SLR Tracking of GNSS Constellations

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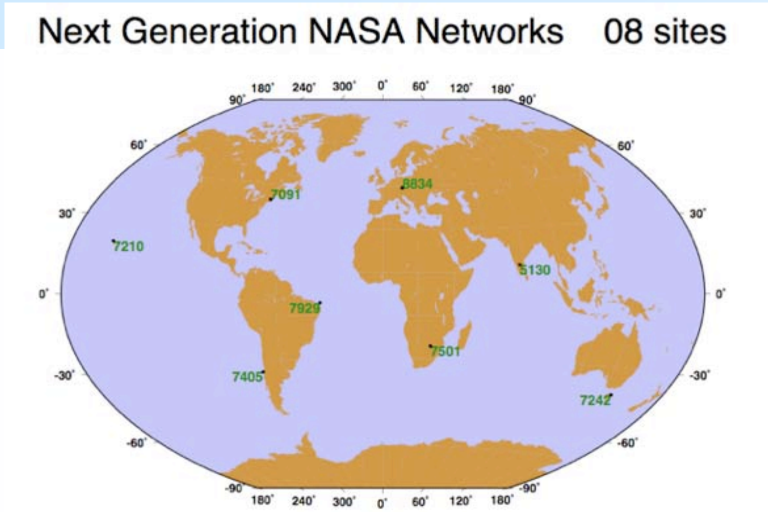
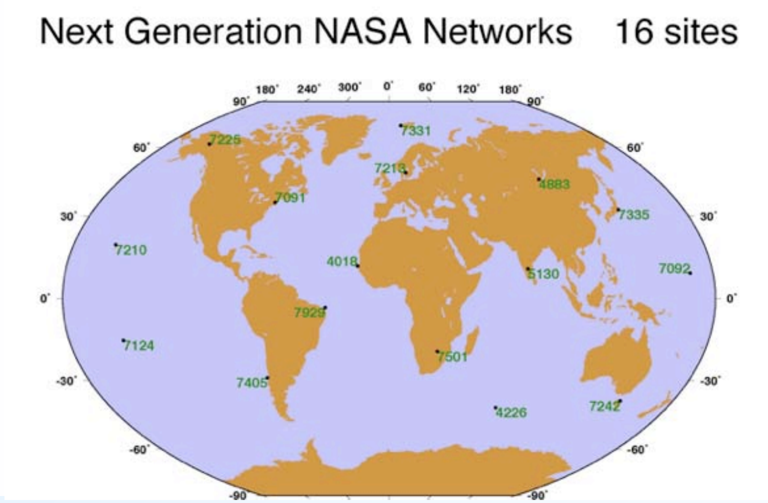
Experiments

- Work with the 8 & 16 site SLR networks
  - Same as those used for the SLR & VLBI simulations
- Examine the contribution of SLR tracking to GNSS
  - Can we transfer origin and scale with required accuracy?
- Simulations for 6 GPS s/c
  - Examined the effect of restricted tracking on orbit quality:
    - Cases of 1, 2, 3, 4, 5, and 6 s/c tracked (incrementally)
    - Tracking over one to seven days (incrementally by day)
  - Origin and scale error due to restricted tracking
  - More than 2000 cases of weekly tests, still being examined

SLR Tracking of GNSS Constellations



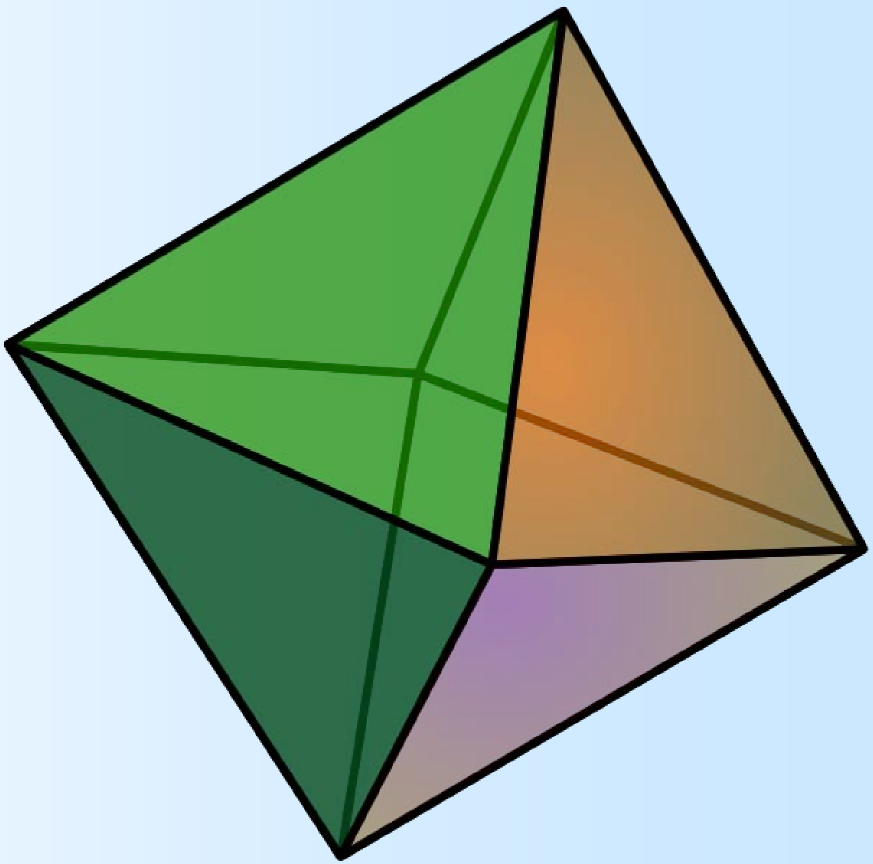


- Two SLR networks of NGSLR systems (24/7 operational capability)
- All stations track all s/c of the GPS Constellation as reference, then one case of only six s/c, (an alternate case of 12 s/c is not discussed here)
- At this stage the errors considered were limited to random walk errors at the stations, similar to those we see at contemporary stations and limited orbital mis-modeling of non-conservative forces

Geometry of the Six GPS Targets

Design constraints:

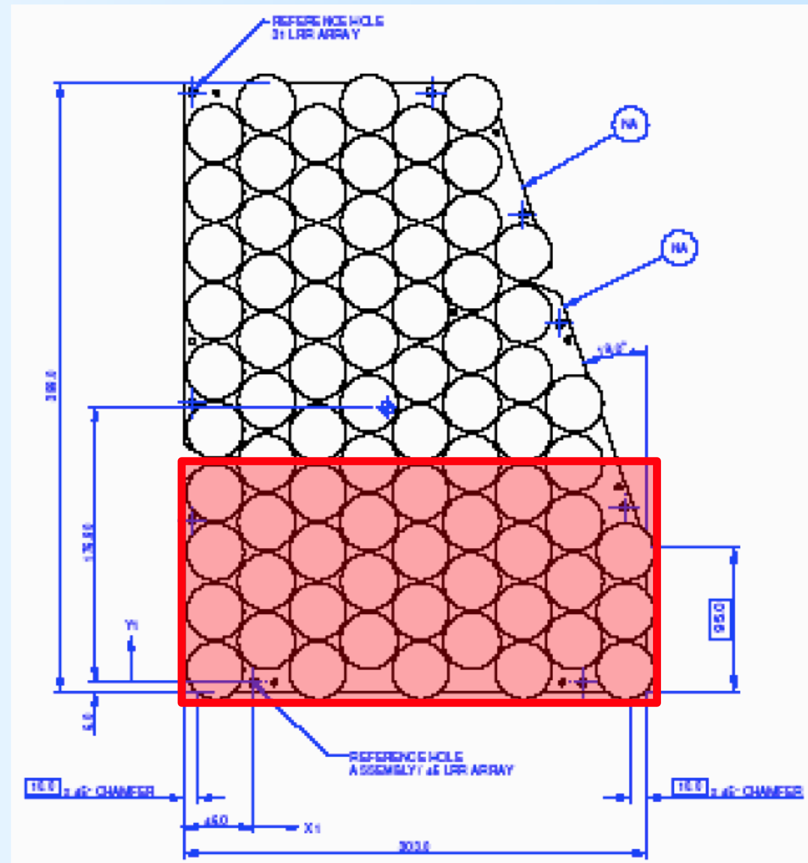
- The six GPS s/c that form the weekly set of SLR targets must be chosen from the constellation in such a manner that the resulting quasi-inertial reference network that they form be close to a regular symmetrical polyhedron, an octahedron, as shown here.



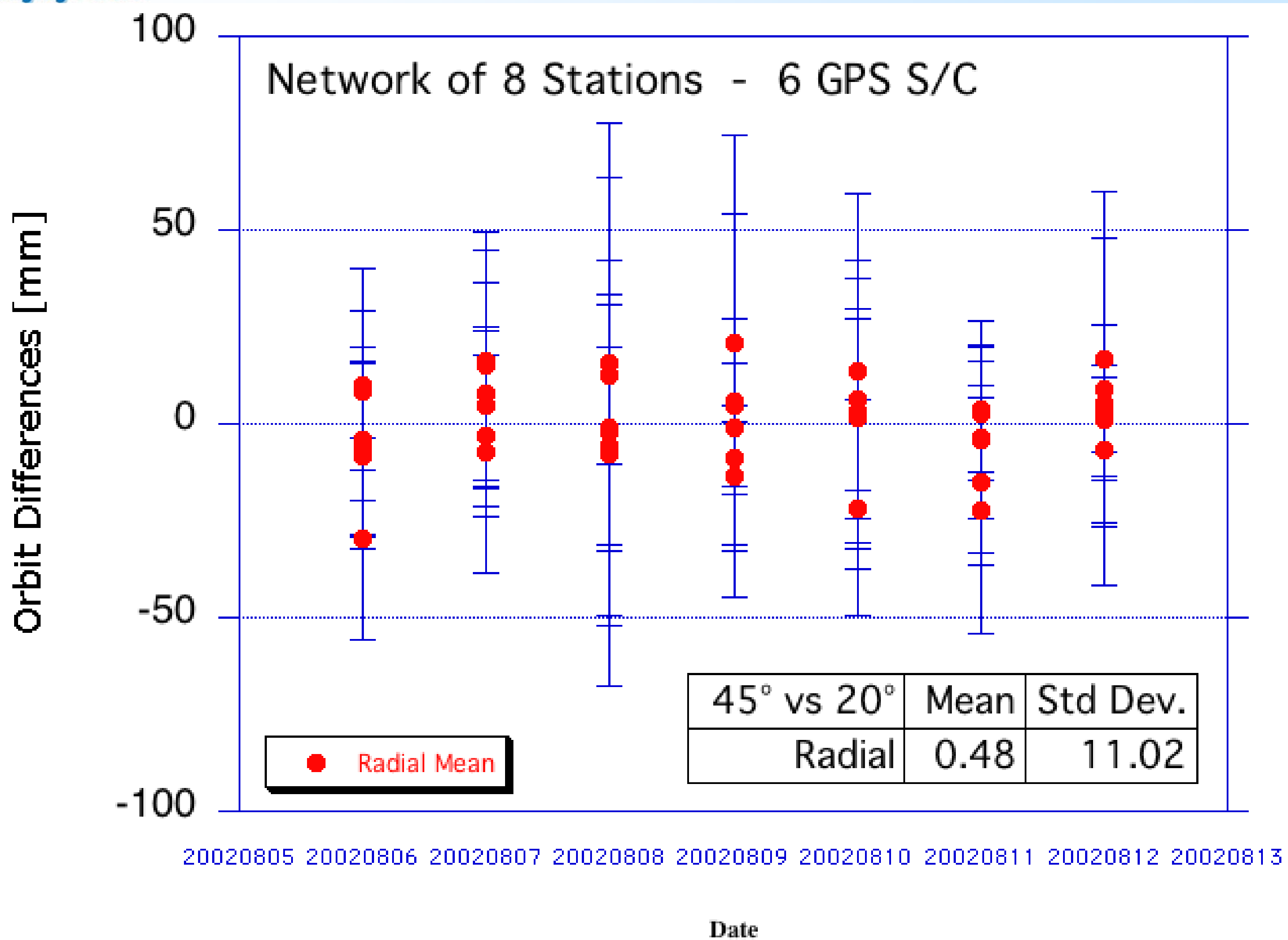
GNSS CCR Arrays

GPS 35 & 36 Array

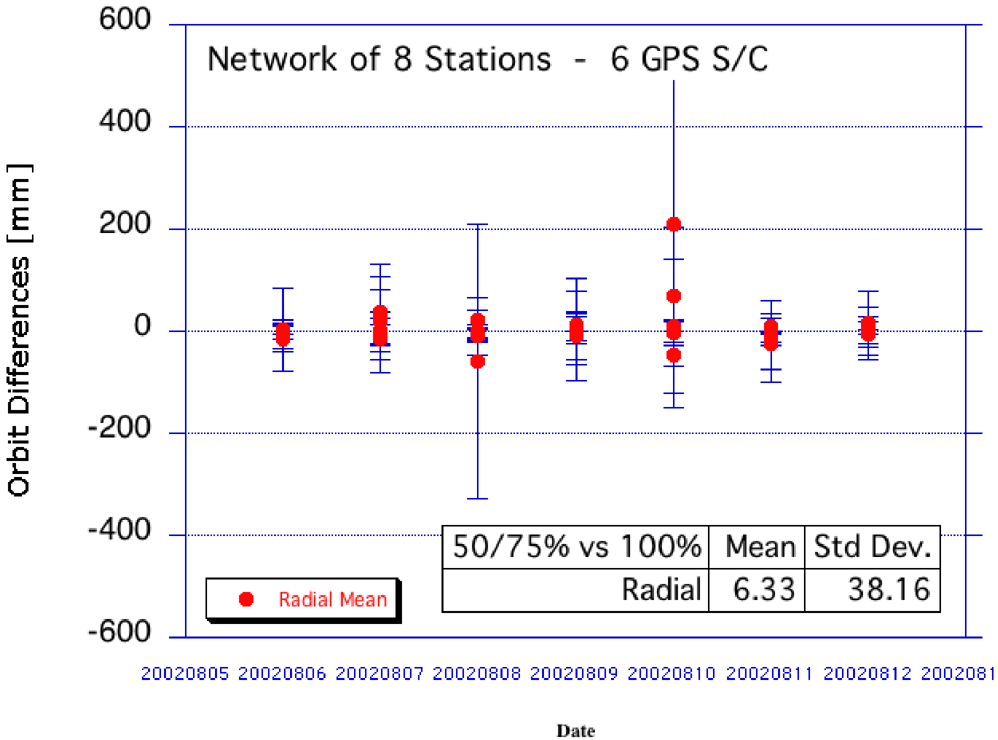
GIOVE – A Array

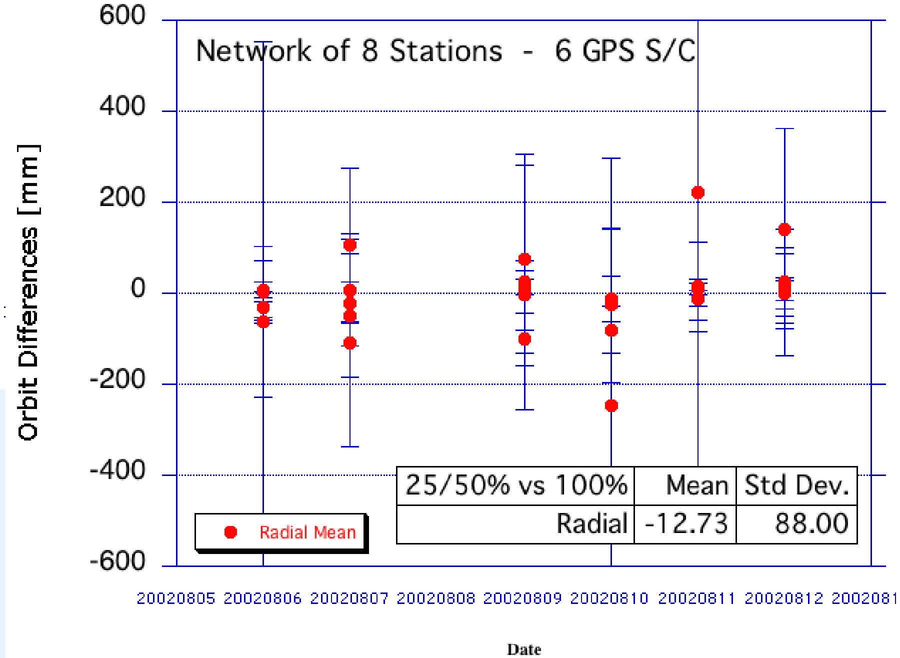


GPS Radial Error - I



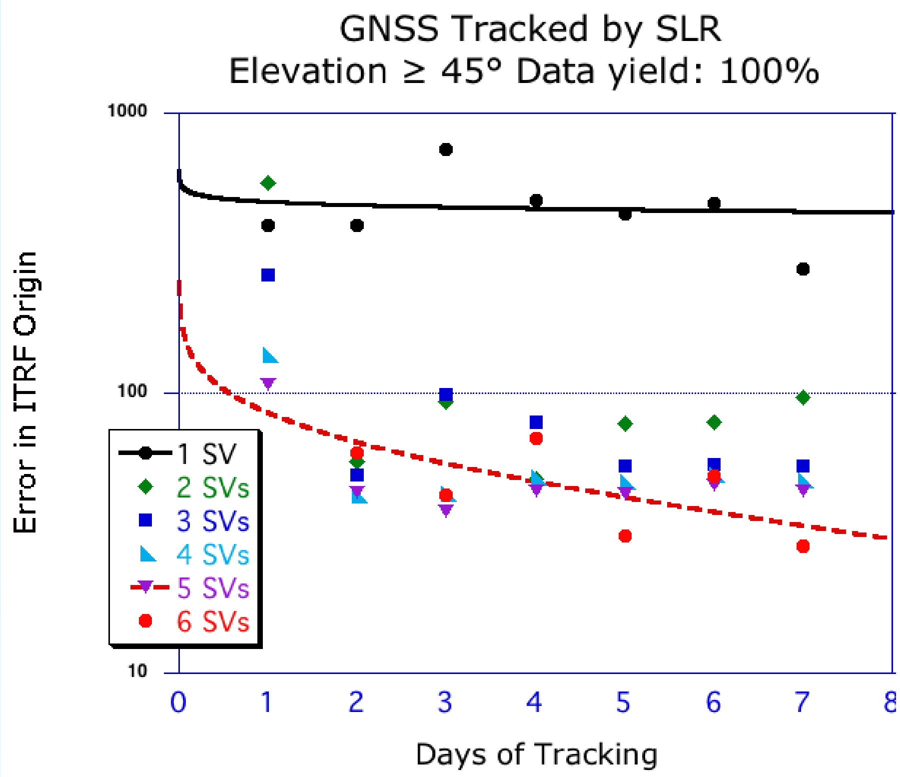
GPS Radial Error - II

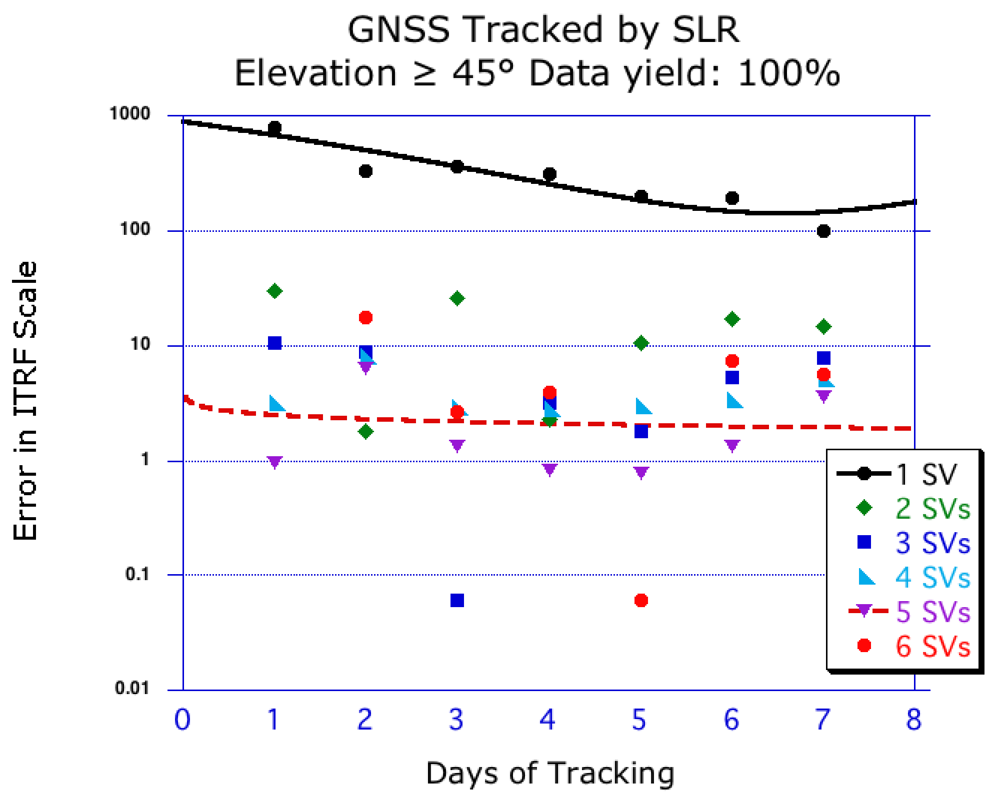




Tracking scenarios vs. Error - I

Ideal Case: 100% of possible data

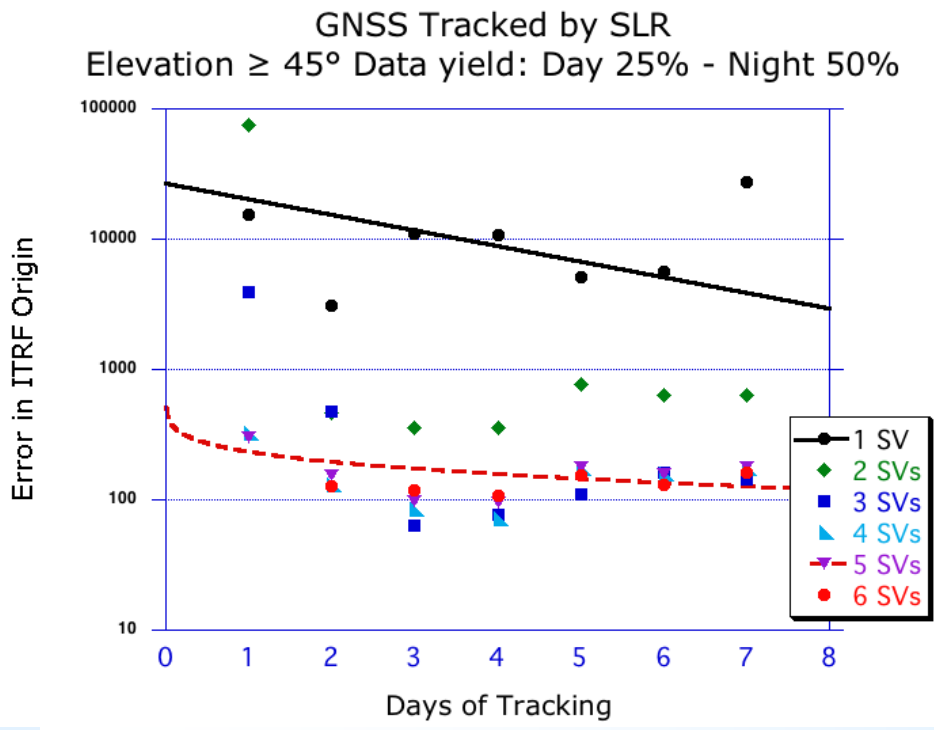


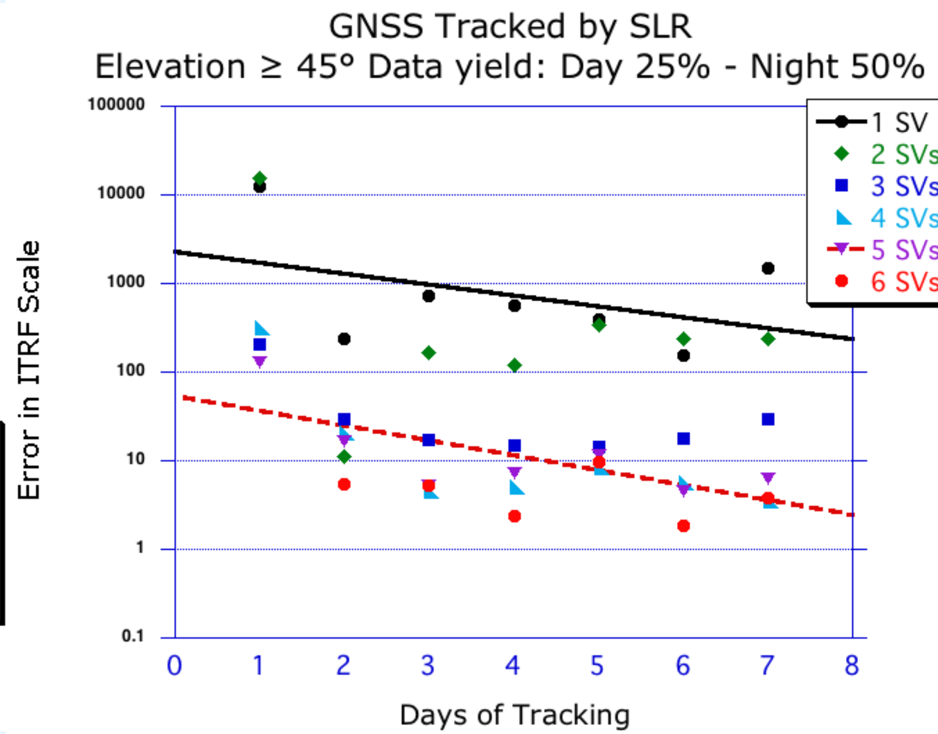


Tracking scenarios vs. Error - III

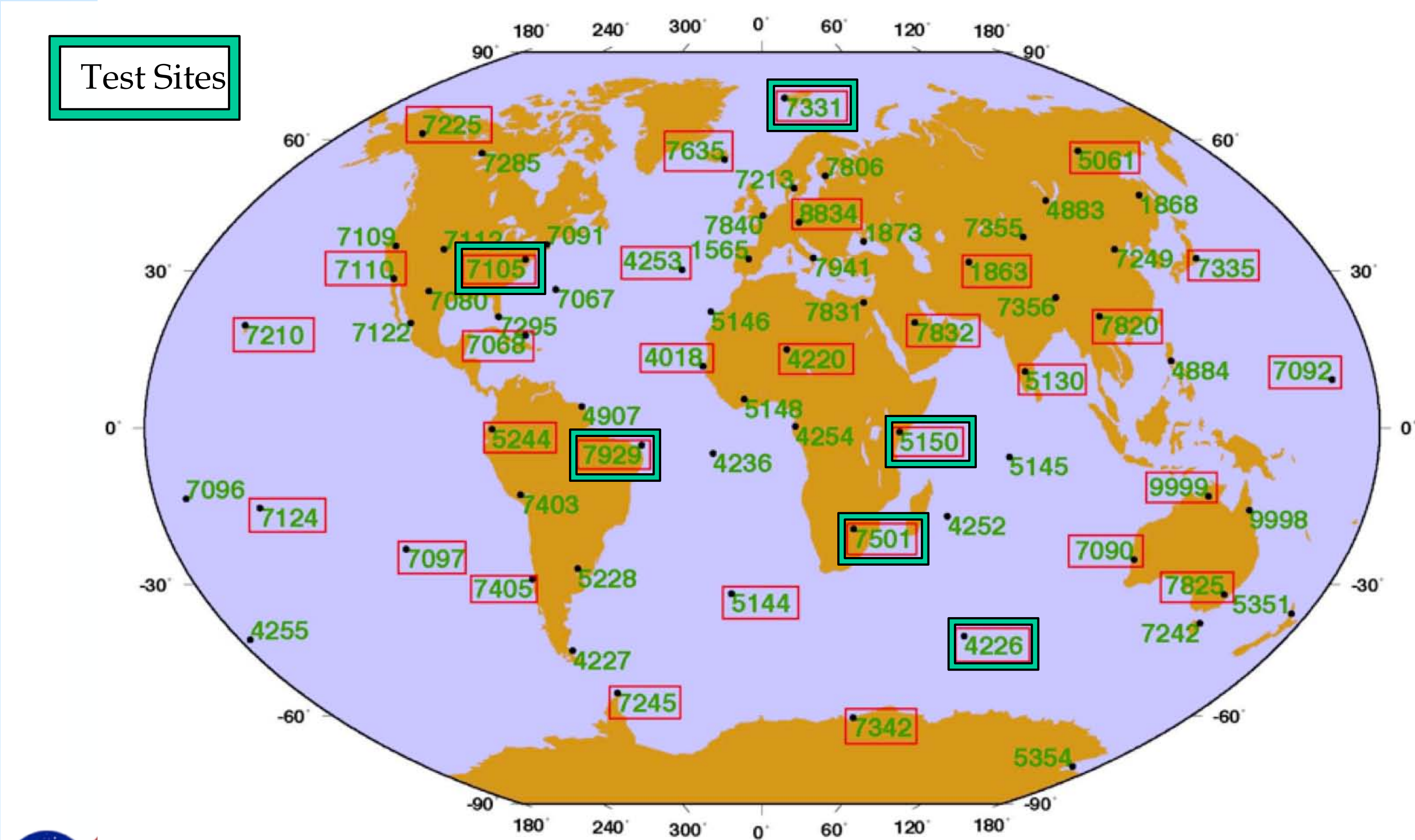
International Laser Ranging Service

Worst Case: 25% daylight and 50% nighttime tracking

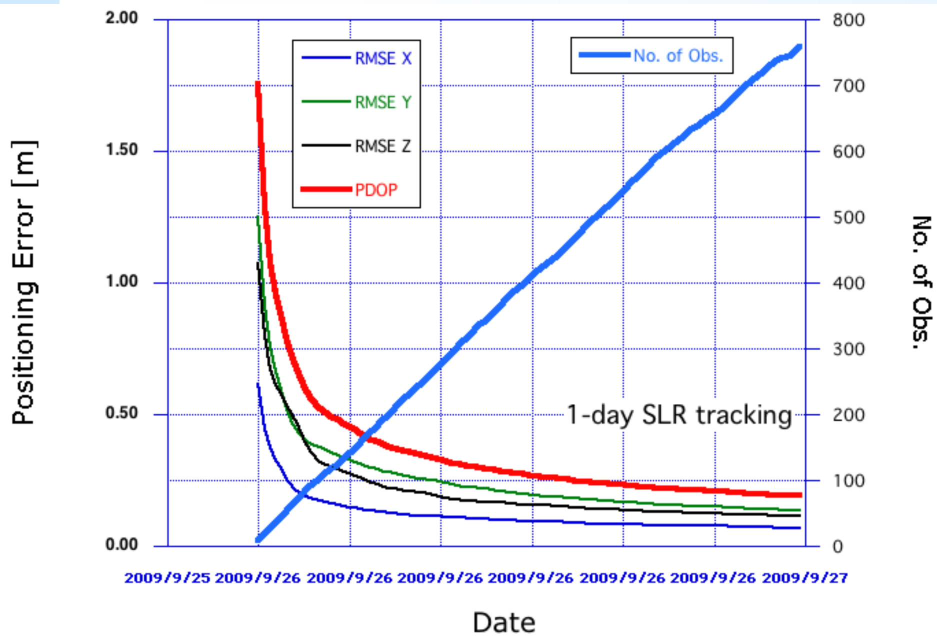


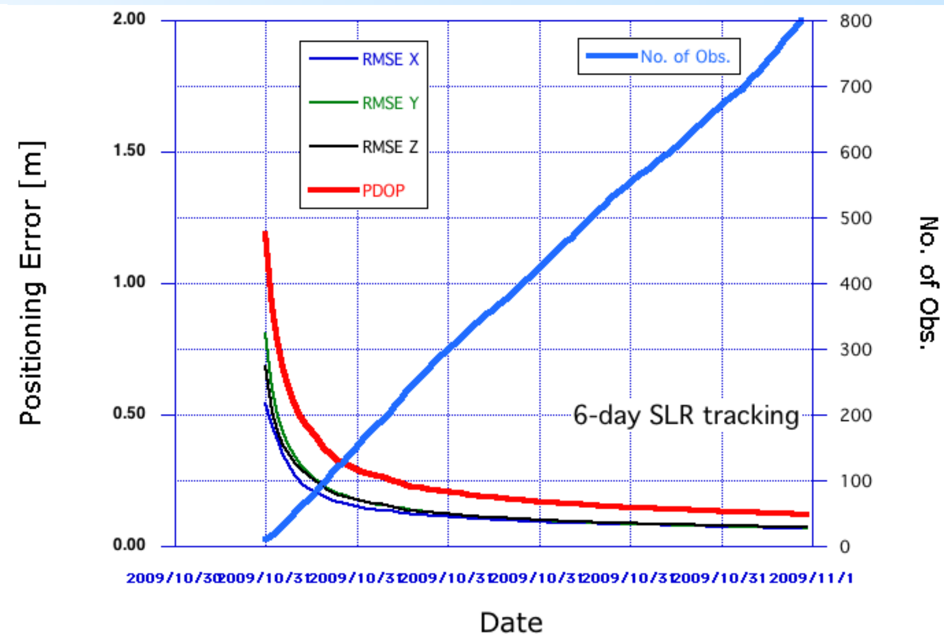


Test Sites for GNSS Positioning Errors



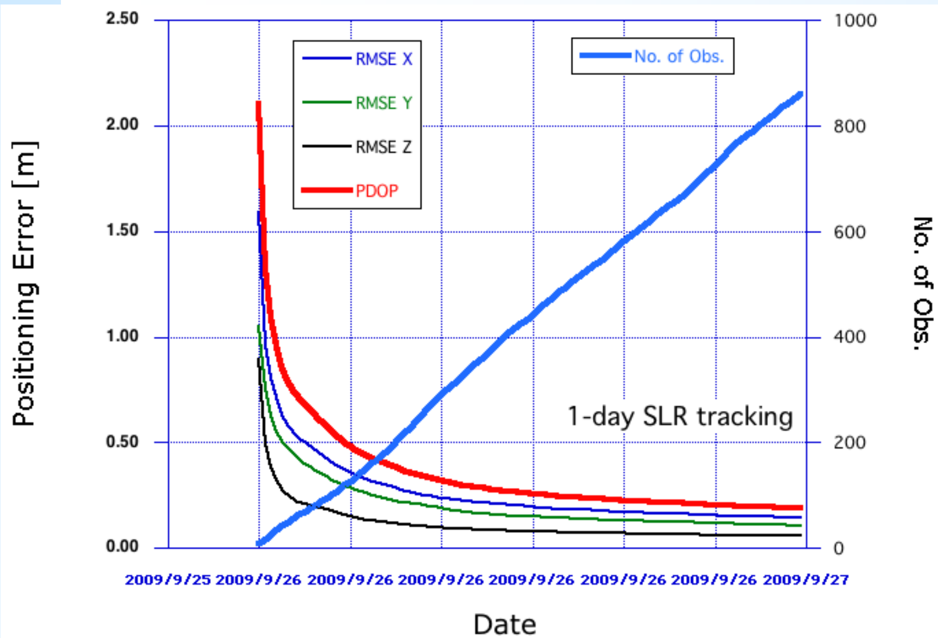
Positioning Errors - I

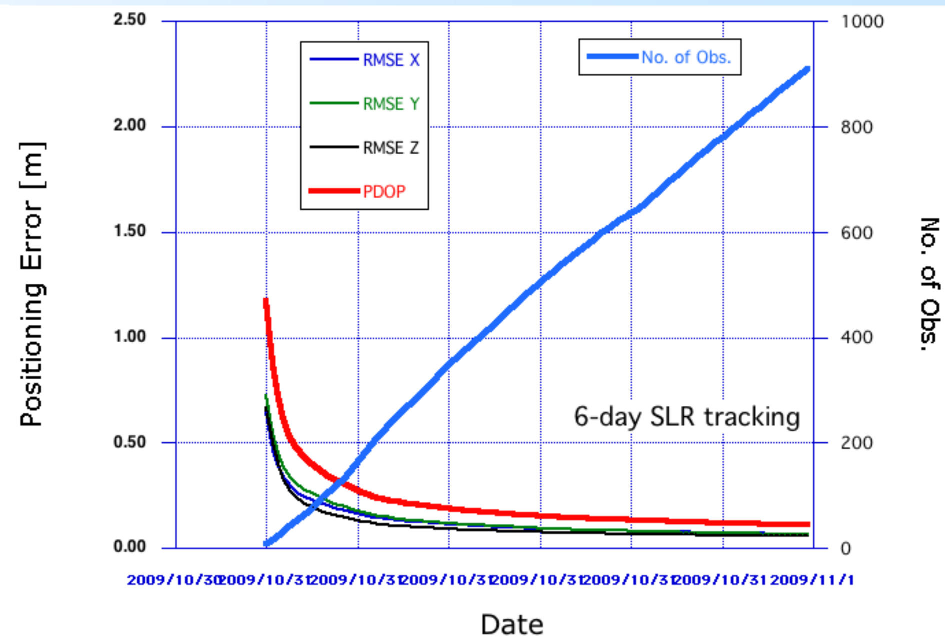




Goddard

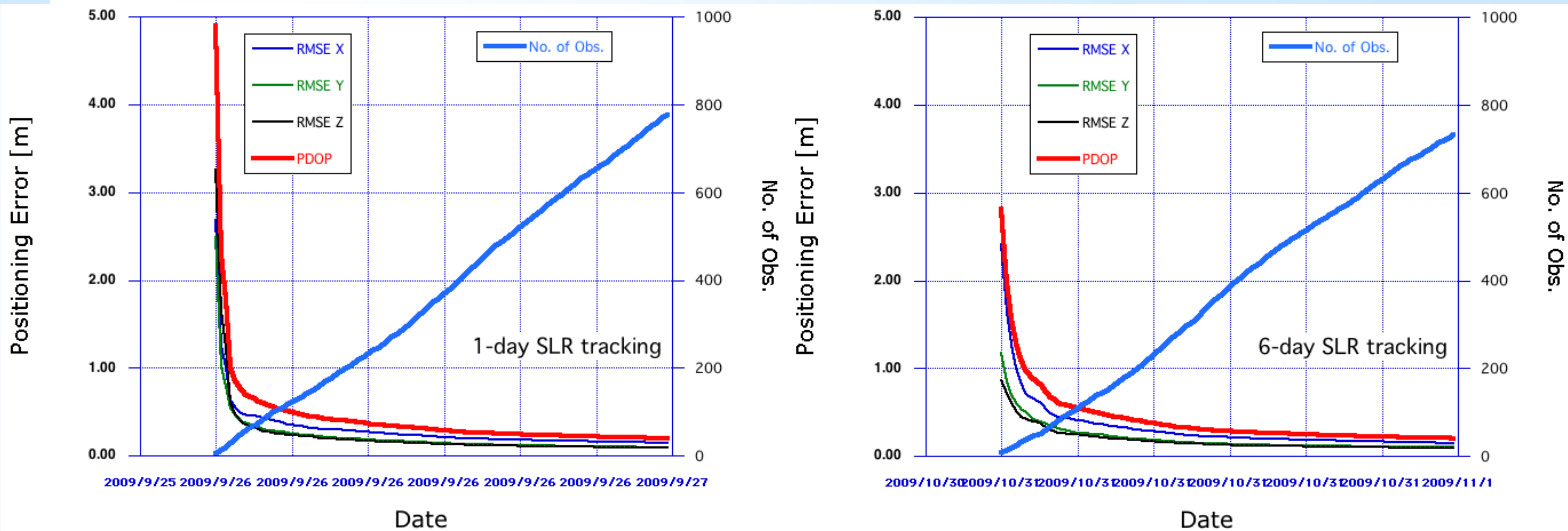
Positioning Errors - II





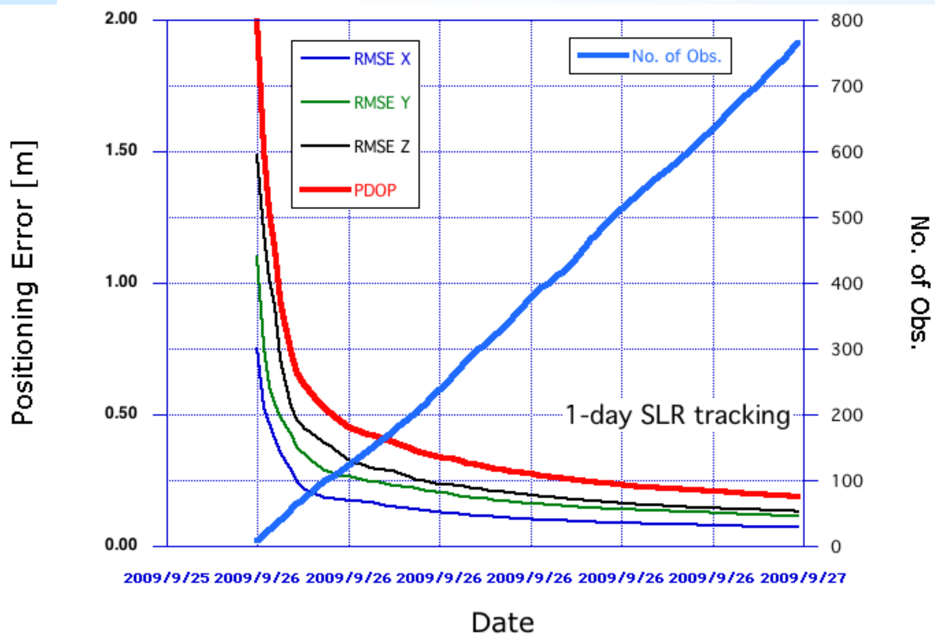
Fortalezza

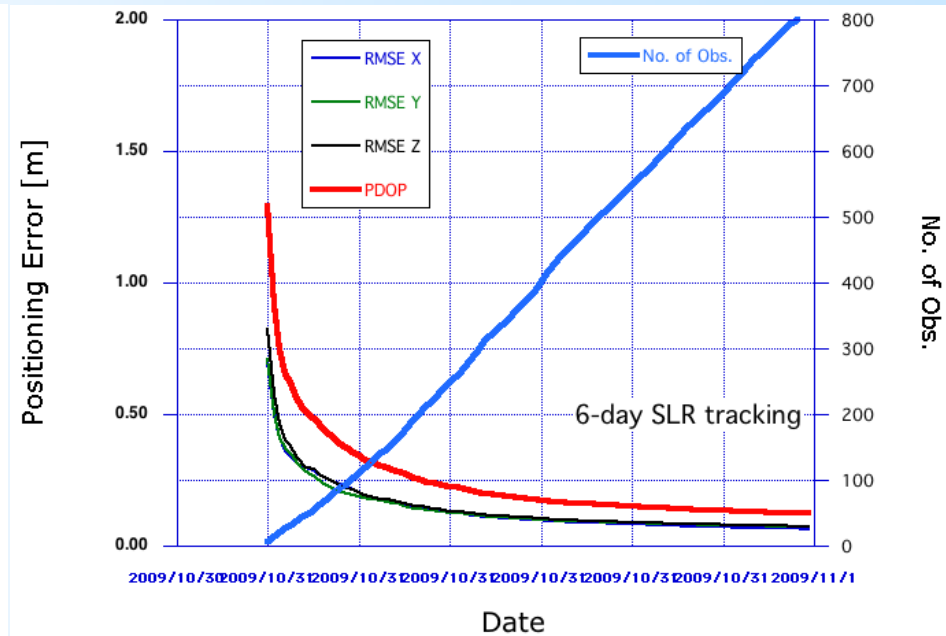
Positioning Errors - III



Hartebeesthoek

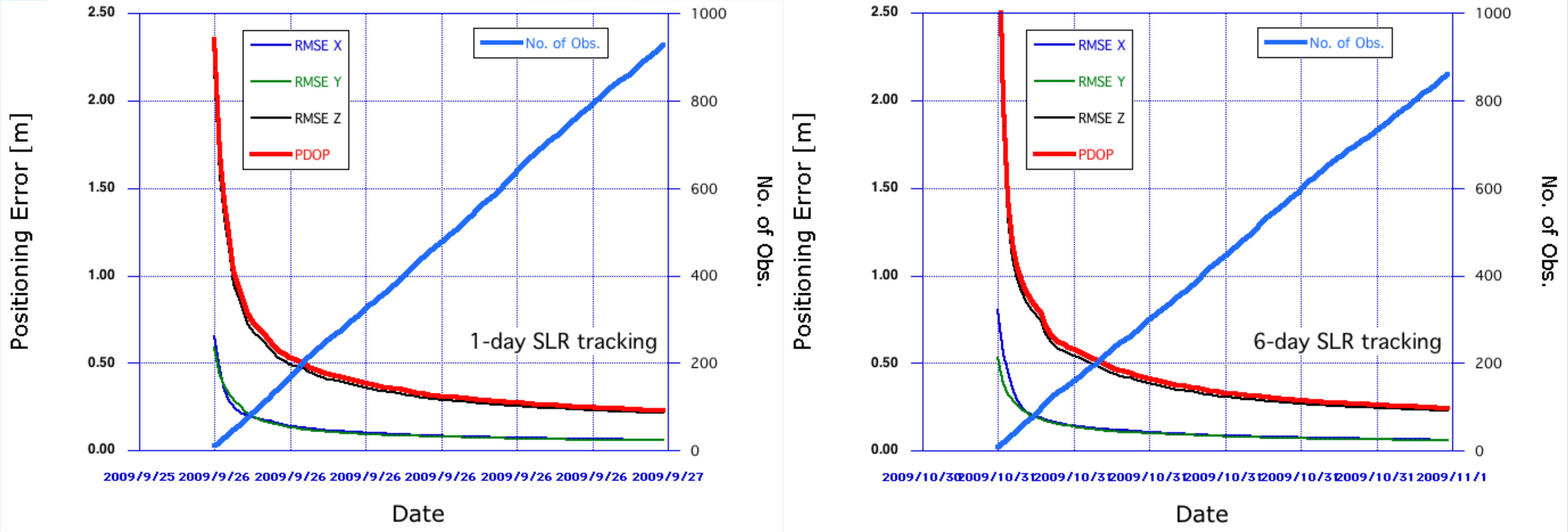
Positioning Errors - IV





Kerguelen

Positioning Errors - V



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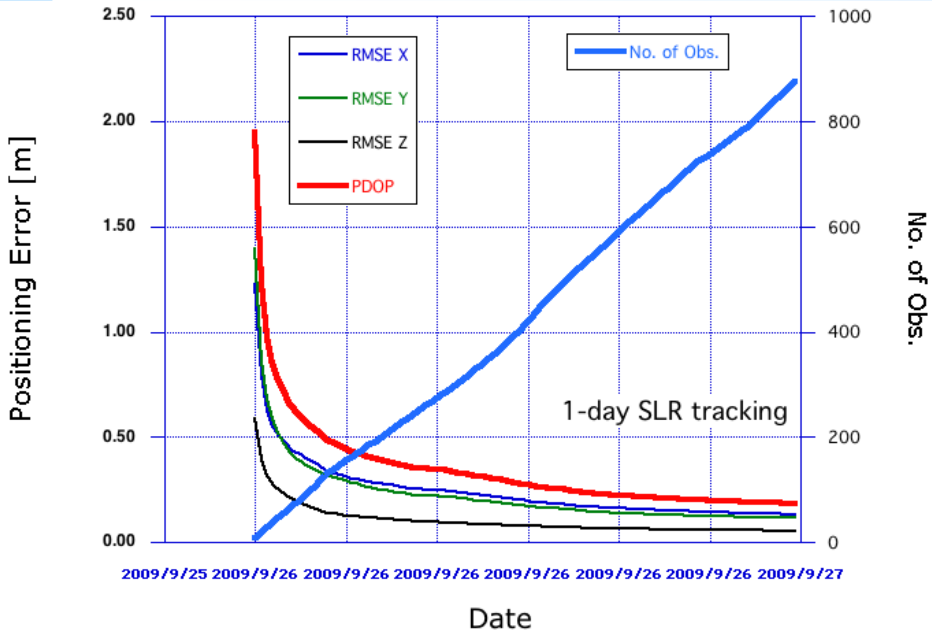
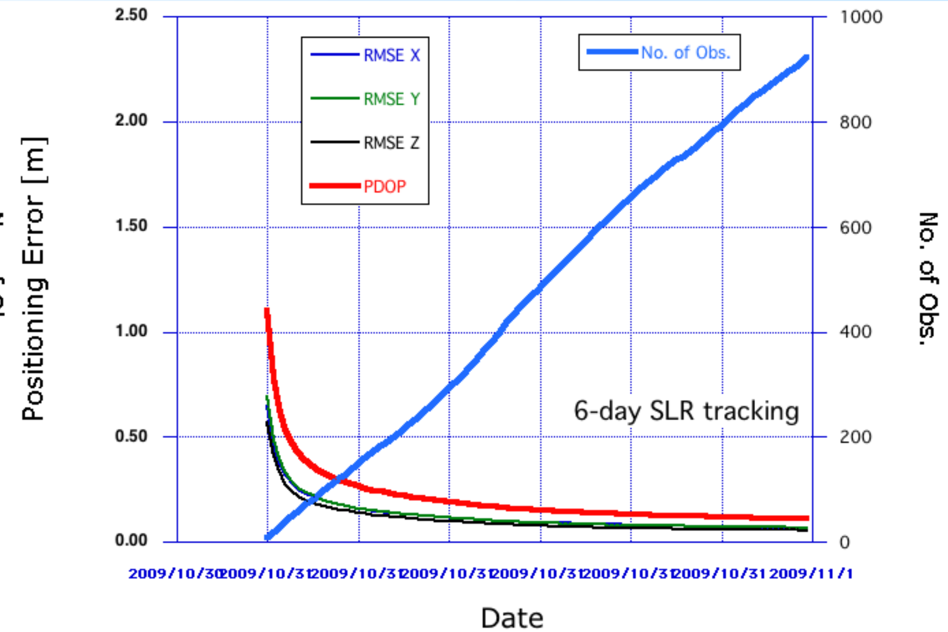
Positioning Errors - VI





Malindi

Summary

- A 16-site SLR network tracking all GPS s/c meets the GGOS accuracy/stability goals
- A variation using only one quarter of the GPS s/c is nearly as effective
- A 16-site network tracking a smaller number of satellites results in severe degradation
- Tracking scenarios for shorter periods (1-4 days) produce significantly worse results also
- GGOS requirement are met with certainty and enough error margin using the 16-site network of uniform distribution and NGSLR-class equipment, tracking 5-6 GPS s/c, each on a separate plane, over a period of one week, tracking in sequence over time the entire constellation.
- Switching s/c from one week to the next, perhaps 3 at a time, should maintain the uniform distribution in space (different GPS orbital planes)

Summary cont.

- GPS orbits based on variable SLR tracking from 16-site network, from 1 day to 1 week
- Orbital errors propagated into the positions of six sites selected to cover all regions of latitude to observe and randomize the effects of geometry
- Positioning done sequentially at 15 min intervals, results are cumulative
- Total error is the product of geometry with the RMSE curves which reflect only the orbital error up to each epoch
- GPS orbits with only 1 day SLR tracking generate several cm errors, even after 24 hrs tracking (for positioning)
- GPS orbits with 6 or more days of SLR tracking result in mm-level errors
- Sites near the poles benefit the least, mid-latitudes & near the equator the most