ILRSA CC
Status of the combination products

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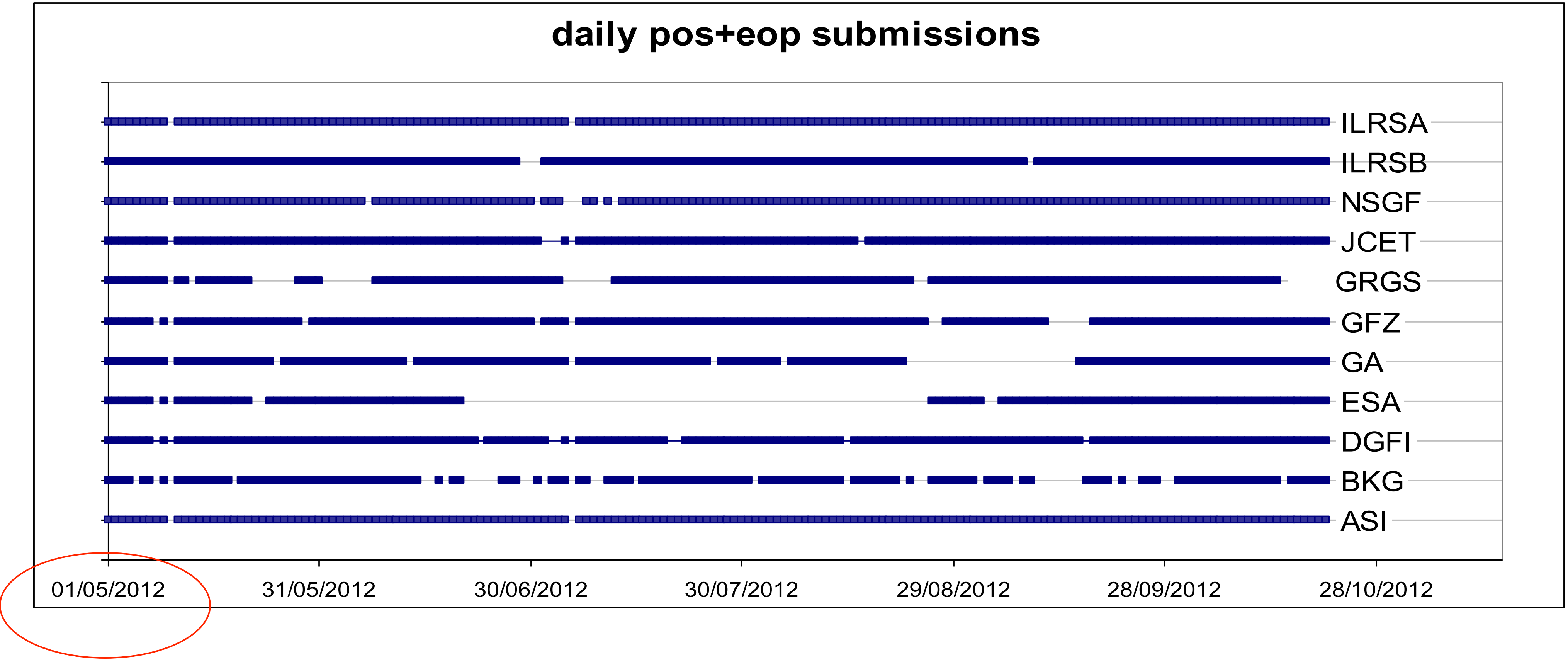
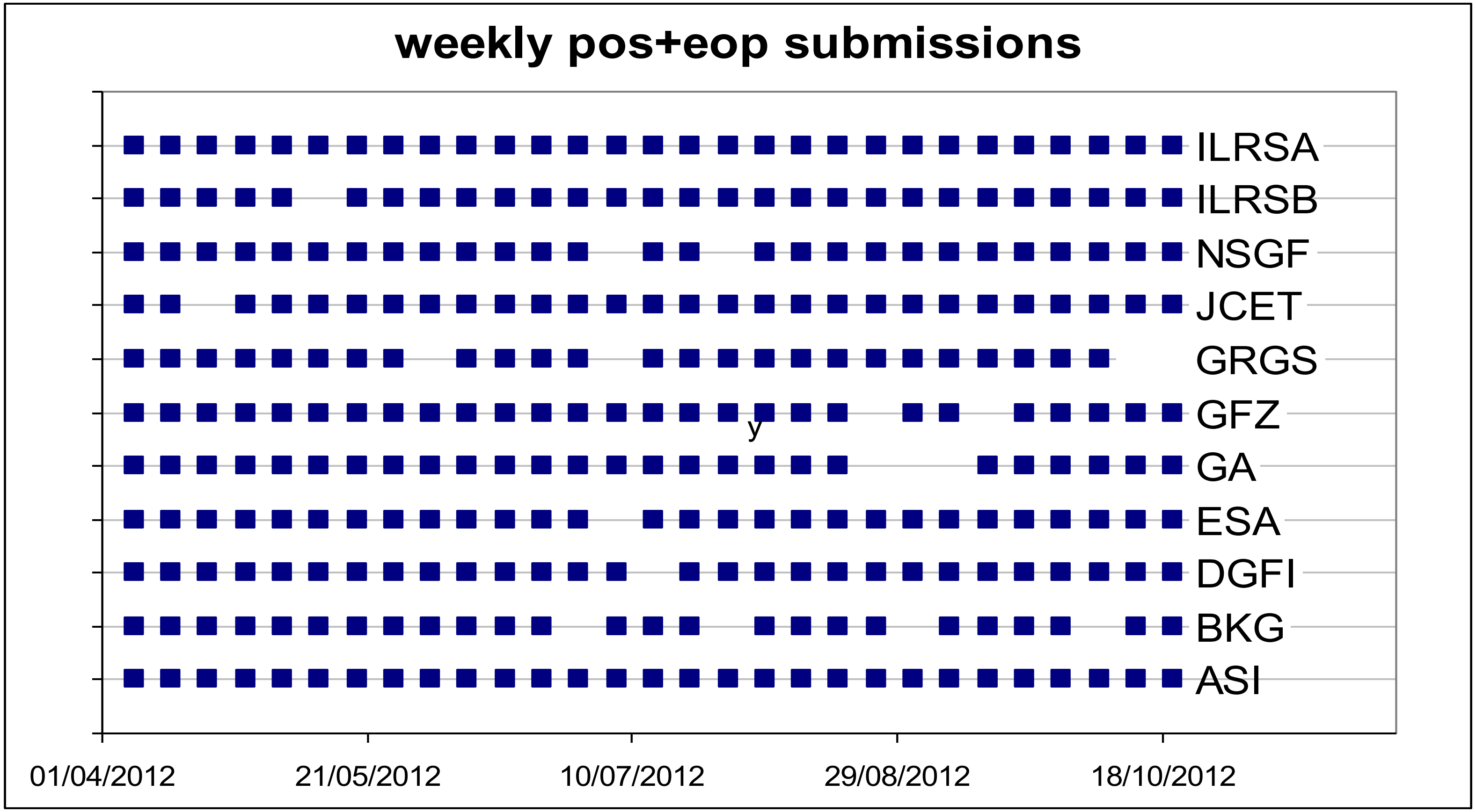
Contents

- ILRS daily&weekly products
- ILRS solutions for IERS GGFC Pilot Project
- SP3c files quality evaluation

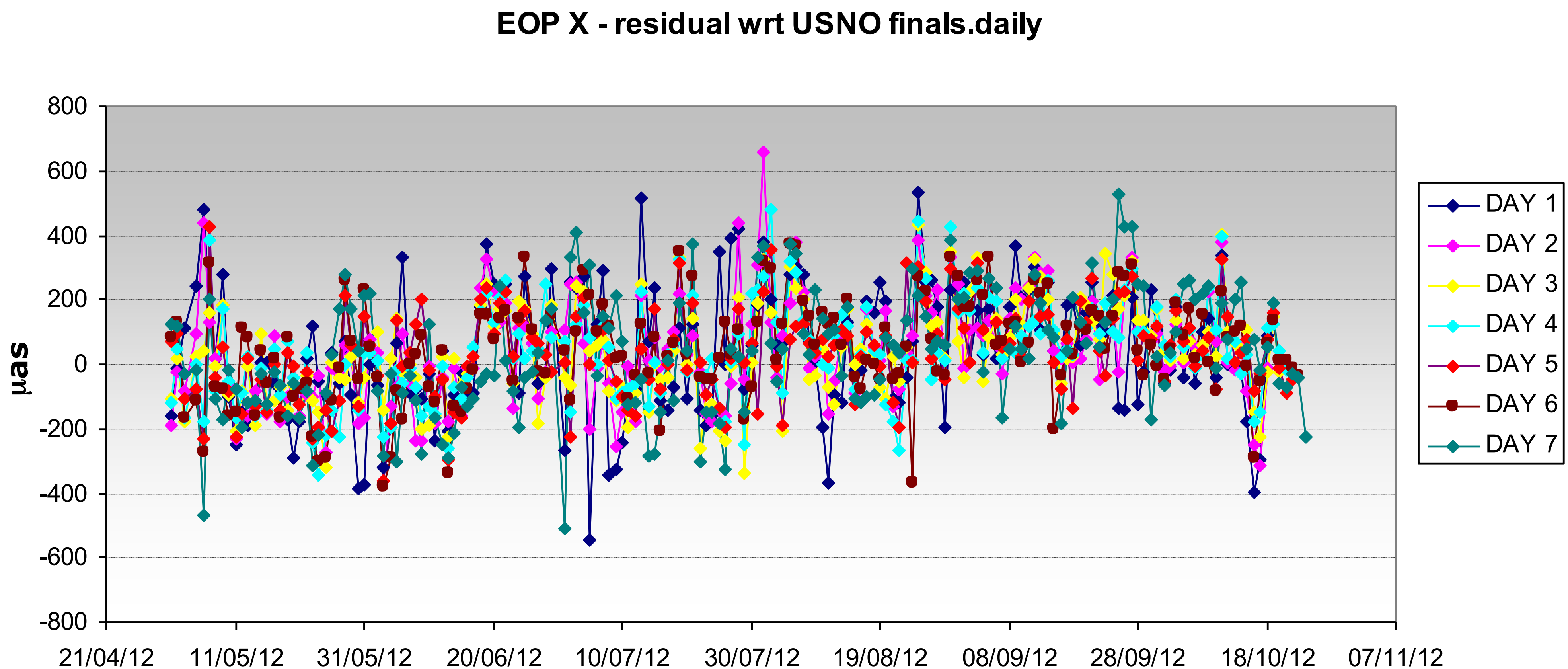
AC daily pos+eop submission



AC weekly pos+eop submission

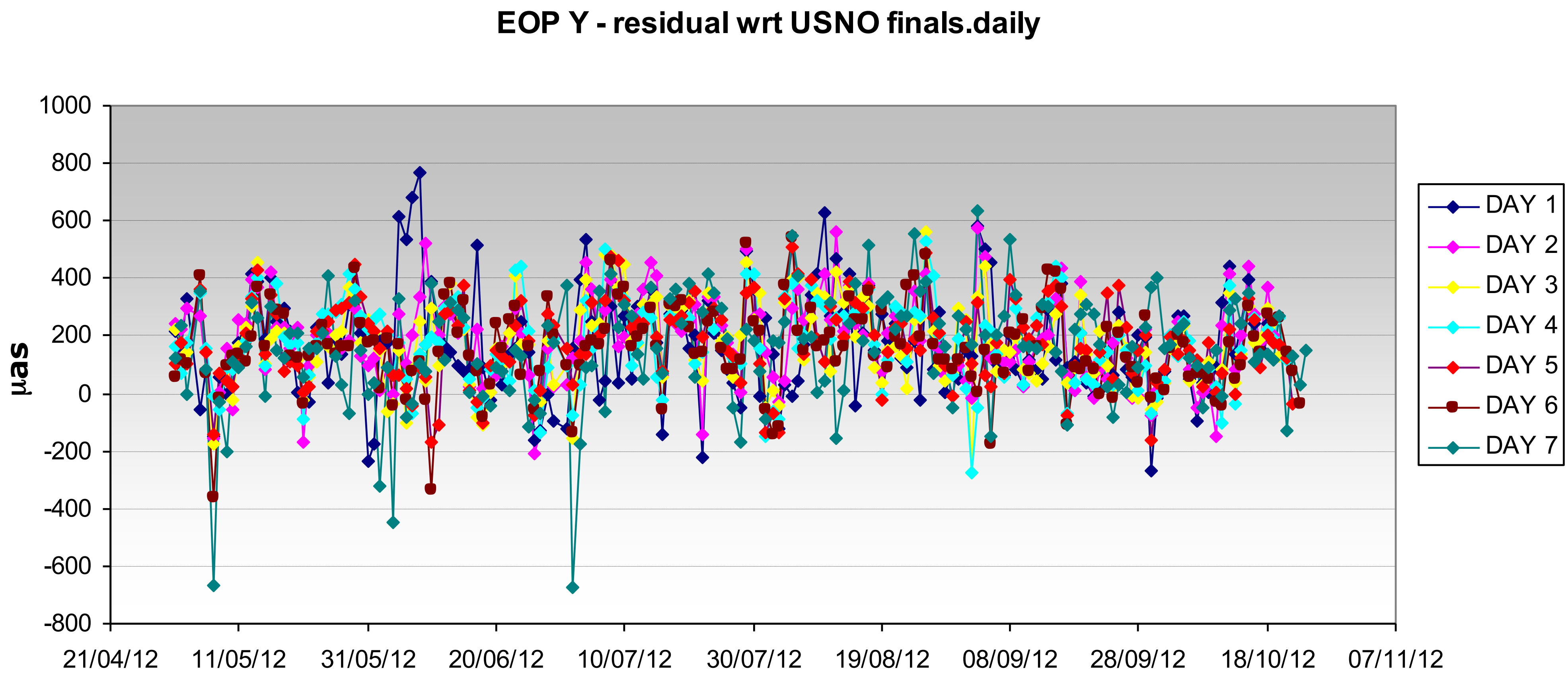


"Peer" combined solutions series



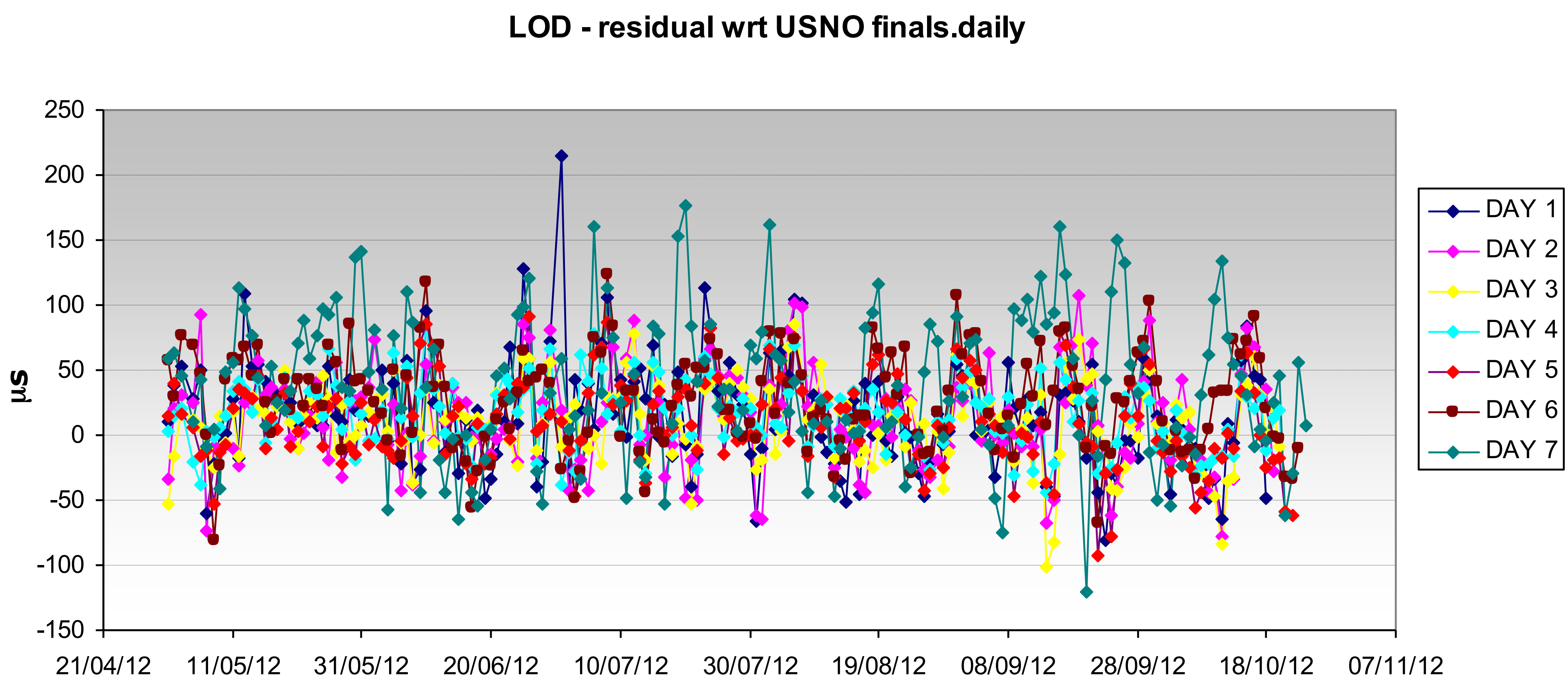
µas	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	Weekly
WRMS	**185**	**160**	**149**	**155**	**138**	**151**	**187**	**160**

“Peer” combined solutions series



μas	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	Weekly
WRMS	236	225	214	220	225	209	239	226

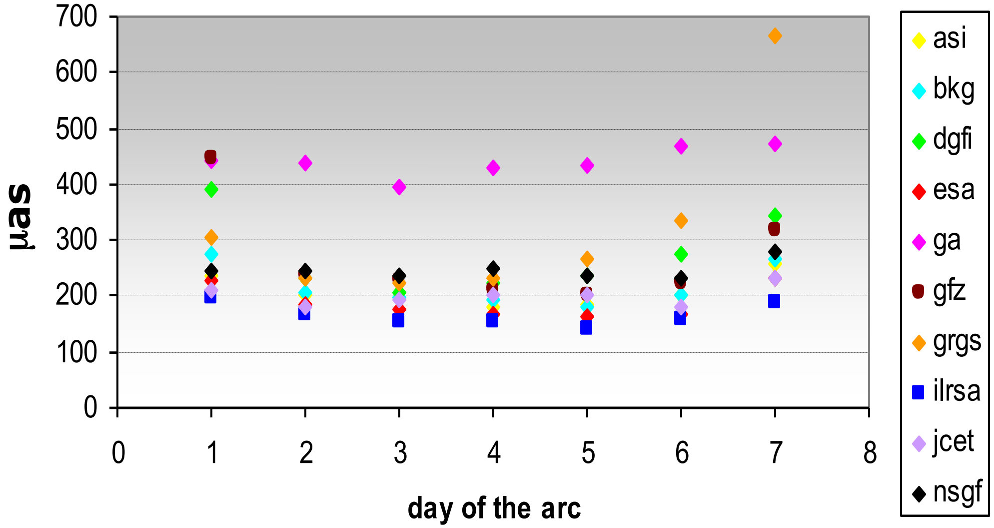
"Peer" combined solutions series



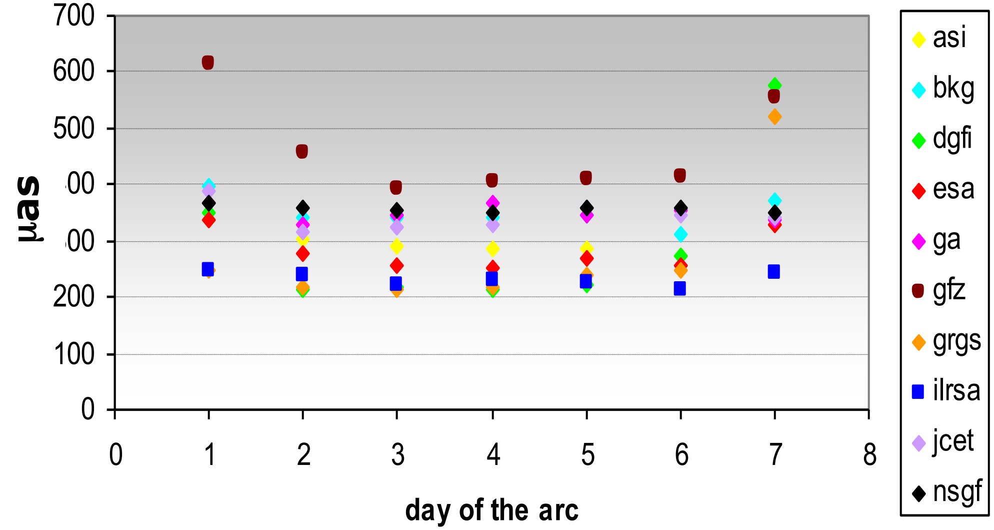
µs	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	Weekly
WRMS	42	38	29	29	31	45	67	32

Contributing peer solutions series

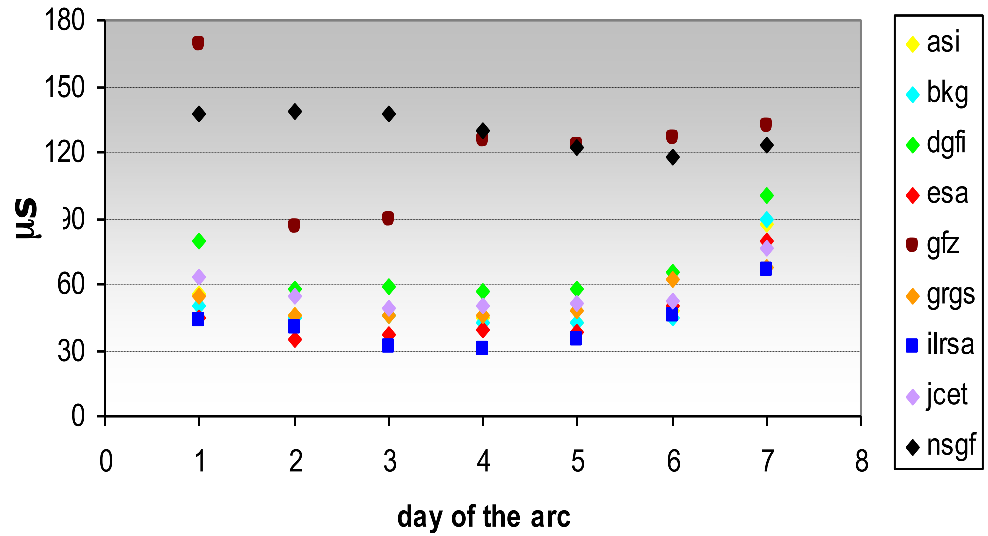
EOP X - RMS of residuals



EOP Y - RMS of residuals



LOD - RMS of residuals



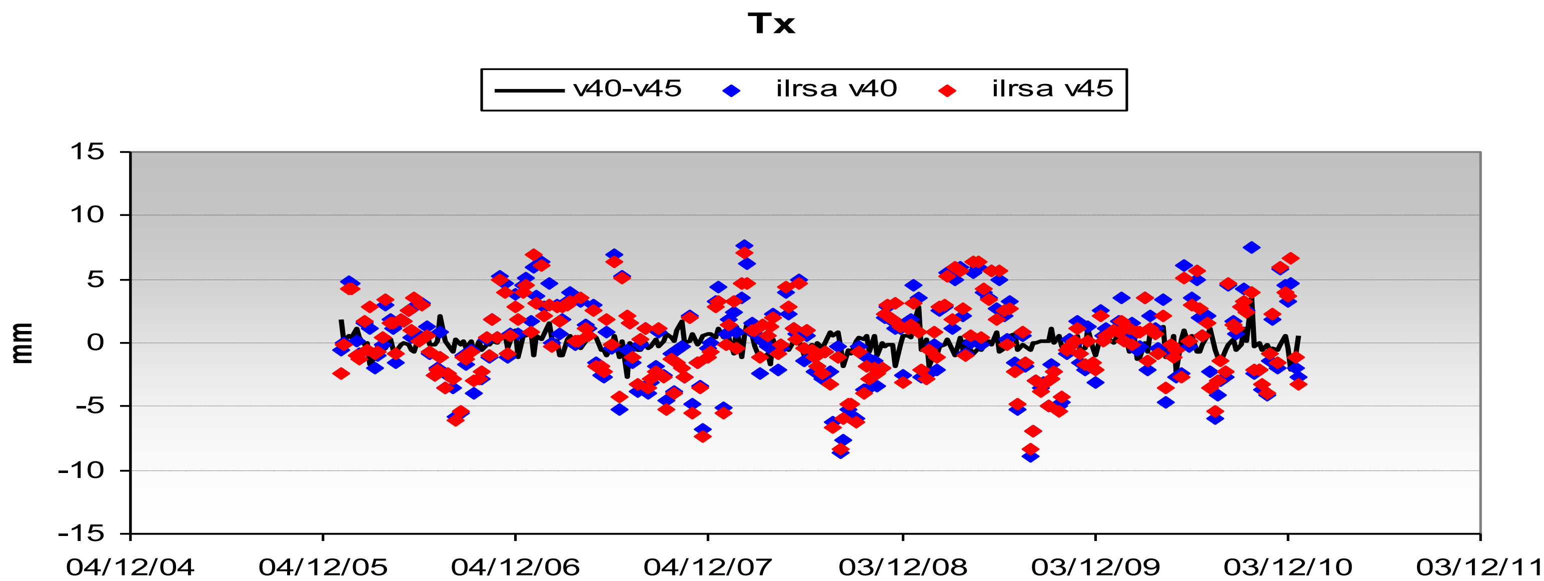
Daily&weekly solutions - remarks

- ILRS official solution is the daily (7-day arc) combined v130 solution starting from 01/05/2012

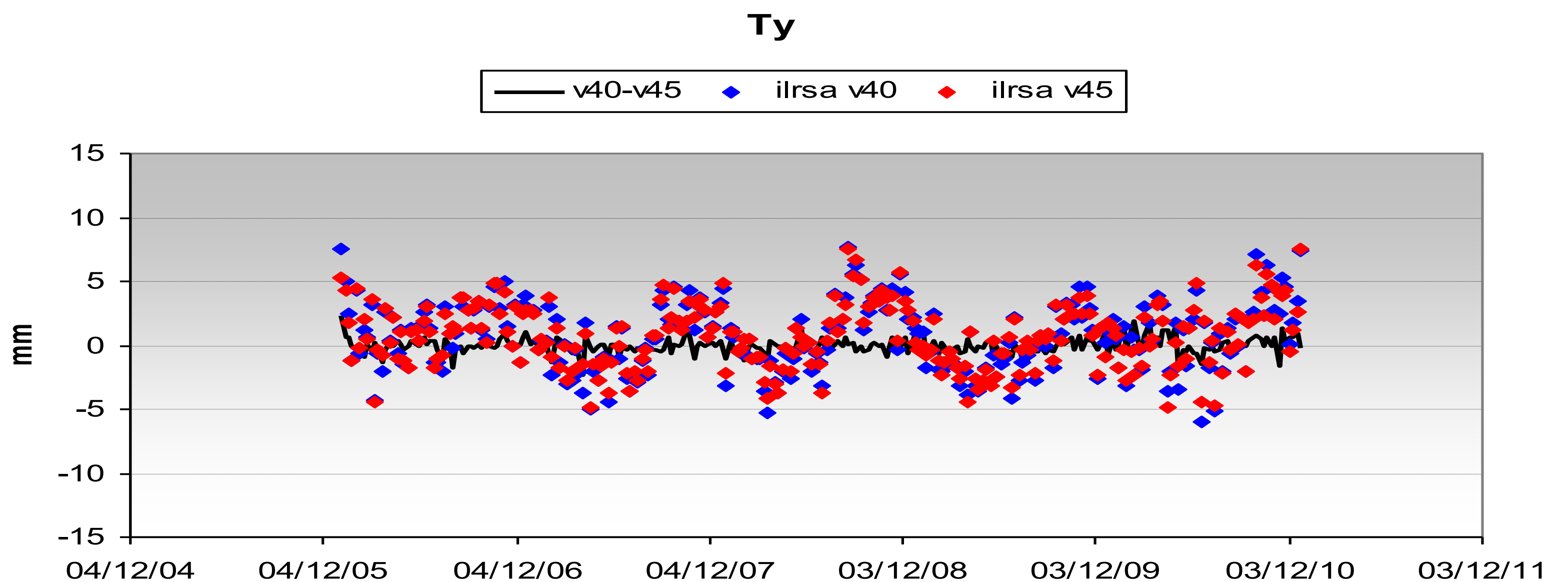
- 9 ILRS ACs contribute; in general, missing solutions are sporadic, the majority of ACs contributes steadily

- Peer solutions series (i.e. "same age" estimate) show the best behaviour for the "middle age" series (day 3,4,5 of the arc); however, the "youngest" estimates (day 6, 7 of the same arc, i.e. 3-, 2-day latency) are good enough (residuals for the day 6 series: 151mas, 209mas, 45ms)

IERS GGFC PP - ILRSA origin&scale

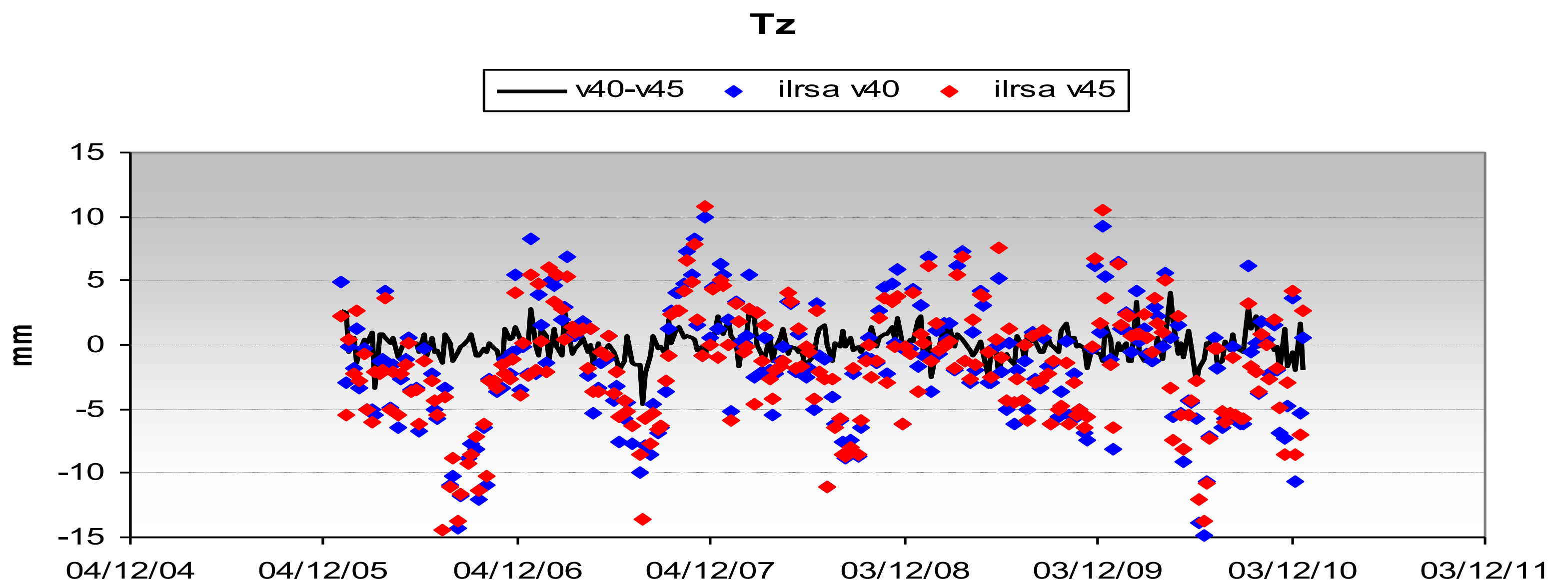


Tx mm	RMS
V40	3,36
v45	3,24

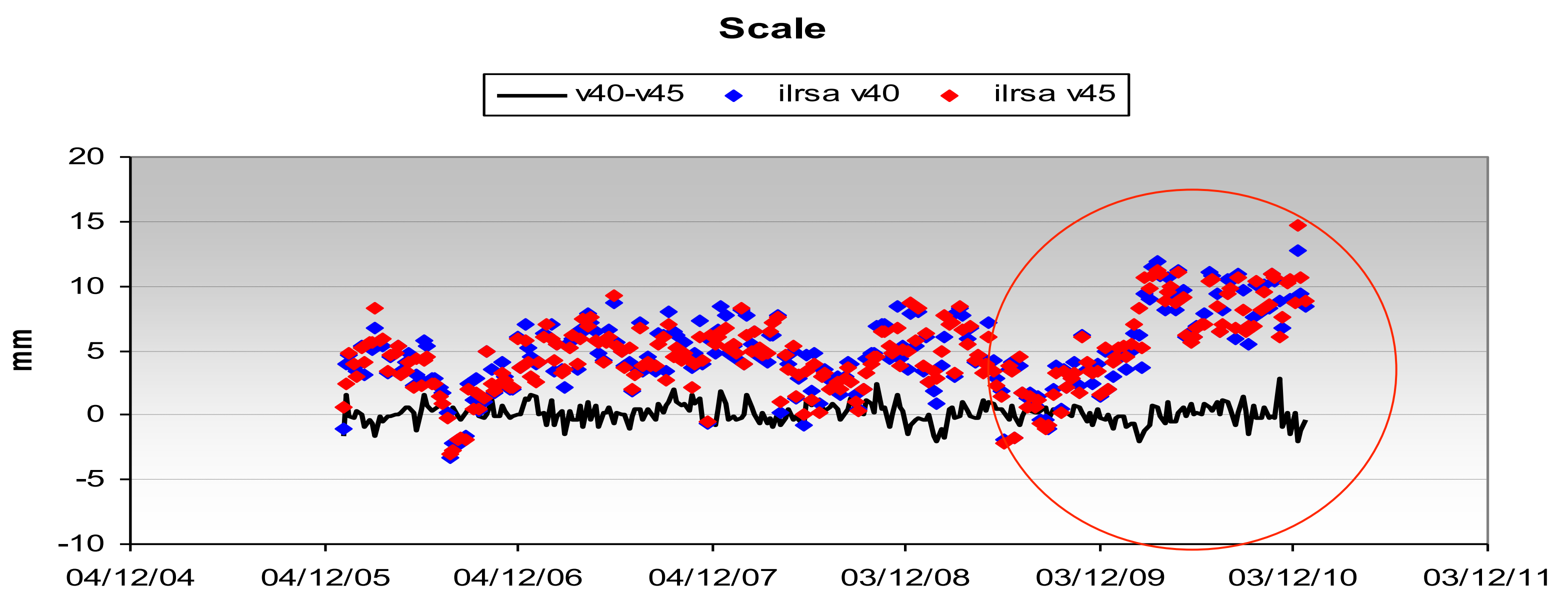


Ty mm	RMS
V40	2,75
v45	2,57

IERS GGFC PP – ILRSA origin&scale

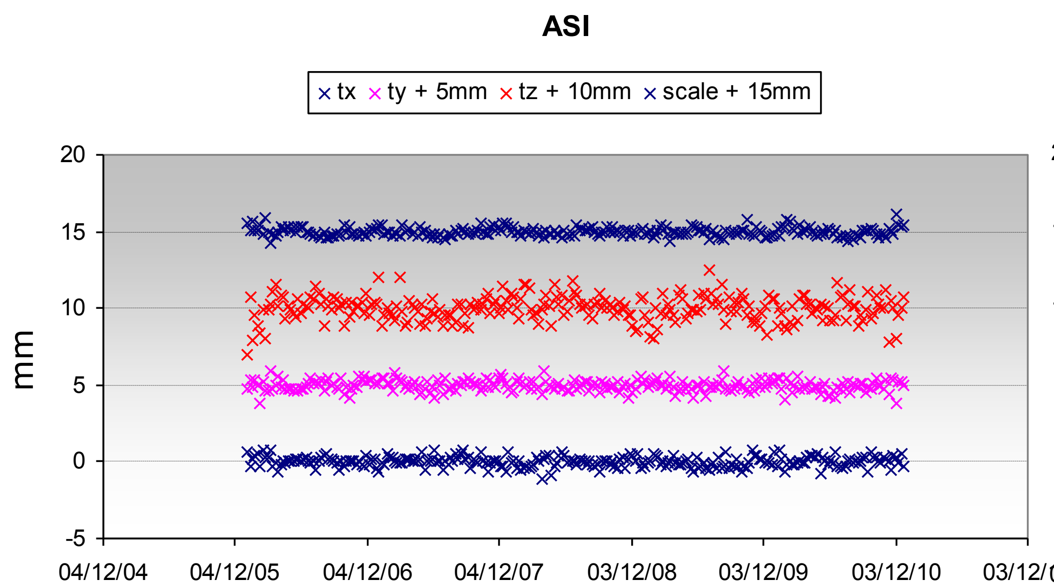


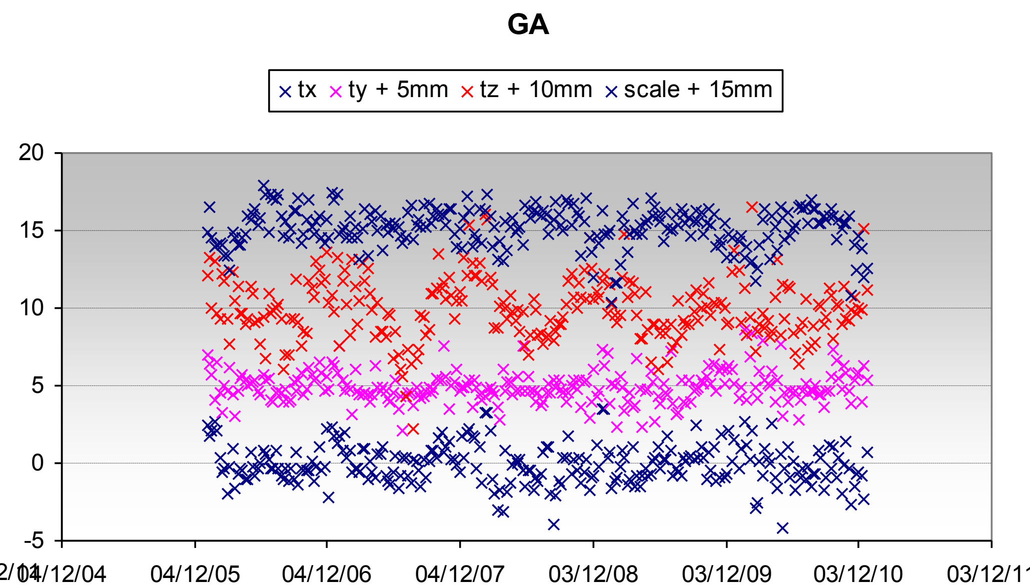
Tz mm	RMS
V40	5,36
v45	5,03

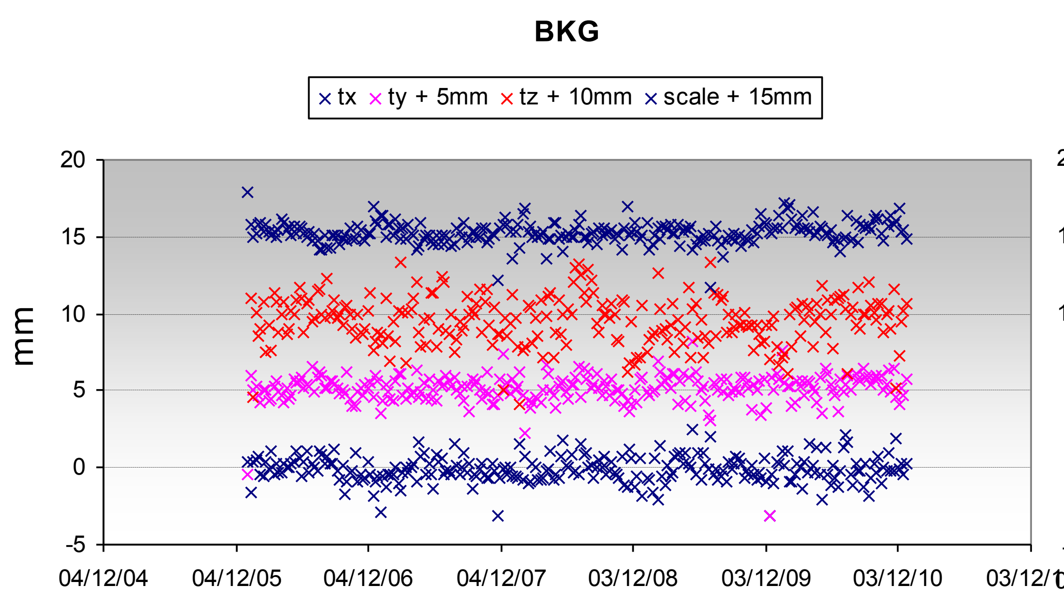


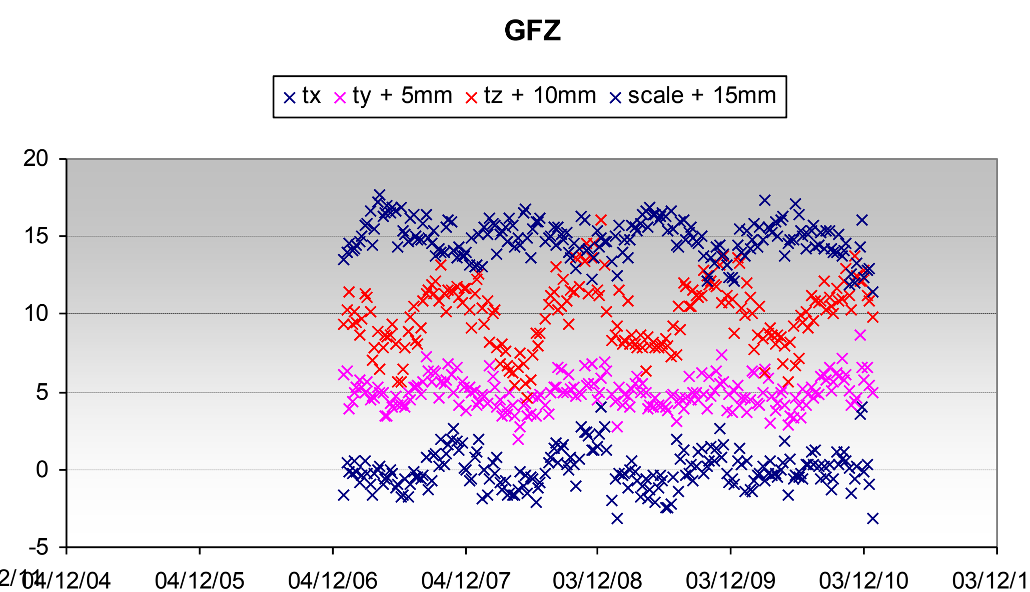
Scale mm	RMS
V40	5,67
v45	5,58

IERS GGFC PP – AC solutions origin&scale

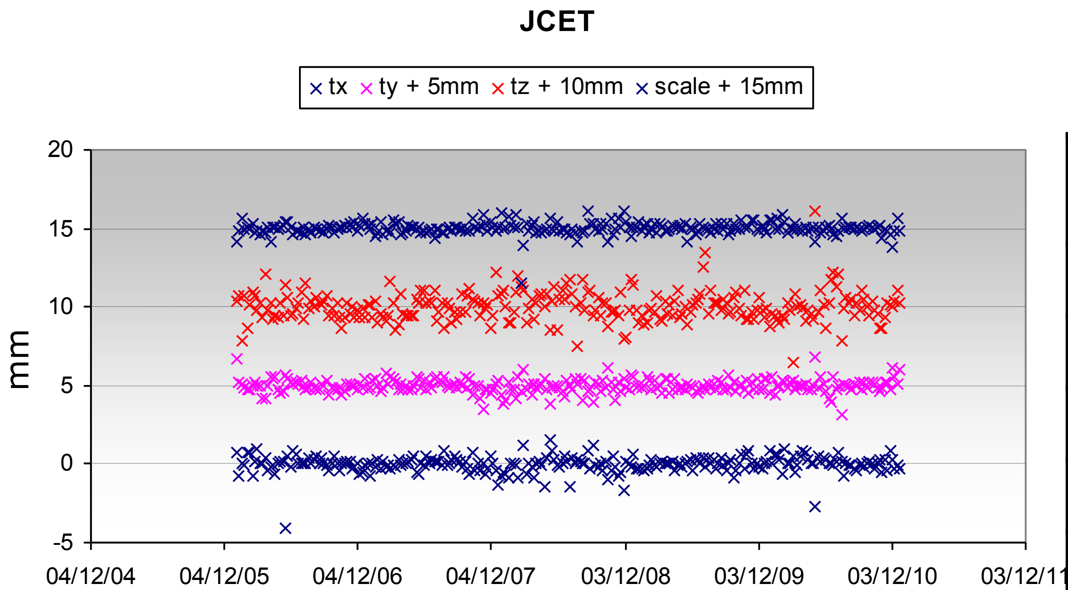


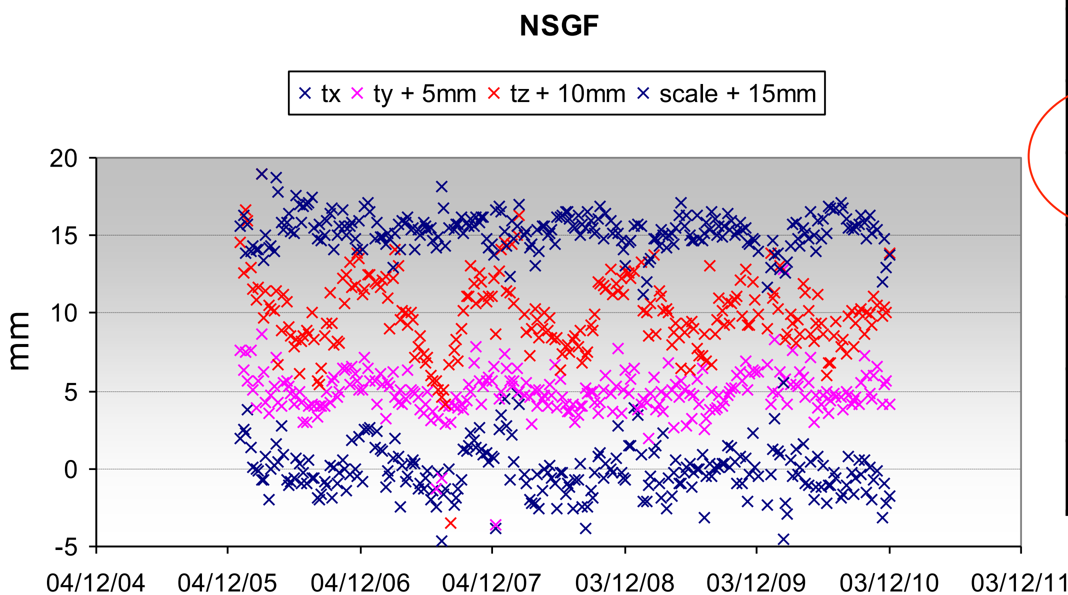






IERS GGFC PP – AC solutions origin&scale



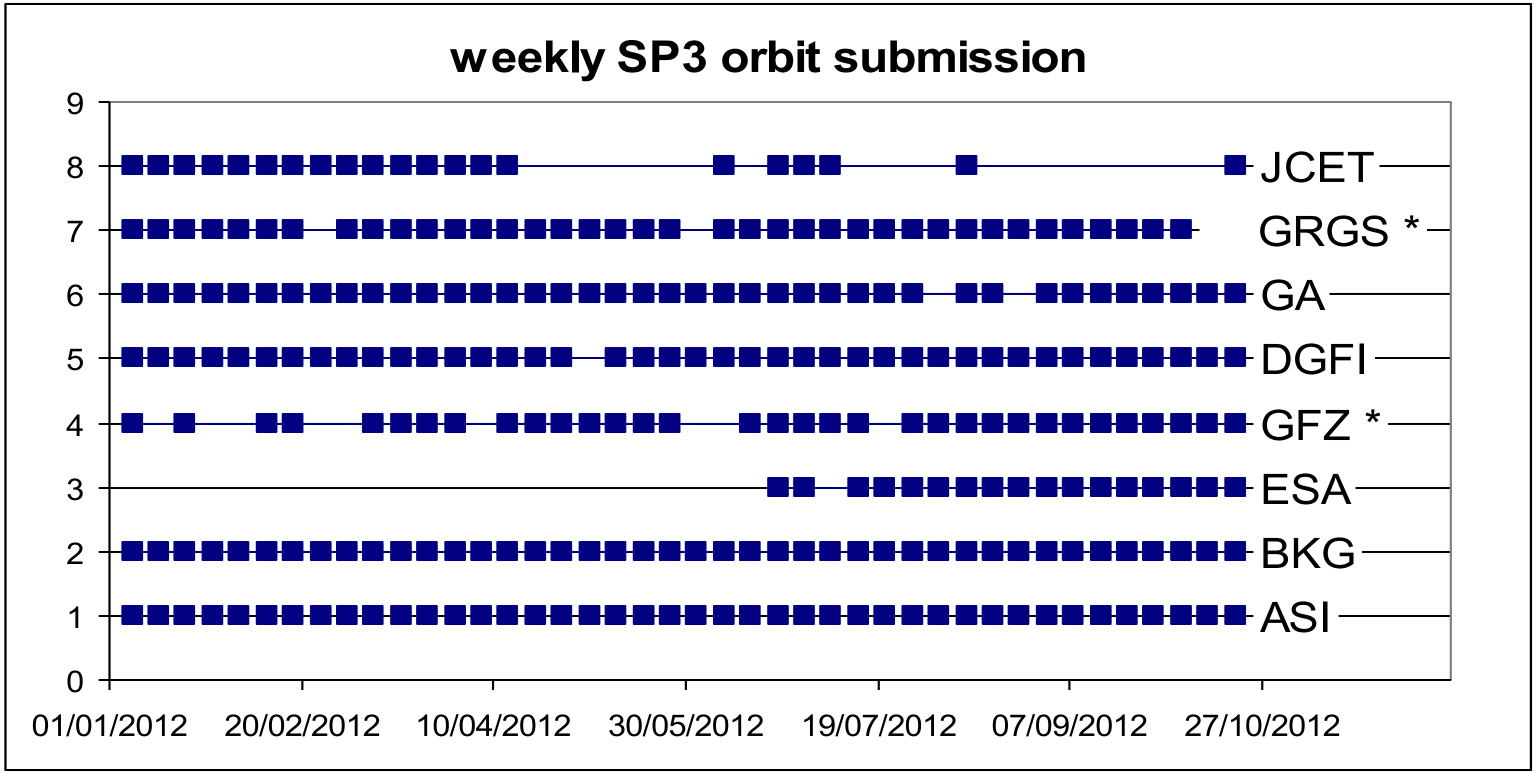


RMS mm	Tx	Ty	Tz	Scale
asi	4,18	3,59	7,13	7,19
asi	4,18	3,59	7,12	7,17
bkg	4,40	2,84	7,13	6,53
bkg	3,37	2,90	5,71	6,11
ga	3,37	3,01	6,48	5,43
ga	3,20	2,75	6,13	5,30
gfz	4,95	3,25	9,22	6,37
gfz	5,26	3,34	9,43	6,45
jcet	4,03	2,95	9,33	5,20
jcet	4,07	2,95	9,44	5,18
nsgf	4,97	3,51	10,28	6,29
nsgf	4,80	3,47	9,40	6,38

IERS GGFC PP - remarks

- 6 ACs: asi, bkg, ga, gfz, jcet, nsgf
- 5 years: 2006.0 – 2011.0
- applying the new model, the RMS of the Translation&Scale parameters wrt SLRF2008 decreases of 0.1-0.3mm for the combined solution
- Different impact of the new model implementation on the contributing solutions; new gfz submission has to be analysed

AC weekly orbit submission



* only Lageos orbits available

SP3c data evaluation

- L51/L52/L53/L54 SP3c files available at CDDIS and EDC – October 2012
- cross-evaluate their consistency ("RAC" in ECF)

Assumptions

- ECF frame tied to SLRF2008
- UTC
- SP3c format
- 2′ POS/VEL L51/L52
- 15′ POS/VEL L53/L54

SP3c format adherence

			Comments/notes
ASI	L51	X	OK
	L52	X	
	L53	X	
	L54	X	
BKG	L51	x	OK
	L52	X	
	L53	X	
	L54	X	
DGFI	L51	x	OK
	L52	X	
	L53	X	
	L54	X	
ESA	L51	X	OK
	L52	X	
	L53	X	
	L54	X	

			Comments/notes
GA	L51	X	OK
	L52	X	
	L53	X	
	L54	X	
GFZ	L51	X	OK
	L52	X	
	L53	-	
	L54	-	
GRGS	L51	X	TAI -> not usable
	L52	X	
	L53	-	
	L54	-	
ESOC	L51	X	L53, L54 every 5’
	L52	X	
	L53	X	
	L54	X	

JCET not available for the period

L51 Overall statistics

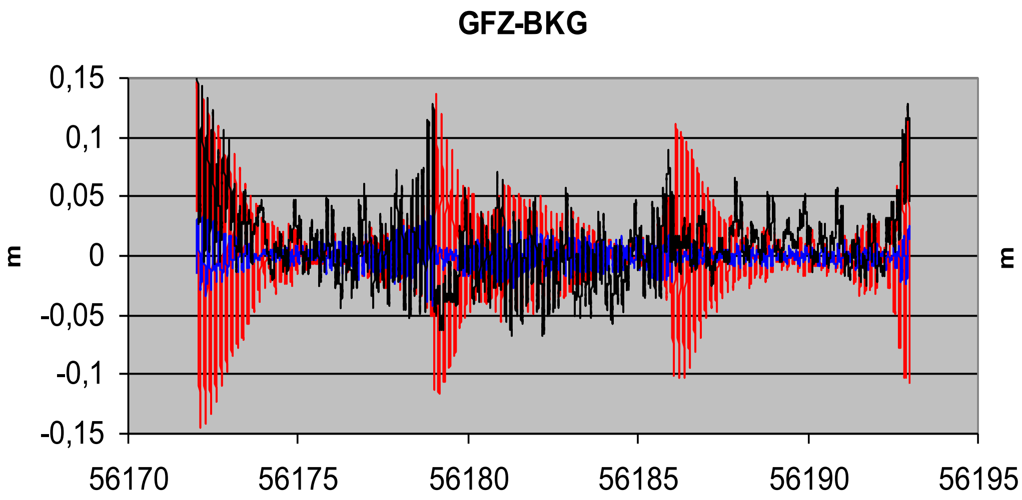
new

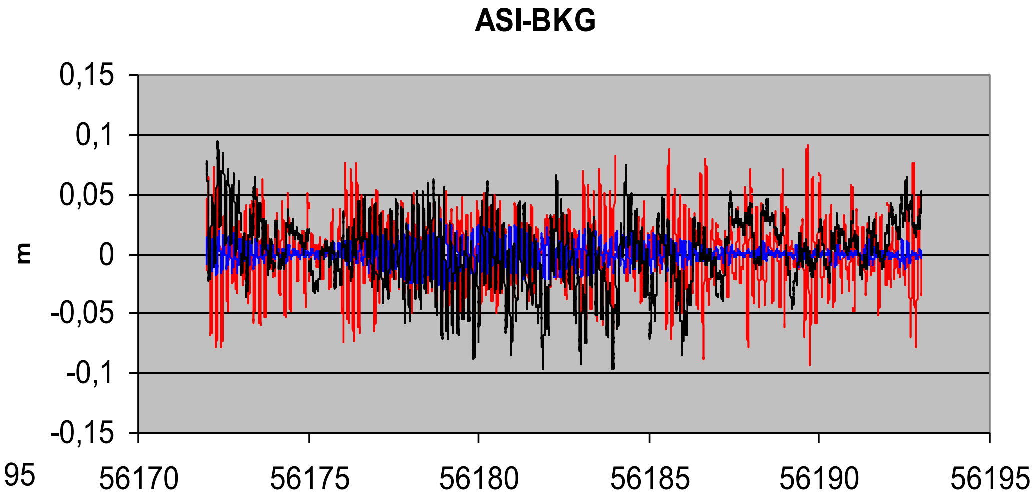
~15cm C, A previously (AWG0412)

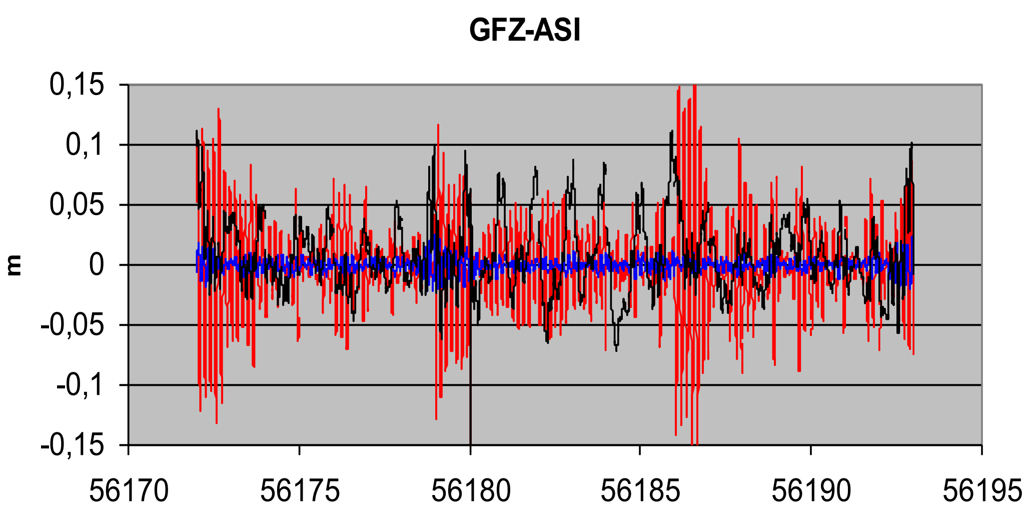
~1m C, A previously (AWG0412)

L51 (cm)		ASI	BKG	ESOC	DGFI	GA
BKG-	R	-0.03±0.94				
	C	-0.08±2.97				
	A	-0.13±3.00				
ESOC-	R	0.02±0.59	0.05±0.66			
	C	-0.04±7.90	0.05±7.57			
	A	1.59±4.65	1.73±5.38			
DGFI-	R	0.05±0.71	0.08±0.84	0.03±0.72		
	C	0.10±3.91	-0.01±3.15	-0.06±7.43		
	A	0.52±5.01	0.65±4.28	-1.08±6.51		
GA-	R	-0.01±0.67	0.03±1.15	-0.02±0.93	-0.06±1.14	
	C	0.07±3.67	0.18±4.50	-0.06±9.21	0.23±5.57	
	A	-1.25±2.46	0.97±3.63	-0.44±5.90	0.17±5.15	
GFZ-	R	-0.02±0.61	0.04±1.04	-0.04±0.75	-0.07±0.90	-0.02±0.80
	C	-0.02±4.07	0.06±3.54	0.01±7.73	0.07±3.26	-0.13±4.71
	A	0.79±3.09	0.92±3.18	-0.81±4.92	0.26±4.39	-0.53±3.44

L51 ASI-BKG-GFZ

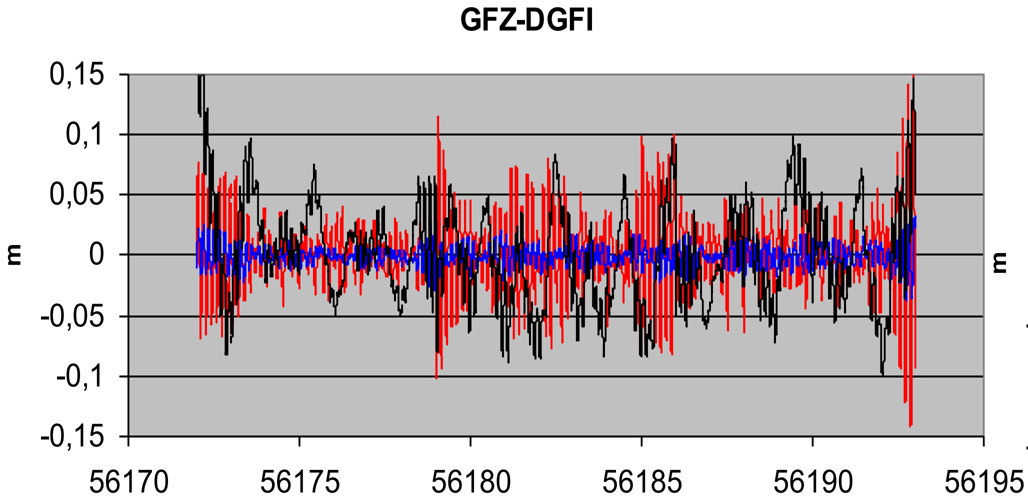


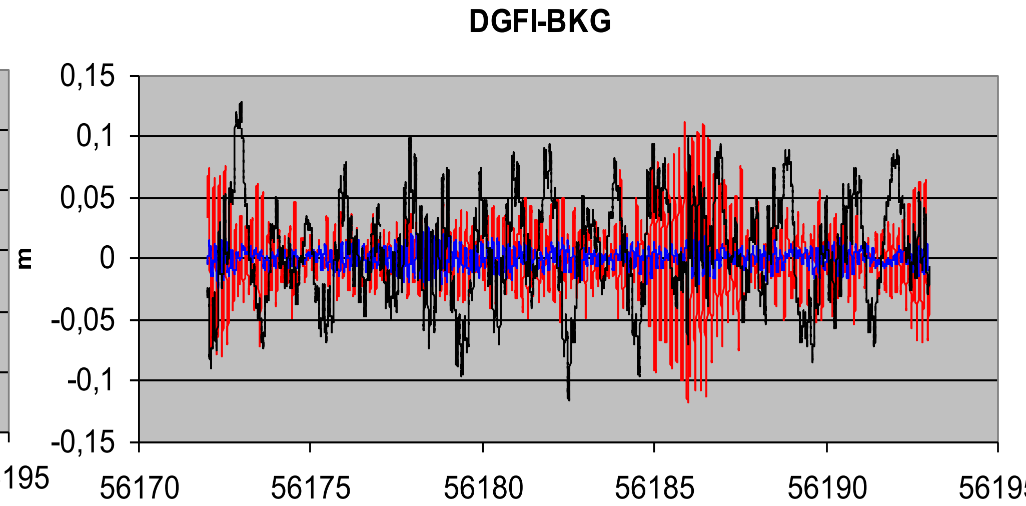


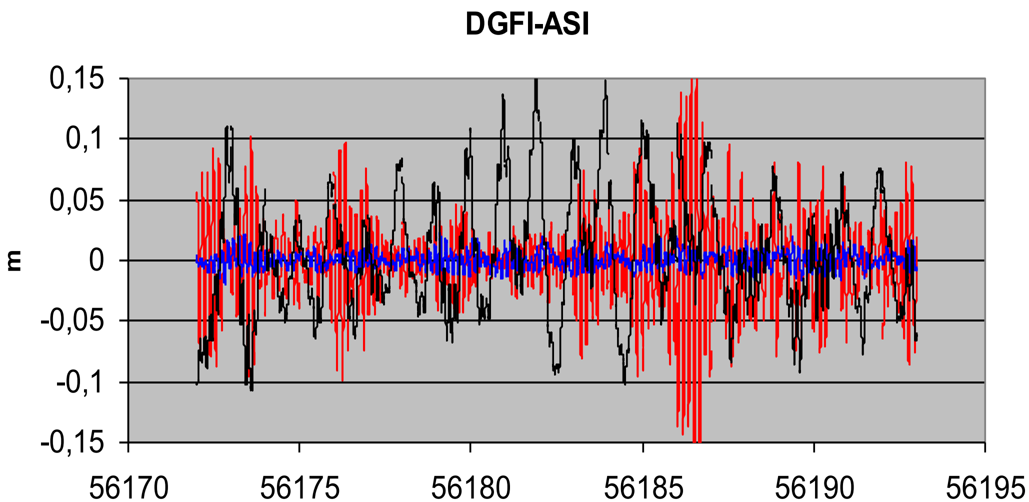


GFZ – BKG cm	R	+0.04 ± 1.04
	C	+0.06 ± 3.54
	A	+0.92 ± 3.18
GFZ – ASI cm	R	-0.02 ± 0.61
	C	-0.02 ± 4.07
	A	+0.79 ± 3.09
ASI-BKG cm	R	+0.03 ± 0.94
	C	+0.08 ± 2.97
	A	+0.13 ± 3.00

L51 DGFI vs ASI-BKG-GFZ

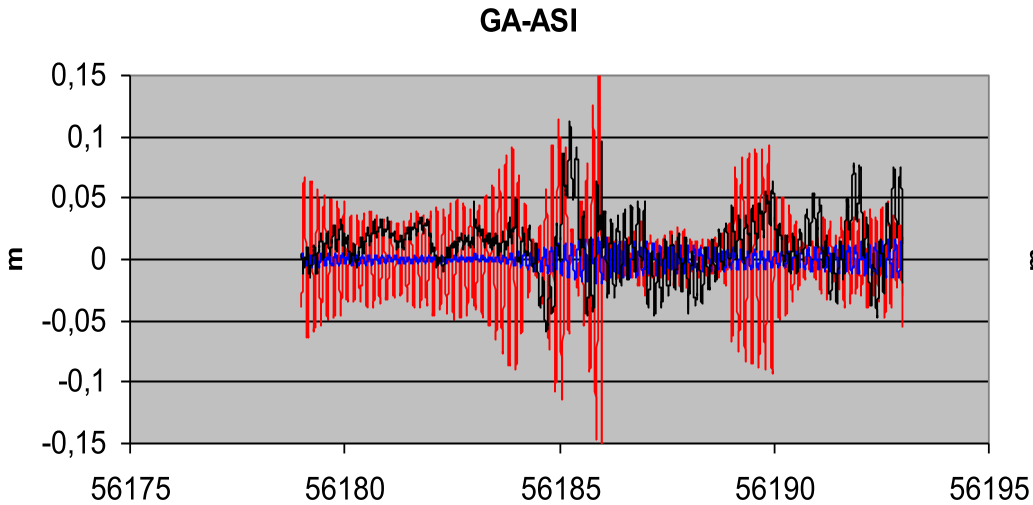


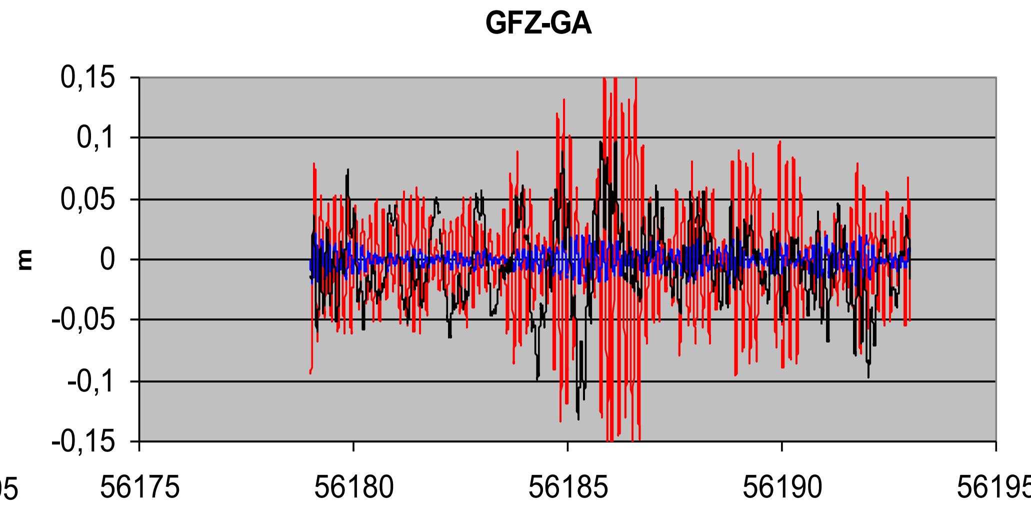


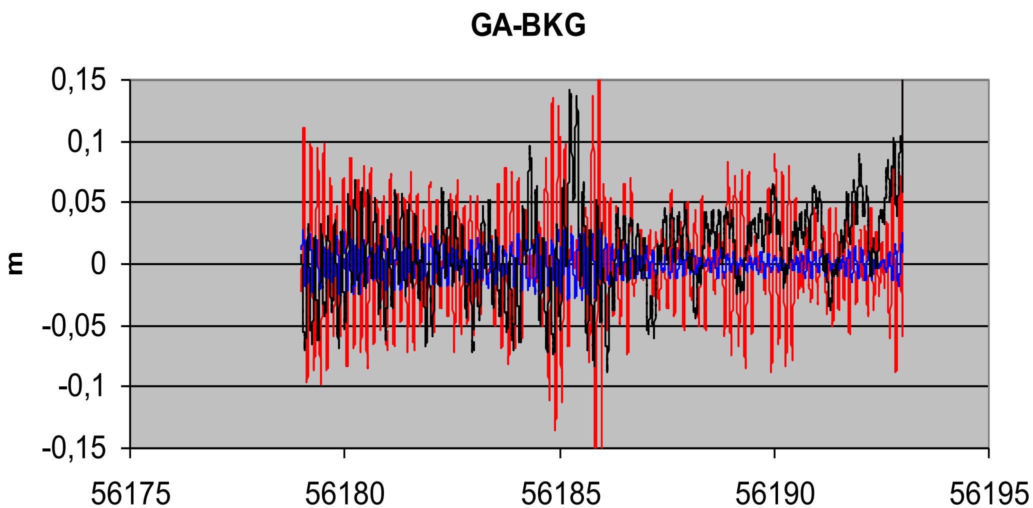


GFZ – DGFI cm	R	-0.07 ± 0.90
	C	+0.07 ± 3.26
	A	+0.26 ± 4.39
DGFI – ASI cm	R	+0.05 ± 0.71
	C	-0.10 ± 3.91
	A	+0.52 ± 5.01
DGFI-BKG cm	R	+0.08 ± 0.84
	C	-0.01 ± 3.15
	A	+0.65 ± 4.28

L51 GA vs ASI-BKG-GFZ



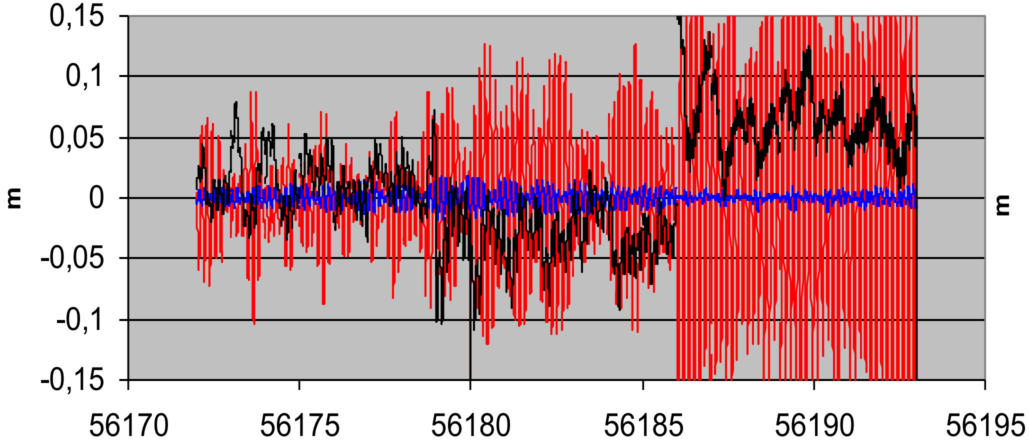




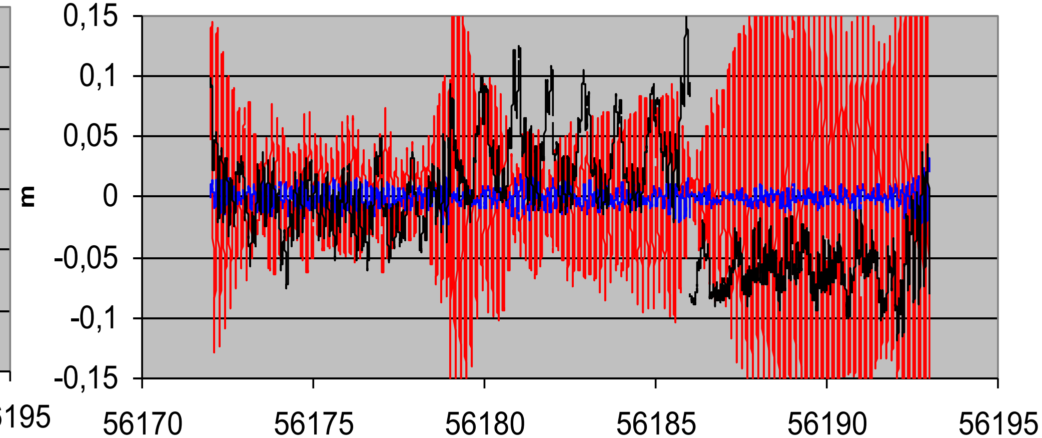
GA-ASI cm	R	-0.01 ± 0.67
	C	+0.07 ± 3.67
	A	-1.25 ± 2.46
GA-BKG cm	R	+0.03 ± 1.15
	C	+0.18 ± 4.50
	A	+0.97 ± 3.63
GFZ - GA cm	R	-0.02 ± 0.80
	C	-0.13 ± 4.71
	A	-0.53 ± 3.44

L51 ESOC vs ASI-BKG-GFZ

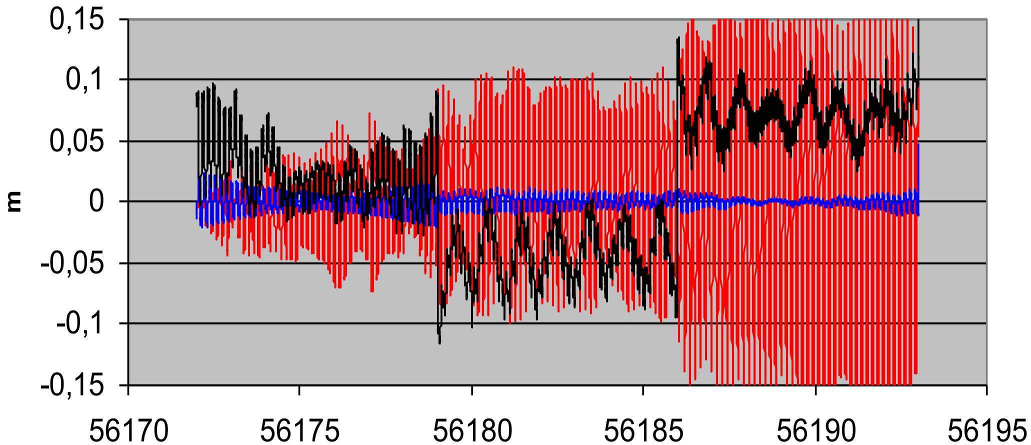
ESOC-ASI



GFZ-ESOC



ESOC-BKG



ESOC-ASI cm	**R**	**+0.02 ± 0.59**
	C	**-0.04 ± 7.90**
	A	**+1.59 ± 4.65**
ESOC-BKG cm	**R**	**+0.05 ± 0.66**
	C	**+0.05 ± 7.57**
	A	**+1.73 ± 5.38**
GFZ - ESOC cm	**R**	**-0.04 ± 0.75**
	C	**+0.01 ± 7.73**
	A	**-0.81 ± 4.92**

L52 Overall statistics

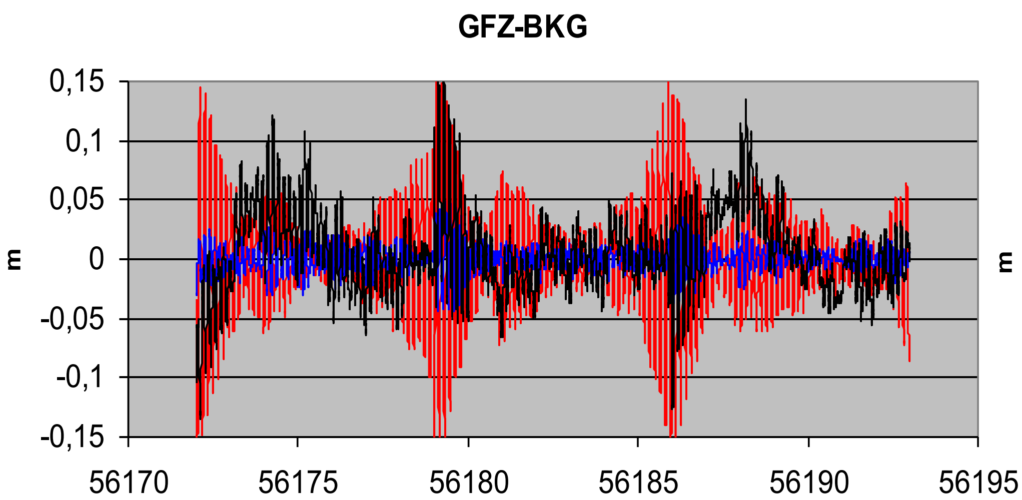
new

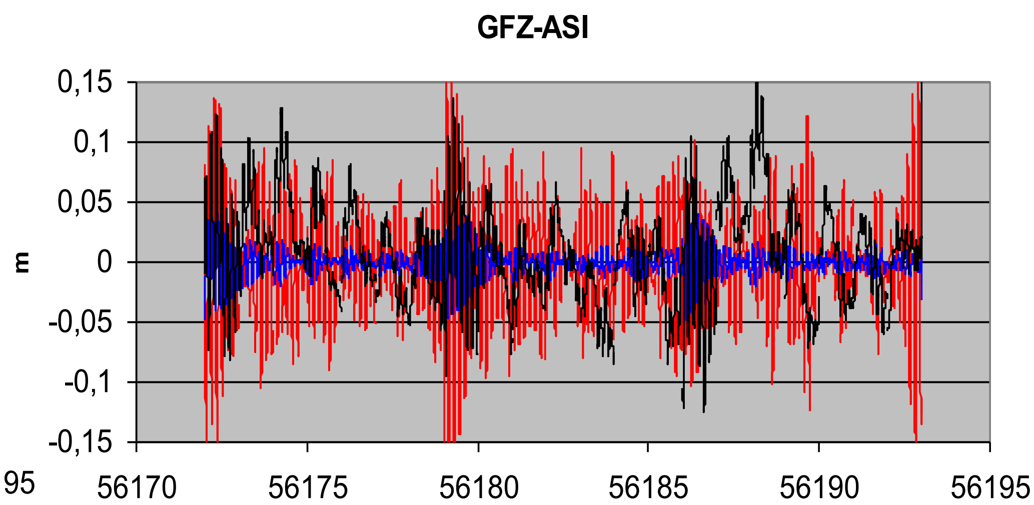
~15cm C, A previously (AWG0412)

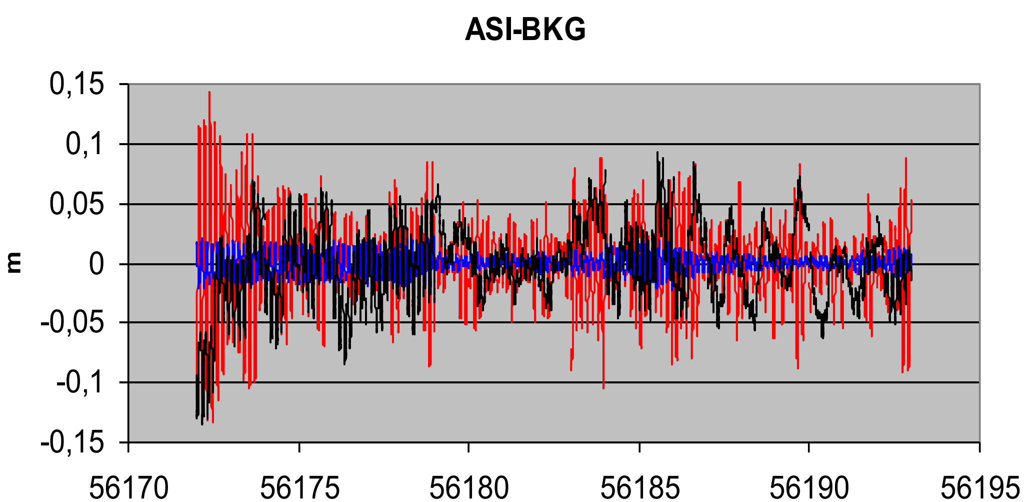
~1m C, A previously (AWG0412)

L52 (cm)		ASI	BKG	ESOC	DGFI	GA
BKG-	R	-0.02±0.85				
	C	-0.08±3.69				
	A	+0.15±3.27				
ESOC-	R	0.02±0.59	0.05±0.66			
	C	-0.04±7.90	0.05±7.57			
	A	1.59±4.65	1.73±5.38			
DGFI-	R	-0.02±0.66	-0.01±0.65	-0.03±0.59		
	C	-0.04±4.66	0.04±3.23	+0.21±6.80		
	A	1.56±5.09	1.41±4.40	+4.13±7.31		
GA-	R	0.00±0.65	0.03±0.92	-0.02±0.78	-0.06±1.14	
	C	-0.01±3.75	-0.03±3.53	+0.40±8.86	0.23±5.57	
	A	-0.87±2.95	-0.58±3.42	+2.41±6.90	0.17±5.15	
GFZ-	R	-0.03±1.19	-0.01±1.22	-0.04±0.75	-0.01±1.11	-0.02±1.24
	C	-0.13±4.90	-0.05±4.52	0.01±7.73	-0.08±4.65	-0.07±4.47
	A	0.82±4.30	0.68±3.67	-0.81±4.92	-0.73±4.33	-1.31±4.48

L52 ASI-BKG-GFZ

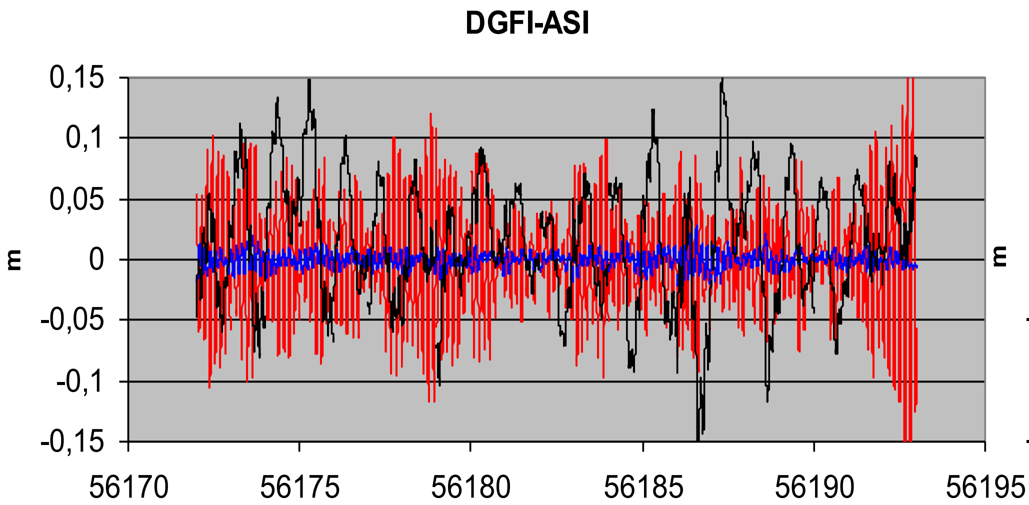


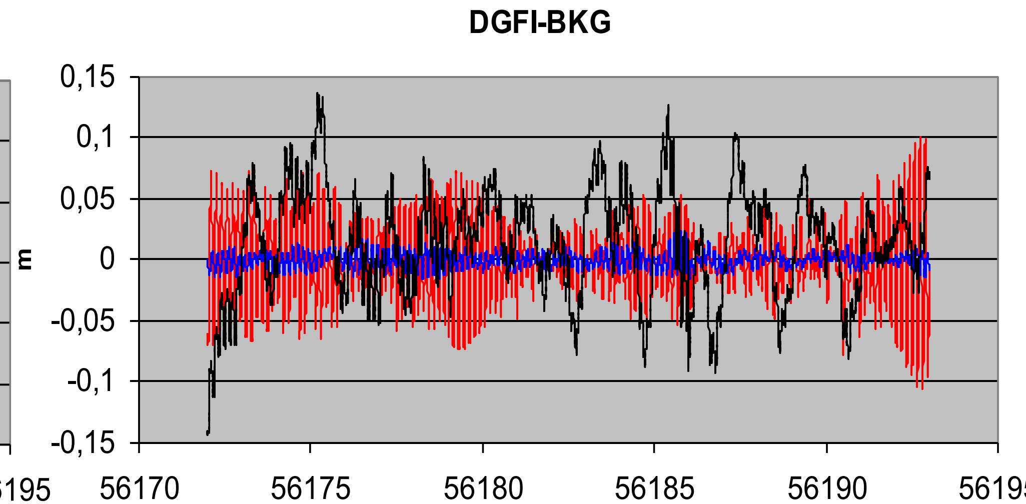


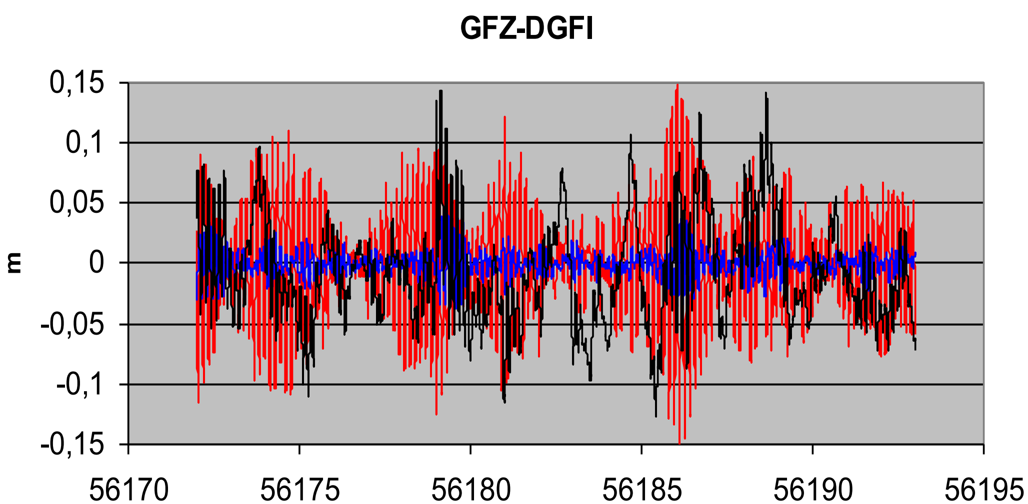


GFZ – BKG cm	**R**	**-0.01 ± 1.22**
	C	**-0.05 ± 4.52**
	A	**+0.68 ± 3.67**
GFZ – ASI cm	**R**	**-0.03 ± 1.19**
	C	**-0.13 ± 4.90**
	A	**+0.82 ± 4.30**
ASI-BKG cm	**R**	**+0.02 ± 0.85**
	C	**+0.08 ± 3.69**
	A	**-0.15 ± 3.27**

L52 DGFI vs ASI-BKG-GFZ

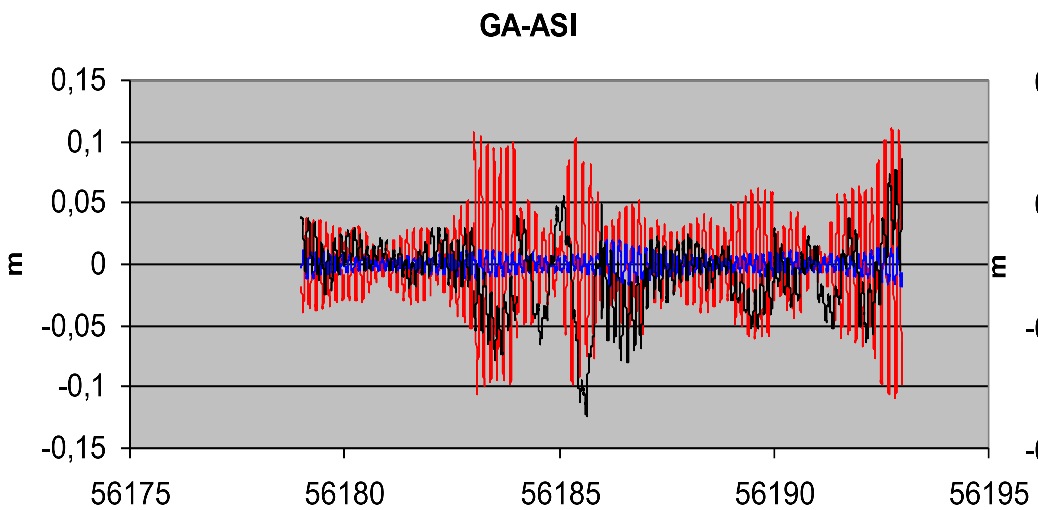


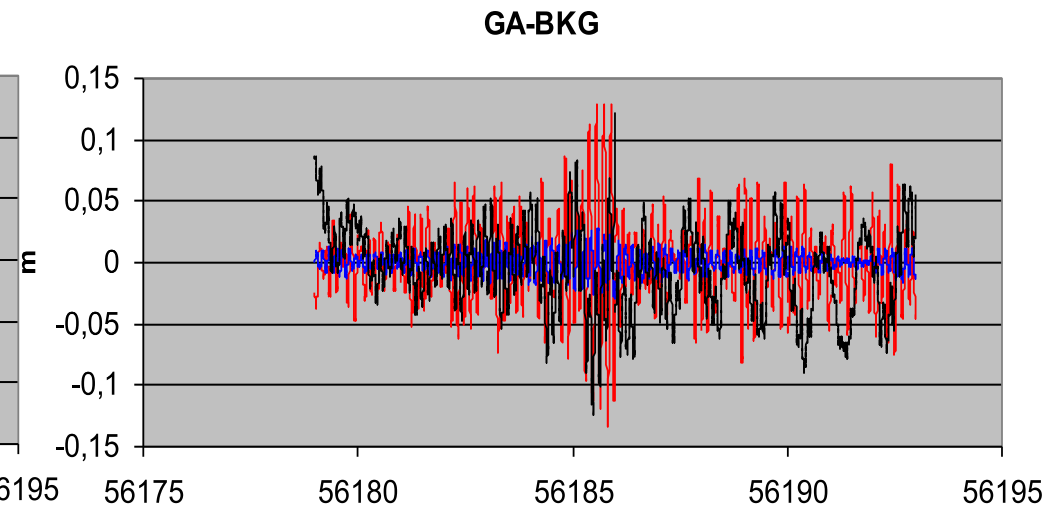


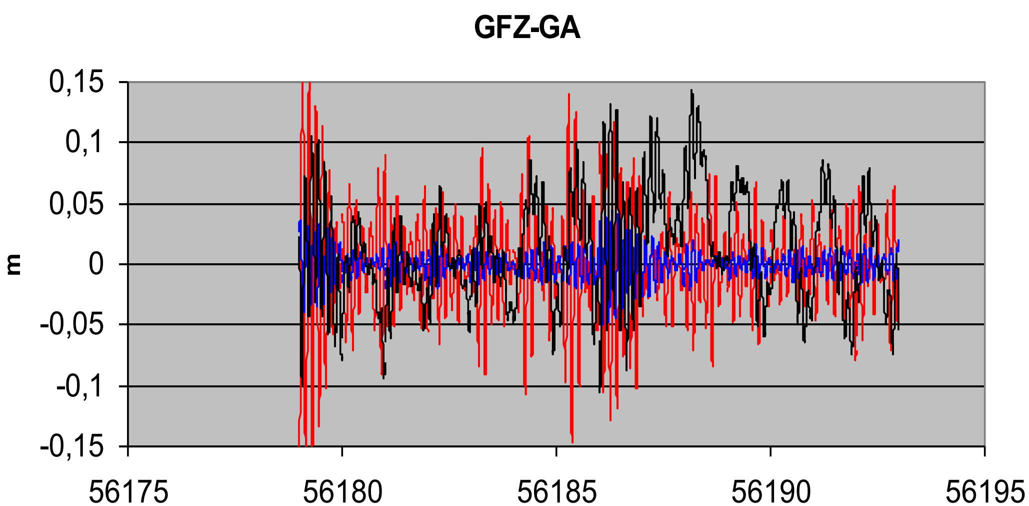


GFZ – DGFI cm	**R**	**-0.01 ± 1.11**
	C	**-0.08 ± 4.65**
	A	**-0.73 ± 4.33**
DGFI – ASI cm	**R**	**-0.02 ± 0.66**
	C	**-0.04 ± 4.66**
	A	**+1.56 ± 5.09**
DGFI-BKG cm	**R**	**-0.01 ± 0.65**
	C	**+0.04 ± 3.23**
	A	**+1.41 ± 4.40**

L52 GA vs ASI-BKG-GFZ

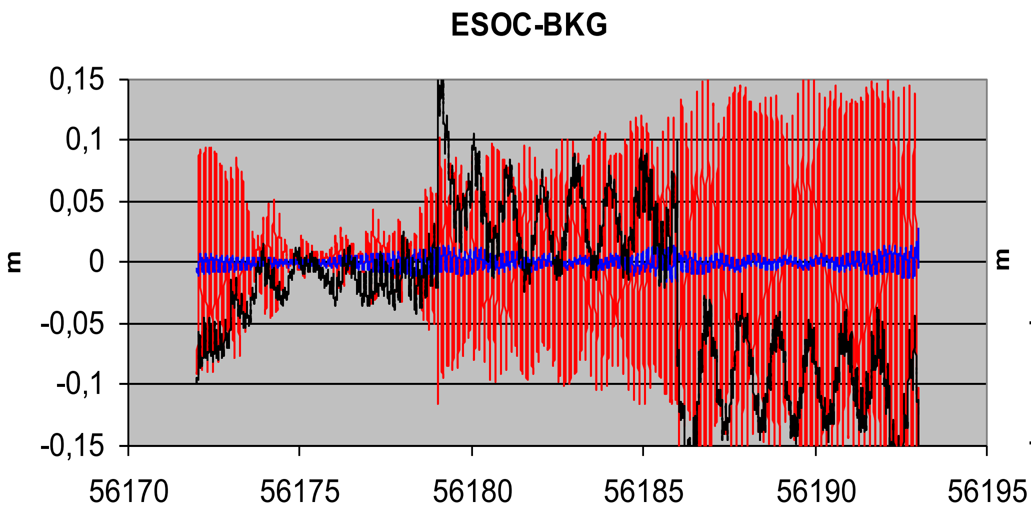


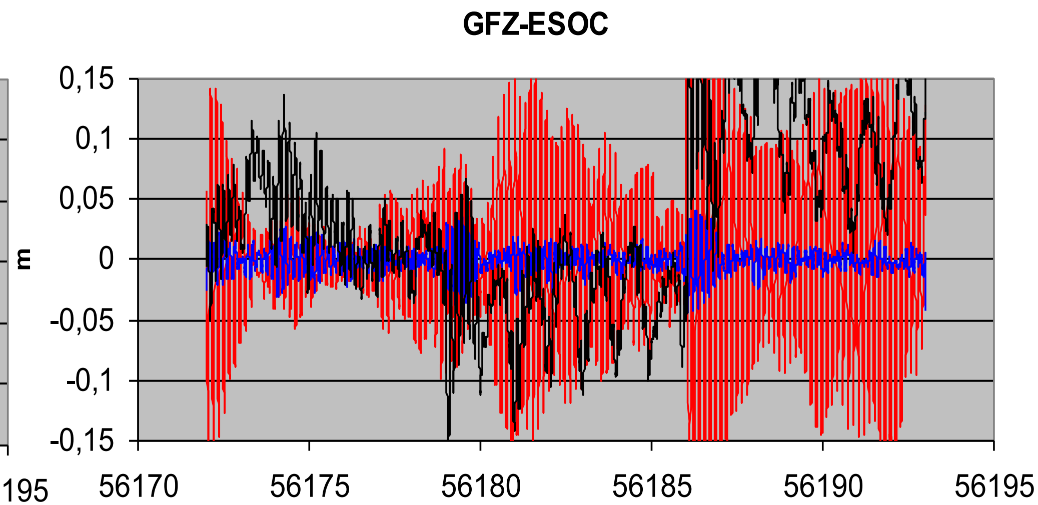


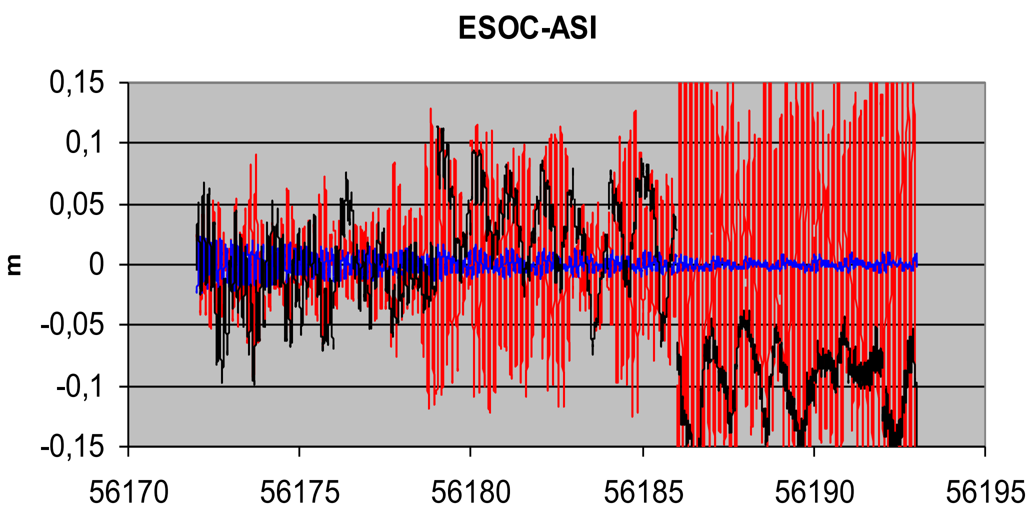


GA-ASI cm	R	+0.00 ± 0.65
	C	-0.01 ± 3.75
	A	-0.87 ± 2.95
GA-BKG cm	R	+0.03 ± 0.92
	C	-0.03 ± 3.53
	A	-0.58 ± 3.42
GFZ-GA cm	R	-0.02 ± 1.24
	C	-0.07 ± 4.47
	A	+1.31 ± 4.48

L52 ESOC vs ASI-BKG-GFZ

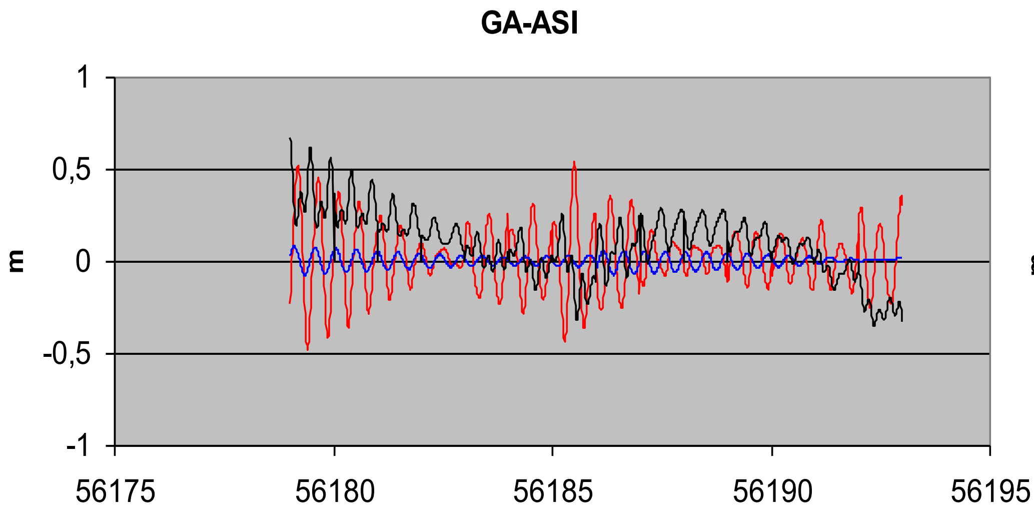


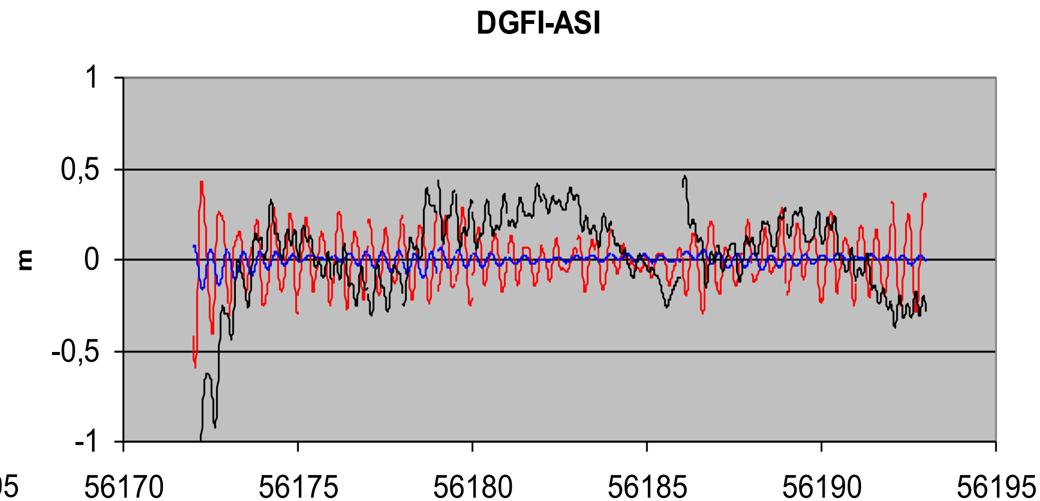


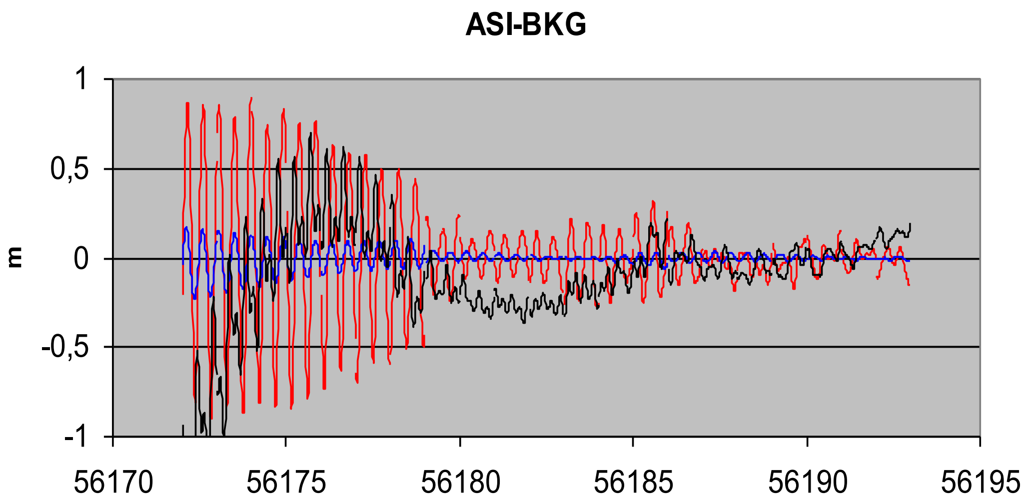


ESOC-ASI cm	R	+0.01 ± 0.70
	C	-0.26 ± 7.97
	A	-2.58 ± 6.32
ESOC-BKG cm	R	+0.03 ± 0.51
	C	-0.18 ± 7.31
	A	-2.72 ± 6.56
GFZ - ESOC cm	R	-0.04 ± 1.10
	C	-0.13 ± 7.67
	A	+3.40 ± 7.27

L53 GA-DGFI-BKG vs ASI







ASI - BKG m	R	-0.002 ± 0.055
	C	+0.010 ± 0.307
	A	-0.098 ± 0.303
GA - ASI m	R	+0.004 ± 0.032
	C	+0.020 ± 0.175
	A	+0.097 ± 0.174
DGFI - ASI m	R	-0.001 ± 0.033
	C	-0.001 ± 0.146
	A	+0.021 ± 0.256

SP3c files - remarks

- L51/L52 asi, bkg, dgfi, ga, gfz, grgs, esoc, jcet
- L53/L54 asi, bkg, dgfi, ga, esoc, jcet
- Format check

  grgs: TAI; jcet: not available; esoc: L53/L54 5'
- asi, bkg, dgfi, gfz, ga coherent (~3-5cm C-A L51/L52)
- esoc ~7cm C, 5cm A L51/L52 vs bkg, gfz, asi
- dgfi and ga: much better performances than in the past
- differences in the AC dynamic modelling

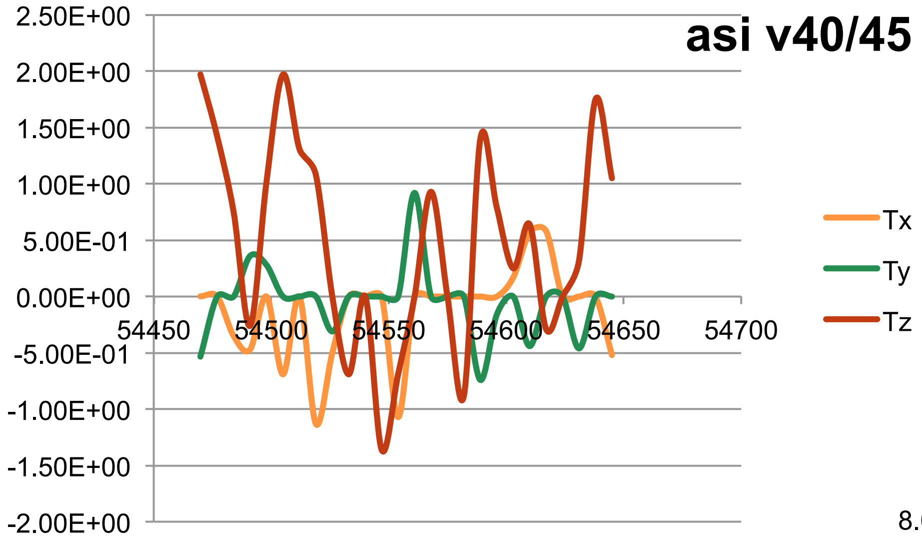
ILRS_AWG Fall 2012

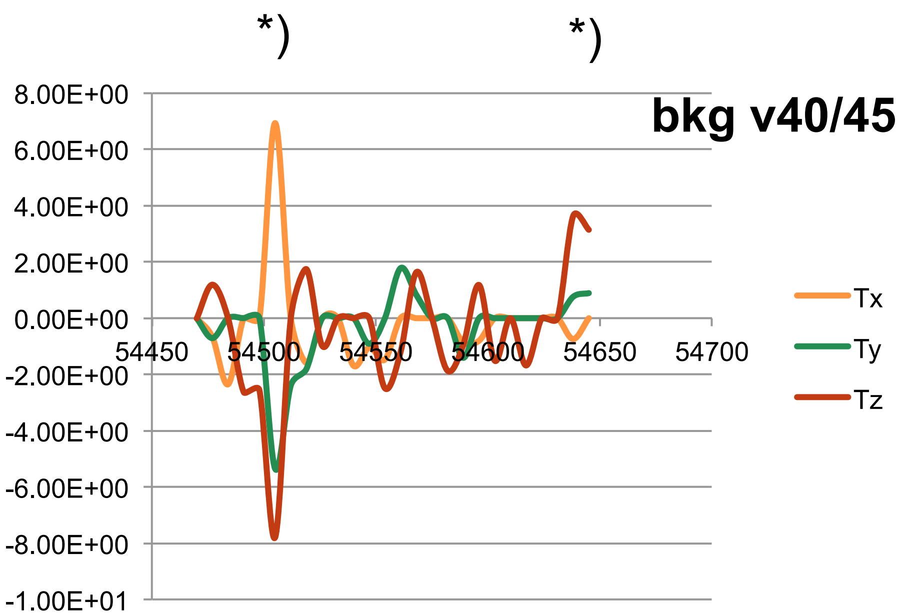
ILRS_AWG@EGU 2012: Zuheir Altamimi :
IERS GGFC Call for non-tidal loading corrections (deadline July,1st)
model by T. van Dam GGFC website
ACs deliver v40 and v45 for 2006-2011

AIUB: *BSW had to be changed for IERS requirements
(BSW has implemented Vienna grids instead of GGFC files)
*T.vanDam reformatted GGFC files to Vienna Grid format
but: several iterations needed due to errors in the reformatting,
finally files were still not usable "as is"
**therefore*: BSW software changes had to be done

BKG: first days in May beginning with v40 series to save time
detecting problems in several weekly runs, ->fixed
several BSW updates were necessary during the processing periods
series v45 in September uploaded ,
but no time left for any quality check,
->message to ilrsa with information on outlier and bkg-reprocessing
October 2012: new compilation of BSW_SLR
November 2012: new update of BSW_SLR (IERS Conventions 2010)

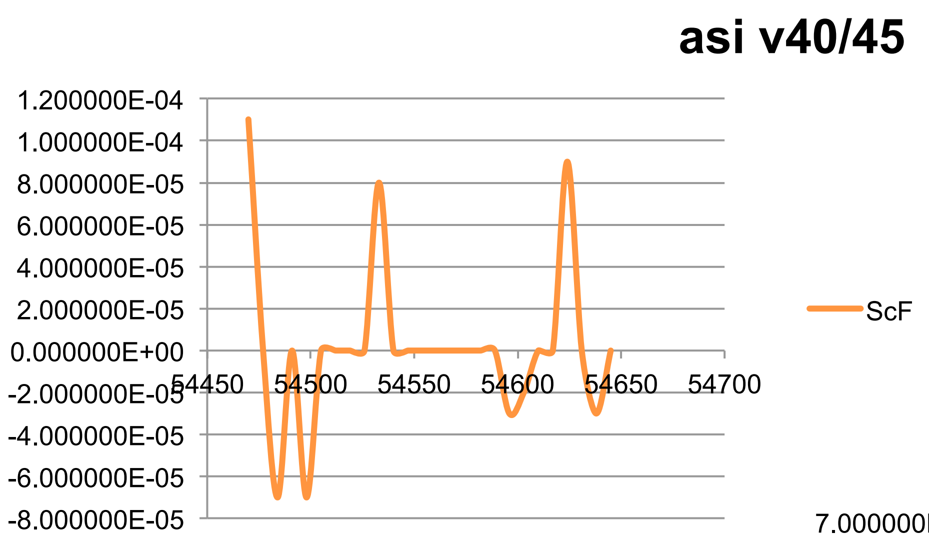
Comparison of coordinates, loose constrained solutions, Translation in mm

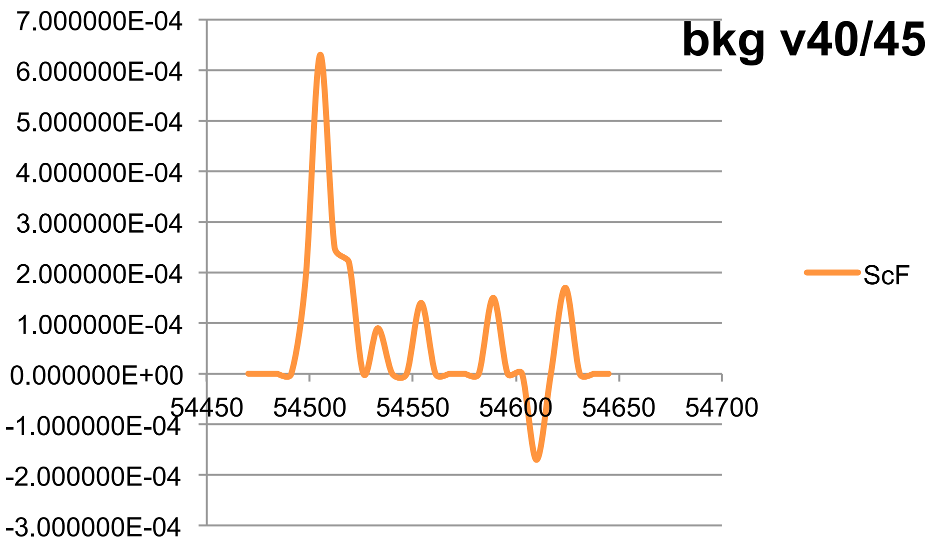




***) „bkg-outlier-weeks“ like week 080209, MJD 54505, will be reprocessed**

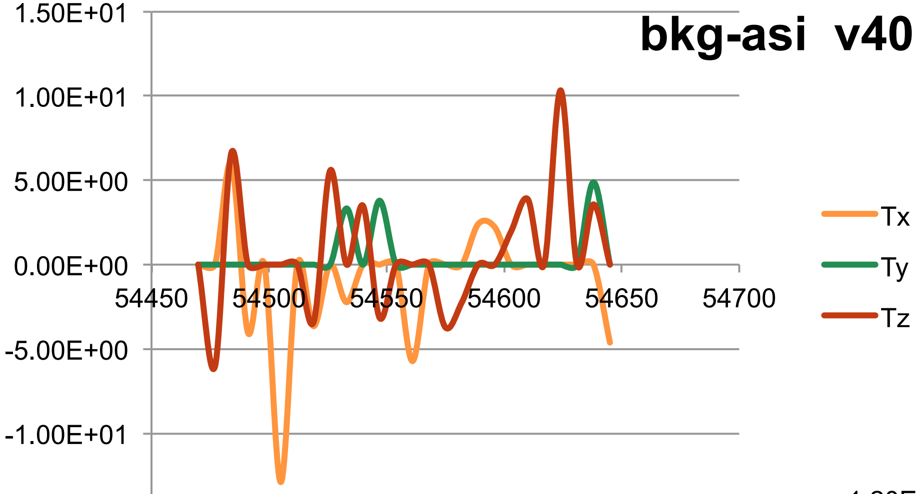
Comparison of coordinates, loose constrained solutions, Scale Factor in mm/km

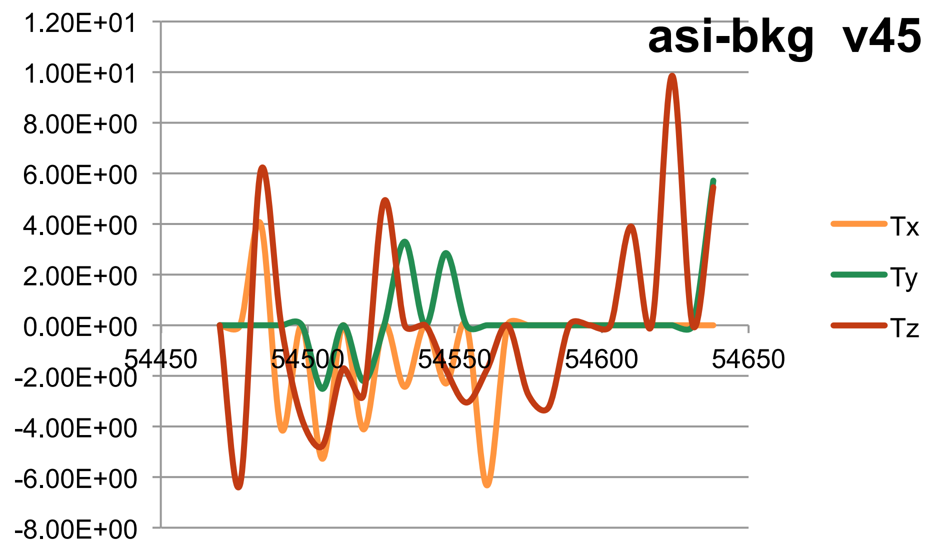




Bundesamt für Kartographie und Geodäsie

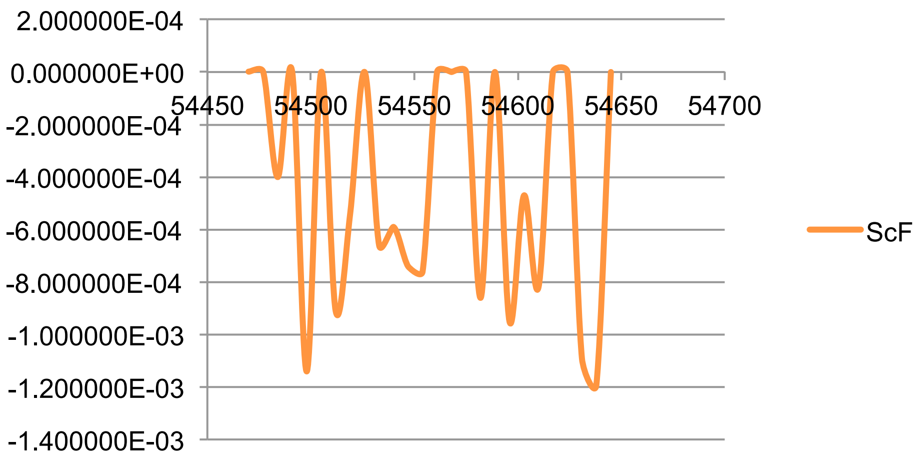
Comparison of coordinates, loose constrained solutions, Translation in mm



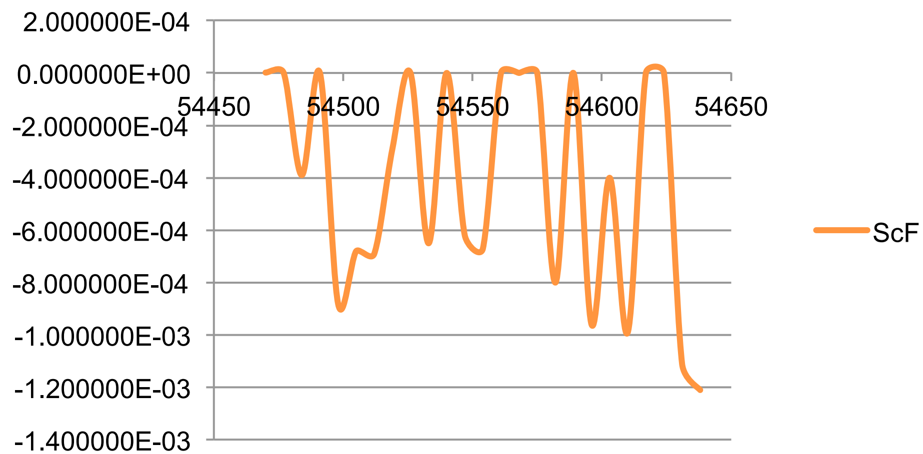


Comparison of coordinates, loose constrained solutions, Scale Factor in mm/km

bkg-asi v40

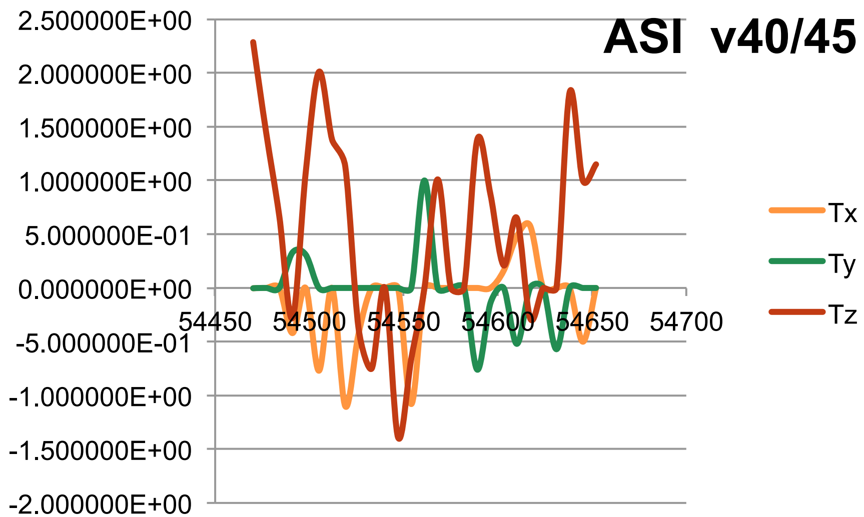


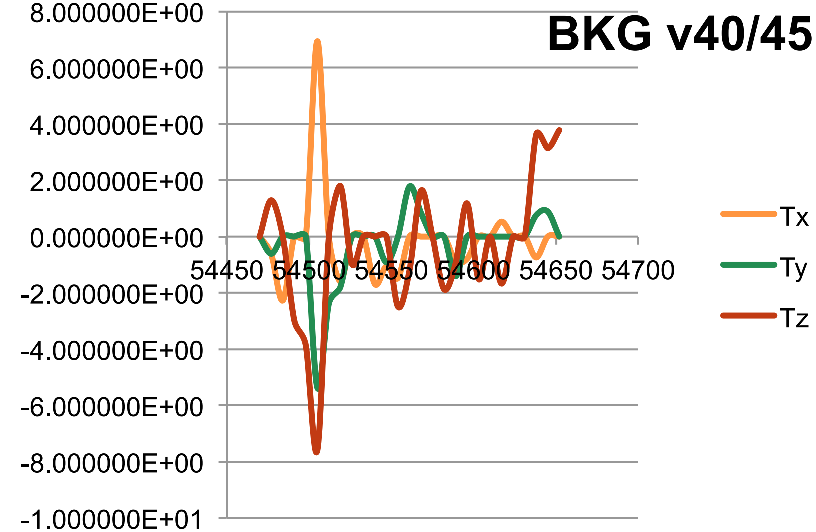
bkg-asi v45



Bundesamt für Kartographie und Geodäsie

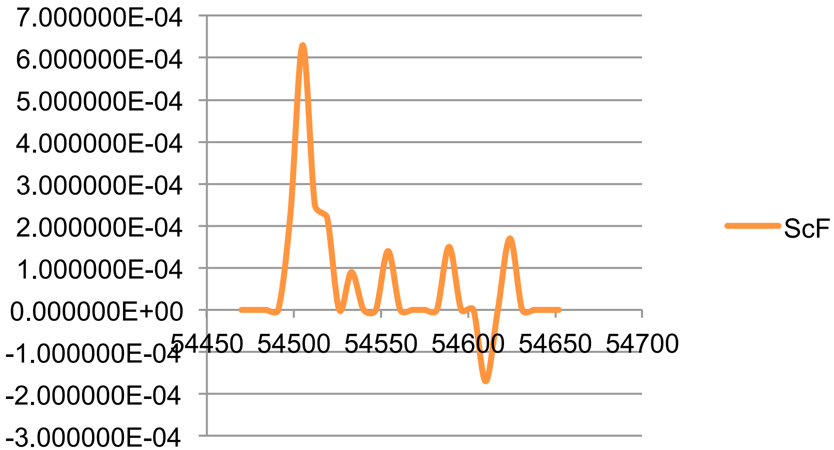
Comparison of coordinates, solutions with NNR condition, Translation in mm



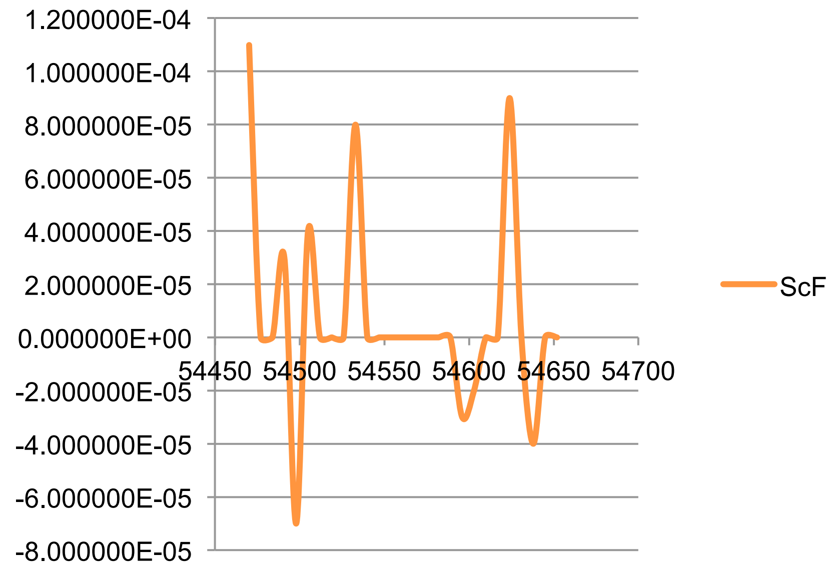


Comparison of coordinates, solutions with NNR condition, Scale Factor in mm/km

BKG v40/45

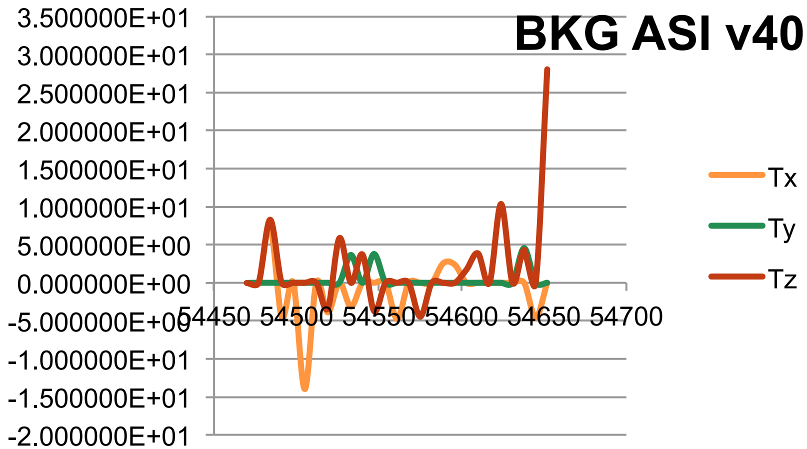


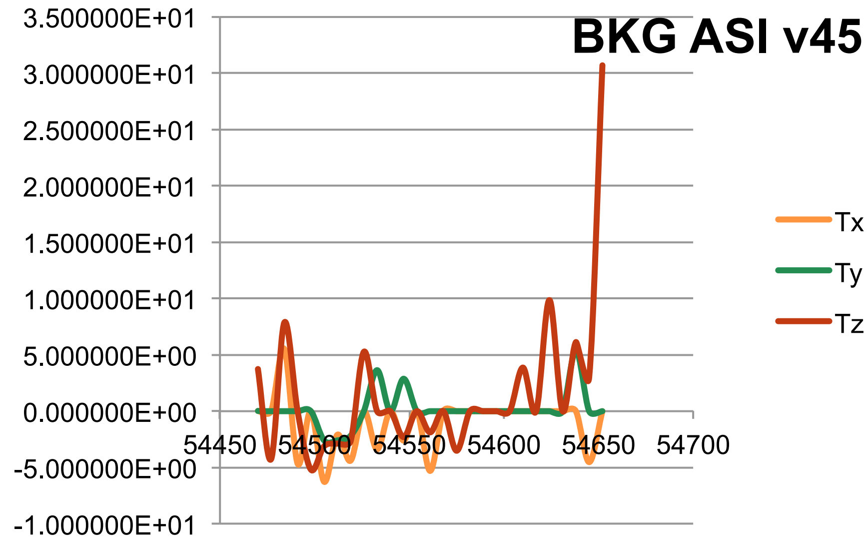
ASI v40/45



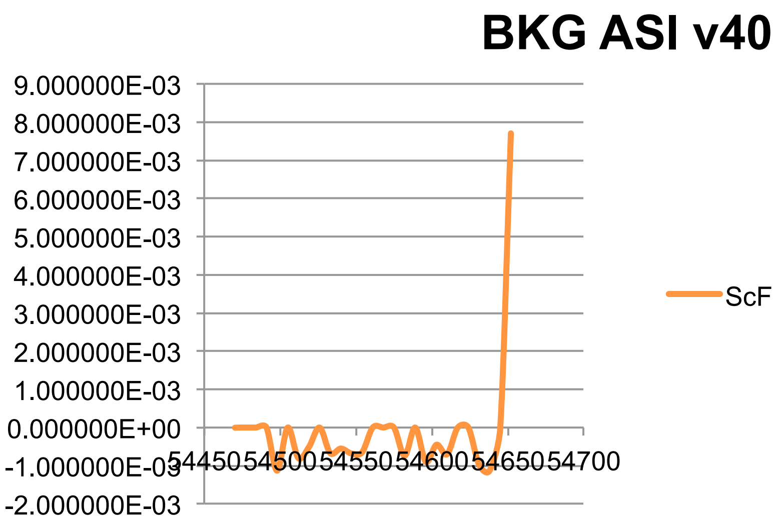
Bundesamt für Kartographie und Geodäsie

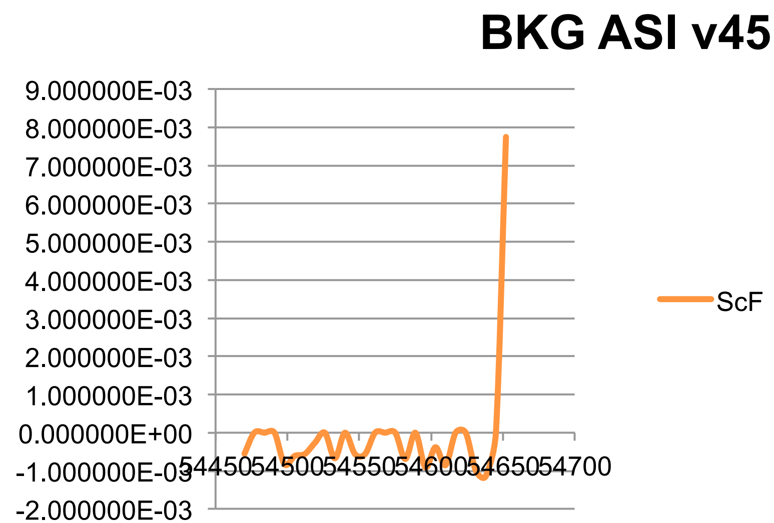
Comparison of coordinates, solutions with NNR condition, Translation in mm





Comparison of coordinates, solutions with NNR condition, Scale Factor in mm/km





International Laser Ranging Service

Report of DGFI/AC

Horst Müller

Deutsches Geodätisches Forschungsinstitut, München
E-Mail: mueller@dgfi.badw.de

DGFI

CGE

Routine POS+EOP Solution

- Status
  - Routinely daily and weekly solutions
  - Quality still not very good, mainly for stations with biases
  - Many changes to DOGS-OC are in preparation
  - Still in test phase, like atm. loading

- Future Plans
  - Contribute to the pilot project on atmospheric loading
  - Loading is fully implemented GGFC model
  - Gravity part: in test phase

Data Handling File

- Status
  - Updated lately Oct. 24, San Juan 2.5 m range bias
  - Needs to be updated more often
  - Eventually also from AC members (with dedicated login)

- Comments
  - More frequent update seems reasonable
  - Who updates?
  - Biases?
  - Weighting of biases?
  - Stations in quarantine?

ILRS Analysis Working Group Meeting, Frascati, Nov. 03, 2012

```
 RELEASE DATE          2012/10/24
 DESCRIPTION           range, time and pressure biases to be applied to SLR tracking
                       data and periods not to be used in analysis.

 INPUT                 Corrections to SLR tracking data collected from
                       various tables at CDDIS and resolutions from the ILRS/AWG

 OUTPUT                ILRS SINEX file with data handling recommentations

 CONTACT               Horst Mueller <mueller@dgfi.badw.de>
 CONTACT               Margarita Vei <vei@gfz-potsdam.de>
-FILE/REFERENCE
*-------------------------------------------------------------------------------
+FILE/COMMENT

Last Updated: Oct. 24 2012  San Juan (7406) with big range biases since Oct. 13 2012
              Sep. 07 2012  Riga (1884) and Simeiz data released from quarantine
              Aug. 07 2012  Riga (1884) CRD data put into quarantine
              Aug. 05 2012  Monument Peak (7110) big time bias
              Jun. 15 2012  Tahiti (7124) data released from quarantine
              Jun. 05 2012  Russian stations, 1887, 1888, 1889, 1890 are in quarantaine
              May. 23 2012  Handling of Beijing data (7249), bias estimation starting 12/03/07
              May. 16 2012  reference to ILRS station upgrades file
              May. 15 2012  Tahiti (7124) put to quarantine (12/05/14), due to receiver upgrade
              Apr. 12 2012  Arequipa (7403) and Monument Peak (7110) data released from quarantine
              Mar. 14 2012  Moblas 4, Monument Peak, (7110) big range bias starting: 12/02/23
              Feb. 06 2012  Delete Observations for Haleakala (7119) 12/01/30-12/01/31
              Oct. 06 2011  Range bias estimation for 7821 (Shanghai) 11/05/28-10/09/03
              Sep. 30 2011  Problem with Matera 7941 Sep.24 18:00 - Sep.25 8:00 2011
              Sep. 21 2011  Exclude Simeiz data starting July 2011, increasing time bias
              Nov. 18 2010  mandatory Bias correction for Wettzell (starting March 2009)
              Nov. 12 2010  Bias correction for Arequipa (7403) added
              Sep. 15 2010  -20cm range bias for Haleakala July and August 2010
              Aug. 12 2010  100 ms time bias for MLRO from doy 221 to 223 2010 included
              Apr. 23 2010  corrections of errors detected by F. Deleflie
              Apr. 15 2010  all corrections from Van's tables at cddis added
```

DGFI

Rapid Service Mail

- Presently 42 messages to stations (HITU,DGFI,JCET,CSR)
- few responses from stations
- More ACs should participate, send email to
  RapidServiceMail@dgfi.badw.de and to station affected
– automatic distribution

Available from:
http://rapidservicemail.dgfi.badw.de/
and via mailing list maintained by DGFI (mailman)

Header:

```
*********************************************************************************
ILRS/AWG Rapid Service Mail   (HITU) 1873 up to 200 ms time bias Message No. 0006
*********************************************************************************
```

Station Qualification

- Stations in quarantine and back to normal
  - 1886 Riga
  - 7249 Beijing
  - 7110 Monument Peak
  - 7249 Beijing
  - 7105 Greenbelt
  - 7822 Tahiti
  - 1873 Simeiz, could solve time bias problem, but is still not good
- New stations, not yet qualified because of bad station coordinates
  - 1888 Svetloe, Russia
  - 1889 Zelenchukskya, Russia
  - 1890 Badary, Russia

Information from ILRS page
http://ilrs.gsfc.nasa.gov/network/site_procedures/station_upgrade_status.html

This page needs to be machine readable, or an other page must inform the analysts on all stations under quarantine

ILRS AWG meeting Frascati
ESOC status

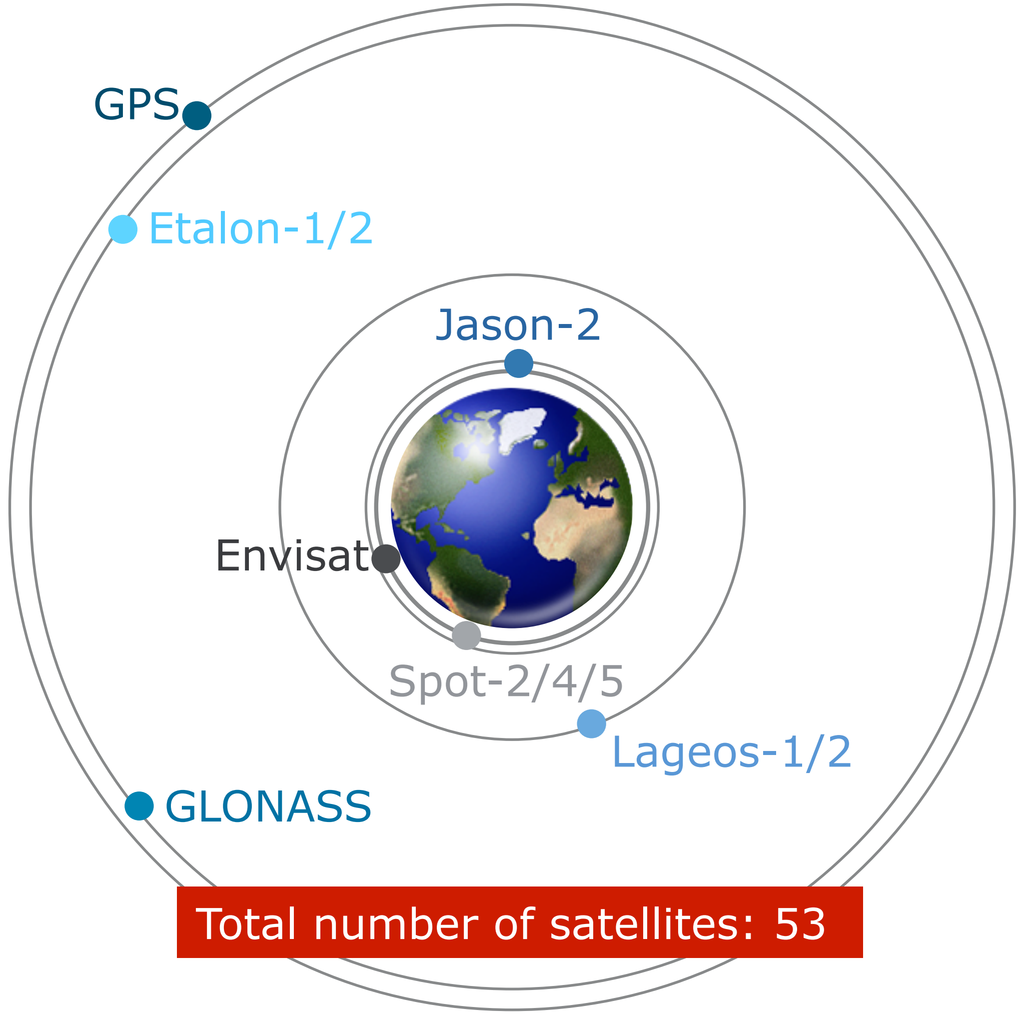
T. Springer, R. Zandbergen
03/11/2012

Routine activities

- Two weekly solutions:
  - standard (V40)
  - test (V35 with 'Appleby CoM model')
- Daily rapid solution (V130)
- In parallel to activities related to IDS, and for combination at observation level:
  - Combined solutions
  - Cross-validation
- Envisat mission data re-processing

COL: Used satellites

GPS	31
GLONASS	13
Etalon-1/2	2
Lageos-1/2	2
Jason-2	1
SPOT-2/4/5	3
Envisat	1



Combining measurement types

Altitude (km)	Satellite	GNSS	DORIS	SLR
20200	GPS	×		×
19100	GLONASS	×		×
	Etalon-1/2			×
5900	Lageos-1/2			×
1340	Jason-2	×	×	×
800	Spot-2/4/5		×	
	Envisat		×	×

Progress since Vienna meeting (21/04/2012)

- Transition to CRD format completed
- Velocities in SP3 files now supported
- Non-tidal atmospheric loading test:
    - S/W not yet implemented
    - So…. not yet participated
    - Is it still of interest?
- No gravity estimation yet
- Ready for ITRF 2013 processing

Galileo data processing

- Support to Galileo project reflected in presentation by D. Navarro of Galileo Project Office
- SLR prediction generation for Giove-A and –B now stopped
- Prediction generation for IOV satellites
- Giove-A SLR temporarily restarted for experimentation with on-board GPS receiver
- Galileo GNSS and SLR orbits used routinely for validation

GFZ SOLUTION DESCRIPTION

	Weekly poseop v40	GGFC v41 (standard)	GGFC v45 (NT-ATML corrected)
Dynamic			
Gravity model	EGM96 20x20	EGM96 20x20	EGM96 20X20
Time var. grav.	$\dot{C}_{20}$, $\dot{C}_{21}$, $\dot{\mathbf{S}}_{21}$	C_{20}, C_{21} , S_{21}	C_{20}, C_{21} , S_{21}
Ocean tides	FES2004	FES2004	FES2004
Atm. Tides	Bode-Biancale 2003	Ray-Ponte 2003	Ray-Ponte 2003
Atm. non-tidal	**NO**	**GGFC stokes_coeff**	**GGFC stokes_coeff**

GFZ SOLUTION DESCRIPTION

	Weekly poseop v40	GGFC v41 (standard)	GGFC v45 (NT-ATML corrected)
Geometrical			
Nut/Prec	IAU1976, IAU2000A	IAU2000A	IAU2000A
EOP	IERS Bull A	EOP08C04	EOP08C04
Station coord	ITRF2000, SLRF2008	SLRF2008	SLRF2008
Ocean load	Scherneck (FES2004)	Scherneck (FES2004)	Scherneck (FES2004)
Atm. tides load	NO	NO	NO
Atm. non-tidal load	**NO**	**NO**	**GGFC call_filtered**

JCET AC/CC REPORTS

Erricos C. Pavlis
GEST/UMBC – NASA Goddard 698
M. Kuzmicz-Cieslak & Keith Evans
GEST/UMBC

ILRS AWG, Frascati, Italy
November 3, 2012

Activities since last AWG

- Analysis Products submitted for DAILY (v130) & WEEKLY (v40) series
- Combination products for DAILY & WEEKLY series continues with no issues, test combinations for v40 & v45 series (GGFC PP), more soon!
- Site log compilation updates (Excel spreadsheets & SCH-SCI database)
- SLRF2008 updates: new Russian sites to be included ("soon")
- Atmospheric signal PP series submitted and re-submitted (**v41 & v46**)

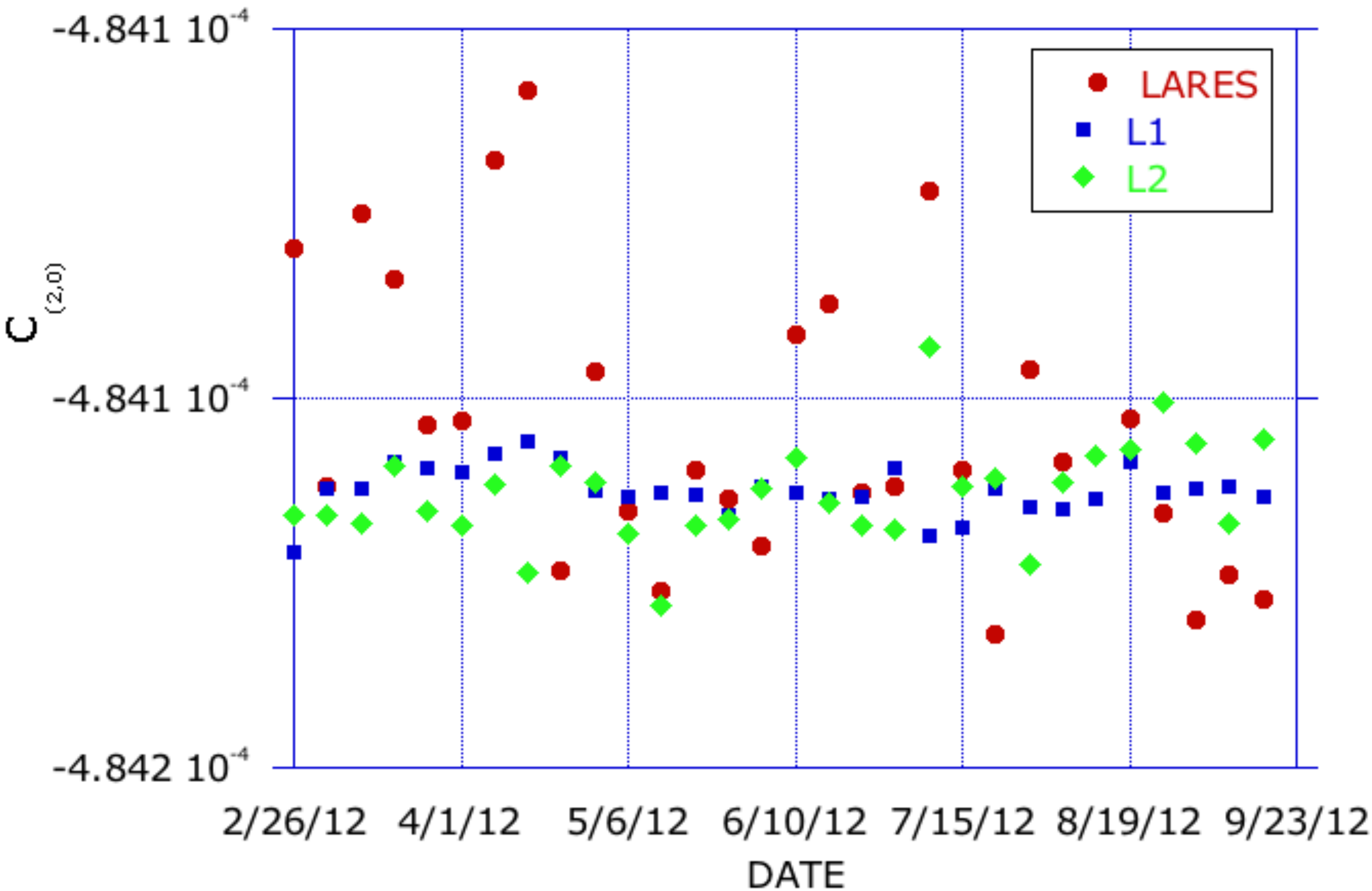
Activities since last AWG (cont.)

- Station validation for old and new sites:
  - Mon. Peak (7110) (ongoing)
  - Arequipa (7403) – returned to operations
  - Hartebeesthoek (7501) – ground target instability
  - Tahiti (7124) – capability to range to GNSS tested with ETALON data
  - Russian sites Badary, Baikonur and Zelenchuskaya in progress (awaiting re-release of corrupted data since July 1, 2012)
  - NGSLR, first test data on geodetic targets examined (need more!)
  - Yarragadee (7090) – Height change (~1 cm) since early 2010 investigated (noticed in JASON-1/2 analysis)

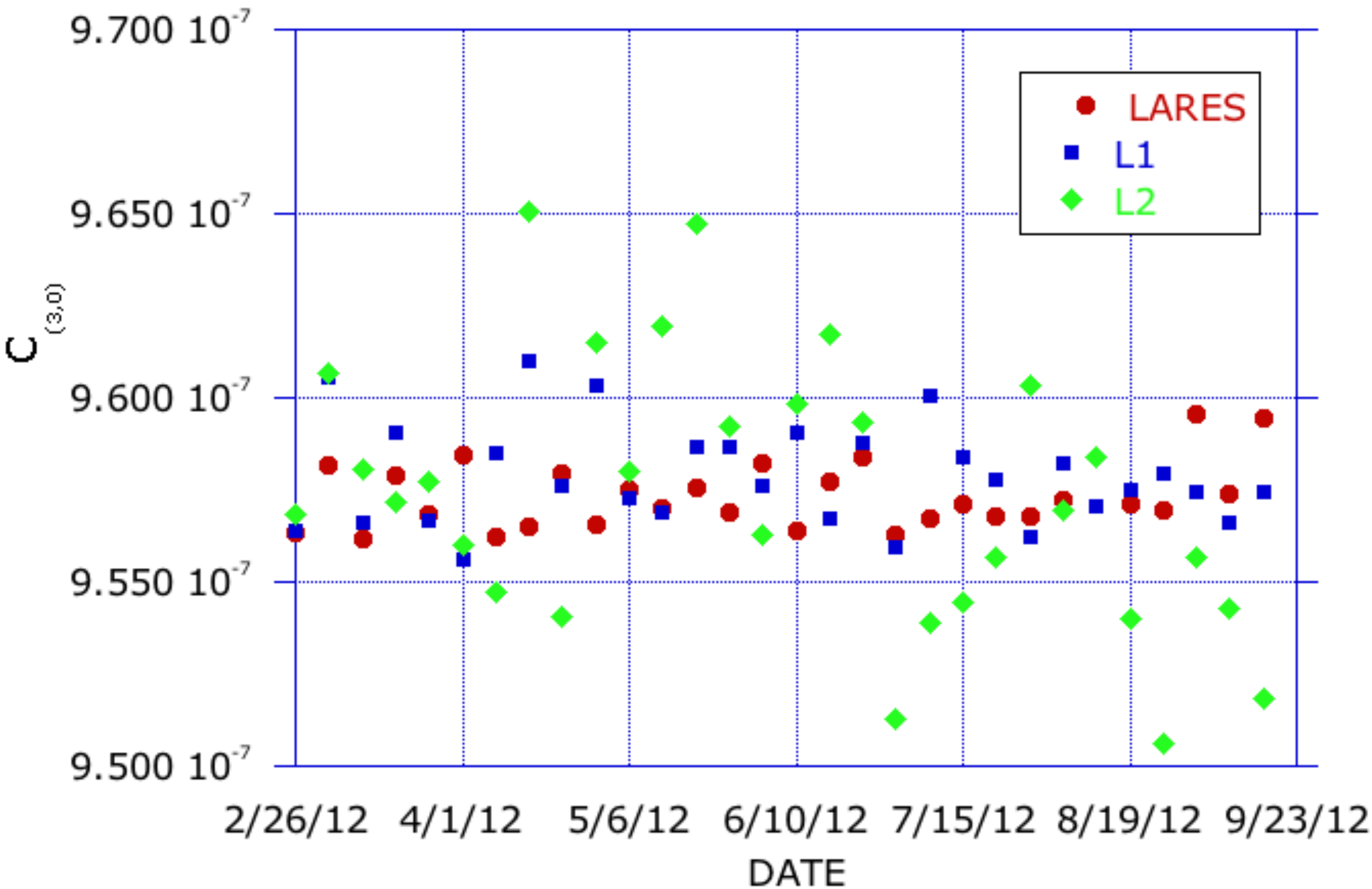
Activities since last AWG (cont.)

- Extensive activity to support various efforts of SLR applications:
  - Assessment of the benefit of outfitting GPS III s/c with ILRS LRAs and development of a CONOPS
  - GGOS/NASAnet Project simulations related to impact of site-tie errors on the ITRF
  - Simulations of LAGEOS 1 & 2 data augmentation with LARES data (and data from a second LARES) for TRF development
  - Analysis of LARES data since February 2012 in combination with LAGEOS 1 & 2 and evaluation of resulting TRF
  - Sensitivity of LAGEOS data analysis to CoM errors examined via simulations (ongoing, next step: GNSS s/c)

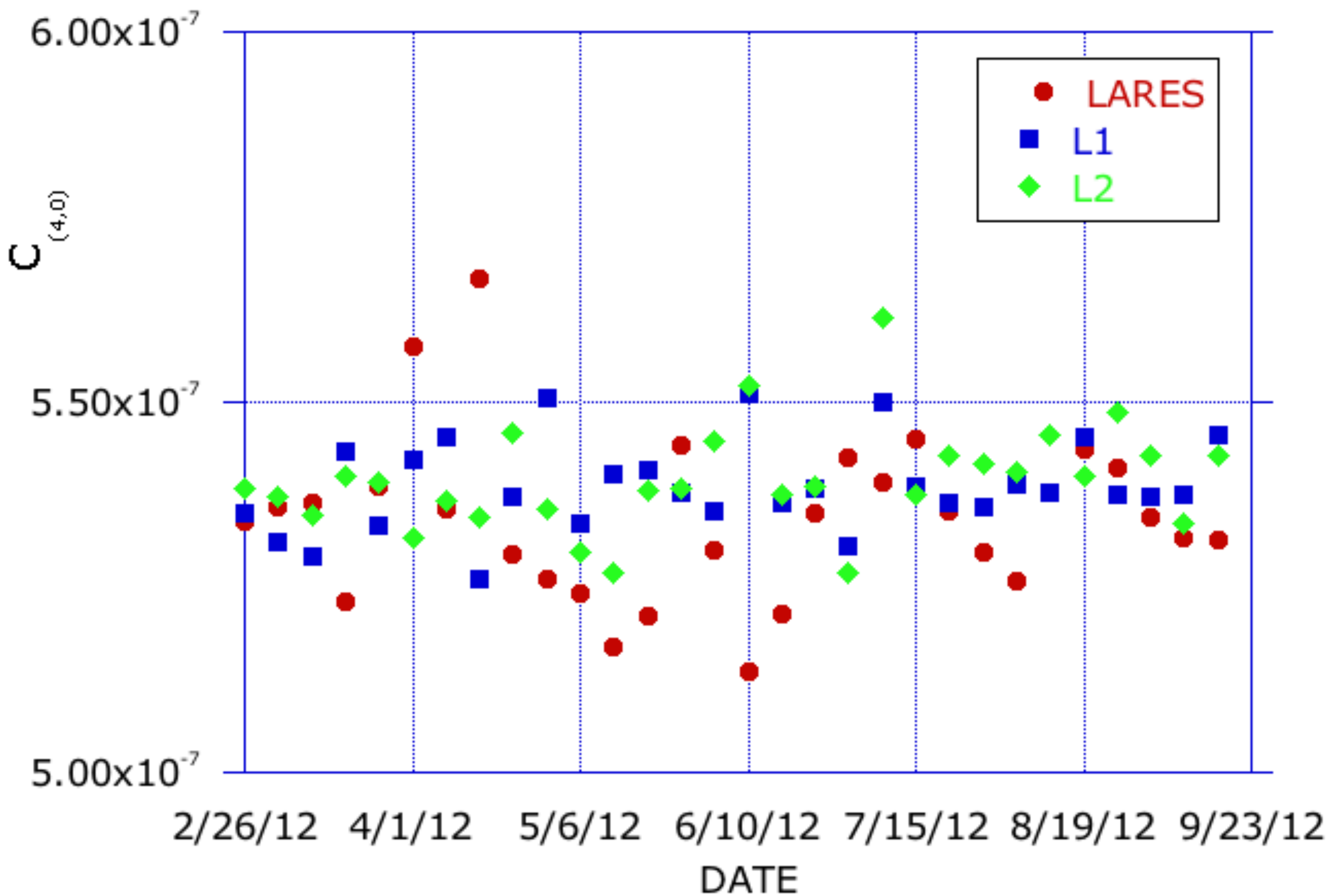
LARES Data Analysis



LARES Data Analysis



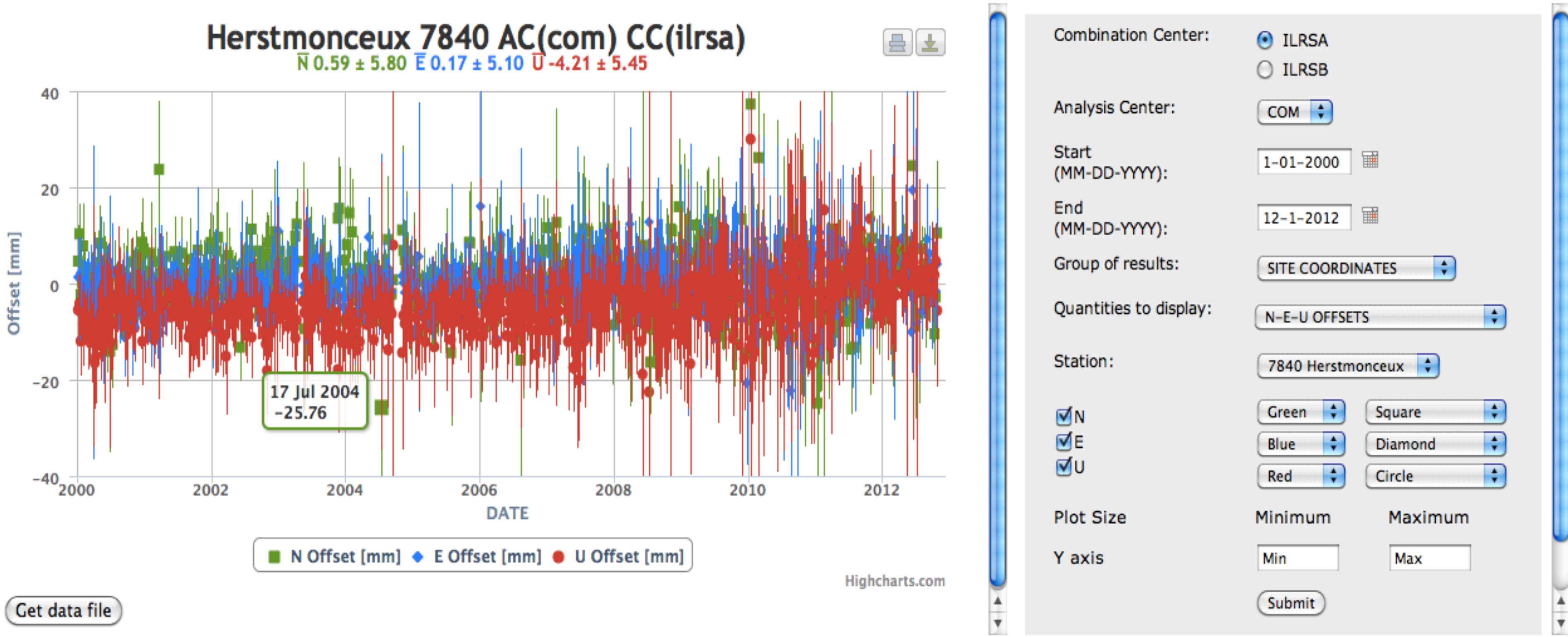
LARES Data Analysis



Activities since last AWG (cont.)

- Updated the ILRS Product Evaluation web site:
  - New plotting engine for better quality, faster plots
  - Capability to download plotted data added for all cases
  - Multiple choices of exporting graphics in a local file (JPEG, PDF, etc.)
  - New page with time series of Station Position evolution and EOP time series
  - Similar pages generated for GGFC PP submissions (v40+/45+, etc.)
- Developed MATLAB viewer of QC reports that works with ALL QC reports from DGFI, HITU, MCC, JCET, SAO (and legacy CSR)
  - Package will run on Mac, Linux and Windows environment and will be distributed with examples, historical QC report data base (up to a certain date) and user's manual

EVALUATION AND MONITORING OF ILRS AWG PRODUCTS



UMBC AN HONORS UNIVERSITY IN MARYLAND

International Laser Ranging Service

Responsible JCET Official: Dr. Erricos Pavlis

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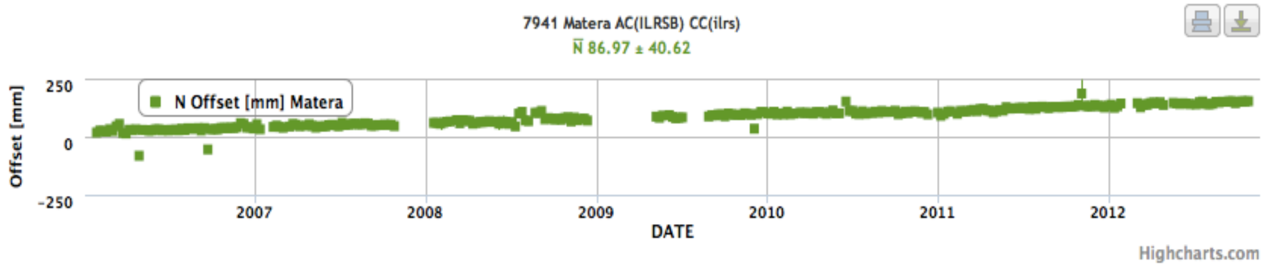
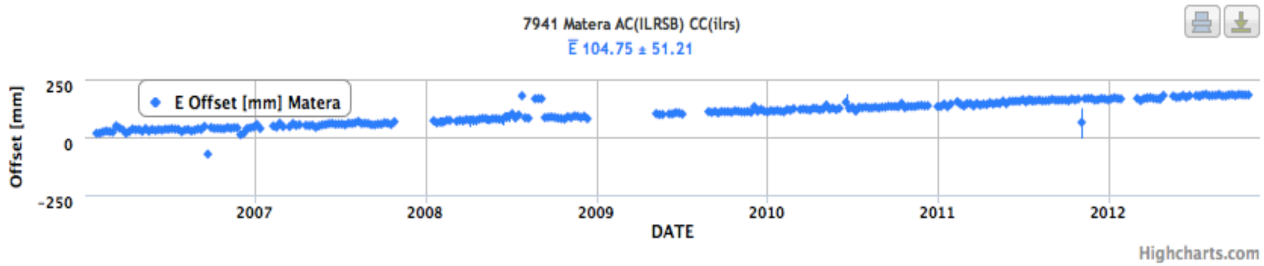
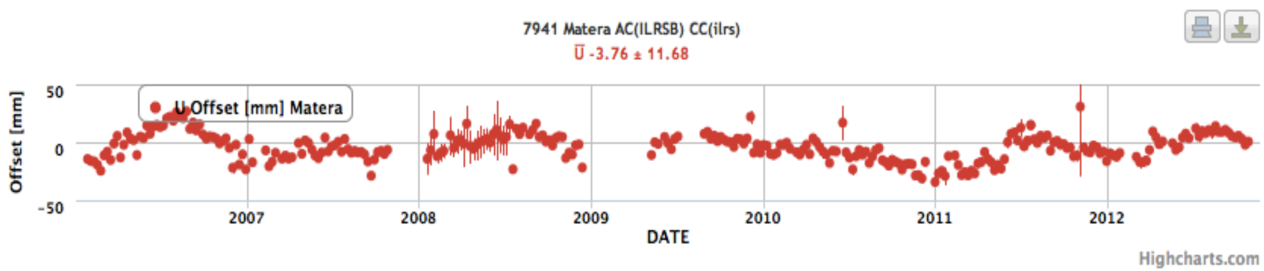
Created and Maintained by: Magda Kuzmicz-Cieslak

EVALUATION AND MONITORING OF ILRS AWG PRODUCTS







Get data file

Type of Product	SITE COORDINATES
Analysis Center	ILRSB
Start (MM-DD-YYYY):	1-01-2006
End (MM-DD-YYYY):	12-1-2012
Quantities to display:	N-E-U OFFSETS
Station:	7941 Matera
☑ N	Green / Square; Min / Max
☑ E	Blue / Diamond; Min / Max
☑ U	Red / Circle; Min / Max

Submit

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International Laser Ranging Service

Responsible JCET Official: Dr. Erricos Pavlis

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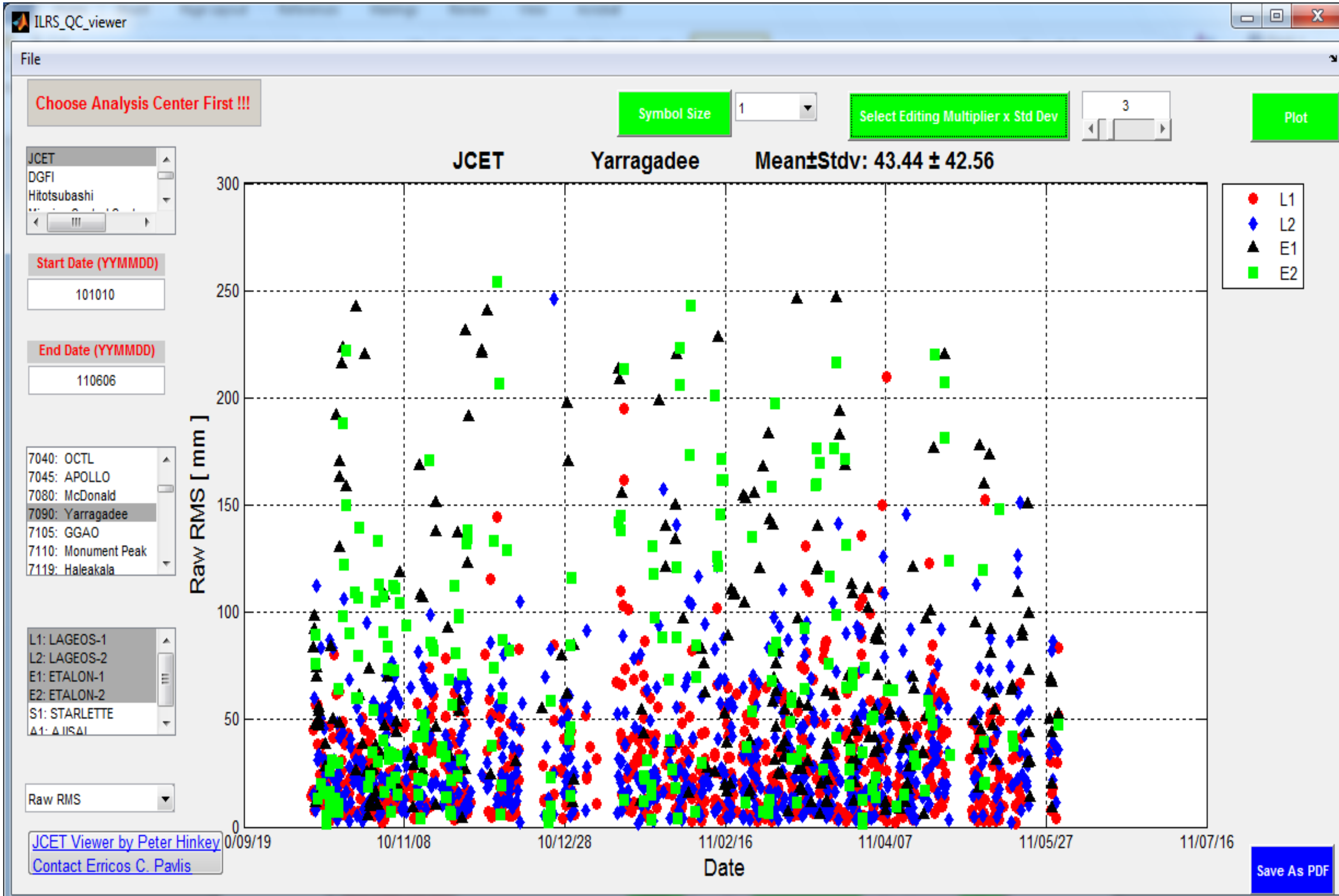
ILRS STATION POSITION & EOP SERIES MONITORING

ILRS QC Viewer GUI



Available loading, gravity, etc. models to test

- Data (atmospheric loading only) available from IERS GGFC web site:
  - http://geophy.uni.lu/ggfc_atmosphere/NCEP-loading.html
- GEODYN-compatible files (atmospheric loading and gravitational effect) available from JCET (ftp site TBD)
  - Eventually it can include compatible oceans and hydrology (from Jean-Paul Boy)
- GRACE project files (atmospheric AND oceanic!) available from GFZ's ISDC:
  - http://isdc.gfz-potsdam.de
- New service from TUW to provide eventually atmos. loading & gravity effect
- New sub-daily EOP model from VLBI+GPS (UniBonn & TUM)
- Need to have these tested and compared between a few ACs: ???
  - Preferably by ACs using a mix of s/w packages (DOGS, EPOS, GINS, GEODYN, etc.)

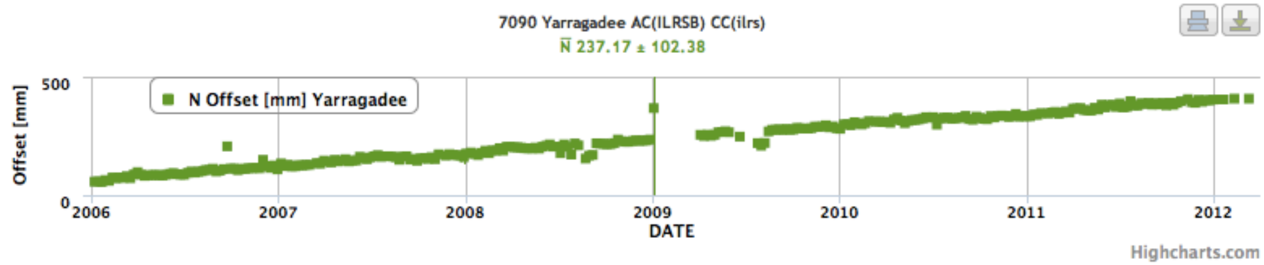
JoG SI Table of Contents – Status 2012.11.03

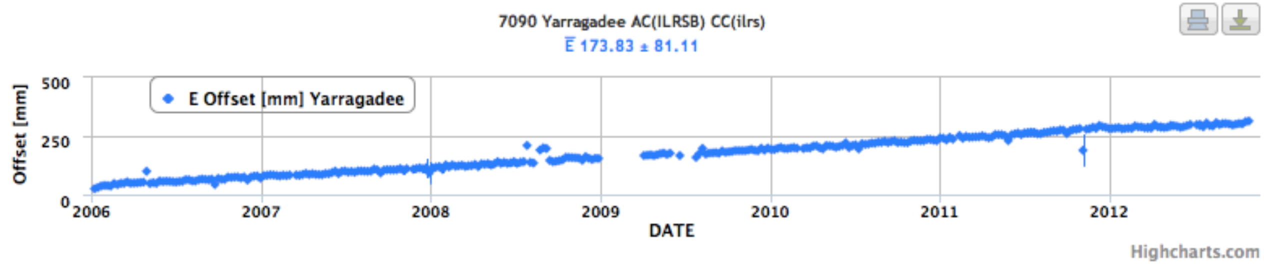
#	TITLE	Lead Author(s)
0	**Foreword**	**The Guest EB**
1	**The International Laser Ranging Service (ILRS): The First Decade and Beyond**	**Pearlman, Appleby, Noll, Pavlis, Torrence**
2	**Information Resources Supporting Scientific Research for the International Laser Ranging Service**	**Noll, Horvath, Ricklefs, Schwatke, Torrence**
3	*Past, Present and Future of the ILRS Global Tracking Network*	*Wetzel, Horvath, Carter, Pierron, Bianco, Govind, ???* Peter Dunn to lead
4	**Next Generation Satellite Laser Ranging Systems**	**Degnan, McGarry, Kirchner, Appleby, Prochazka, Jäggi, Moore, Artyukh, Samain, Schreiber**
5	**Geodetic satellites: a high accuracy positioning tool**	**Pearlman, Arnold, Davis, Barlier, Biancale, Vasiliev, Paolozzi. Ciufolini, Pavlis**
6	**Satellite Laser Ranging to Global Navigation Satellite Systems**	**Thaller, Dell'Agnello, Fumin, Govind, Nakamura, Noda, Springer**
7	**Lunar Laser Ranging – A Tool for General Relativity, Lunar Geophysics and Earth Science**	**J. Müller, Murphy, Schreiber, Shelus, Torre, Williams, Boggs**
8	**Interplanetary Ranging**	**Degnan, Schreiber, McGarry, Sun, Zagwodzki, Murphy, Samain, Turyshev**
9	**Target Signature Systematic Errors for Geodetic Satellites and Novel LR Array Design**	**Appleby, Otsubo, Arnold, Kirchner, Neubert, Grunwaldt, Vasilliev**
10	**Data Quality Control Service for the ILRS Tracking Network**	**Otsubo, H. Müller, Pavlis, Torrence, Thaller, Glotov, Xiaoya, Appleby**
11	**Systematic errors in SLR Data: Documentation and Discussion of their Sources**	**Luceri, H. Müller, Vei, Appleby and Pavlis**
12	**Operational and Definitive Products of the ILRS Analysis Working Group**	**Sciarretta, Luceri, Pavlis and Kelm**
13	*Monitoring Mass Redistribution in the Earth System with SLR*	*Pavlis, König, Ries, Deleflie, Cheng, H. Müller, ???*
14	*The ILRS Contribution to the International Terrestrial Reference Frame (ITRF)*	*Pavlis and the AWG ACs and CCs*

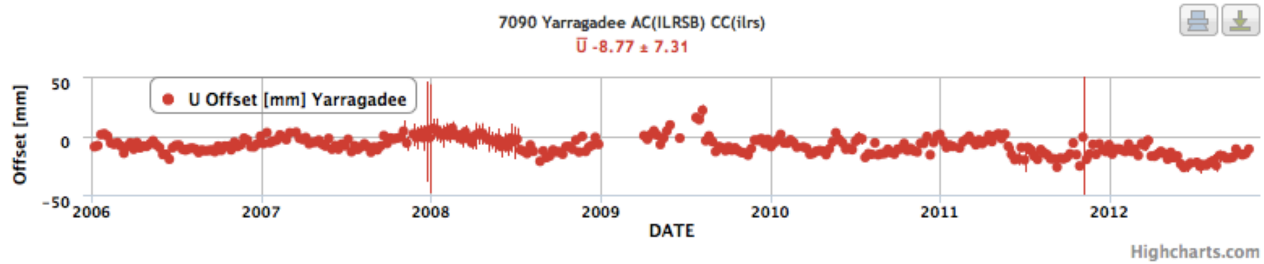
We also have EIGHT (8) "un-solicited" abstracts so far

1) **BOLD** indicates working title from author(s) for a submitted abstract
2) **RED** indicates lead author
3) *Non-bold entries in italics are still pending!!!*

ILRS STATION POSITION & EOP SERIES MONITORING







Get data file

Type of Product: SITE COORDINATES

Analysis Center: ILRSB

Start (MM-DD-YYYY): 1-01-2006

End (MM-DD-YYYY): 12-1-2012

Quantities to display: N-E-U OFFSETS

Station: 7090 Yarragadee

☑ N: Green | Square | Min | Max

☑ E: Blue | Diamond | Min | Max

☑ U: Red | Circle | Min | Max

Submit

UMBC AN HONORS UNIVERSITY IN MARYLAND

International Laser Ranging Service

Responsible JCET Official: Dr. Erricos Pavlis

Last modified

Created and Maintained by: Magda Kuzmicz-Cieslak

The Impact of Target Signature Errors (CoM) on the Official ILRS Products

Erricos C. Pavlis and Magdalena Kuźmicz-Cieślak
Goddard Earth Sciences and Technology Center/UMBC

Fall ILRS AWG Meeting,
Frascati, Italy
November 3, 2012

International Laser Ranging Service

Simulations of LAGEOS CoM Errors

- The PP for the implementation of the new, time-dependent model of CoM offsets for LAGEOS 1 & 2 and ETALON 1 & 2 did not provide a clear answer on the improvement or lack of, for the ILRS official products

- One of the AI from the last AWG was to investigate the sensitivity of the current network in errors in the CoM model through simulations with errors at the level of those expected in the current model

Selected LAGEOS CoM Errors

- We chose the real SLR network and LAGEOS data distribution of 2005 to generate a set of simulated observations using the default CoM model as a reference (Case 0)

- We reduced the simulated data forming normal equations with everything modeled as in the reference case, except for the LAGEOS CoM value, which was varied six different ways as follows:

  - Case 1: +10 mm
  - Case 2: +5 mm
  - Case 3: +1 mm
  - Case 4: -1 mm
  - Case 5: -5 mm
  - Case 6: -10 mm

TRF Solutions

- The six sets of normal equations along with the reference case were used to form one-year TRF models (velocities fixed)
- The seven products were generated with the same constraints and solving for the same parameters
- The station parameterization was similar to what is done for the operational products, all sites are allowed to have a bias, except for a few “core” sites
- The results were compared via:
  - (a) 7-parameter transformations,
  - (b) comparison of the resulting station heights and estimated biases
  - (c) the series of geocenter variations

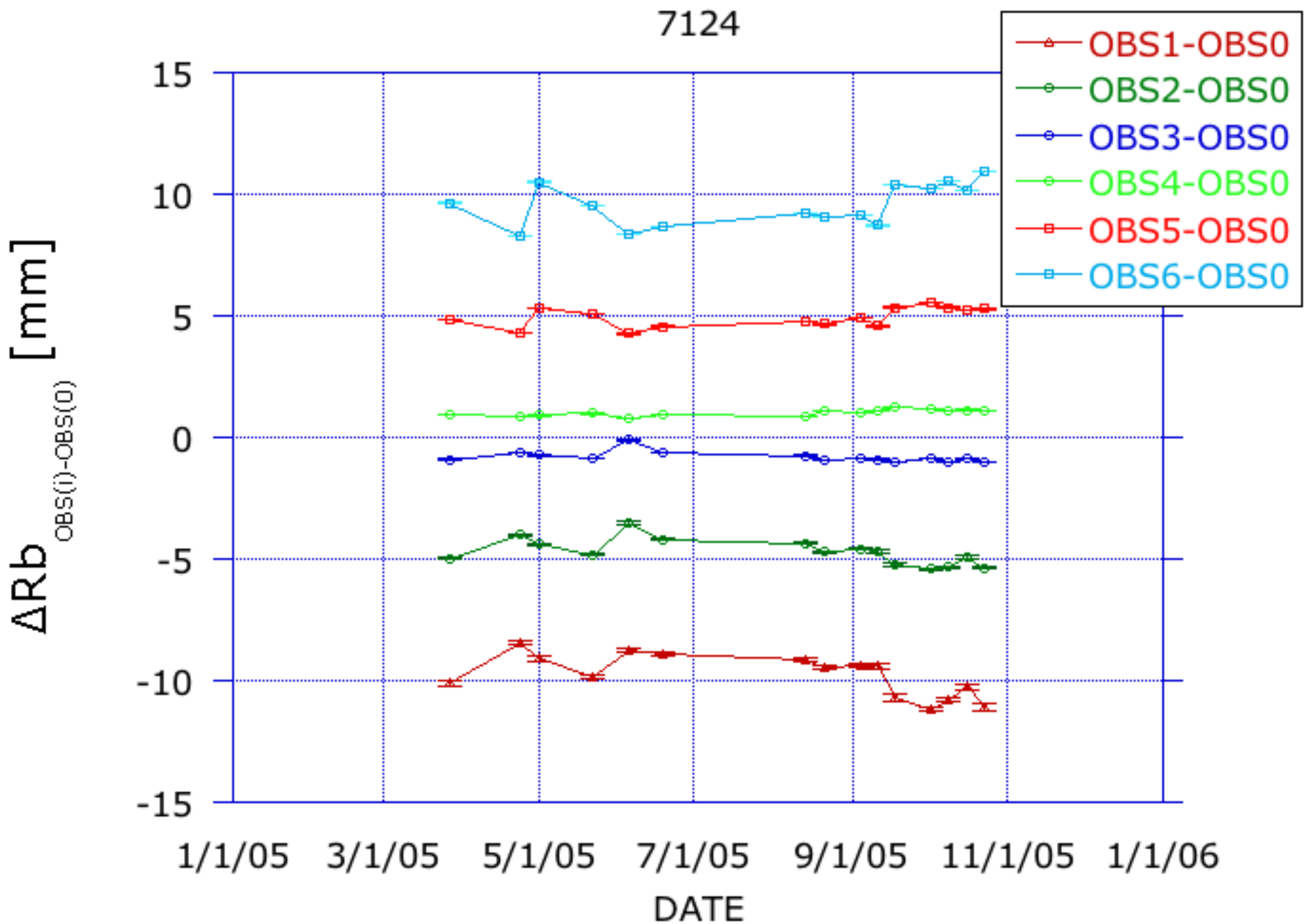
Transformation Parameters to Reference Network

Parameter / Error	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
	+10 mm	+ 5 mm	+ 1 mm	-1 mm	-5 mm	-10 mm
T_X [mm]	-0.86 ± 3.35	-0.38 ± 3.34	-0.06 ± 3.34	0.26 ± 3.34	0.65 ± 3.34	1.27 ± 3.34
T_Y [mm]	1.07 ± 3.35	0.50 ± 3.34	0.06 ± 3.34	-0.08 ± 3.34	-0.61 ± 3.34	-1.15 ± 3.34
T_Z [mm]	-1.44 ± 3.21	-0.82 ± 3.20	-0.03 ± 3.20	0.20 ± 3.20	0.72 ± 3.20	1.41 ± 3.20
D_S [ppb]	0.27 ± 0.49	0.14 ± 0.49	0.01 ± 0.49	-0.03 ± 0.49	-0.12 ± 0.49	-0.25 ± 0.49
R_X [mas]	0.03 ± 0.13	0.01 ± 0.13	0.00 ± 0.13	-0.01 ± 0.13	-0.02 ± 0.13	-0.04 ± 0.13
R_Y [mas]	0.01 ± 0.13	0.00 ± 0.13	0.00 ± 0.13	0.00 ± 0.13	0.00 ± 0.13	-0.01 ± 0.13
R_Z [mas]	-0.01 ± 0.11	-0.01 ± 0.11	0.00 ± 0.11	0.00 ± 0.11	0.01 ± 0.11	0.02 ± 0.11

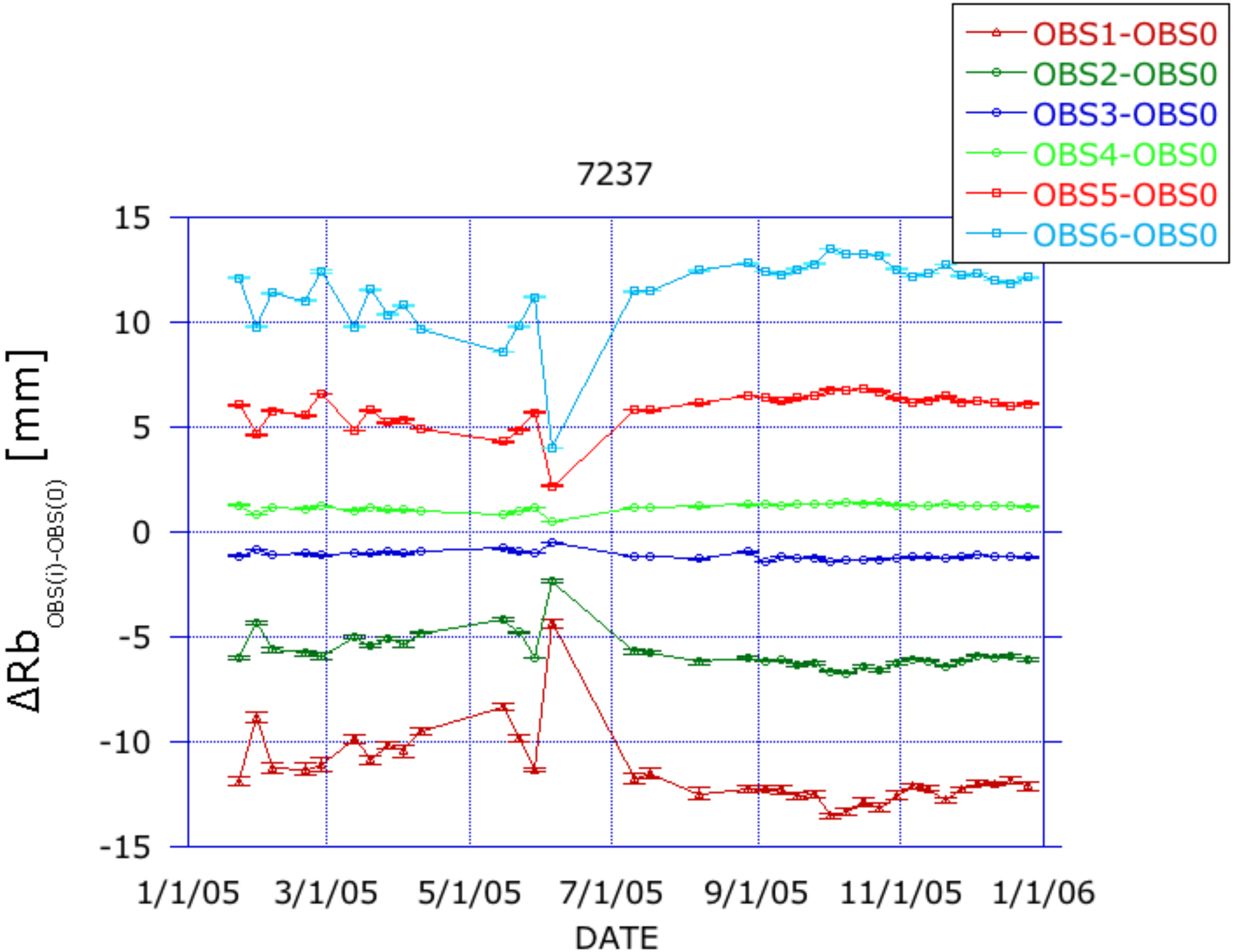
Network Height Error Due to CoM Modeled Error

Experiment vs. Reference	CoM Introduced Error [mm]	Global Network Scale Error [ppb]
Case 1	+10	0.165 ± 0.450
Case 2	+5	0.089 ± 0.233
Case 3	+1	0.017 ± 0.048
Case 4	-1	-0.010 ± 0.043
Case 5	-5	-0.065 ± 0.209
Case 6	-10	-0.146 ± 0.419

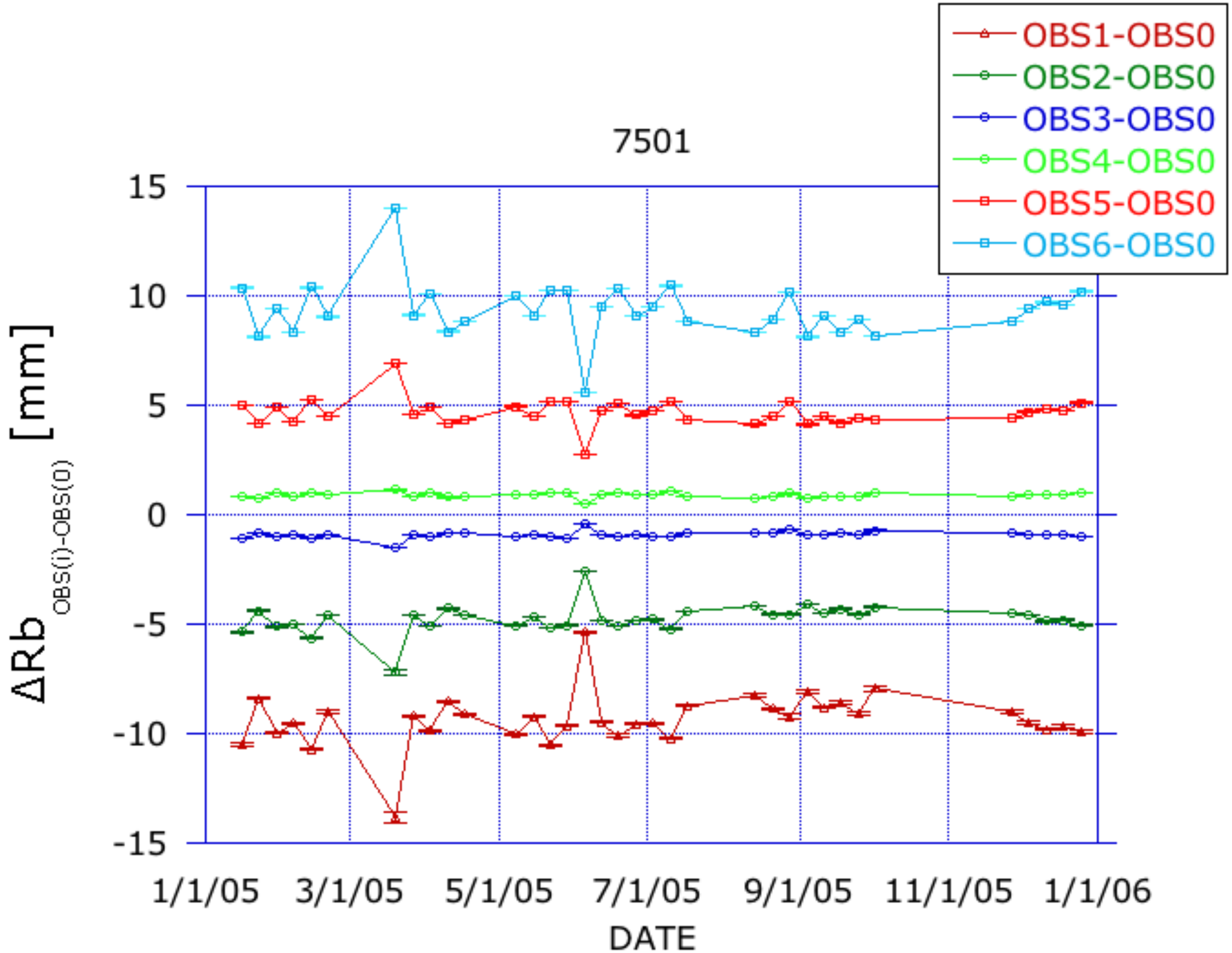
Estimated Measurement Bias



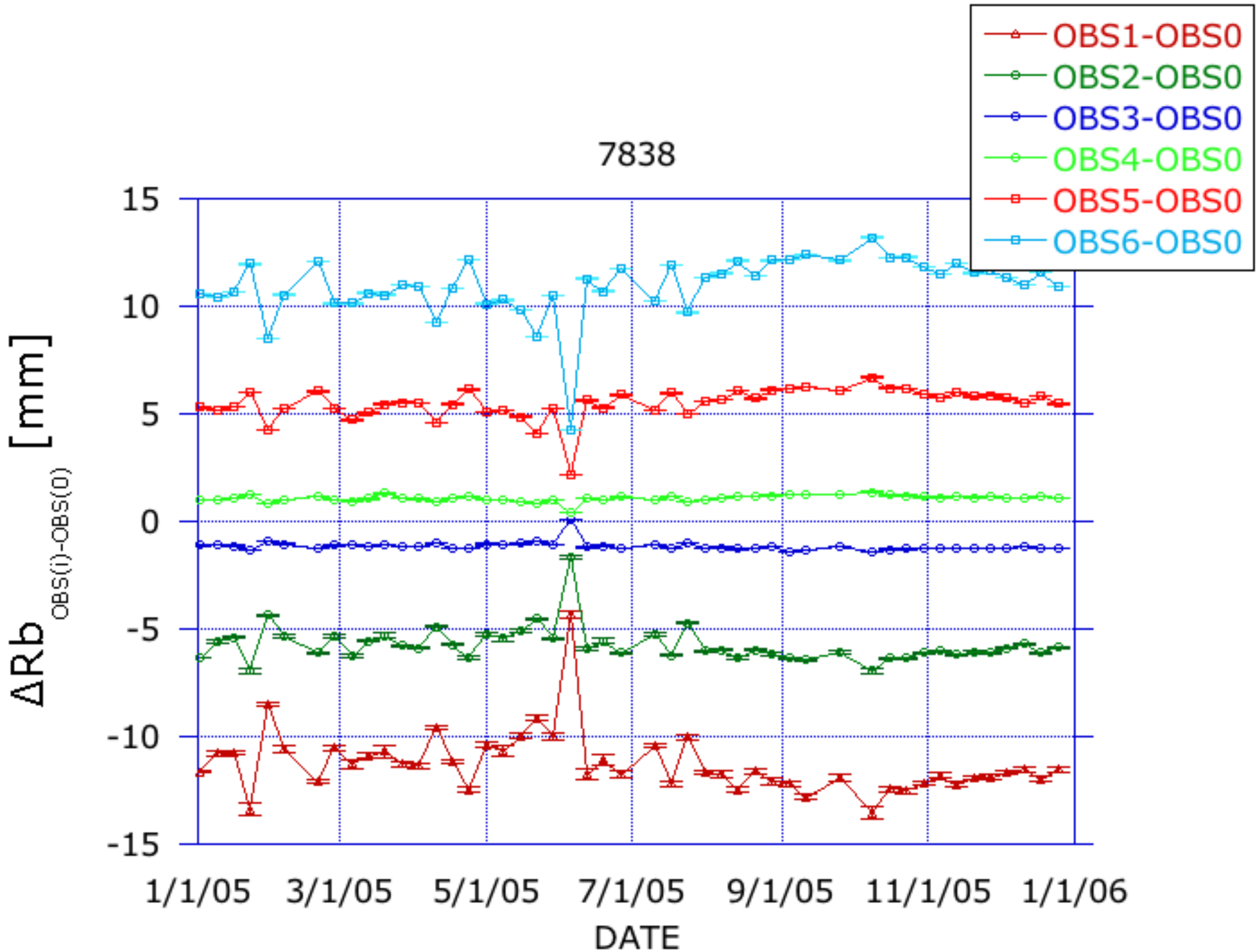
Estimated Measurement Bias



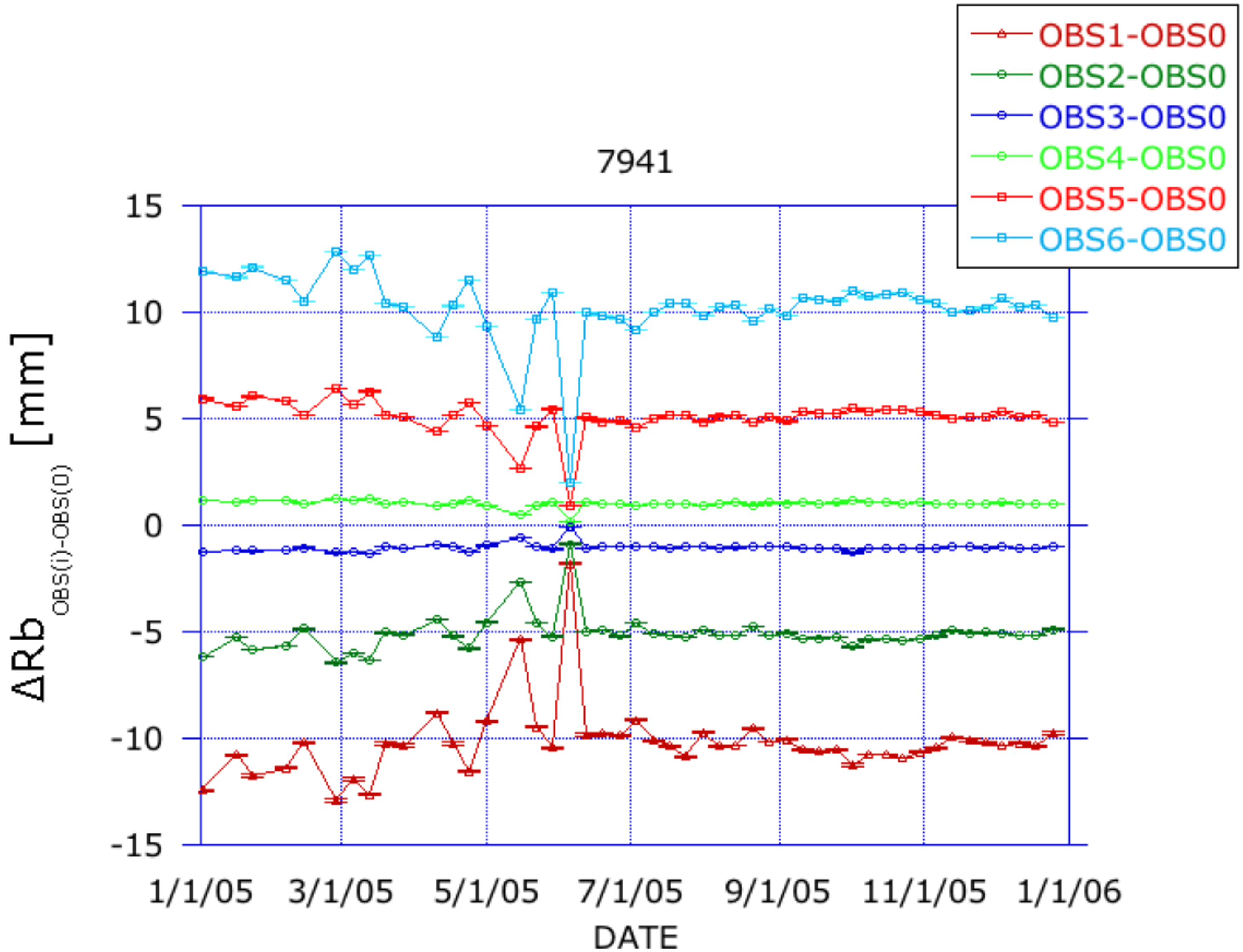
Estimated Measurement Bias



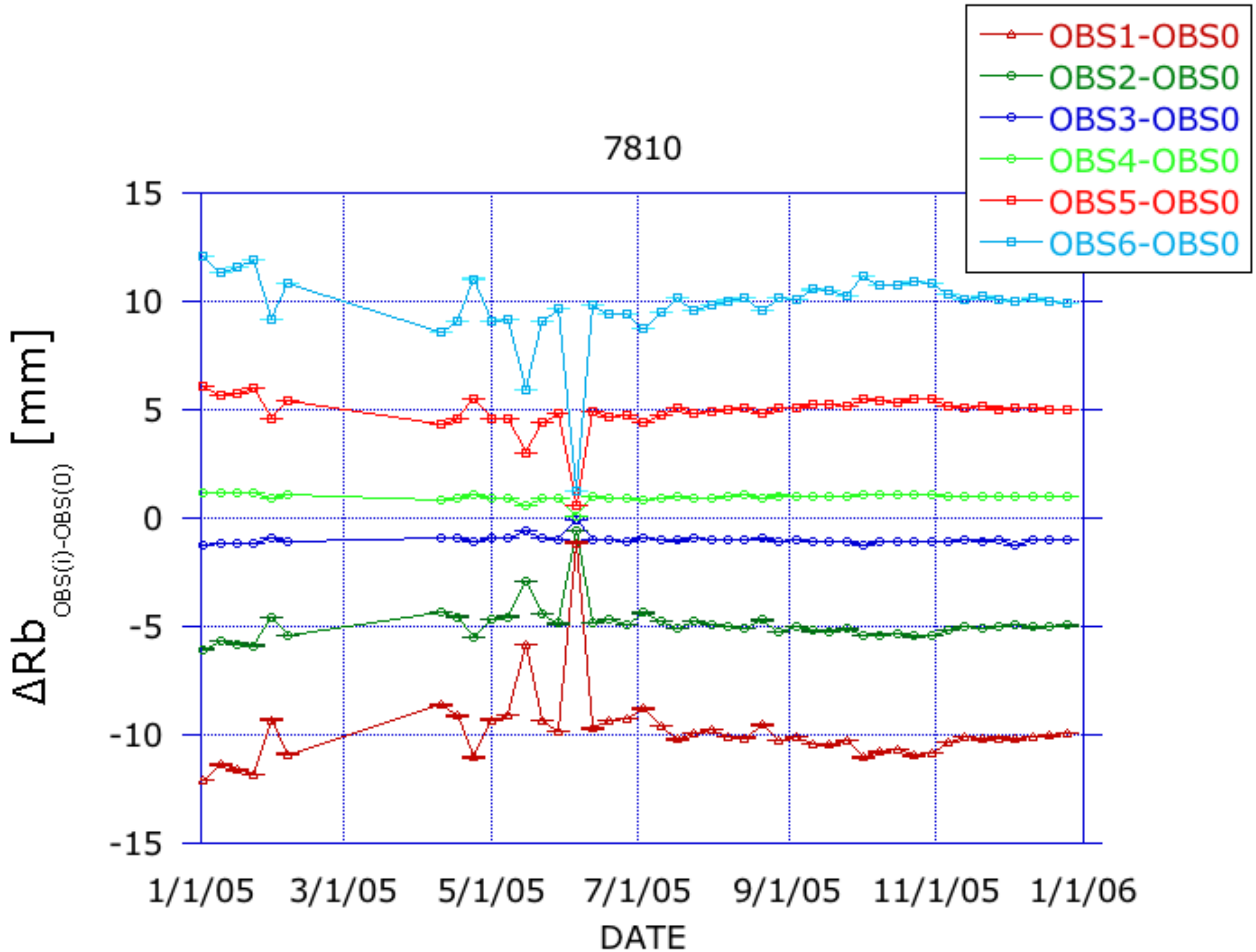
Estimated Measurement Bias



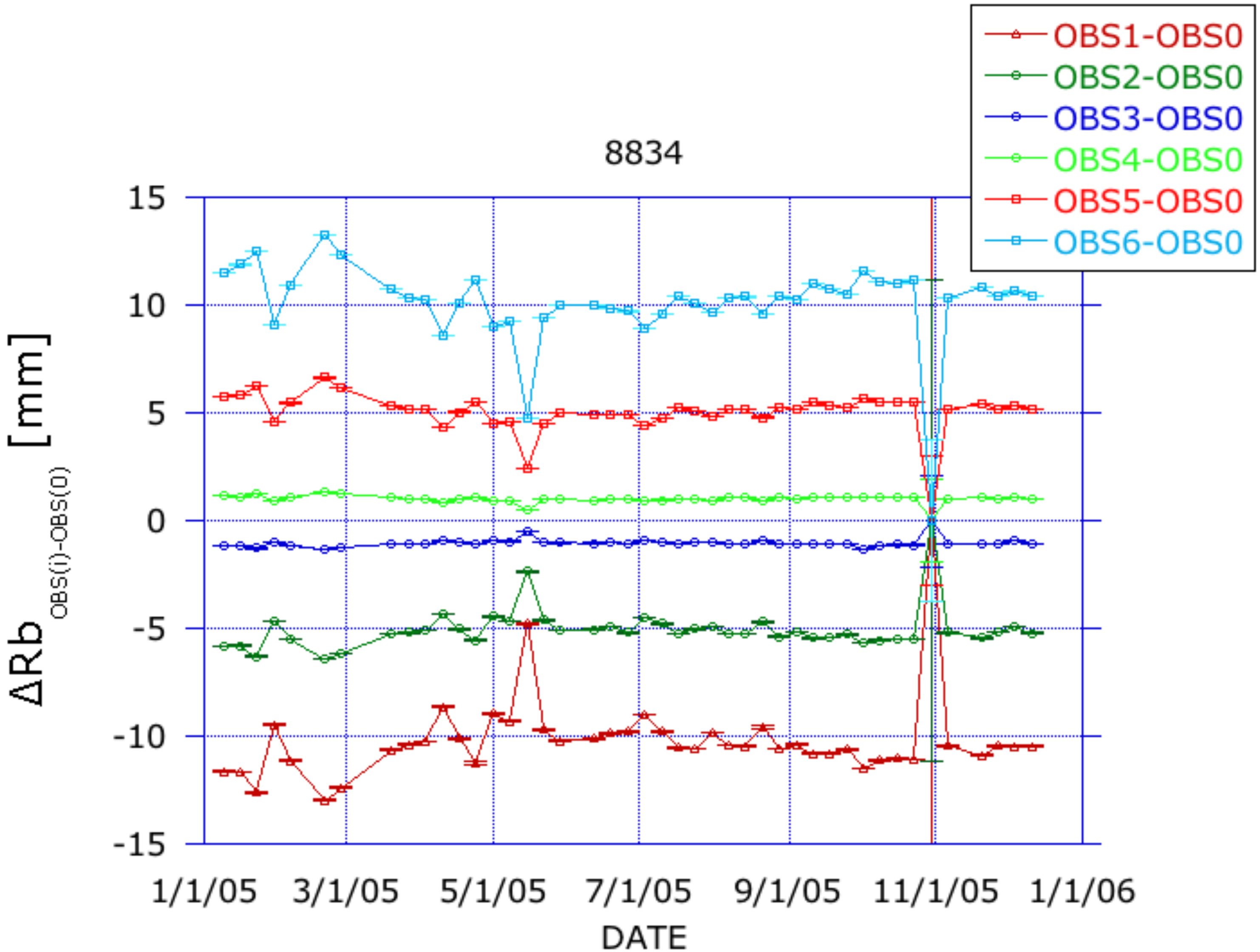
Estimated Measurement Bias



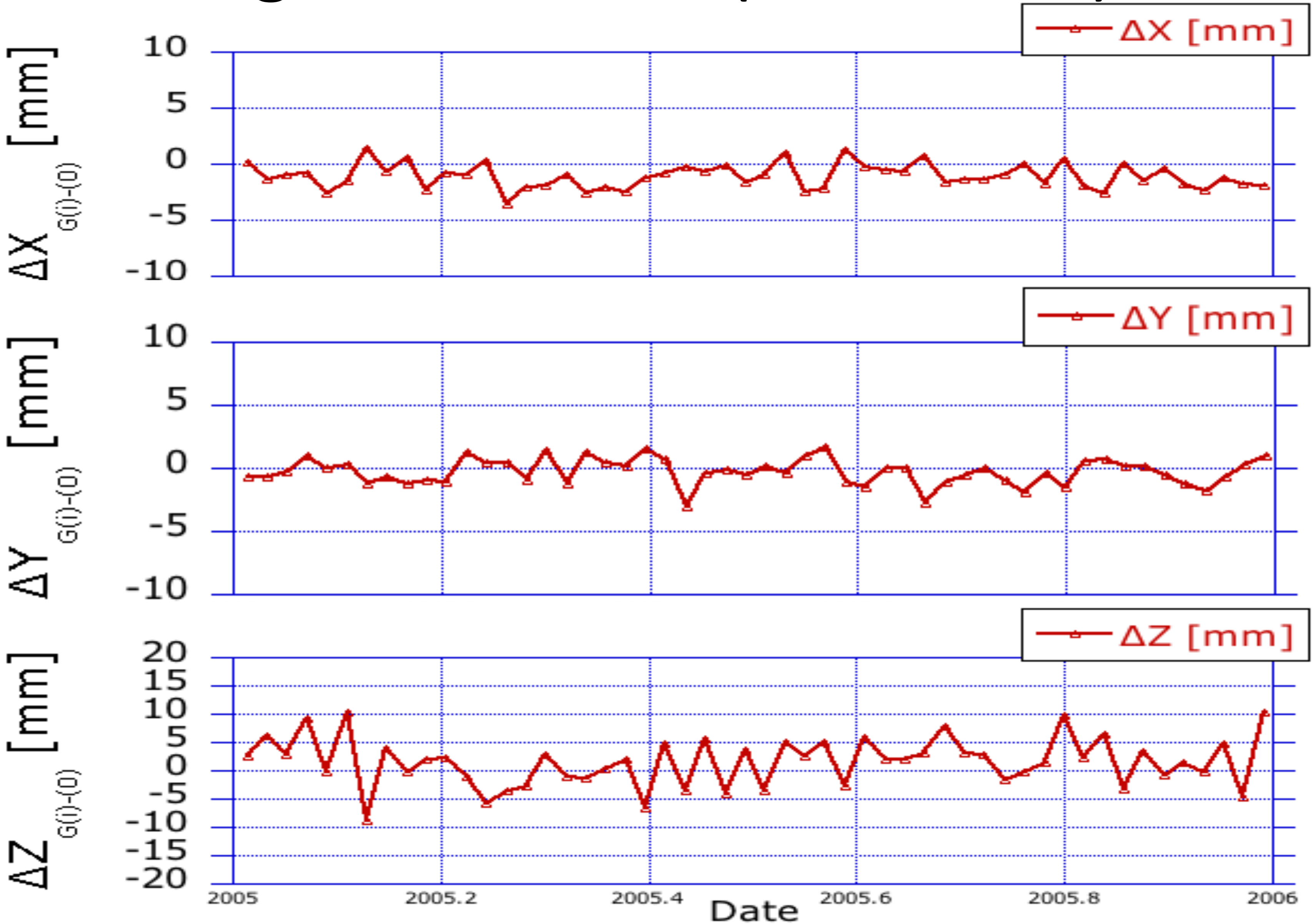
Estimated Measurement Bias



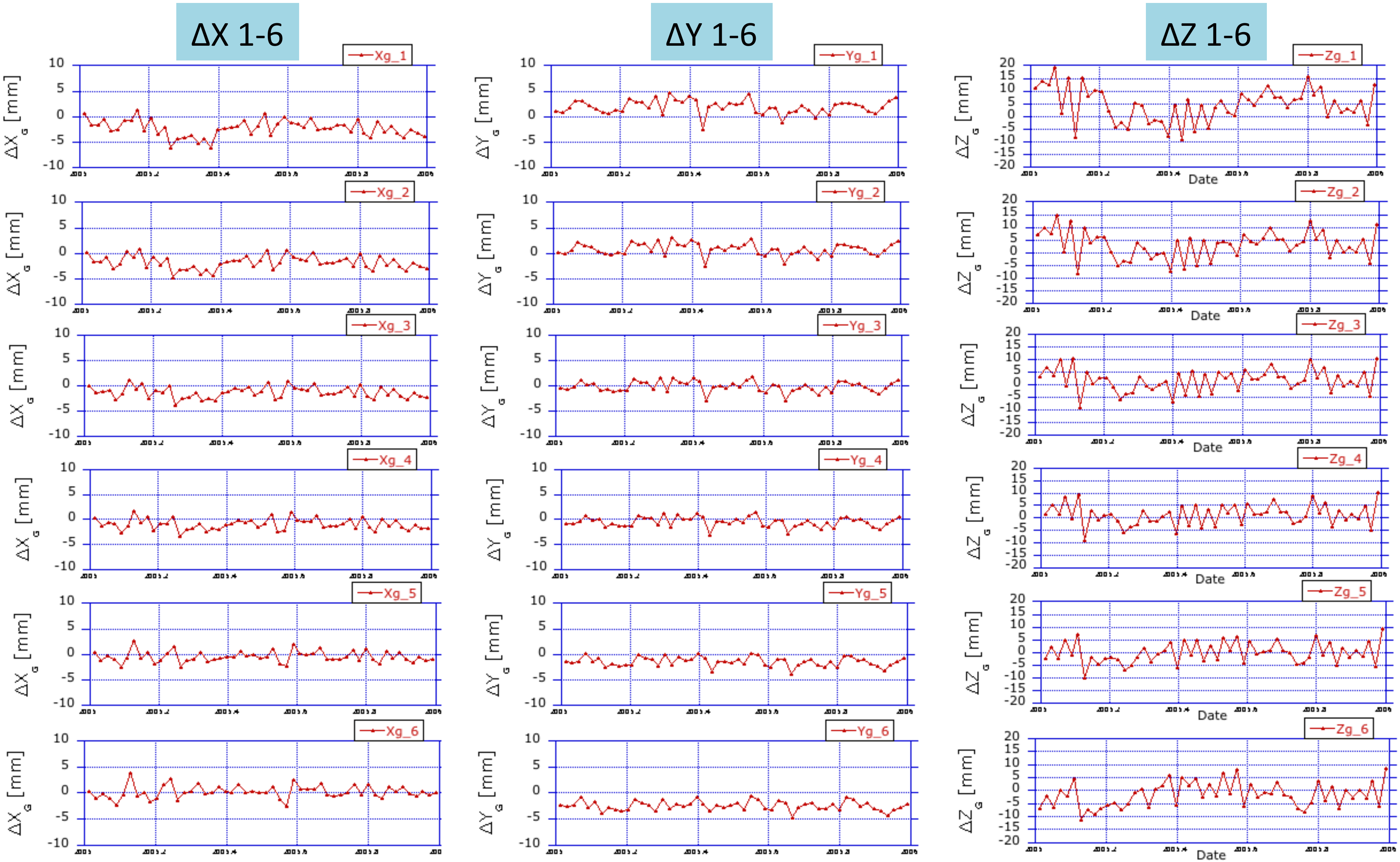
Estimated Measurement Bias



Origin Variations (Reference)



Origin Variation Errors due to CoM Errors

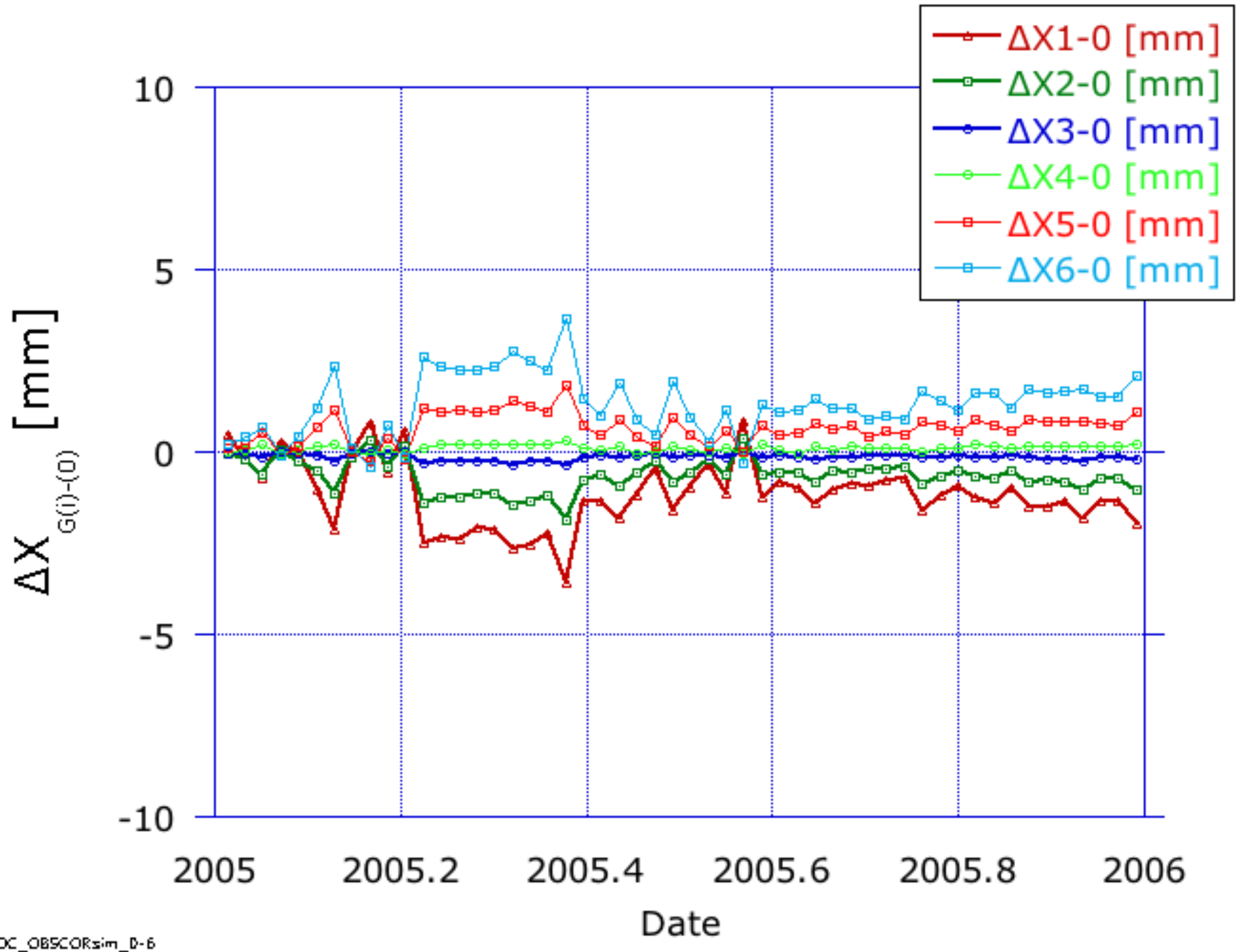


Origin Variations Statistics

Mean and Std. Deviation of 1 year series

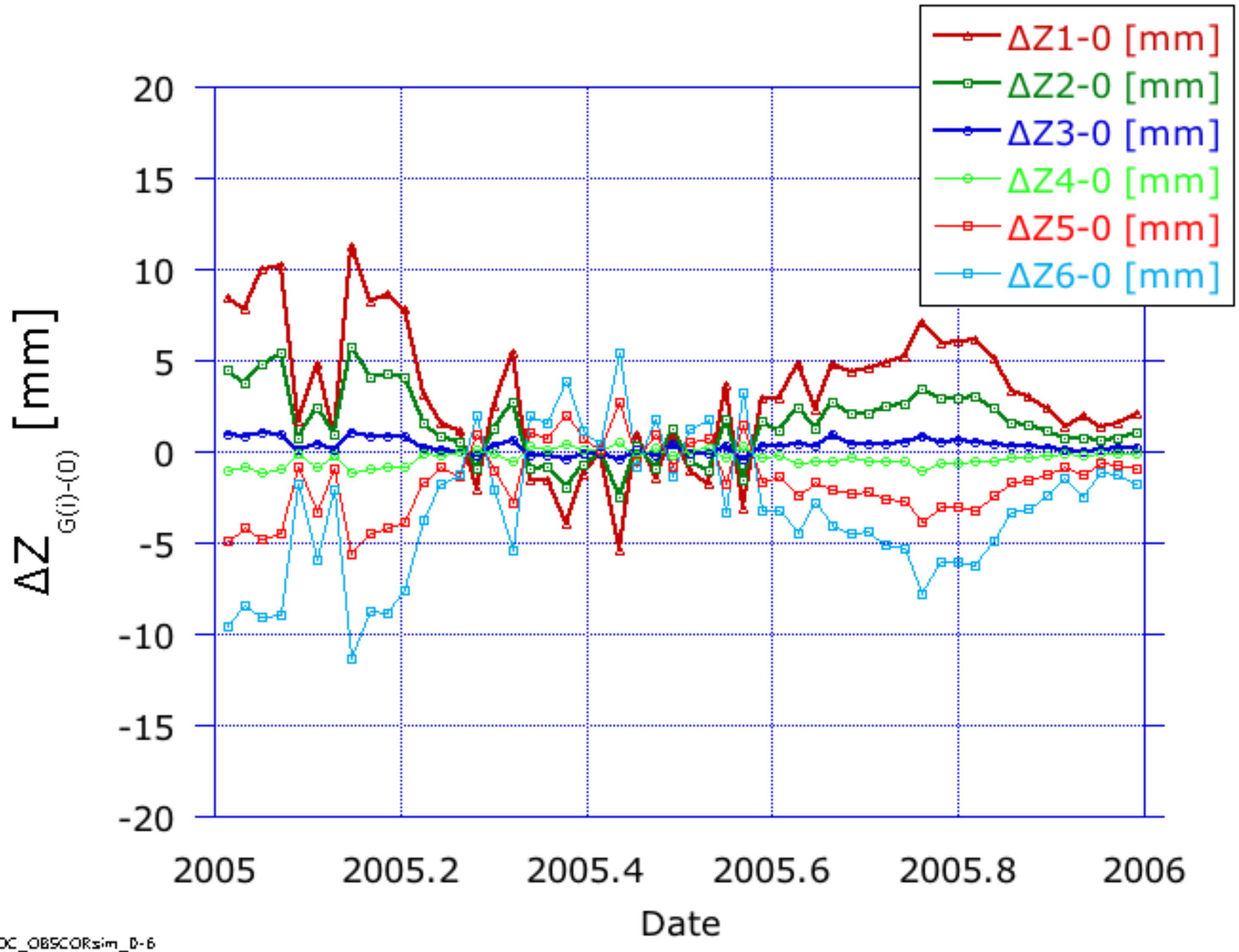
	Error in CoM	Mean ΔX	Mean ΔY	Mean ΔZ	Std. Dev. ΔX	Std. Dev. ΔY	Std. Dev. ΔZ
Reference	[mm]	-1.08	-0.28	1.54	1.12	1.04	4.35
Case 1	+10	-1.19	2.22	3.09	0.91	0.49	3.76
Case 2	+5	-0.67	1.15	1.56	0.45	0.25	1.89
Case 3	+1	-0.14	0.23	0.33	0.09	0.06	0.38
Case 4	-1	0.12	-0.23	-0.31	0.09	0.06	0.41
Case 5	-5	0.67	-1.13	-1.60	0.42	0.27	1.90
Case 6	-10	1.32	-2.15	-3.11	0.85	0.55	3.80

Origin Variations Errors - ΔX_G



Origin Variations Errors - ΔY_G

Origin Variations Errors - ΔZ_G



Conclusions

- Simulated six series of weekly products for year 2005 introducing CoM errors of ± 10 m, ±5 and ±1 mm to investigate the ability of the analysis process to recover the errors and the effect of these errors on the products
- Minimal (≤10%) error in the definition of the secular origin, scale and orientation of the TRF
- Height changes are also minimal (≤10%) for sites with adjusted biases
- Measurement biases absorb the majority of the mean error
- Origin ("geocenter") variations are affected in two ways:
  - (a) a mean effect distributed amongst X-Y-Z, largest portion in Z
  - (b) a change in the variability mostly as a function of network geometry and data distribution
- This type of error clearly reduces the "absoluteness" of SLR and must be kept to a minimum: ≤ few mm to keep effects well below 1 mm

LLR Status Report
- 2012 update -

Jürgen Müller

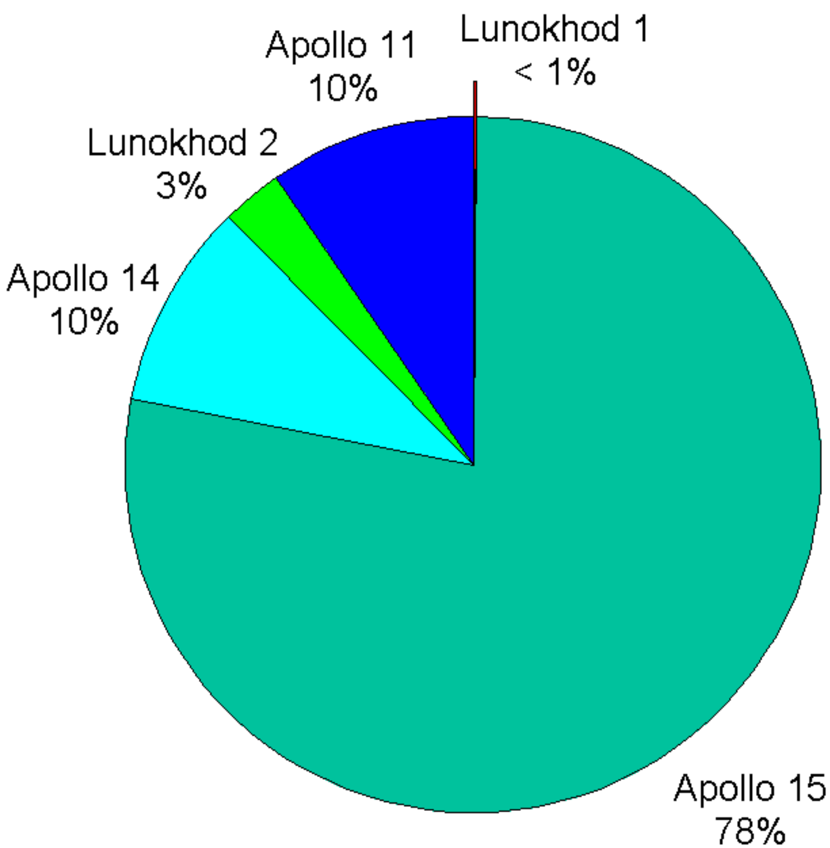
Institut für Erdmessung (Institute of Geodesy) and

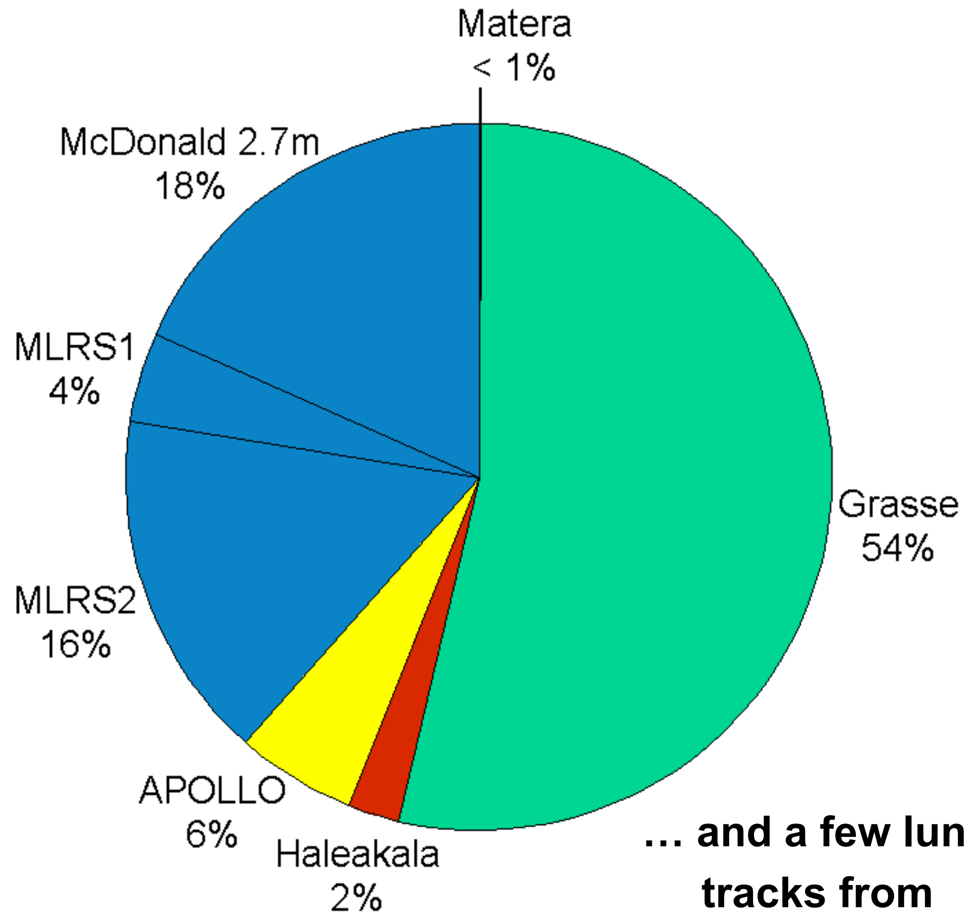
Center of Excellence QUEST
(Quantum Engineering and Space-Time Research)

Leibniz Universität Hannover (University of Hannover)

Statistics – retro-reflectors and observatories

Time span **1970-2012**





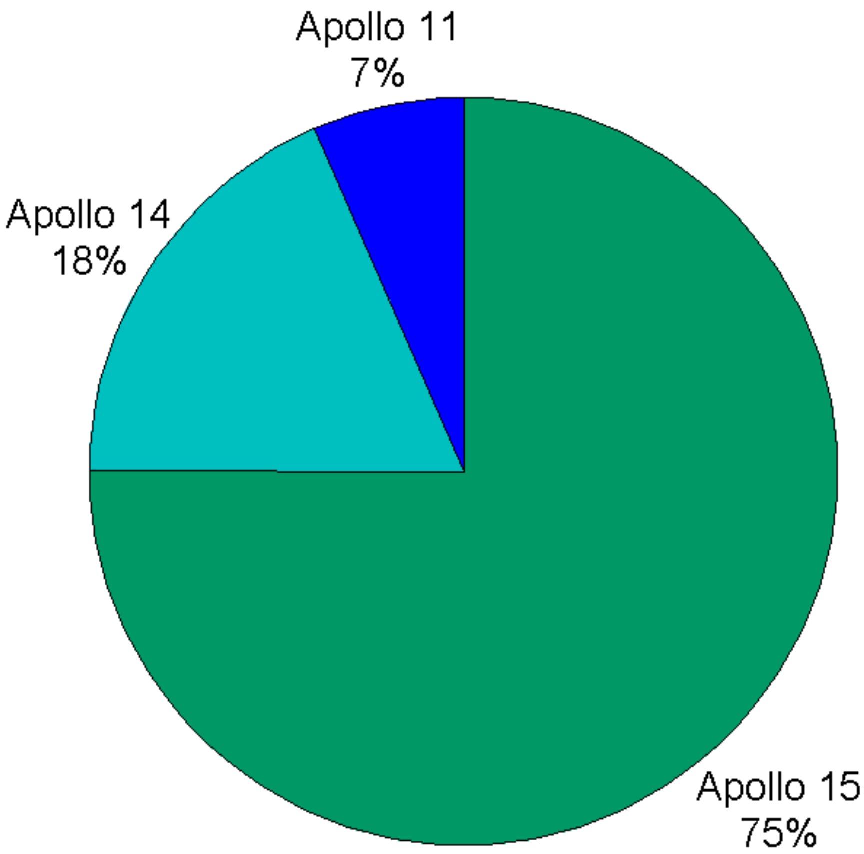
about 17.300 normal points

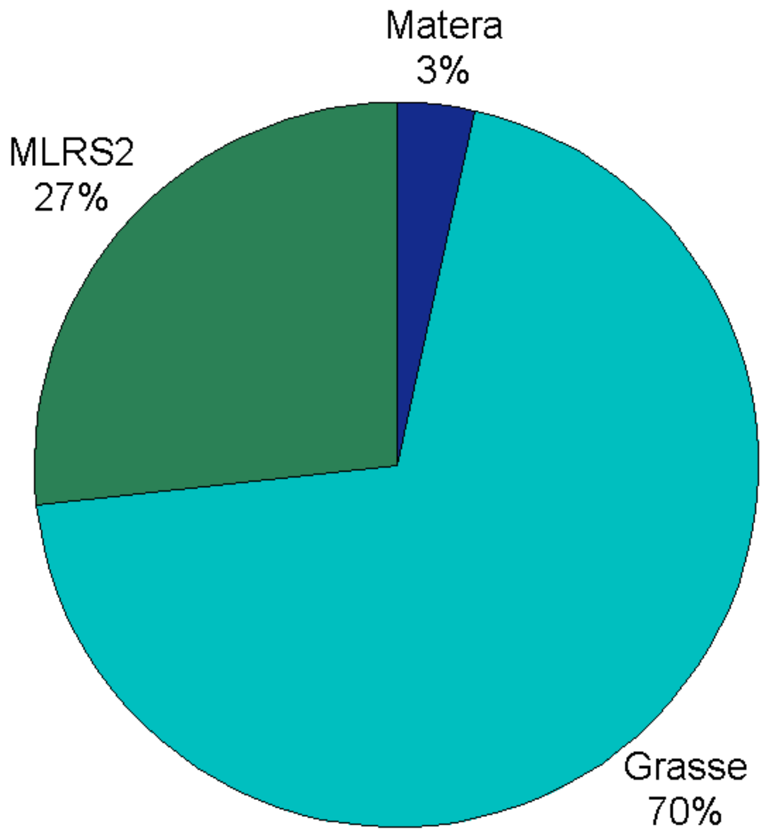
… and a few lunar tracks from

- **Orroral**
- **Wettzell**

Statistics – retro-reflectors and observatories

Only **2011** (‚weak ‘ year)



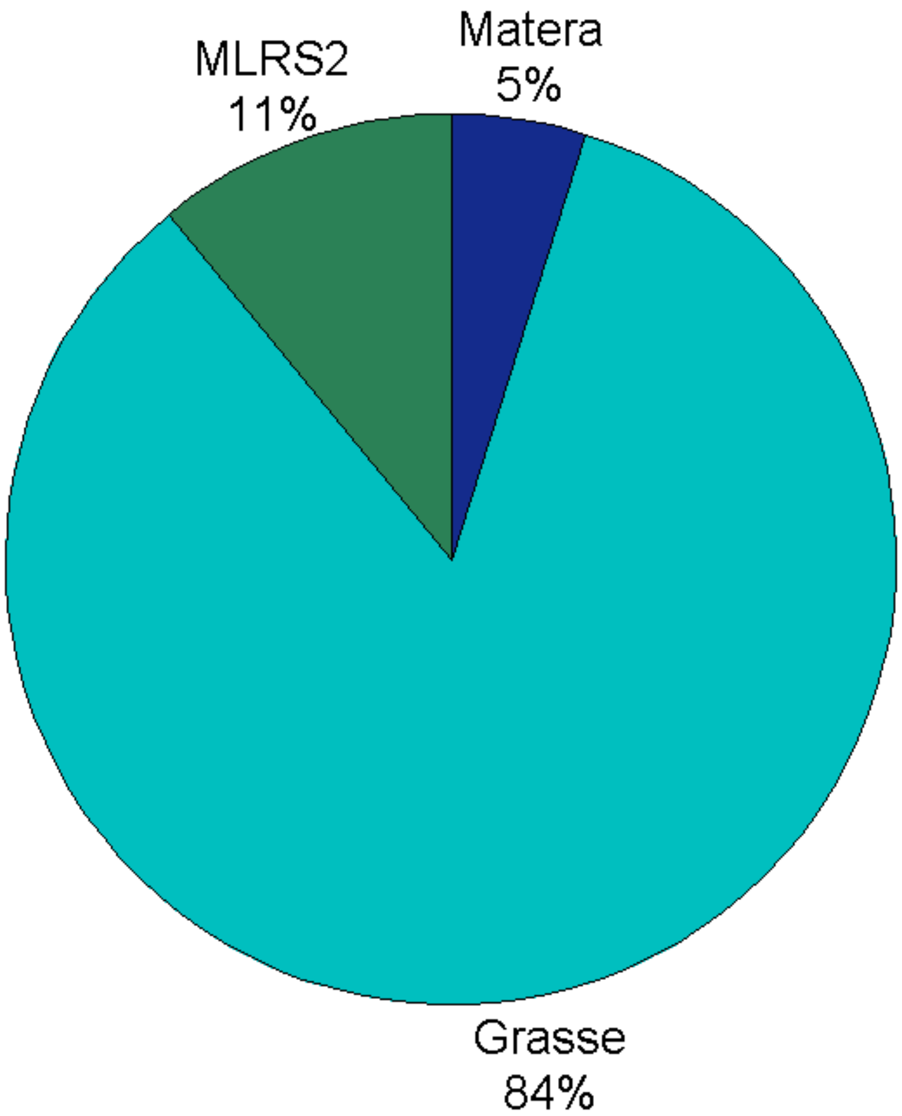


- no APOLLO normal points (in archive)
- no tracks to Lunokhod 1 and 2

Statistics – observatories 2012

Only **2012** (until October)

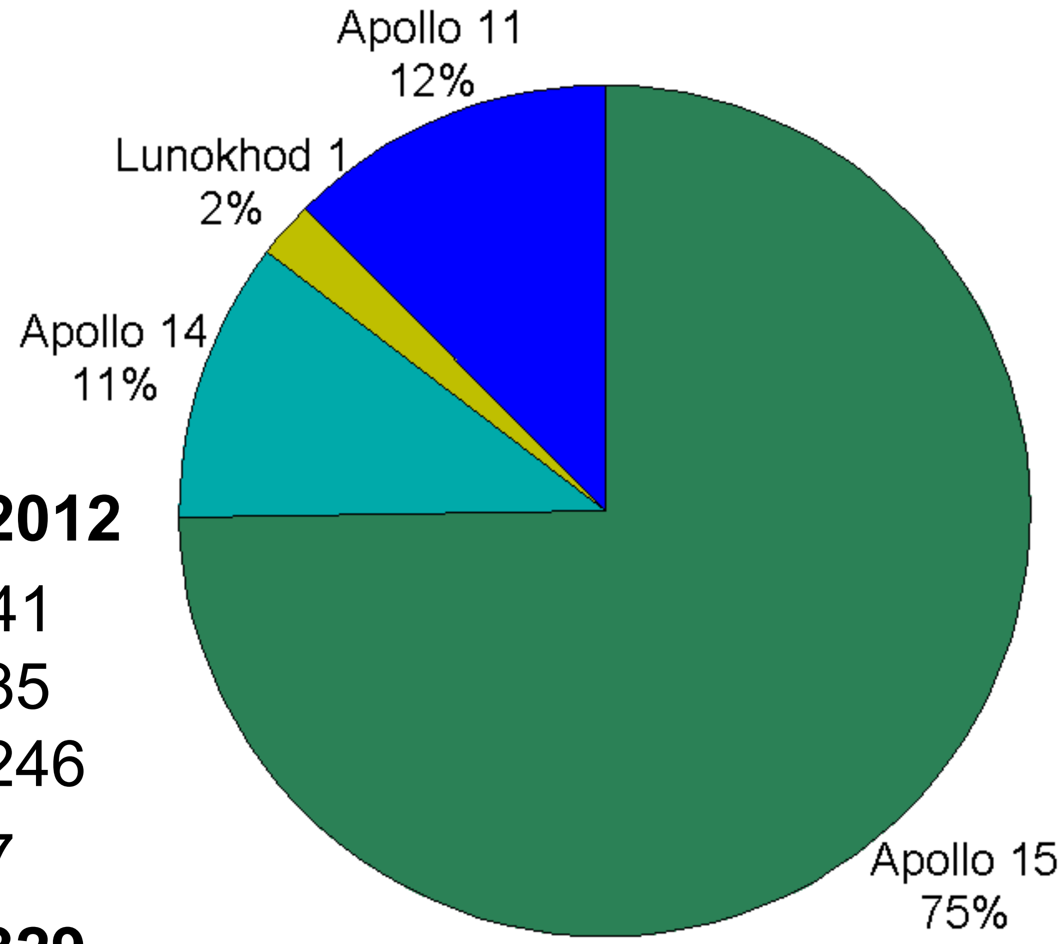
Normal points	**2011**	**2012**
McDonald	23	36
Grasse	60	277
Matera	3	16
In total	**86**	**329**



Statistics – retro-reflectors 2012

Only **2012** (until October)

Normal points	**2011**	**2012**
Apollo 11	6	41
Apollo 14	16	35
Apollo 15	64	246
Lunokhod 1	0	7
In total	**86**	**329**



2012 quite similar to 42-year average

Status, perspective at the LLR sites

- McDonald - lunar tracking at low level
- Matera re-started in spring 2010 - lunar tracking at low level
- APOLLO - good LLR data until end of 2010 (new detector required refined pre-processing → reduced accuracy, i.e. cm instead of mm level), problem fixed in 2012
- Grasse re-started by end of 2009, less returns in 2010/2011, good performance since end of 2011; new offices (2012) for staff far away; more publications needed
- Wettzell will (soon) resume – first attempts, but problems with the new SLR system have to be resolved first

Remarks on LLR Normal Points (NP)

Normal points in CDDIS and EDC databases are not identical?

- Cases
  - different NP's in both archives
  - identical NP's with different information (differences in ranging time, time of flight, RMS, meteorological information)
  - more than one NP for the same measurement
- Causes
  - different NP formats
  - processing at the observatories
  - ...

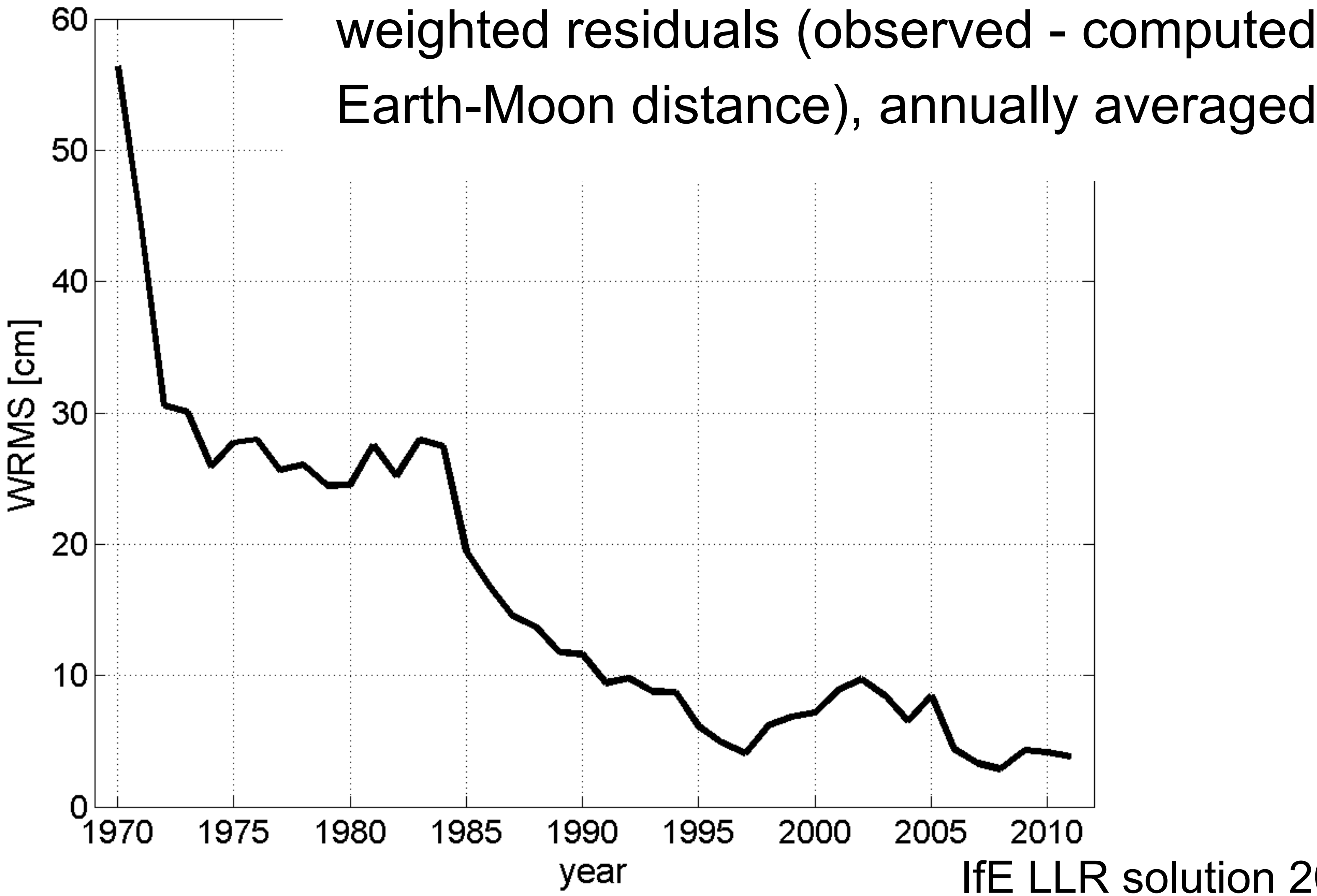
Major LLR-related activities

- ISSI workshop series on LLR modelling and analysis, last meeting was in spring 2012 – now final reporting
- Comparison of LLR software (Boston workshop), ongoing work between CfA (PEP), Paris (INPOP) and Hannover
- Own LLR part on new ILRS website with links to LLR sites, lunar AC’s, French website for data qualification, etc.
- Support to include Moon-related research in the Cooperative Agreement Notice (CAN) → prerequisite for proposals/funding
- ESA plans for Lunar impact mission?
- Special issue in CQG 2012 on EP tests with 3 LLR papers
- Joint LLR paper in ILRS JoG special issue (subm., 2012)

Main research at lunar analysis centers

- Jet Propulsion Laboratory (JPL), Jim Williams recovered
  - lunar interior, lunar core
  - relativity
- Paris Observatory Lunar Analysis Center (POLAC)
  - libration theory
  - reference frames
- Institute of Geodesy (IfE), new project funding
  - relativity
  - Earth orientation
  - lunar interior
- Others: special topics ...

Weighted annual residuals



IfE LLR solution 2011

Results - relativity

Parameter	Results
Nordtvedt parameter η (violation of the strong equivalence principle)	$(3 \pm 3.6) \cdot 10^{-4}$
time variable gravitational constant $\dot{G}/G\,[yr^{-1}]$ $\ddot{G}/G\,[yr^{-2}]$ (→ unification of the fundamental interactions)	$(1 \pm 2.5) \cdot 10^{-13}$ $(4 \pm 5) \cdot 10^{-15}$
difference of geodetic precession $\Omega_{GP} - \Omega_{deSit}$ [″/cy] (1.92 ″/cy predicted by Einstein's theory of gravitation)	$(6 \pm 9) \cdot 10^{-3}$
metric parameter γ - 1 (space curvature; γ = 1 in Einstein)	$(4 \pm 5) \cdot 10^{-3}$
metric parameter β - 1 (non-linearity; β = 1) or using $\eta = 4\beta - \gamma_{Cassini} - 3$ with $\gamma_{Cassini}-1$ ($\sim 10^{-5}$)	$(-2 \pm 4) \cdot 10^{-3}$ $(0.8 \pm 1.0) \cdot 10^{-4}$

Results – relativity (2)

Parameter	Results
Yukawa coupling constant $\alpha_{\lambda=400\,000\ \mathrm{km}}$ (test of Newton's inverse square law for the Earth-Moon distance)	$(3 \pm 2) \cdot 10^{-11}$
special relativity $\zeta_1 - \zeta_0 - 1$ (search for a preferred frame within special relativity)	$(-5 \pm 12) \cdot 10^{-5}$
influence of dark matter δ_{gc} [cm/s²] (in the center of the galaxy; test of strong equivalence principle)	$(0 \pm 2) \cdot 10^{-14}$
preferred frame effects α_1 α_2 (coupled with velocity of the solar system)	$(-4 \pm 9) \cdot 10^{-5}$ $(2 \pm 2) \cdot 10^{-5}$
preferred frame effect α_1 (coupled with dynamics within the solar system)	$(1.6 \pm 3) \cdot 10^{-3}$

Report from SGF Herstmonceux Analysis Centre

Graham Appleby
SGF Herstmonceux, UK

NATURAL ENVIRONMENT RESEARCH COUNCIL

AWG Pilot Study GGFC/APL

- In common with all ACs, SGF carried out two weekly solutions, for 2006-2011:
- One (v40) the standard pos+eop
- Two (v45) using the GGFC six-hourly site-dependent APL and global Stokes corrections
- Solutions delivered to DCs in August and late-September 2012

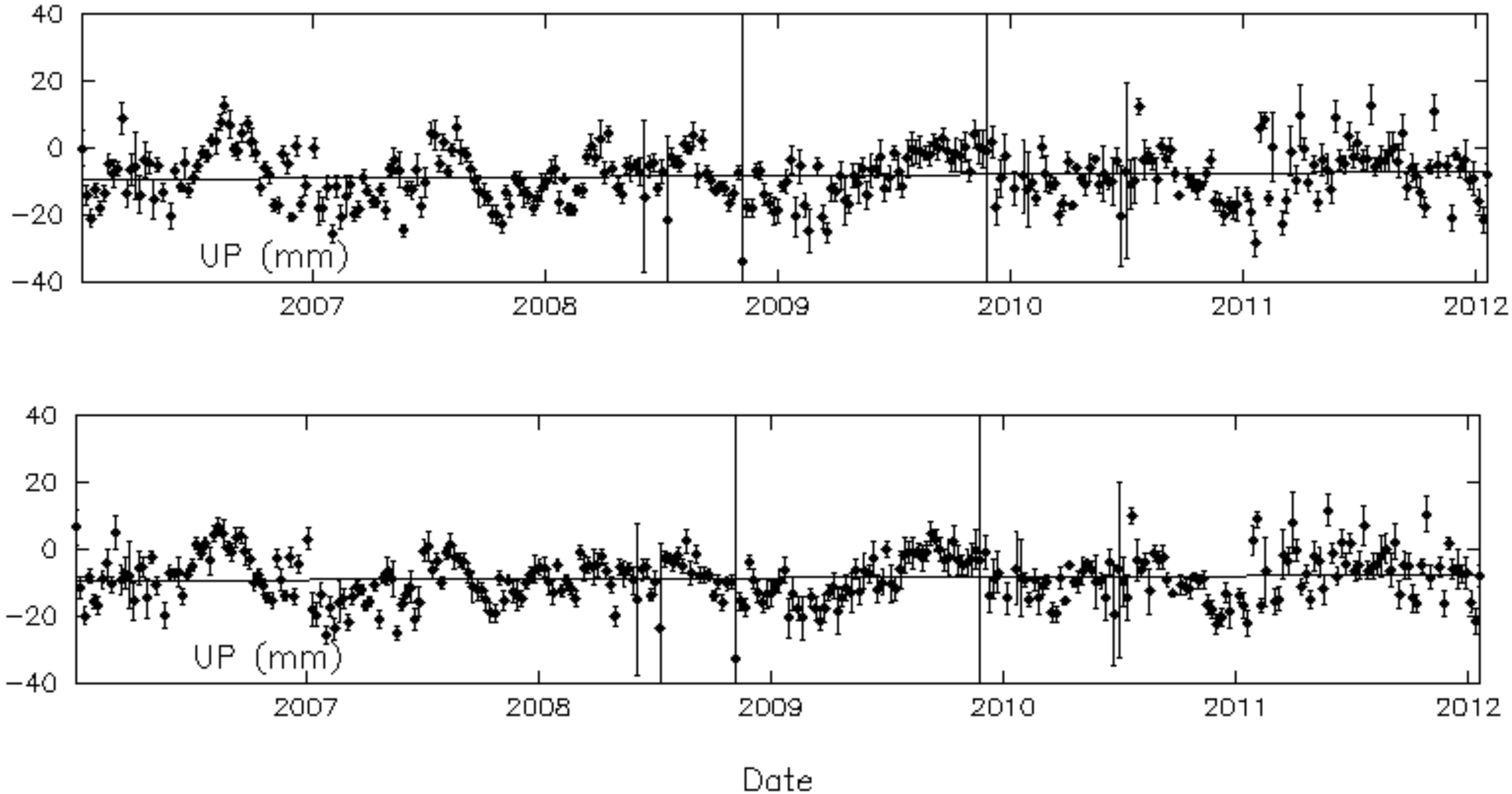
Strategy in SATAN

- Site-specific APL from GGFC for 2006-11:
- Six-hourly neu deformation in files named after site DOMES;
- During data pre-processing stage, when data corrections applied, interpolate in APL to epoch of each observation
- APL values remain with each observation throughout weekly solutions – efficient process

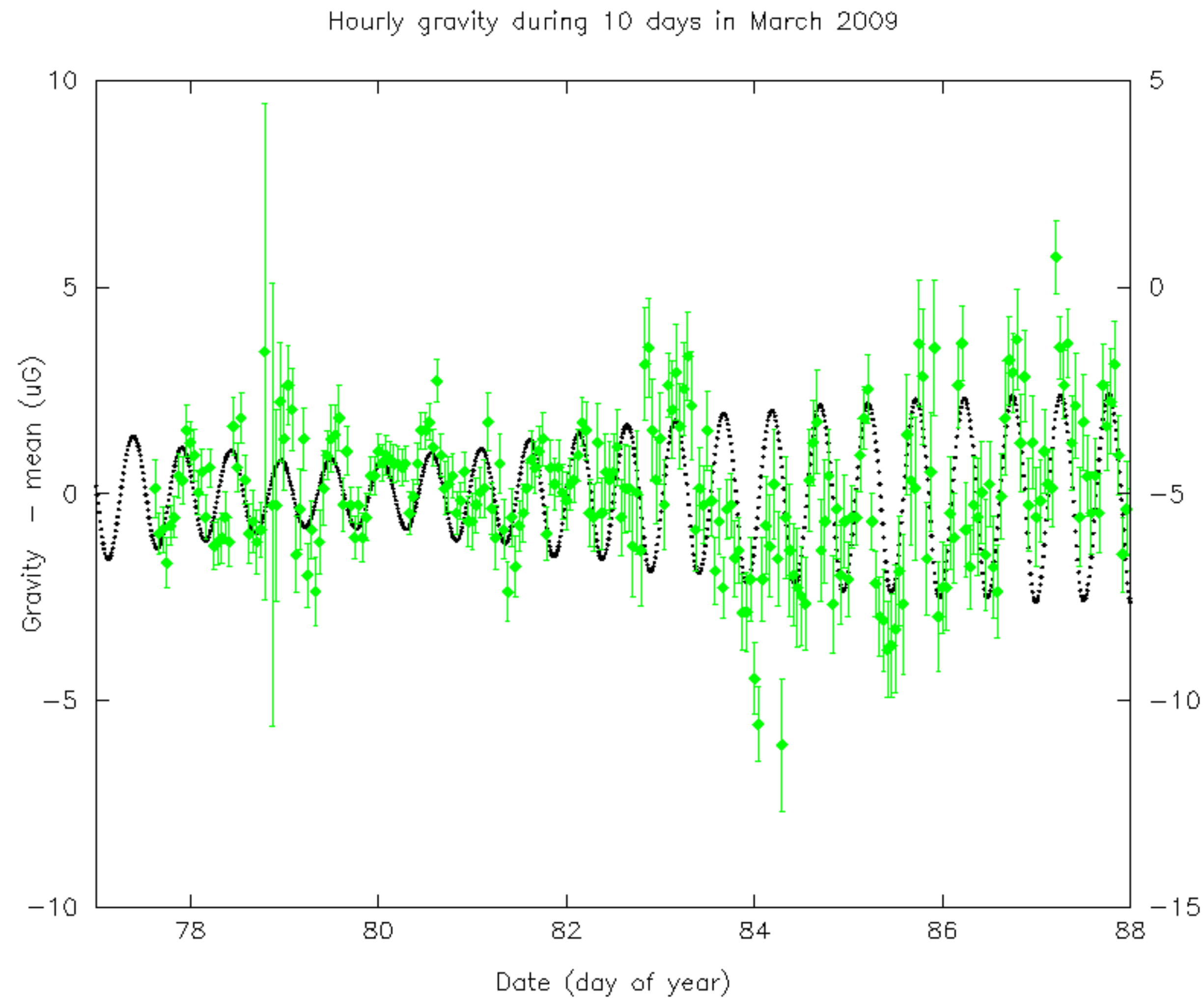
Strategy in SATAN

- Six-hourly delta Stokes (c_{lm}, s_{lm}) values in daily files from GGFC for 50x50 in l,m
- Interpolated (to 20x20) to epoch of each step during orbit integration;
- Not efficient, and time-consuming;
  - Needs optimisation (next step).
- Time series of station heights with/without APL is a good measure of the effectiveness:

Height time-series w and w/o APL for 7840, from SGF solutions – variance decreases from 126 to 114 mm^2



AG recent results – hourly gravity values contain strong tidal residual signals



From: "Margarita Vei" <vei@gfz-potsdam.de>
Subject: **frascati NO SHOW**
Date: November 1, 2012 8:53:25 AM EDT
To: "Erricos C. Pavlis" <epavlis@umbc.edu>
1 Attachment, 44.7 KB

Dear Erricos

Due to a - hopefully - minor sudden health problem the doctors strictly recommended not to travel during the next days, so unfortunately I cannot attend the meeting as it was planned..

I apologise for this short notice and I hope you will understand

I like just to mention an issue which I wanted to be discussed
The models , and standards which the AC's are using for the official and the PP products should be compared again to see if we all still use what was once agreed. I think Rolf has already mentioned this in his mails.

Attached you will find a short summary of GFZ- solution description. (for poseop v40 and GGDC PP v41, v45)
(-sorry for any typing mistakes - no time to correct them)

Concering all other topics on the agenda, GFZ is actually ready for all the changes in the operational product. (low degree SH etc)

about the IERS conventions 2010
atmospheric pressure loading is not yet implemented

and of cource we wiil participate to any future re-analysis in 2013

I hope you will have a good meetng - even without me

see you next year in Vienna

best regards

margarita

e-mail: vei@gfz-potsdam.de
phone : (+49)8153-28-3371

frascati.pdf (44.7 KB)

From: Toshimichi Otsubo <t.otsubo@r.hit-u.ac.jp>
Subject: **Re: [ilrs-aac] DRAFT Agenda for the Fall 2012 AWG Meeting in Frascati, (Saturday, Nov. 3, 2012, 9:00-17:00)**
Date: October 7, 2012 11:13:51 PM EDT
To: "Erricos C. Pavlis" <epavlis@umbc.edu>
Cc: ILRS A WG <ilrs-awg@lists.nasa.gov>, ILRS AC <ilrs-ac@lists.nasa.gov>, ILRS AAC <ilrs-aac@lists.nasa.gov>, "ILRS/CB Bureau" <ilrs-cb@lists.nasa.gov>

Erricos and all,

I am arriving at Frascati on Sunday evening as I have to attend a domestic conference. I am afraid I cannot attend the AWG meeting, but there are a few issues I would like to raise/report:

- the next next AWG meeting is expected on 9 Nov (Sat) 2013, in or around the LW18 venue in Japan. The main workshop starts on 11 Nov 2013. Please confirm this date is ok, and is the time "9am to 5pm"?

- I would like to use updated station coordinates in our quality check analysis: Koganei, Simosato, and Concepcion that experienced earthquakes and afterslips, and a few new station added in Russia. The point is: do we (QCACs) have to use the exactly same set of station cooridinates for these stations? I am ok if the answer is no. But, if yes, how and how often shall the AWG revise/update SLRF20xx?

- the CoM correction study is ongoing on the "smaller" satellites like LARES and STARLETTE (and automatically its twin STELLA). Not ready to provide the numerical tables yet, but you will hear the progress from Reinhart and myself in the main meeting.

Erricos, can you shortly mention these isseus at the meeting?

See you all at Frascati on Monday.

Best Regards,
Toshi

Toshimichi Otsubo <t.otsubo@r.hit-u.ac.jp>
Hitotsubashi University
Web http://geo.science.hit-u.ac.jp/ Tel & Fax +81-42-580-8968

2012/10/8 Erricos C. Pavlis <epavlis@umbc.edu>:

> Dear all,
>
> Attached find a DRAFT version of the proposed agenda for our upcoming meeting on Saturday, November 3, at LNF, Frascati. Directions will be sent soon with the finalized version, once I receive your comments, suggestions, corrections, etc. Please respond ASAP so that we can have the final version out before the end of this week. I would appreciate it also if you reconfirmed your participation or provided an explanation for your absence.
>
> ecp
>
> +++

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> Research Scientist FAX: +1 (410) 455-5868
> US Mobile: +1-240-381-9879
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> Baltimore, Maryland
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>
> +++

Leap Second Survey Results

The June 30/July 1, 2012 leap second caused some confusion and concern among the stations, prediction providers, and analysts. This documents pulls together some of the experiences and some of the issues that we need to address.

Stations

This section is based on answers received to an ILRSsta mail query regarding problems experienced by the stations around the time of the leap second.

1) Many stations have hardware that adds the leap second at the right epoch.
2) Software at many stations does not use the leap second flag.
3) Some stations were not on duty or had weather problems over the June 30/July 1 change.
4) Key personnel were at times not available due to the weekend or vacation.
5) Some stations had a difficult time tracking or even finding certain satellites with predictions from certain providers.

Predictions

The leap second issue revolves around the prediction providers taking the endorsed course of action and doing something predictable, and the stations changing their clocks at the right time.

The CPF manual says that if a leap second is scheduled, **there must be a leap second flag in the predictions, and the provider should not have applied the leap second to the predictions.** This allows predictions for times before and after the leap second to coexist without a discontinuity. The stations must apply the leap second to the hardware at the correct epoch, and also to the predictions after the leap second occurred until the flag changes back to "0" in a subsequent prediction file.

If a provider has inadvertently applied the leap second to the predictions as well as setting the leap second flag, then there will be a one-second time-bias in the predictions after the time of leap second insertion, which the stations have no way to anticipate. So, it is quite important to follow the procedures precisely.

If there is no leap second flag in the predictions, the assumption is that the provider has applied the leap second to the predictions for times after leap second insertion. The stations must still apply the leap second to the hardware at the correct epoch.

If there is no leap second flag, the predictions will have a discontinuity for passes straddling the time of leap second insertion (assuming the station clock inserts the leap second automatically). If a station uses a 10-point interpolator, the discontinuity will be smoothed over 10 prediction records centered at the leap second insertion time. The greatest error will be at the leap second insertion time. For low satellites, this transition would happen over +/- 5 minutes centered on the leap second, but for most high satellites, +/- 1.25 hours (and +/- 4 hours for Etalon).

Because of this discontinuity and the potential of a one second time bias until the end of the predictions, the leap second flag must be used correctly by both the prediction providers and the stations.

Errors Observed

1. Most prediction providers (5) did not set the leap second flag.
2. Two providers set the flag improperly.
3. Two providers handled the leap second properly.

Providers that used the leap second flag incorrectly were contacted and will rectify the problem by the next leap second. Those who did not use it at all have not yet been contacted.

Predictions were and continue to be missing in a few cases. For at least one satellite there are no predictions from either EDC or CDDIS for July 1. July 1 predictions for several satellites were on EDC but not on CDDIS, probably as a consequence of the power outage at GSFC during on June 30 and July 1.

Analysis Centers

The analysis centers were also affected by leap second issues, such as: normal point time tag errors, internal leap second handling, and an error on the part of the USNO.

USNO inadvertently inserted the second leap second twice in their EOP files; this was not caught until the afternoon of July 1. This caused some bad data fits and confusion for several analysis centers and prediction providers until the source of the problem was found and corrected. In one case, the problem was not caught and the effects of the bad USNO input remained for a couple weeks.

One analysis center had to manually insert the leap second (a procedure that has since been automated). This, together with the USNO issue and some station(s) not applying the leap second, made for a difficult transition.

The absence of key personnel during the time of leap second insertion only made the problems worse.

The creation of predictions at another center required maintenance of an "artificial" continuous UT1-UTC series, one without the 1-second discontinuity. This required extra labor and care for a few days on either side of the leap second.

There is only one station that reported to have significant time tag problems due to the leap second, and it had a one-second time bias for the first 10 hours (15 passes) on July 1st. Another station reportedly submitted one pass with a time-tag problem.

Conclusion

There are several aspects of leap second handling that could be improved.

1) **PREDICTION PROVIDERS AND STATIONS MUST USE THE LEAP SECOND FLAG, AND USE IT CORRECTLY**
2) **STATIONS MUST APPLY THE LEAP SECOND PROPERLY TO ACCOMMODATE THE PREDICTIONS.**
3) Several SLRmail messages from the ILRS (most likely from the Central Bureau) reminding station personnel, analysts, and prediction centers of the leap second should be sent in the

months, weeks, and days prior to leap second insertion.

4) USNO input should not be trusted blindly, as this is an exceptional process for them as well as us.
5) Key personnel may want to consider postponing vacation time scheduled around the date of leap second insertion. This can be problematic when the leap second is inserted on weekends, and, typically, the leap second is inserted on January 1 or July 1, both prime vacation times.
6) Many stations automatically update their clock for the leap second. Those that don't should find a way to either automatically update it or to automatically remind the station staff to manually update it.
7) To assist stations, modified CPF sample code that handles the leap second flag and suggestions on its integration should be provided.