

Impact of range biases on global reference frames

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Motivation

- Bias are still a problem in SLR analysis
 - Stations (calibration, hardware, ...)
 - Analysis (models, software,)
- What do we see on from the analysis side
- Do Biases influence the terrestrial reference frame?
 - Scale
 - Origin
- DGFI is one of the ITRF combination centres and we are using our combination software to compute terrestrial reference frames.
- DGFI acts as Q/C centre within ILRS
- Therefore we are interested in the stability of SLR stations back to 1983.

Background

- Present ILRS/AWG solutions assume core stations bias free resp. for few stations fixed biases for a specific period
- The ILRS Data Handling File includes a list of biases for a number of stations
(http://ilrs.dgfi.tum.de/data_handling/ILRS_Data_Handling_File.snx)
- Additionally some analysis centres allow weekly biases for non core stations
- Have biases an influence on the scale of the global reference frame?
- Do we have to solve for biases for all stations in the ILRS/AWG solutions?

Procedure

- To avoid correlations between biases through the orbit
 - Step 1: Processing of range biases for each station individually fixing the other stations in orbit for the satellites Lageos1 and Lageos2
 - Step 2: Reprocessing using the biases from step 1 with the same processing scheme
- Processing of weekly resp. 15day arcs, fixing the biases from step 2
- Stacking of single arcs normal to a combined multiyear solution, same procedure as for the DTRF solutions
- To verify the biases the procedure was repeated with Lares, Starlette, Ajisai, Etalon1 and Etalon2
- We analysed various effects on the resulting biases
 - CoM correction
 - Non tidal loading (not finished)

Solution setup

- ❑ 3 different types of solutions
 - **SLRF** TRF solution with biases handled according to consequently maintained ILRS data handling file (ILRS processing standards)
 - **BIAS** TRF solution with fixed 'previously' estimated biases for each station
 - **BIASFREE** TRF solution with biases estimated for each station (constrained with 1cm)
- ❑ observations to Lageos 1 and 2 are used
- ❑ weekly normal equations (NEQs) contain
 - 3D station coordinate offsets
 - 2D terrestrial pole coordinate offsets @ 0h epochs
 - LOD offsets @ 12h epochs (originally parameterized as UT1 offsets @ 0h epochs)
 - (satellite-specific initial state vectors, orbit parameters and possible station biases are reduced from the NEQ)
- ❑ 2 time periods considered
 - 1982.5 – 2015.0 (1982.5 – 1993.0 → only LA1 observations available)
 - 1993.0 – 2015.0

Bias analysis

Mean biases for ILRS core stations Lageos1

	1983 - 2000			2000 - 2015		
7080	-0.04	+-	2.76	-0.12	+-	1.54
7090	0.01	+-	1.42	0.21	+-	0.97
7105	-0.15	+-	1.64	-0.18	+-	1.40
7109	0.78	+-	2.21	0.00	+-	0.00
7110	0.25	+-	1.84	0.40	+-	1.27
7119				0.22	+-	1.83
7210	-1.41	+-	3.77	-0.40	+-	2.52
7237	0.28	+-	4.49	-0.97	+-	2.75
7403	-0.13	+-	1.73	1.51	+-	2.36
7501	-0.10	+-	1.42	0.33	+-	1.23
7810	-0.61	+-	3.15	-0.36	+-	2.04
7810	-0.61	+-	3.15	-0.36	+-	2.04
7825				0.67	+-	0.95
7832				0.37	+-	0.98
7835	1.55	+-	2.23	0.37	+-	0.90
7836	0.72	+-	1.22	0.59	+-	0.94
7837	0.76	+-	7.02	0.20	+-	1.53
7839	-1.43	+-	3.05	0.38	+-	0.81
7840	-0.09	+-	1.98	-0.23	+-	1.42
7849	0.35	+-	0.95	0.21	+-	1.03
7907	-2.60	+-	5.31			
7939	-1.05	+-	4.20			
7941	0.00	+-	0.00	0.23	+-	1.13
8834	1.50	+-	3.75	0.27	+-	1.20

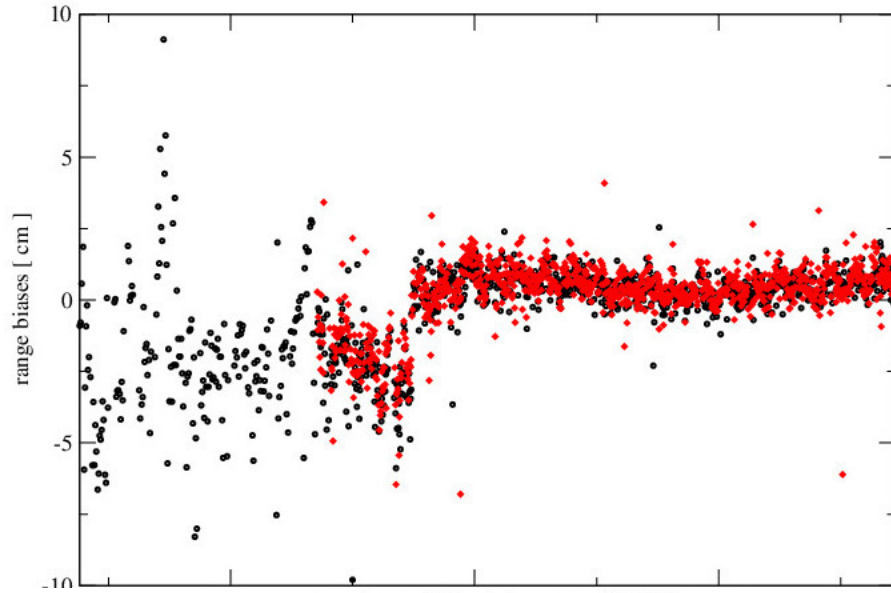
Bias analysis

Mean biases for ILRS core stations Lageos2

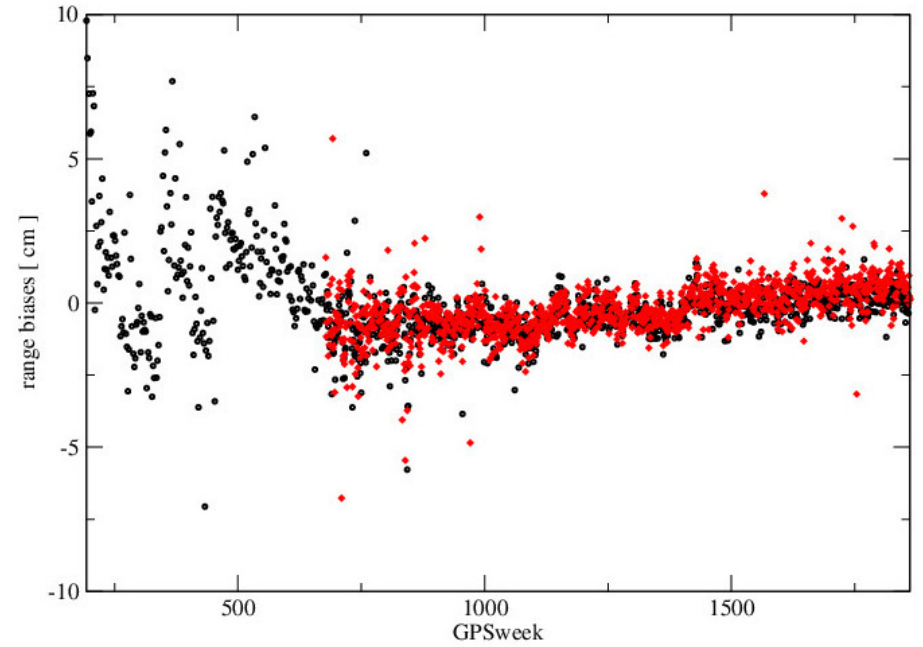
	1993 - 2000			2000 - 2015		
7080	-0.03	+-	1.65	-0.04	+-	1.49
7090	0.01	+-	1.20	0.31	+-	0.89
7105	0.11	+-	1.36	-0.11	+-	1.36
7109	-0.09	+-	3.16	0.00	+-	0.00
7110	0.13	+-	2.10	0.56	+-	1.40
7119				0.18	+-	1.88
7210	-1.94	+-	3.60	-0.40	+-	2.18
7237	0.18	+-	4.49	-1.00	+-	3.08
7403	-0.14	+-	1.71	1.16	+-	2.25
7501	-1.54	+-	2.79	0.36	+-	1.24
7810	-0.75	+-	2.76	-0.20	+-	1.87
7810	-0.75	+-	2.76	-0.20	+-	1.87
7825				0.92	+-	0.87
7832				0.51	+-	0.90
7835	1.83	+-	2.01	0.53	+-	0.84
7836	0.91	+-	1.13	0.80	+-	0.80
7837	0.53	+-	5.74	0.42	+-	1.48
7839	-0.57	+-	2.13	0.48	+-	0.78
7840	-0.50	+-	1.70	-0.04	+-	1.28
7841				0.60	+-	1.10
7849	0.23	+-	1.08	0.19	+-	1.03
7939	-0.99	+-	4.19	-0.14	+-	9.48
7941				0.39	+-	1.09
8834	2.59	+-	2.89	0.46	+-	1.14

Bias analysis

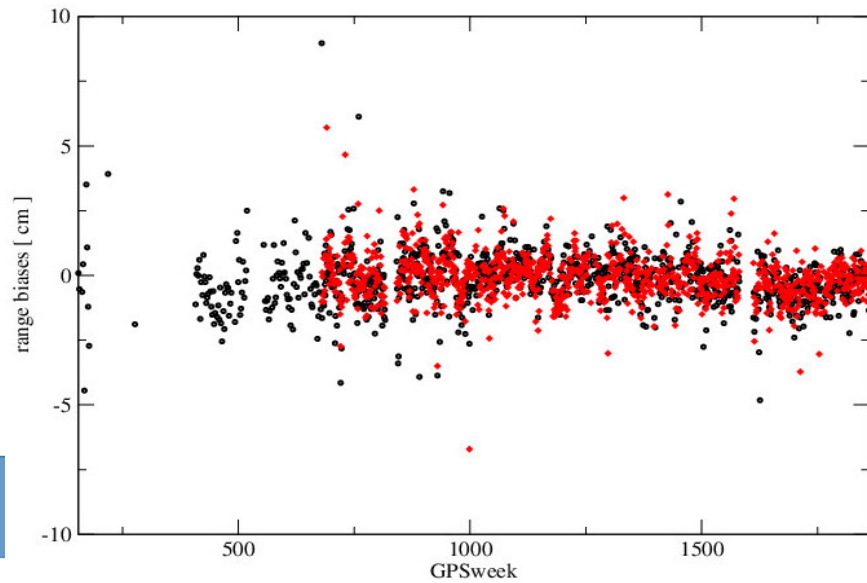
station: Graz, Aust (7839)



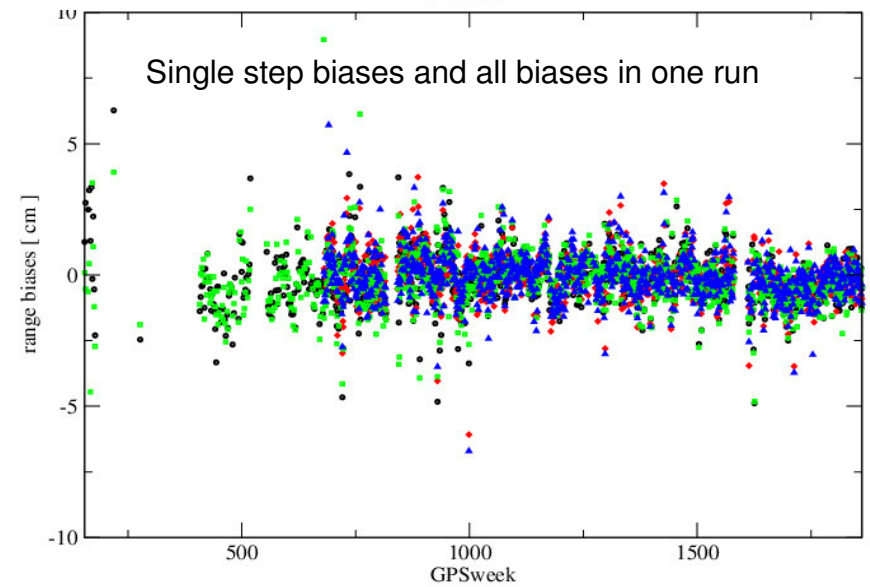
station: Herstmonce (7840)



station: Washington (7105)



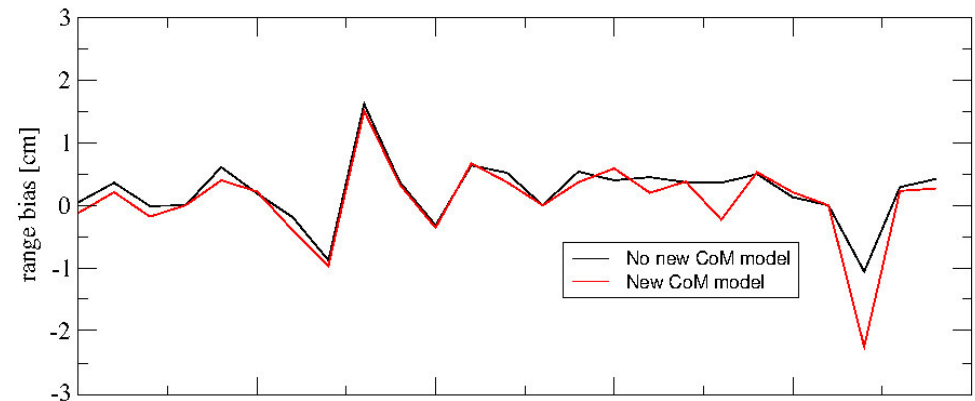
Single step biases and all biases in one run



Bias analysis

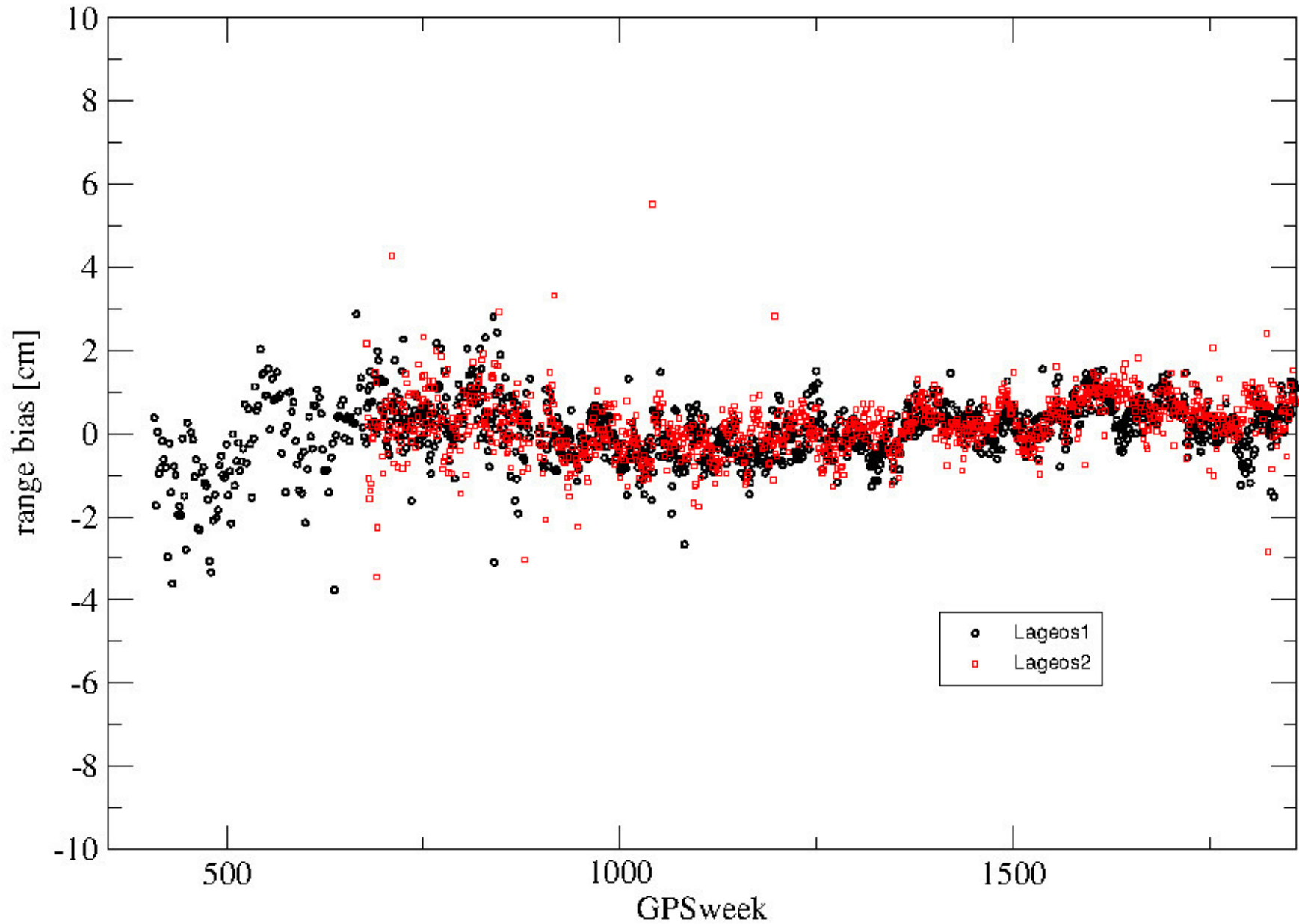
Range biases with old (251 mm) and with new CoM model

	1983 - 2000		2000 - 2015	
7080	0.00	-0.04	0.05	-0.12
7090	0.22	0.01	0.36	0.21
7105	0.02	-0.15	-0.01	-0.18
7109	0.63	0.78		
7110	0.45	0.25	0.61	0.40
7119	0.00	0.00	0.19	0.22
7210	-1.30	-1.41	-0.19	-0.40
7237	0.48	0.28	-0.88	-0.97
7403	0.09	-0.13	1.62	1.51
7501	0.15	-0.10	0.37	0.33
7810	-0.32	-0.61	-0.32	-0.36
7825	0.00	0.00	0.64	0.67
7832	0.00	0.00	0.52	0.37
7835	1.49	1.55	0.54	0.37
7836	0.27	0.72	0.40	0.59
7837	0.74	0.76	0.45	0.20
7839	-1.49	-1.43	0.37	0.38
7840	0.34	-0.09	0.36	-0.23
7841	0.00	0.00	0.50	0.53
7849	0.36	0.35	0.13	0.21
7907	-2.99	-2.60		
7939	0.01	-1.05	-1.06	-2.26
7941	0.00	0.00	0.29	0.23
8834	1.67	1.50	0.42	0.27

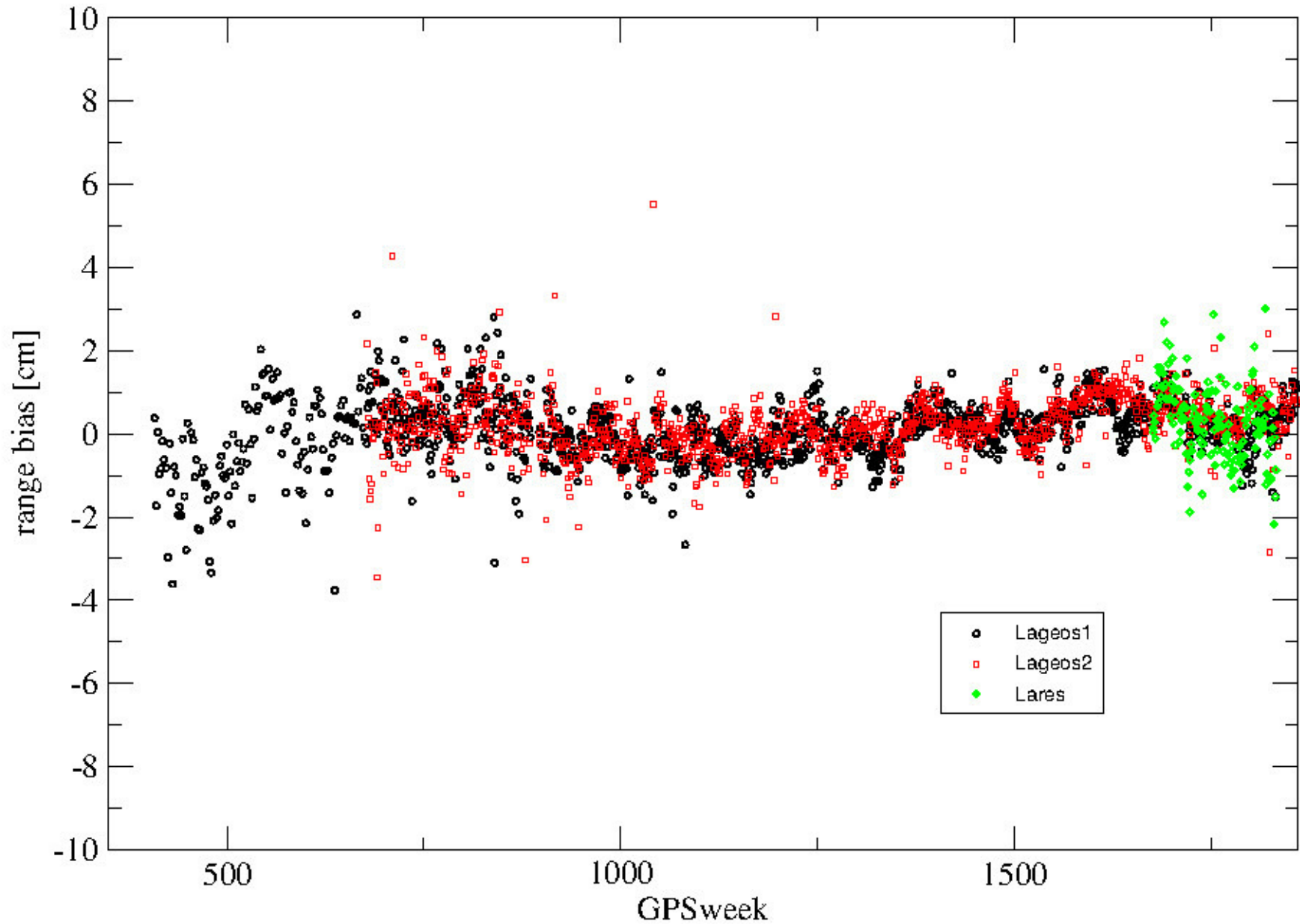


Core stations numerical ordered

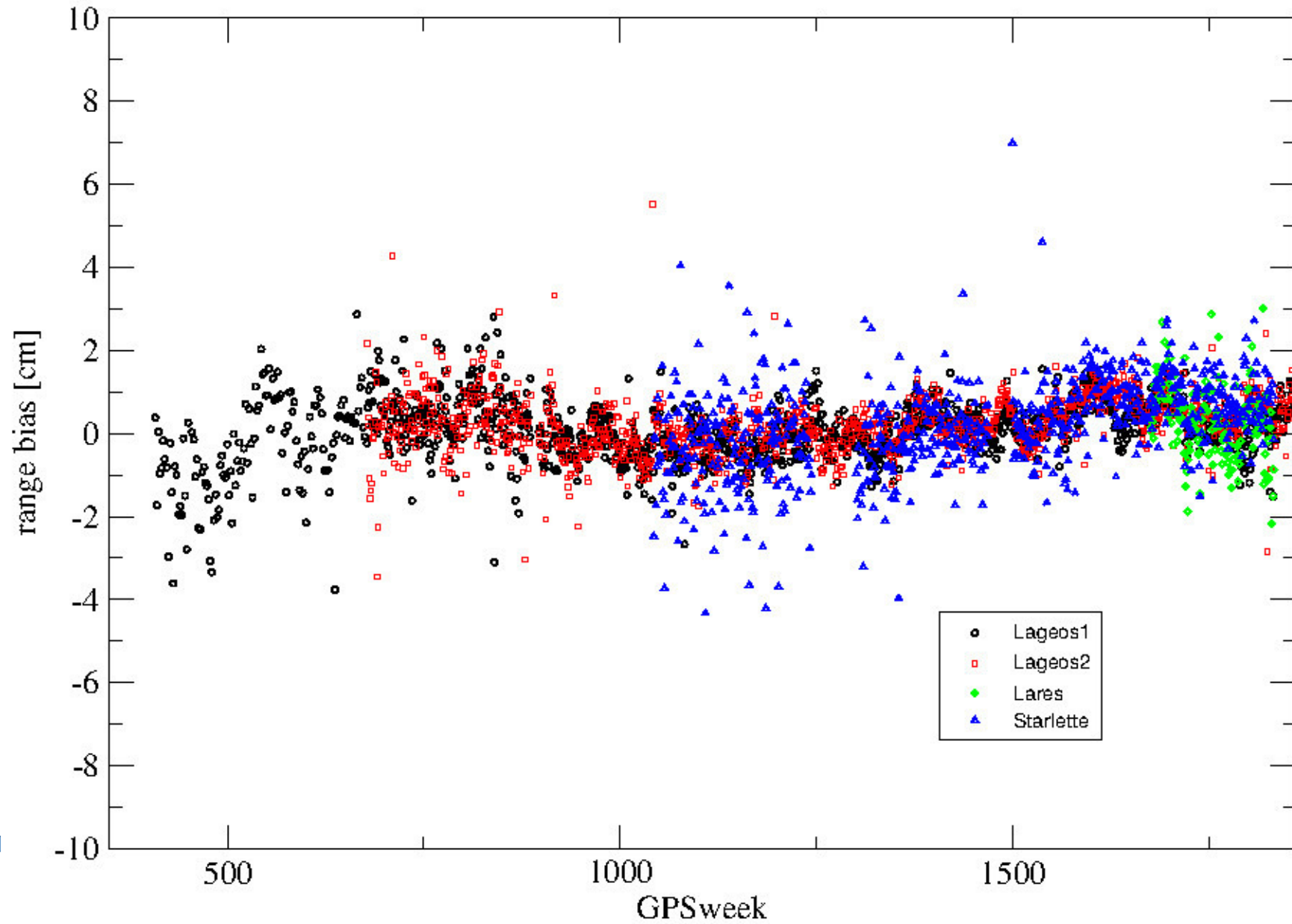
Bias analysis Yarragadee (7090) biases



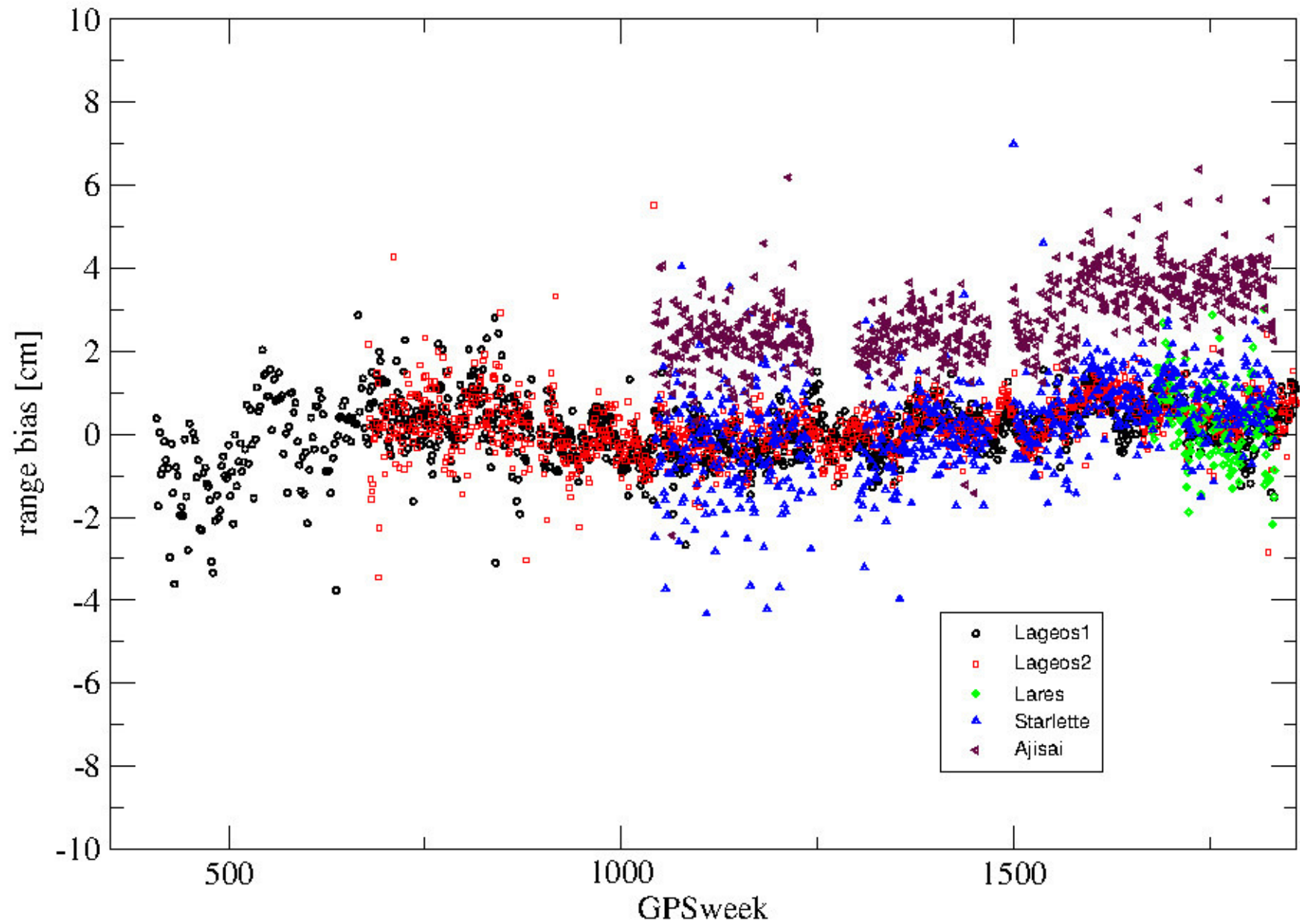
Bias analysis Yarragadee (7090) biases



Bias analysis Yarragadee (7090) biases

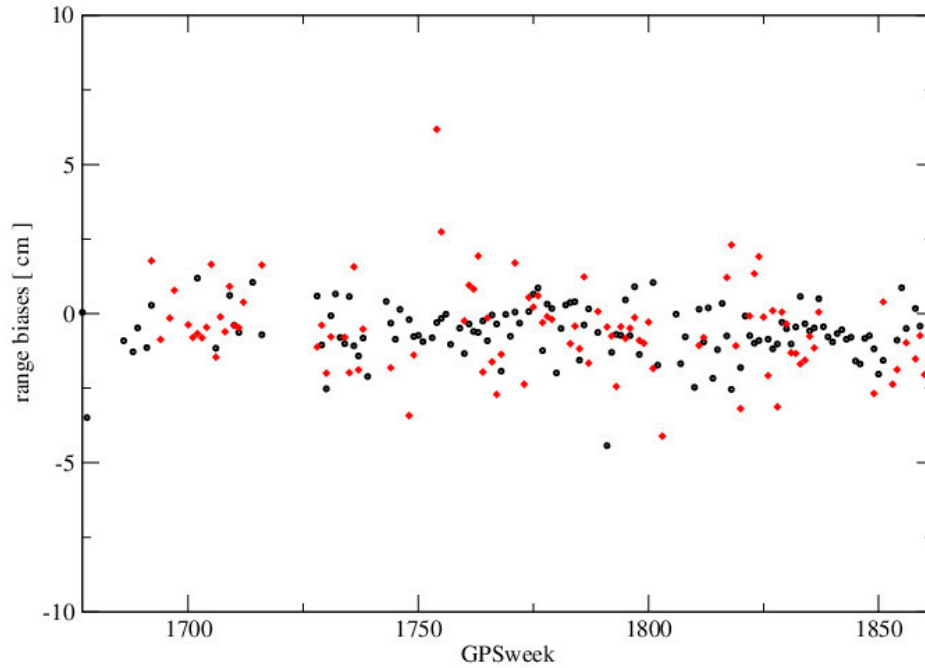


Bias analysis Yarragadee (7090) biases

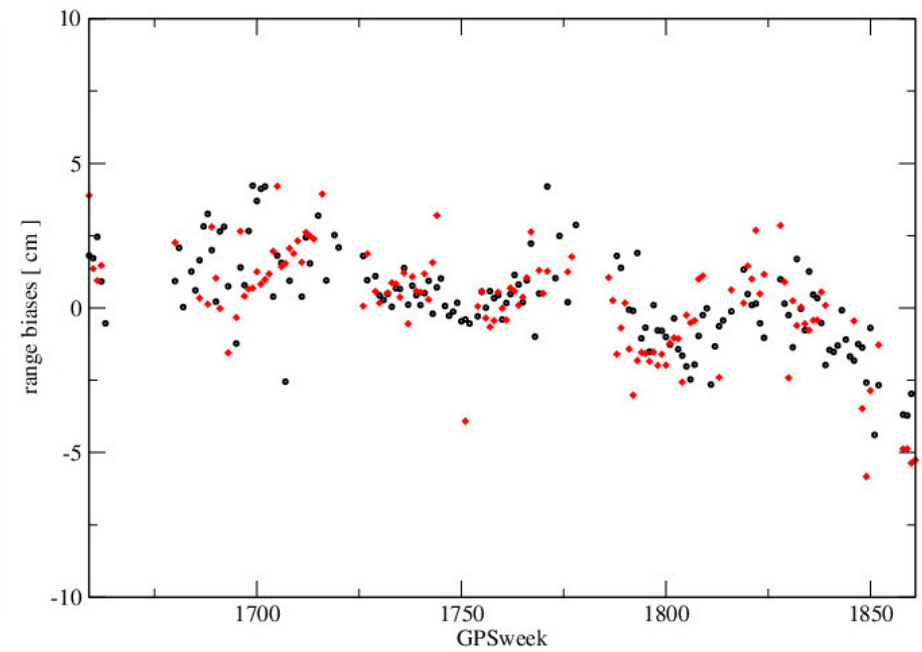


Bias analysis

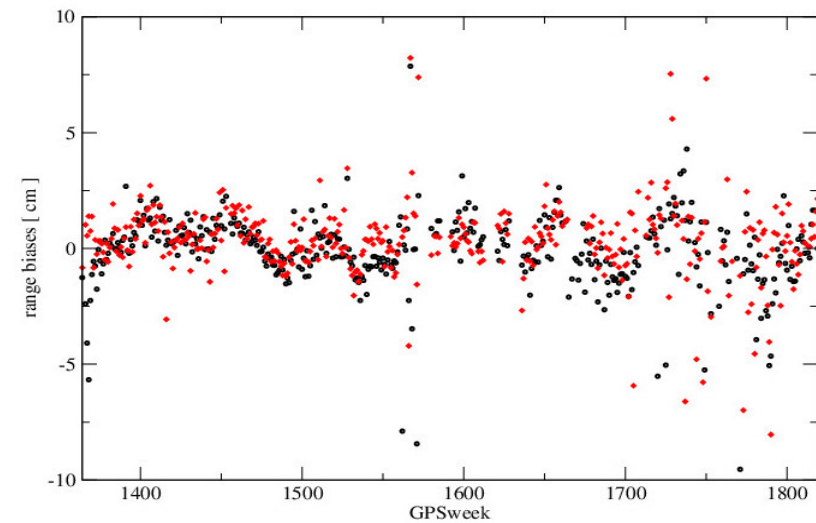
station: Badary (1890)



station: Baikonur (1887)

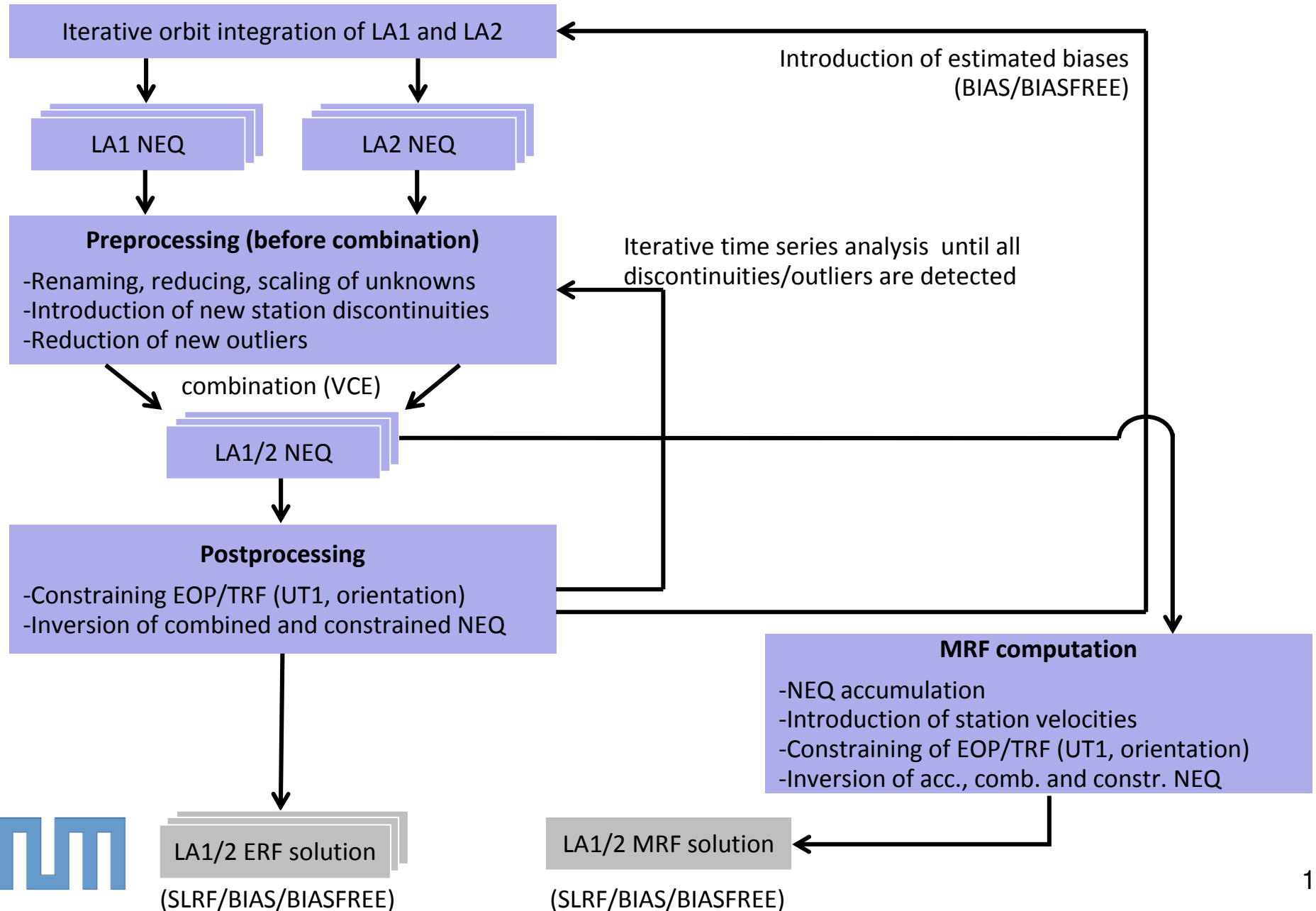


station: San Juan, (7406)



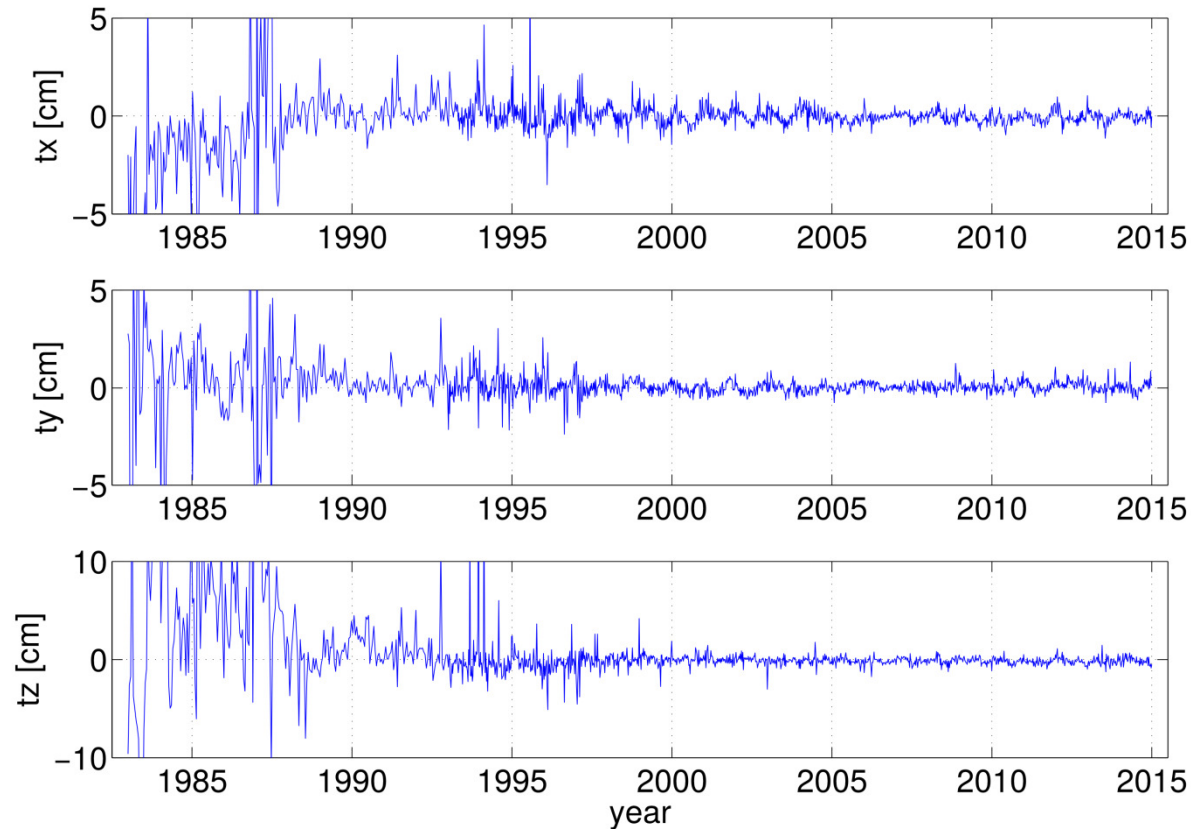
1886	0.29	+-	3.04
1887	0.11	+-	1.91
1888	-0.51	+-	1.90
1889	0.56	+-	1.25
1890	-0.74	+-	1.94
1891	0.07	+-	1.20

Computation strategy



epoch-wise solutions

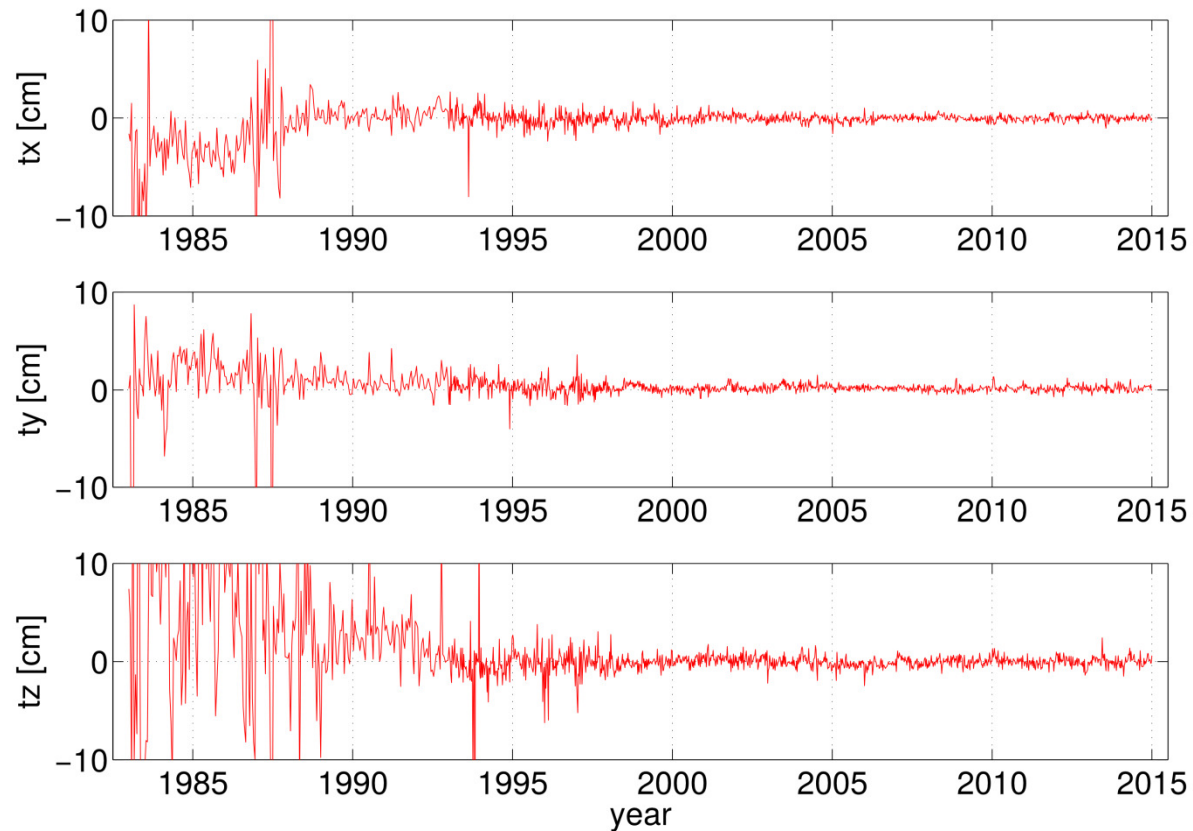
BIAS w.r.t. SLRF (1982.5 – 2015.0)



- systematic signals in LA1-only observation period (1982.5 – 1993.0)
- annual signal in all translational components

epoch-wise solutions

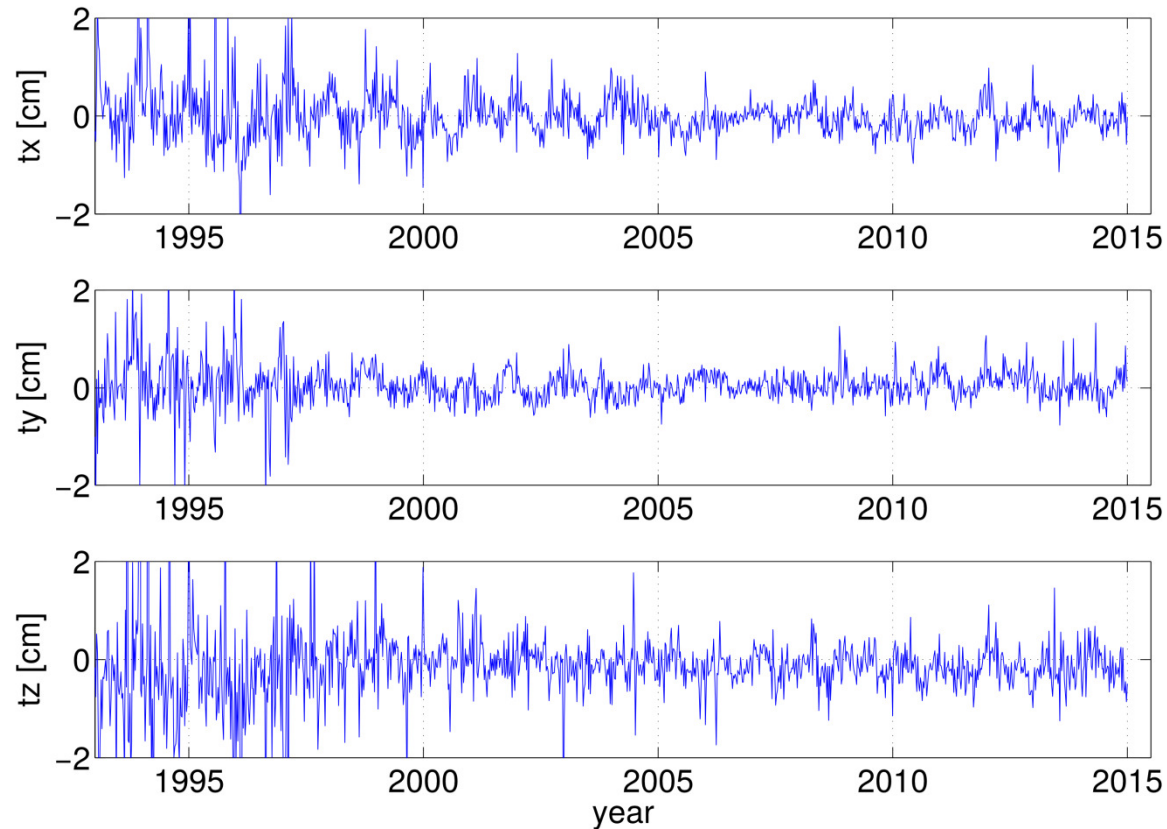
BIASFREE w.r.t. SLRF (1982.5 – 2015.0)



- slightly increased scatter due to estimated biases instead of fixed biases
- annual signal disappears!

epoch-wise solutions

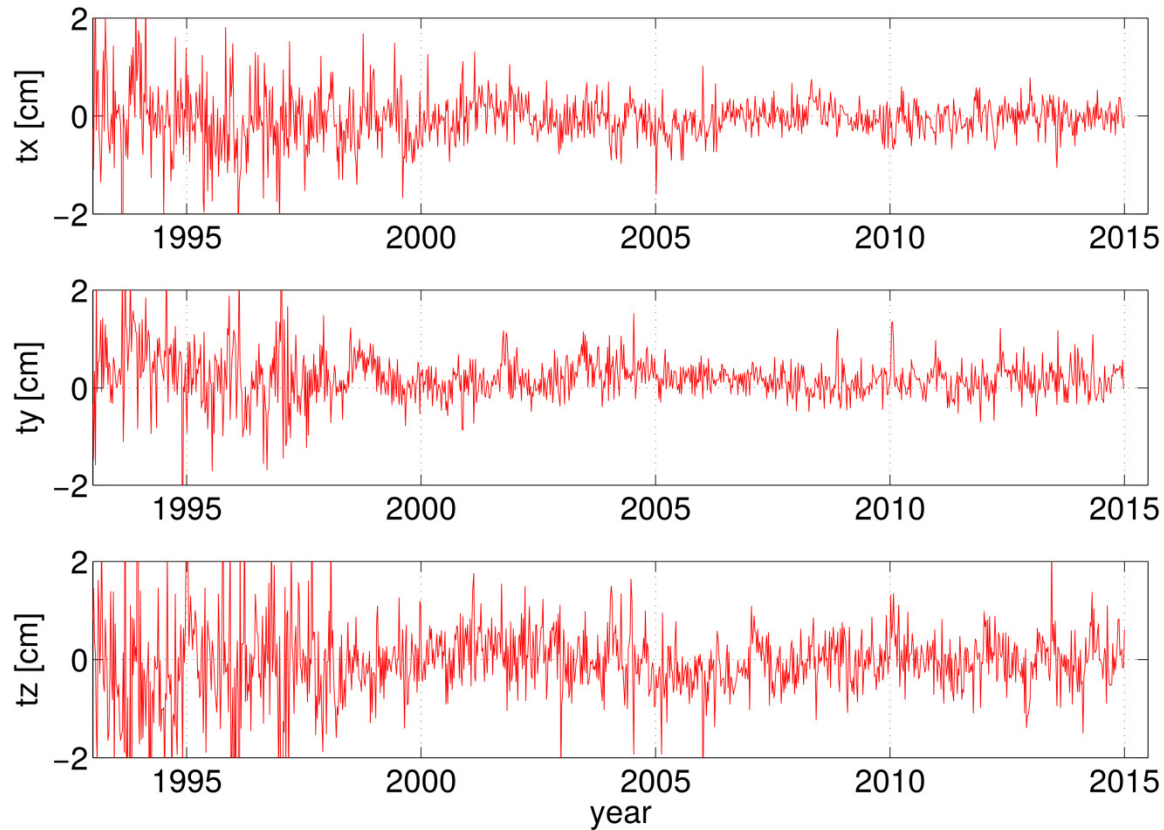
BIAS w.r.t. SLRF (1993.0 – 2015.0)



- time period 1982.5 – 1993.0 neglected due to significant systematics
- clear annual signal in all translational components since 1993.0 (LA1/LA2 obs)

epoch-wise solutions

BIASFREE w.r.t. SLRF (1993.0 – 2015.0)

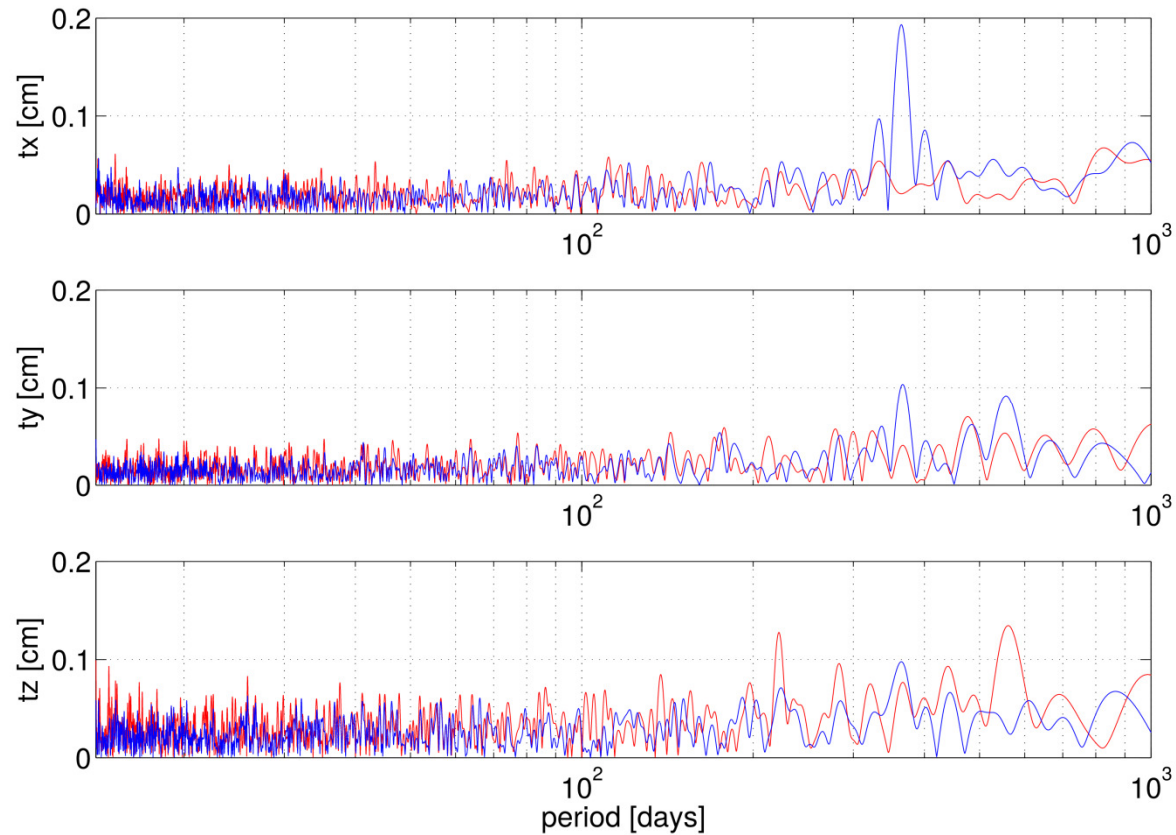


- slightly increased scatter can be clearly seen
- annual signal disappears in all translational components!

epoch-wise solutions

BIAS w.r.t. SLRF (1993.0 – 2015.0)

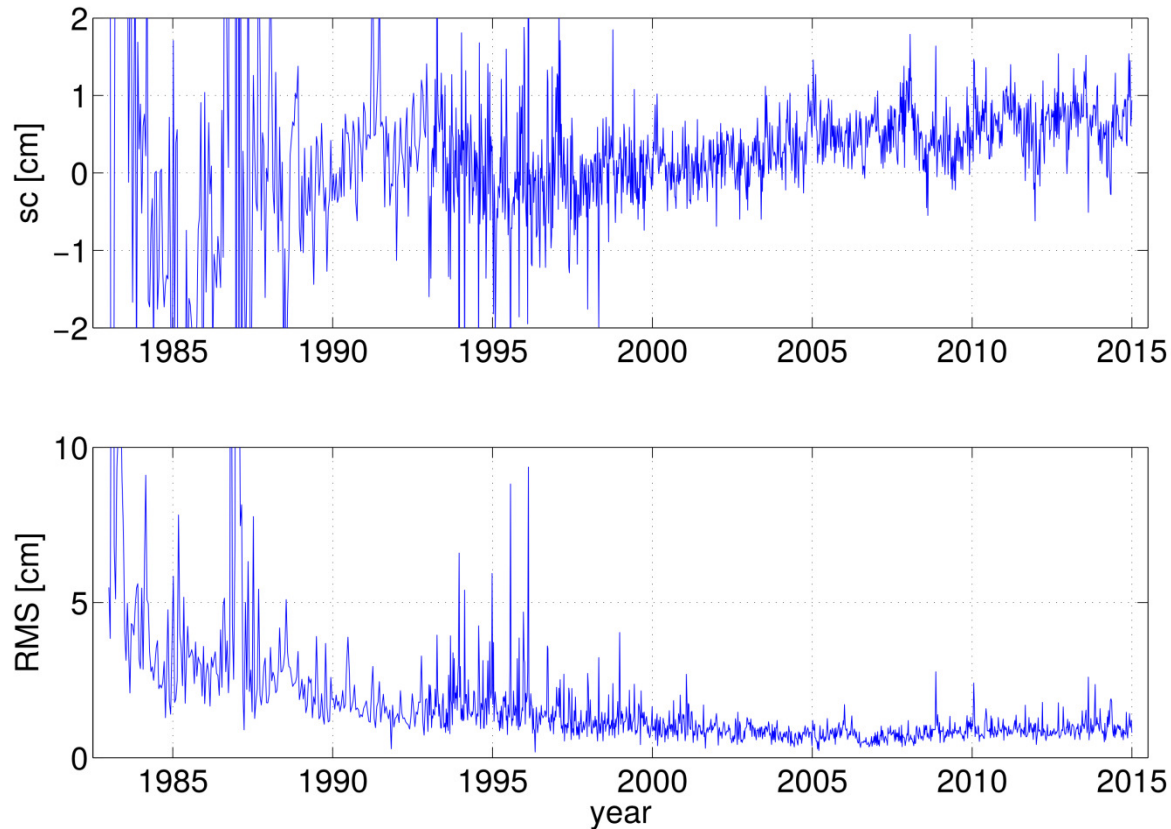
BIASFREE w.r.t. SLRF (1993.0 – 2015.0)



- annual signal in all translational components vanishes in BIASFREE time series!!

epoch-wise solutions

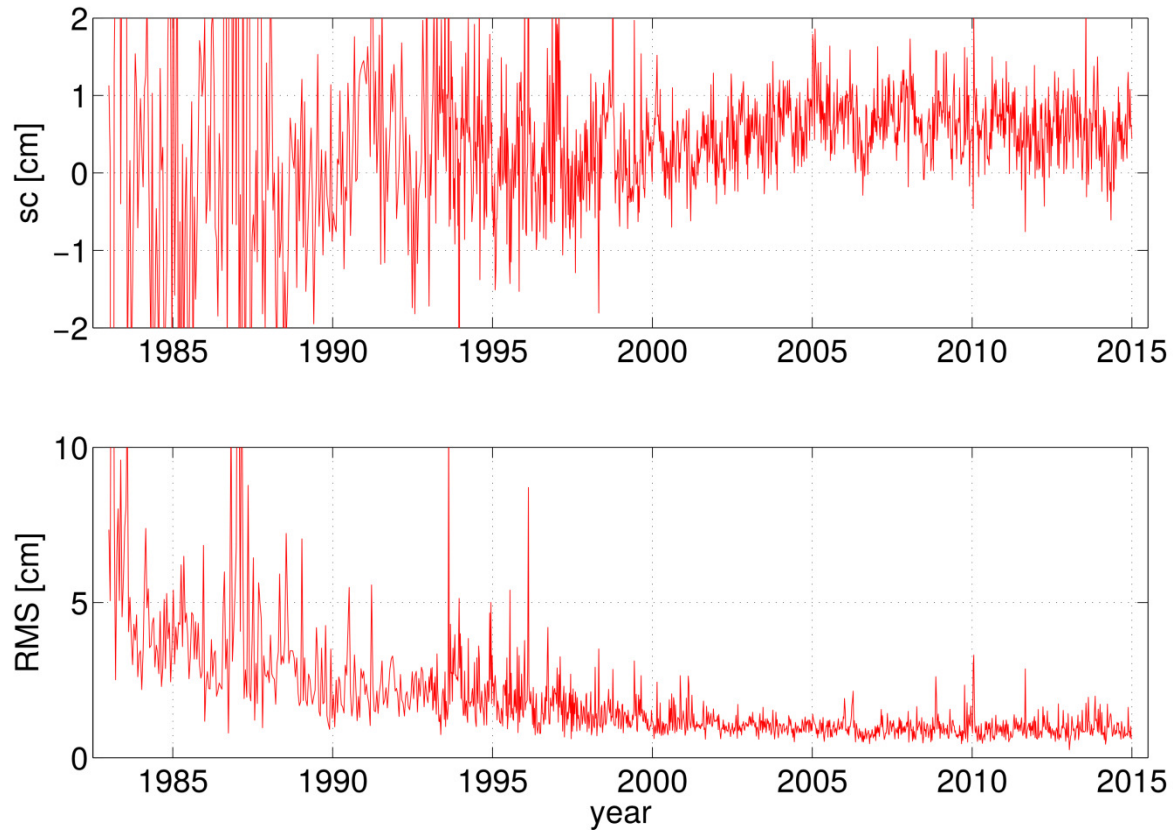
BIAS w.r.t. SLRF (1982.5 – 2015.0)



- also scale is affected by significant systematics between 1982.5 and 1993.0
- slight drift in scale time series since 1995.0 (about 1 cm in 20 years)

epoch-wise solutions

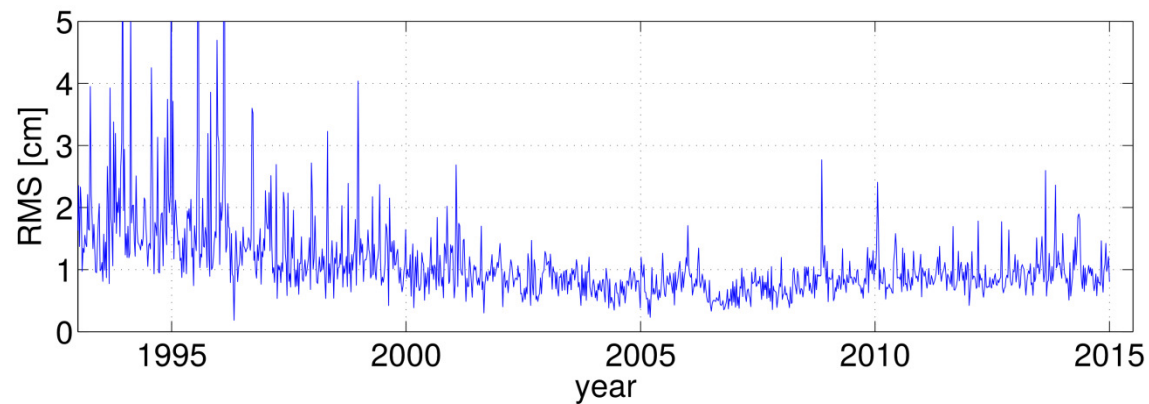
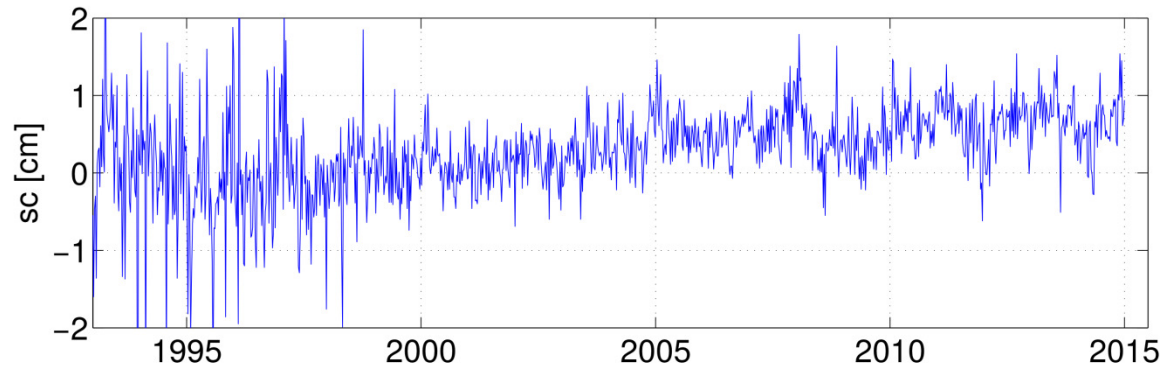
BIASFREE w.r.t. SLRF (1982.5 – 2015.0)



- also slightly increased scatter as seen in translations
- slight drift in scale time series since 1995.0 decreased

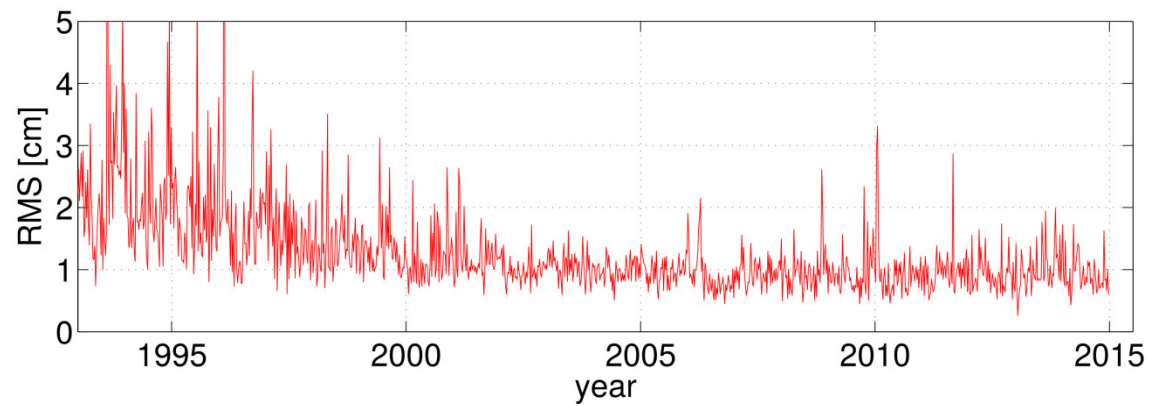
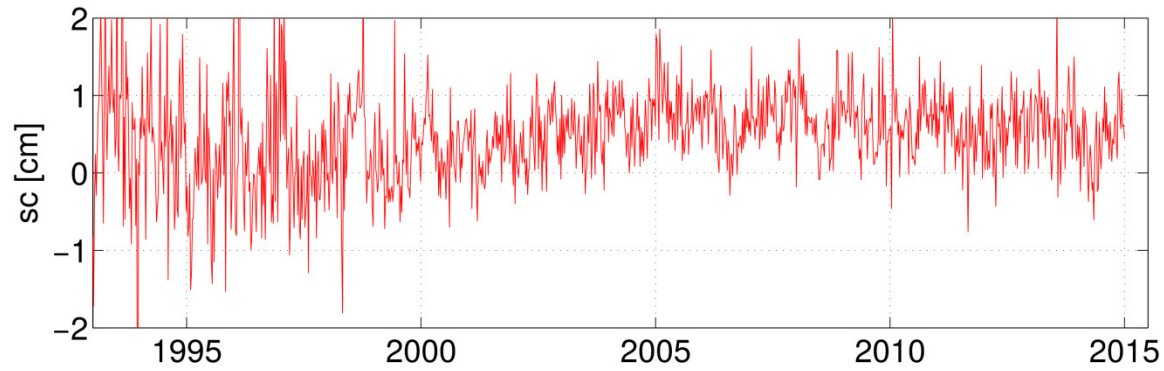
epoch-wise solutions

BIAS w.r.t. SLRF (1993.0 – 2015.0)



epoch-wise solutions

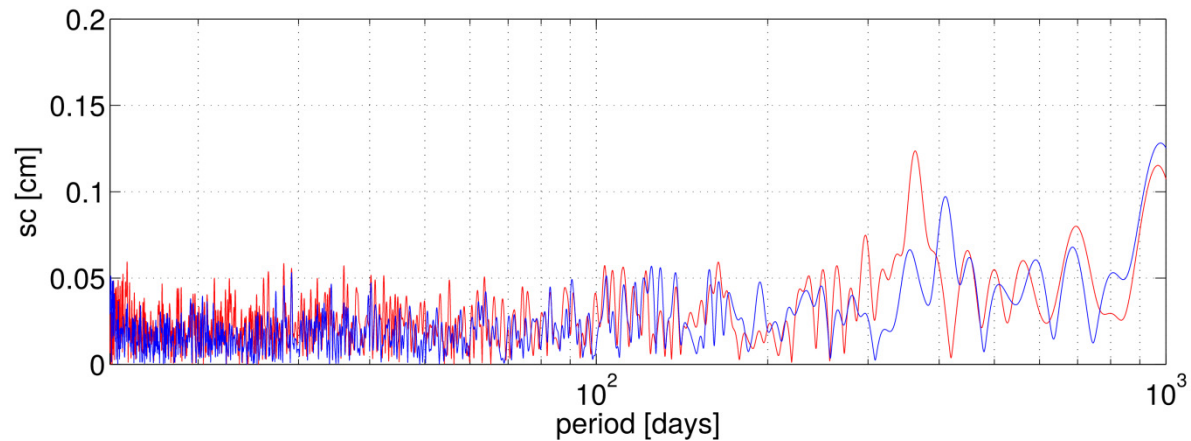
BIASFREE w.r.t. SLRF (1993.0 – 2015.0)



epoch-wise solutions

BIAS w.r.t. SLRF (1993.0 – 2015.0)

BIASFREE w.r.t. SLRF (1993.0 – 2015.0)

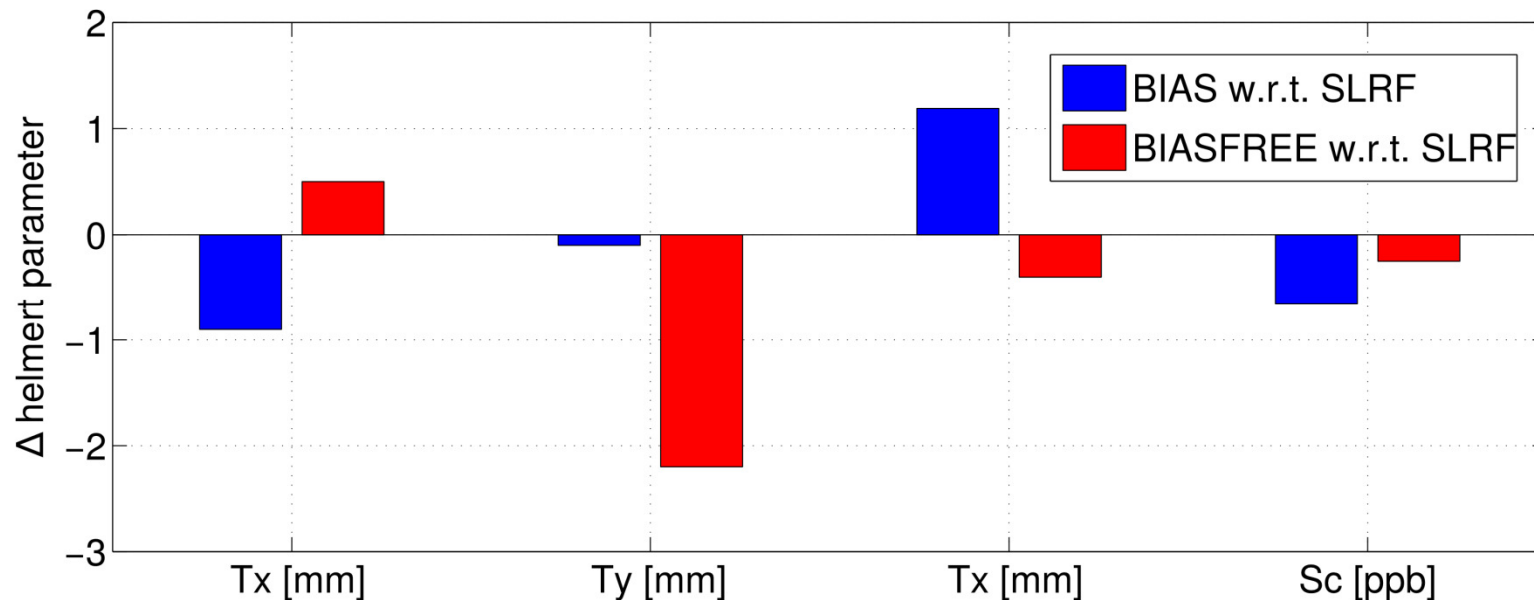


- in contrast to spectra of translations show the spectra of the scale time series an increased annual signal in the BIASFREE solution

accumulated multi-year solutions

BIAS w.r.t. SLRF (1993.0 – 2015.0)

BIASFREE w.r.t. SLRF (1993.0 – 2015.0)



- differences in the origin up to 2.2 mm (Ty component)
- scale difference BIAS w.r.t. SLRF: -0.65 ppb (\rightarrow ca. -4.3 mm)
- scale difference BIAS w.r.t. SLRF: -0.25 ppb (\rightarrow ca. -1.6 mm)

Conclusion

- Biases are still part of the SLR measurement and can not be neglected
- The present coordinate set of SLRF2008 is, at least for the core stations correct
- But it is worth having a closer look at the station behaviour
- There is no need to solve for each station bias in a separate run
- Solving for biases and station coordinates together leads to significant change in origin and scale

Thank you