ITRF2013 preparation

Model assessment

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(version: 15/10/2013)

Tests of various models on CONT11

Models

Standard	Current model	Proposed model	Recommandation	Comments
Gravity field	EIGEN-6S_c20corrected	EIGEN-6S.V5	Yes	Soon available at ICGEM
Atmospheric gravity	6hr grids from ECMWF (IB for ocean)	3hr grids ERA-interim + TUGO R12	Yes	Grids available (see JML's email), except 2013
Tides	FES2004	FES2012	Yes	See LEGOS's web site
Atmospheric density	DTM94bis	DTM2012	-	
Tropospheric gradients	Not applied	one daily tropospheric gradient per station in North & East directions	Yes	
Antenna phase law	None	ALCATEL: manufacturer PL STAREC: CNES PL 2013	Yes	

Each model tested on CONT11 period = GPS weeks 1653, 1654, 1655
Satellites: Spot4, Spot5, Jason2, Cryosat2 and Envisat

Tests of various models

DORIS RMS average
SPOT-4: 3 weeks, 5 arcs

Spot-4	DORIS RMS (mm/s)
(3) = all new proposed models except DTM2012	**0,371783**
(2) = all new proposed models	0,372174
(1) + gradients applied	0,373279
(1) + phase law applied	0,378999
(1) with EIGEN6s2v5 instead of current model	0,380004
(1) with 3hr grids ERA-interim + TUGO R12 instead of current model	0,38008
(1) with FES2012 instead of current model	0,380126
(1) = with current models	**0,380281**
(1) with DTM2012 instead of current model	**0,380631**

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Tests of various models

DORIS RMS average
SPOT-5: 3 weeks, 6 arcs

Spot-5	DORIS RMS (mm/s)
(3) = all new proposed models except DTM2012	**0,338075**
(2) = all new proposed models	0,338752
(1) + gradients applied	0,338756
(1) with 3hr grids ERA-interim + TUGO R12 instead of current model	0,344669
(1) + phase law applied	0,344915
(1) with EIGEN6s2v5 instead of current model	0,345036
(1) with FES2012 instead of current model	0,345256
(1) = with current models	**0,345274**
(1) with DTM2012 instead of current model	**0,346738**

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Tests of various models

DORIS RMS average
ENVISAT: 3 weeks, 7 arcs

Envisat	DORIS RMS (mm/s)
(3) = all new proposed models except DTM2012	**0,367168**
(2) = all new proposed models	0,368173
(1) + gradients applied	0,368192
(1) + phase law applied	0,373135
(1) with 3hr grids ERA-interim + TUGO R12 instead of current model	0,373276
(1) with EIGEN6s2v5 instead of current model	0,373423
(1) with FES2012 instead of current model	0,373621
(1) = with current models	**0,373884**
(1) with DTM2012 instead of current model	**0,375449**

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Tests of various models

DORIS RMS average
CRYOSAT-2: 3 weeks, 6 arcs

Cryosat-2	DORIS RMS (mm/s)
(3) = all new proposed models except DTM2012	**0,33503**
(2) = all new proposed models	0,337236
(1) + gradients applied	0,337546
(1) + phase law applied	0,341532
(1) with EIGEN6s2v5 instead of current model	0,342329
(1) with 3hr grids ERA-interim + TUGO R12 instead of current model	0,342346
(1) with FES2012 instead of current model	0,342553
(1) = with current models	**0,342712**
(1) with DTM2012 instead of current model	**0,345713**

Tests of various models

DORIS RMS average
JASON-2: 3 weeks, 6 arcs

Jason-2	DORIS RMS (mm/s)
(3) = all new proposed models except DTM2012	**0,310891**
(1) + gradients applied	0,312282
(2) = all new proposed models	0,312381
(1) with EIGEN6s2v5 instead of current model	0,315557
(1) + phase law applied	0,317078
(1) = with current models	**0,317562**
(1) with FES2012 instead of current model	0,317594
(1) with 3hr grids ERA-interim + TUGO R12 instead of current model	0,318299
(1) with DTM2012 instead of current model	**0,31922**

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Tests of various models

SLR RMS average
ENVISAT: 3 weeks, 7 arcs

Envisat	SLR RMS (m)
(3) = all new proposed models except DTM2012	**0,0104374**
(2) = all new proposed models	0,0107453
(1) + gradients applied	0,0108531
(1) with EIGEN6s2v5 instead of current model	0,0109799
(1) with FES2012 instead of current model	0,011163
(1) with 3hr grids ERA-interim + TUGO R12 instead of current model	0,0112684
(1) = with current models	**0,0114144**
(1) + phase law applied	0,0114323
(1) with DTM2012 instead of current model	**0,0117714**

Tests of various models

SLR RMS average
CRYOSAT-2: 3 weeks, 6 arcs

Cryosat-2	SLR RMS (m)
(3) = all new proposed models except DTM2012	**0,0105843**
(2) = all new proposed models	0,0108437
(1) with EIGEN6s2v5 instead of current model	0,0119068
(1) + gradients applied	0,0123808
(1) with 3hr grids ERA-interim + TUGO R12 instead of current model	0,012641
(1) with FES2012 instead of current model	0,0127468
(1) + phase law applied	0,0128382
(1) = with current models	**0,0128573**
(1) with DTM2012 instead of current model	**0,0132713**

Tests of various models

SLR RMS average
JASON-2: 3 weeks, 6 arcs

Jason-2	SLR RMS (m)
(3) = all new proposed models except DTM2012	**0,0159112**
(1) with EIGEN6s2v5 instead of current model	0,0161575
(1) + gradients applied	0,017236
(2) = all new proposed models	0,0172893
(1) = with current models	**0,0175445**
(1) + phase law applied	0,0175503
(1) with FES2012 instead of current model	0,0175572
(1) with 3hr grids ERA-interim + TUGO R12 instead of current model	0,0182197
(1) with DTM2012 instead of current model	**0,0188173**

Tests of various models

Positioning performances
3 weekly multi-satellite solutions CONT11
Comparison to DPOD2008

Week #1653	stations #	3D-rms (mm)	N rms	E rms	U rms	N std	E std	U std	N mean	E mean	U mean
(1) + phase law applied	45	16,5	13,8	18,7	16,8	13,8	18,7	16,8	-0,9	0,1	0
(1) = with current models	**45**	**16,7**	**13,8**	**18,8**	**17**	**13,7**	**18,8**	**17**	**-0,9**	**0,1**	**0**
(3) = all new proposed models except DTM2012	45	11,9	8	11,7	15	7,8	11,7	15	-2	0,1	0
(1) + gradients applied	45	12,5	8,3	12,8	15,5	7,9	12,8	15,5	-2,6	0	0
Week #1654											
(1) + phase law applied	47	14,6	11,7	17,2	14,3	11,7	17,2	14,3	0,8	-0,6	0
(1) = with current models	**47**	**14,2**	**11,6**	**16,8**	**13,9**	**11,6**	**16,8**	**13,9**	**0,9**	**-0,5**	**0**
(3) = all new proposed models except DTM2012	47	10,3	6,3	10,9	12,6	6,2	10,9	12,6	-0,9	-0,3	0
(1) + gradients applied	47	10,5	6,2	11,4	12,7	6,2	11,4	12,7	-0,7	-0,4	0
Week #1655											
(1) + phase law applied	45	18,8	14,6	22,2	18,7	13	22,2	18,7	6,7	-0,3	0
(1) = with current models	**45**	**18,7**	**14,7**	**21,6**	**19**	**12,9**	**21,6**	**19**	**7,2**	**-0,3**	**0**
(3) = all new proposed models except DTM2012	45	12,7	7,9	14,7	14,2	7,2	14,7	14,2	3,3	0,1	0
(1) + gradients applied	45	14,5	9,2	17,5	15,6	7,7	17,5	15,6	5	0	0

Tests of various models

Scale + Translation
3 weekly multi-satellite solutions CONT11
Comparison to DPOD2008

Week #1653	TX (mm)	TY (mm)	TZ (mm)	Scale (ppb)	*sTX*	*sTY*	*sTZ*	*sScale*
(1) + phase law applied	3,11	12,49	3,58	**-1,79**	*2,49*	*2,51*	*2,5*	*0,39*
(1) = with current models	**3,35**	**12,85**	**4,5**	**-0,51**	*2,51*	*2,53*	*2,52*	*0,39*
(3) = all new proposed models except DTM2012	0,75	4,37	8,18	-1,14	*1,8*	*1,81*	*1,8*	*0,28*
(1) + gradients applied	0,82	8,56	9,99	-0,04	*1,89*	*1,9*	*1,89*	*0,3*
Week #1654	TX	TY	TZ	FE	*sTX*	*sTY*	*sTZ*	*sFE*
(1) + phase law applied	-1,08	12,17	14,2	**-2,12**	*2,15*	*2,15*	*2,15*	*0,34*
(1) = with current models	**-1,14**	**11,98**	**13**	**-0,85**	*2,1*	*2,11*	*2,1*	*0,33*
(3) = all new proposed models except DTM2012	-0,84	1,23	19,96	-1,93	*1,51*	*1,52*	*1,52*	*0,24*
(1) + gradients applied	0,19	6,32	17,64	-0,78	*1,54*	*1,55*	*1,55*	*0,24*
Week #1655	TX	TY	TZ	FE	*sTX*	*sTY*	*sTZ*	*sFE*
(1) + phase law applied	2,02	7,51	-53,1	**-2,07**	*2,82*	*2,83*	*2,83*	*0,44*
(1) = with current models	**2,47**	**7,25**	**-57,02**	**-0,85**	*2,81*	*2,82*	*2,81*	*0,44*
(3) = all new proposed models except DTM2012	0,56	-1,29	-33,52	-1,67	*1,91*	*1,91*	*1,91*	*0,3*
(1) + gradients applied	1,27	1,83	-45,52	-0,73	*2,19*	*2,19*	*2,19*	*0,34*

Additionnal results of tests of new time-variable geopotential models based on EIGEN-6S

Description of the geopotential models tested

EIGEN-6S c20corrected:

EIGEN-6S model, but provides additionally corrections to the C(2,0) term with 18,6 year period

This model is currently used in our processing with GINS software

EIGEN-6S.V5:

This model (2013) is based on the EIGEN-6S2 model and provides yearly time series of drifts for degree 2-50 geopotential terms obtained from GRGS GRACE RL02 solution, but zero drifts for degree 3-50 terms outside of the GRACE period (2003-2012)

This model is the best candidate for the ITRF reprocessing

Comparison between EIGEN-6S c20corrected and .V5

DORIS/SLR RMS – Radial overlaps (Mean/RMS)

•Year 1995 - GPS week 782 → 833

Satellites: Spot2, Spot3 and Topex

Spot2	DORIS RMS (mm/s)	Radial Overlap (cm)	
EIGEN-6S_c20corrected	0.475	1.19	0.163
EIGEN-6S.V5	0.473	-0.32	0.137

Spot3	DORIS RMS (mm/s)	Radial Overlap (cm)	
EIGEN-6S_c20corrected	0.436	-0.46	0.152
EIGEN-6S.V5	0.434	-0.24	0.130

Topex	SLR RMS (cm)	DORIS RMS (mm/s)	Radial Overlap (cm)	
EIGEN-6S_c20corrected	1.63	0.491	-0.67	0.2
EIGEN-6S.V5	1.51	0.489	-1.09	0.18

Comparison between EIGEN-6S c20corrected and .V5

DORIS/SLR RMS – Radial overlaps (Mean/RMS)

•Year 2012 - GPS week 1675 → 1720

Satellites: Spot4, Spot5, Jason2, Cryosat2 and Hy2a

Spot4	DORIS RMS (mm/s)	Radial Overlap (cm)	
EIGEN-6S_c20corrected	0.402	0.21	2.09
EIGEN-6S.V5	0.401	0.17	2.02

Spot5	DORIS RMS (mm/s)	Radial Overlap (cm)	
EIGEN-6S_c20corrected	0.353	0.11	1.29
EIGEN-6S.V5	0.353	0.10	1.33

Comparison between EIGEN-6S c20corrected and .V5

DORIS/SLR RMS – Radial overlaps (Mean/RMS)

•Year 2012 - GPS week 1675 → 1720

Satellites: Spot4, Spot5, Jason2, Cryosat2 and Hy2a

Jason2	SLR RMS (cm)	DORIS RMS (mm/s)	Radial Overlap (cm)	
EIGEN-6S_c20corrected	1.64	0.322	-0.16	1.41
EIGEN-6S.V5	1.53	0.319	-0.14	1.31

Cryosat-2	SLR RMS (cm)	DORIS RMS (mm/s)	Radial Overlap (cm)	
EIGEN-6S_c20corrected	1.24	0.344	0.06	1.37
EIGEN-6S.V5	1.10	0.344	0.05	1.35

Hy2a	SLR RMS (cm)	DORIS RMS (mm/s)	Radial Overlap (cm)	
EIGEN-6S_c20corrected	1.26	0.334	-0.01	0.76
EIGEN-6S.V5	1.18	0.333	0.06	0.90

Additional results of tests of antenna phase laws

Phase law applied for ALCATEL and STAREC antennas

DORIS/SLR RMS
1995- GPS weeks 782 to 795 (1995/01/01_1995/04/01)
Satellites: Spot2, Spot3, Topex

Spot2	DORIS RMS (mm/s)
Not applied	0.464683
Applied	0.463927

Spot3	DORIS RMS (mm/s)
Not applied	0.431395
Applied	0.430172

Topex	DORIS RMS (mm/s)	SLR RMS (cm)
Not applied	0.482315	1.64480
Applied	0.481900	1.64435

Phase law applied for ALCATEL and STAREC antennas

35 weekly multi-satellite solutions (Spot-2+Spot-3+Topex) between 1995/04/09 and1995/12/30
46 stations = 36 Alcatel + 10 Starec
Comparison to DPOD2008

Positioning performances (average values over the 35 weeks)

1995	solutions #	**3D-rms (mm)**	N rms	E rms	U rms	N std	E std	U std	N mean	E mean	U mean
Phase law applied	35	26.0	18.9	33.4	23.1	18.6	33.4	23.1	0.7	-0.7	-0.0
Not applied	**35**	**27.1**	**19.6**	**35.1**	**24.0**	**19.3**	**35.1**	**24.0**	**0.0**	**-0.6**	**0.0**

Scale + Translation (average values over the 35 weeks)

1995	TX (mm)	TY (mm)	TZ (mm)	Scale (ppb)
Phase law applied	3.26	12.91	-0.89	**-1.77**
Not applied	**3.31**	**13.6**	**6.29**	**-0.95**

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Additionnal results of tests of density model DTM2012

Description of the density models tested

DTM94:

Based on data 1969-1983

DTM2012:

Based on data 1969-1983 and high-resolution data CHAMP and GRACE (2000-2010), and Starlette and Stella (1993-2010)

Data analysis and result description

Two series of POD:
1. current models, including DTM94 (reference)
2. current models, with DTM12 instead of DTM94

Satellites: Spot4, Spot5, Hy-2A, Jason-2, Cryosat-2.

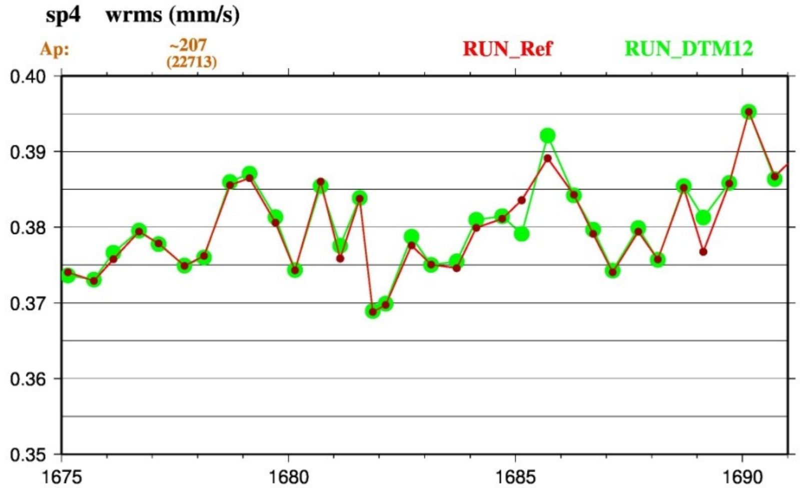
Results:

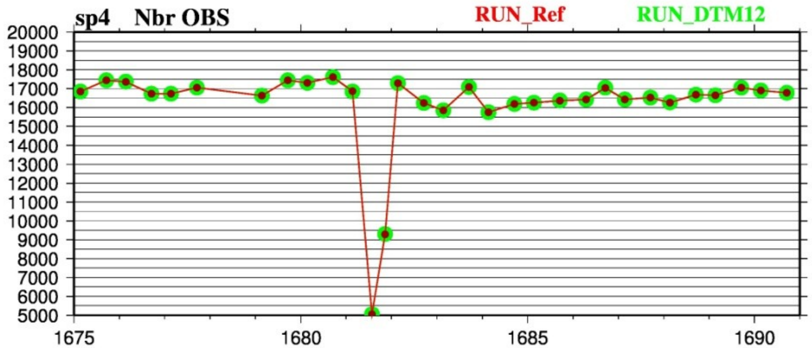
- DORIS WRMS for the two series + data amount + data amount differences for each arc
  Analysis over 15 weeks = GPS weeks 1675 -1690 (Feb - May 2012)
  NB: **Ap =207** on March 9, 2012 (CNES julian day 22713, GPS week 1678)

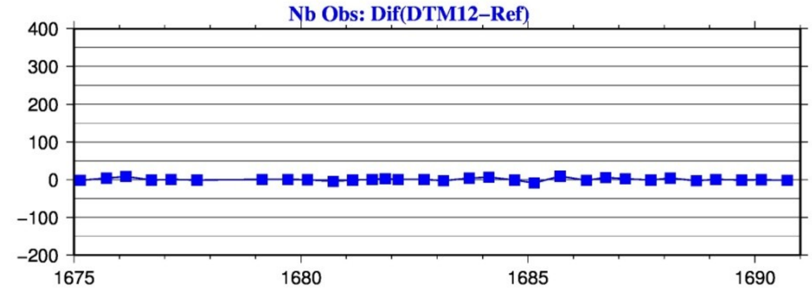
- orbit comparisons between the two series for two arcs (Feb 29 – Mar 04 ; Mar 7 -11)

- statistics for drag coefficients
  - Spot-4 in 2008 (1491-1494)
  - Spot-5 in 2008 (1491-1494) and 2012 (1674-1690)
  - Jason-2 in 2008 (1491-1494) and 2012 (1674-1690)

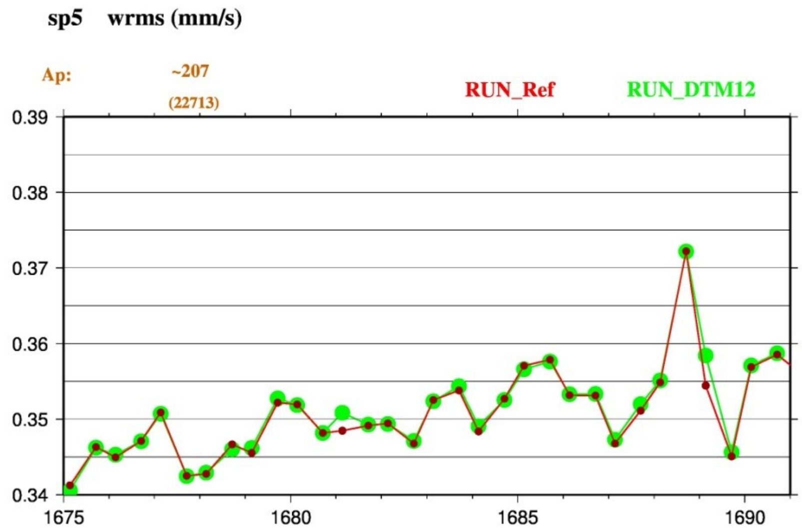
SPOT4

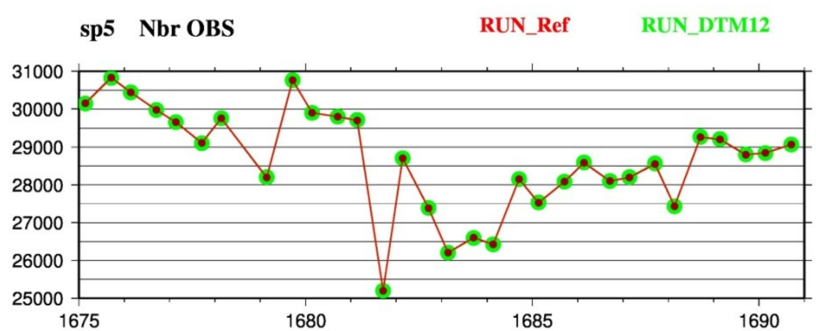

sp4 wrms (mm/s)
Ap:
~207
(22713)
RUN_Ref
RUN_DTM12
0.40
0.39
0.38
0.37
0.36
0.35
1675
1680
1685
1690

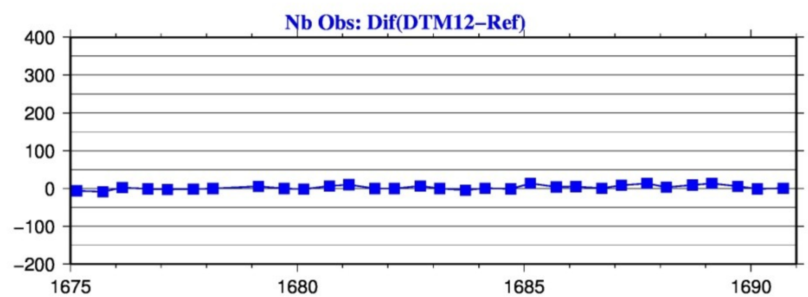

sp4 Nbr OBS
RUN_Ref
RUN_DTM12
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
1675
1680
1685
1690


Nb Obs: Dif(DTM12–Ref)
400
300
200
100
0
–100
–200
1675
1680
1685
1690

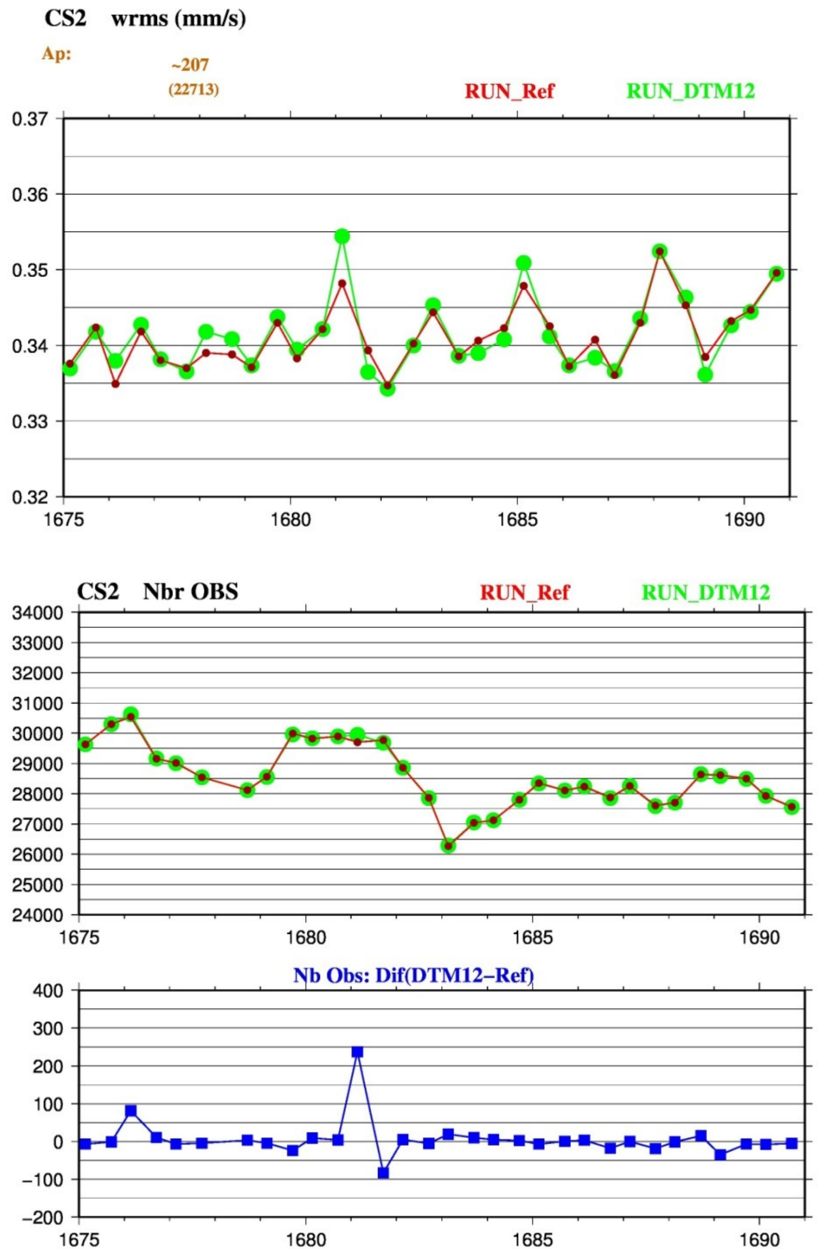
SPOT5


sp5 wrms (mm/s)
Ap:
~207
(22713)
RUN_Ref
RUN_DTM12
0.39
0.38
0.37
0.36
0.35
0.34
1675
1680
1685
1690


sp5 Nbr OBS
RUN_Ref
RUN_DTM12
31000
30000
29000
28000
27000
26000
25000
1675
1680
1685
1690


Nb Obs: Dif(DTM12–Ref)
400
300
200
100
0
−100
−200
1675
1680
1685
1690

CRYOSAT-2



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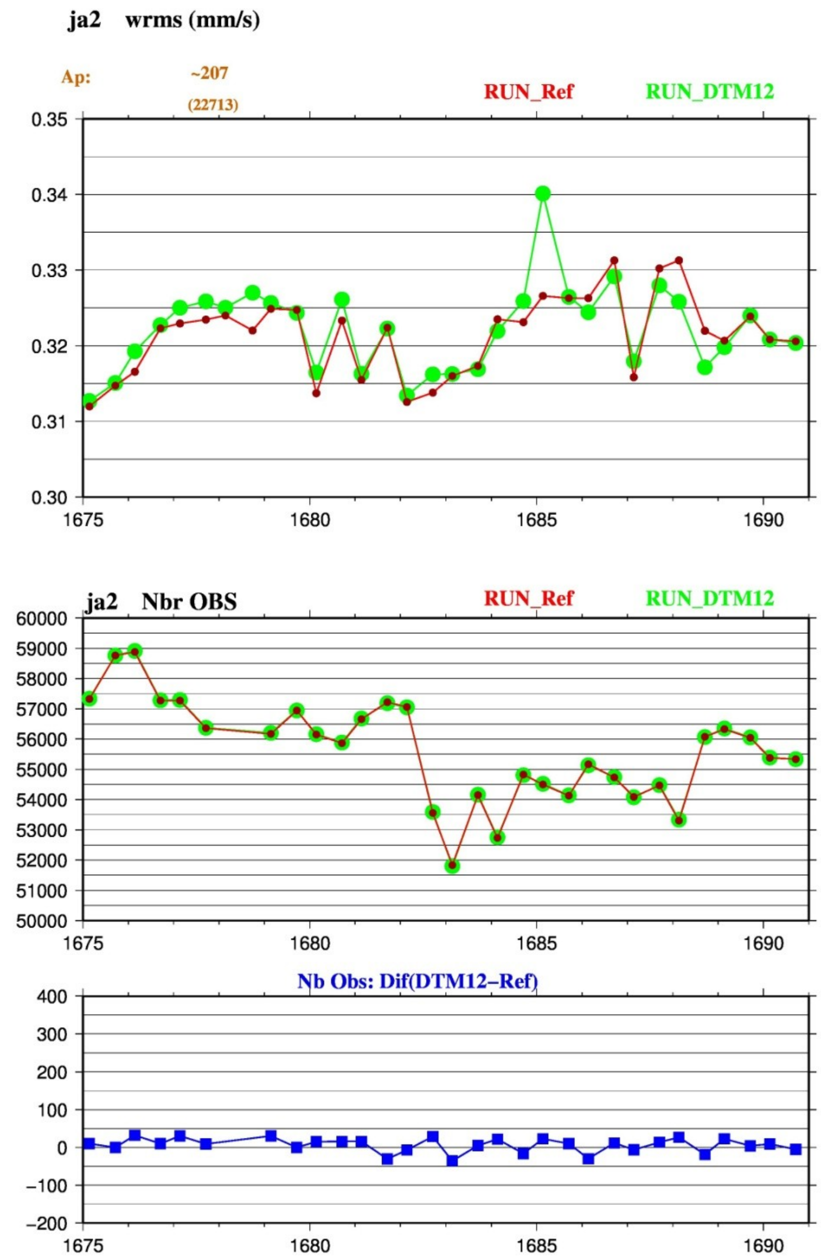
JASON2



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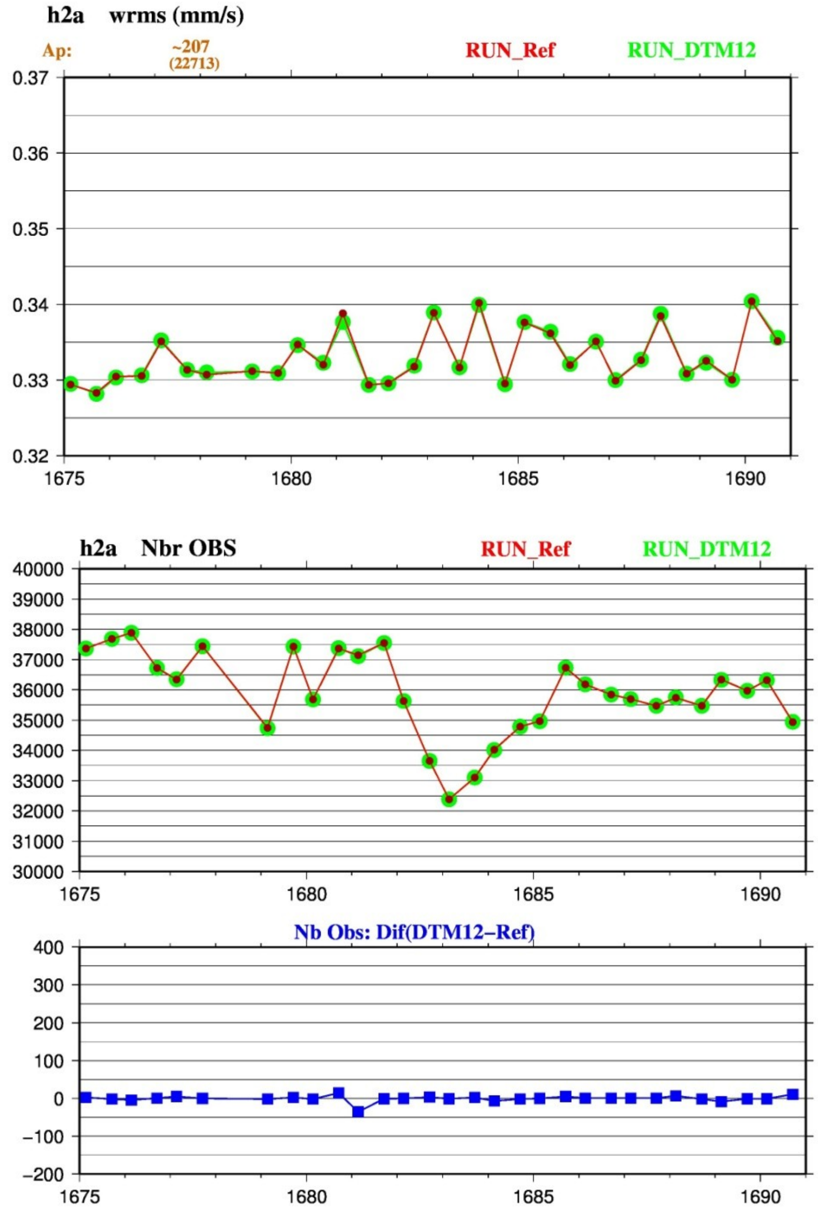
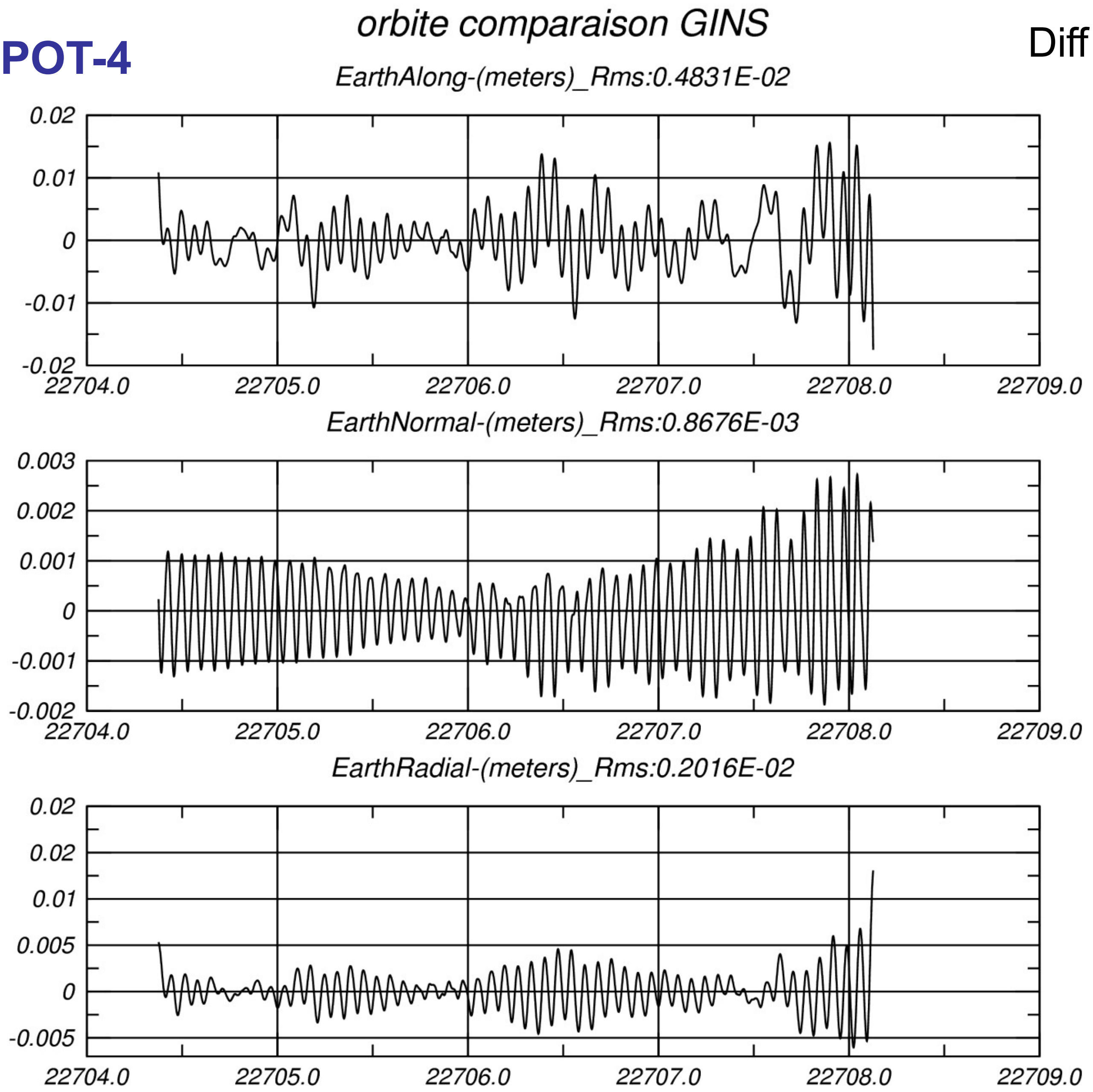
HY-2A


h2a wrms (mm/s)
Ap:
~207
(22713)
RUN_Ref
RUN_DTM12
h2a Nbr OBS
RUN_Ref
RUN_DTM12
Nb Obs: Dif(DTM12–Ref)

SPOT-4

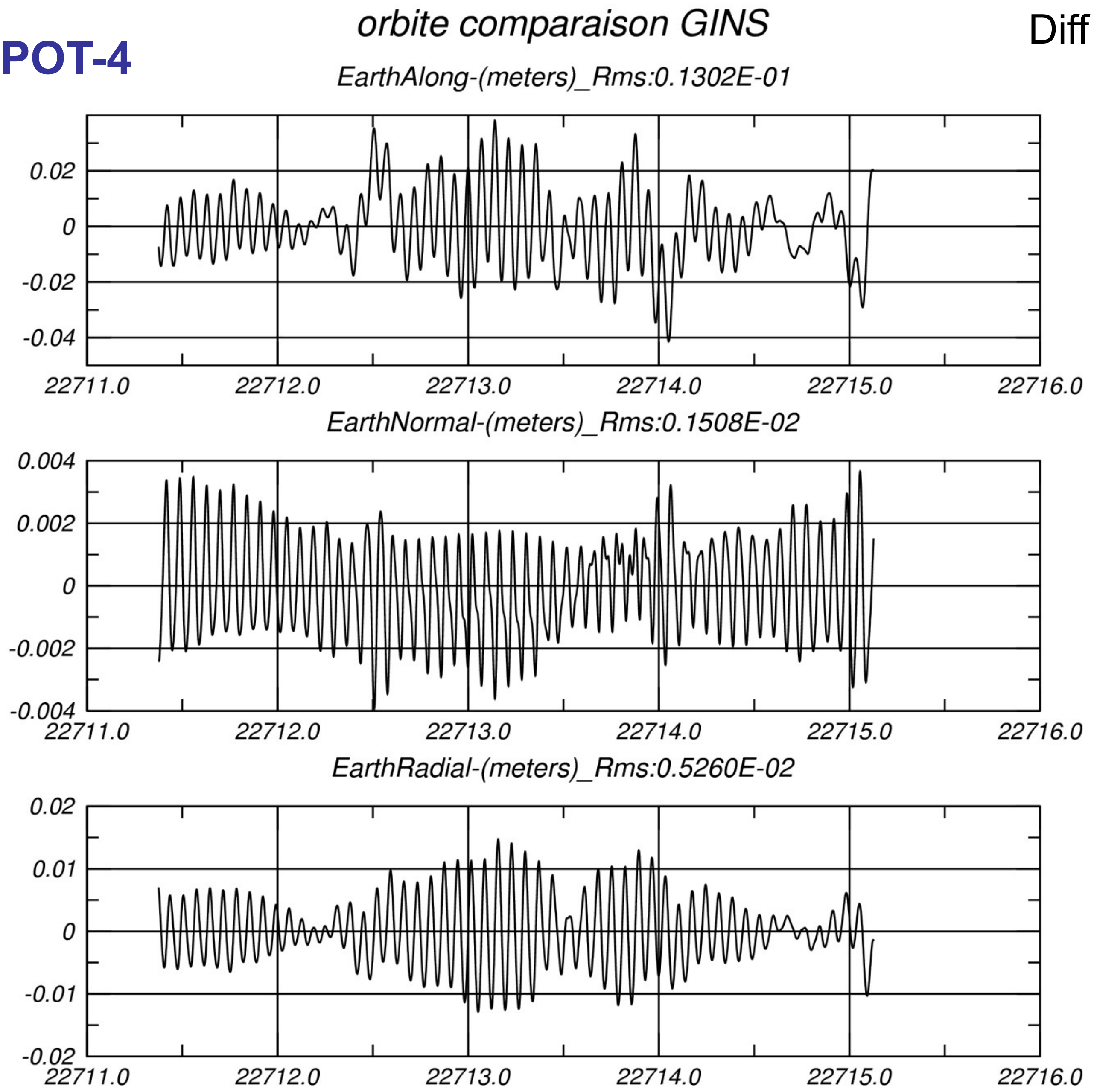
Diff (DTM12-pasdeDTM12)



Feb 29 – March 4

SPOT-4

Diff (DTM12-DTM94b)

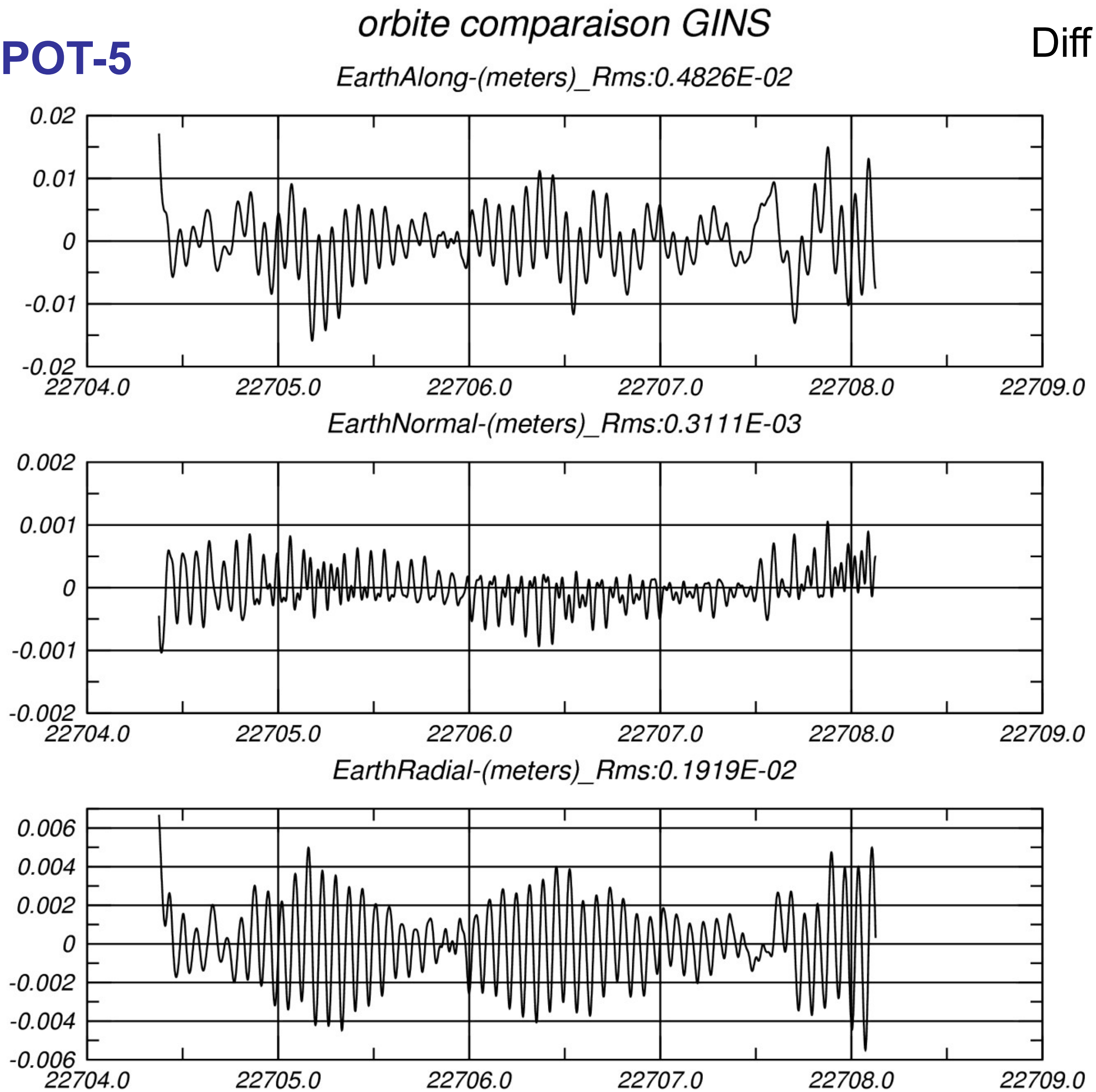


AP(22713)=210

March 7 – March 11

SPOT-5

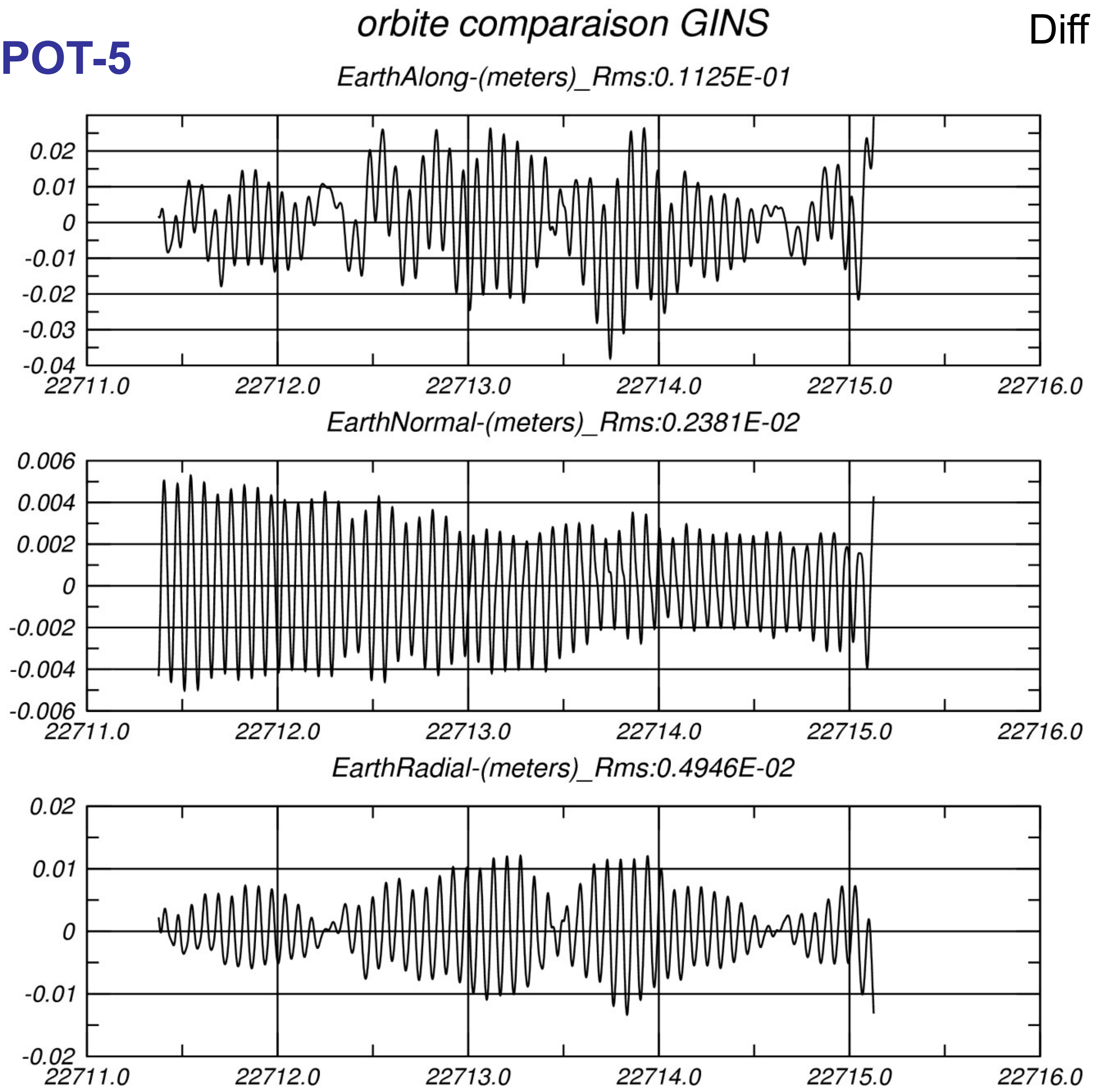
Diff (DTM12-pasdeDTM12)



Feb 29 – March 4

SPOT-5

Diff (DTM12-DTM94b)

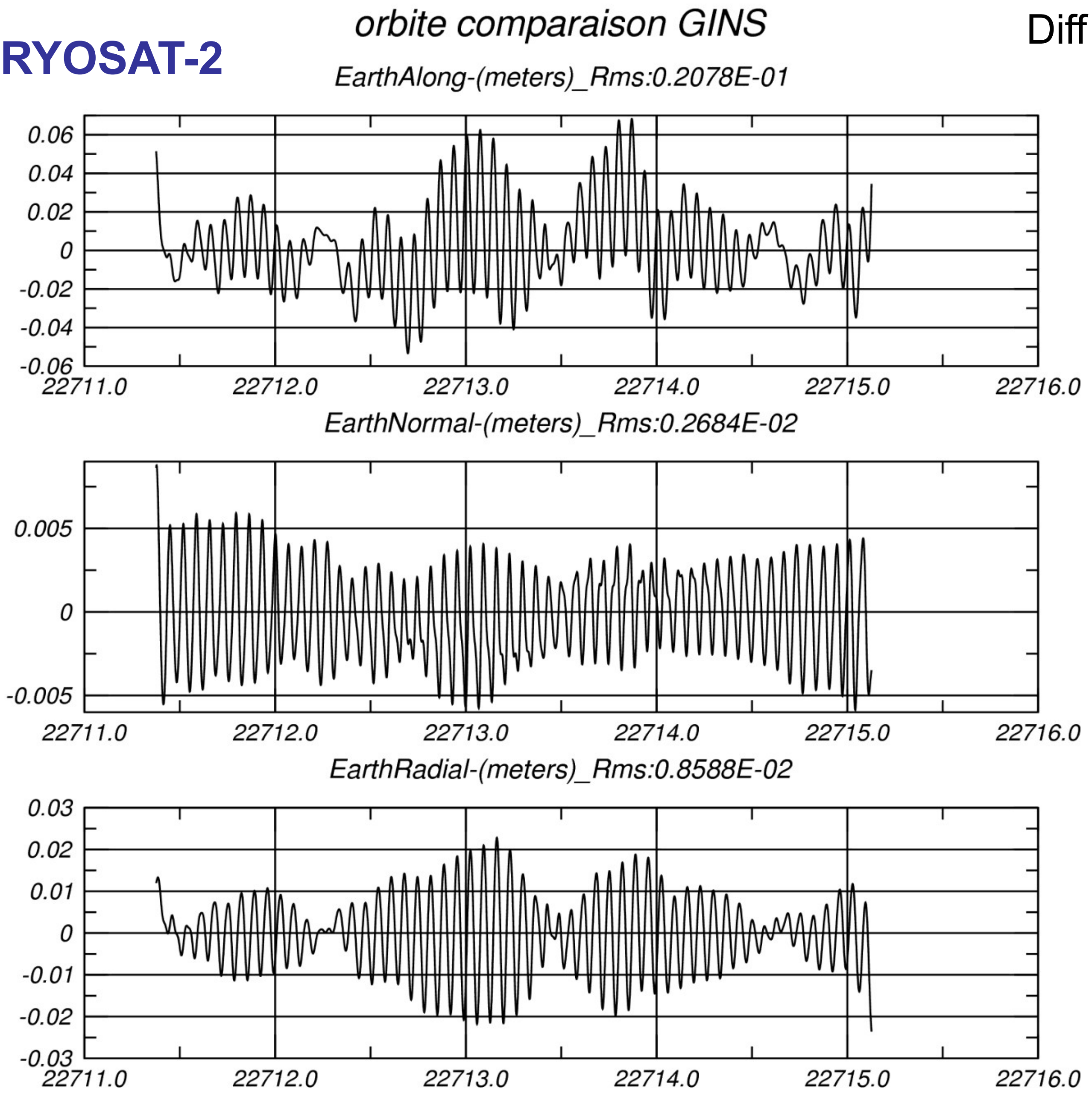


AP(22713)=210

March 7 – March 11

CRYOSAT-2

Diff (DTM12-DTM94b)



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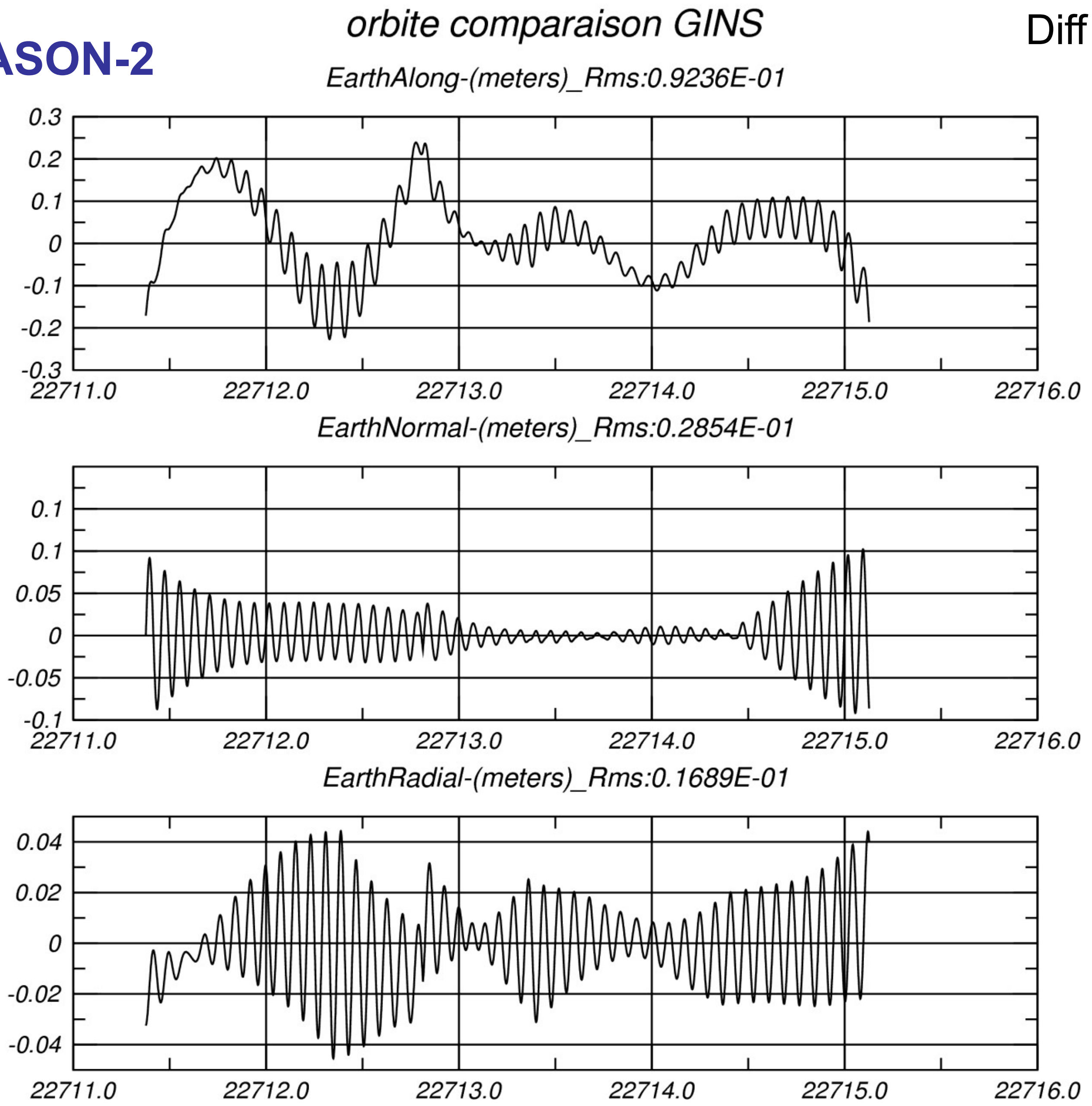
March 7 – March 11

JASON-2

Diff (DTM12-DTM94b)



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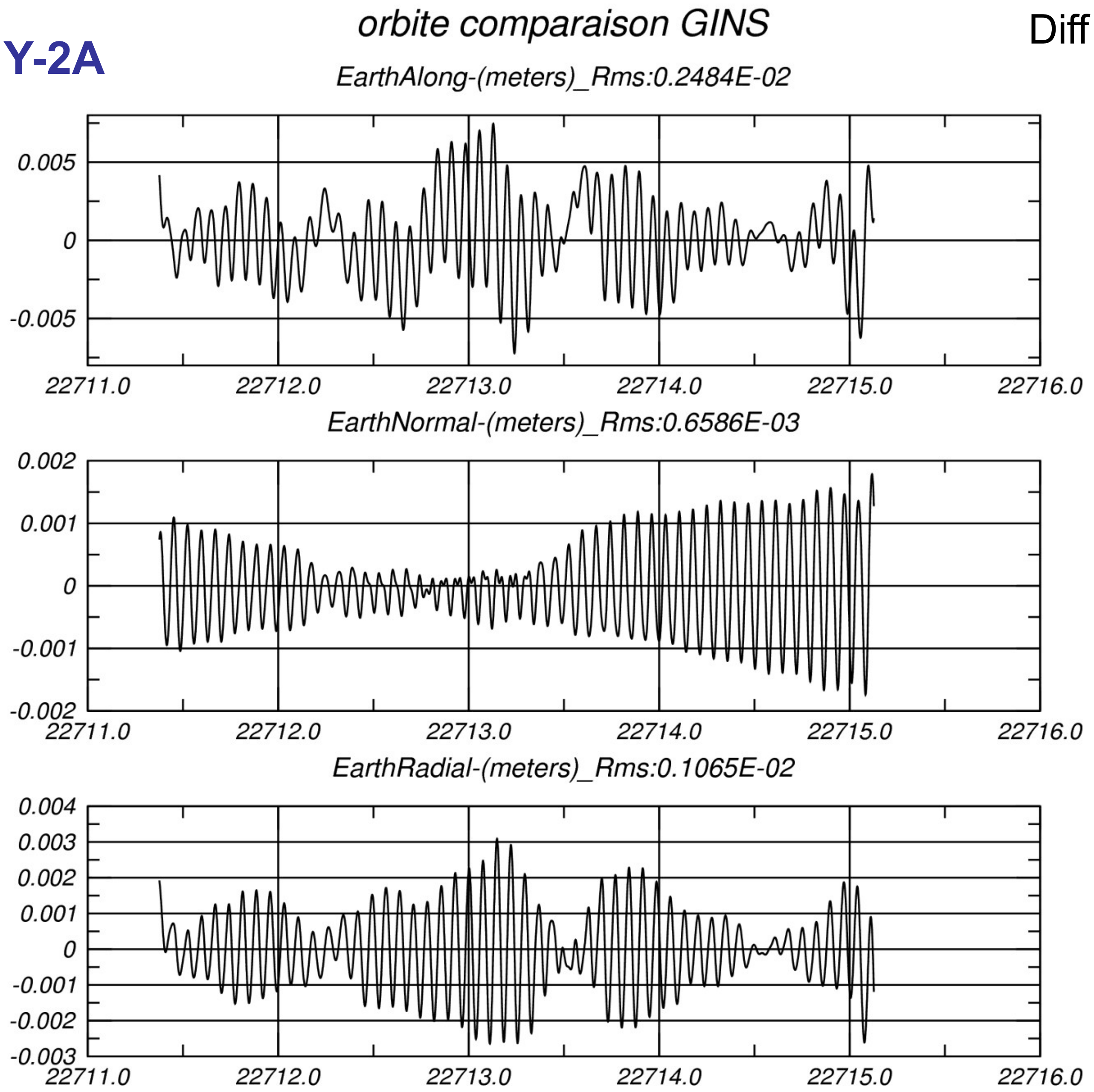
March 7 – March 11

HY-2A

Diff (DTM12-DTM94b)



AP(22713)=210

March 7 – March 11

Drag coefficients

Spot4	**Average**	St. Dev	RMS	Min	Max
With DTM94	0.703	0.160	0.721	0.152	1.186
With DTM2012	0.668	0.142	0.683	0.181	1.134

Spot5	**Average**	St. Dev	RMS	Min	Max
With DTM94	1.021	0.172	1.036	-0.972	1.795
With DTM2012	0.920	0.121	0.932	-0.731	1.539

Jason-2	**Average**	St. Dev	RMS	Min	Max
With DTM94	1.131	0.372	1.191	1.348	2.434
With DTM2012	1.016	0.442	1.108	0.021	2.931

Results of tests of tropospheric model GPT2-VMF1

Some results of tests of tropospheric model

Description of troposheric model tested

GMF-GPT:

Mapping function GPT with Model Zenithal Bias GMF(GMFPT in GINS)

GPT2-VMF1:

Mapping function VMF1 with GPT2 (GPVMF in GINS)

Testing period

Each model tested on CONT11 period = GPS weeks 1653, 1654, 1655
Satellites: Spot4, Spot5, Jason2, Cryosat2 and Envisat

Comparison between GMF-GPT and GPT2-VMF1

DORIS/SLR RMS – Radial overlaps (Mean/RMS)

CONT11 period = GPS weeks 1653, 1654, 1655

Satellites: Spot4, Spot5, Jason2, Cryosat2 and Envisat

Spot4	DORIS RMS (mm/s)	Radial Overlap (cm) Bias/RMS	
GMF-GPT	0.38	~0	1.1
GPT2-VMF1	0.38	~0	1

Spot5	DORIS RMS (mm/s)	Radial Overlap (cm) Bias/RMS	
GMF-GPT	0.345	~0	1.6
GPT2-VMF1	0.345	~0	1.6

Jason2	SLR RMS (cm)	DORIS RMS (mm/s)	Radial Overlap (cm) Bias/RMS	
GMF-GPT	1.755	0.318	0.1	1.8
GPT2-VMF1	1.758	0.318	0.1	1.77

Comparison between GMF-GPT and GPT2-VMF1

DORIS/SLR RMS – Radial overlaps (Mean/RMS)

CONT11 period = GPS weeks 1653, 1654, 1655

Satellites: Spot4, Spot5, Jason2, Cryosat2 and Envisat

Cryosat2	SLR RMS (cm)	DORIS RMS (mm/s)	Radial Overlap (cm) Bias/RMS	
GMF-GPT	1.285	0.342	~0	1.5
GPT2-VMF1	1.283	0.342	~0	1.5

Envisat	SLR RMS (cm)	DORIS RMS (mm/s)	Radial Overlap (cm) Bias/RMS	
GMF-GPT	1.14	0.373	~0	2.15
GPT2-VMF1	1.14	0.373	~0	2.1

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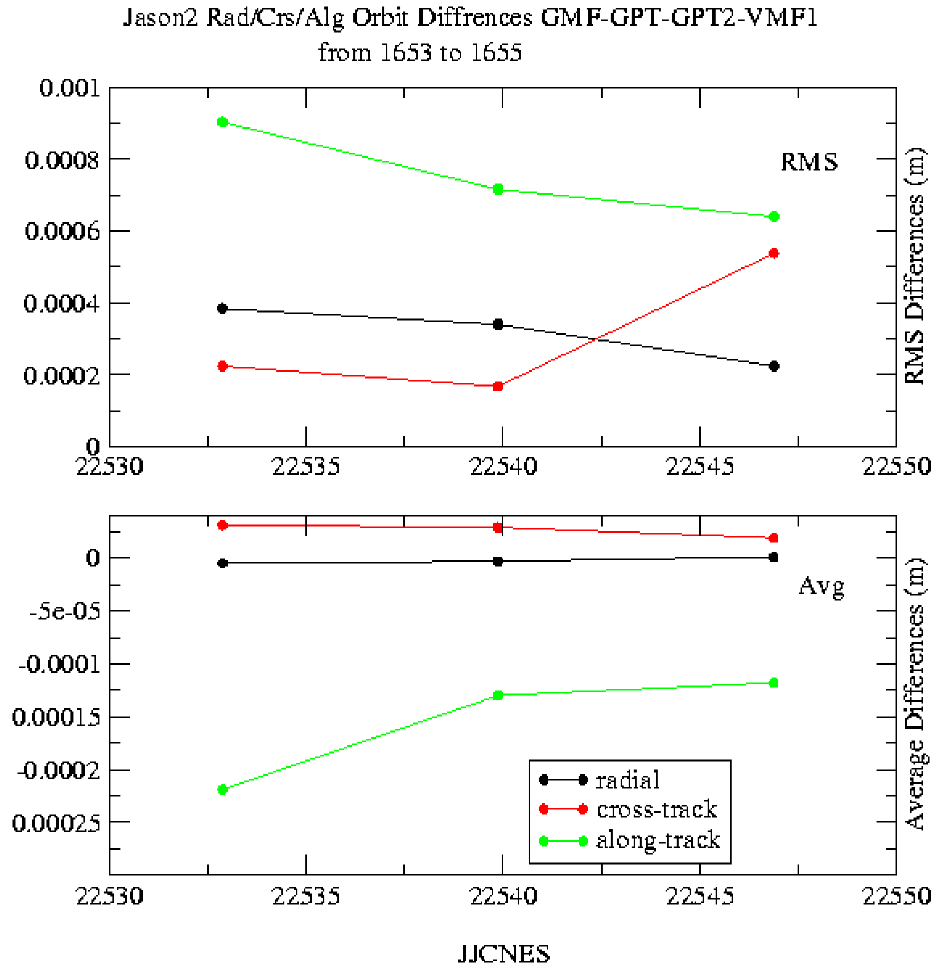
Comparison between GMF-GPT and GPT2-VMF1

Jason2 Orbit comparison – CONT11 period = GPS weeks 1653, 1654, 1655



No differences significantly between the both models on the orbit except on the adjusted tropospheric bias per pass

Comparison between GMF-GPT and GPT2-VMF1

Impact on the positioning

Multisatellite (Spot4, Spot5, Jason2, Cryosat2 and Envisat) weekly solutions
Comparison to DPOD2008 (values are calculated after the application of the Helmert transformation parameters)
RMS3D and RMS by component
(Mean values on the 3 weeks of the CONT11 period, GPS weeks 1653, 1654, 1655)

Solutions CONT11	RMS3D (mm)	Lat (mm)	Lon (mm)	Up (mm)
GMF-GPT	16.5	13.2	19.4	16.2
GPT2-VMF1	16.3	13.2	19.3	15.9

RMS3D and RMS by component are very close between both models

Results of tests of SAA stations downweighting for Jason1

Effect of the SAA stations downweighting for Jason1

We downweight the following SAA stations by a factor 10:

Ascension ASDB-ASEB
Saint-Hélène HELA-HELB-HEMB
Cachoeira CACB-CADB
Santiago SANA-SAOB-SANB
Arequipa AREA-AREB-ARFB
Kourou KRUA-KRUB-KRVB-KRWB

We downweight the following SAA stations by a factor 2:

Libreville LIBRA-LIBB-LICB
San-Cristobal GALA
Easter-Island EASA-EASB
Sal SALB
Tristan Da Cunha TRIA-TRIB-TRJB

Effect of the SAA stations downweighting for Jason1

Impact on the orbit

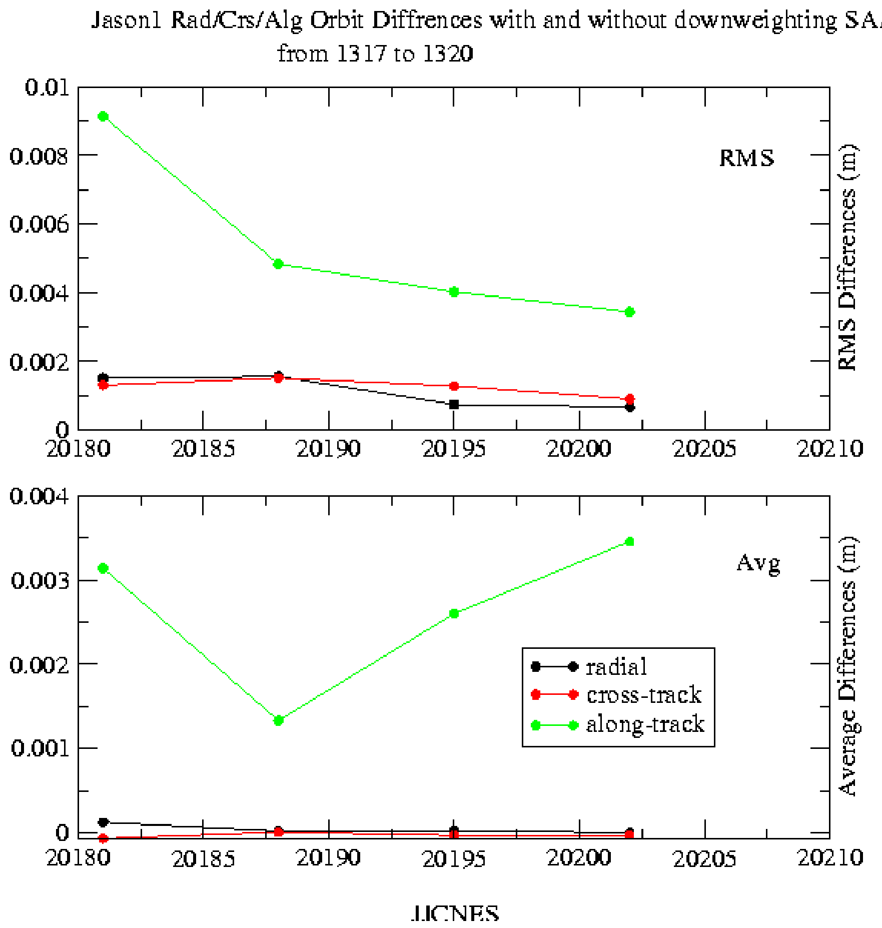
One month in 2005, 4 GPS weeks from 1317 to 1320

DORIS/SLR RMS (mean RMS)

Jason1 Orbit comparison

Jason1	SLR RMS (cm)	DORIS RMS (mm/s)
without SAA stations downweighting	1.44	0.32
with SAA stations downweighting	1.43	0.31

No differences significantly



Effect of the SAA stations downweighting for Jason1

Impact on the positioning

3 Multisatellite (Satellites: Spot2, Spot4, Spot5 and Envisat) weekly solutions
- without Jason1
- with Jason1 without donwweighting Jason-1 satellite
- with Jason1 with donwweighting Jason-1 satellite

Comparison to DPOD2008 (values are calculated after the application of the Helmert transformation parameters)
RMS3D and RMS by component
(Mean values on the 4 GPS weeks from 1317 to 1320)

Solutions	RMS3D (mm)	Lat (mm)	Lon (mm)	Up (mm)
Without Jason1	11.6	6.1	13.1	13.8
With jason1 without downweighting SAA	11.3	5.7	12.6	13.8
with Jason1 with downweighting SAA	11.3	5.8	12.6	13.8

RMS3D and RMS by component slightly reduced when Jason-1 is included.
No impact of the downweighting.

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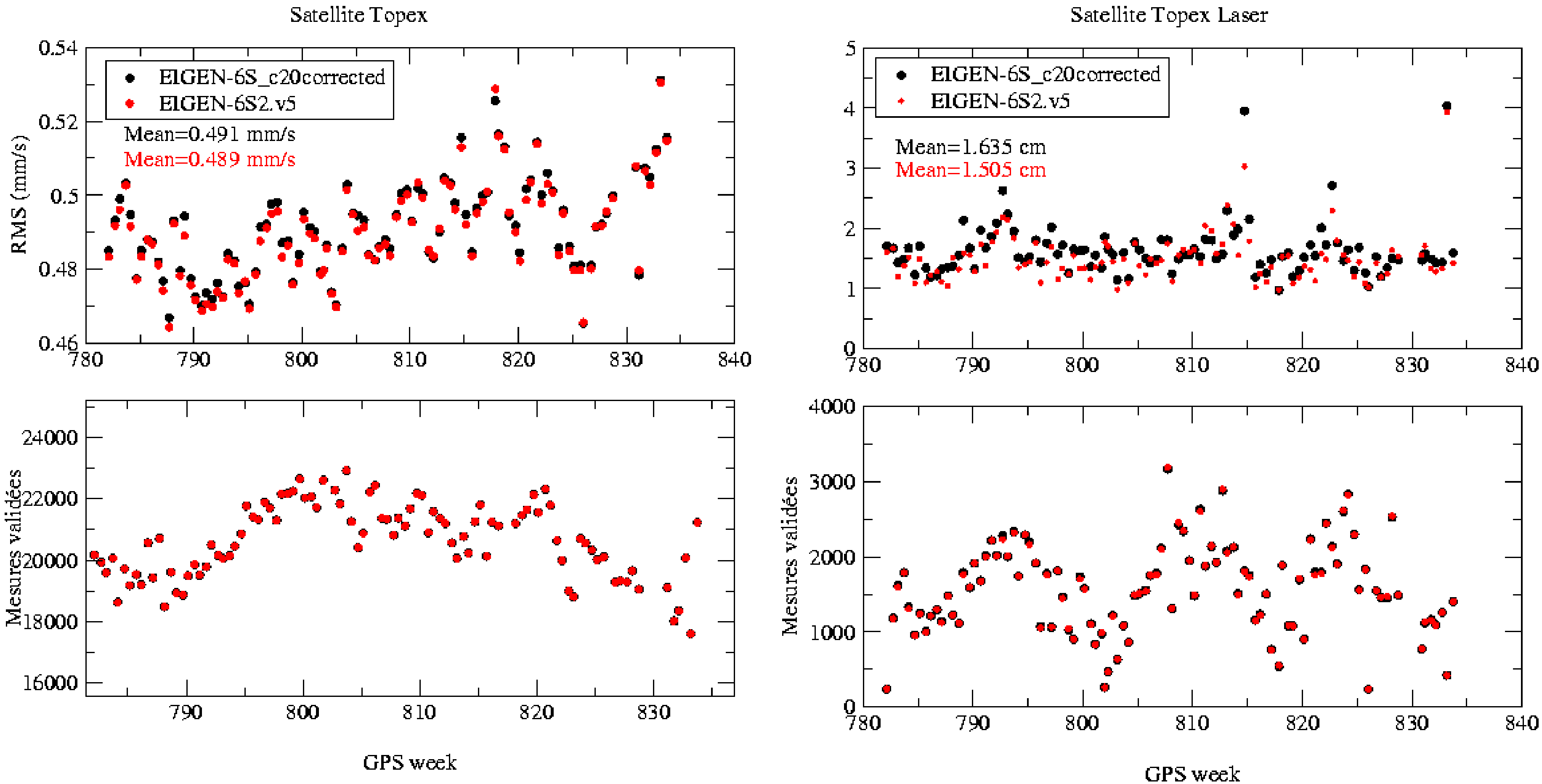
BACK-UP

Additionnal results of tests of new time-variable geopotential models based on EIGEN-6S

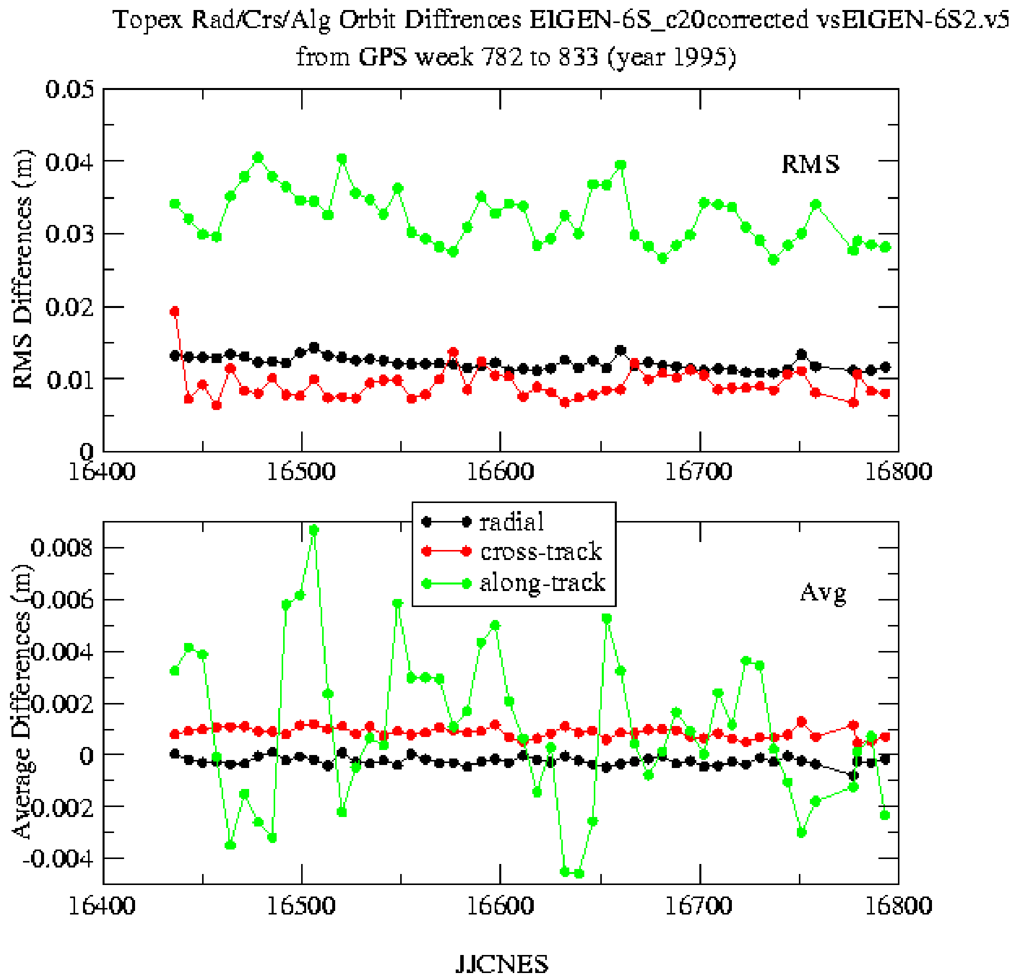
Backup

Topex DORIS/SLR RMS – Year 1995 - GPS week 782 → 833



Backup

Topex Orbit comparison – Year 1995 - GPS week 782 → 833



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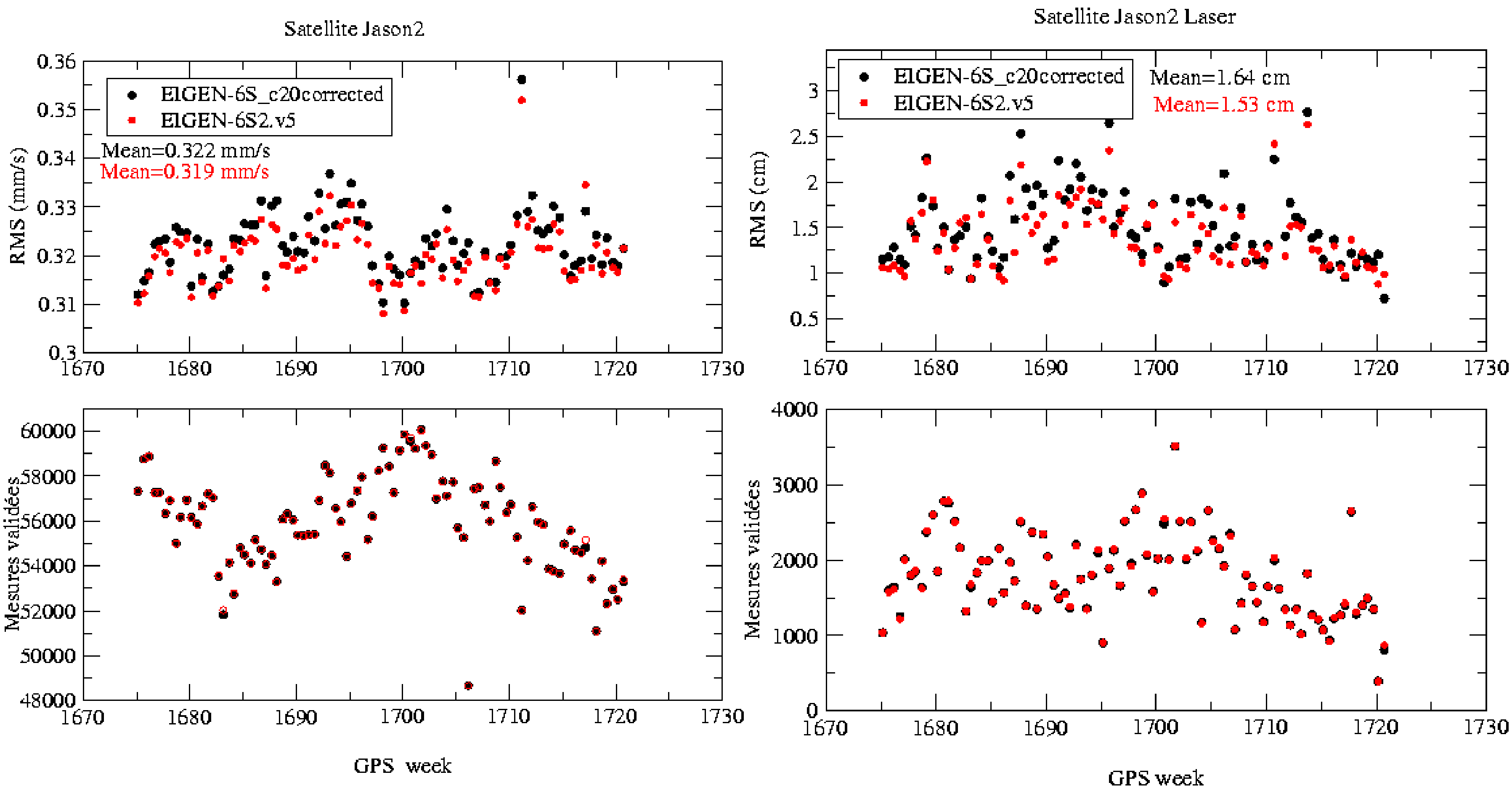
Backup

Jason2 DORIS/SLR RMS – Year 2012 - GPS week 1675 → 1720



Backup

Jason2 Orbit comparison – Year 2012 - GPS week 1675 → 1720