

Simulation of realistic SLR observations to optimize tracking scenarios

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Introduction: Overview

- Simulation of Satellite Laser Ranging measurements to GNSS and geodetic satellites.
- Calculation of pseudorange due to geometry, then apply:
 - Corrections
 - Noise
- Synthetic observations upon which comparison and optimization can be done.
- Impact of target selection.

Introduction: Procedure

- Bernese GNSS Software.
- Independent noise generation for each observation.
 - Adding/removing satellites at other epochs.
 - Exchanging satellites at specific epoch.
- Observation selection separate from simulation.

Introduction– ILRS Tracking Campaigns

- **Campaign1: August 01 – September 30, 2014**
 - All GNSS satellites (on ILRS priority list, 18 satellites); more if able
 - Three sets of two normal points distributed over transit; normal point includes 1000 FR points or last 5 minutes, whichever is shorter
- **Campaign2: November 22,2014– February 28, 2015**
 - Six GLONASS as first priority, Beidou and Galileo as second priority , remaining GLONASS as third priority
 - minimum three segments along each pass with three NPTs in each segment
- **Campaign3: August 20 – October 16, 2015**
 - Six GLONASS as first priority, Compass-M3 and Galileo as second priority, remaining GLONASS as third priority
 - Nine NPTs over the pass; 3 during the ascending/early region, 3 in the central region, 3 in the descending/late region of the pass

Introduction– ILRS Tracking Campaigns

- **Common Results**
 - Need more data
 - Few stations could fulfill requirements all the time
 - More daylight data
- **ILRS can handle tracking of all the required satellites (for now).**
- **Simulation might give a definite answer in future.**

Simulation– Requirements

- Ability to generate synthetic SLR measurements to satellites in form of NP.
- Include station/satellite specific noise handling.
- +- Based on final orbit products (or predictions).
- Possibility to alter observations as needed.
- Lie within the accuracy requirements of the ILRS.

Simulation – Implementation

- Separate SLR mode within Bernese GNSS Software Simulation tool.
 - Selectable noise
 - Selectable stations
 - Selectable observation list
- Result are range observation files.

Simulation – Observation Selection

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YYYY	MM	DD	STAT	TIME IN SECONDS	PRN	
****	**	**	****	*****	***	*
2015	05	06	7810	32046.185902247878	108	1
2015	05	06	7810	32126.060302248032	108	1
2015	05	06	7810	34742.648702320352	107	1
2015	05	06	7810	34862.552302311269	107	1
2015	05	06	7810	35154.578702318162	107	1
2015	05	06	7810	36243.455102316861	108	1
2015	05	06	7810	36376.229502318871	108	1
2015	05	06	7810	40050.113102219737	111	1
2015	05	06	7810	50219.056302341145	111	1
2015	05	06	7810	51928.352112342225	121	1
2015	05	06	7810	51932.583932335045	121	1
2015	05	06	7810	51936.500912335854	121	1
2015	05	06	7810	51942.945872333563	121	1
2015	05	06	7810	51946.872112332734	121	1
2015	05	06	7810	51951.641012342428	121	1
2015	05	06	7810	51958.623052340256	121	1
2015	05	06	7810	51962.188152332608	121	1
2015	05	06	7810	51967.808972341074	121	1
2015	05	06	7810	51972.374152341465	121	1
2015	05	06	7810	51977.856072334798	121	1
2015	05	06	7810	51982.106412339985	121	1
2015	05	06	7810	51987.792052336998	121	1
2015	05	06	7810	51992.042392342613	121	1
2015	05	06	7810	51997.524312334826	121	1
2015	05	06	7810	52001.691312335461	121	1
2015	05	06	7810	52007.451032332443	121	1
2015	05	06	7810	52018.155592334660	121	1
2015	05	06	7810	52022.054052340201	121	1
2015	05	06	7810	52027.526712332408	121	1
2015	05	06	7810	52031.951052338896	121	1
2015	05	06	7810	52037.587572334320	121	1
2015	05	06	7810	52042.560972338986	121	1
2015	05	06	7810	52047.119922336395	121	1
2015	05	06	7810	52052.738022335390	121	1
2015	05	06	7810	52056.818052335875	121	1
2015	05	06	7810	52061.561202337041	121	1
2015	05	06	7810	54224.806702237183	123	1
2015	05	06	7810	61700.233082270584	124	1
2015	05	06	7810	62868.262582268966	113	1
2015	05	06	7810	63549.433102269177	113	1
2015	05	06	7810	63843.317902267241	113	1
2015	05	06	7810	63903.531902260132	113	1
2015	05	06	7810	78878.631902225781	103	1
2015	05	06	7810	79022.709502223472	103	1
2015	05	06	7810	79281.893502318562	102	1
2015	05	06	7810	79286.484302322424	102	1

Simulation – Noise

- **White noise**
 - Selectable
 - Elevation dependent sigmas
 - Repeatable
- +- **Normal distributed noise**
 - Different parameters for each station/satellite combination.
 - Resembling bin RMS found in NP files.

Simulation – First Results

- **First Results**
 - **Without noise**
 - **White noise**
 - **Normal distributed noise**

Simulated observation file

```
GPSSIM2      : simulate SLR data to GNSS satellites 18433
MEASUREMENT TYPE: RANGE          CREATED : 26-MAY-16 15:37
REFERENCE EPOCH : 2015-05-06 0:37:43 (126) MODIFIED: 26-MAY-16 15:37

# DIFFERENCES   ::    0      FORMAT NUMBER   ::    6
# FREQUENCIES   ::    1      SESSION IDENTIFIER :: 126S
# SATELLITES    ::    0      SUBSESSION IDENTIF.: S
# EPOCHS        :: 77051     OBS. INTERVAL (S)  :: 1.000000
# FLAGGED EPOCHS::    0      REMARK NUMBER    ::    0

STATION NAME   :: ZIMM 14001S007
OPERATOR NAME   :: 
RECEIVER TYPE   :: SIMULA DEFAULT
ANTENNA TYPE    :: SIMULA      NONE
RECEIVER/ANTENNA:    0 /    0

CLOCK CORRECTION: POLYNOMIAL DEG 0

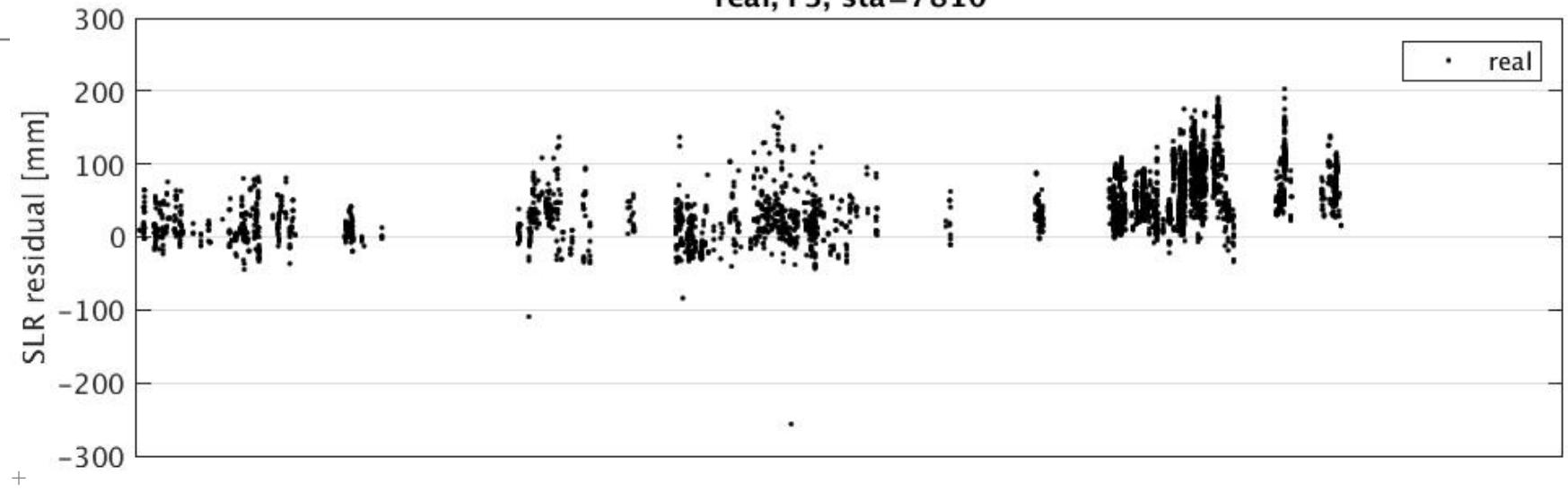
POS.ECCENTR. (M): 0.0000  0.0000  0.0000
SAT #L1-OBS OK #L1-OBS BAD #L2-OBS OK #L2-OBS BAD  Station1  Station2
      #L1-OBS OK #L1-OBS BAD #L2-OBS OK #L2-OBS BAD  Obstype1  Obstype2  Obstype1  Obstype2

L1,L2 OBSERVATIONS:
OBS.N TIME F #S RANGE (M) FFS SA ... AT THE END: DATE, FRACT.(S), CLOCK (S)
  1 8:54:06 1 21468293.625 0 108 15-05-06 0.000000000 -0.000000000
  121 8:55:26 1 21555114.393 0 108 15-05-06 0.000000000 -0.000000000
  413 9:39:02 1 21771033.657 0 107 15-05-06 0.000000000 -0.000000000
  903 9:41:02 1 19687406.544 0 107 15-05-06 0.000000000 -0.000000000
  983 9:45:54 1 19660905.183 0 107 15-05-06 0.000000000 -0.000000000
  5100 10:04:03 1 19554801.692 0 108 15-05-06 0.000000000 -0.000000000
  5233 10:06:16 1 19595476.023 0 108 15-05-06 0.000000000 -0.000000000
  19701 11:07:30 1 19678965.284 0 111 15-05-06 0.000000000 -0.000000000
  26550 13:56:59 1 21223037.746 0 111 15-05-06 0.000000000 -0.000000000
  26555 14:25:28 1 21225342.651 0 121 15-05-06 0.000000000 -0.000000000
  26562 14:25:32 1 21228575.446 0 121 15-05-06 0.000000000 -0.000000000
  26576 14:25:36 1 21235060.791 0 121 15-05-06 0.000000000 -0.000000000
  26582 14:25:42 1 21237848.203 0 121 15-05-06 0.000000000 -0.000000000
  26586 14:25:46 1 21239709.436 0 121 15-05-06 0.000000000 -0.000000000
```

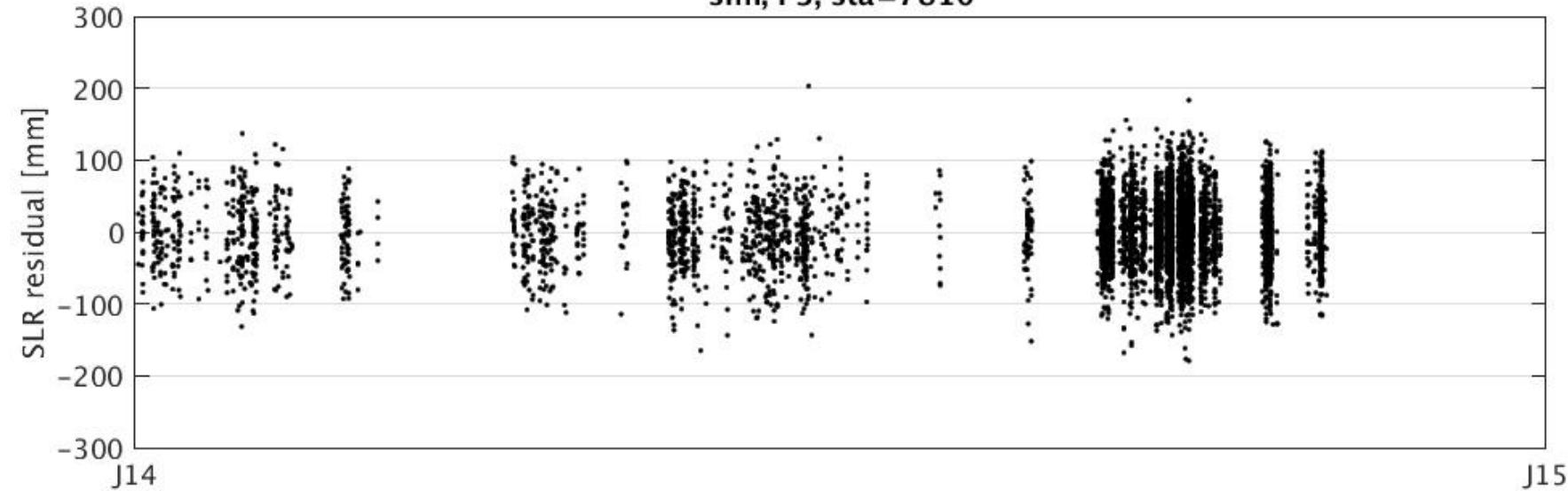
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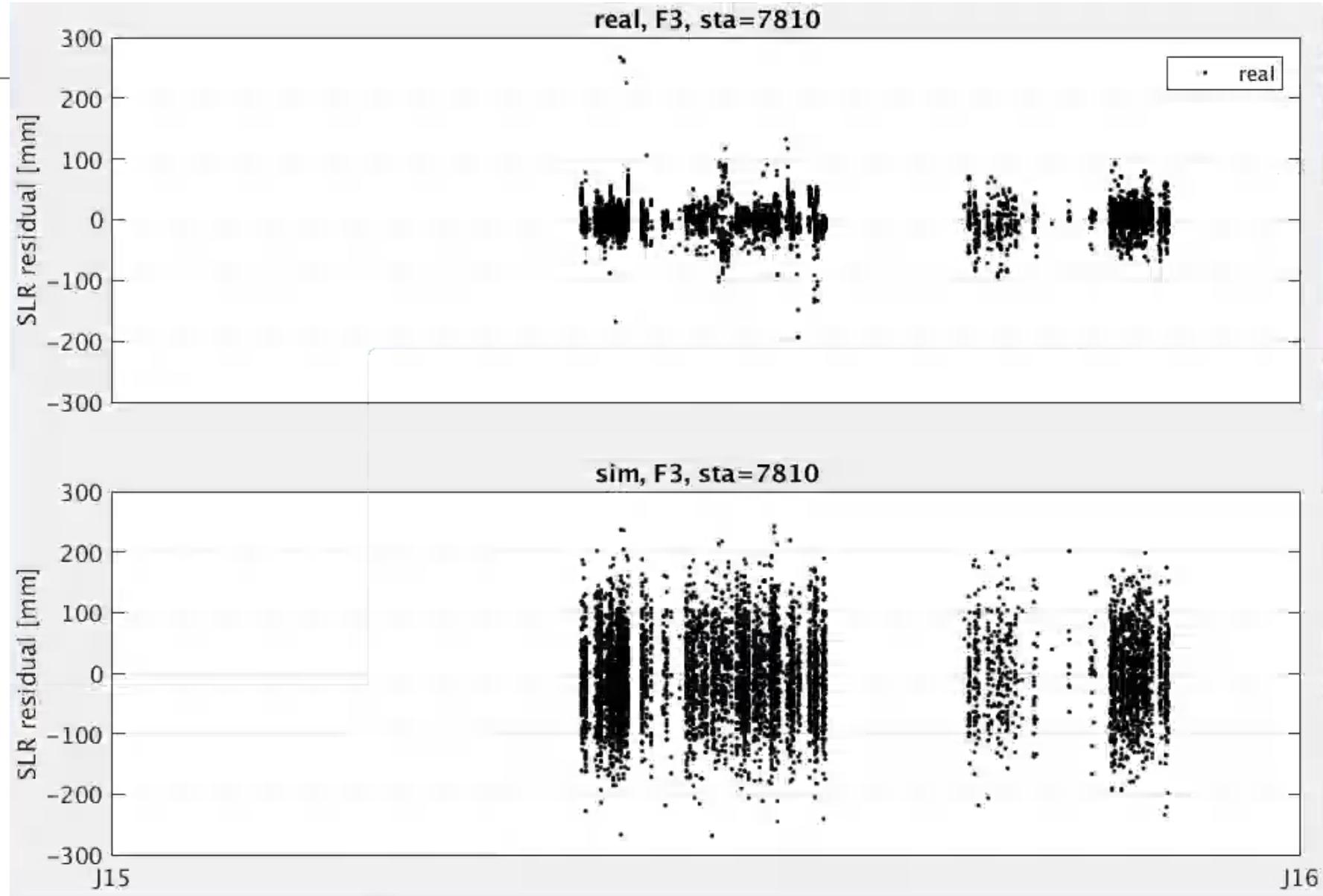
White noise

real, F3, sta=7810



sim, F3, sta=7810





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Normal distributed noise

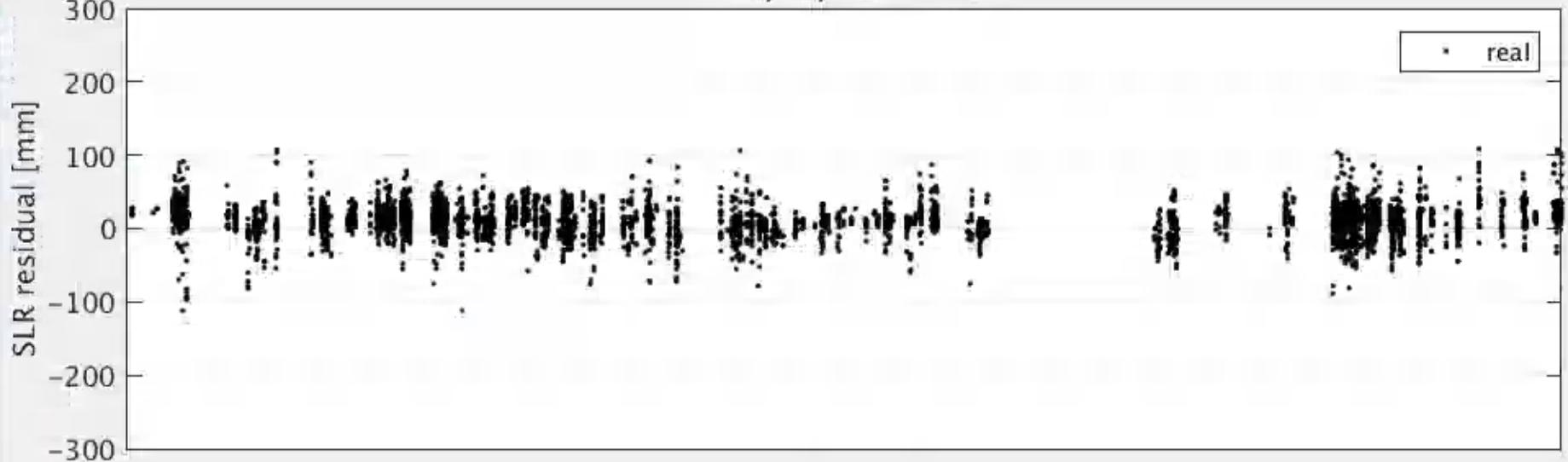
Noise parameters

+

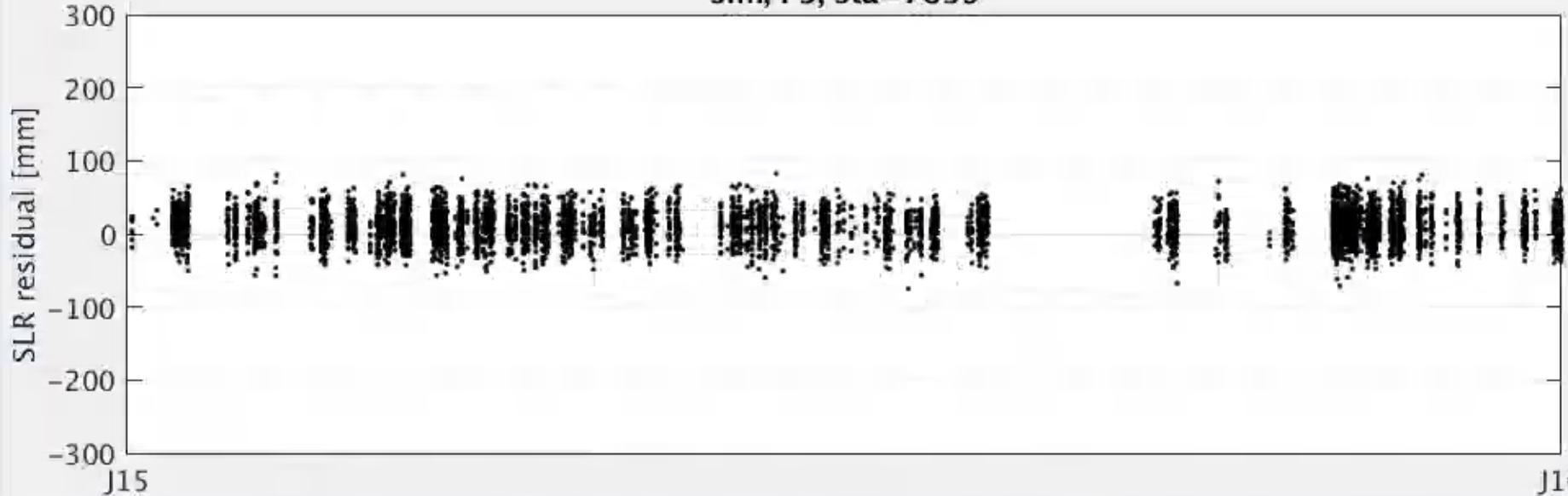
Noise parameters

+

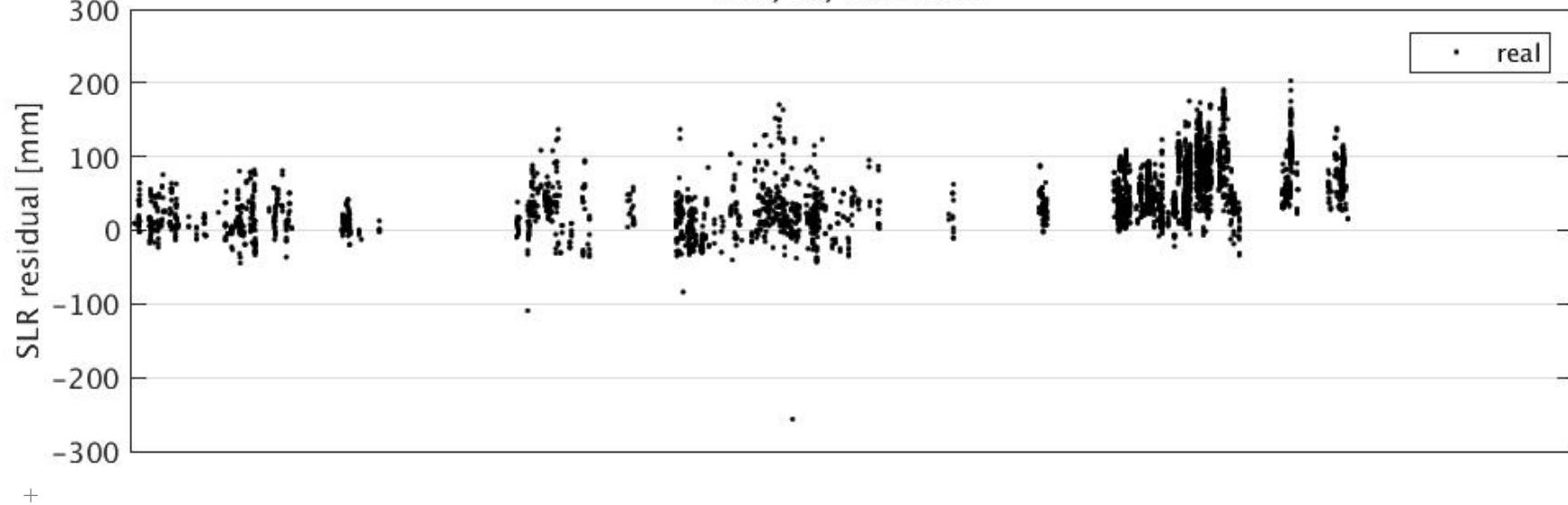
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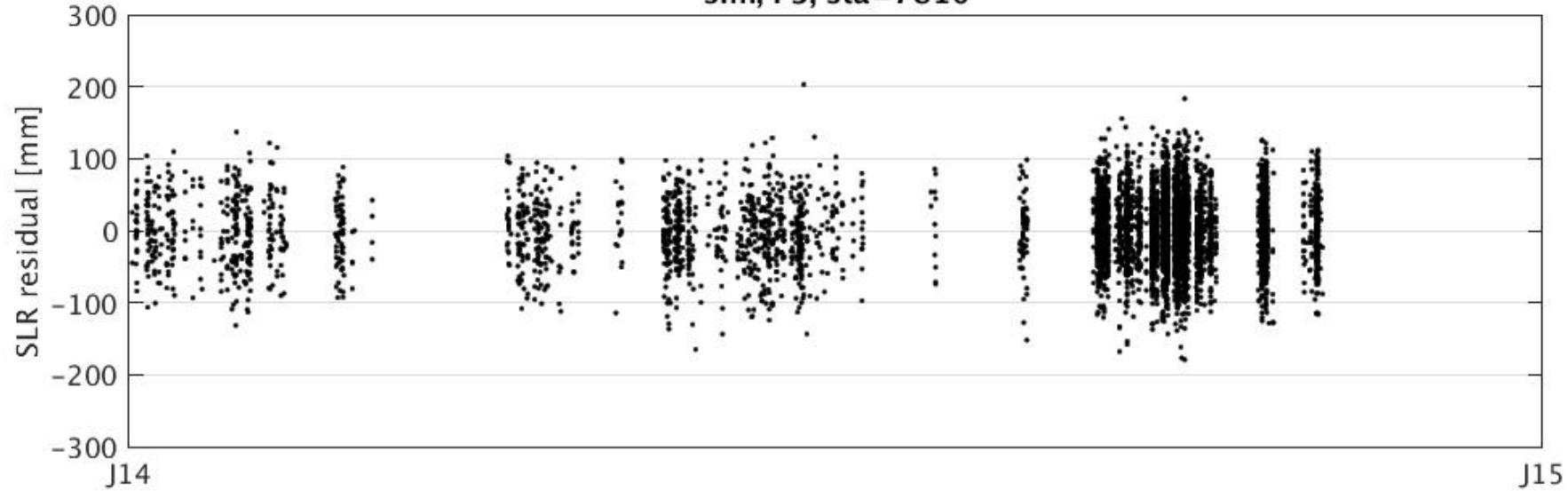
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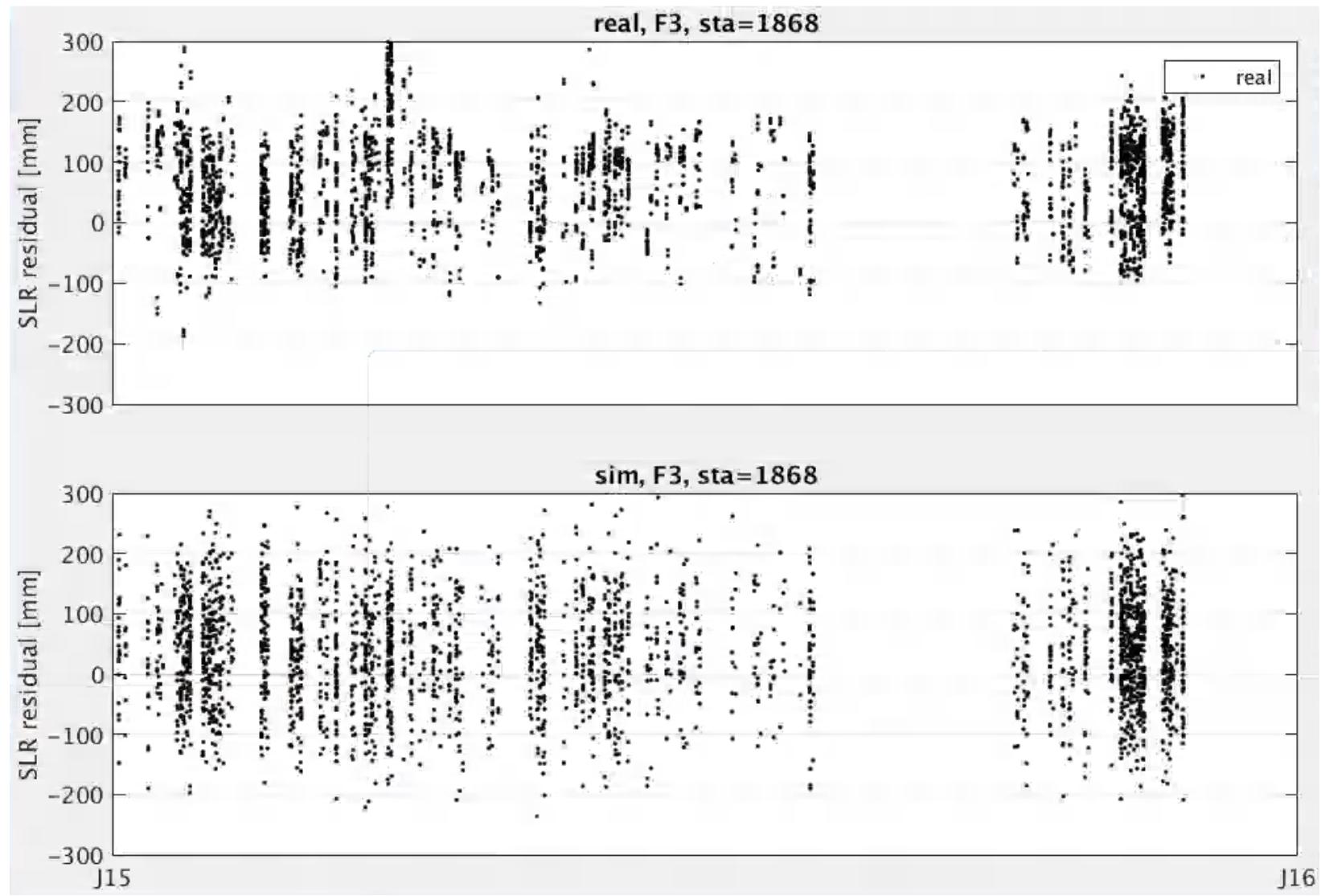


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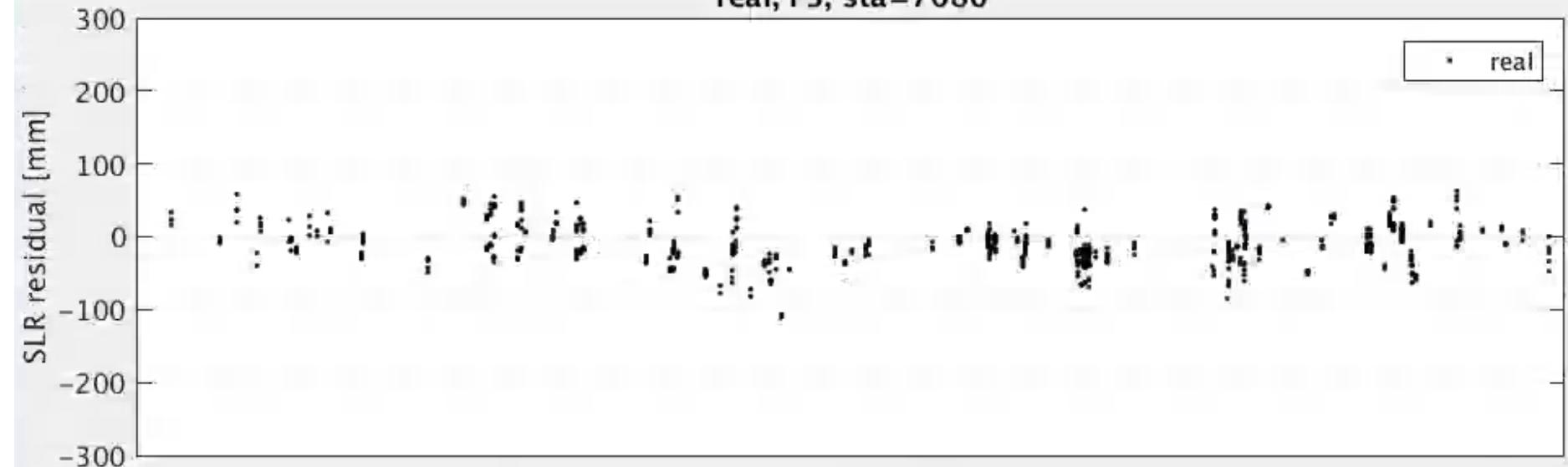


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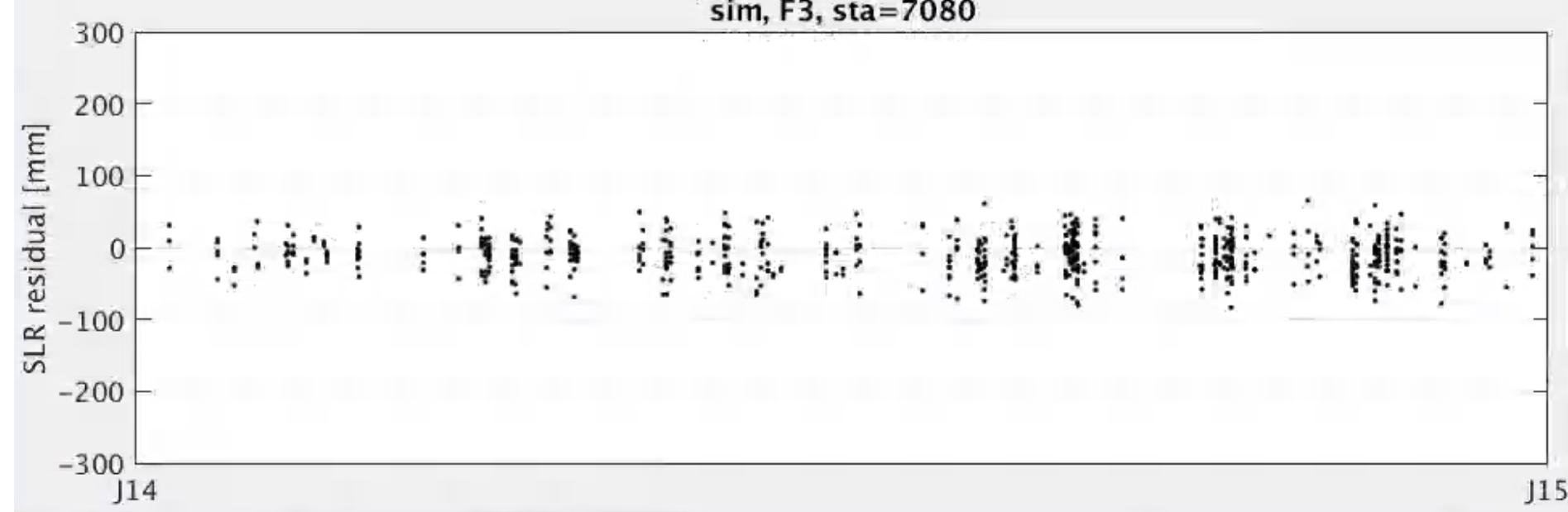




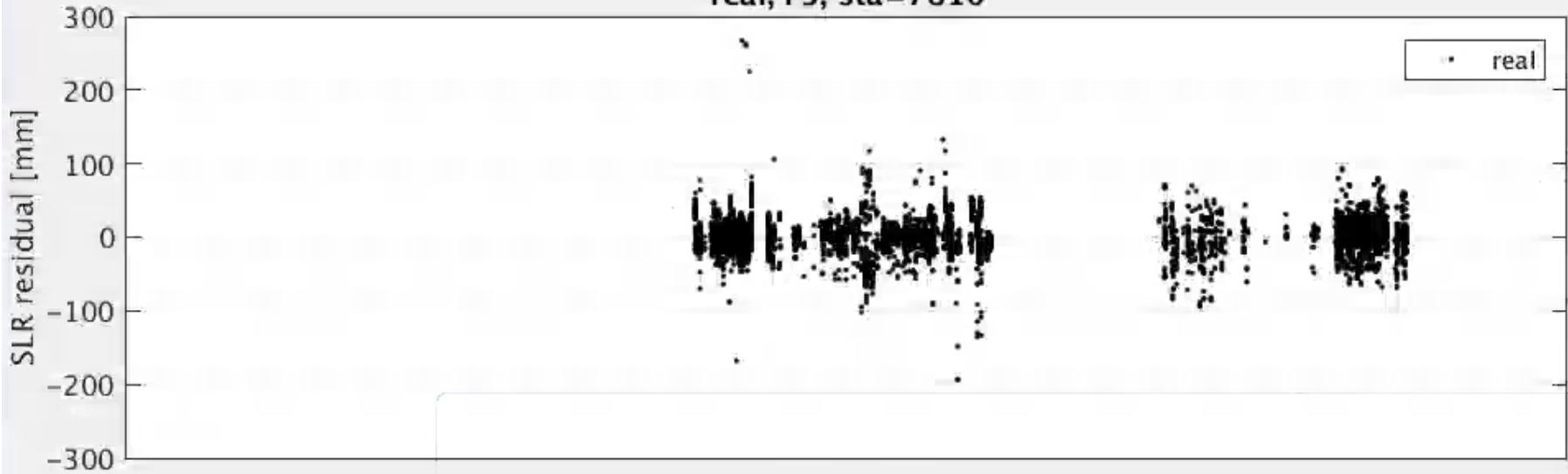
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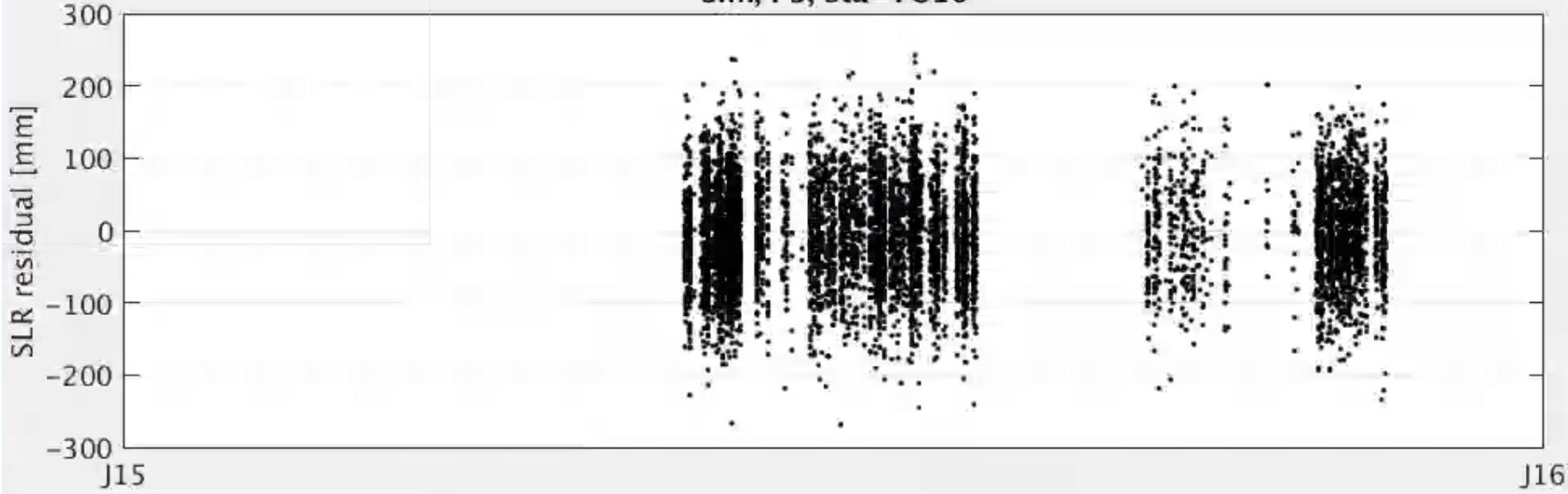
sim, F3, sta=7080



real, F3, sta=7810



sim, F3, sta=7810



Conclusions & Outlook

- Promising results that compare well in terms of residuals for existing observations.
- Different tracking strategies will be generated and used for comparison
- Investigating the impact of reducing observations to specific satellites in favor of more observations to others

Thank you for your attention.

References

- Dach, R., S. Lutz, P. Walser, P. Fridez (Eds); 2015: Bernese GNSS Software Version 5.2. User manual, Astronomical Institute, Universtiyy of Bern, Bern Open Publishing. DOI: 10.7892/boris.72297; ISBN: 978-3-906813-05-9.
- Pearlman, M.R., Degnan, J.J., and Bosworth, J.M., "The International Laser Ranging Service", Advances in Space Research, Vol. 30, No. 2, pp. 135–143, July 2002, DOI:10.1016/S0273-1177(02)00277-6.