Expanded SLR Target Constellation for Improved Future ITRFs

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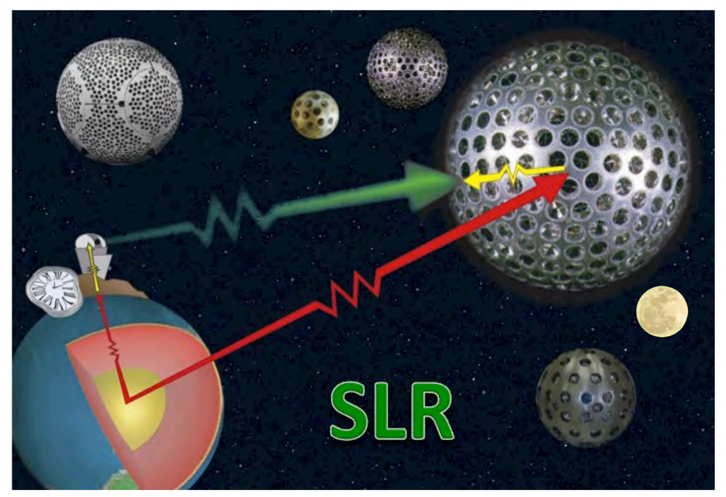
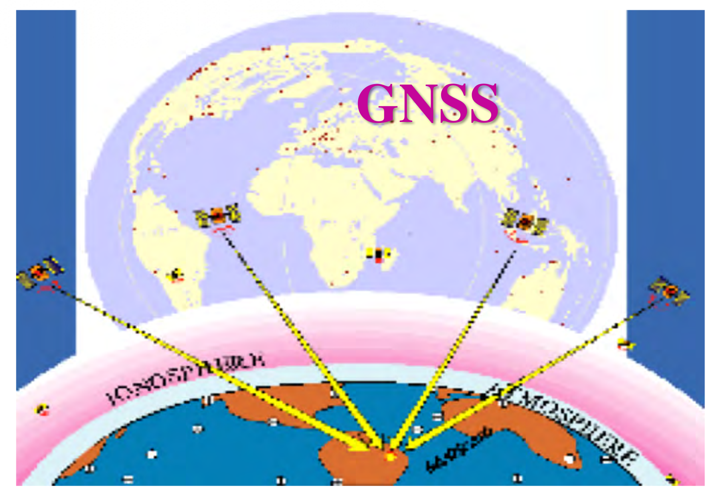
Abstract

The GGOS-imposed requirements to be met by all geodetic techniques per decade are very stringent: 1 mm position and 0.1 mm/y temporal stability. We are an order of magnitude worse today due to a poor ground segment and limitations in the space segment. The unavailability of daily sessions on SLR targets results in loss of geometry leading to lower accuracy and resolution of SLR products. The limited (4) satellites used in ITRF development led to several attempts to launch better-designed targets, leading to ASI's LARES (LAser RElativity Satellite), launched by ESA in 2012. Along with the LAGEOS' and Etalon it will now contribute to ITRF2020. Furthermore, ASI approved the development of LARES-2 with a launch in late 2019.

We can increase the number of contributing targets by including GNSS spacecraft and LEO cannonballs. GNSS constellations with LRAs provide an opportunity to improve the daily sky-coverage and tracking data geometry over each station. These targets can contribute to ITRF realizations and impose strong ties between the techniques in space, after careful calibration of their LRA reference point, their RF antenna phase center and their center of gravity. We evaluate the utility of extended tracking of the two Etalon satellites, already underused today. Next we evaluate the likely contribution of LARES- 2, following with existent in-orbit missions, and finally the addition of selected GNSS targets. We will present here initial results of combination studies with specific targets towards the achievement of the GGOS accuracy goals.

INTERNATIONAL LASER RANGING NETWORK TODAY





GROUND NETWORK – SPACE SEGMENT GEOMETRY

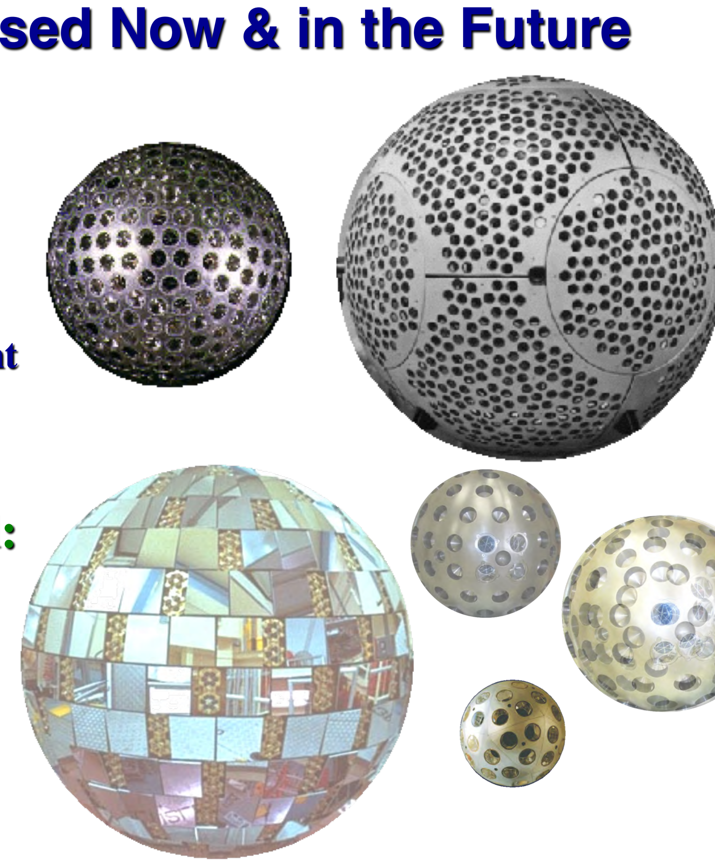
SLR systems track one target at a time, limiting the referencing of the site's position with respect to a single trajectory. A precise position is determined after multiple such events are stacked over a period of several days with varying geometry in every arc (weekly).

In the case of a GNSS system, several reference satellites are tracked simultaneously, allowing (depending on the required accuracy) a result to be obtained from within minutes, to hours, or a day.

Geometry between the space segment and the tracking network is even more important when it comes to Earth Orientation Parameter (EOP) determination. **SLR, with the currently limited number of targets and the sparse, lopsided network**, has a huge handicap over **GNSS with the continuous, global coverage at any instant, 24/7 around the world.**

SLR Targets Used Now & in the Future

- **At present:**
  - **LAGEOS 1 & 2**
    - **1993 - present**
  - **ETALON 1 & 2**
    - **April 2001 – present**
  - **LARES (ITRF2020)**
- **Considering to add:**
  - **Starlette & Stella**
  - **Ajisai**
  - **LARES-2 (soon!)**
  - **…**

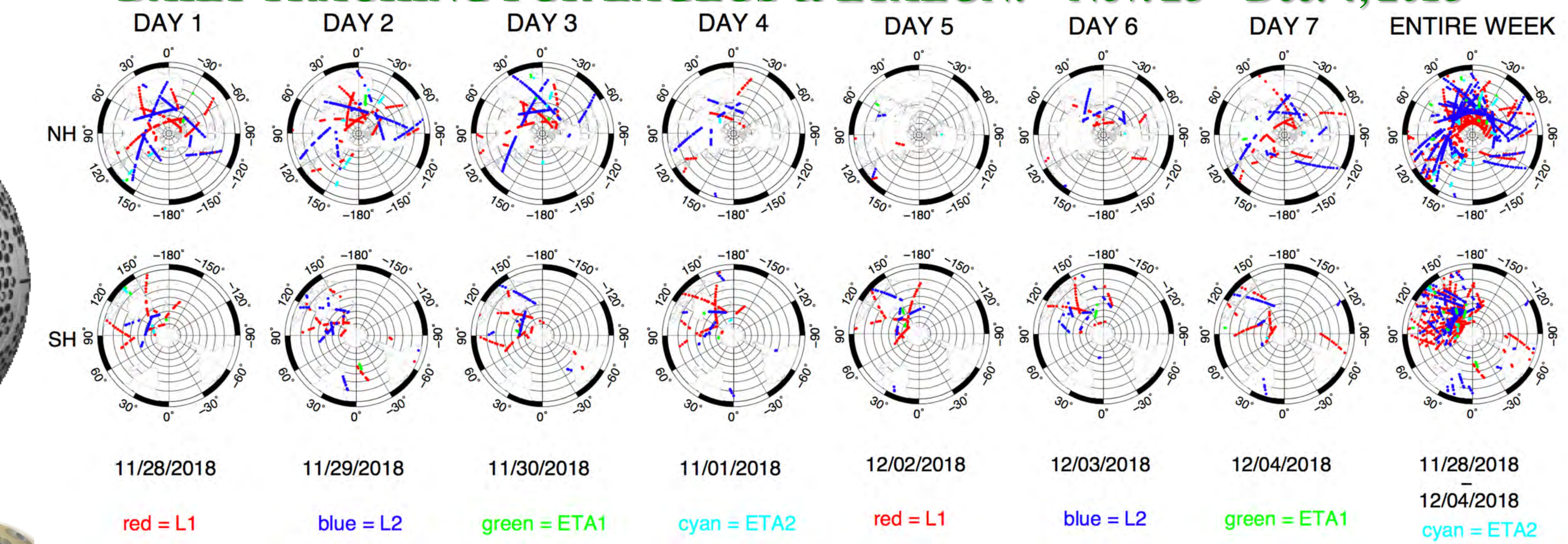


SLR TRACKING MODE FOR GNSS CONSTELLATIONS

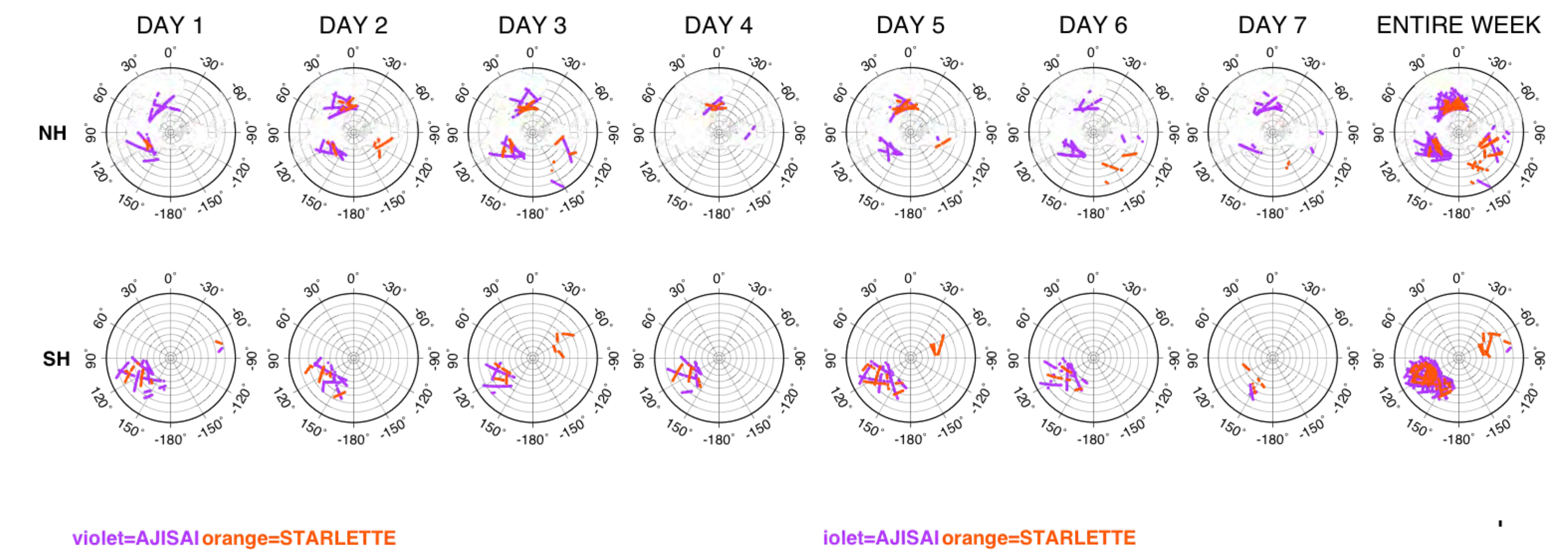
The large number of GNSS targets (~100) necessitates that we develop efficient tracking routines taking advantage of the new technology (kHz rates, pass interleaving, etc.)

Simulations of the above tracking scenario examined the capability of the future ILRS network (at 5 and 10 years from present) to meet the GGOS goals. The results demonstrated that a 16-station, globally & uniformly distributed network can accomplish the task on a weekly basis and under realistic conditions.

DAILY TRACKING FOR LAGEOS & ETALON: Nov. 28 – Dec. 4, 2018

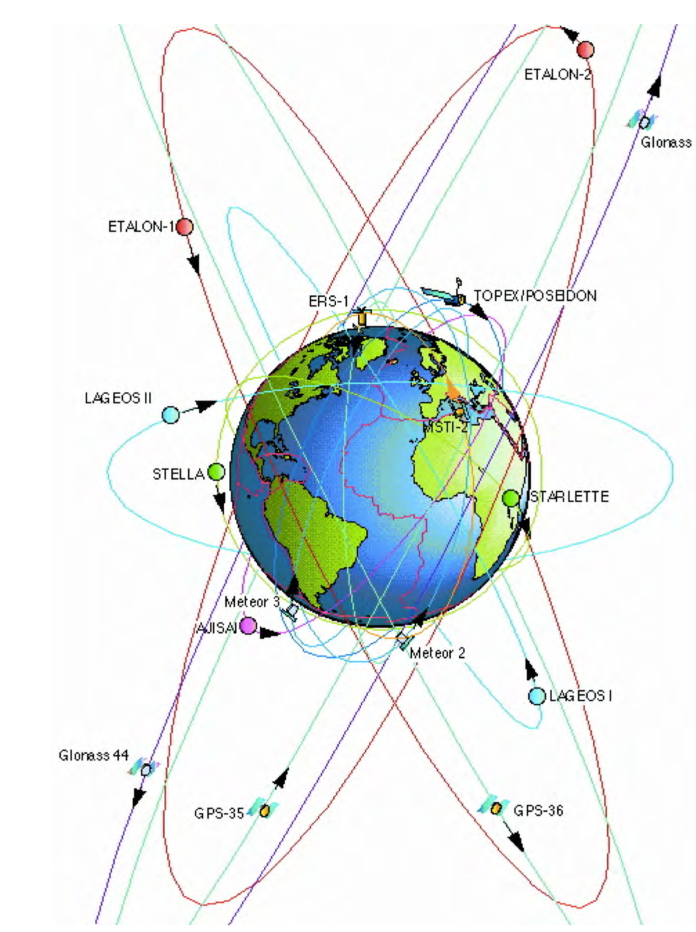


DAILY TRACKING FOR AJISAI & STARLETTE : Nov. 28 – Dec. 4, 2018

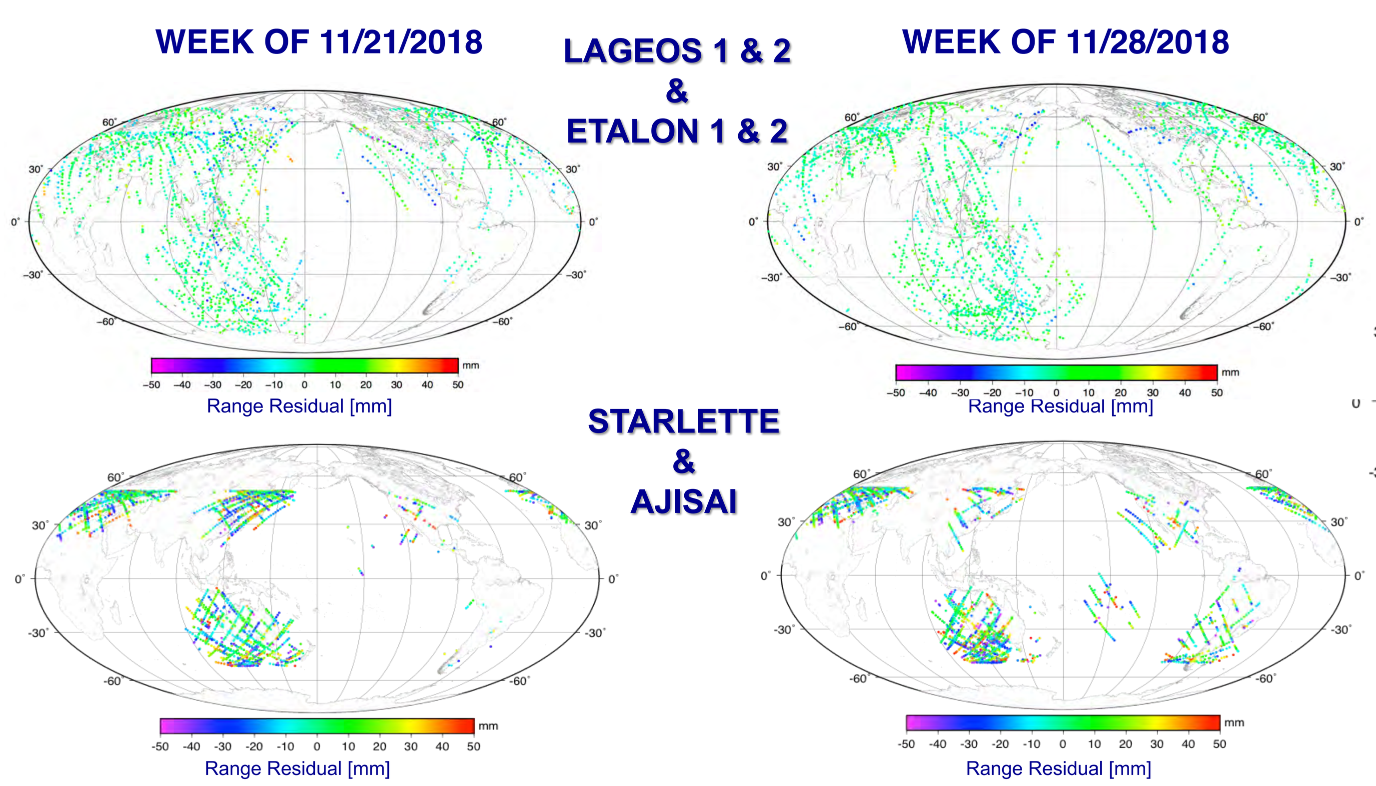


GEOMETRY ENHANCEMENT

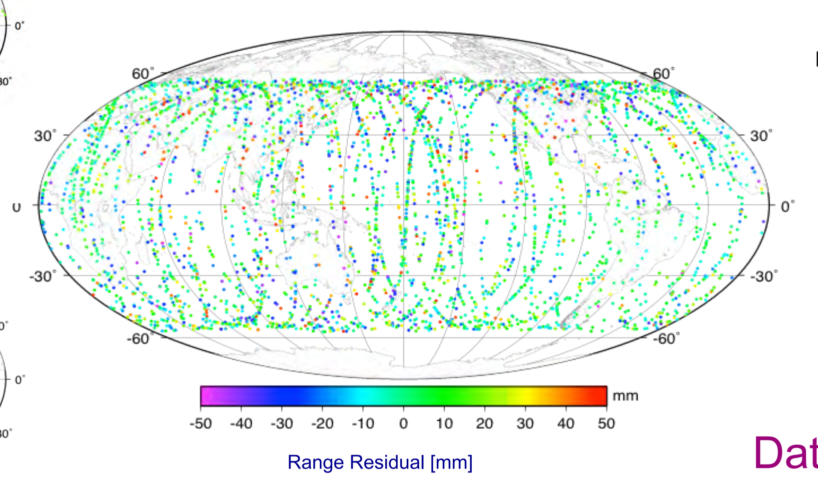
Extending the gamut of SLR target satellites in number, orbit variety and upgrading the network to a more balanced global distribution of stations with 24/7 tracking capability will enhance the geometric strength of station positioning and determination of EOP problem. The automated tracking and the optimal interleaving of targets will provide quasi-near-simultaneous tracking geometry similar to that enjoyed by GNSS systems. If these SLR systems have GNSS-tracking capability, then the SLR network will reach an enhanced geometry similar or superior to GNSS (since SLR will track HEO-MEO-LEO!).



RANGE RESIDUAL DISTRIBUTION FOR 6 S/C OVER TWO WEEKS

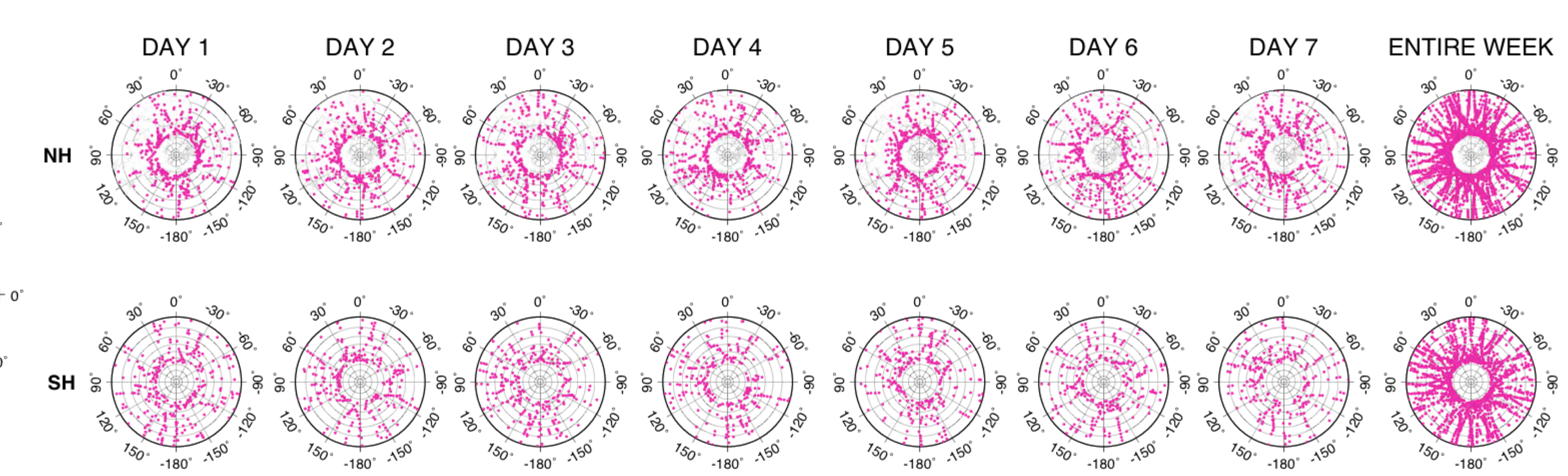


SLR RANGE RESIDUAL DISTRIBUTION FOR 24 GNSS S/C OVER ONE WEEK



EXTENDING THE RANGE: SLR TRACKING of 24 GNSS s/c

DAILY TRACKING FOR 24 GNSS s/c



Data coverage from simulated tracking of 16 SLR sites (globally distributed) of 24 GNSS s/c assuming realistic performance with **daily tracking success rate of 25%** and **night tracking success rate of 50%.** Only data ≥ 30° elevation were considered.

Summary

The data yield and the "ground segment" – "space segment" geometry of the current and near-future SLR network will be vastly improved for ITRF applications, if we consider the addition of targets such as STARLETTE, STELLA, AJISAI and selected parts of Global Navigation System Constellations' s/c such as GALILEO, GLONASS, BeiDu, GPS, etc.

To ensure that the ITRF products' accuracy is not compromised, we need to enhance the modeling of the tracking data, especially with regards to the LEO targets which are a lot more sensitive to the atmosphere, gravity, etc., and to the large GNSS targets that are plagued primarily by non-conservative forces (solar radiation) and limited accuracy s/c models.

Acknowledgements: This work is performed under Goddard's Space Geodesy Project, funded under NASA Grant NNX15AT34A. NASA's support is gratefully acknowledged.