ILRSA contribution to ITRF2013: the V60 solution

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Outline

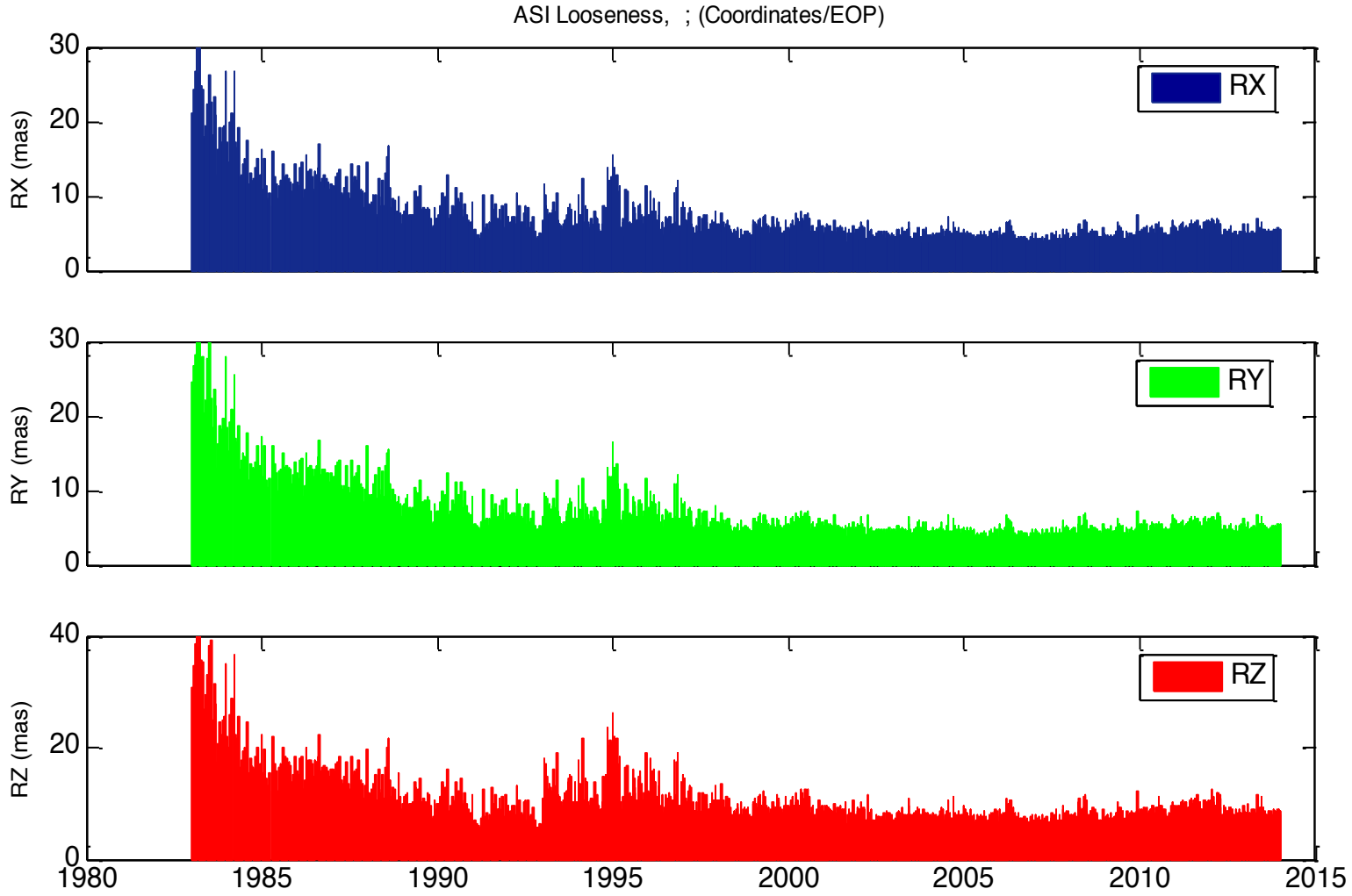
- AC/CC solution verification
  - Looseness
  - AC Bias application and editing
  - AC Scale factor
  - SSC residuals
  - EOP residuals
  - Translations & scale

ILRSA timeline

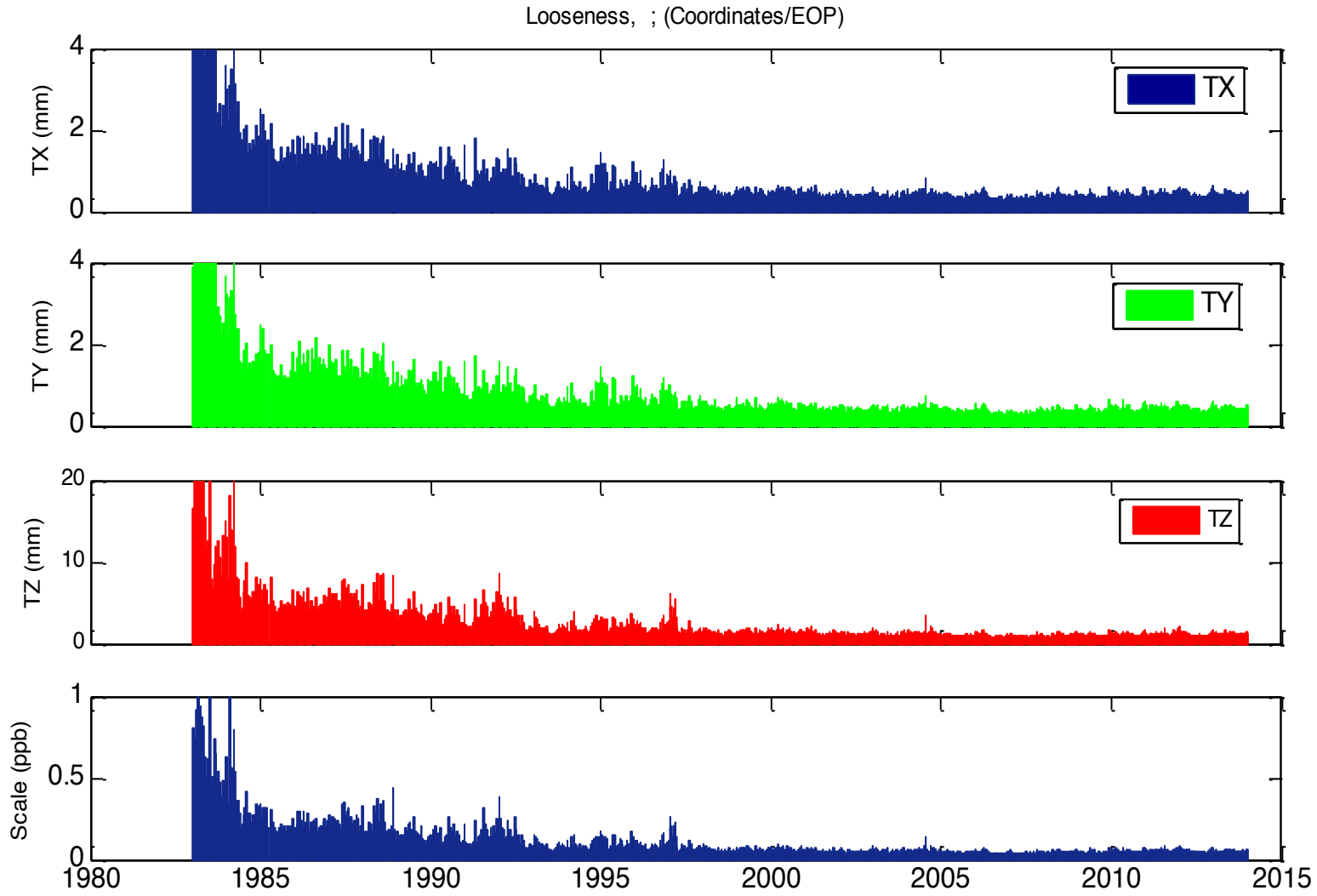
AC	Version	Issue date 1993-2013	Issue date 1983-1992
ASI	V60	23/04/2014	04/06/2014
BKG	V60	17/09/2014	--------
DGFI	V60	21/08/2014	17/10/2014
ESA	V60	26/08/2014	26/08/2014
GFZ	V60	23/05/2014	23/05/2014
GRGS	V60	03/10/2014	03/10/2014
JCET	V60	30/07/2014	21/10/2014
NSGF	V60	29/07/2014	10/09/2014
ILRSA	V60	09/10/2014	24/10/2014

- Multiple AC submissions mainly due to erroneous bias application

Looseness: typical values



Looseness: typical values

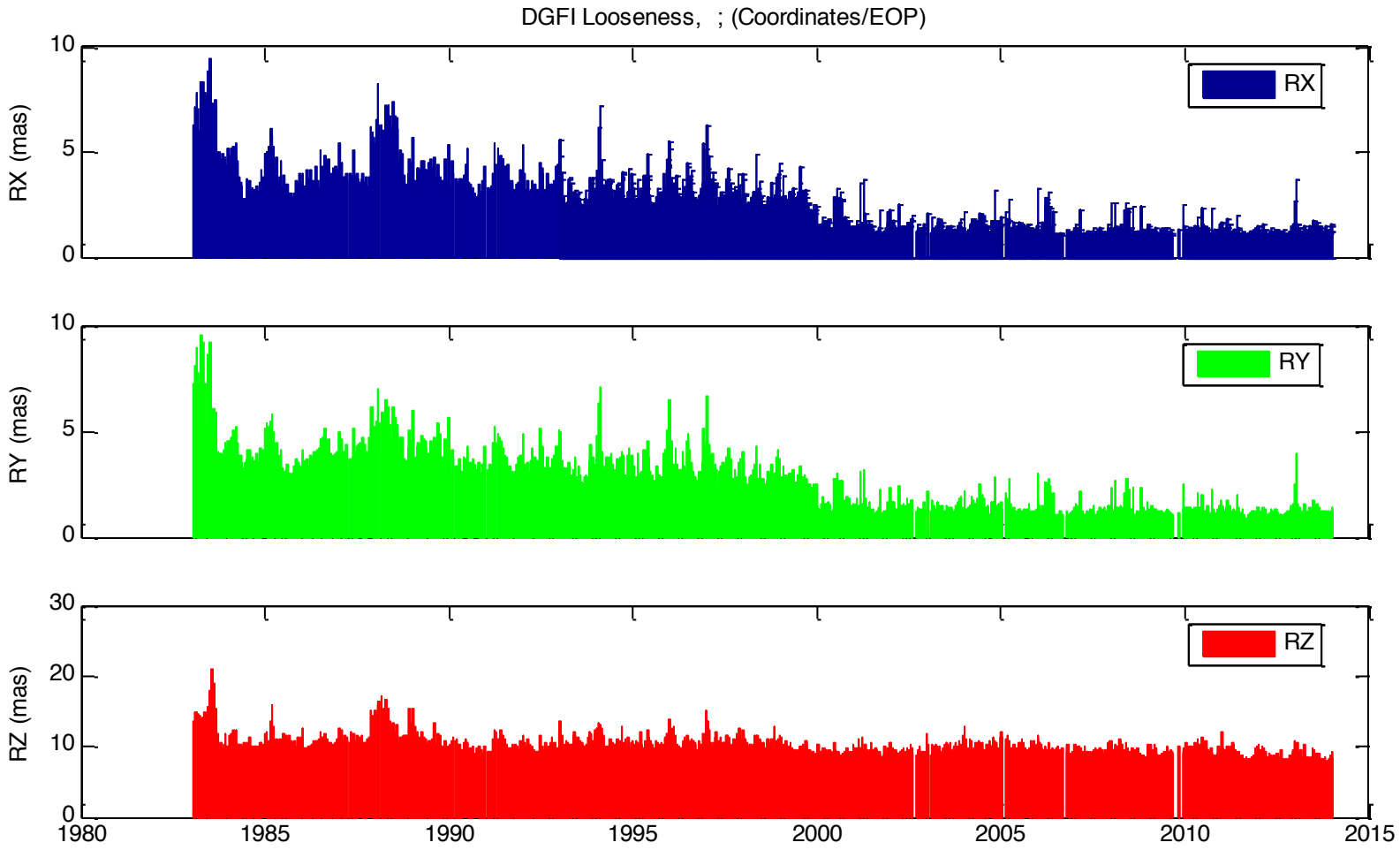


Looseness

	1983-1992								
	ASI	BKG	DGFI	ESA	GFZ	GRGS	JCET	NSGF	ILRSA
RX (mas)	11.32		4.88	10.02	5.36	9.73	4.44	20.60	**5.94**
RY (mas)	11.64		4.73	10.33	5.43	10.40	4.44	21.07	**6.04**
RZ (mas)	15.23		12.03	13.00	11.70	13.06	26.02	27.06	**10.07**
TX (mm)	1.71		0.79	1.07	1.44	1.69	1.60	1.50	**0.93**
TY (mm)	1.58		0.78	1.08	1.38	1.62	1.50	1.47	**0.93**
TZ (mm)	6.12		3.24	4.09	5.20	5.78	5.72	5.74	**3.36**
Scale (mm	1.66		1.01	1.19	1.92	1.71	1.56	1.60	**0.97**

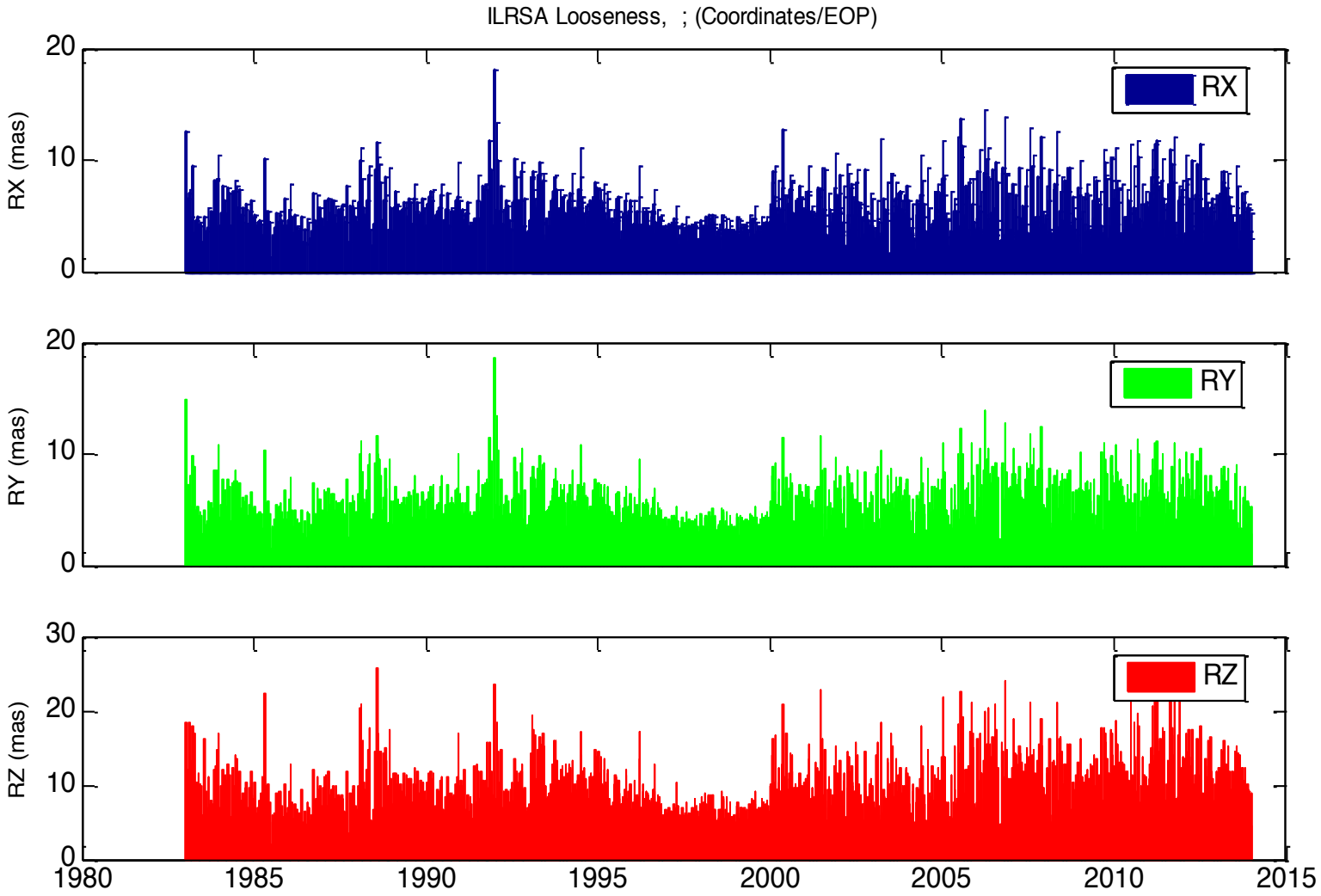
	1993-2013								
	ASI	BKG	DGFI	ESA	GFZ	GRGS	JCET	NSGF	ILRSA
RX (mas)	5.46	8.17	1.98	5.97	4.10	6.57	5.13	7.33	**5.15**
RY (mas)	5.29	7.91	1.94	5.80	3.97	6.29	4.96	7.28	**5.17**
RZ (mas)	9.04	11.10	9.73	8.05	10.80	8.53	9.47	11.79	**9.27**
TX (mm)	0.46	0.50	0.33	0.42	0.55	0.72	0.41	0.64	**0.47**
TY (mm)	0.45	0.50	0.33	0.41	0.55	0.69	0.40	0.63	**0.47**
TZ (mm)	1.33	1.49	0.99	1.27	1.63	2.51	1.21	1.94	**1.38**
Scale (mm	0.38	0.44	0.28	0.37	0.66	0.71	0.35	0.55	**0.41**

Looseness: the DGFI case

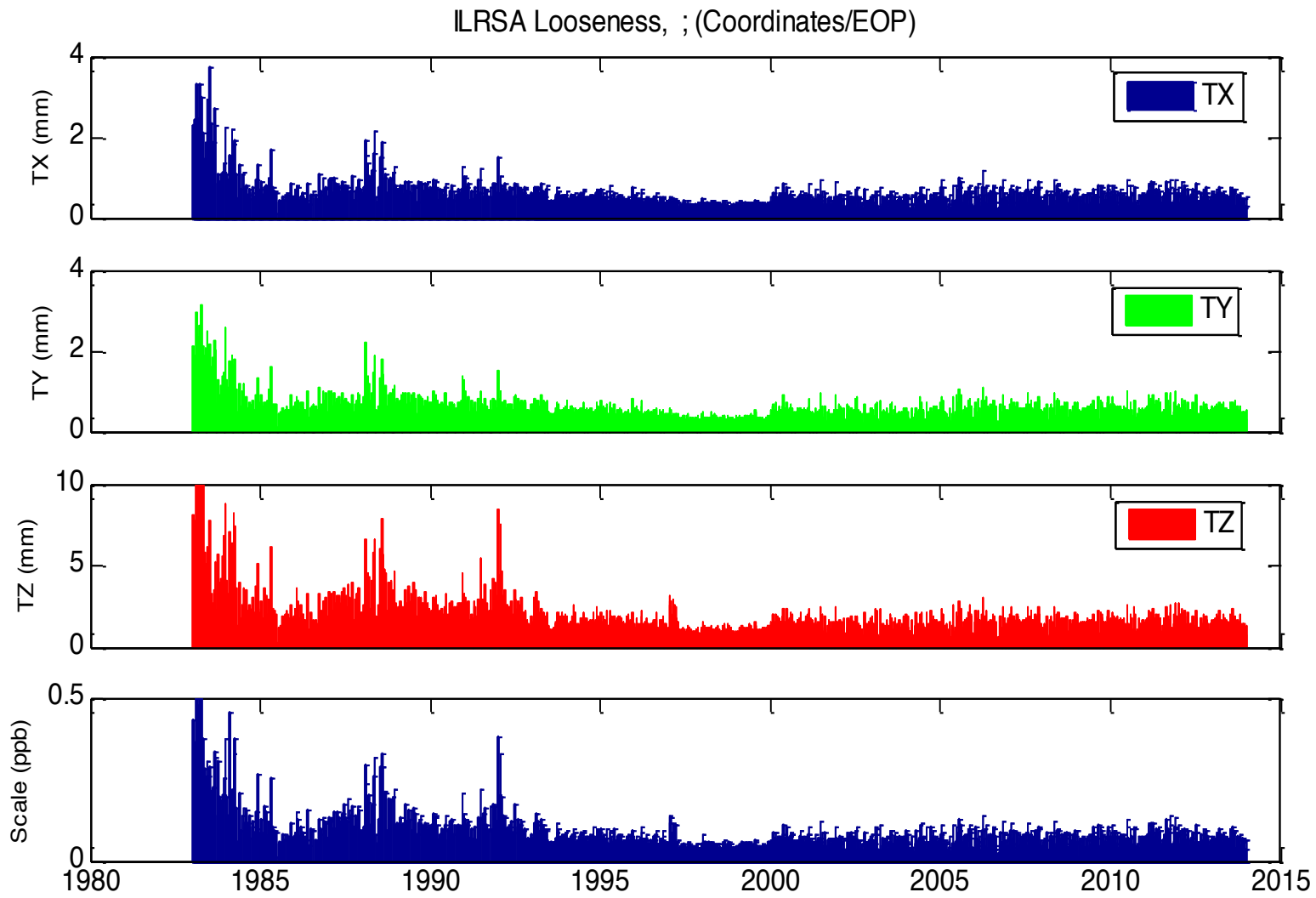


- A loosening was applied before making the combination

ILRSA Looseness: rotations



ILRSA Looseness: translations and scale



Data & bias

BKG
% 7810 since 96:336 to 08:001 : bias estimated when not requested
% 1873 since 11:182 to 12:153: data to be deleted as specified in the data handling file
% 7080 since 96:026 to 96:130: -30/40 mm UP offset

DGFI
% 1824 since 03:001 to 06:001 :a few points (<20) with large offsets
% 1884 since 94:001 to 98:001: large UP negative offset
% 7080 since 96:026 to 96:130 : -30/40 mm UP offset in the UP component
% 7821 since 09:146 to 10:069: : -200 mm UP offset

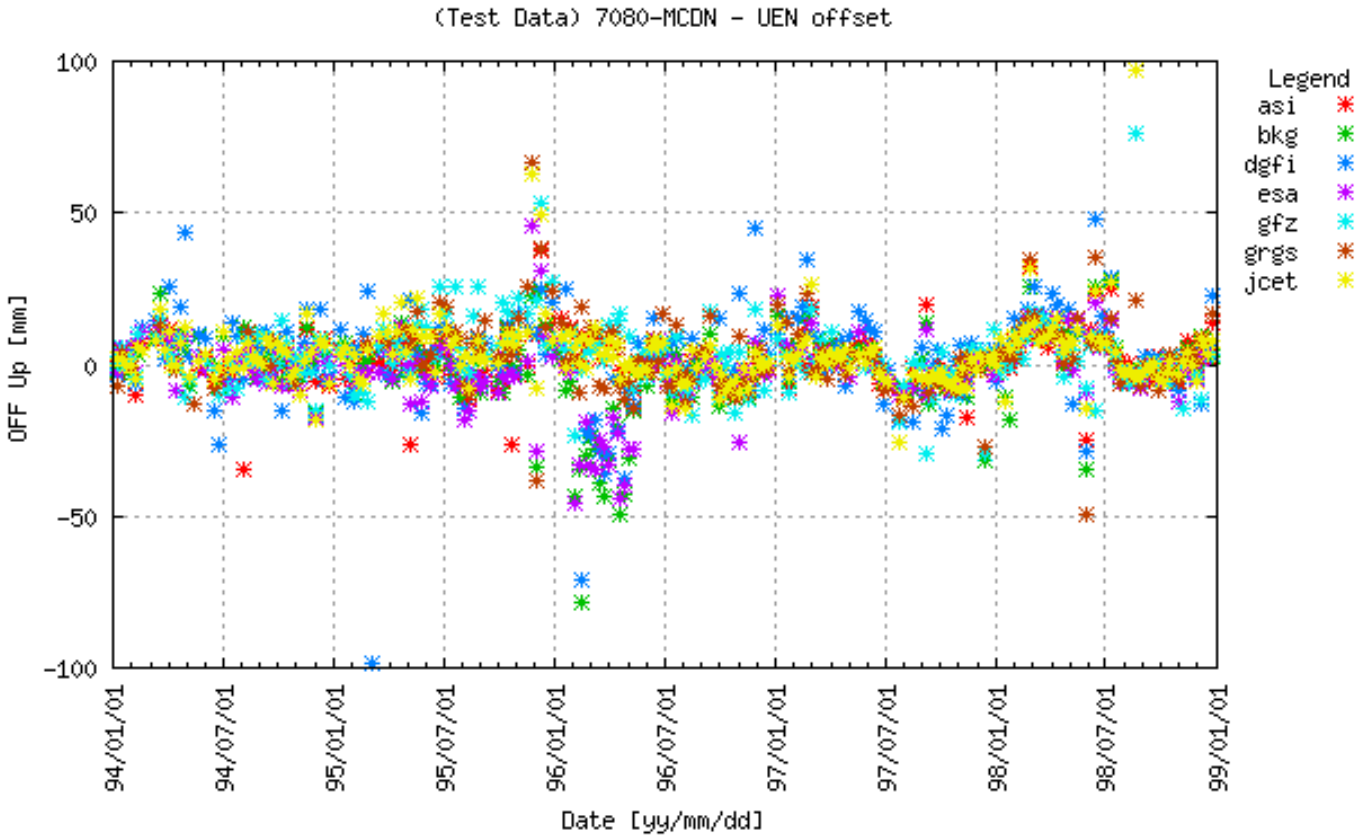
JCET
% 1824 since 03:001 to 06:001: a few points (<20) with large offsets
% 7308 since 11:152 to 13:001: -100 mm offset in the UP component
% 7821 since 09:146 to 10:069: -200 mm offset in the UP component

ESA
% 7080 since 96:026 to 96:130 : -30/40 mm offset in the UP component
% 7907 since 83:001 to 87:001 : large UP scatter and offset

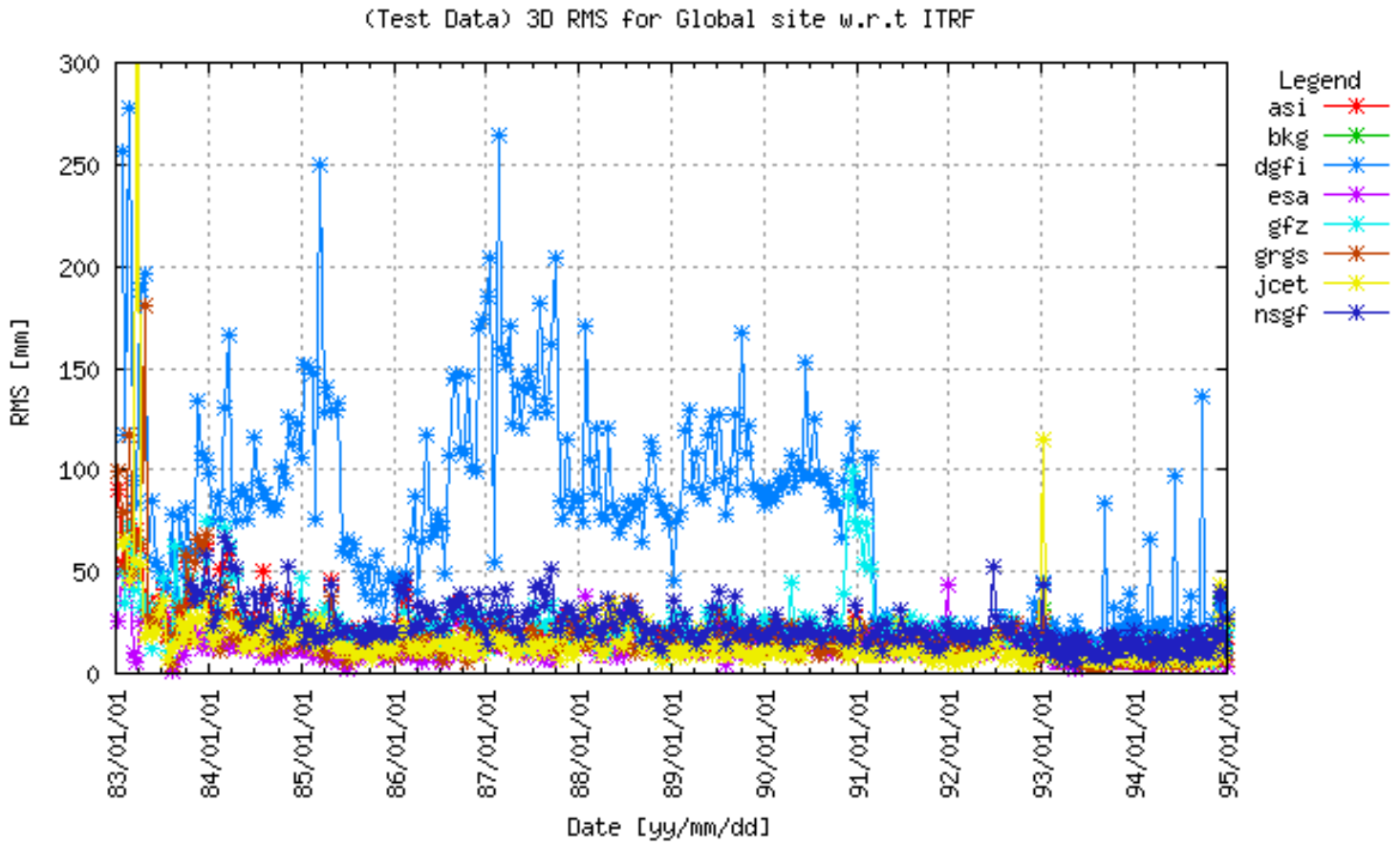
GFZ
% 1884 since 94:001 to 98:001 : large UP negative offset

NSGF
% 7907 since 83:001 to87:001 : large UP scatter and offset

Data & bias

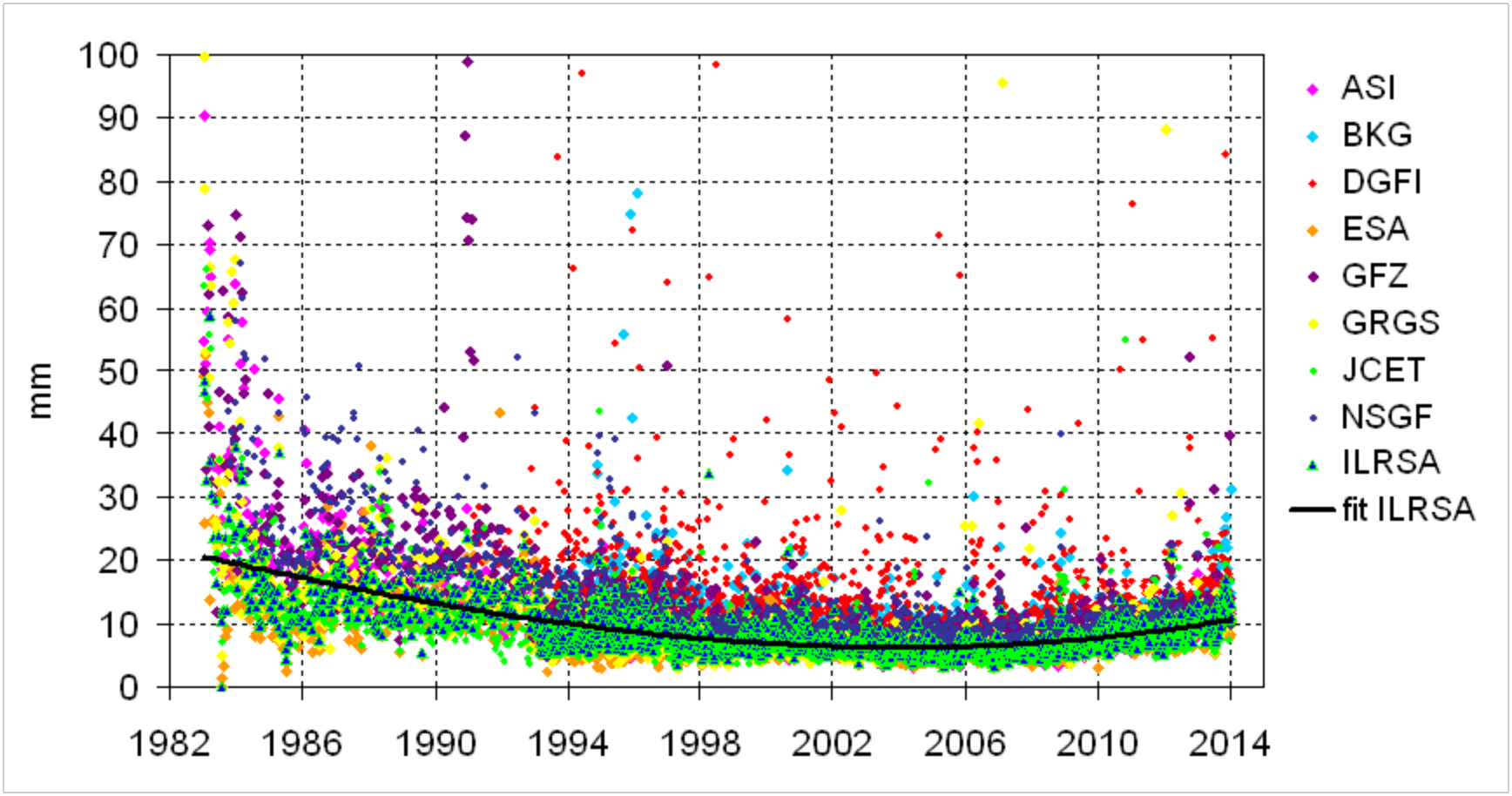

(Test Data) 7080-MCDN - UEN offset
OFF Up [mm]
100
50
0
-50
-100
94/01/01
94/07/01
95/01/01
95/07/01
96/01/01
96/07/01
97/01/01
97/07/01
98/01/01
98/07/01
99/01/01
Date [yy/mm/dd]
Legend
asi
bkg
dgfi
esa
gfz
grgs
jcet

AC historic submissions

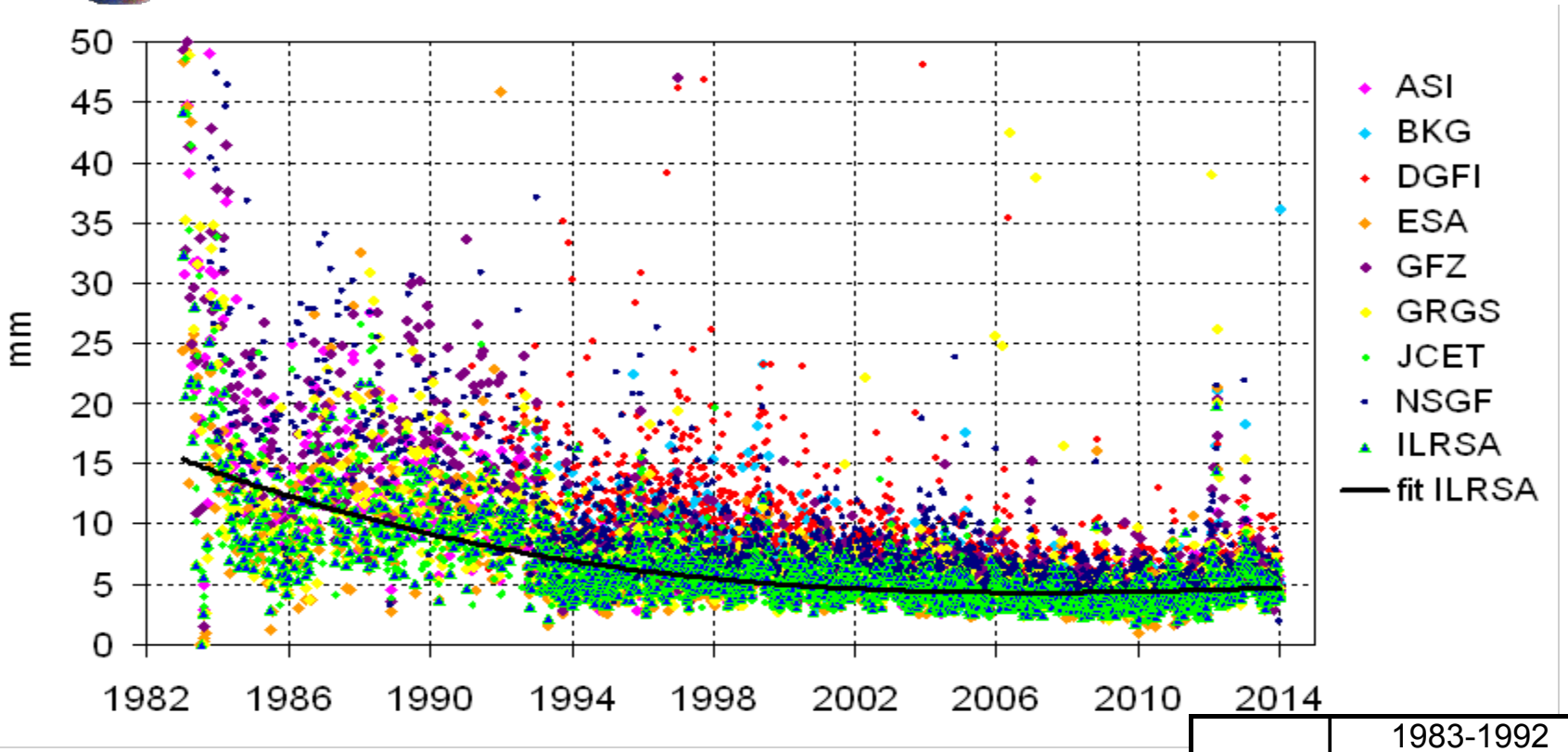


- The DGFI solution was not used until March 1991

SSC All Sites - 3D WRMS of residuals wrt SLRF2008

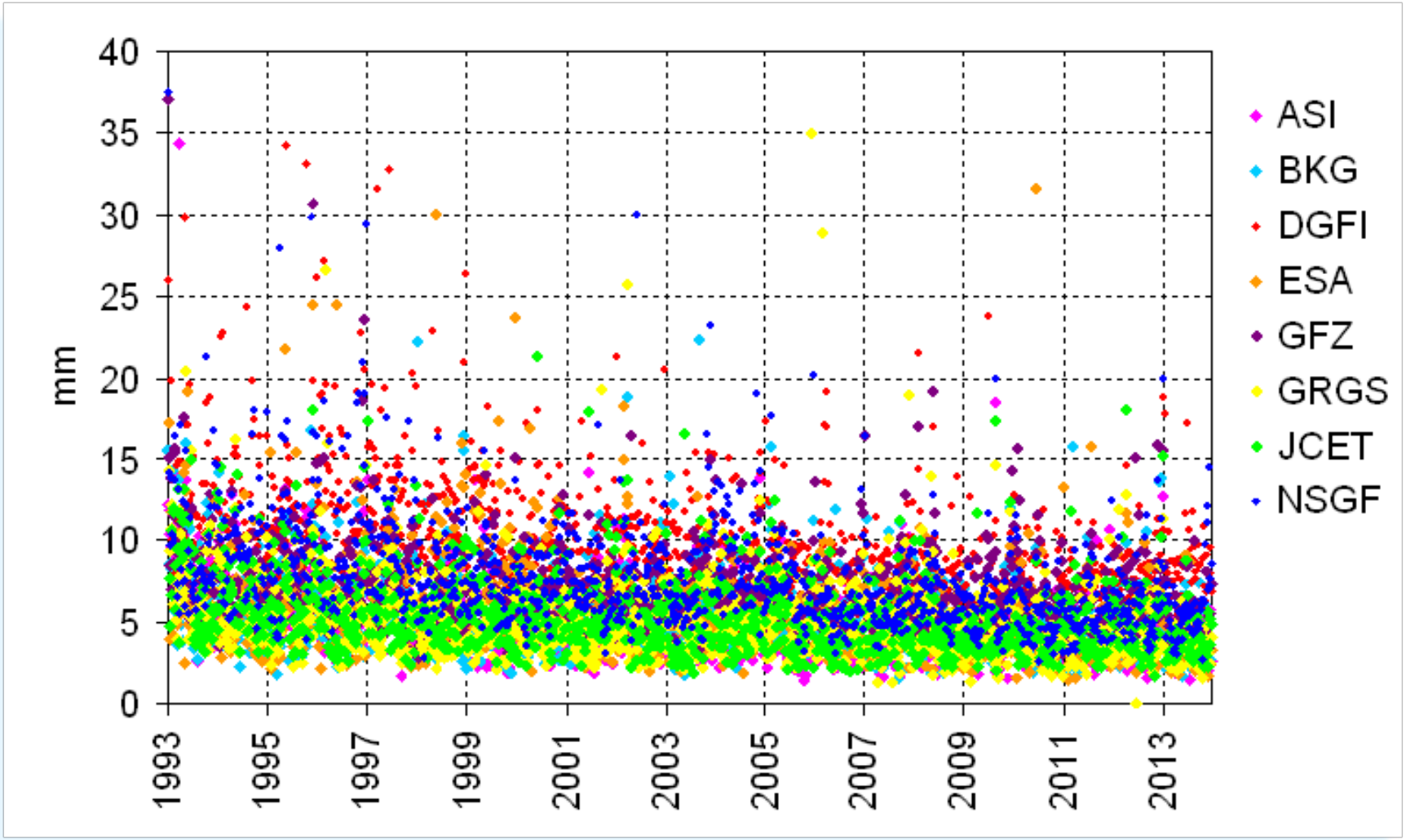


SSC Core Sites – 3D WRMS of residuals wrt SLRF2008

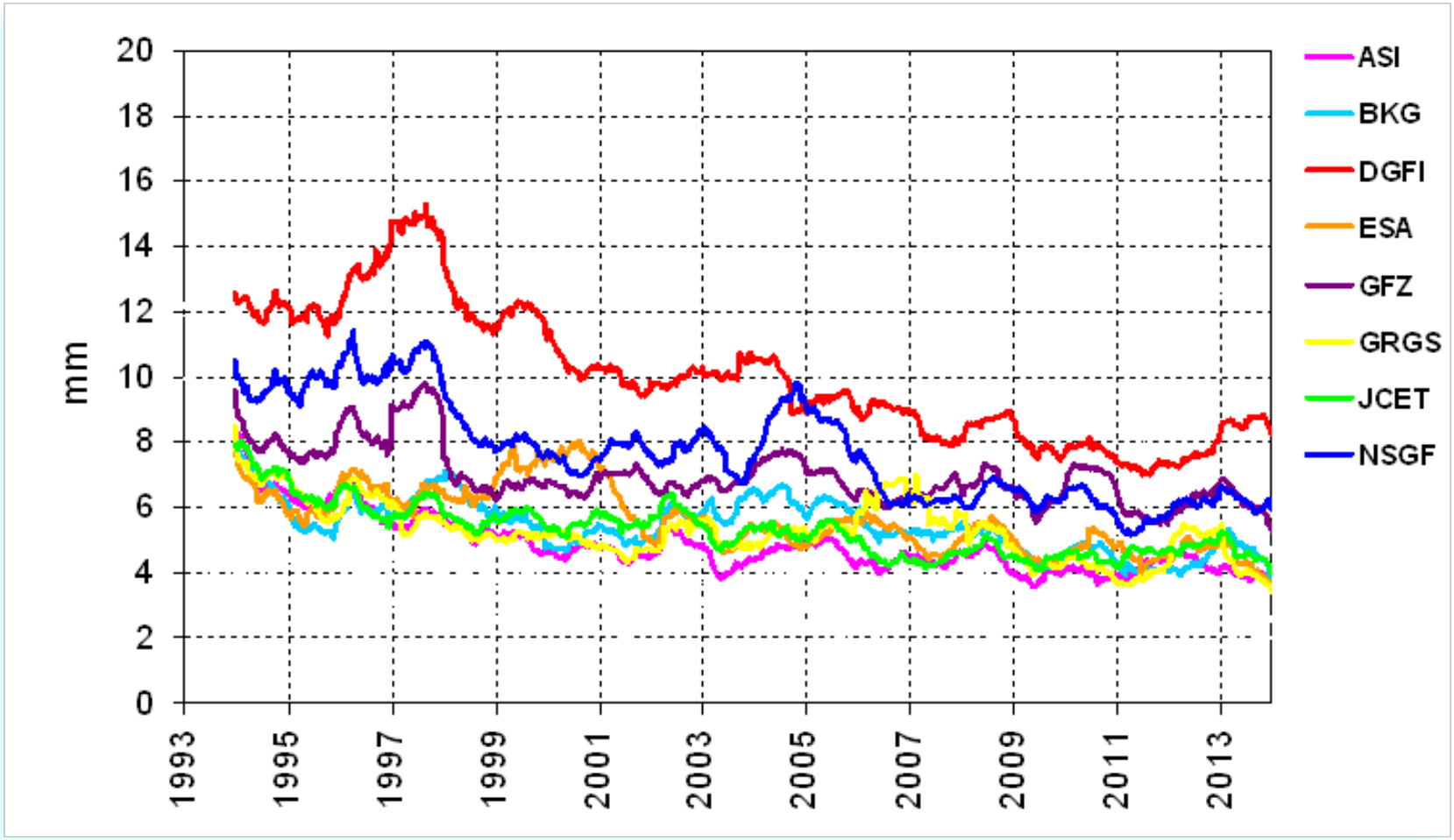


	1983-1992		1993-2013	
	mean	std	mean	std
ASI	14.2	6.2	5.6	1.8
BKG	---------	---------	6.2	2.7
DGFI	---------	---------	**9.1**	4.2
ESA	11.7	7.2	5.2	1.8
GFZ	17.7	6.9	6.3	2.5
GRGS	12.6	6.0	5.6	2.7
JCET	11.5	5.4	5.4	2.0
NSGF	**18.0**	6.4	7.4	3.1
ILRSA	**11.2**	**5.8**	**5.0**	**1.7**

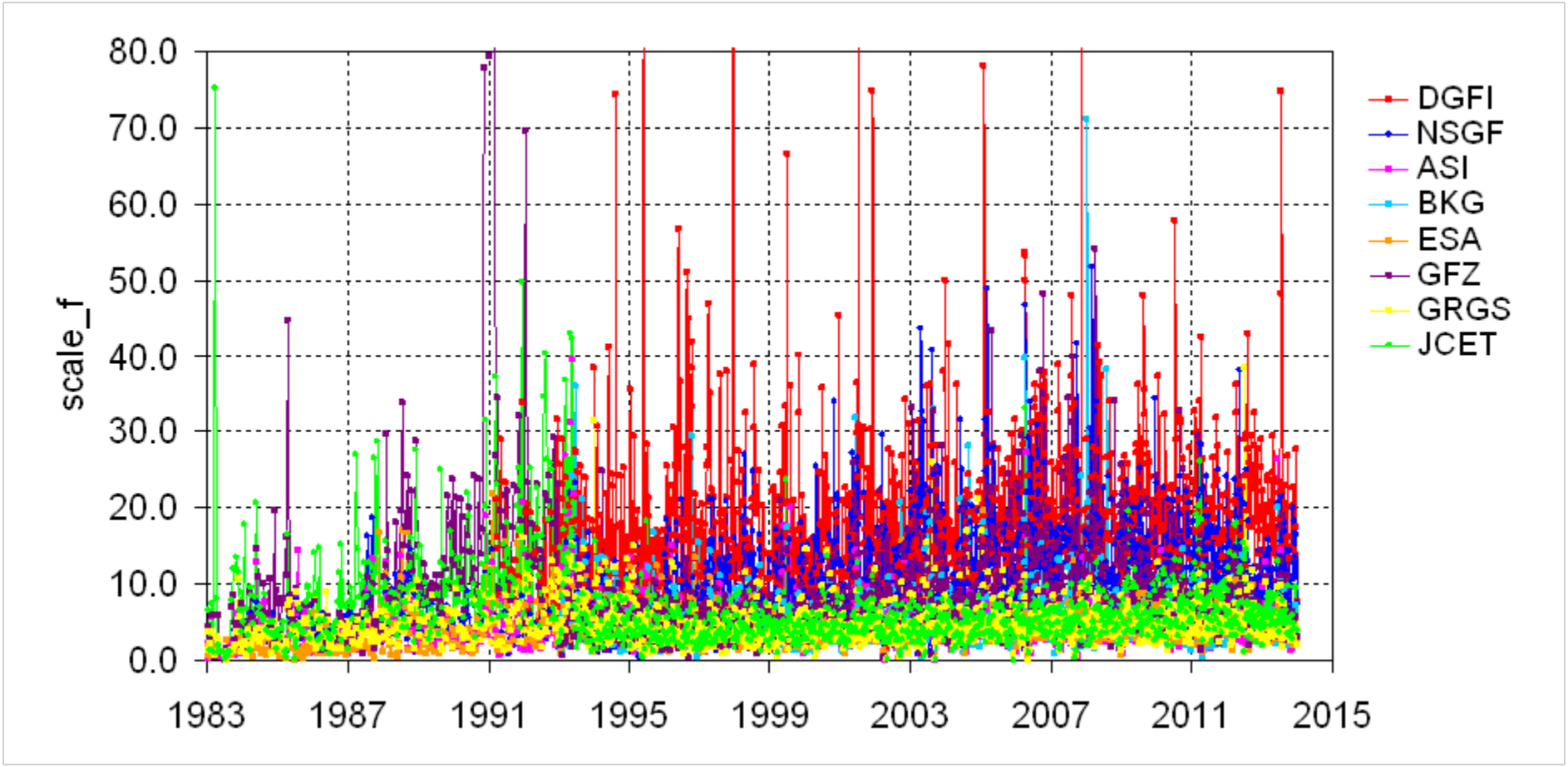
Intra-technique consistency



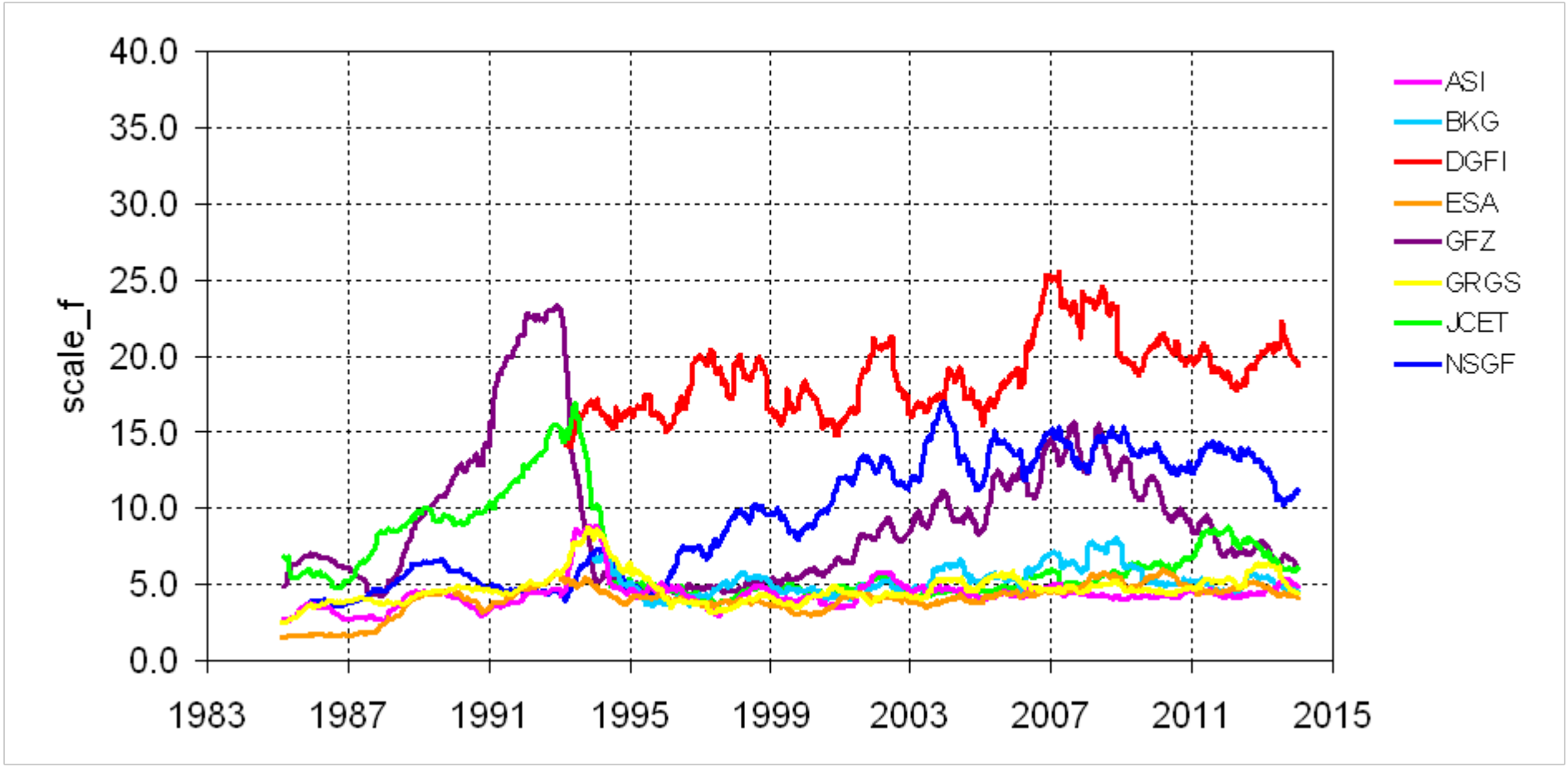
Intra-technique consistency



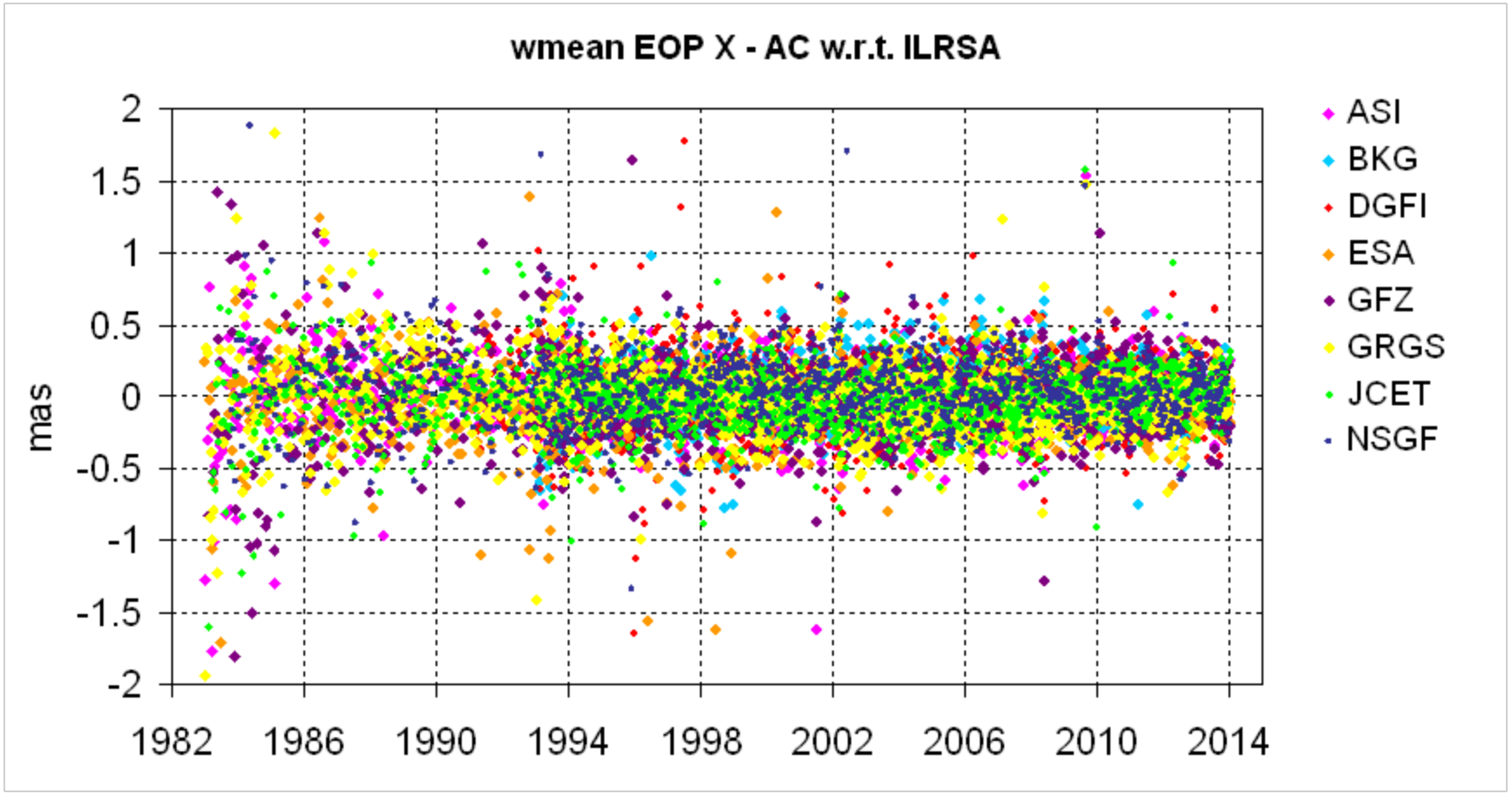
AC scale factors



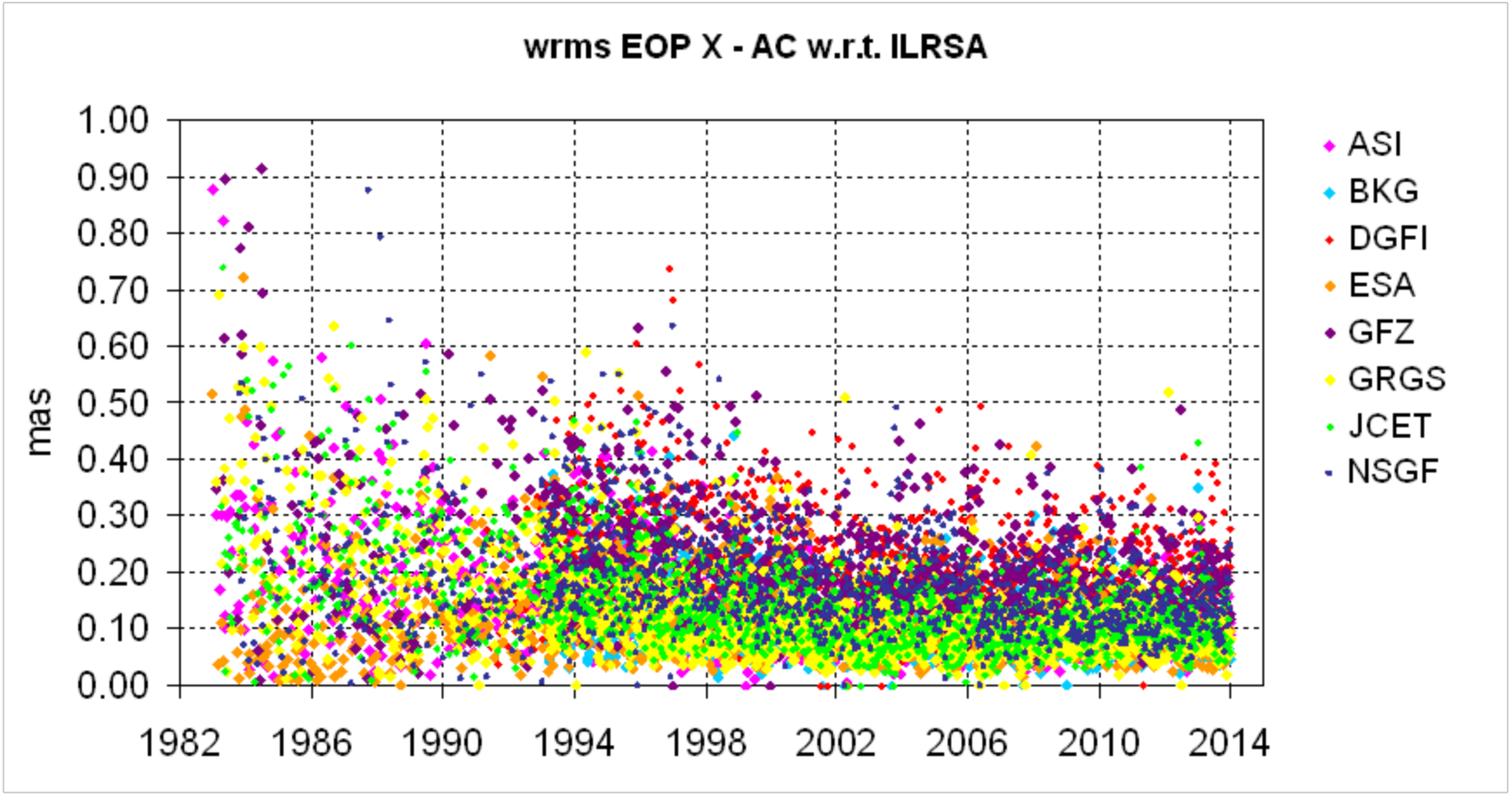
AC scale factors



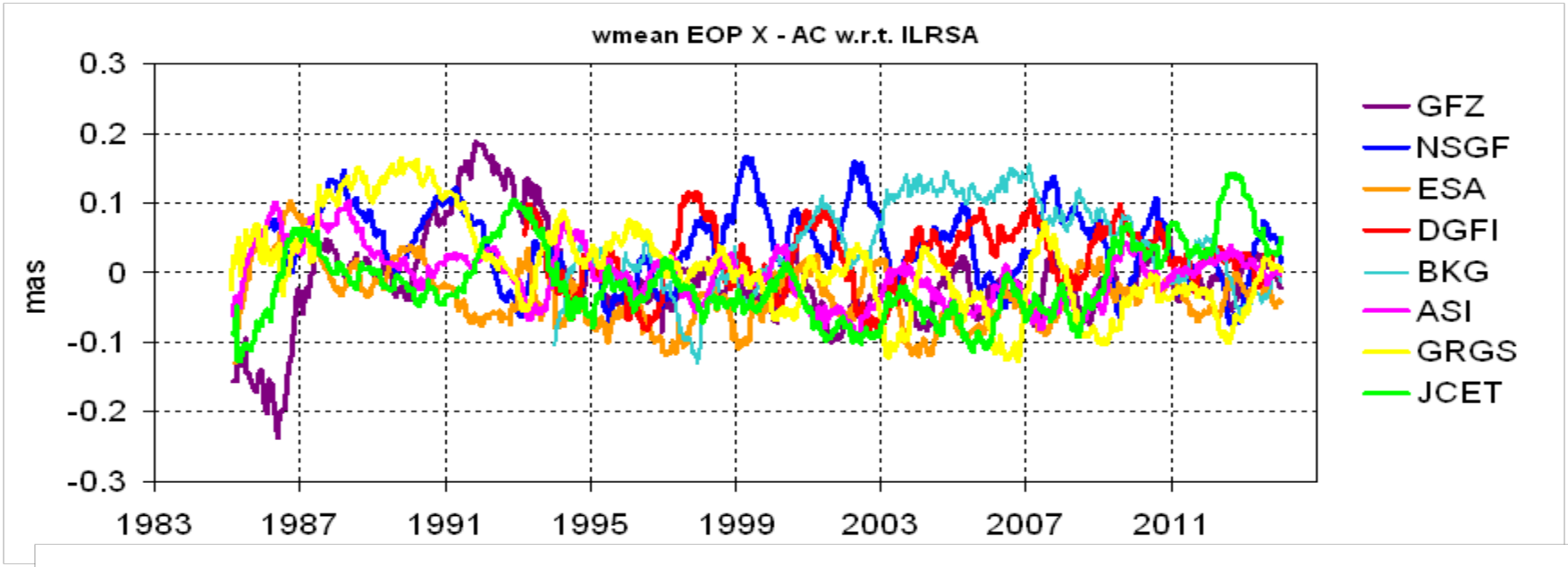
EOP X - Weekly Mean of residuals wrt ILRSA

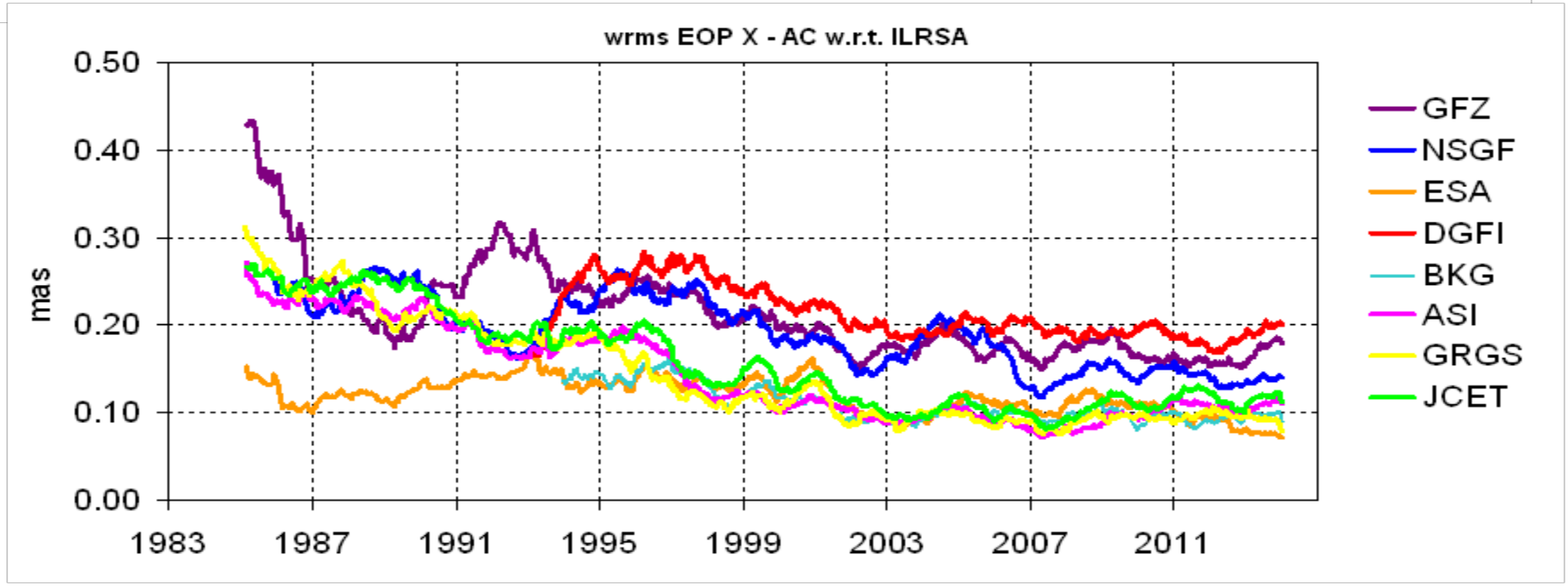


EOP X - Weekly STD of residuals wrt ILRSA

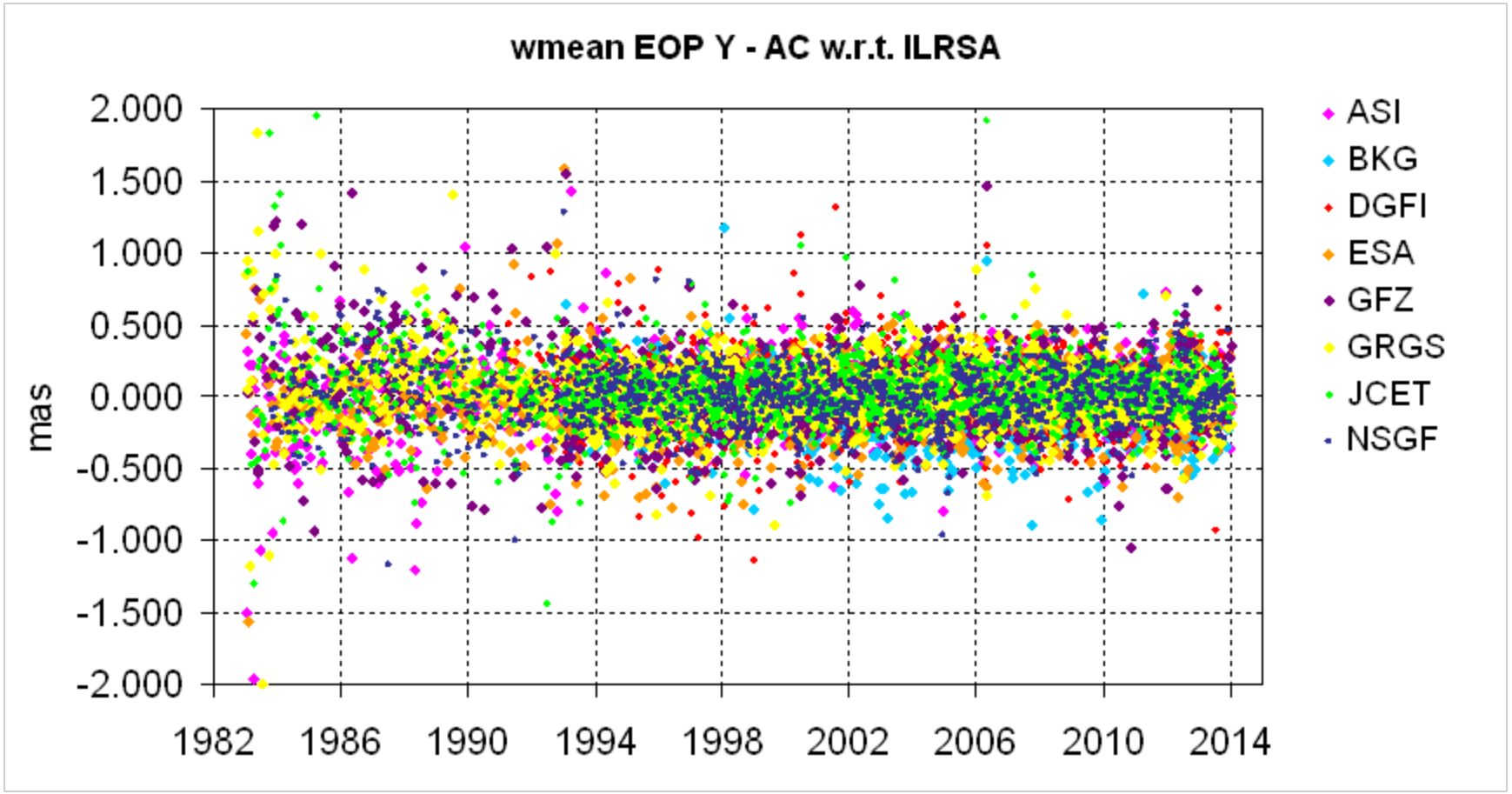


EOP X - Weekly residuals wrt ILRSA

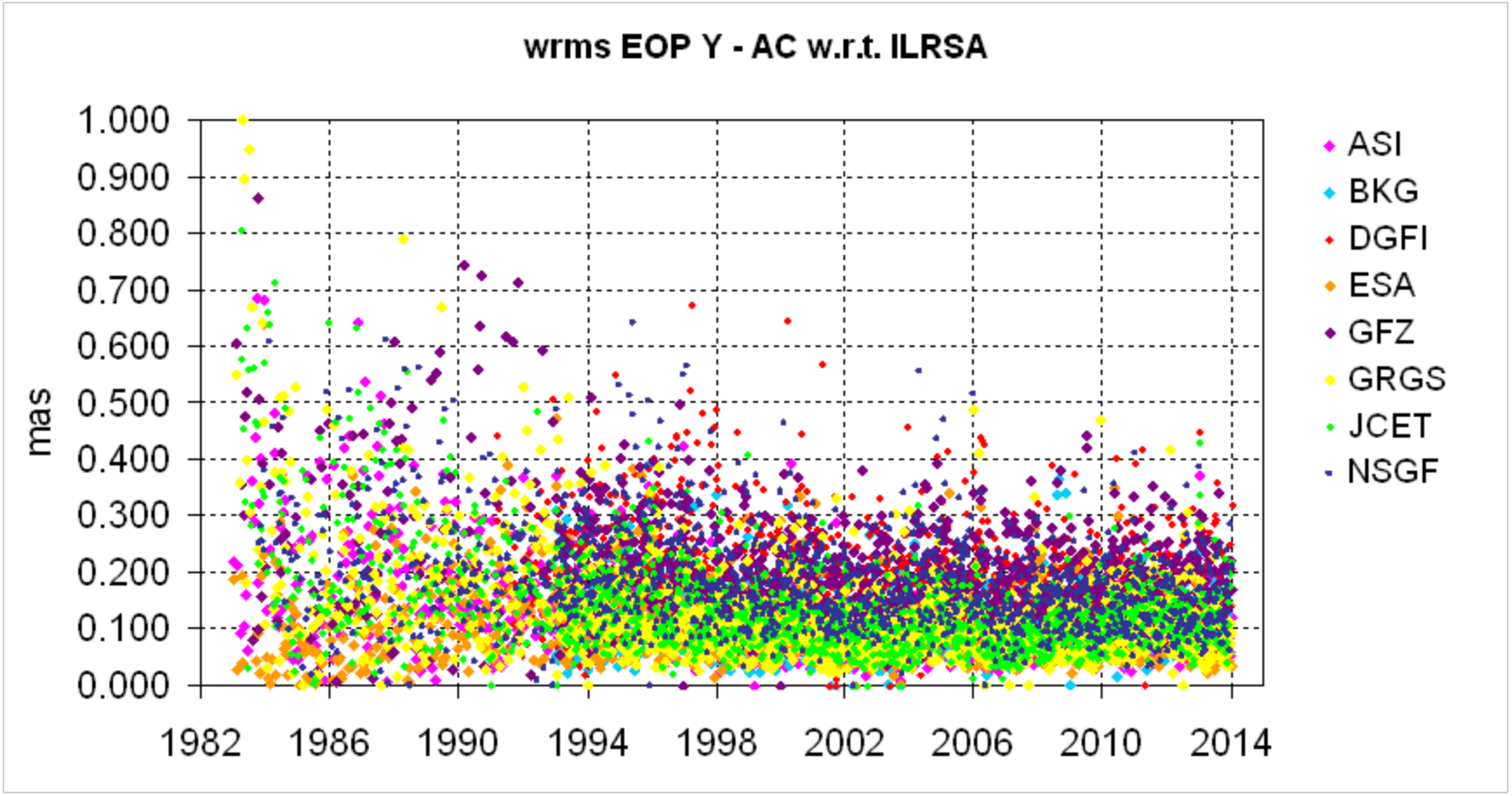




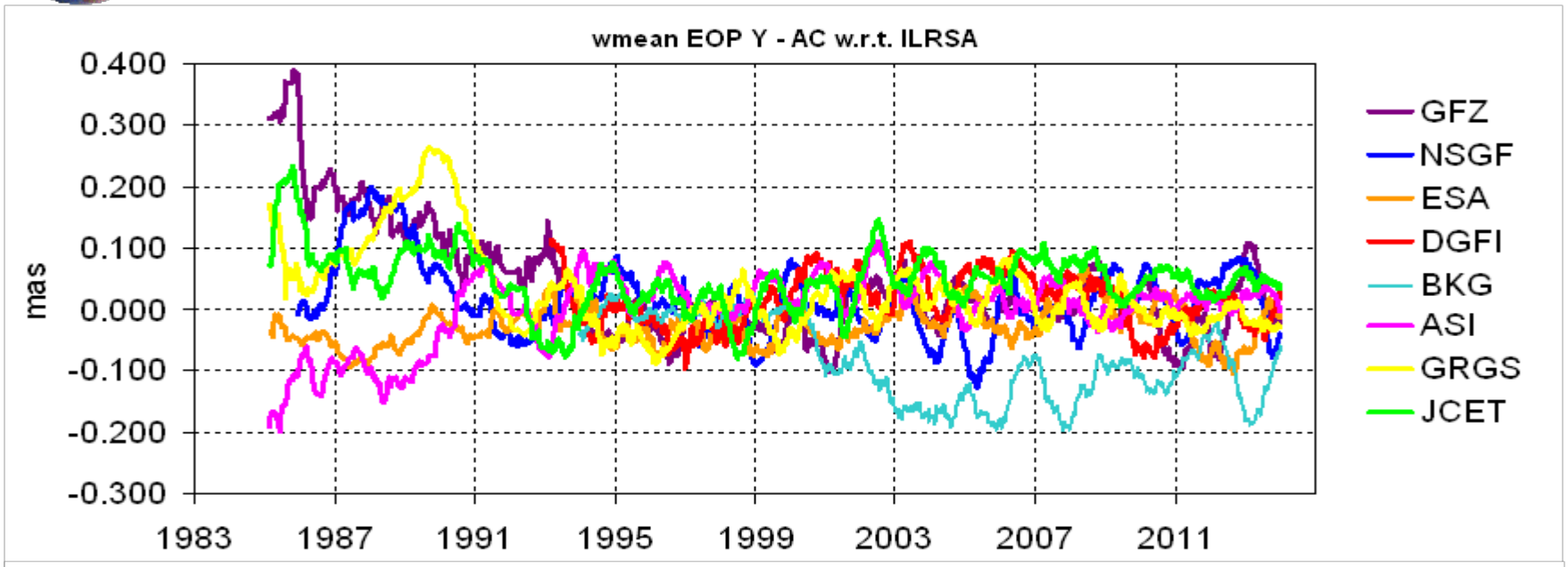
EOP Y - Weekly mean of residuals wrt ILRSA

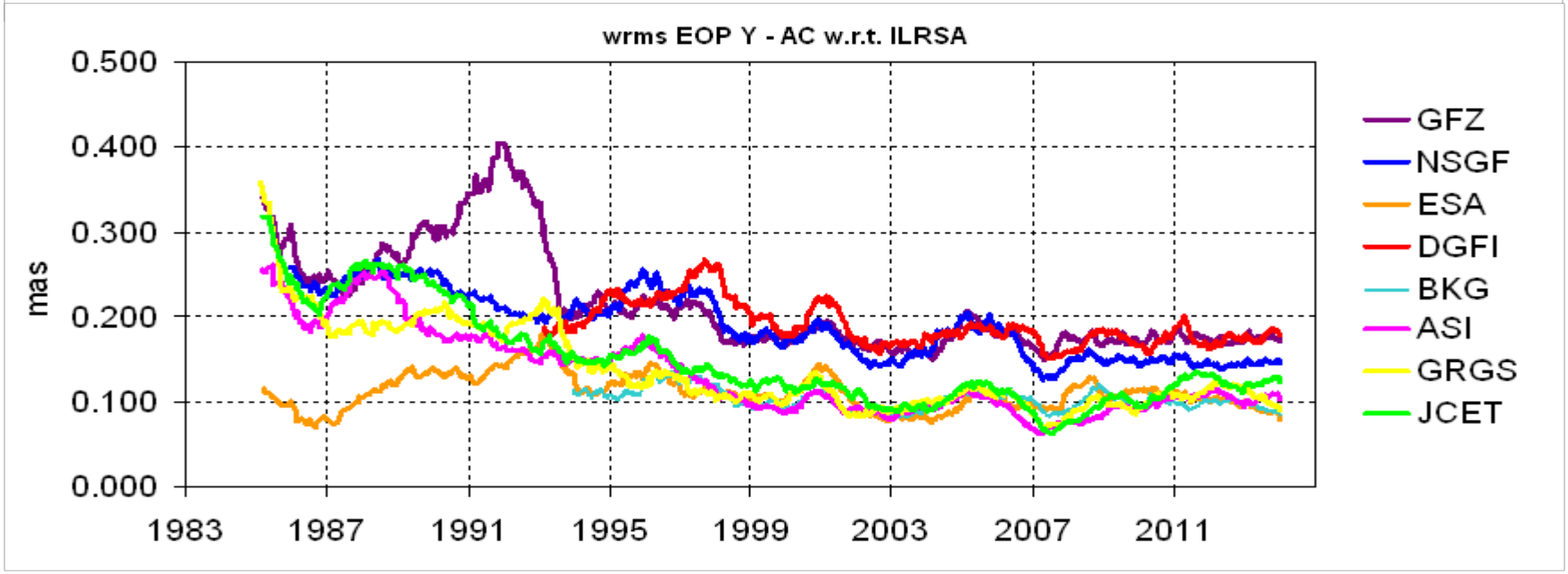


EOP Y - Weekly STD of residuals wrt ILRSA

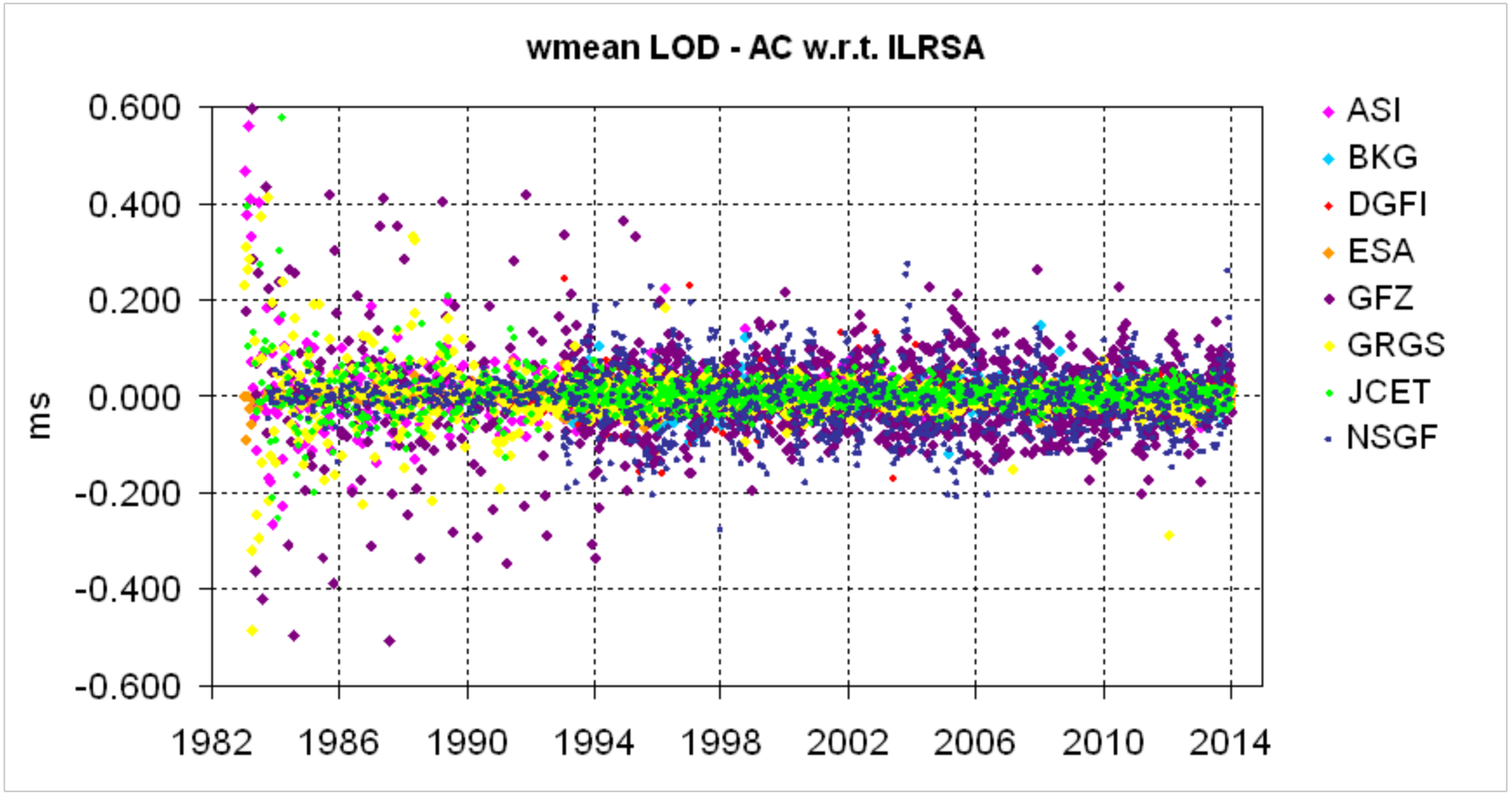


EOP Y - Weekly residuals wrt ILRSA

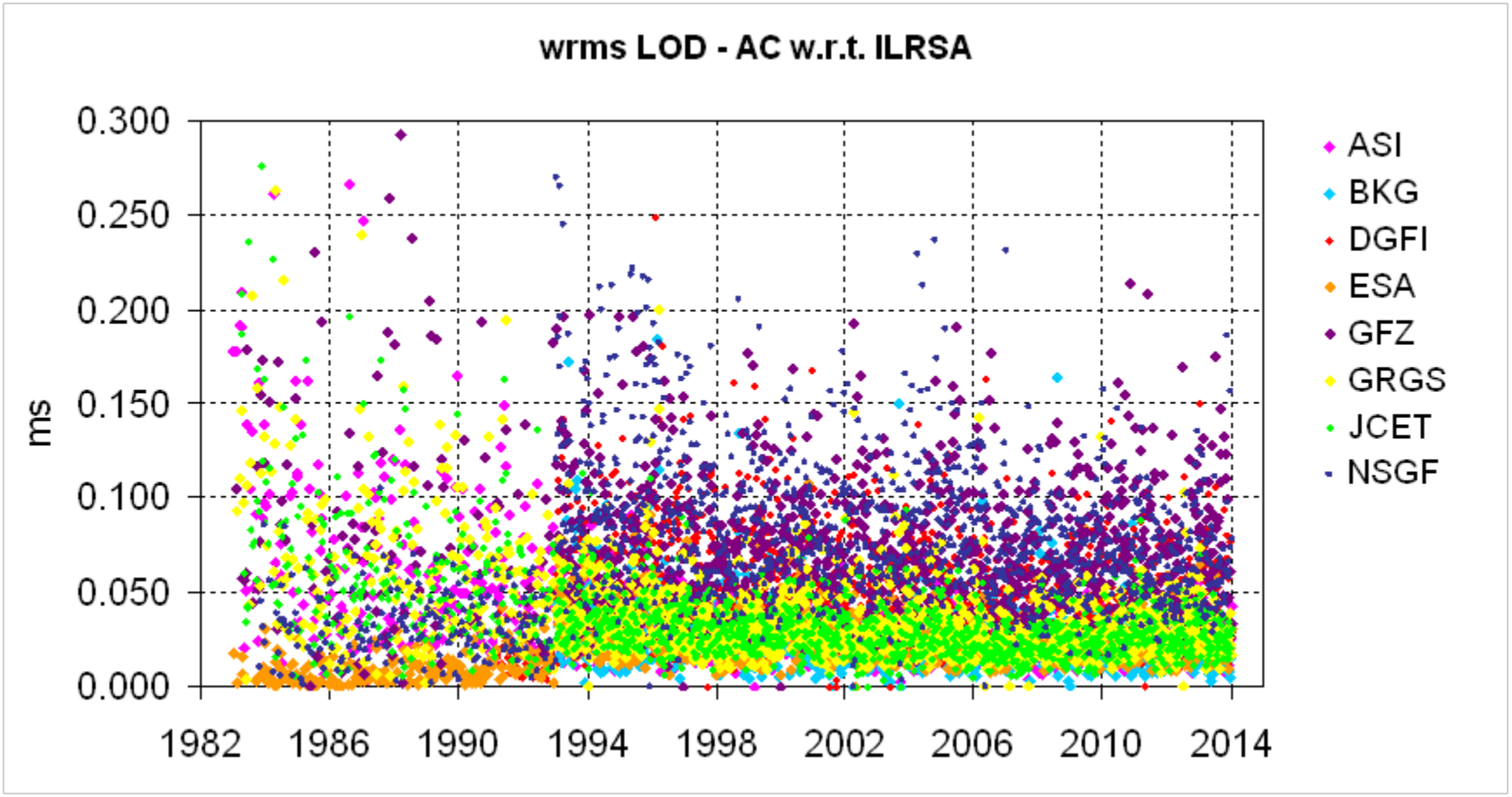




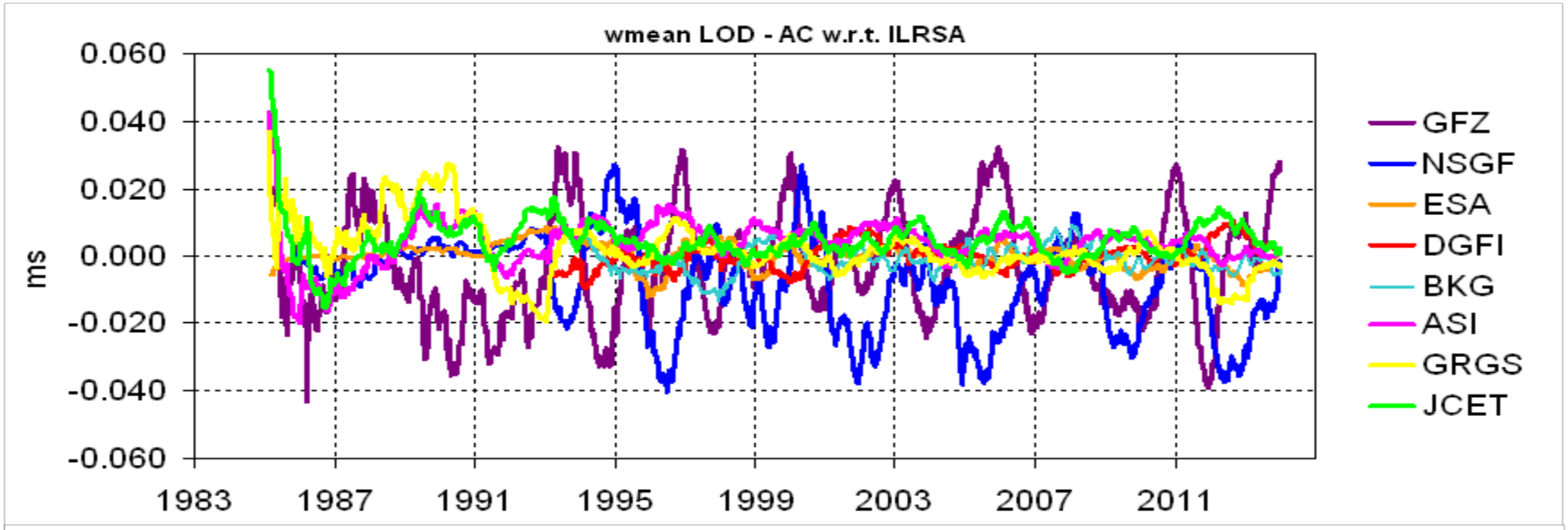
LOD - Weekly Mean of residuals wrt ILRSA

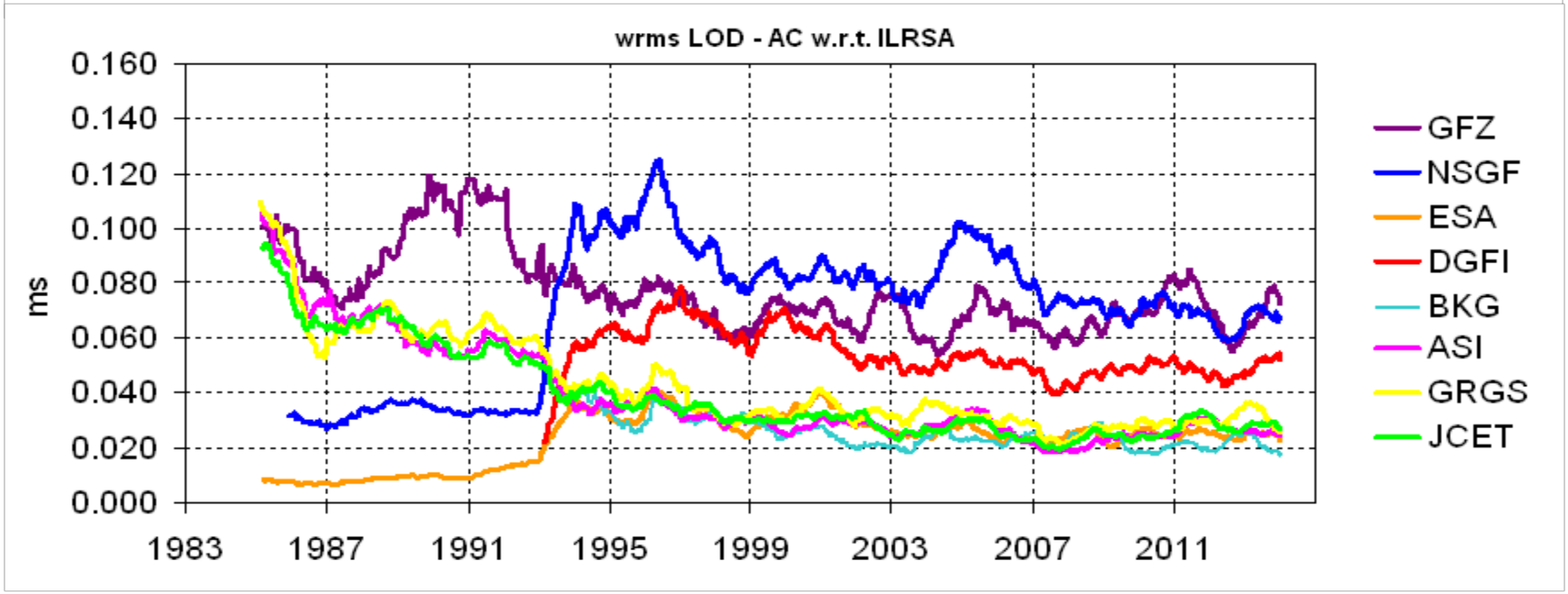


LOD - Weekly STD of residuals wrt ILRSA

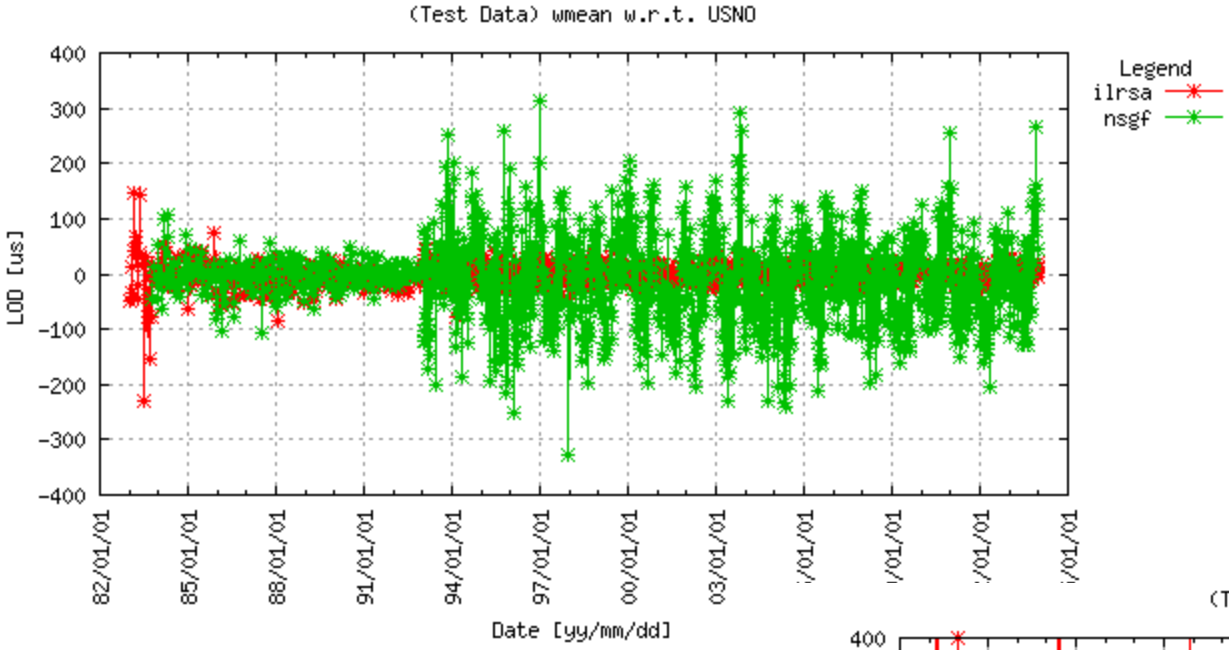


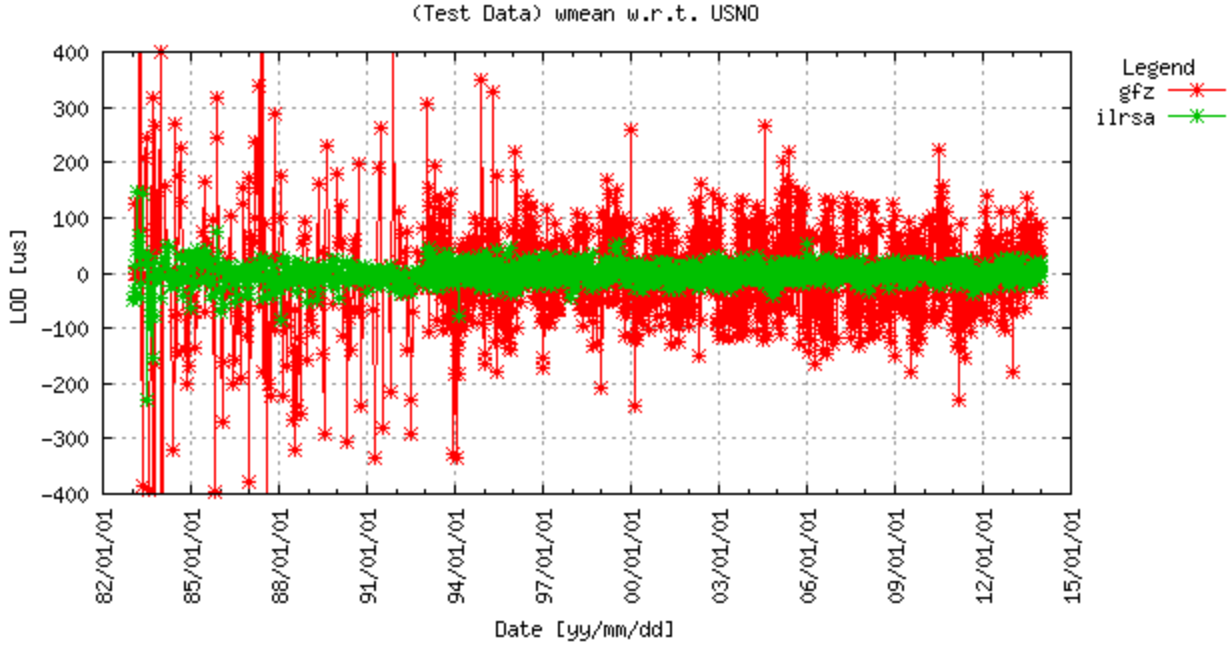
LOD - Weekly residuals wrt ILRSA





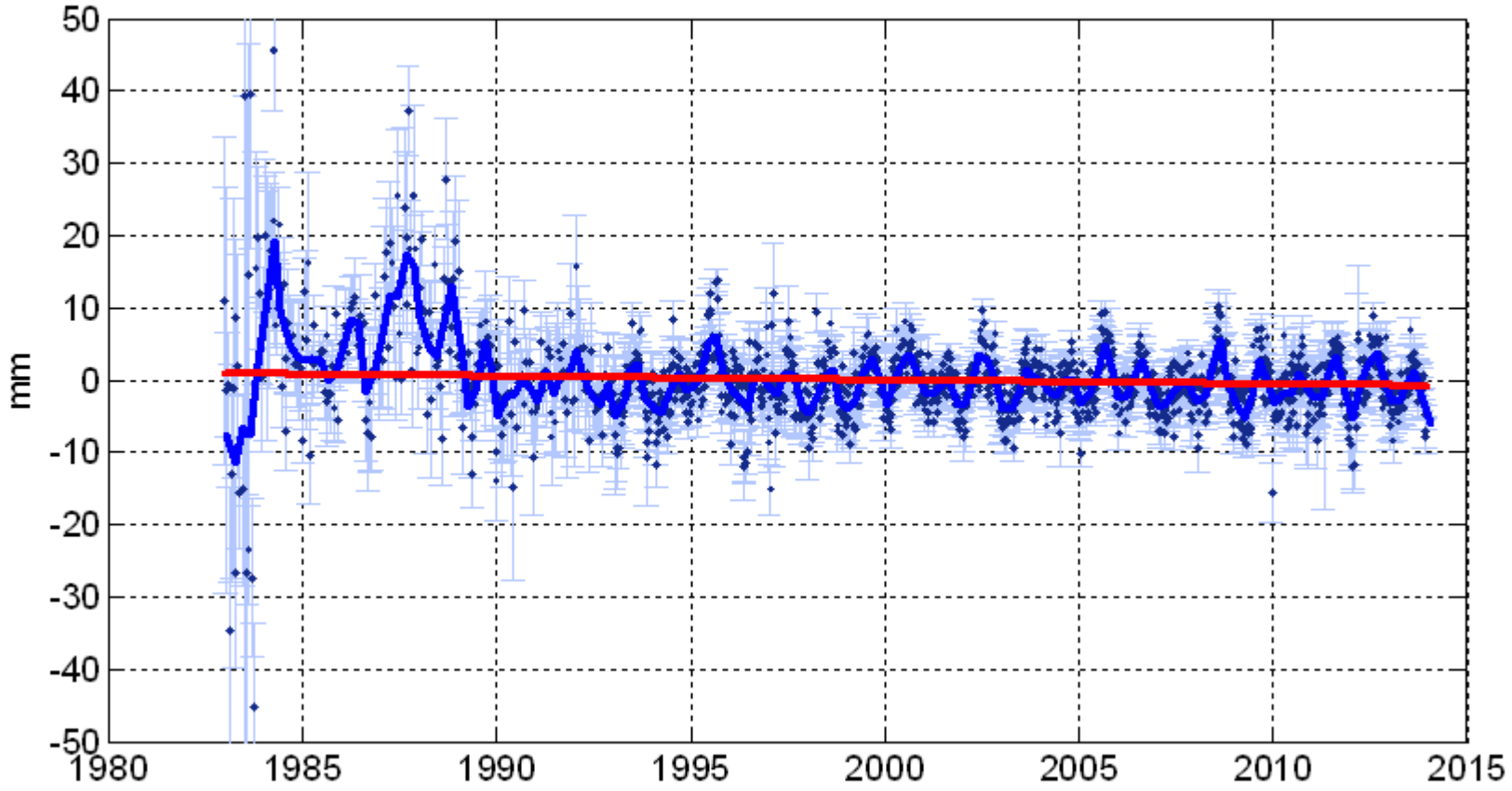
LOD: NSGF and GFZ w.r.t. USNO





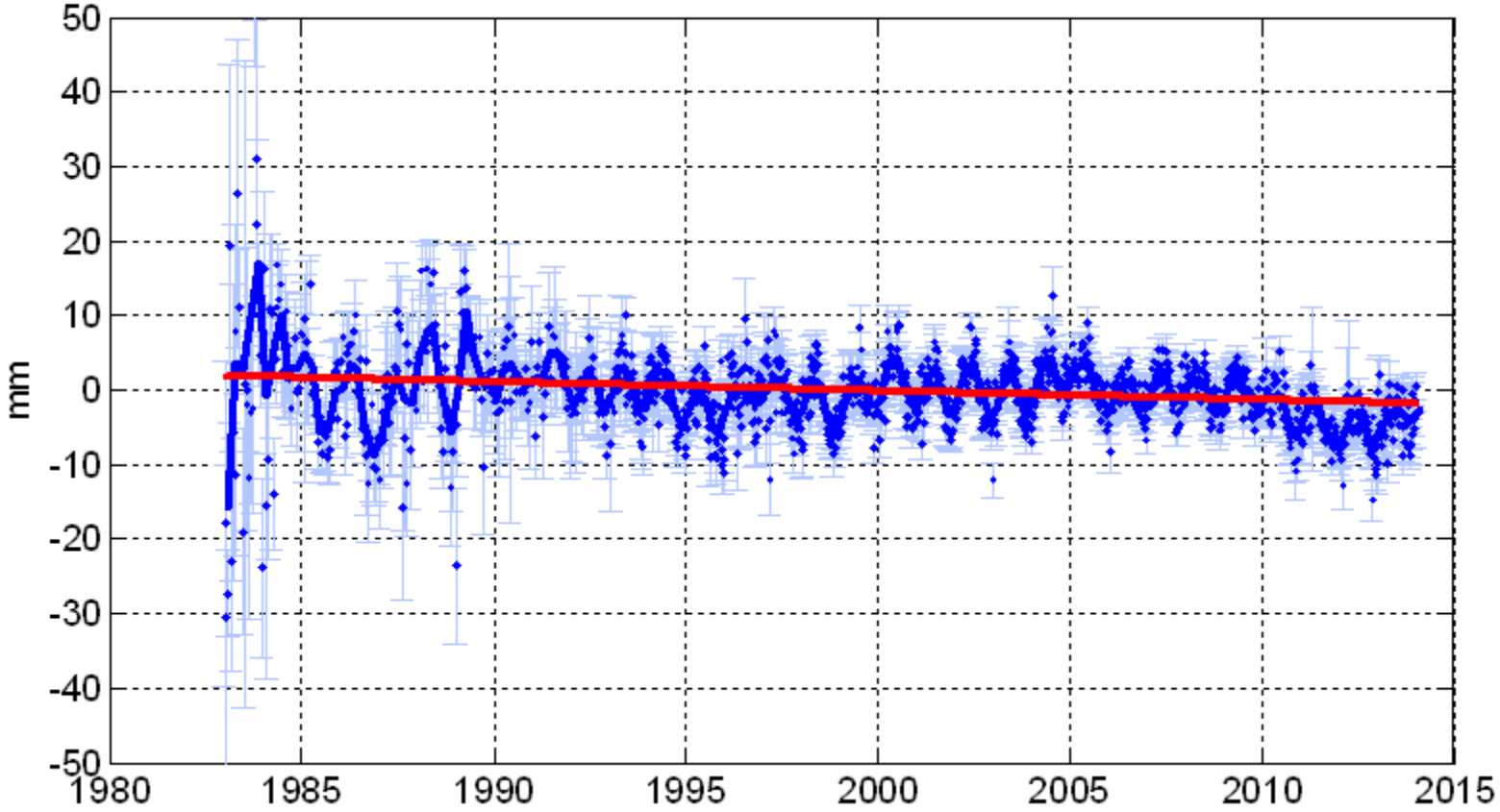
Helmert parameters – ILRSA Tx

- Tx has a slope of -0.05 +/- 0.01 mm/yr, with a residual WRMS of 2.5 mm after removal of the annual and semiannual signals
- 2 mm annual signal



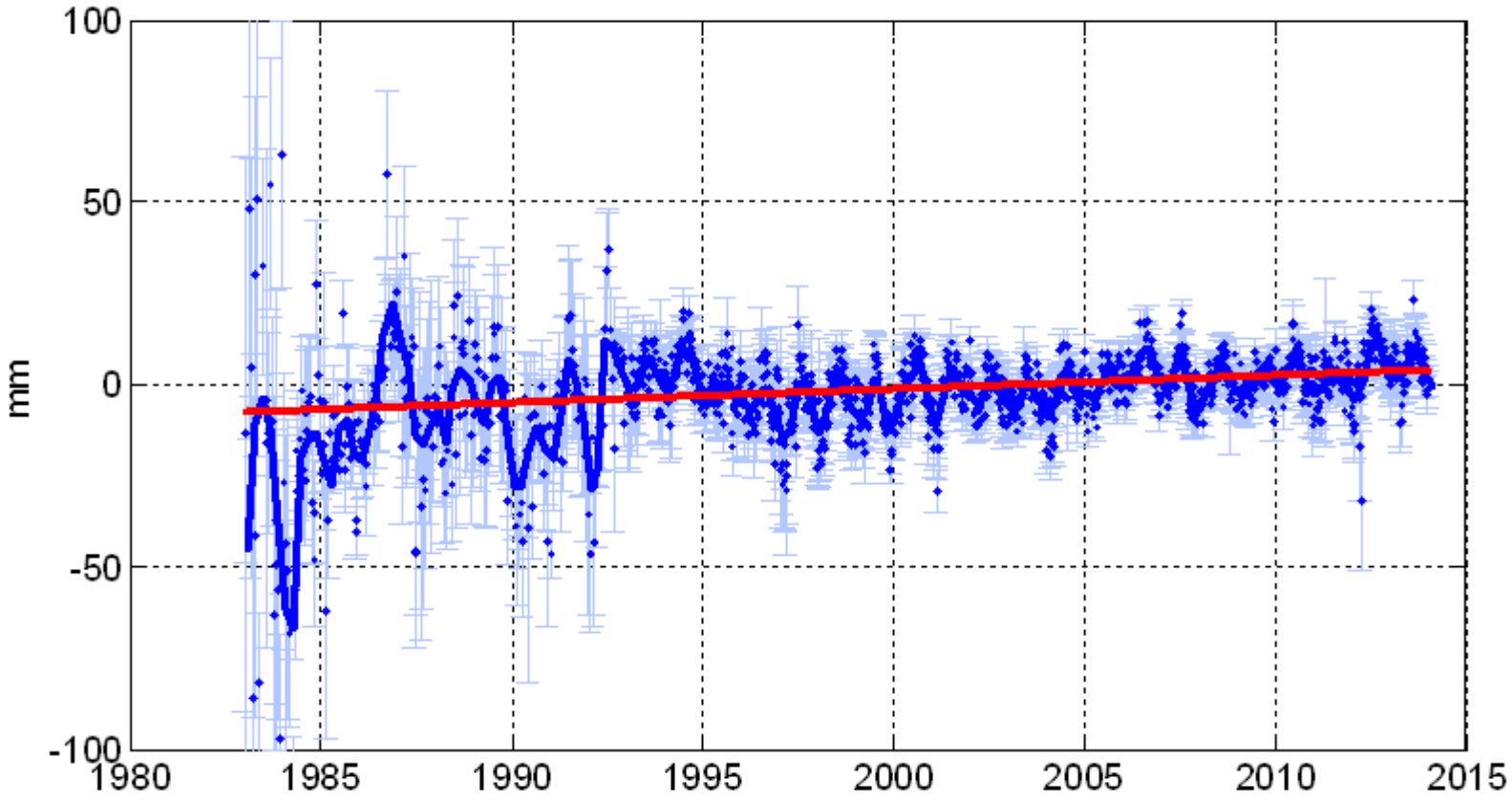
Helmert parameters – ILRSA Ty

- Ty shows a slope -0.11+/-0.01 mm/yr and WRMS of the residuals of 2.3 mm after removal of the annual and semiannual signals
- 2 mm annual signal



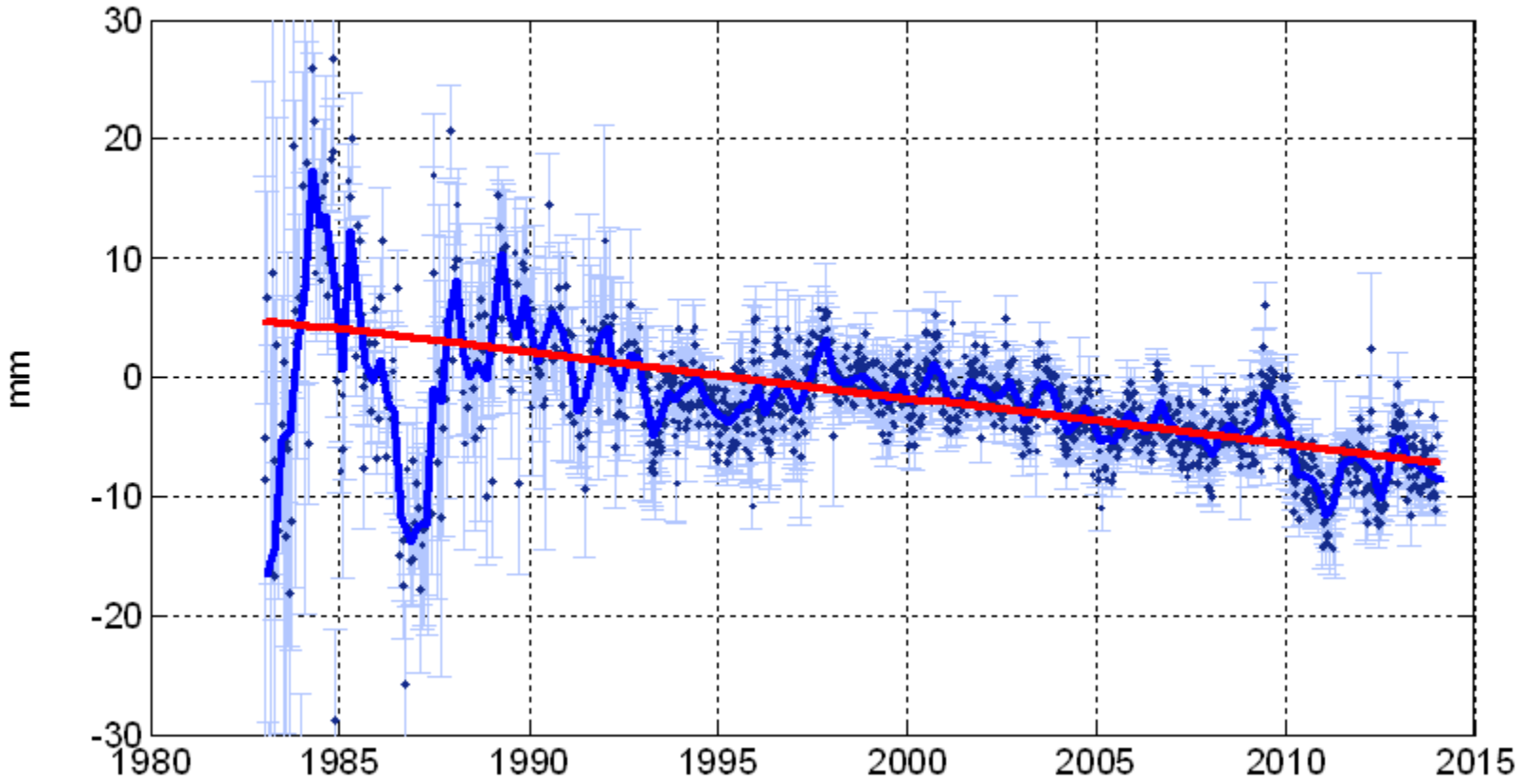
Helmert parameters – ILRSA Tz

- Tz slope is 0.36 +/- 0.02 mm/yr with a residual WRMS of 4.5 mm after removal of the annual and semiannual signals
- 4.5 mm annual signal

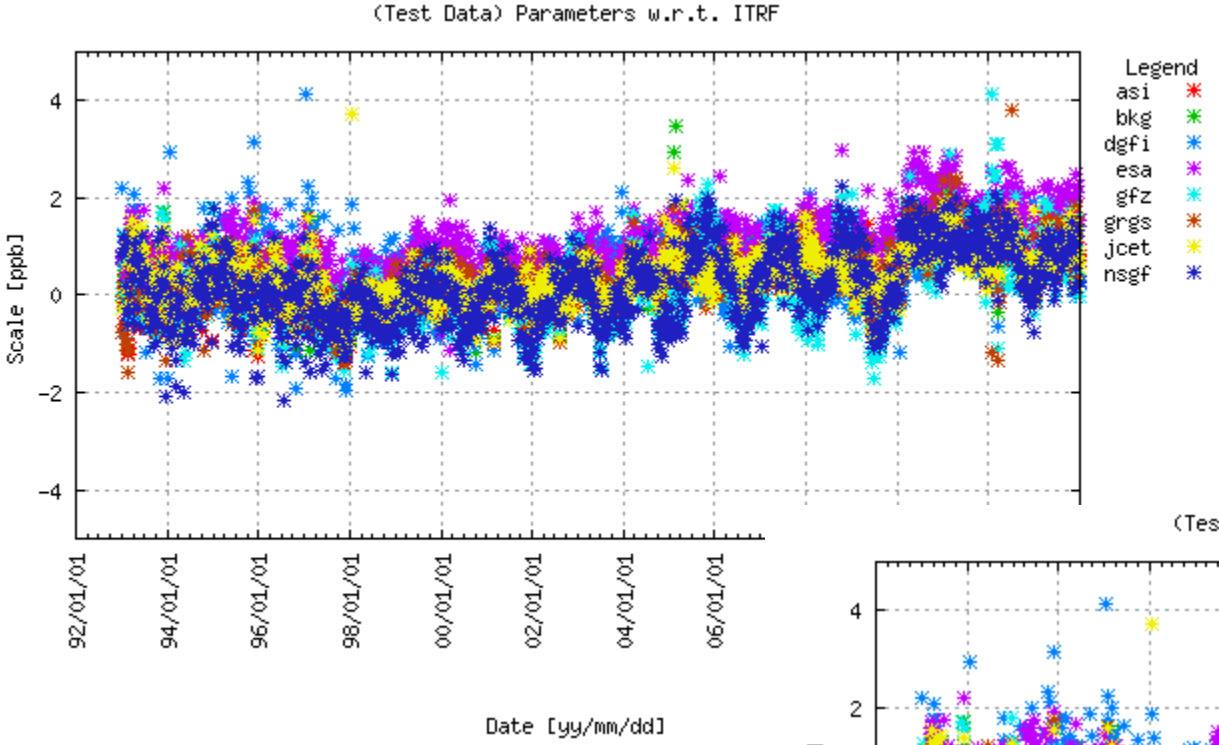


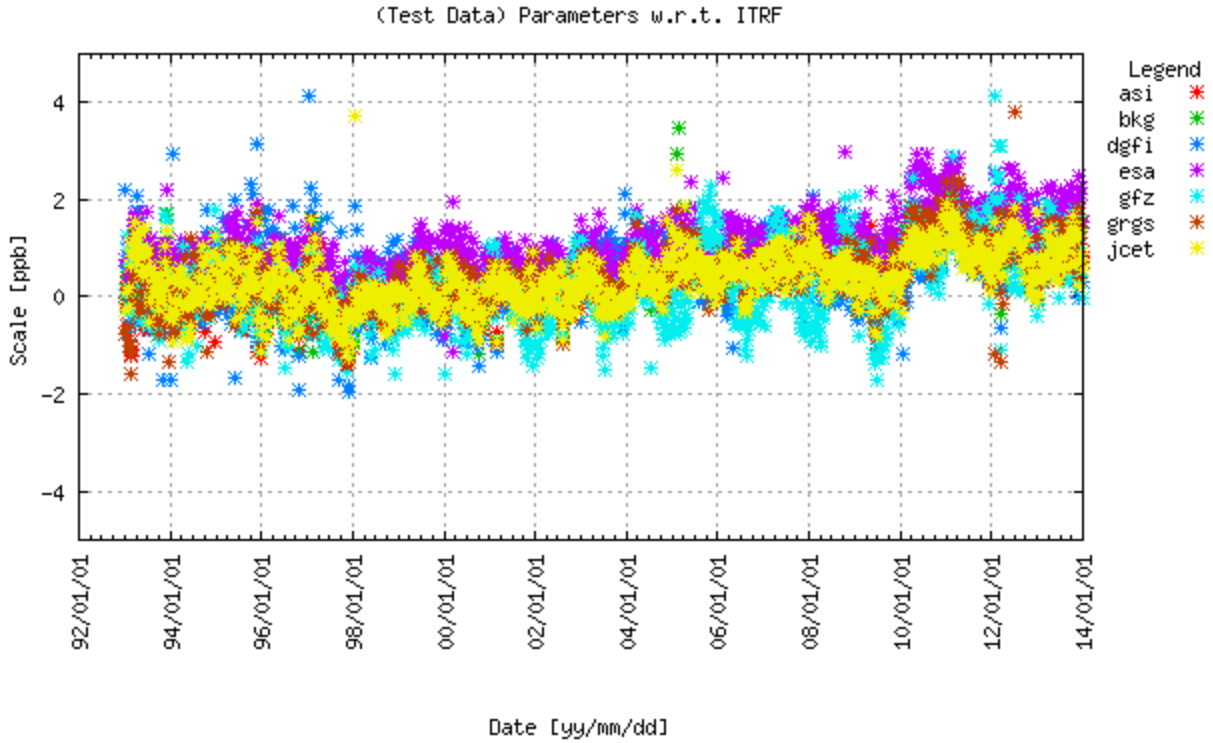
Helmert parameters – ILRSA Scale

- Δ_scale shows a slope of -0.38+/- 0.01 mm/yr with a residual WRMS of 2.85 mm



Helmert parameters – AC Scale





Early Results from New Initiatives on SLR Tracking of GNSS and Synchronous Satellites

M. R. Pearlman[1], G. Appleby[2], A. Ipatov[3], V. Jayaraman[4], C. E. Noll[5], E. Pavlis[6], V. Shargorodsky[7], J. Woo[8]

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[2]Space Geodesy Facility, Herstmonceux, East Sussex, UK
[3]Institute of Applied Astronomy, Russian Academy of Sciences, St. Petersburg, Russia,
[4] ISTRAC/ISRO, Bangalore, INDIA
[5]NASA Goddard Space Flight Center, Greenbelt MD, USA
[6]University of Maryland, Baltimore MD, USA
[7]OJC"RPC"PSI", Moscow, Russia
[8] Exelis Inc., Greenbelt, MD, USA

International Workshop on Laser Ranging
Annapolis MD
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M. R. Pearlman, G. Appleby, A. Ipatov, V. Jayaraman, C. E. Noll, E. Pavlis, V. Shargorodsky, J. Woo

The ILRS is faced with a large increase in the number of GNSS satellites that will require SLR tracking. New technology systems and operational procedures need to recognize this need.

As a result of the LARGE meeting in Vienna in April 2014, an SLR Pilot Project was undertaken to assess the current ability of the ILRS Network to expand tracking on GNSS satellites. A campaign took place during August and September asking stations to track all of the present constellations: GLONASS, Galileo/Giove, Compass, and GPS and provide us with feedback on their experience. During this same period special short campaigns have been conducted on the IRNSS 1A and 1B. A number of stations were able to provide some data on all of the GNSS satellites; several averaged a few passes a week on each. In the IRNSS campaigns, periods of simultaneous observations were scheduled to include east-west and north-south baselines for geometric calibration of the orbits.

This talk will present the results from these tests and the implications for future tracking on these satellites by the ILRS network.

GNSS Action from the GNSS Study Group

- Recommend an operational strategy for expanded SLR tracking of the GNSS constellations taking into account the GLONASS, GGOS, and ILRS requirements and constraints, and the issues delineated in the note from the April 8, 2013 meeting (see Attachment 3);
- Evaluate the network performance based on data already acquired and new data flowing from the implementation of expanded strategies, including the informal campaign with expanded GNSS tracking which has been underway since October 2013;

GNSS Action

- Tasks for the Study Group to be initiated should include:
  - Assess past performance of the ILRS network stations on GNSS in terms of passes, normal points per pass, and quality of the normal points;
  - Using an agreed measure of performance, examine the tradeoffs among data segments per pass, number of passes per satellite, and number of satellites tracked (e.g. do we want more data per pass, more passes with fewer NP's per pass, or more satellites tracked with less data on each satellite?)
  - Organize through the Central Bureau a campaign to test the capability of the ILRS network, using an expanded set of GNSS satellite targets (perhaps all of the GNSS satellites), inviting all stations to participate. The Study Group should recommended tasking including priorities, the strategy for cycling through the constellations, etc. The campaign might be based on a something like the following scenario:
    - The stations should make their best effort to acquire three sets of 3 normal points distributed over that transit of the satellite.
    - The stations should try to cycle through all of the GNSS satellites on the updated roster;
    - Those stations with high repetition rate lasers should try to use the 1000 FR/NP recipe to improve their yield and lessen the impact on other missions;
    - The Campaign could start as early as July 1, 2014.

GNSS Campaign
August 1 – September 30, 2014

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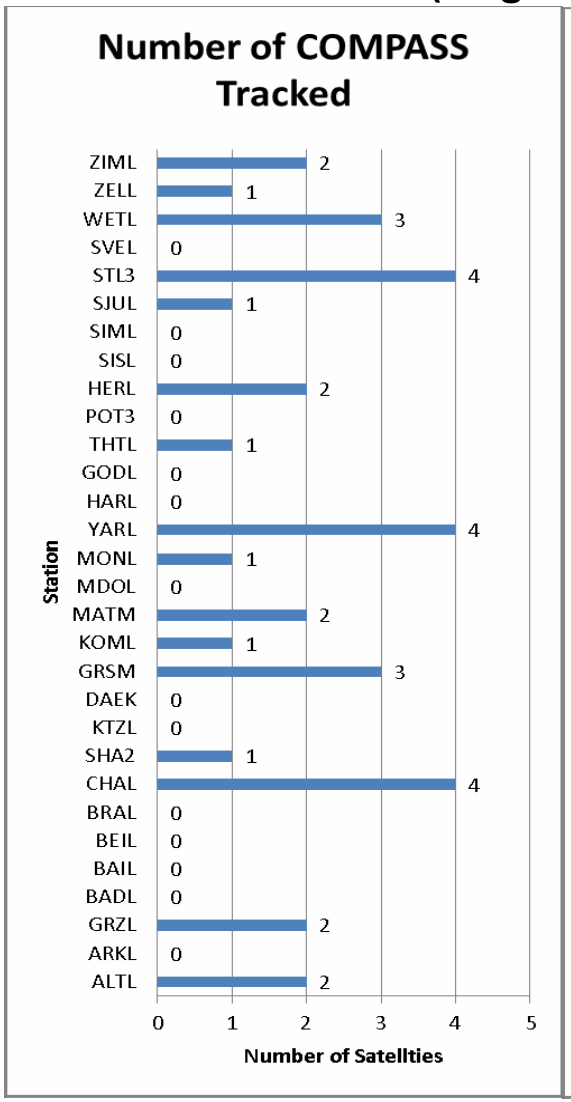
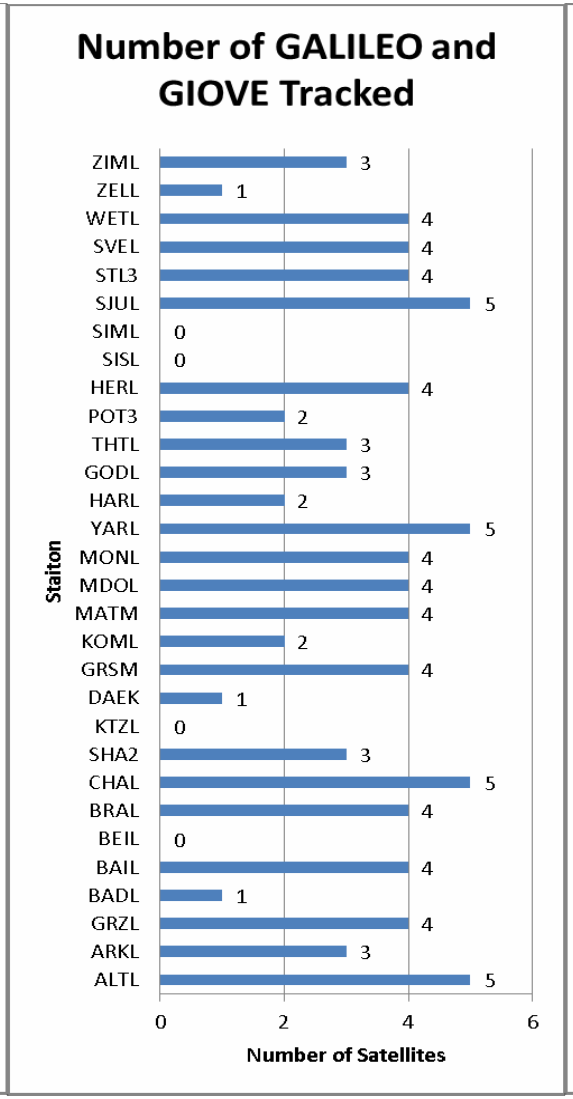
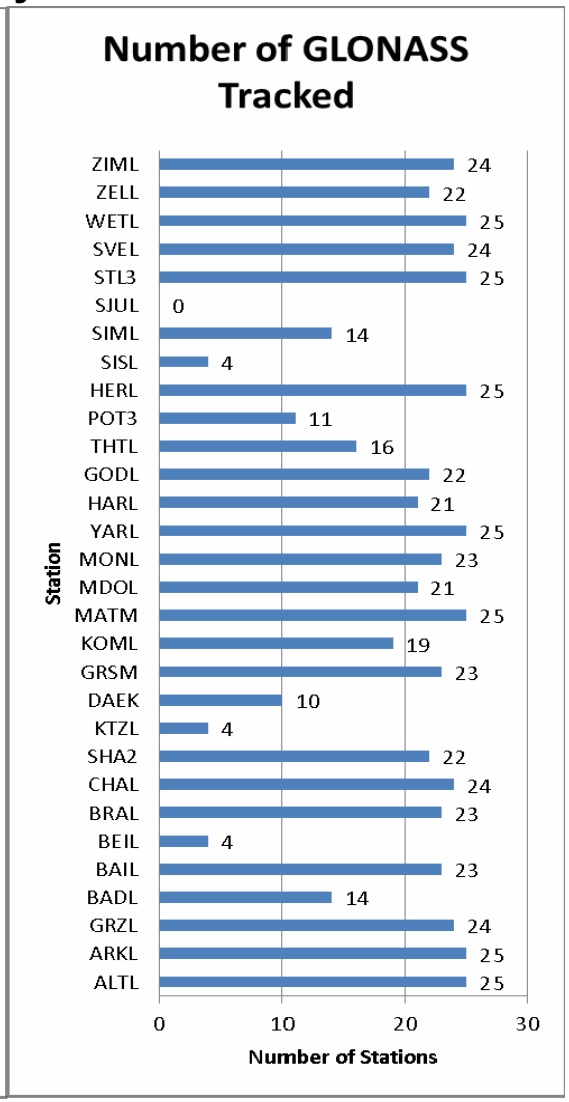
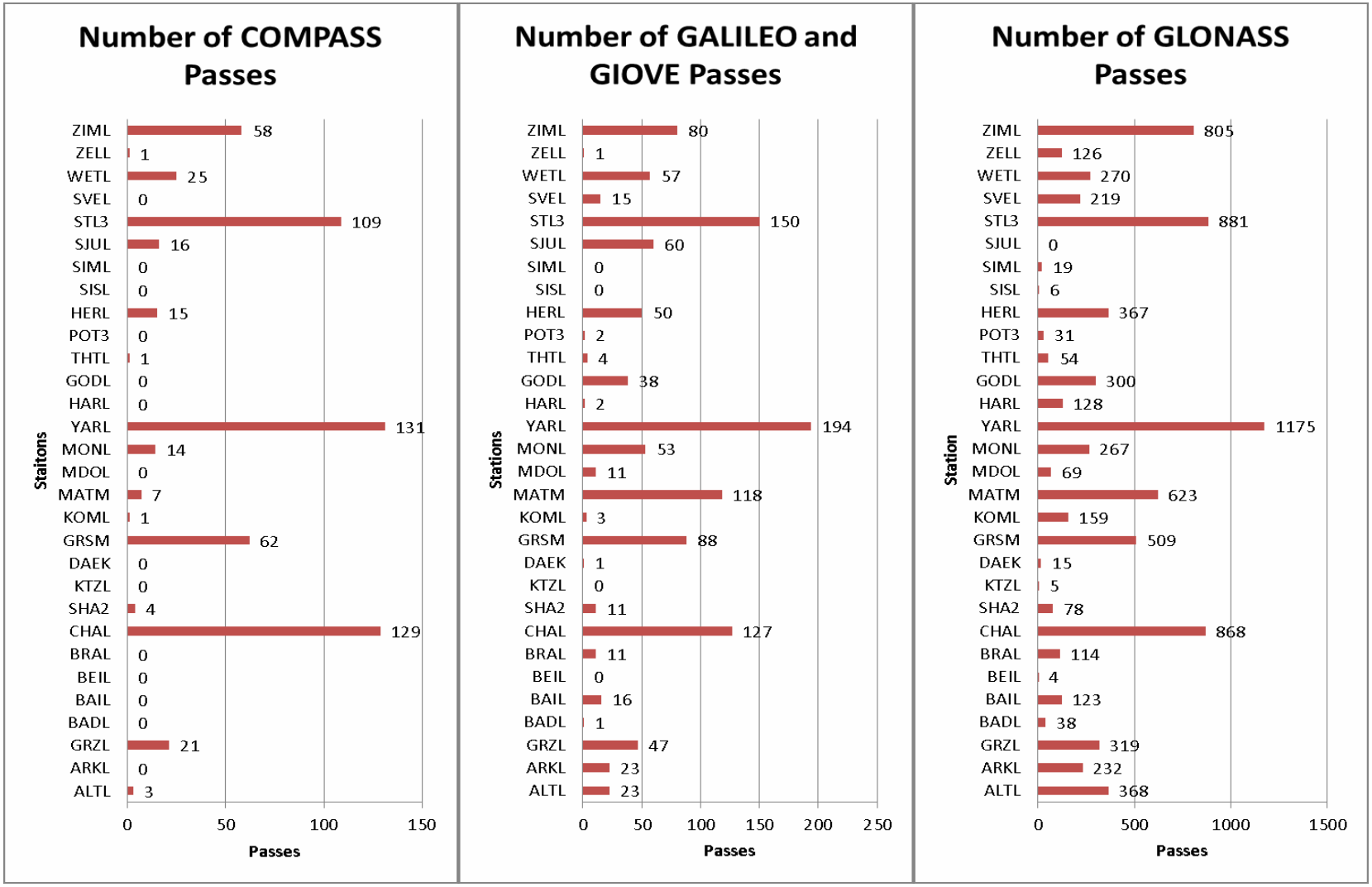
Number of Satellites by Category Tracked During the GNSS Tracking Campaign (August 1 – September 30, 2014) By Station



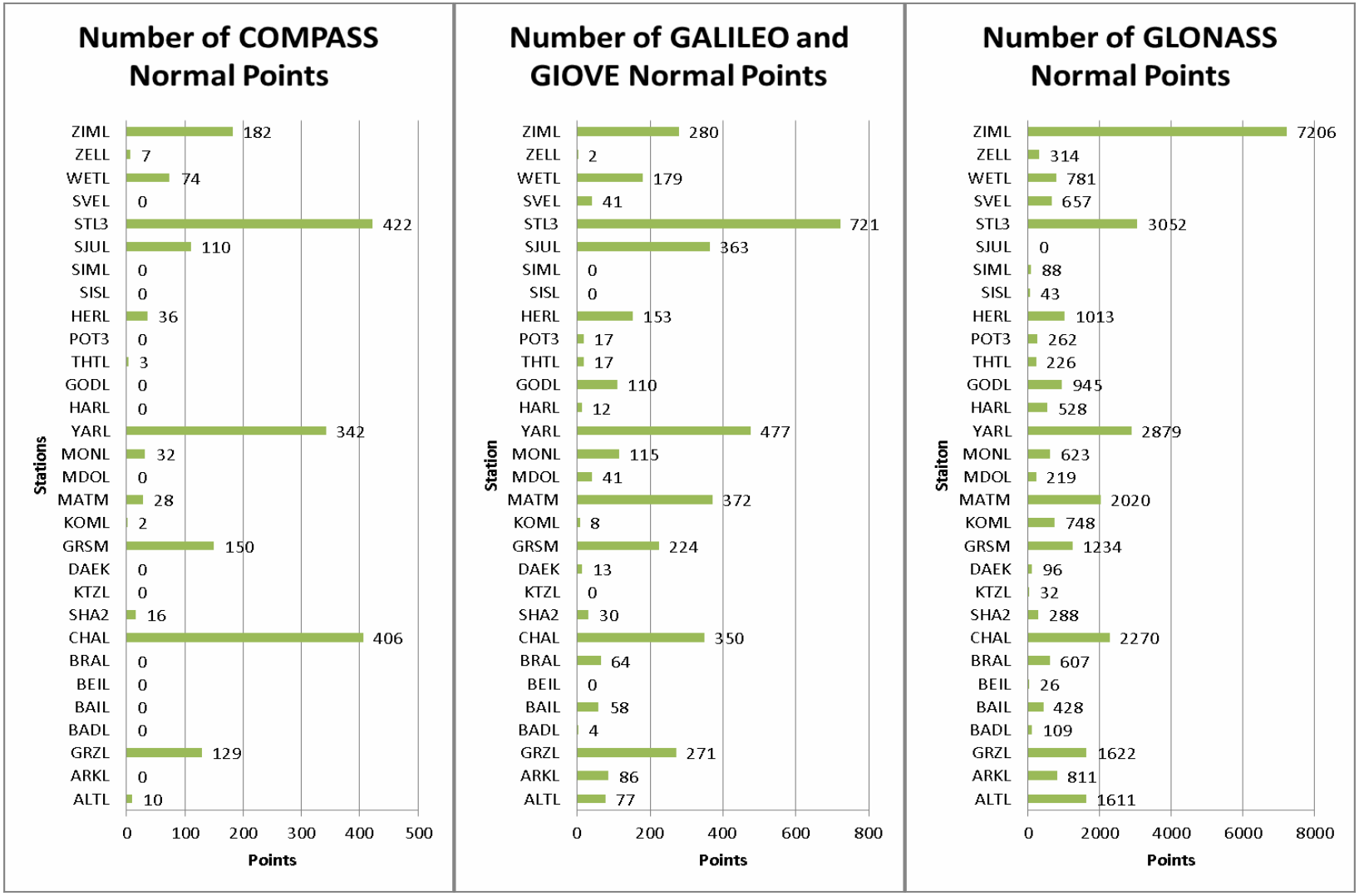




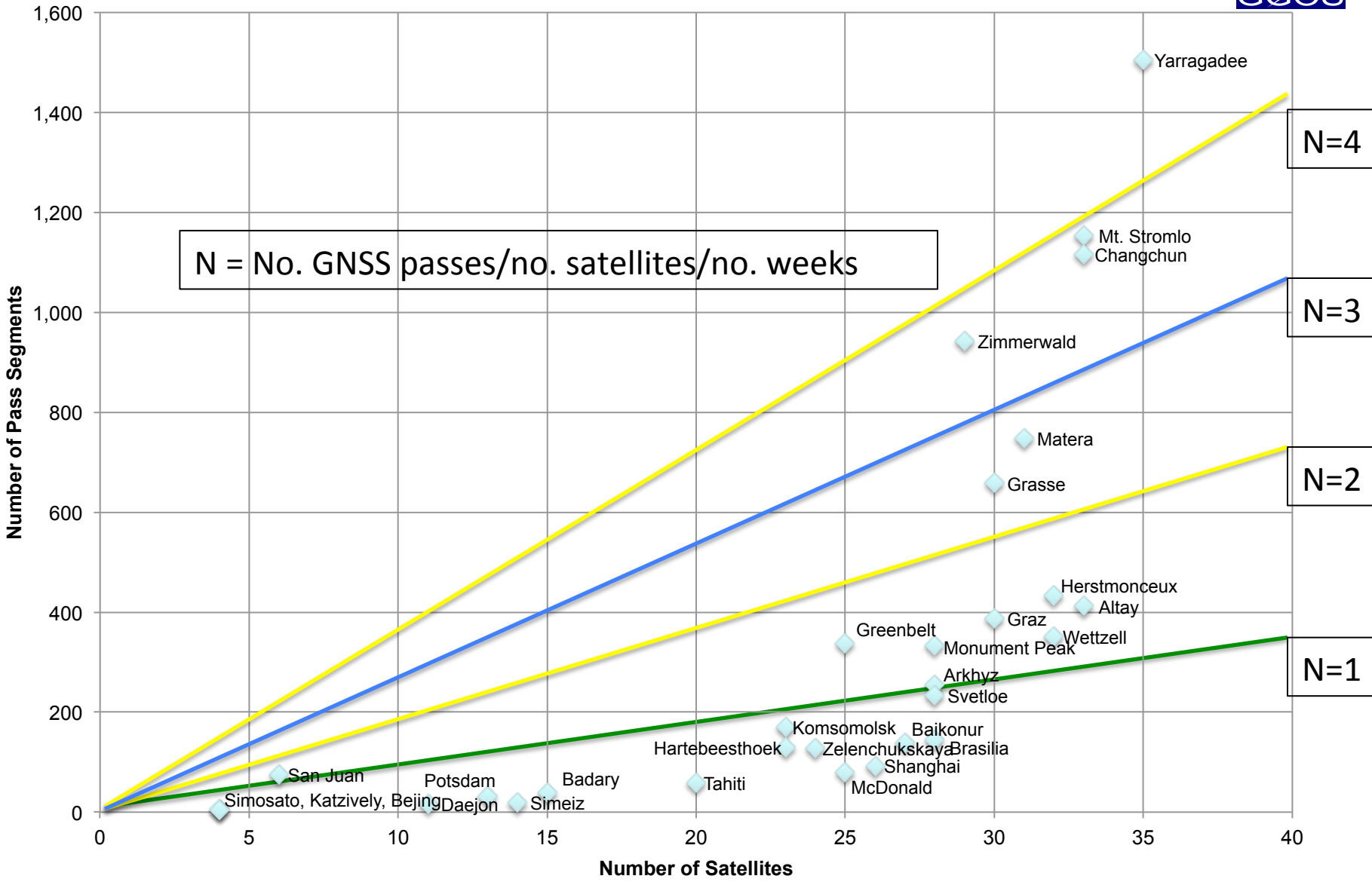
Number of Passes by Category Tracked During the GNSS Tracking Campaign (August 1 – September 30, 2014) By Station



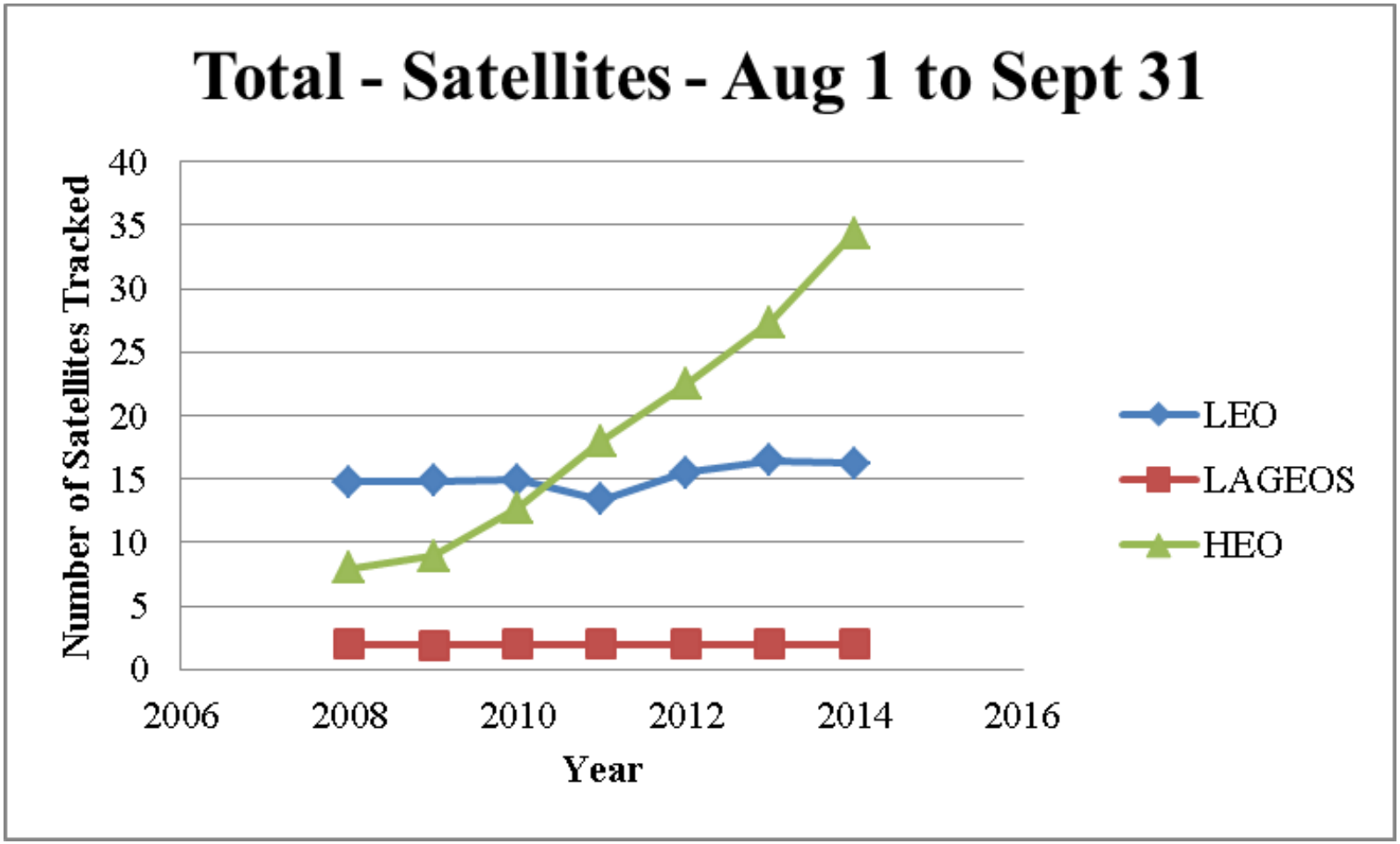
Number of Points by Category Tracked During the GNSS Tracking Campaign (August 1 – September 30, 2014) By Station



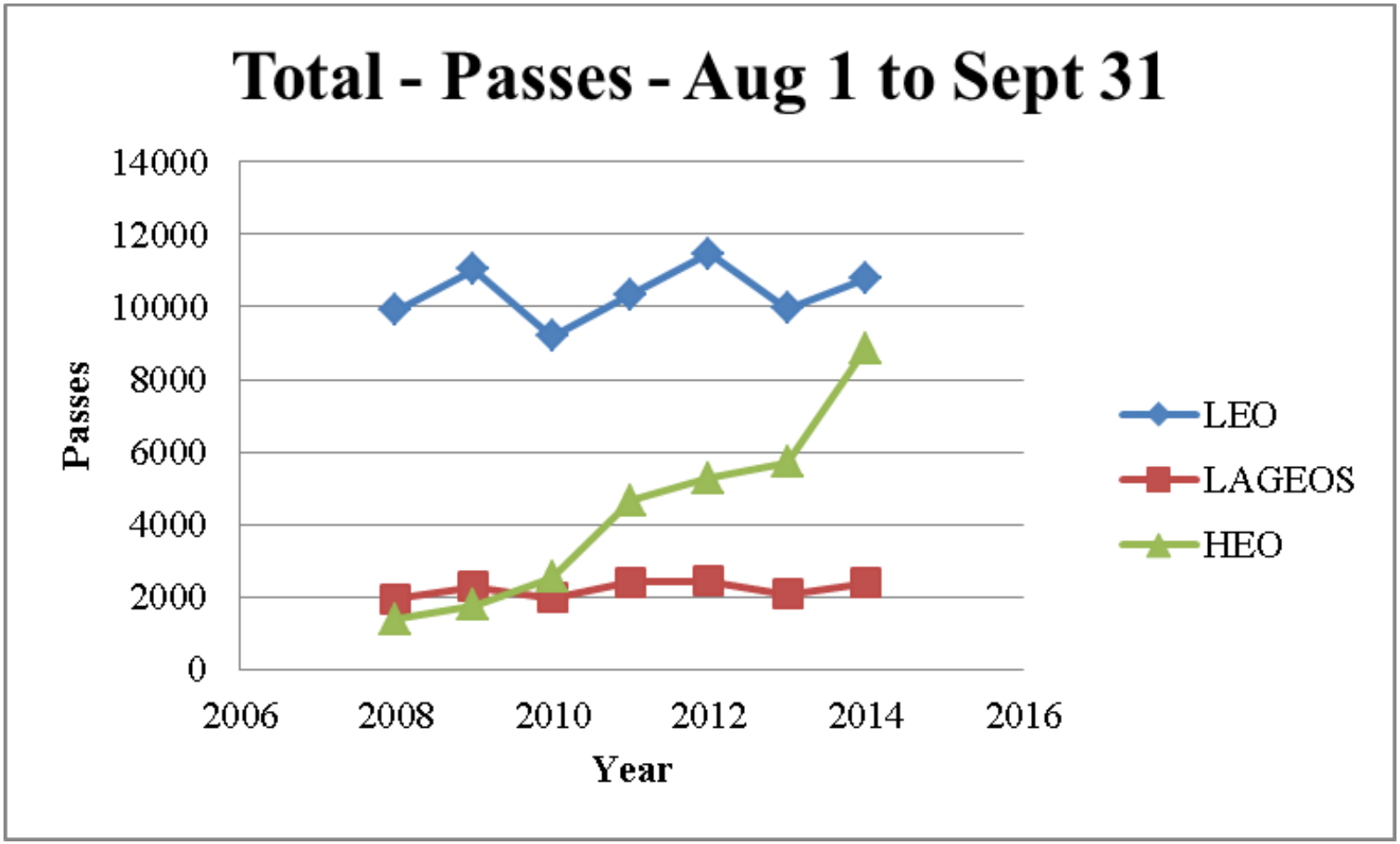
GNSS Campaign Results



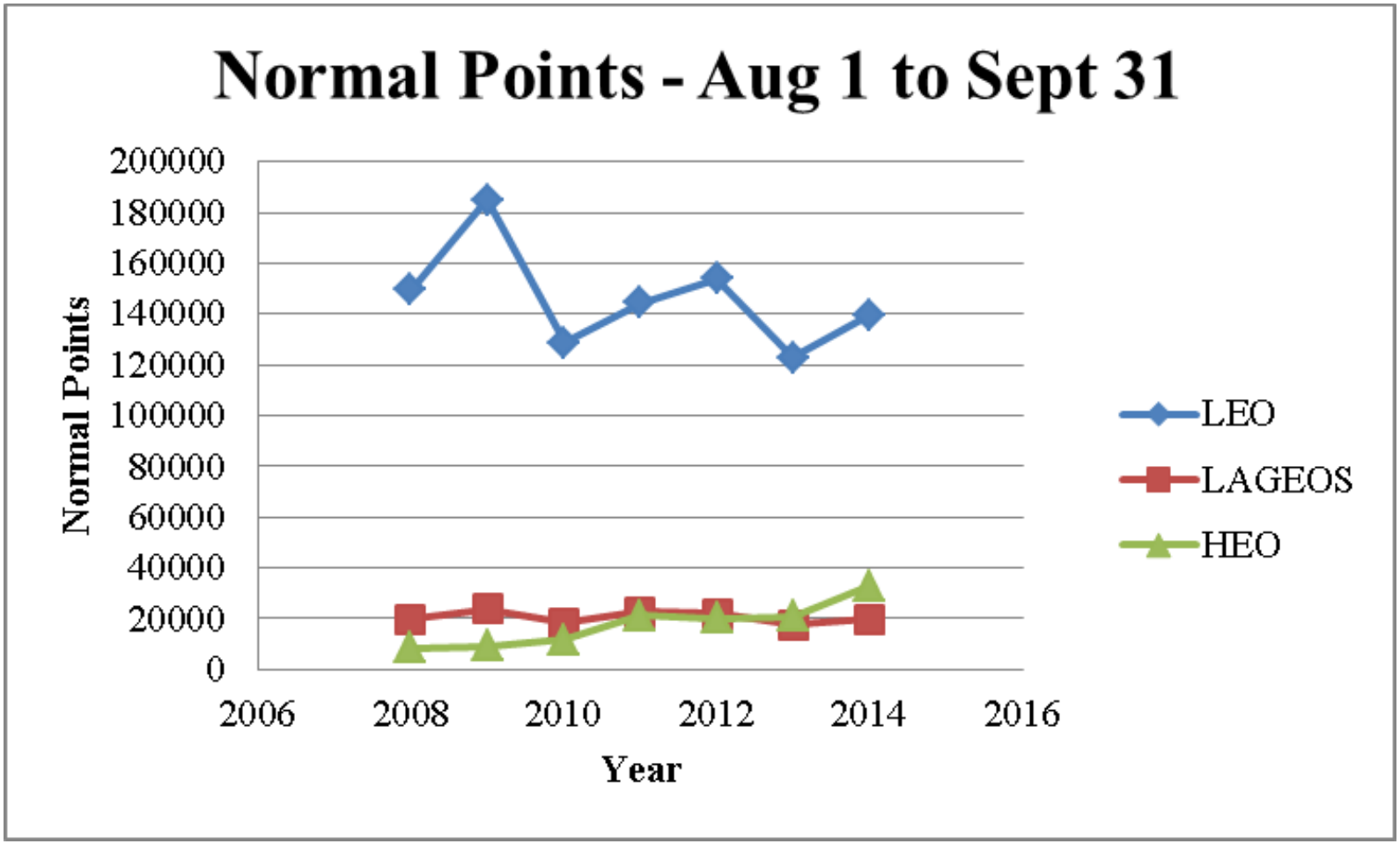
Number of Satellites Tracking During the August – September Period



Number of Passes Acquired During the August – September Period



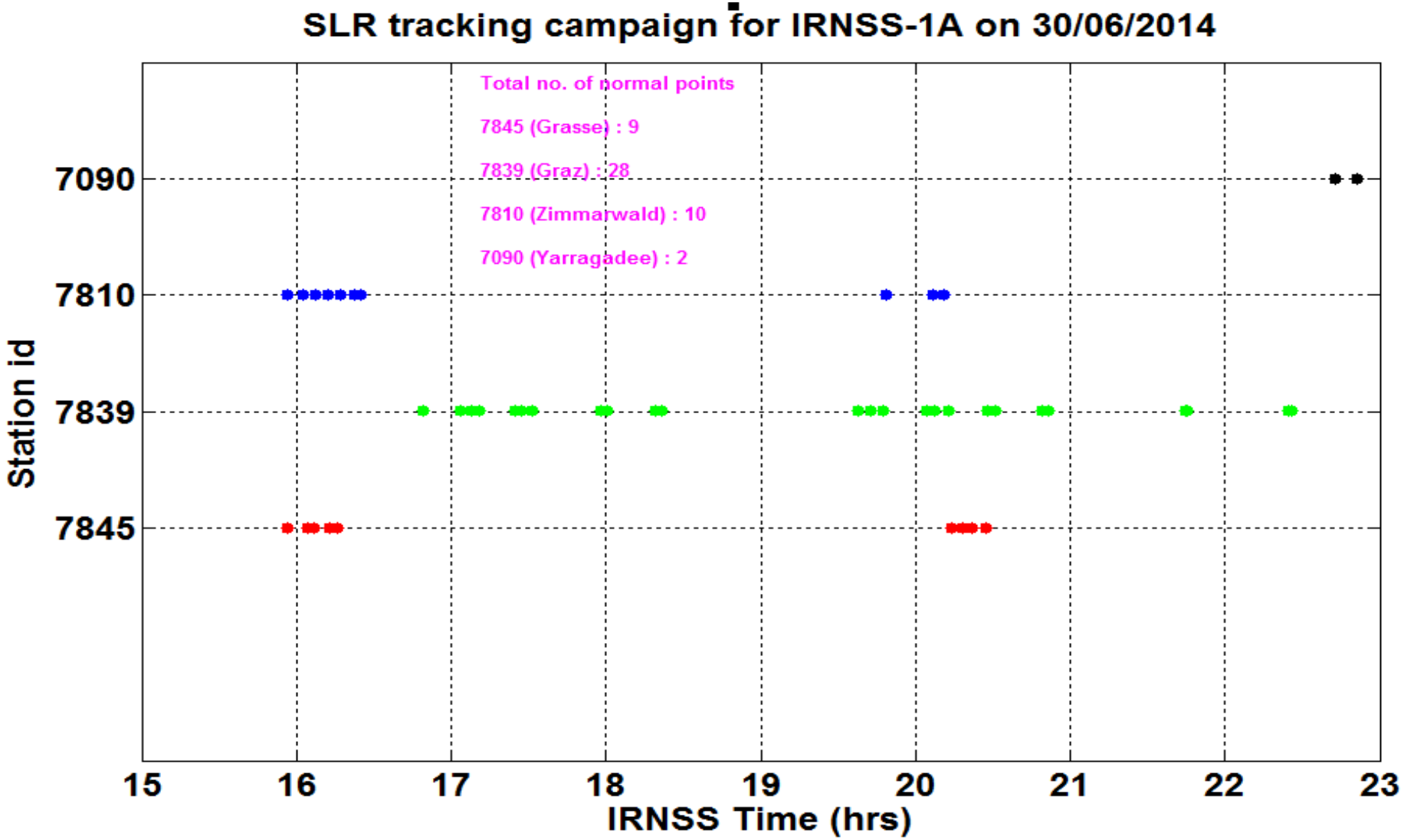
Number of NP's Acquired During the August – September Period

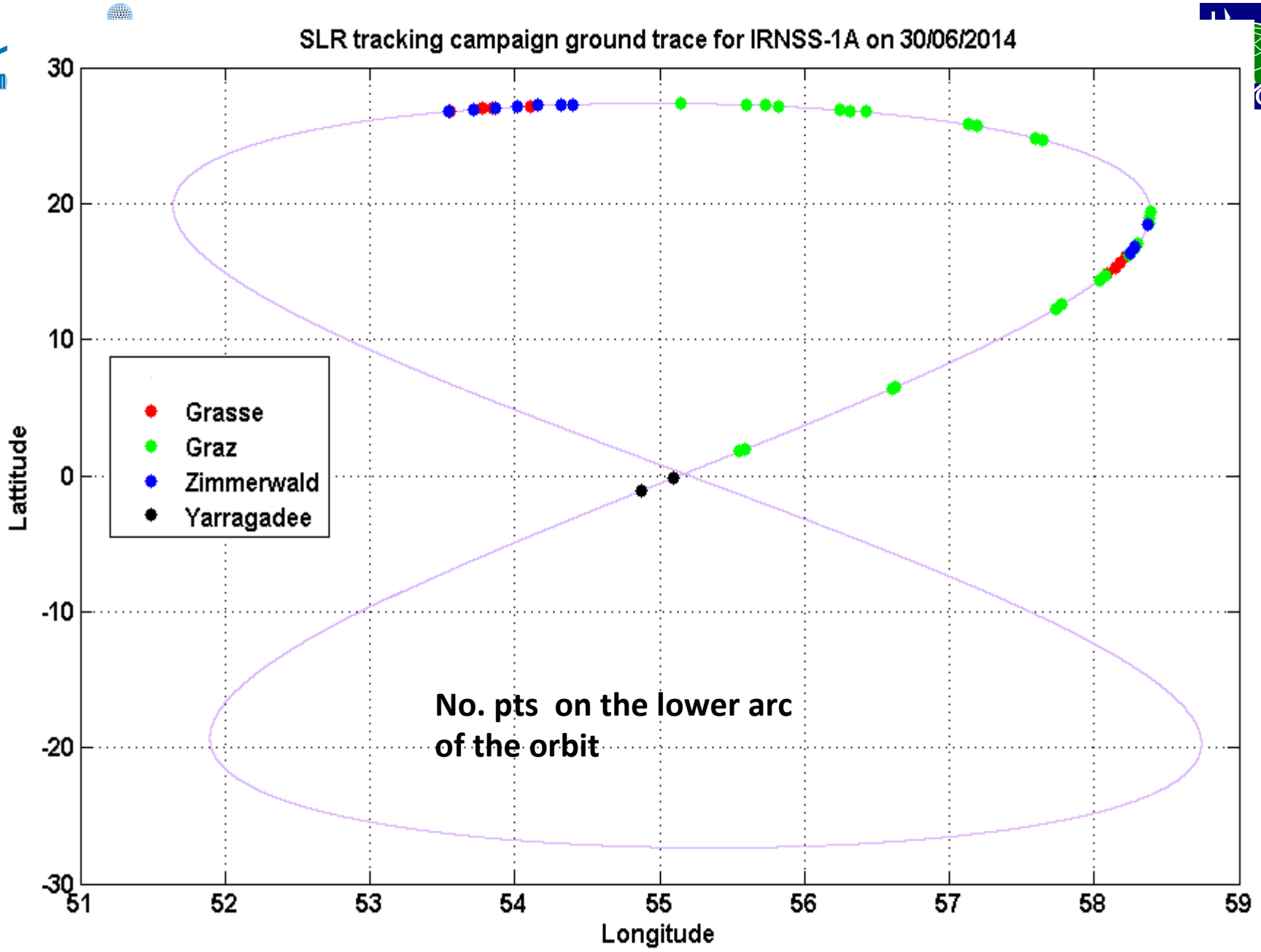


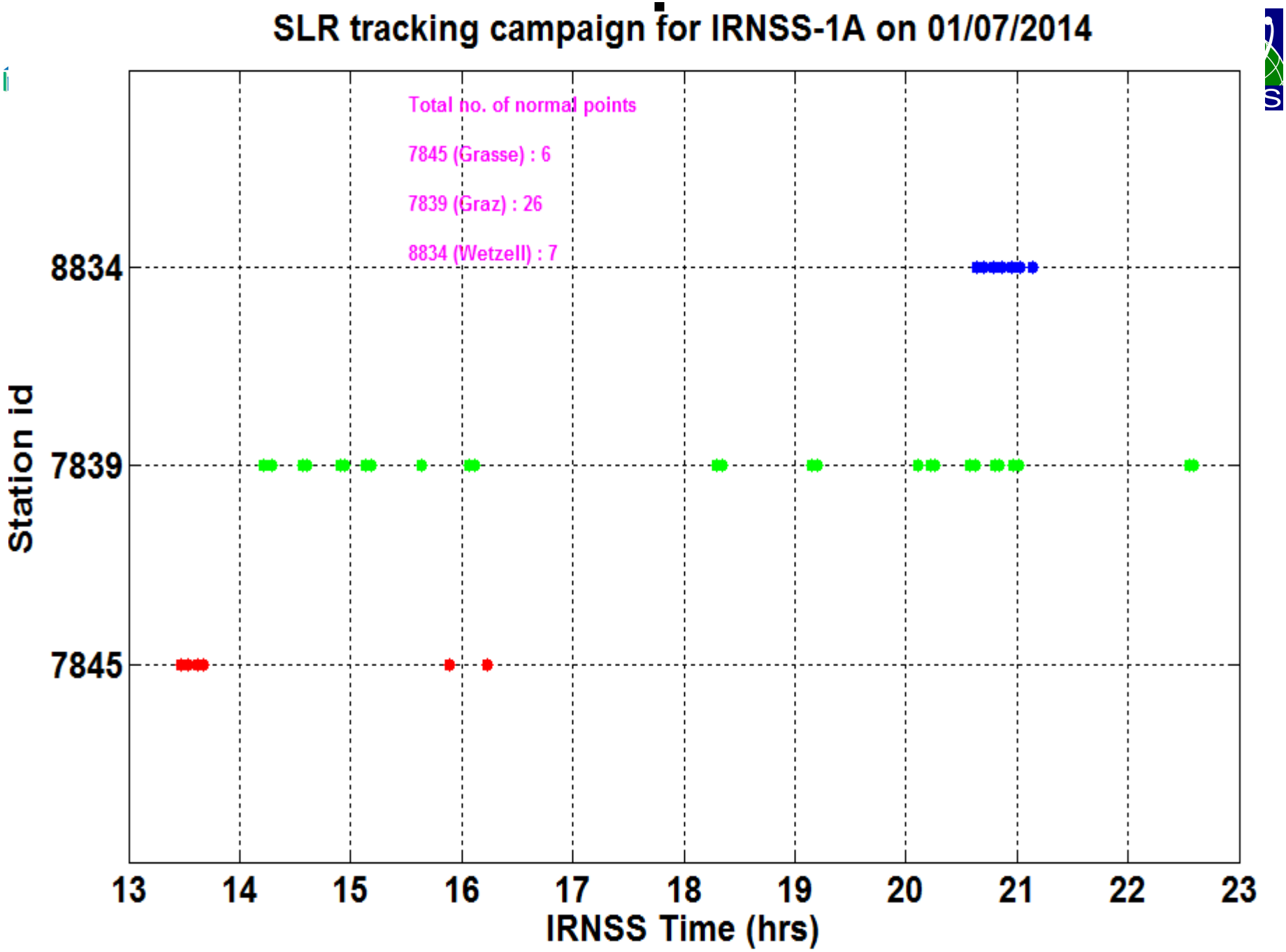
IRNSS-1A SLR tracking Campaign Statistics

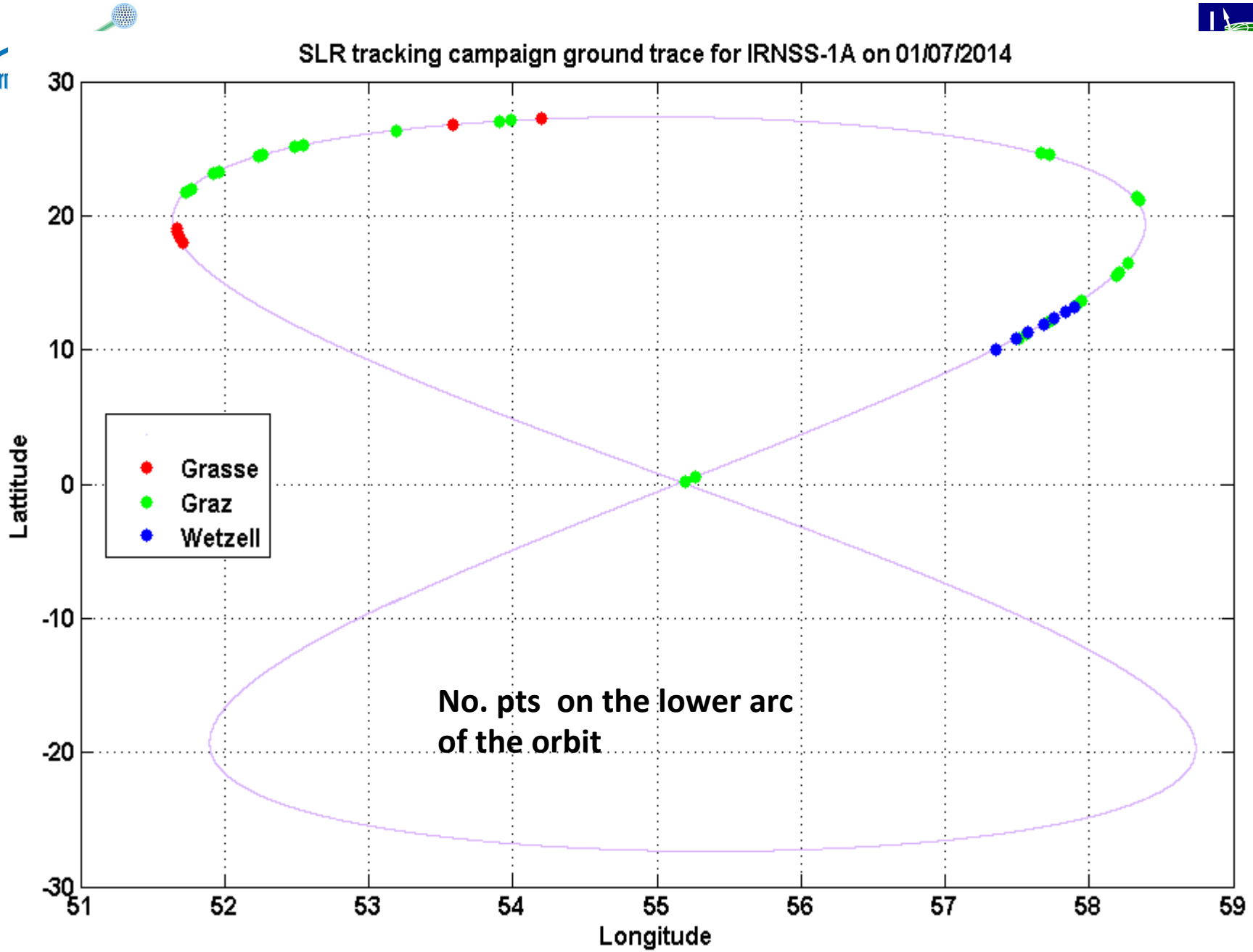
Space Navigation Group
ISRO Satellite Centre
Bangalore

SLR tracking campaign for IRNSS 1A on 29/06/014: No. of stns tracked: 1 No .of pts: 19




SLR tracking campaign ground trace for IRNSS-1A on 30/06/2014
Grasse
Graz
Zimmerwald
Yarragadee
No. pts on the lower arc of the orbit
Lattitude
Longitude
30
20
10
0
-10
-20
-30
51
52
53
54
55
56
57
58
59


SLR tracking campaign for IRNSS-1A on 01/07/2014
Total no. of normal points
7845 (Grasse) : 6
7839 (Graz) : 26
8834 (Wetzell) : 7
Station id
8834
7839
7845
13
14
15
16
17
18
19
20
21
22
23
IRNSS Time (hrs)


SLR tracking campaign ground trace for IRNSS-1A on 01/07/2014
Lattitude
Longitude
30
20
10
0
-10
-20
-30
51
52
53
54
55
56
57
58
59
Grasse
Graz
Wetzell
No. pts on the lower arc
of the orbit

Summary

S.N	Date	No. of stations	Station names	No. of NP
1	29/06/2014	9	Grasse	19
2	30/06/2014	4	Grasse,Graz,Zimmerwald & Yaerragadee	49
3	01/07/2014	3	Grasse,Graz & Wetzell	39

Remarks:

- Data quality of all tracked stations is observed to be good and the noise is well within 0.05m with no outliers.
- Atleast two stations have tracked IRNSS-1A simultaneously for each day.
  - 30/06/14: 3 station simultaneous tracking
  - 01/07/14: 2 station simultaneous tracking
- No data points are available during the lower arc of IRNSS-1A ground trace which is preferred for orbit determination.
- Data points from Hartesbeesthoek station may help in covering the lower arc of IRNSS-1A ground trace.
- Daily tracking from Yaerragadee is preferred since it improves the geometry for orbit determination

IRNSS-1B SLR tracking Campaign Statistics

(10 Aug-18 Aug2014)

Space Navigation Group
ISRO Satellite Centre
Bangalore

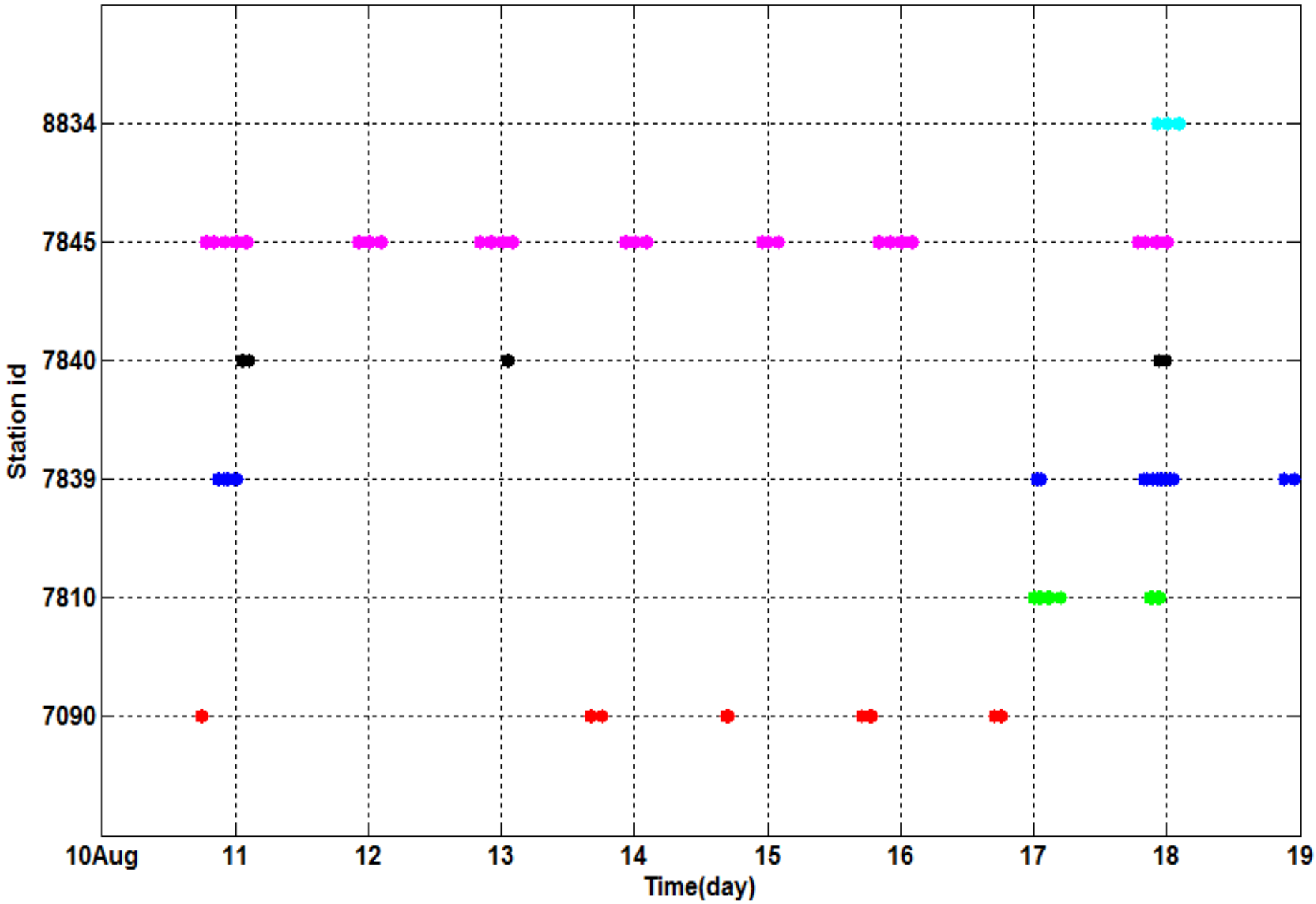
Overall Statistics of the data availability

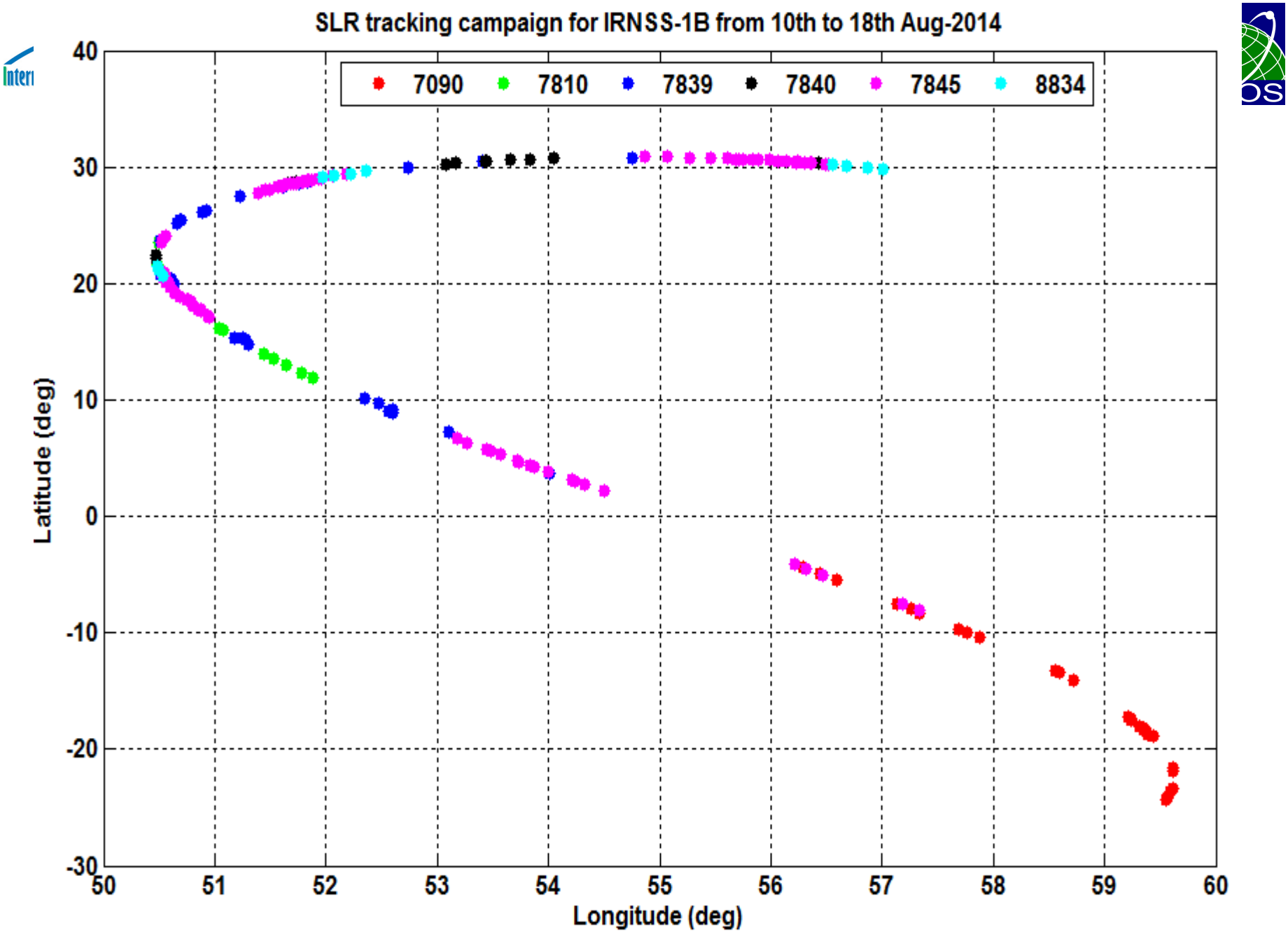
S.No	Date	Station name (Stn id)	No. of points
1.	10/08/2014	Yarragadee (7090)	3
	10/08/2014	Grasse (7845)	8
	10/08/2014	Graz (7839)	13
2.	11/08/2014	Grasse (7845)	12
	11/08/2014	Herstmonceux (7840)	4
3.	12/08/2014	Grasse (7845)	16
4.	13/08/2014	Yarragadee (7090)	5
	13/08/2014	Grasse (7845)	9
	13/08/2014	Herstmonceux (7840)	4
5.	14/08/2014	Yarragadde (7090)	5
	14/08/2014	Grasse (7845)	9
6.	15/08/2014	Yarragadee (7090)	8
	15/08/2014	Grasse (7845)	13
7.	16/08/2014	Yarragadee (7090)	8
	16/08/2014	Grasse (7845)	6
8.	17/08/2014	Grasse (7845)	10

Data Statistics

S. No	Date	No. of stations	Station IDs	No. of NP	Stations involved in simultaneous tracking
1	10/08/2014	3	7090 7845 7839	21	7839,7845
2	11/08/2014	3	7845 7839 7840	19	7839,7840,7845
3	12/08/2014	1	7845	16	-
4	13/08/2014	3	7845 7840 7090	17	7840,7845
5	14/08/2014	2	7845 7090	14	-
6	15/08/2014	2	7845 7090	21	-
7	16/08/2014	2	7845 7090	13	-
8	17/08/2014	5	7845 7839 7810 8834 7840	39	7810,7839,7840, 7845,8834
9	18/08/2014	3	7845 8834 7839	18	7839,7845,8834

- Data quality of all tracked stations is observed to be good and the noise is well within 0.05m with no outliers.
- Simultaneous tracking has been observed for 5days over tracking campaign.


SLR tracking campaign for IRNSS-1B from 10th to 18th Aug-2014
Station id
8834
7845
7840
7839
7810
7090
10Aug
11
12
13
14
15
16
17
18
19
Time(day)


SLR tracking campaign for IRNSS-1B from 10th to 18th Aug-2014
7090
7810
7839
7840
7845
8834
Latitude (deg)
Longitude (deg)
40
30
20
10
0
-10
-20
-30
50
51
52
53
54
55
56
57
58
59
60

International Laser Ranging Service

IAG GGOS

Thank you

AWG GRGS ILRC AC

Florent Deleflie[1], David Coulot[2,1],
and Franck Reinquin[4]

[1] Institut de Mécanique Céleste et de Calcul des Ephémérides/GRGS, Paris
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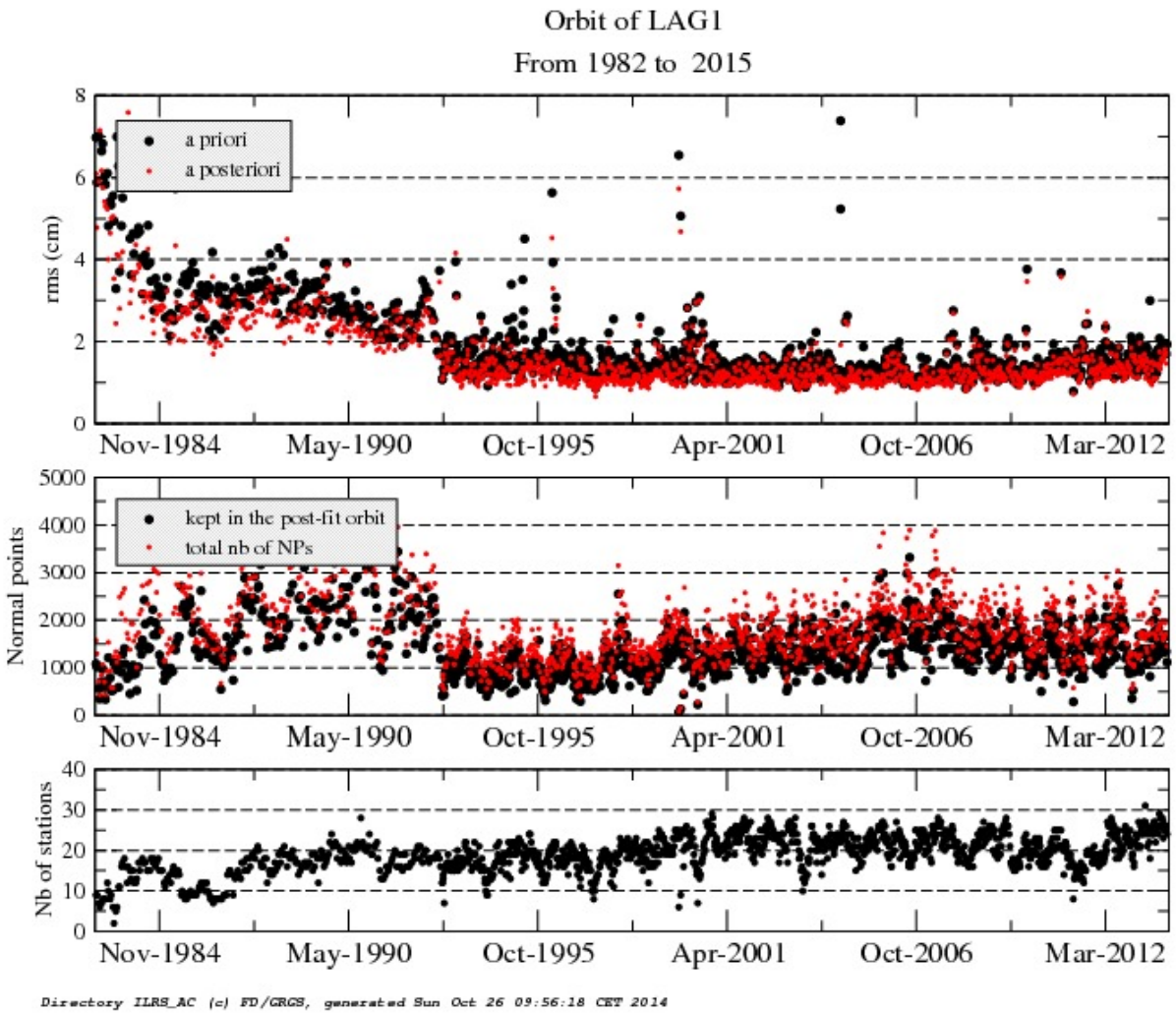
[3] Observatoire de la Côte d'Azur/GRGS, Caussols, France
[4] Centre National d'Etudes Spatiales/GRGS,Toulouse, France

27th October, 2014

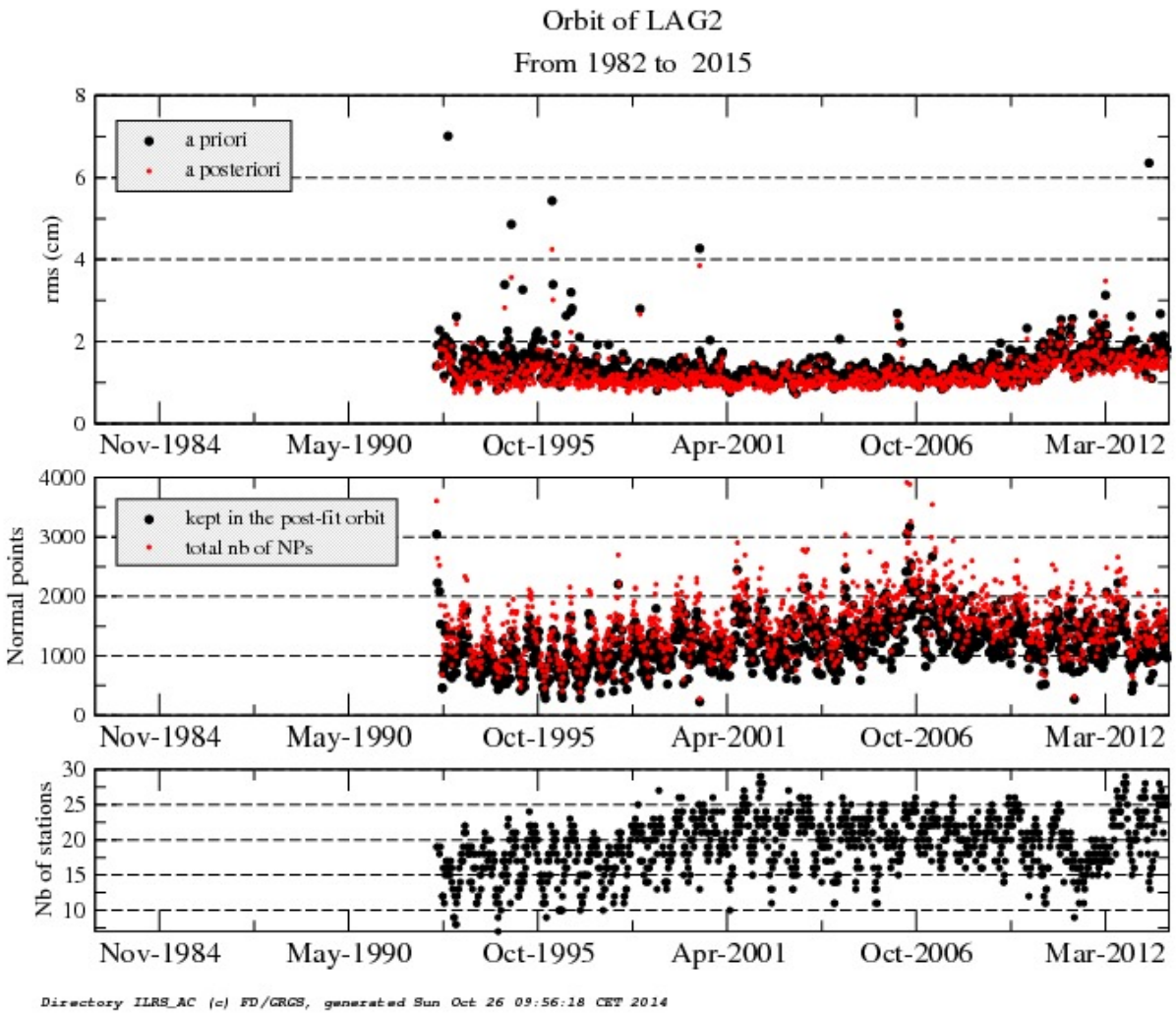
Orbital Computations and ILRS related products

- Satellites:
  - LAG1: 26th, Nov. 1982 - 21st, Dec. 2013
  - LAG2: 3rd, Nov. 1992 - 21st, Dec. 2013
  - ETA1: 29th, Dec. 1990 - 21st, Dec. 2013
  - ETA2: 29th, Dec. 1990 - 21st, Dec. 2013
- Modelling: as the one recommended by AWG for ITRF2013
- Data a priori corrections, accordingly
- Elimination critera in the gins s/w: 4σ, and a priori greater than 1400m (ETA), and 100m (LAG)
- Related products:
  - SSC and EOP: 1 value every day or 3 days ("historical period")

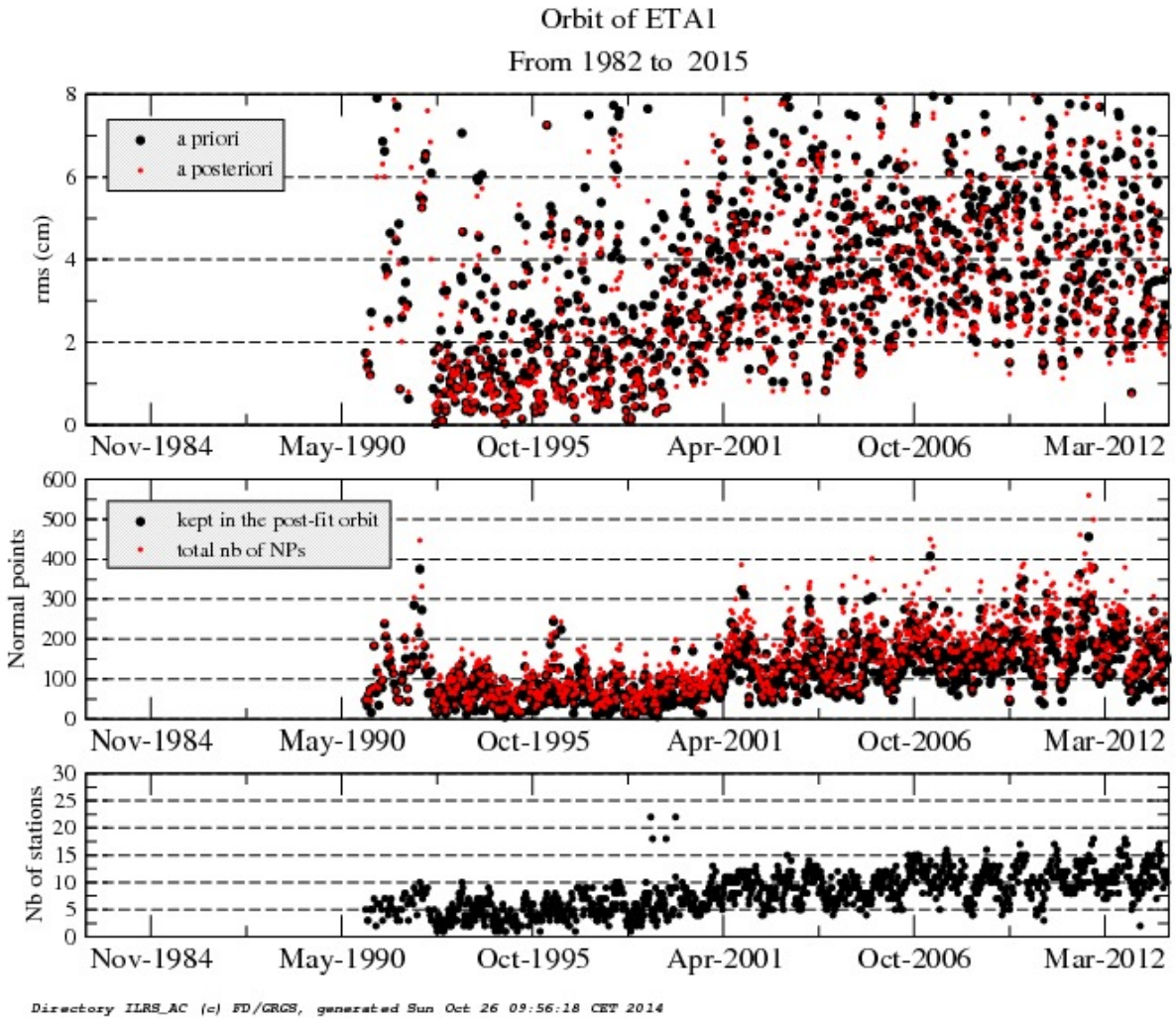
Adjustment of LAG1 trajectory



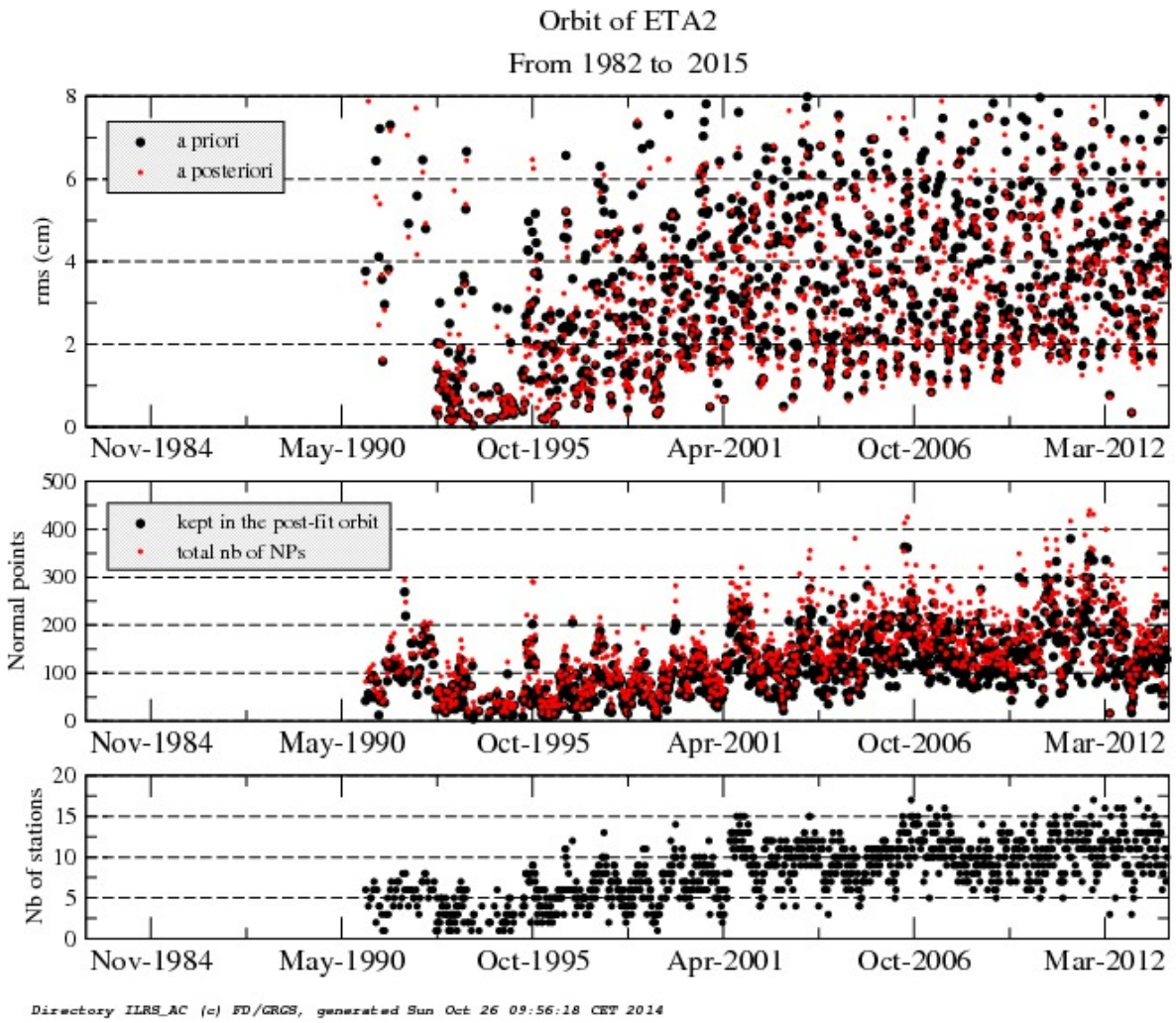
Adjustment of LAG2 trajectory



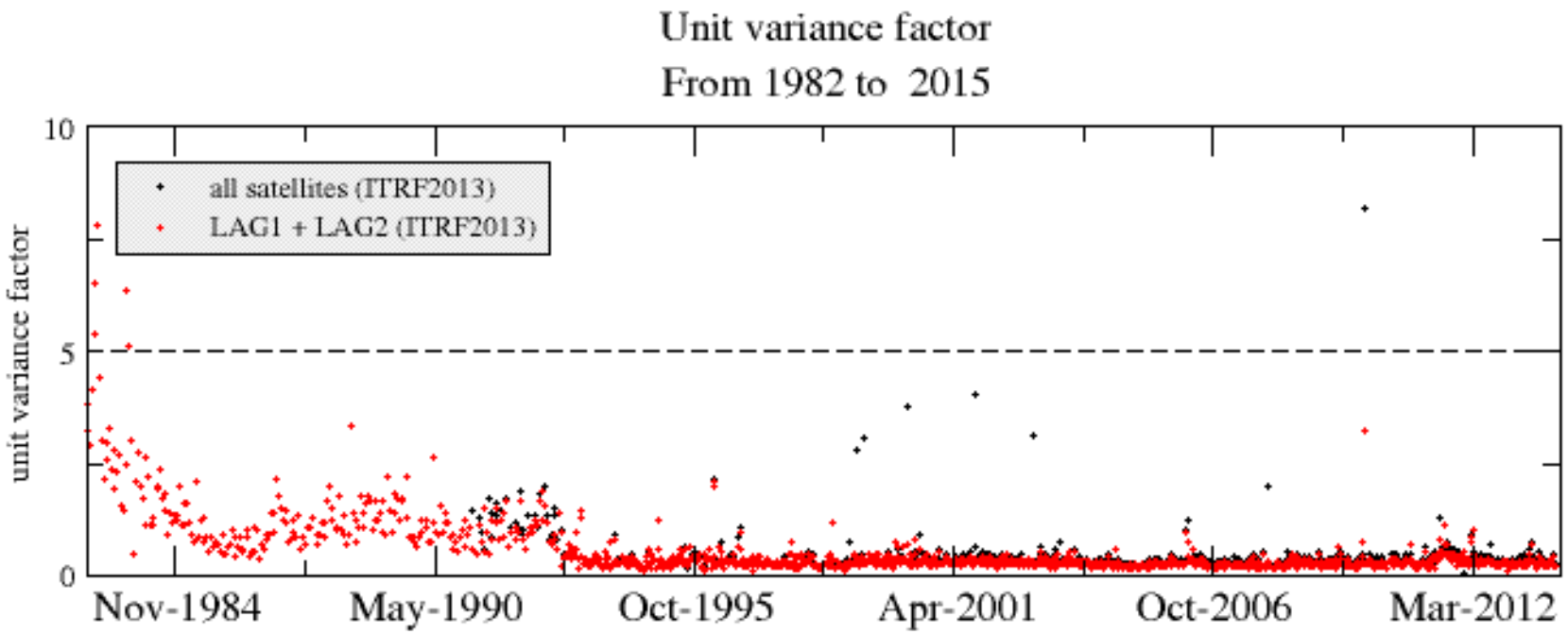
Adjustment of ETA1 trajectory



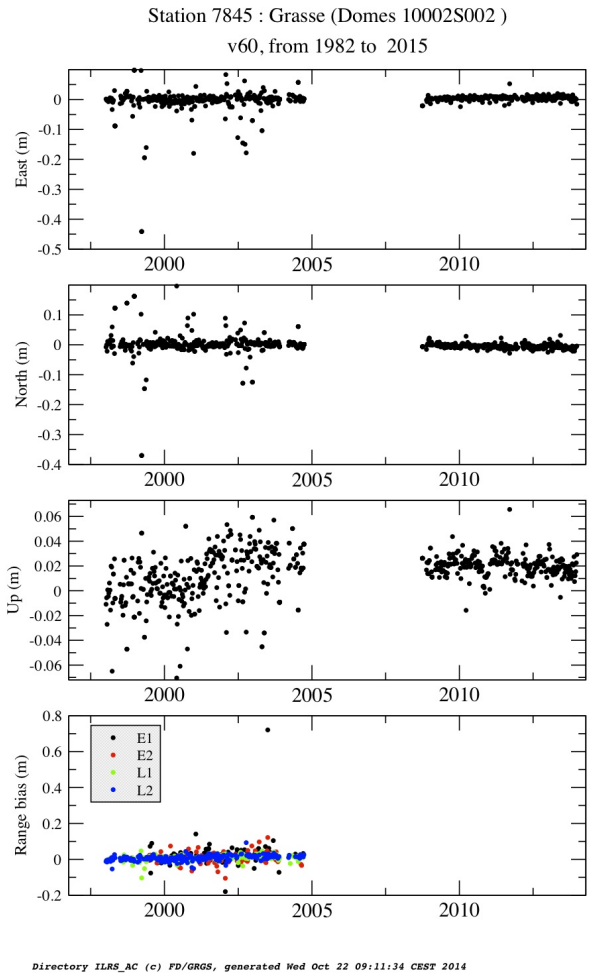
Adjustment of ETA2 trajectory



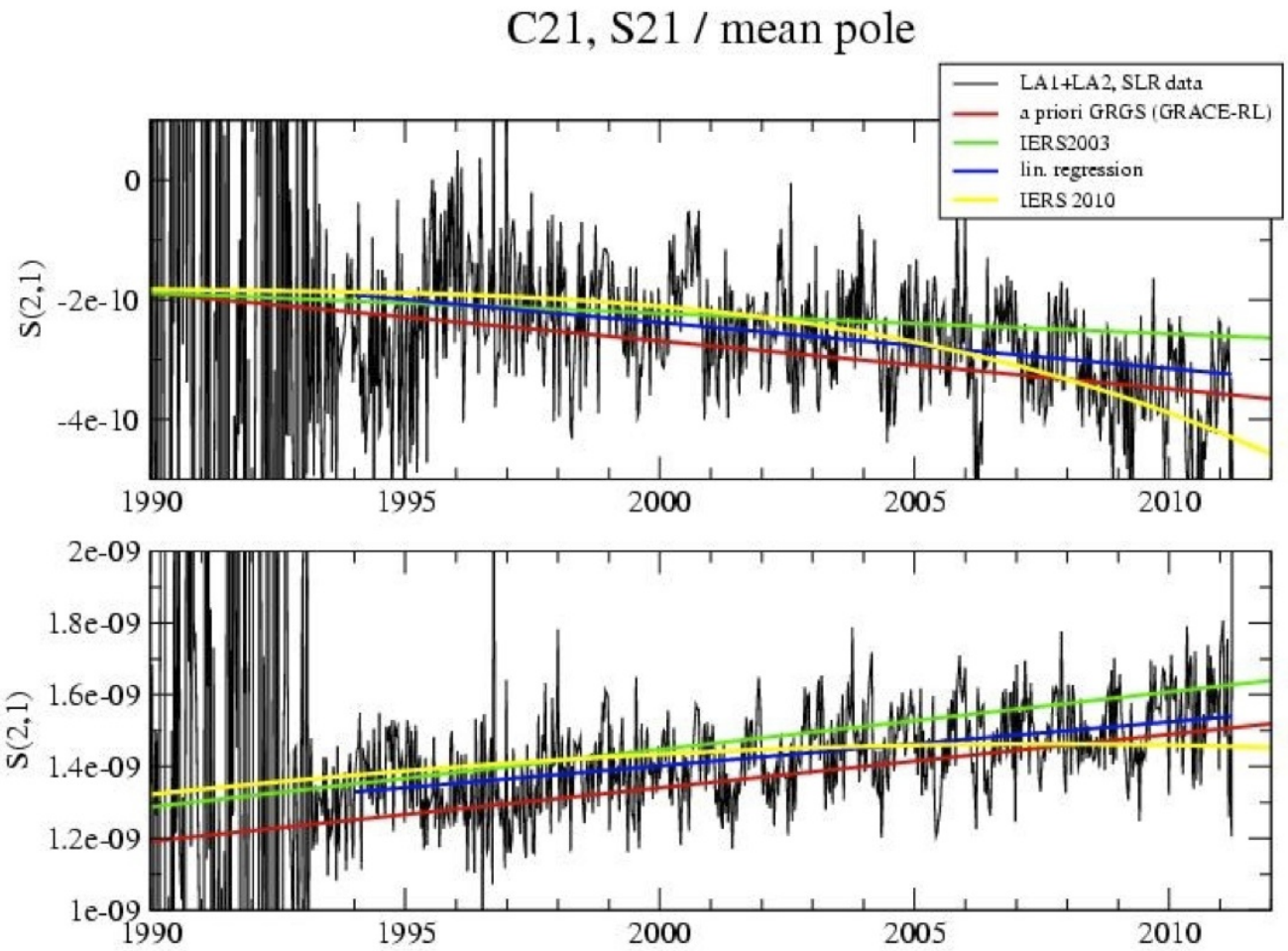
GRGS ILRS AC contribution to ITRF2014: Unit variance factor



Example of a station: 7845

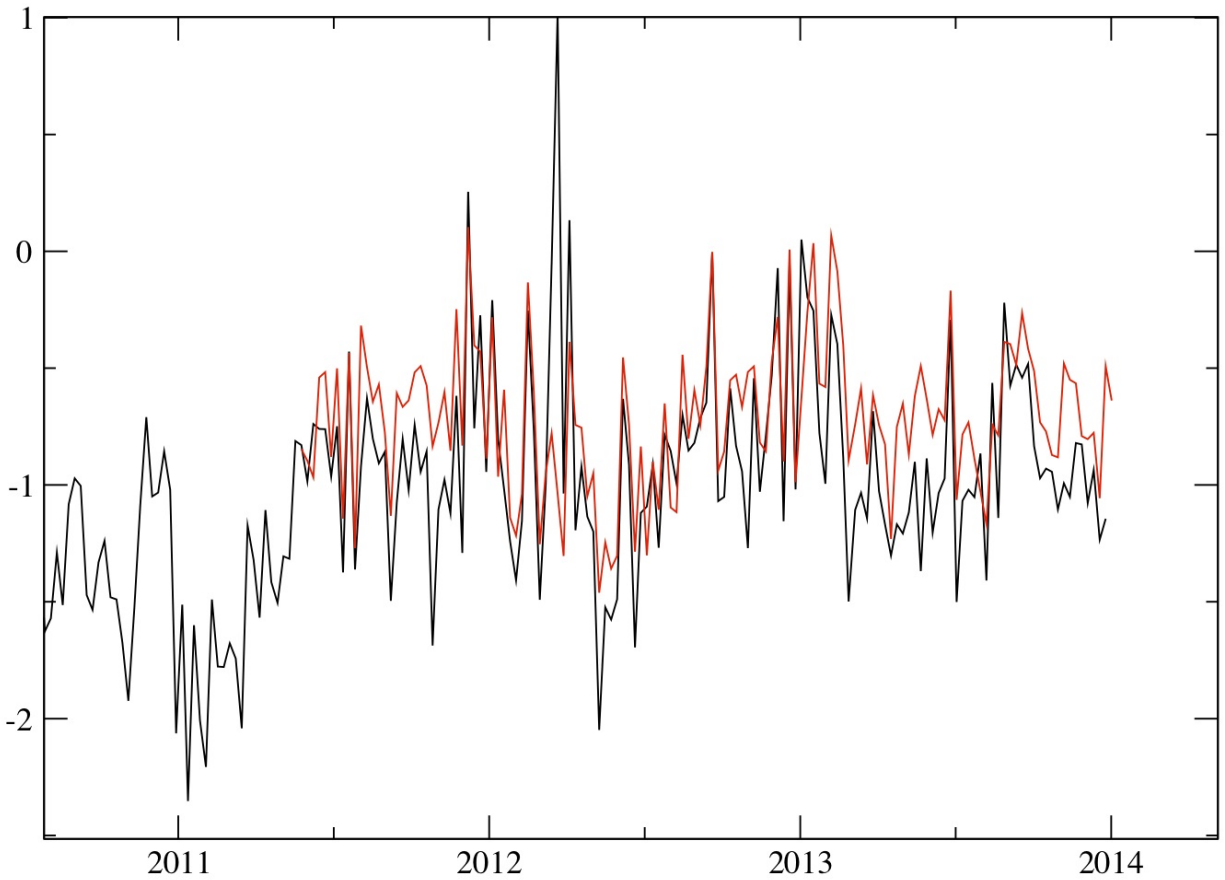


mean pole: conventional or not ? ;)



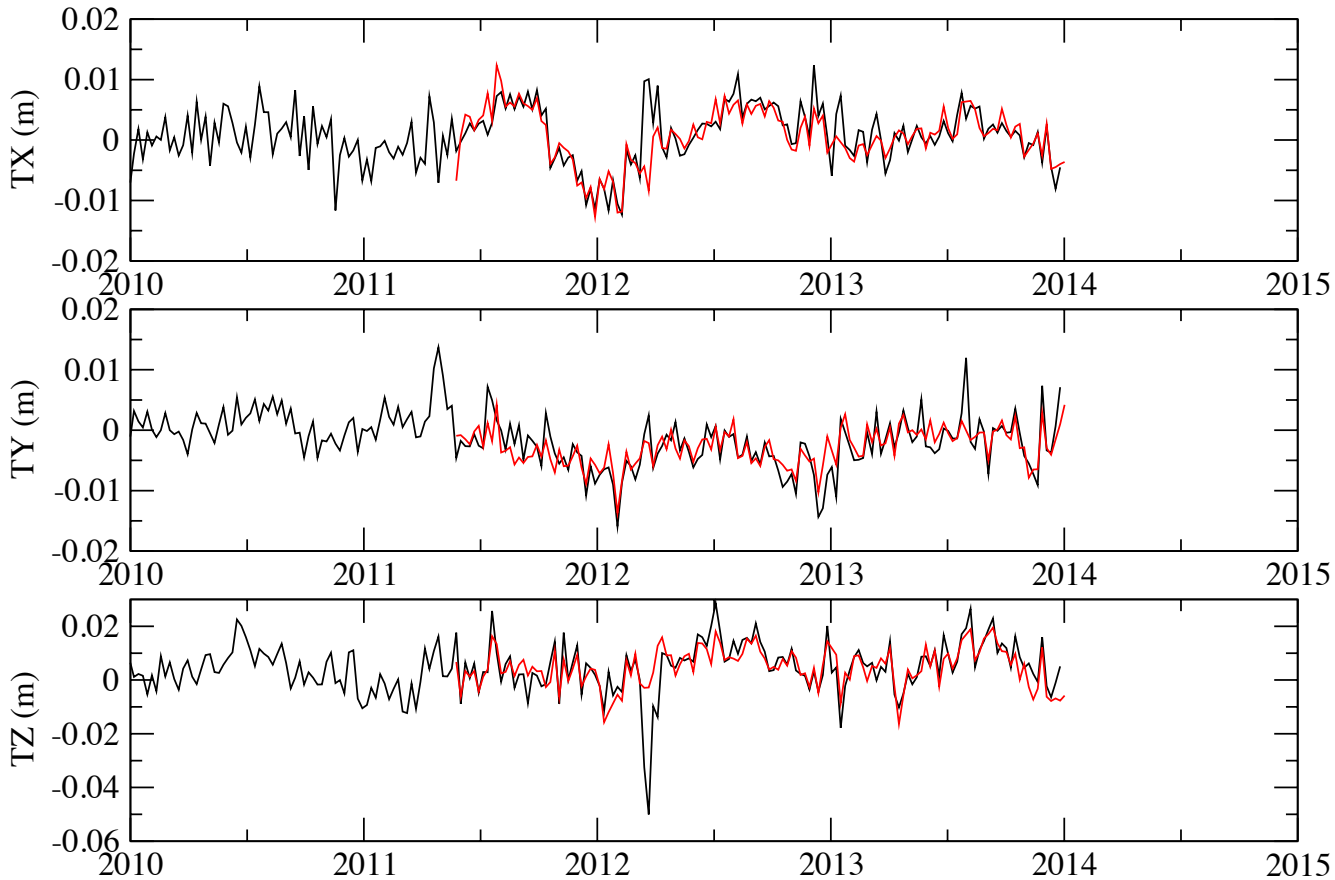
v60/"v61": The scale

This v61: EIGEN6S2-extended + IERS convention for the mean pole



v60/"v61": Translations

This v61: EIGEN6S2-extended + IERS convention for the mean pole



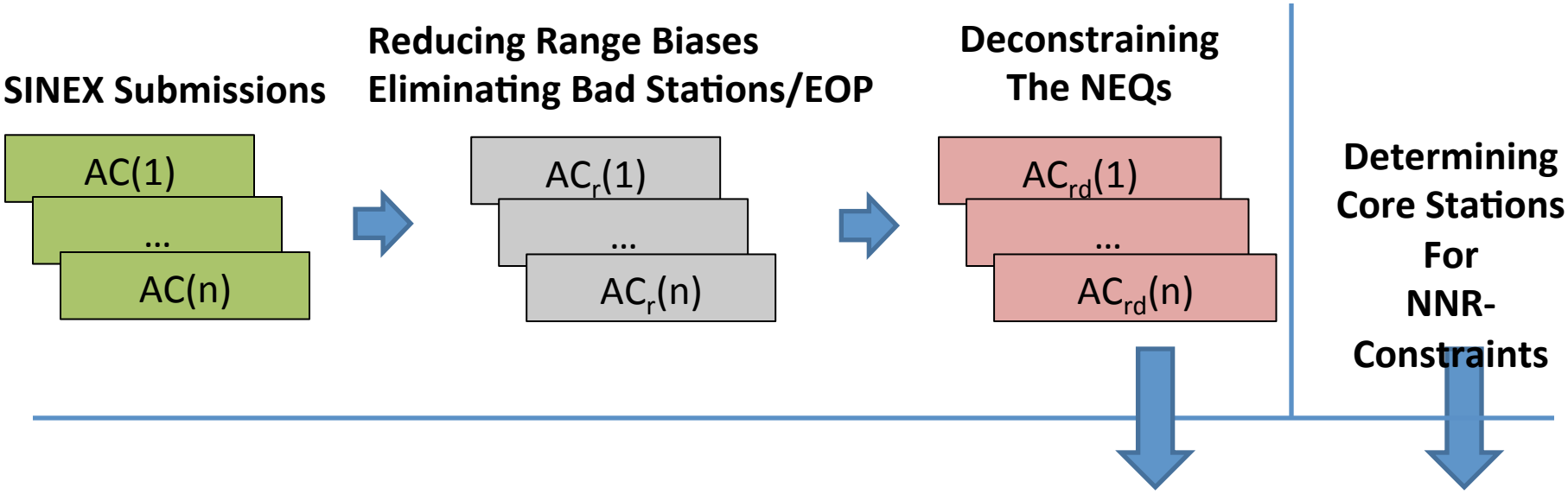
The ILRS-B Combination For ITRF2013

Procedures and Results

October 2014

D. König, E. C. Pavlis, M. Kuzmicz-Cieslak

Principle of ILRS-B Combinations



Minimum-Constraints Solution (positions, EOP)

(1) for each AC separately by
- adding NNR-constraints

(2) as the ILRS-B combination by
- accumulating the NEQs
- adding NNR-constraints

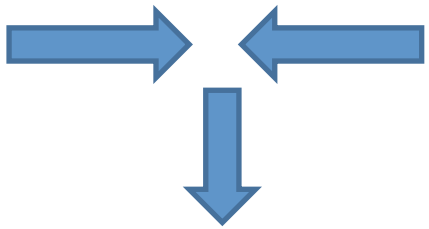
Quality Assessment (c.f. SUM files)
- RMS of parameter corrections
- Helmert transformation w.r.t SLRF2008
- Trend Analysis of EOP

Checking/Validation Software (1)

Table with stations selected + position sigmas

SINEX Submissions
- SOLUTION/ESTIMATE

-> list of stations used
-> position sigmas



Summary file (ILRS-A or ILRS-B)
-> accepted ACs
-> core stations selected

For each <Date> **of combination**

Table 1 **<- For each** <Station> **of ILRS Full List ->**

<Date 1> <Combination successful?> <Station used/core station/not used>
<AC 1> <AC accepted?> <Variance factor> <Station used/core station/not used>
<Position sigmas of used/core stations>

…
<AC n> <AC accepted?> <Variance factor> <Station used/core station/not used>
<Position sigmas of used/core stations>

<Date 2> …

Checking/Validation Software (2)

Example for Table 1

```
#-------------------------------------------------------------------------------------------
# yymmdd | Submission |*Combination | Stations
#        | accepted?  | successful? |  -: station not used / x: station used / c: station used
#        |   [0,1]    |    [0,1]    | *pos. coord. <sigma X> [m]
#  AC    | 0: no      | 0: no       | *pos. coord. <sigma Y> [m]
#        | 1: yes     | 1: yes      | *pos. coord. <sigma Z> [m]
#        | -: no info | -: no sum.  |
#        |            |             | *range bias begin epoch
#        |            |             | *range bias end   epoch
#        |            |*Var. factor |  1148    1181    1824    1831    1863    1864    1866
#========|============|=============|=========================================================
 000101 |            |       1     |    -       -       -       -       -       x       -
  asi   |      1     |  0.373E-04  |    -       -       -       -       -       -       -
        |            |             |
        |            |             |
        |            |             |
  dgfi  |      1     |  0.128E+01  |    -       -       -       -       -       x       -
        |            |             |                                                0.3E+00
        |            |             |                                                0.1E+00
        |            |             |                                                0.1E+00
  esa   |      1     |  0.539E+00  |    -       -       -       -       -       -       -
        |            |             |
        |            |             |
        |            |             |
  gfz   |      0     |  0.991E+01  |    -       -       -       -       -       x       -
        |            |             |                                                0.7E+00
        |            |             |                                                0.4E+00
        |            |             |                                                0.4E+00
  grgs  |      1     |  0.165E+00  |    -       -       -       -       -       -       -
        |            |             |
        |            |             |
        |            |             |
  jcet  |      1     |  0.511E-04  |    -       -       -       -       -       x       -
        |            |             |                                                0.2E-02
        |            |             |                                                0.1E-02
        |            |             |                                                0.1E-02
  nsgf  |      1     |  0.722E-02  |    -       -       -       -       -       -       -
        |            |             |
        |            |             |
        |            |             |
#-------|------------|-------------|-------------------------------------------------------
 000102 |            |       -     |    -       -       -       -       -       x       -
  dgfi  |      -     |  0.128E+01  |    -       -       -       -       -       x       -
        |            |             |                                                0.3E+00
        |            |             |                                                0.1E+00
        |            |             |                                                0.1E+00
#-------|------------|-------------|-------------------------------------------------------
```

Checking/Validation Software (3)

Table with range bias (RB) information

SINEX Submissions

- SOLUTION/ESTIMATE

-> list of RBs

- BIAS/EPOCHS

-> epochs of each RB in the list

For each <Date> **of combination**

Table 2

<Date 1>	<Station 1>	<Satellite>	<Estimate>	<Sigma>	<Begin>	<End>
…	…	…	…	…	…	…
<Date 1>	<Station n>	<Satellite>	<Estimate>	<Sigma>	<Begin>	<End>
<Date 2> …						

Checking/Validation Software (4)

Example for Table 2

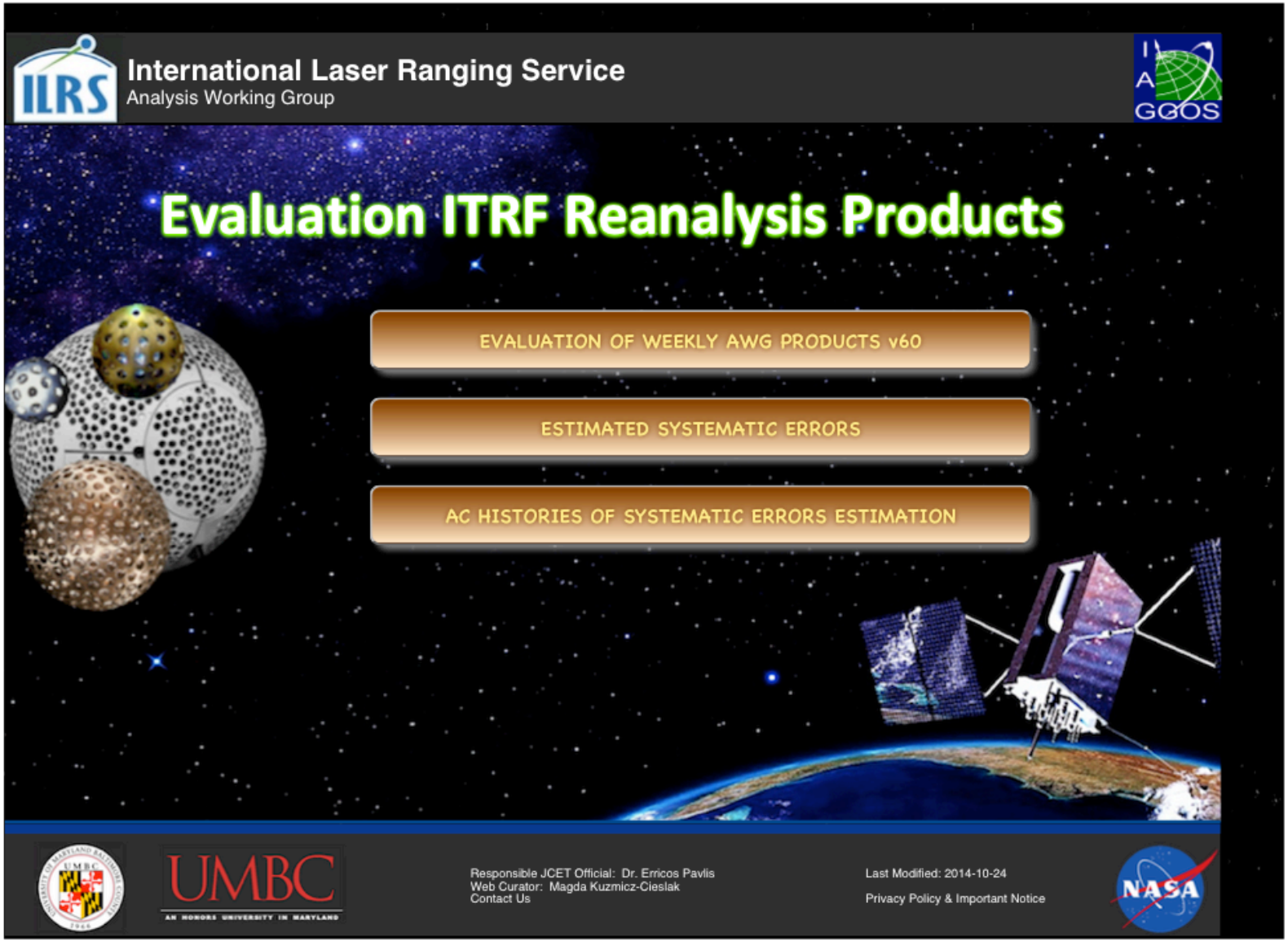
Date	Station	Satellite	RBIAS Estimate	RBIAS Sigma	Begin	End
yyyy/mm/dd	Code4	[PT]			yyyy/mm/dd sssss	yyyy/mm/dd sssss
2000/01/01	7845	L1	0.400901100000000E-02	.151600E-02	1999/12/29 76518	1999/12/30 03875
2000/01/01	7845	L2	0.255177000000000E-02	.162822E-02	1999/12/29 78675	1999/12/29 81424
2000/01/08	7845	L1	-.139727600000000E-01	.205255E-02	2000/01/04 47006	2000/01/06 50667
2000/01/08	7845	L2	-.156900800000000E-01	.187291E-02	2000/01/04 51793	2000/01/06 55342
2000/01/22	7845	E1	0.116250400000000E-01	.572389E-02	2000/01/16 02381	2000/01/21 23164
2000/01/22	7845	L1	-.131646600000000E-02	.299755E-02	2000/01/16 64057	2000/01/20 71188
2000/01/22	7845	L2	0.132937900000000E-01	.464247E-02	2000/01/18 28618	2000/01/20 61137
2000/01/29	7845	E2	0.173816300000000E-01	.280475E-02	2000/01/26 31372	2000/01/28 78614
2000/01/29	7845	L1	-.272924000000000E-02	.168360E-02	2000/01/24 37150	2000/01/28 82715
2000/01/29	7845	L2	-.636649200000000E-02	.183530E-02	2000/01/26 31858	2000/01/26 48391
2000/02/05	7845	E1	-.192682100000000E-02	.323215E-02	2000/02/04 62634	2000/02/04 66084
2000/02/05	1864	L1	-.105325500000000E+00	.553614E-01	2000/02/02 55193	2000/02/05 53961
2000/02/05	1868	L1	-.207707000000000E-01	.449193E-01	2000/01/31 52994	2000/02/04 58824
2000/02/05	7845	L1	-.469302700000000E-02	.141456E-02	2000/02/01 48171	2000/02/04 73622
2000/02/05	7845	L2	-.268521000000000E-02	.153857E-02	2000/01/31 26719	2000/02/04 60519
2000/02/12	1868	L1	-.870705500000000E-02	.300338E-01	2000/02/07 42211	2000/02/11 49688
2000/02/12	7845	L1	-.963408800000000E-02	.238767E-02	2000/02/07 31899	2000/02/09 49711
2000/02/12	7845	L2	-.103886200000000E-01	.258490E-02	2000/02/07 36467	2000/02/10 31828
2000/02/19	1864	L1	-.114963000000000E+00	.101666E-01	2000/02/13 52082	2000/02/18 53678
2000/02/26	1864	L1	0.309026600000000E-01	.104352E-01	2000/02/20 68743	2000/02/25 57042

Summary

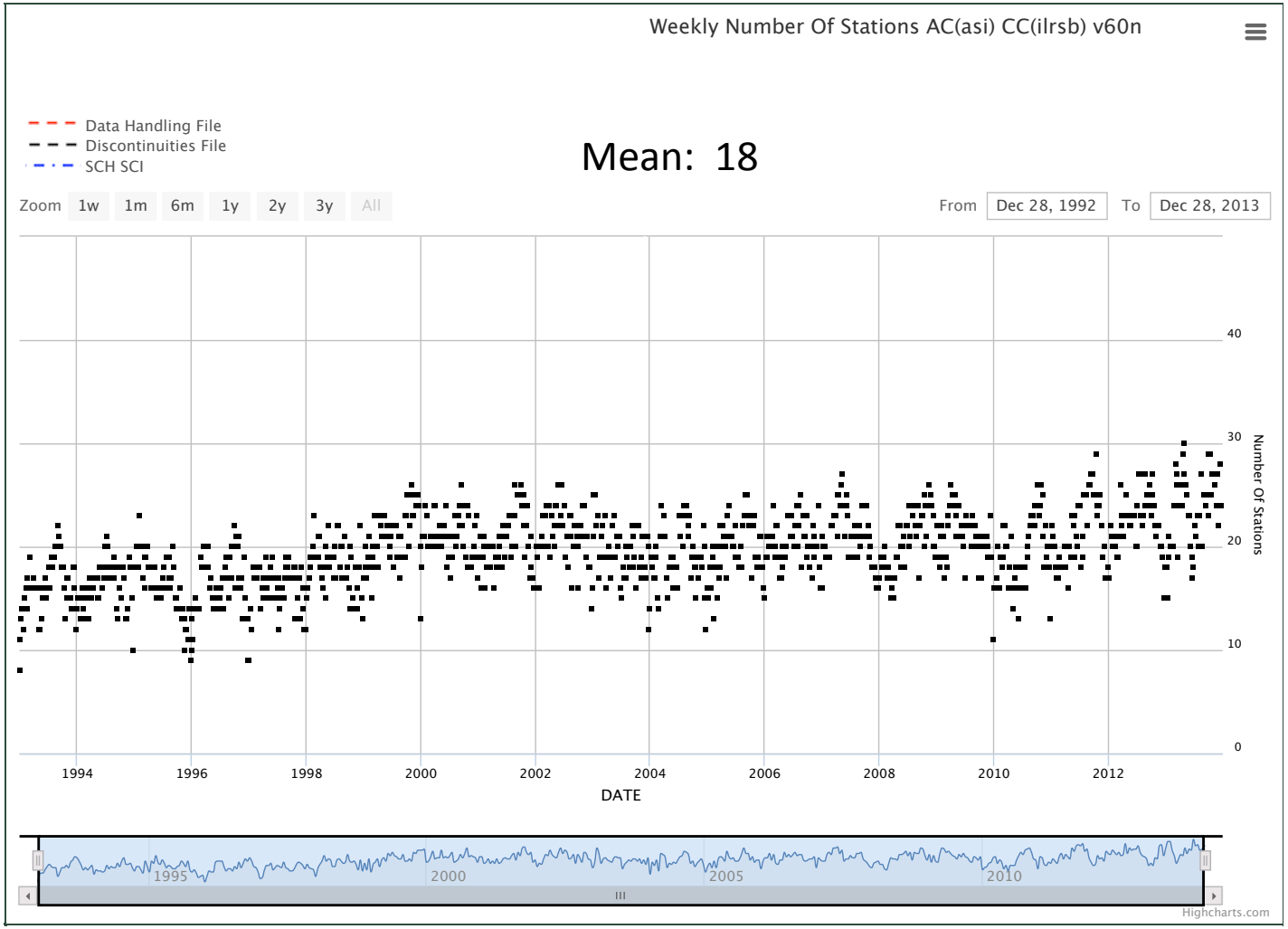
- **ILRS-B Combination Series**
  - 1983-2013 completed
  - 1983-1992 w/o BKG (will not submit), NSGF (excluded – ill-conditioned)
  - Input SINEX file issues:
    * wrong/missing EOP epochs (e.g. bkg, esa)
    * reporting of range biases in BIAS/EPOCHS
      but not found in SOLUTION/ESTIMATE
    * outliers in estimates (all AC)

- **Software completed for checking/validating SINEX submissions + SUM files**
  - produces tables of estimated range biases or position sigmas
  - gives information about stations (used/core station/not used)

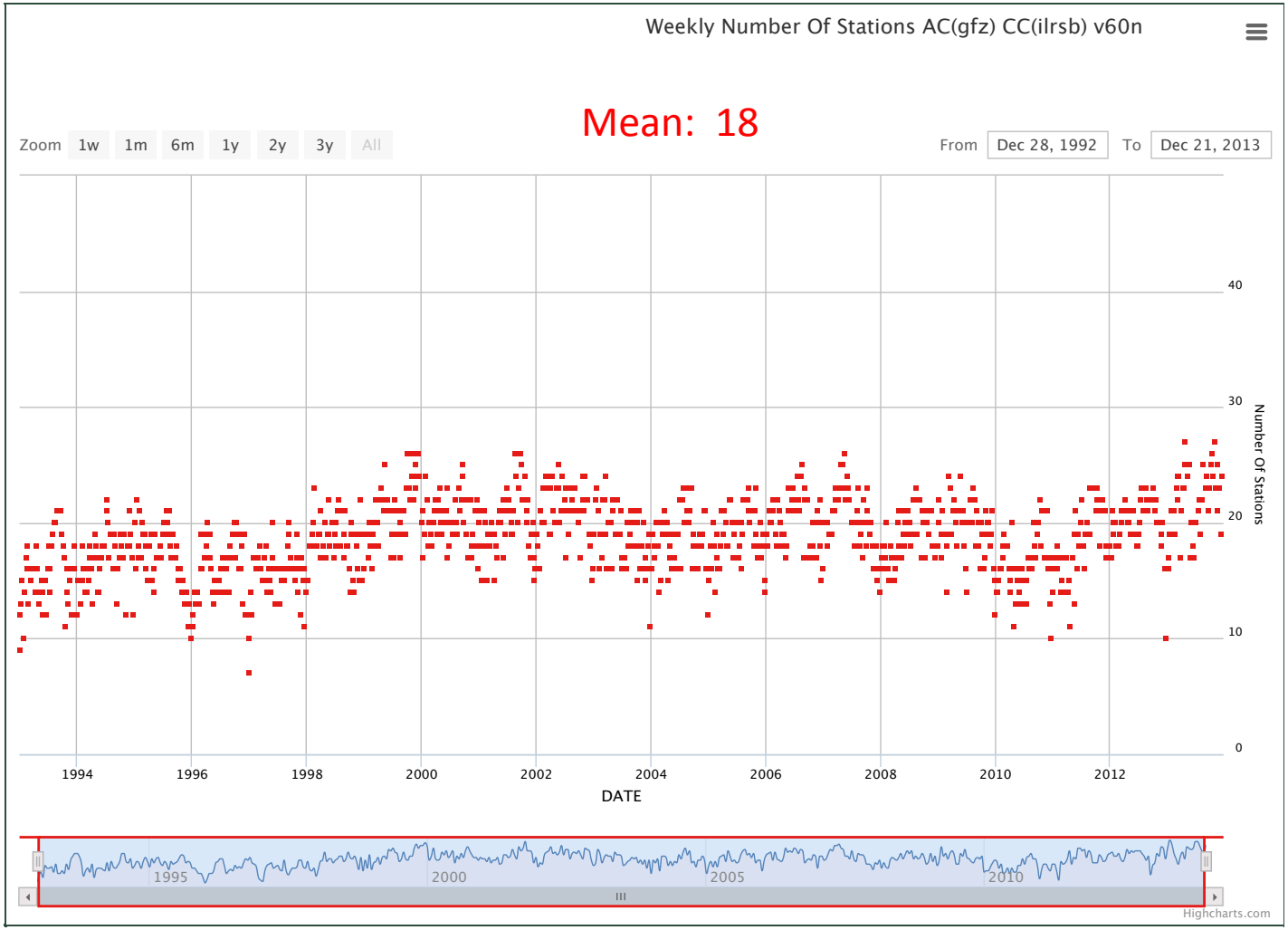
Visualization Site



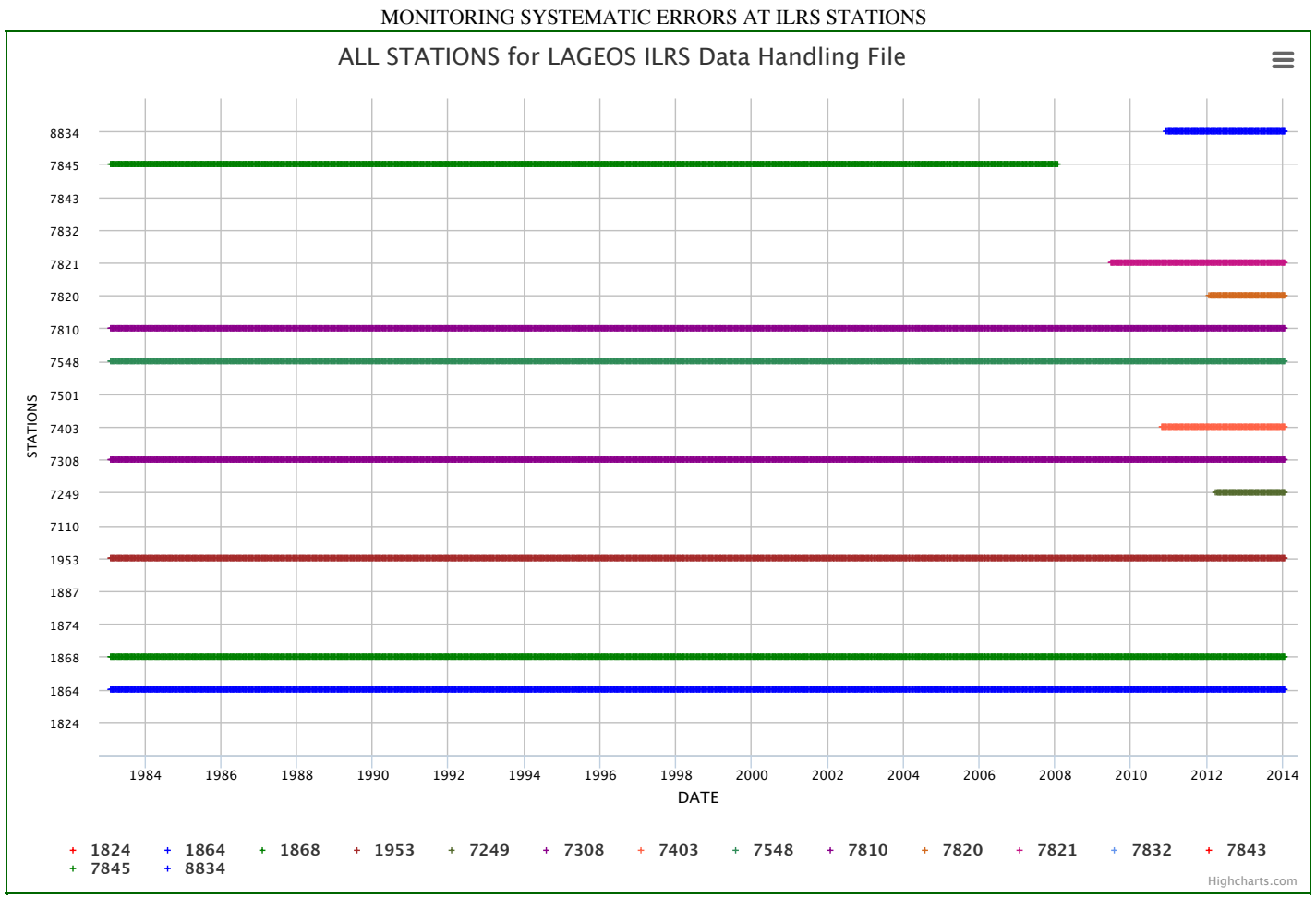
Number of Stations Used Weekly by ASI



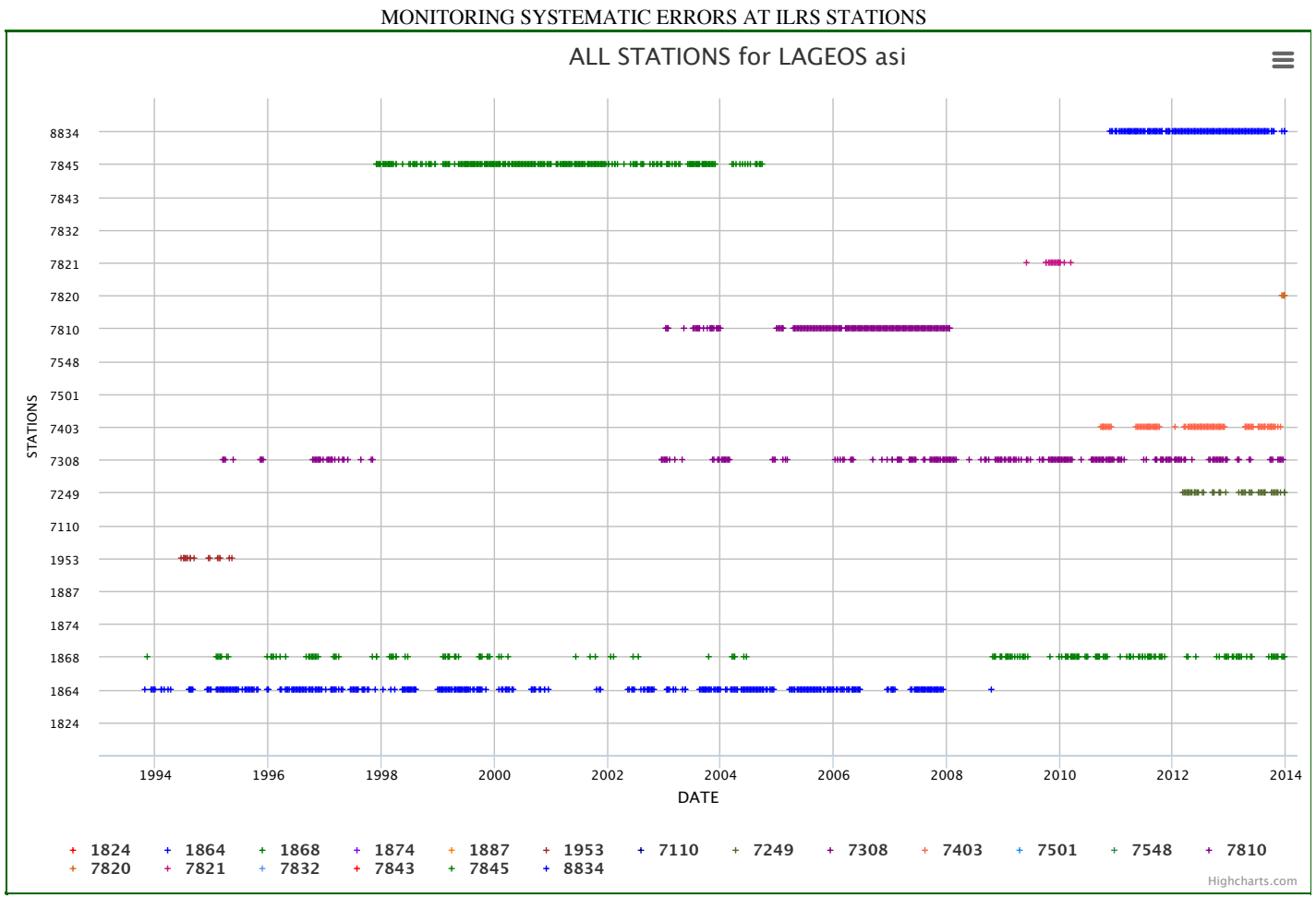
Number of Stations Used Weekly by GFZ



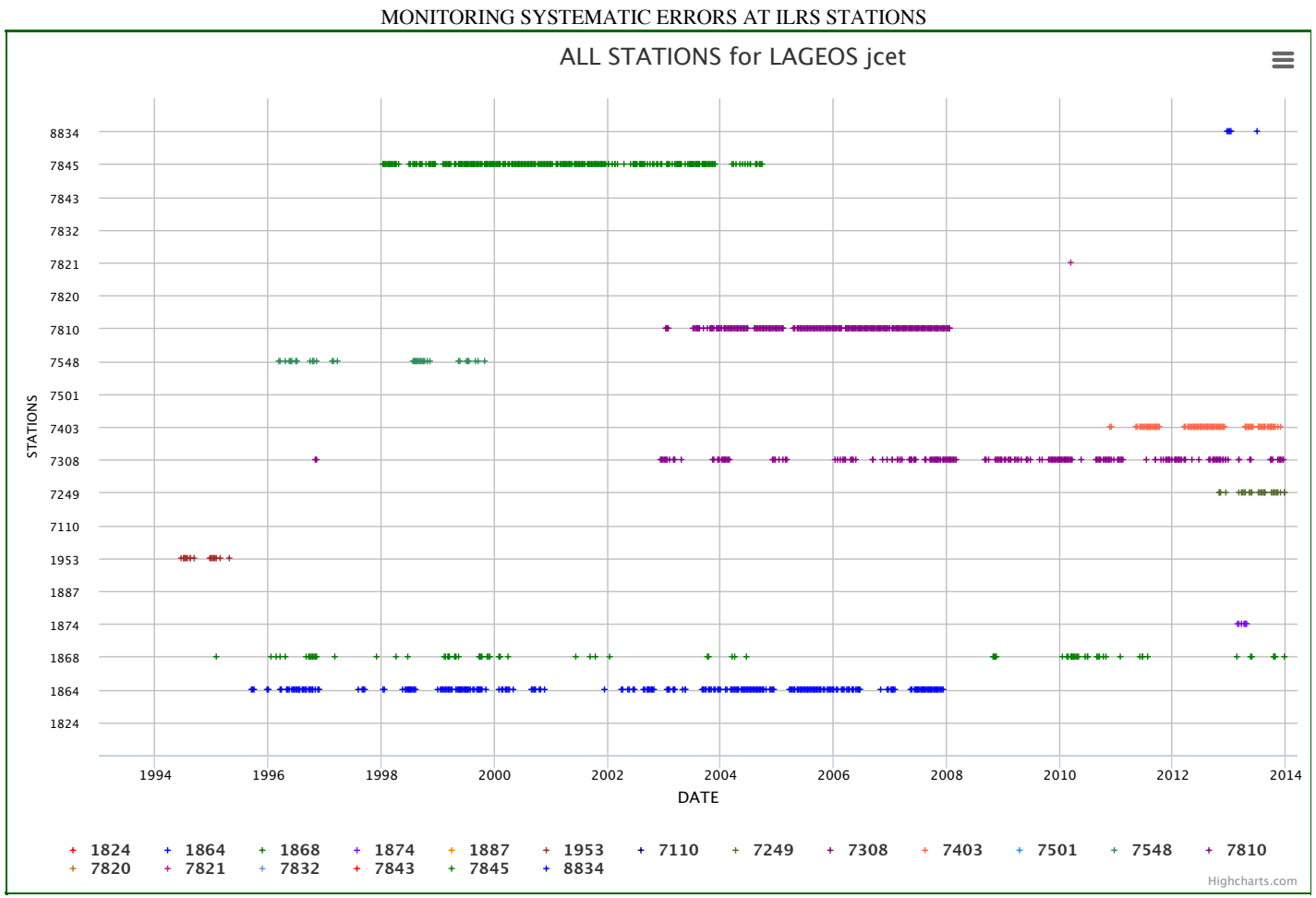
Systematic Error Model from DH File



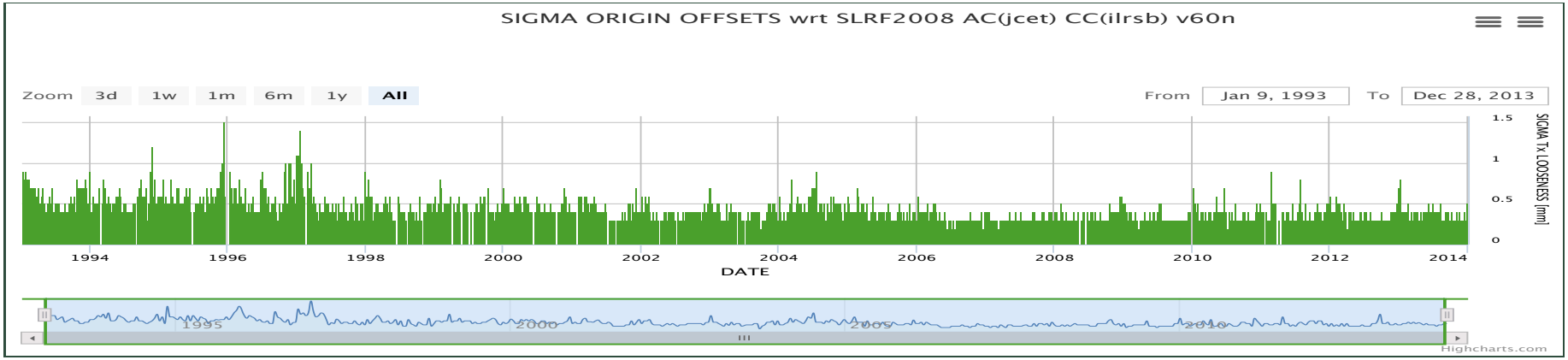
Estimated Systematic Errors (ASI)

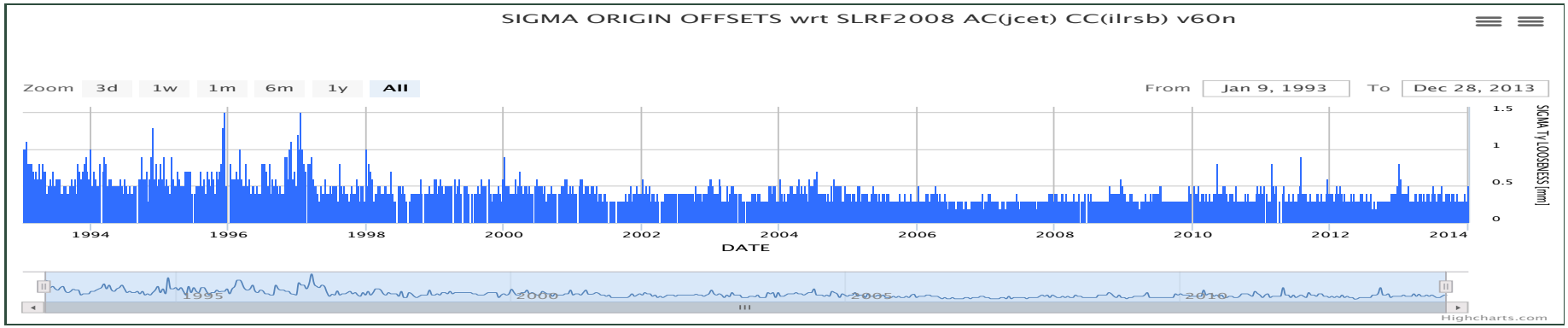


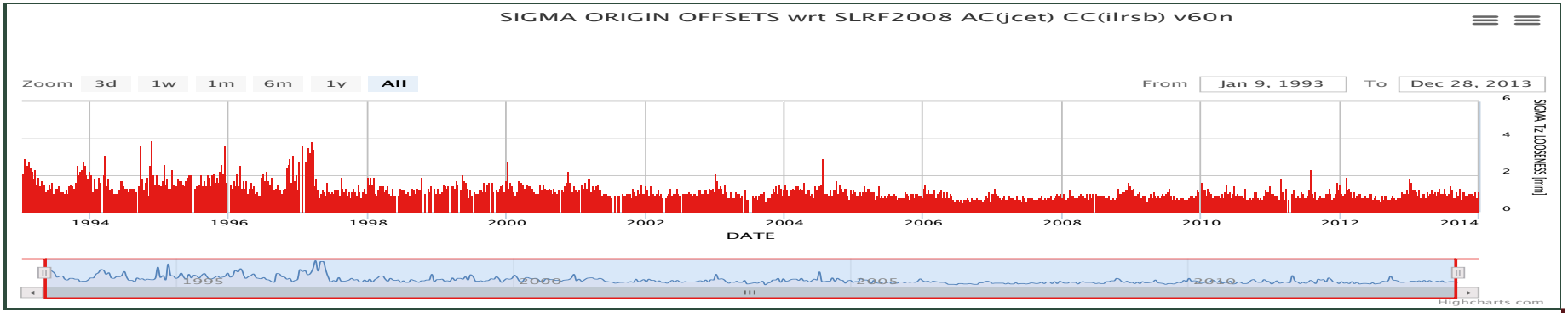
Estimated Systematic Errors (JCET)



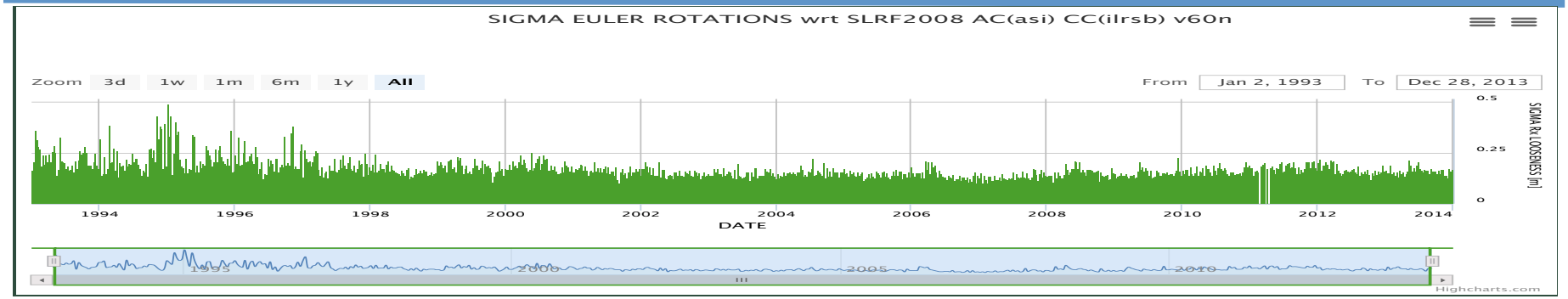
Looseness of Solution (Translations) (JCET)

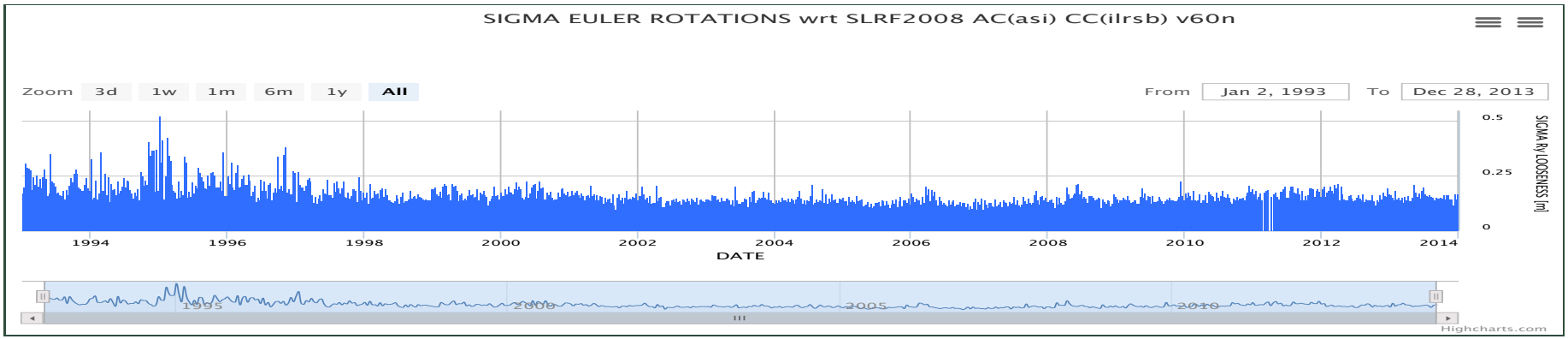


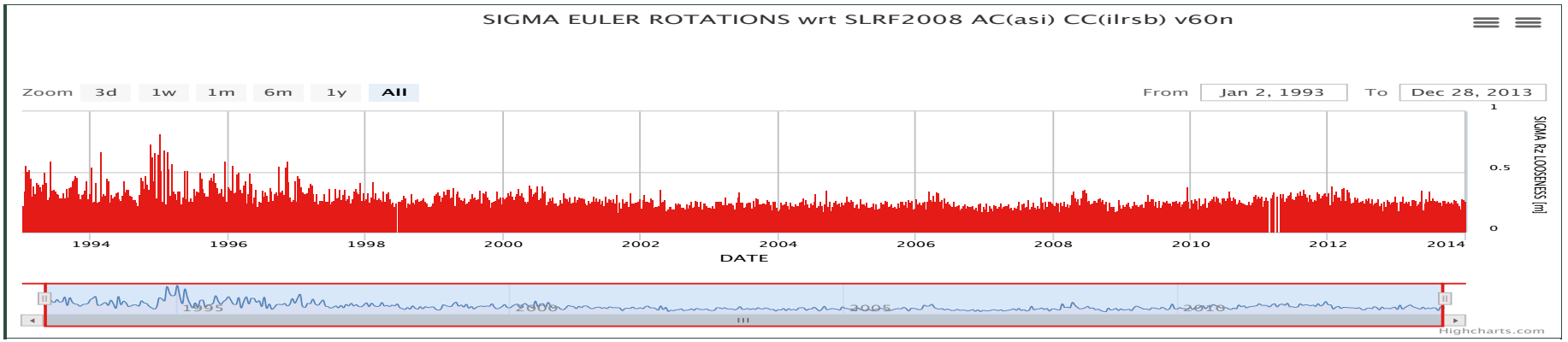




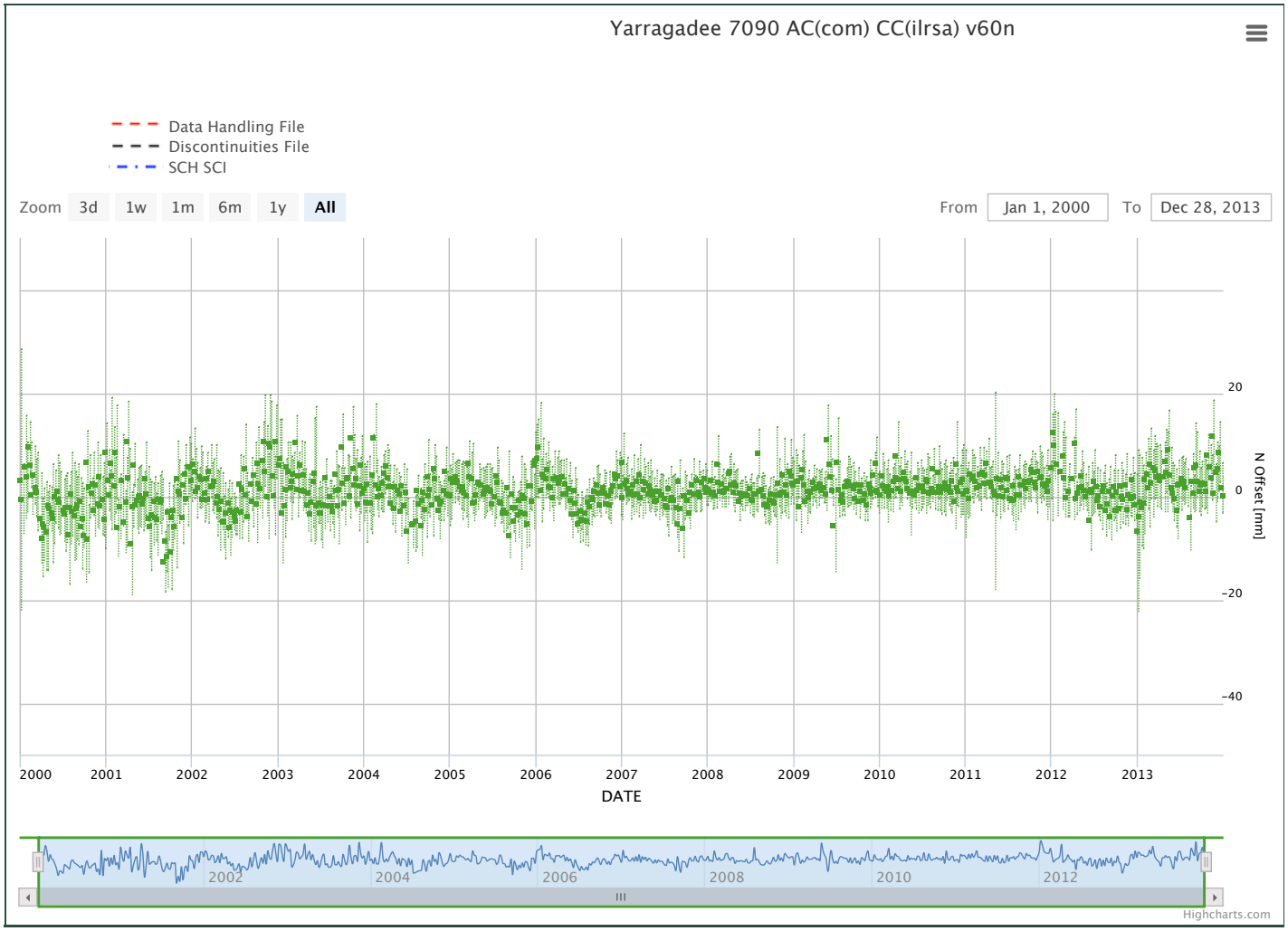
Looseness of Solution (Rotations) (ASI)



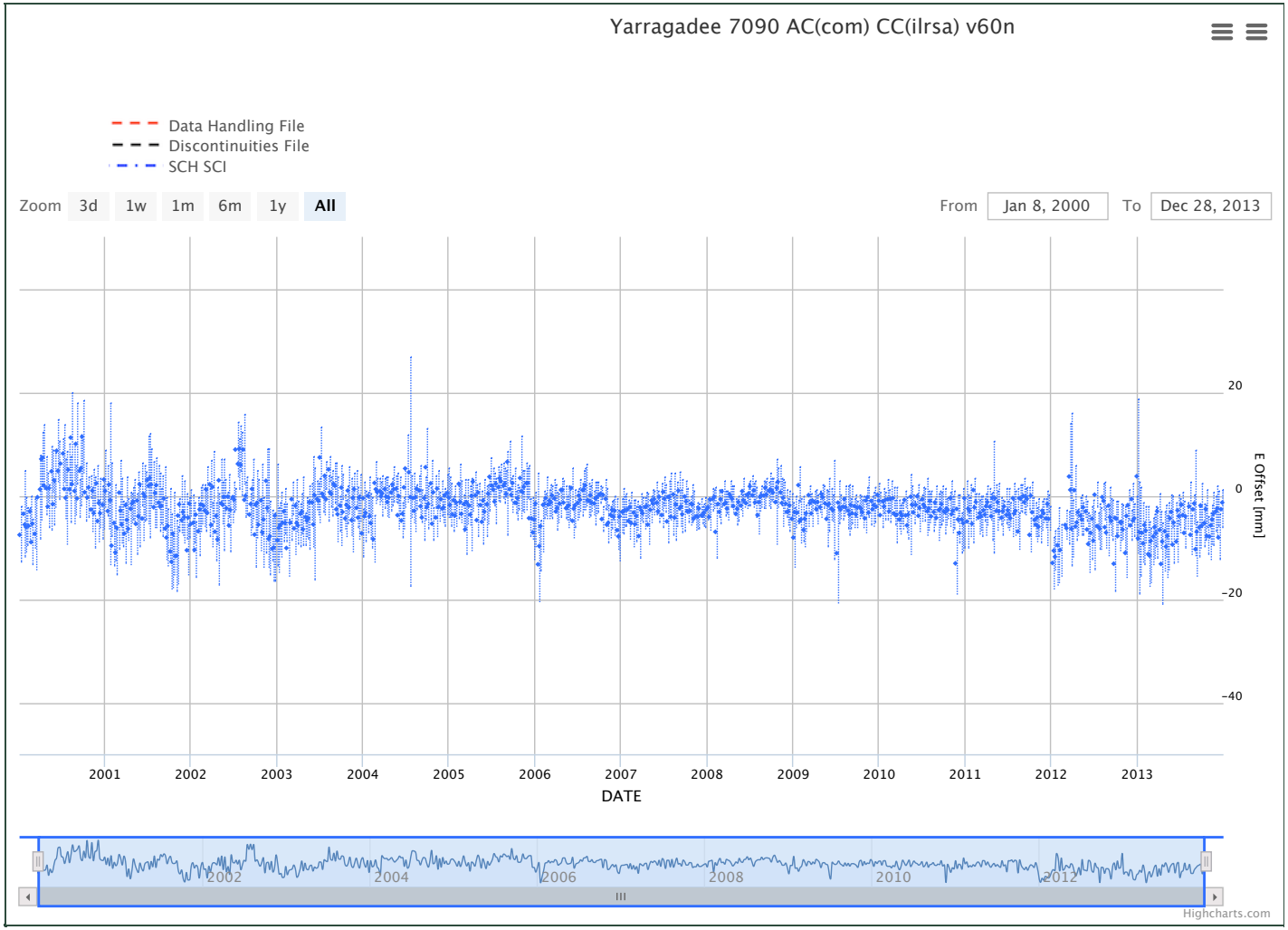




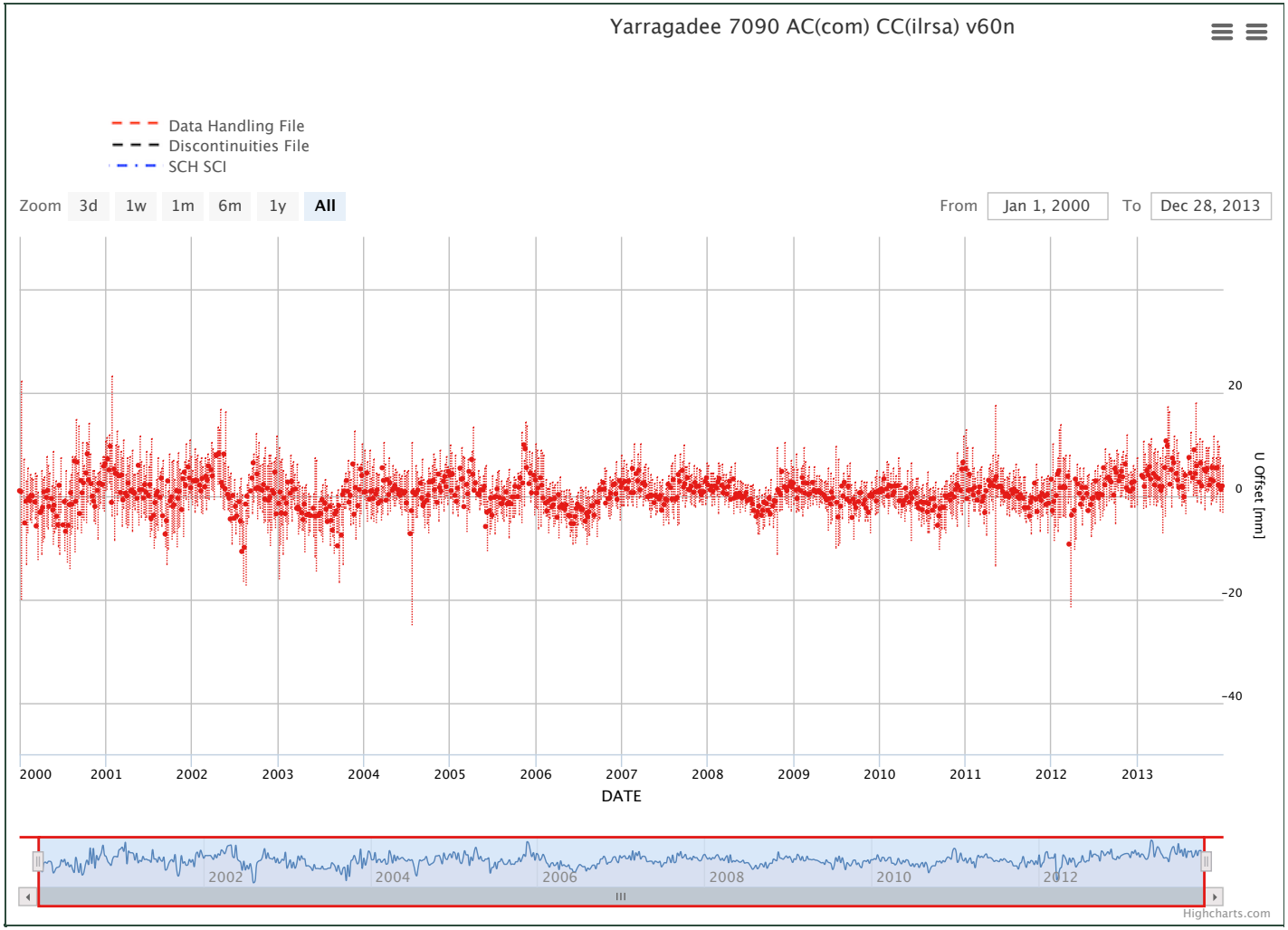
Yarragadee (7090) North



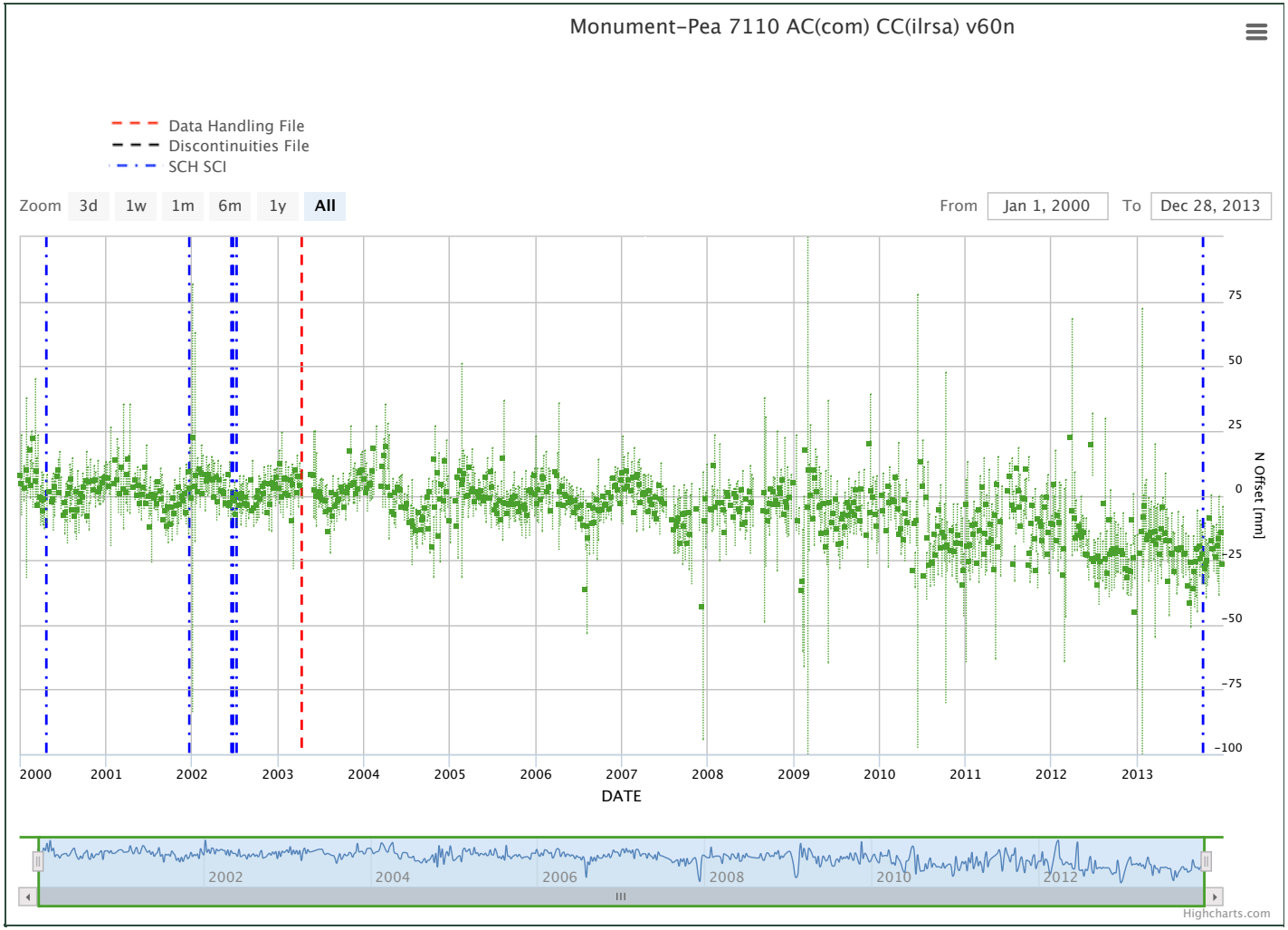
Yarragadee (7090) East



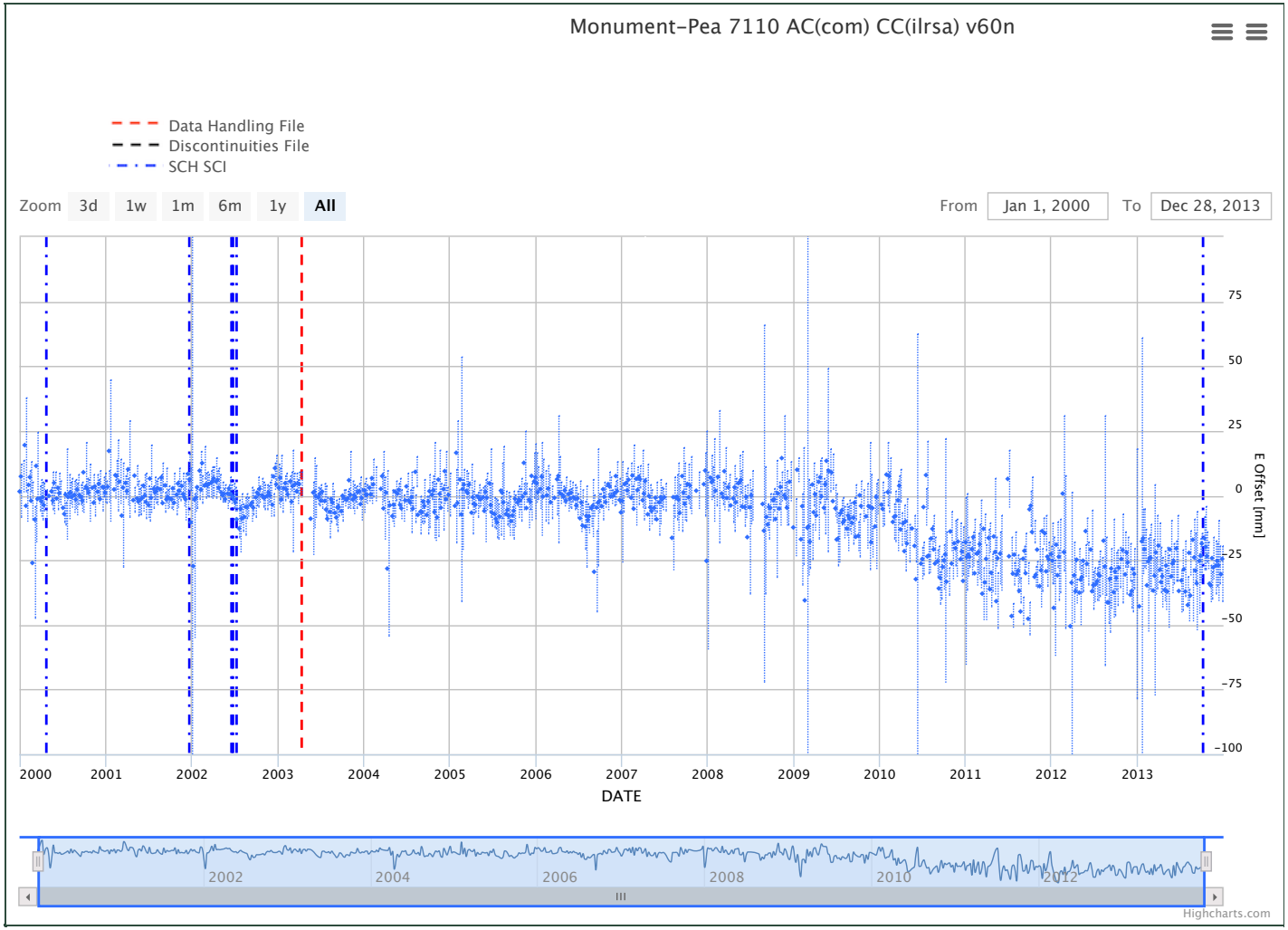
Yarragadee (7090) Up



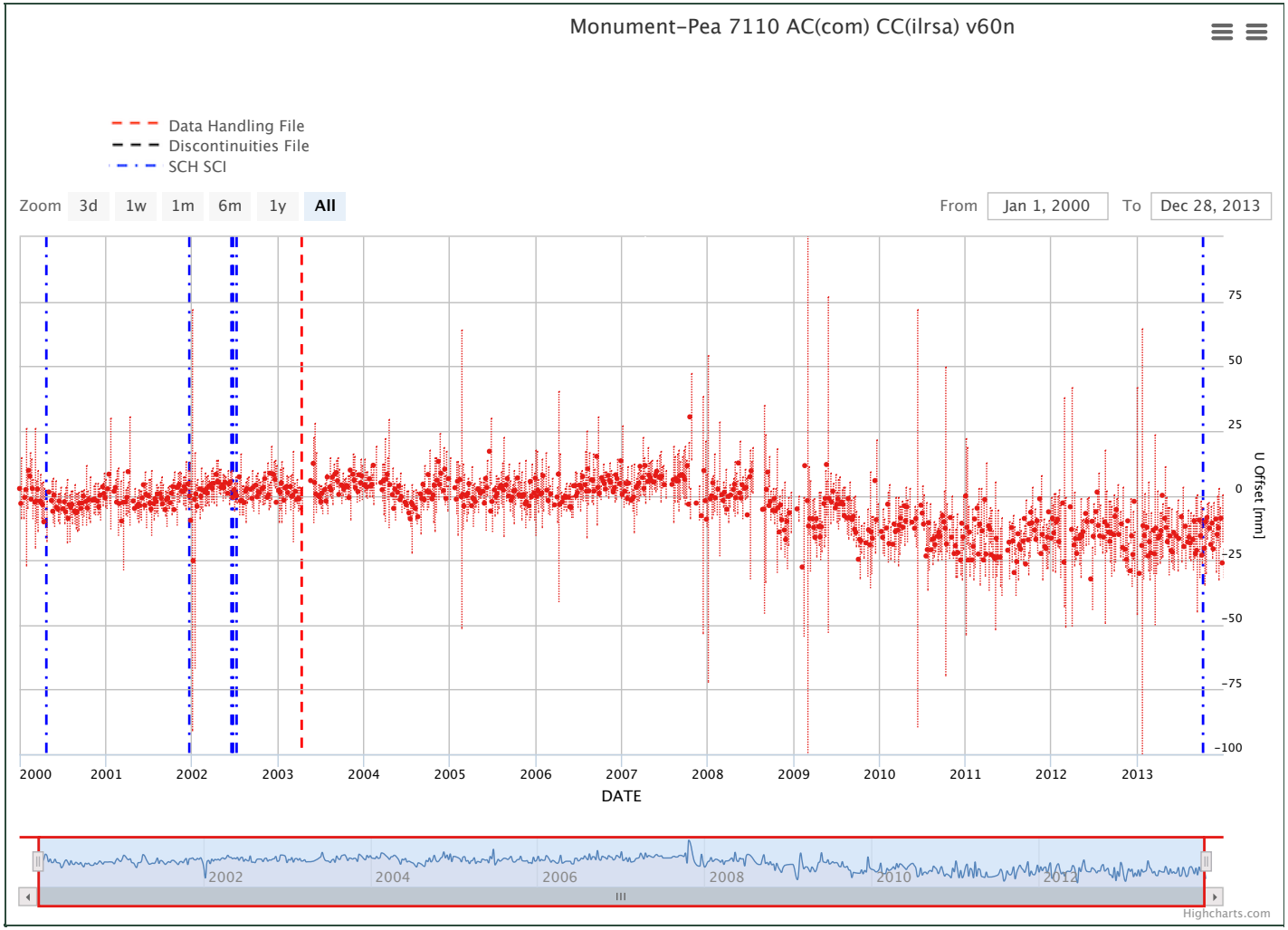
Mon. Peak (7110) North



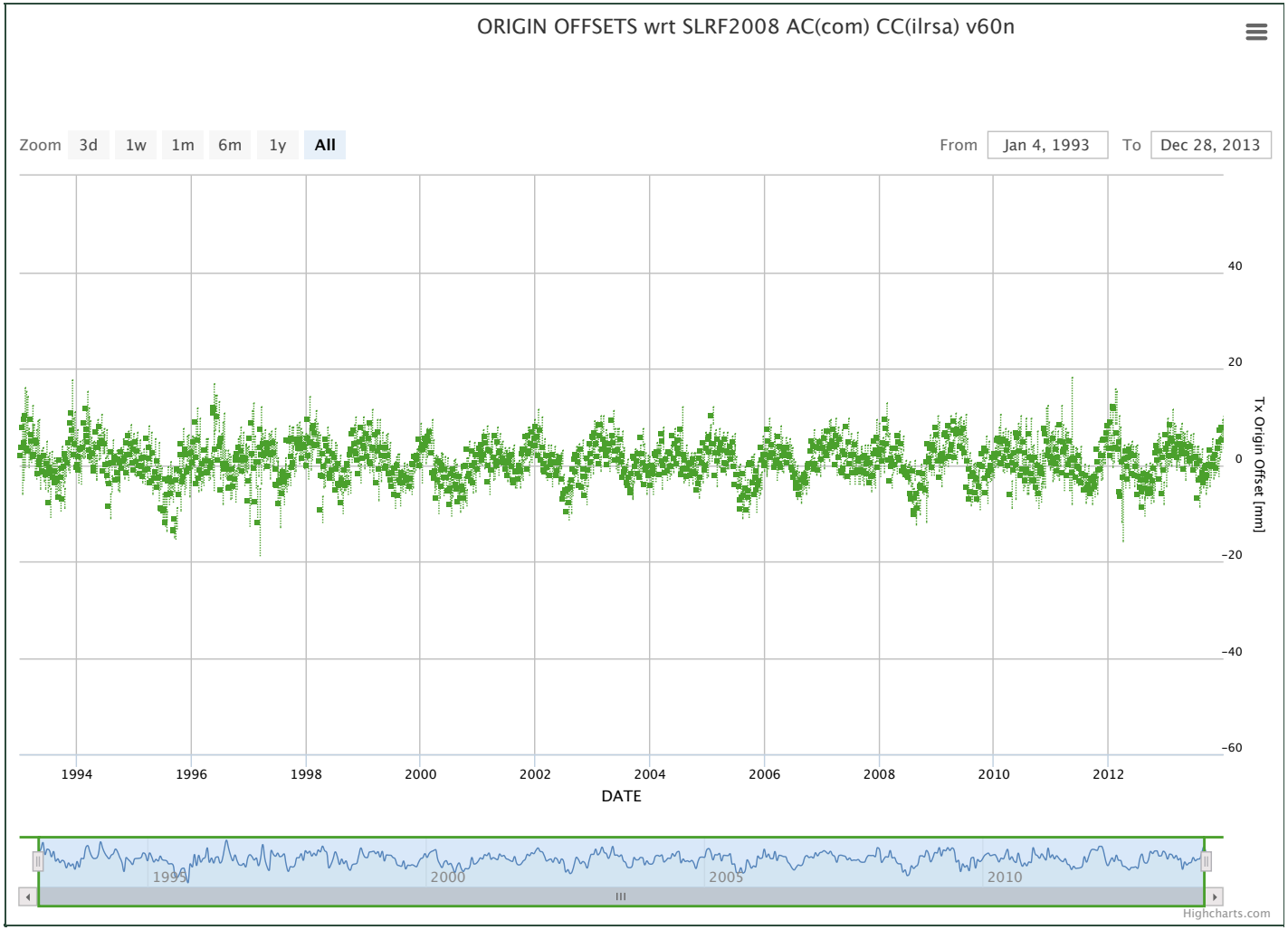
Mon. Peak (7110) East



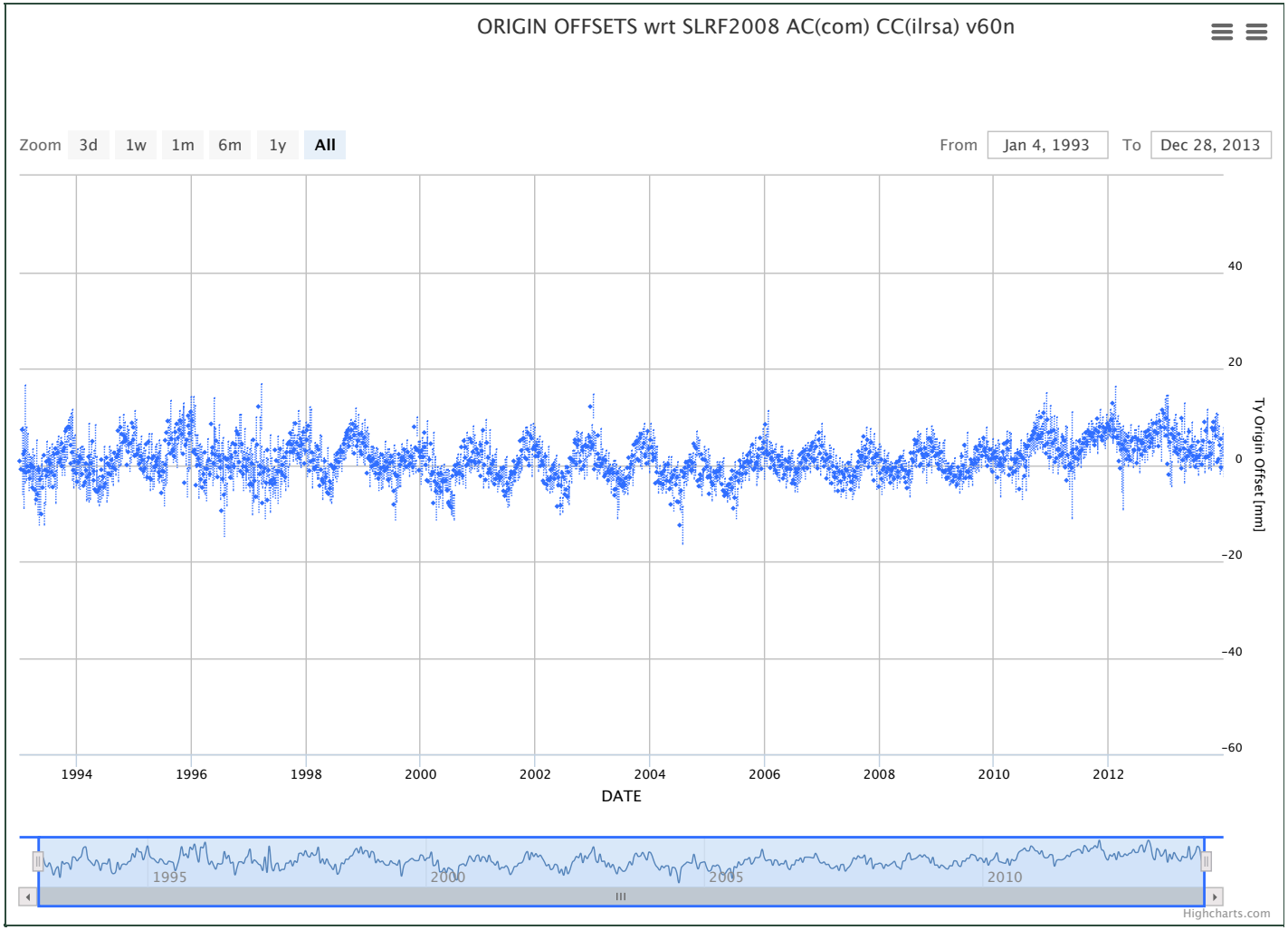
Mon. Peak (7110) Up



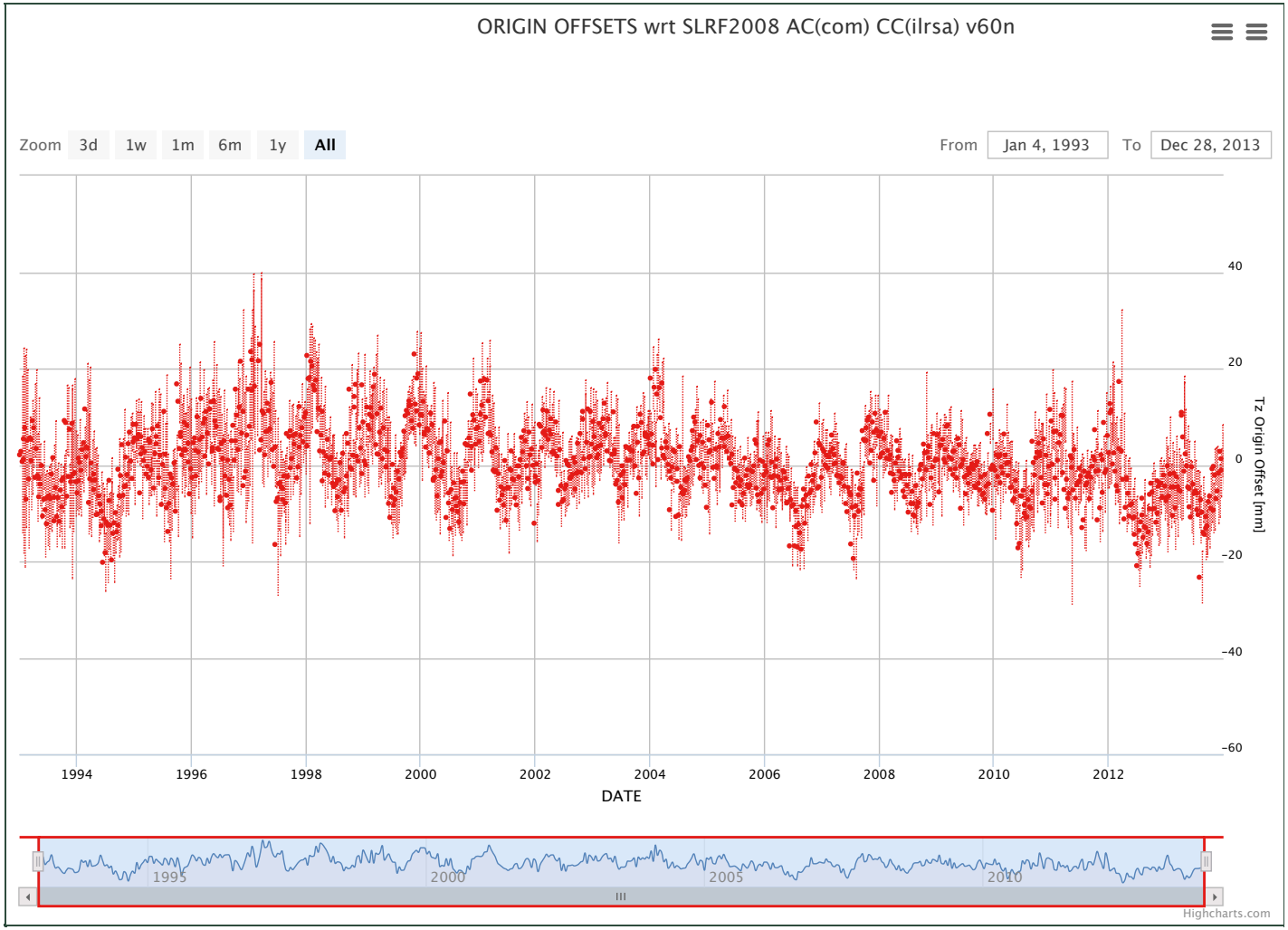
TRF Origin wrt SLRF2008 - X



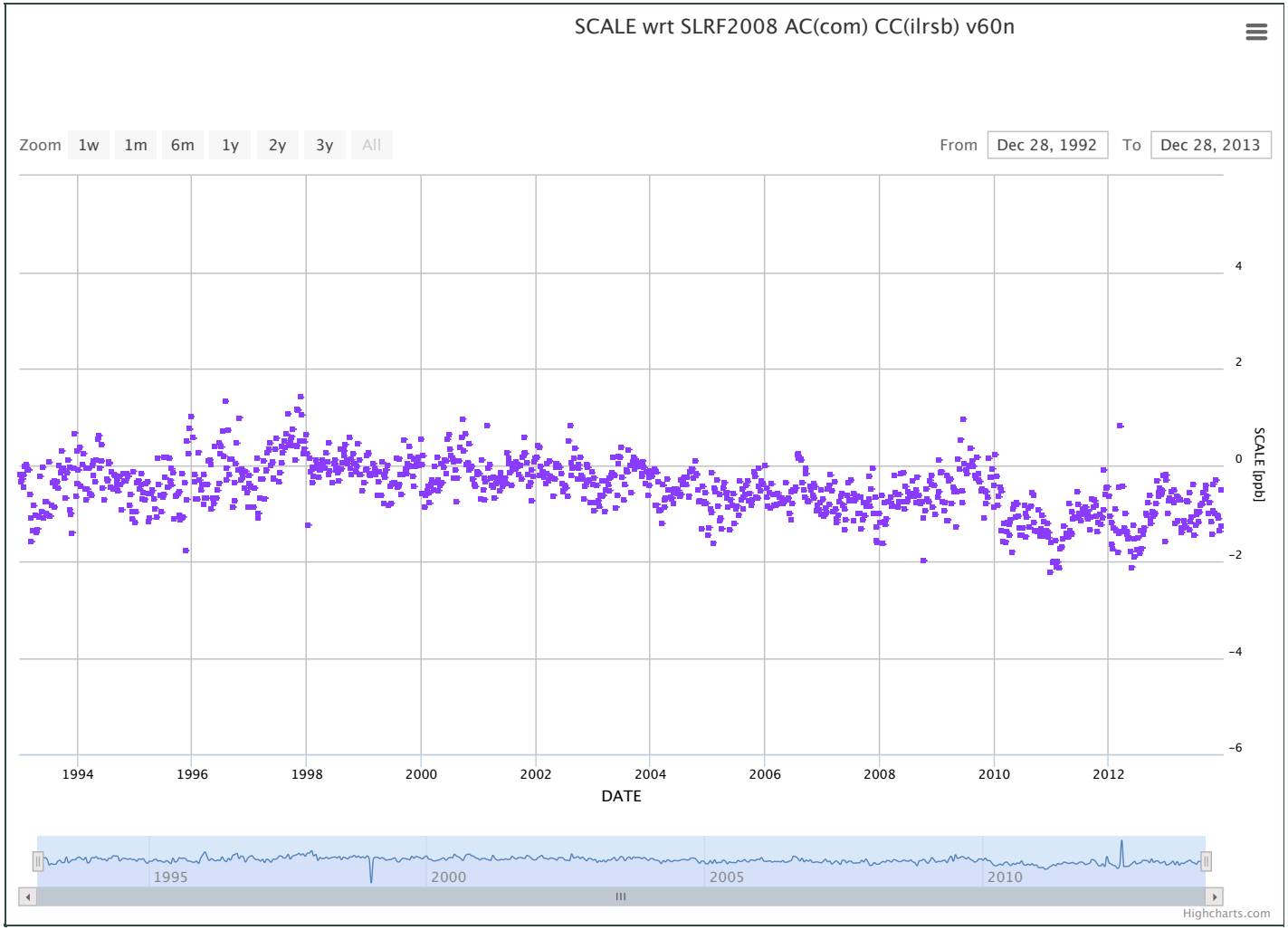
TRF Origin wrt SLRF2008 - Y



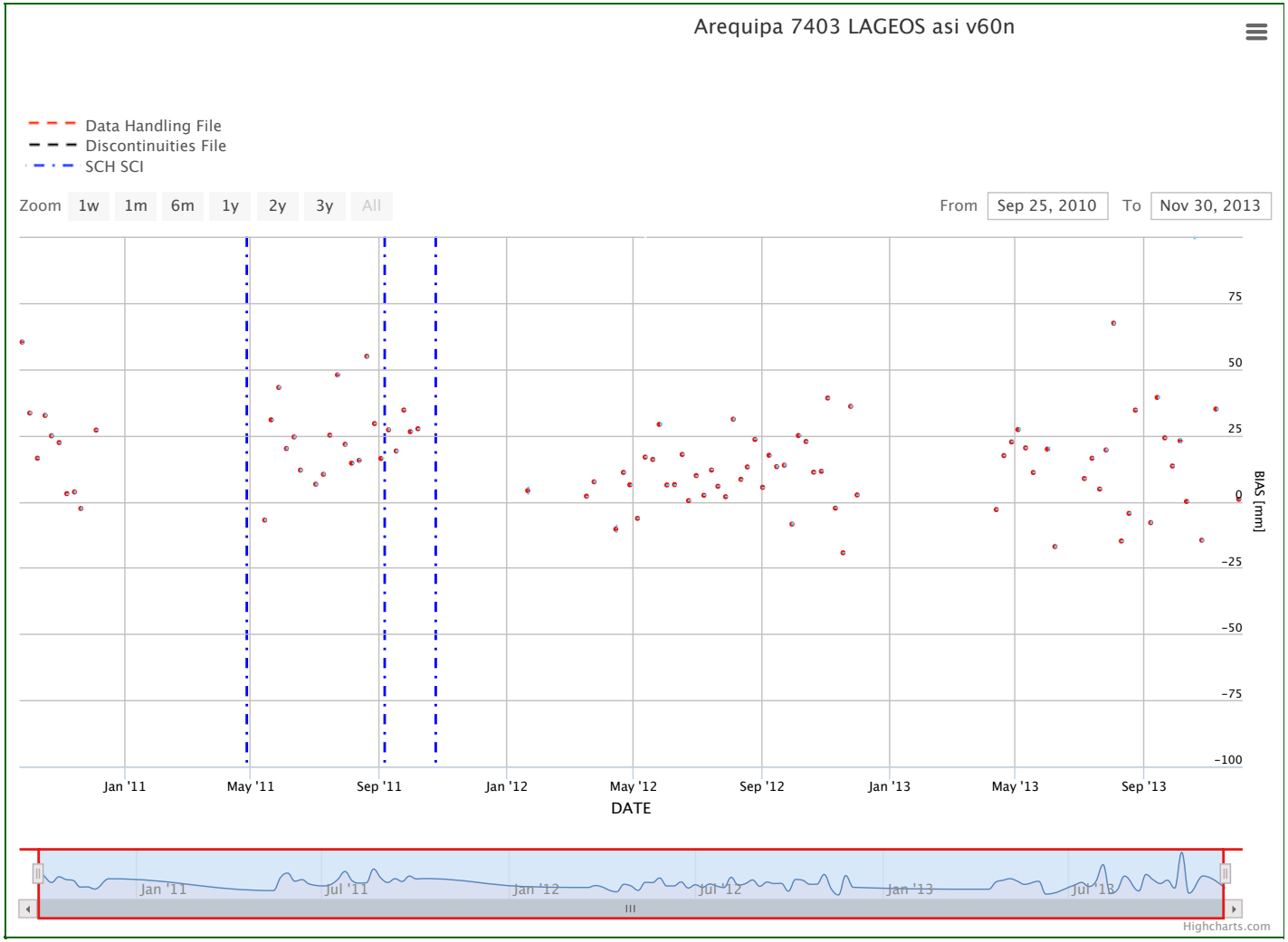
TRF Origin wrt SLRF2008 - Z



TRF Scale wrt SLRF2008

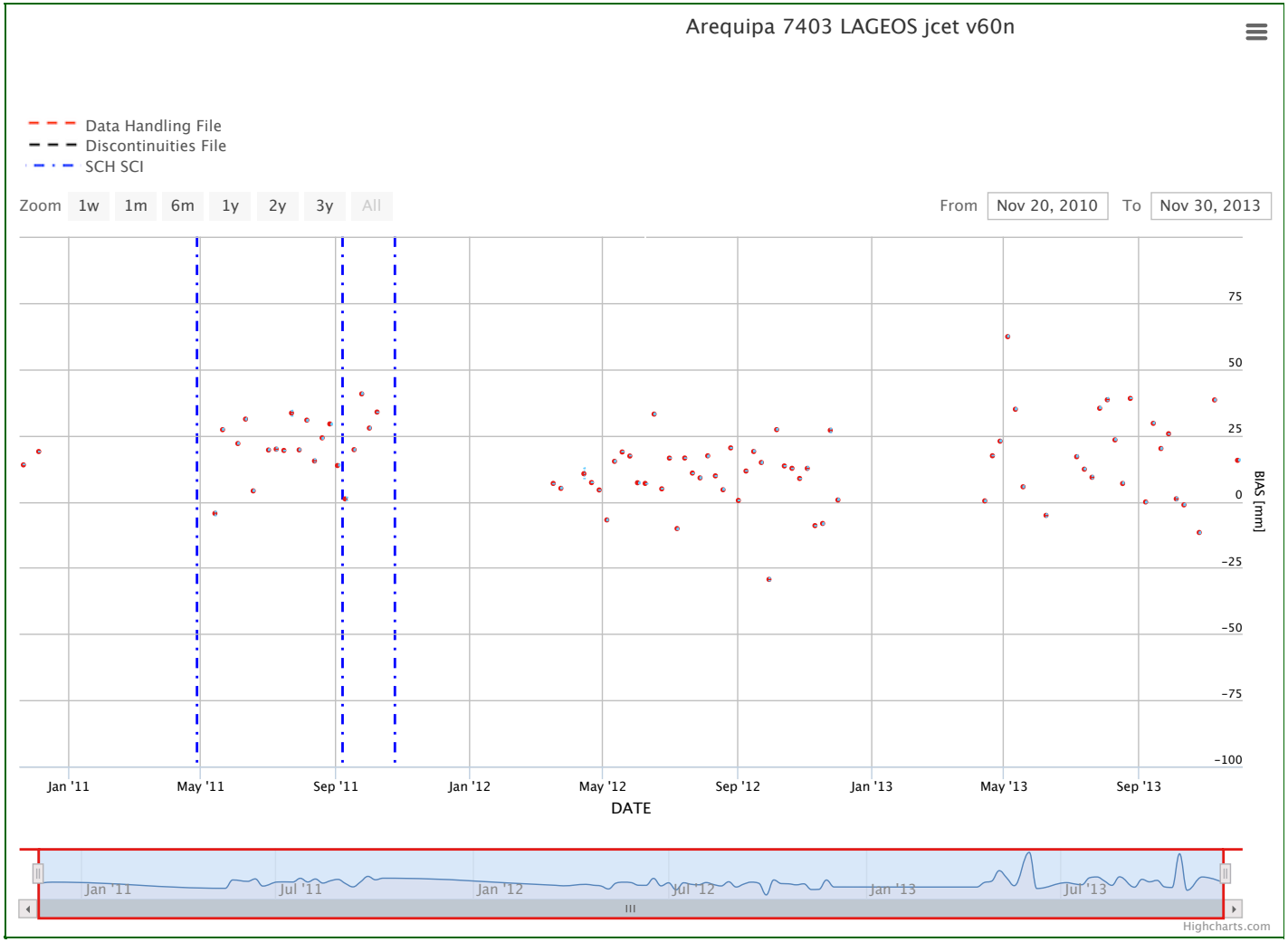


Estimated Systematics – Arequipa (7403)



ASI AC

Estimated Systematics – Arequipa (7403)



JCET AC

International Laser Ranging Service

LLR Status Report
- 2014 update -

Jürgen Müller

Institut für Erdmessung (Institute of Geodesy) and

Center of Excellence QUEST
(Quantum Engineering and Space-Time Research)

Leibniz Universität Hannover (University of Hannover)

ife

Leibniz Universität Hannover

Major LLR-related activities

- Lunar tracking at LLR sites: Business as usual (some more details in the LLR session on Thursday)
- Data screening, homogenization of archived LLR data: French and IfE data set prepared
- → statistics update at spring ILRS/AWG meeting
- IfE LLR solution submitted for ITRF2013, French contribution?
- SHELLI: Proposal for a new LLR site at NTT Nasmyth (ESO) was NOT successful
- Simulation of impact of new LLR sites and/or reflectors with various options (see last meeting) – ongoing with D. Currie
- Various studies on combined use of LLR, GRAIL and LRO data

APOLLO 15 coordinates from LLR and NAC LRO images

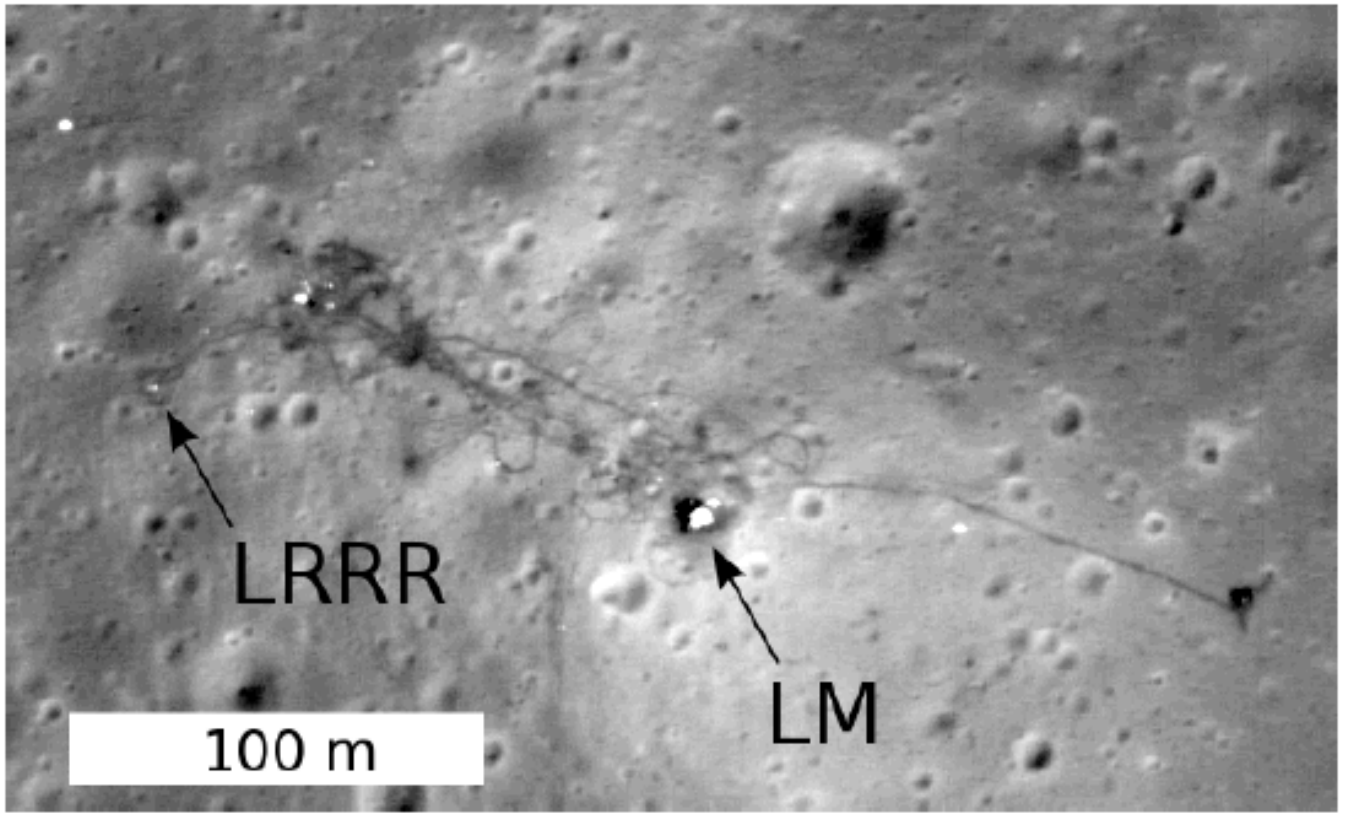


Figure 1: Apollo 15 landing site with Lunar Module and LRRR (NAC image: M111578606L).

APOLLO 15 coordinates from LLR and NAC LRO images

ME coordinates of the Apollo 15 reflector, derived from LLR and LROC images with underlying DE/IfE ephemeris

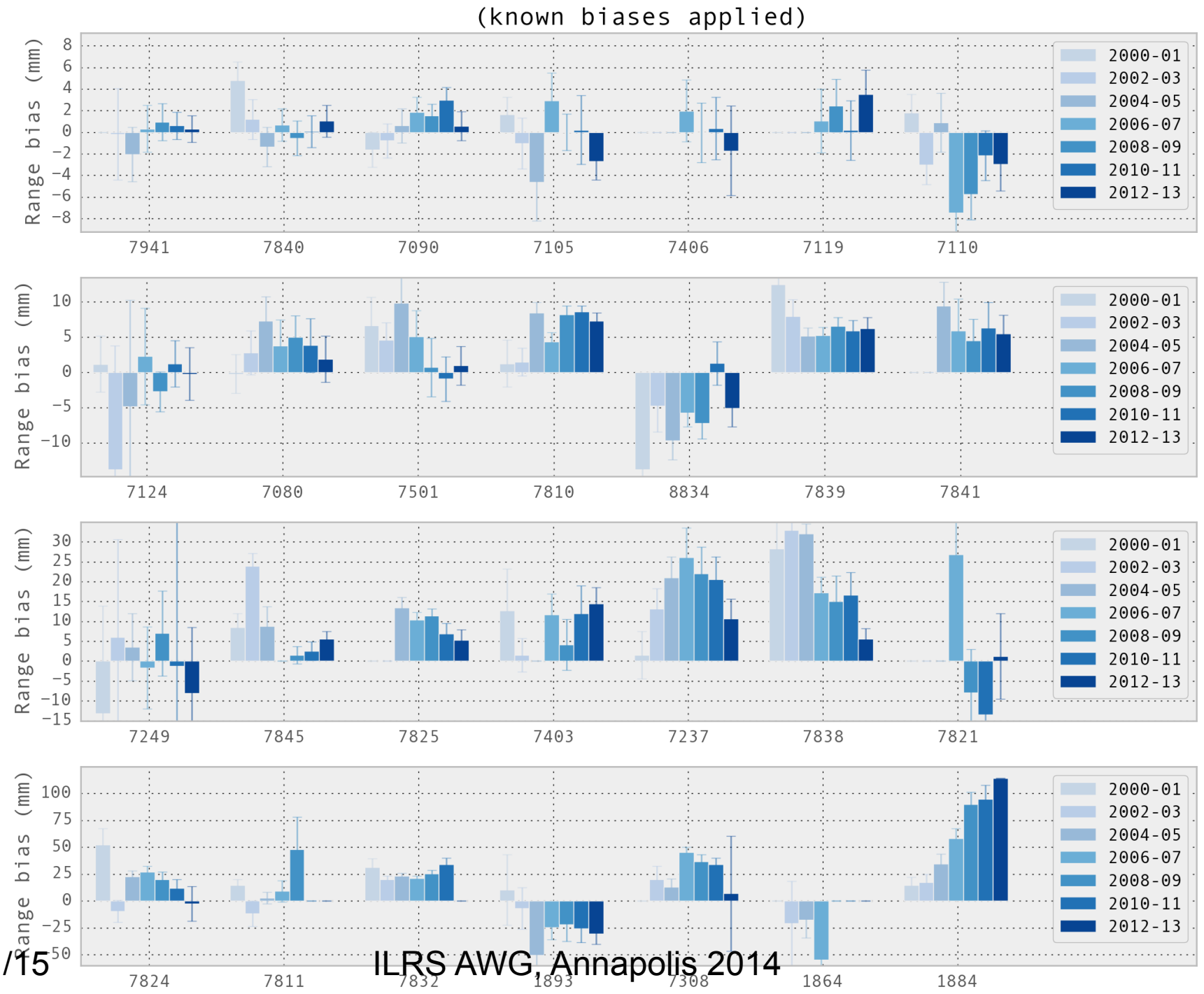
	Long. [°]	Lat [°]	Diff. [m]	
LLR (DE421)	3.628507	26.133395		DE421 LLR solution
P1 NASA	3.628177	26.133462	9.22	NASA LRO orbit, GRAIL
P1 DE421	3.628213	26.133775	14.01	own orbit and DE ephem.

	Long. [°]	Lat [°]	Diff. [m]	
LLR (IfE)	3.628177	26.133063		IfE LLR solution
P1 IfE	3.628195	26.133791	22.08	own LRO orbit and ephem.

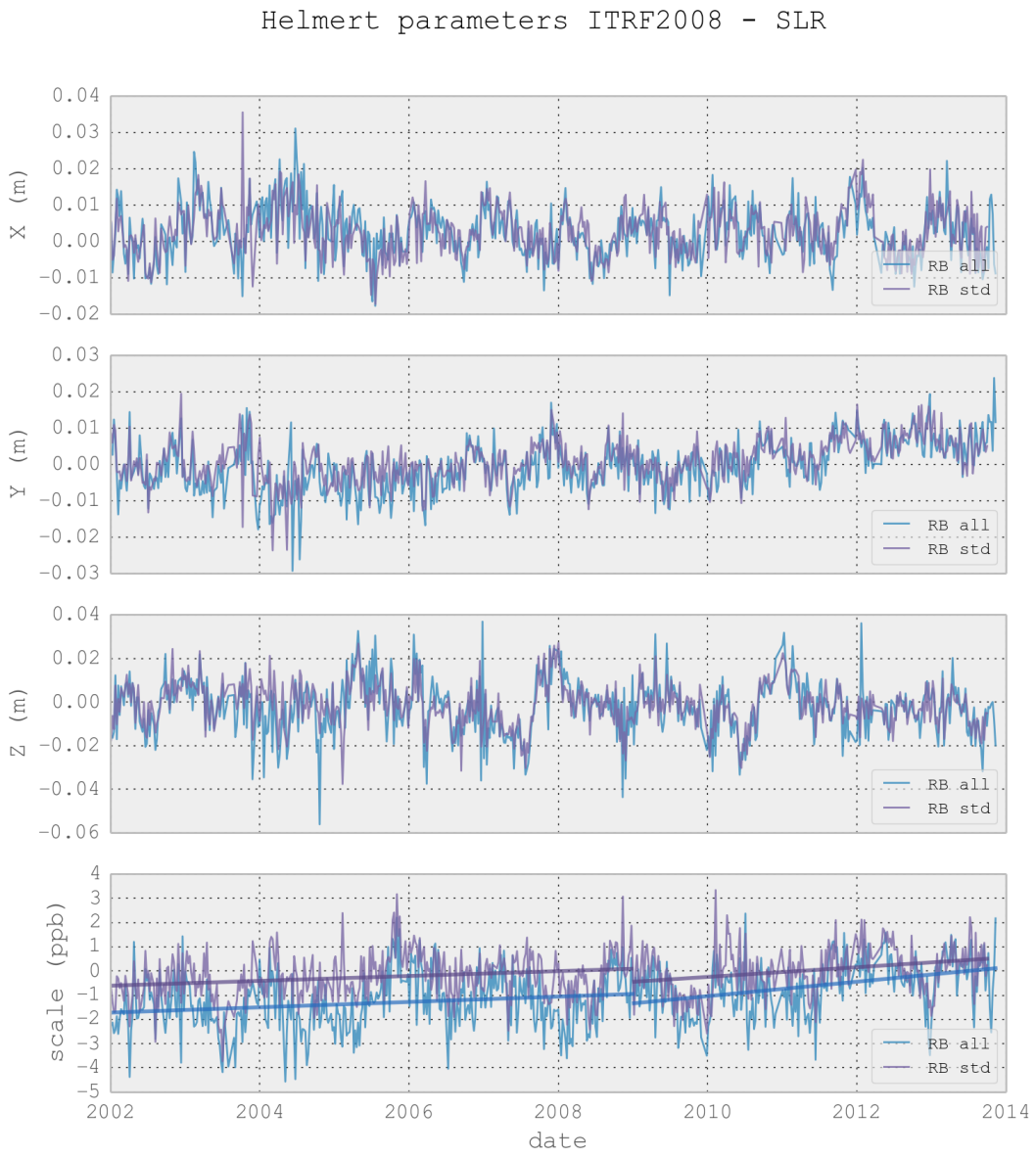
SGF Herstmonceux AC

Graham Appleby & Jose Rodriguez

- Submitted Solutions for 1993-2013 finally in September 2014
  - Issues with lack of rotational looseness sorted out with great help from Cinzia
- Submitted solutions for 1983-1992 finally in October 2014
  - Many looseness problems found by JCET back-up CC
  - Apparently not a problem for ASI CC processing?
- Bias work – summary in next two plots.


Two-year RB averages of most productive ILRS stations 2000-2013
(known biases applied)
Range bias (mm)
2000-01
2002-03
2004-05
2006-07
2008-09
2010-11
2012-13
7941
7840
7090
7105
7406
7119
7110
7124
7080
7501
7810
8834
7839
7841
7249
7845
7825
7403
7237
7838
7821
7824
7811
7832
1893
7308
1864
1884

Helmert solutions w.r.t. ITRF2008



TRF scale change implied by solving for all RB is ~ 1ppb