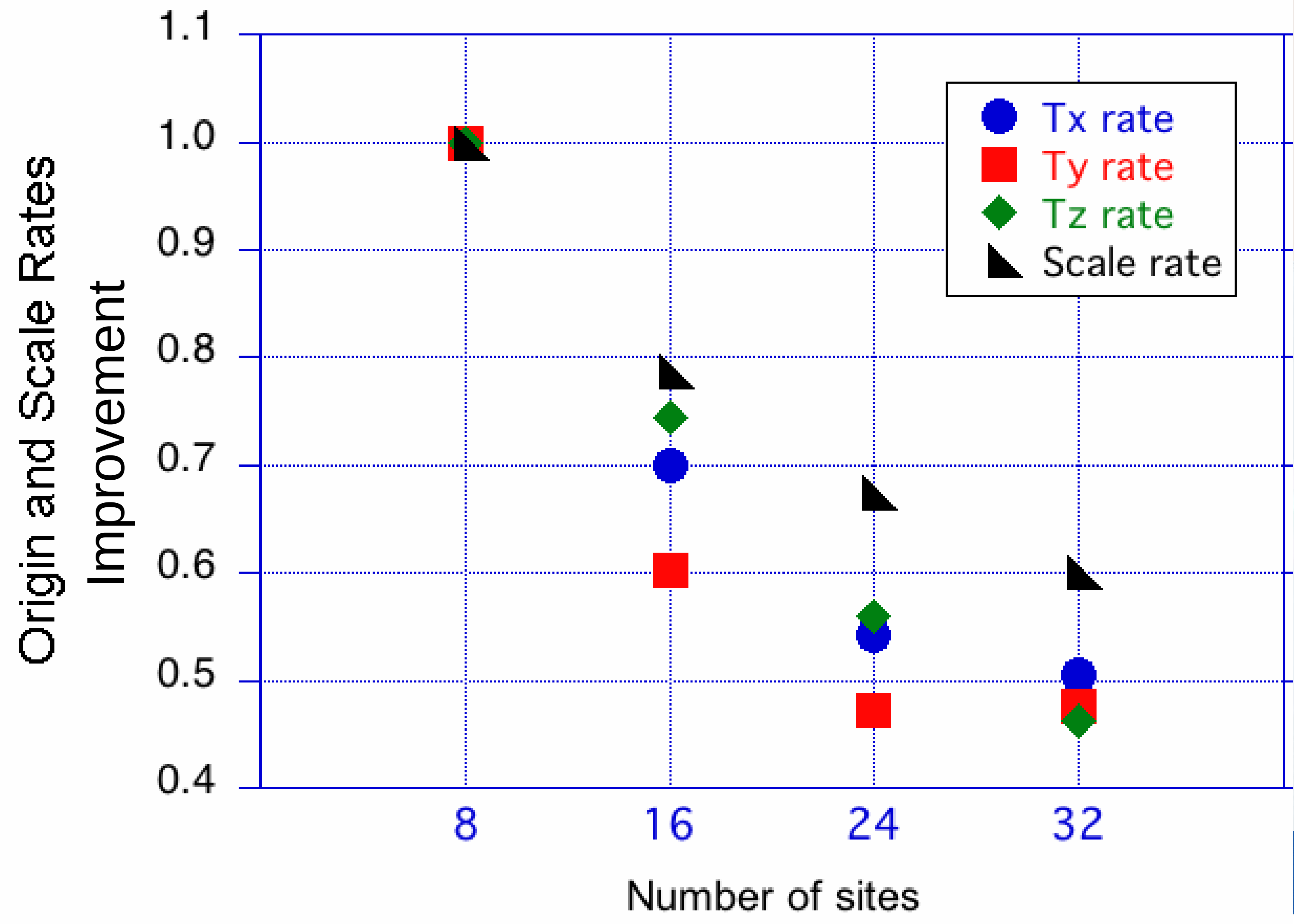
Next Generation NASA Networks 32 sites



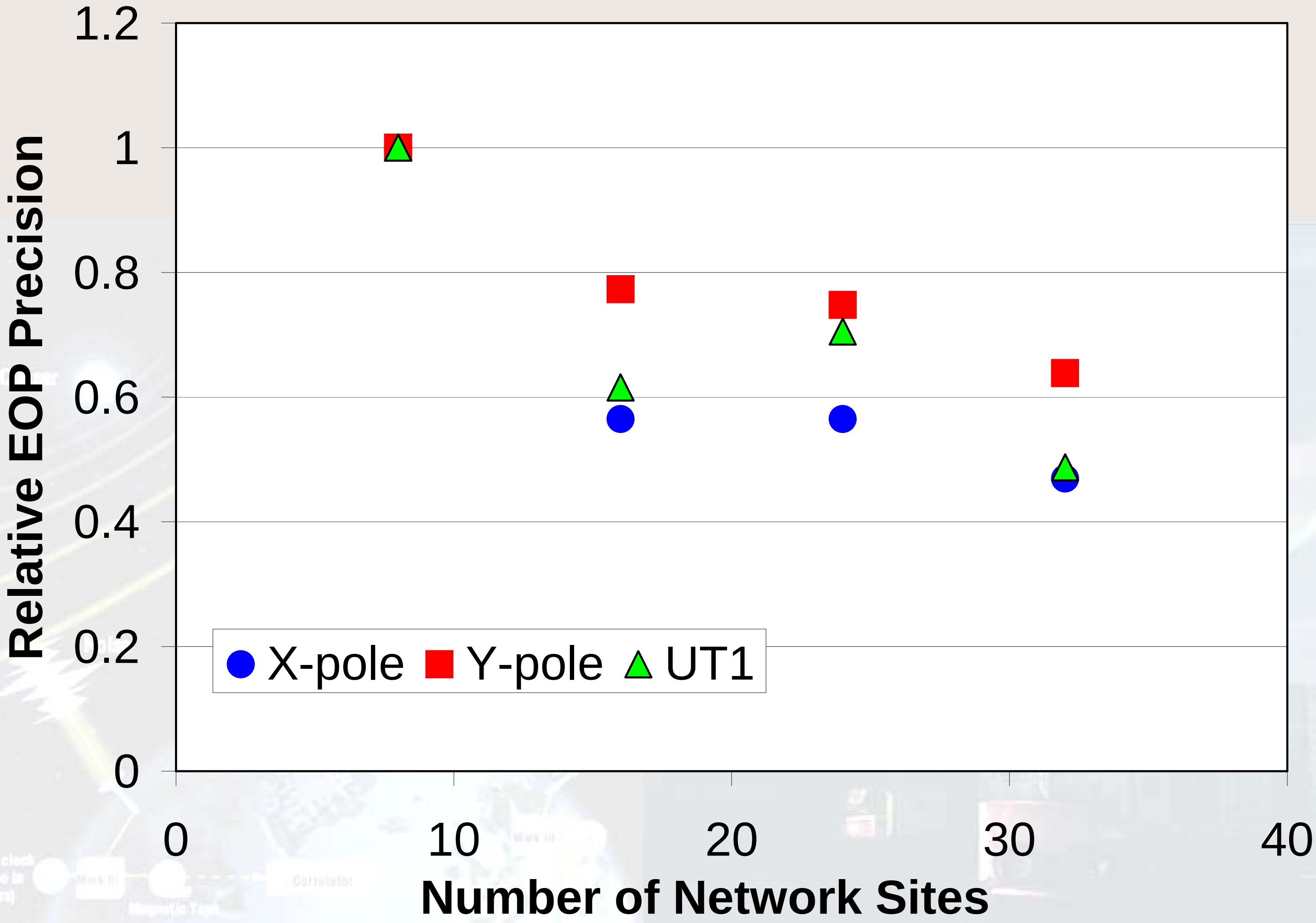
Relative Improvement: Origin & Scale



Relative Improvement: Origin & Scale Rates



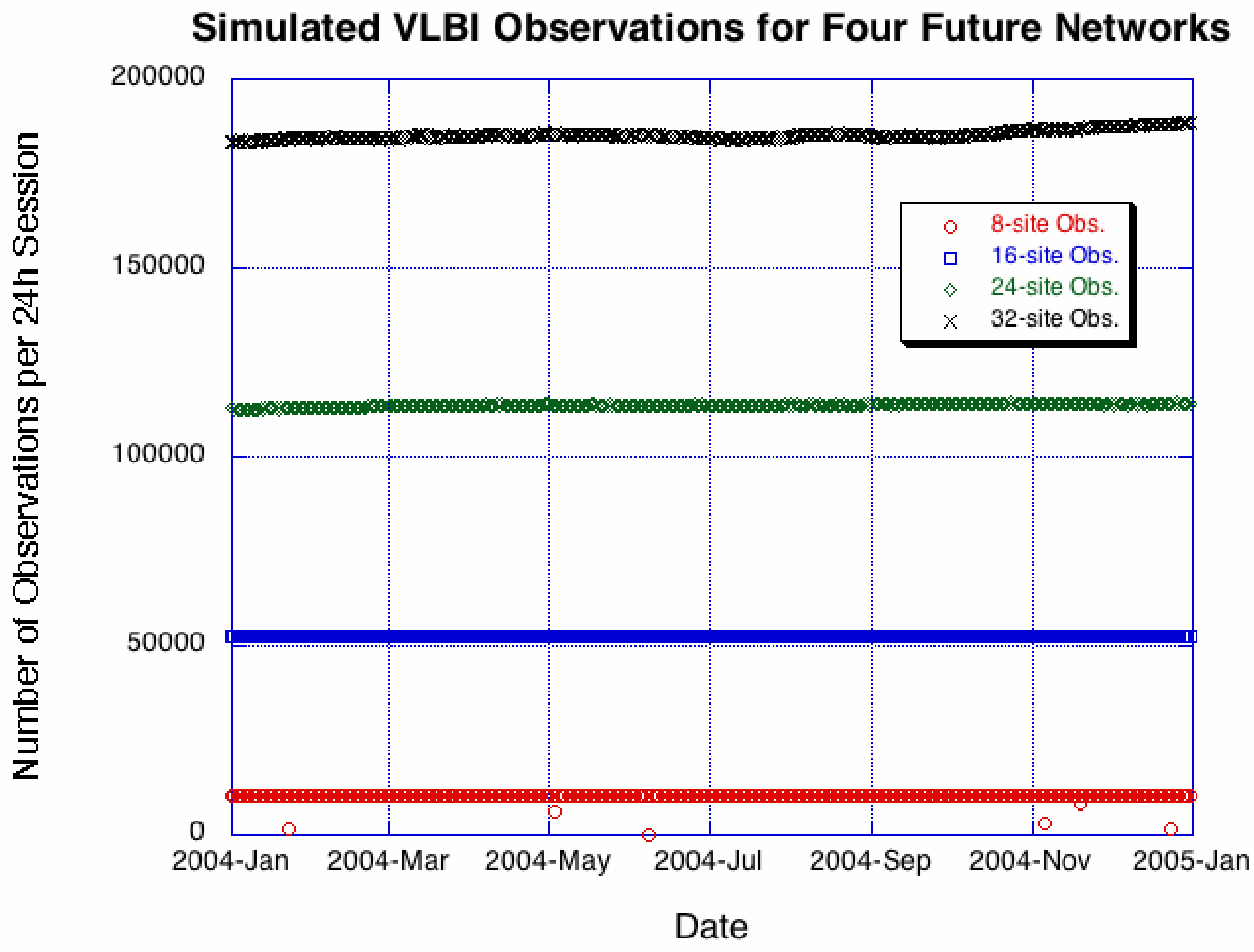
Relative Improvement: EOP



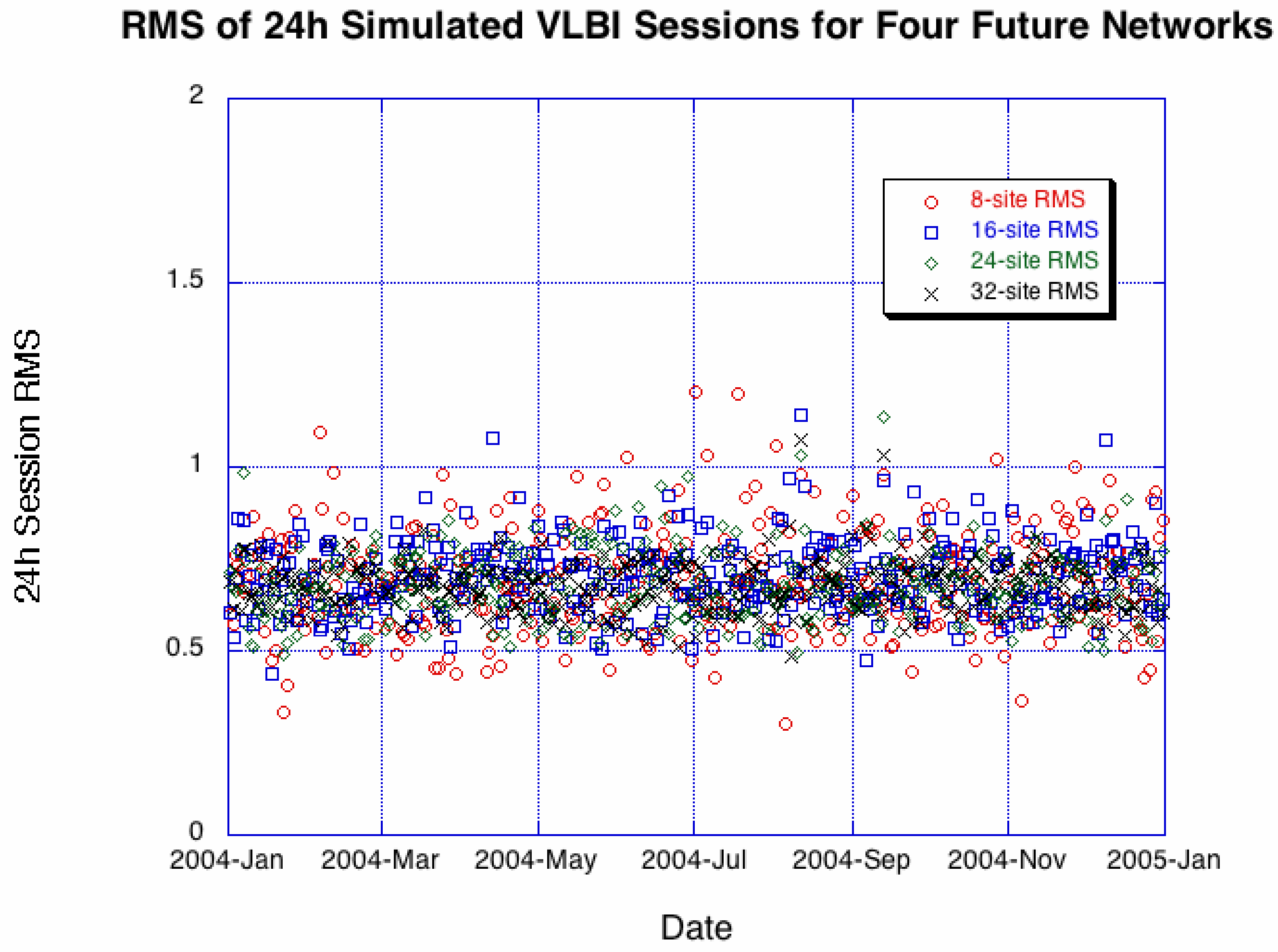
Full Scale SLR & VLBI Simulations

1. Multi-step procedure:
   - Schedule VLBI data for specific network
   - Simulate data and form NEQs
2. Generate SLR data for maximum size network
   - Generate SLR NEQs for specific network
3. Accumulate and combine NEQs from SLR and VLBI data
4. Invert the combined set to produce a TRF realization
5. Step #1 proved much more CPU-intensive than expected due to VLBI2010 specs

Data yield: Four VLBI Networks



RMS of fit: Four VLBI Networks



NG^{3}N Simulation Issues:

- Present design based on two component techniques (SLR & VLBI)
- Looking only at optimal network size with constrained system performance and background model quality
- Current focus is on "TRF" quality: origin, scale and orientation (and their temporal variations)
- The effect of additional techniques on the quality of the TRF is not assessed yet:
  - GNSS, DORIS, Gravity, Altimetry, etc.
- Guidelines needed for the level of contributions from other techniques
- Need scenarios of "degradation" and "improvement" of nominal design parameters

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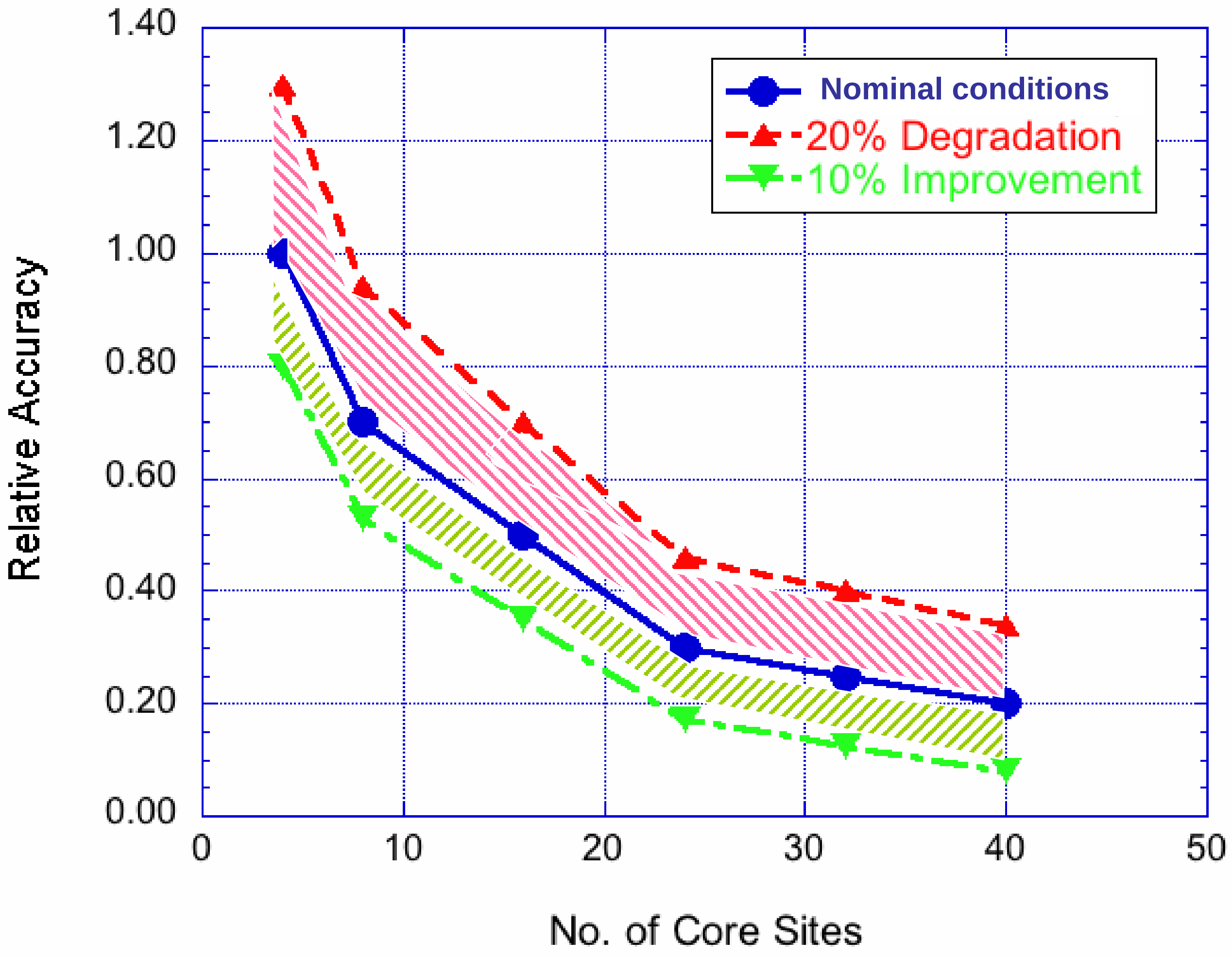
The NG^{3}N Simulation Goal:

"X" Parameter Accuracy vs. Network size



"X": Origin, Scale, EOP, their rates, etc.

Summary

- So far we have "guiding" results from Monte-Carlo simulations for SLR & VLBI co-located sites
- The Z-component of the origin, the scale and their rates are the parameters most affected by the size of the defining network
- Networks with more than ~24 sites show slower improvement rate with the addition of more sites
- One year of 8, 16, 24 and 32-site networks' NEQs done, and combinations with corresponding SLR normals in progress
- The simulation process is in the final step: the combined recovery of a TRF from simulated SLR and VLBI data

Outlook

- We are reaching the limiting size of a realistic future CORE network (30-40 sites), yet the improvement is far from our target (1 mm @ t_0 & 0.1 mm/y)
- We may have to consider *improvement of our models, analysis techniques and our space segment* (add new SLR targets such as **LARES**) to accelerate the improvement rate