SLR in the framework of the EGSIEM project

Andrea Maier[1], Andreja Sušnik[1], Daniel Arnold[1], Krzysztof Sośnica[1,2], Ulrich Meyer[1], Rolf Dach[1], Adrian Jäggi[1], Daniela Thaller[3]

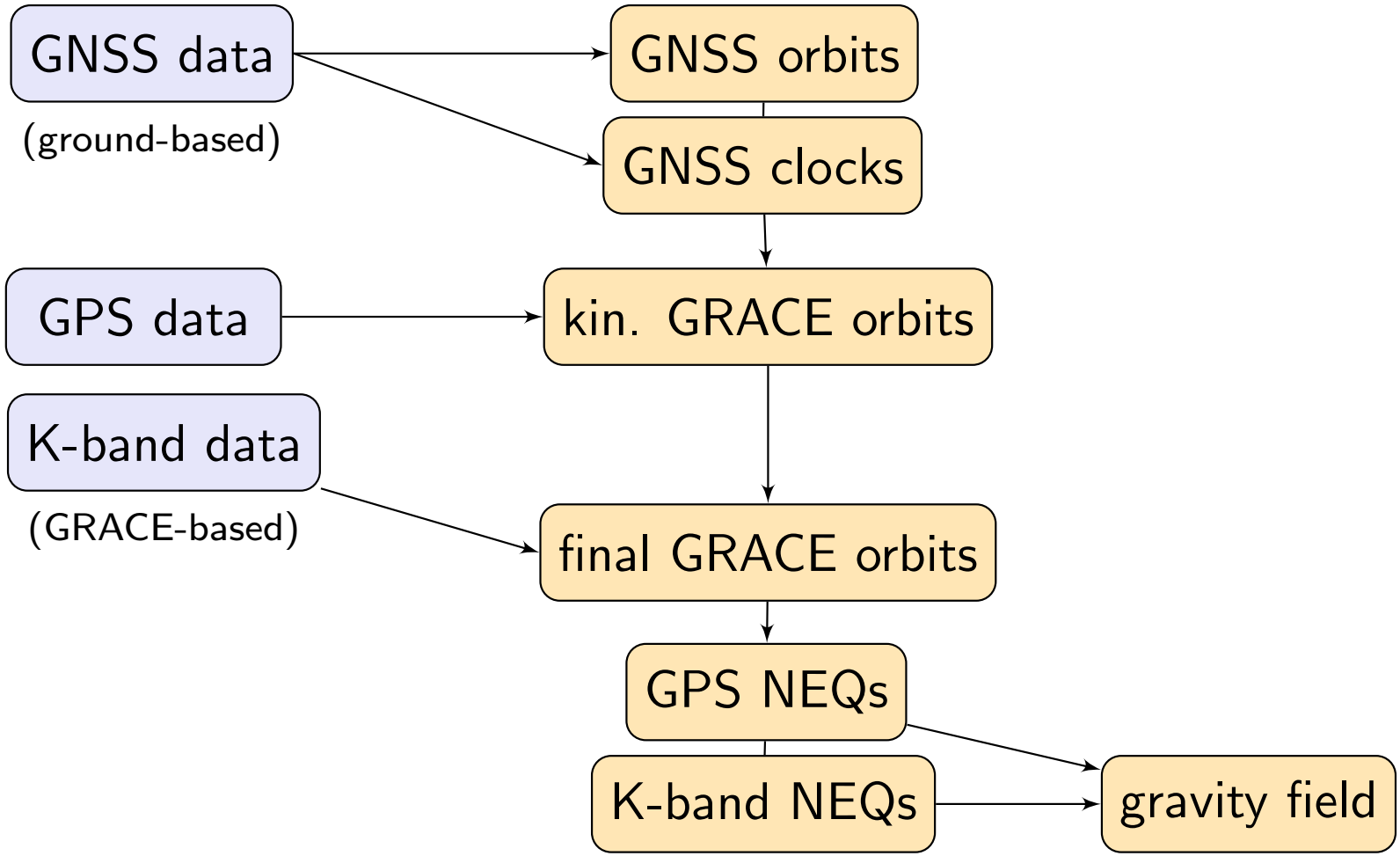
[1] Astronomical Institute, University of Bern, Switzerland
[2] Institute of Geodesy and Geoinformatics, Wroclaw University of Environmental and Life Sciences, Poland
[3] Federal Agency for Cartography and Geodesy, Frankfurt, Germany

2015 ILRS Technical Workshop

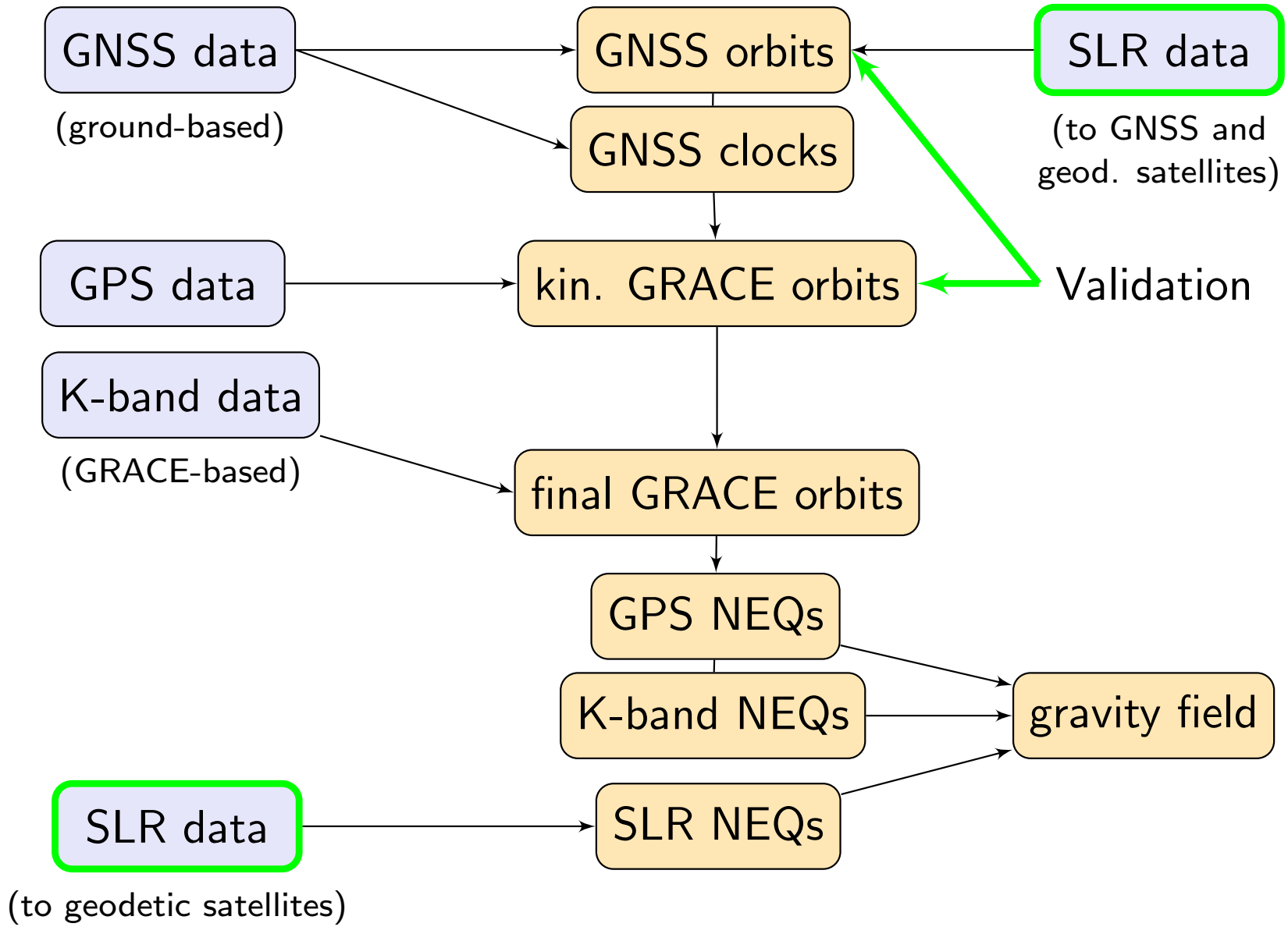
EGSIEM project overview

- European Gravity Service for Improved Emergency Management
- submitted in 2014 to the EO-1 Space Call of the Horizon 2020 Framework Program for Research and Innovation
- started on January 1, 2015
- three main objectives:
  1. deliver the best gravity products for applications in Earth and environmental science research
  2. reduce the latency and increase the temporal resolution of the gravity and therefore mass redistribution products
  3. develop gravity-based indicators for extreme hydrological events and demonstrate their value for flood and drought forecasting and monitoring services

Deriving monthly gravity fields at AIUB (1)



Deriving monthly gravity fields at AIUB (2)



GNSS reprocessing campaign

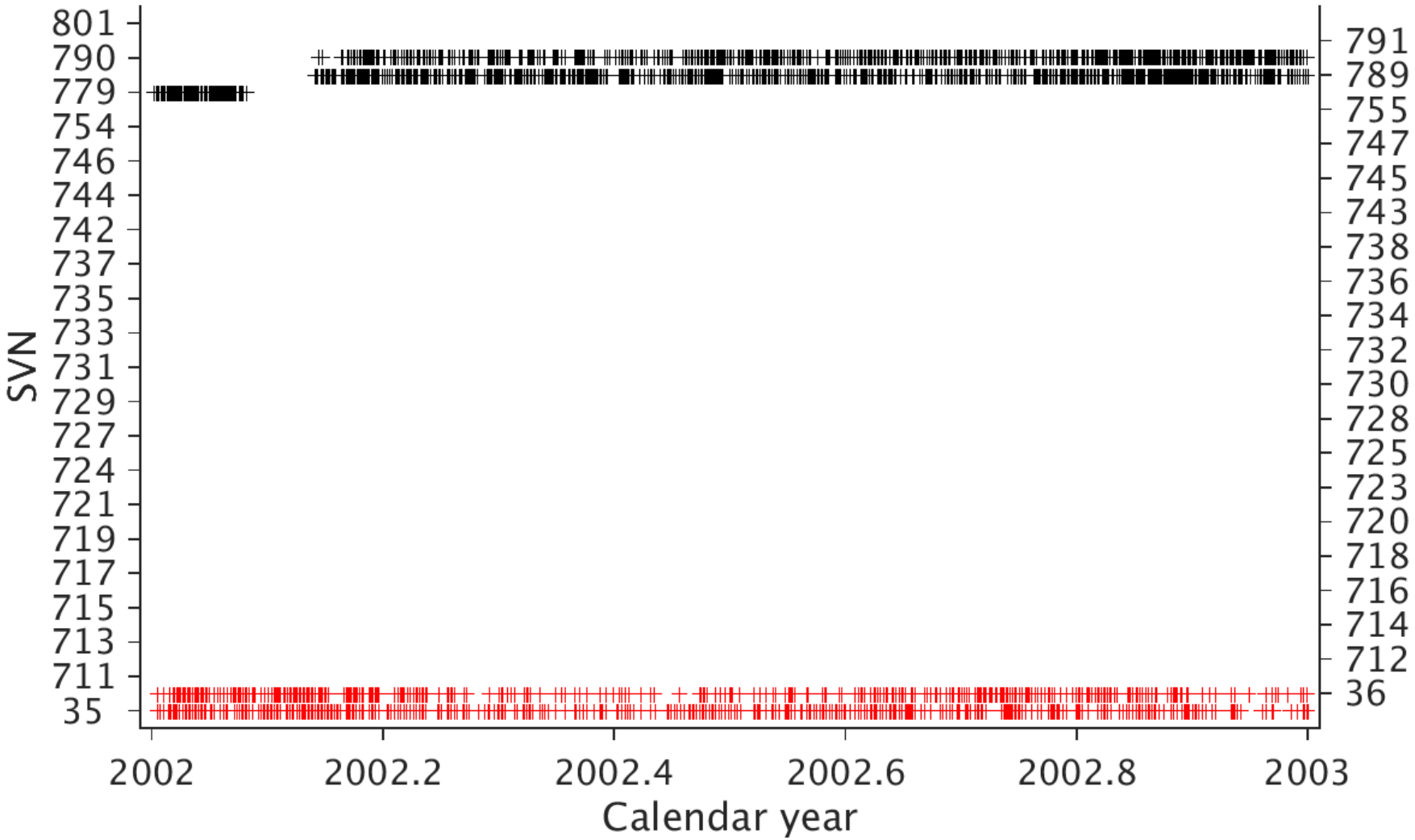
- ongoing reprocessing campaign
- time span: 2002 to 2015
- GNSS products: orbits, Earth orientation parameters, clocks, etc.
- new Empirical CODE Orbit Model (ECOM) is used:

	Parameters estimated in		
	D	Y	B
Old ECOM	constant	constant	constant, 1-cpr
New ECOM	const., 2-cpr, (4-cpr)	constant	constant, 1-cpr

D . . . satellite-Sun direction
Y . . . direction along the satellite's solar panels axes
B . . . completes the orthogonal right-handed system

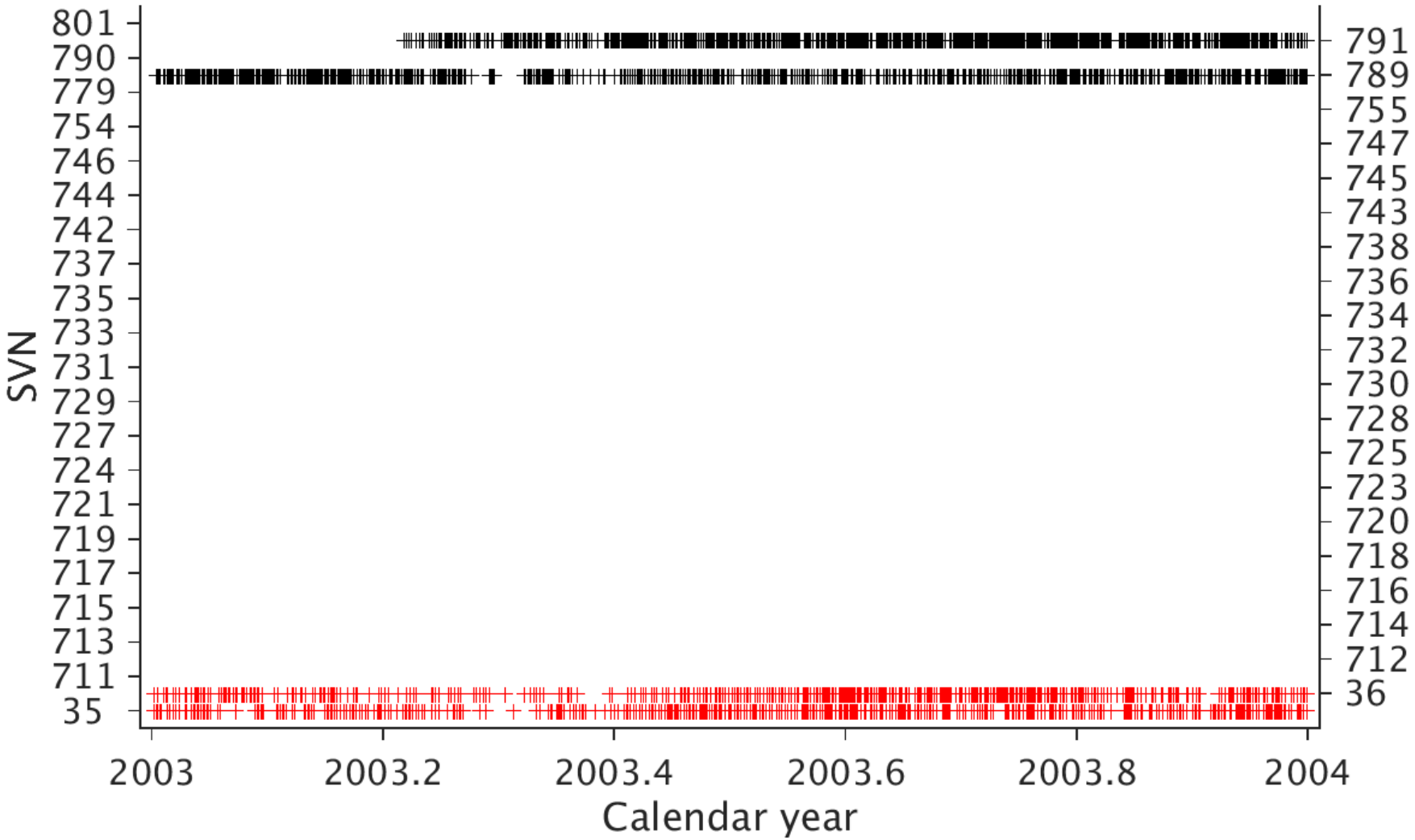
SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



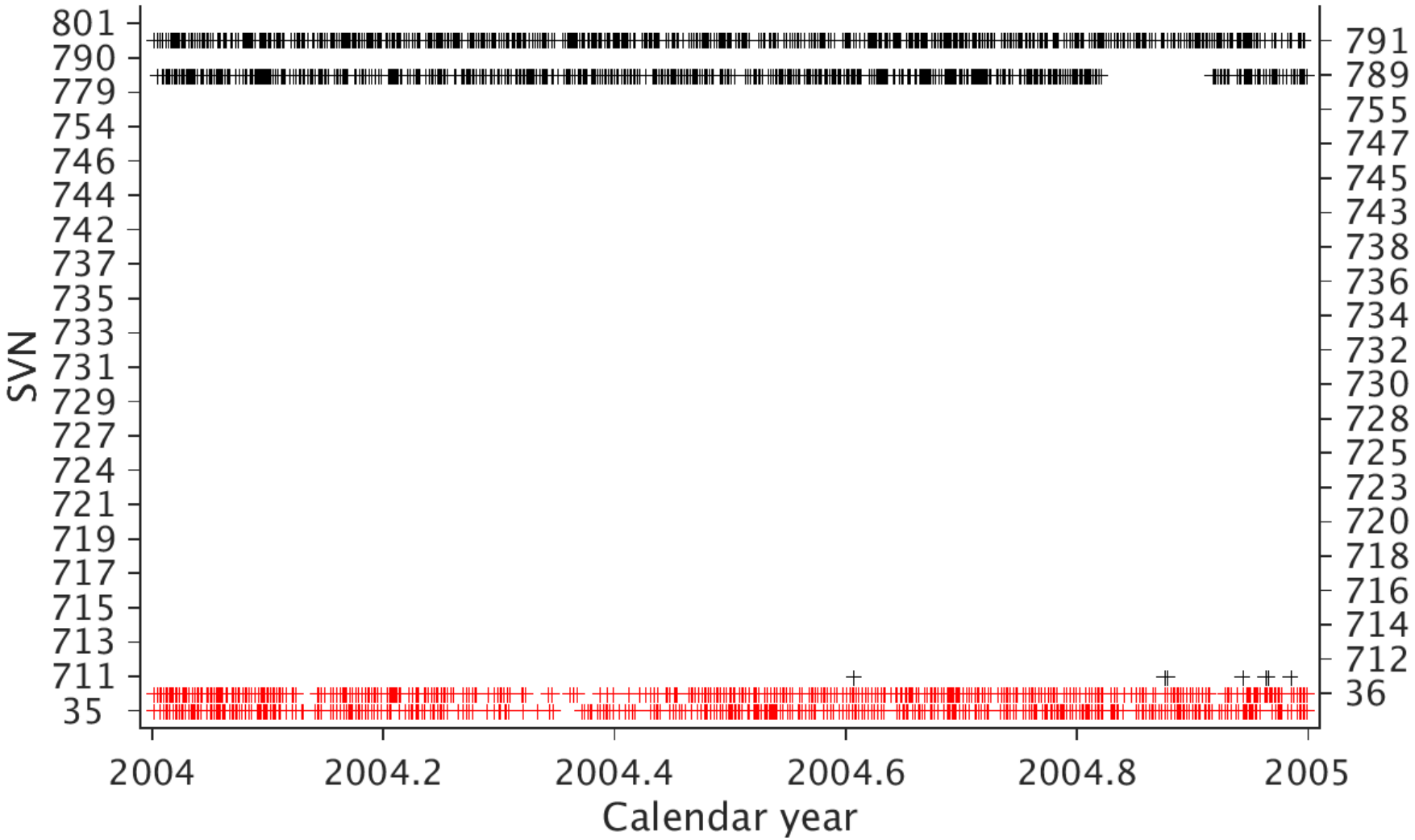
SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



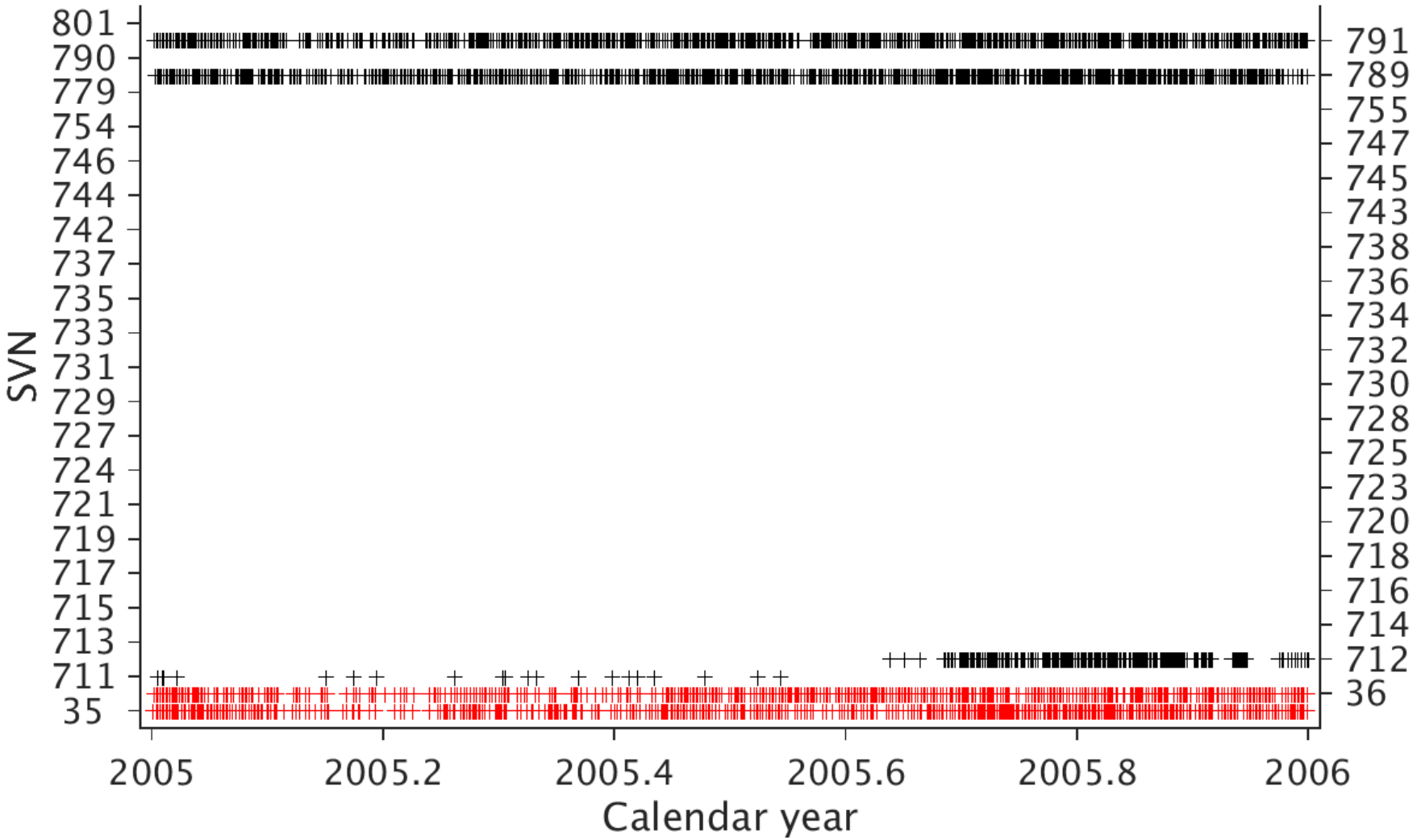
SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



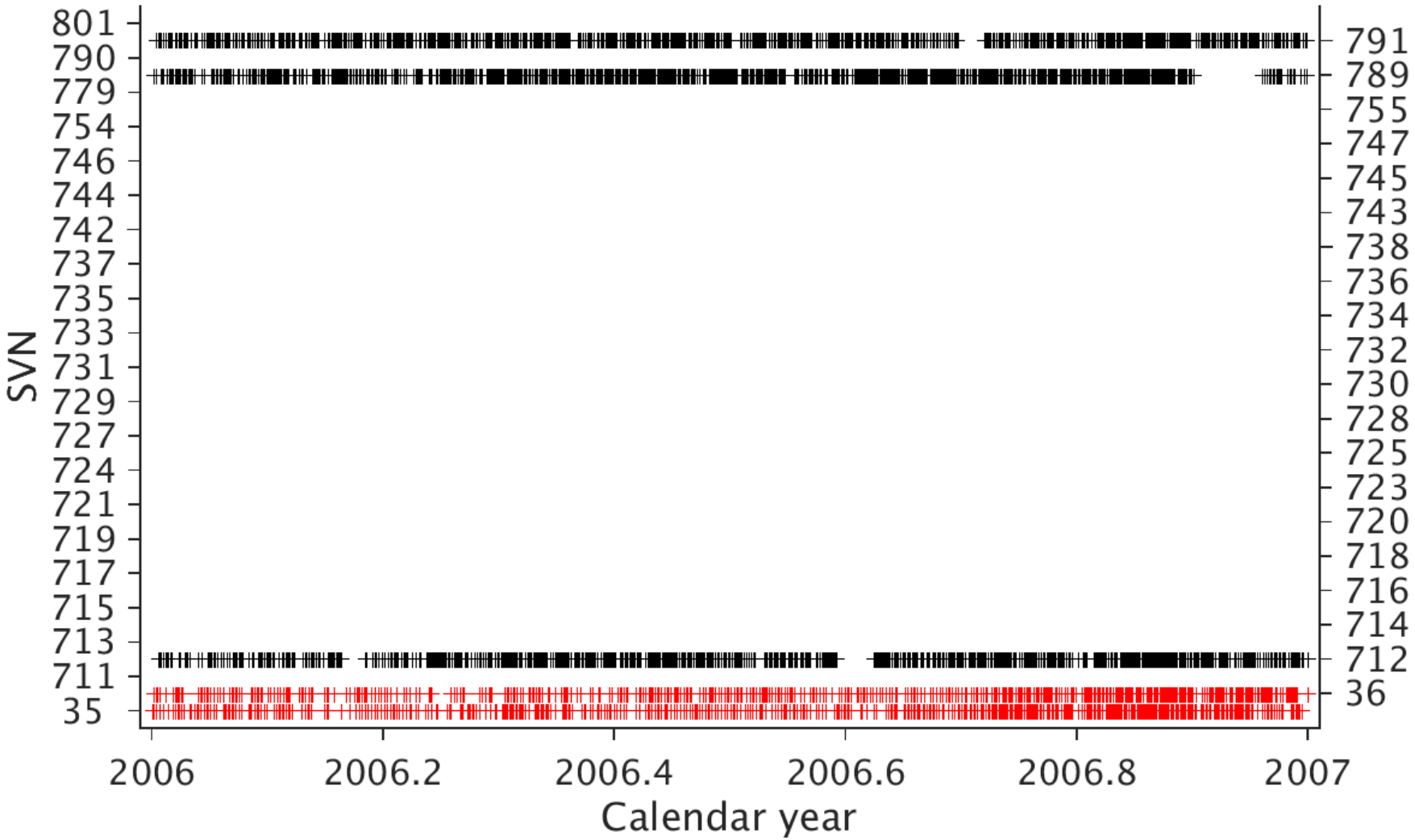
SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



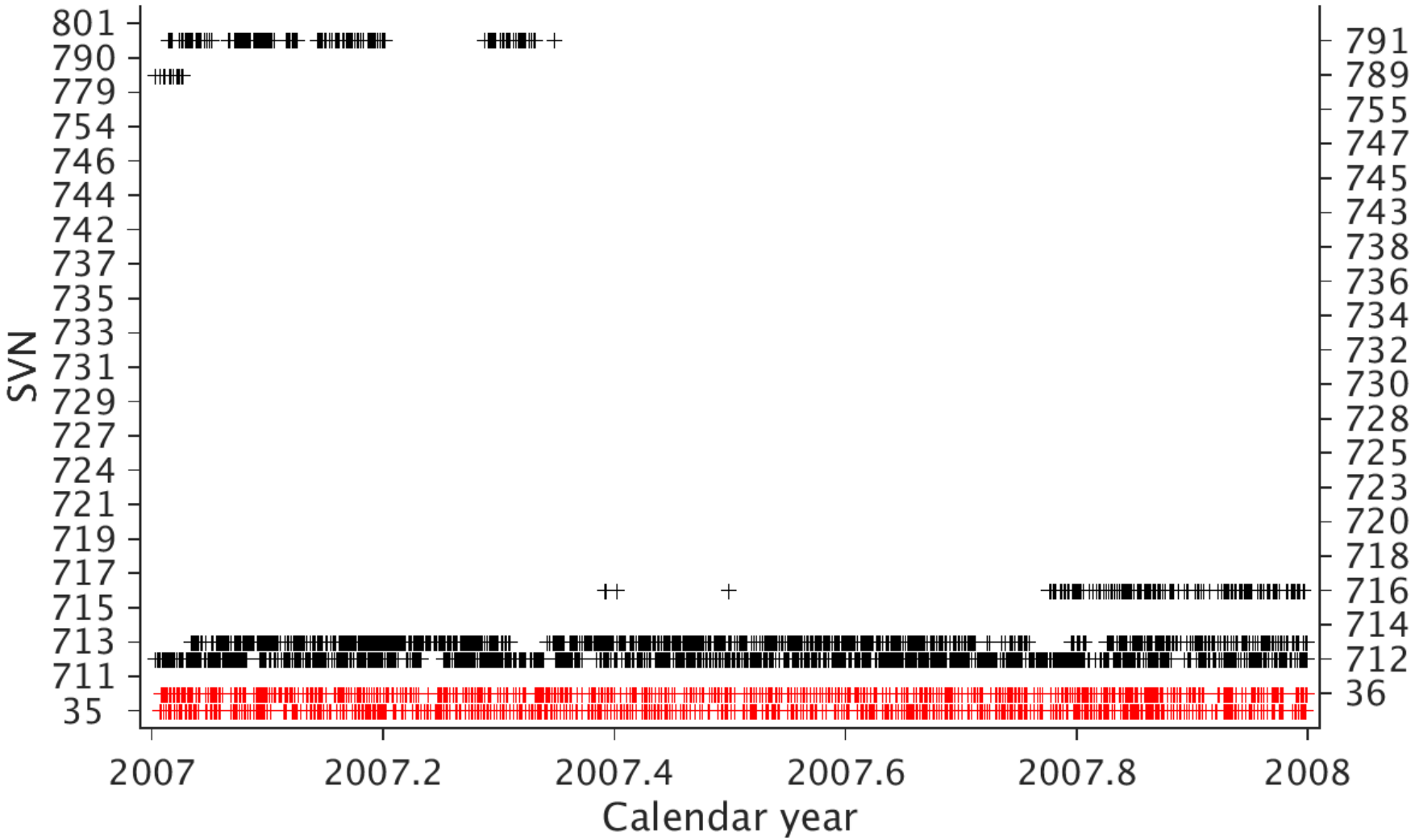
SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:

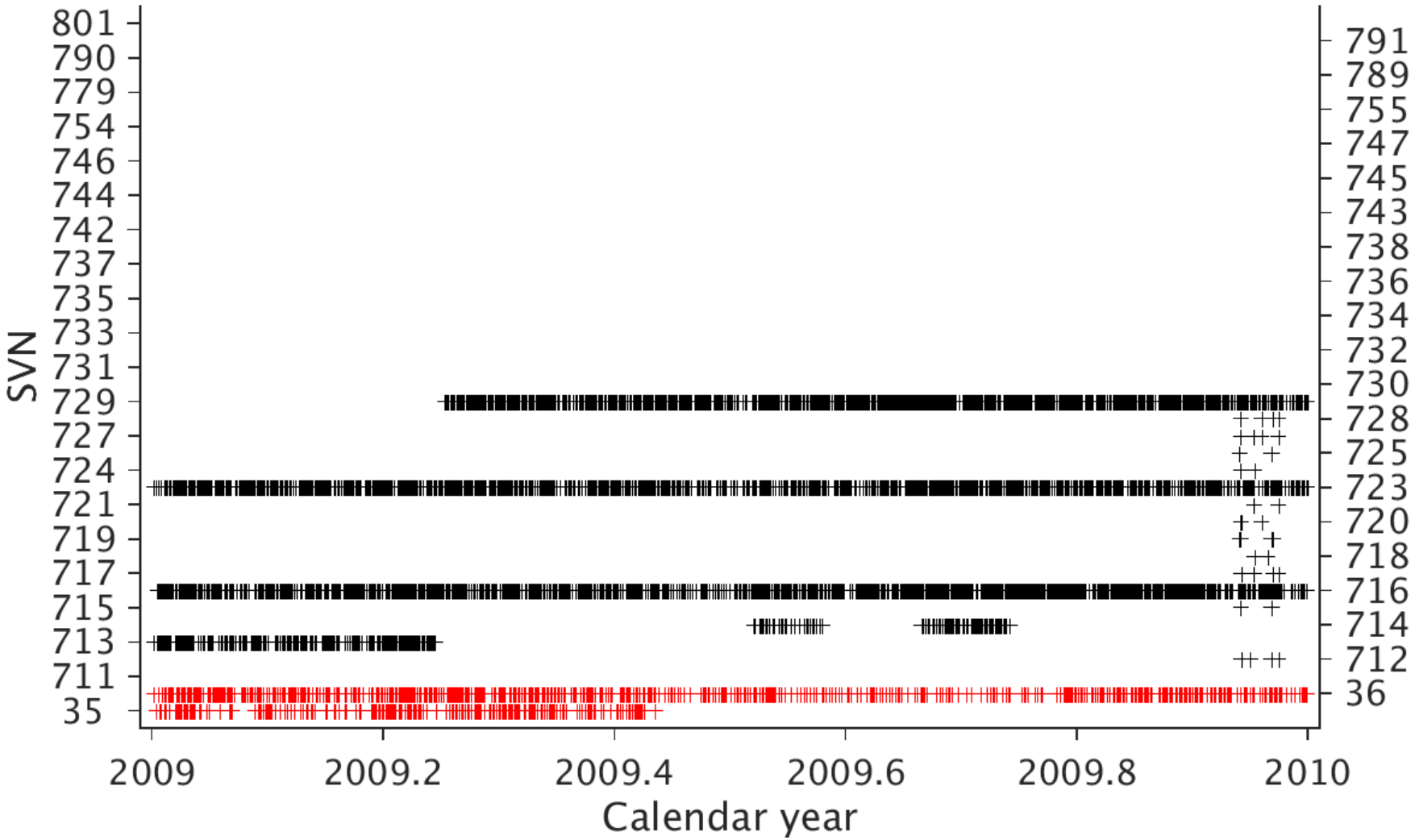


SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:

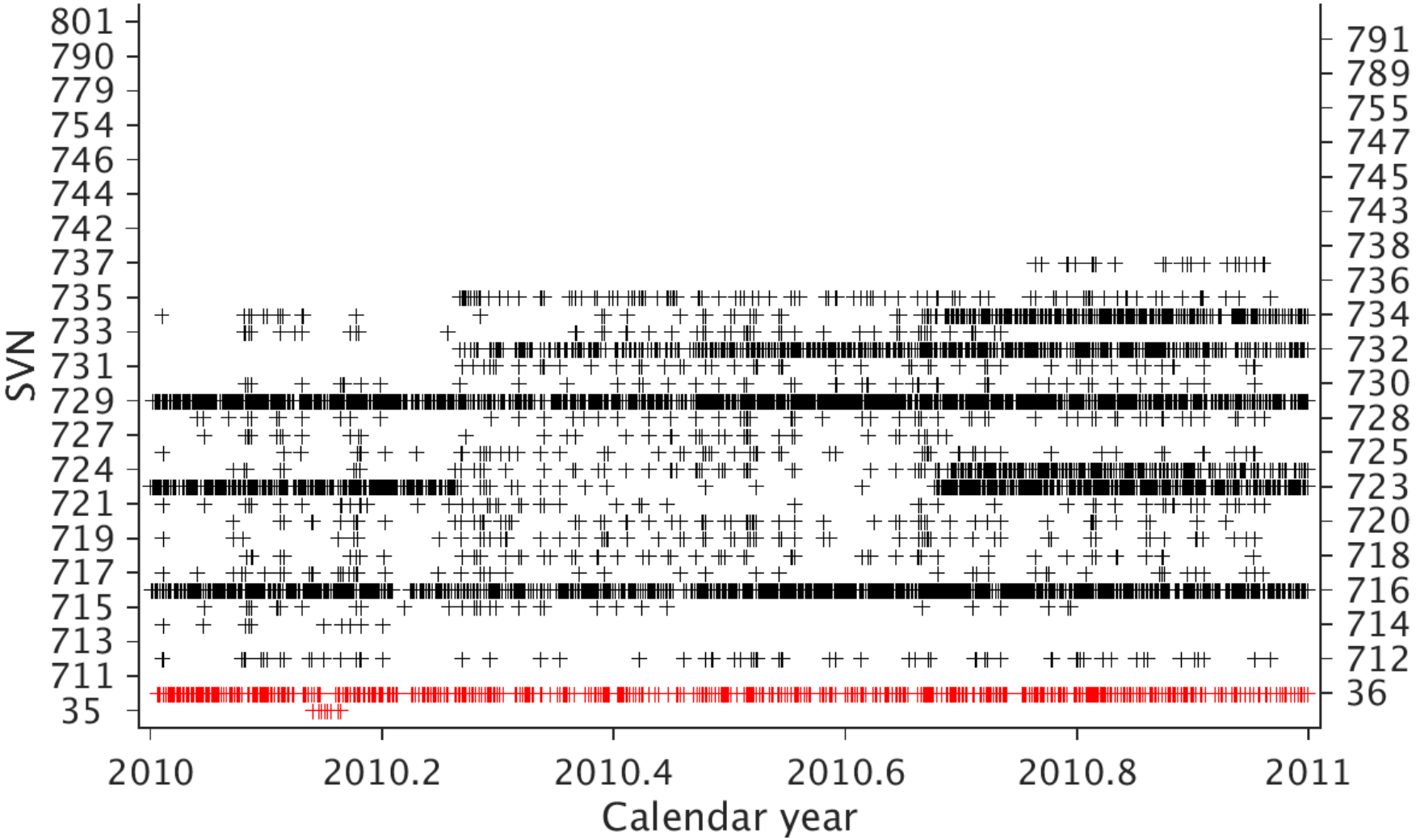
SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



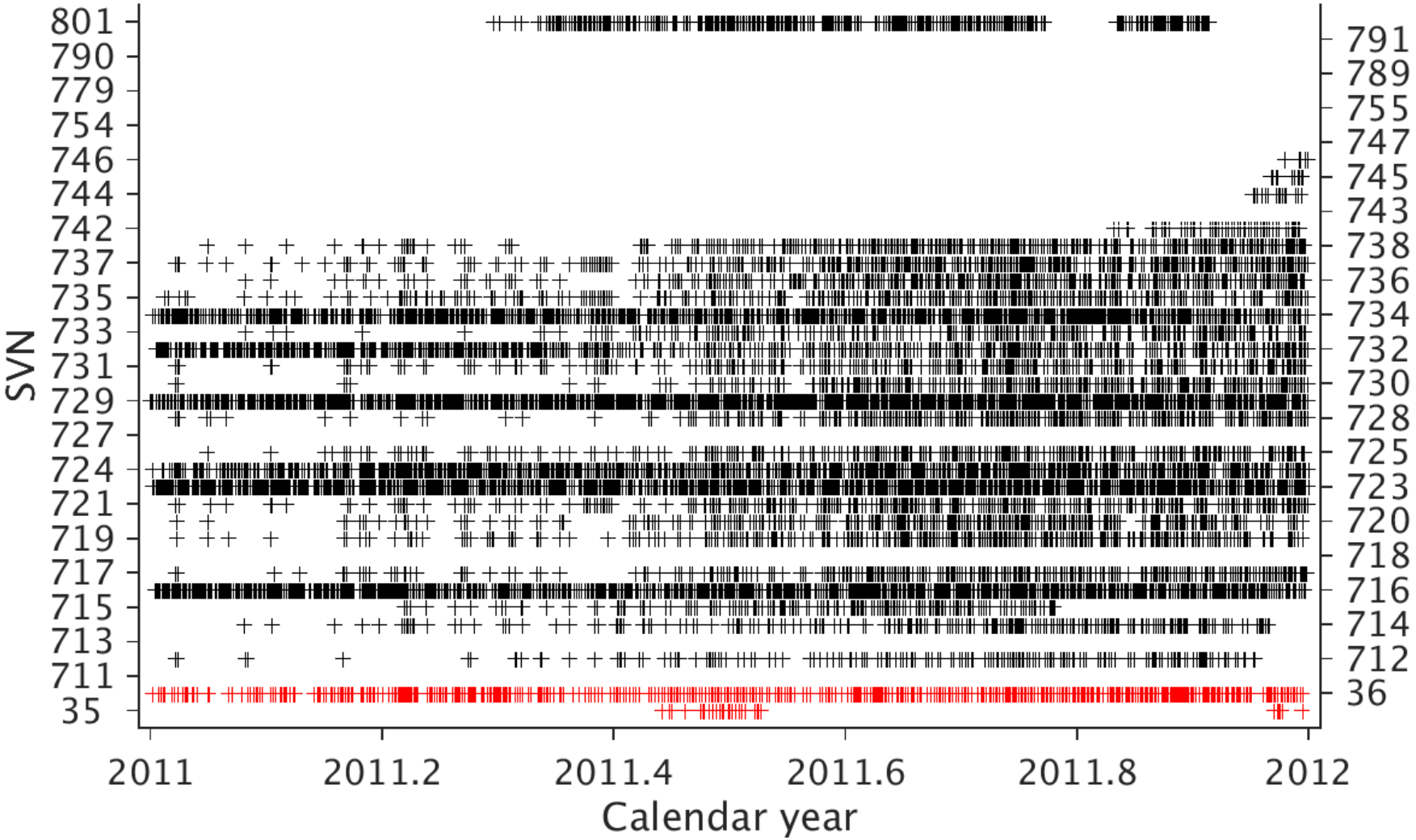
SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



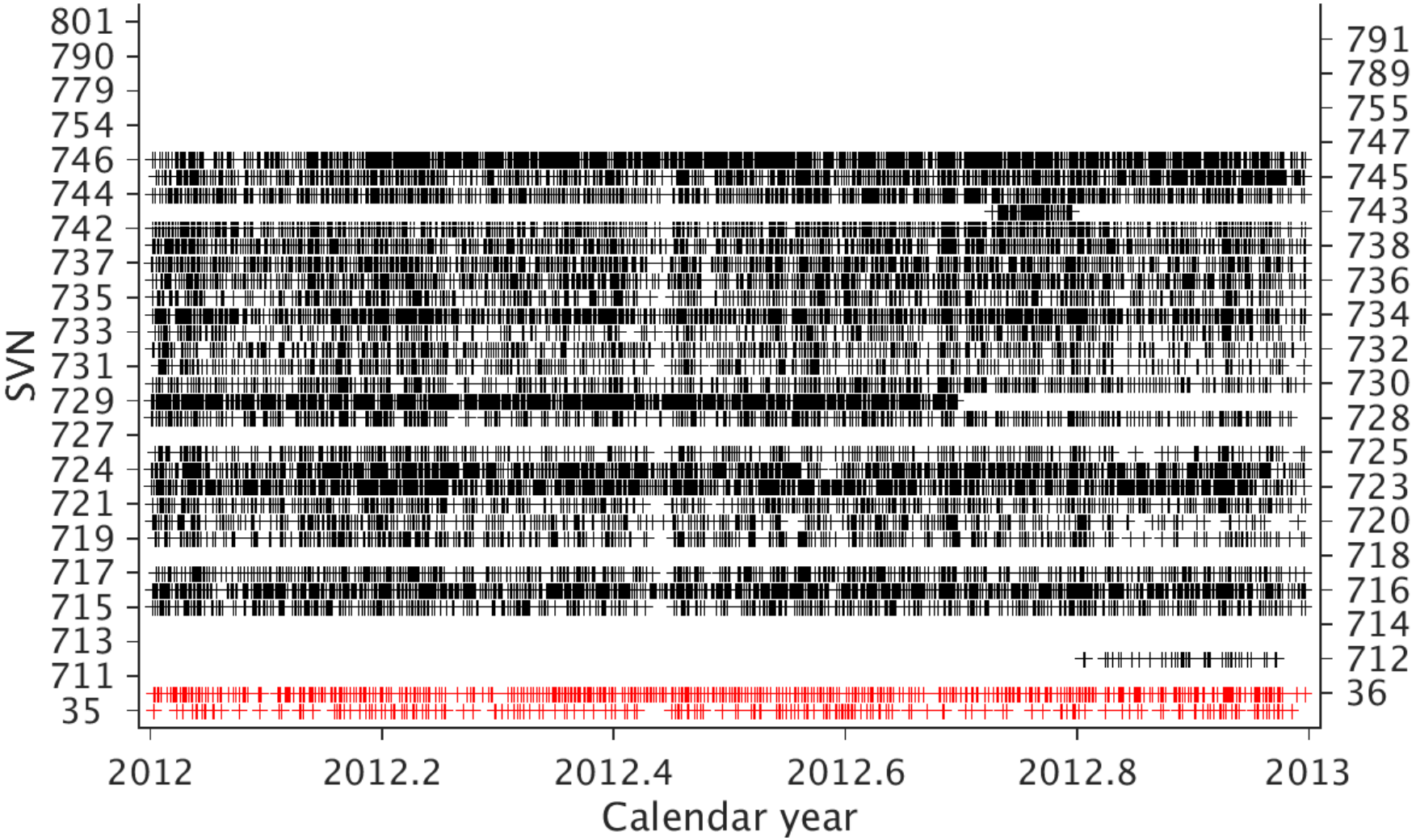
SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



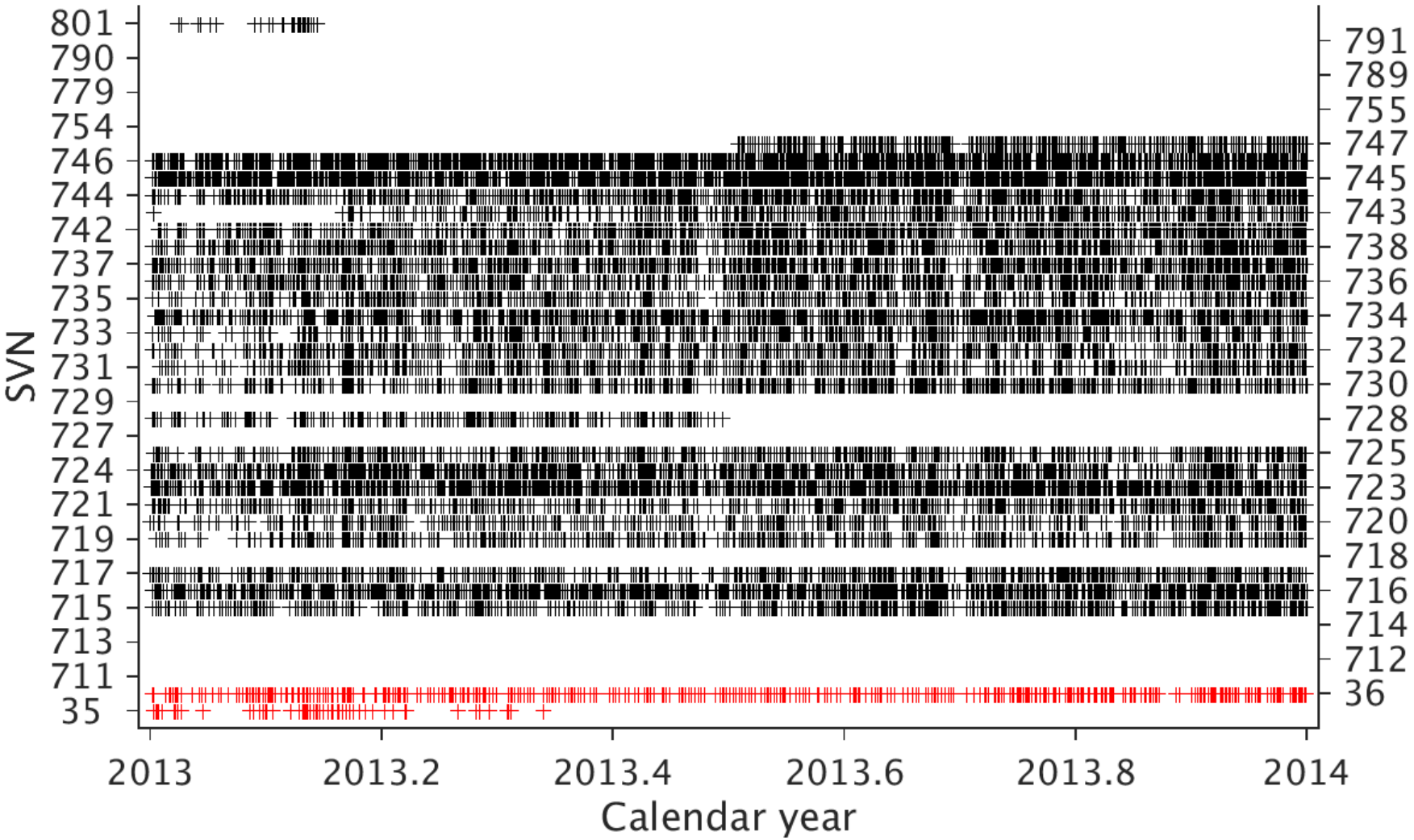
SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



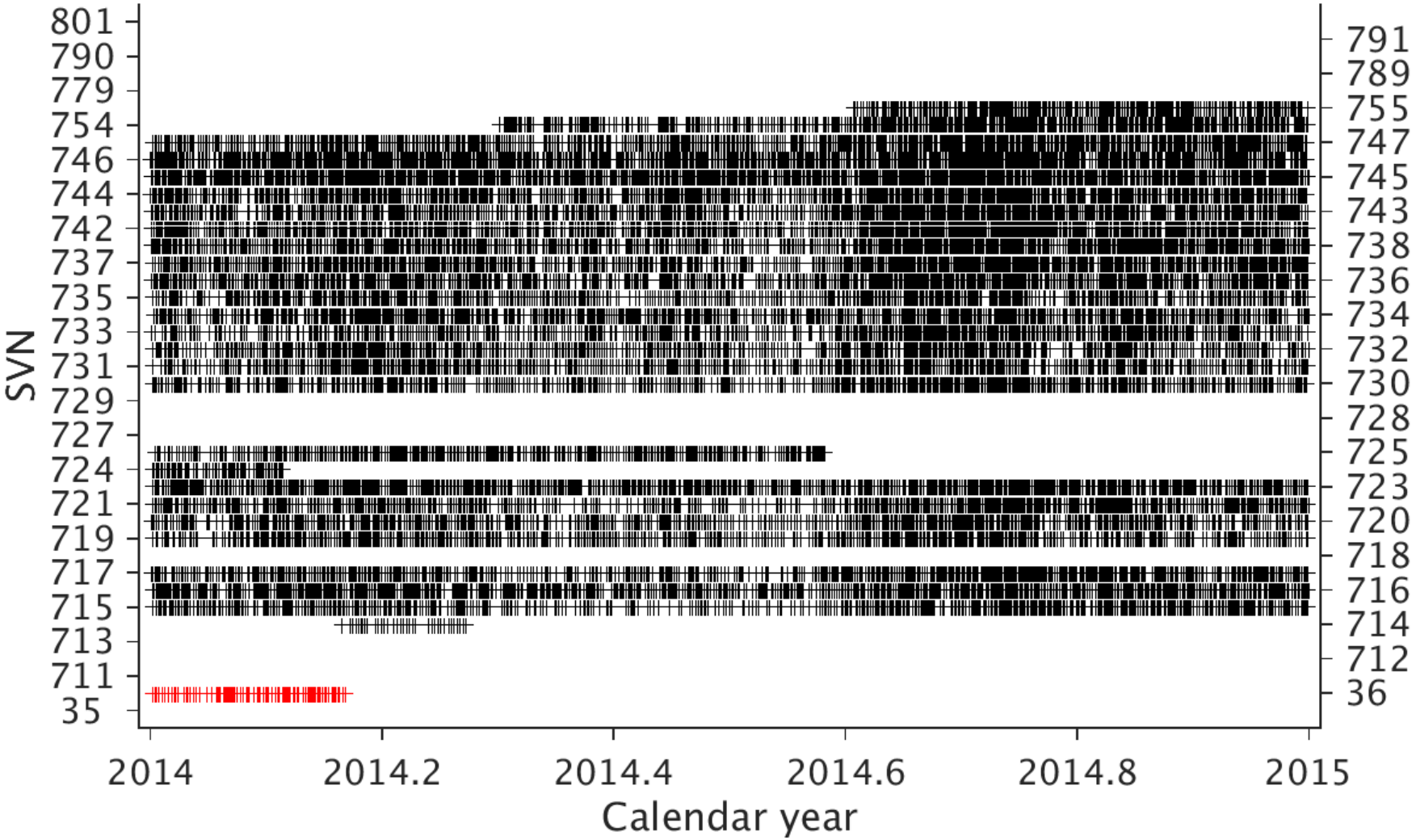
SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



SLR measurements to GNSS satellites

- SLR observations to GPS and GLONASS satellites:



Principle of SLR validation

- SLR residuals w.r.t. microwave-based orbits:

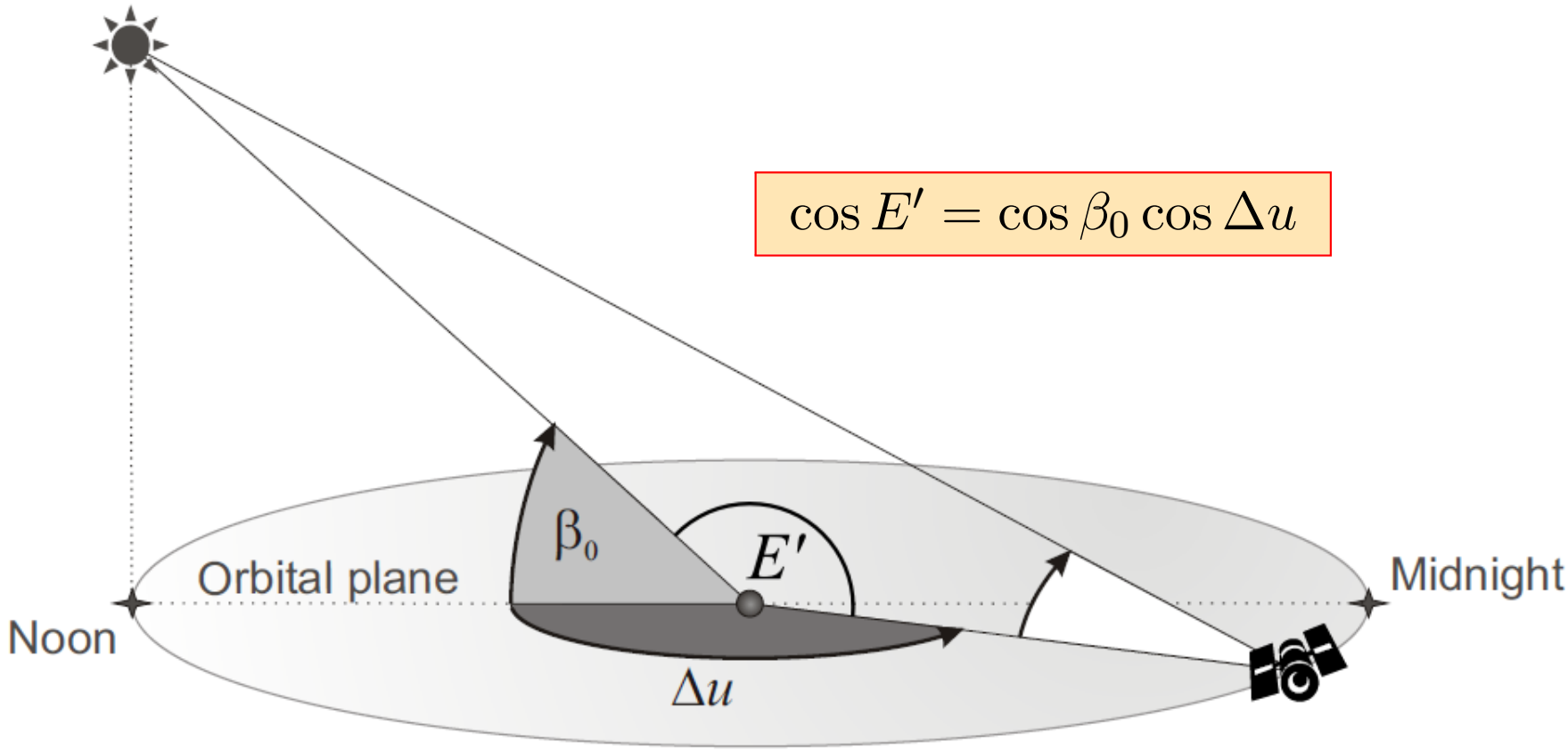
  $o - c$ . . . 'observed minus computed'

  - observed quantity: satellite laser distance to satellite
  - computed quantity: distance between station and microwave-based orbit

- no parameters are estimated $\Rightarrow$ SLR residuals contain biases!

GNSS orbit validation (1)

- SLR residuals w.r.t. microwave-based orbits as a function of the elongation angle E'

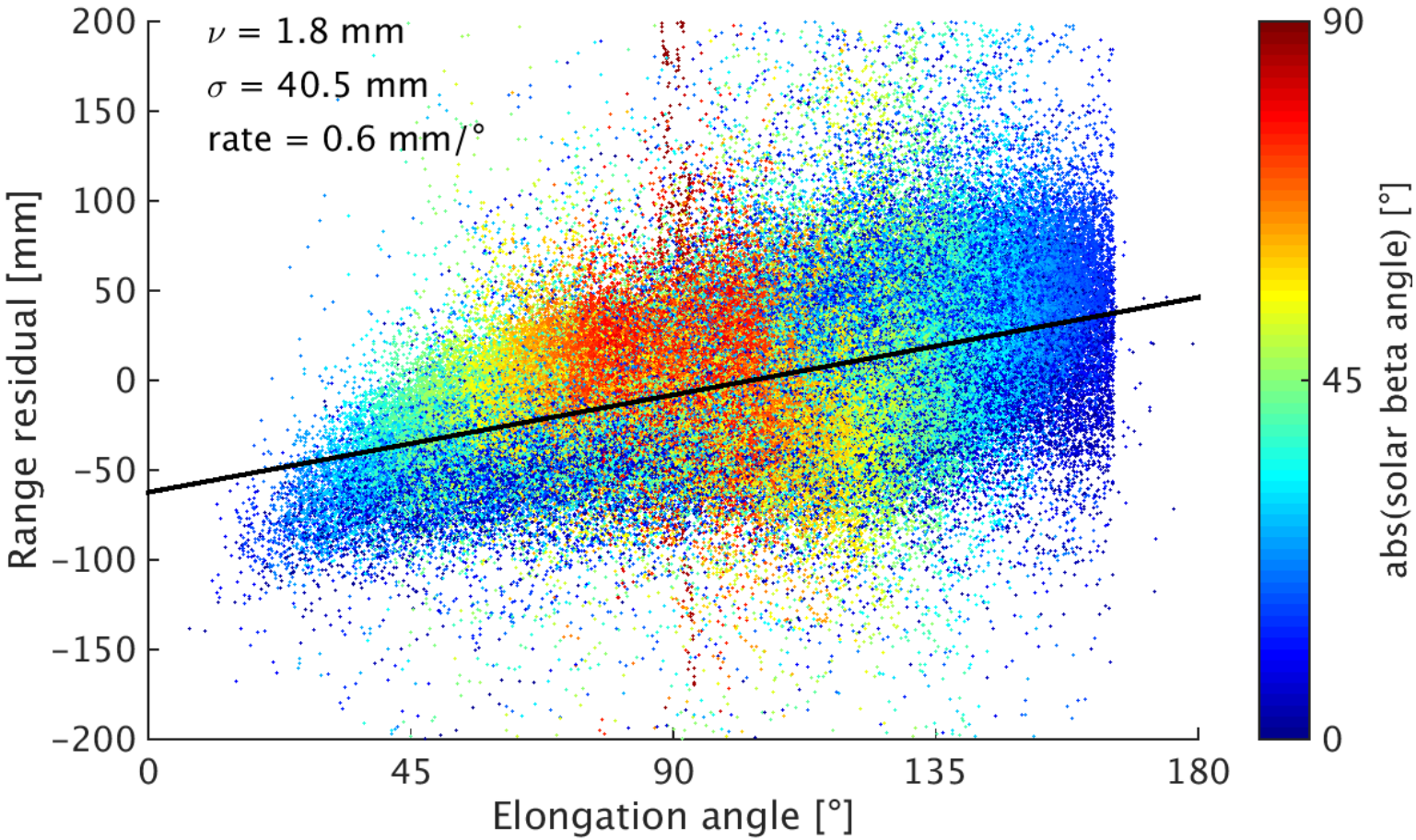


β_0 . . . elevation of the Sun above the orbital plane

Δu . . . difference between the argument of latitude of the satellite and the argument of latitude of the Sun

GNSS orbit validation (2)

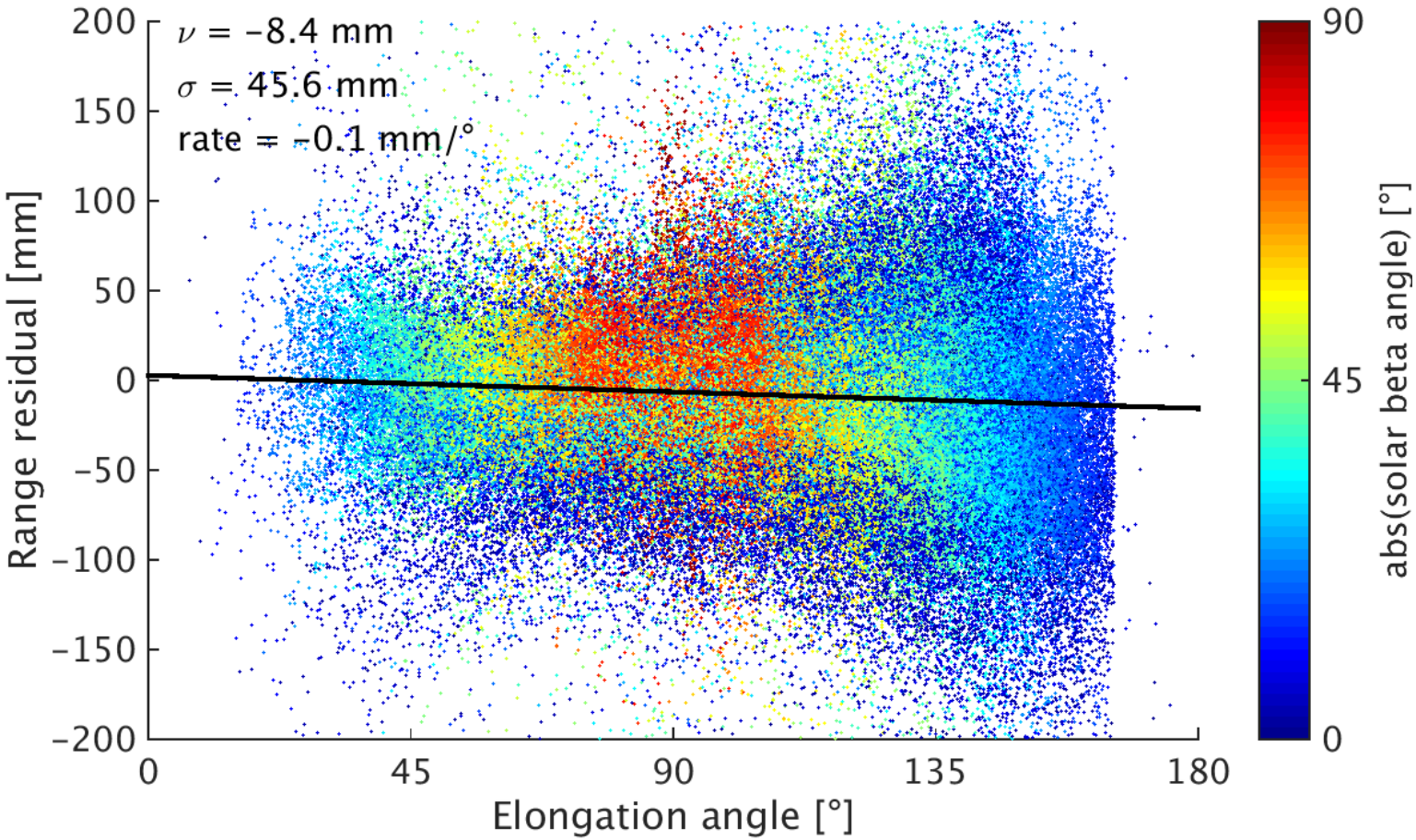
- SLR residuals w.r.t. microwave-based GLONASS-M orbits for the time span 2003 to 2014 (old ECOM):



ν . . . mean value
σ . . . standard deviation

GNSS orbit validation (3)

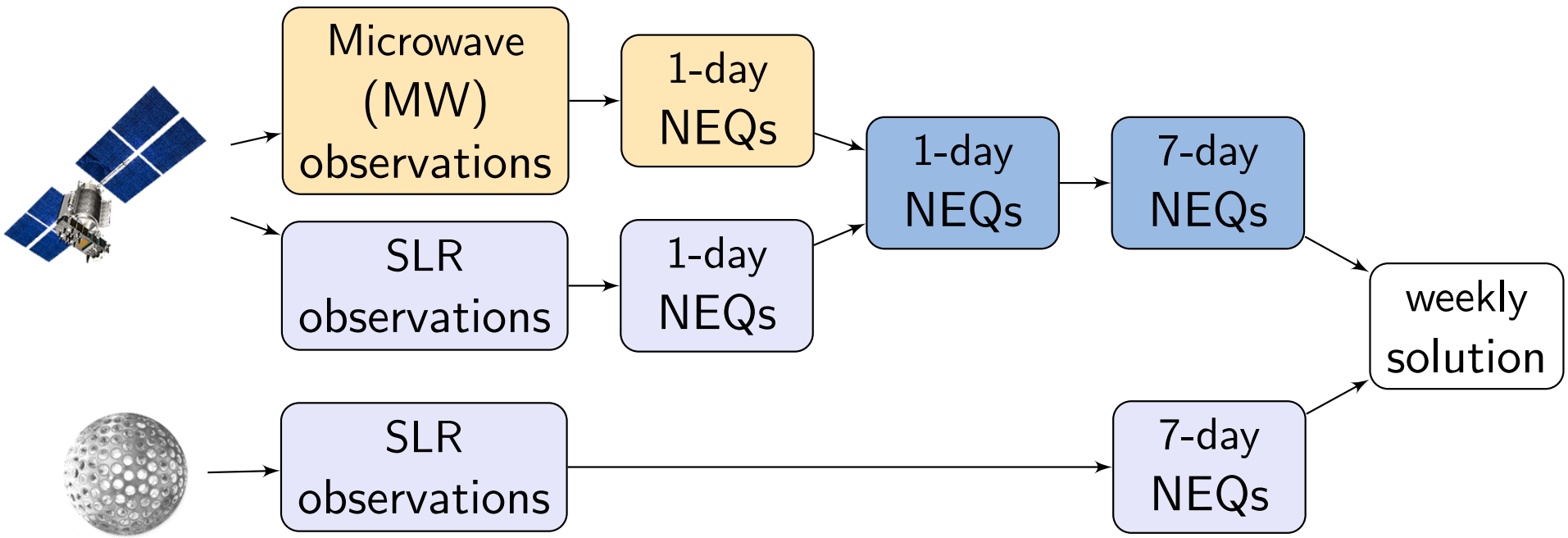
- SLR residuals w.r.t. microwave-based GLONASS-M orbits for the time span 2003 to 2014 (new ECOM):



ν . . . mean value
σ . . . standard deviation

Combined reference frame (1)

- current status: reference frame derived from GNSS data
- instead: reference frame derived from both GNSS and SLR data
- workflow to derive a combined reference frame:

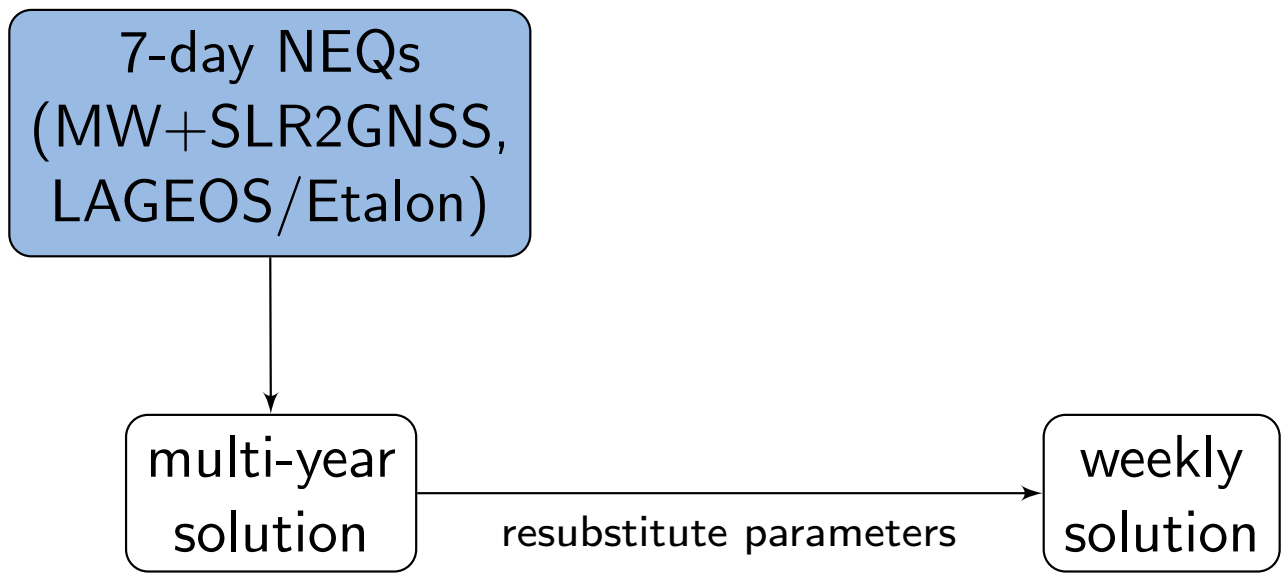


- output of weekly solution: station coordinates, orbits, Earth rotation parameters, geocenter coordinates

Combined reference frame (2)

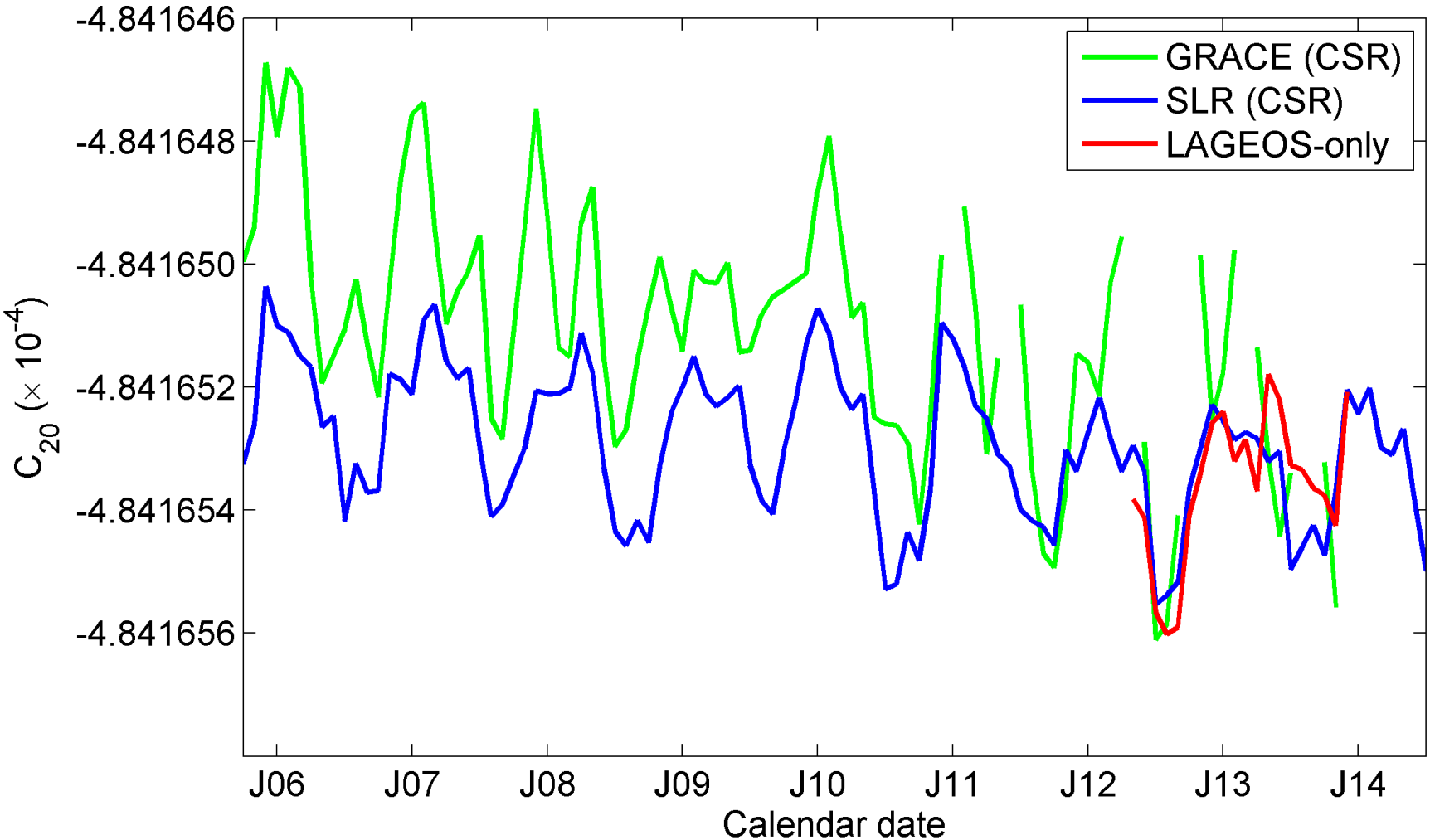
- issues with weekly solutions
  - range biases,
  - satellite antenna offsets, and
  - laser retroreflector array offsets are not well determined

$\Rightarrow$ create multi-year solution and re-substitute range biases and offsets to generate improved weekly solutions



Gravity field coefficients from SLR (1)

- satellites to be analyzed:
  - LAGEOS 1/2
  - Ajisai, Stella, Starlette, Lares (LEOs)
- arc length:
  - 10 days for LAGEOS 1/2
  - 1 day for LEOs
- estimated arc parameters:
  - empirical parameters:
    - constant and 1/rev in along track for LAGEOS 1/2
    - constant and 1/rev in along track, 1/rev cross track for LEOs
  - pseudo-stochastic pulses:
    - 1/rev in along track for LEOs (none for LAGEOS)
- estimated global parameters:
  - gravity field coefficients up to degree/order $\sim$6
  - station coordinates
  - geocenter coordinates
  - Earth rotation parameters
  - range biases

Gravity field coefficients from SLR (2)

- C_{20} (Earth's flattening):