NUMERICAL NOISE IN SATELLITE LASER RANGING DATA PROCESSING

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Abstract

The SLR station Graz is producing millimeter precision ranging data at a return rate of 2 kHz. Ranging to terrestrial targets, the ranging precision below 1 mm is achieved, ranging to low pulse spreading satellite, the precision of 2-3 mm is achieved. These ranging data sets have been analyzed / smoothed using two different algorithms and working groups. The first solution has been based on the polynomial fitting, the second one on the orbital fitting approach. The computed o-c residuals have been compared for both solutions on a shot by shot basis. These differences are on single picosecond level, just indicating the order of magnitude of a numerical noise within the SLR data processing algorithms.
Goals:

- WHAT CAN WE GET FROM 2kHz / mm large volumes data averaging?
- To optimise the procedure for 2kHz millimeter ranging data processing
- To estimate the performance of the SLR data processing software:
  - fitting algorithms (orbit, residuals) accuracy
  - numerical noise of the computation

Philosophy

- numerical experiments based on Graz SLR data Oct.2003 - Jan 2004
  2 kHz / C-SPAD, rms < 3mm
- satellite signature eliminated by single CCR echoes / data selection
- inter-comparison of two completely independent data processing / fitting algorithms on a echo-by-echo basis:
  Graz SLR X Portable Calib. Standard PET2k
- MERIT2 data format : 1 psec granularity
SLR data fitting procedures compared

- **Graz SLR data fit**
  - orbit IRVINT integrator, 1 minutes x,y,z
  - 8-pt Lagrange interp., topocentric conversion
  - optional manual RB / TB tuning
  - Polynomial fitting, standard scheme, deg. 5-10 (20)
  - data screening / editing

- **Portable Calibration Standard 2k**
  - orbit RGO integration, 1 minutes x,y,z
  - 8-pt Lagrange interp., topocentric conversion
  - automated RB / TB / DUT tuning
  - Iterative polynomial fitting & automated data editing

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SLR data sample used for tests

- ERS-2 Jan 29, 2004, 10 h UT, 86 deg. max. elevation,
- first 80 seconds of tracking selected, 32 ooo echoes
- note two retro response, the first one used, only
Sample SLR data fitting

- ERS-2 Jan 29, 2004, 10 h UT, 86 deg. max. elevation,
- first 80 seconds of tracking selected, 32,000 echoes
- PCS data fit,
  - the first retro => 18 ps RMS (1-10 PE)
  - the second retro => 22 ps RMS (1 PE)

SLR data residuals comparison

- random / numerical noise / format < 1 ps RMS < 2 ps half p-p
- slowly varying +/- 3 ps half p-p
Normal point construction

2kHz SLR normal points data spread
ERS2,Graz,11.10.'03,750 echoes/sec
single shot 17 ps r.m.s.

- deviation from ideal: > 100 echoes / NPT 2.5 psec
- saturation: > 2000 echoes / NPT 1.0 psec

Conclusion

- The limits of averaging of the 2kHz / mm SLR data have been characterised
- the SLR data processing numerical noise is of the order of 1 psec (random numerical, interpolation)
- the normal point precision saturates at 1 psec level compressing > 2000 echoes
- these limit values are negligible in comparison to satellite signatures (!)