# *ILRSA CC*
# *Status of the combination products*


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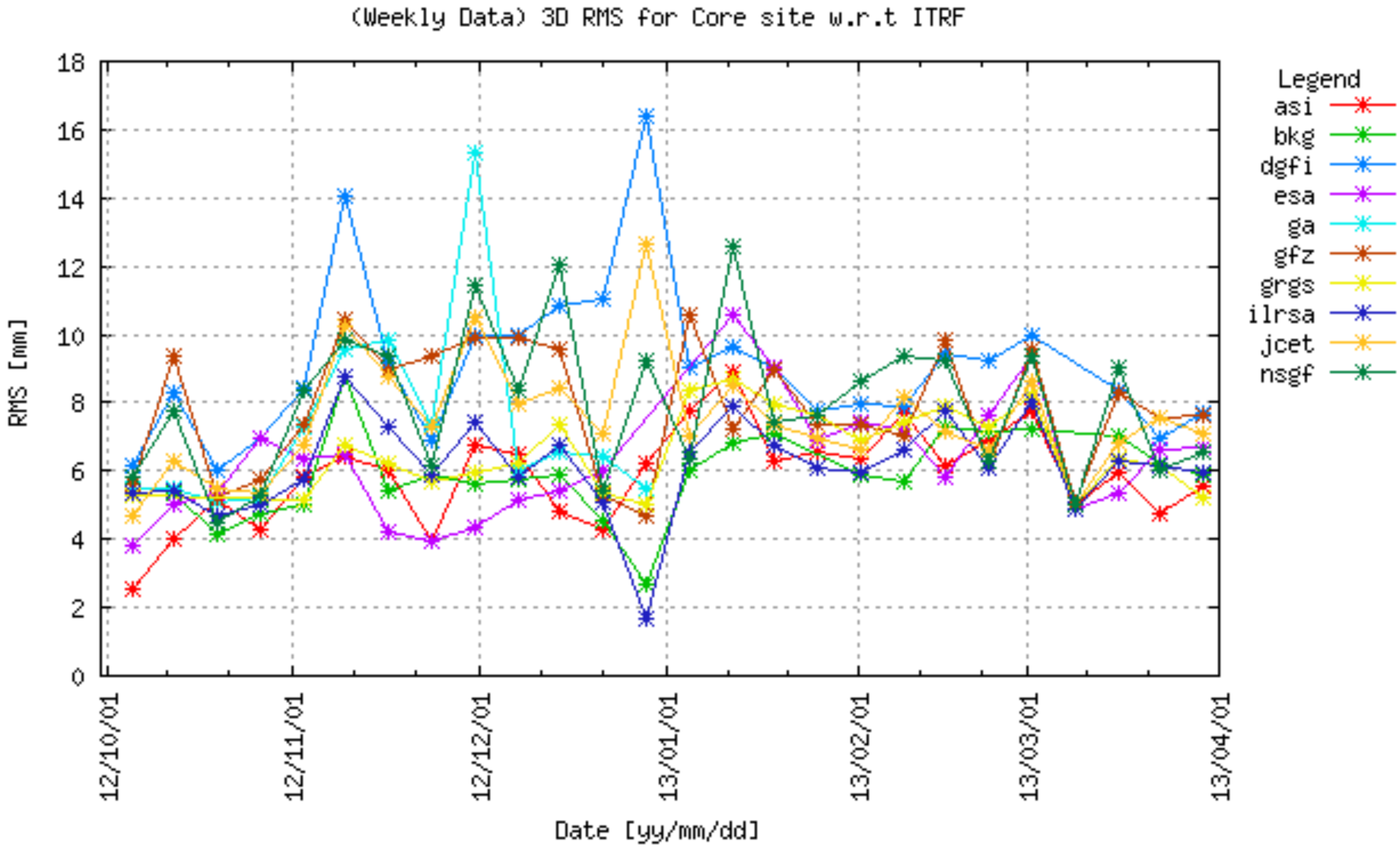
**ILRS AWG Meeting, 7 April 2013, Wien**

# Contents

- ILRS daily&weekly products
- SP3c files quality evaluation

# Site Coordinates



# “Peer” combined EOP solutions series vs IERS C04

**X**

| µas | DAY 1 | DAY 2 | DAY 3 | DAY 4 | DAY 5 | DAY 6 | DAY 7 |
|---|---|---|---|---|---|---|---|
| **RMS** | **219** | **204** | **217** | **255** | **259** | **225** | **242** |

**Y**

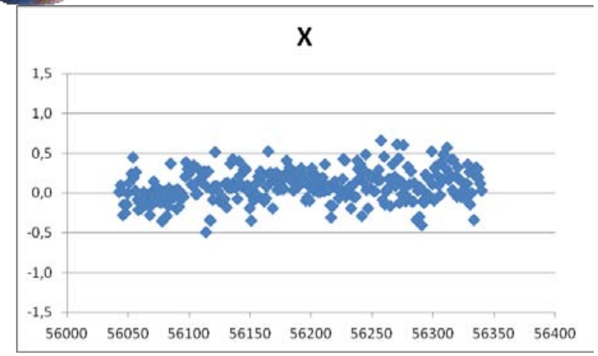
| µas | DAY 1 | DAY 2 | DAY 3 | DAY 4 | DAY 5 | DAY 6 | DAY 7 |
|---|---|---|---|---|---|---|---|
| **RMS** | **262** | **273** | **263** | **282** | **248** | **249** | **257** |

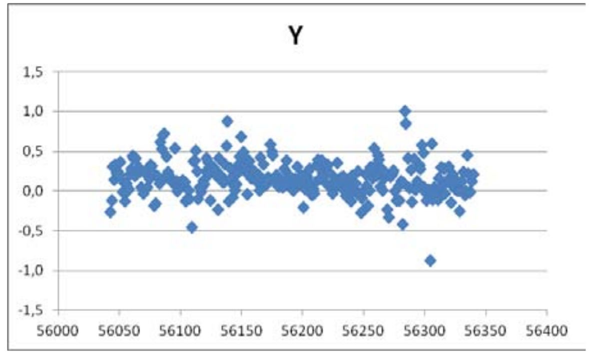
**LOD**

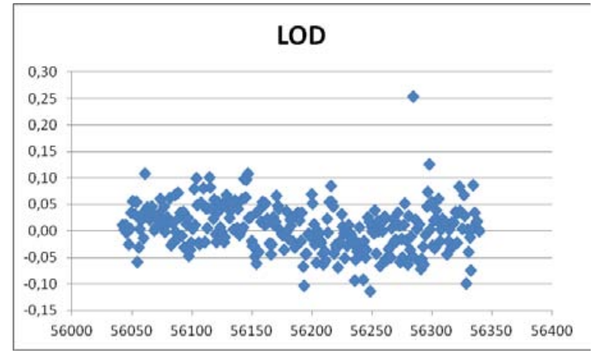
| µs | DAY 1 | DAY 2 | DAY 3 | DAY 4 | DAY 5 | DAY 6 | DAY 7 |
|---|---|---|---|---|---|---|---|
| **RMS** | **43** | **40** | **36** | **34** | **37** | **43** | **48** |

# "Peer" combined solutions series vs IERS C04

1

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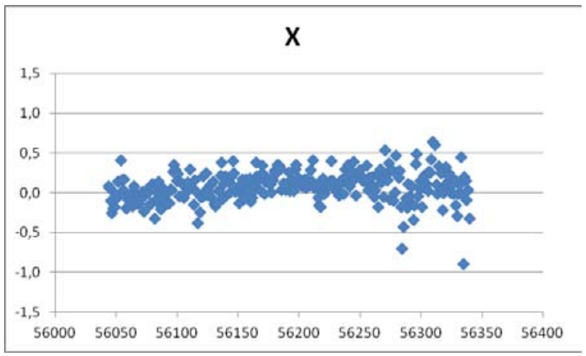


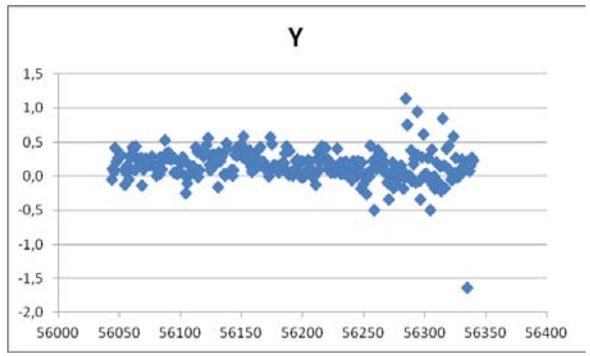


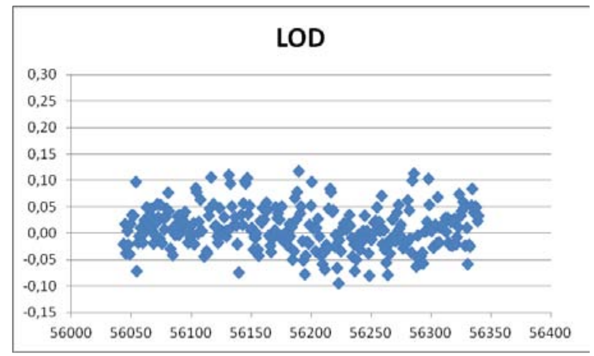


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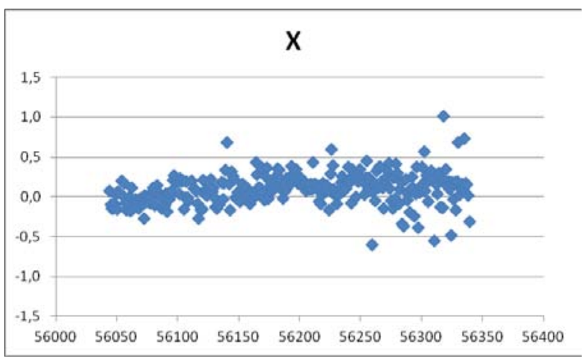
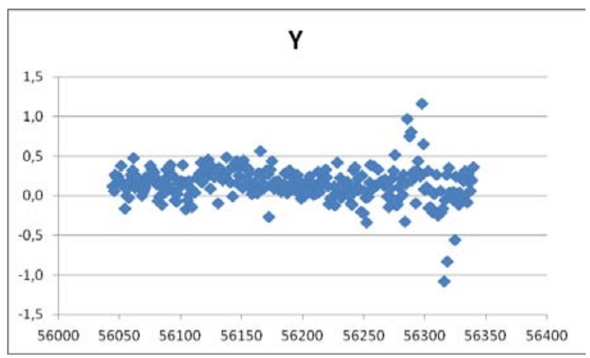
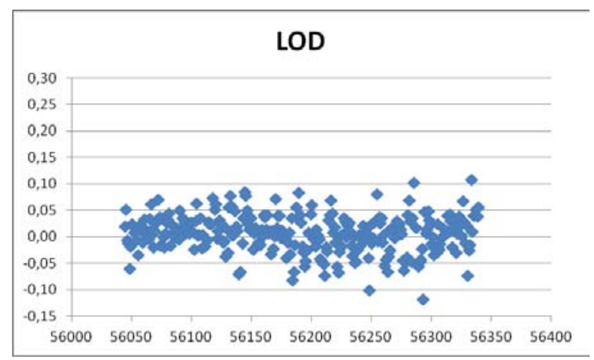
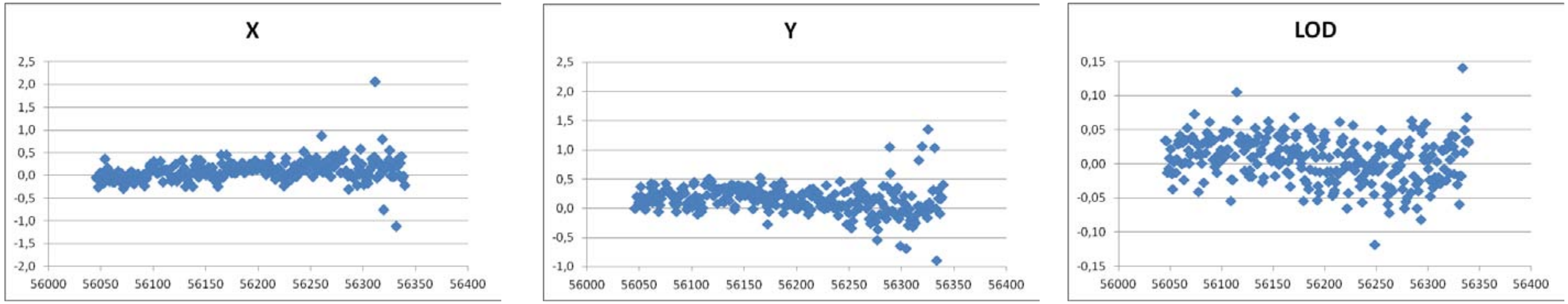


# "Peer" combined solutions series vs IERS C04

4

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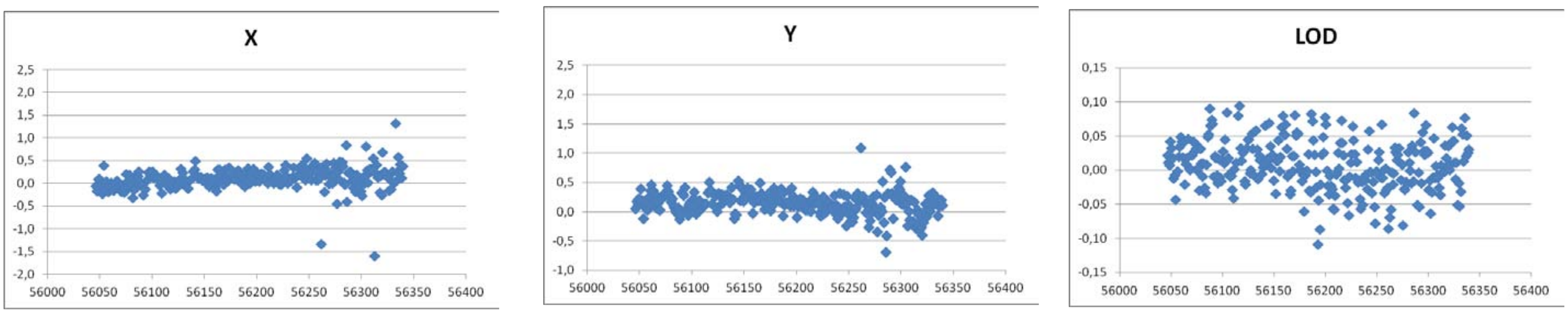


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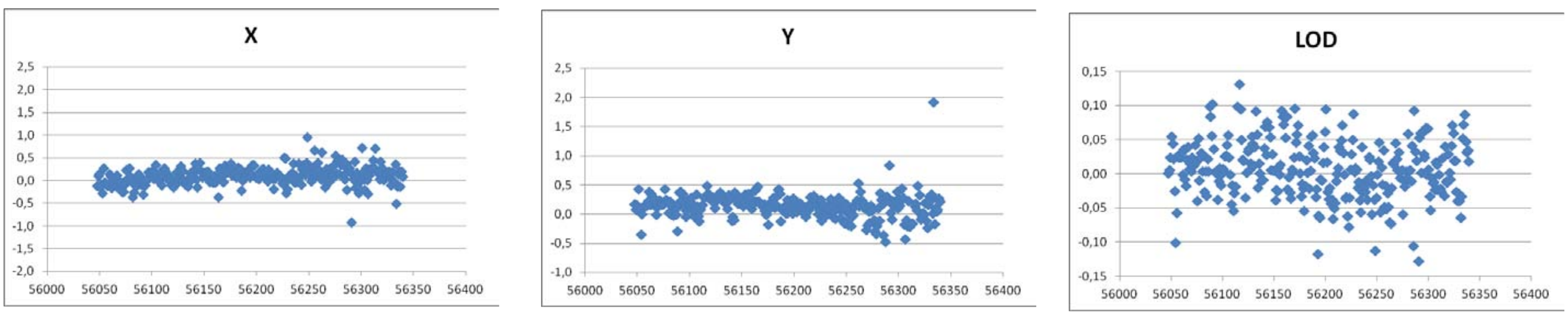

# “Peer” combined solutions series vs IERS C04

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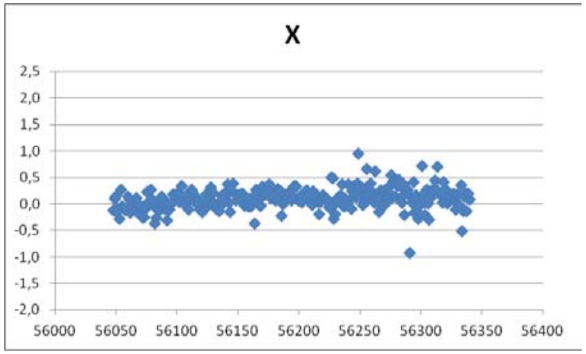


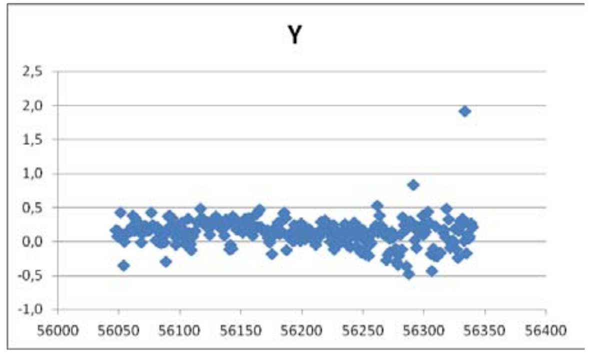


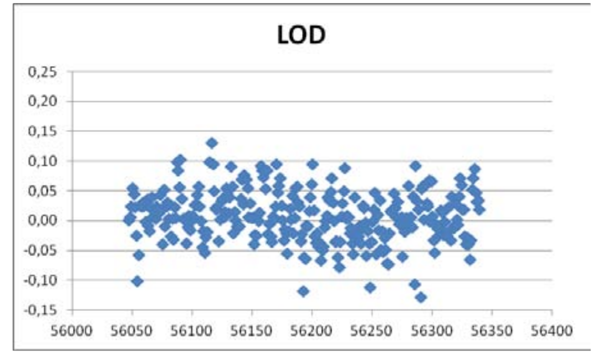


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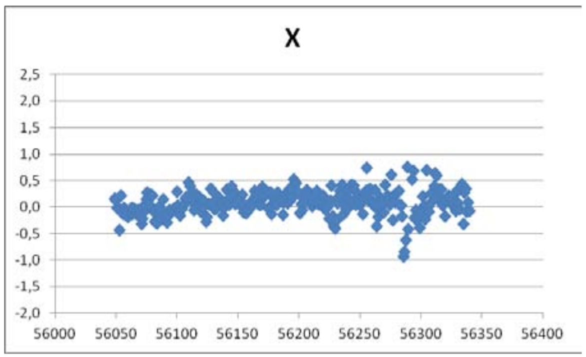
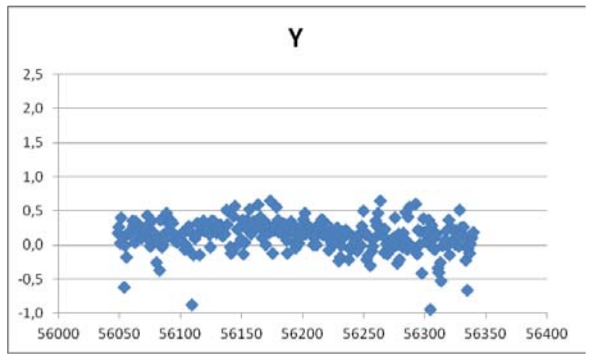
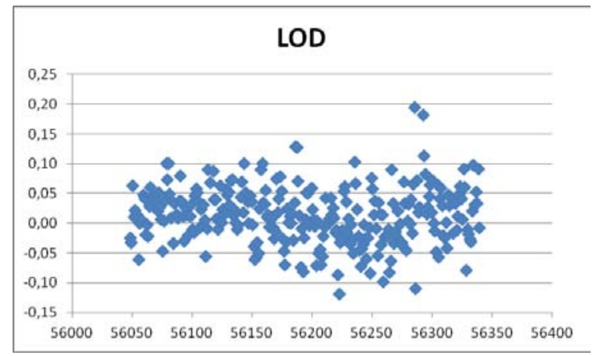


# Daily&weekly solutions - remarks

- ILRS official solution is the daily (7-arc) combined v130 solution starting from 01/05/2012
- 8 ILRS ACs contribute; 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

# AC weekly orbit - present status

| | | | 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 | |
| JCET | L51 | X | *OK* |
| | L52 | X | |
| | L53 | X | |
| | L54 | X | |

| | | | Comments/notes |
|---|---|---|---|
| GA | L51 | - | - |
| | L52 | - | |
| | L53 | - | |
| | L54 | - | |
| GFZ | L51 | X | OK |
| | L52 | X | |
| | L53 | - | |
| | L54 | - | |
| GRGS | L51 | - | No more available since Oct 2012 |
| | L52 | - | |
| | L53 | - | |
| | L54 | - | |
| ESOC | L51 | X | L53, L54 every 5' |
| | L52 | X | |
| | L53 | X | |
| | L54 | X | |
| NSGF | L51 | X | OK<br>Available since Feb 2013 |
| | L52 | X | |
| | L53 | X | |
| | L54 | X | |

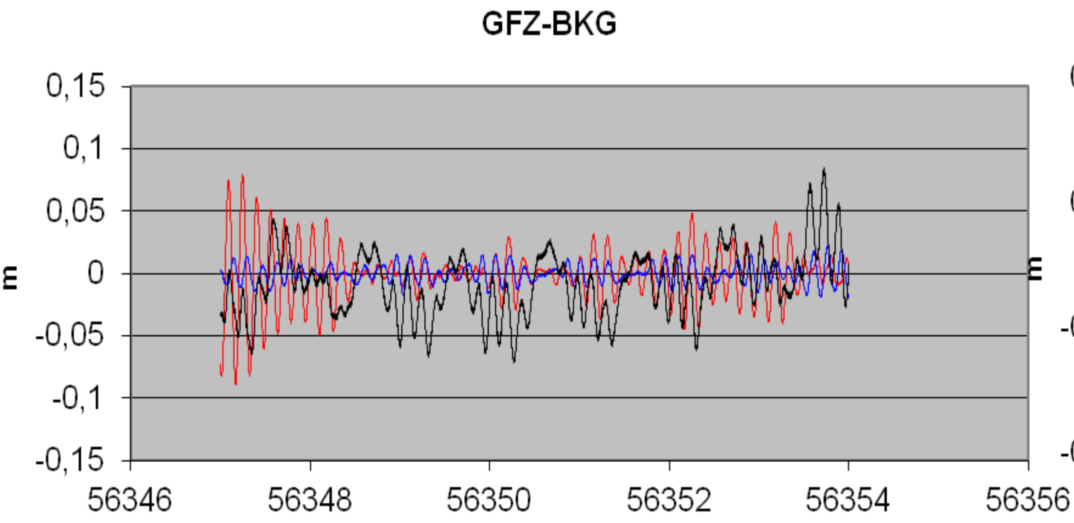
# SP3c data evaluation

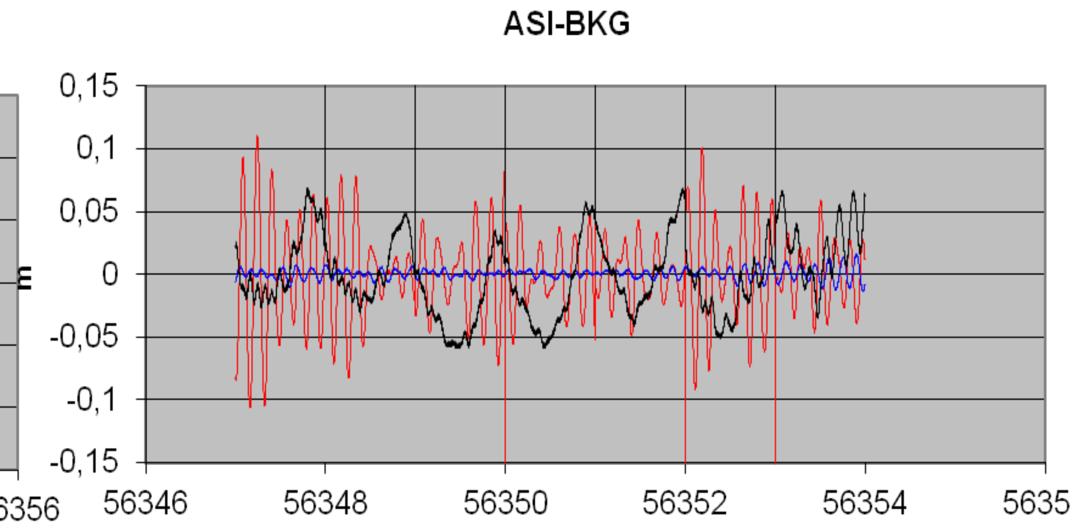
- L51/L52/L53/L54 SP3c files available at CDDIS and EDC – march 2013
- cross-evaluate their consistency (RAC)
- Try a preliminary combination among the more coherent ones

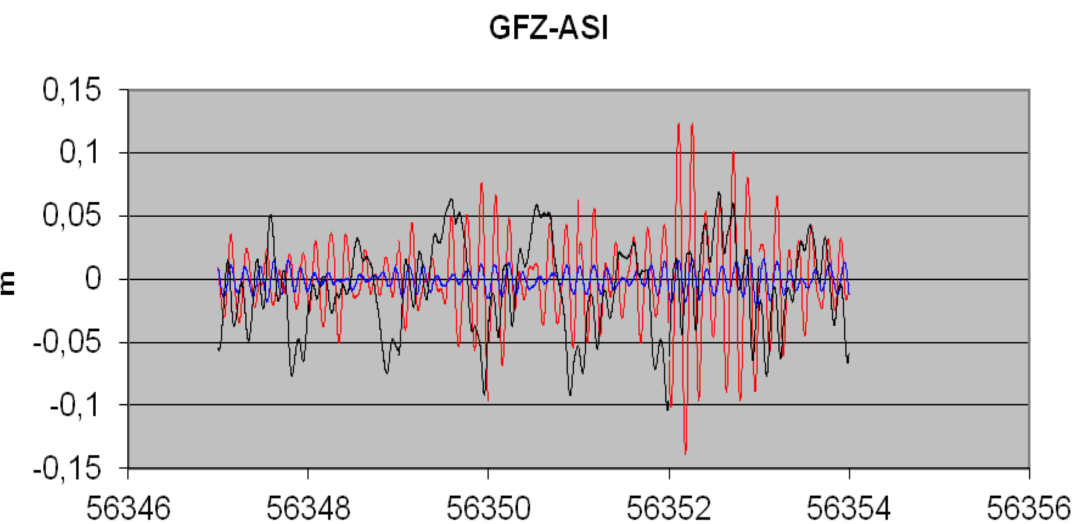
*Product Features*

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

# L51 ASI-BKG-GFZ

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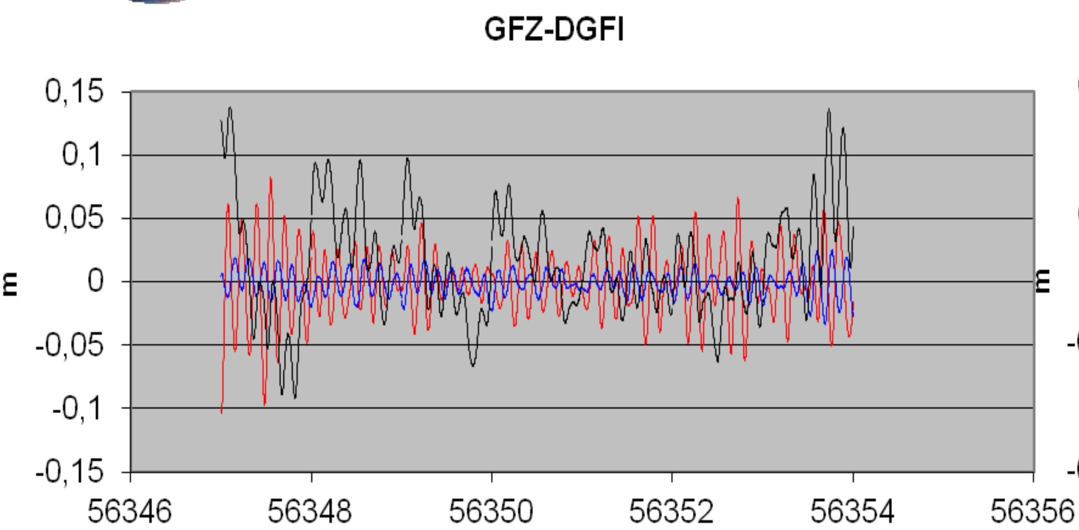
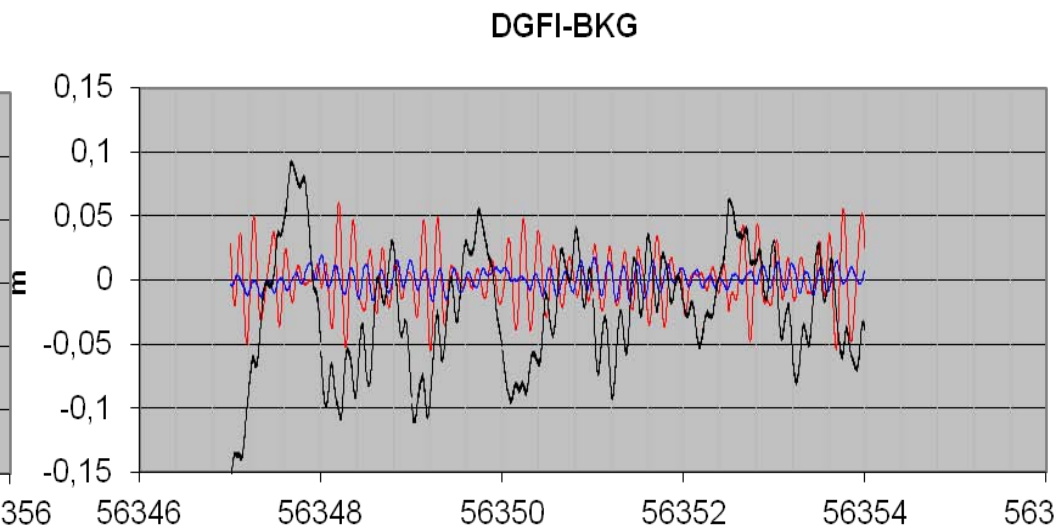
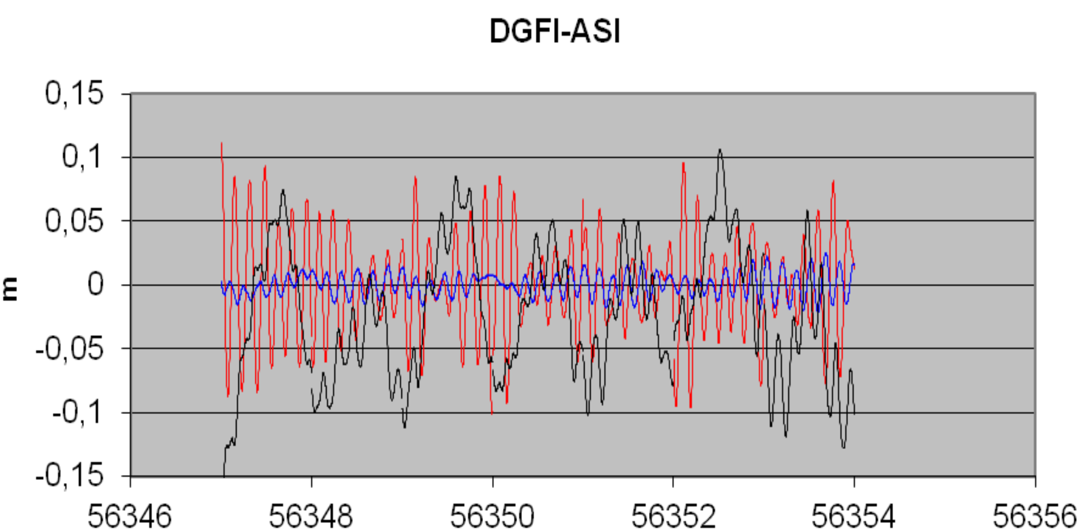
| | | |
|---|---|---|
| **GFZ – BKG cm** | **R** | **-0.01 ± 0.75** |
| | **C** | **-0.05 ± 2.30** |
| | **A** | **-0.87 ± 2.61** |
| **GFZ – ASI cm** | **R** | **-0.06 ± 0.77** |
| | **C** | **-0.10 ± 3.55** |
| | **A** | **-0.52 ± 3.57** |
| **ASI-BKG cm** | **R** | **+0.05 ± 0.43** |
| | **C** | **+0.05 ± 4.34** |
| | **A** | **-0.09 ± 3.59** |

# L51 DGFI vs ASI-BKG-GFZ

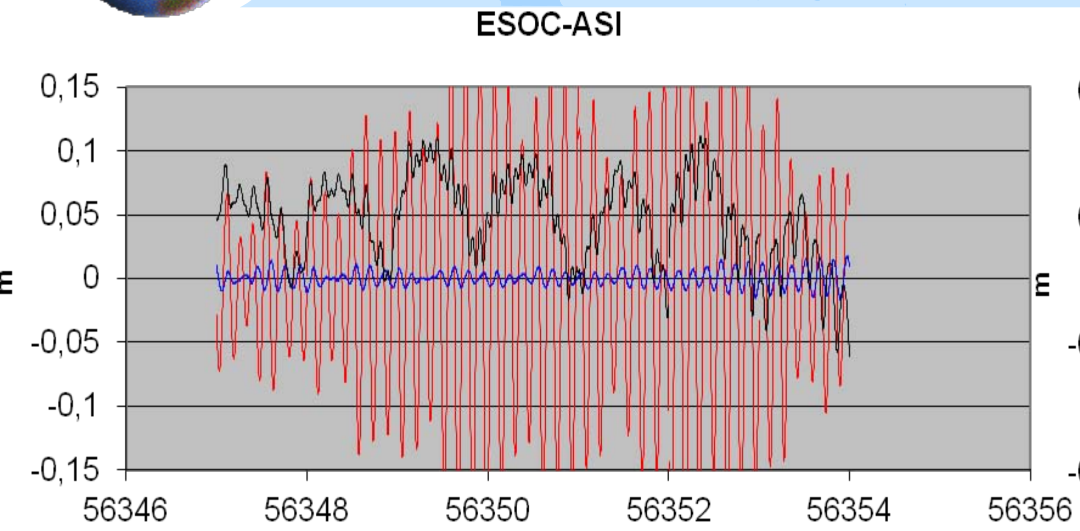


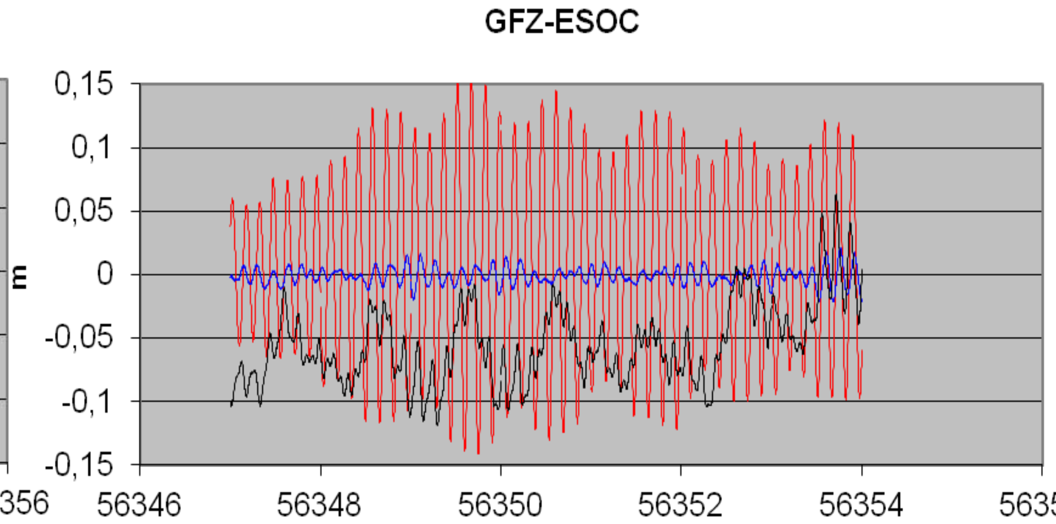



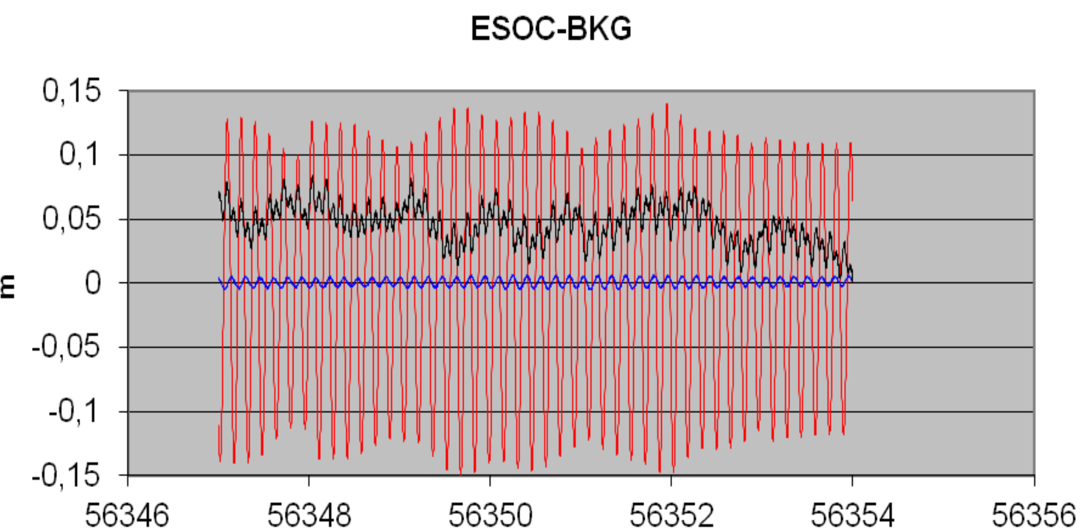




| | | |
|---|---|---|
| **GFZ – DGFI cm** | **R** | **-0.08 ± 0.97** |
| | **C** | **-0.08 ± 2.78** |
| | **A** | **+1.57 ± 4.24** |
| **DGFI – ASI cm** | **R** | **+0.02 ± 0.91** |
| | **C** | **-0.01 ± 3.96** |
| | **A** | **-2.29 ± 5.30** |
| **DGFI-BKG cm** | **R** | **+0.07± 0.74** |
| | **C** | **+0.03 ± 2.13** |
| | **A** | **-2.44± 4.71** |

# L51 ESOC vs ASI-BKG-GFZ

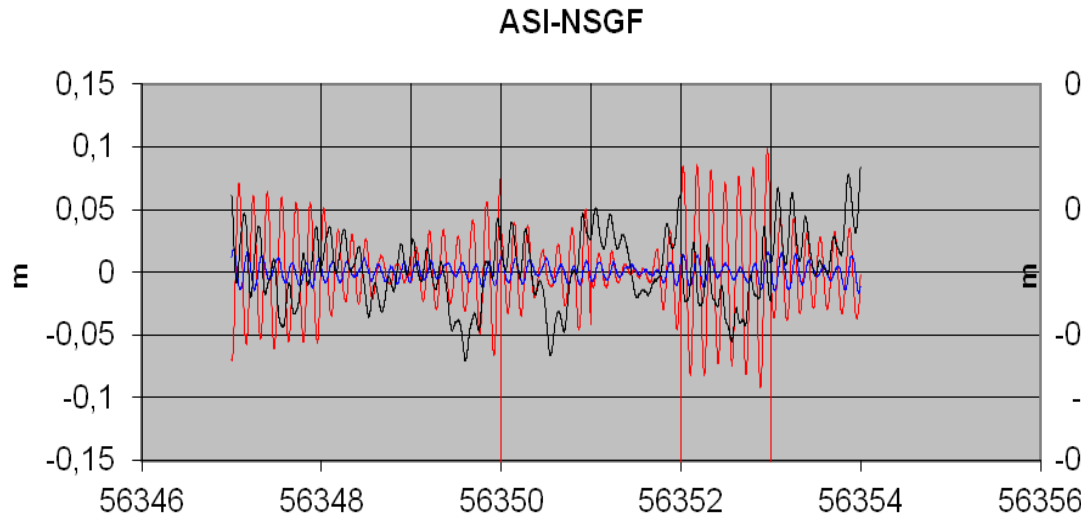


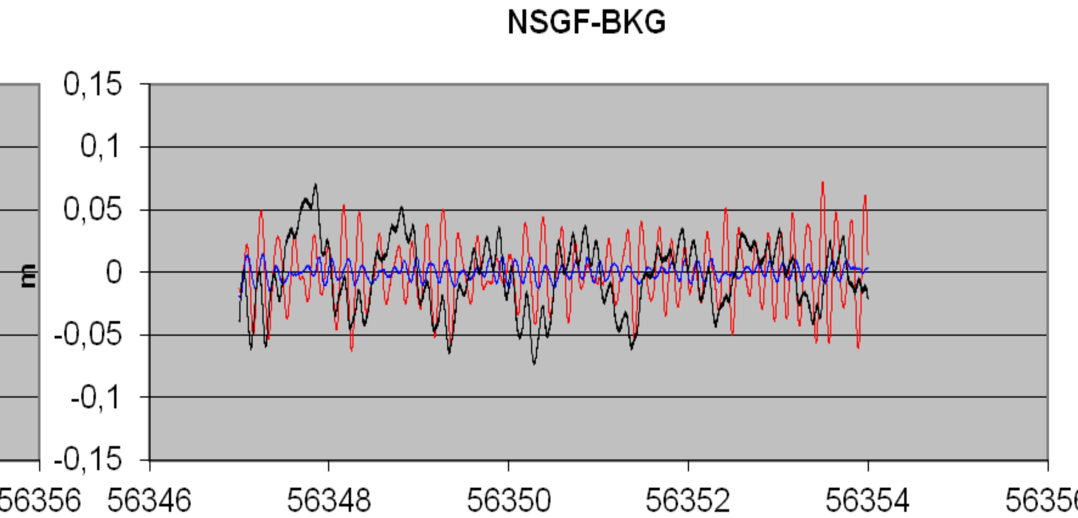



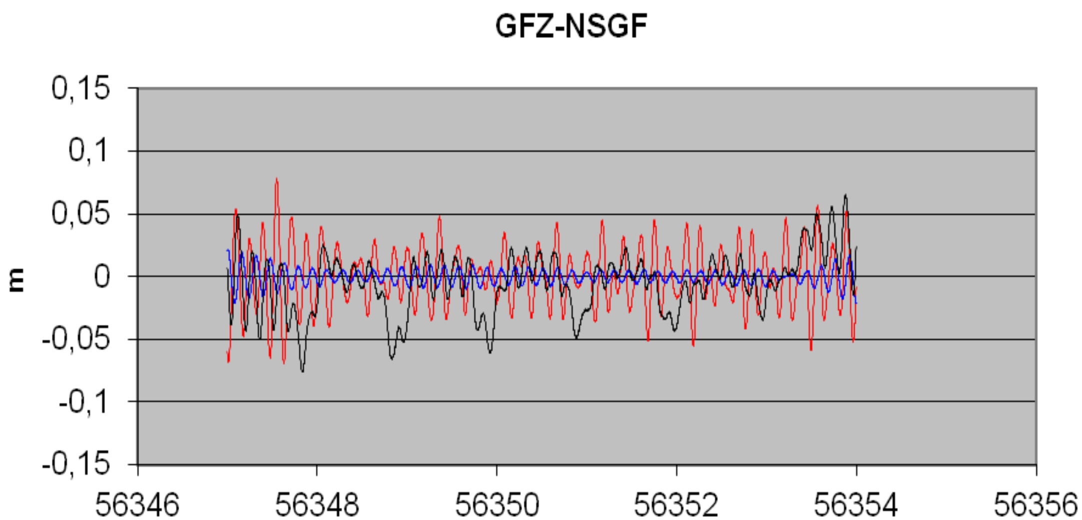




| | | |
|---|---|---|
| ESOC-ASI cm | R | +0.04 ± 0.62 |
| | C | -0.58 ± 9.66 |
| | A | +4.77 ± 3.44 |
| ESOC-BKG cm | R | +0.09 ± 0.30 |
| | C | -0.53 ± 8.98 |
| | A | +4.62 ± 1.51 |
| GFZ - ESOC cm | R | -0.10 ± 0.67 |
| | C | +0.48 ± 7.59 |
| | A | -5.49 ± 3.15 |

# L51 NSGF vs ASI-BKG-GFZ



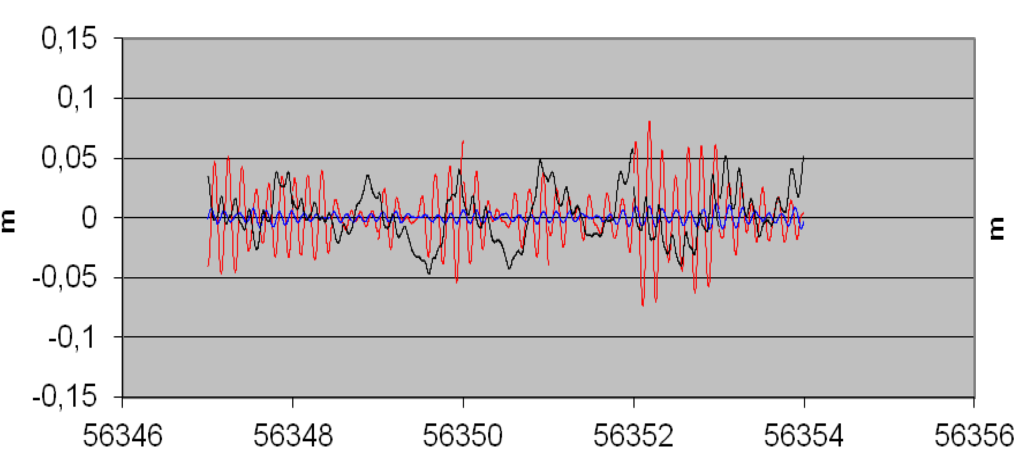



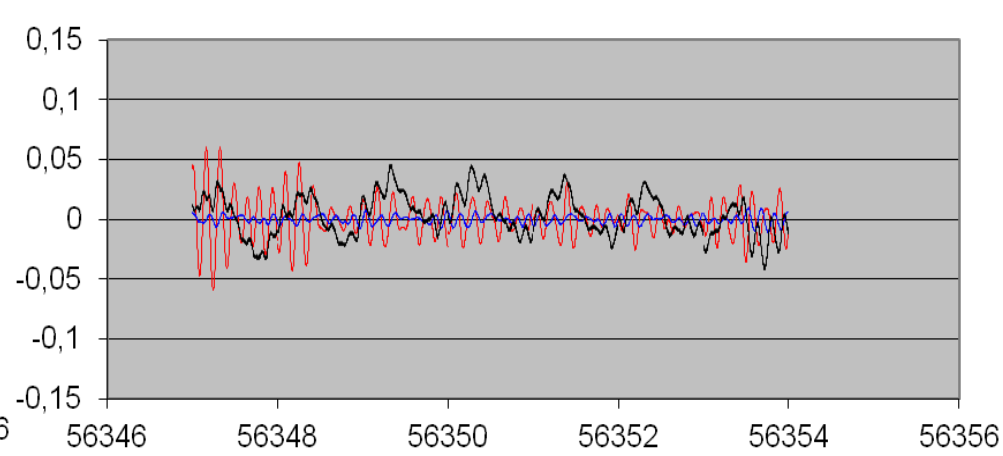

| | | |
|---|---|---|
| **ASI-NSGF cm** | **R** | **+0.05 ± 0.67** |
| | **C** | **+0.08 ± 4.05** |
| | **A** | **+0.28 ± 3.30** |
| **NSGF-BKG cm** | **R** | **+0.01 ± 0.60** |
| | **C** | **-0.03 ± 2.55** |
| | **A** | **-0.36 ± 2.78** |
| **GFZ - NSGF cm** | **R** | **-0.02 ± 0.62** |
| | **C** | **-0.01 ± 2.49** |
| | **A** | **-0.51 ± 2.37** |

# L51 NSGF-ASI-BKG-GFZ vs Combination

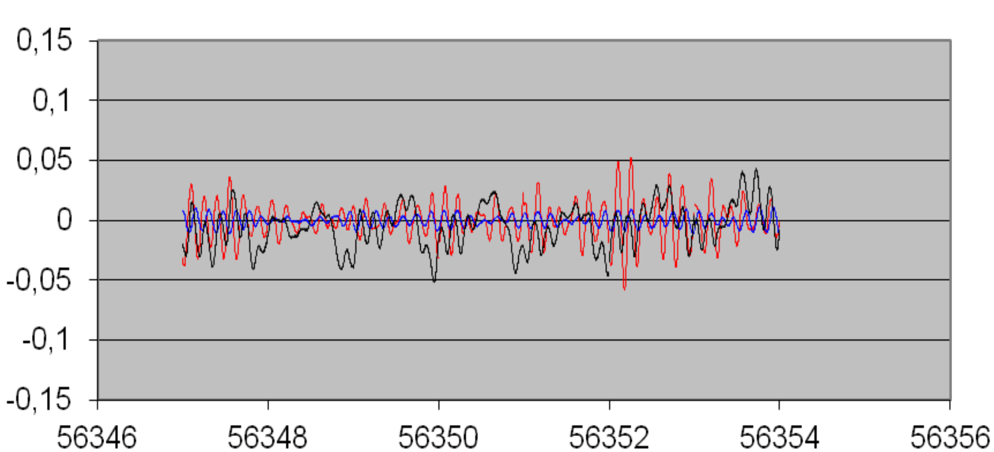
ASI-C



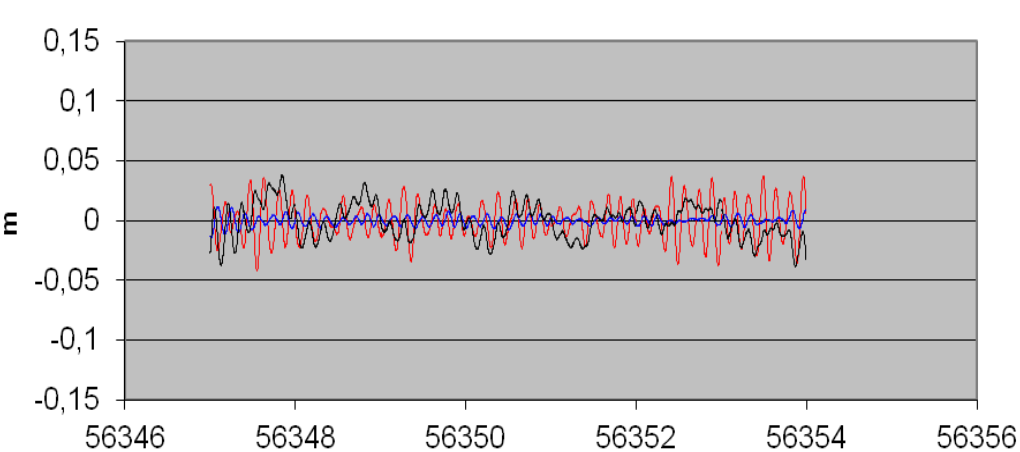

BKG-C




GFZ-C




NSGF-C



# L51 NSGF-ASI-BKG-GFZ vs Combination

| | | |
|---|---|---|
| ASI - C cm | R | +0.04 ± 0.38 |
| | C | +0.06 ± 2.42 |
| | A | +0.20 ± 2.10 |
| GFZ - C cm | R | -0.02 ± 0.47 |
| | C | -0.04 ± 1.61 |
| | A | -0.52 ± 1.77 |

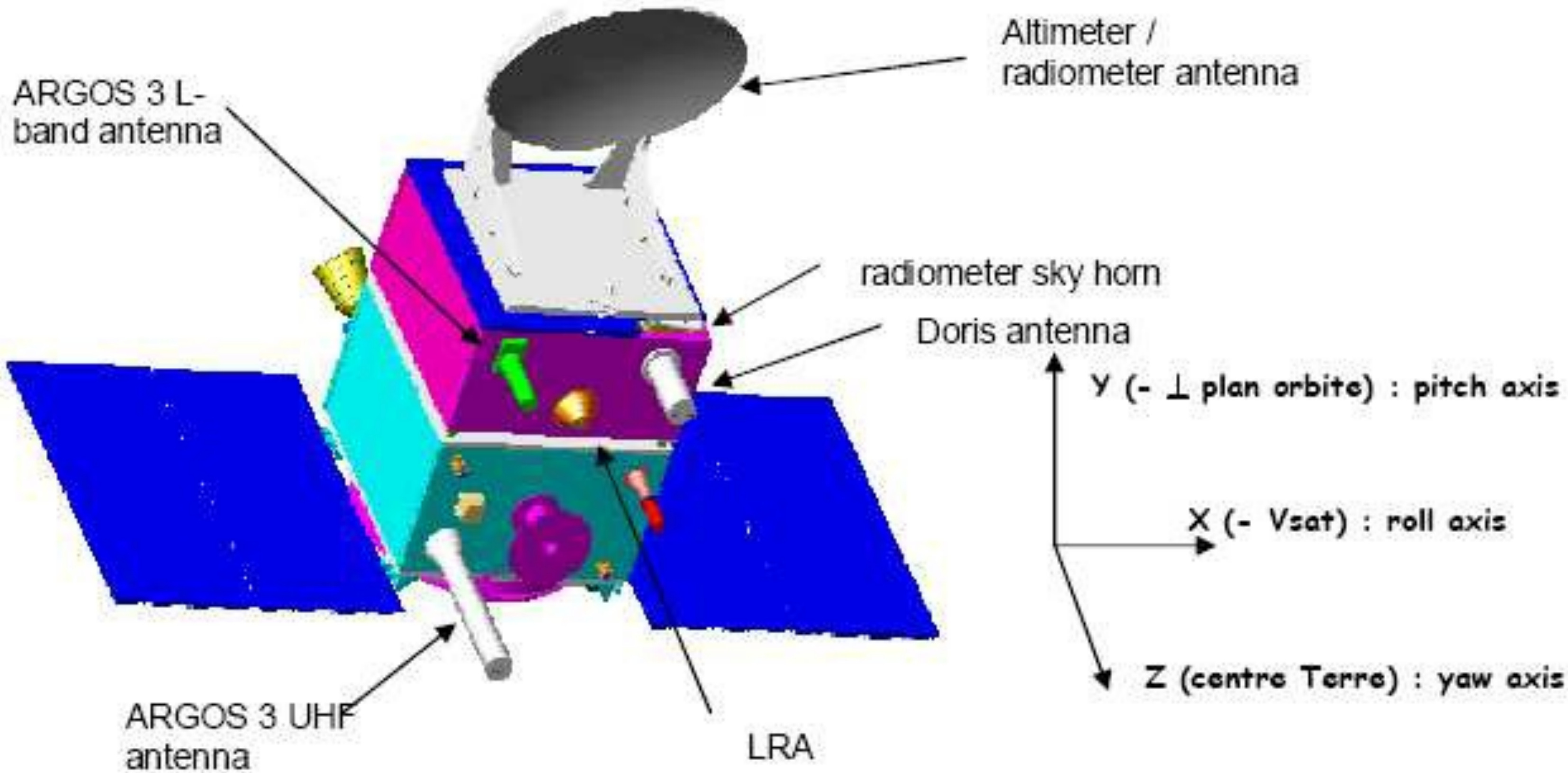
| | | |
|---|---|---|
| BKG - C cm | R | -0.01 ± 0.34 |
| | C | +0.01 ± 1.70 |
| | A | +0.35 ± 1.71 |
| NSGF -C cm | R | -0.01± 0.37 |
| | C | -0.02 ± 1.57 |
| | A | -0.02 ± 1.46 |

# SP3c files - remarks

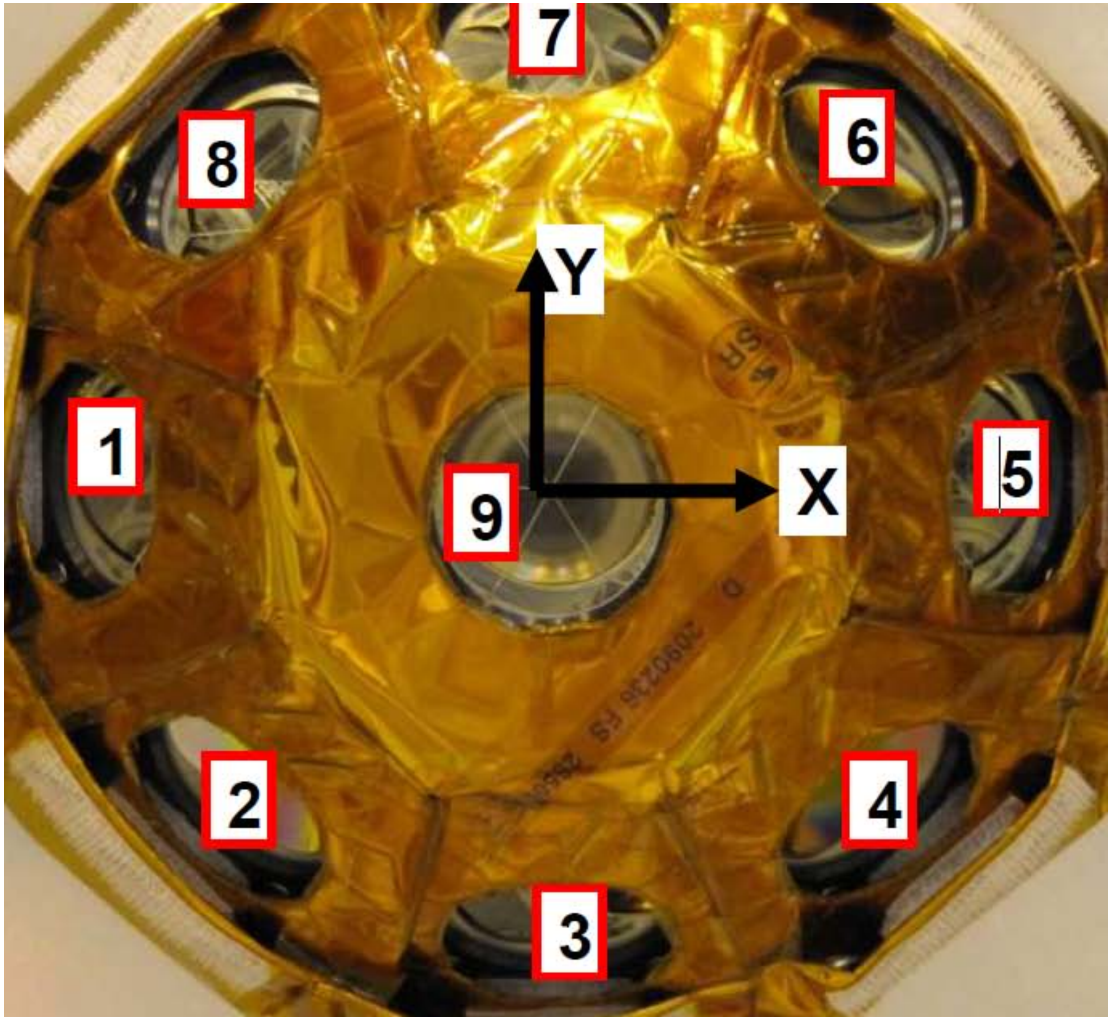
- L51/L52 asi, bkg, dgfi, gfz, jcet, nsgf
- L53/L54 asi, bkg, dgfi, jcet, nsgf
- Format check

  esa: L53/L54 5'
- asi, bkg, gfz, nsgf coherent (~2-4cm C-A L51/L52)
- dgfi shows discrepancies in A component
- jcet shows big differences in C component
- Evident differences in the dynamic modelling
- Test combination for L51 using asi, bkg, gfz, nsgf

# AltiKa from CNES' document



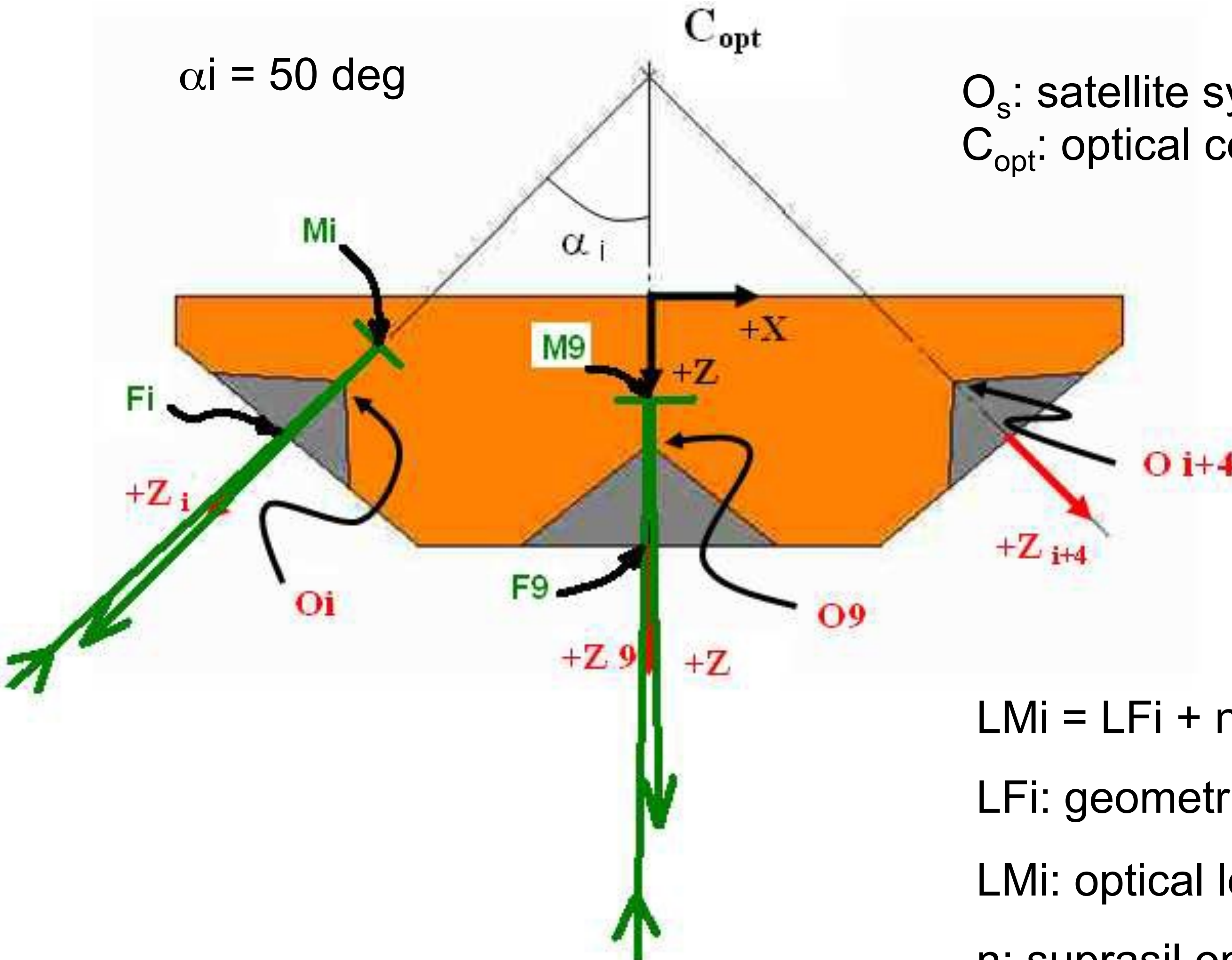
# The Laser Reflector Array (LRA)



$O_sC_{opt}$ : X= 0.0 ± 0.15 mm
Y= 0.0 ± 0.15 mm
Z=

$O_s$: satellite system origin
$C_{opt}$: optical center

αi = 50 deg



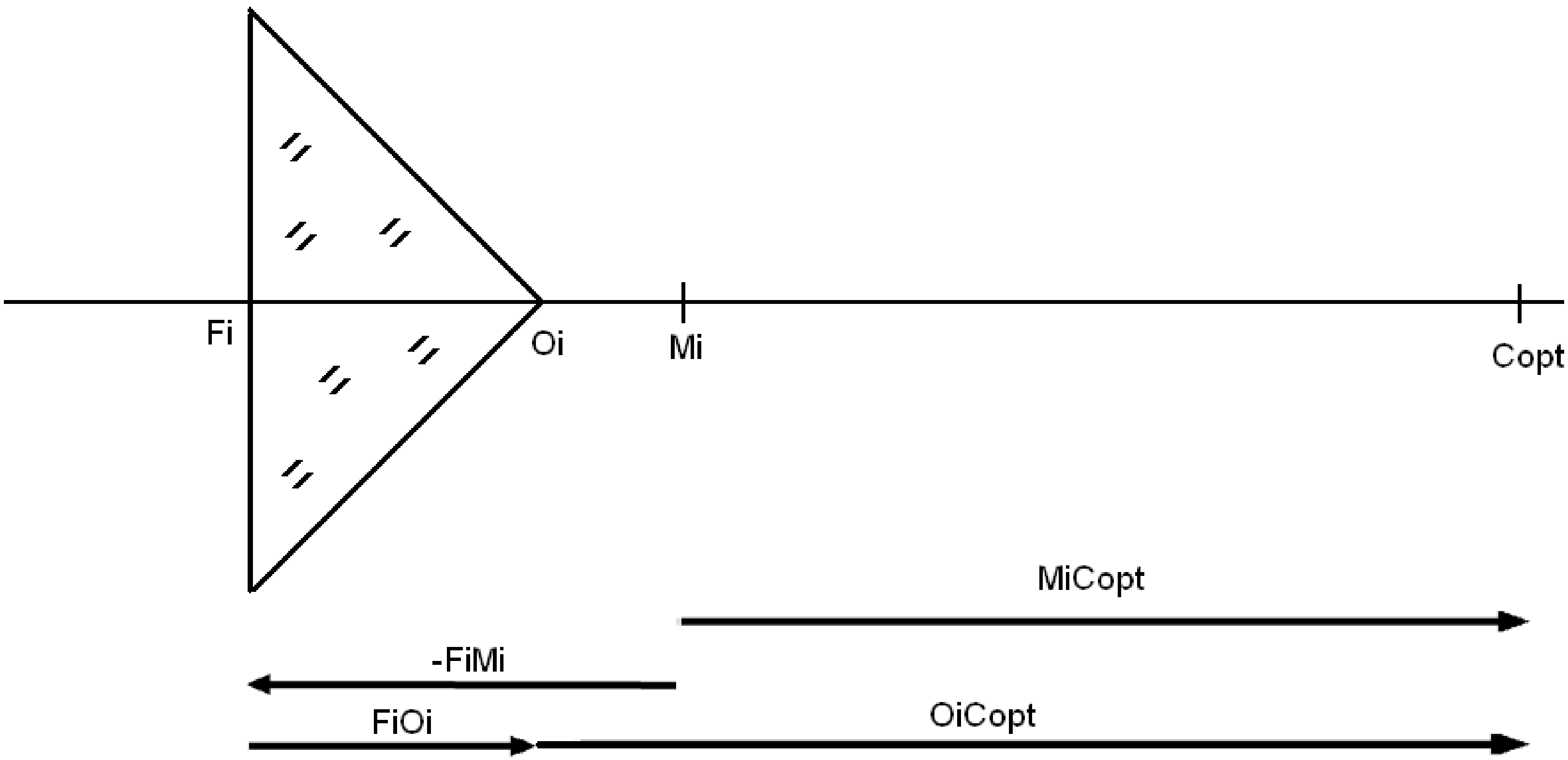

LMi = LFi + n FiOi

LFi: geometrical length to face i

LMi: optical length

n: suprasil optical index (=1.461)

# Correction to the optical center

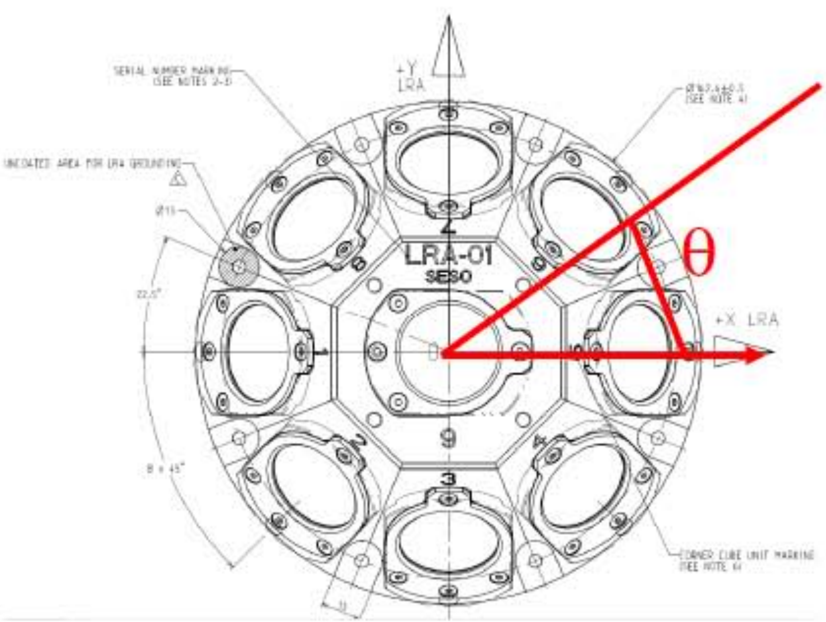



FiOi = 24.3 ± 0.1 mm, except for corner cube 8: 24.45 mm

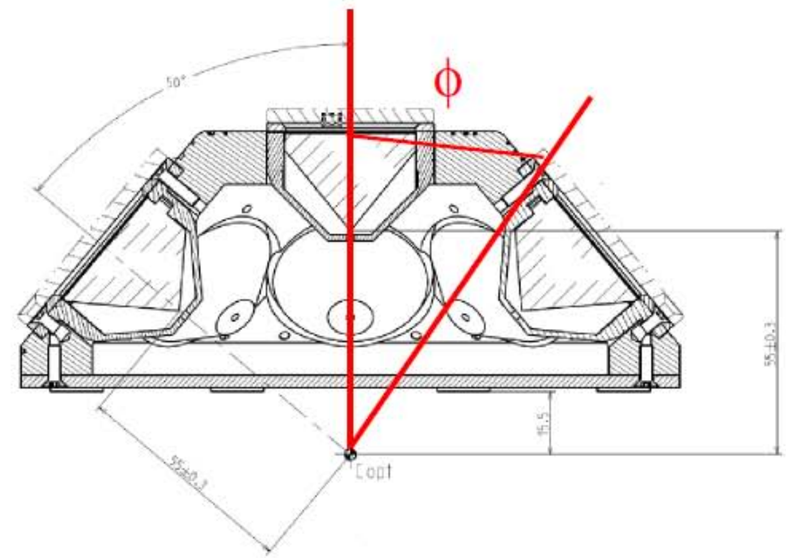
FiMi = 35.5 ± 0.1 mm, except for corner cube 8: 35.72 mm

$OiC_{opt}$ = 55.0 ± 0.1mm, except for corner cube 8: 54.6 mm

**$MiC_{opt}$ = 43.8 ± 0.1 mm, except for corner cube 8: 43.4 mm**

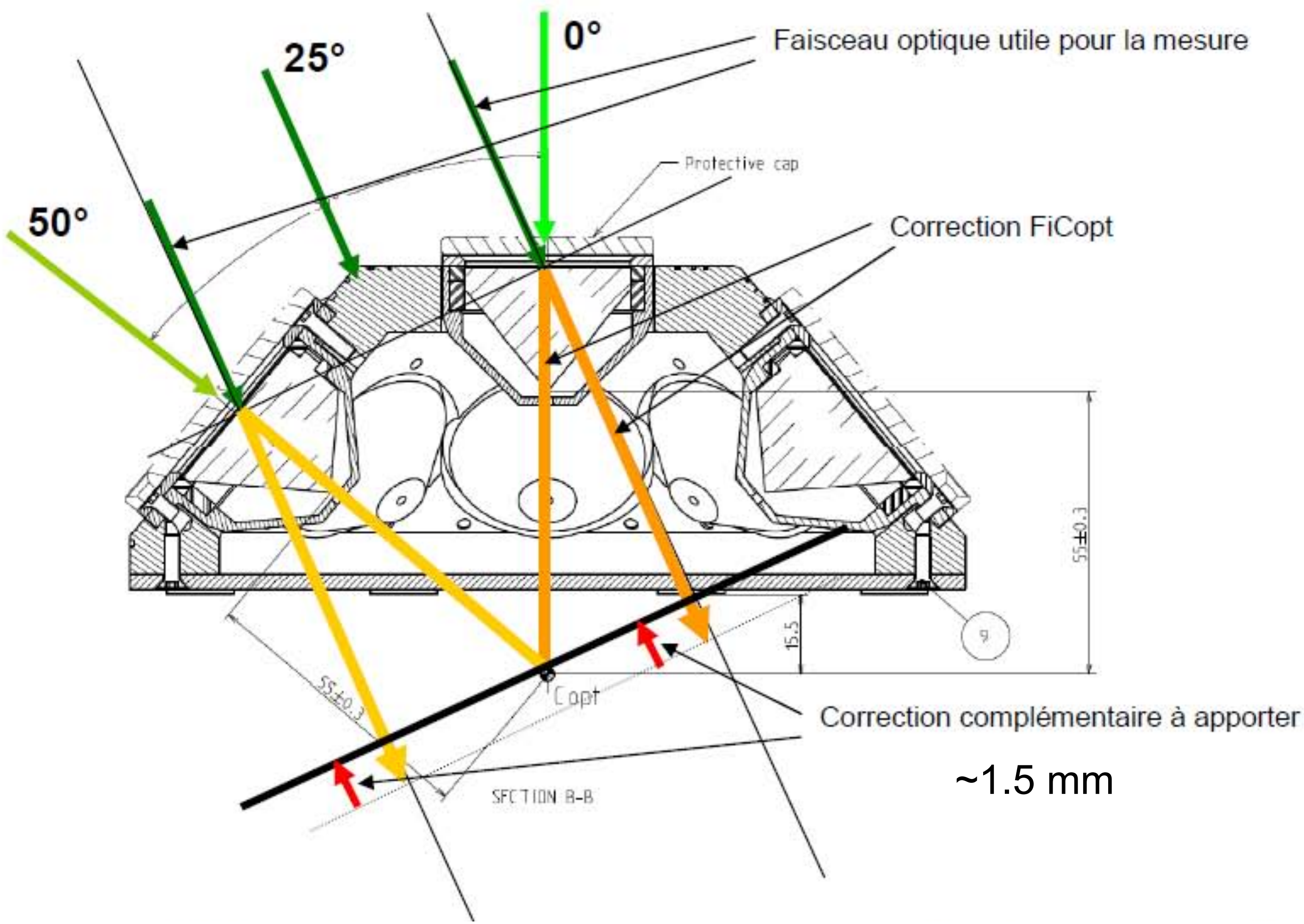


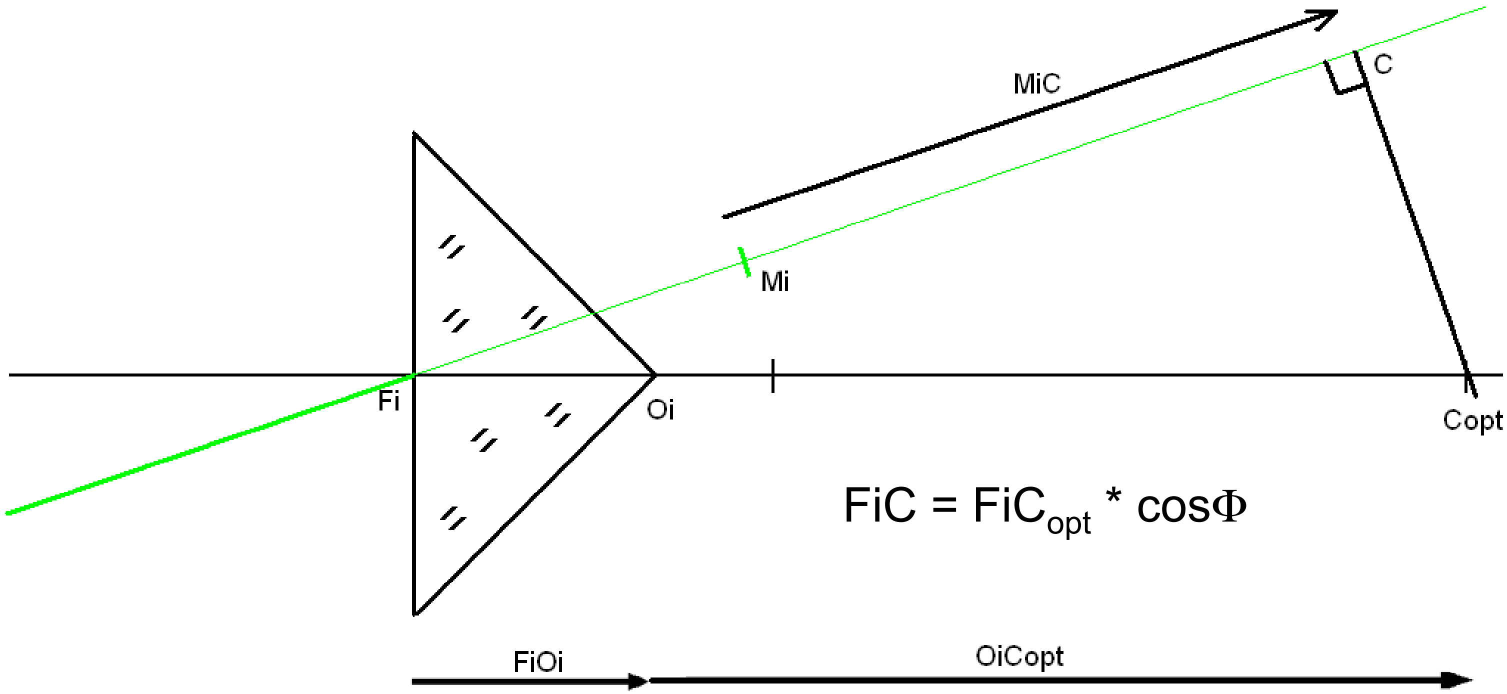

θ = azimuth angle




Φ = incidence angle

# Incidence correction






| angle incident en degrés | chemin optique FiMi en mm |
|---|---|
| 0 | 35,50 |
| 1 | 35,50 |
| 2 | 35,49 |
| 3 | 35,48 |
| 4 | 35,46 |
| 5 | 35,44 |
| 6 | 35,41 |
| 7 | 35,38 |
| 8 | 35,34 |
| 9 | 35,30 |

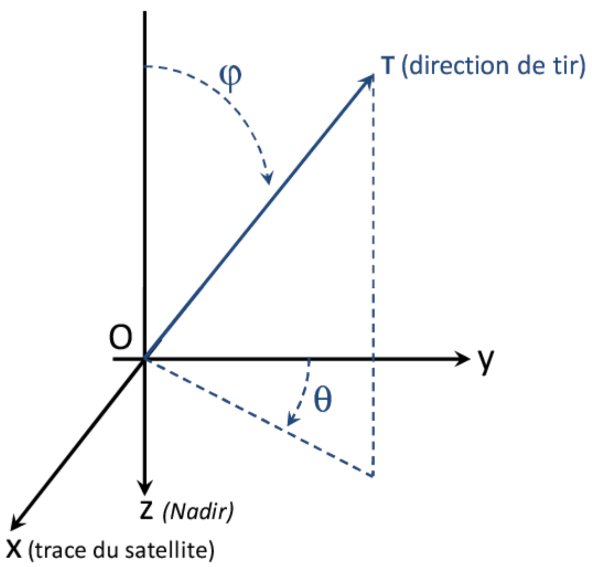
| angle incident en degrés | chemin optique FiMi en mm |
|---|---|
| 10 | 35,25 |
| 11 | 35,20 |
| 12 | 35,14 |
| 13 | 35,08 |
| 14 | 35,01 |
| 15 | 34,94 |
| 16 | 34,86 |
| 17 | 34,78 |
| 18 | 34,70 |
| 19 | 34,61 |

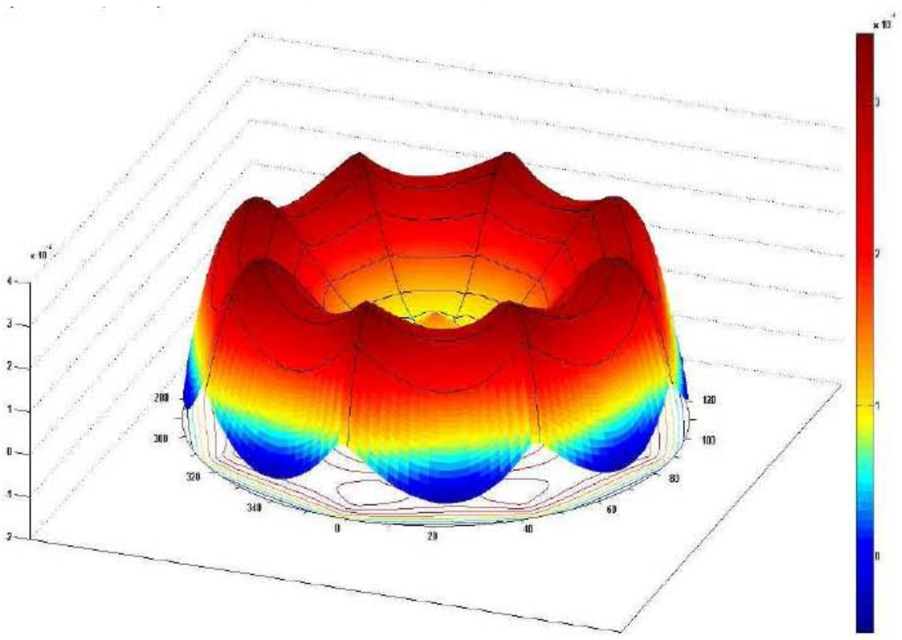
| angle incident en degrés | chemin optique FiMi en mm |
|---|---|
| 20 | 34,52 |
| 21 | 34,42 |
| 22 | 34,32 |
| 23 | 34,21 |
| 24 | 34,10 |
| 25 | 33,98 |
| 26 | 33,87 |
| 27 | 33,74 |
| 28 | 33,62 |

**Flux budget**

- normal incidence: 0 deg 50 deg
- laser beam divergence: 7 as
- satellite altitude: 800 km
- laser energy: 23 mJ
- telescope diameter: 0.2 m
- telescope efficiency: 5.1%

- link budget: 194 000 photons 82 000 photons



# IDS, IGS, ILRS, IVS & COL standards to get ready for the GRGS contribution to ITRF2013

| Gravitational Forces | DORIS | GNSS | SLR | LLR | VLBI | COL |
|---|---|---|---|---|---|---|
| Geopotential | EIGEN-6S2 up to degree 95 including time variable terms up to degree 50 (bias & drift per yr from 2002 to 2012, periodic 18.6, 1, 0.5 yrs) | EIGEN-6S2 up to degree 12 | EIGEN-6S2 up to degree 30 (for LAGEOS) | | | Static gravity field model is based on EIGEN-GRGS.RL02, tide-free, complete to degree and order 2 up to 160 ftp://hpiers.obspm.fr/iers/eop/grgs/Models/Gravity_Field/ |
| Third-body | JPL DE421 | JPL DE421 | JPL DE421 | | JPL DE421 | |
| Solid Earth Tides | IERS 2010 conventions | IERS 2010 conventions | IERS 2010 conventions | | | IERS 2010 conventions |
| Ocean Tides | FES 2012 (32 principal waves, + 60 admittance waves) up to degree 50 | FES 2012 (32 principal waves, + 60 admittance waves) up to degree 12 | FES 2012 (32 principal waves, + 60 admittance waves) up to degree 20 | | | FES 2004 ftp://hpiers.obspm.fr/iers/eop/grgs/Models/Ocean_Tide_Loading/ |
| Atmospheric gravity | 3hr ERA-interim / ECMWF up to degree 50 | 3hr ERA-interim / ECMWF up to degree 12 | 3hr ERA-interim / ECMWF up to degree 20 | | | |
| Non tidal oceanic gravity | TUGO R12 up to degree 50 | TUGO R12 up to degree 12 | TUGO R12 up to degree 20 | | | |
| Atmospheric tides | none (considered through the ECMWF atmospheric data) | none | none | | | Ray & Ponte 2003 ftp://hpiers.obspm.fr/iers/eop/grgs/Models/Atmospheric_Tide/ |
| Earth pole tide | IERS2010 conventions | IERS2010 conventions | IERS2010 conventions | | | |
| Ocean Pole Tide | Desai 2002 up to degree 12 | Desai 2002 up to degree 12 | Desai 2002 up to degree 12 | | | |

| Non Gravitational Forces | DORIS | GNSS | SLR | LLR | VLBI | COL |
|---|---|---|---|---|---|---|
| Atmospheric drag | DTM2012 (with Am indices)<br>Spots, Envisat, Cryosat2, HY-2A: one coef/4 hrs (one/1hr in high solar activity periods) ;<br>Topex, Jasons: one coef/half day | | DTM2012<br>None for Lageos | | | DTM 94 |
| Solar radiation pressure | one coef/day strongly constrained (1.e-4) to:<br>0.98 for Topex;<br>1.15 for Spot-2;<br>1.16 for Spot-3/-4;<br>1.17 for Spot-5;<br>1.29 for Envisat;<br>0.97 for Jason-2;<br>0.85 for Cryosat-2;<br>1.13? for HY-2A | one coefficient adjusted per day? | one scale coefficient adjusted per arc | | | applied |
| Albedo + infra-red | interpolated from grids issued from ECMWF 6hr 4.5° grids | interpolated from grids issued from ECMWF 6hr 9° grids | interpolated from grids issued from ECMWF 6hr 9° grids | | | applied |
| Satellite emissivity | none | none | none | | | Stefan's law |
| Relativity | Schwarzschild model + Lense-Thirring + geodetic precession | Schwarzschild model + Lense-Thirring + geodetic precession | Schwarzschild model + Lense-Thirring + geodetic precession | | IERS 2010 conventions | Schwarzschild model |
| Hill/empirical | once/rev along-& cross-track per x day | | | | | |

| Geometry | DORIS | GNSS | SLR | LLR | VLBI | COL |
|---|---|---|---|---|---|---|
| Earth reference system | DPOD2008 | Set of 50-60 station coordinates & velocities from ITRF2008 & IGb08 | ITRF2008 (SLRF2008) | | VTRF2008 | ITRF 2008 |
| Celestial reference system | inertial J2000 | inertial J2000 | inertial J2000 | | J2000, ICRF2 | J2000, ICRF2 |
| Pole & UT1 | daily EOPC04_i08 | daily EOPC04_i08 | daily EOPC04_i08 | | daily EOPC04_i08 | EOPC04 initial values interpolated (Lagrange polynomial method) with 3hr time intervals generated by EOP Center |
| Precession / Nutation | IERS 2010 using NRO origin | IERS 2010 using NRO origin | IERS 2010 using NRO origin | | IERS 2010 using NRO origin | IAU2000A - IAU2006 A-priori set to zero |
| Solid Earth tidal displacement | IERS 2010 conventions | IERS 2010 conventions | | | | |
| Ocean loading | FES2012 | FES2012 | FES2012 | | FES2012 | Ocean tide loading models per stations are obtained from Scherneck's ocean loading site and provided in the BLQ format according to the IERS Conventions 2010 |
| Tidal atmospheric loading | S1/S2 Ray & Ponte (2003) | S1/S2 Ray & Ponte (2003) | S1/S2 Ray & Ponte (2003) | | S1/S2 Ray & Ponte (2003) | none |
| Non tidal atmospheric loading | none | none | none | | none | none |
| Solid pole tide displacement | IERS 2010 conventions | IERS 2010 conventions | IERS 2010 conventions | | IERS 2010 conventions | IERS 2010 conventions |
| Ocean pole tide displacement | none | none | none | | none | |

| Geometry | DORIS | GNSS | SLR | LLR | VLBI | COL |
|---|---|---|---|---|---|---|
| Troposphere | GPT/GMF modelling from Boehm et al. (2006). One zenith delay/pass + one tropospheric gradient per station in North & East directions | GPT/GMF modelling from Boehm et al. (2006). One zenith delay/2hr using PWL, continuous model + one tropospheric gradient per station in North & East directions | Mendles-Pavlis Mapping Function | | GPT/GMF modelling from Boehm et al. (2006). One zenith delay/2hr + one tropospheric gradient per station in North & East directions | GPT/GMF for radio-electrical waves and Mendes-Pavlis for SLR + one tropospheric gradient per station in North & East directions |
| Ionosphere | 2nd order corrections using IGS TEC values and igrf2011 magnetic field model | 2nd order corrections using IGS TEC values and igrf2011 magnetic field model | | | | |
| Satellite system | Centre of mass / Phase centre vector from macro model + attitude law<br>No phase law applied | Centre of mass offsets / Phase centre corrections from file: igs08_wwww.atx | | | | |
| Ground system | Phase centre / reference point vector from manufacturer values<br>Phase law applied | Absolute elevation/ azimuth dependent phase centre corrections are applied according to igs08_wwww.atx | | | Antenna thermal expansion: Nothnagel (2008)<br>Antenna axes offset: IVS files | |
| Elevation cut-off | 12 degrees<br>Down weighting law for elevation <= 20 deg; Weight of the observation is multiplied by the factor elevation**2/400 with elevation in degrees) | 10 degrees | 10 degrees | | 12 degrees | |

# DGFI Report

**Horst Müller**
Deutsches Geodätisches Forschungsinstitut (DGFI)
Centrum für Geodätische Erdsystemforschung (CGE)
München
email: mueller*@dgfi.badw.de*

# DGFI Products



- Delivered regularly daily and weekly products V40 and v35
  - Orbits for Lageos/Etalon delivered v40
- No participation in pilot project ITRS/GGFC
  - Manpower problems, gravity effect is still missing
- Pilot project new CoM model, Sinex files delivered, cor files will follow
  - takes some time to change the s/w to get the required information
  - presently correction to nominal value of 251/558 applied, program will be modified to read table with CoM values

# Data Handling/Discontinuities Files



- Update of this files follows no rules

- Last Update: March 08 2013 , Simeiz big range bias
- Inclusion with subsequent deletion of that entry for stations in quarantine, now 1874 not included
- Entries and control only manually, problem in case ov vacation, ...

- Suggestion to allow other to make changes to the files
  - Some kind of email method
  - Login for given users to make changes

# New stations



- Presently new Russian station Mendeleevo 1874 in quarantine, no new coordinates available, using old coordinates the data quality is good, Daedeok 7359, no data available.
  - Few observations in February, last passes April 04

- Other Russian stations Badary 1890, Svetloe 1888 and Zelenchuksya 1889 have good coordinates, but velocities are missing (IGS, Nouvel), adopted end of 2012
  - Altai Mountains 1879 needs better coordinates (since 2009)
  - Arkhyz 1886 accepted Sep. 2011

- Bad coordinates/velocities due to earthquakes for Koganai 7308, Simosato 7838 and Concepcion 7405.
  - Need of better velocities resp. update of coordinates (monitoring of station movement)

- San Juan 7406 is also affected by the Chile earthquake
  - wait for Itrf2013?

# Menedeleevo 1874 biases (DGFI coordinates)



| year | mm | dd | hh mm | | range-bias [cm] | sigma [cm] | prec.est. [cm] | no of observations | edit. | satellite |
|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 2 | 20 | 18:41 | : | -1.33 | 0.93 | 0.89 | 6 | 0 | lageos1 |
| 2013 | 2 | 20 | 21:50 | : | 0.02 | 1.26 | 0.66 | 10 | 0 | lageos2 |
| 2013 | 2 | 20 | 22:15 | : | -1.96 | 0.80 | 0.78 | 12 | 0 | lageos1 |
| 2013 | 2 | 21 | 19:57 | : | 0.76 | 1.28 | 0.64 | 11 | 0 | lageos2 |
| 2013 | 2 | 21 | 20:49 | : | -1.94 | 0.81 | 0.49 | 13 | 0 | lageos1 |
| 2013 | 2 | 25 | 18:55 | : | -3.44 | 10.39 | 0.82 | 10 | 0 | lageos1 |
| 2013 | 3 | 4 | 19:14 | : | -0.35 | 1.02 | 0.94 | 10 | 0 | lageos2 |
| 2013 | 3 | 4 | 19:58 | : | -1.10 | 2.22 | 0.69 | 13 | 0 | lageos1 |
| 2013 | 4 | 3 | 17:57 | : | -1.76 | 0.85 | 1.20 | 11 | 0 | lageos1 |
| 2013 | 4 | 3 | 18:33 | : | 0.78 | 0.74 | 1.16 | 12 | 0 | lageos2 |
| 2013 | 4 | 3 | 21:25 | : | -0.12 | 0.71 | 1.55 | 14 | 0 | lageos1 |

# ILRS AWG meeting Vienna
# ESOC status

T. Springer, R. Zandbergen
07/04/2013

European Space Agency

# Routine activities

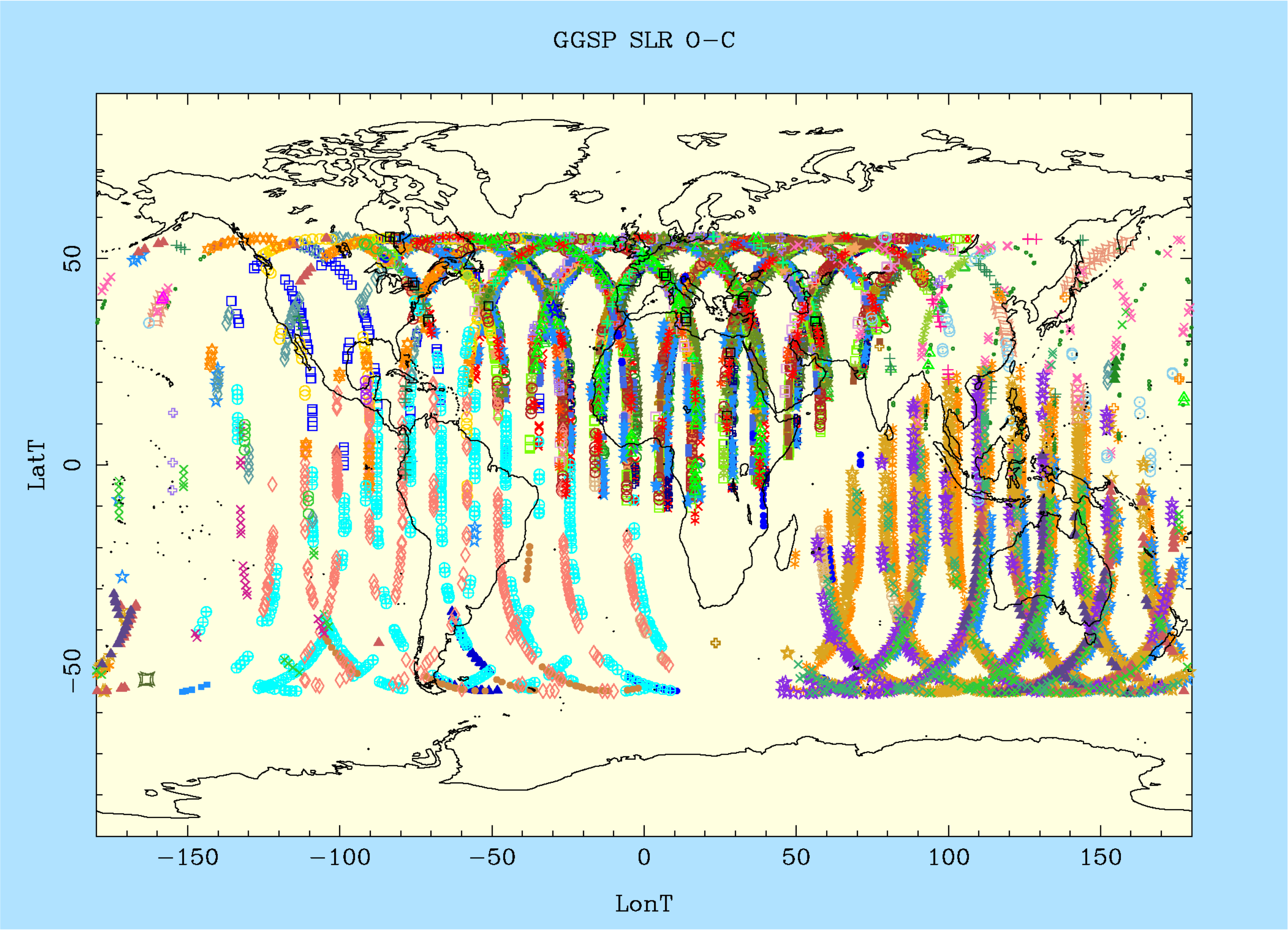
- Two weekly solutions:
    - standard (V40)
    - test (V35 with ‘Appleby CoM model’)
- Daily rapid solution (V130)
- In parallel to activities related to IDS, GNSS, and for combination at observation level:
    - Combined solutions
    - Cross-validation
    - Validation of GNSS orbit

# Progress since Frascati meeting (03/11/2012)

- Non-tidal atmospheric loading test:
  - S/W still not yet implemented
  - Is it still of interest?
- No gravity SH estimation yet
- Working on CoM test, results to be available mid April
- Ready for ITRF 2013 processing
  - IERS 2010 conventions implemented

# Galileo data processing

- Support to Galileo project
- Prediction generation for Galileo IOV satellites
- Galileo GNSS and SLR orbits used routinely for validation


GGSP SLR O−C
LatT
LonT
50
0
−50
−150
−100
−50
0
50
100
150

# Standards as of SINEX Headers

| | ASI | BKG | DGFI |
|---|---|---|---|
| **Dynamic** | | | |
| Gravity model | GGM02C 70x70 | EIGEN-GL04C 70x70 | GGM02S 30x30 |
| Time var. grav. | $C_{20}$, $C_{21}$, $S_{21}$ | $C_{20}$, $C_{30}$ , $C_{40}$ | $C_{20}$ |
| Solid Earth tides | Wahr | IERS 2010 | Wahr |
| Ocean tides | Ray GOT4.7 | CSR4.0 | GOT.99b |
| Atm. tides | No | No | No |
| Albedo | Yes | Yes | Yes |
| Thermal forces | No | No | No |
| Solar radiation pr. | Yes | Yes | Yes |
| Dyn. Polar motion | Yes | Yes | Yes |

# Standards as of SINEX Headers

| | GFZ | GRGS | JCET |
|---|---|---|---|
| **Dynamic** | | | |
| Gravity model | EGM96 20x20 | EIGEN-GL04S 40x40 | GGM02C 30x30 |
| Time var. grav. | $C_{20}$, $C_{21}$, $S_{21}$ | No | JCET 12x12 set |
| Solid Earth tides | IERS 2003 | IERS 2003 | IERS 2003 |
| Ocean tides | FES2004 | FES2004 | Ray GOT4.7 |
| Atm. tides | Bode-Biancale 2003 | No | Ray-Ponte |
| Albedo | No | Yes | Yes |
| Thermal forces | No | No | Yes |
| Solar radiation pr. | Yes | Yes | Yes |
| Dyn. Polar motion | Yes | Yes | Yes |

# Standards as of SINEX Headers

| | ASI | BKG | DGFI |
|---|---|---|---|
| **Geometrical** | | | |
| Solid Earth tides | Love model | Love model | Love model |
| Ocean tidal load | Based on RayGOT4.7 | Scherneck (FES2004) | Scherneck (GOT00b) |
| Atm. tidal load | No | No | No |
| Atm. non-tidal load | No | No | No |

# Standards as of SINEX Headers

| | GFZ | GRGS | JCET |
|---|---|---|---|
| **Geometrical** | | | |
| Solid Earth tides | IERS 2003 | Love model | IERS 2003 |
| Ocean tidal load | Scherneck (FES2004) | img-fes2002 | Scherneck (GOT99.2) |
| Atm. tidal load | No | No | No |
| Atm. non-tidal load | No | No | No |

No header given in ESA products

# ITRF2013 CfP

**Z. Altamimi, X. Collilieux, L. Métivier**

**ILRS AWG, Vienna, April 07, 2013**

# Solicited solutions

- Solutions with removable constraints;
- Loosely constrained solutions (constraint level: $\sigma > 1$ m);
- Free singular normal equations.
- NO loading corrections should be applied
- Should cover full history of observations of each technique

# Outline of ITRF2013 analysis strategy

- Remove original constraints (if any);
- Apply non-tidal atmospheric (and possibly other loading) effects corrections;
- Perform per-technique combinations (TRF + EOP) of each individual time series;
- Combine the per-technique combinations adding local ties in co-location sites.

# Impact of NT-ATML model corrections on an ITRF-like combination

**Use three solutions per technique:**

- **Standard (no correction), abbreviated as STD**
- **Corrected a priori (at the obs. level) APR**
- **Corrected a posteriori, before multi-technique combination APS**

==> Combine long-term solutions with local ties

Results: **the three test combinations are equivalent, except up velocities for stations with time-span < 3 years**

# NT-ATML test campaign: analyzed solutions

| Tech. | S/W | AC | contact | Loading model | Solution type |
|---|---|---|---|---|---|
| SLR | EPOSOC 06.69 | GFZ | R. Koenig | GGFC | Solution |
| VLBI | CALC/ SOLVE | GSFC | D. MacMillan | GGFC | Solution + NEQ |
| DORIS | Geodyn/ Solve | GSFC | F. Lemoine | GGFC | NEQ |
| GPS | Bernese | CODE | R. Dach | GGFC / TU Wien | NEQ |

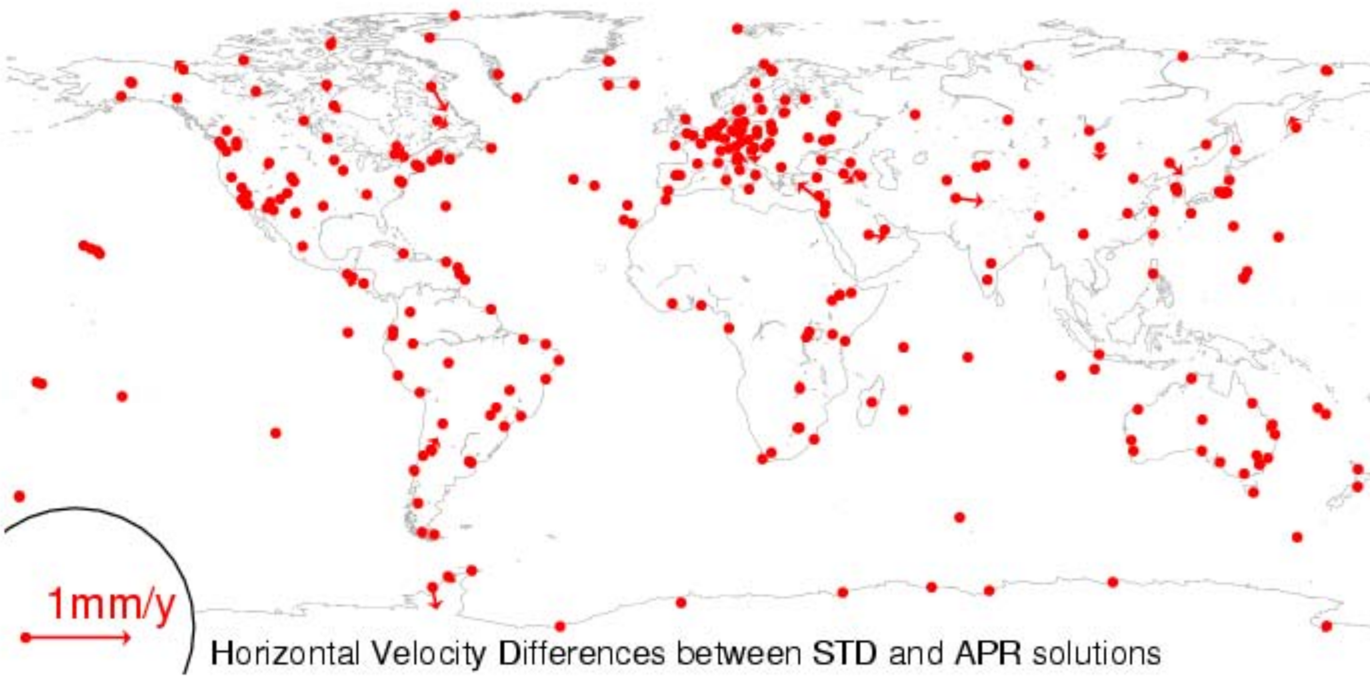
# Transformation Parameters

- **Combinations of APR and APS solutions yield the same parameters at the level of 0.1 mm and 0.1 mm/yr**

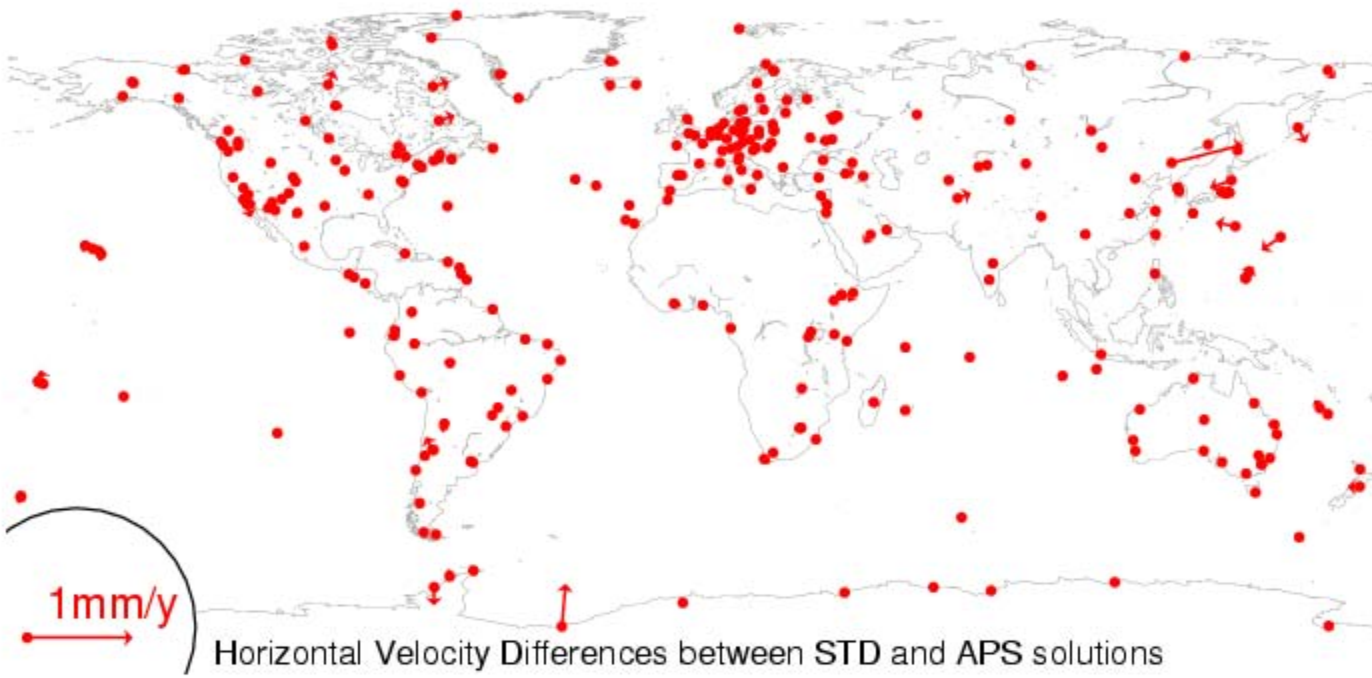
**Table 1: Translation and scale parameters at 2009.0 and their rate with respect to ITRF2008 for STD solutions**

| Solution | TX mm | TY mm | TZ mm | D $10^{-9}$ |
|---|---|---|---|---|
| VLBI/GSFC | --- | --- | --- | 0.56 |
| ± | --- | --- | --- | *0.22* |
| Rates | --- | --- | --- | 0.01 |
| ± | --- | --- | --- | *0.03* |
| SLR/GFZ | -0.9 | -6.6 | -10.4 | -0.37 |
| ± | *1.8* | *1.7* | *1.7* | *0.27* |
| Rates | 0.3 | -1.6 | -0.1 | -0.06 |
| ± | *0.2* | *0.3* | *0.3* | *0.04* |
| DORIS/GSFC | -4.6 | -6.7 | -13.1 | 0.24 |
| ± | *1.8* | *1.5* | *1.3* | *0.25* |
| Rates | -3.6 | -4.5 | 13.9 | -0.37 |
| ± | *0.4* | *0.3* | *0.3* | *0.05* |
| GNSS/CODE | -5.1 | -3.4 | -4.3 | 0.00 |
| ± | *0.1* | *0.1* | *0.2* | *0.01* |
| Rates | 0.2 | 0.1 | 0.9 | -0.04 |
| ± | *0.1* | *0.1* | *0.1* | *0.00* |

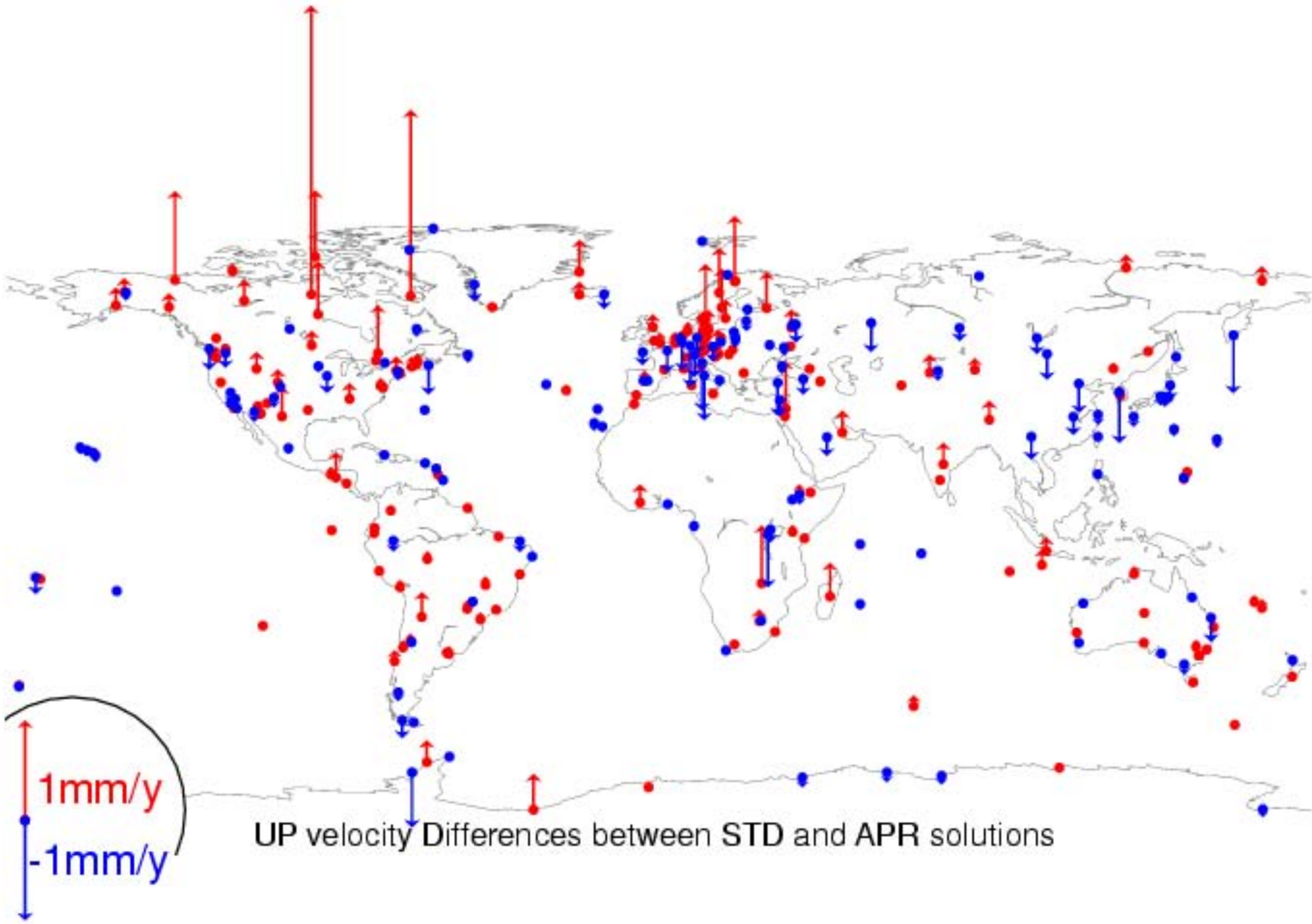
# Horizontal Velocity differences btw standard and load corrected (a priori) solutions



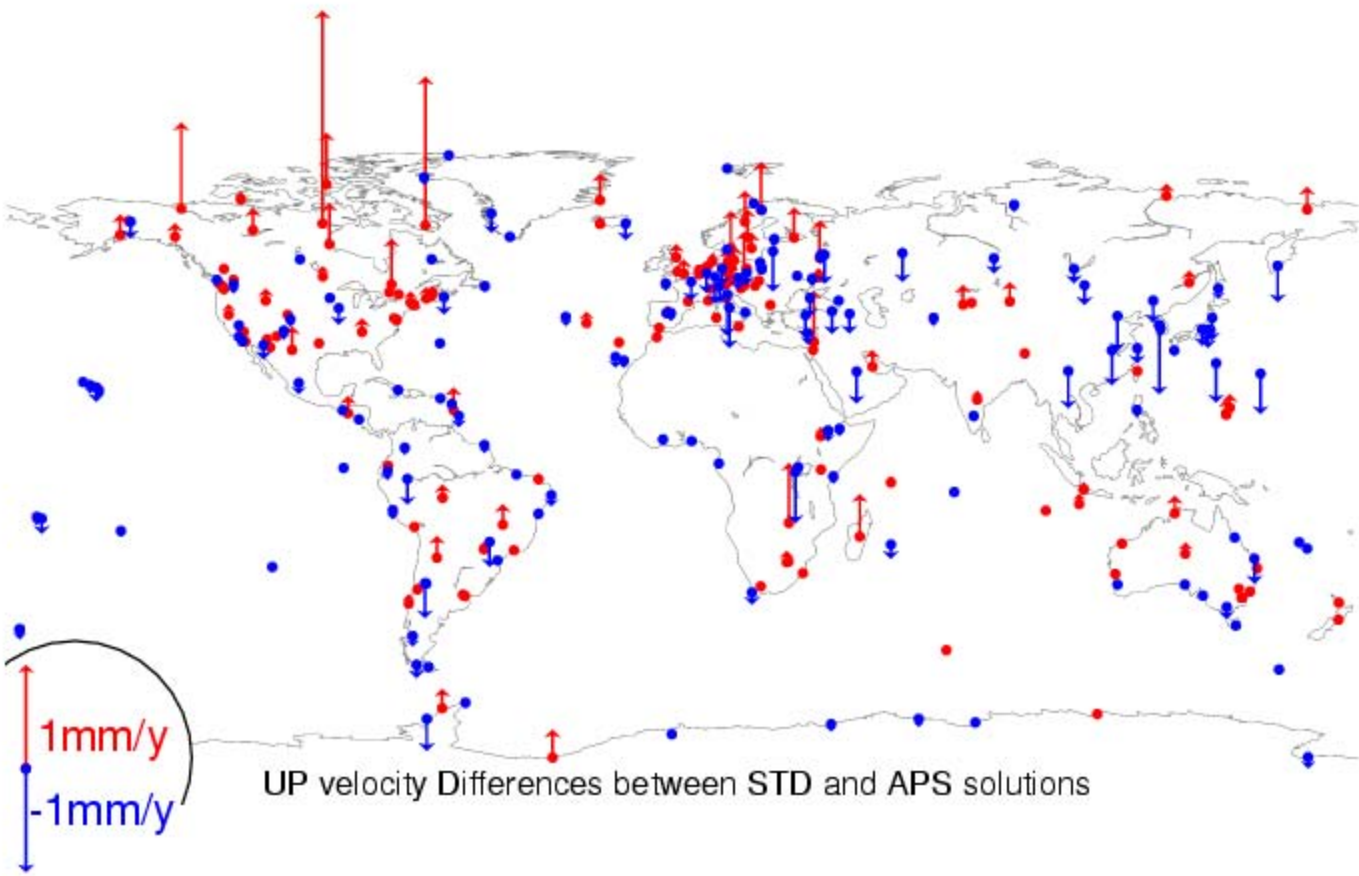
# Horizontal Velocity differences btw standard and load corrected (a posteriori) solutions



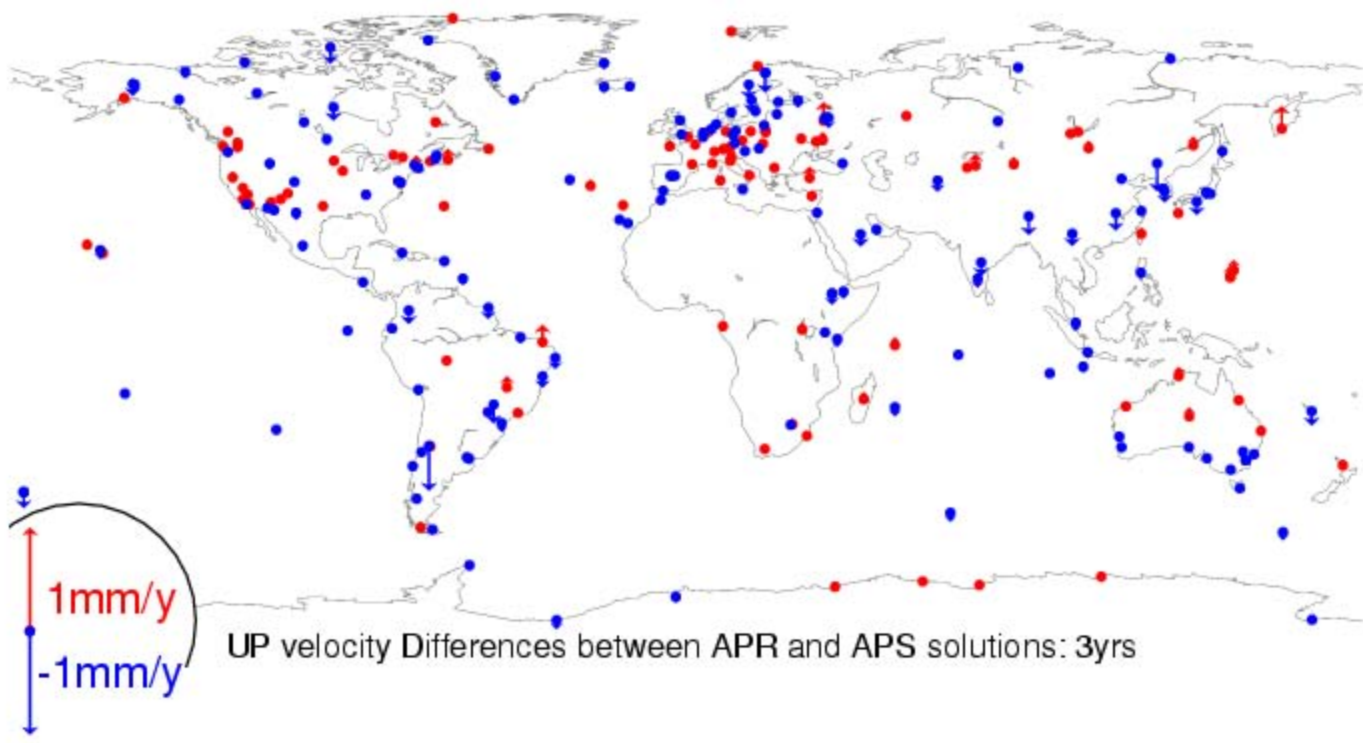
# Vertical velocity differences btw standard and load corrected (a priori) solutions



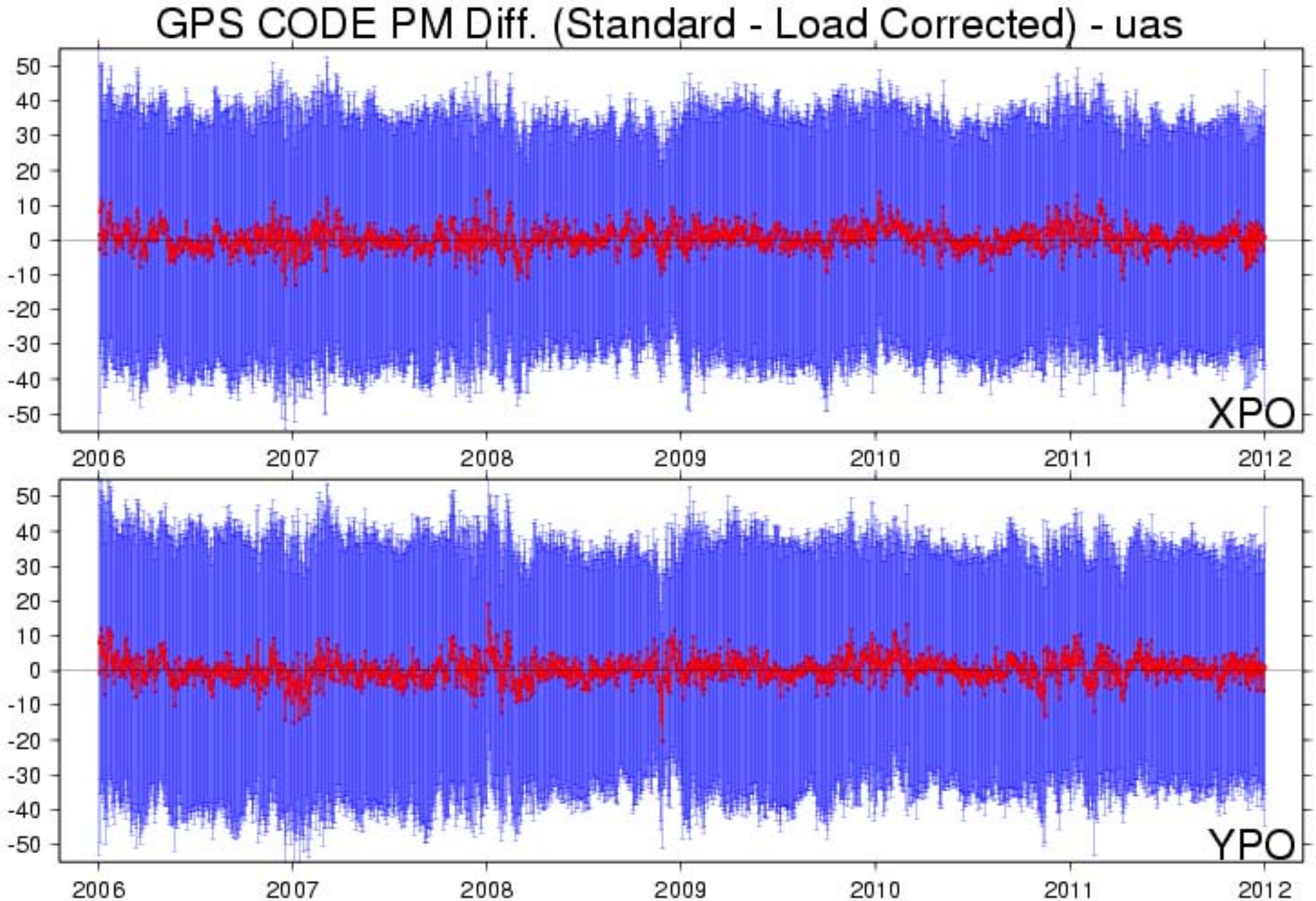
# Horizontal Velocity differences btw standard and load corrected (a posteriori)  solutions



# Vertical velocity diffs btw load corrected a priori and a posteriori solutions (sites with time-span > 3 years)



# NT-ATML impact on Polar Motion



# Schedule

- **February 10, 2014** Deadline for solution submissions by Technique Centers. Earlier submissions are welcome.
- **April 2014** First results and discussions at EGU General Assembly
- **Until end of May, 2014** Inter comparisons of the ITRF CCs solutions
- **June, 2014** Preliminary ITRF2013 solution available for evaluation by the Technique/ Analysis Centers
- **July-August, 2014** Final ITRF2013 solution released by the ITRS Center.

# JCET AC/CC REPORTS

Erricos C. Pavlis
GEST/UMBC – NASA Goddard 698
Magda Kuzmicz-Cieslak, Keith Evans and Daniel König
GEST/UMBC

ILRS Spring AWG Meeting at EGU2013, Vienna, Austria
April 7, 2013

# Activities since last AWG

- Analysis Products submitted for DAILY (v130) & WEEKLY (v40) series and v3y & v4y series for CoM PP implementation test
- Combination products for DAILY & WEEKLY series continues with no major issues, test combinations for v4x & v4x series (GGFC PP)
- Site log compilation updates:
  - Excel spreadsheets to be redone soon – new Grasse sitelog just released !!!
  - SCH-SCI database – NOW HISTORICAL !!!
- SLRF2008 updates: new Russian sites included and new solutions for earthquake-affected sites will be updated ("soon") as we prepare for ITRF2013

# Activities since last AWG (cont.)

- Station validation for old and new sites:
  - Russian sites Badary, Baikonur and Zelenchukskaya approved as ILRS sites – data still very sparse!!!
  - NGSLR, currently undergoing co-location testing with MOB7 at GGAO and data will soon be submitted for validation
  - Yarragadee (7090) – Height change (~1 cm) in early 2010 is still under investigation (noticed in JASON-1/2 analysis), similar, correlated signatures seen in Hx (7840) and Zimmerwald (7810) series over the same period…???
  - Some sites which were exemplary sites in earlier times have by now fallen into a very unstable mode (e.g. San Juan) and it is unclear what the reason is, and they seem to be nonresponsive despite several notices

# Activities since last AWG (cont.)

- Extensive activity to support various efforts of SLR applications:
  - New task for the assessment of the benefit of incorporating GLONASS in future analysis and development of a CONOPS for GLONASS, similar to what was done GPS III
  - GGOS/NASA-net 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 (continued)
  - Analysis of LARES data since February 2012 in combination with LAGEOS 1 & 2 and evaluation of resulting TRF(continued)
  - New websites with improved visualization and new options monitoring the AWG products, the site positions, EOP and about to put online our “Systematics Monitoring” site, pending the outcome from our discussions during this meeting

# 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 (PNG, 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.)
  - New site with the systematics for all sites, monitored on a WEEKLY basis (and soon from our DAILY products also)
- MATLAB viewer of QC reports that works with ALL QC reports from DGFI, HITU, MCC, JCET, SHAO (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 a simple user's manual

## JCET Monitoring Plots

WEEKLY ILRS STATION POSITION & EOP SERIES MONITORING

Visualization data

WEEKLY EVALUATION AND MONITORING OF ILRS AWG PRODUCTS

Visualization data

BIAS Monitoring

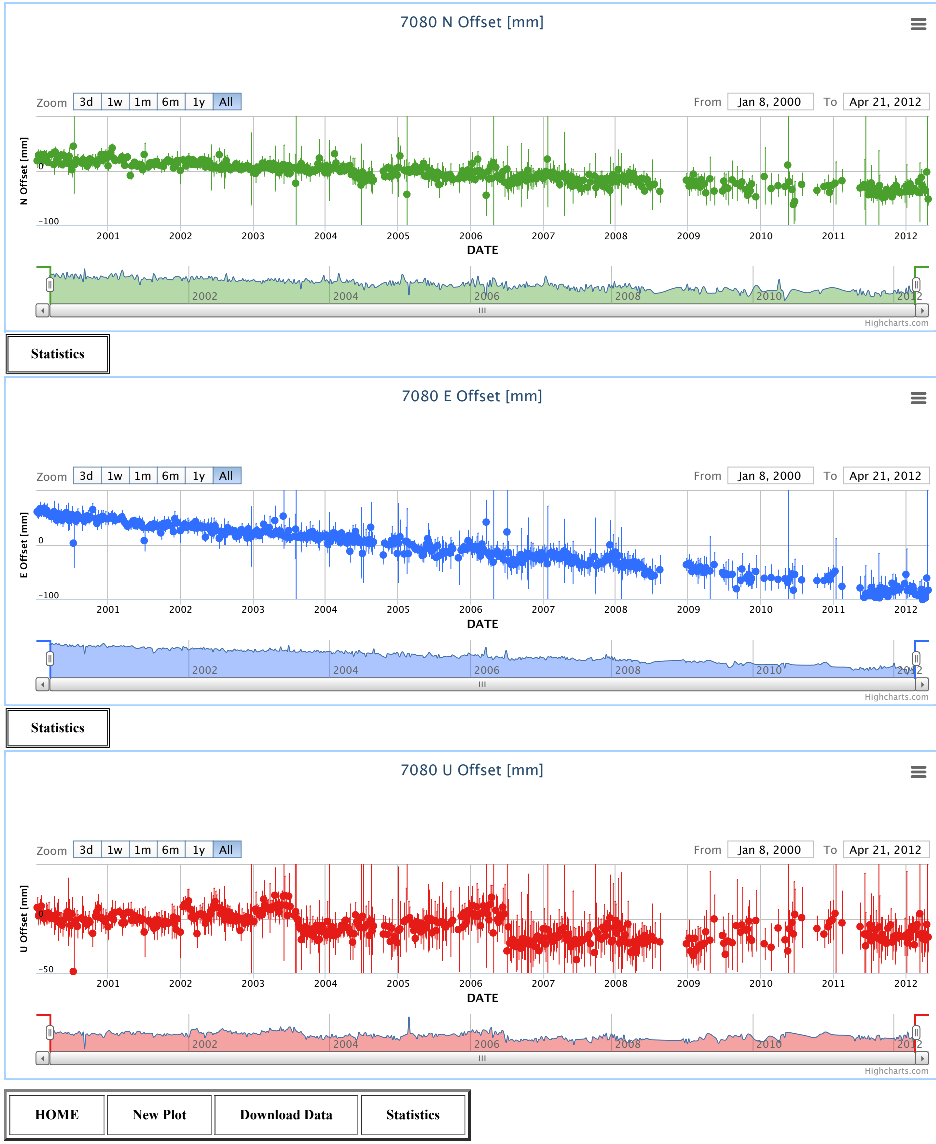
Visualization data

ILRS Normal Point Data Monitoring

Visualization data

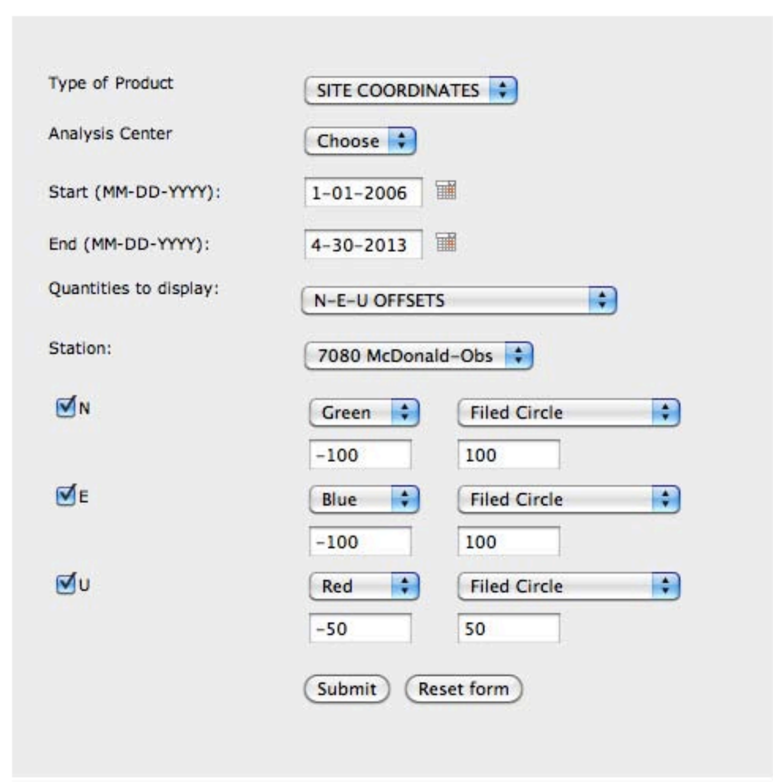
International Laser Ranging Service

# GRAPHICS WINDOW




# SITE POSITION & EOP SERIES

## CONTROL ENTRY WINDOW



# GRAPHICS WINDOW


# DAILY/WEEKLY PRODUCTS SERIES

## CONTROL ENTRY WINDOW

Combination Center: (●) ILRSA ( ) ILRSB

Analysis Center: JCET

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

End (MM-DD-YYYY): 4-30-2013

Group of results: HELMERT TRANS.

Quantities to display: ORIGIN OFFSETS w.r.t SLRF2008

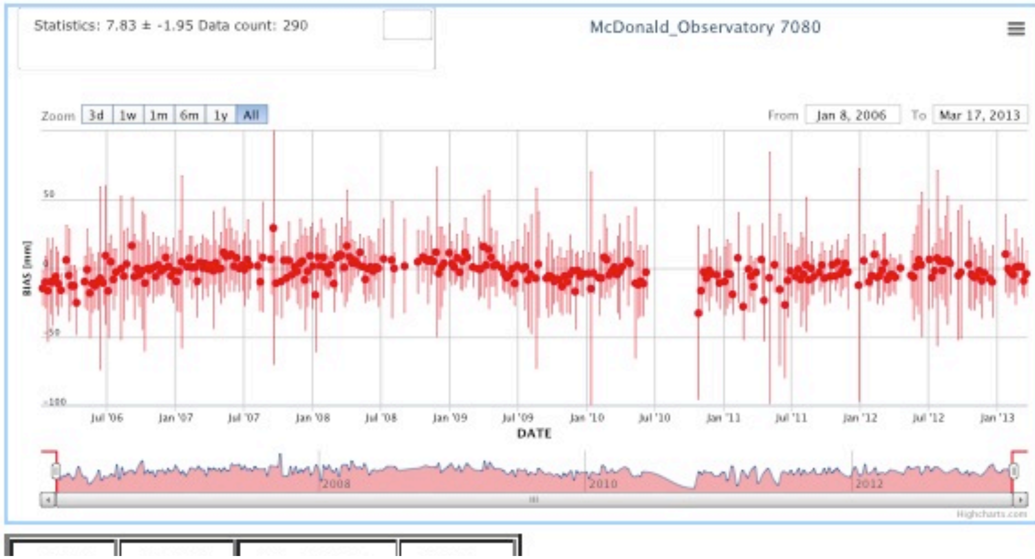
Station: N/A

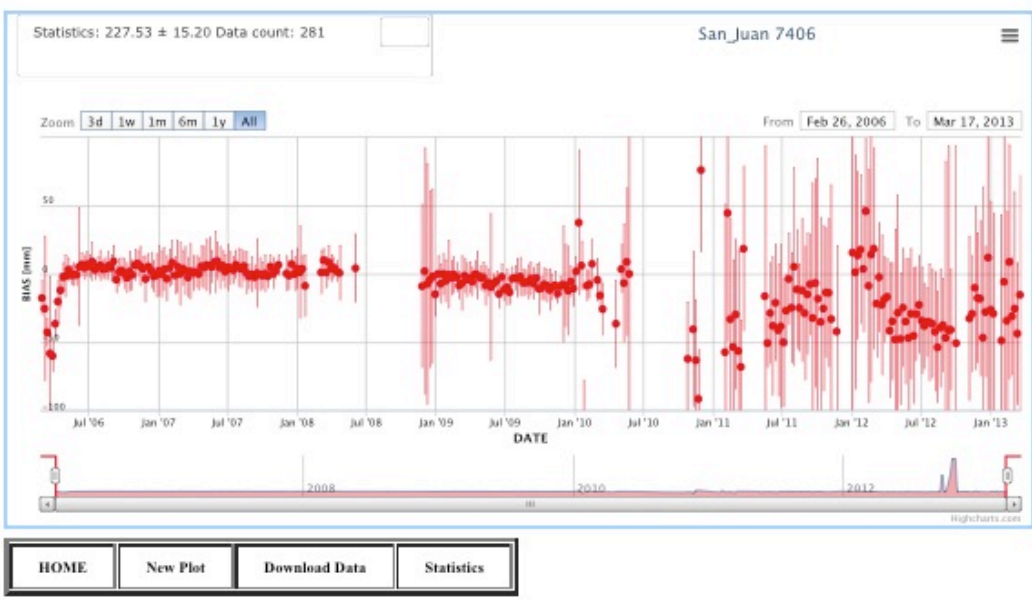
| | | |
|---|---|---|
| ☑ Tx | Green | Filed Circle |
| ☑ Ty | Blue | Filed Circle |
| ☑ Tz | Red | Filed Circle |

| Plot Size | Minimum | Maximum |
|---|---|---|
| Y axis | -50 | 50 |

Submit | Reset form

# GRAPHICS WINDOW

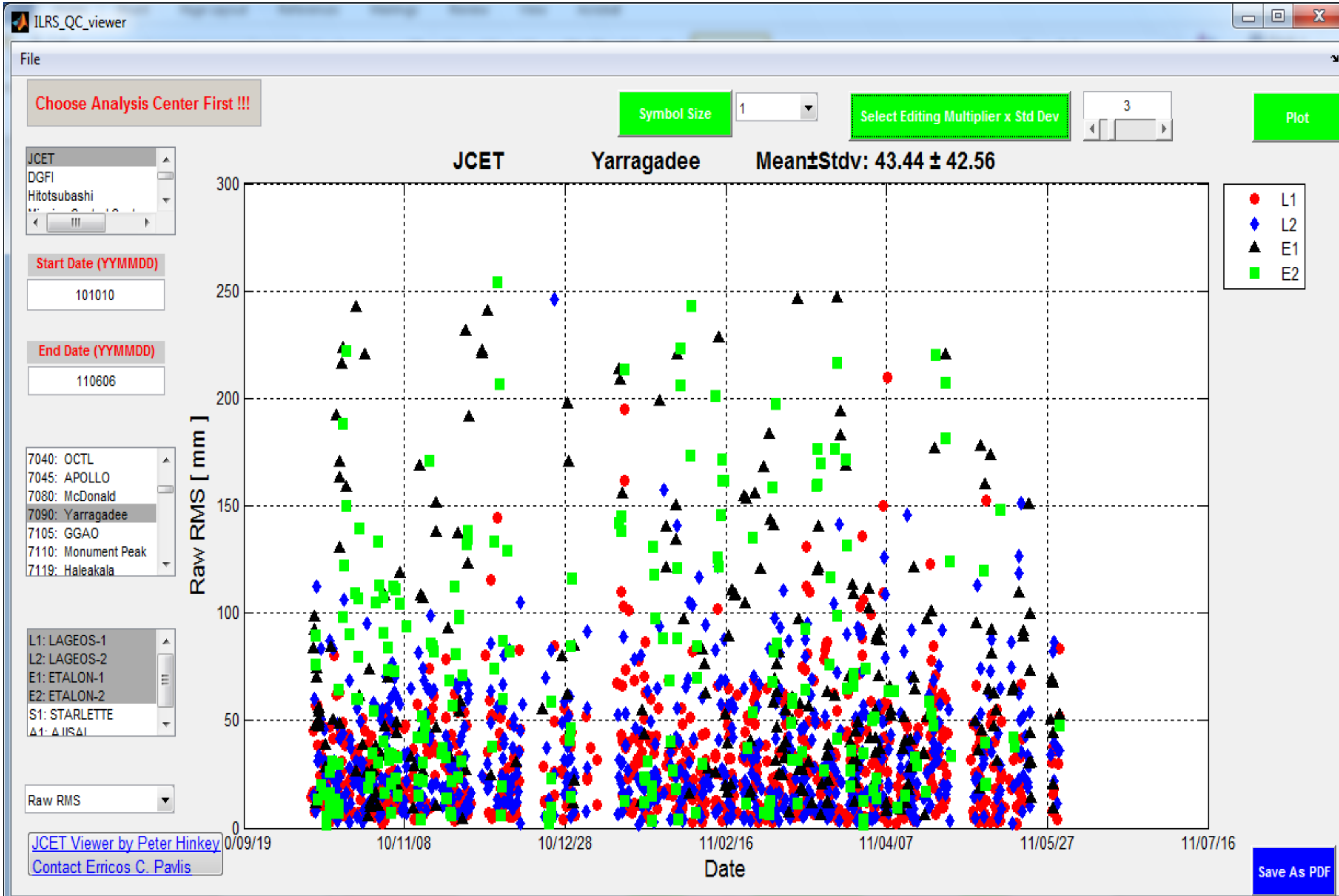



# WEEKLY BIAS SERIES

## CONTROL ENTRY WINDOW

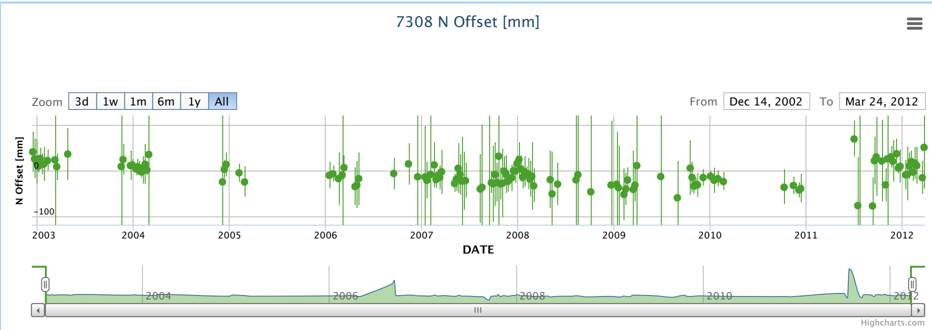
# ILRS QC Viewer GUI



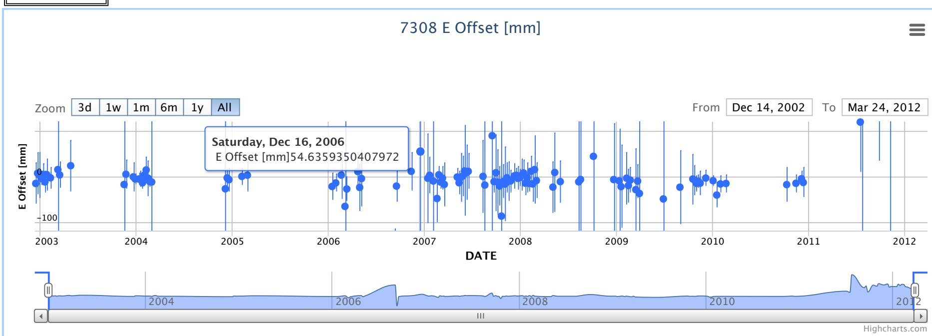
Resolution Needed Before ITRF2013 Reanalysis

# EARTHQUAKE AFFECTED SITES, TIME SERIES BRAKES, ETC.

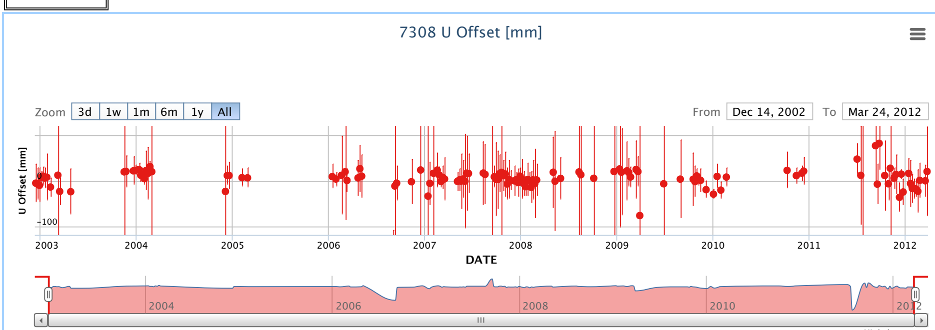
# KOGANEI 7308




Statistics

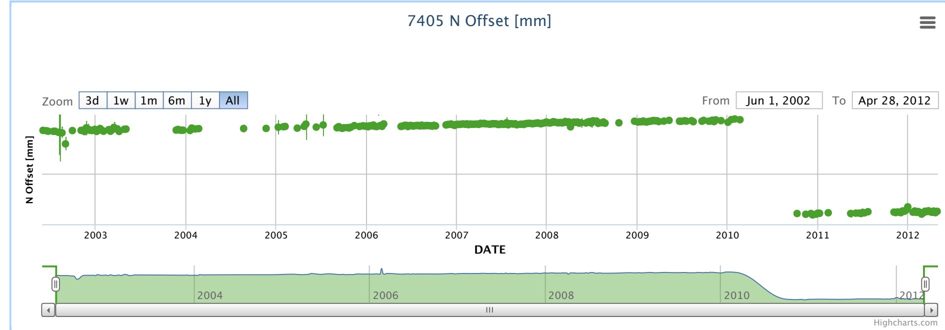



Statistics

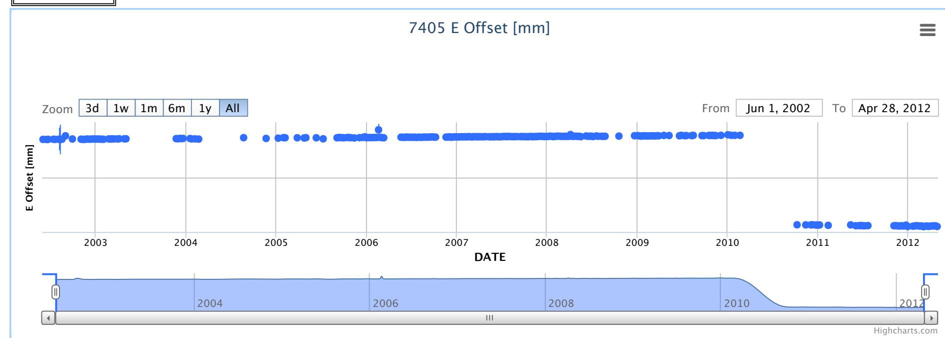



HOME | New Plot | Download Data | Statistics

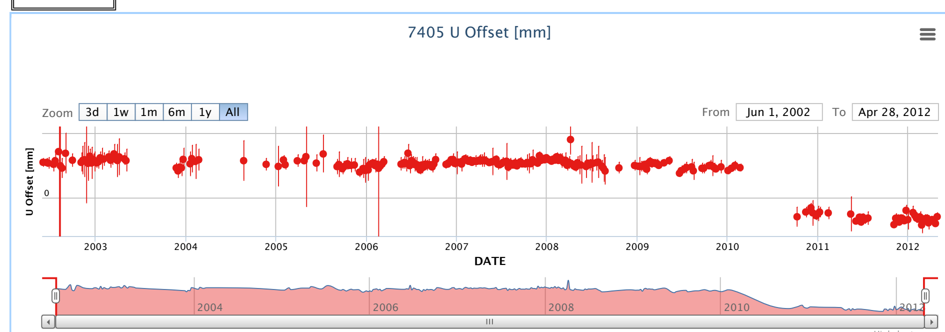
# CONCEPCION 7405




Statistics




Statistics

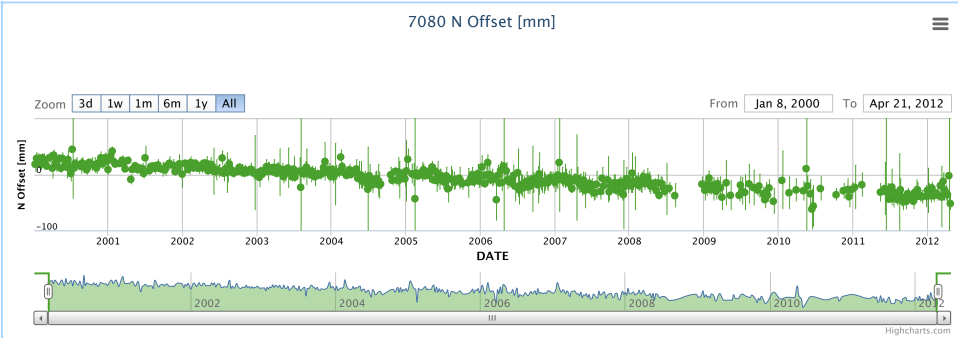



HOME | New Plot | Download Data | Statistics

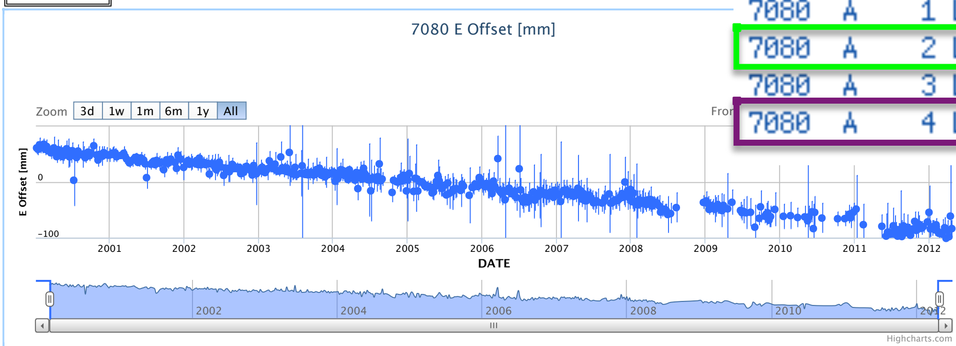
# MLRS 7080 POSITION (NEU)

## WEEKLY PRODUCT SERIES

## BREAKs INTRODUCED BY ITRS?



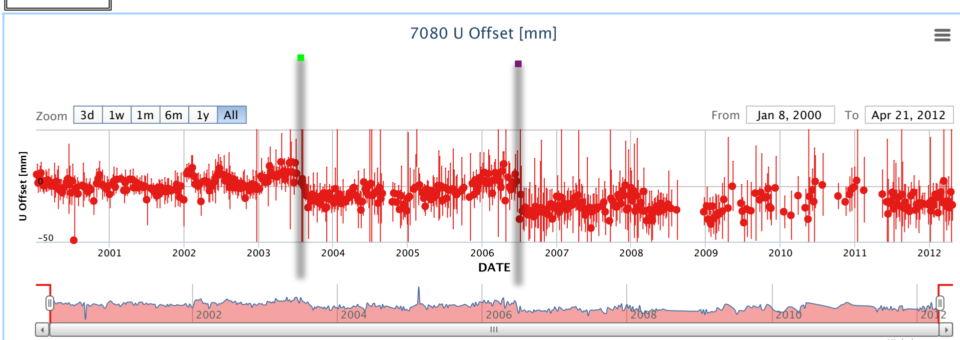

Statistics




```
7080  A    1 L 00:000:00000 96:034:00000 P -
7080  A    2 L 96:034:00000 03:217:00000 P - change of flashlamps
7080  A    3 L 03:217:00000 06:175:00000 P -
7080  A    4 L 06:175:00000 00:000:00000 P -
```

?

Statistics




HOME | New Plot | Download Data | Statistics

# SINEX ISSUE WITH ESA SUBMISSIONS

```
##################################
# Original Domes numbers
##################################

From esa.pos+eop.110419.v123.snx

+SITE/ID
*CODE PT DOMES____ T STATION_DESC
1879  A 12372S001 L 1879, UKRAINE
1884  A 12302S002 L RIGA, LATVIA
7080  A 40442M006 L FORT DAVIS, U
7090  A 50107M001 L YARRAGADEE, A
7105  A 40451M105 L WASHINGTON, U
7110  A 40497M001 L MONUMENT PEAK
7237  A 21611S001 L CHANGCHUN, CH
7358  A 21749S001 L TANEGASHIMA I
7810  B 14001S007 L ZIMMERWALD, S
7821  A 21605S010 L SHANGHAI, CHI
7825  A 50119S003 L MOUNT STROMLO
7838  A 21726S001 L SIMOSATO, JAP
7839  A 11001S002 L GRAZ LUSTBUEH
7840  A 13212S001 L HERSTMONCEUX,
7841  A 14106S011 L POTSDAM, GERM
7845  A 10002S002 L GRASSE, FRANC
7941  A 12734S008 L MATERA, I
8834  A 14201S018 L WETTZELL
-SITE/ID
```

```
#############################################
# Domes numbers changed on April 20, 2011
#############################################

From esa.pos+eop.110420.v123.snx

+SITE/ID
*CODE PT DOMES____ T STATION_DESCRIPTION___ APPROX_LON_ APPROX_LAT_ _APP_H_
1884  A 12302S002 L RIGA, LATVIA             24  3 32.7  56 56 54.8    31.6
7080  A 40442M306 L FORT DAVIS, USA         255 59  5.3  30 40 49.0  2006.5 ***
7110  A 40497M001 L MONUMENT PEAK, USA      243 34 38.4  32 53 30.3  1842.7
7237  A 21611S001 L CHANGCHUN, CHINA        125 26 36.5  43 47 25.8   274.6
7358  A 21749S001 L TANEGASHIMA ISLAN, JAP  131  0 55.5  30 33 23.4   141.8
7810  B 14001S007 L ZIMMERWALD, SWITZERLAN    7 27 54.8  46 52 38.0   951.8
7821  A 21605S010 L SHANGHAI, CHINA         121 11 11.8  31  5 45.9   100.4
7825  A 50119S003 L MOUNT STROMLO, AUSTRAL  149  0 35.6 -35 18 58.1   805.4
7838  A 21726S101 L SIMOSATO, JAPAN         135 56 13.3  33 34 39.7   102.1 ***
7839  A 11001S202 L GRAZ LUSTBUEHEL, AUSTR   15 29 36.1  47  4  1.7   539.8 ***
7840  A 13212S001 L HERSTMONCEUX, UNITED K    0 20 10.1  50 52  2.6    75.8
7841  A 14106S011 L POTSDAM, GERMANY         13  3 41.2  52 22 58.8   127.8
7845  A 10002S102 L GRASSE, FRANCE            6 55 17.7  43 45 16.7  1323.8 ***
7941  A 12734S008 L MATERA, ITALY            16 42 16.6  40 38 55.2   537.4
8834  A 14201S118 L WETTZELL, GERMANY        12 52 40.8  49  8 39.9   665.8 ***
-SITE/ID
```

```
Stations found in later files
7124  A 92201M107 L PAPEETE (TAHITI), TAHI 210 23 37.6 -17 34 36.5    98.0 ***
7403  A 42202M503 L AREQUIPA, PERU         288 30 25.3 -16 27 56.6  2492.0 ***

Should be
7124  A 92201M007 L ....
7403  A 42202M003 L ....

Starts on 110420 through 110729, versions v23, v30, v123, v130
          111016 through 120327, versions v30, v130
          120714 through 130327, versions v40, v130
```

# LLR Status Report
# - 2013 -

**Jürgen Müller**

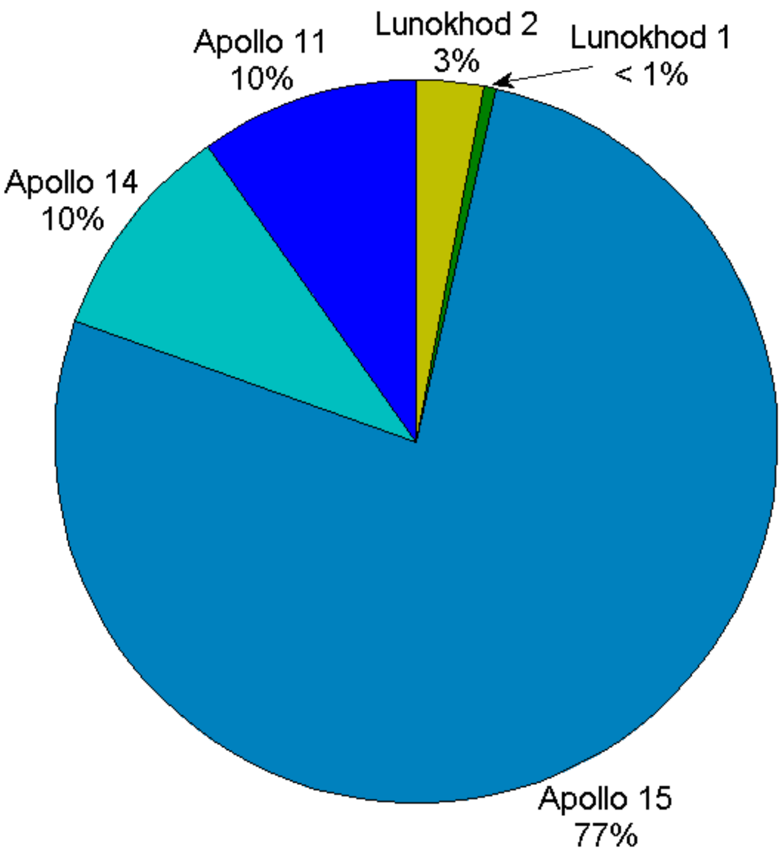
**Institut für Erdmessung (Institute of Geodesy) and**

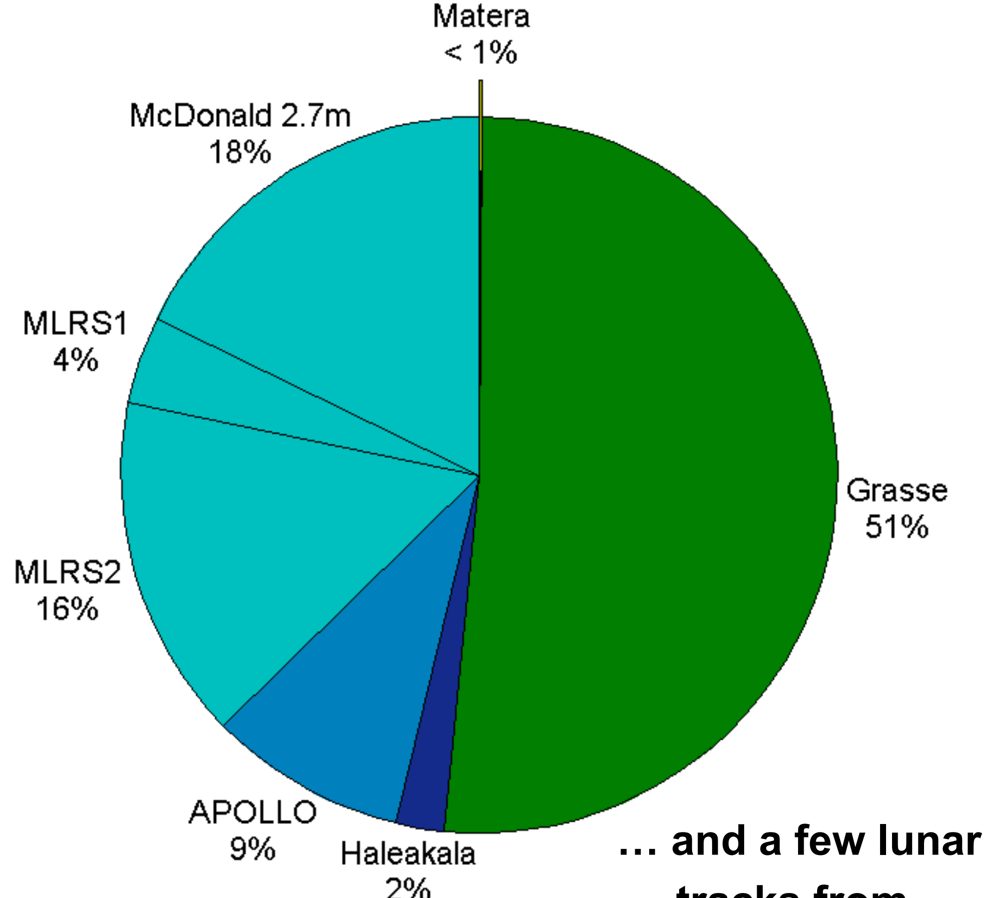
**Center of Excellence QUEST**
**(Quantum Engineering and Space-Time Research)**

**Leibniz Universität Hannover (University of Hannover)**

# Statistics – retro-reflectors and observatories

Time span **1970-2012**



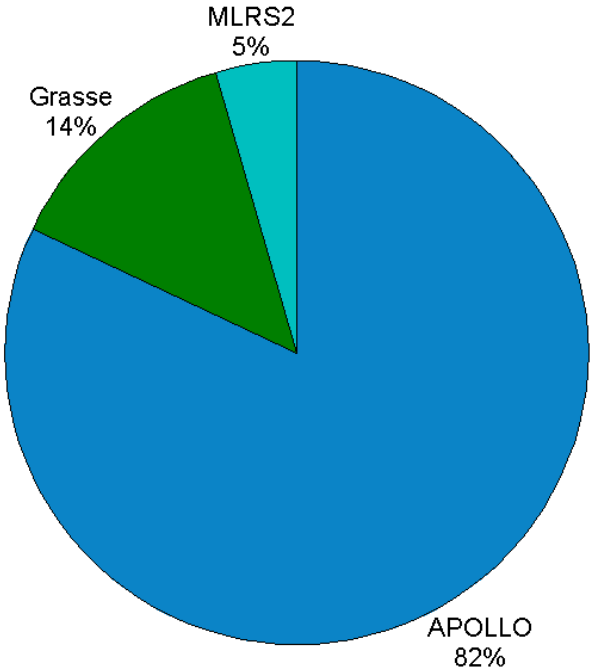

about 17,700 normal points

… and a few lunar tracks from

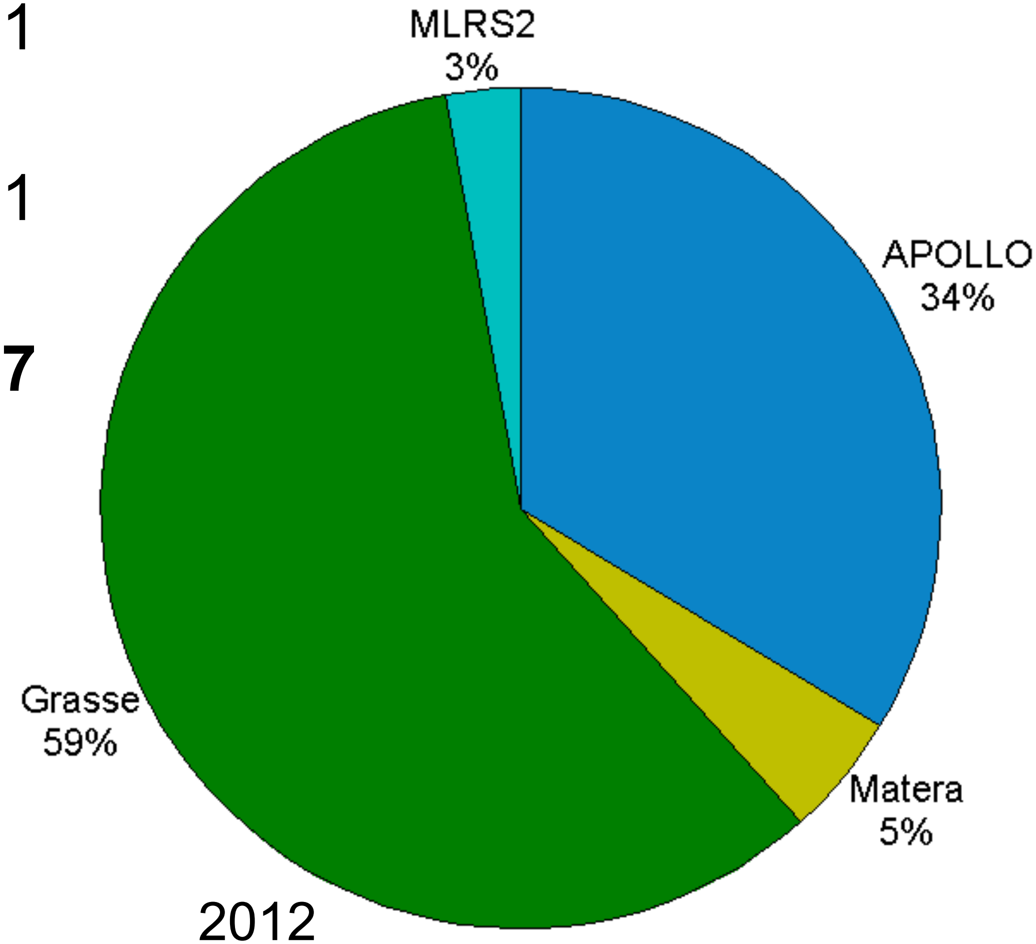
- **Orroral**
- **Wettzell**

# Statistics – observatories 2012

| Normal points | *2011* | 2012 |
|---|---|---|
| APOLLO | *364* | 201 |
| McDonald | *20* | 17 |
| Grasse | *60* | 351 |
| Matera | *(3)* | 28 |
| **In total** | ***444*** | **597** |




2011




2012

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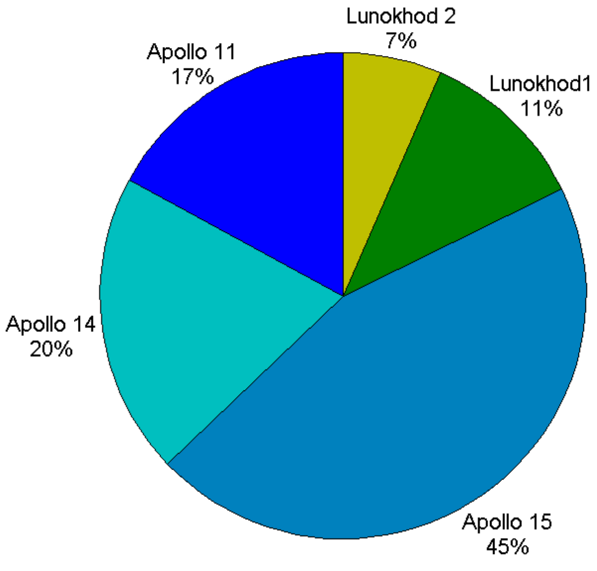
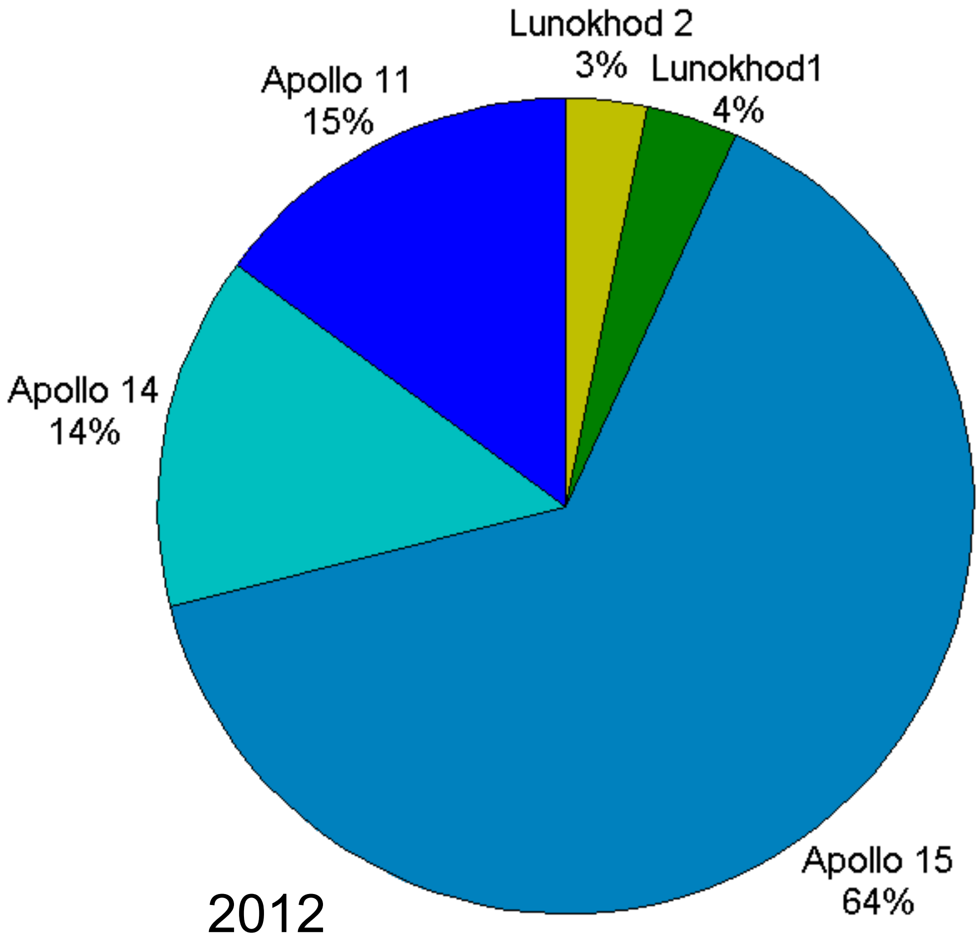
# Statistics – retro-reflectors 2012

| **Normal points** | ***2011*** | **2012** |
|---|---|---|
| Apollo 11 | *76* | 89 |
| Apollo 14 | *89* | 84 |
| Apollo 15 | *200* | 383 |
| Lunokhod 1 | *50* | 22 |
| Lunokhod 2 | *29* | 19 |
| **In total** | ***444*** | **597** |




2011




2012

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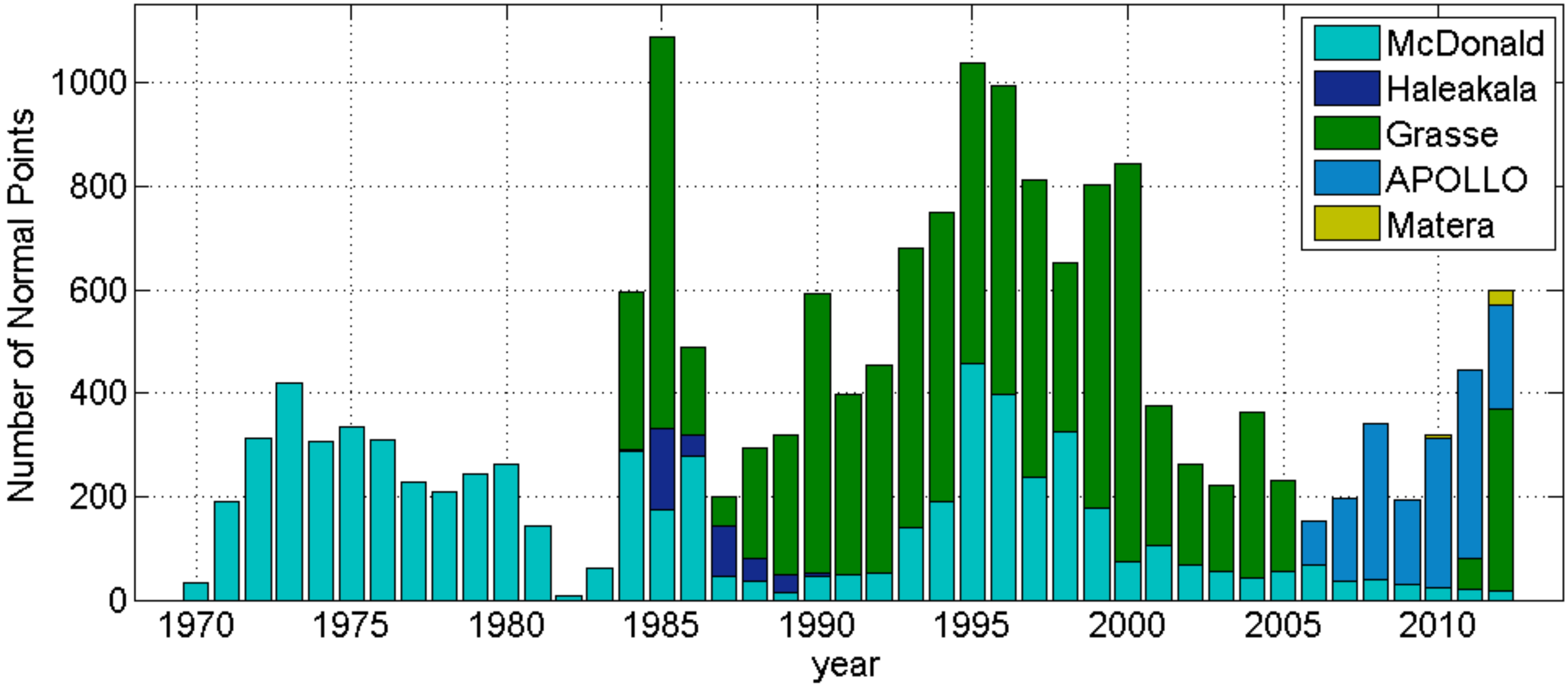
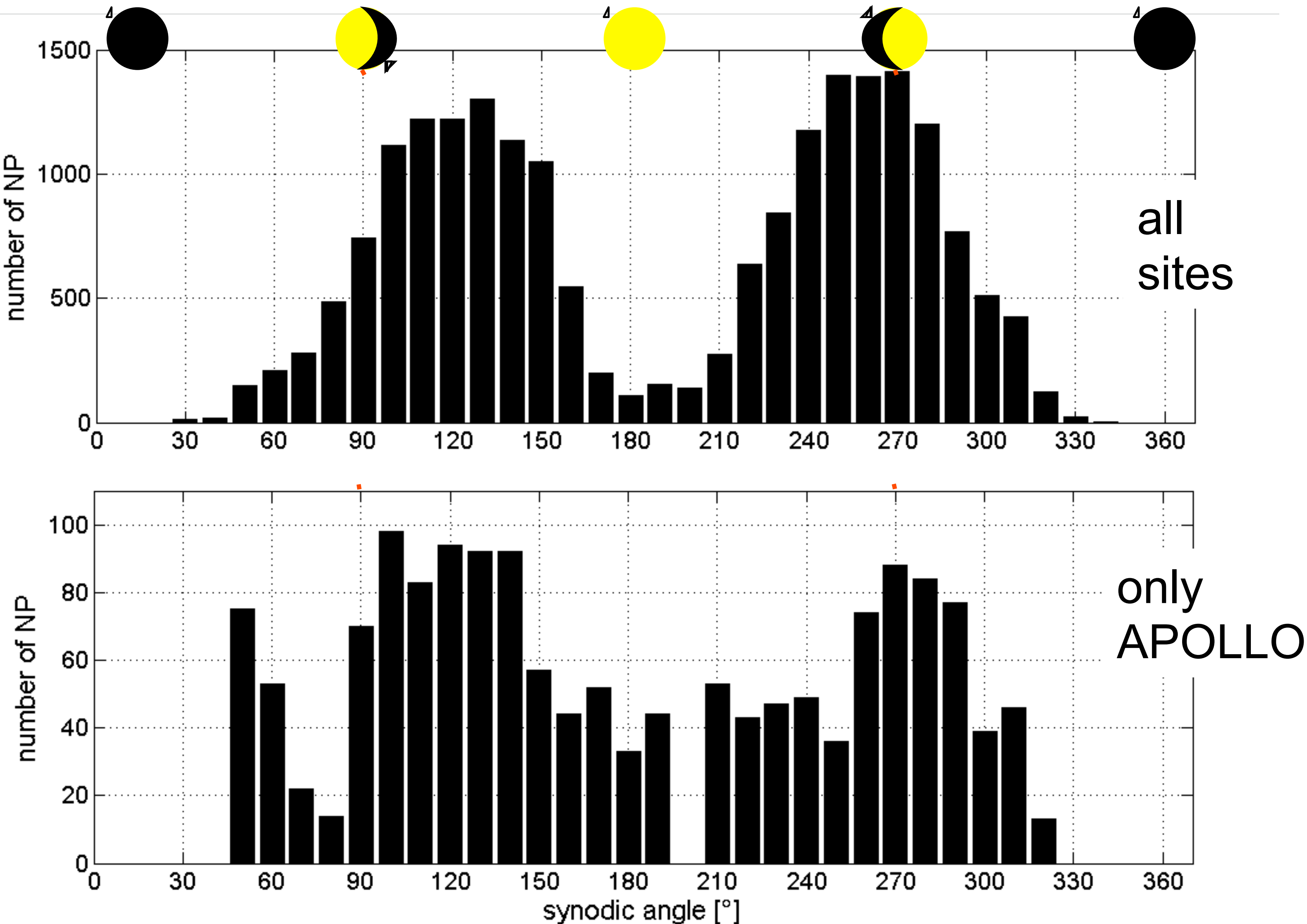
# Number of normal points

1970 - 2012: ca.17,700 normal points

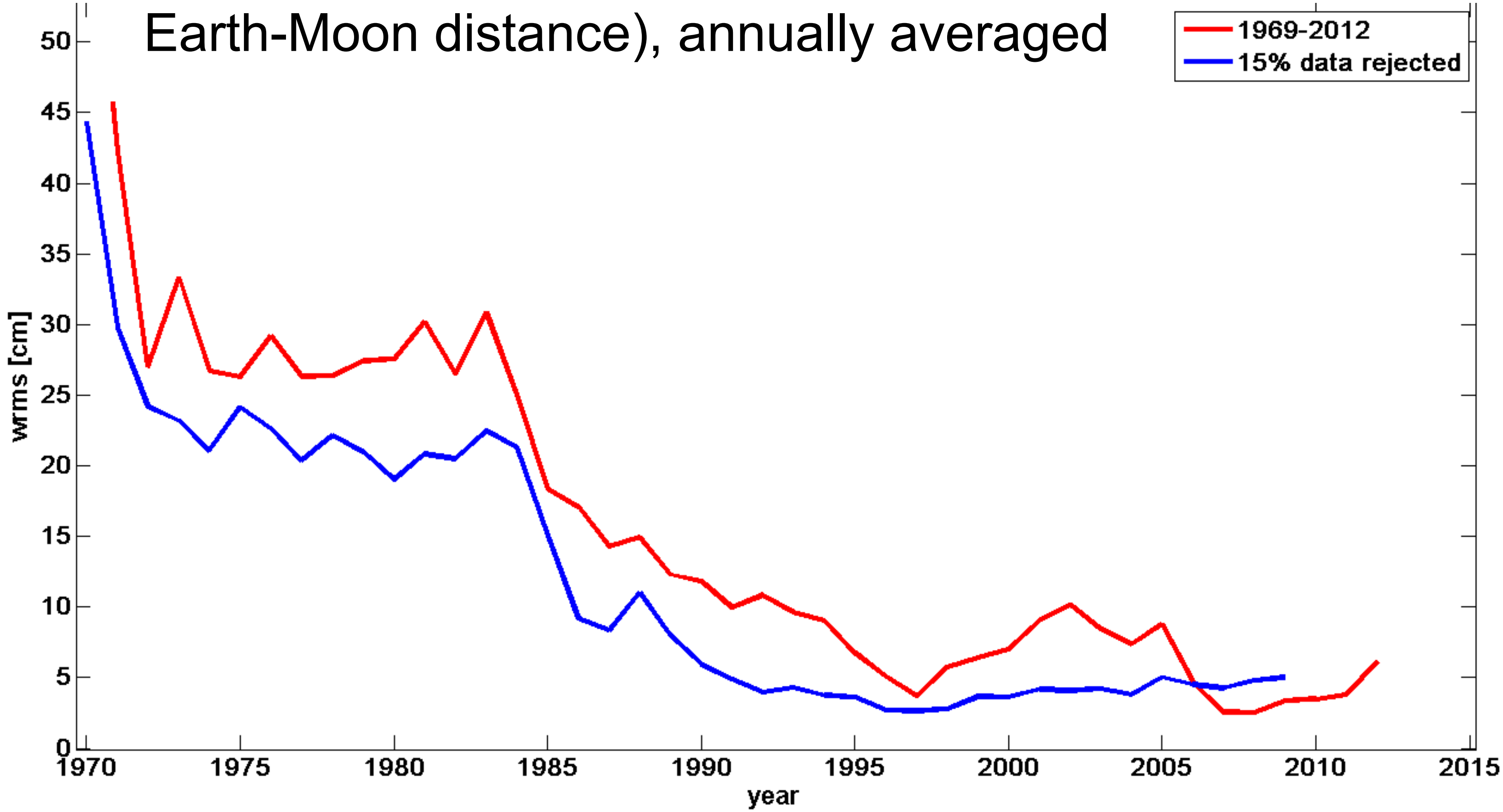


# Distribution of observations per synodic month

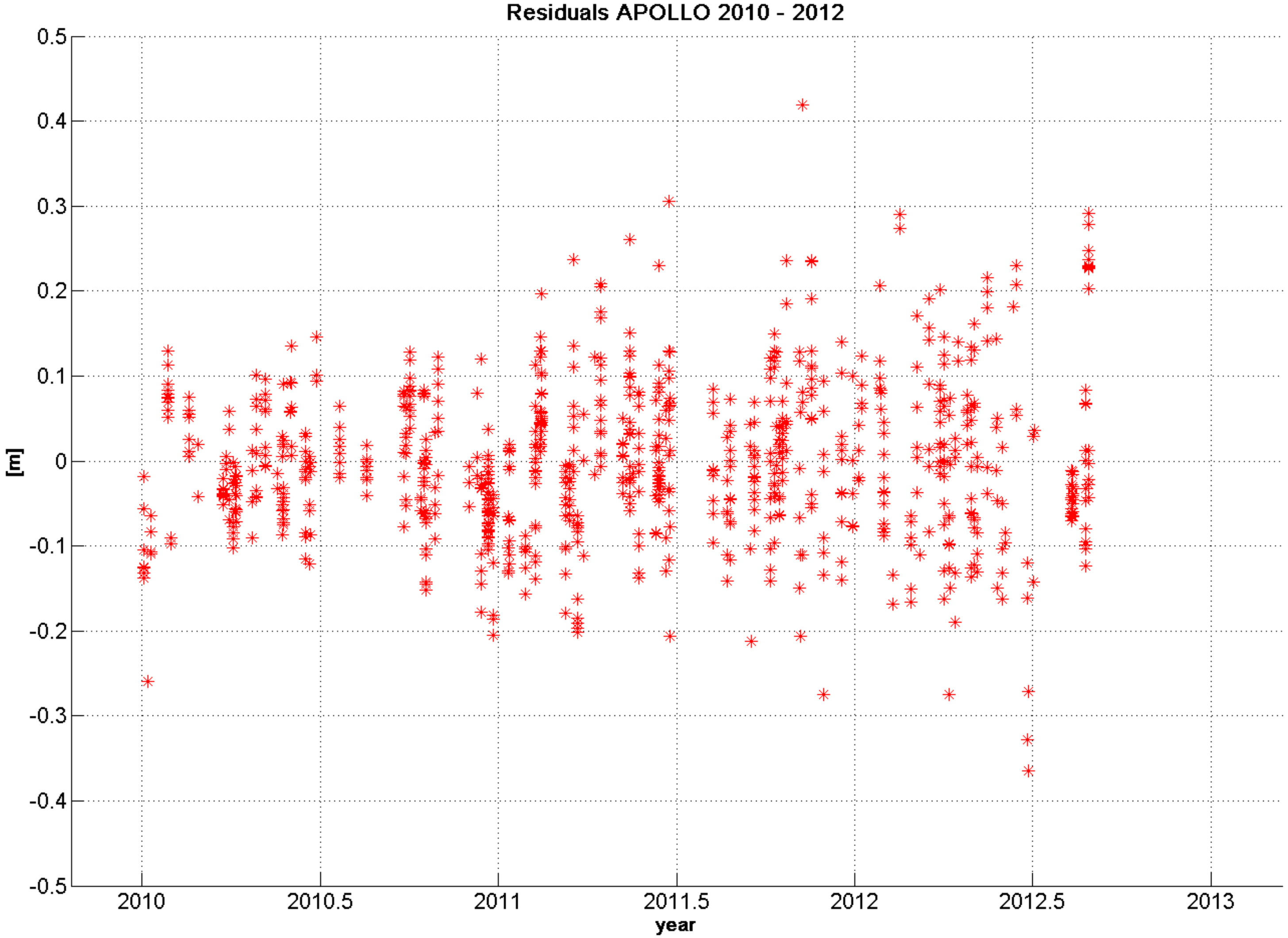


# Weighted annual residuals

weighted residuals (observed - computed Earth-Moon distance), annually averaged



# Residuals of APOLLO




Outliers removed

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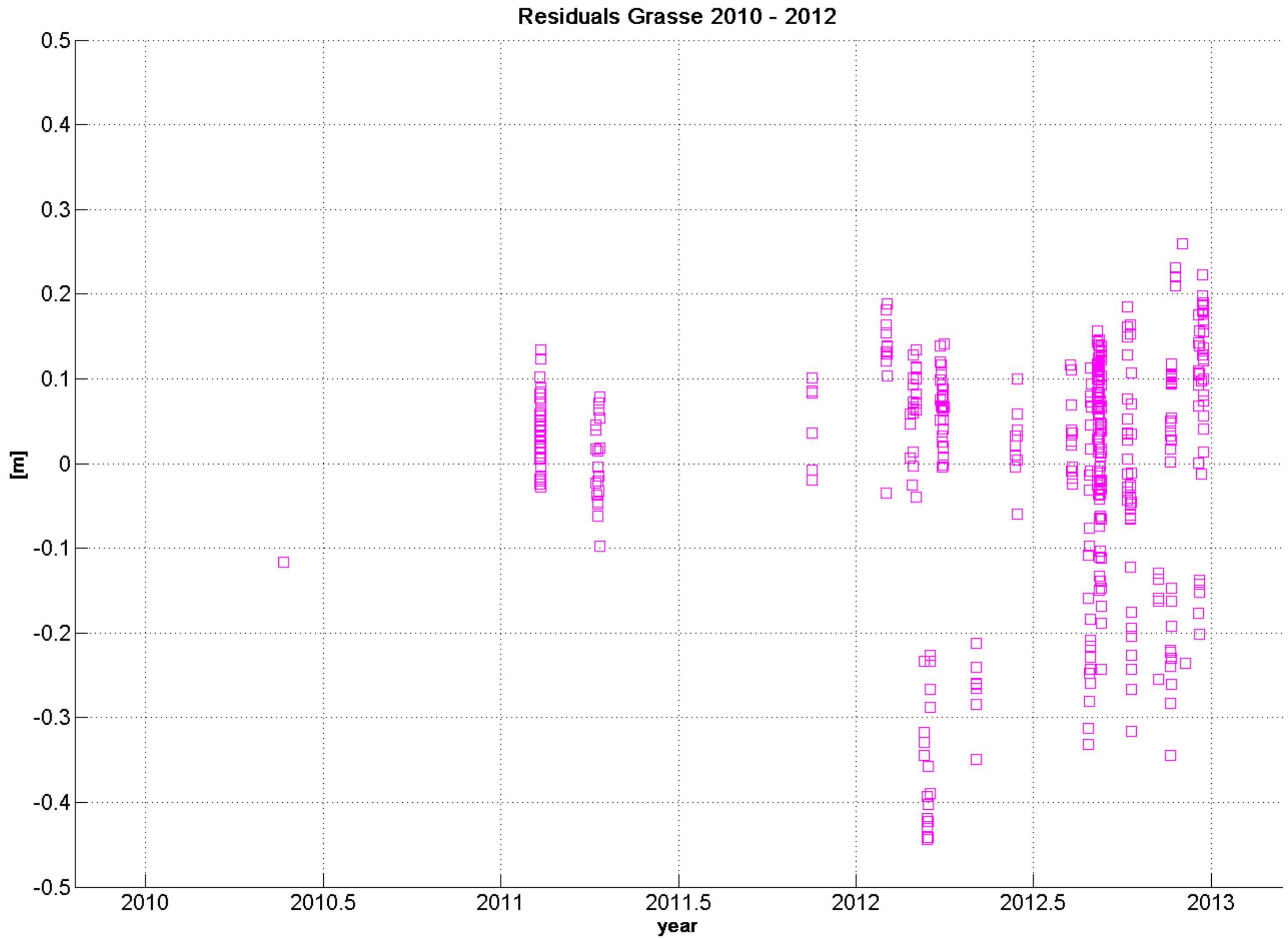
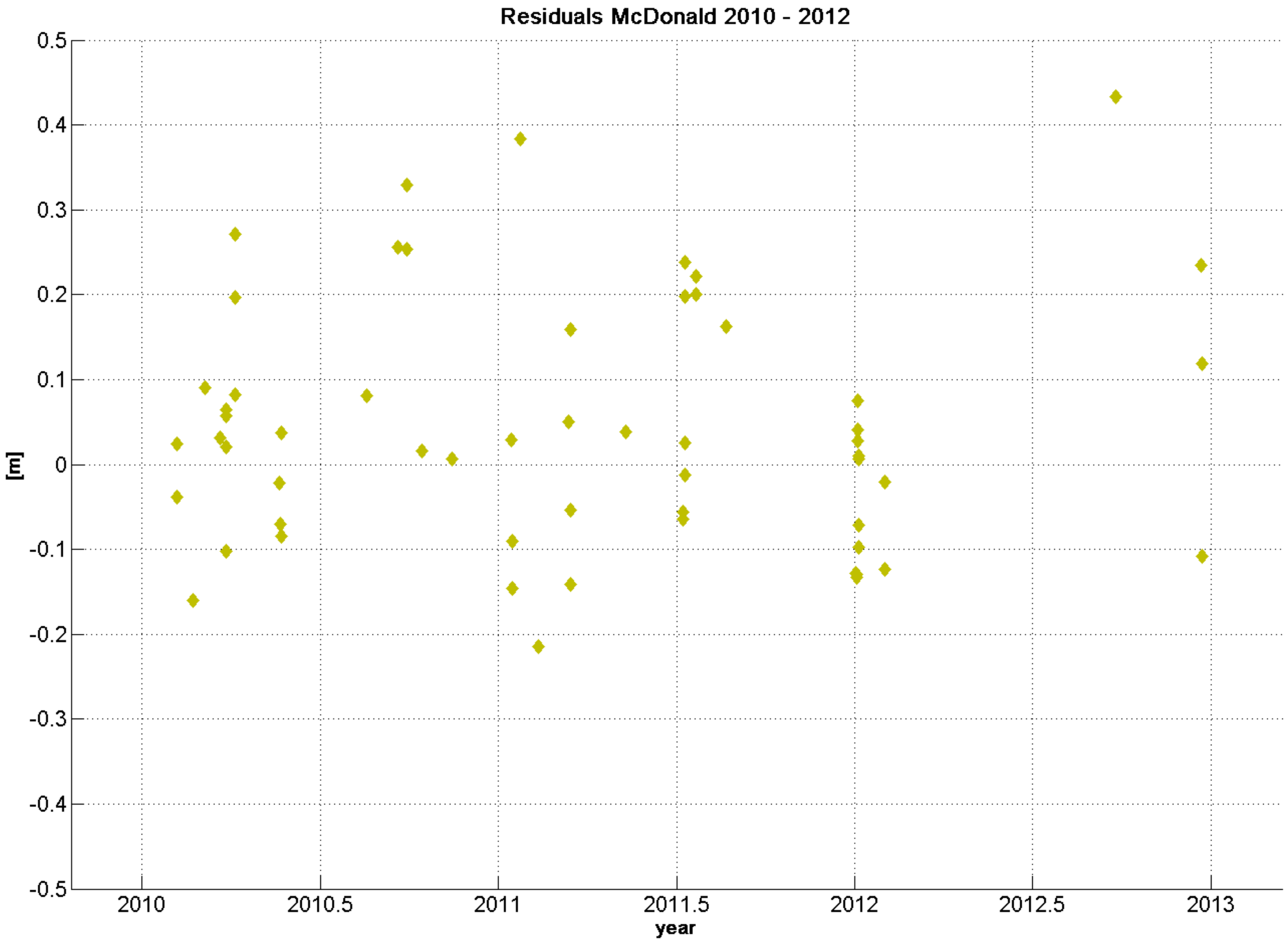
# Residuals of OCA, Grasse



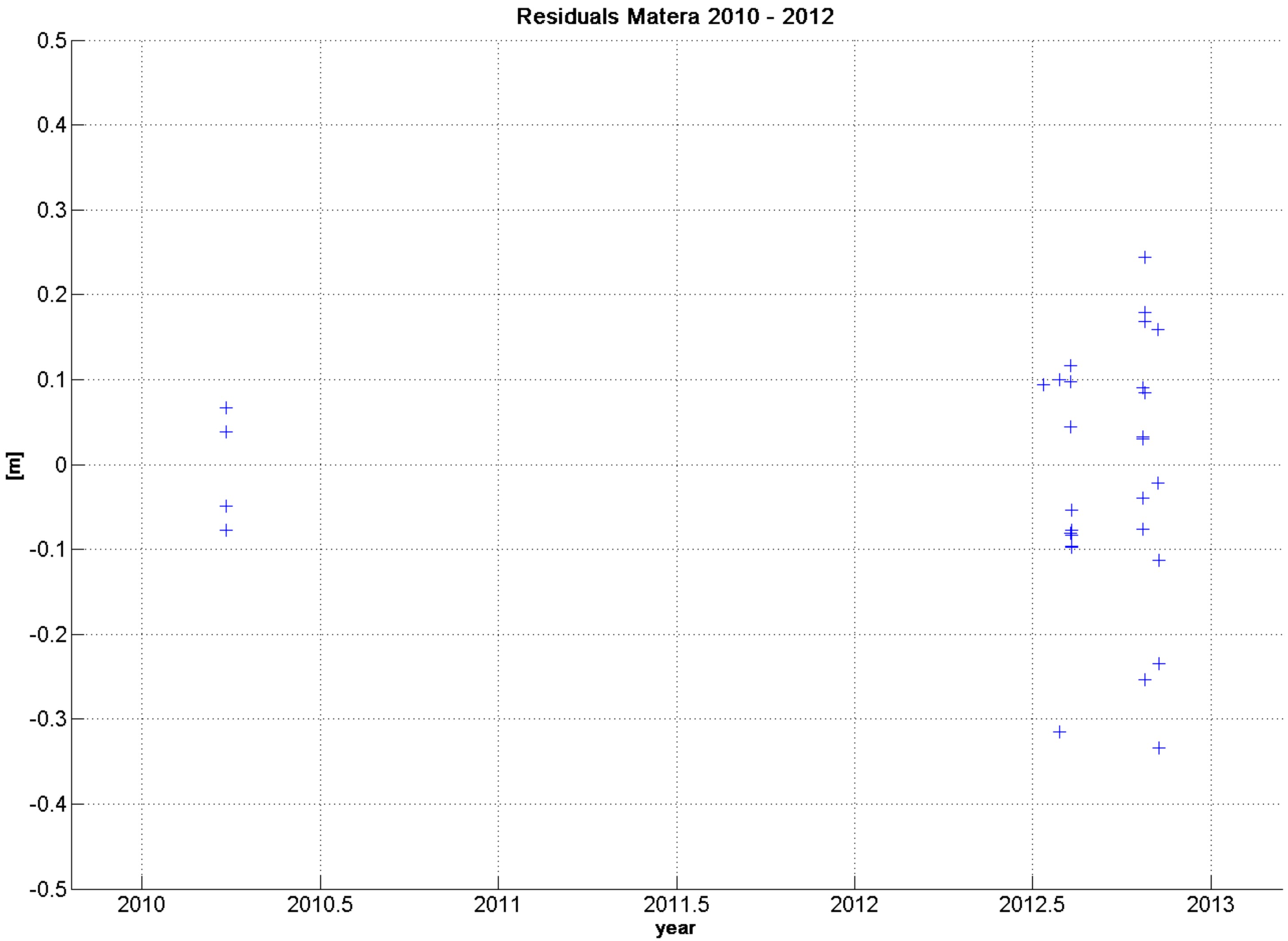

Outliers removed

# Residuals of McDonald




Outliers removed

# Residuals of Matera



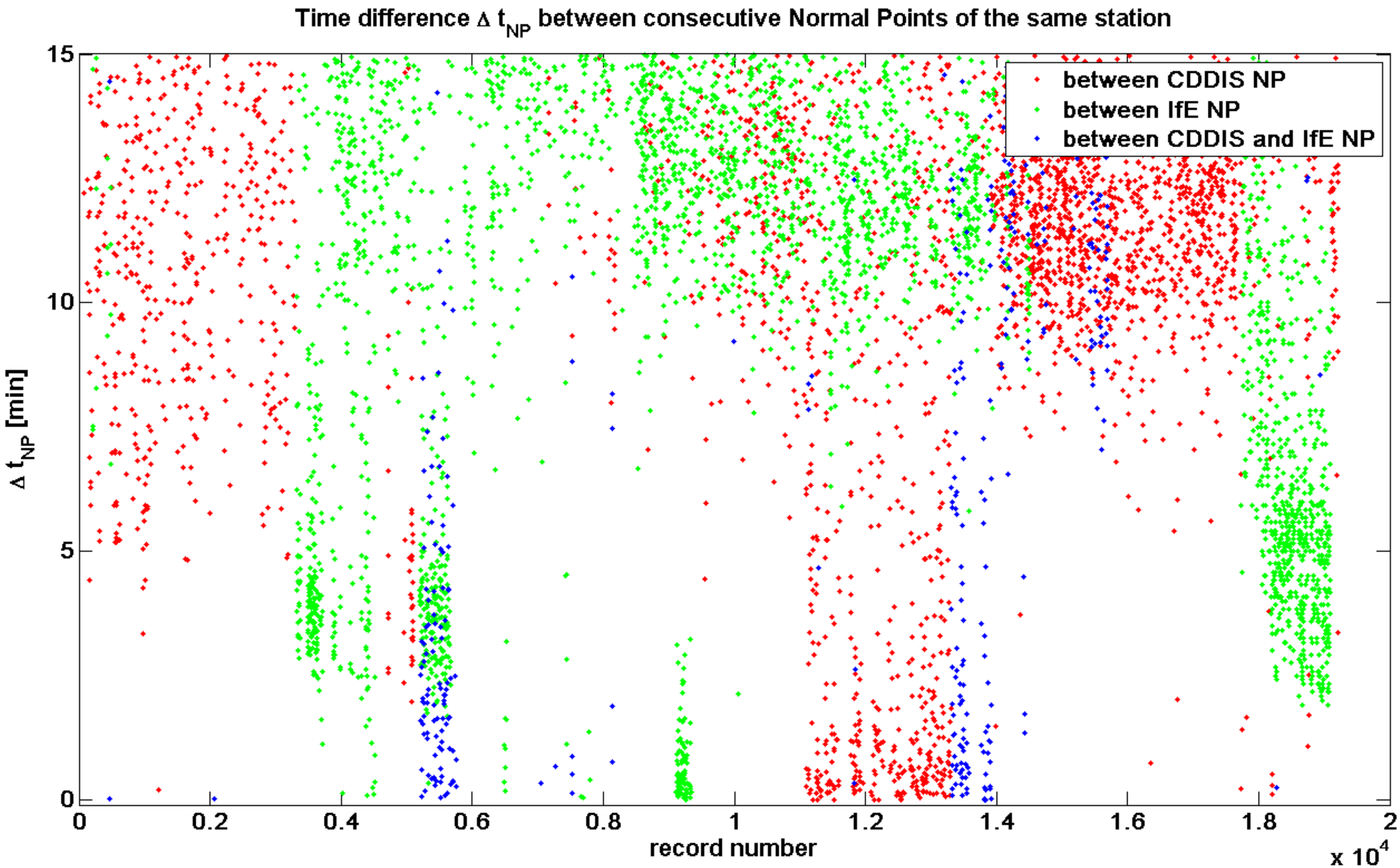

Outliers removed

# Remarks on LLR Normal Points (NP)

Normal points in CDDIS, EDC and LLR AC data archives are neither complete nor identical?

- Example: IfE data base has 17700 NP, CCDIS 11000 NP
  → Merging data sets from IfE, JPL, SYRTE, CDDIS
- Many „doubled“ points with small differences
  -Laser transmission time
  -Light travel time
  … probably because old NP have not been replaced, after NP re-processing at the sites.
- Which normal point is „correct“?
  -~ 20000 NP with Δ laser transmission time > 1s
  → Careful data screening

# Time interval between normal points



# Major LLR-related activities

- Comparison of LLR software (Boston workshop), ongoing work between CfA (PEP)*, Paris (INPOP) and Hannover
- **Potential use of LLR in ITRF2013 solution (tests with DGFI …)**
- Own LLR part on new ILRS website with links to LLR sites, lunar AC's, French website for data qualification, etc.
- ESA plans for Lunar impact mission with Herschel satellite?
- Joint LLR paper in ILRS JoG special issue (subm., 2012), to be updated

*collaborating with INFN-LNF, Italy

# 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

# Report from SGF Herstmonceux Analysis Centre

Graham Appleby
Jose Rodriguez
SGF Herstmonceux, UK

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# Organisation

- In April 2013 SGF organisation changed from being based at NERC HQ to the NERC British Geological Survey (BGS)
- Fits well into the 'observatory' format of BGS, cf Hartland Magnetic Observatory, Seismic Observatories, etc.
- Maybe SGF -> Herstmonceux Space Geodetic Observatory

# General

- CoM files updated to include recent stations
- Contributed to CoM PP – half the solutions and correction files submitted – rest to follow
- Orbit files now routinely submitted
  - Jose worked on formatting the SP3c files
  - See his presentation on comparisons with other Acs

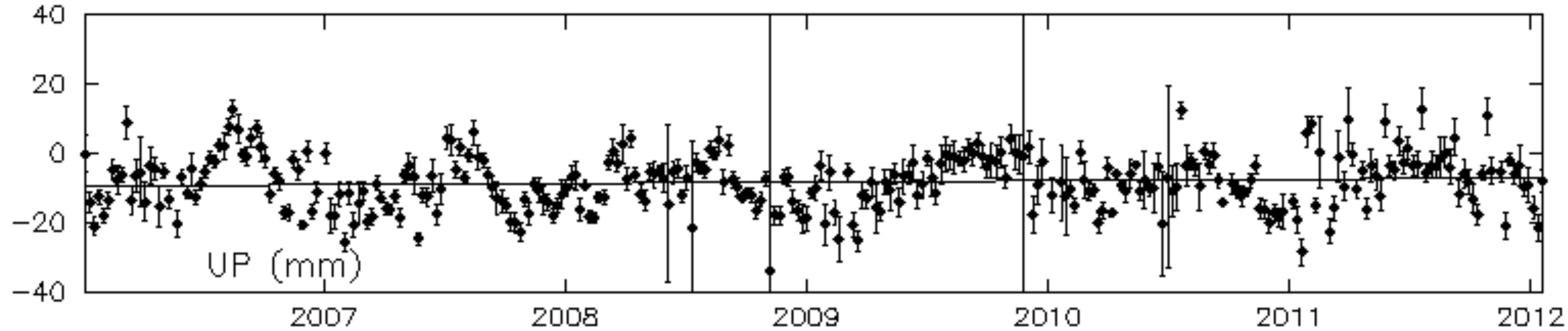
# Bias Issues

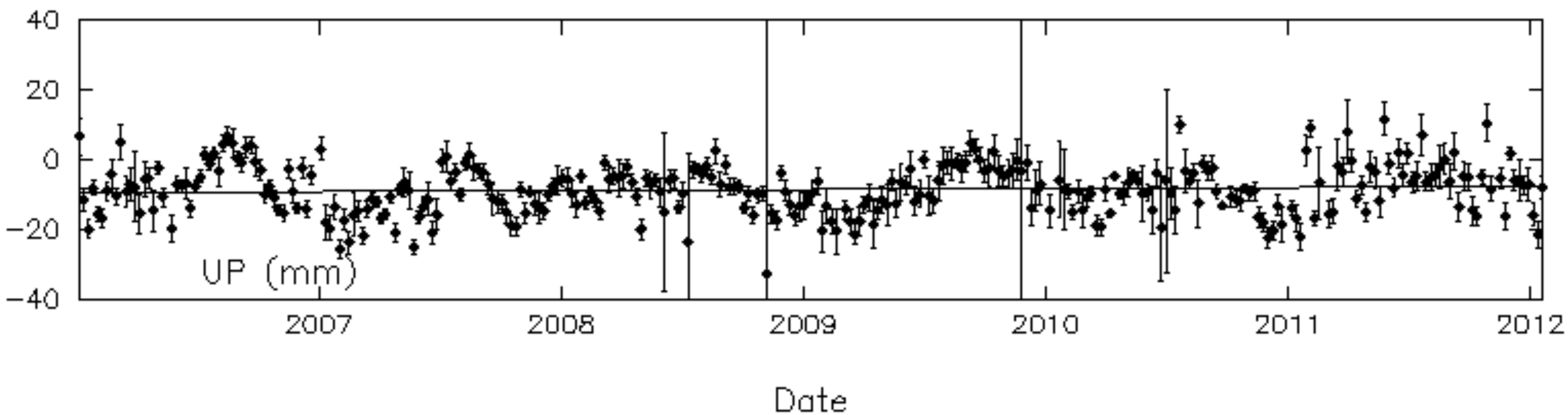
- Work carried out for AGU 2012 presentation:
- Solved for weekly RB for many of the major sites along with the TRF solutions:
- Some large biases for the ‘known bias’ stations
- But also few mm bias for the stations whose RB are not solved
  - E.g. YARR (7090) ~5mm, Graz (7839) 2mm, HERL (7840) ~0mm
- Discussion with Erricos about RB issues

# Predictions

- Continue with CPF production for many of the satellites
- Full comparison (xyz) between predictions from all providers
  – Results available daily on SGF and ILRS web

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



# Some brief notes on the sp3 orbits

José Rodríguez

NERC Space Geodesy Facility

April 6, 2013

# Briefly...

- NSGF uploading sp3c files since February
- Minor format issues identified
- Orbit comparison

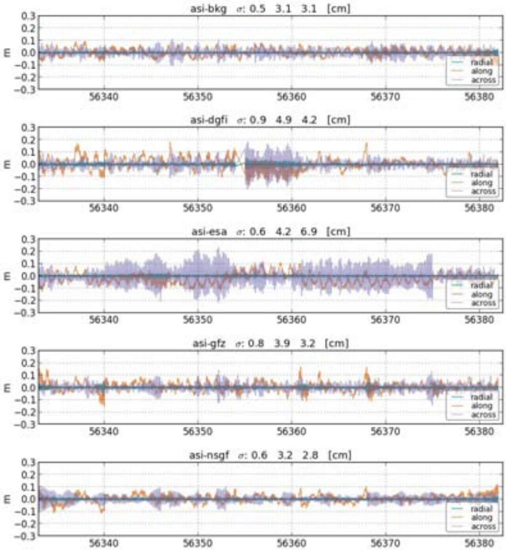
# Format issues

- JCET: two extra comment lines (first epoch header expected at line 23)
- BKG: non-integer seconds in epochs
- NSGF: velocity fields in wrong units!

# Orbit comparison

- Used orbits "as is" (no further rotations performed, assumed SLRF2008 frame)
- Rounded up BKG epochs
- Comparison on radial-along-across directions
- Period: 10/02/2013 – 30/03/2013

# Lageos-1

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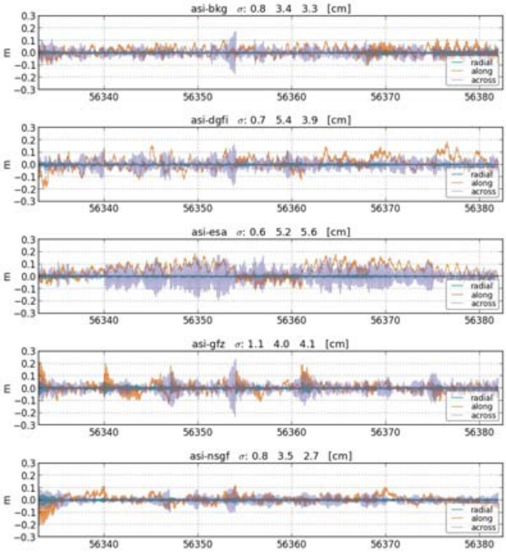
# Lageos-2

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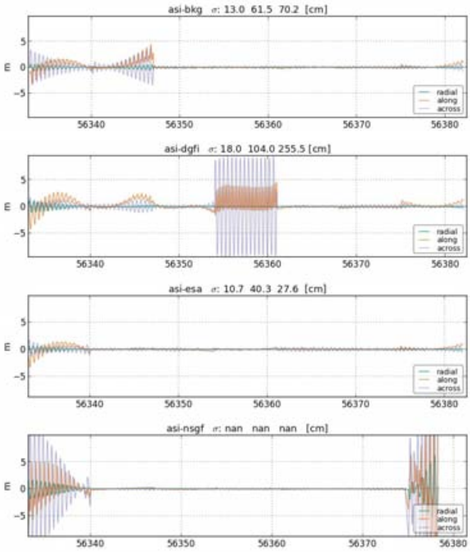
# Etalon-1

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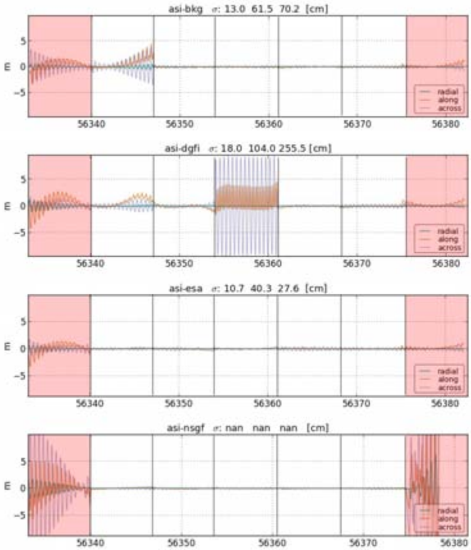
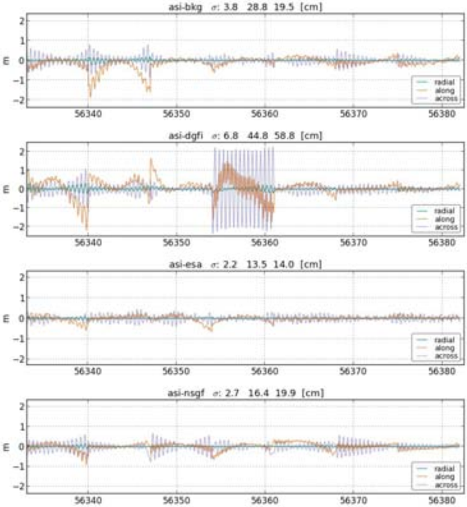
# Etalon-1

NP weekly average: 41 (173 for LGA)




NP at highlighted weeks: 19, 24

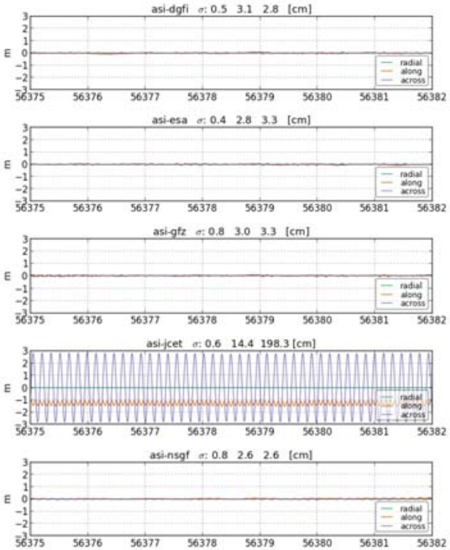
# Etalon-2


asi-bkg σ: 3.8 28.8 19.5 [cm]
asi-dgfi σ: 6.8 44.8 58.8 [cm]
asi-esa σ: 2.2 13.5 14.0 [cm]
asi-nsgf σ: 2.7 16.4 19.9 [cm]
m
radial
along
across
56340
56350
56360
56370
56380

# Something obvious missing?

- Disparity between JCET orbits and the rest of ACs, for both Lageos and Etalon
- Differences only present in X, Y coordinates (Z component in line with other orbits)
- Also, sporadic discontinuities in X, Y components

# Lageos-1

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# Conclusions

- Good agreement between ACs for Lageos
- Poor quality for Etalon satellites (big differences, obvious data discontinuities, incomplete weeks)
- However, some periods show much better figures for some ACs (∼2.5 cm radial, ∼15 cm along and across track)
- Seemingly different success for Etalon-1 and Etalon-2 (NP time distribution?)