The temporary ILRS reference frame: SLRF2005

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ILRS Fall Meeting, 24-28 September 2007, Grasse

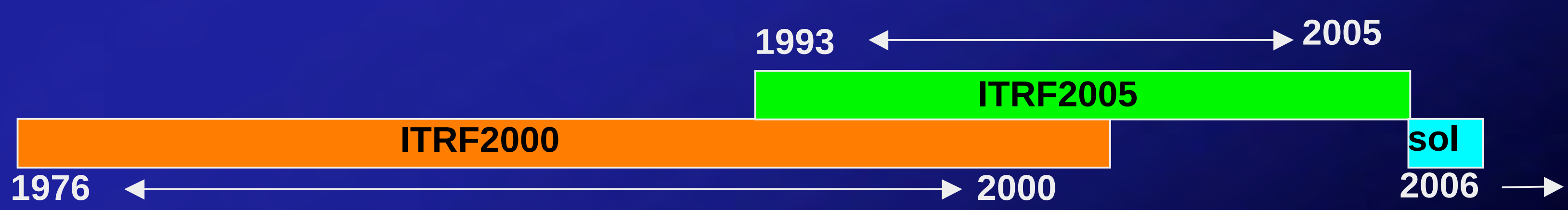
Existing Reference Frame

Benefits from :

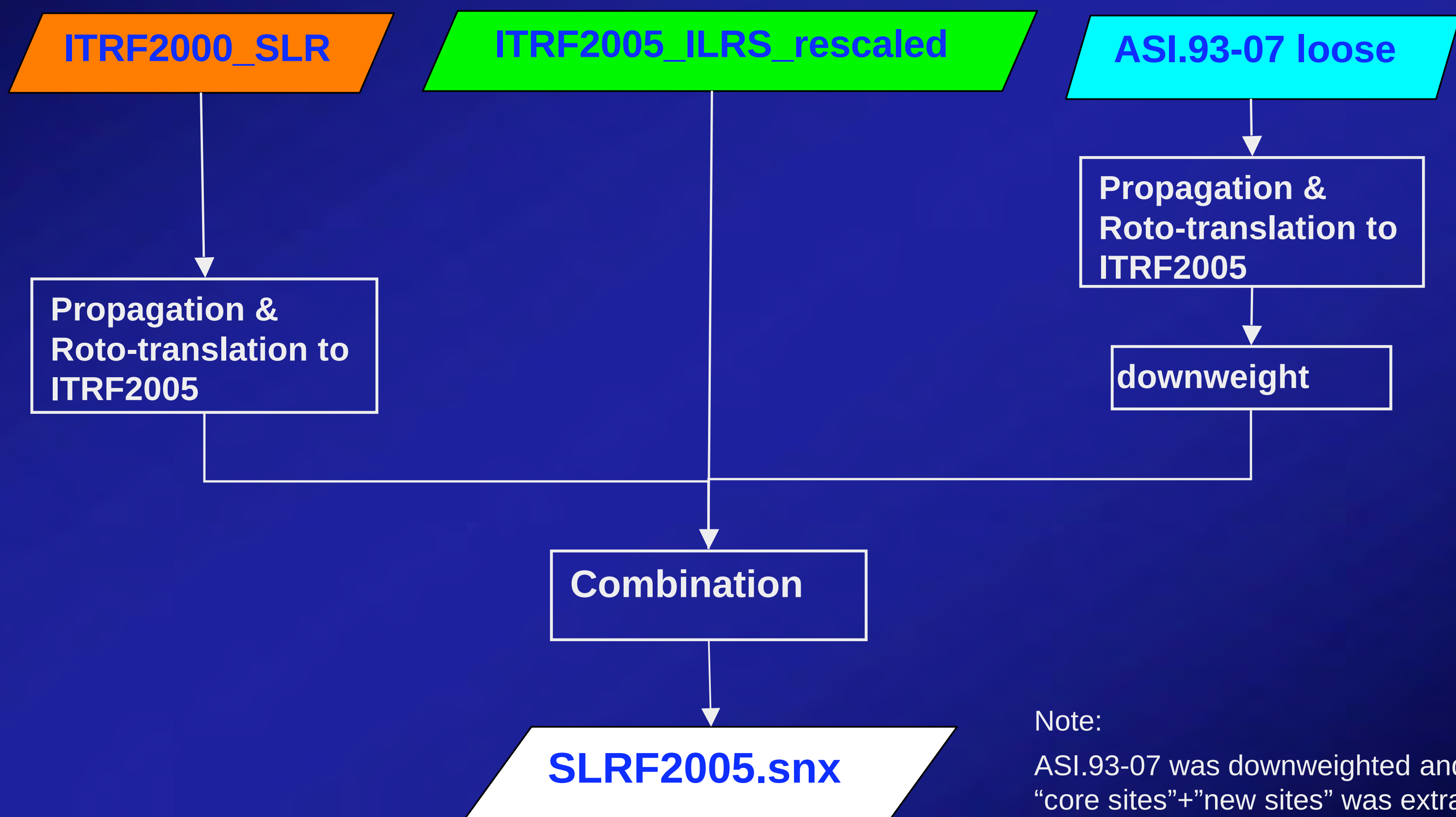
ITRF2000
- Pre-1993 sites

ITRF2005 rescaled
- New models, better estimates
- New sites up to 2005

Updated solution
- New sites since 2006



SLRF2005 generation flowchart



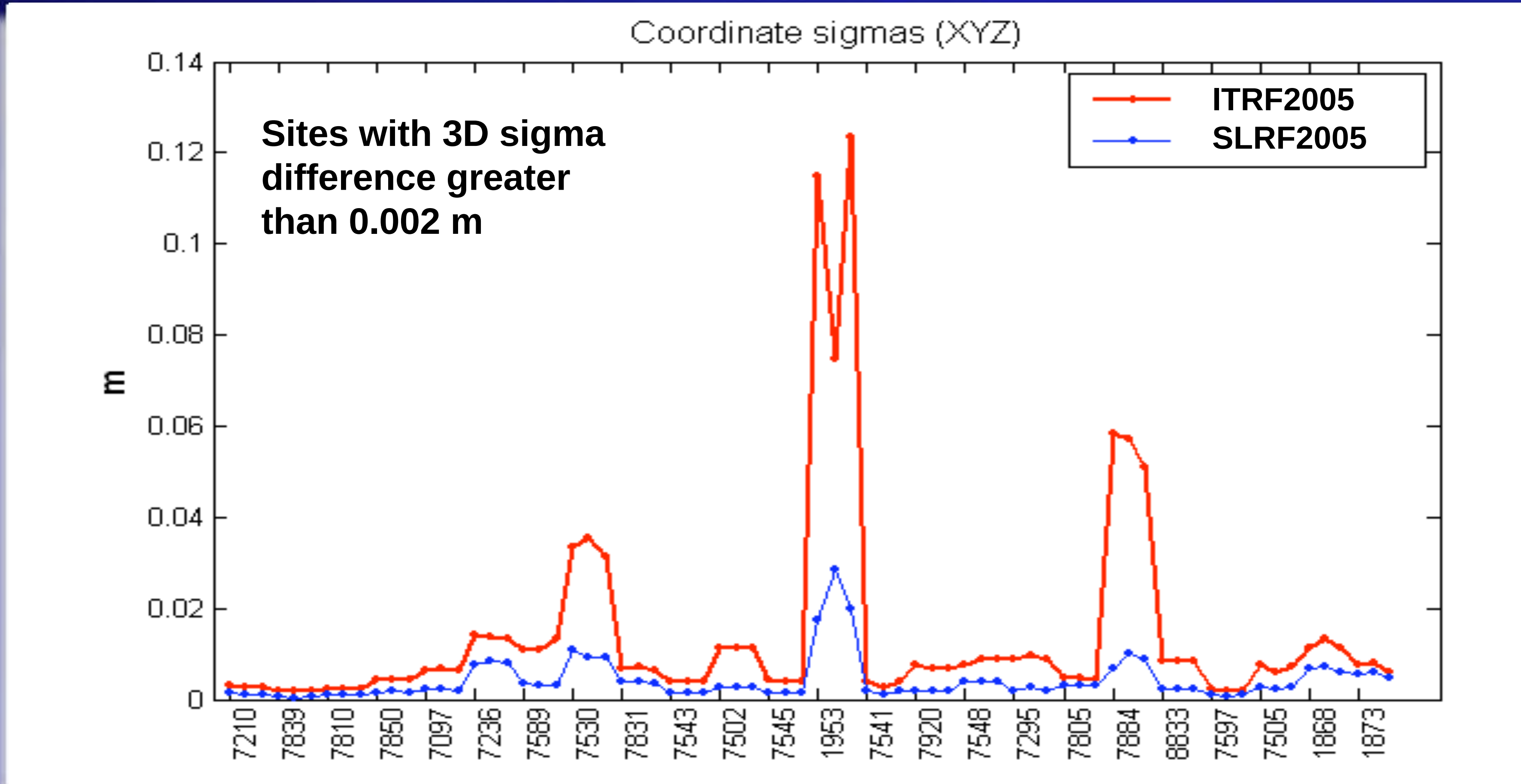
Note:

ASI.93-07 was downweighted and a subnetwor
“core sites”+”new sites” was extracted from the
solution to be combined with the other 2 TRF w
the aim to minimize its influence over the netwo

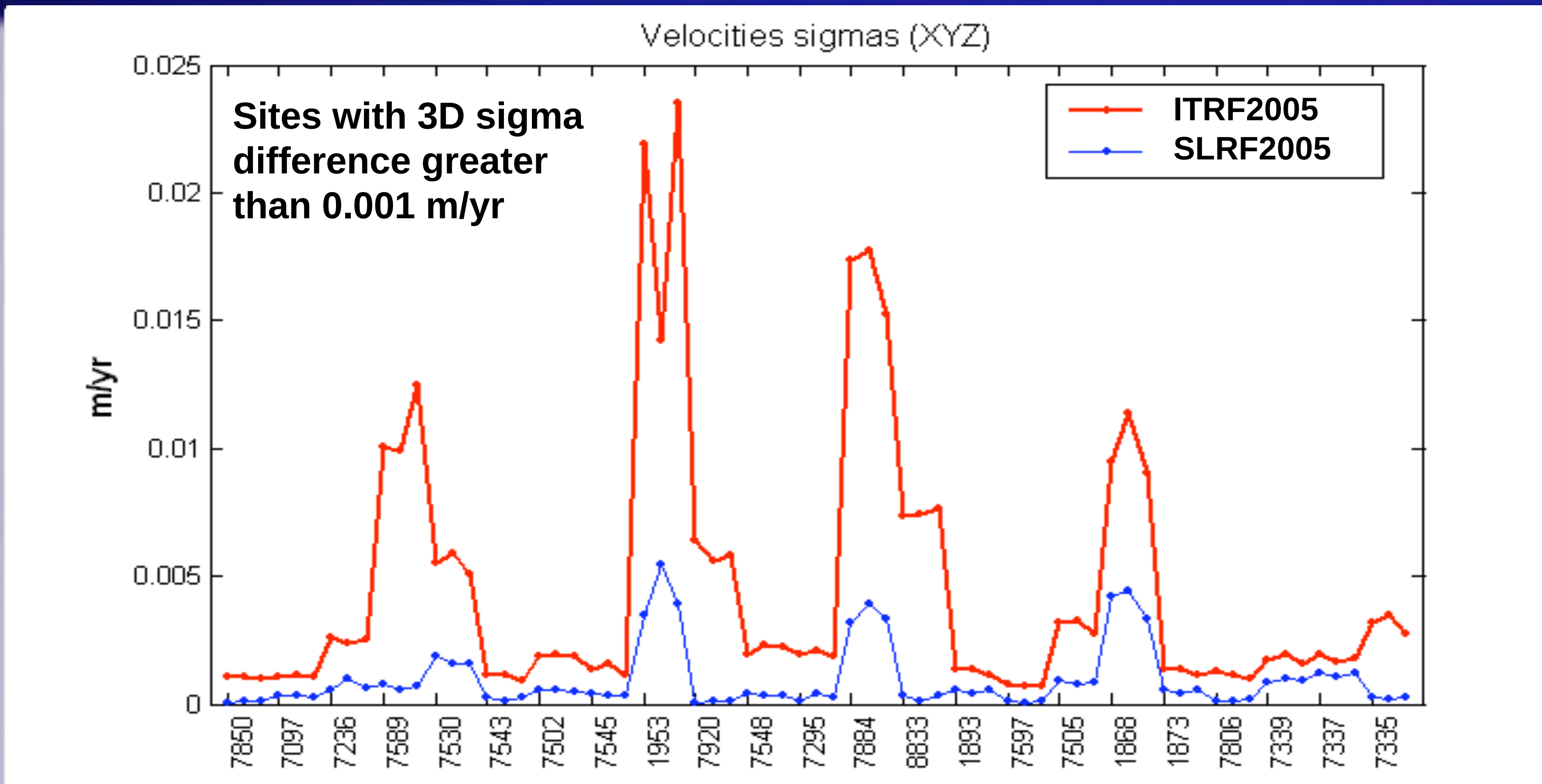
Bad stations in ITRF2005 – edited before combination

```
+SOLUTION/EPOCHS
*Code PT SOLN T Data_start__ Data_end____ Mean_epoch__
 7122  A    1 C 92:364:20108 93:010:41381 93:004:30953    ok in ITRF2000
 7123  A    1 C 93:112:25806 93:310:42948 93:211:34377    ok in ITRF2000
 7883  A    1 C 93:335:28394 94:042:64147 94:006:46271    ok in ITRF2000
 7882  A    1 C 94:075:53242 94:130:15383 94:102:77512    ok in ITRF2000
 7411  A    1 C 94:193:04556 94:258:43738 94:225:67347    ok in ITRF2000
 7525  A    1 C 94:199:13073 94:279:84021 94:239:48547    ok in ITRF2000
 7520  A    1 C 95:238:65872 95:260:74471 95:249:70172    ok in ITRF2000
 7847  A    1 C 96:098:46968 96:105:50693 96:102:05631    bad also in ITRF2000
 7307  B  1 C 97:253:56118 97:298:62932 97:276:16325  not in ITRF2000, discarded
 7307  D  1 C 99:260:46043 99:288:43839 99:274:44941  not in ITRF2000, discarded
 7355  A  1 C 01:119:62133 01:145:75983 01:132:69058  not in ITRF2000, discarded
 7830  A  1 C 03:097:70658 03:290:51783 03:194:18021  not in ITRF2000, discarded
 7357  A  1 C 03:217:45220 03:290:67834 03:254:13327  not in ITRF2000, discarded
 7823  A  1 C 04:172:04739 04:178:01370 04:175:03054  not in ITRF2000, discarded
 7130  A  1 C 05:213:45454 05:307:03282 05:260:24368  not in ITRF2000, discarded
 7358  A  1 C 05:214:30940 05:333:72723 05:274:08632  not in ITRF2000
```

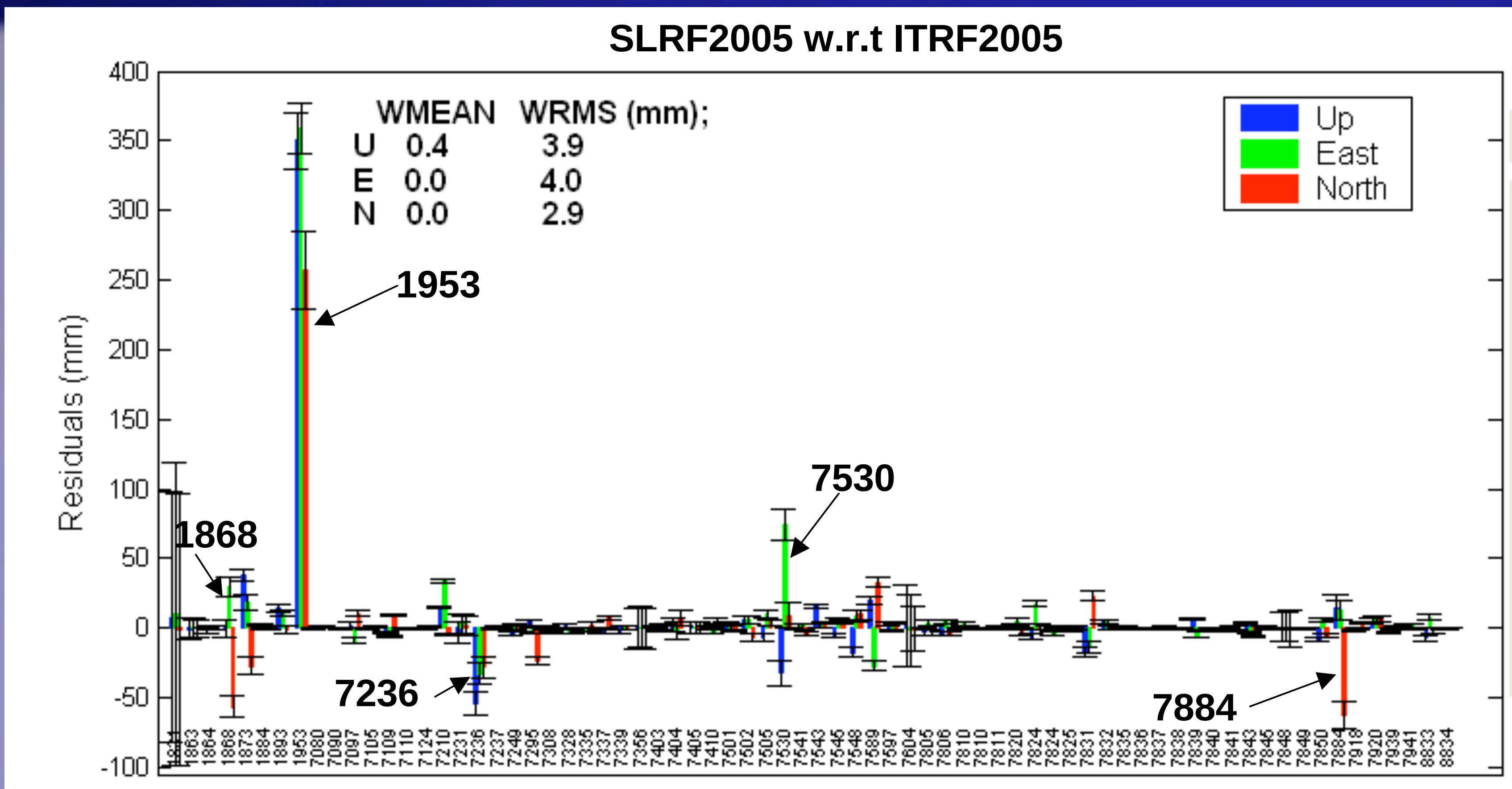
Coordinate sigma comparison



Velocity sigma comparison

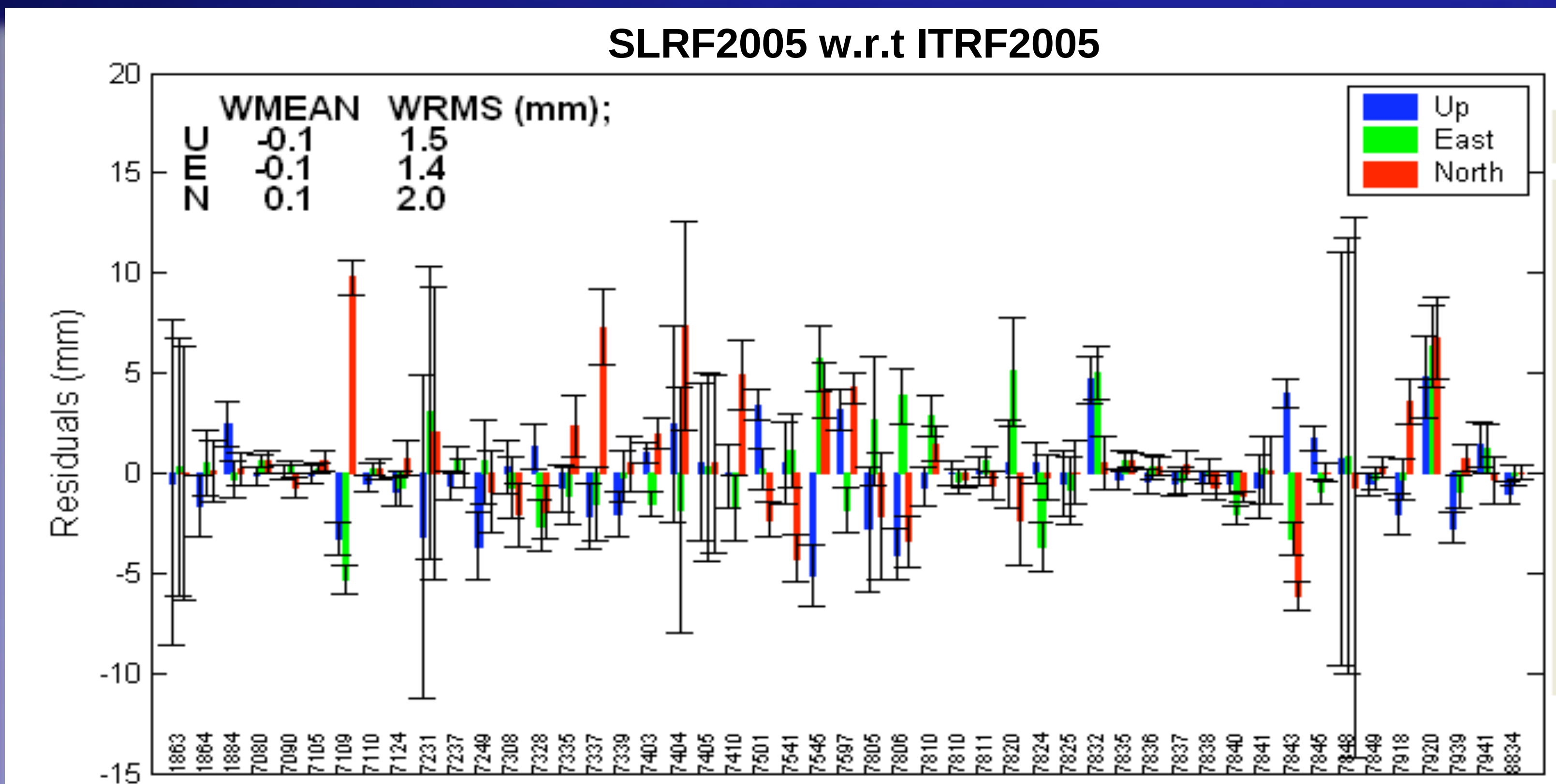


SLR2005 coordinate comparison: full network



Higher residuals for those sites with short history in one of the two frames

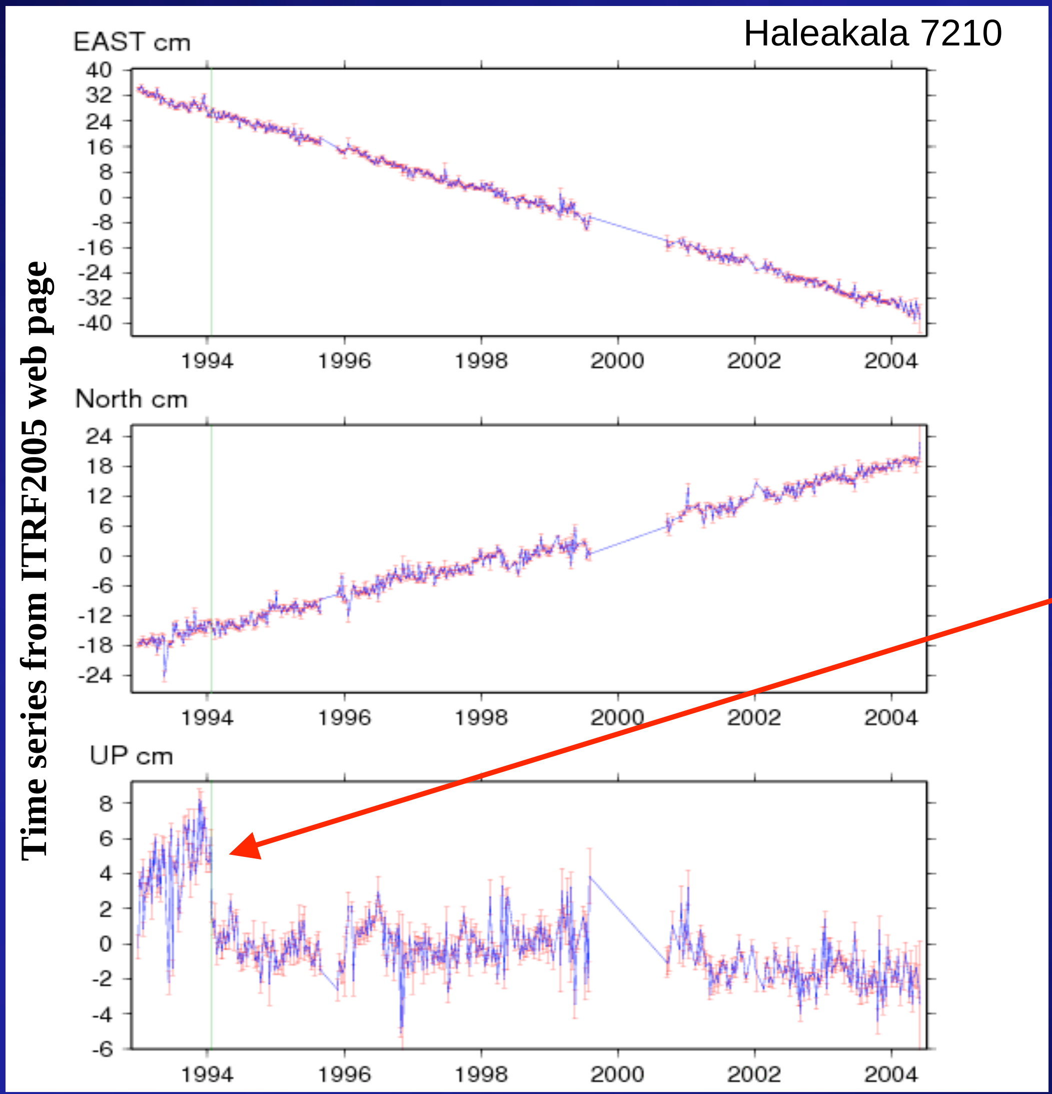
SLR2005 coordinate comparison: selected sites



Edited sites: all SOLN > 1 for 7210, 7839, 7840, 7403
1953, 1868,1873,7884,7236,7530,1831,7589, 7294,7824A , 7502, 7505
7543,7850, 7097,7831,1893,7604, 7839,8833,7548,7356

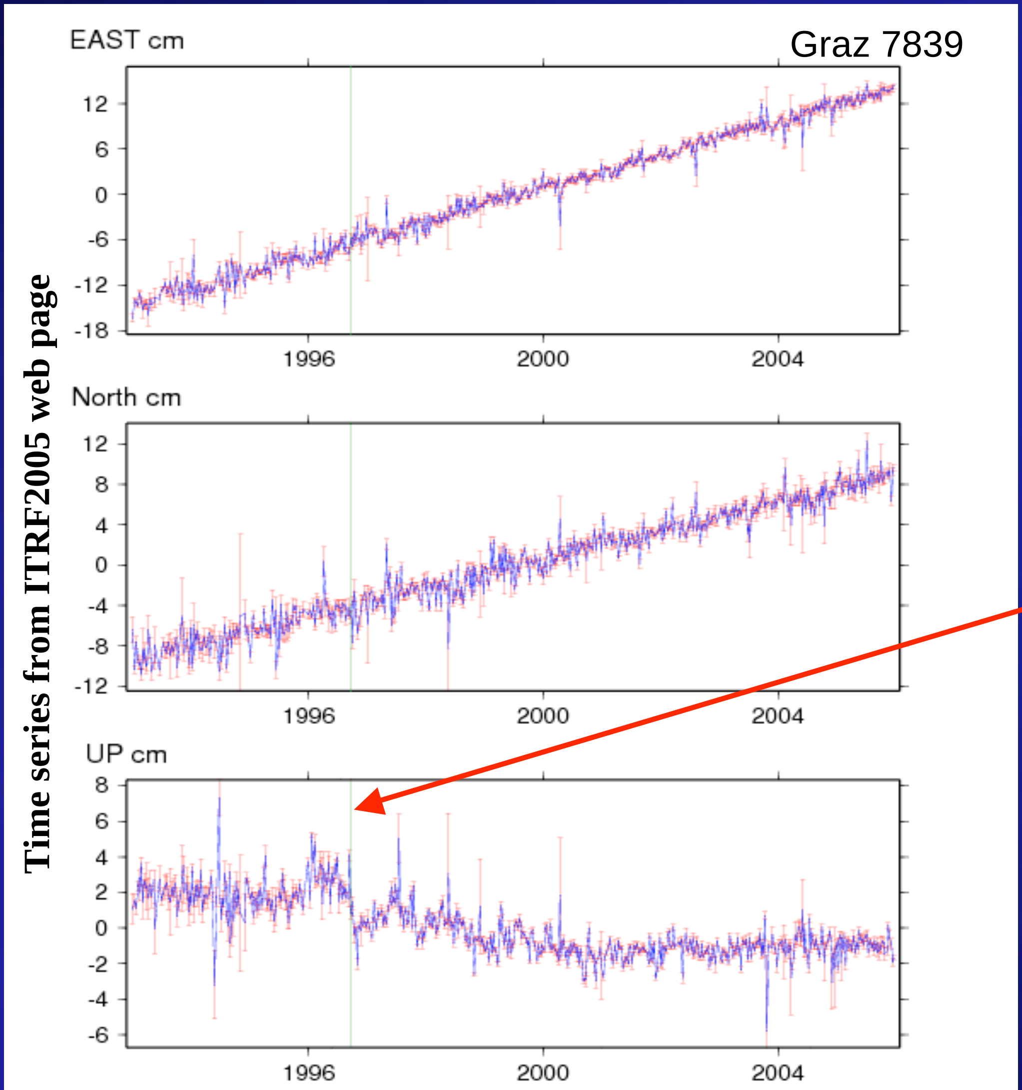
Most of this sites have a longer history in ITRF2000

Stations with jumps: Haleakala (7210)



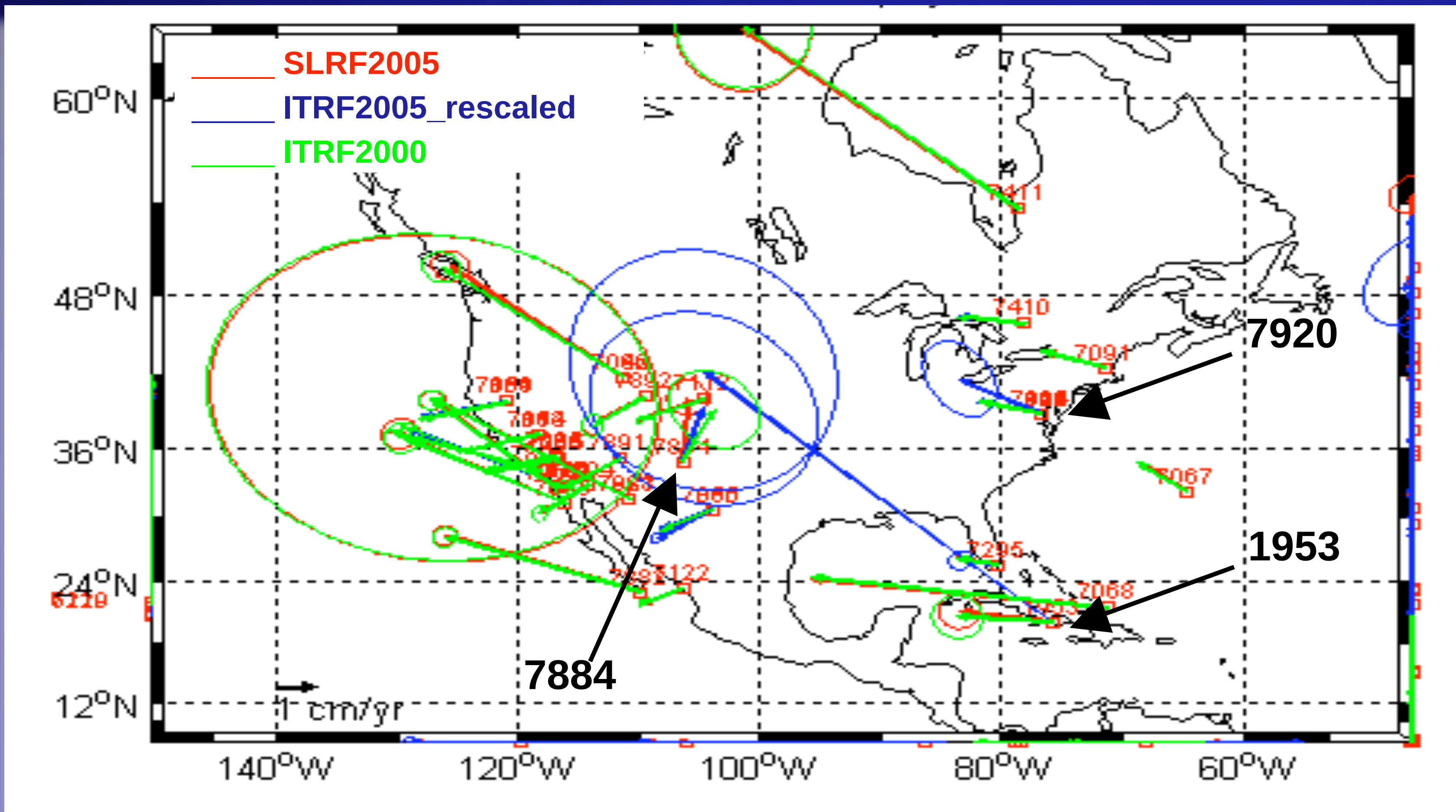
ITRF2005 SOLN 1 combined with ITRF2000 to get a better estimate (above all for velocities)

Stations with jumps: Graz (7839)

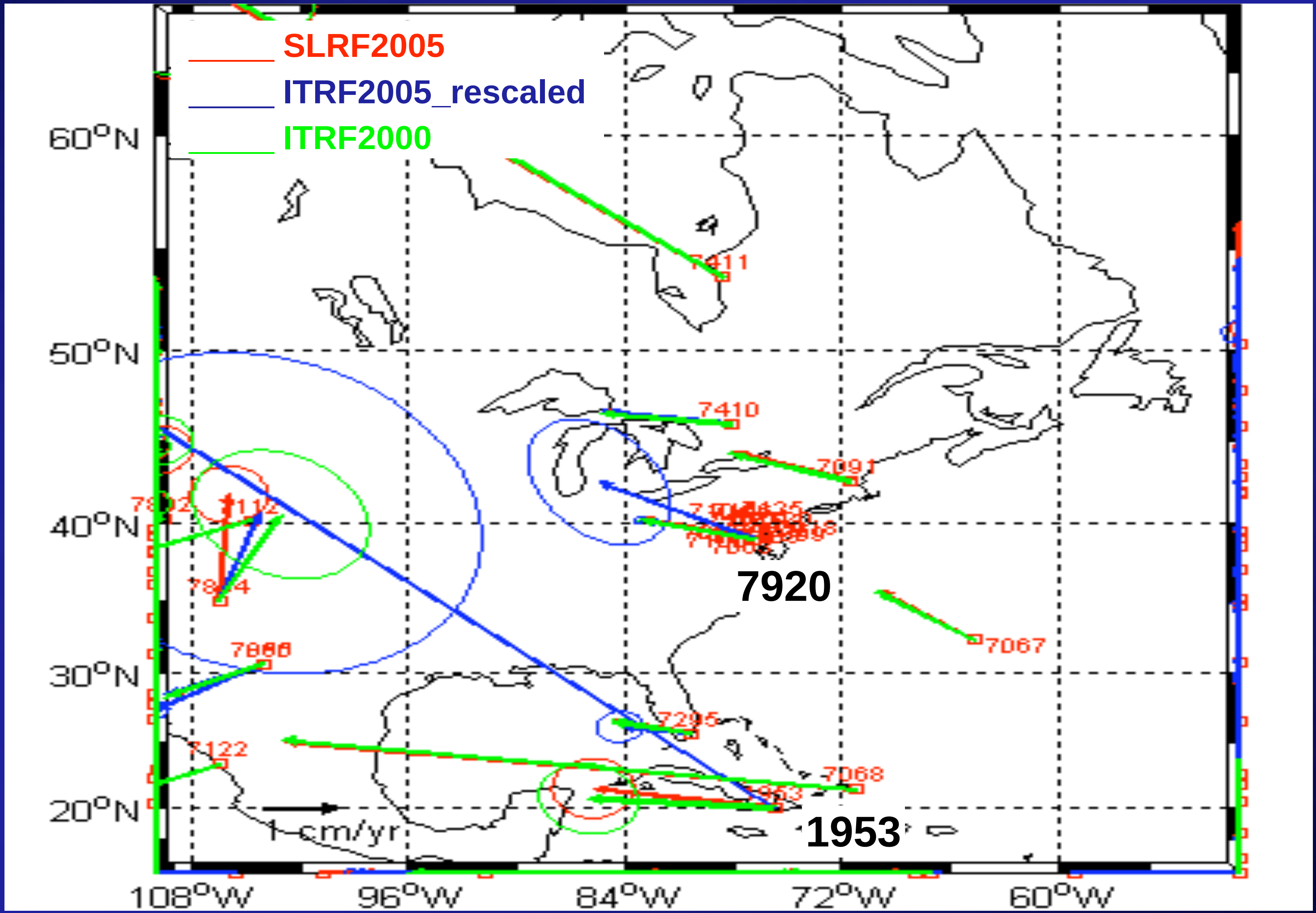


ITRF2005 SOLN 1 combined with ITRF2000 to get a better estimate

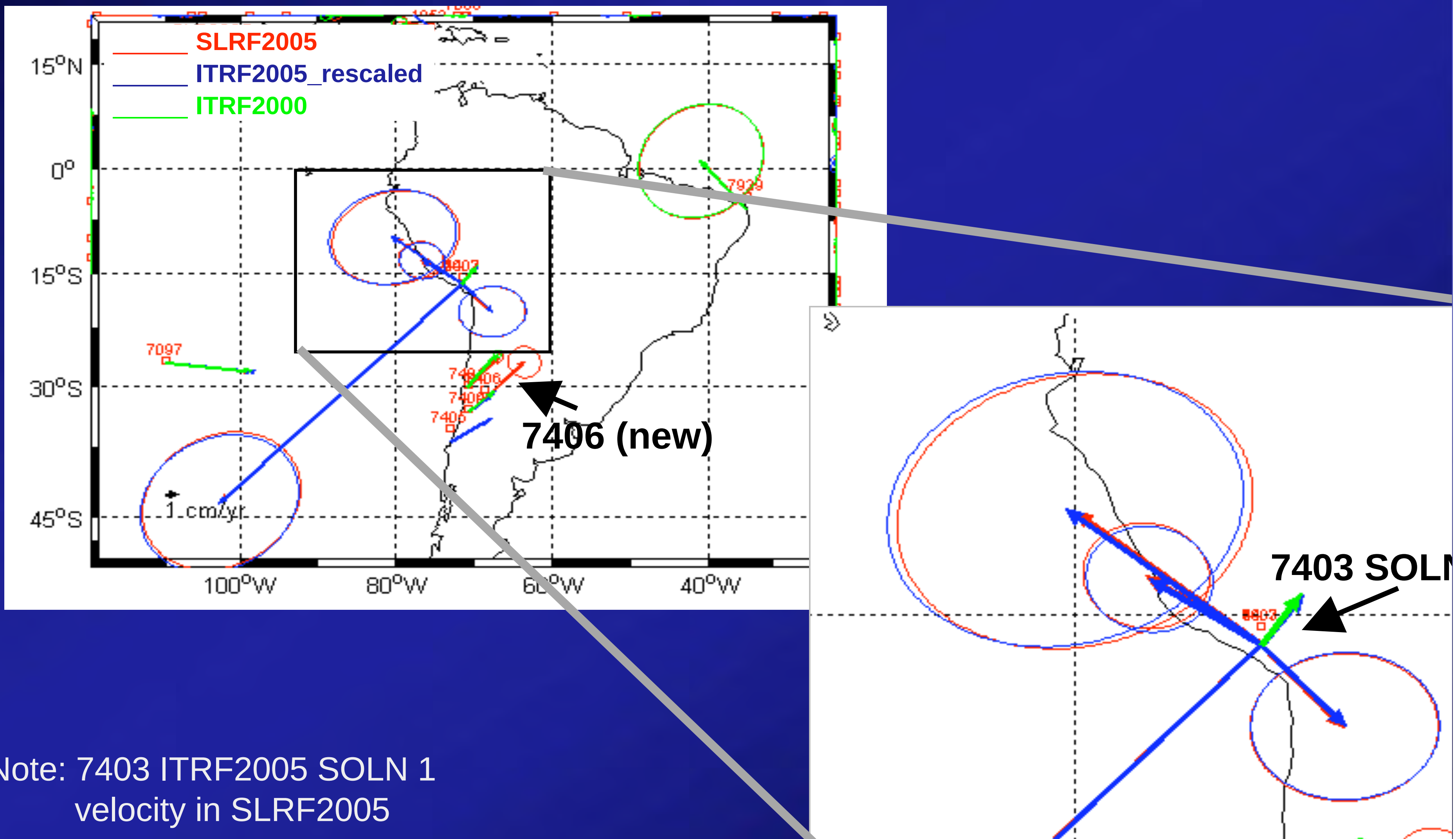
Velocities: North America



Velocities: North America

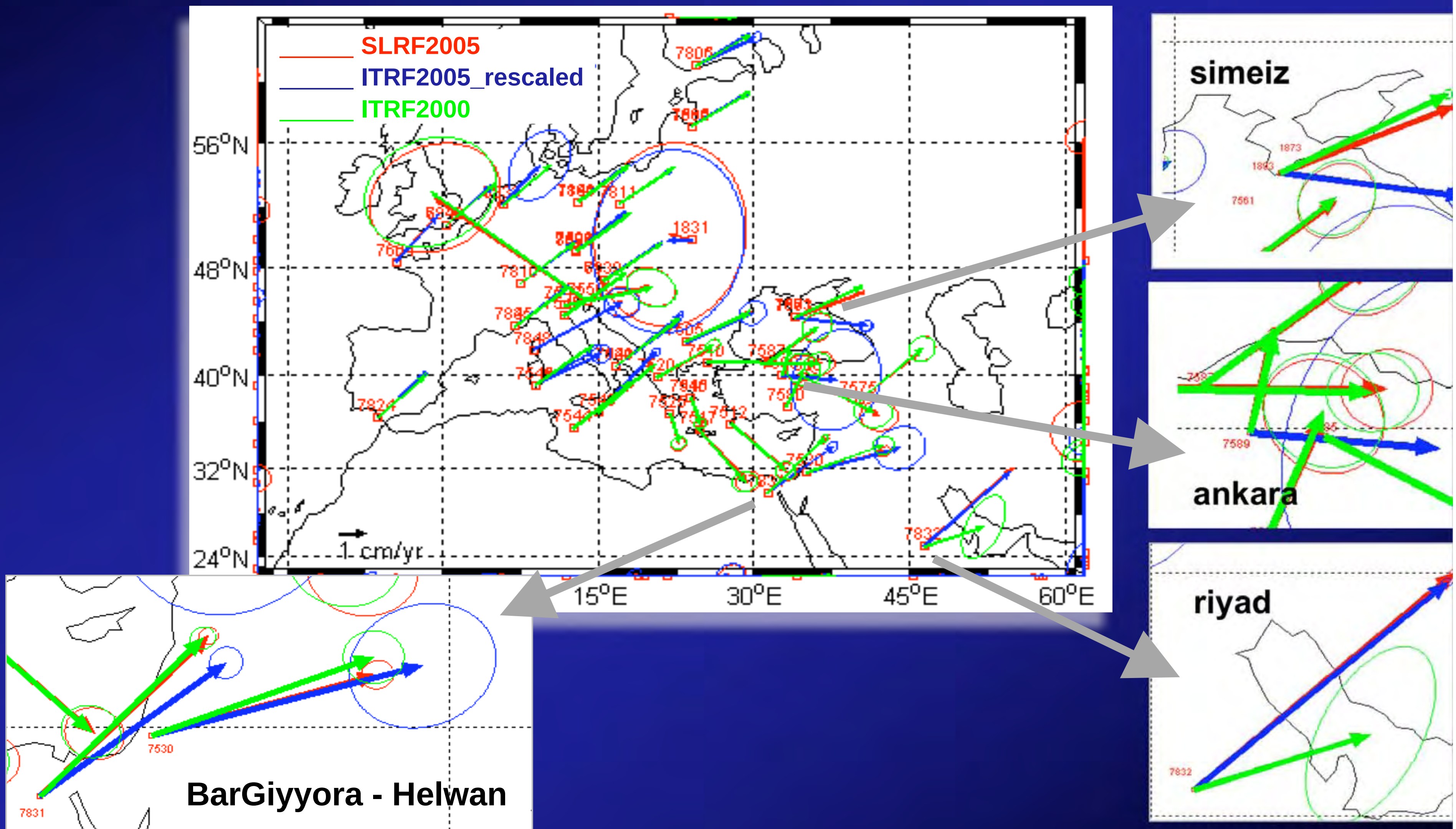


Velocities: South America

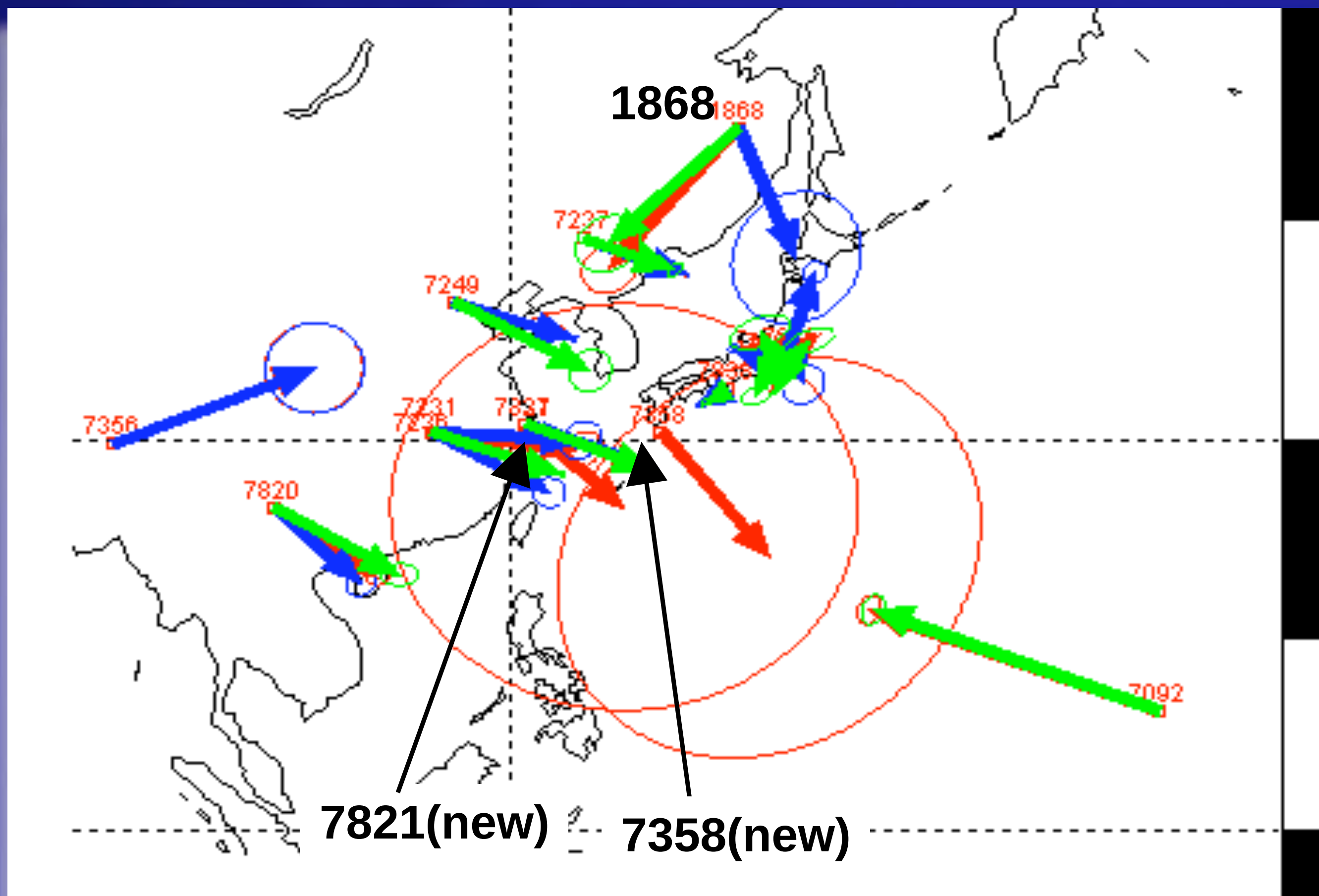


Note: 7403 ITRF2005 SOLN 1
velocity in SLRF2005

Velocities: Europe



Velocities: Western Pacific



Conclusions

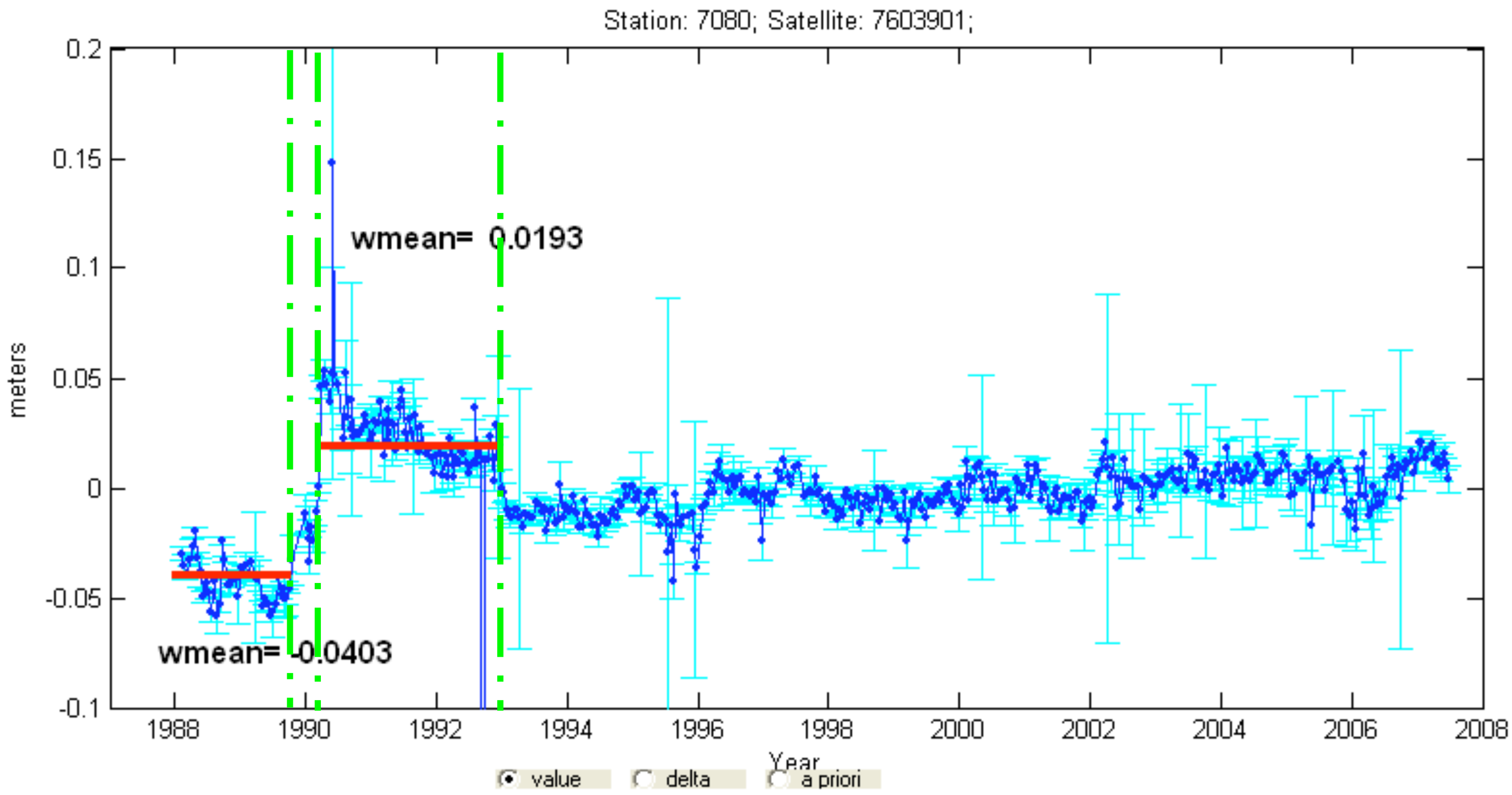
- SLRF2005 is temporary until a new ILRS reference frame will be set
- It takes the best from ITRF2000 and ITRF2005
- All SLR sites are represented in one reference frame

ILRS/AWG Core sites

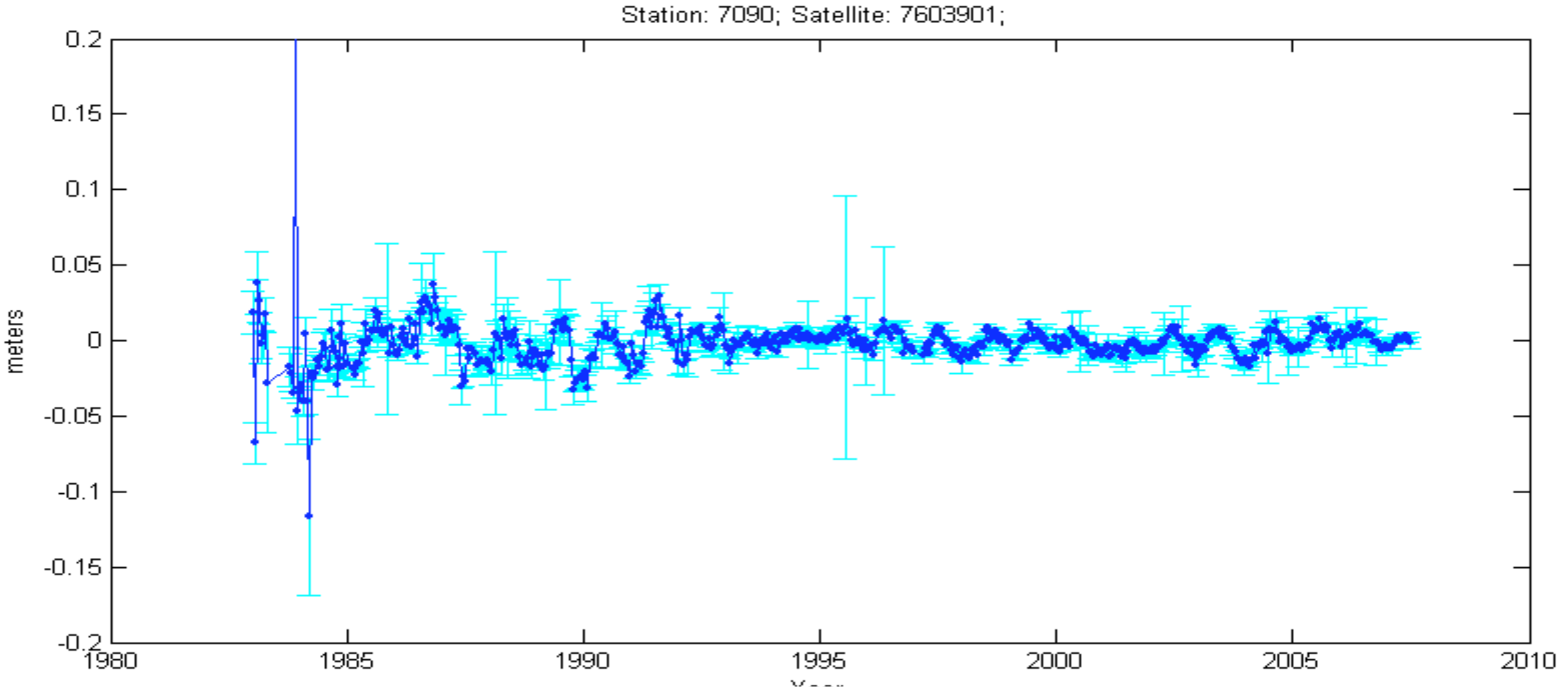
V. Luceri – e-GEOS S.p.A.

G. Bianco – ASI

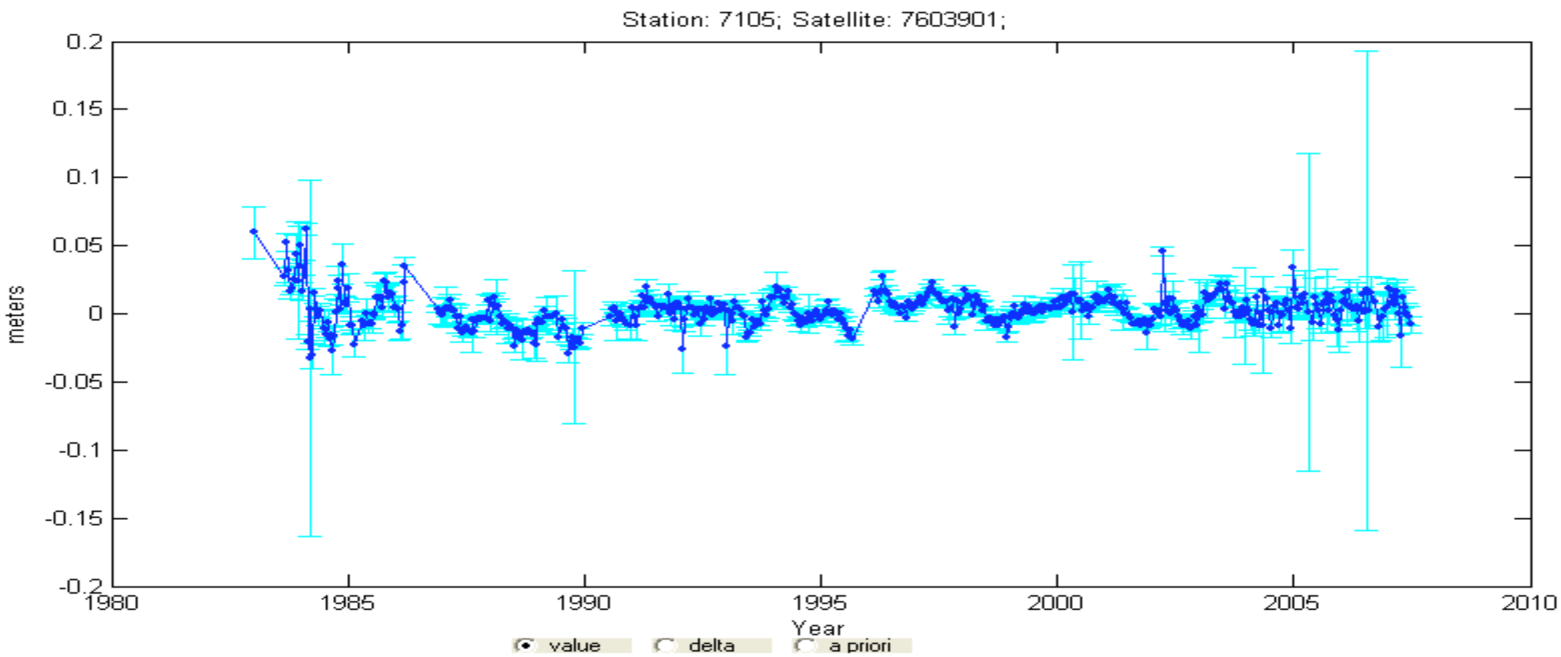
MacDonald: range residuals from solution CGS2006_new



range residuals from solution CGS2006_new

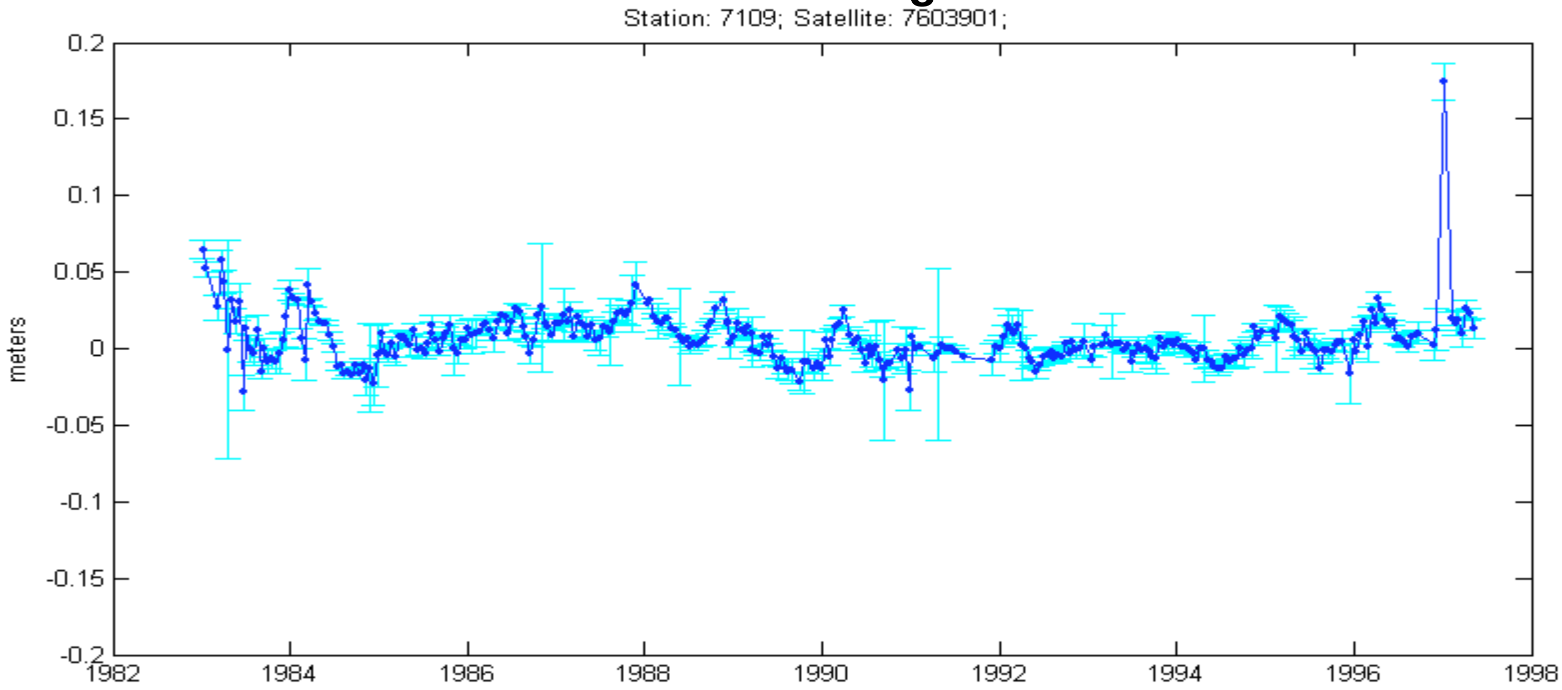


Yarragadee

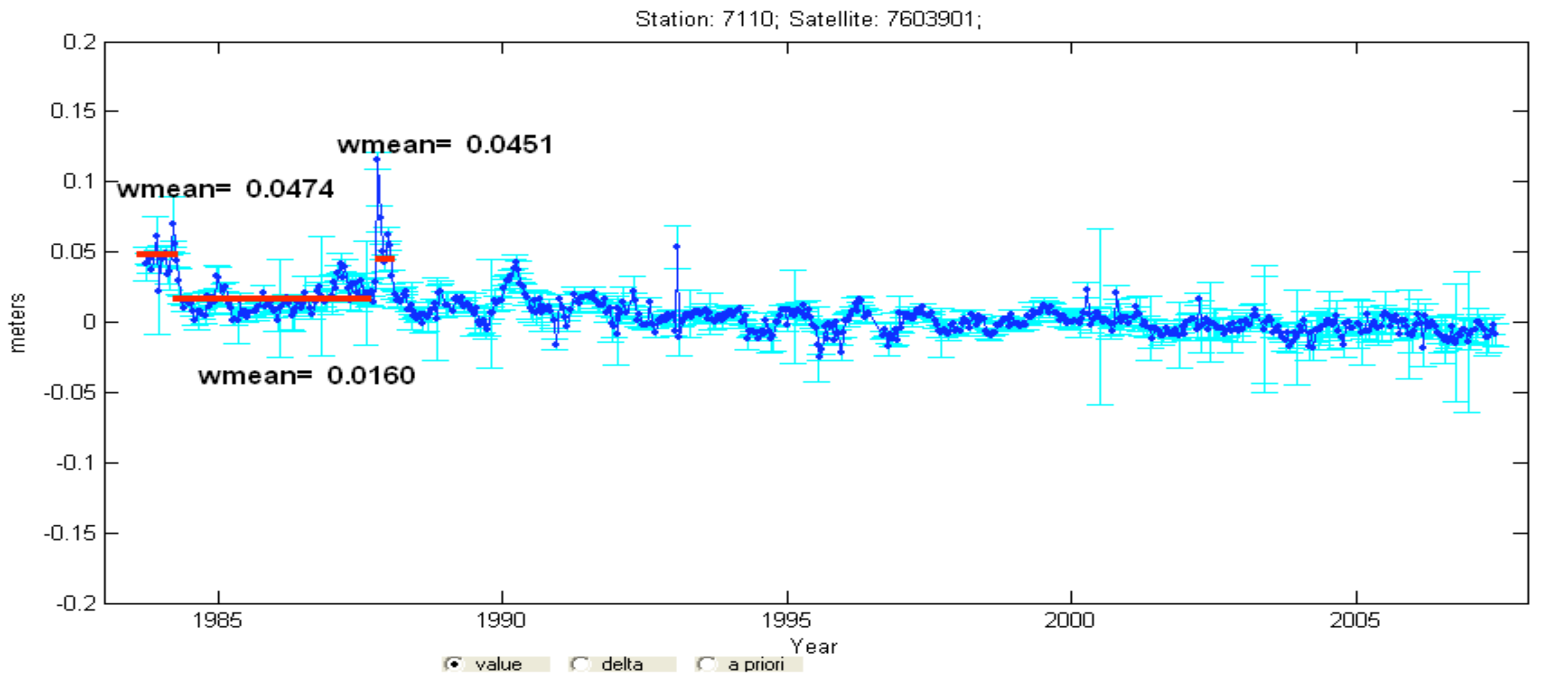


Greenbelt

range residuals from solution CGS2006_new

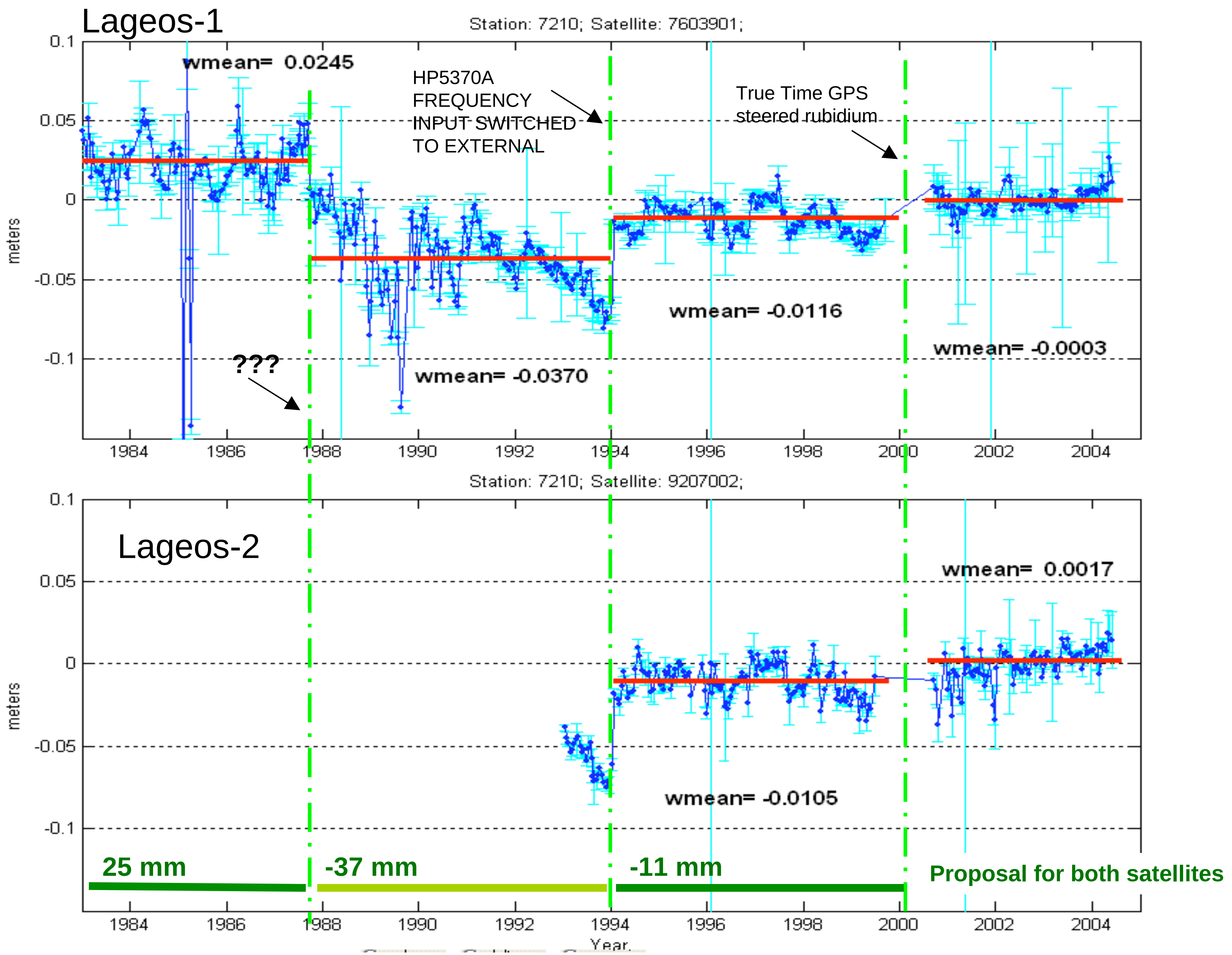


Quincy

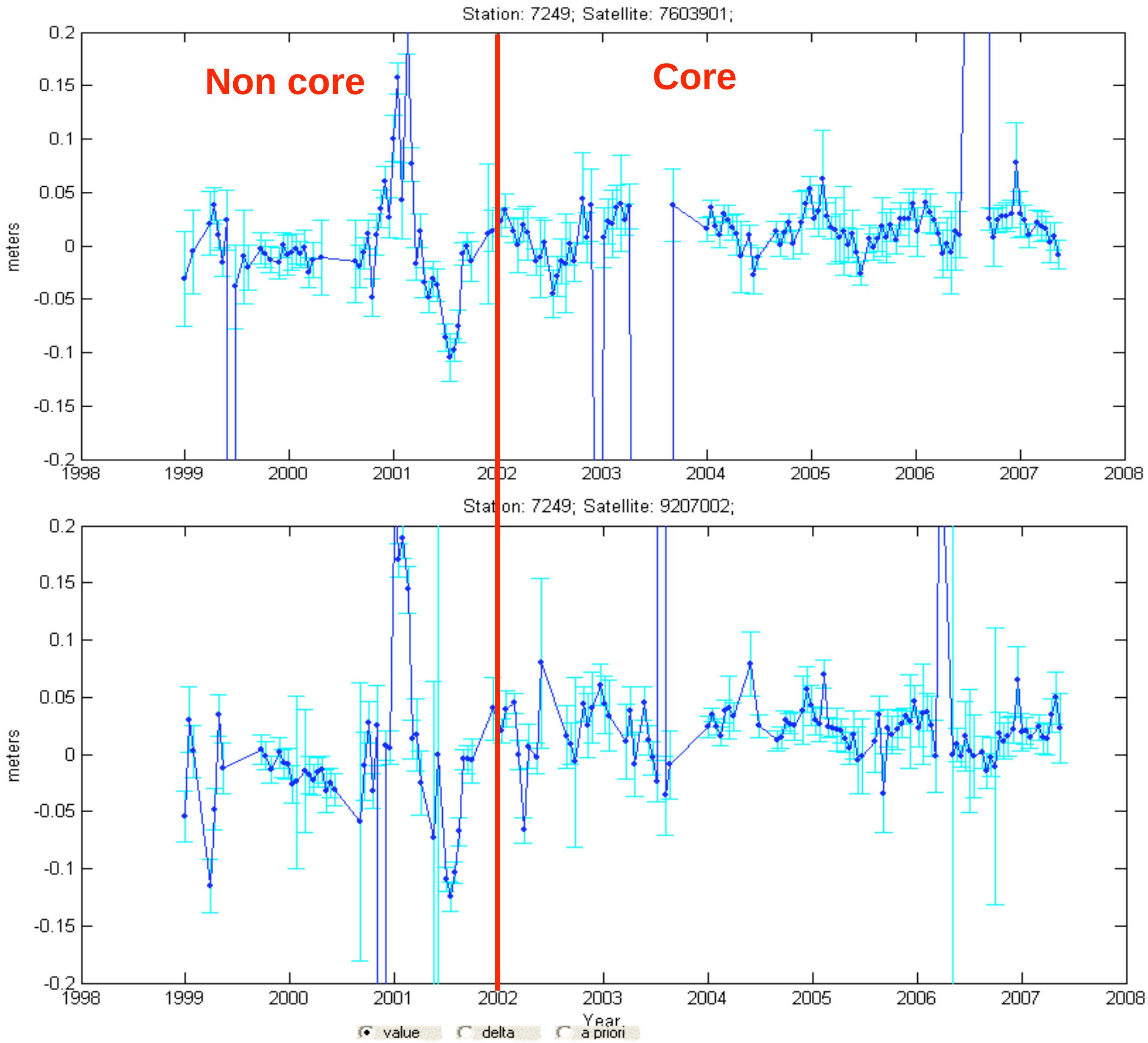


Monument

Haleakala: range residuals from solution CGS2006_new

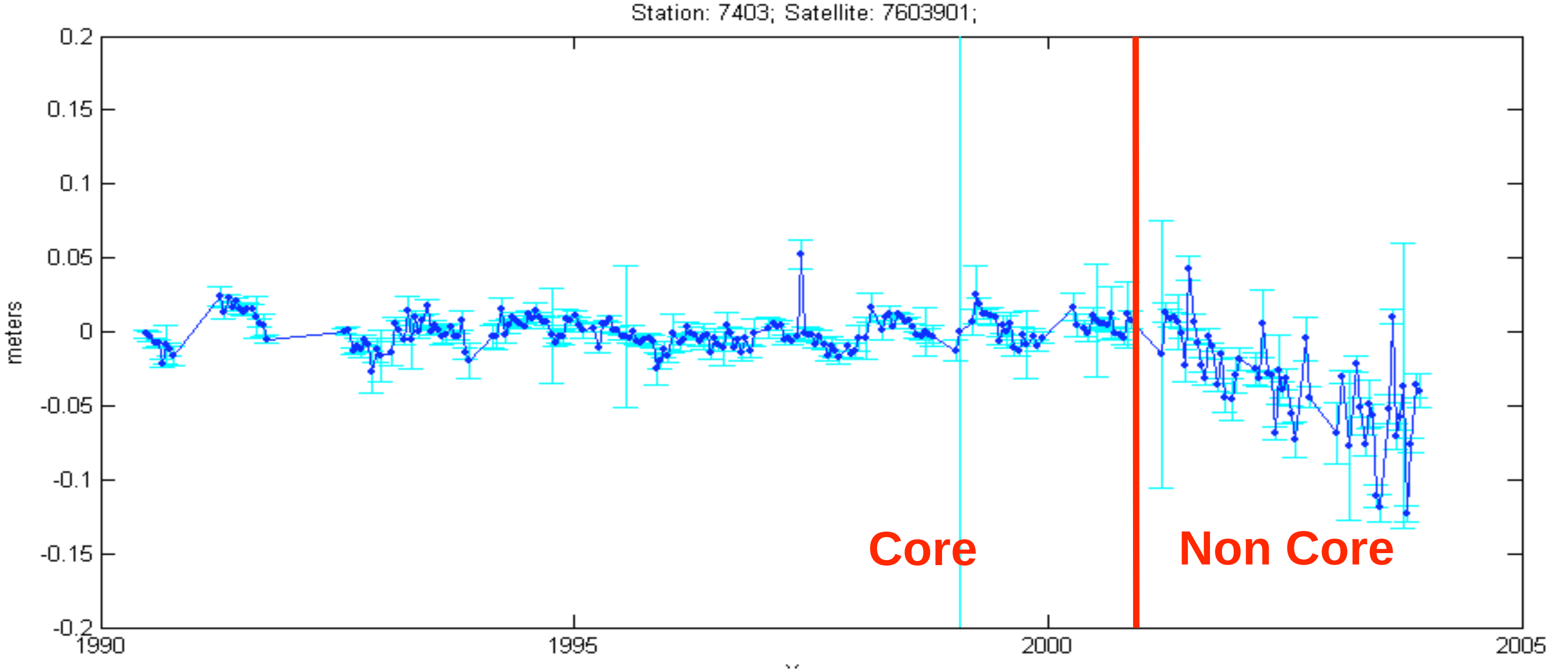


Bejing : range biases from solution CGS2006_new

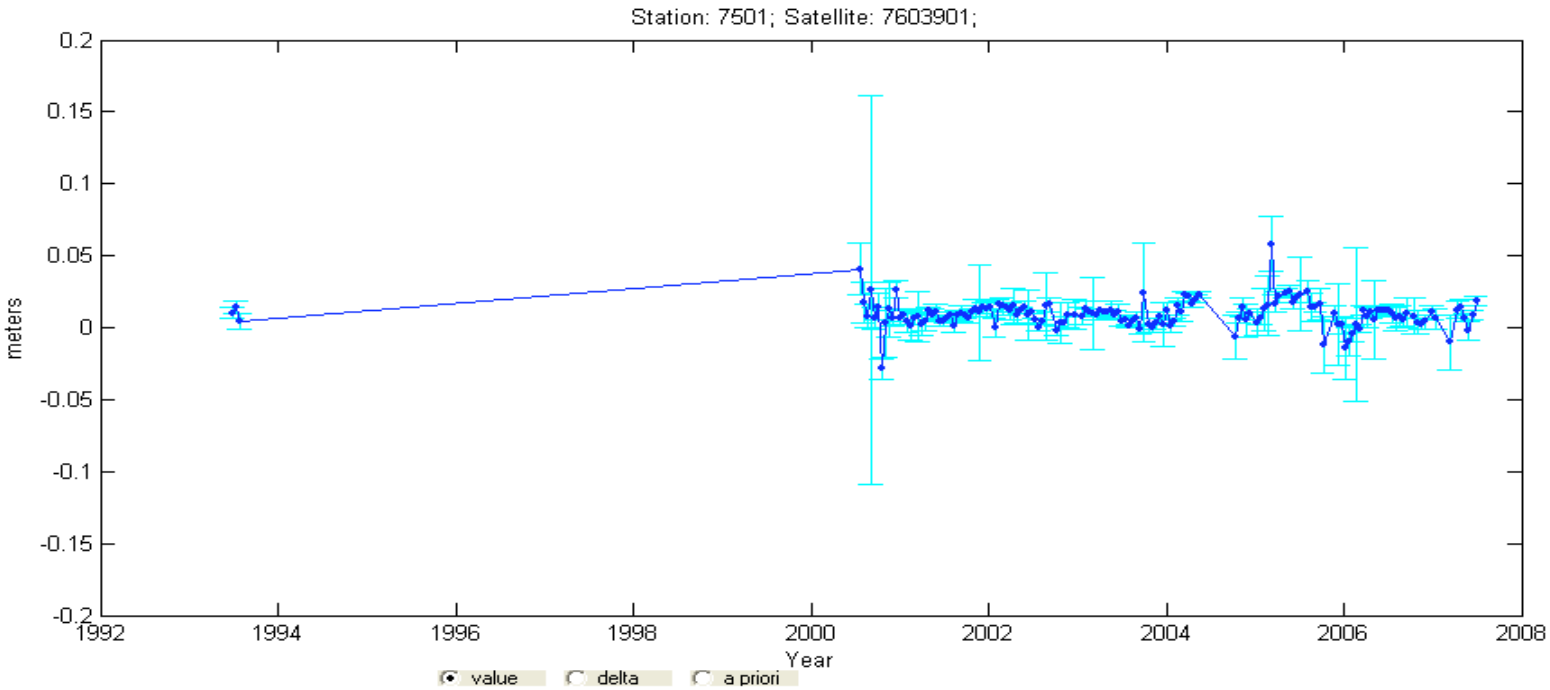


Data before 1999 deleted

range residuals from solution CGS2006_new

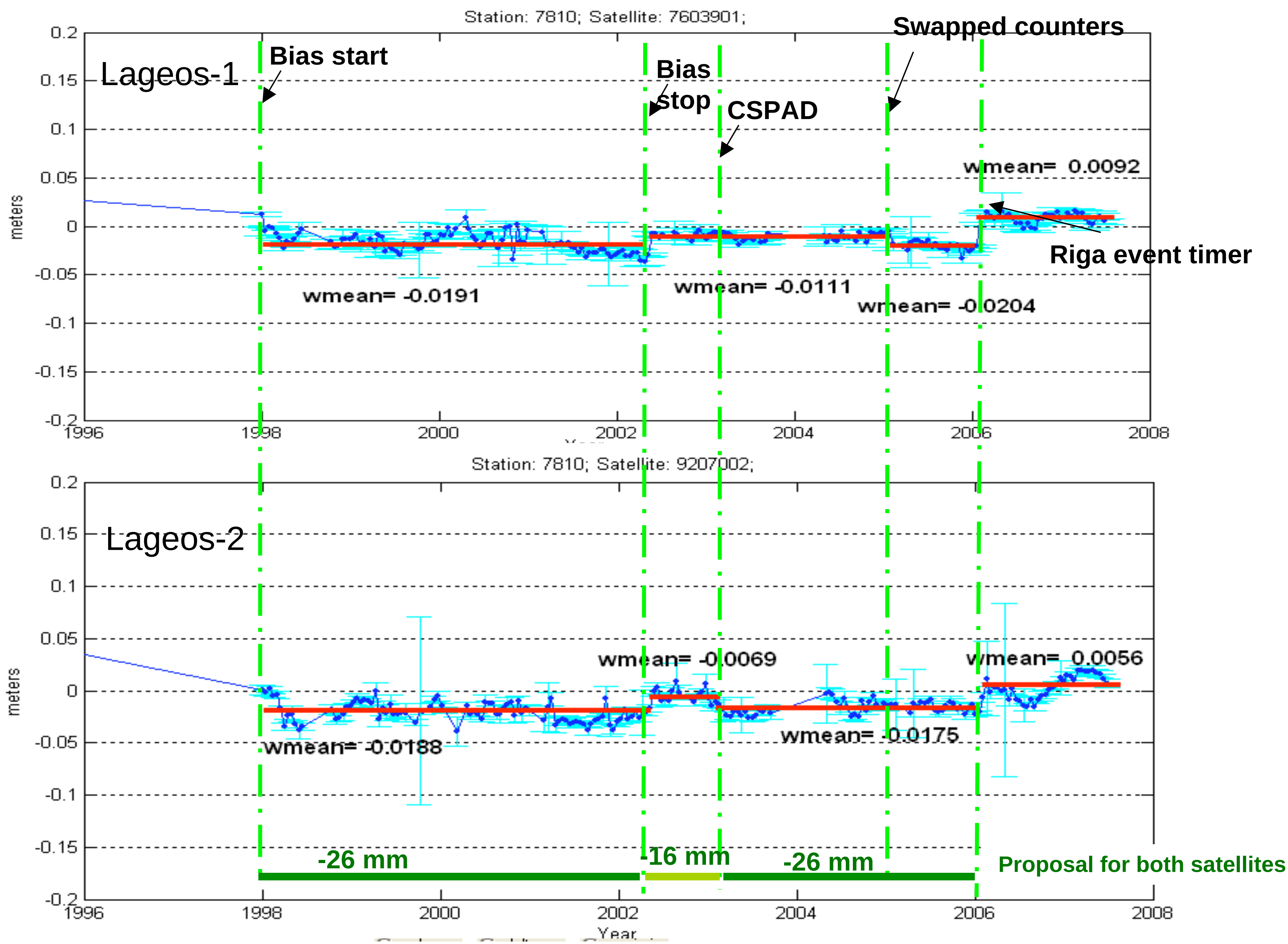


Arequipa

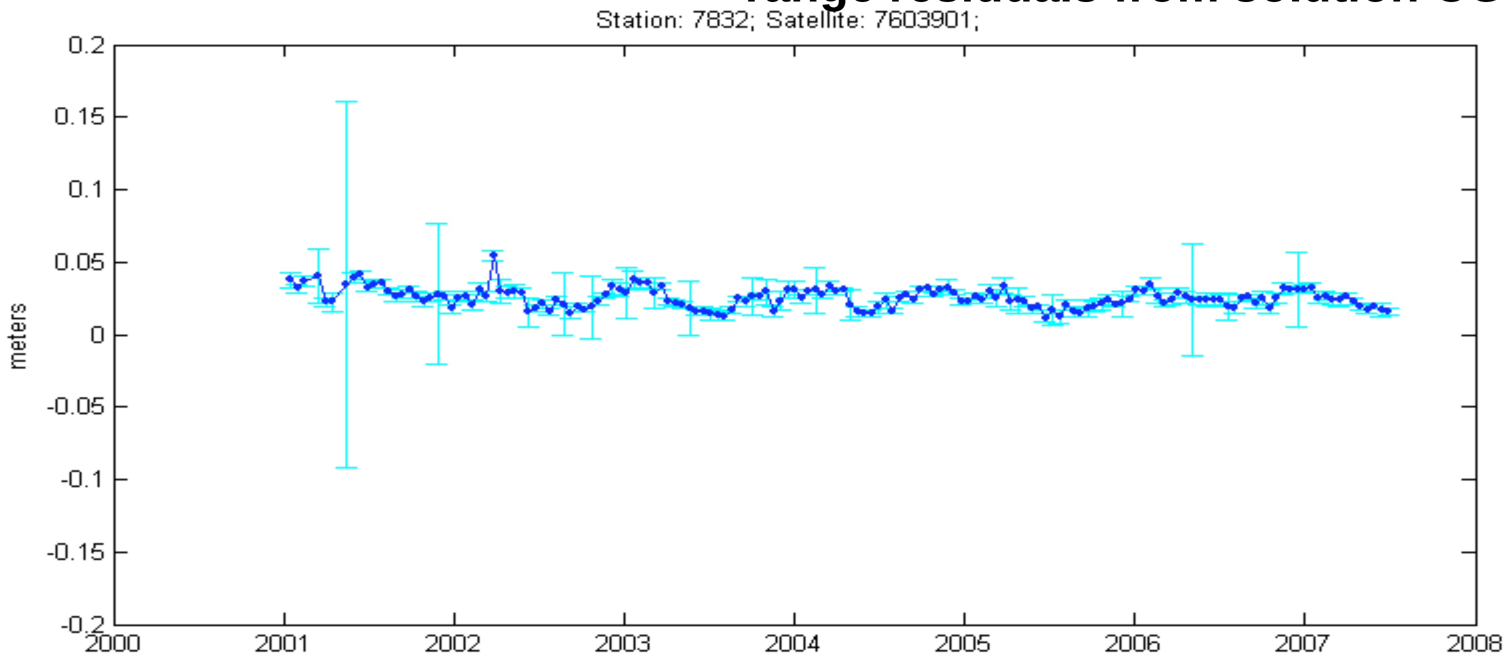


Hartebeestock

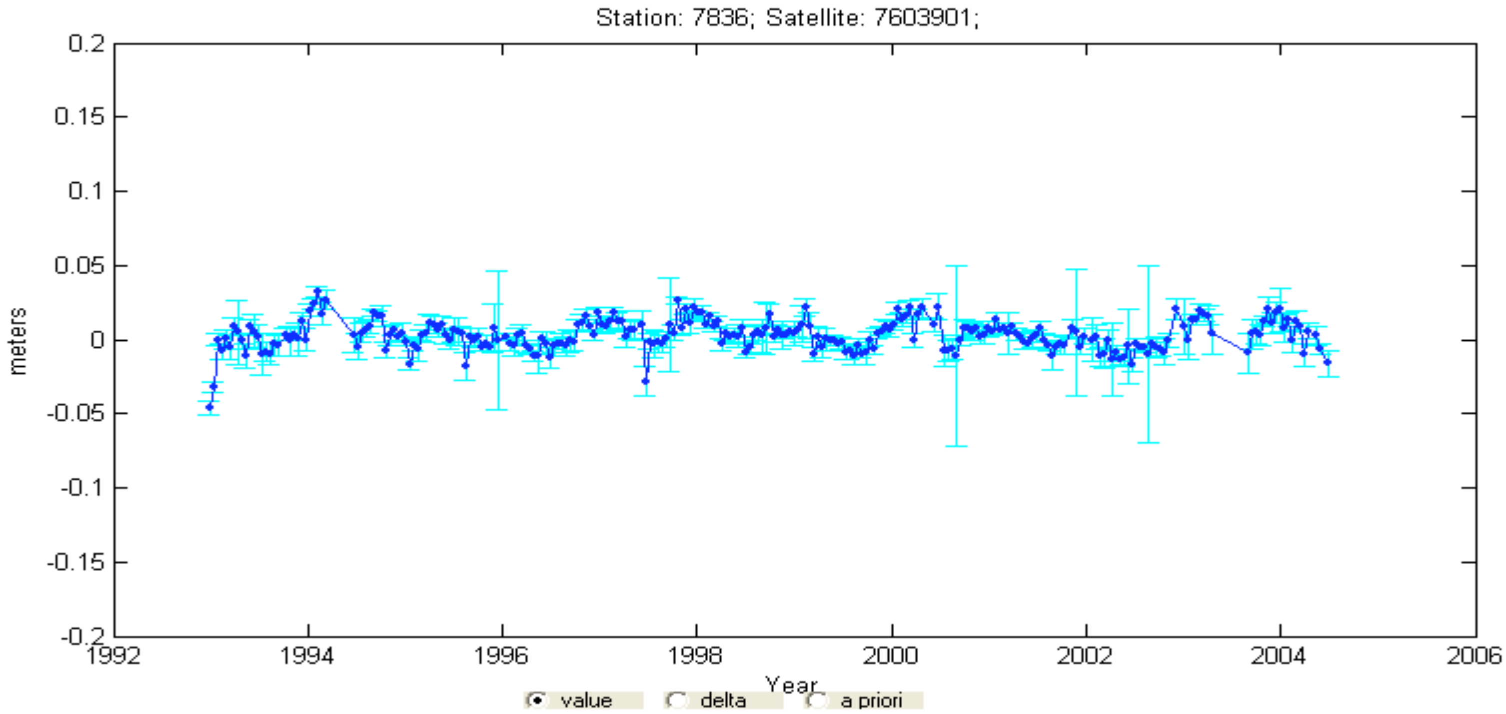
Zimmerwald: blue range bias from solution CGS2006_new



range residuals from solution CGS2006_new

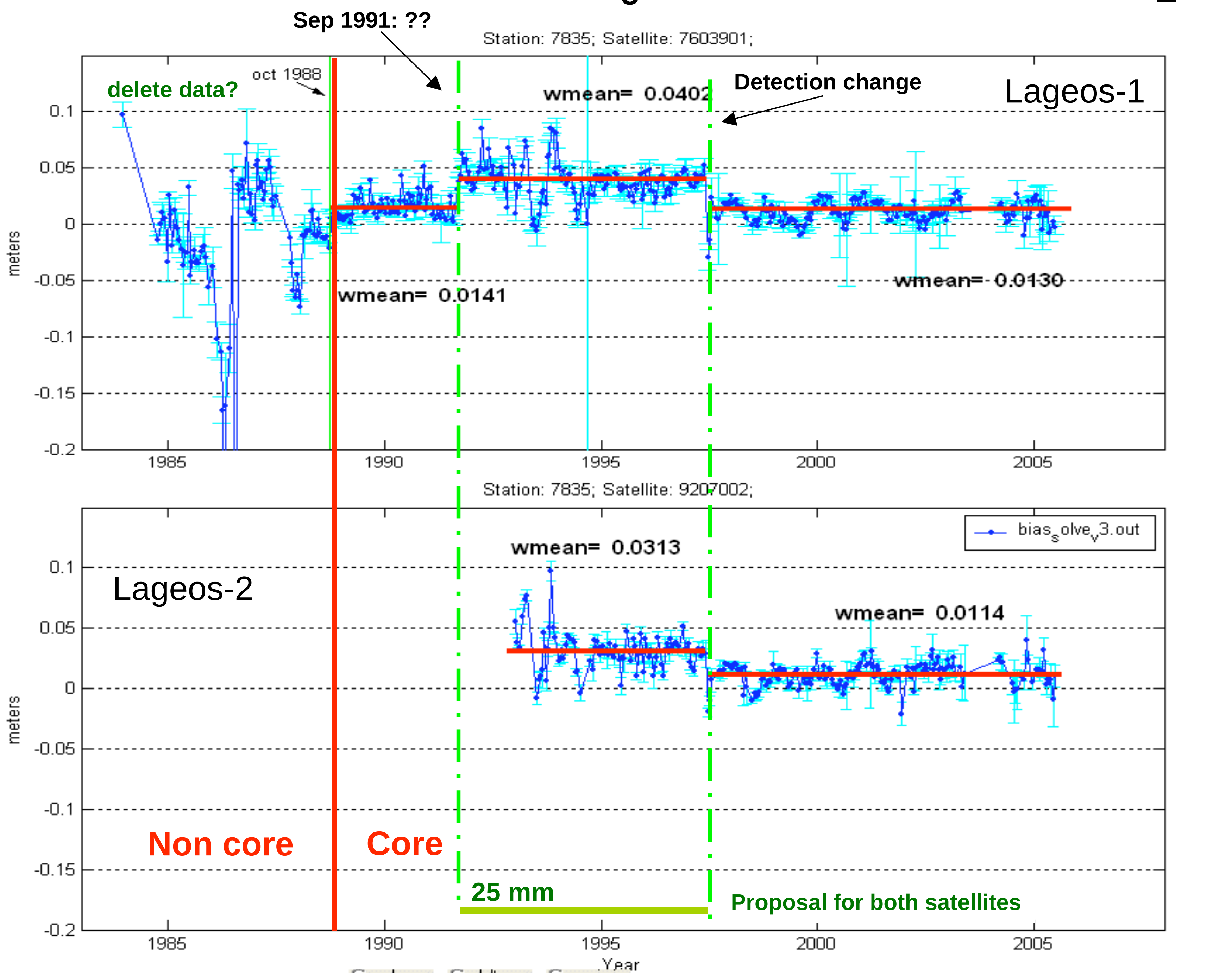


Riyadh

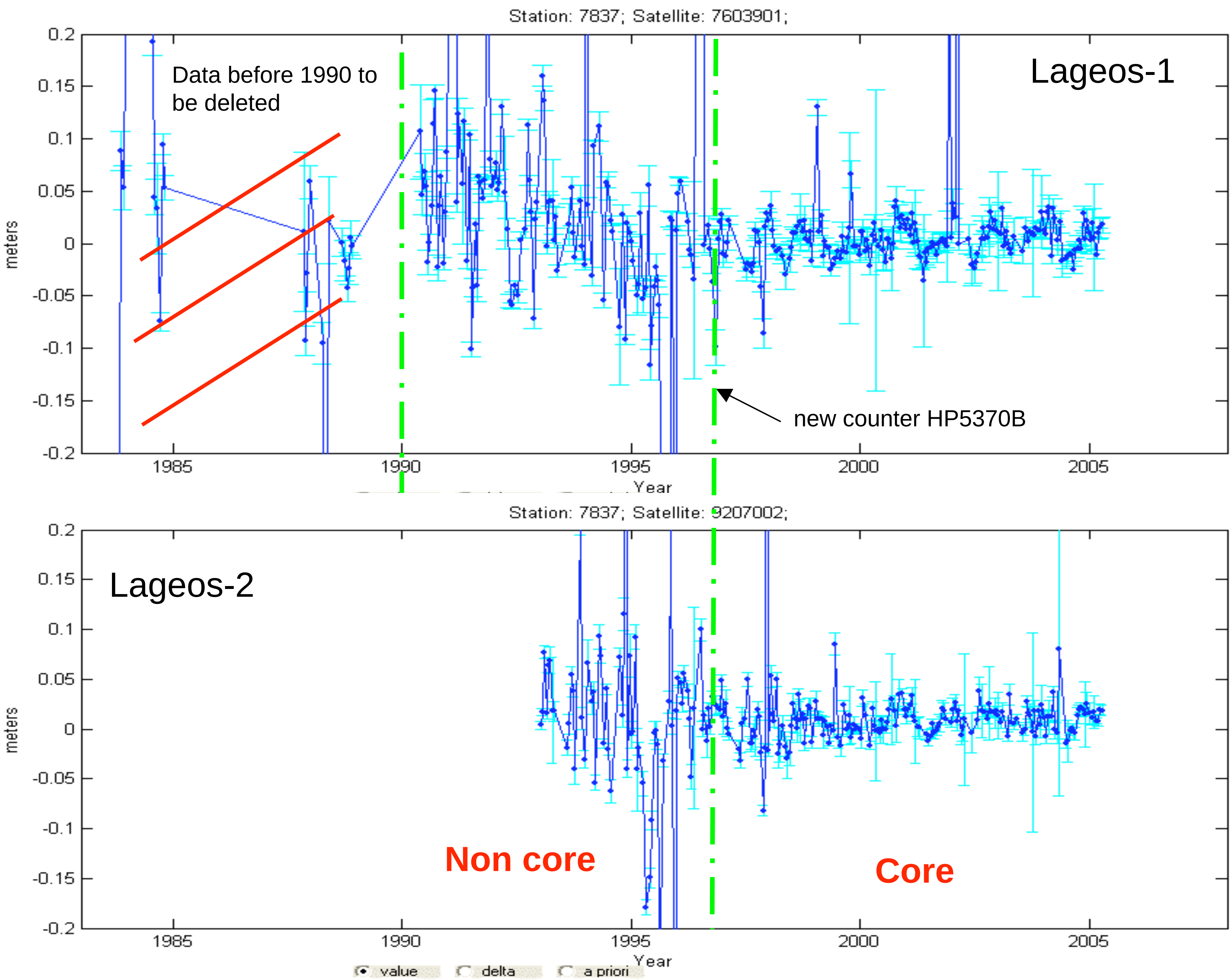


Potsdam

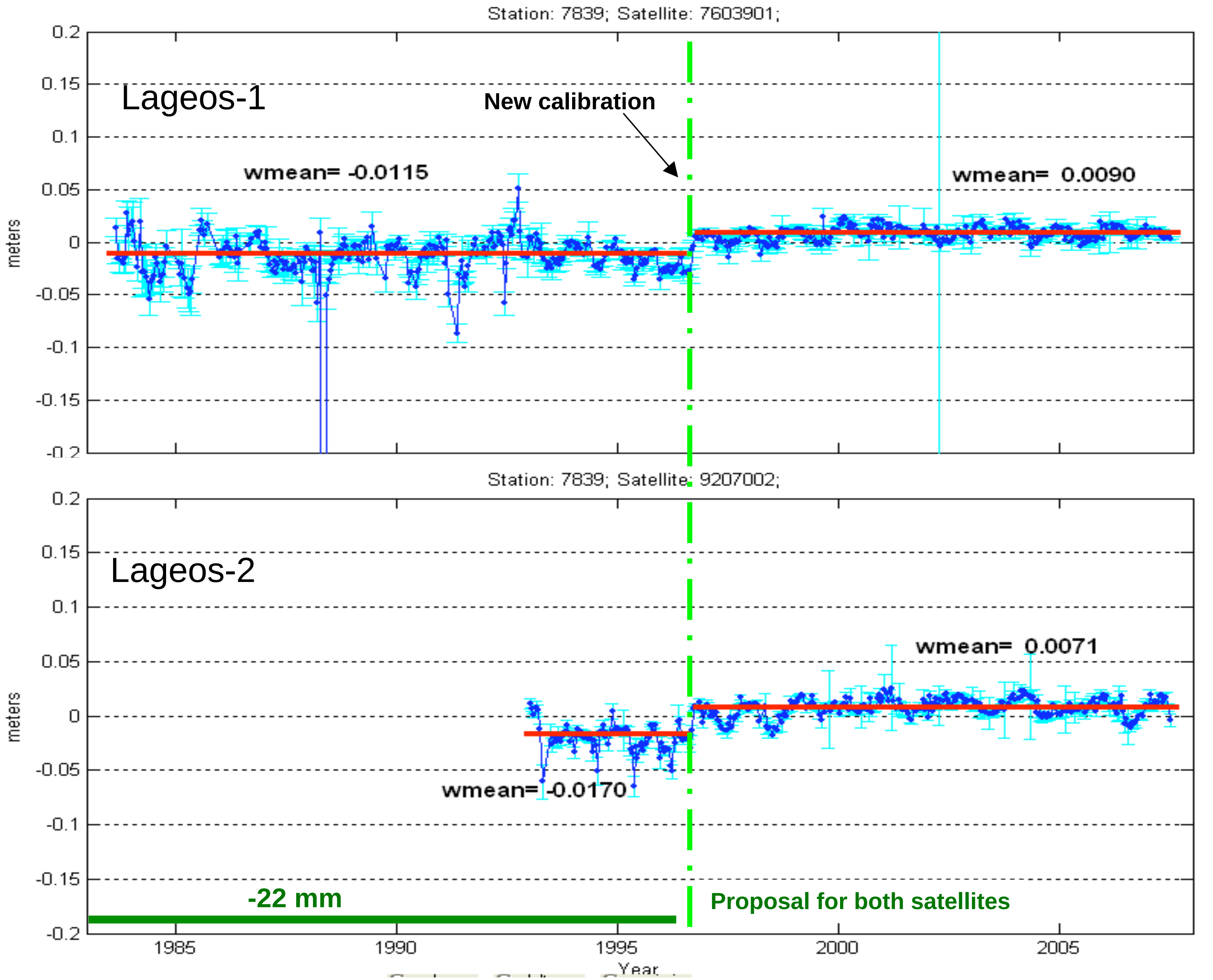
Grasse: range biases from solution CGS2006_new



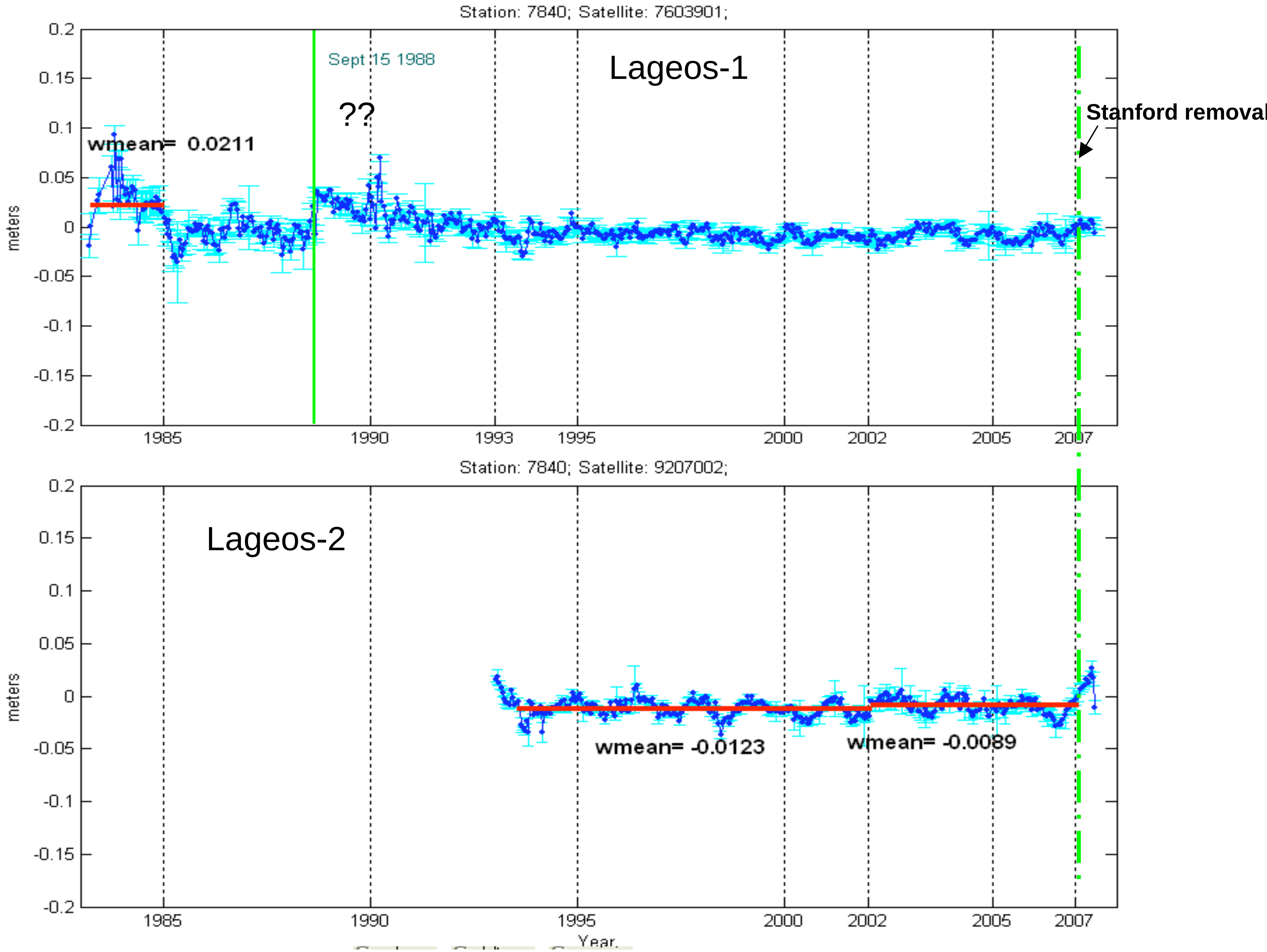
Shanghai : range biases from solution CGS2006_new



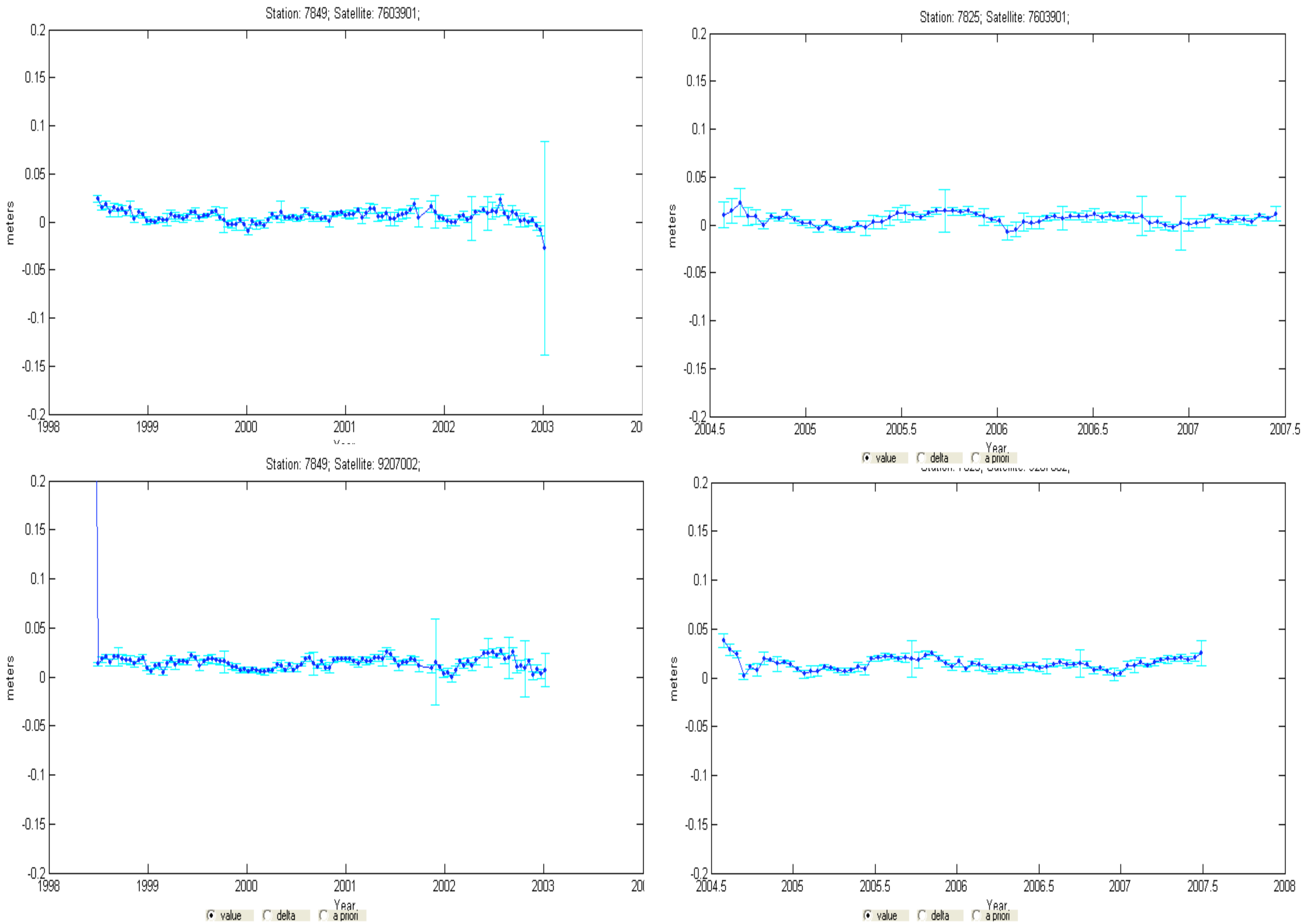
Graz: range biases from solution CGS2006_new



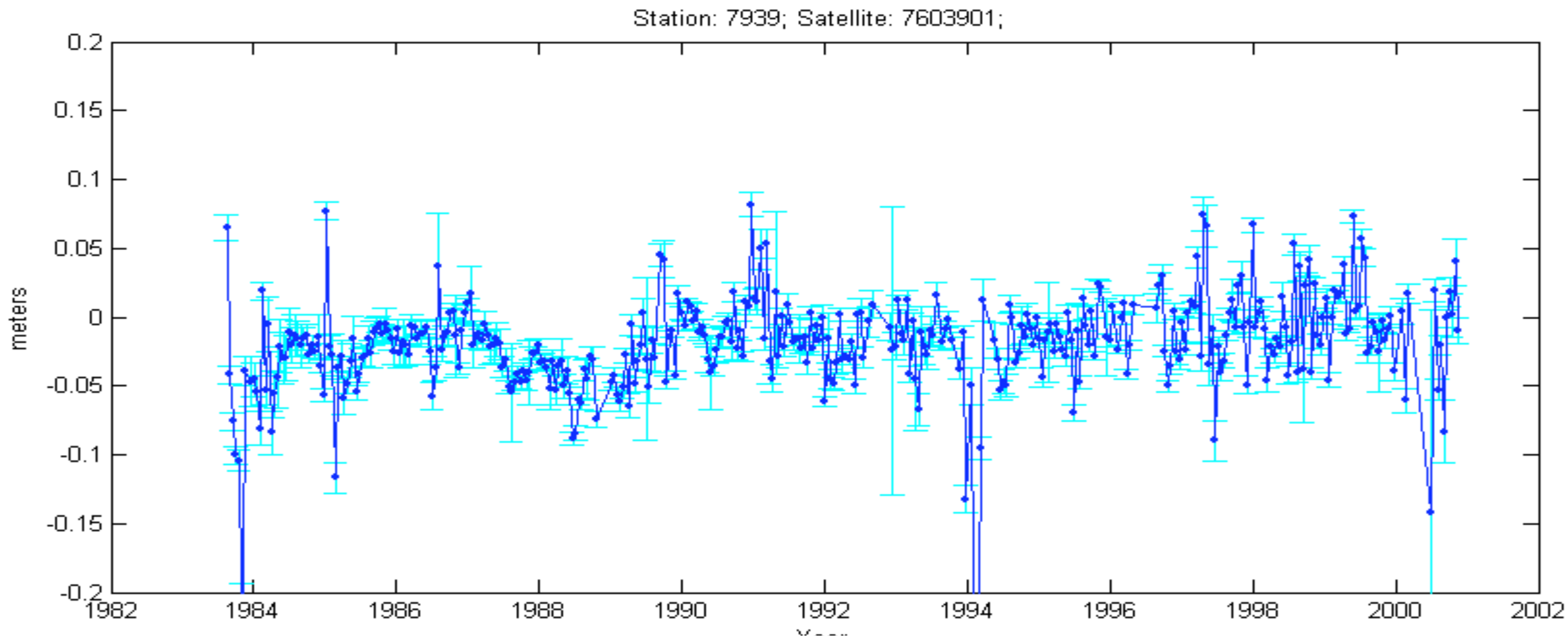
Herstmonceux: range biases from solution CGS2006_new

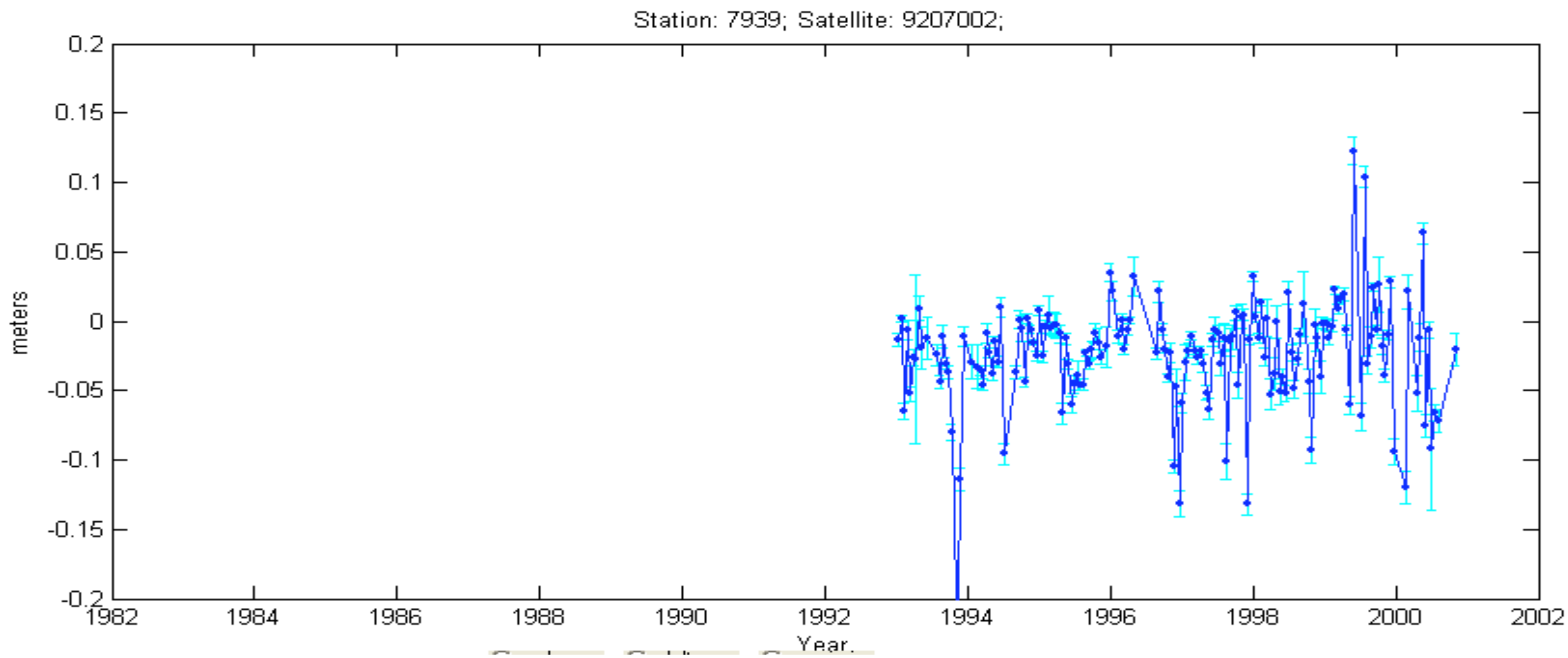


Stromlo : range biases from solution CGS2006_new

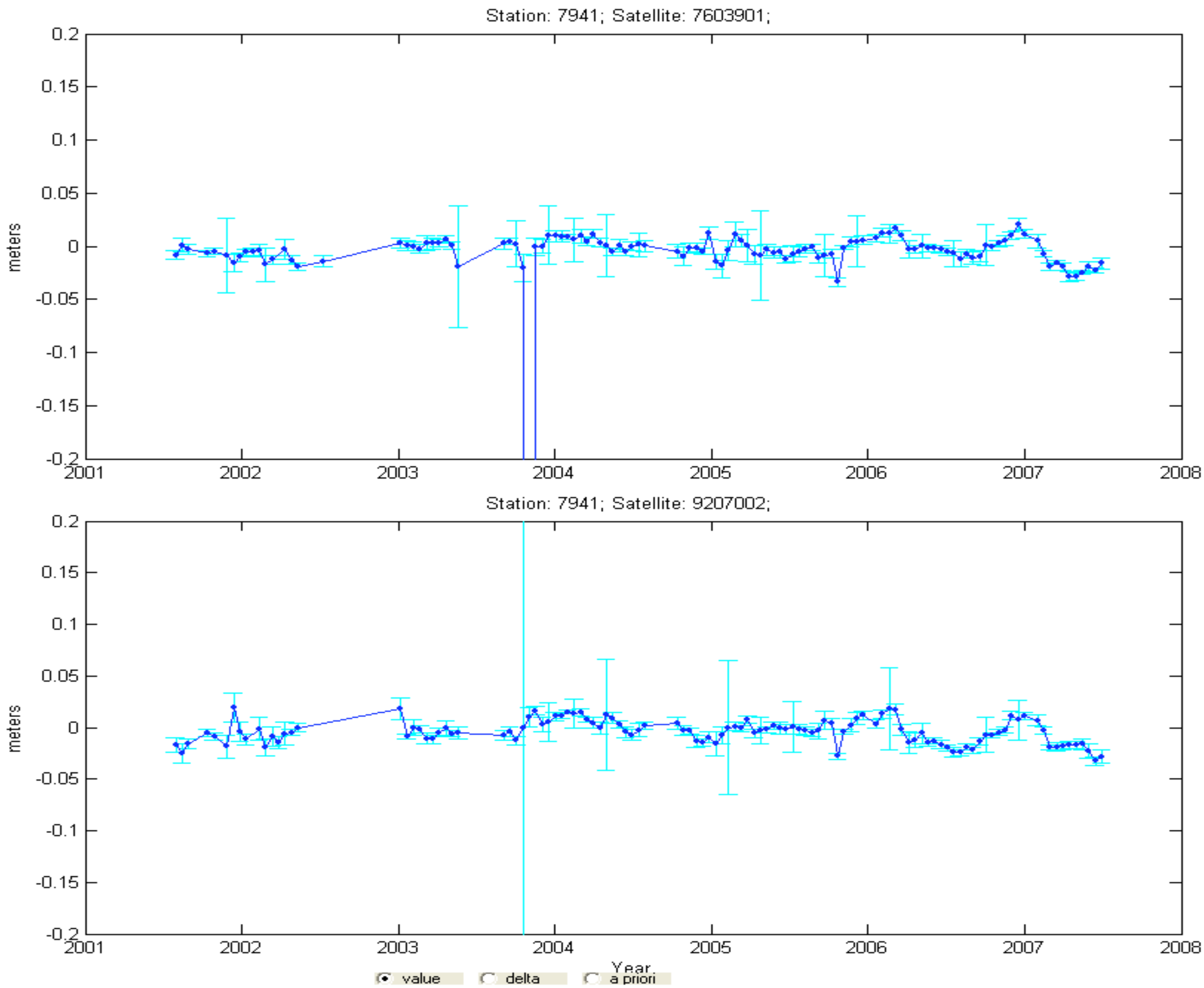


Matera (7939) : range biases from solution CGS2006_new

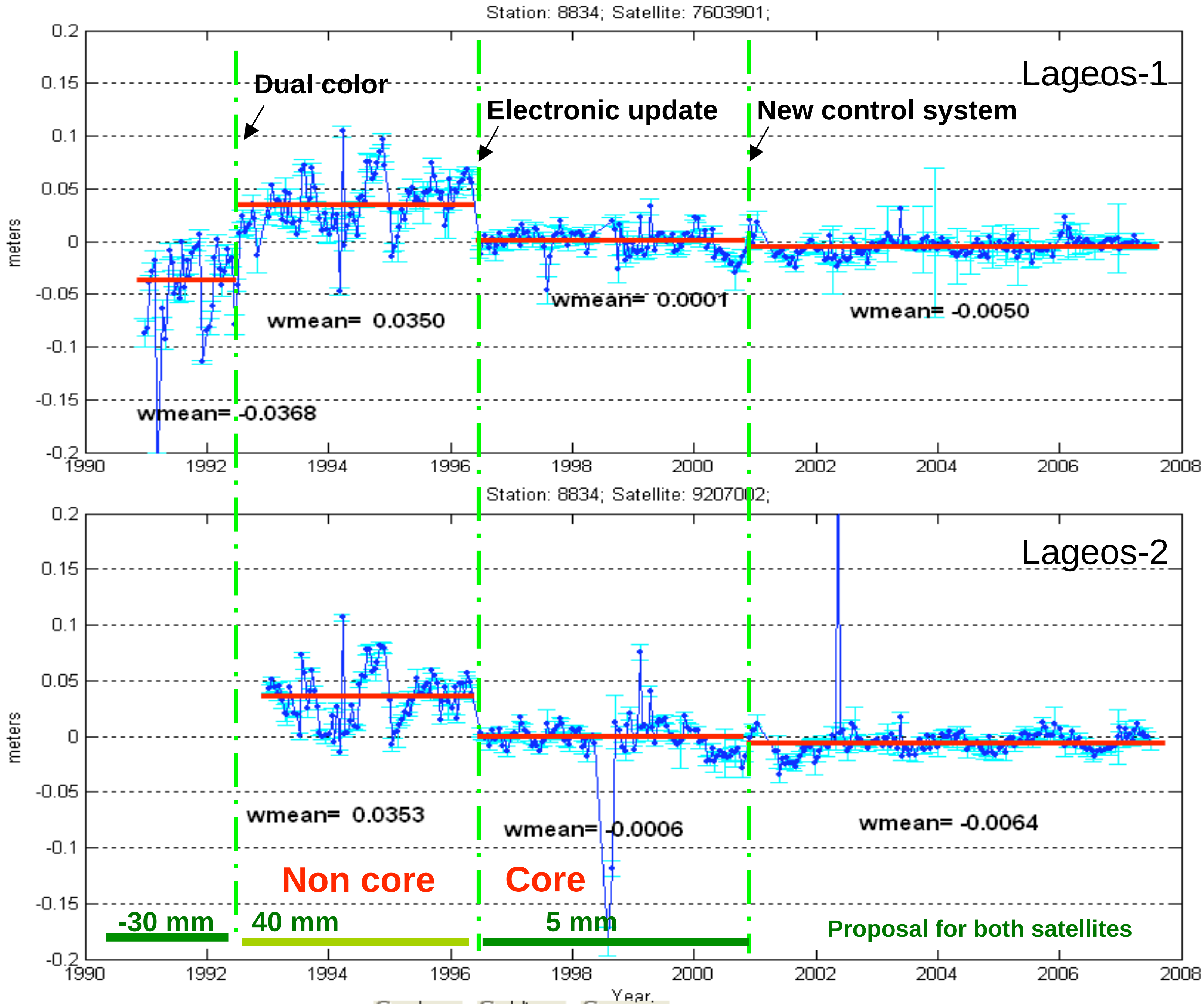




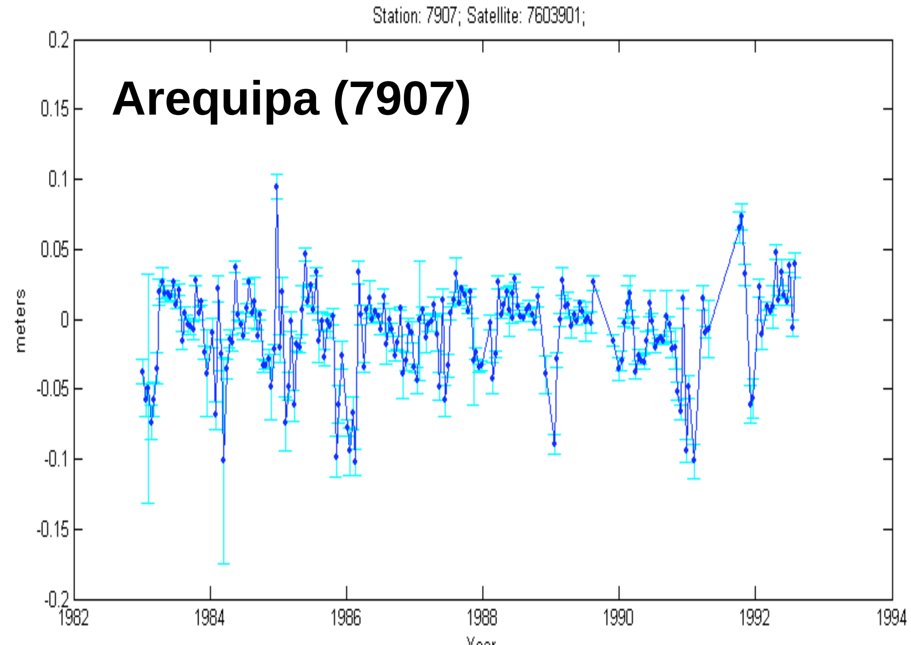
Matera (7941) : range biases from solution CGS2006_new

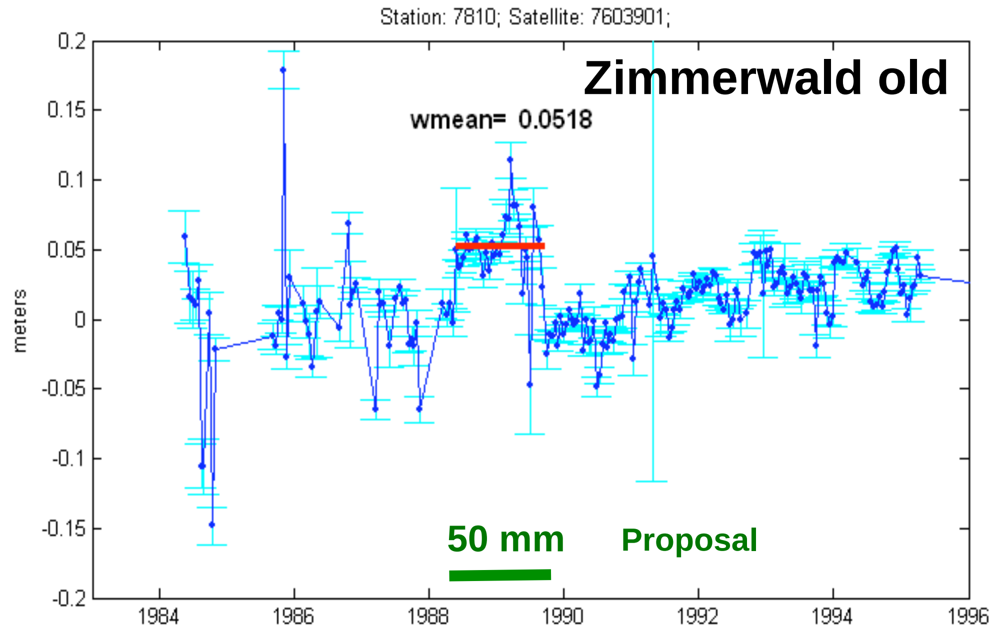


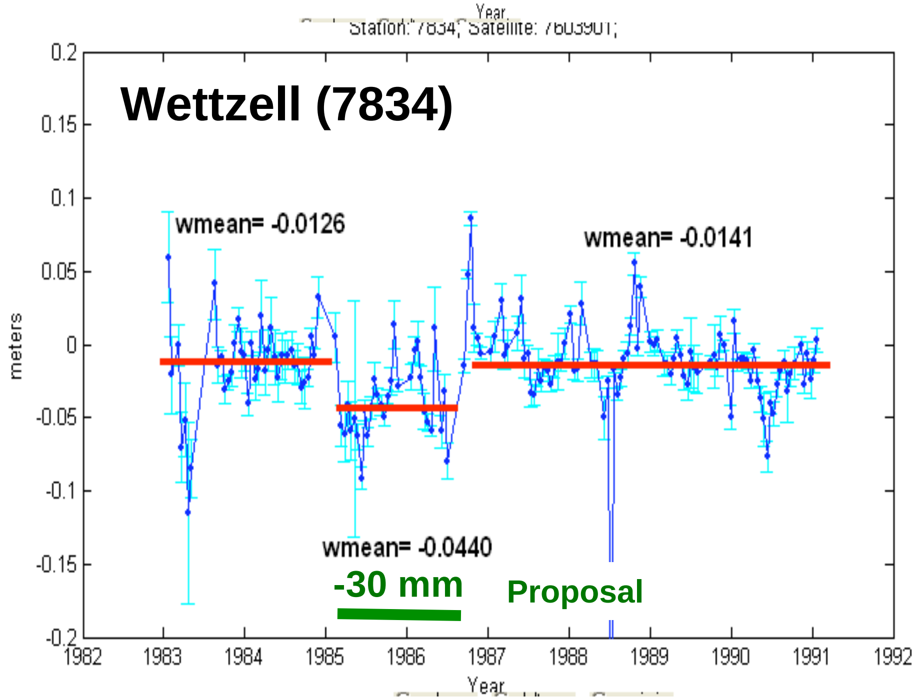
Wettzell: range biases from solution CGS2006_new

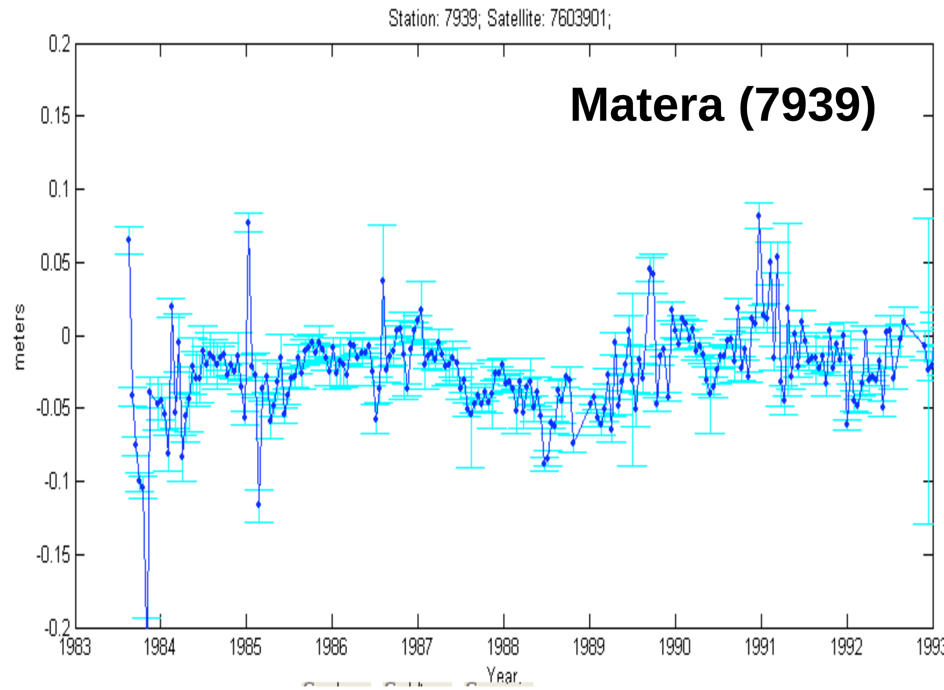


Range residuals from solution CGS2006_new

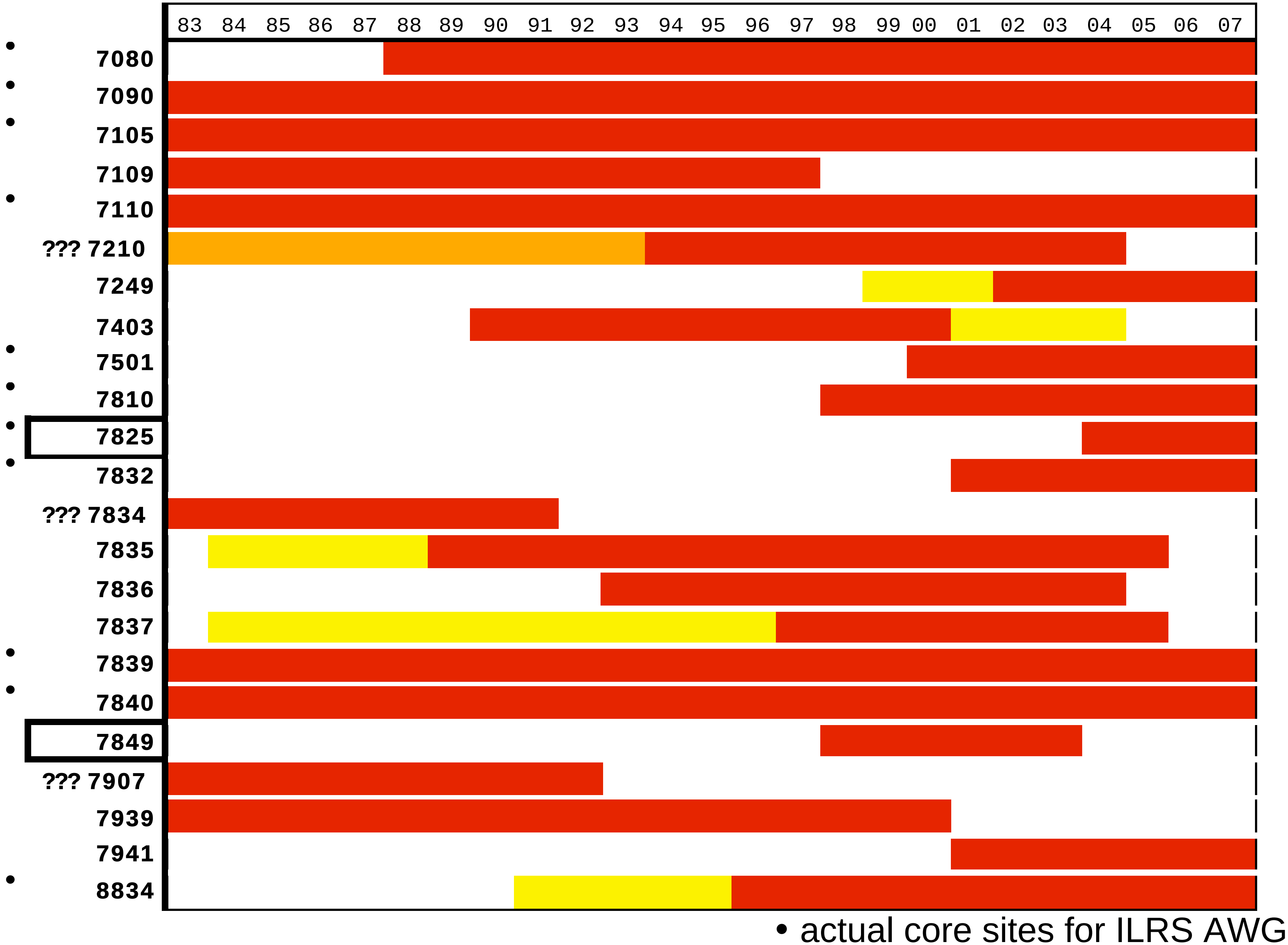








ILRS core sites for EOP referencing



ILRS core sites for EOP referencing

Site No.	dome	Wav	from	to	Notes
7080	40442M006	G	1988	--	
7090	50107M001	G	1979	--	
7105	40451M105	G	1981	--	
7109	40433M002	G	1981	1997	
7110	40433M002	G	1981	--	
7210	40497M001	G	1976	2004	only from 1994 on???
7249	21601S004	G	2002	--	subset
7403	42202M003	G	1990	dec 2000	subset
7501	30302M003	G	2000.5	--	
7810	14001S007	B	1998	--	
7825	50119S003	G	2004	--	Stromlo
7832	20101S001	G	2001	--	
7834	14201S002	G	1976	1991	????????
7835	10002S001	G	oct 1988	2005	subset
7836	14106S009	G	1993	2004	
7837	21605S001	G	1997	2005	subset
7839	11001S002	G	1983	--	
7840	13212S001	G	1983	--	
7849	50119S001	G	1998	2003	Stromlo
7907	42202S001	G	1976	1992	????????
7939	12734S001	G	1983	2000	
7941	12734S008	G	2001	--	
8834	14201S018	G	may 1996	--	subset

REMARK

The definition of core sites for the ILRS should be unique.

No difference anymore between “core sites” and “sites for EOP referencing”

ILRS/AWG Data corrections

V. Luceri – e-GEOS S.p.A.
G.. Bianco – ASI

ILRS/AWG Meeting September 24, 2007 ,
Grasse

LIST OF DATA TO BE DELETED

Site No.	Wav	Core NonCore in V50	Solve ?	Model ?	bias in sol V50	**SOLUTION PROPOSAL**	**Source**
1873	G	NC	NO	NO	--	data before 1995.0	
1884	G	NC	NO	NO	1993.0 ->	data before august 1994	
1893	G	NC	NO	NO	--	data before 1998.0	CDDIS
7112	G	NC	NO	NO	--	data before 1985.0 ????	
7123	G	NC	NO	YES	--	data from 25 to 30 august, 1988 (3 m bias) data on may 12, 1993 (> 500 meter bias)	
7236	G	NC	NO	NO	--	data after 1998.0 (a few acquisitions)	
7249	G	NC	NO	NO	--	data before 1999.0	
7355	G	NC	NO	NO	--	use only data in 2003	
7510	G	NC	NO	NO		data from 920623 to 920930 to be deleted	CDDIS
7585	G	NC	NO	NO		data from 920623 to 920930 to be deleted	CDDIS
7810	B	C	NO	YES	--	data from dec 18, 1996 to dec 29, 1997	
7811	G	NC	NO	YES	1993.0 -1994.0	data before 1993:202	CDDIS
7820	G	NC	NO	NO	--	data before 2000:291	CDDIS
7824	G	NC	NO	NO	--	data before 1996	
7831	G	NC	NO	YES	--	data before 1984	
7832	G	C	NO	NO	__	data before 1998	
7835	G	NC	NO	YES	--	data before oct 1988 ????	
7837	G	C	NO	NO	__	data before 1990	
7841	G	NC	NO	NO	--	data before feb 19, 2004????	

LIST OF SITES WITH BIAS ESTIMATION

Site No.	Wav	Core NonCore in V50	Solve ?	Model ?	bias in sol V50	**SOLUTION PROPOSAL**
1864	G	NC	YES	NO	1993.0 ->	bias to be estimated over all the period
1868	G	NC	YES	NO	1993.0 ->	bias to be estimated over all the period
1953	G	NC	YES	NO	--	bias to be estimated over all the period
7237	G	NC	YES	NO	1993.0 ->	bias to be estimated over all the period
7530	G	NC	YES	NO	--	bias to be estimated over all the period
7548	G	NC	YES	NO	--	bias to be estimated over all the period
7810	I	C	YES	NO	--	bias to be estimated over all the period
7845	G	NC	YES	NO	--	bias to be estimated over all the period (bad for EOP referencing)

LIST OF SITES WITH RANGE BIAS APPLICATION

The range correction should be subtracted from the data and is one-way

Site No.	Wav	Core NonCore in V50	Solve?	Model?	bias in sol V50	SOLUTION PROPOSAL			Bias Source
						Start Date	**End Date**	**Correction**	
7080	G	C	NO	YES	__	Jan 1, 1988	Dec 15, 1989	-40 mm	Analysis
						April 4, 1990	Jan 31, 1993	25 mm	CDDIS
								Correction to be added to the pressure values	
						March 6, 1995	Jan 25, 1996	2.1 mB	CDDIS
						Jan 26, 1996	April 24, 1996	10.3 mB	CDDIS
						April 25, 1996	May 8, 1996	9.7 mB	CDDIS
7109	G	NC	NO	YES		Jan 9, 1997	Jan 17, 1997	164.9 mm	CDDIS
7110	G	C	NO	YES	__	jan 01, 1984	may 15, 1984	30 mm	Analysis
						oct 27, 1987	jan 25, 1988	30 mm	Analysis
						Aug 27, 1996	Oct 2, 02:50	163,6 mm	CDDIS
7122	G	NC	NO	YES		May 1984	Mar 15, 1987	30 mm	Analysis
7123	G	NC	NO	YES		July 14, 1987	Oct 8, 1987	-30 mm	CDDIS
7210	G	NC	NO	YES	1993 -2005	1983.0	sep 15, 1987	25 mm	Analysis
						sep 16, 1987	jan 21, 1994	-37 mm	Analysis
						jan 22, 1994	2000	-11 mm	Analysis
7308	G	NC	NO	YES		Mar 7, 1995	May 19, 1995	-300 mm	Analysis
7512	G	NC	NO	YES		Mar 1992	May 1992	-30 mm	Analysis
7517	G	NC	NO	YES		june 1992	august 1992	-94 mm	Analysis

7525	G	NC	NO	YES		march 1992	June 1992	11 mm	CDDIS
7544	G	NC	NO	YES		sept 1992	Dec 1992	-85 mm	Analysis
7545	G	NC	NO	YES		Oct 1993	Mar 1994	15 mm	Analysis
7580	G	NC	NO	YES		Nov 1992	Jan 1993	68 mm	Analysis
7587	G	NC	NO	YES		Aug 1992	Oct 1992	30 mm	Analysis
7810	G	C	NO	YES	__	May 24, 1988	Sept 30 1989	50 mm	Analysis
7810	B	C	NO	YES	__	Jan 1998	May 29, 2002	-26 mm	Analysis
						May 29, 2002	Mar 11, 2003	-16 mm	Analysis
						Mar 11, 2003	Feb 6, 2006	-26 mm	Analysis
7811	G	NC	NO	YES	1993 -1994	jul 20, 1993	may 19, 1998	-50 mm	Analysis
						may 20, 1998	mar 28, 2003	-35 mm	Analysis
7831	G	NC	NO	YES		1987	June 1990	+85 microsec	CDDIS
7834	G	NC	NO	YES		Mar 11, 1985	Jul 18, 1986	-30 mm	Analysis
7835	G	NC	NO	YES	1993 - 1998	sep, 1991	Sept 9, 1997	25 mm	Analysis
7836	G	NC	NO	YES		Jan 1, 1994	Oct 12, 1994	18.45 mm	CDDIS
7839	G	C	NO	YES	93.0 to 09/96	1983	April 17, 1996	-22 mm	Analysis
7840	G	C	NO	YES	__	jan 1984	dec 1984	30 mm	Analysis
						Oct 1, 1994	Feb 1, 2002	-2.5 mm	Appleby
						Feb 1, 2002	Feb 10, 2007	5.5 mm	Appleby
7843	G	NC	NO	YES		may 29, 1992	Feb 28, 1993	492.9 mm	CDDIS
8834	G	C	NO	YES	1993 - 1997	1990	Sept 9, 1992	-35 mm	CDDIS
						Sept. 10, 1992	April 15, 1996	40 mm	Analysis
						April 15, 1996	Oct 13,2002	5 mm	Analysis

Site range biases

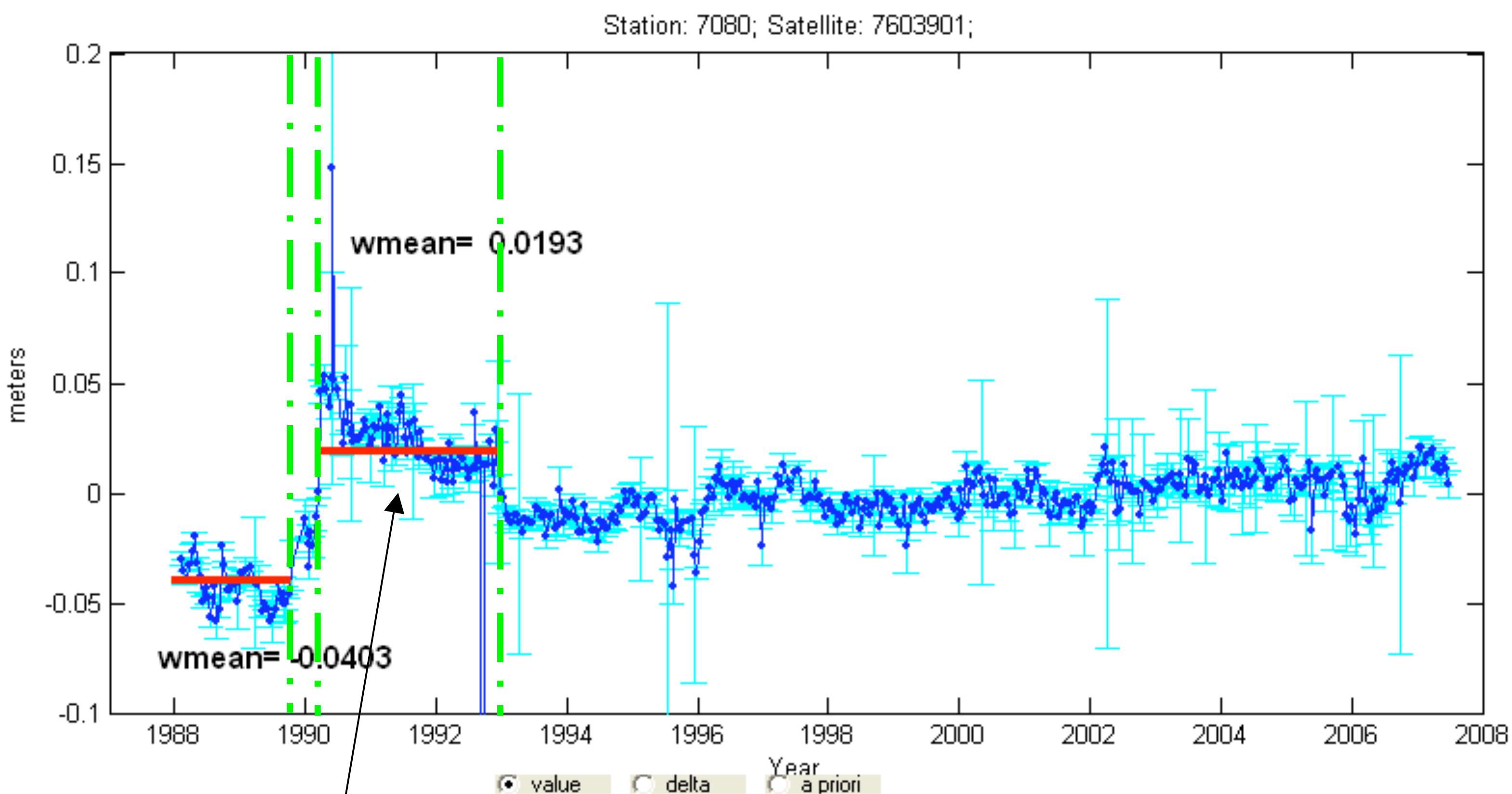
V. Luceri – e-GEOS S.p.A.

G. Bianco – ASI

Bias estimation

- The biases are estimated with a long arc solution from jan 1983 to jul 2007 (CGS2006_new)
- The solution is loose and SSC/SSV are estimated over the entire time span
- The biases before 1992, distributed by Erricos, have been applied
- One bias estimate every 15 days after the SSC/SSV/EOP adjustment
- The biases are one-way and should be subtracted by the observations
- The pressure values from McDonald in 1995 and 1996 are corrected
- Monument Peak bias of 16.36 cm from august 27, 1996 to oct 2 is corrected

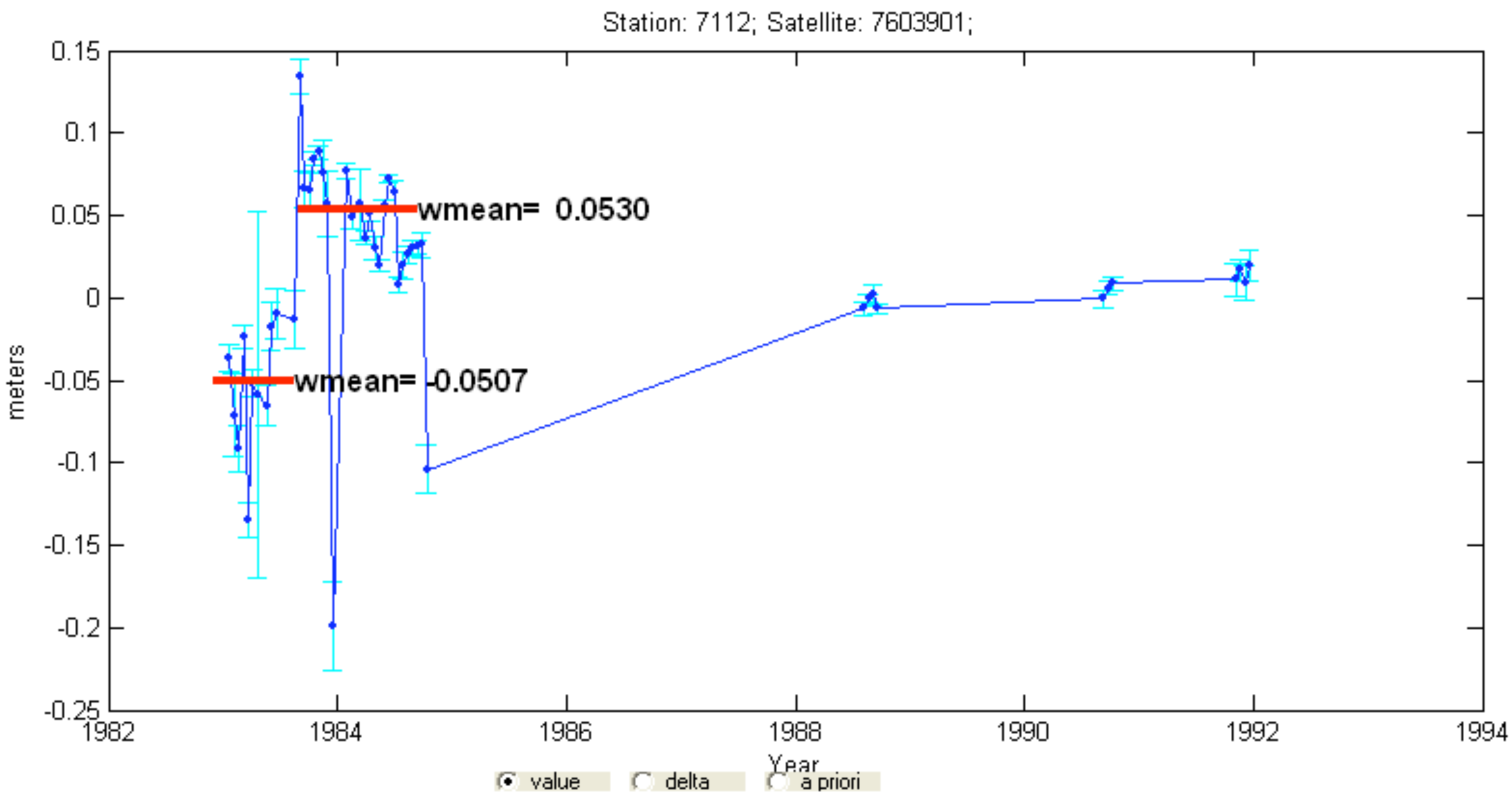
McDonald: range biases from solution CGS2006_new



CDDIS bulletin 7080 MLRS data was biased long by 2.5 cm between April 4, 1990 and January 31, 1993

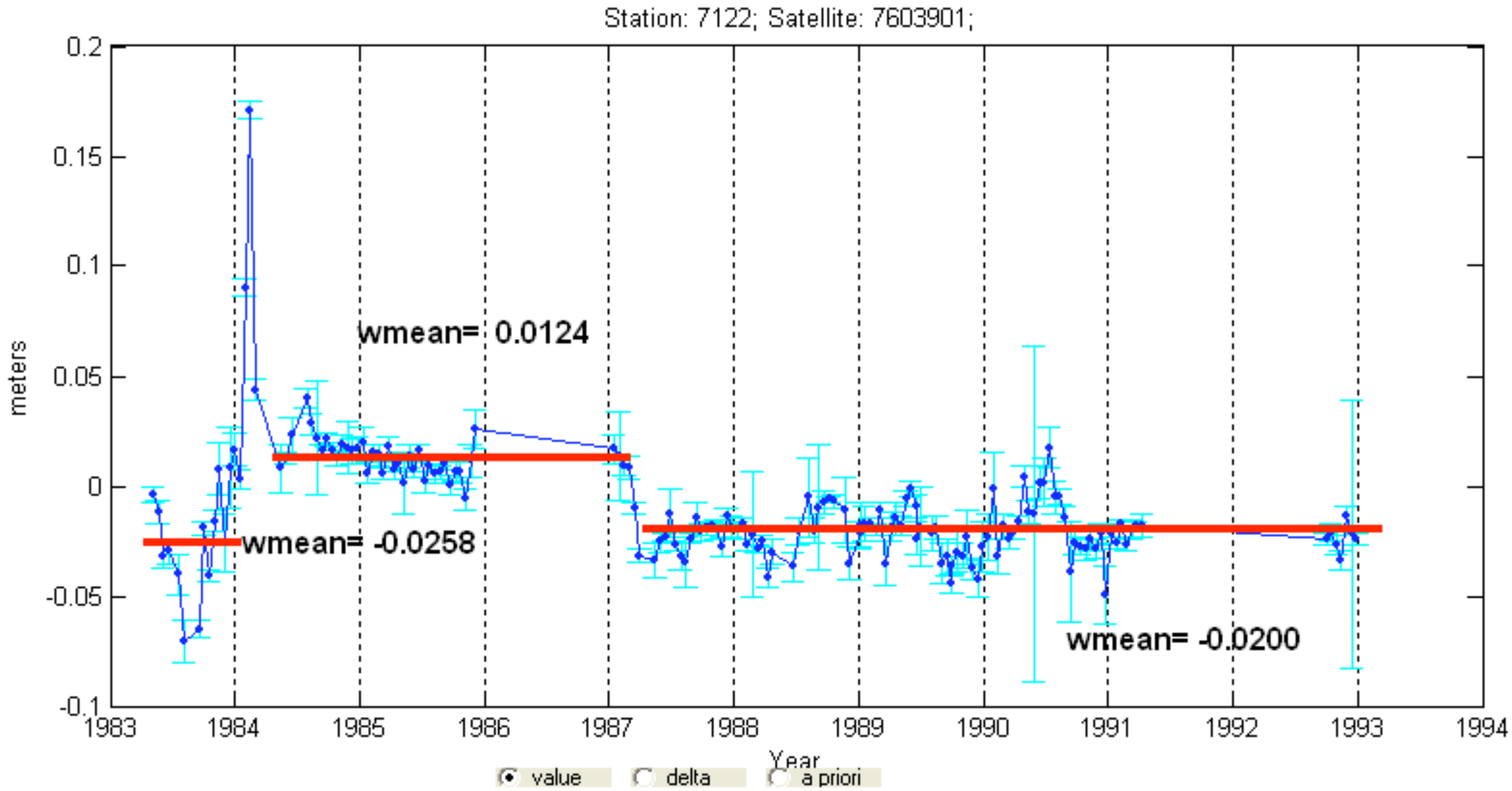
Start Date	End Date	Correction
jan 1, 1988	dec 15, 1989	-40 mm
mar 30, 1990	jan 28, 1993	20 mm

Platteville: range biases from solution CGS2006_new



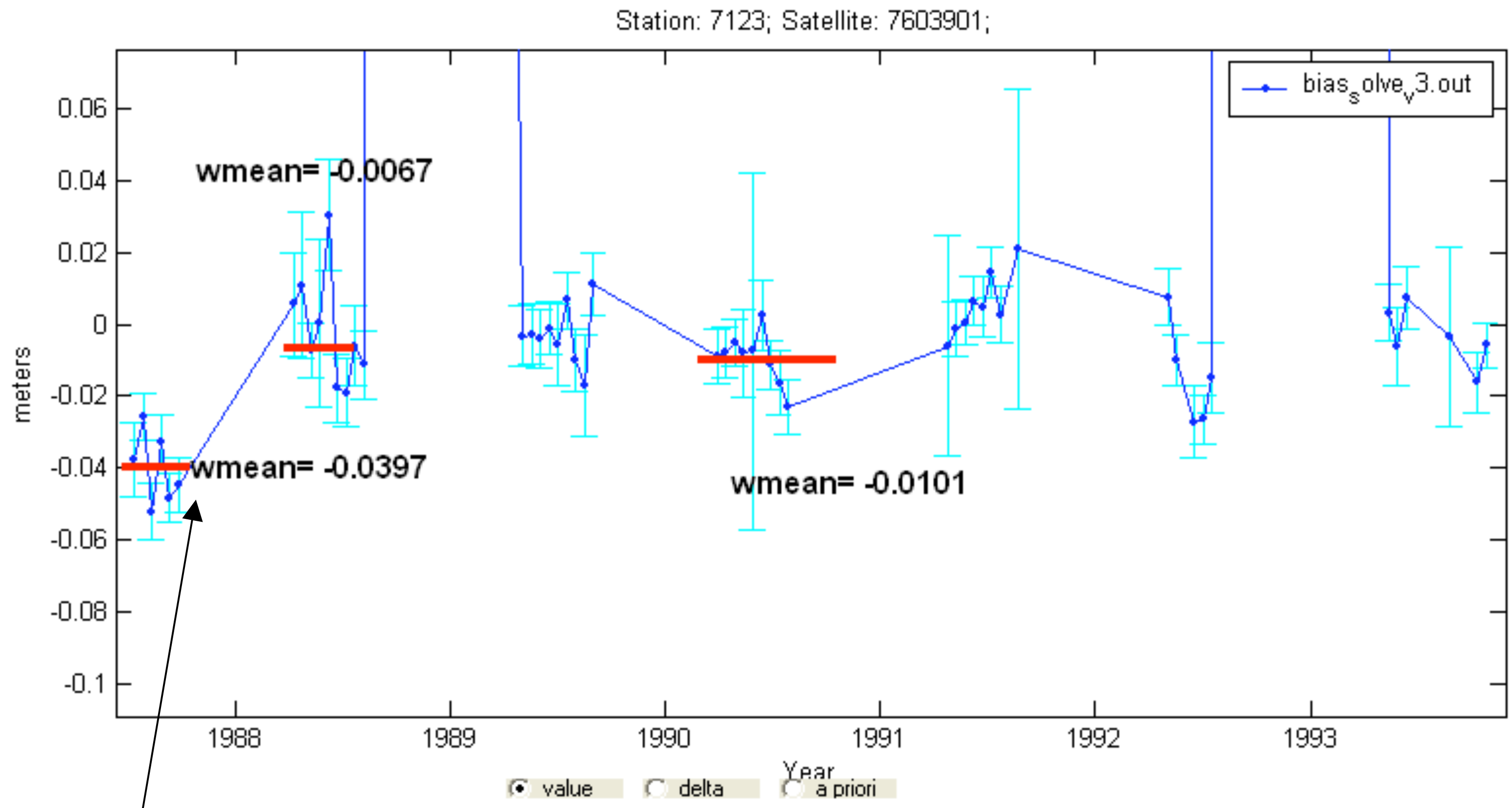
Data before 1985 to be deleted?

Mazatlan: range biases from solution CGS2006_new



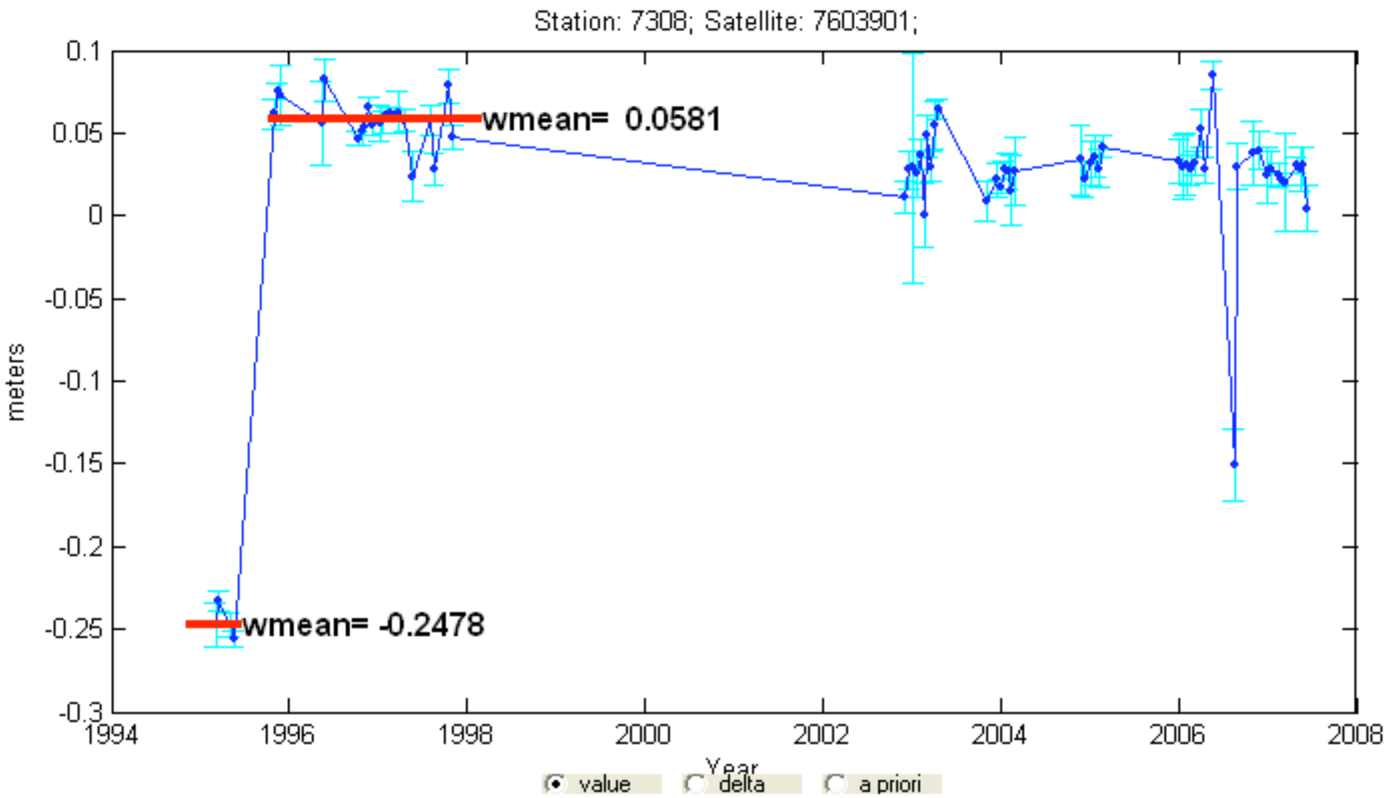
Start Date	End Date	Correction
may 1984	mar 15, 1987	30 mm

Huahine: range biases from solution CGS2006_new



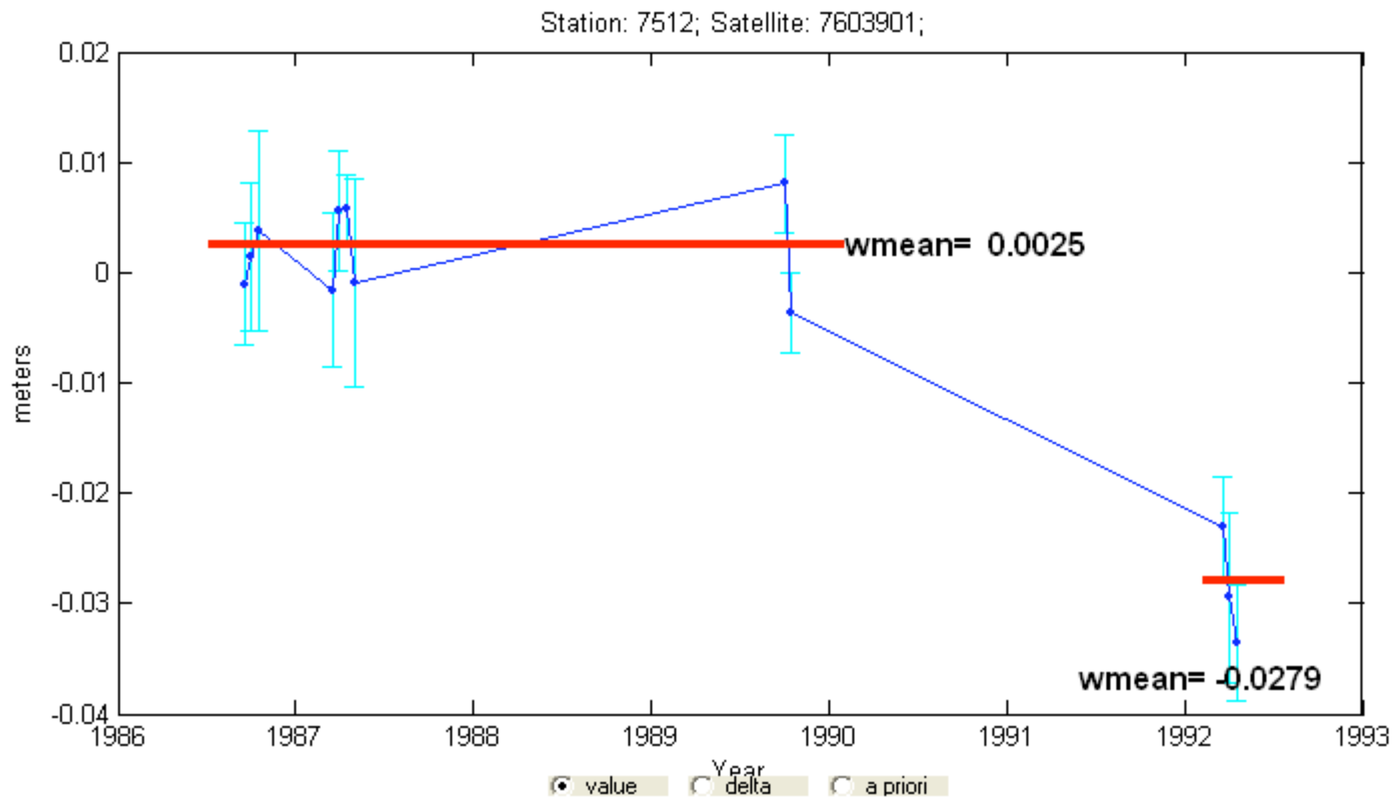
From CDDIS Bulletin vol. 8, num 6
ATSC reports that TLRS-2 data from the 1987 occupation of Huahine, French Polynesia (July 14 to October 08) was biased short by 3 cm

Tokyo: range biases from solution CGS2006_new



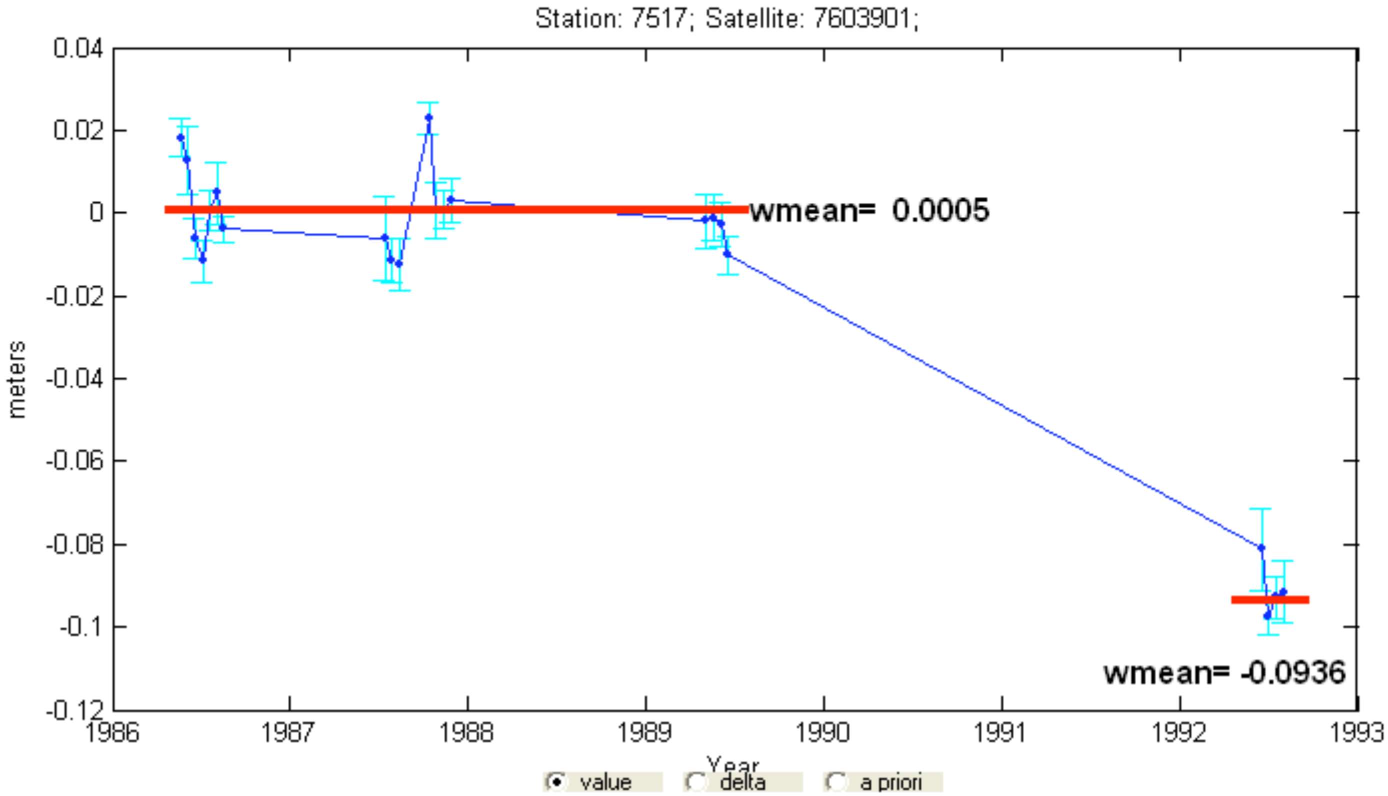
From 950307 to 950519 the bias is -300 mm

Kattavia: range biases from solution CGS2006_new



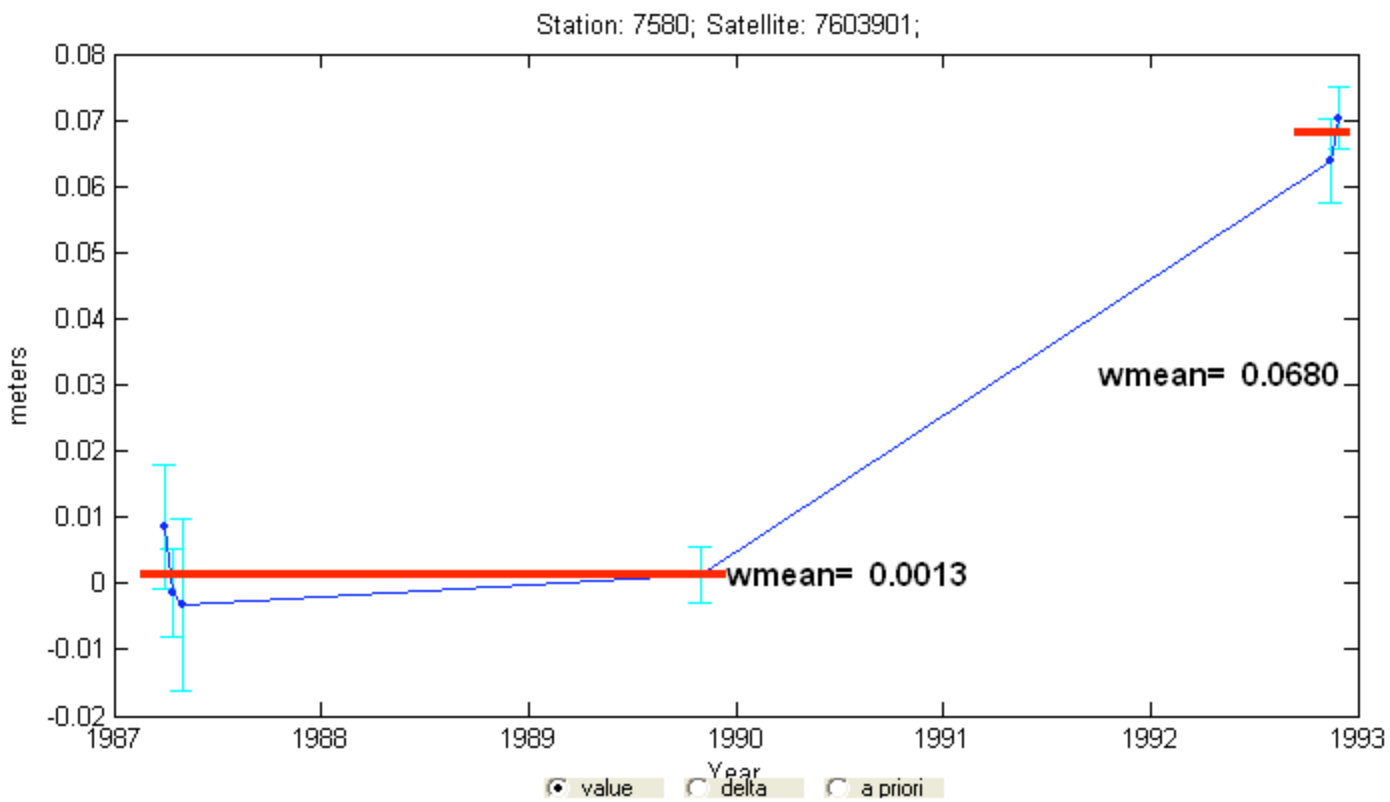
In the 1992 occupation the bias is -30 mm

Roumelli: range biases from solution CGS2006_new



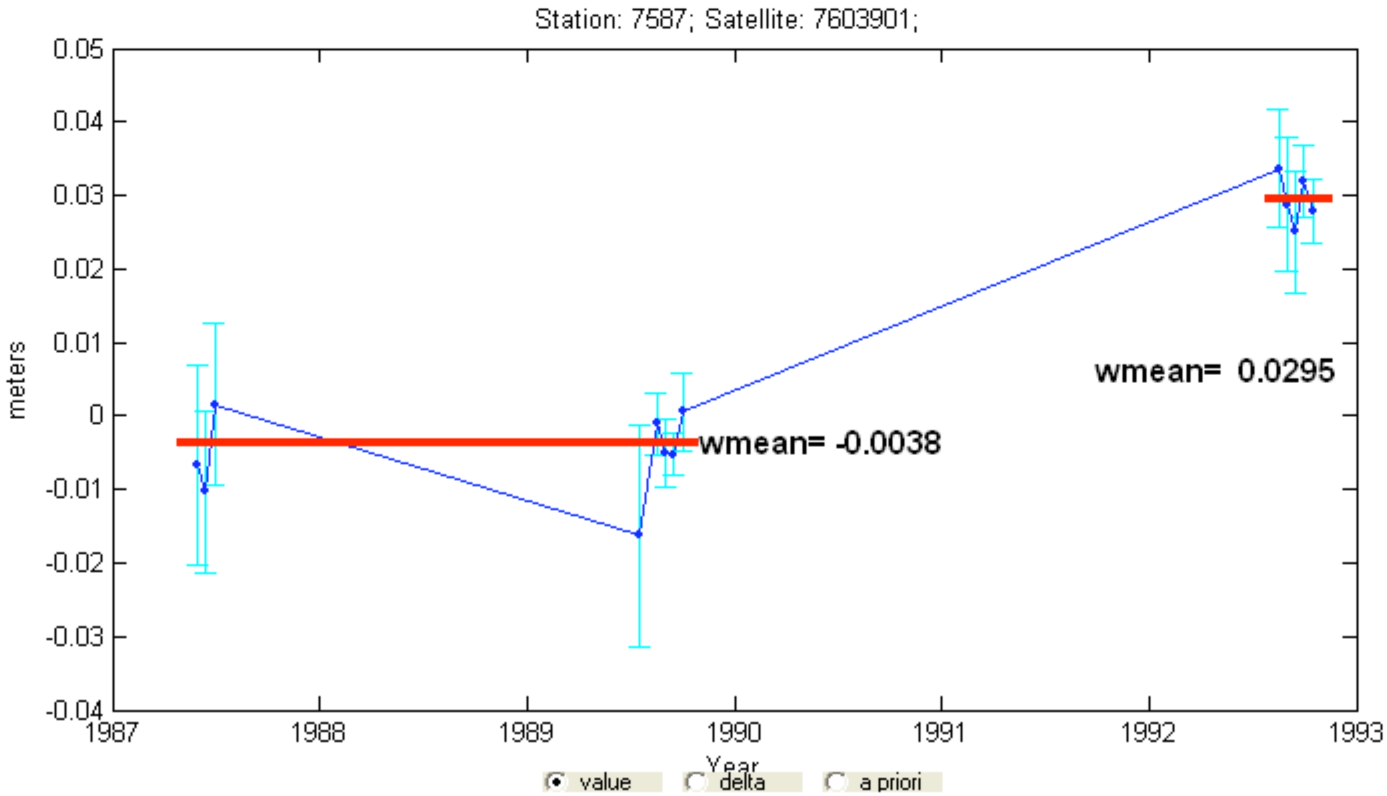
In the 1992 occupation the bias is -94 mm

Melengiclik: range biases from solution CGS2006_new



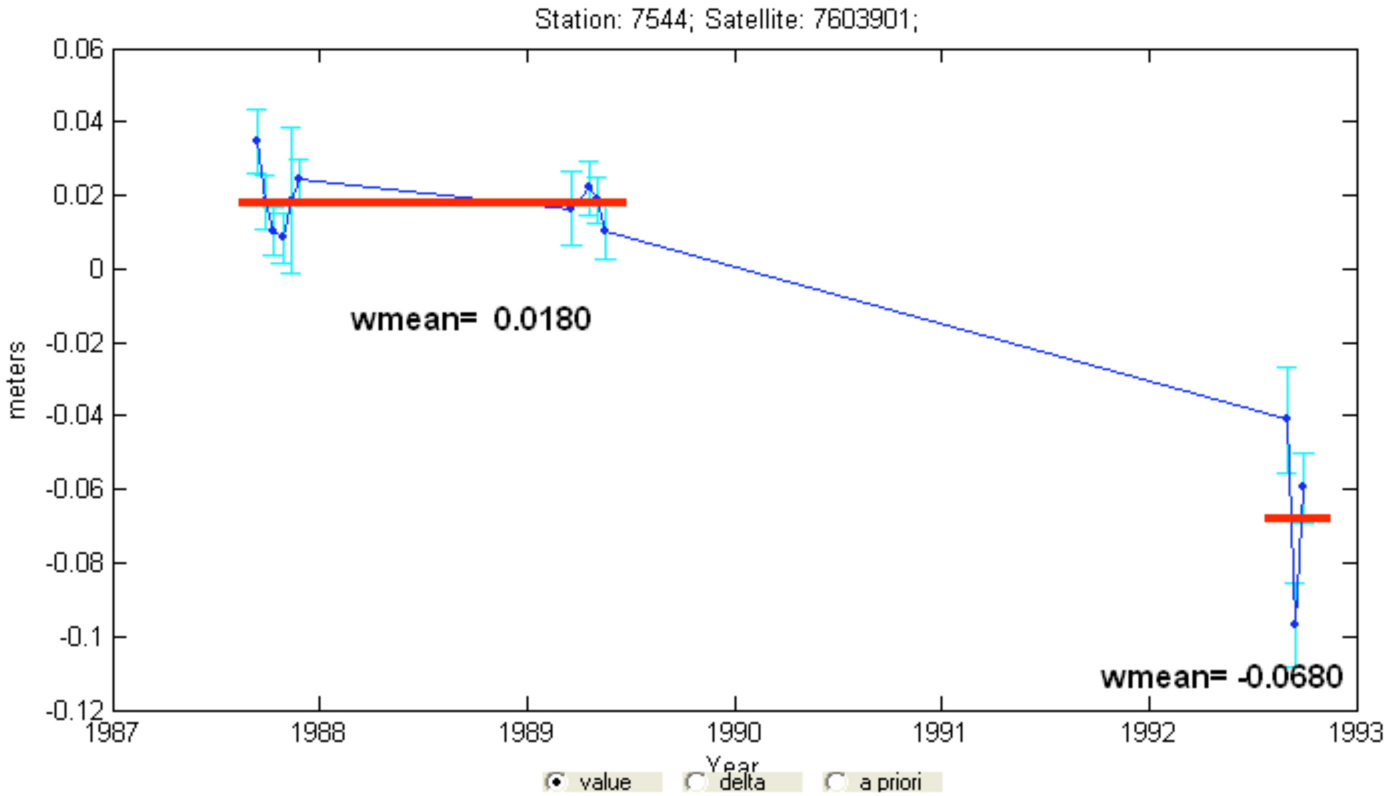
In the 1992 occupation the bias is 68 mm

Yigilca: range biases from solution CGS2006_new



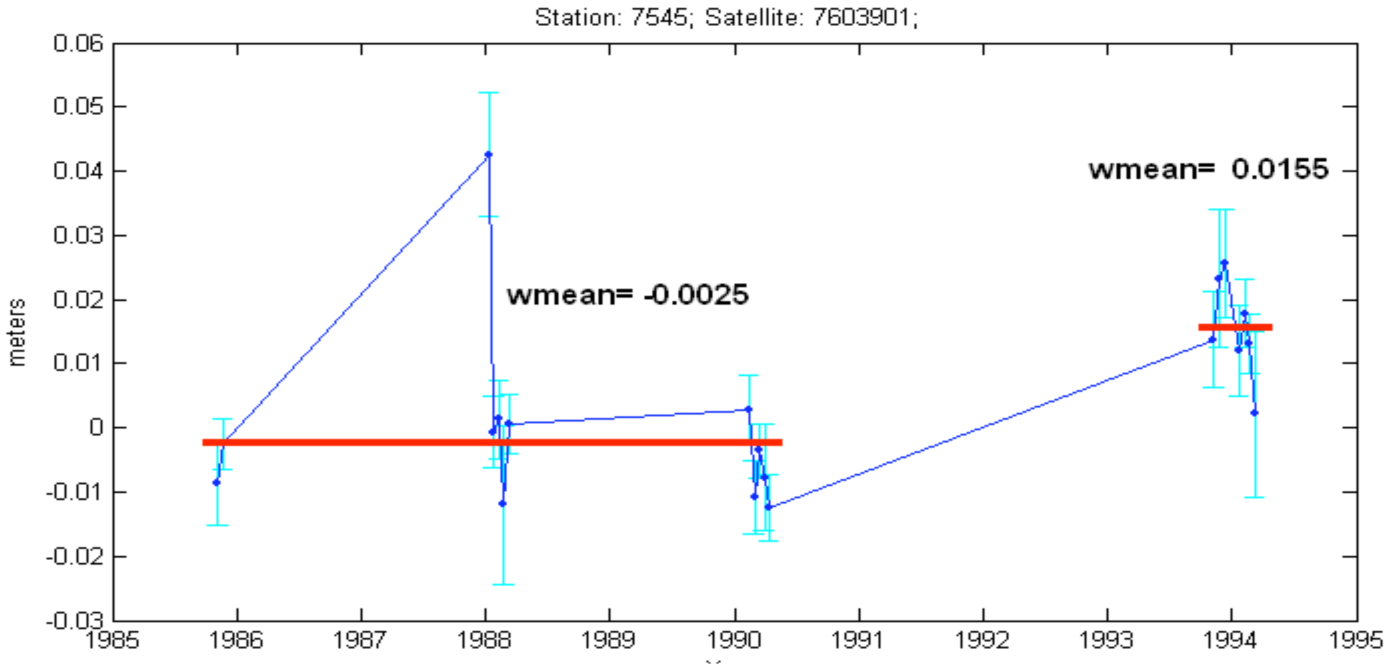
In the 1992 occupation the bias is 30 mm

Lampedusa: range biases from solution CGS2006_new

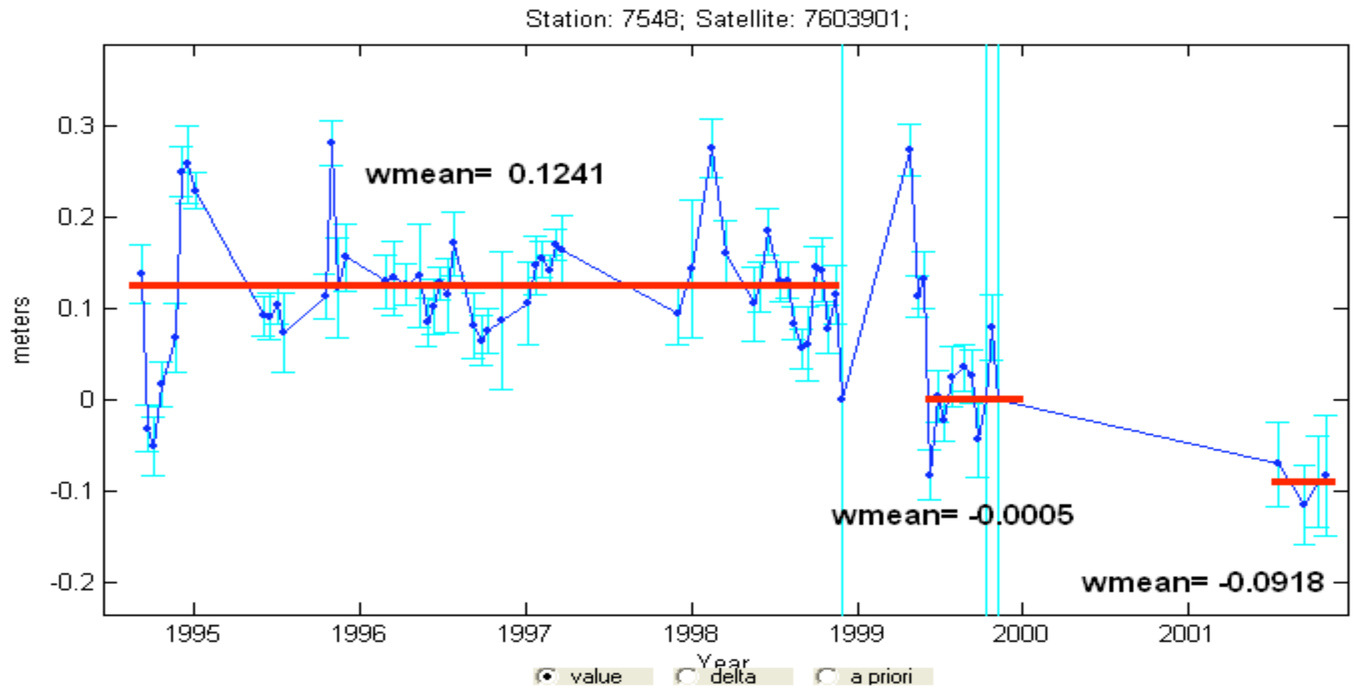


In the 1992 occupation the bias is -85 mm

Cagliari: range biases from solution CGS2006_new

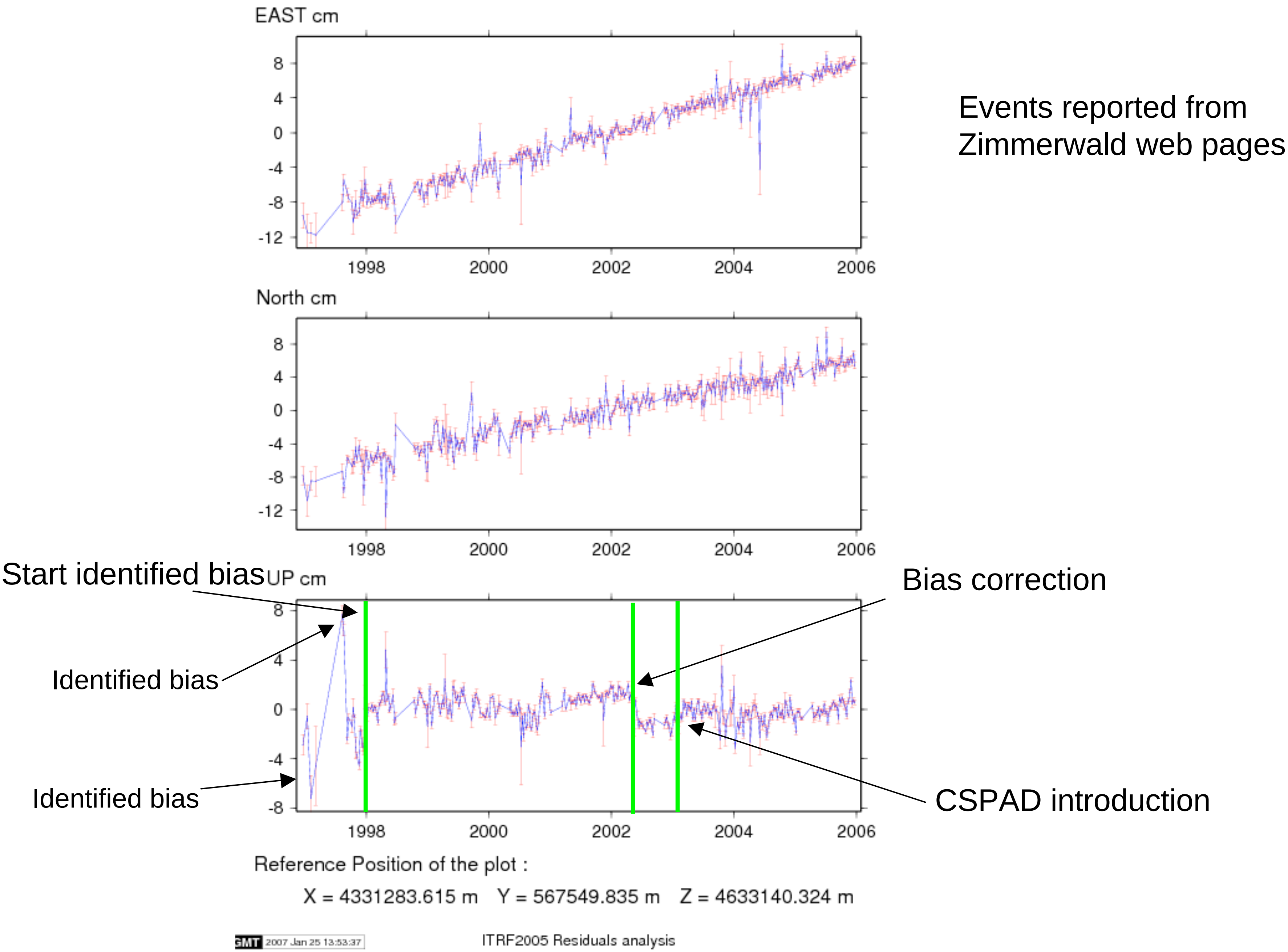


In the 1993 occupation the bias is 15 mm

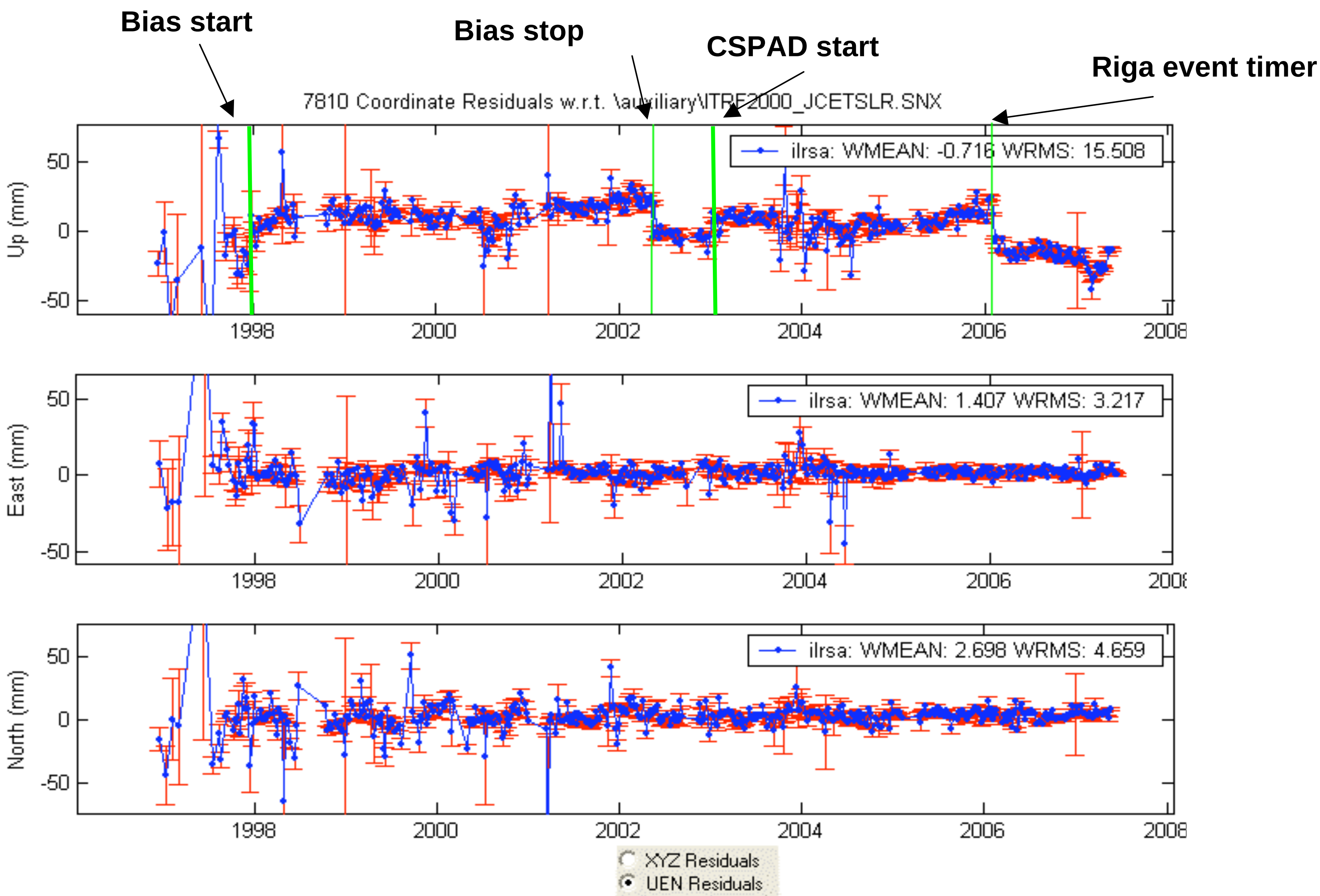


Bias to be estimated

Zimmerwald coordinate time series from ITRF web page



Zimmerwald: ILRSA UEN residuals w.r.t. ITRF2000



- 1997 biases not explicitly reported but evident in the time series
- 2007 ILRSA solutions to be neglected due to wrong Stanford corrections applied

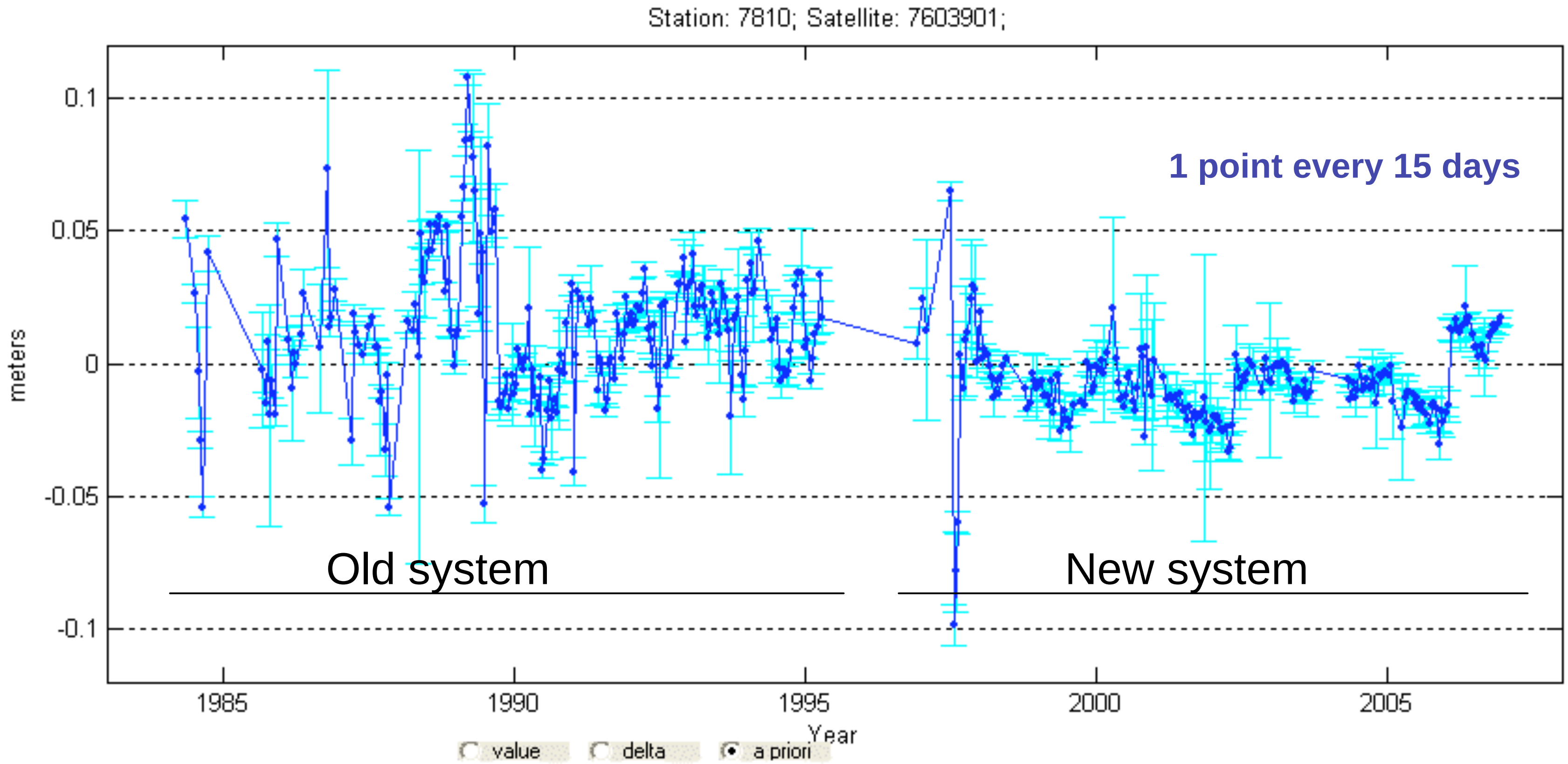
Zimmerwald Range Biases from Zimmerwald web page (http://aiuli3.unibe.ch:8000/slr/zm_calibration.html)

Date	Events, might of might not generate a change in the range biases
01 Jan 1997	ZIMLAT: Start of Operation
09 Jul 1997	Begin identified range bias
17 Jul 1997	End range bias
30 Jul 1997	Begin identified range bias
03 Sep 1997	End range bias
01 Jan 1998	Begin identified range bias
29 May 2002 00:00	End range bias
29 May 2002 00:00	Start applying Stanford counter corrections
11 Mar 2003 10:00	Blue: Start using CSPAD
28 Dec 2004 12:00	Blue: Swapped counters: 0236-->3113
28 Dec 2004 12:00	Infrared: Swapped counters: 3113-->0236
03 Feb 2006 15:00	Blue: Riga Event timer replaces Stanford
03 Feb 2006 15:00	Infrared: Applying new Stanford counter corrections
22 Mar 2006 12:00	Infrared: Riga Event timer replaces Stanford
21 Jun 2006 09:10	Blue and IR: Switched to external calibration
06 Mar 2007 17:00	Blue: Temporarily using PM again

Observations between 09 July 1997 and 17 July 1997: All ranges are too long by 0.45 ns = 68 mm
Observations between 30 July 1997 and 03 Sept 1997: All ranges are too short by 0.43 ns = 64 mm
Observations between January 1998 and 29 May 2002, 00:00 UT: All ranges are too short by 0.12 ns = 18 mm.
After february 6, 2006 423 nm: Lageos 1/2 flight times will become shorter by about 50 ps (i.e. -> from 1/1/97 to 6/2/06 range too long by 50 ps)
846 nm: Lageos 1/2 flight times will become longer by about 100 ps (i.e. -> from 1/1/97 to 6/2/06 range too shor by 100 ps)

Zimmerwald: Lageos-1 range bias (blue) from solution CGS2006_new

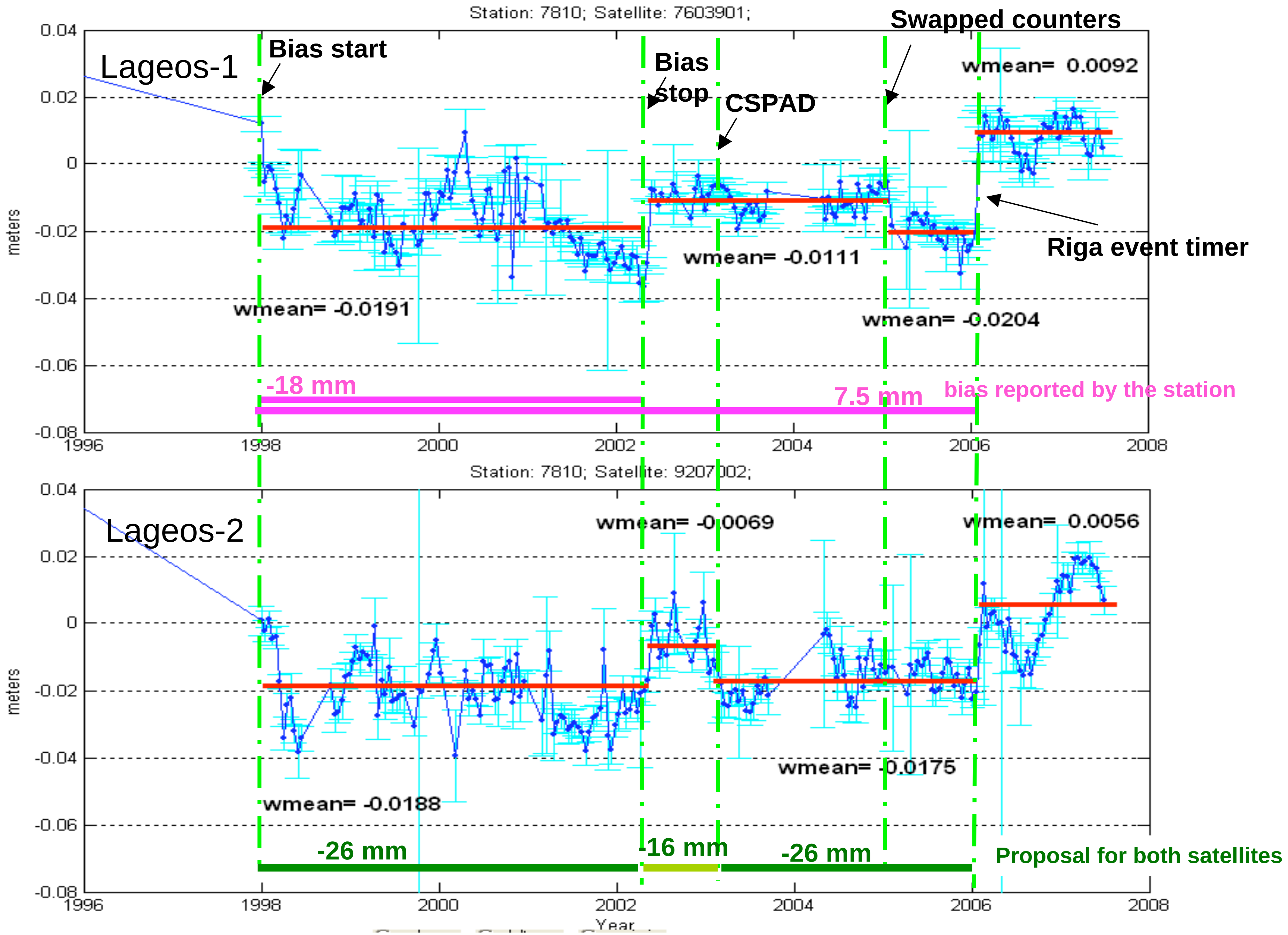
Bias with ITRF2000 coordinates



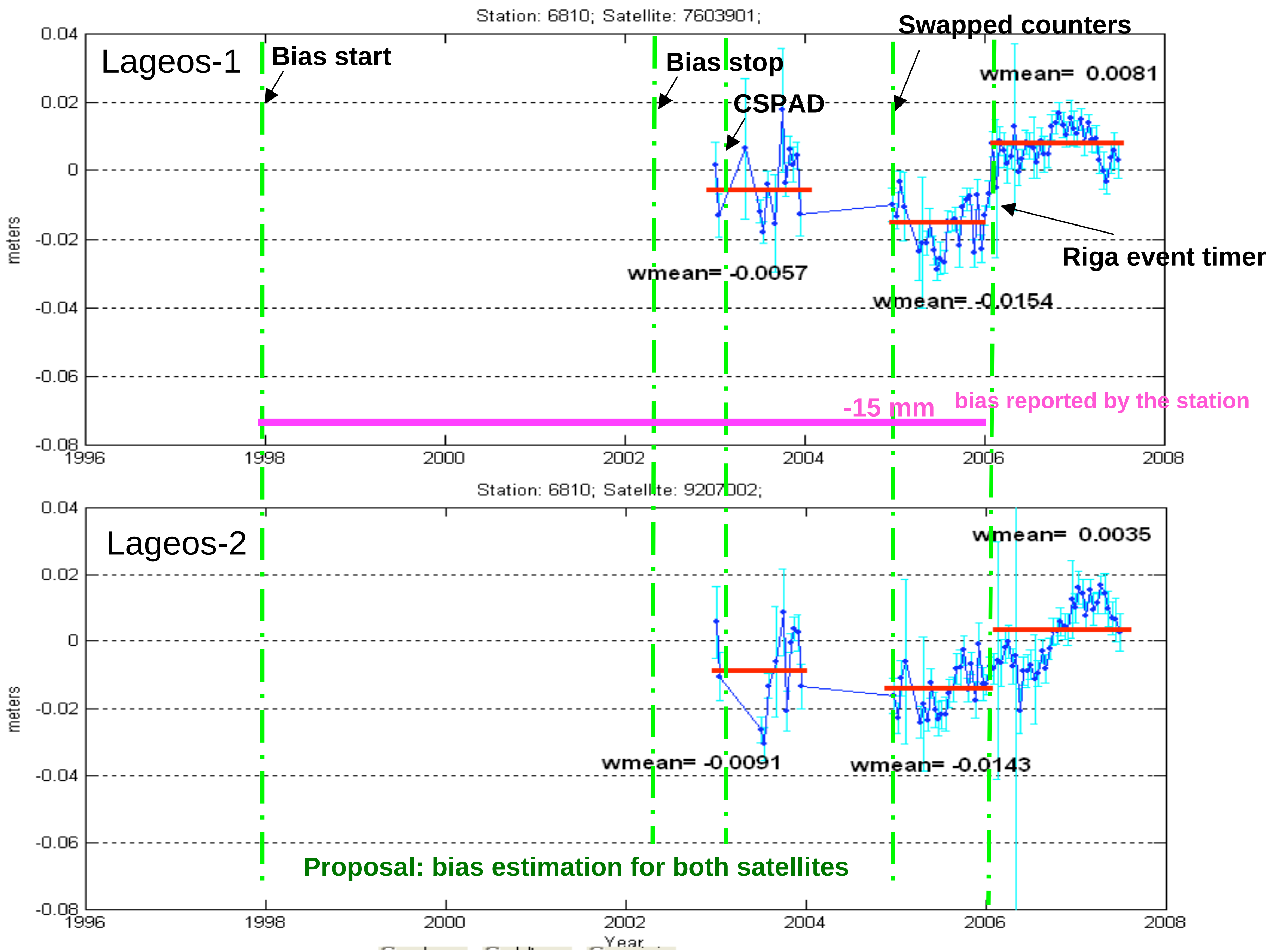
The biases have been estimated without applying any correction to the data, the table on the right side reports the corrections reported by the stations, as a reference

Start Date	End Date	Correction
July 9, 1997	July 17, 1997	All ranges are too long by 0.45 ns (68 mm 1-way)
July 30, 1997	Sept 30, 1997	All ranges are too short by 0.43 ns (64 mm 1-way)
january 1998	May 29, 2002	All ranges are too short by 0.12 ns (18 mm 1-way)
January 1997	Feb 6, 2006	50 ps too long for 423 (blue) 100 ps too short for 846 (infrared)
LAGEOS time bias for pass 97-08-15 23:18:57 23:24:47 microsec 68.0		

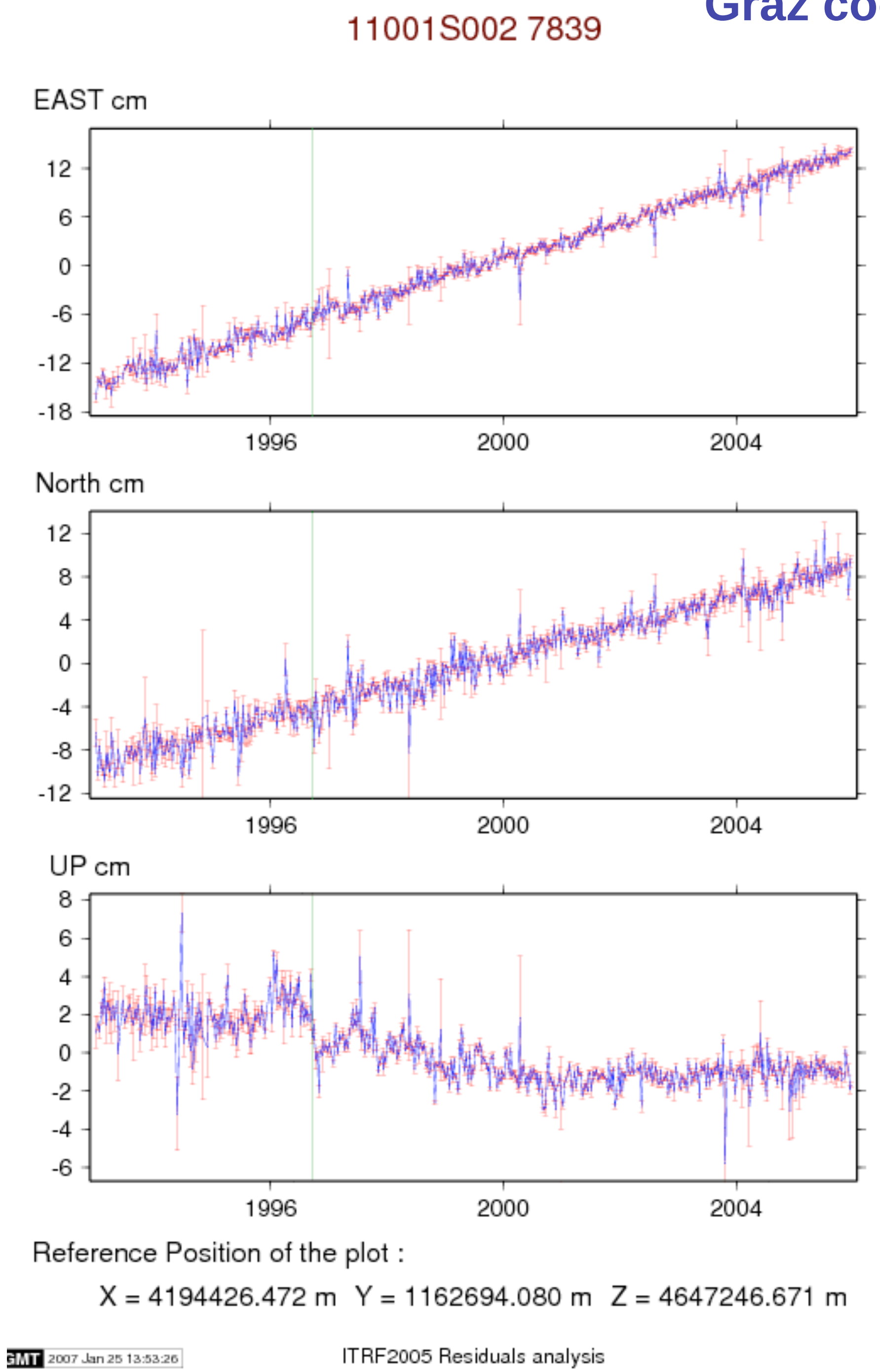
Zimmerwald: blue range bias from solution CGS2006_new



Zimmerwald: infrared range bias from solution CGS2006_new



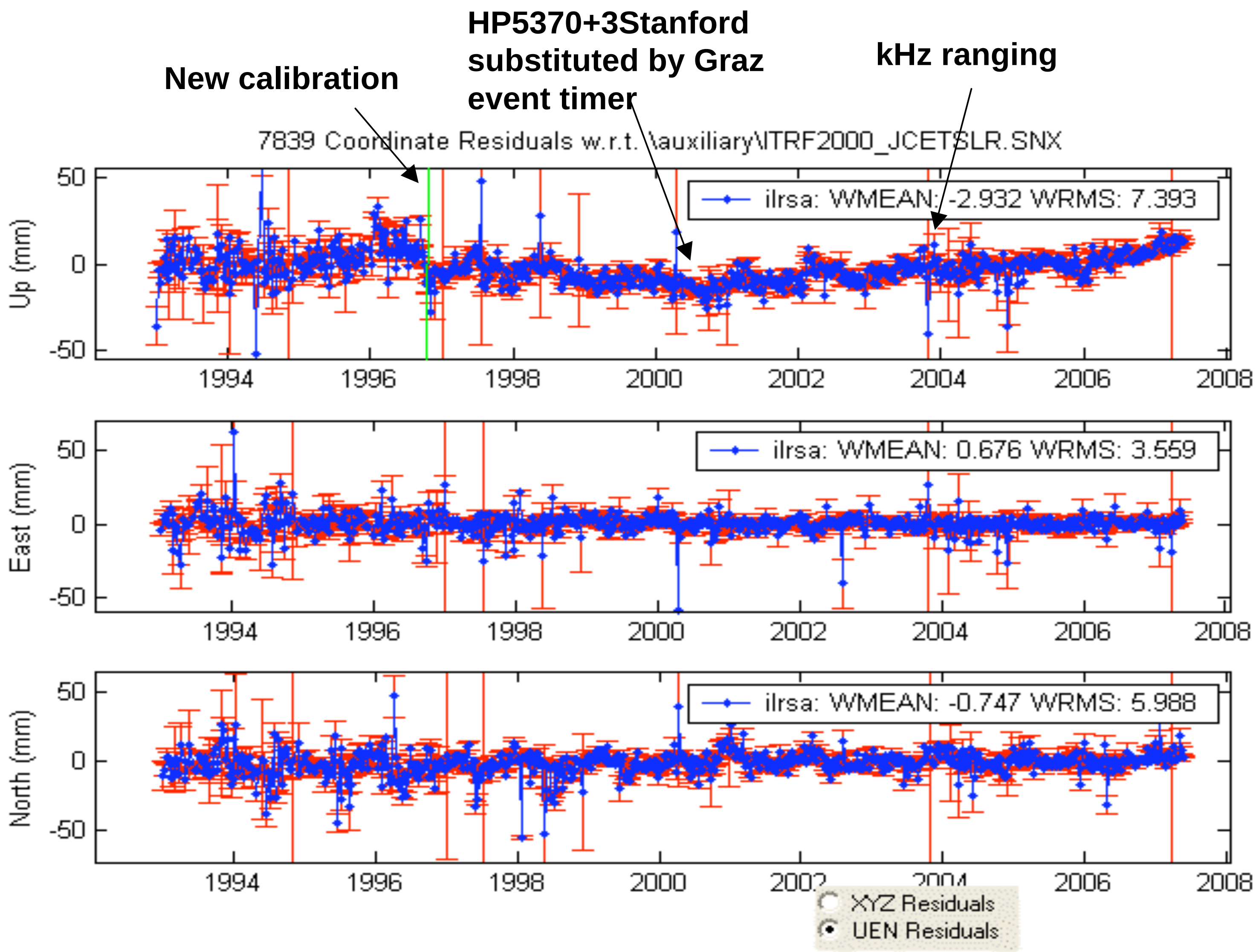
Graz coordinate time series from ITRF web page



SLRMail 0013: new calibration from april 17, 1996 and no bias to be applied.

Jump probably due to the estimation of the bias until the end of 1996

Graz: ILRSA UEN residuals w.r.t. ITRF2000



Graz: information from configuration file

78393402 5 1995289 HP5370A: Trigger Thresholds from 0.25/0.21 to 0.25/0.17 V

78393402 6 1996025 HP5370A+2xSR620 now measure parallel; not yet in results
78393402 7 1996030 All 3 Counter Results now fully used

78393402 1 1996254 Counter #4 (SR620) added for parallel measurements
78393402 5 1996271 Time Walk Compensation: New Adjustment
78393402 6 1996296 3 Counters only; last SR620 removed
78393402 8 1996351 4 Counters again: HP5370A + 3 x SR620

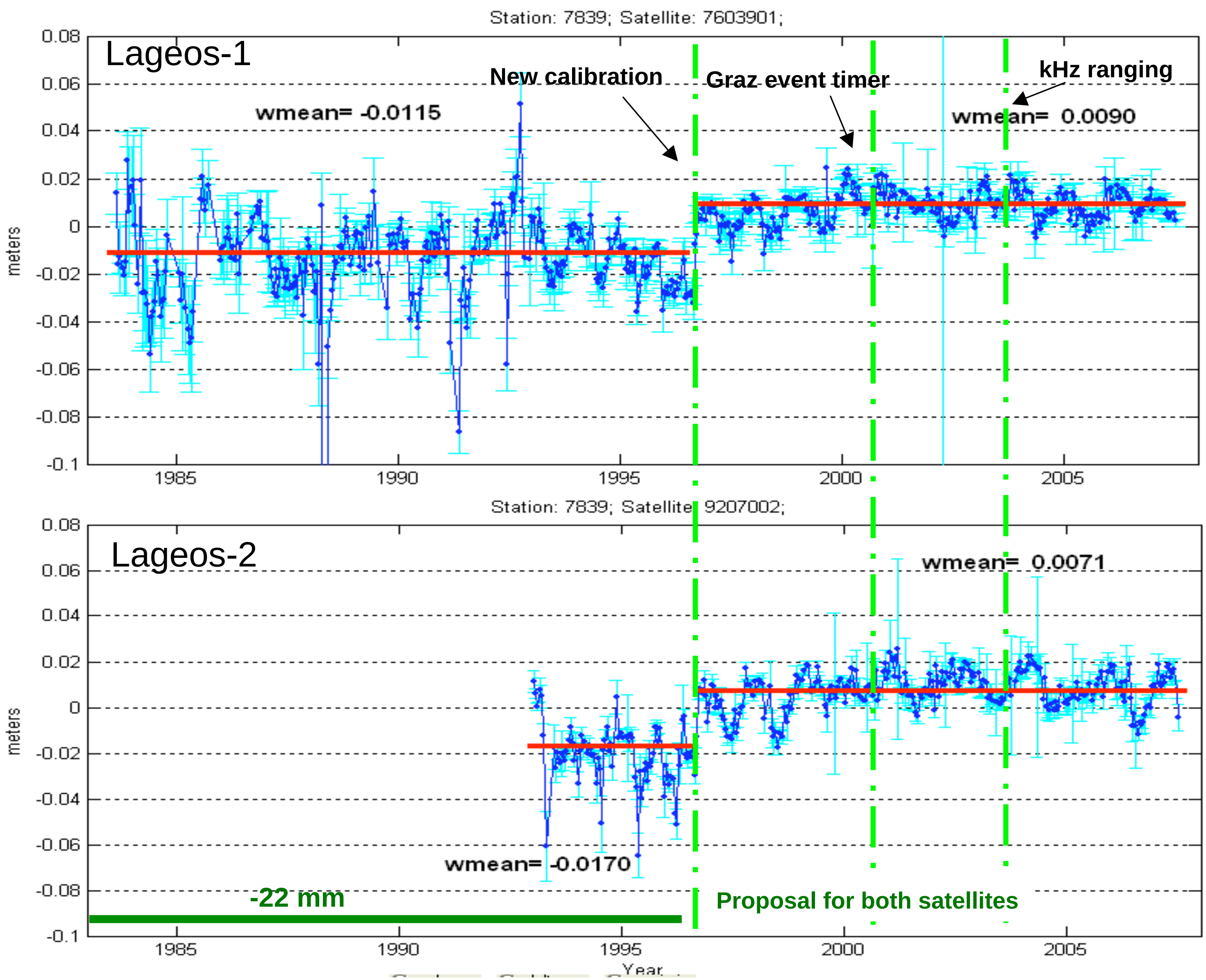
78393402 1 1997030 UTC(TUG) supplies 1 pps, 10 MHz again
78393402 2 1997034 SR620/#1 now as reference counter (instead of HP5370A)

78393402 8 1997114 SR620#3 removed; HP5370A+2xSR620 remain
78393402 9 1997126 SR620#3 added again; Now: HP5370A+3xSR620

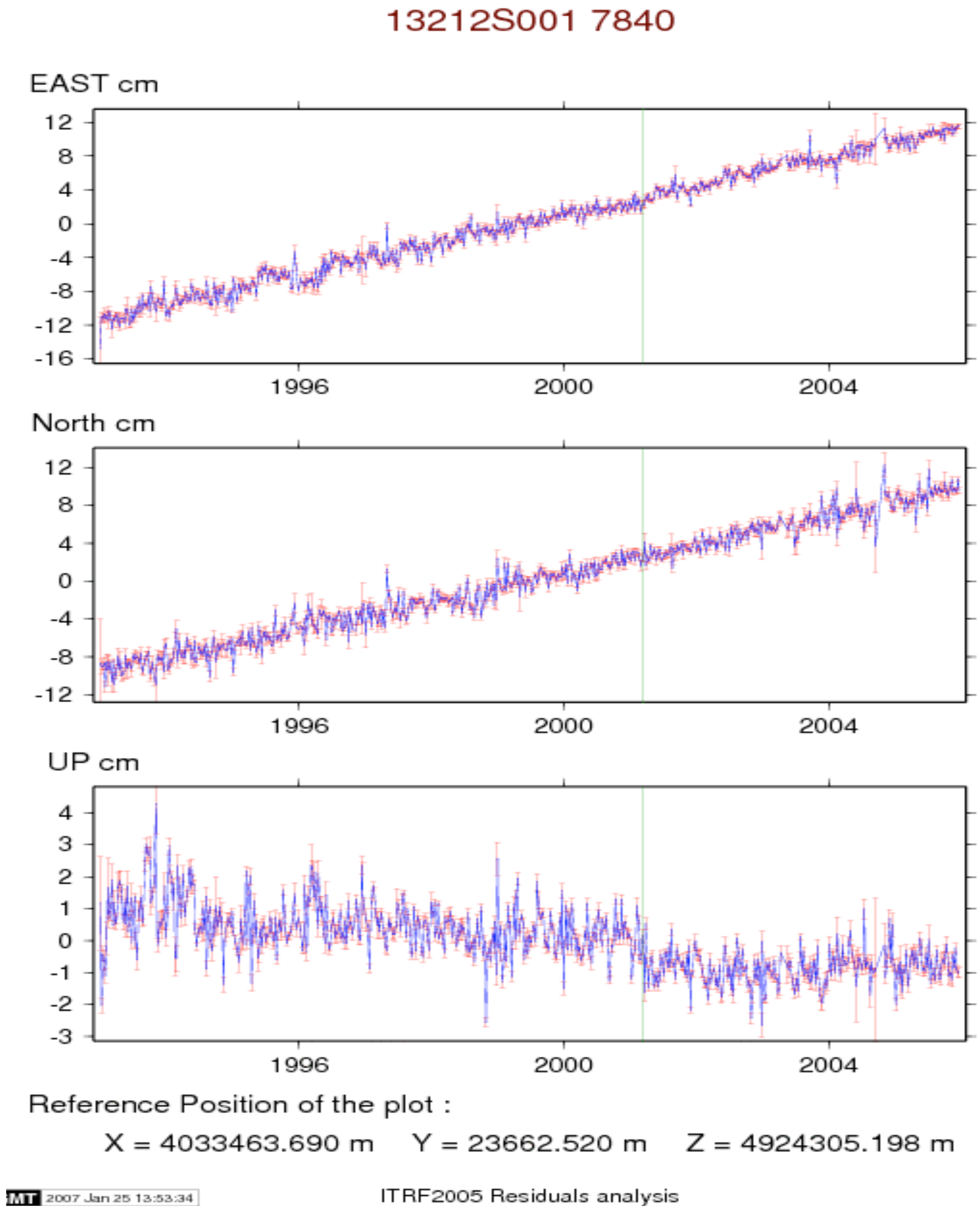
78393402 0 2000213 HP5370A + all 3 SR620's replaced by Graz Event Timer

October 9, 2003 kHz ranging

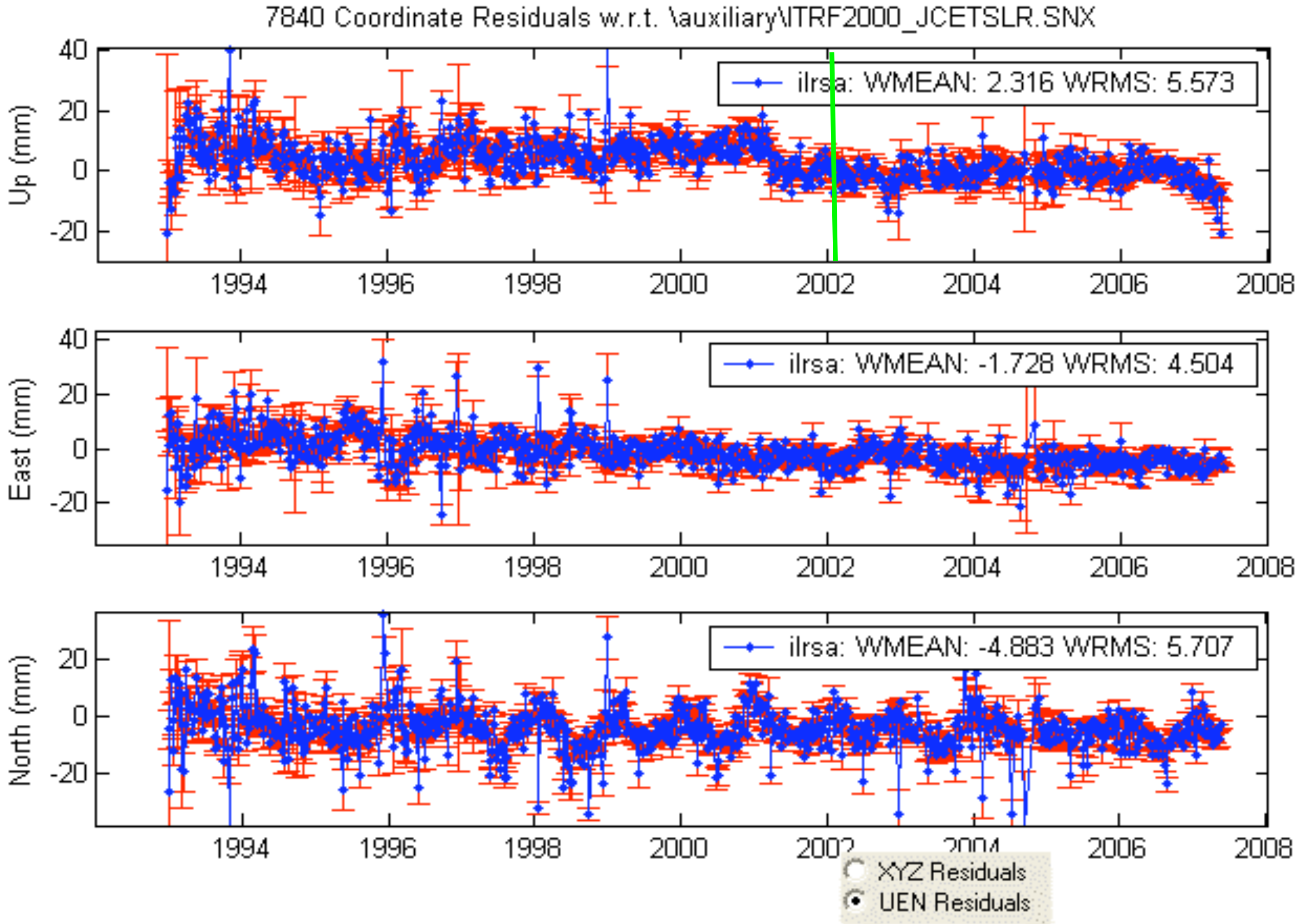
Graz: range biases from solution CGS2006_new



Herstmonceux coordinate time series from ITRF web page



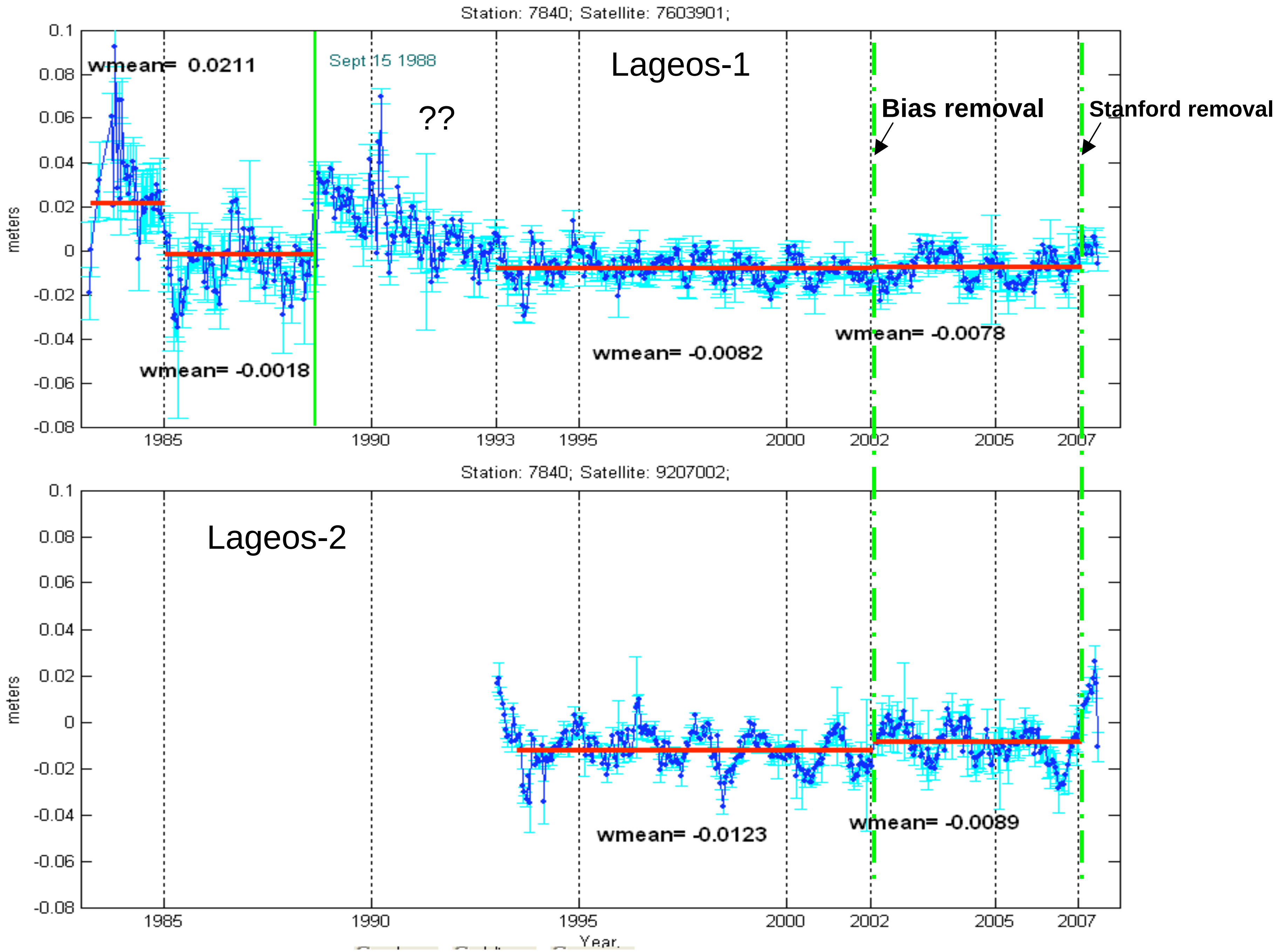
Herstmonceux: ILRSA UEN residuals w.r.t. ITRF2000



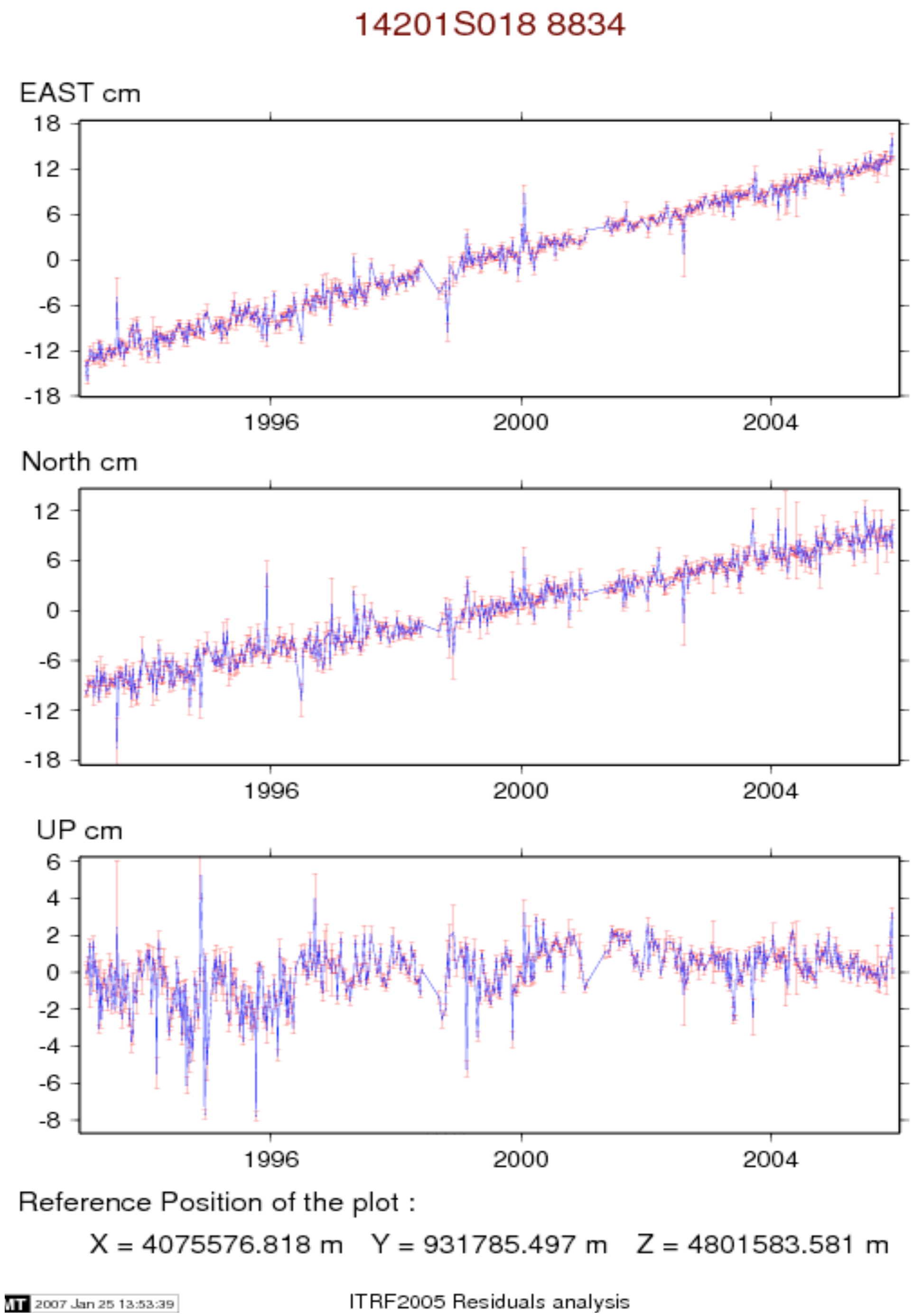
Correction reported by the station

Start Date	End Date	Correction to be subtracted
october 1, 1994	february 1, 2002	-2.5 mm
february 1, 2002	february 10, 2007	5.5 mm

Herstmonceux: range biases from solution CGS2006_new

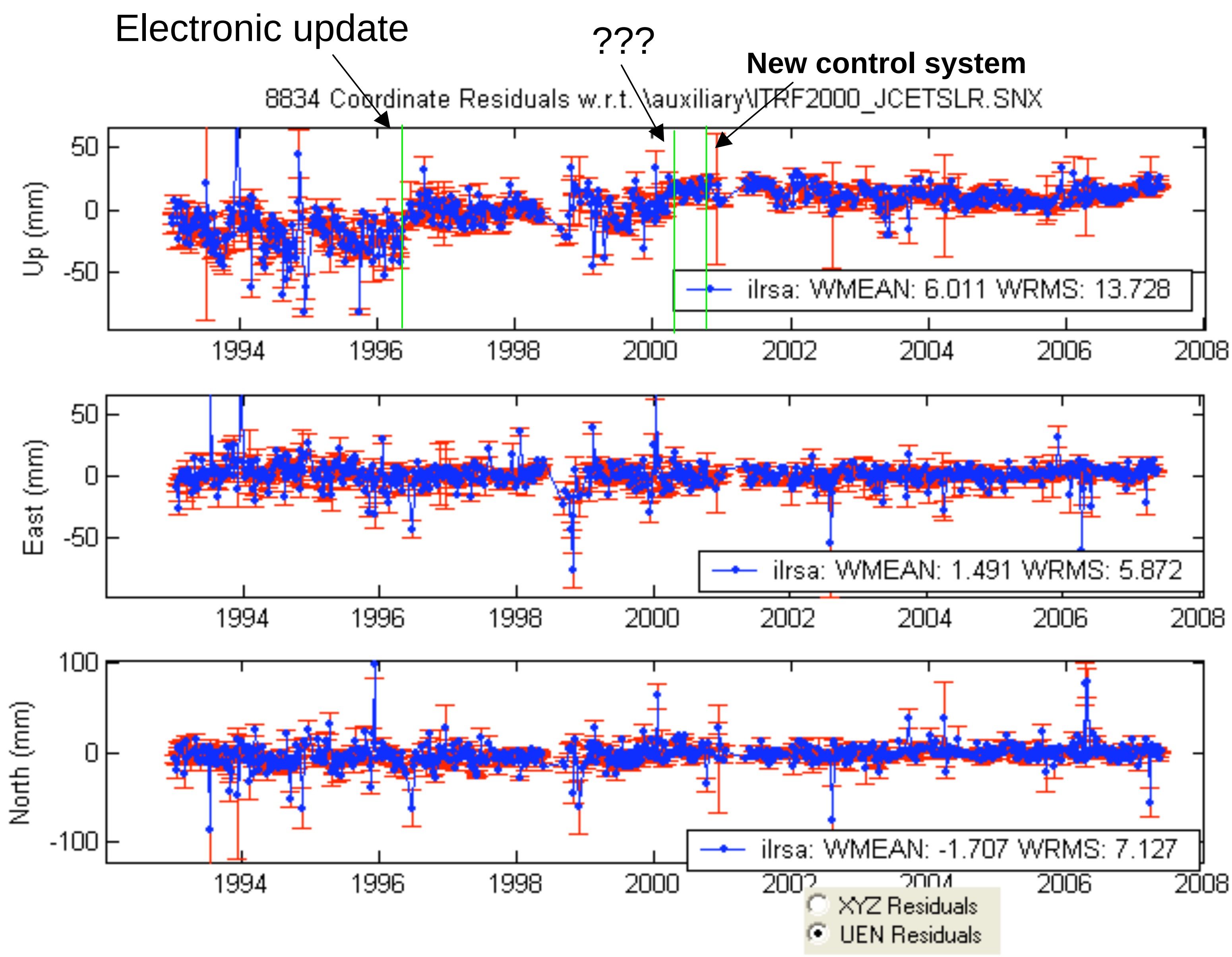


Wettzell coordinate time series from ITRF web page



Jump probably due to the estimation of the bias until the end of 1996 (AWG decision)

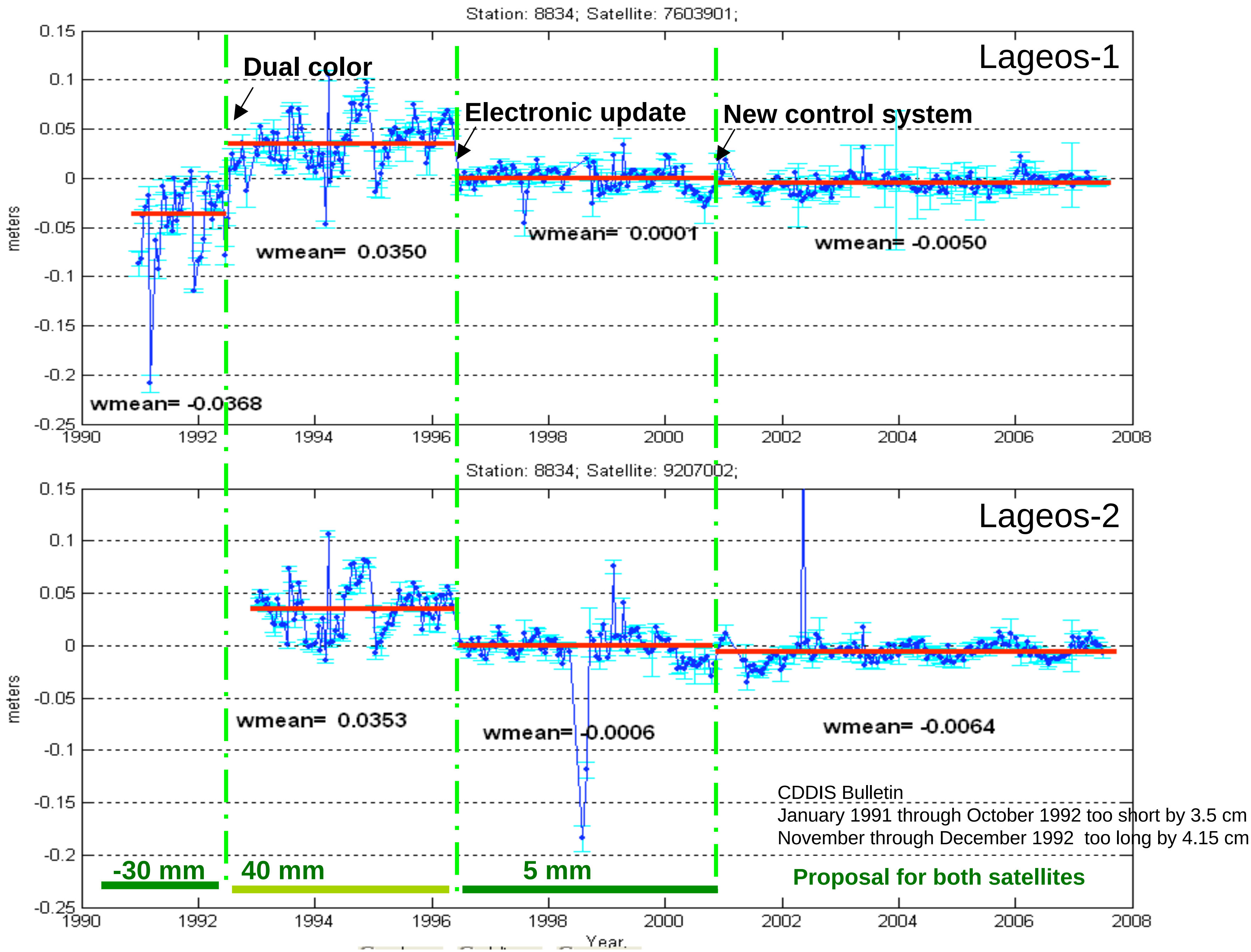
Wettzell: ILRSA UEN residuals w.r.t. ITRF2000



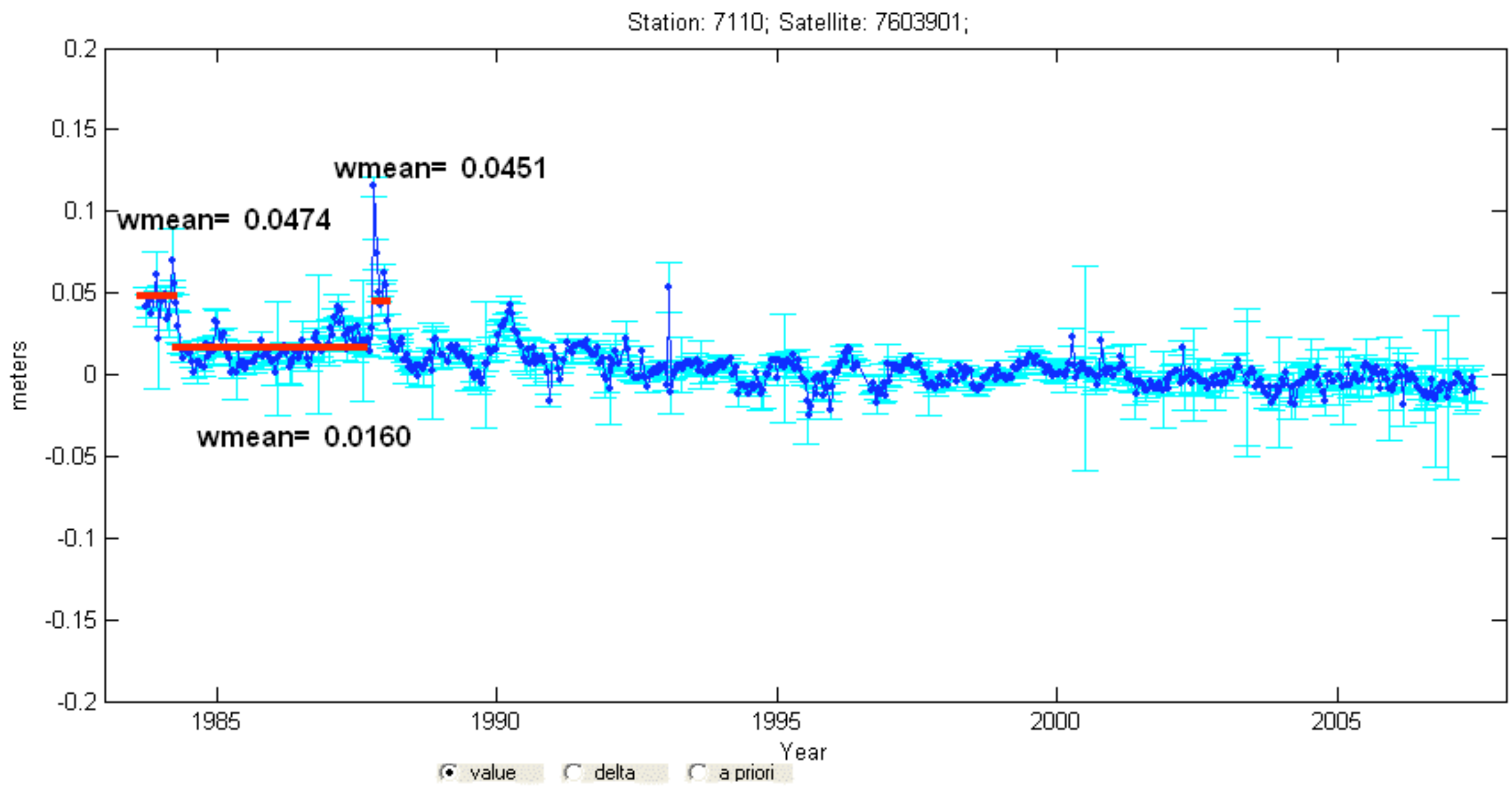
Wettzell system change file

```
SOD     Byte  Start Description
          46     date
-------- -- ------- -------------------------------------------------------
88341001  1 1991001 Baseline system configuration:
                    MCP,PMT constant fraction discriminator Tennelec TC454
                    200 ps (FWHM)  ND: YAG laser 532nm/1064nm
                    timing system lecroy 2229 TDC
                    GPS time receiver TTR6 Allen Osborne and BVA-quarz
                    (oscilloquarz)
                    mercury barometer Lambrecht 809 Digiquarz
88341001  2 1992253 APD (SP114) for dual colour
88341001  3 1993277 PMT replaced by APD (SP114), 2 detektor setup
88341001  4 1994060 new T/R system installed
88341001  5 1994173 SP114 for start-diode installed
88341001  6 1995158 new APD (SP114) installed
88341001  7 1995327 new MCP installed
88341001  8 1996087 BVA-quarz replaced by h-maser
88341001  9 1996106 upgrade of the mcp-electronic, 2 detektor setup
88341001  0 1998201 new nd:YAG laser (diode pumped, 80 psec pulse length)
88341001  1 2000286 new control system
```

Wettzell: range biases from solution CGS2006_new



Monument Peak: range biases from solution CGS2006_new

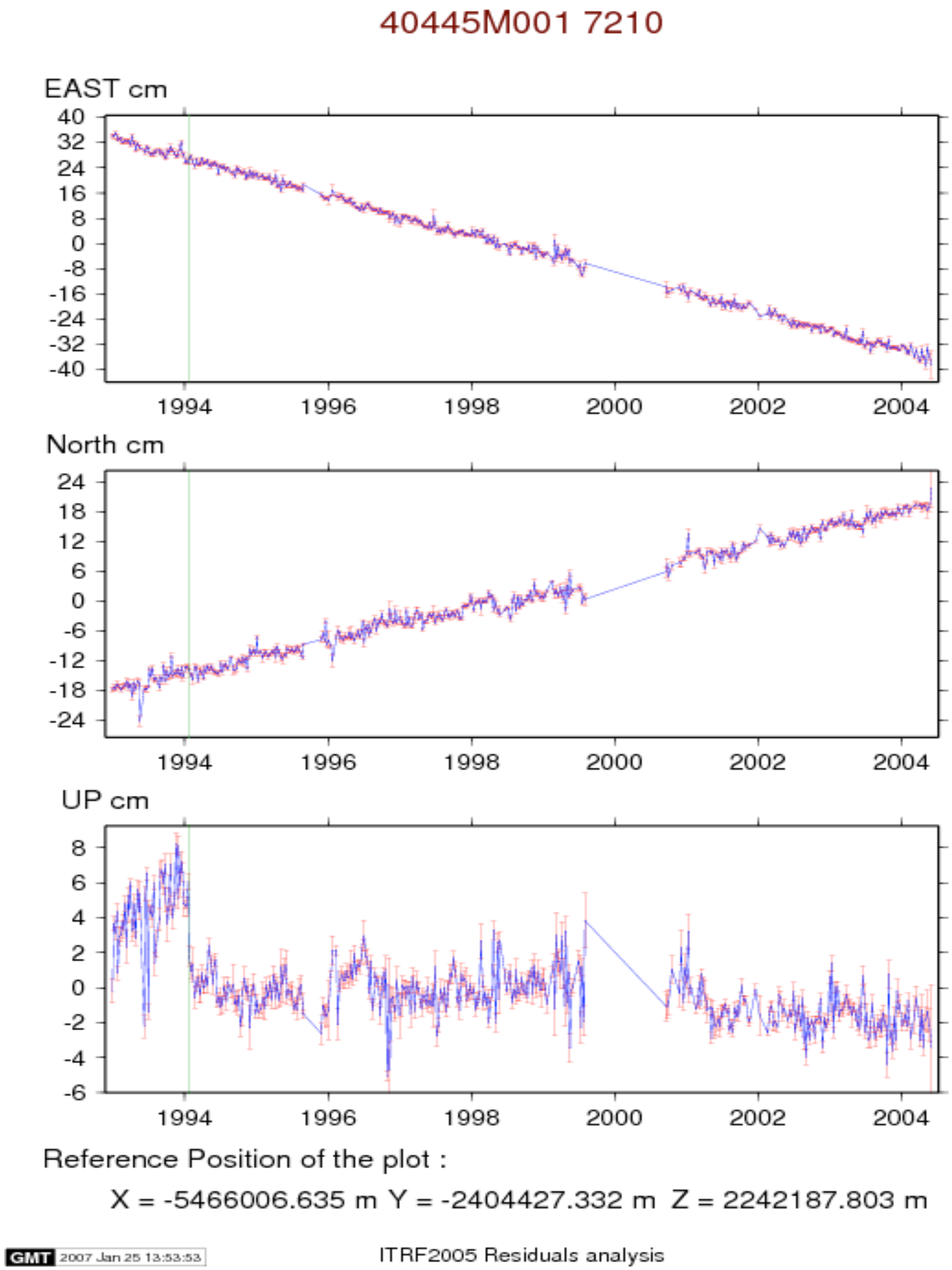


Until april 30, 1984 -> 35 mm

Oct 20, 1987 to jan 20, 1988 -> 35 mm

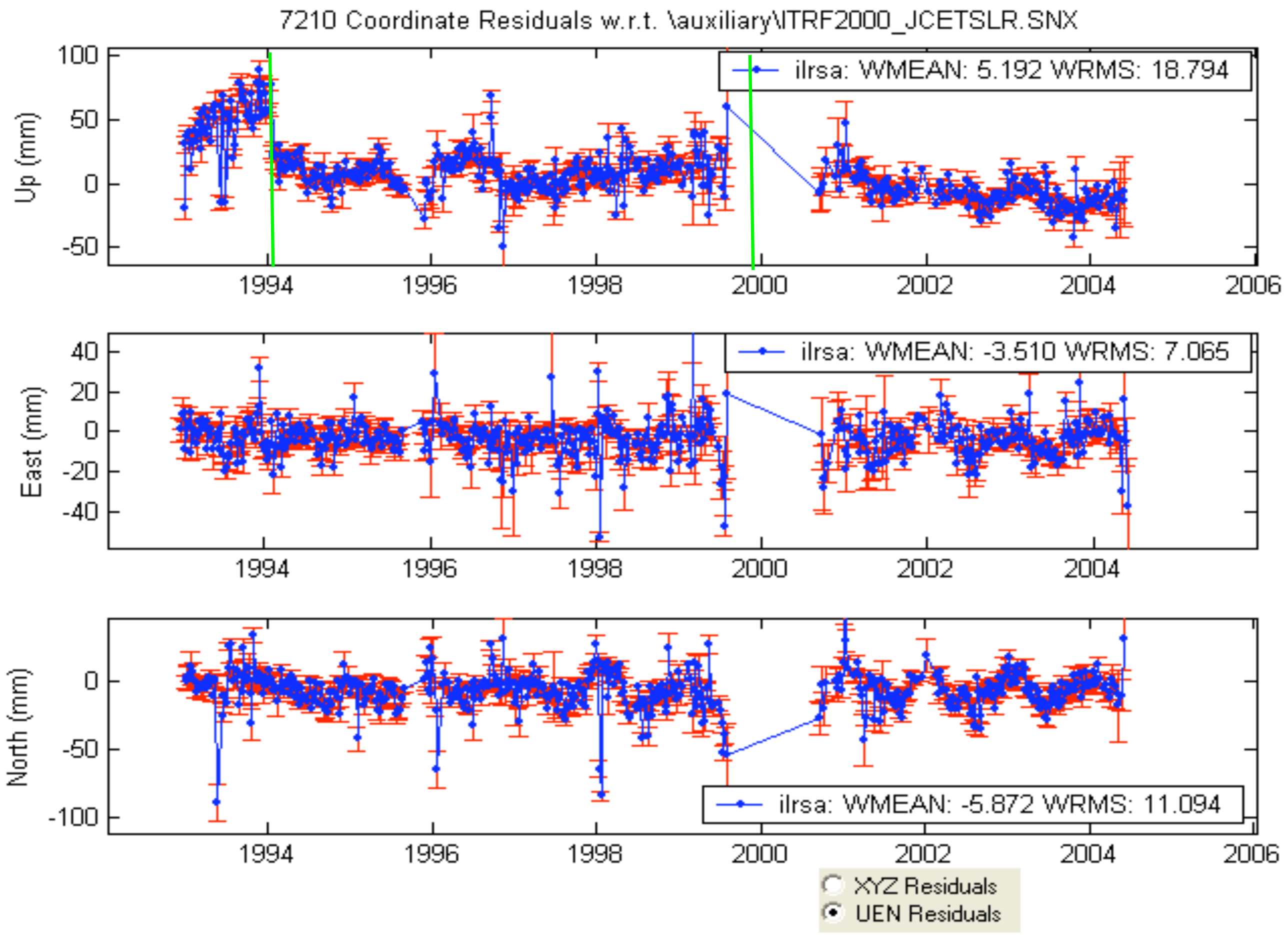
Rivedere le date

Haleakala coordinate time series from ITRF web page



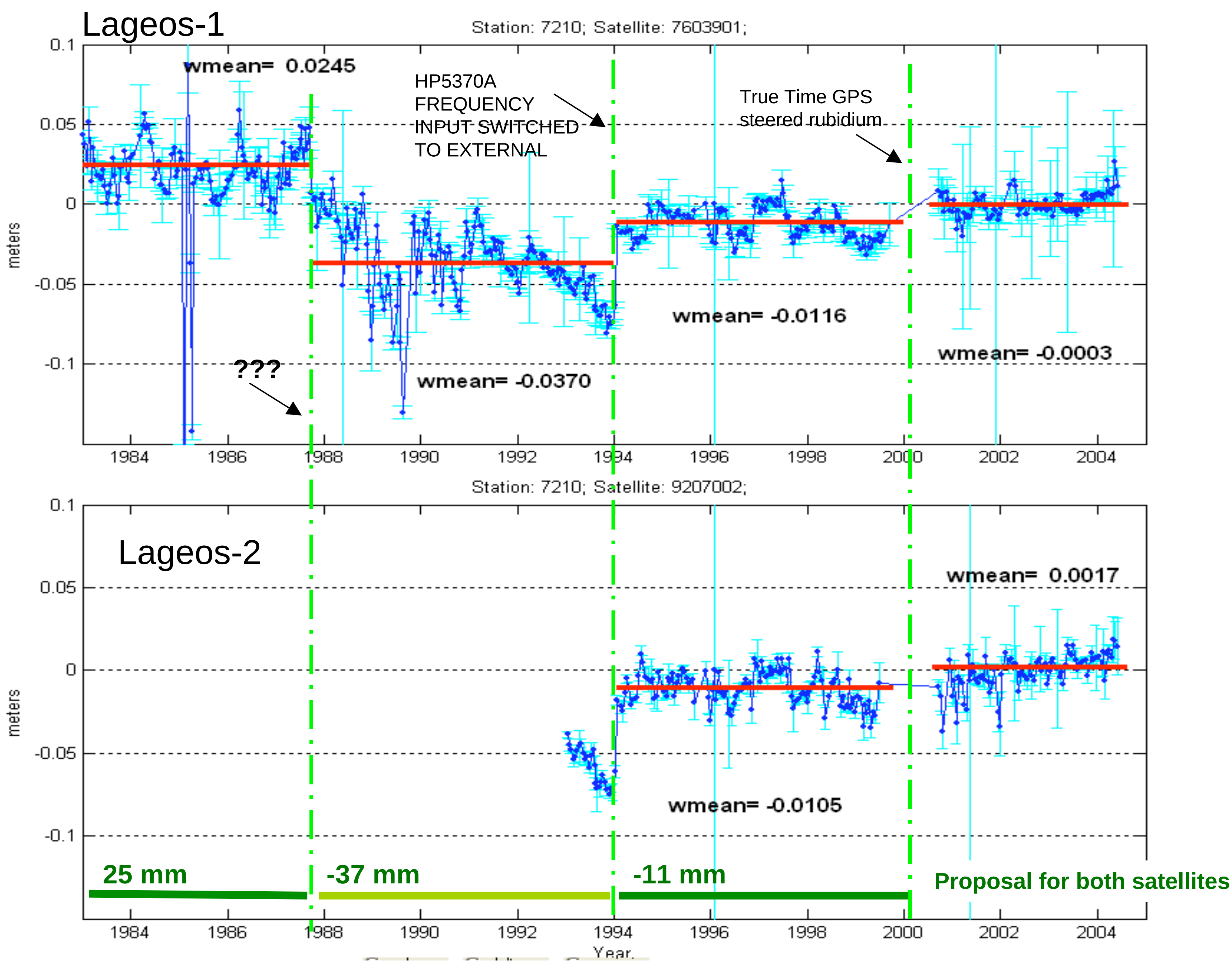
1994:021 HP5370A FREQUENCY INPUT
SWITCHED TO EXTERNAL
1999:233 True Time GPS steered rubidium

Haleakala: ILRSA UEN residuals w.r.t. ITRF2000

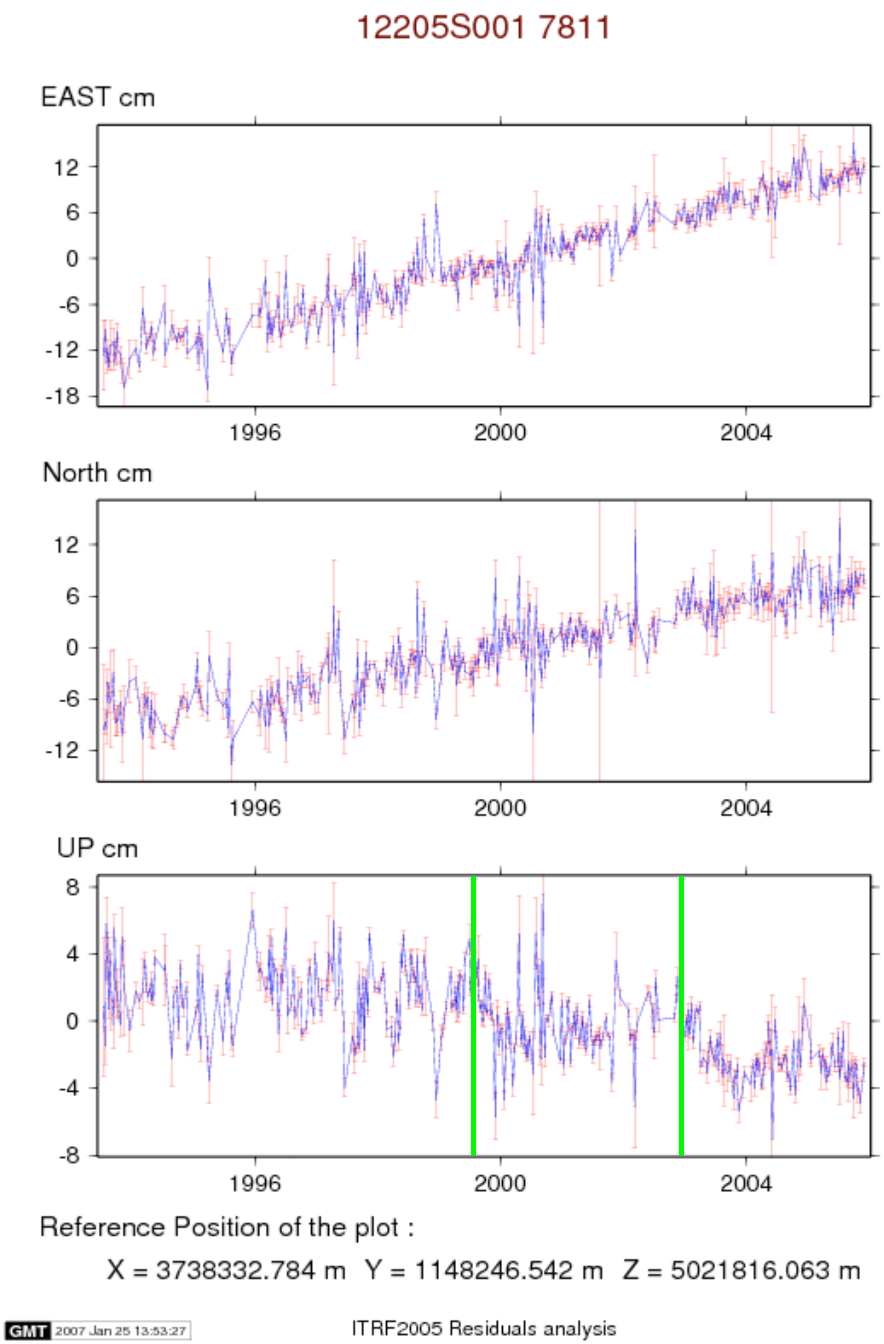


1994:021 HP5370A FREQUENCY INPUT SWITCHED TO EXTERNAL
1999:233 True Time GPS steered rubidium

Haleakala: range residuals from solution CGS2006_new



Borowiec coordinate time series from ITRF web page



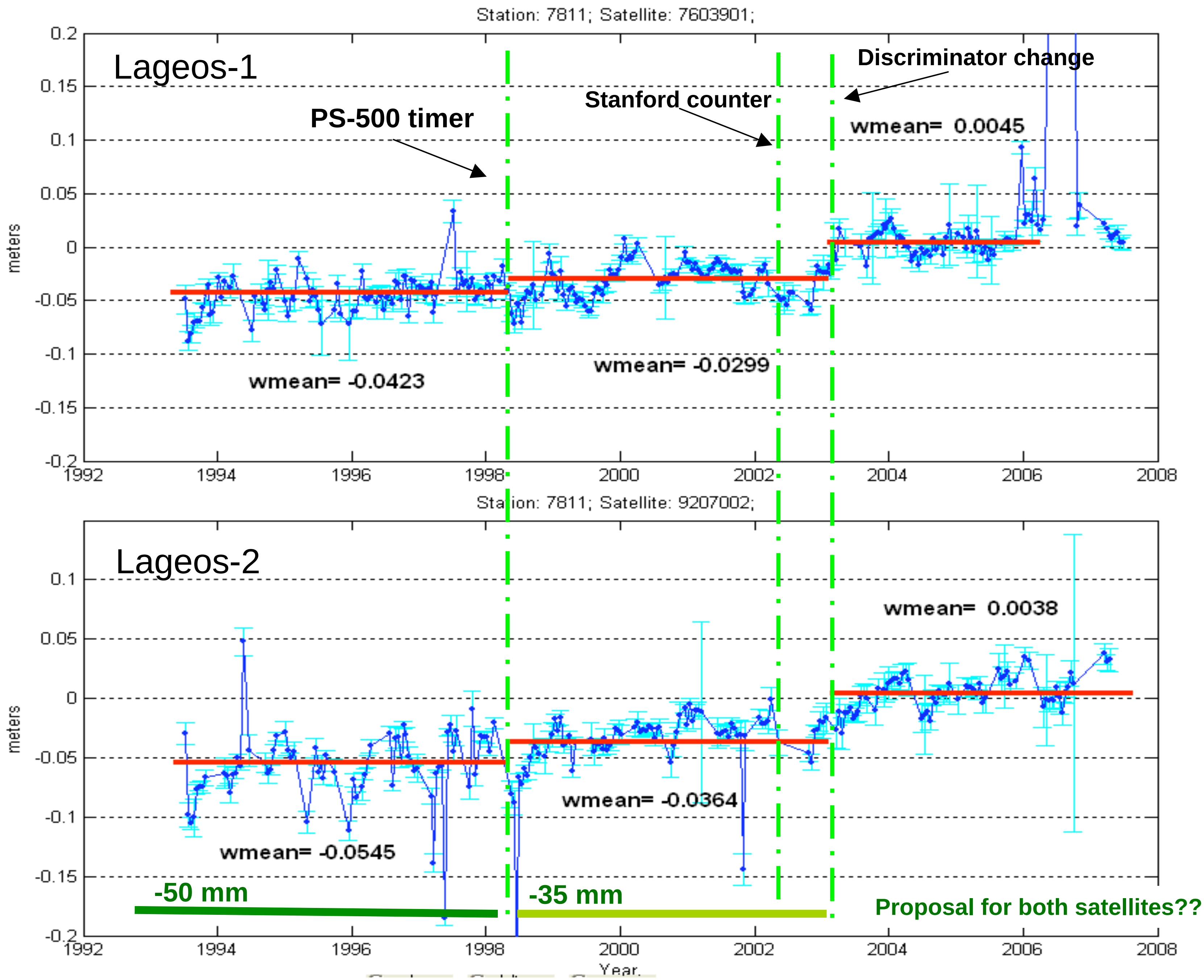
1993:202 Rb-frequency standard for PS-500 Timer (elimination of large range bias!)

1998:139 Time Interval Counter STANFORD SR620 replaced PS-500-2

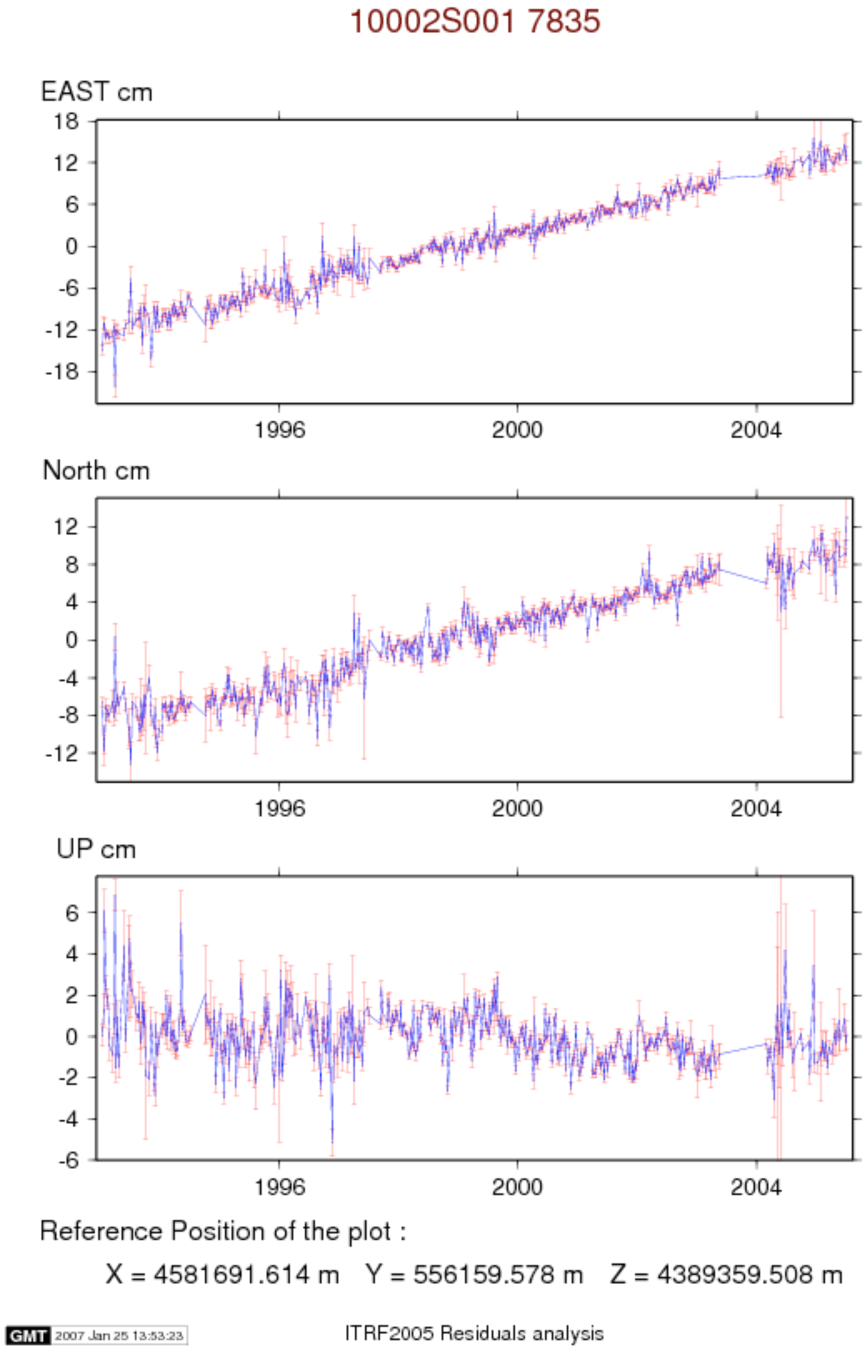
2002:127 Time Interval Counter PS500-2 replaced by STANFORD SR620

2003:088 Discriminator B6 replaced by discriminator TENNELEC TC454 in stop channel

Borowiec: range biases from solution CGS2006_new



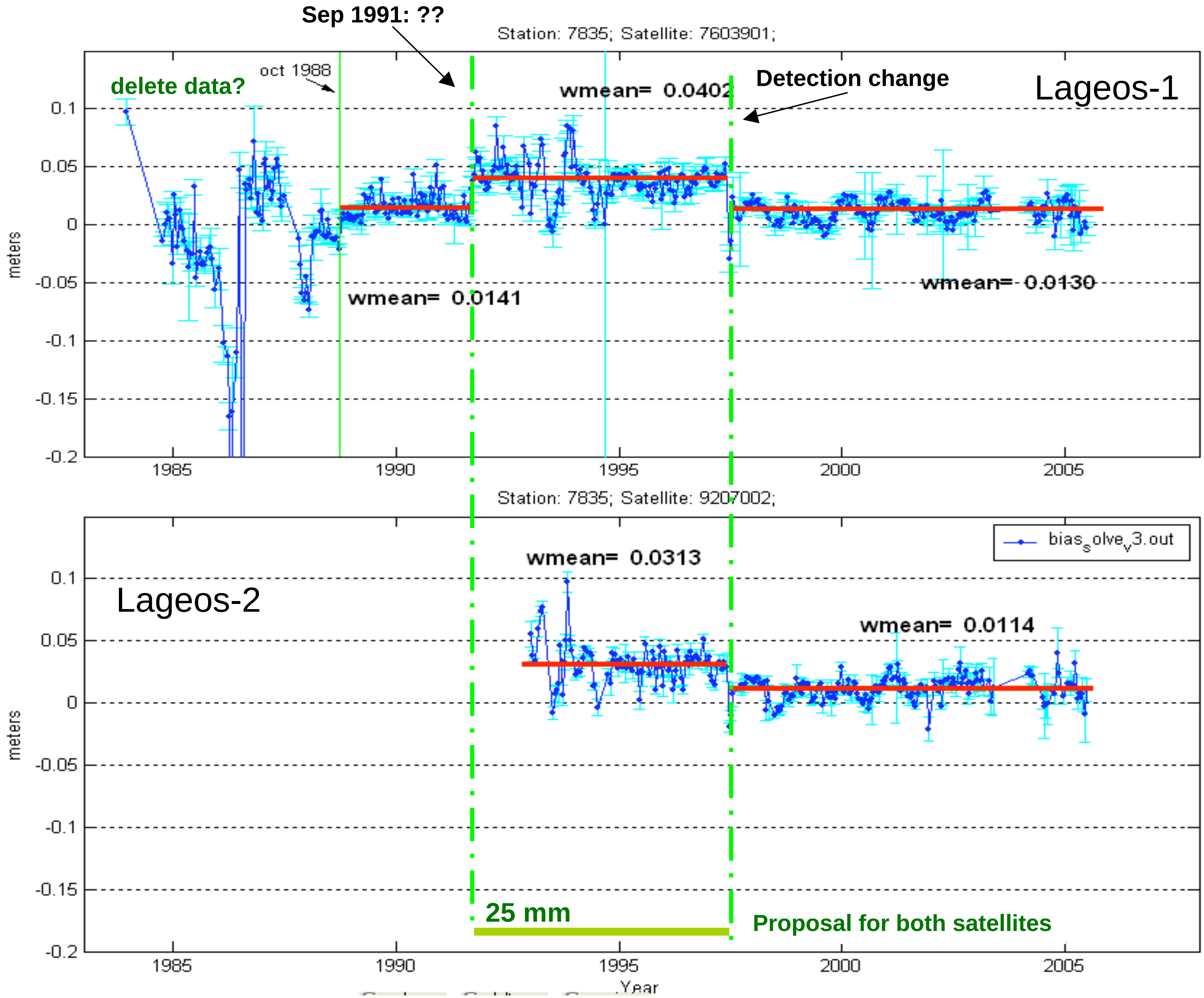
Grasse (7835) coordinate time series from ITRF web page



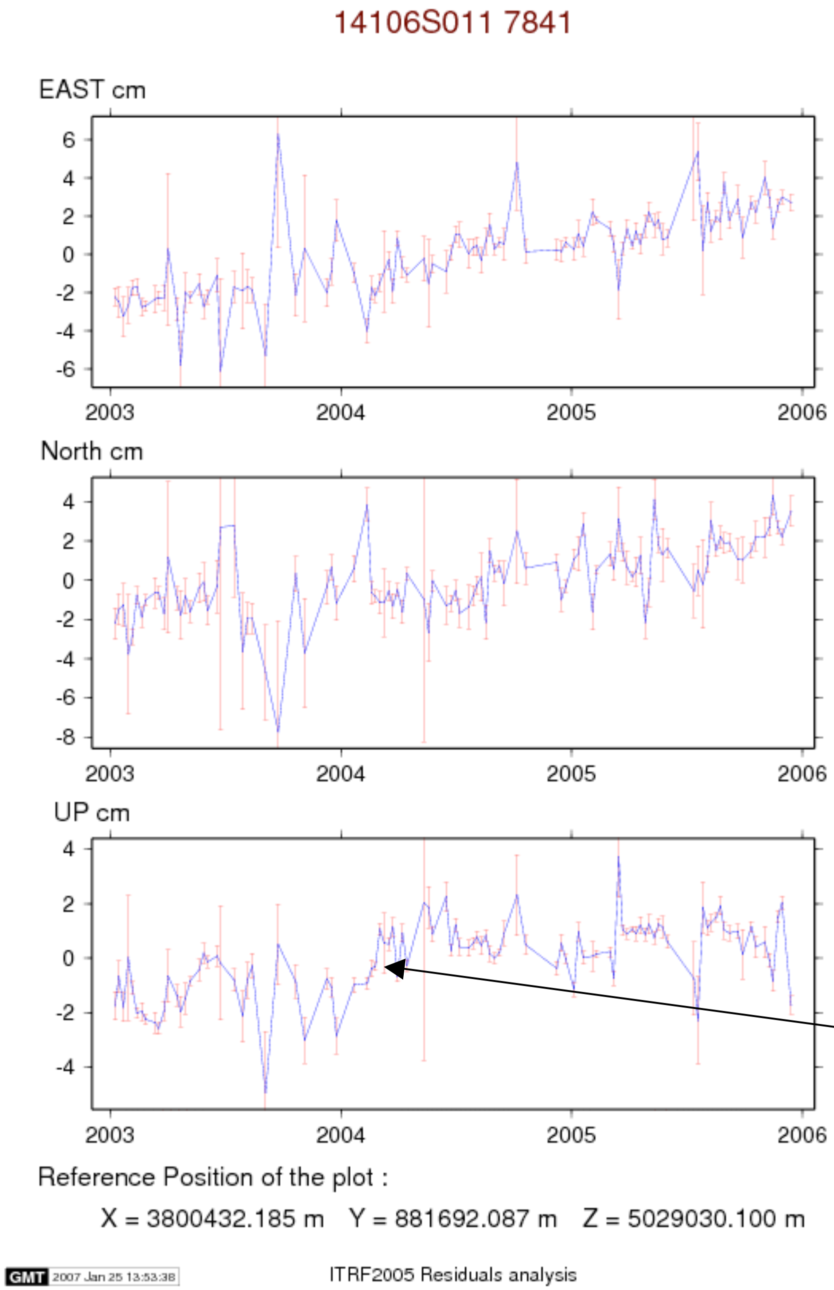
September 8, 1997: new detection package

Grasse: ILRSA UEN residuals w.r.t. ITRF2000

Grasse: range biases from solution CGS2006_new

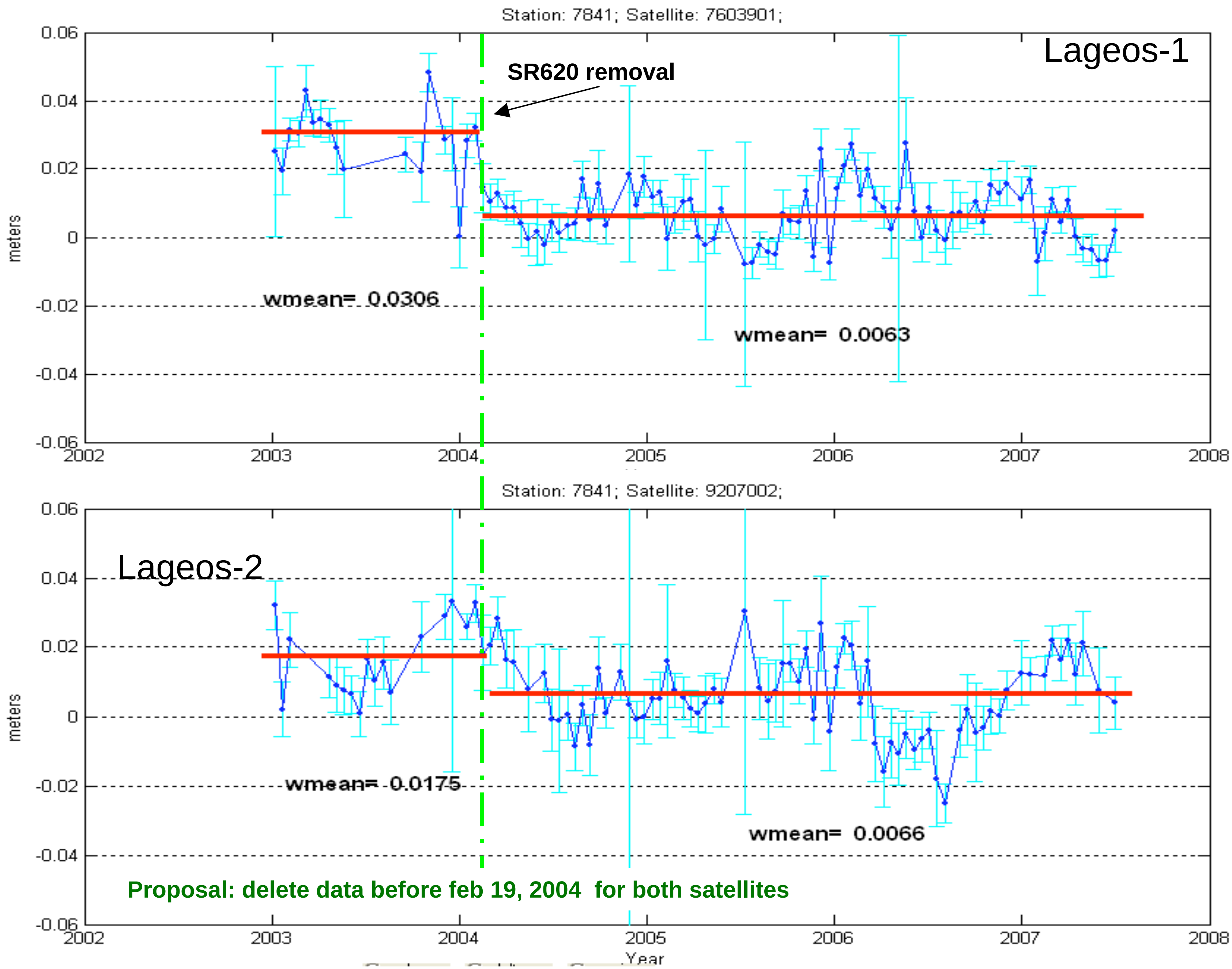


Potsdam coordinate time series from ITRF web page

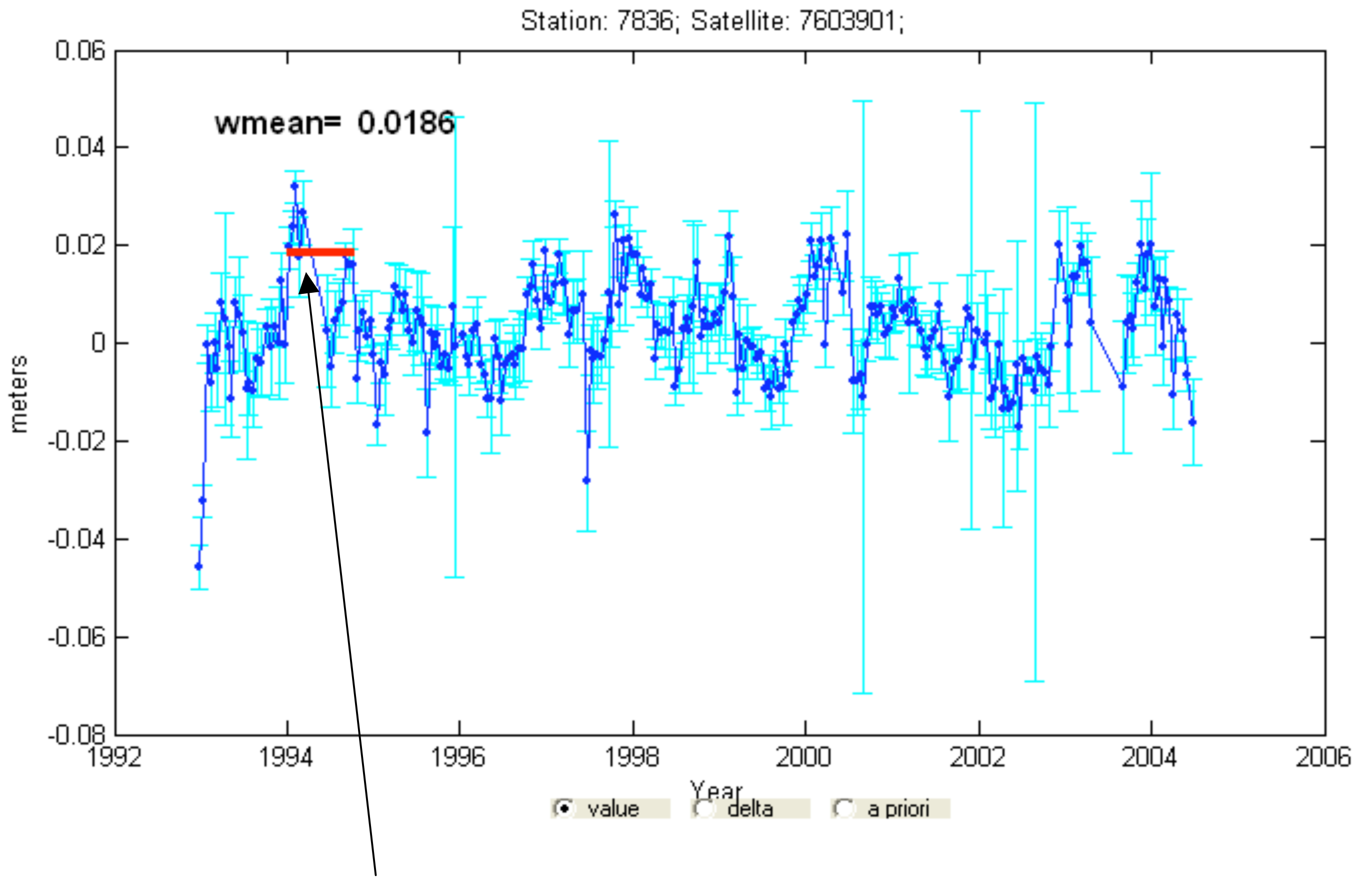


2004:050 A031 Event Timer replacing SR620 time interval counter

Potsdam (7841) : range biases from solution CGS2006_new



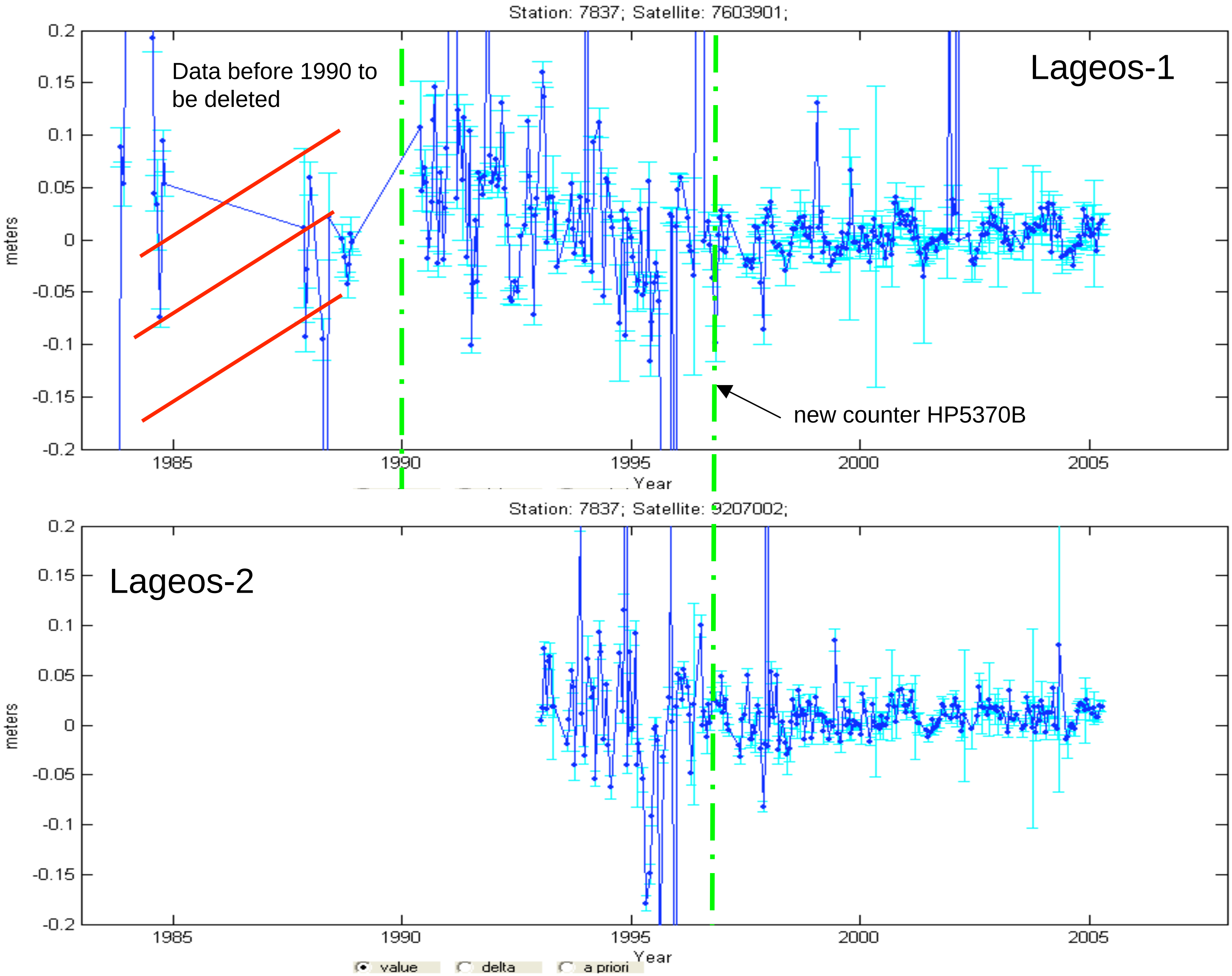
Potsdam (7836) : range biases from solution CGS2006_new



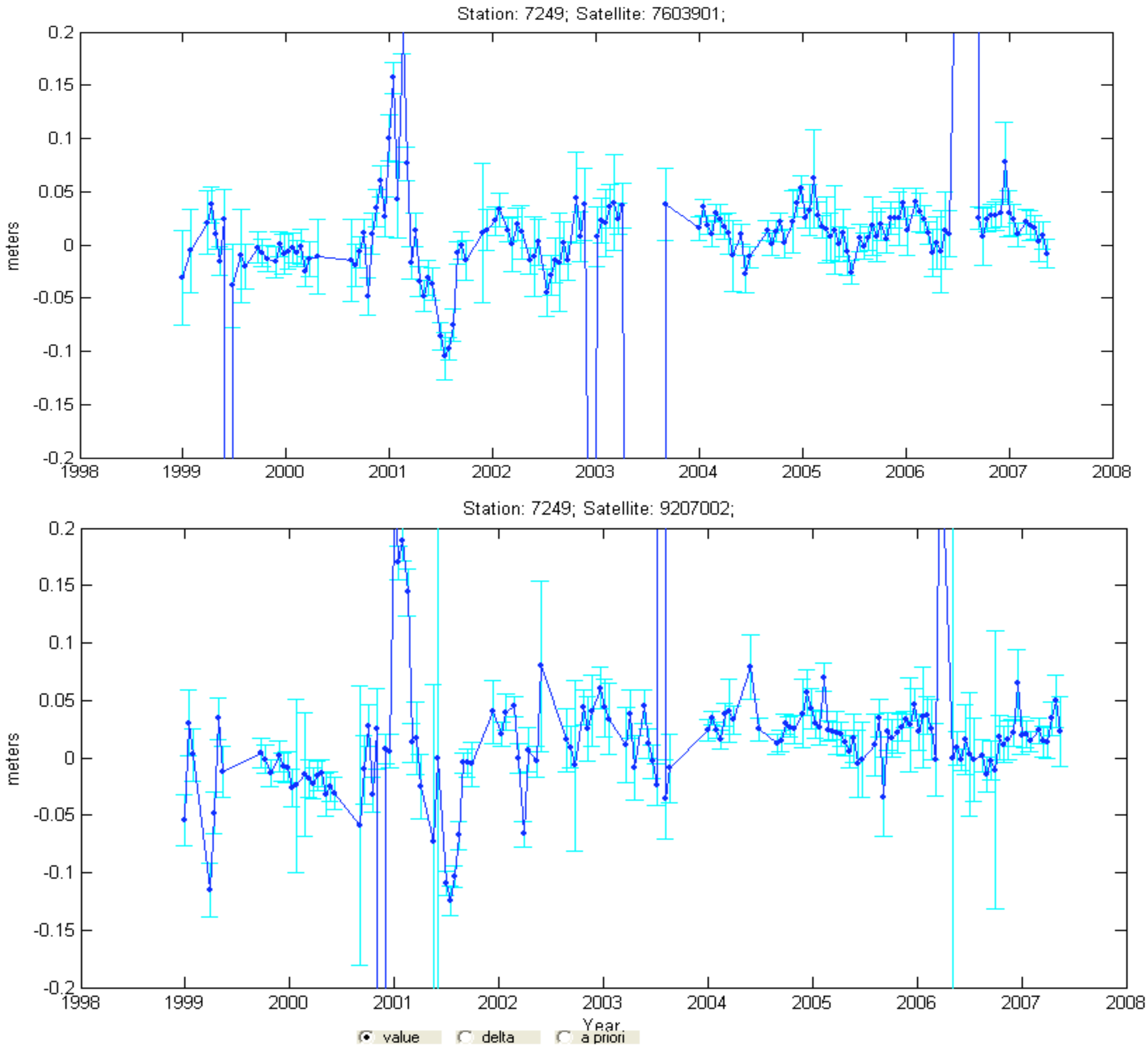
7836 Potsdam data must be corrected by subtracting this value (123 picoseconds) from the two-way laser range: period January 01, 1994 through October 12, 1994.

123 picosec two way = 0.01845 mm

Shanghai : range biases from solution CGS2006_new



Bejing : range biases from solution CGS2006_new



Data before 1999 deleted

Remarks

- Zimmerwald: The jumps in the Lageos-2 bias series are also visible in the coordinate time series: higher correlation with the heights? Biases are roughly aligned to latest estimates.
- Herstmonceux: 8 mm jump at feb 1, 2002 not visible. Jump at feb 2007 still not detectable. Biases from sep 15 1988 to 1993.0 have a drift.
- Wettzell: A bias change appears (~ 1 cm) before the new control system, from the beginning of 2000.0. Biases are aligned to latest estimates.
- Grasse: correction on the data before oct 1988? What happened on sept 1991?
- Potsdam (7841): remove data before feb 19, 2004?
- Platteville (7112): remove data before 1985?

ILRSA "backwards" Combined Solution pre-1993

G. Bianco, C. Sciarretta, V. Luceri

ILRS AWG Meeting, September 24, 2007, Grasse, France

ILRSA “backwards” solution – 1983-92

Status

- ILRSA CCs have been requested to generate the “backwards” combined solution starting from 1983
- The contributing solutions have to be provided as SINEX files, ‘loose’, with 15-day SSC and 3-day EOP estimates.
- At present, a preliminary set of contributing solutions is available from:

ASI, JCET, NSGF, GA

Even if the final solutions will be provided after the agreed ILRS AWG revision on the overall assumptions (e.g. bias), the preliminary solutions are useful to test the combination procedure under more difficult conditions: old solutions are expected to be less accurate and precise, due to the lower number of contributing SLR stations and lower overall data quality.

ILRSA "backwards" solution – 1983-92

Combination procedure test

- In order to give a feedback to the contributing ACs for the final solutions generation, a test combination has been performed on the **1985** SINEX files
- The test combination is necessary also to the CCs to verify if the combination strategy must be modified to take into account the worse quality of the old solutions
- In the test, the loose combination strategy has been relaxed: weak sites and EOP estimates are not pre-eliminated, to keep as much as possible the data information; instead, estimates other than SSC and EOP in the SINEX files are pre-eliminated

ILRSA "backwards" solution – 1983-92

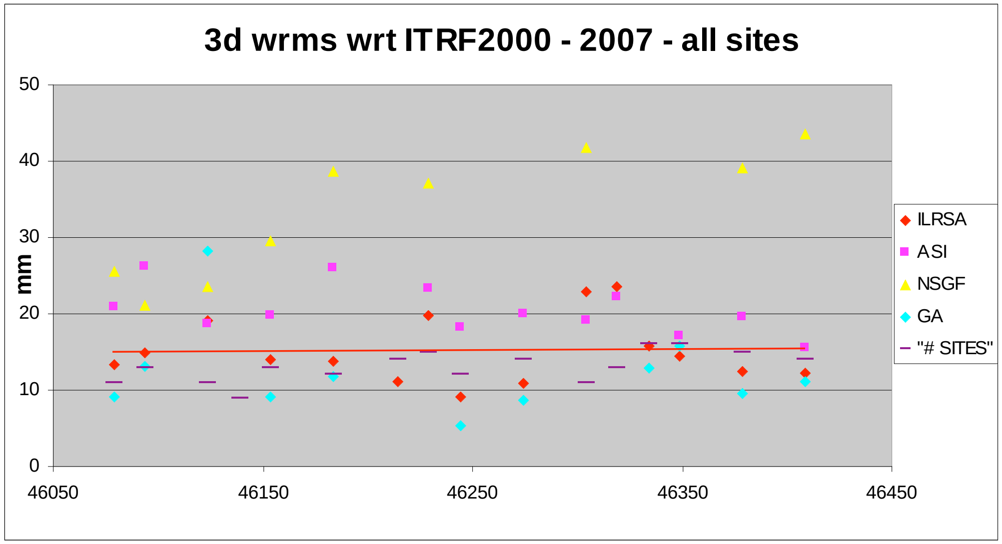
Combination procedure test

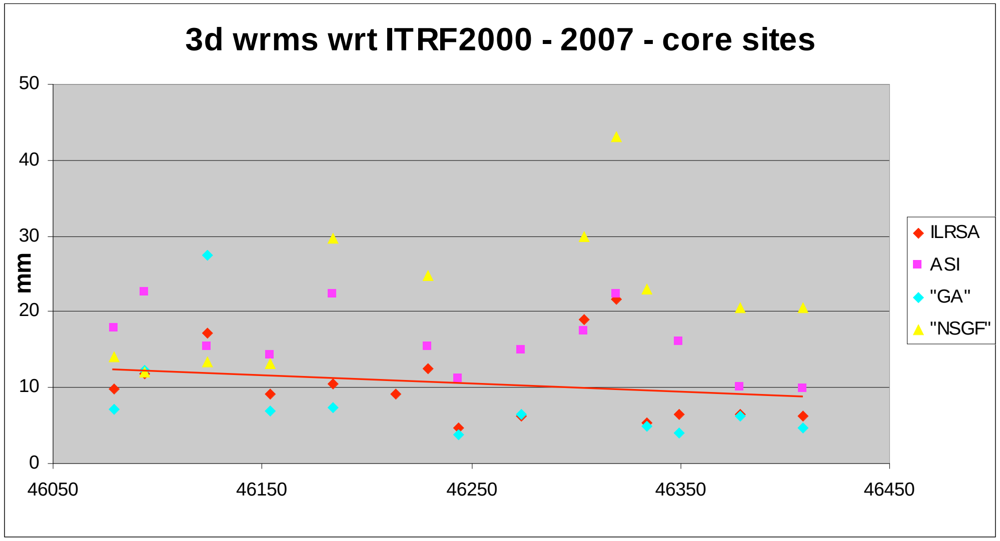
- The ASI CGS combination procedure performs a very rigorous check of the SINEX formalism for each contributing solution: misalignment in the SINEX blocks (e.g. SITE/ID vs SOLUTION/ESTIMATE, incoherent PT code, ...) causes the rejection of the input file
- Outlier rejection strategy in the combination procedure must be carefully revised and adapted to the case of the old solutions: in several cases the combination test failed due to excessive outlier rejection

Only 15 combined solutions out of the possible 24 have been successfully completed, partly due to input files inconsistency and partly to the severe outlier rejection.

The partial results however give several indications.

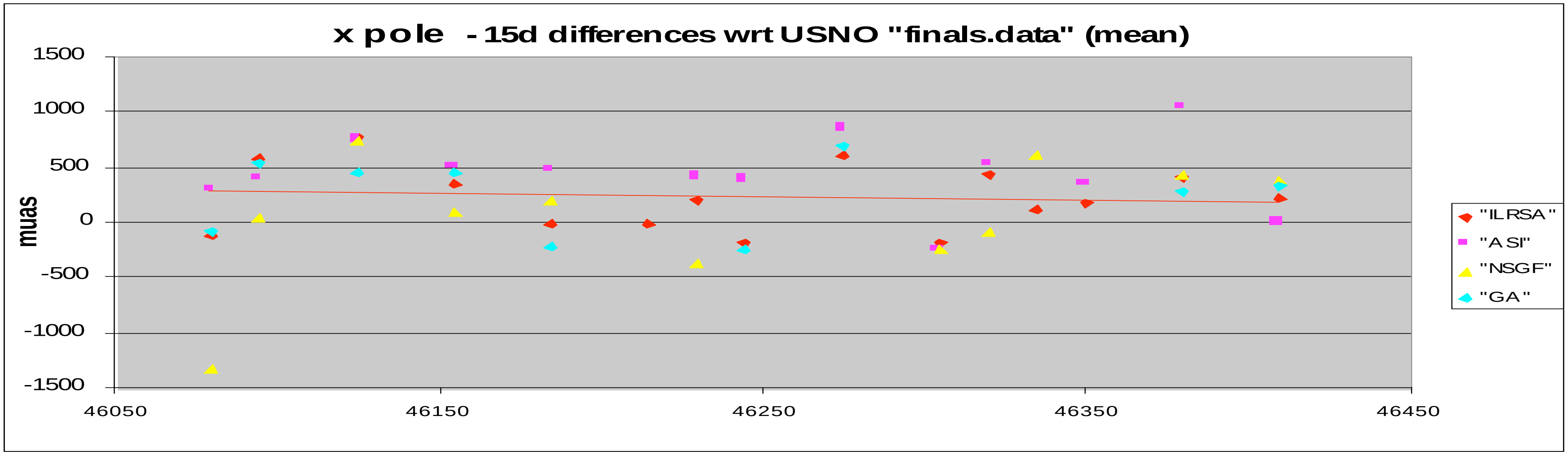
ILRSA “backwards” solution– 3d WRMS

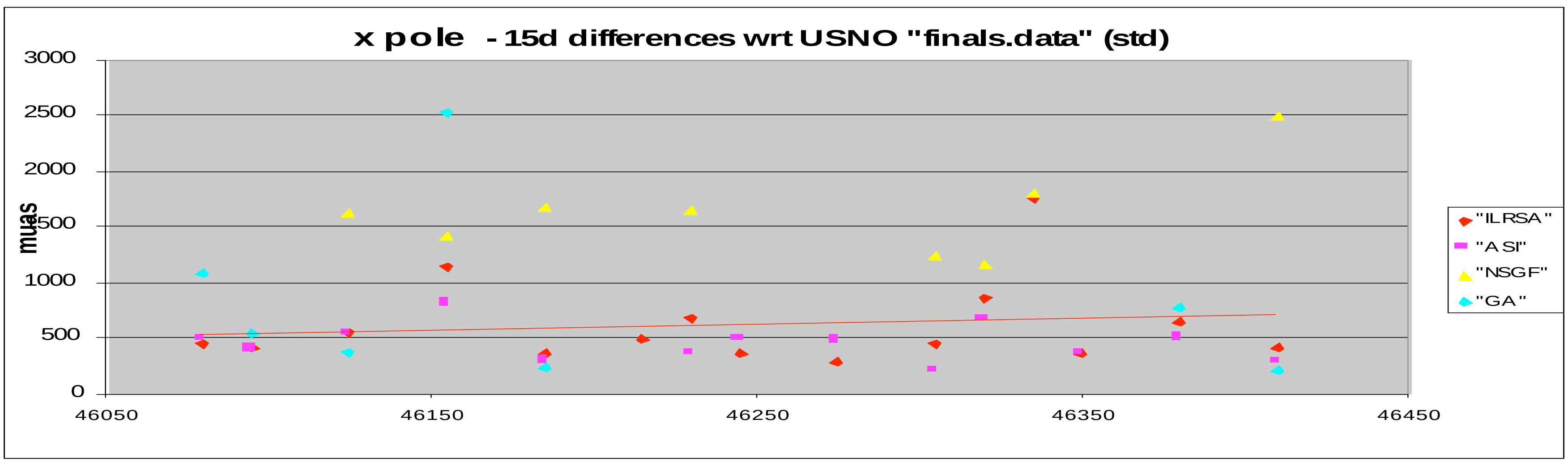




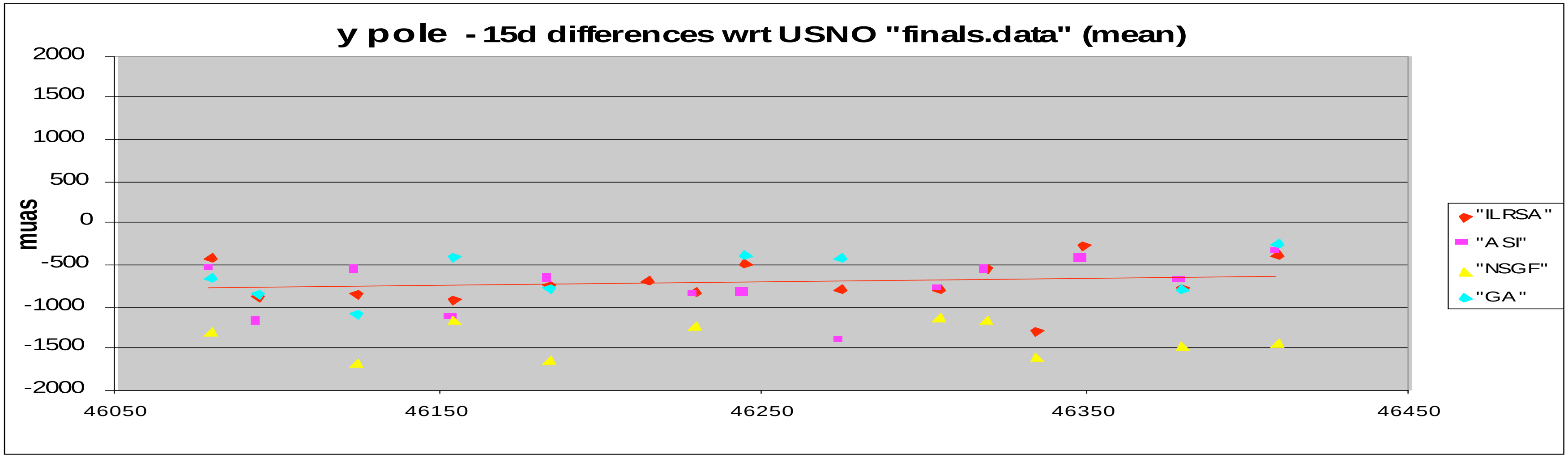
- On average, **13 sites** are included in each 15d combined solution.
- The combined solution gives **15mm level 3d wrms** for all sites and **10mm** level for the **core sites**.
- **GA** shows the best performances (**12mm, 8mm**)
- NSGF seems to be less aligned with ITRF2000 (**38mm, 22mm)**

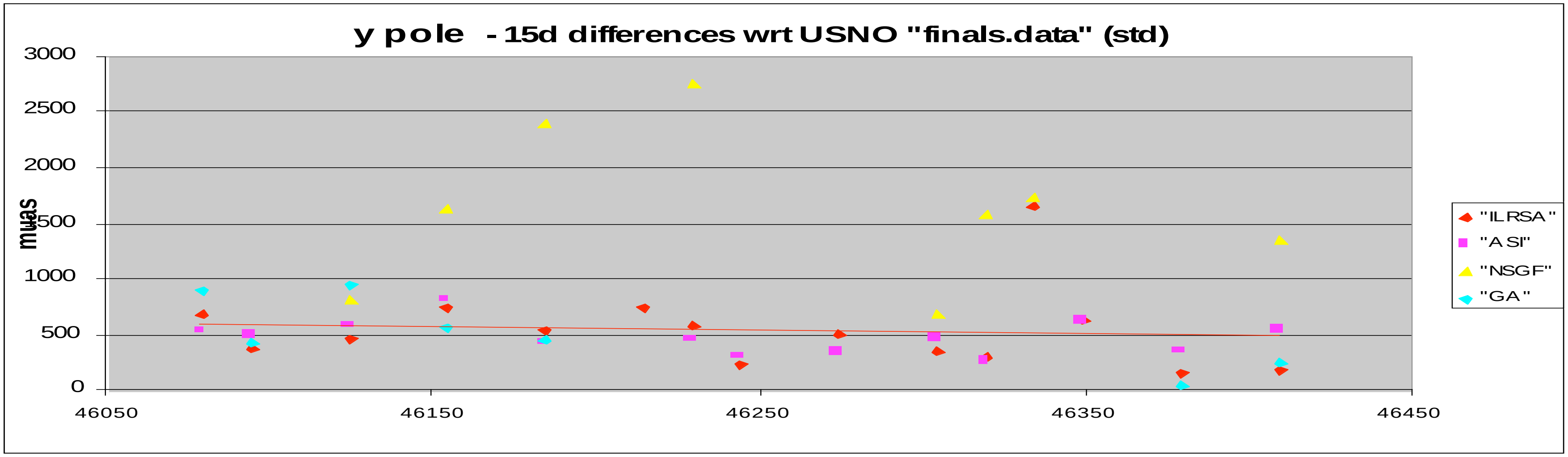
ILRSA “backwards” solution– EOP



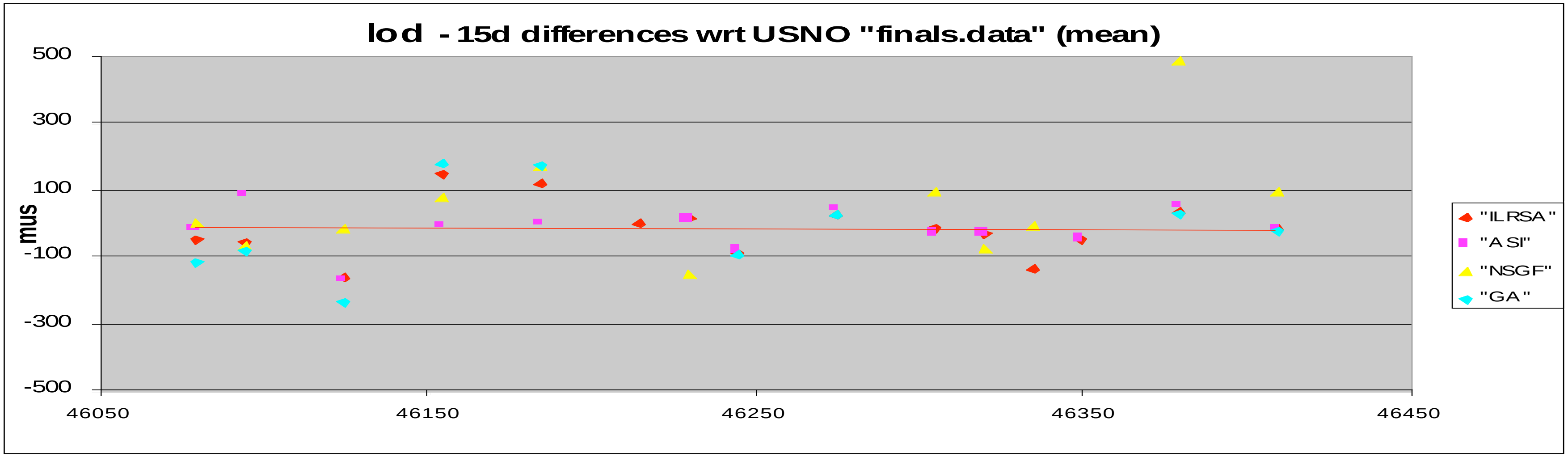


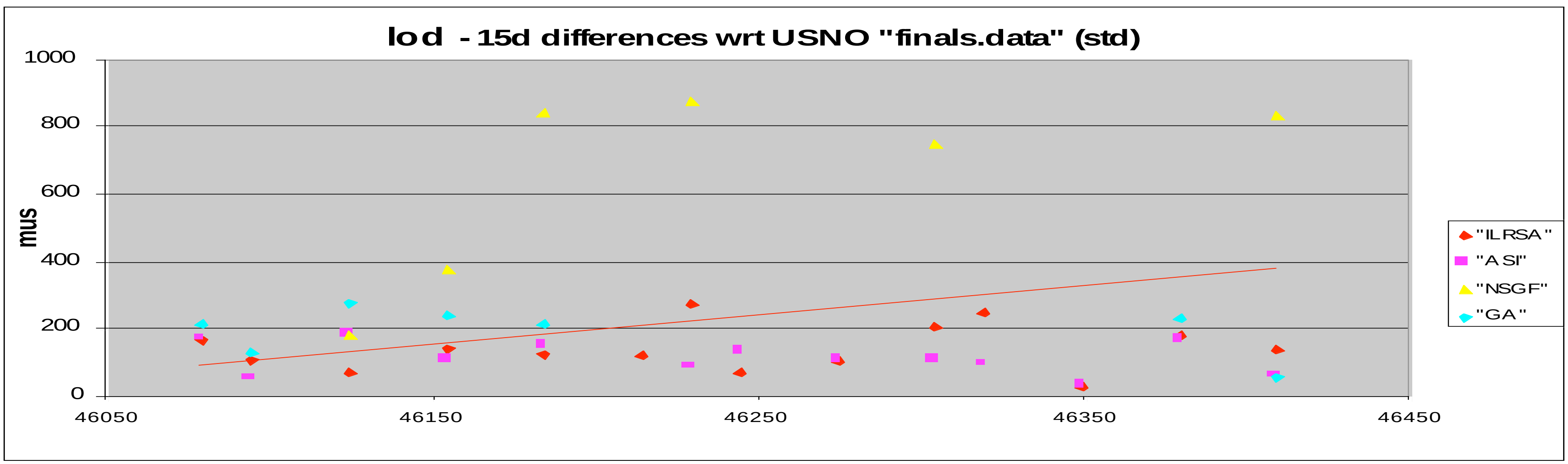
ILRSA “backwards” solution– EOP





ILRSA “backwards” solution– EOP





ILRSA “backwards” solution– EOP

•The table below summarizes the statistics on the EOP residuals w.r.t. USNO finals.data (1 value each 3d) for the **1985** combined solutions (15) and the relevant contributing ones.

•The statistics on EOP residuals from the ILRSA combined solution for the **jan-jun 2007** period are also reported as reference

Solution	X mean µas	X std µas	Y mean µas	Y std µas	LOD mean µs	LOD std µs
ILRSA	231	625	-700	550	-15	238
ASI	449	463	-766	481	-14	114
GA	251	829	-616	520	-14	198
NSGF	51	1640	-1487	1630	59	858
ILRSA jan-jun 07	-240	148	194	132	10	35

ILRSA "backwards" solution
Next Future work

•1983-1992 contributing solutions should be re-issued after conclusive ILRS AWG discussion on assumptions (e.g. bias)

•Contributing solutions are expected in the dedicated, agreed archive folder and with the agreed naming convention (at present, GA is different)

•Careful revision to be performed by ACs on the SINEX formalism, in particular block alignment and coherence and on the analysis strategy if discrepant evidences result from the combination test (1985)

•Individual feedback on specific solution problems given (e.g. JCET)

•Careful analysis of the outliers rejection criteria by ILRSA CC; in particular, specific issues related to the loose combination strategy will be checked

ILRSA Weekly Combined Solution Status Report

G. Bianco, C. Sciarretta

ILRS AWG Meeting, September 24, 2007, Grasse, France

ILRSA solution – Jan/Sep 2007

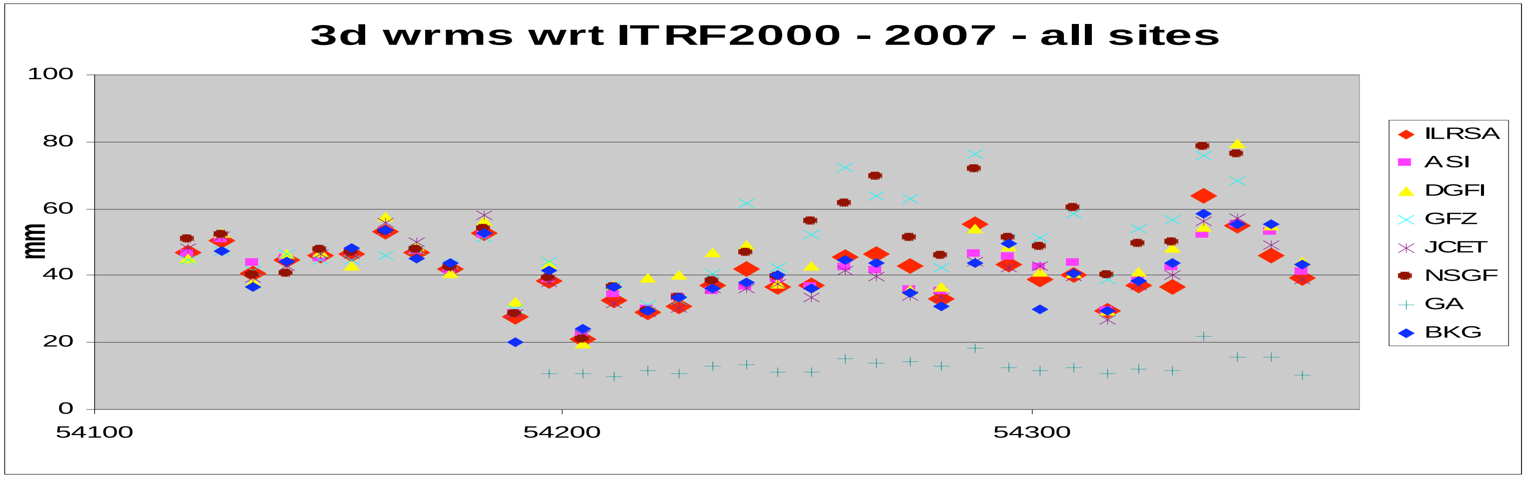
Status

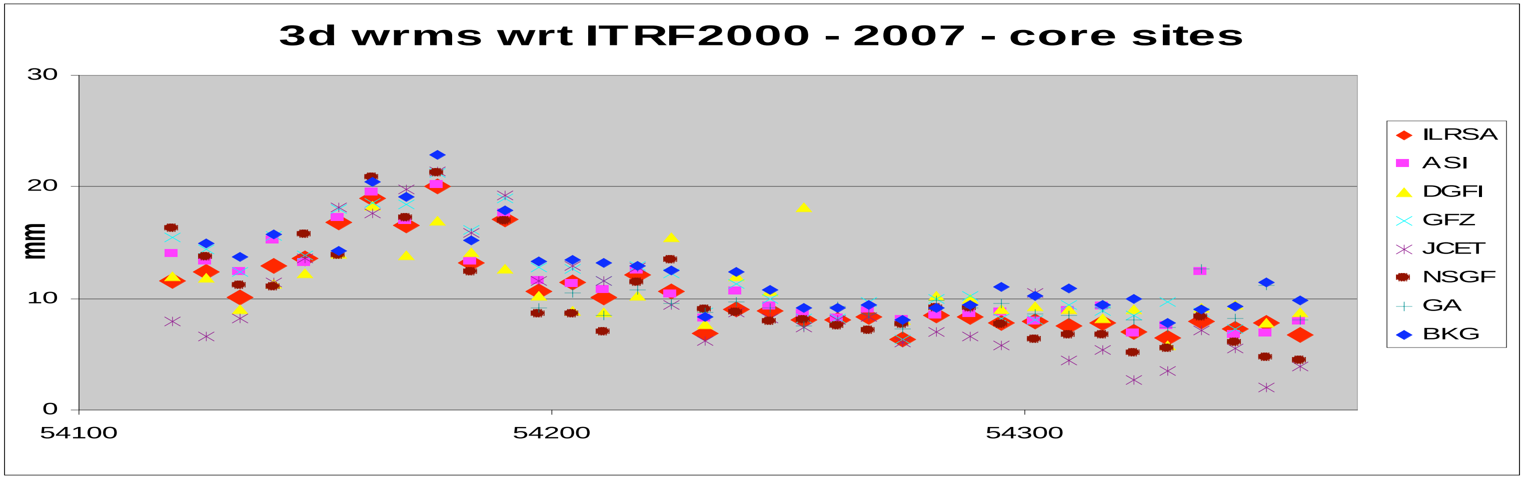
- ILRSA CC performed the combination activities in a nominal way
- The contributing solutions and the derived combination are still compared to ITRF2000 for SSC
- The contributing solutions and the derived combination are compared to “finals.daily” USNO values; they have been aligned to ITRF2005 since 14 June 2007: it causes visible bias in the residual series, as described by the USNO note n.24
- GA solution routinely ‘in’ since 070404
- 7941 excluded form core sites (to frame in ITRF2000) since 070411:

  apriori SSC/SSV to be updated

- No major criticality has been found in the 2007 solutions

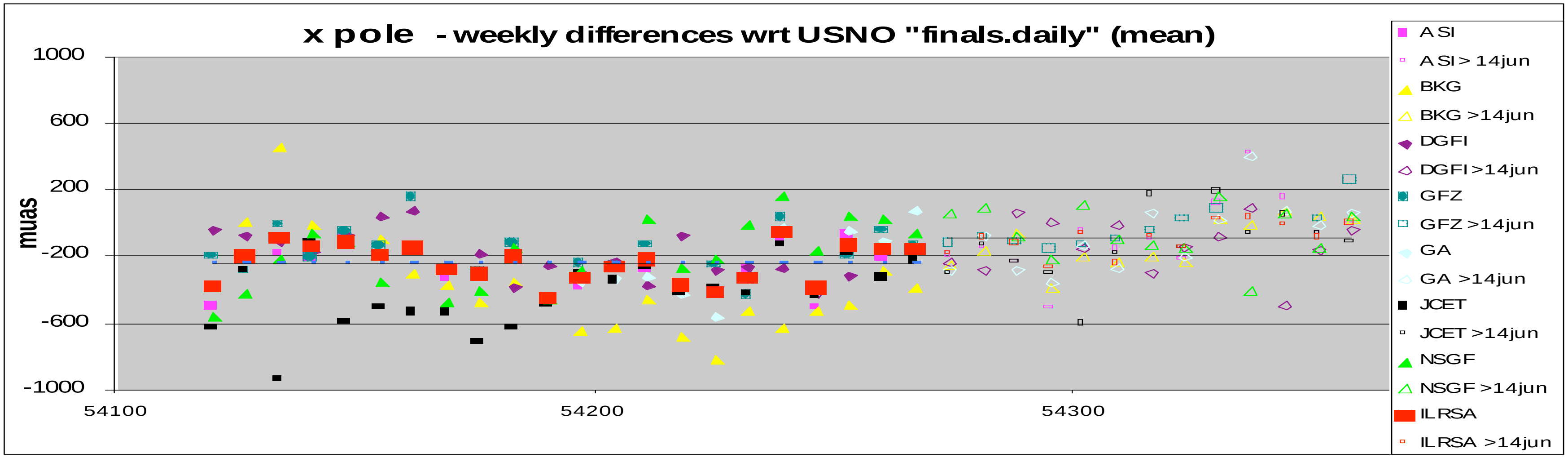
ILRSA solution – 3d WRMS

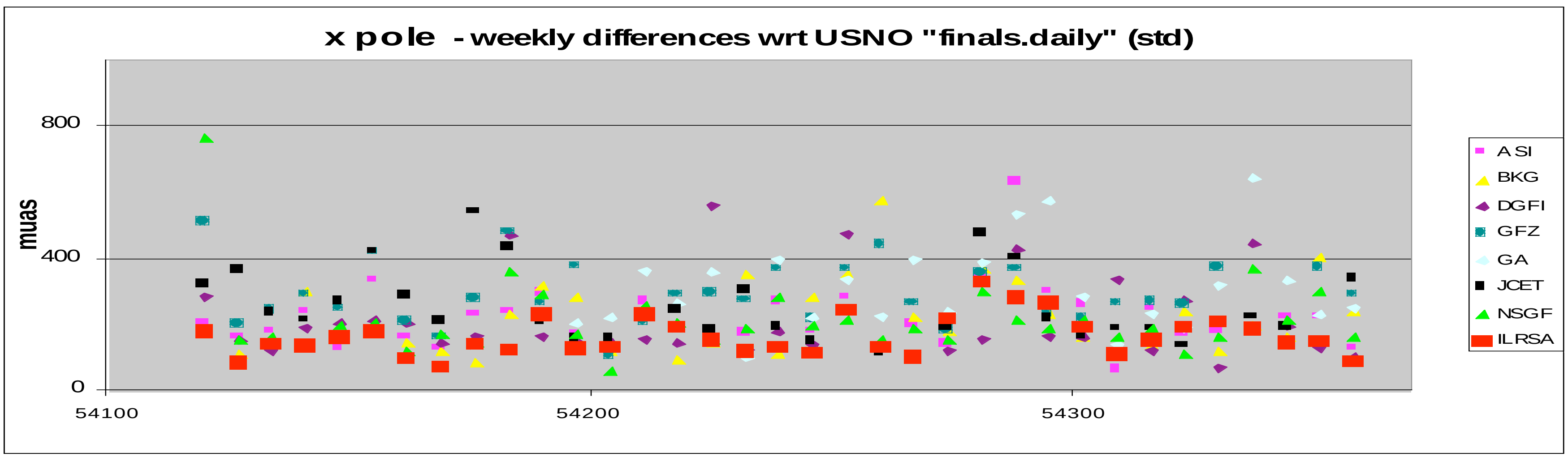




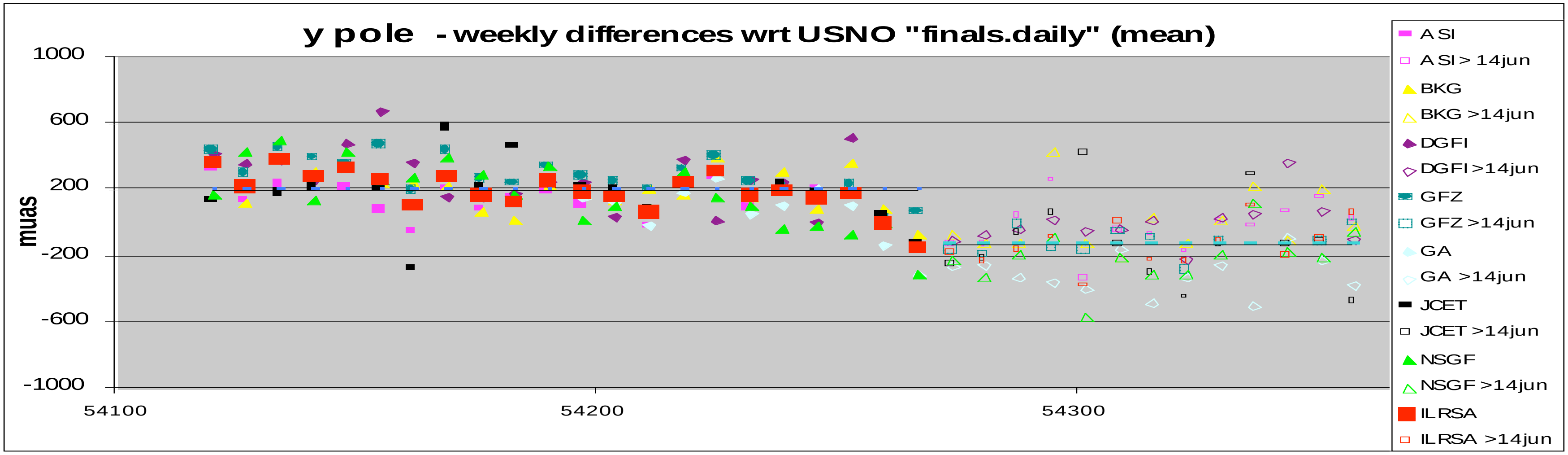
070404

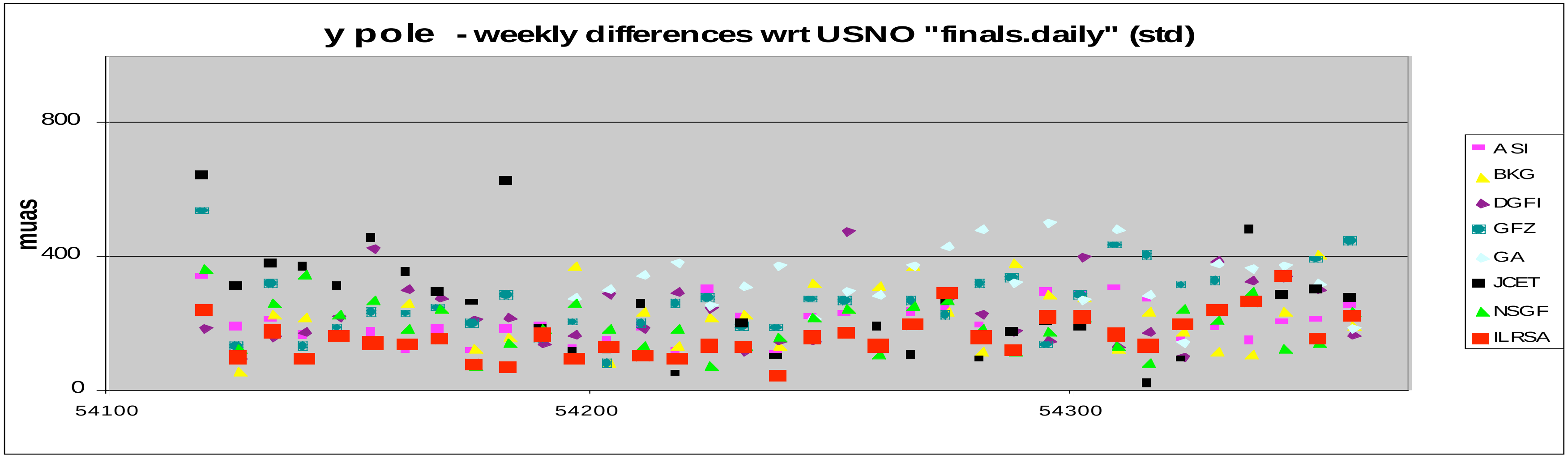
ILRSA solution – EOPs



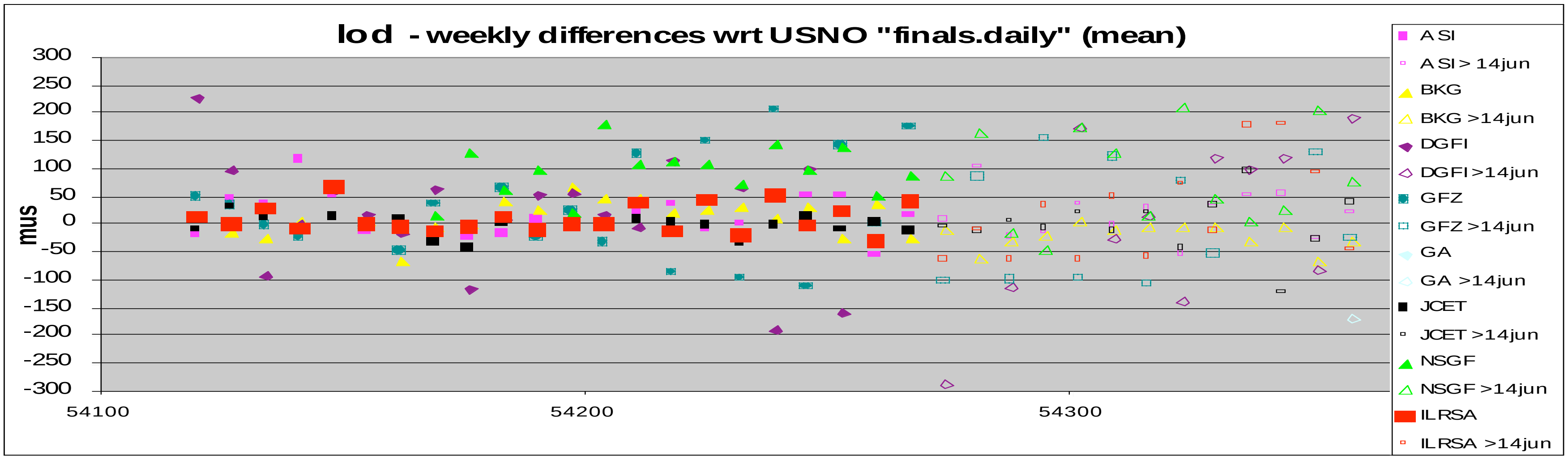


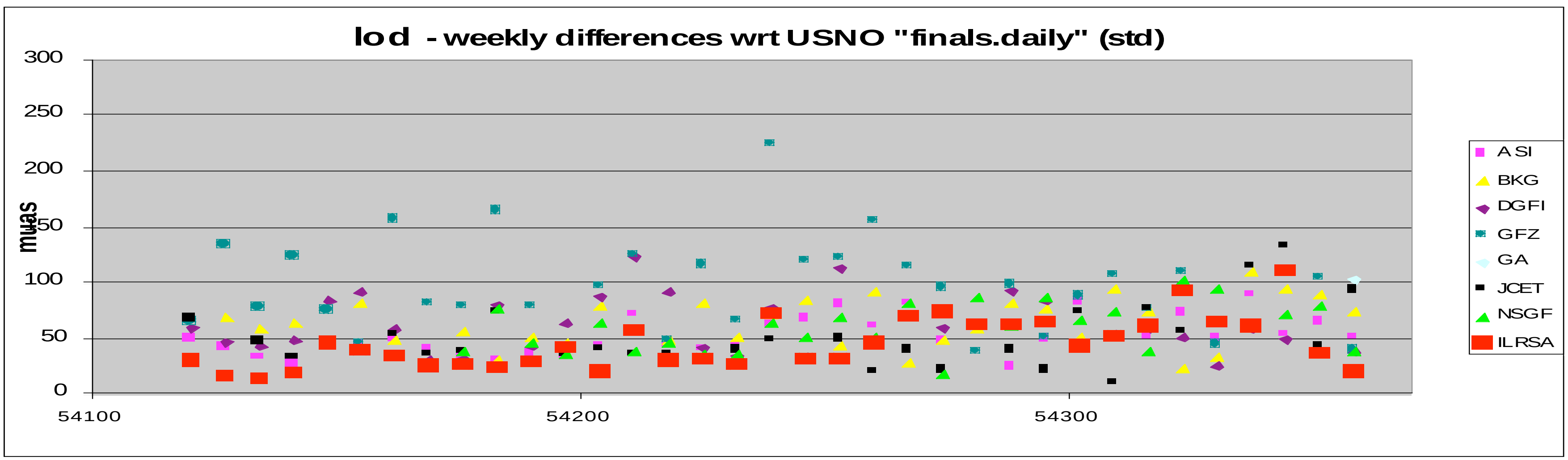
ILRSA solution – EOPs



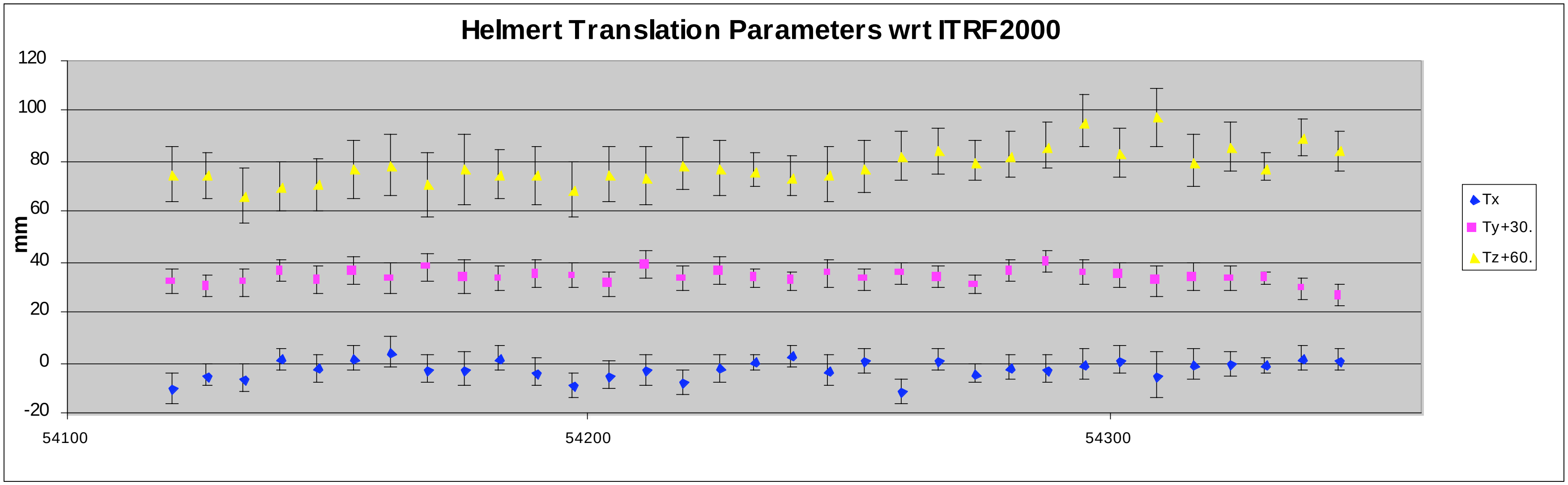


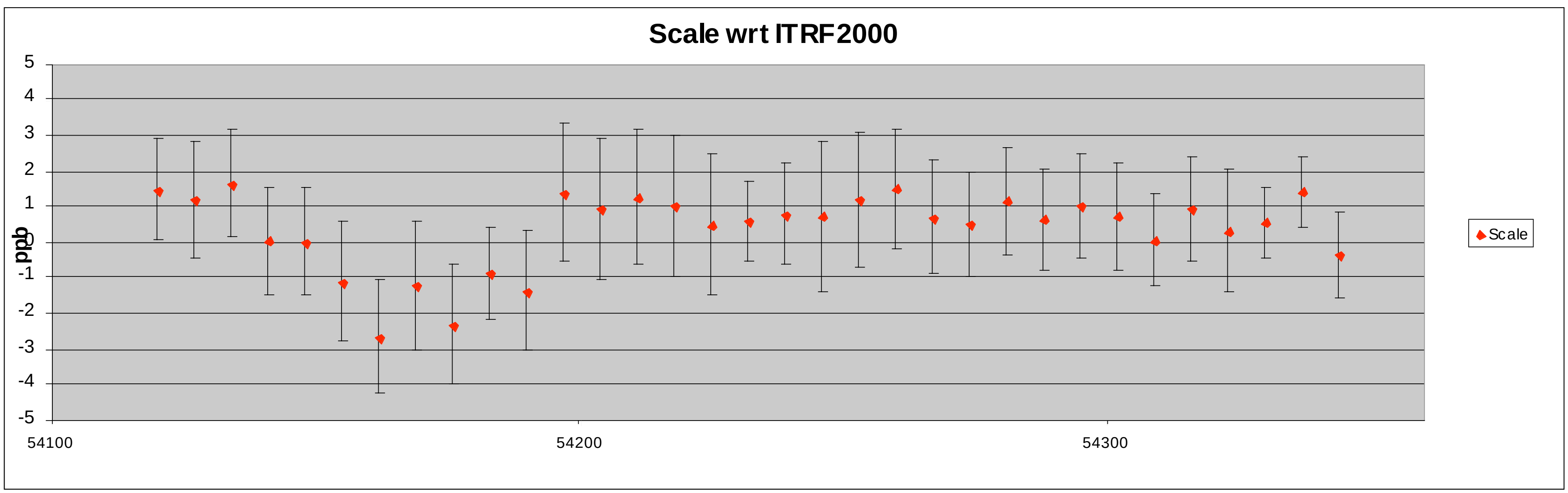
ILRSA solution – EOPs





ILRSA solution – Helmert Parameters





ILRSA solution – Conclusive statements

Remarks

- The performance indicators show the expected good agreement of the combined solution w.r.t. the references (e.g. 1cm level 3d wrms for ITRF2000 residuals, core sites)
- The contributing solutions show an overall high-level behavior; ACs may check their individual performance from the weekly reports.

Future activities

- Inclusion of new AC contributions (e.g. OCA-GRGS)
- Alignment to ITRF2005

Status of ILRSB

Rainer Kelm
Deutsches Geodätisches Forschungsinstitut

Actual combination

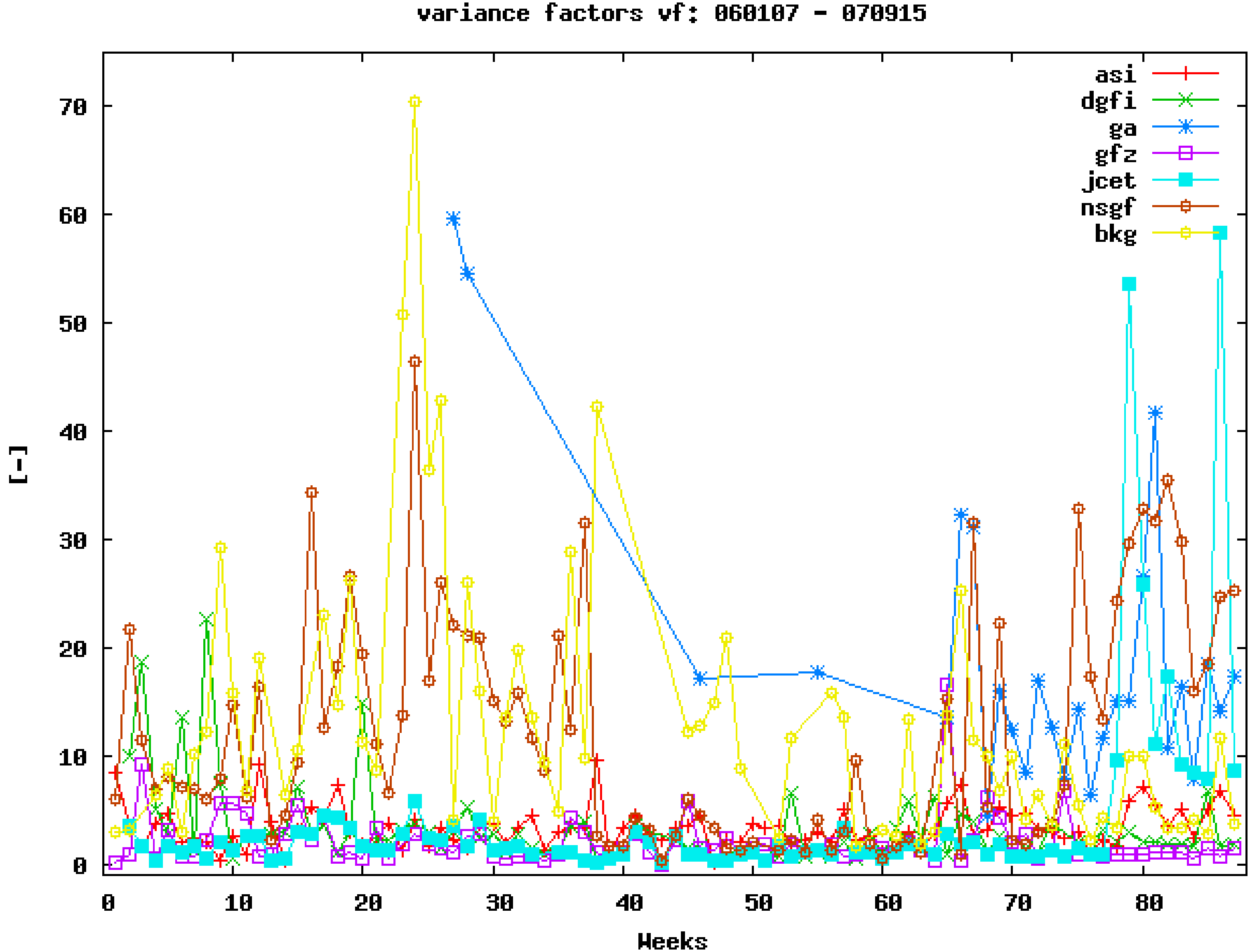
Analysis 1983 -1992

Reanalysis 1993 -2007

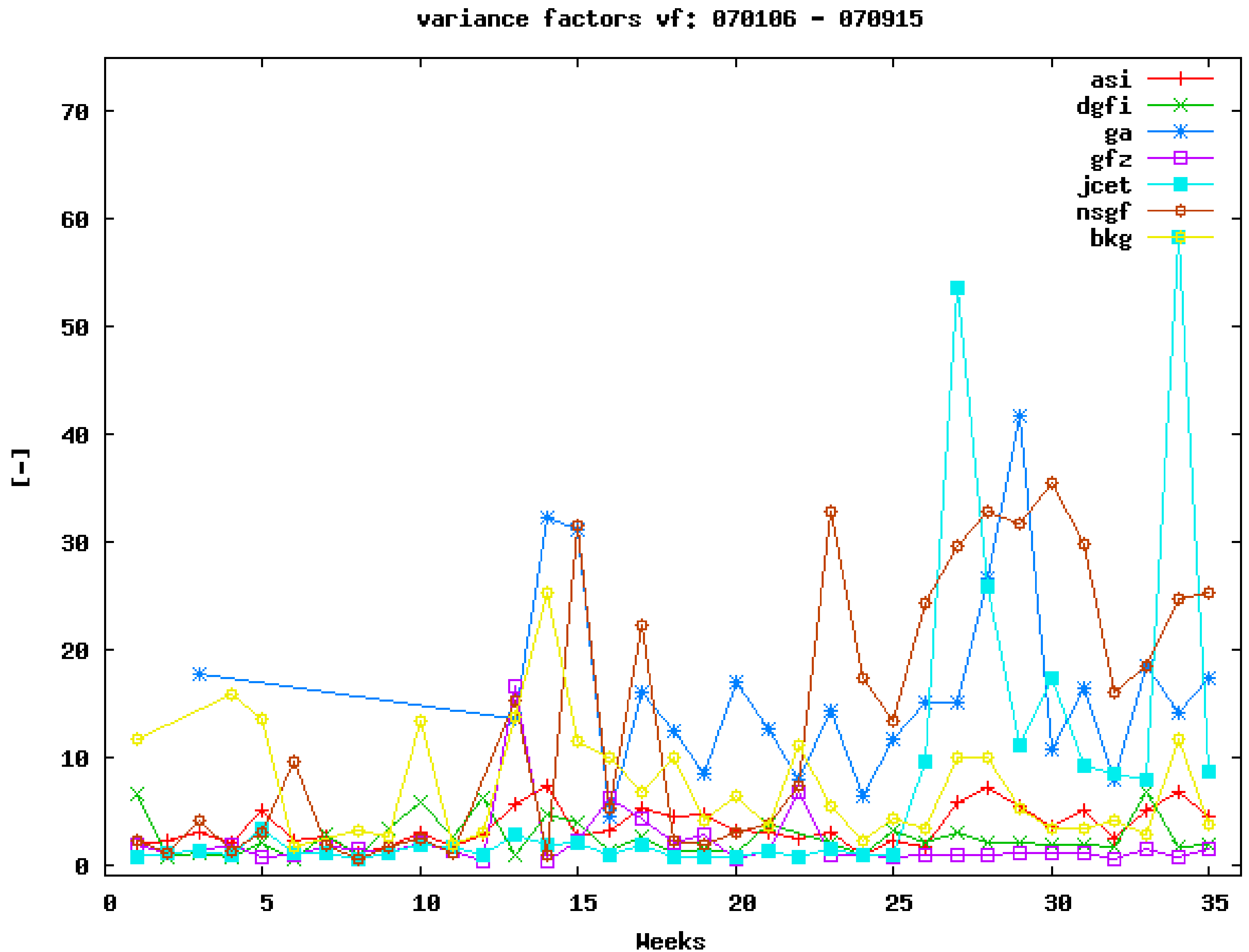
Daily Combination

SP3C

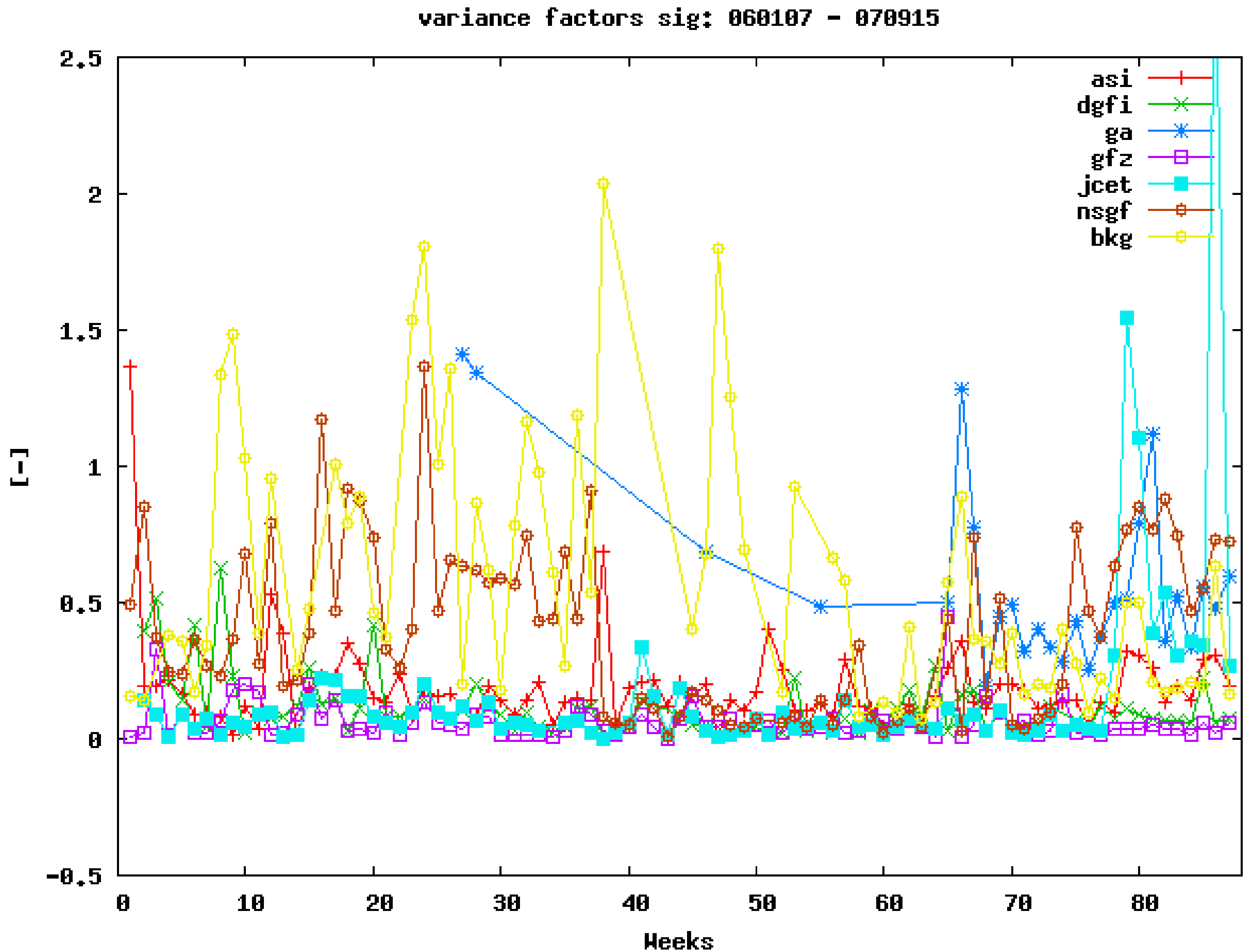
Actual combination (1)



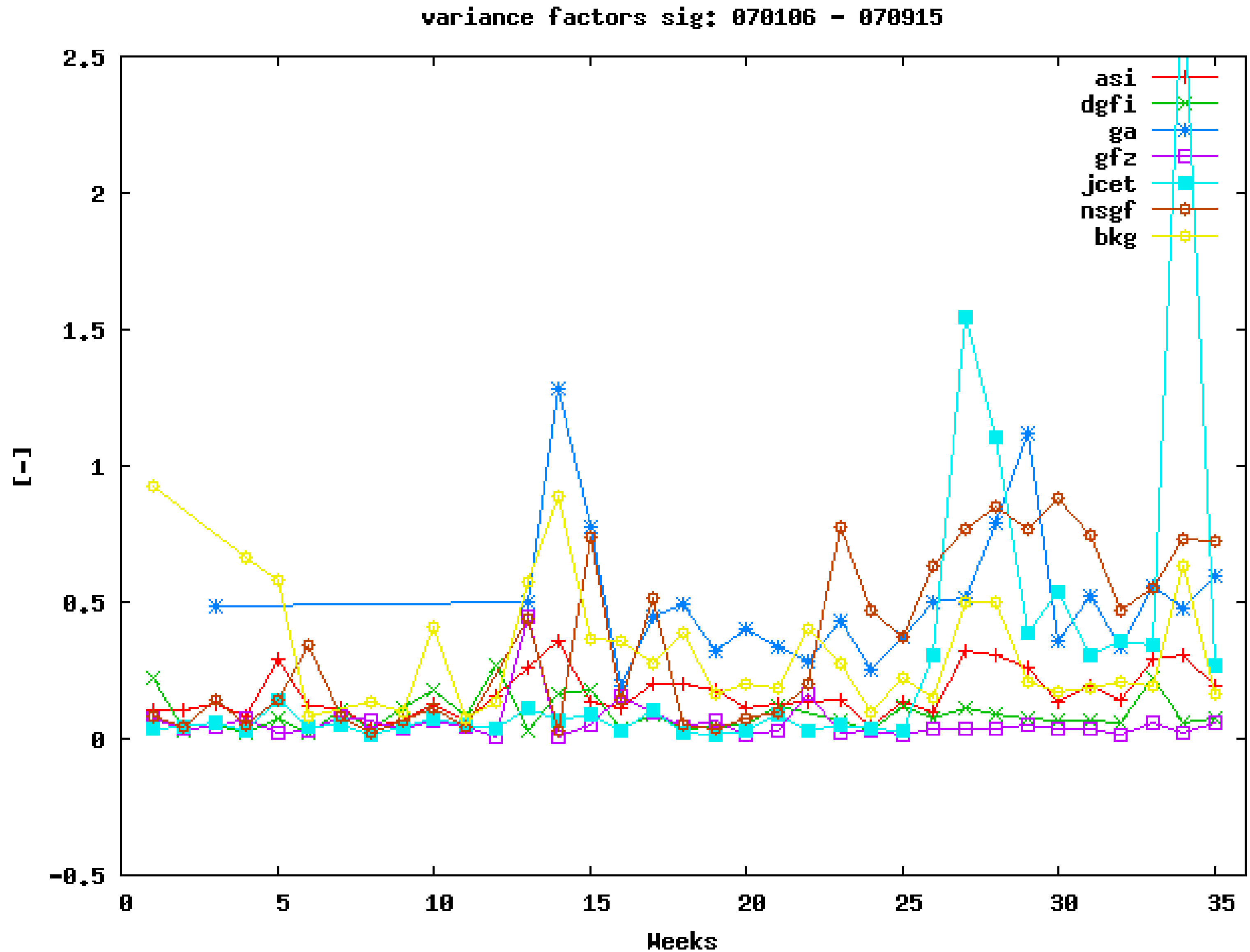
Actual combination (2)



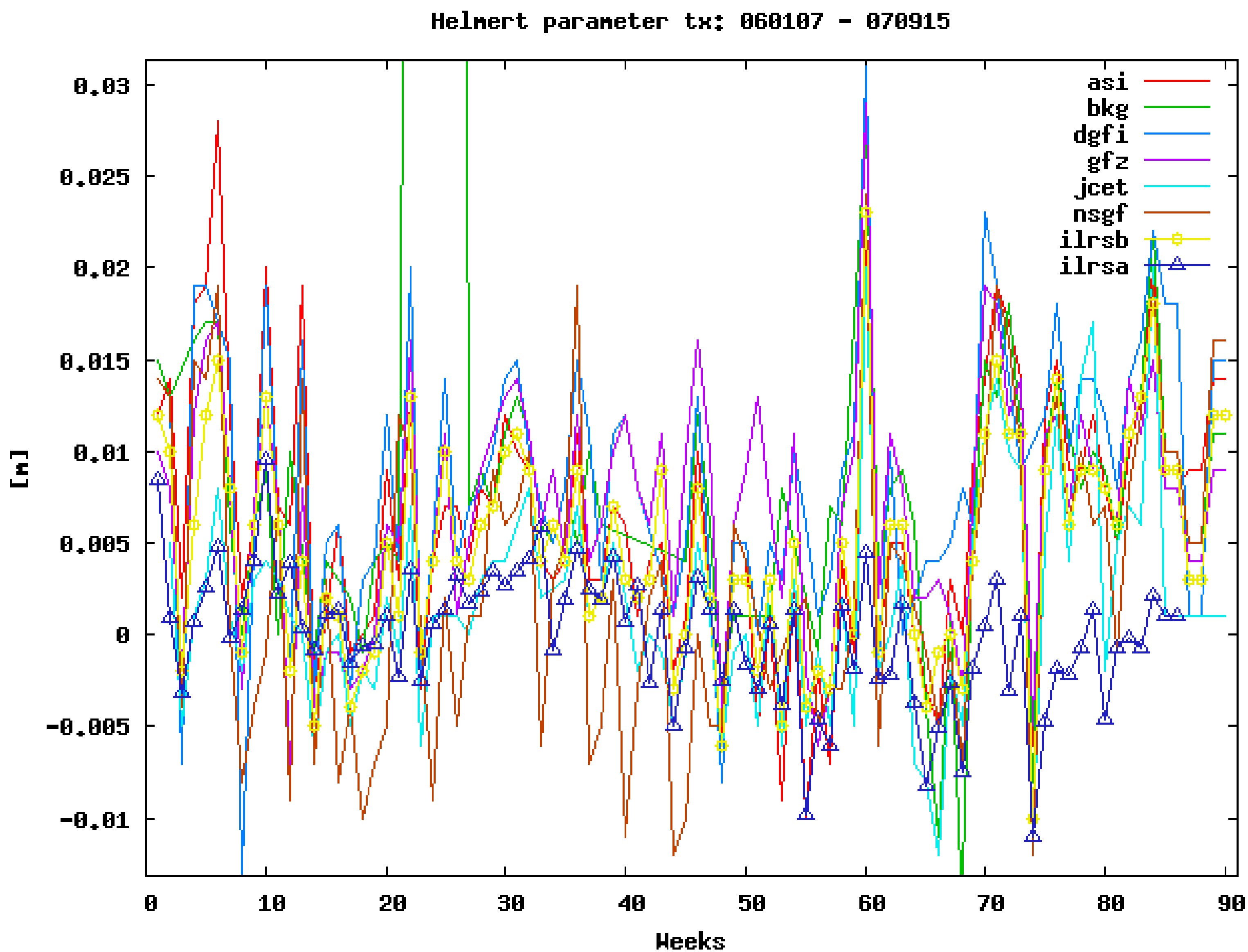
Actual combination (3)



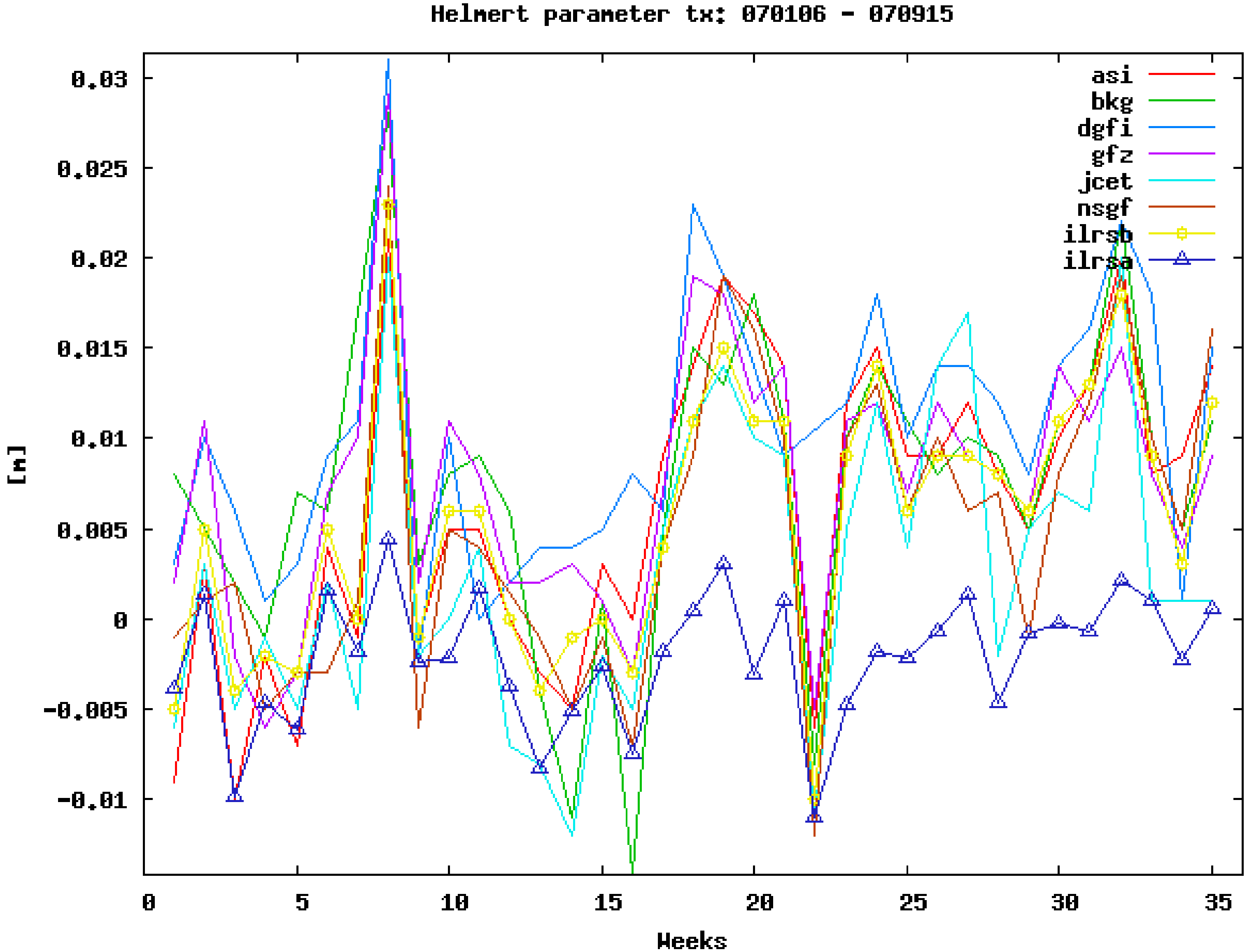
Actual combination (4)



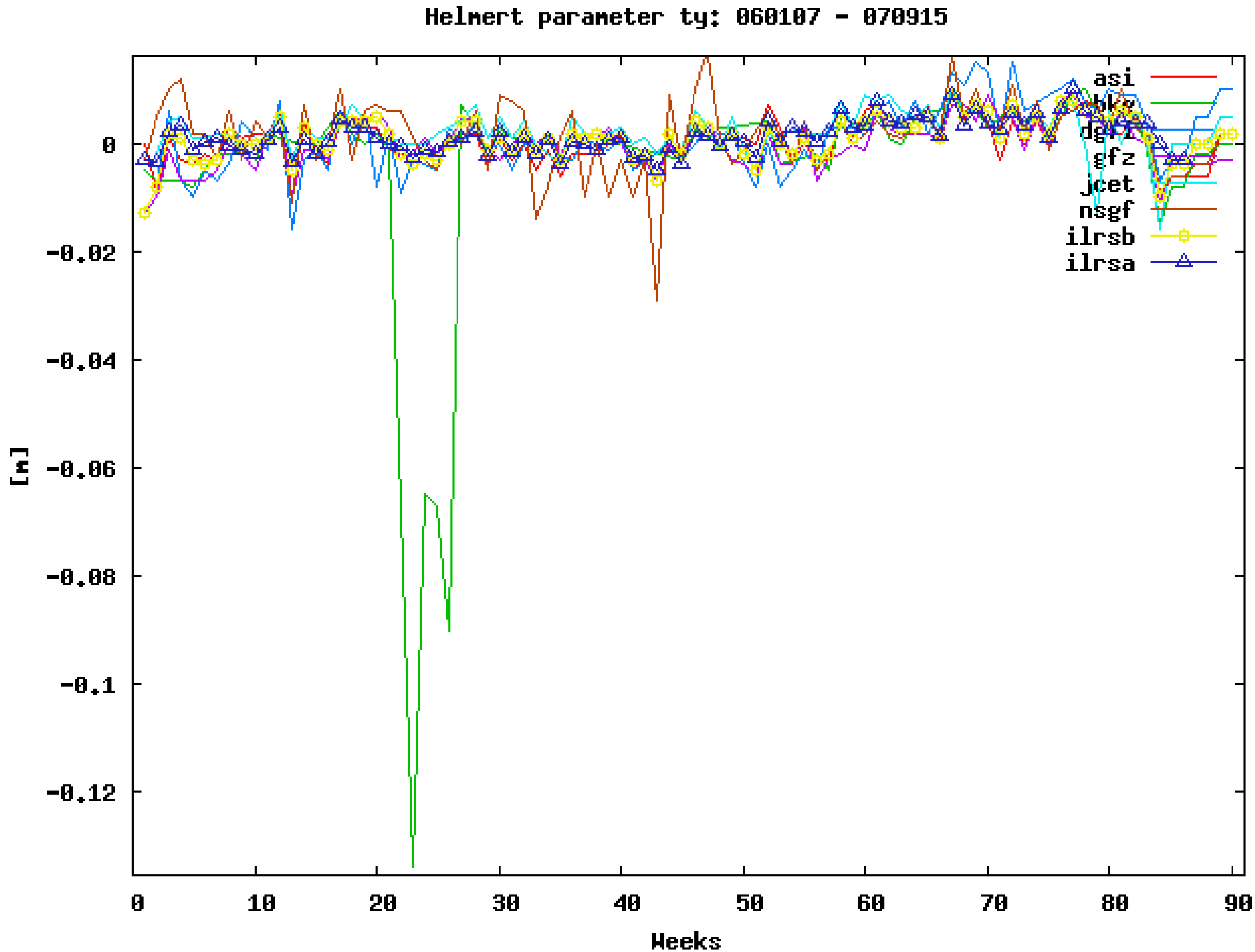
Actual combination (5)



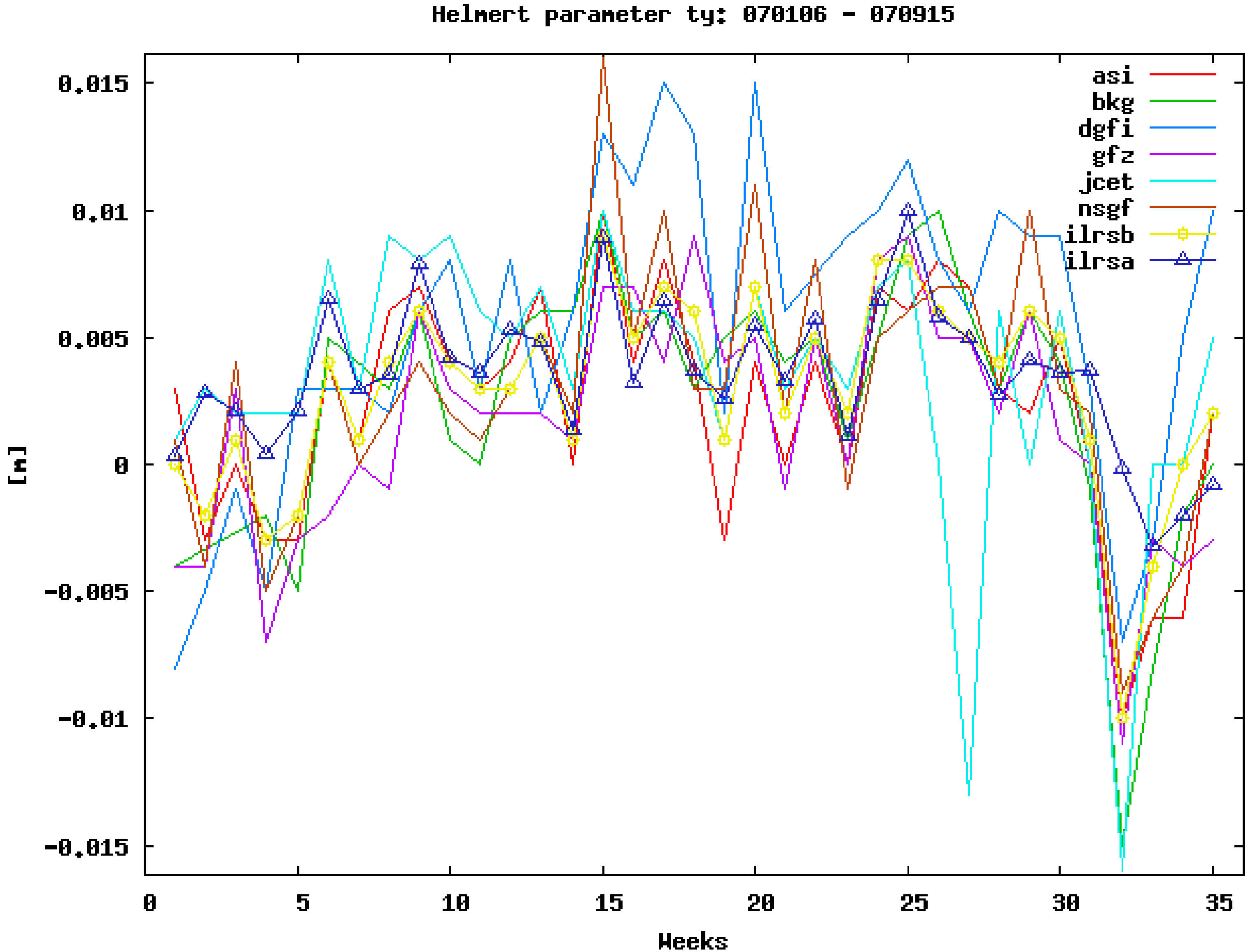
Actual combination (6)



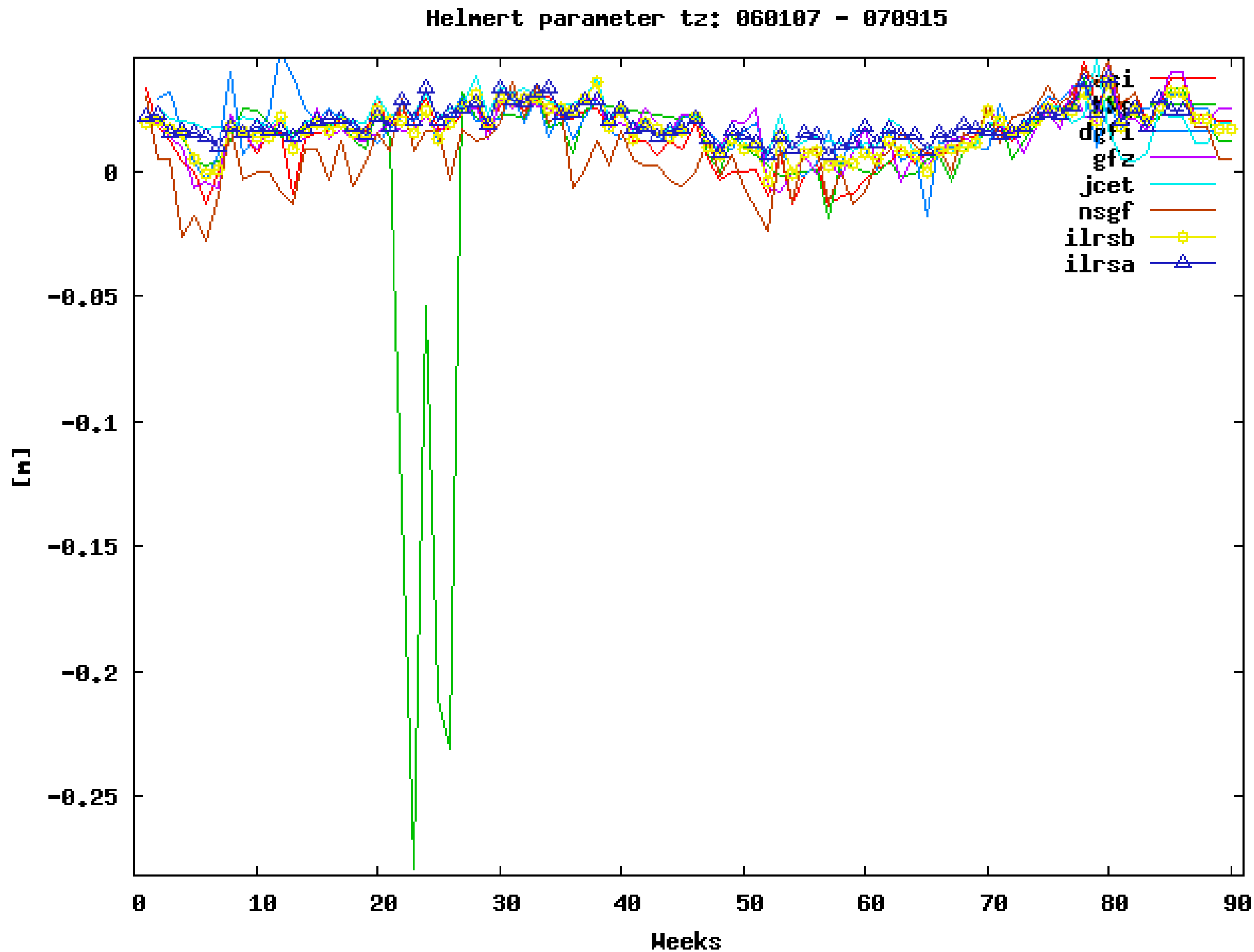
Actual combination (7)



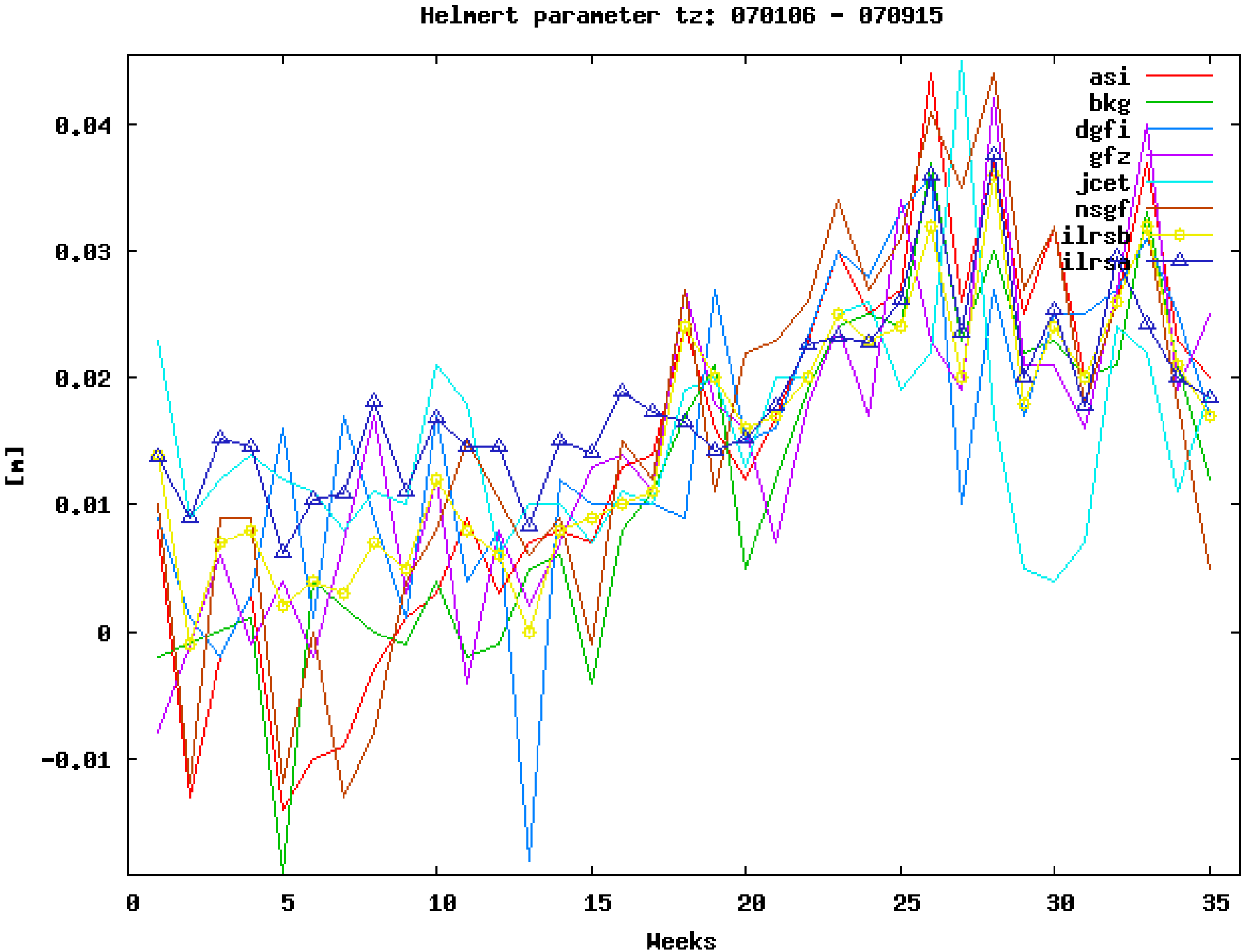
Actual combination (8)



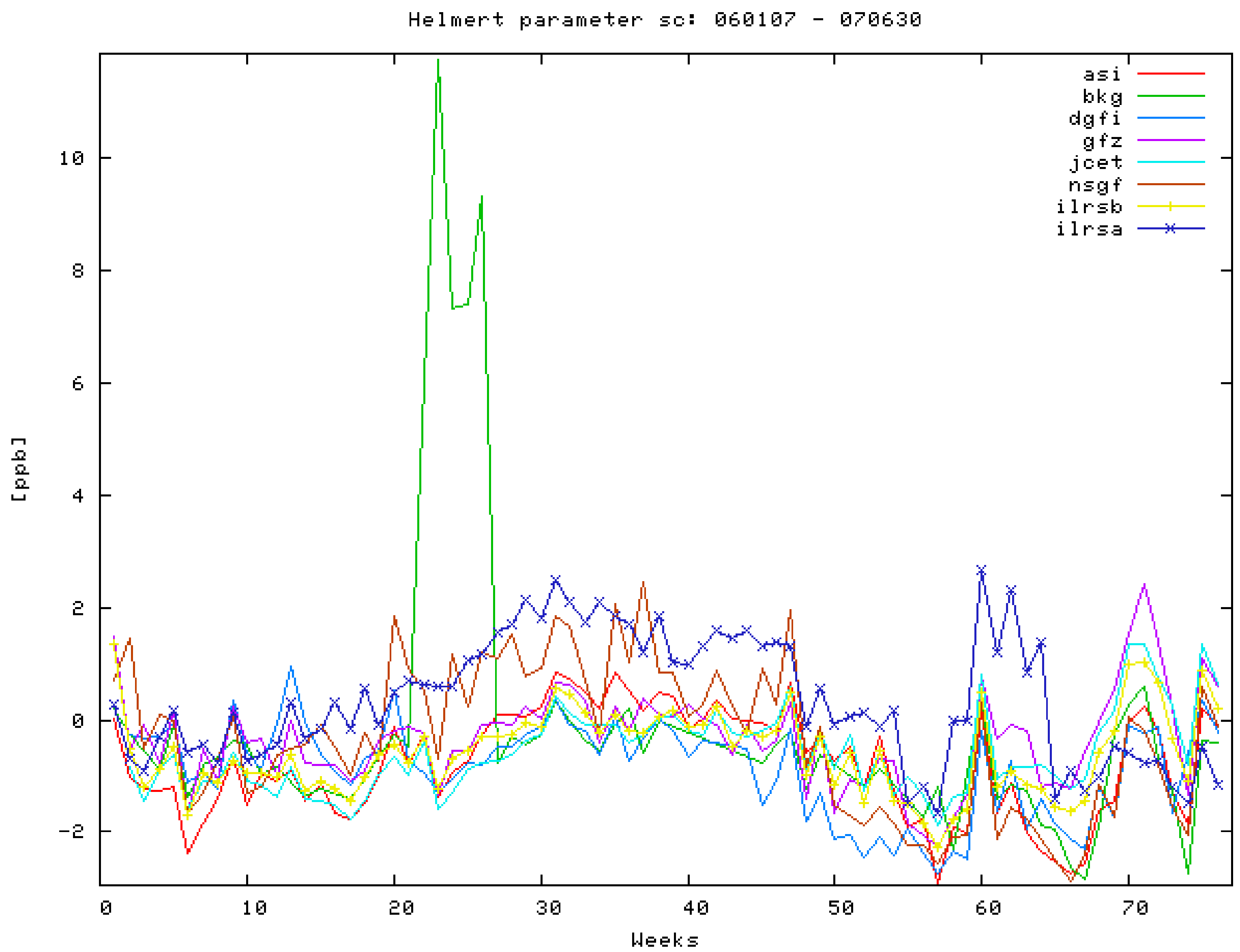
Actual combination (9)



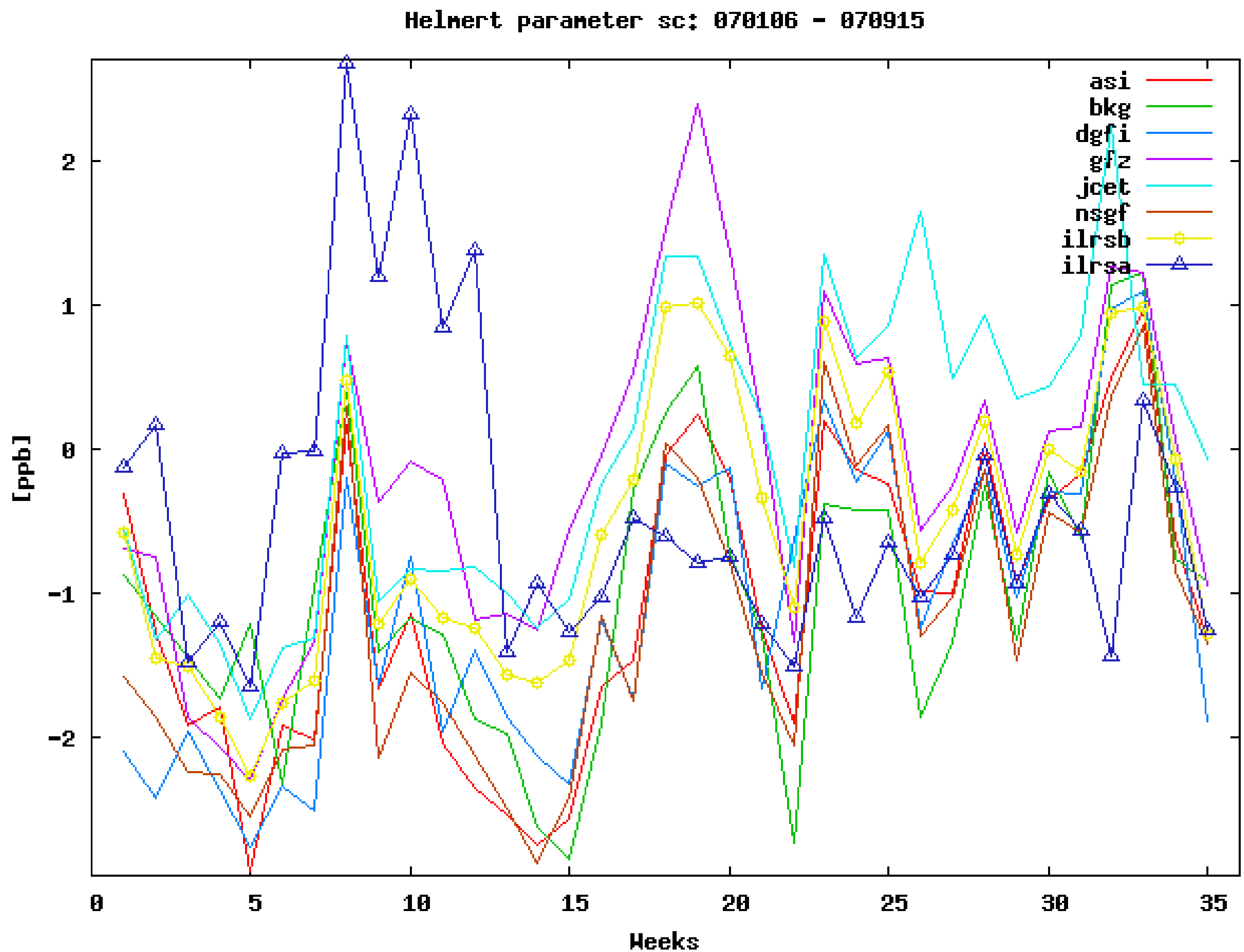
Actual combination (9)



Actual combination (10)



Actual combination (10)



Analysis 1983 - 1992

* Software is updated

* Remarks to test week 890607:
  - only GA solution available

Variance factors and their variances (VCE)
****

ga.pos+eop.831121:	4.64476	0.41227
jcet.pos+eop.831121:	3.79798	0.32881
nsgf.pos+eop.831121:	11.46697	0.70269

Renalysis 1993 - 2007

- **waiting for new input solutions**

Daily Combination

- **waiting for input solutions**

SP3C

* Test files of DGFI and JCET for Lageos 1, 2 and Etalon 1, 2 received on 2007-09-18

* After a first look: no precision information (in contrast to GPS)
large discrepancies between the two orbits (about 10 km)

* Combination strategy: Helmert transformation, then computation of mean?

* software updating in preperation

Australian Government

Geoscience Australia

Activity Report to ILRS AWG

Ramesh GOVIND

ILRS AWG Meeting

24th September 2007

Grasse

Current Status and Activities

- Upgraded from Geodyn0401 to Geodyn0511
- Lageos-1 & Lageos-2 recomputed with new version for the period beginning 2002 to mid-2007 – testing new features (ATGRAV, annual variable gravity) + GGM02C
- Continue to submit the weekly SINEX product using Geodyn0401 – change from October 2007 submissions

Re-processing

Status of Reprocessing –

Satellite	Start	End
Stella and Starlette (Progressing)	960107	070520
Etalon-1	000102	070520
Etalon-2	010107	070225
Giovea	060528	070520
Glonass-80 (0401)	991024	020217
Glonass-84 (0401)	010701	050828
Glonass-86	020303	021229
Glonass-87	020303	070128
Glonass-89	030323	070429
Glonass-95	050904	070225
Glonass-99	070121	070520

Re-processing

- Stella/Starlette experiments for appropriate parametisation
- Combinations for Glonass/Etalon/Giove to be re-done for the Geodyn0511 processing

JCET AC Activities Report

Erricos C. Pavlis

ILRS Analysis Coordinator

JCET/UMBC & NASA Goddard

International Laser Ranging Service

UMBC NASA-GSFC JCET

GODDARD SPACE FLIGHT CENTER

UMBC

Topics

- **JCET Activities since last AWG:**
  - **Tested new SLRF2005** ***(not implemented in routine ops yet)***
  - **Running 1[d] EOP DAILY with L 1 & 2 and E 1 & 2 since June**
  - **Added Starlette & Ajisai in test mode** ***(in ops by November?)***
  - **Implemented a bias report for all sites** ***(L1/2, E1/2, ST & AJ)***
  - **Updated eccentricities file, ready for release** ***(Haleakala???)***
  - **Addressed most action items from Vienna/Perugia (SP3,…)**
  - **…**

Comments

- SLRF2005 performs equally well and at times a lot better for tested sample arcs from various periods of the 1976 - present period
- Separate report on the 1d EOP from DAILY solutions (7-day arcs)
- Starlette & Ajisai analysis is limited to EOP results at present (more…)
- Developed a station bias report, format is a mix of CSR & Hit-U Rpts.
- An updated SINEX of eccentricities was developed (CDDIS 070625), release is pending imminent release of new Haleakala survey (when ???)
- Working on atmospheric correction files from ECMWF (soon :-)
- Testing the proposed CRD format that will replace the FR/QL/NP format

LEO s/c in weekly ops

- Starlette & Ajisai data were used for one year (2006) to test the improvement in 1[d] EOP estimates due to the improved tracking geometry (more longitude coverage compared to just L1/2 & E1/2)
- Proper analysis of these data in TRF products will require the inclusion of atmospheric circulation modeling, on the ground and in orbit
- This makes the inclusion of these targets dependent on the regular availability of atmospheric field products from ECMWF
- We are currently obtaining such fields on a monthly basis from J.P. Boy
- We need a quicker turn-around and we need to work with the IERS Geophysical Fluids Center for such a service, using possibly the forecasts too, if we want these included for the DAILY EOP product (makes a big difference)

Station Bias Report + …

```
# @070809
# @Date span:  070722 - 070729
# @contact epavlis@umbc.edu
# @website http://geodesy.jcet.umbc.edu/
# @version 1.0
#
# each line contains:
#
# STA ID           = site name
# YY/MM/DD HH:MM   = pass starting time
# SAT              = satellite name (L1: LAGEOS1; L2: LAGEOS2; E1: ETALON1; E2:ETALON2; S1: STARLETTE; A1: AJISAI
# GOOD OBS         = number of accepted normal points
# RAW RMS          = residual RMS before editing & bias estimation
# PREC EST         = post-fit scattering rms
# RANGE BIAS       = estimated range bias
# RANGE BIAS SIGMA = estimated range bias sigma
# TIME BIAS        = estimated time bias
# TIME BIAS SIGMA  = estimated time bias sigma
# PASS DUR         = pass duration
# EDIT OBS         = number of bad normal points
# CALIB+ MEAN      = mean Applied System Delay (ILRS FR format cols 97-104)
# CALIB SDEV       = mean System Calibration Method (ILRS FR format cols 126)
# CALIB SHIFT+     = mean Root Mean Square (ILRS FR format cols 111-114)
# STPASS RMS       = mean Pass RMS (ILRS FR format cols 58-64)
# TEMP             = mean surface temperature [K]
# HUM              = mean relative humidity of surface %
# PRES             = mean pressure [hPa]
# WLEN             = wavelength [nm]
# SCH              = System Change Indicator (ILRS FR format cols 127)
# SCI              = System Configuration (ILRS FR format cols 128)
# DRF              = Data Release Flag (ILRS FR format cols 130)
# ELEVATION MAX    = maximum elevation for pass [degress]
# ELEVATION MIN    = minimum elevation for pass [degrees]
#
#1864 Maidanak  12340S002
# STA ID YY/MM/DD HH:MM SAT GOOD  RAW   PREC  RANGE RANGE  TIME  TIME  PASS  EDIT CALIB+  CALIB CALIB++ STPASS TEMP   HUM   PRES   WLEN  S S D    ELEVATION
#                           OBS   RMS    EST  BIAS  BIAS   BIAS  BIAS  DUR   OBS  MEAN    SDEV  SHIFT   RMS    [K]    %     [hPa]  [nm]  C C R   MAX      MIN
#                                 [mm]  [mm]  [mm]  SIGMA  [us]  SIGMA [min]      [mm]    [mm]  [mm]    [mm]                              H I F   [degrees]
#
18645401 7/07/22 16:27 L1    7  29.8  25.7  -16.3 12.2   -4.6   2.8   12    0  21416 E    0     0 P    44   285.1   58.0  732.0  532.0 0 0 0   33.8     30.8
18645401 7/07/22 16:27 L1    7  29.8  25.7  -16.3 12.2   -4.6   2.8   12    0  21416 E    0     0 P    44   285.1   58.0  732.0  532.0 0 0 0   33.8     30.8
18645401 7/07/23 16:53 A1    6  13.9  11.0   -8.5  8.9    1.3   3.6    3    3  21413 E    0     0 P    82   287.1   50.0  732.0  532.0 0 0 0   68.2     53.1
18645401 7/07/23 18:37 L1    4  55.4  35.1  -25.6  8.2   -3.5   2.7   15    2  21412 E    0     0 P    88   287.1   50.0  732.0  532.0 0 0 0   52.4     32.2
18645401 7/07/23 18:37 L1    4  55.4  35.1  -25.6  8.2   -3.5   2.7   15    2  21412 E    0     0 P    88   287.1   50.0  732.0  532.0 0 0 0   52.4     32.2
18645401 7/07/24 15:58 A1    4  11.4  11.4   -0.6 10.6   -5.0   4.1    4    6  21415 E    0     0 P   104   287.1   41.0  734.7  532.0 0 0 0   54.6     45.6
18645401 7/07/24 17:11 L1    6  21.5   7.9  -25.1 10.9    2.6   2.8   10    0  21415 E    0     0 P    49   287.1   41.0  734.7  532.0 0 0 0   38.7     34.0
18645401 7/07/24 17:11 L1    6  21.5   7.9  -25.1 10.9    2.6   2.8   10    0  21415 E    0     0 P    49   287.1   41.0  734.7  532.0 0 0 0   38.7     34.0
```

DAILY Delivery Schedule

- JCET (last to deliver) delivers on: yy/mm/dd ~15:00 EST (20:00 UTC)
- CCs initiate Combination process on: yy/mm/dd+1 ~10:00 CET (09:00 UTC)
- Assuming ~3 hours processing time, CCs deliver the combined product back in the archive by: yy/mm/dd+1 ~13:00 CET (12:00 UTC)
- Product available to IERS, ITRS and NEOS: yy/mm/dd+1 ~13:00 CET/ 12:00 UTC
- With this schedule the weekly product covering Sunday-Saturday of the week, could be delivered as early as the following Monday at 12:00 UTC (07:00 EST) instead of the current delivery on Wednesday
- **Do the ACs and <u>CCs in particular</u>, see this as a feasible schedule?**

Atmospheric de-aliasing fields

- The topic has the attention of many groups as IERS is looking into adopting a consistent treatment across techniques
- If we use a purely mean gravitational field, we then need to account for the atmospheric signals (beyond those at TIDAL frequencies!!!) on the orbit and their loading part on the sites' positions
- Currently GEODYN handles both, however:
  - For our operations we need a prompt service
  - JPB provides monthly fields only, 5-10 days post-fact
  - DAILY 1^d EOP with LEOs would require these within 1 day

New LR data format (CRD)

International Laser Ranging Service

JCET

Consolidated Laser Ranging Data Format (CRD)

Version 0.26

R. L. Ricklefs
The University of Texas at Austin / Center for Space Research
C. J. Moore
EOS Space Systems Pty. Ltd.
For the ILRS Data Formats and Procedures Working Group

28 March 2007

Abstract

Due to recent technology changes, the existing International Laser Ranging Service (ILRS) formats for exchange of laser fullrate, sampled engineering and normal point data are in need of revision. The main technology drivers are the increased use of kilohertz firing-rate lasers which make the fullrate data format cumbersome, and anticipated transponder missions, especially the Lunar Reconnaissance Orbiter (LRO), for which various field sizes are either too small or non-existent. Rather than patching the existing format, a new flexible format encompassing the 3 data types and anticipated target types has been created.

Sample of new format data

FR

```
H1 CRD 1 2007 3 20 14
H2 MLRS 7080 24 19 4
H3 LAGEOS2 9207002 5986 22195 0
H4 0 2006 11 13 15 23 52 2006 11 13 15 45 35 1 1 1 1 0 0 2
C0 0 532.000 std1
60 std1 5 2
10 55432.0414338 0.047960587856 std1 2 0 0 0
12 55432.0414338 std1 20735.0 1601.0000 0.00 0.0000
20 55432.0414338 801.80 28.21 39
30 55432.0414338 297.2990 38.6340 0 2 1
40 55432.0414338 0 std1 -1 -1 0.000 -913.0 0.0 56.0 -1.000 -1.000 -1.0 3 3
10 55435.6429746 0.047926839980 std1 2 0 0 0
12 55435.6429746 std1 20697.0 1601.0000 0.00 0.0000
30 55435.6429746 297.4480 38.7190 0 2 1
...
10 56735.8021609 0.046094881873 std1 2 0 0 0
12 56735.8021609 std1 18092.0 1601.0000 0.00 0.0000
30 56735.8021609 15.2330 45.7100 0 2 1
H8
H9
```

NP

```
H1 CRD 1 2007 3 20 14
H2 MLRS 7080 24 19 4
H3 LAGEOS2 9207002 5986 22195 0
H4 1 2006 11 13 15 25 4 2006 11 13 15 44 40 0 0 0 0 1 0 2

C0 0 532.000 std1
60 std1 5 2
11 55504.9728030 0.047379676080 std1 2 120 18 94.0 -1.000 -1.000 -1.0 0.0
20 55504.9728030 801.80 282.10 39
11 56680.8785419 0.045804632570 std1 2 120 10 55.0 -1.000 -1.000 -1.0 0.0
20 56680.8785419 801.50 282.00 39
50 std1 86.0 -1.000 -1.000 -1.0 0
H8
H9
```

2WL

```
H1 CRD 1 2007 3 20 14
H2 ZIMMERWALD 7810 68 1 7
H3 LAGEOS1 7603901 1155 8820 0
H4 1 2006 12 30 7 35 34 2006 12 30 8 12 29 0 0 0 0 1 0 2
C0 0 846.000 std1
C0 0 423.000 std2
60 std1 9 0
60 std2 9 1
11 27334.1080890 0.051571851861 std1 2 120 36 154.0 -1.000 -1.000 -1.0 0.0
20 27334.1080890 923.30 275.40 43
40 27334.1080890 0 std1 -1 -1 0.000 113069.0 0.0 138.0 -1.000 -1.000 -1.0 2 2
11 29544.4080897 0.051445695153 std1 2 120 19 164.0 -1.000 -1.000 -1.0 0.0 11
29549.5080897 0.051535764981 std2 2 120 14 87.0 -1.000 -1.000 -1.0 0.0
50 std1 165.0 -1.000 -1.000 -1.0 0
50 std2 78.0 -1.000 -1.000 -1.0 0
H8
H9
```

QL

```
H1 CRD 1 2007 3 20 14
H2 MLRS 7080 24 19 4
H3 LAGEOS2 9207002 5986 22195 0
H4 2 2006 11 13 15 24 17 2006 11 13 15 44 59 0 0 0 0 0 0 2
C0 0 532.000 std1
60 std1 5 2
10 55457.0521861 0.047753624332 std1 2 0 0 0
20 55457.0521861 801.80 282.10 39
30 55457.0521861 298.3470 39.2230 0 0 0
10 55482.4631214 0.047552685849 std1 2 0 0 0
30 55482.4631214 299.4370 39.8100 0 0 0
10 56699.7866762 0.045901952309 std1 2 0 0 0
30 56699.7866762 13.2310 46.3060 0 0 0
50 std1 86.0 -1.000 -1.000 -1.0 0
H8
H9
```

Future Work

- SLRF2005: Reanalysis of 1976 to present (new IERS C04 *a priori* series)
- 1d EOP DAILY: submit to NEOS for comments
- Starlette & Ajisai: more tests with improved modeling
- Station bias report: release on a weekly basis (more often?)
- Updated SINEX of eccentricities: release without Haleakala now?
- Atmospheric correction files from ECMWF : format conversion soon
- Testing CRD format: Test files from CSR on CDDIS

DAILY 1^d EOP ILRS products

Errricos C. Pavlis
ILRS Analysis Coordinator
JCET/UMBC & NASA Goddard

Introduction

- 1d EOP PP for Daily delivery at JCET
- Status:
  - EOP (x_p, y_p, and LOD)
  - Running with L 1 & 2 and E 1 & 2 since June
  - Comparison with NEOS "finals"
  - Add Starlette & Ajisai (October)
  - Other items to be delivered if desirable (SINEX)…

Potential users

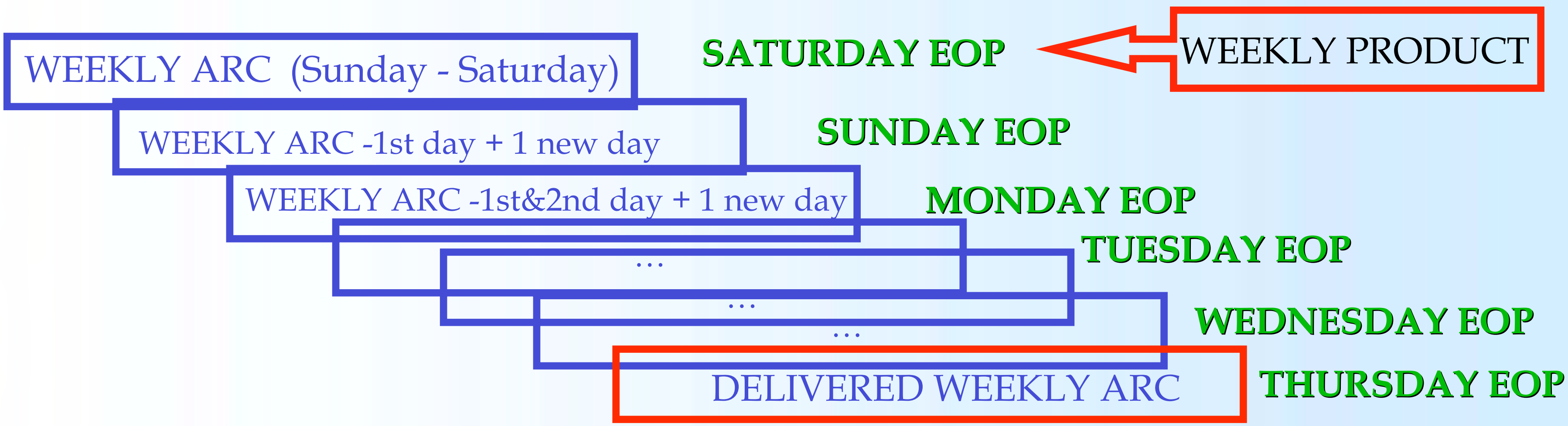
International Laser Ranging Service

JCET

- For the EOP: primarily the **IERS Rapid Service (NEOS)**
- ITRF-origin-to-geocenter vector: **IERS/ITRS, IAU, geophysicists**
- Station health reports: of interest to **station managers**
- Orbit files: may be of interest to **other techniques** that use SLR to calibrate their systems (GNSS, RADAR, etc.)
- Daily SINEX files: may be of interest to **ITRS**

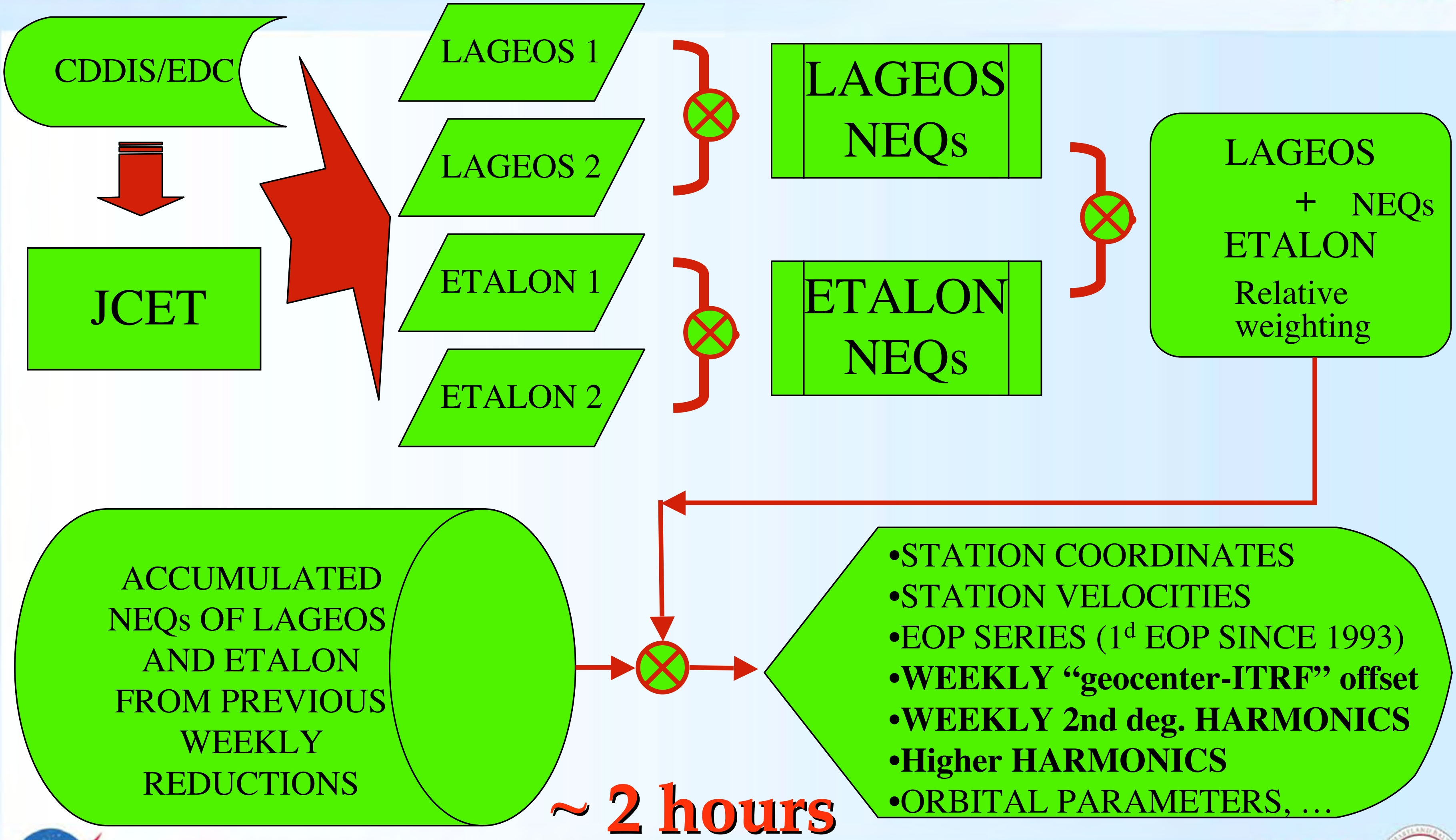
Daily EOP Product(s)

- **The operational scheme for the daily products is:**



- **The PP is running at JCET since June 2007**

JCET Analysis Process



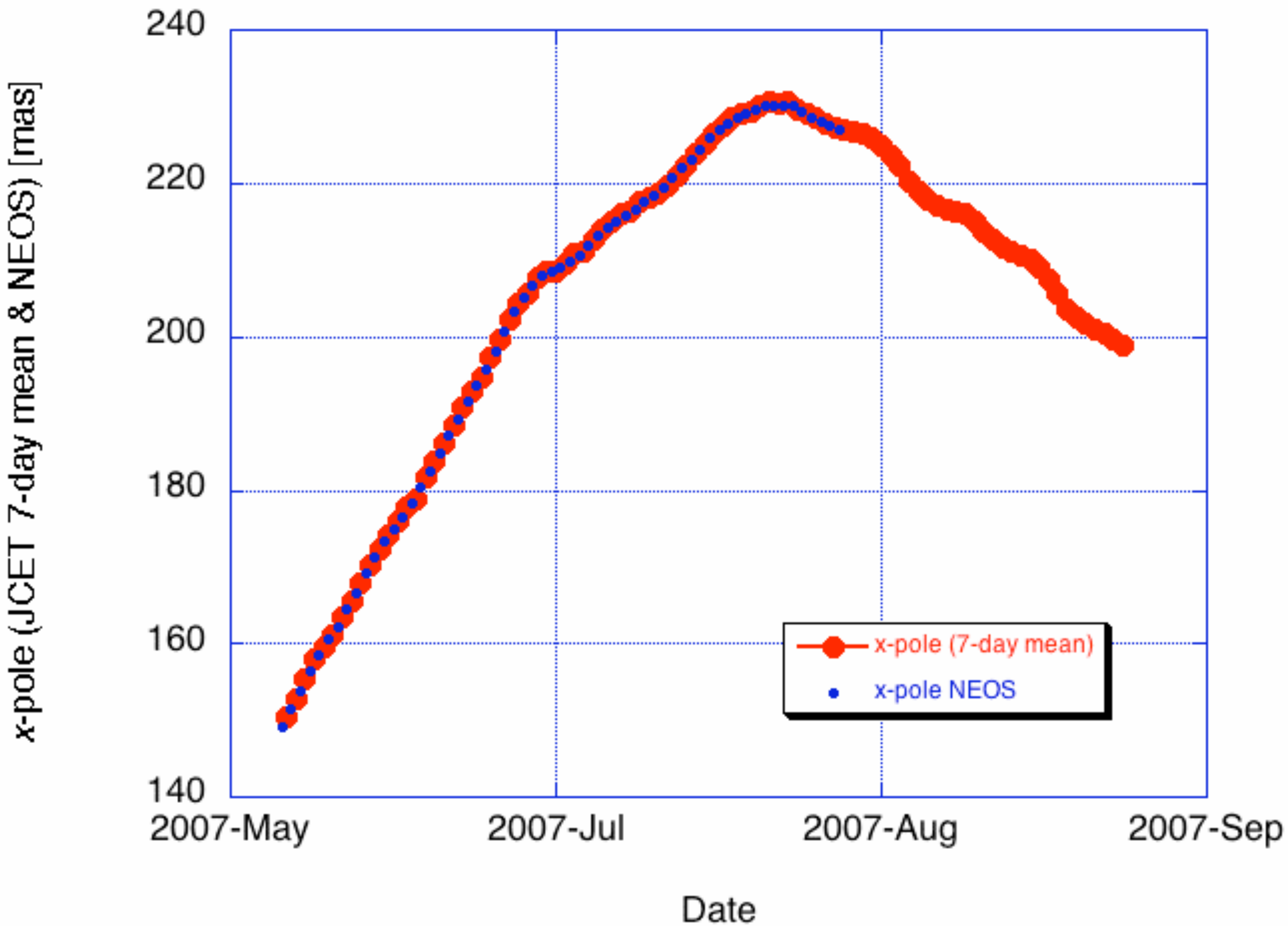
DAILY Delivery Schedule

- JCET (last to deliver) delivers on: yy/mm/dd ~15:00 EST (20:00 UTC)
- CCs initiate Combination process on: yy/mm/dd+1 ~10:00 CET (09:00 UTC)
- Assuming ~3 hours processing time, CCs deliver the combined product back in the archive by: yy/mm/dd+1 ~13:00 CET (12:00 UTC)
- Product available to IERS, ITRS and NEOS: yy/mm/dd+1 ~13:00 CET/ 12:00 UTC
- With this schedule the weekly product covering Sunday-Saturday of the week, could be delivered as early as the following Monday at 12:00 UTC (07:00 EST) instead of the current delivery on Wednesday
- **Do the ACs and CCs in particular, see this as a feasible schedule?**

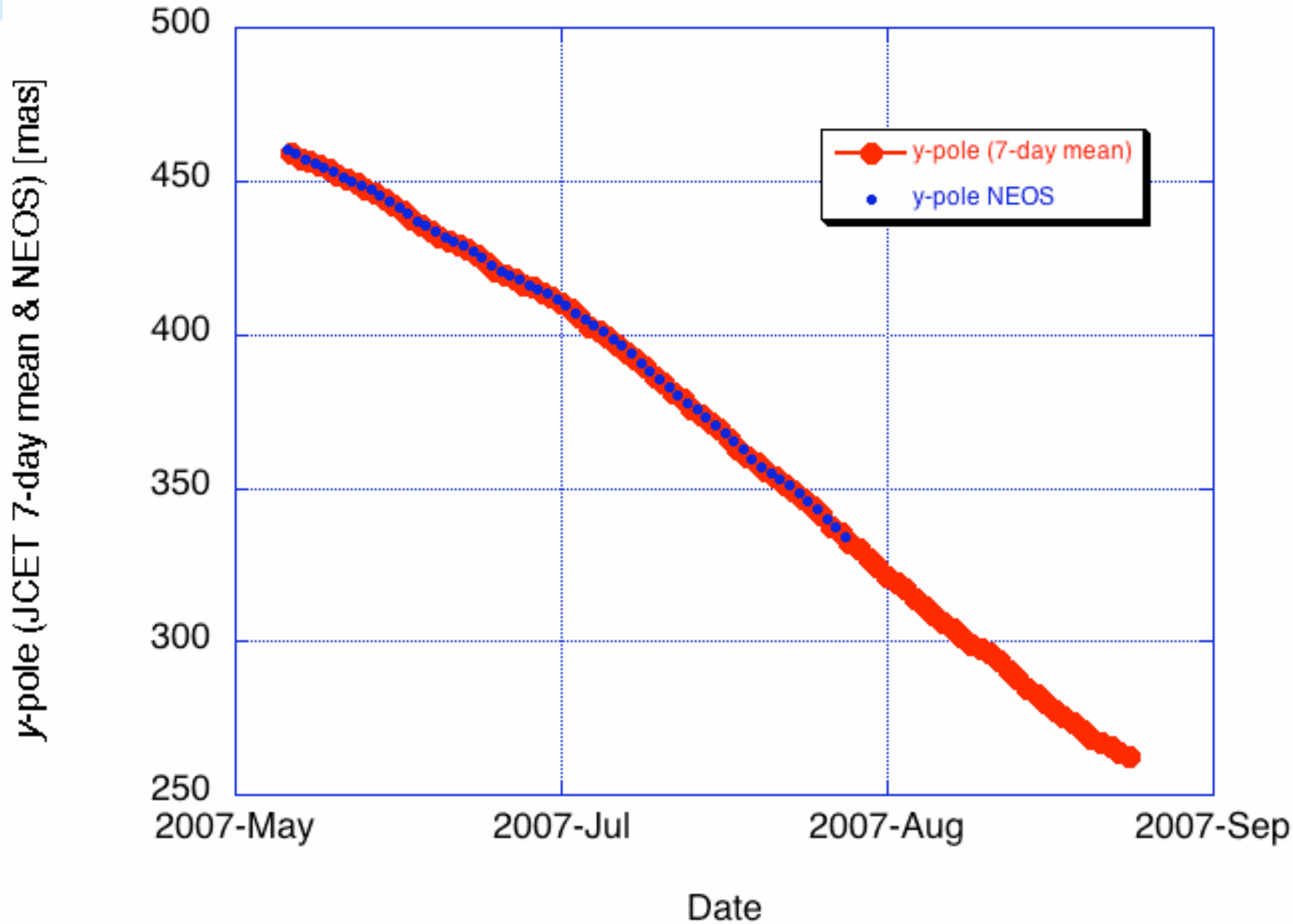
Daily EOP Test Statistics

- DAILY production test running at JCET since June
- Characterize the quality and stability of the product and its dependence on the available data by examination of the multiple estimates for each day (7) during each cycle of the process
- We have computed statistics for:
  - Orbital fits for different “7-day” arcs
  - The mean of the seven estimates and its std. deviation
  - The day being reported (last day of the arc, next to last, etc.)

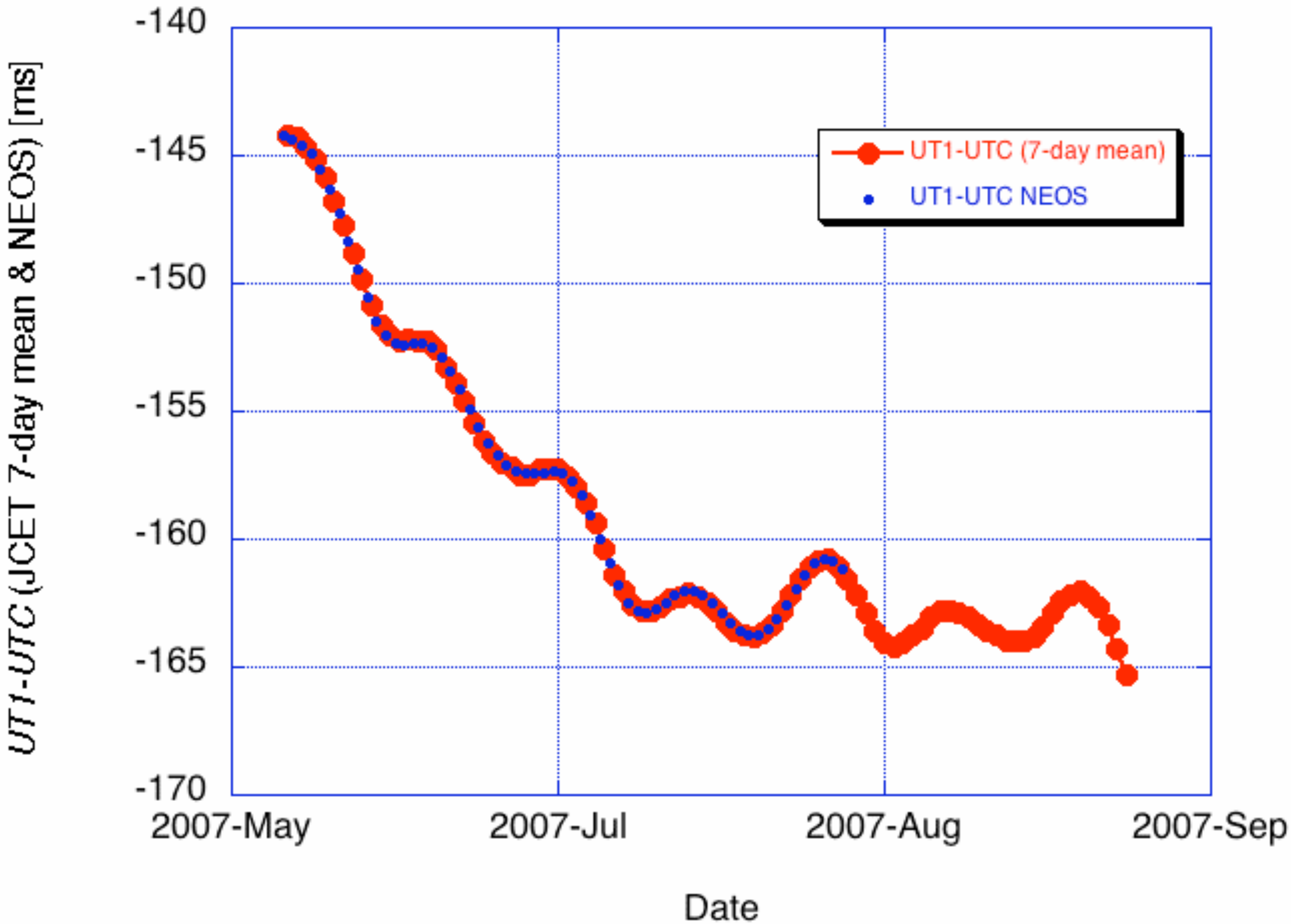
SLR Daily x_p *vs.* NEOS Finals



SLR Daily y_p *vs.* NEOS Finals



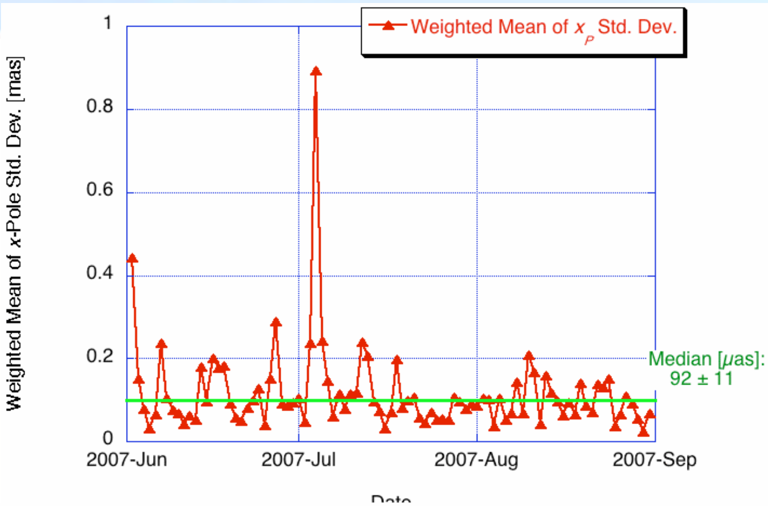
SLR Daily *UT1-UTC vs.* NEOS Finals

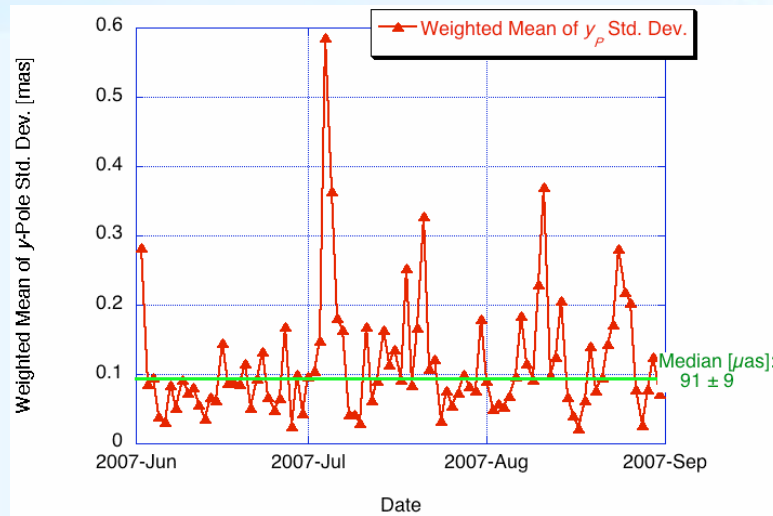


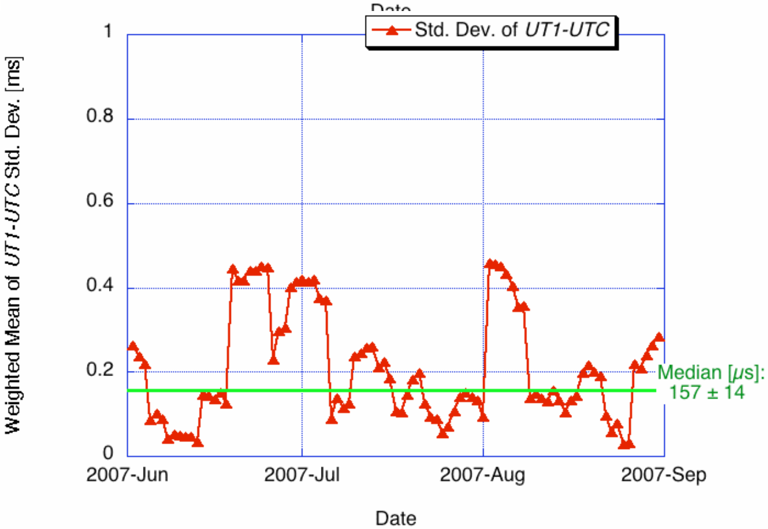
International Laser Ranging Service

SLR Daily EOP Statistics

JCET





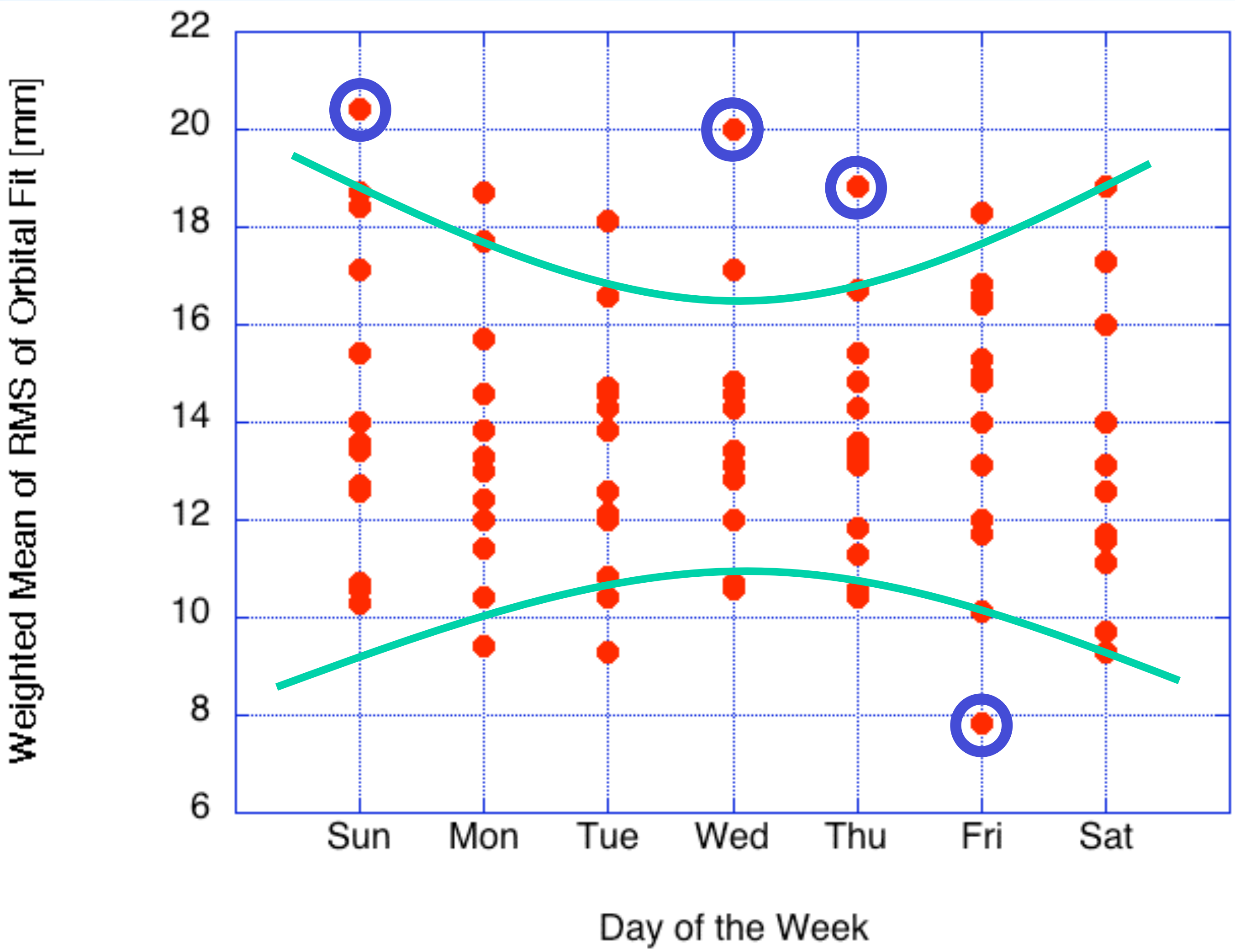


Daily 1d EOP Statistics vs. NEOS Finals	
Weighted mean std. dev. of *x-pole [μas]*	92 ± 11
Weighted mean std. dev. of *y-pole [μas]*	91 ± 9
Weighted mean std. dev. of *UT1-UTC [μts]*	157 ± 14

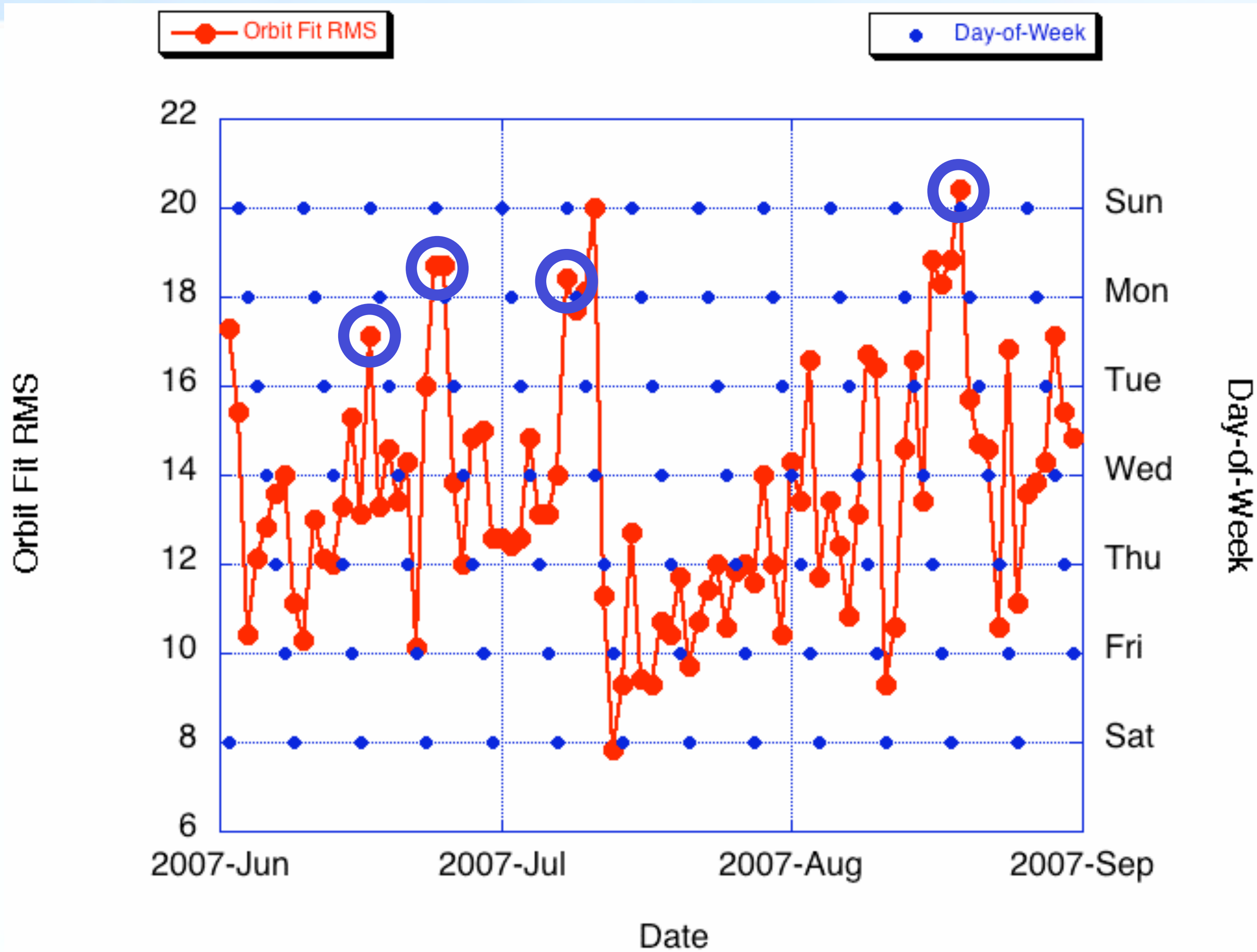
Summary

- New ILRS product: DAILY EOP SINEX (with respect to adopted ITRF)
- Initially only EOP to be reported
  - We can extend this to full SINEX
- A 3-month test at JCET shows consistency with WEEKLY products
  - Estimated Std. Dev. of EOP at ~ 90 μas (PM) and ~160 μs (UT1)
  - Combined product of more ACs, will likely improve by a factor of 2
- We expect that all ACs and CCs will participate by the end of 2007
- Currently investigating the addition of Starlette & Ajisai in our analysis to improve the geometry in longitude coverage for even more robust EOP estimates

Orbital Arc Fit vs. DOW



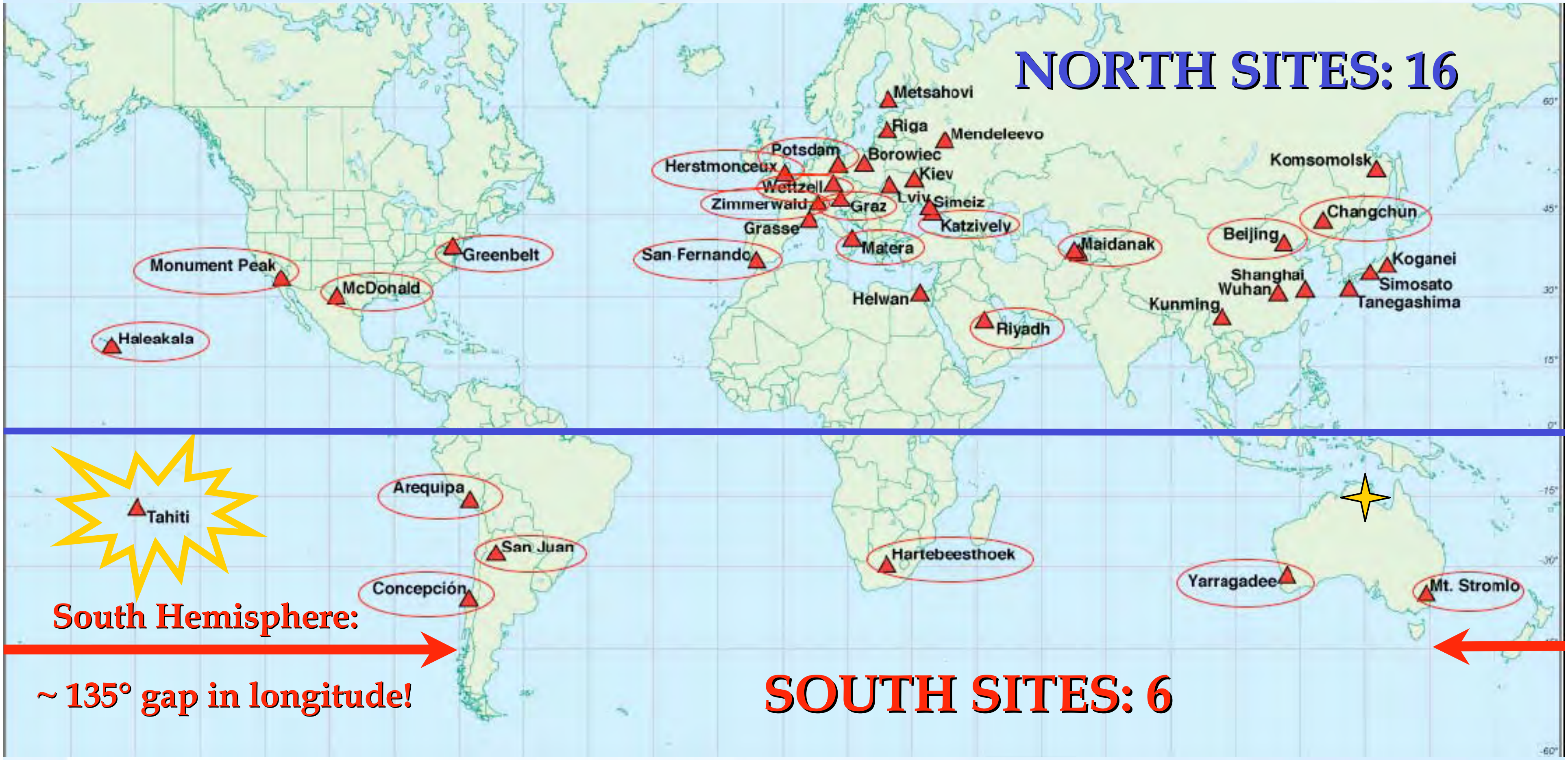
Orbital Arc Fit vs. DOW



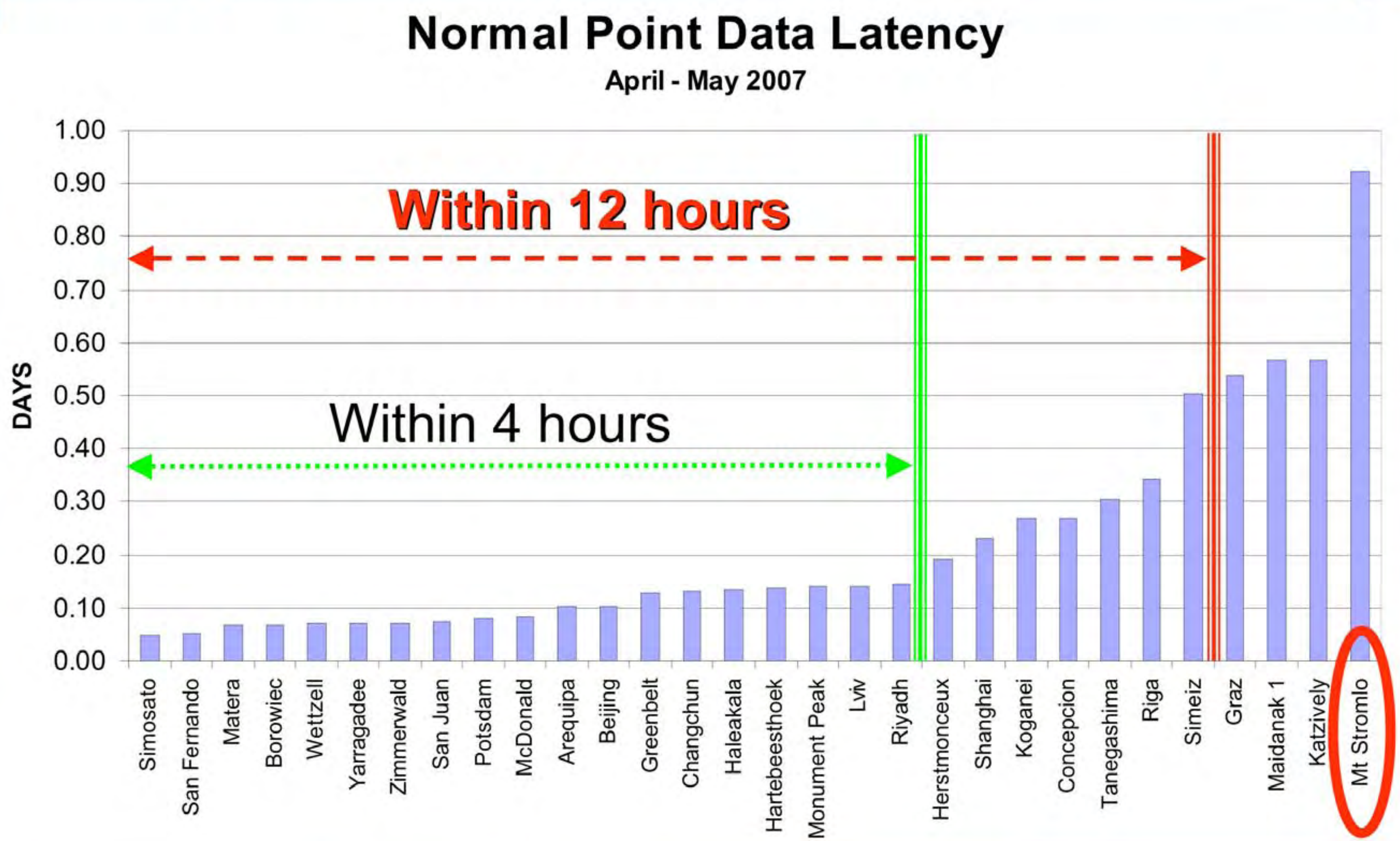
Daily Products' Issues

- **The routine delivery of ILRS products daily raises some issues :**
  - **Network non-uniformity (short- and long-term issues)**
  - **Data delivery latency**
  - **Quality AC products to facilitate CC's work in tight schedule**
    - *Daily delivery means that CCs will operate in an automated fashion, so no more "fixing" of e.g. SINEX format problems!*
  - **DCs need to be aware of increased traffic and ensure 24/7 availability of their servers, minimizing down-times and ftp outages**

The ILRS Network



Network Delivery Record



Data Center availability

- Over the past couple of years we have encountered cases where unavailability of a DC delayed deliveries from one day to weeks
- ACs would like to see DC operate in a "mirror" mode, with identical data, organization and access privileges
- With the price reduction of GBs/$ it should be possible for each DC to run a second disk on a separate server (much smaller than the primary one), with ONLY the data of the last 12 months
- If something happens to the main server, switching to the secondary one should minimize ftp disruptions for AC access

Daily Product(s)

- Due to the peculiarities of the SLR data delivery schedule and the sparseness of the network, there are also questions about what to deliver as the "daily product"
- Some of the issues are being checked now and will be decided with input from the user community (and primarily NEOS):
  - The day to be *reported* (last day of the arc, next to last, etc.)
  - Weigh trade-off between having a "fresher" set of EOP vs. a more accurate one, etc.

Daily Product(s)

- Currently working on a DAILY IERS product, initially for EOP <u>only</u>
  - Pilot project (PP) in progress
  - Evaluating the quality and reliability of this product
  - Exploring interest for additional products (full SINEX?)

- The PP will likely run until the product is accepted, at which time it will become part of the operational routine of the ACs & CCs

The IERS Conventions Workshop
and
Journées on Spatio-Temporal Reference Systems

IERS Workshop on Conventions 2007

20-21 Sept. 2007, Sèvres, France

JSR2007

17-19 Sept. 2007, Meudon, France

International Laser Ranging Service

UMBC NASA-GSFC JCET

GODDARD SPACE FLIGHT CENTER

UMBC

International Laser Ranging Service

JCET

GODDARD SPACE FLIGHT

UMBC

ILRS Presentation at Jounées

- See the 1[d] EOP DAILY product presentation

IERS Workshop on Conventions: 20-21 September 2007

Version française

Over the last three years the **IERS Conventions Center** has worked on updating the IERS Conventions (2003), since 2005 with the help of an Advisory Board on IERS Conventions Update. This work is reflected in the website http://tai.bipm.org/iers/convupdt/convupdt.html, which keeps track of all updates since the 2003 version.

Nevertheless much remains to be done in order to present a consistent set, in agreement with the current state of knowledge, and to have it actually put into practice by analysis centres. To this end a workshop on the IERS Conventions will be organized at the BIPM on 20-21 September 2007, with the following goals:

- to discuss models recently introduced or considered for introduction in the Conventions, and to present results of tests for these models;
- to define the directions towards a next edition of the IERS in the not-too-distant future;
- to discuss possible longer term issues, either institutional (e.g. scope of the Conventions, links to GGOS Working Group on Conventions, Analysis and Modelling), or technical, such as the definition of tbe regularized positions of stations (which dispacement effects should be modelled and removed in the analysis, and which should not).

Scientific Organizing Committee:
F. Arias, B. Luzum, G. Petit (chair), J. Ray, B. Richter,
J. Ries, M. Rothacher, H. Schuh, T. van Dam, P. Wallace

The workshop is organized in conjunction with the ***Journées 2007 "Systèmes de référence spatio-temporels"***, to be held from 17-19 September 2007 in Meudon.

Summary

- **Preliminary scientific programme**
- **Practical information**
- **Registration form**
- **List of registered participants**
- **Workshop programme** (as of 19 September 2007)
- **List of papers**

BIPM

Bureau International des Poids et Mesures

New search facility

BIPM Home | Site map | Metrology portal | KCDB | JCTLM-DB | Contact us

> You are here: BIPM events > IERS workshop > scientific programme

Preliminary scientific programme

Summary

Direct access

The scientific programme will cover five themes, as indicated below. Contributed papers are welcome for all five themes. In addition, some of the themes will include position papers, invited talks, and discussions.

Theme 1. Recent advances and validations of the IERS Conventions models

- Ocean pole tide
- Atmospheric S1/S2
- Models of tropospheric propagation
- ITRF2005
- ...

Theme 2. Conventional contributions to local station displacements: what to include?

- Should non-tidal loading effects be considered as conventional?
- How should loading effects be handled?
- How should conventional models (for loading) be distributed?
- Accounting for geocenter motion
- ...

Theme 3. Evolution of the realization of reference systems

- ITRF: possible new approaches / new datum specifications
- ICRF
- Transformation Celestial-Terrestrial e.g.:
  - specification for translational (geocenter) motion
  - new theories
- ...

Theme 4. Technique-dependent conventions

- Presentations for each IERS technique
- Definition of a reference temperature
- Impact of technique-dependent effects on local ties
- ...

Theme 5. Evolution of the Conventions

- Scope of the IERS Conventions
- Guiding principles for IERS Conventions models
- The Conventions as an electronic document
- Conventional software
- SINEX documentation of models
- ...

Workshop Links

- **Journées on Spatio-Temporal Reference Systems 2007:**

  http://syrte.obspm.fr/journees2007/

- **IERS Conventions Workshop 2007:**

  http://www.bipm.org/en/events/iers/

Overview of SLR topics

- The ILRS Network
  - Geometry and (in)homogeneity
- A look at the LR measurement chain
  - Level of uncertainty in the various components
  - Deficiencies in LR modeling (by choice or real)
- ILRS plans to address deficiencies
  - Areas where IERS can coordinate the consistent adoption of models for all space geodetic techniques

The ILRS Network

International Laser Ranging Service

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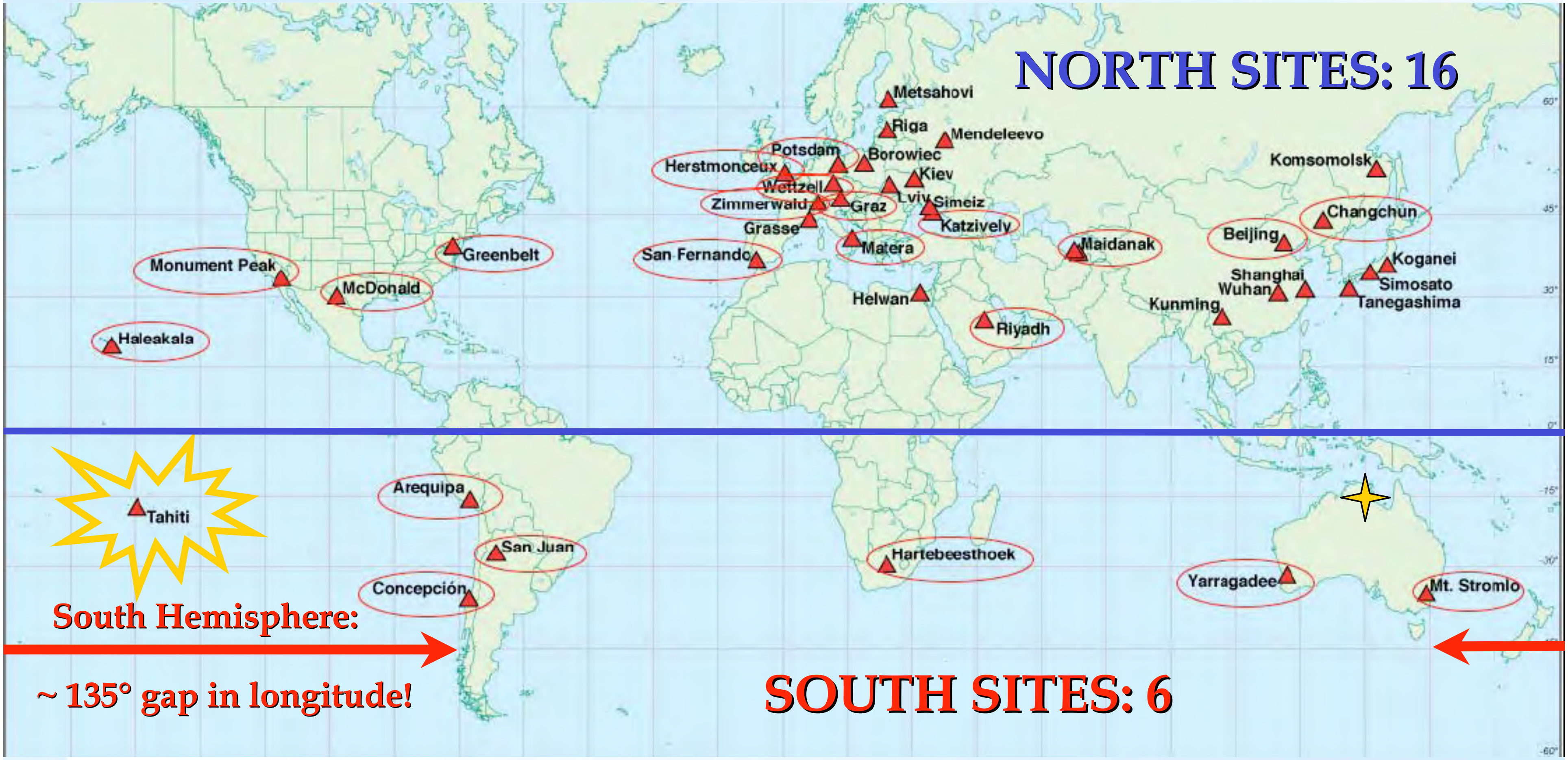
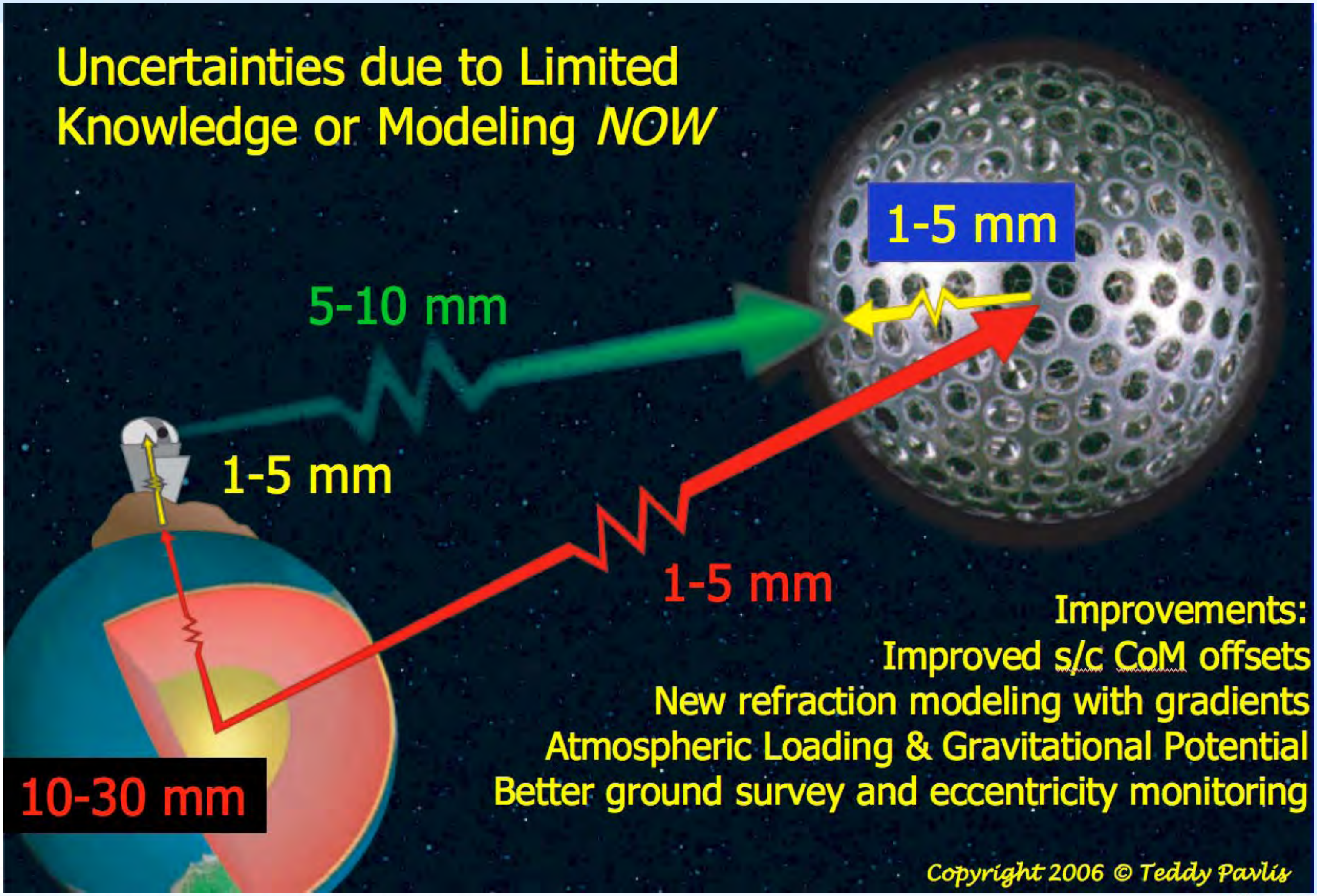
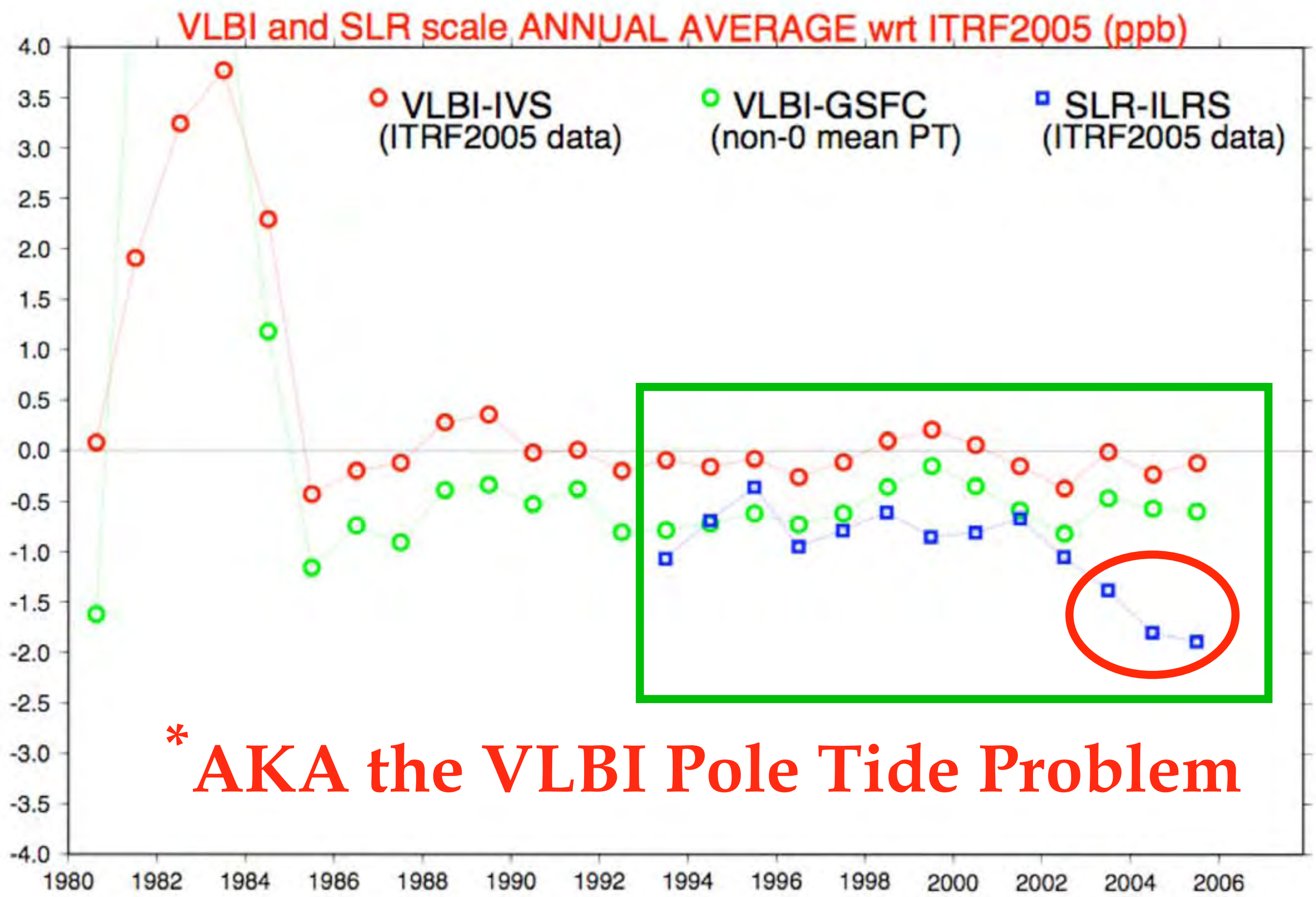


SLR Error Budget



The SLR scale "non-problem*"



Force Models

International Laser Ranging Service

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- **Satellite orbit (force) modeling**:
  - gravity (temporal signal primarily) from Earth fluid envelope, secular and seasonal signals (GRACE)
  - empirical accelerations, (catch-all “sponges”)
  - Earth albedo (setup a service?),
  - Solar Flux at 1 AU (adopt a new constant? - 1367.2035 W/m^2),
  - thermal force modeling (L1/L2 ~OK, other s/c?),
  - solar/lunar eclipsing, etc.
- ***Conventions:*** should conventional model and parameterization strategies be documented (some effects apply to other techniques too) ?
- ***Relation to other techniques:*** similar situation for GNSS, DORIS, and other satellite systems
- ***Impact:*** uniform treatment of similar phenomena, consistent products

Attitude Models

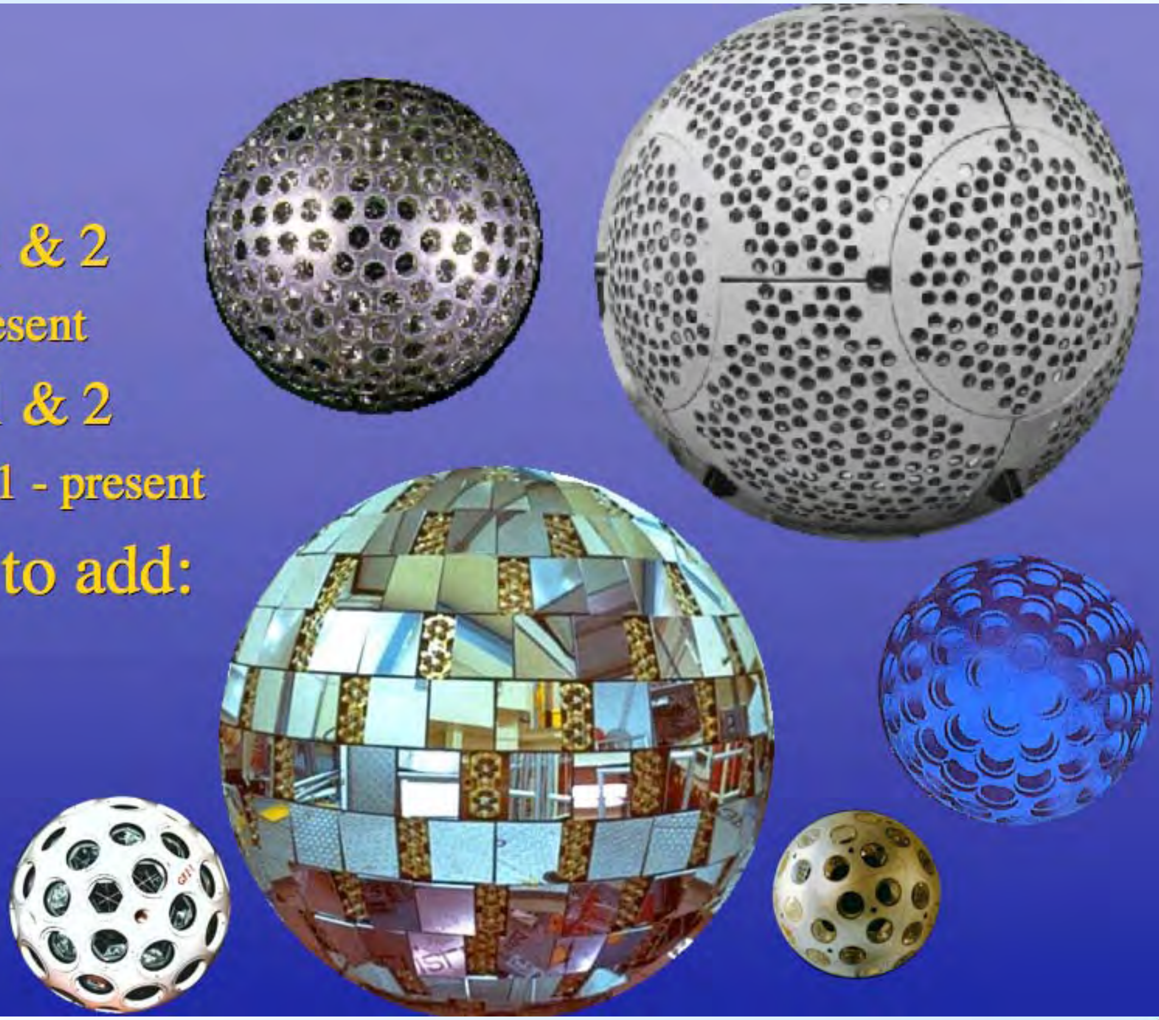
- **Satellite attitude modeling**:
  - Limited mostly to non-TRF contributing s/c, e.g. altimeter satellites (JASON, ENVISAT, etc.) and to GNSS s/c that in the future will contribute to TRF products with SLR observations
  - For cannonball s/c it amounts to a time series of the spin-axis direction and spin rate (adequate models only for L1/2).
- ***Current treatment:*** documentation in progress for remote sensing s/c, improved models for LAGEOS s/c, difficult to maintain without observations from the ground
- ***Relation to other techniques:*** similar situation for GNSS, DORIS, and other satellite systems
- ***Impact:*** it can strongly influence estimated orbital parameters, especially in describing the thermal response of the s/c in orbit

Spacecraft Center-of-Mass

- **<u>Satellite Center-of-Mass offset</u>**:
  - Once a fixed correction determined from pre-launch measurements
  - For GGOS/ITRF this correction is not only S/C dependent (obvious), but also "*tracking-station-ops-regime dependent*"
- ***Current practice:*** ILRS descriptions for all LR-tracked s/c: **http://ilrs.gsfc.nasa.gov/satellite_missions/center_of_mass**
- ***Relation to other techniques:*** issue exists for all s/c whose position is determined with SLR technique
- ***Impact:*** strongly affects network scale, scale-rate, and deformation, as well as cm-level position of tracking sites, current knowledge indicates that this is an error source that limits the quality of SLR orbital products

Spacecraft Targets

- At present:
  - LAGEOS 1 & 2
    - 1993 - present
  - ETALON 1 & 2
    - April 2001 - present
- Considering to add:
  - Starlette
  - Ajisai
  - ???



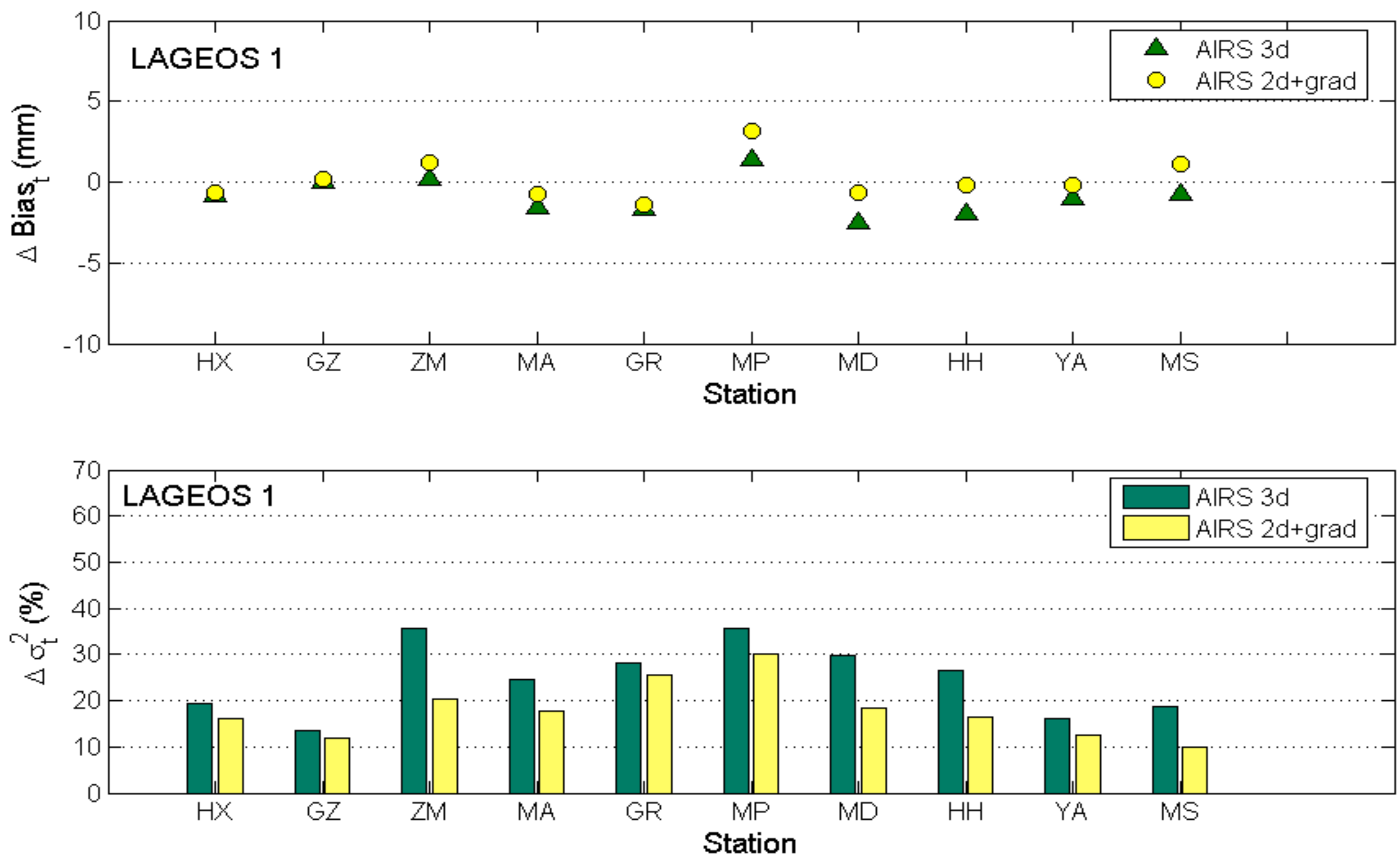
International Laser Ranging Service

Atmospheric delay modeling

JCET

- <u>**Atmospheric delay models**</u>:
  - LR is insensitive to water in the atmosphere, the delay being mainly that due to the hydrostatic effects. For high accuracy applications though, both effects need to be corrected for
  - Few stations (2-3) range in two different wavelengths in hopes of using the different delay paths for the two wavelengths to correct for the atmosphere. Unfortunately, we are far from able to make use of this technique due to extremely stringent timing requirements in measuring the differential delay
- ***Current practice:*** precise modeling has been used for many decades, using environmental observations at the site, during the observing session
  - Until recently, ILRS used a model developed in 1973 (Marini-Murray).
  - Since January 2006, a new model (Mendes-Pavlis) that incorporates a new zenith delay model and new mapping functions, is used (already in the new IERS Conventions)
  - It is now evident that for even higher accuracy at low elevation tracking, we will need to introduce the modeling of horizontal gradients. There are plans to do so in the near future, but success depends largely on the availability of global synoptic satellite measurements from space (e.g. AIRS, COSMIC, etc.)
- ***Relation to other techniques:*** VLBI & GPS affected even more, but able to self-estimate the signal due to strong geometry of data
- ***Impact:*** neglected effects cause small internal deformations in frame

Atmospheric Gradients



Measurement Biases

- <u>**Types of biases encountered**</u>:
  - LR is in general a bias-free, absolute ranging technique. However, stations can develop biases due to errors in calibration, hardware malfunctioning, incorrect application of sub-system corrections, etc.
  - Simple measurement biases, timing biases or scale biases (very rare) can occur at times
- ***Current practice:*** Biases need to <u>be monitored for all sites</u> and for a number of sites (very few, poor data-yield sites) ILRS requires that biases be determined at all times
  - Pilot project is in progress, to monitor the biases and report back to the stations in near-realtime to minimize their impact on solutions and avoid the persistence of faulty operations for extended periods of time
- ***Relation to other techniques:*** VLBI & GPS probably face similar problems, but the relative nature of the measurements requires estimation of bias-type parameters anyway and this alleviates the problem for the most part
- ***Impact:*** if neglected, they will cause disastrous internal frame deformations

Event Timer Biases

Worse-case error estimates (mm)

Station		ID	Calibration error	LAGEOS error	Total error
BEIL	Beijing	7249	-12	+10	- 2
BORL	Borowiecz	7811	- 9	+ 0 meas	- 9
BREF	Brest	7604	-10	+10	0
GLSV	Kiev	1824	- 6	+10	+ 4
HELW	Helwan	7831	0	+10	+10
KTZL	Katzively, Ukraine	1893	0	+10	+10
KUNL	Kunming, China	7820	- 9	+10	+ 1
POT3	Potsdam	7841	0	+10	+10
POTL	Potsdam	7836	0	+ 5 meas	+ 5
SFEL	San Fernando	7824	0	+ 8 meas	+ 8
SISL	Simosato, Japan	7838	+1	+10	+11
SJUL	San Juan	7406	0	+10	+10
WUHL	Wuhan	7231	0	+10	+10
ZIML	Zimmerwald	7810	-3	+ 8 appl	- 3
Closed sites					
GRSL	Grasse	7835	- 1	10	11

meas = measured on particular Stanford counters; **appl** = applied at station

Site motion models

International Laser Ranging Service

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- **Types of models**:
  - Local deformation, tidal, loading, transient
- ***Current practice:*** LR at present follows the IERS Conventions 2003 in applying tidal motions at sites, including ocean loading effects and allows for local deformation (beyond linear tectonic motions) with ad hoc resets of the reference epoch of the position
  - At present there are no other loading signals considered (e.g. atmospheric)
  - Pilot project is in progress, to quantify the effect of atmospheric loading in the SLR products delivered to IERS.
- ***Relation to other techniques:*** The implementation of loading (and other similar signals) should be coordinated across all techniques and implemented simultaneously to avoid skewing the IERS/ITRF products
- ***Impact:*** if neglected, causes severe systematic signals in heights of sites and a component maps on the TRF scale due to the network shape and distribution

Summary

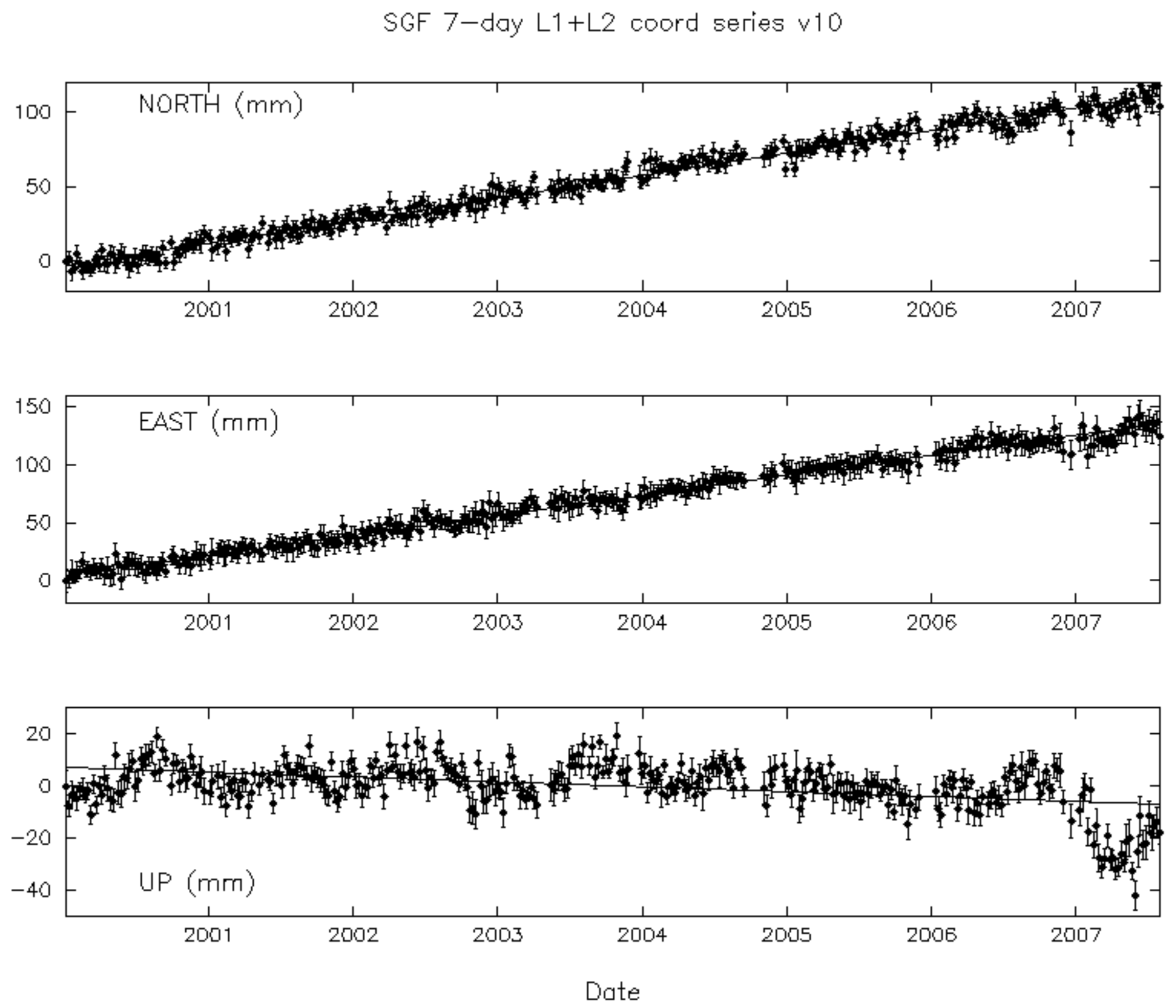
- LR analysis is in general well-supported by the current standards and conventions
  - Recent revisions of atmospheric delay models included already
- Analysis now suffers more from the non-implementation of known geophysical models (e.g. atmospheric loading, atmospheric gravity variations on orbits, etc.) and some **coordination here is needed**
  - A clear definition of cross-technique "tools" (e.g. SINEX for estimated parameters, SP3 format for orbits, etc.) is also required to ensure that all techniques' needs and peculiarities are accommodated in any changes/extensions
- All of the (known at present) deficiencies in the LR processing and modeling chain are being addressed
- In the future, it will be desirable to cross-examine the compatibility of certain models across techniques, e.g. GR implementation

NSGF AC

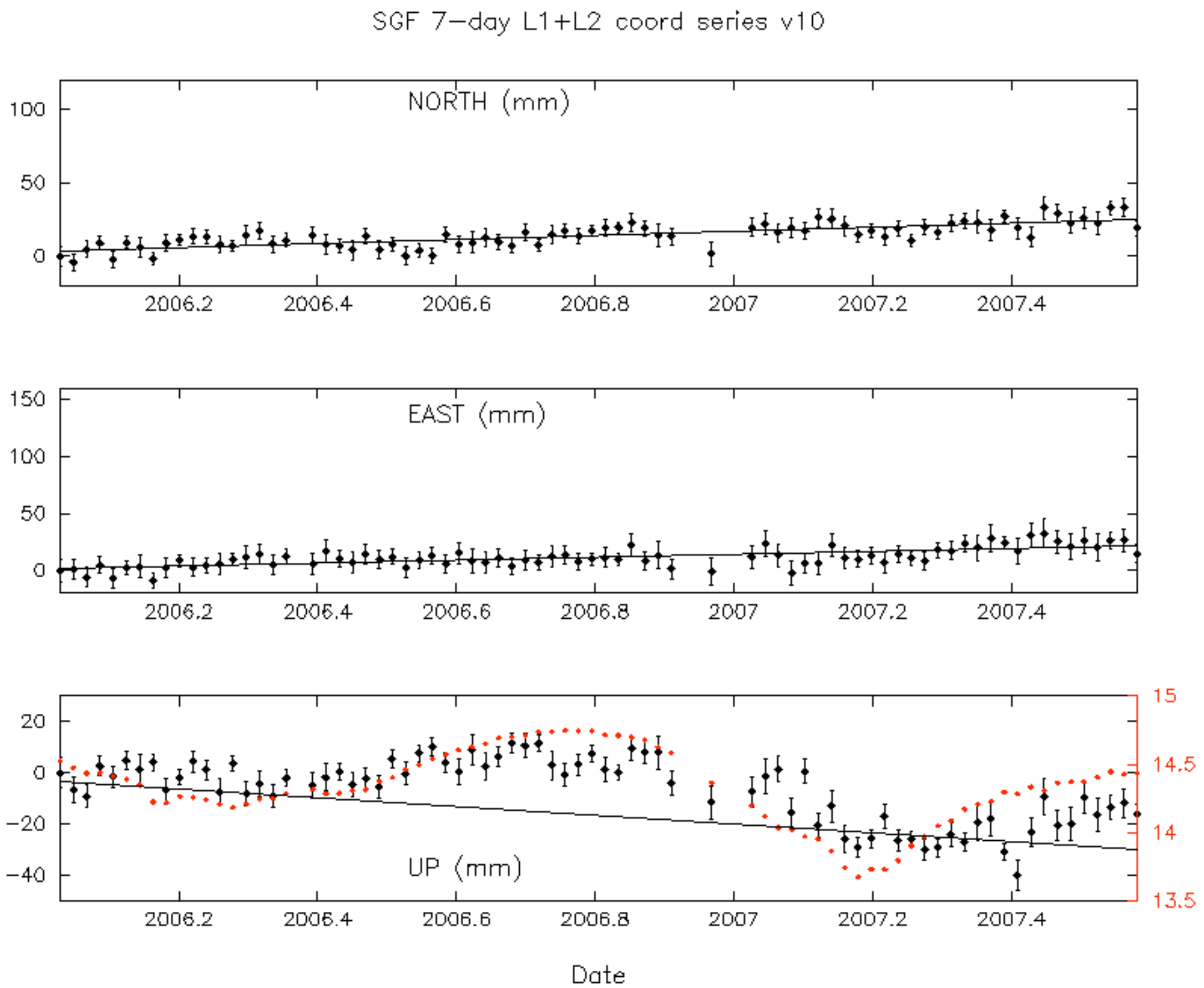
- Regular weekly solutions automatic;
- Using new IERS C04_05 for a-priori
- Using LAGEOS and ETALON
- Solutions 1983-1992 submitted.
- Re-processed 2000-2007 using Stanford corrections:

Herstmonceux 7840 SGF solution

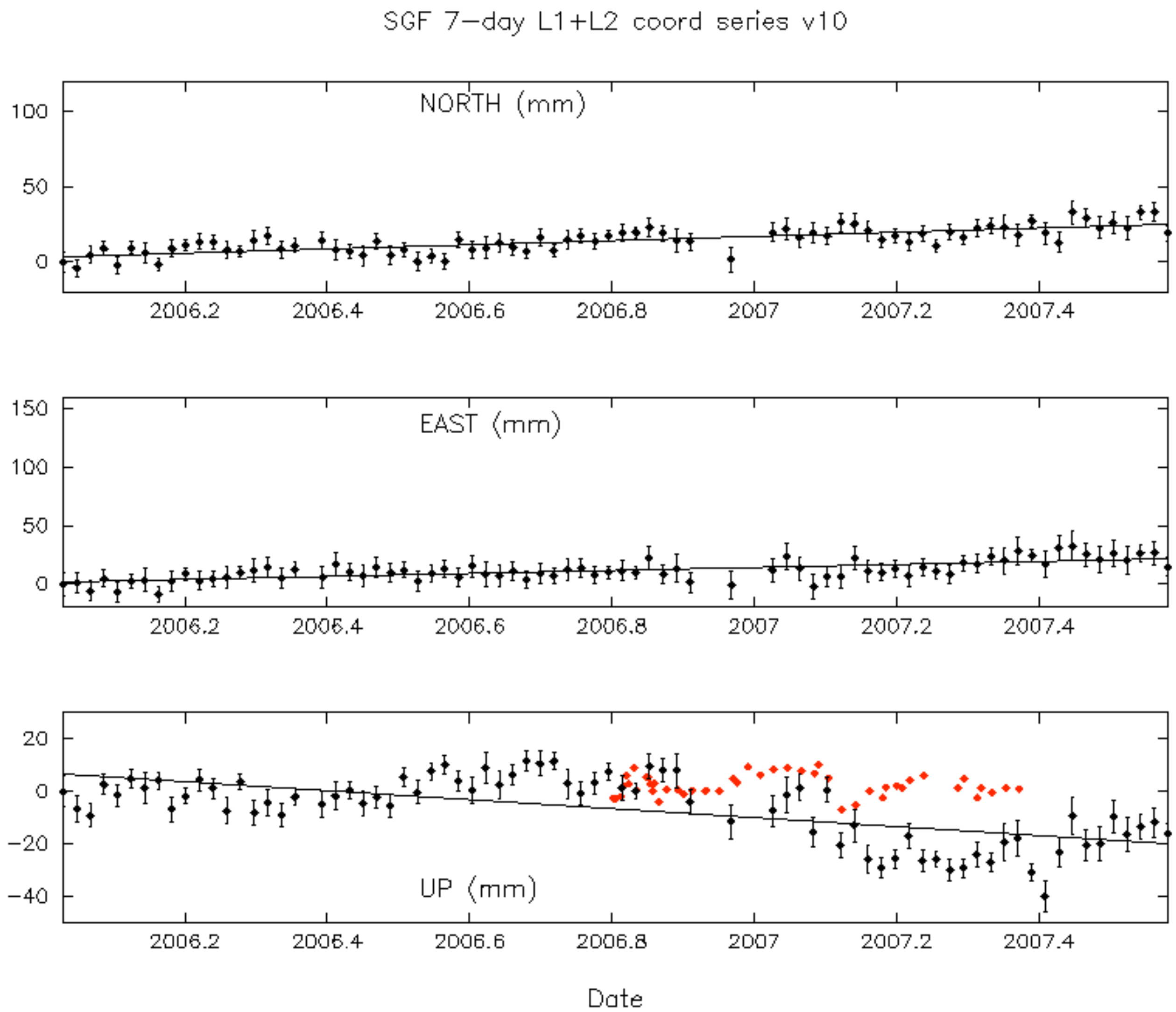
reprocessed with Stanford corrections included



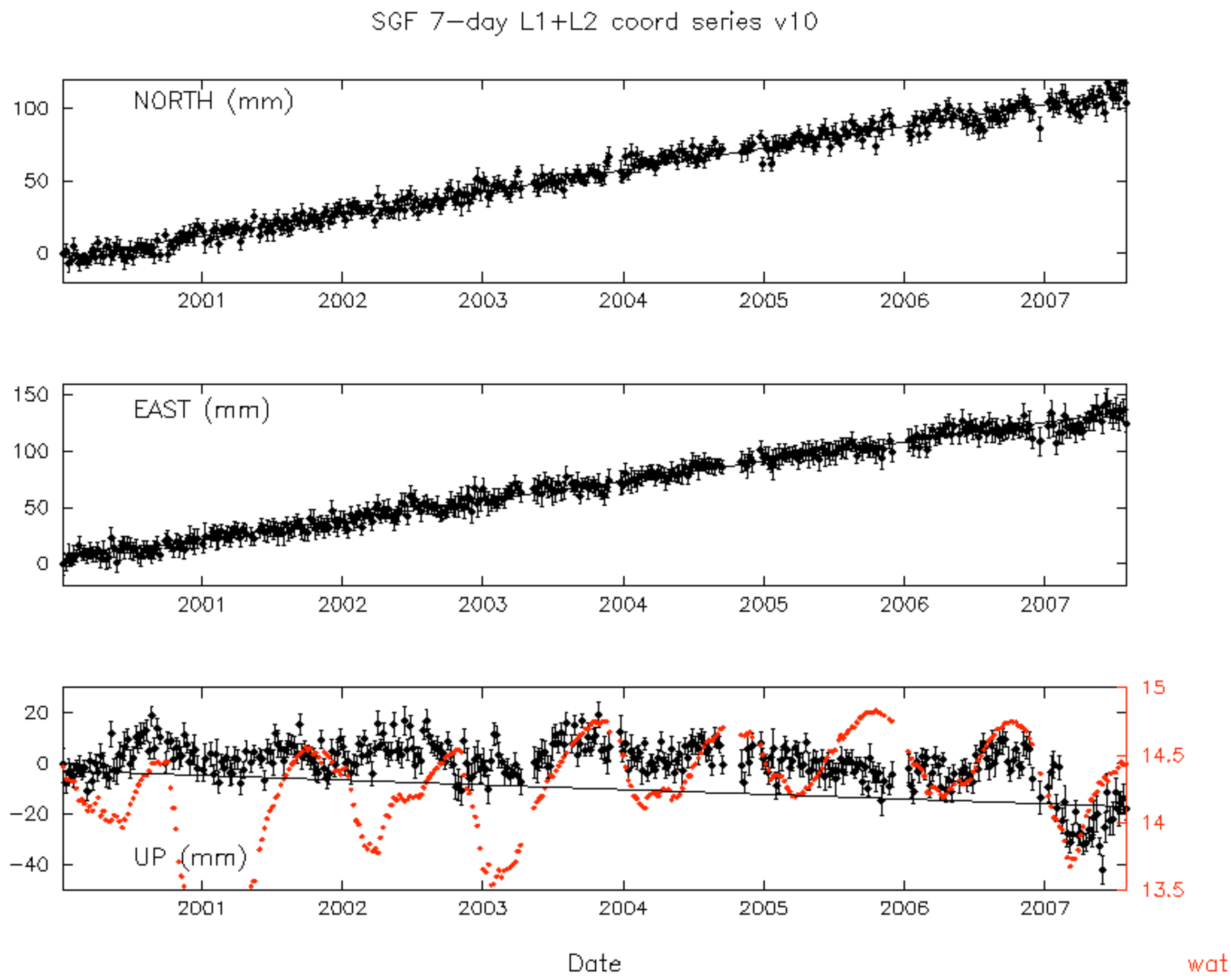
Herstmonceux 7840 SGF solution



Herstmonceux 7840 SGF solution



Herstmonceux 7840 SGF solution



Progress on Systematic Effects in Stanford counters used for Laser Ranging Observations

Graham Appleby, and **Philip Gibbs**

Space Geodesy Facility, Herstmonceux, UK

ILRS AWG, Grasse, 24th Sept 2007

NATURAL ENVIRONMENT RESEARCH COUNCIL

BNSC BRITISH NATIONAL SPACE CENTRE

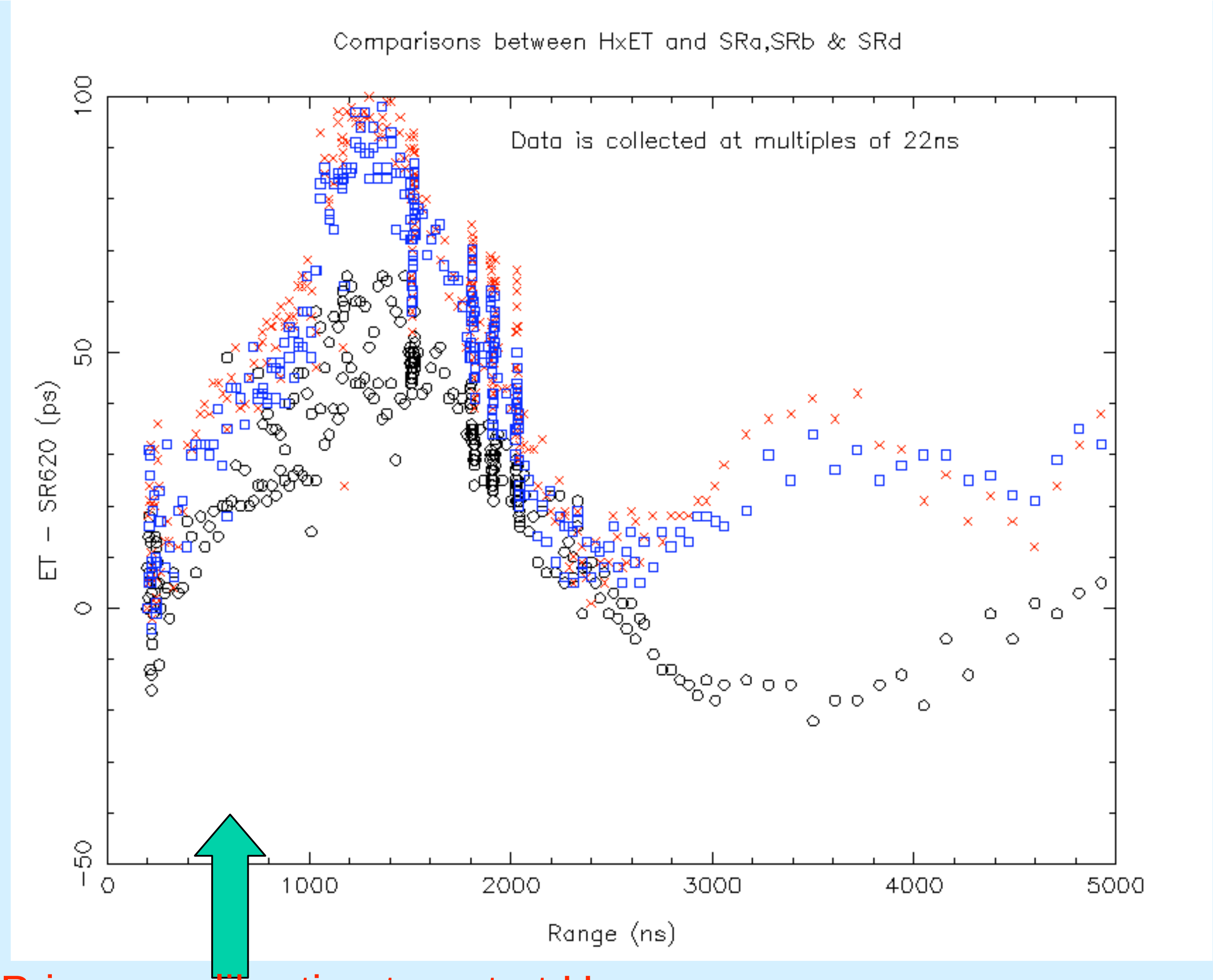
Tests on counter linearity

- Relative to a 'perfect' time-of-flight counter, what are the characteristics of the counters in common use over the last 15+ years?
- Work was started by a careful examination of *Stanford* counters in use at Herstmonceux, relative to a high-spec, ps-level event timer.
- Counters from Potsdam and Boroweic also tested at Herstmonceux.
- Studied effects at LAGEOS and at local calibration target distances.

Herstmonceux counters

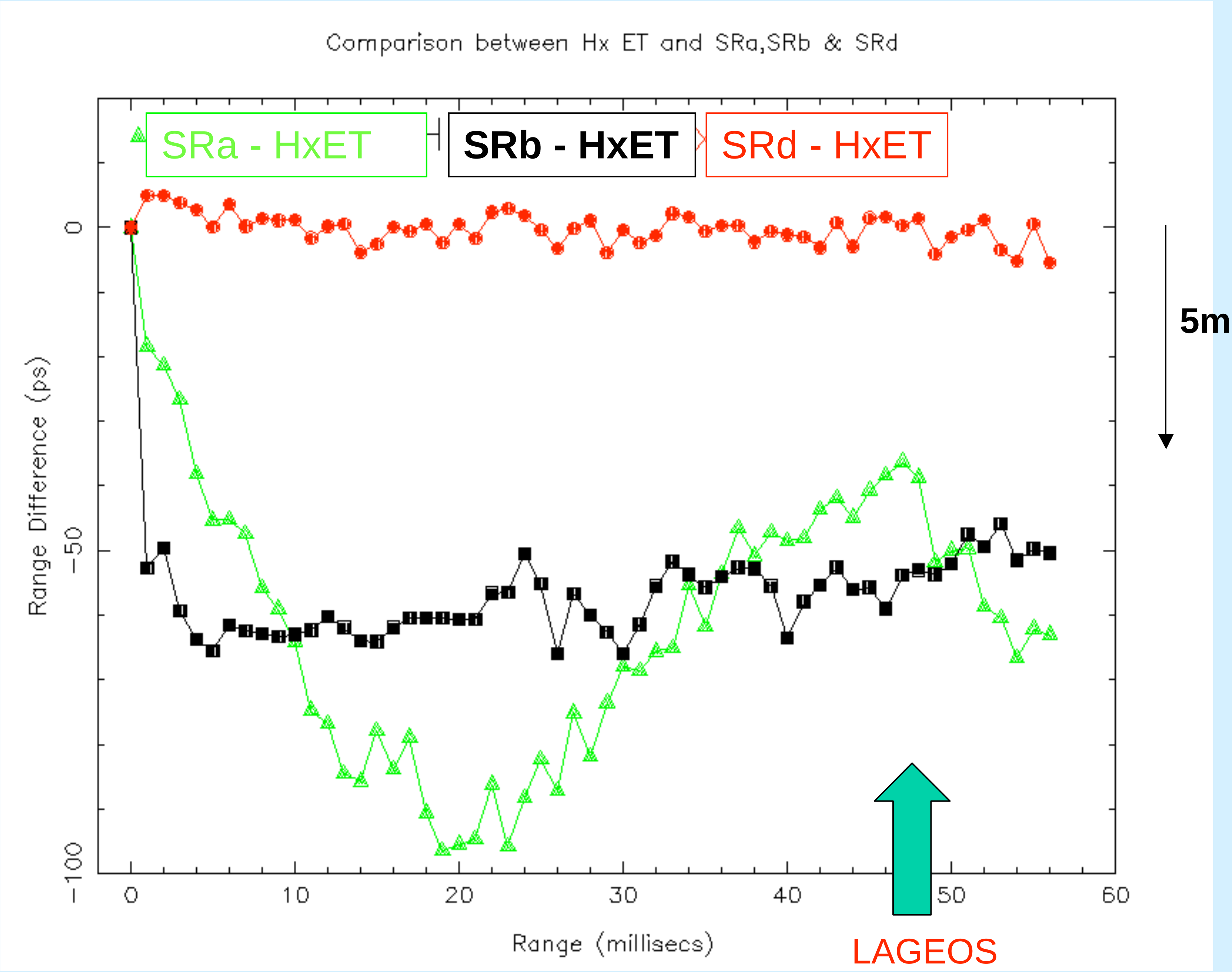
- A ps-level event timer (HET) has been built in-house from *Thales* clock units;
- A prerequisite for the upcoming kHz operations.

- Extensive use of HET to calibrate existing cluster of *Stanford* counters prior to routine use of HET;
- In particular we wish to **back-calibrate** Hx data 1994-present.



Primary calibration target at Hx

Comparisons between HxET and the Stanford counters for calibration boards' distances;
Behaviour very similar to spec;
Errors up to 100ps (15mm), with some systematic detailed structure



Comparison between Hx ET and SRa,SRb & SRd
SRa - HxET
SRb - HxET
SRd - HxET
5mm
Range Difference (ps)
0
−50
−100
0
10
20
30
40
50
60
Range (millisecs)
LAGEOS

Summary of effect on range measurements at Herstmonceux (1994-2007)

- The non-linearity of the Stanfords:
- imparts an average of ~-5.5±2mm error onto the observed **calibration** range;
  - The calibrations are too short;
  - Hence calibrated satellite ranges are **too long by 5.5mm**.
- Value is dependent on the target range, electronic delays and on the particular Stanford;
  - Hence the inherent 2mm uncertainty in this correction

Summary of effect on range measurements at Herstmonceux (1994–2002)

- At distance of LAGEOS, range error is ~ −8 ± 2mm;
  - observed raw LAGEOS ranges are too short
- **So total range error is:**
  - + 5.5 − 8.0 = − 2.5 ± 3mm
  - i.e. need to **add** 2.5mm to LAGEOS ranges

- **This correction applies to the period 1994 October 1 to 2002 January 31**

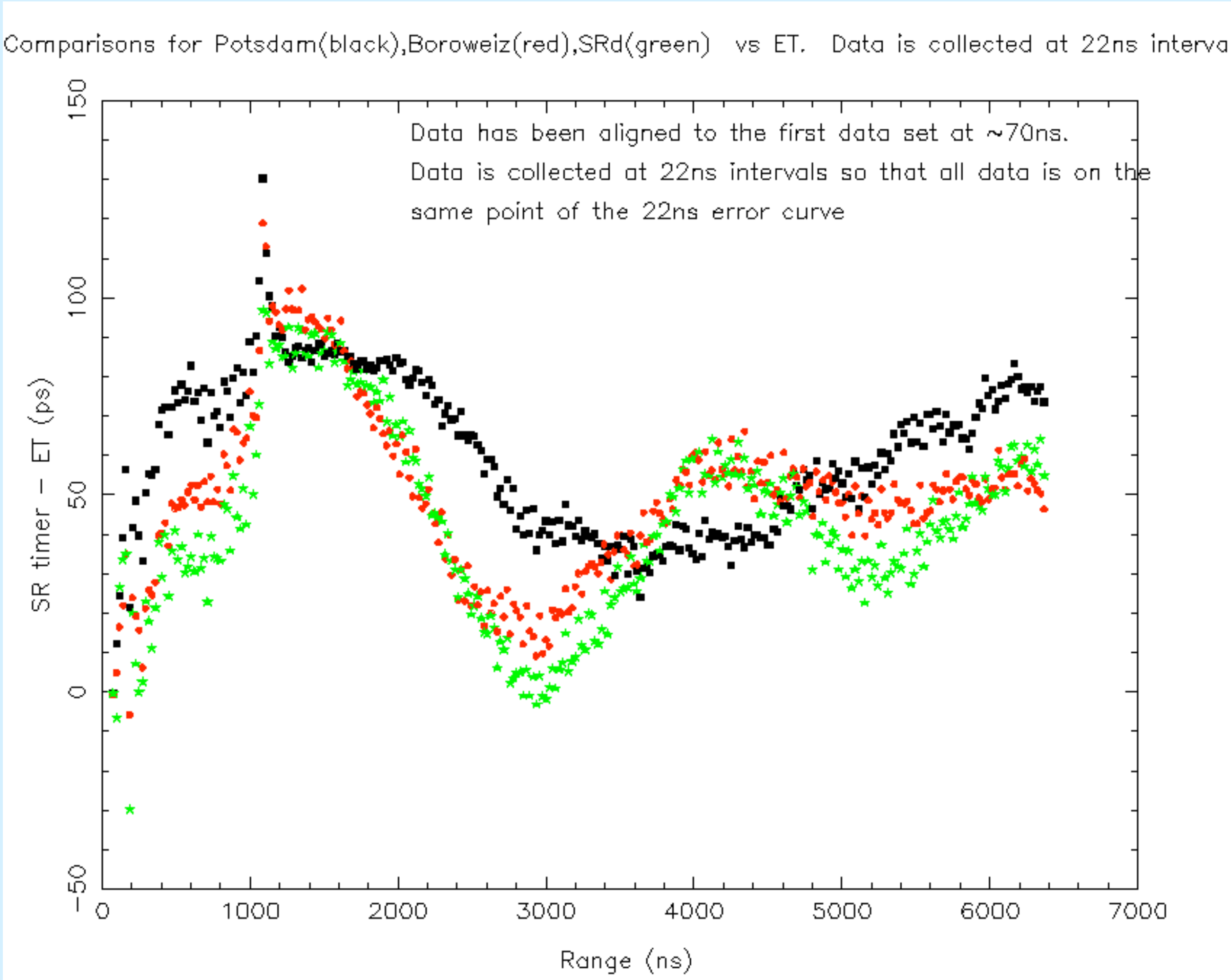
Summary of effect on range measurements at Herstmonceux (2002–2007)

- From 2002 February 1 the satellite-range-dependent correction has been applied on-site
- The calibration error has **not been applied**
- So for the period 2002 February 1 – 2007 February 10:
  - Subtract 5.5mm from **all satellite ranges** from Herstmonceux

- **From 2007 February 11, range error for all satellites is ~zero, using new event timer**

Effect present in other ILRS stations?

Tests at Hx with Potsdam (7836) and Borowiec counters - at calibration ranges



Tests at Hx with Potsdam (7836) and Borowiec counters – at calibration and LAGEOS ranges

- We find similar behaviour at 'calibration' ranges between the two counters and when compared with Stanford manual and with Hx counters;
- For Potsdam 7836 for 1992 May onwards, **add** 3mm to LAGEOS ranges;
- For Potsdam 7841, estimate that between 2001 July and 2004 February **add 5mm** to LAGEOS ranges (counter no longer available to test);
- For Borowiec for 2002 May onwards **subtract 9mm** from LAGEOS ranges.

Effect present in other ILRS stations?

- At this stage, we confine our investigation to Stanford counters;
  - Our limited experience with *e.g.* HP timers suggests they do not have problem - used by NASA network
- We have made 'worst case' **estimates** of calibration error and total range error at LAGEOS for all 'Stanford stations':
- We take target range from Log files and calibration values from ILRS NP headers;
- Thus estimate *tof* for calibration ranging, hence Stanford error.
- Use worst-case estimate at LAGEOS range.

- Error span is -9 to +11mm, frequent error +10mm
- Uncertainty in these **estimates** could be up to ~5mm

Worse-case error estimates (mm)

Station		ID	Calibration error	LAGEOS error	Total error
BEIL	Beijing	7249	-12	+10	- 2
BORL	Borowiec	7811	- 9	+ 0 meas	- 9
BREF	Brest	7604	-10	+10	0
GLSV	Kiev	1824	- 6	+10	+ 4
HELW	Helwan	7831	0	+10	+10
KTZL	Katzively, Ukraine	1893	0	+10	+10
KUNL	Kunming, China	7820	- 9	+10	+ 1
POT3	Potsdam	7841	0	+ 5	+ 5
POTL	Potsdam	7836	0	+ 3 meas	+ 3
SFEL	San Fernando	7824	0	+ 8 meas	+ 8
SISL	Simosato, Japan	7838	+1	+10	+11
SJUL	San Juan	7406	0	+10	+10
WUHL	Wuhan	7231	0	+10	+10
ZIML	Zimmerwald	7810	-3	+ 8 appl	- 3
Closed sites					
GRSL	Grasse	7835	- 1	10	11

meas = measured on particular Stanford counters; **appl** = applied at station

Comments

- We emphasise the preliminary nature of this table;
  - The plots of the 3 Herstmonceux Stanford counters show large inter-counter differences;
- Calibration of each stations' counter(s) is valuable but not absolute – still uncertainty in 'zero point'.
- Interested to get other examples;
- Particularly important to look at San Juan, San Fernando

Summary/outlook

- We also note that:
- The stations are a subset of the full ILRS network, but do contain some core sites;
- The counters' errors can be estimated (ongoing) and data reprocessed;
  - Counter characteristics remain static over time;
- Several of the stations have already upgraded to higher-quality counters.