Satellite laser ranging network: Where should a new station be placed?

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Scope of this study: SLR Network good enough?

• **Current SLR (Satellite Laser Ranging) Network**
  About 40 stations operational.
  Filling gaps: S. hemisphere, Russia.
  Still far from uniform distribution.

• **Question:** Where should we place a new station?
2-Step Simulation

[1] Generating Simulation Data Sets

Fly-over chances as a function of a satellite orbit and a station position.

SLR: not a 100%-time observable technique (weather, operator,..).

→ Realistic amount/coverage based on the actual observing statistics.

[2] Simulating POD Analysis

To be explained later.
The number of fly-over normal points with respect to the latitude (in degrees) of a ground station, for six geodetic satellites during a one-year period from July 2014 to June 2015. The distance (km) and the angle (degrees) in the legend are the altitude and the inclination of satellite orbits.
Pass-based success rates and normal-point-based success rates for four types of satellites during a one-year period from July 2014 to June 2015. The horizon for observability is uniformly set at $E_I = 20 \text{ deg}$. 

Assume:
Pass rate 25%
NP rate 15%
(equiv. 5^{th}-10^{th})
Parameters to be investigated
- Geocenter (TRF translation)
- TRF Scale
- Low-degree Earth gravity terms (up to degree/order 4)
- (EOP), (Orbit), ...

POD analysis simulation using software “c5++” R854
- 6 satellites (LAGEOS-1, LAGEOS-2, Ajisai, Starlette, Stella & LARES)
- Baseline setup: Existing ground station network (equal weights for all)
- Virtual setup: Baseline + one of virtual stations (134 points: latitude 15-deg, longitude 30-deg interval)
- Span: Mar-Apr 2015
- Estimated formal error = \sqrt{\text{Diagonal element of covariance matrix}}
- Look at the improvement rate from baseline to virtual
- 4-6% increase of total number of observation $\rightarrow$ 2-3% improvement expected according to the $\sqrt{\text{N}}$ rule.
Results

- **Improvement rate:** mostly better than 2-3% (predicted by the Sqrt(N) rule).
  - Building a new station should be encouraged almost anywhere.
- **High latitude stations in S hemisphere effective in general.**
- High-latitude station effective
  - TX, TY, C22, S22 (Sectoral terms)
- Middle-latitude station effective
  - C21, S21 (Tesseral terms)
- Low-latitude station effective
  - TZ, C20 (Zonal terms)
- Similar results for gravity degree-3 & 4 terms
- No significant improvement
  - TRF Scale, Polar motion XY

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Future Studies

• To relate the outcome with physical phenomena & future projects.
  Proposals welcome.

• To add “orbits” to the target parameters.
  For uniform orbit quality all over the world.

• To compare/combine with VLBI, GNSS, DORIS etc.
  Analysis software development. GGOS.
No SLR Stations below 36 S
Explanatory Research (not fully funded) in National Institute of Polar Research, Japan  
“Development of Satellite Laser Ranging System for Antarctica” (PI: T. Otsubo; 2016.4-2018.3)