WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES

Quality of Orbit Predictions for Satellites Tracked by SLR Stations

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Mateusz Drożdżewski, Dariusz Strugarek

Consolidated Prediction Format (CPF) – is information on the quality provided?

Missions

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- Mission Operations
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New Mission Support

Request for ILRS laser ranging tracking support of new missions must be formally submitted to the ILRS Central Bureau (CB), reviewed by the Missions Standing Committee (MSC) and approved by the ILRS Governing Board (GB).

The ILRS was established to support applications and programs in geodesy, geodynamics, and space science; the service's primary emphasis is placed on tasks that support the IAG's Global Geodetic Observing System (GGOS). As of 2018, the ILRS network ranges to more than 100 satellites and missions continue to submit additional requests for tracking support. The ILRS reviews new Mission Support Requests (MSRs) on the basis of laser tracking need and the likelihood of mission success. Although the ILRS tries to accommodate all new tracking requests, the submission of a request does not guarantee ILRS support.

New missions requesting ILRS tracking support should review the following **Guidelines for Submitting an ILRS New Mission Support Request** to ensure the ILRS can support the upcoming mission. Following this review, the mission must then complete an ILRS SLR Mission Support Request Form. The ILRS will consider the following points when reviewing the submitted MSR form:

1. Does SLR provide a unique capability that other tracking systems cannot? Is SLR the primary or secondary tracking technique? Can the tracking requirement be met by another technique?
2. What added value will SLR data provide to the data products?
3. Has the mission sufficiently quantified its tracking requirement (accuracy, data volume, coverage, etc.)? A request for "Everything you can get" and "do the best you can do" would result in a **very low priority** for the ILRS.
4. Does the mission have a vulnerable payload aboard that will require special tracking procedures?
5. What is the procurement source of the retroreflector array(s)? Does the design include accommodation for the velocity aberration? See https://ilrs.cddis.eosdis.nasa.gov/technology/spaceSegment/ for more information.
6. Has the signal link budget been estimated either through comparison with spacecraft already tracked by SLR or through the link equation?
7. Have provisions been made to provide reliable predictions in CPF format? Has this source tested their CPF files or are there plans to do such testing? See https://ilrs.cddis.eosdis.nasa.gov/data_and_products/predictions/index.html and https://ilrs.cddis.eosdis.nasa.gov/data_and_products/formats/cpf.html for more information.

The ILRS expects missions to submit their official MSR form at least 6 months prior to launch or from when missions expect tracking support to begin. Upon completion and submission to the CB, the forms are forwarded to the MSC for review, iteration with the user, if necessary, and development of a recommendation on ILRS support including tracking priorities. This recommendation takes into consideration the realism of the program, anticipated scientific achievements and interest of others in these results, the ILRS role in the mission, and the overall tracking load on the ILRS network. After MSC review, the CB then submits the request to the Governing Board for approval.

Quick Links

- List of Missions
- List of Satellite Names
- Mission News
- Mission Campaigns
- Mission Support Request
- Predictions
- Priorities

Consolidated Prediction Format (CPF)

Header type 3 Expected accuracy
1-2 A2 Record Type(="H3")
4-8 I5 Along-track run-off after 0 hours (meters)
10-14 I5 Cross-track run-off after 0 hours (meters)
16-20 I5 Radial run-off after 0 hours (meters)
22-26 I5 Along-track run-off after 6 hours (meters)
28-32 I5 Cross-track run-off after 6 hours (meters)
34-38 I5 Radial run-off after 6 hours (meters)
40-44 I5 Along-track run-off after 24 hours (meters)
46-50 I5 Cross-track run-off after 24 hours (meters)
52-56 I5 Radial run-off after 24 hours (meters)

Consolidated Laser Ranging Prediction Format
Version 1.01

R. L. Ricklefs
The University of Texas at Austin/ Center for Space Research
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for the ILRS Prediction Format Study Group
of the ILRS Data Format and Procedures Working Group

17 February 2006

Abstract

The International Laser Ranging Service (ILRS) Predictions Formats Study Group was

3.Estimated accuracy

These records give an **estimate of the expected accuracy (peak-to-peak) at certain points** during the day. This will be based on the experience of the prediction provider. The intention is to use this information to suggest or automatically set a station's range gate. This will be especially valuable to automated stations so that excessive time is not spent in searching for an optimal range gate and tracking settings.

CPF allows for informing about the quality of predictions. Is it really used?

Consolidated Prediction Format (CPF) – is information on the quality provided?

EDC)
Forschungsinstitut
ünchen

Welcome › Data › Predictions (CPF) › Dataset No. 660998

Detail View for Predictions (CPF) - Dataset No. 660998

Data Information

Satellite:	Ajisai (8606101)
Station	SGF
Start Data Date:	2019-10-13 00:00:00
End Data Date:	2019-10-18 23:55:00
Eph.Seq.:	7871
Incoming Date:	2019-10-14 01:42:36
Incoming Filename:	ajisai_cpf_191014_7871.sgf

System Information

Status:	Valid

FTP

FTP:	ftp://edc.dgfi.tum.de/pub/slr/cpf_predicts/2019/ajisai/ajisai_cpf_191013_7871.sgf

Data

```
H1 CPF  1  SGF 2019 10 14  2  7871 ajisai
H2  8606101 1500    16908 2019 10 13  0  0  0 2019 10 18 23 55  0   240 1 1  0 0 0
H9
10 0 58769      0.00000  0   5442194.625   4039021.298  -4011832.802
10 0 58769    240.00000  0   5112357.675   5211969.565  -2947788.191
10 0 58769    480.00000  0   4581507.066   6157232.195  -1745299.399
10 0 58769    720.00000  0   3865418.839   6837119.532   -460727.336
10 0 58769    960.00000  0   2987498.423   7225555.523    845532.249
10 0 58769   1200.00000  0   1978147.292   7309132.851   2111903.928
10 0 58769   1440.00000  0    873798.471   7087587.003   3278574.533
10 0 58769   1680.00000  0   -284346.473   6573666.715   4290367.106
```

chungsinstitut
en

Welcome › Data › Predictions (CPF) › Dataset No. 661079

Detail View for Predictions (CPF) - Dataset No. 661079

Data Information

Satellite:	TanDEM-X (1003001)
Station	GFZ
Start Data Date:	2019-10-13 23:59:42
End Data Date:	2019-10-16 23:59:42
Eph.Seq.:	7871
Incoming Date:	2019-10-14 08:51:14
Incoming Filename:	tandemx_cpf_191014_7871.gfz

System Information

Status:	Valid

FTP

FTP:	ftp://edc.dgfi.tum.de/pub/slr/cpf_predicts/2019/tandemx/tandemx_cpf_191013_7871.gfz

Data

```
H1 CPF 01  gfz 2019 10 14 08  7871 tandemx
H2 1003001  6202 36605    2019 10 13 23 59 42 2019 10 16 23 59 42   120 1 1  0 0 0
H9
10 0 58769  86382.000000  0     830341.619  -2900652.252  -6199965.569
10 0 58770    102.000000  0     746673.462  -3706232.635  -5765944.381
10 0 58770    222.000000  0     636531.173  -4445814.103  -5231171.626
10 0 58770    342.000000  0     503086.390  -5106053.407  -4604902.115
10 0 58770    462.000000  0     350140.191  -5675014.675  -3898004.254
10 0 58770    582.000000  0     182032.435  -6142394.604  -3122780.832
10 0 58770    702.000000  0       3537.352  -6499720.147  -2292761.970
10 0 58770    822.000000  0    -180252.477  -6740515.699  -1422472.892
```

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Welcome › Data › Predictions (CPF) › Dataset No. 661103

Detail View for Predictions (CPF) - Dataset No. 661103

Data Information

Satellite:	SNET-1 (1801410)
Station	DLR
Start Data Date:	2019-10-14 00:00:00
End Data Date:	2019-10-21 00:00:00
Eph.Seq.:	7871
Incoming Date:	2019-10-14 05:00:00
Incoming Filename:	snet1_cpf_191014_7871.dlr

System Information

Status:	Valid

FTP

FTP:	ftp://edc.dgfi.tum.de/pub/slr/cpf_predicts/2019/snet1/snet1_cpf_191014_7871.dlr

Data

```
H1 CPF  1  DLR 2019 10 14 08  7871 snet1
H2  1801410 6204    43189 2019 10 14 00 00 00 2019 10 21 00 00 00    60 1 1  0 0 0
H9
10 0 58770      0.000000  0      5159735.417     -1389957.965     -4468331.840
10 0 58770     60.000000  0      4845537.658     -1410164.277     -4800984.778
10 0 58770    120.000000  0      4510764.691     -1421583.417     -5113241.792
10 0 58770    180.000000  0      4156912.233     -1423995.547     -5403782.963
10 0 58770    240.000000  0      3785556.887     -1417232.179     -5671380.941
10 0 58770    300.000000  0      3398348.971     -1401177.492     -5914905.846
10 0 58770    360.000000  0      2997005.093     -1375769.373     -6133329.747
10 0 58770    420.000000  0      2583300.540     -1341000.151     -6325730.738
10 0 58770    480.000000  0      2159061.414     -1296917.031     -6491296.636
```

Services dedicated to assessment of the orbit predictions: http://slr.gfz-potsdam.de:5000/tb/v1

Prediction Centers

Below is a table of prediction providers for SLR and LLR:

Agency	Abbreviations in CPF Files/Historic Files	Contact Information
Air Force Research Laboratory/Kirtland AFB, USA	STP	Lawrence Schmitt Lawrence.Schmitt@wpafb.af.mil
Austrian Academy of Sciences (AAS), Austria, Graz	AAS	Sandro Krauss sandro.krauss@oeaw.ac.at
Beijing Aerospace Control Center (BACC), Beijing, China	BACC	Tang Geshi tanggeshi@bacc.org.cn Li Xie Lixie_afdl@163.com
Cabinet Office, Government of Japan/QSS	QSS	Shiraishi Masakazu m-shiraishi@yk.jp.nec.com
Center for Orbit Determination in Europe (CODE), Astronomical Institute University of Bern (AIUB)	COD/COD	Rolf Dach code@aiub.unibe.ch
Center for Space Research University of Texas, USA	UTX/CSR	Randy Ricklefs ricklefs@csr.utexas.edu
Centre National d'Etudes Spatiales (CNES), France	CNE/CNES	Alexandre Couhert alexandre.couhert@cnes.fr Jean-Marc Walter Jean-Marc.Walter@cnes.fr
Copernicus POD Service (CPOD), GMV, Tres Cantos, Madrid	ESA	Jaime Fernández jfernandez@gmv.com Pierre Féménias Pierre.Femenias@esa.int
European Space Operations Centre (ESOC)	ESA/ESOC	Dirk Kuijper Dirk.Kuijper@esa.int Erik Schoenemann Erik.Schoenemann@esa.int
European Space Operations Centre, Earth Observation Missions Support Section (ESOC)/Swarm, Cryosat	ESA/ESOC	Detlef Sieg Detlef.Sieg@esa.int Gerald Ziegler Gerald.Ziegler@esa.int
Galileo Control Centre (GAL), DLR, Germany	GAL	Erik Schoenemann Erik.Schoenemann@esa.int Jens Martin jens.martin@esa.int
GFZ German Research Centre for Geosciences	GFZ/GFZ	Krzysztof Snopek prd@gfz-potsdam.de
Georgia Institute of Technology, USA	GIT	Sean Chait Cschait3@gatech.edu
German Aerospace Center (DLR)	DLR	Merlin Barschke merlin.barschke@tu-berlin.de
HISDESAT, Spain	HDS	Carlos Gonzalez cgonzalez@hisdesat.es
Indian Space Research Organization (ISRO)	ISRO/ISTRAC	Subramanya Ganesh ganesht@istrac.gov.in
International Space Time Analysis Research Centre (IST)	IST	Giampiero Sindoni giampiero.sindoni@uniroma1.it
Japan Aerospace Exploration Agency (JAXA), Japan	JAX/JAXA	Shinichi Nakamura nakamura.shinichi@jaxa.jp
Keldysh Institute of Applied Mathematics (IAM)/RAS	IAM	Mikhail Zakhvatkin zakhvatkin@kiam1.rssi.ru
Korea Advanced Institute of Science and Technology (KAIST)	KAI	Sang-Hyun Lee magpuri0@kaist.ac.kr
Korea Aerospace Research Institute (KARI)	KGS	Ok-Chul Jung ocjung@kari.re.kr
Korea Astronomy and Space Science Institute (KASI)	KAS	Young-Rok Kim yrockkim@kasi.re.kr

Watch List | LEO Targets | Geodetic Targets | Debris Targets | GNSS Targets

CPF time bias prediction

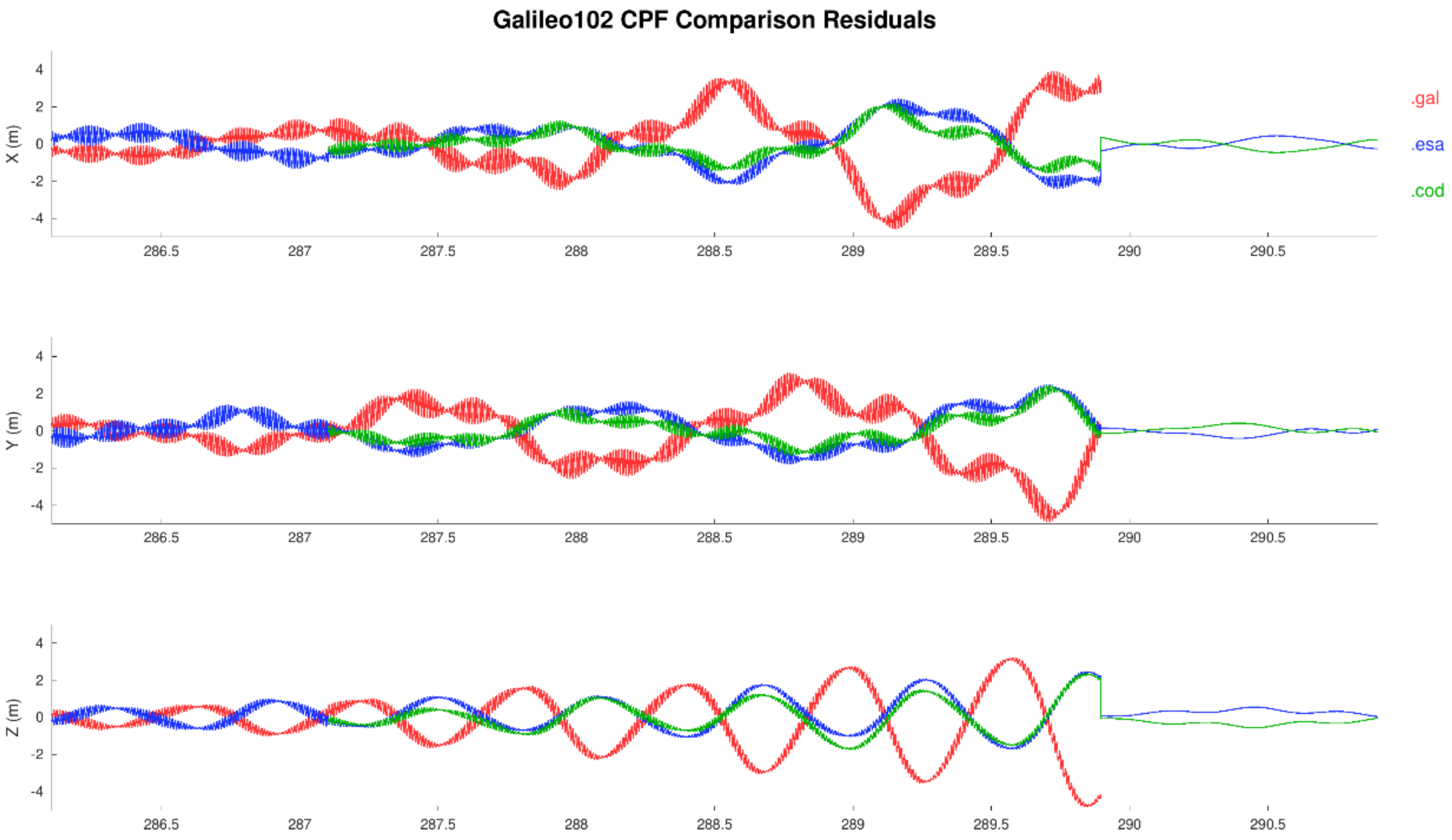
Contact:
jens.steinborn@digos.eu
sven.bauer@gfz-potsdam.de

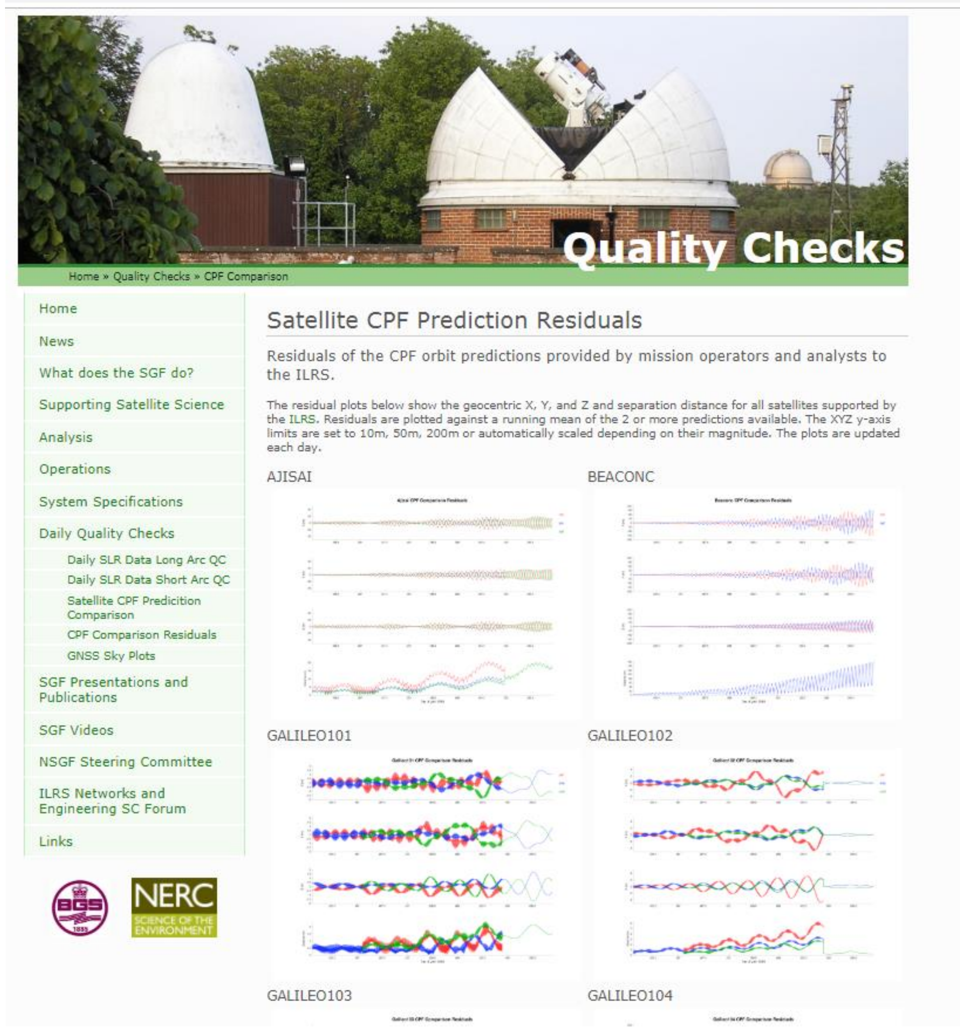
Watch List
Predictions for: 2019-10-14 11:35:13 UTC

Target	Provider	CPFs			
beaconc 6503201 / 317	HTS	HTS7861 -5.3ms (0.6 / #24)	HTS7851 -20.2ms (0.7 / #35)	HTS7841 -40.7ms (0.6 / #53)	HTS7831 -56.1ms (0.8 / #59)
beaconc 6503201 / 317	SGF	SGF7871 -5.1ms (0.2 / #24)	SGF7861 -15.0ms (0.1 / #35)	SGF7851 -20.4ms (0.3 / #53)	SGF7841 -41.4ms (0.5 / #59)
geoik2 1603401 / 5561	SPN	SPN7861 -0.0ms (0.3 / #20)	SPN7841 6.4ms (1.0 / #48)	SPN7831 8.2ms (1.3 / #55)	SPN7821 3.4ms (1.1 / #57)
gracefo1 1804701 / 123	GFZ	GFZ7871 -0.4ms (Last / #2)	GFZ7862 -1.4ms (0.1 / #10)	GFZ7861 -5.6ms (0.1 / #10)	GFZ7852 -9.8ms (0.4 / #16)
gracefo2 1804702 / 124	GFZ	GFZ7871 -0.1ms (Last / #2)	GFZ7862 0.1ms (0.1 / #9)	GFZ7861 -11.6ms (0.2 / #9)	GFZ7852 -9.4ms (0.4 / #16)
hy2a 1104301 / 2201	SHA	SHA7871 3.3ms (0.1 / #4)	SHA7861 -13.2ms (2.1 / #13)	SHA7851 -36.9ms (2.3 / #24)	
hy2b 1808101 / 2208	SHA	SHA7871 -0.0ms (0.1 / #5)	SHA7861 0.2ms (0.1 / #14)	SHA7851 -22.3ms (0.2 / #25)	SHA7841 -0.0ms (0.3 / #36)
icesat2 1807001 / 6873	GSF	GSF7861 -103.7ms (0.3 / #3)	GSF7851 -46.1ms (2.5 / #5)	GSF7841 97.6ms (13.7 / #7)	GSF7831 159.7ms (24.6 / #11)
kompsat5 1304201 / 3803	KGS	KGS7871 2.9ms (Last / #2)	KGS7861 -67.4ms (Last / #2)	KGS7851 -67.5ms (Last / #2)	
paz 1802001 / 2501	HDS	HDS7851 -19.1ms (0.2 / #16)	HDS7841 -34.2ms (0.4 / #24)	HDS7831 -15.9ms (0.3 / #29)	
snet1 1801410 / 6204	AAS	AAS7861 -2.5ms (Last / #2)	AAS7861 -2.5ms (Last / #2)	AAS7851 -170.7ms (74.2 / #4)	AAS7841 -12.9ms (0.5 / #9)
snet1 1801410 / 6204	DLR	DLR7871 No Data	DLR7861 -2.0ms (Last / #2)	DLR7851 -12.9ms (0.4 / #4)	DLR7841 6.6ms (0.4 / #9)
snet3 1801408 / 6206	AAS	AAS7861 No Data	AAS7851 No Data	AAS7841 No Data	AAS7831 No Data
snet4 1801409 / 6207	AAS	AAS7861 2.1ms (0.3 / #4)	AAS7851 -4.1ms (0.3 / #8)	AAS7841 5.0ms (0.4 / #14)	AAS7831 17.8ms (0.4 / #17)
snet4 1801409 / 6207	DLR	DLR7871 5.1ms (Last / #1)	DLR7861 -2.6ms (0.8 / #4)	DLR7851 -16.9ms (0.5 / #8)	DLR7841 -6.3ms (1.4 / #14)
[illegible]	ESA	ESA7861	ESA7851	ESA7841	ESA7831

Services dedicated to assessment of the orbit predictions

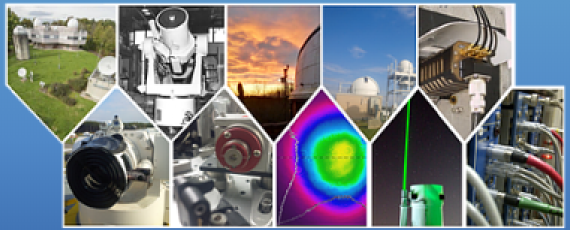
http://sgf.rgo.ac.uk/qualityc/cpf_qc_resids.html





http://sgf.rgo.ac.uk/forumNESC/

International Laser Ranging Service forum
Networks and Engineering Standing Committee



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Networks and Engineering Standing Committee Forum › General Topics › Mission Tracking Feedback (Moderators: Toshimichi Otsubo, SWetzel) › COMPASS-MS1/MS2 predictions

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Pages: [1]

REPLY NOTIFY MARK UNREAD SEND THIS TOPIC PRINT

Author **Topic: COMPASS-MS1/MS2 predictions (Read 1822 times)**

March 08, 2018, 02:56:47 PM

jose_sgf
Newbie
Posts: 6

COMPASS-MS1/MS2 predictions
« **on:** March 08, 2018, 02:56:47 PM »

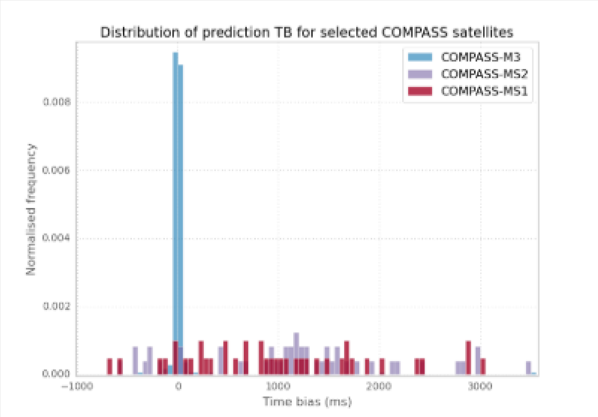
Quote

The predictions for COMPASS-MS1 and COMPASS-MS2 have been consistently poor since the start of their laser tracking operations. This is strange, for the COMPASS-M3 predictions are of the regular good quality we expect for this kind of satellite.

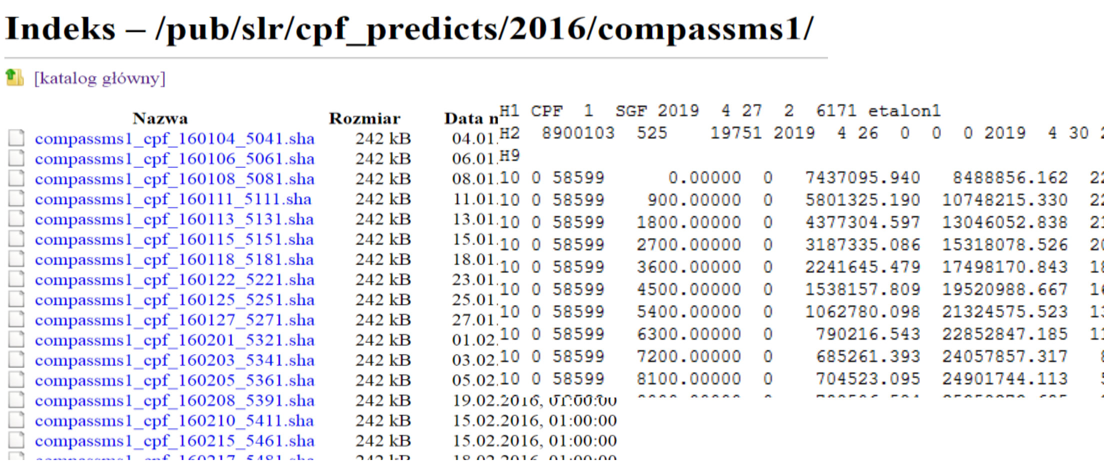
We are talking about time biases of seconds, plus up to hundreds of milliarcseconds cross-track offsets. This makes daytime tracking simply impossible, and requires substantial additional time and effort to obtain returns during night time operations.

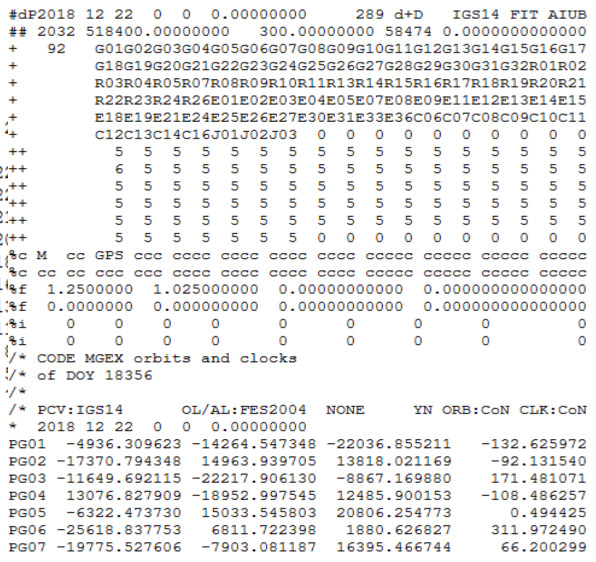
COMPASS-MS1 has been recently included in the high priority list of the LARGE campaign. The intensive tracking requirements for this campaign are obviously harder to fulfill if the predictions are sub-standard. Two questions come to mind: 1) Why are predictions so poor for these objects? 2) When should we expect them to improve?

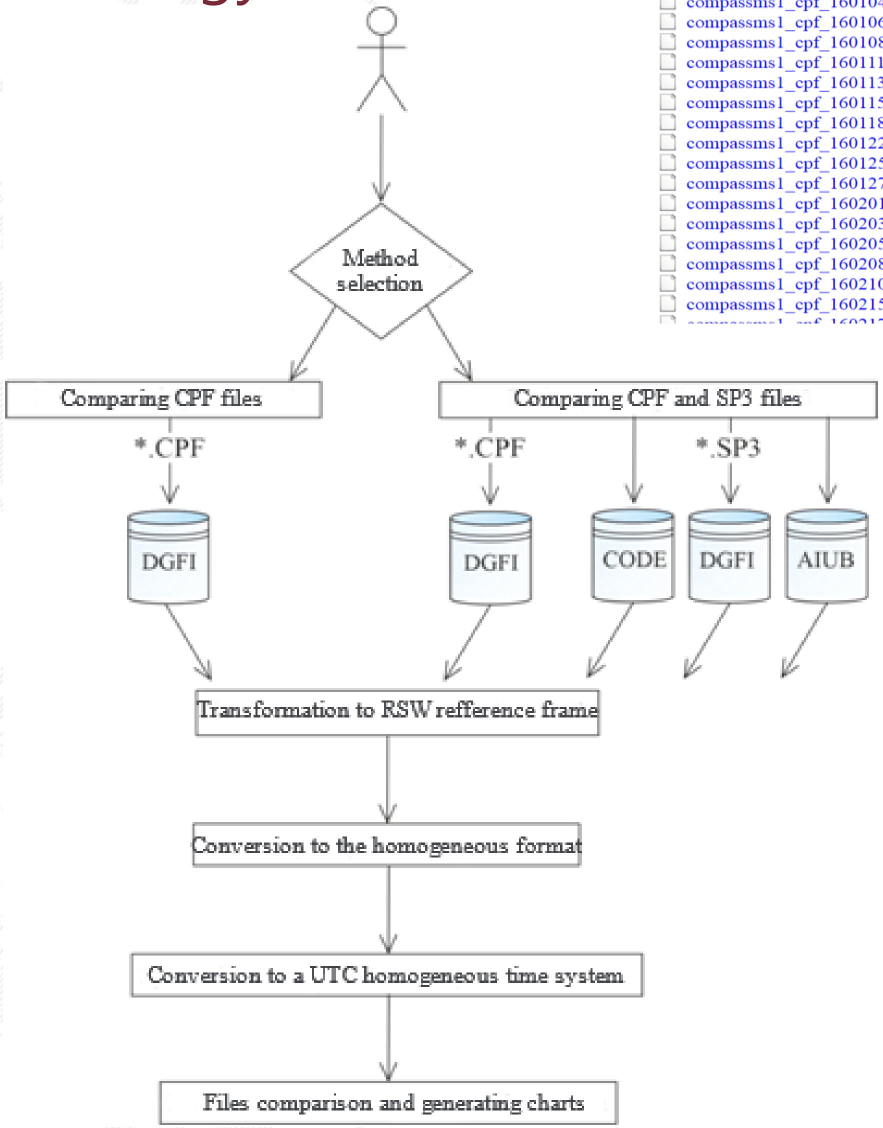
In the interim, perhaps it would be useful to include COMPASS-MS1 in the time bias prediction service run by Potsdam?



Metodology







Scheme of multi-source data processing

Predicted orbits (CPF)

Based on satellite state vector, not updated empirical parameters and physical models

Precise orbits (SP3) of:

1. Geodetic satellites

Determined on the basis of SLR observations

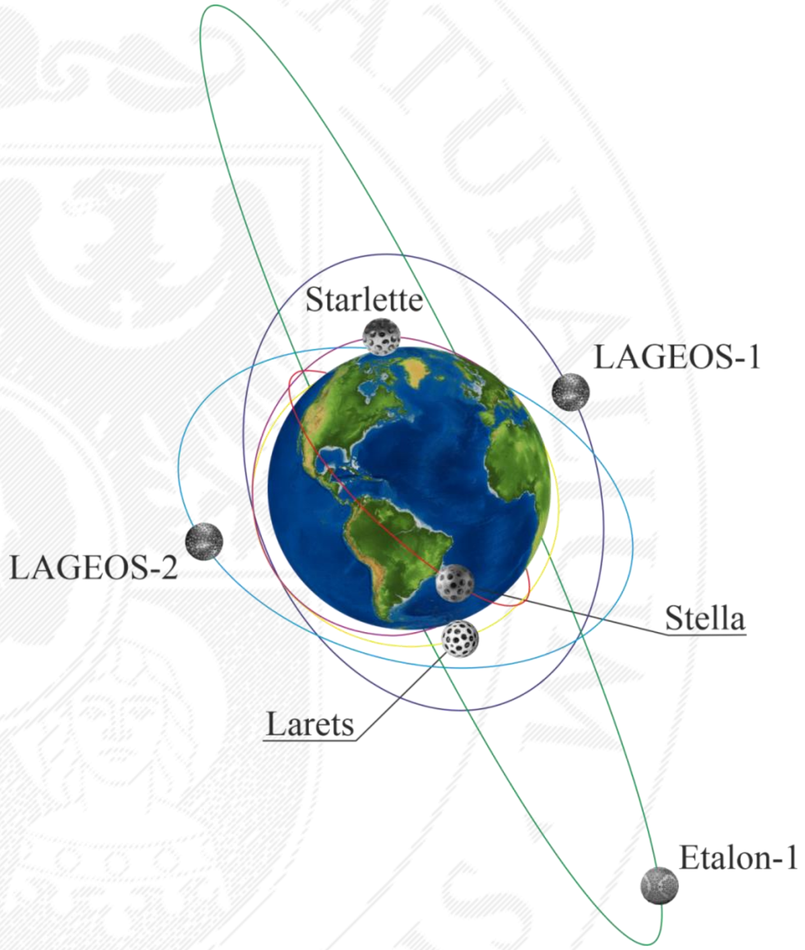
2. Navigation satellites

Determined on the basis of real multi-GNSS observations collected by MGEX station network

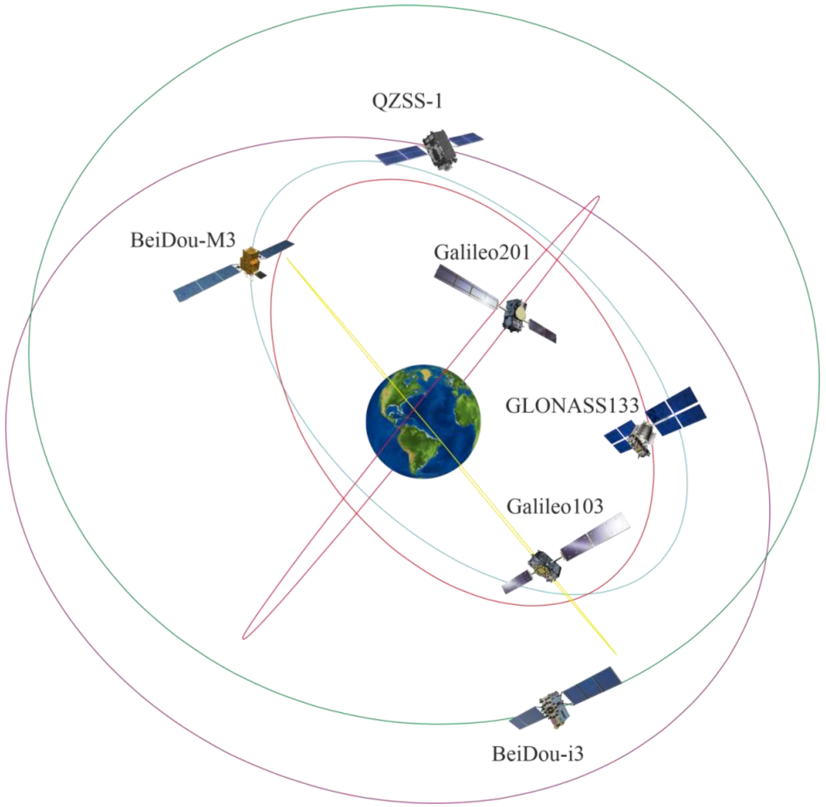
3. Research satellites

Determined on the basis of real-time GPS observations collected by GRACE and SWARM satellites

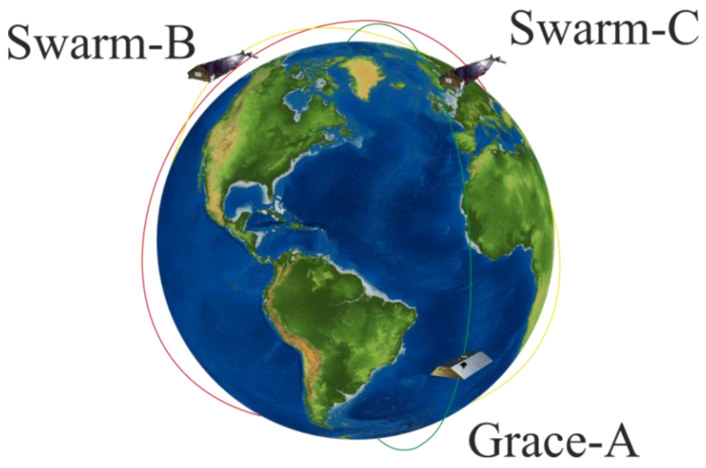
Quality of the orbit predictions – reference for the comparison



Geodetic: SLR solutions



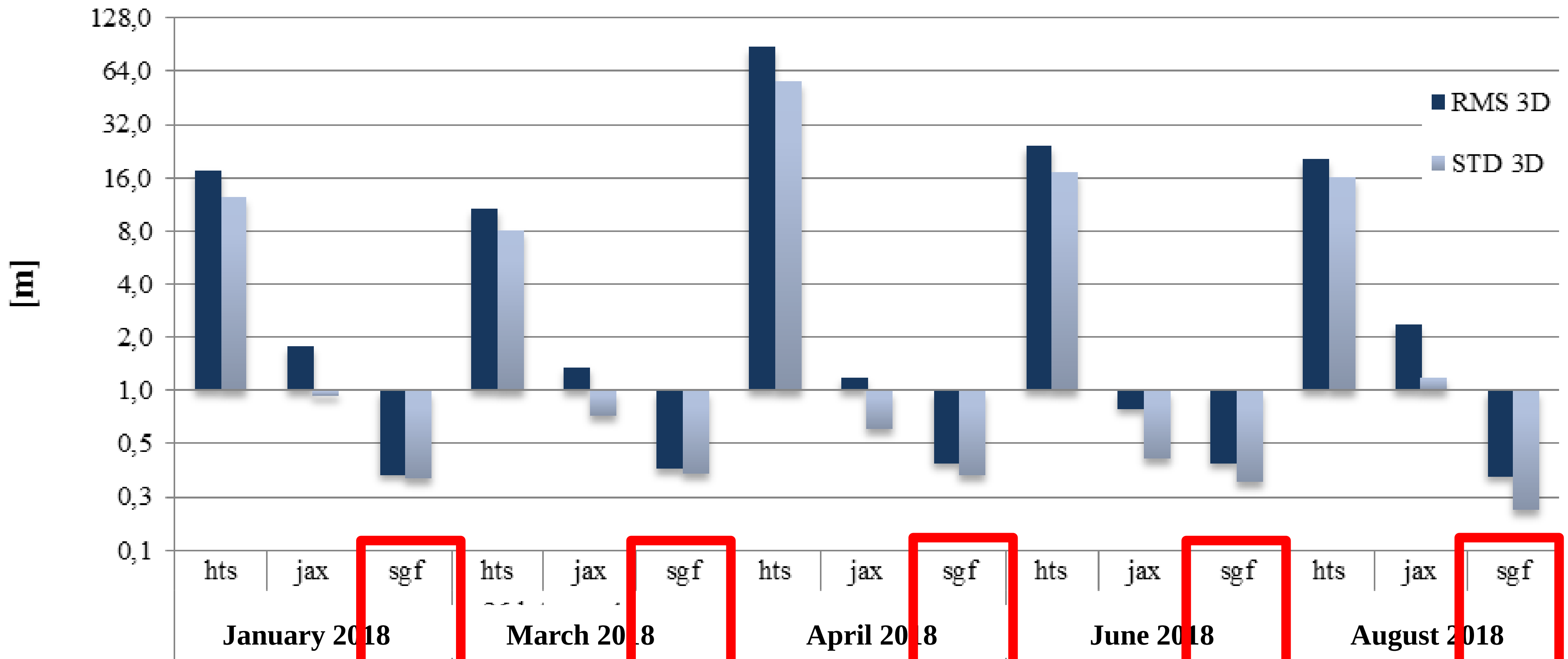
GNSS: precice final IGS MGEX orbits



LEO: GPS kinematic orbits

Quality of the orbit predictions – LAGEOS-1

3D RMS and STD of differences between final orbits and LAGEOS-1 predictions



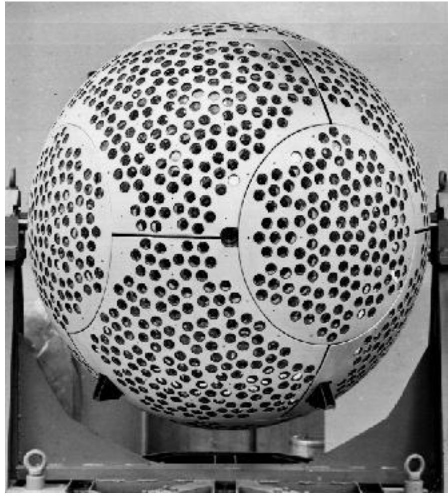
	January 2018			March 2018			April 2018			June 2018			August 2018		
	hts	jax	sgf	hts	jax	sgf	hts	jax	sgf	hts	jax	sgf	hts	jax	sgf
RMS 3D	17,6	1,8	0,3	10,7	1,4	0,4	88,2	1,2	0,4	24,4	0,8	0,4	20,4	2,4	0,3
STD 3D	12,4	0,9	0,3	8,0	0,7	0,3	56,5	0,6	0,3	17,2	0,4	0,3	16,0	1,2	0,2

JAX - Japanese Aerospace Exploration Agency,

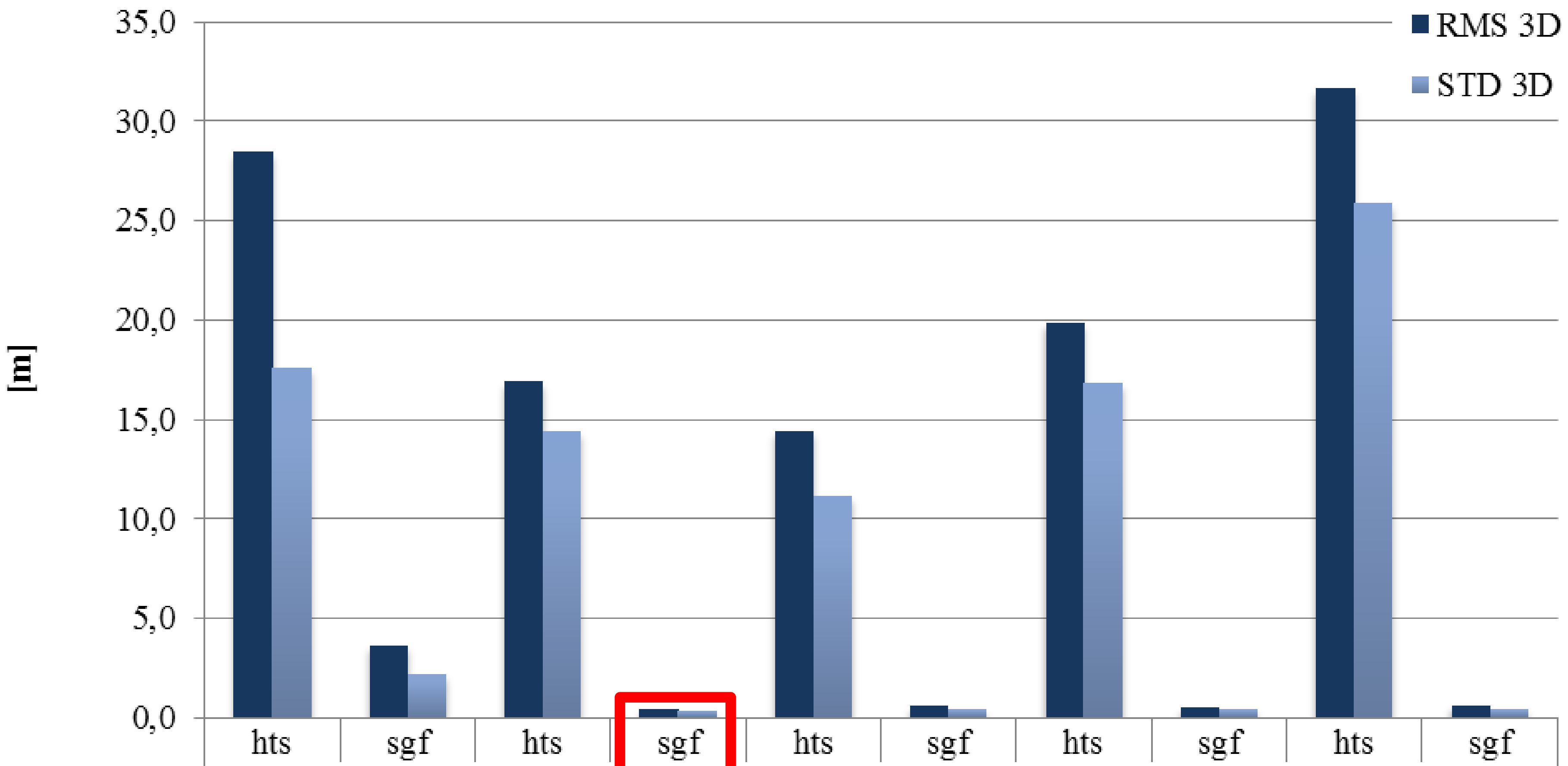
SGF – NERC Space Geodesy Facility,

HTS – Former NASA GSFC SLR Mission Contractor

Quality of the orbit predictions – Etalon-1



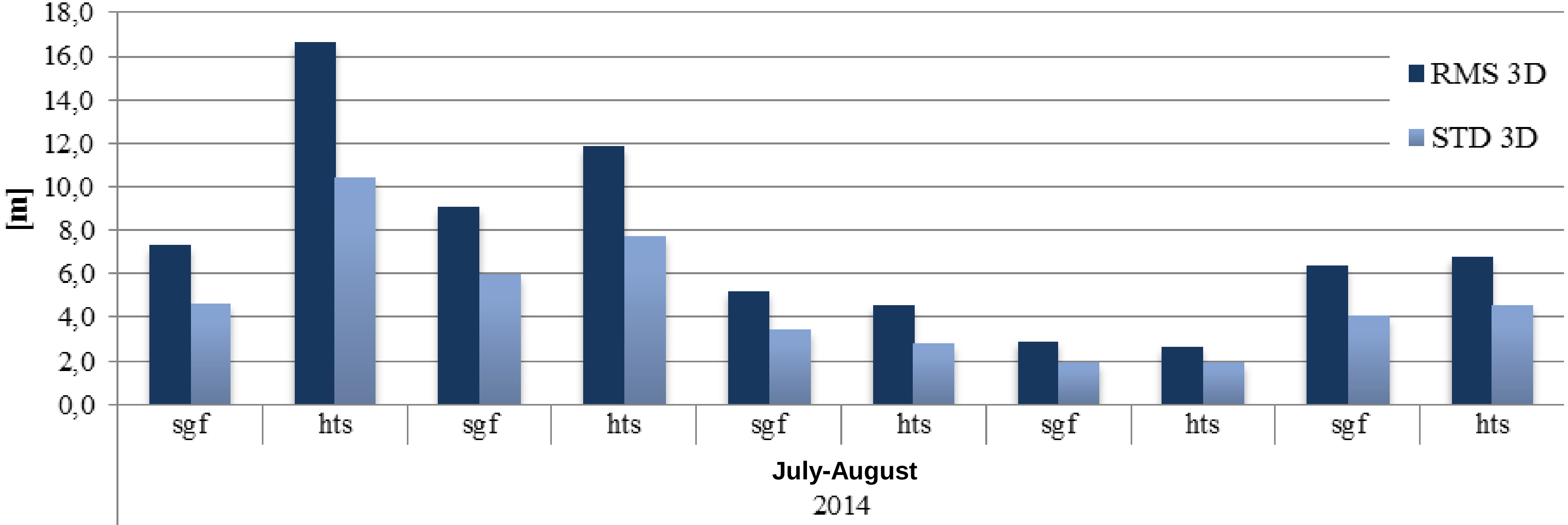
RMS and STD of differences between final and predicted orbits for Etalon-1



	January 2018		February 2018		March 2018		April 2018		May 2018	
	hts	sgf	hts	sgf	hts	sgf	hts	sgf	hts	sgf
RMS 3D	28,4	3,6	16,9	0,4	14,4	0,6	19,9	0,5	31,6	0,6
STD 3D	17,6	2,2	14,4	0,3	11,1	0,4	16,8	0,4	25,9	0,4

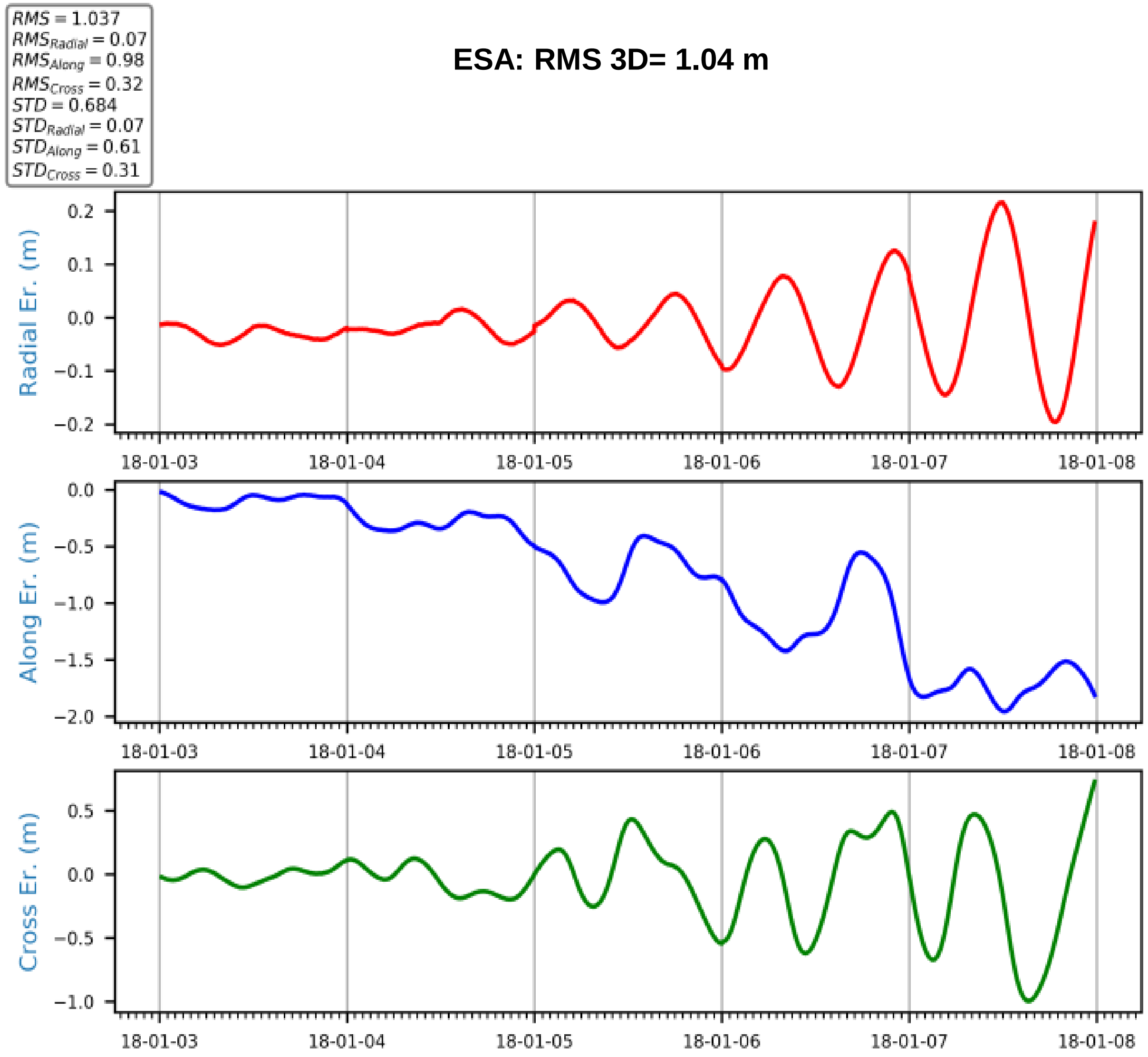
Quality of the orbit predictions – Starlette

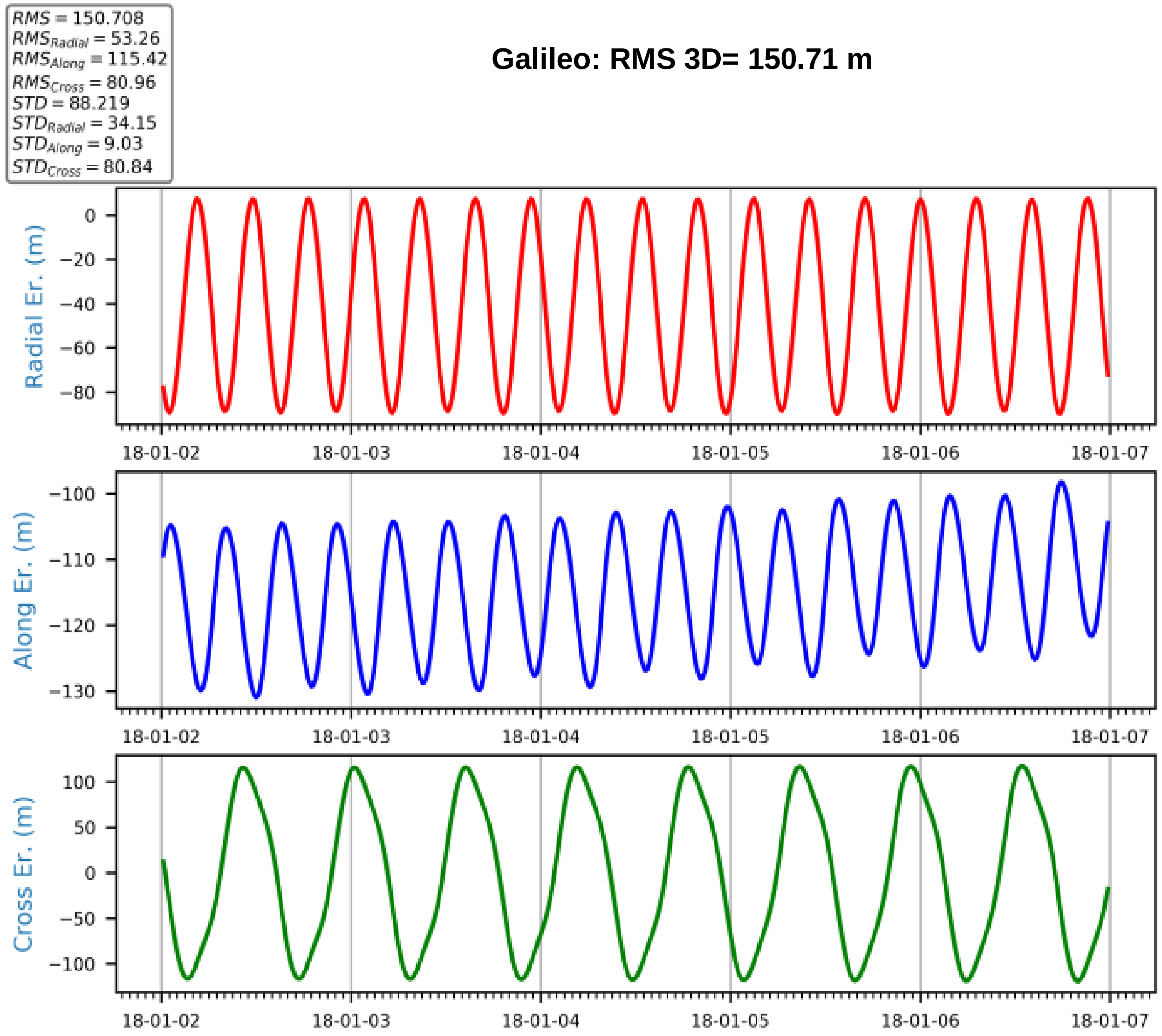
3D RMS and STD differences between final and predicted Starlette orbits



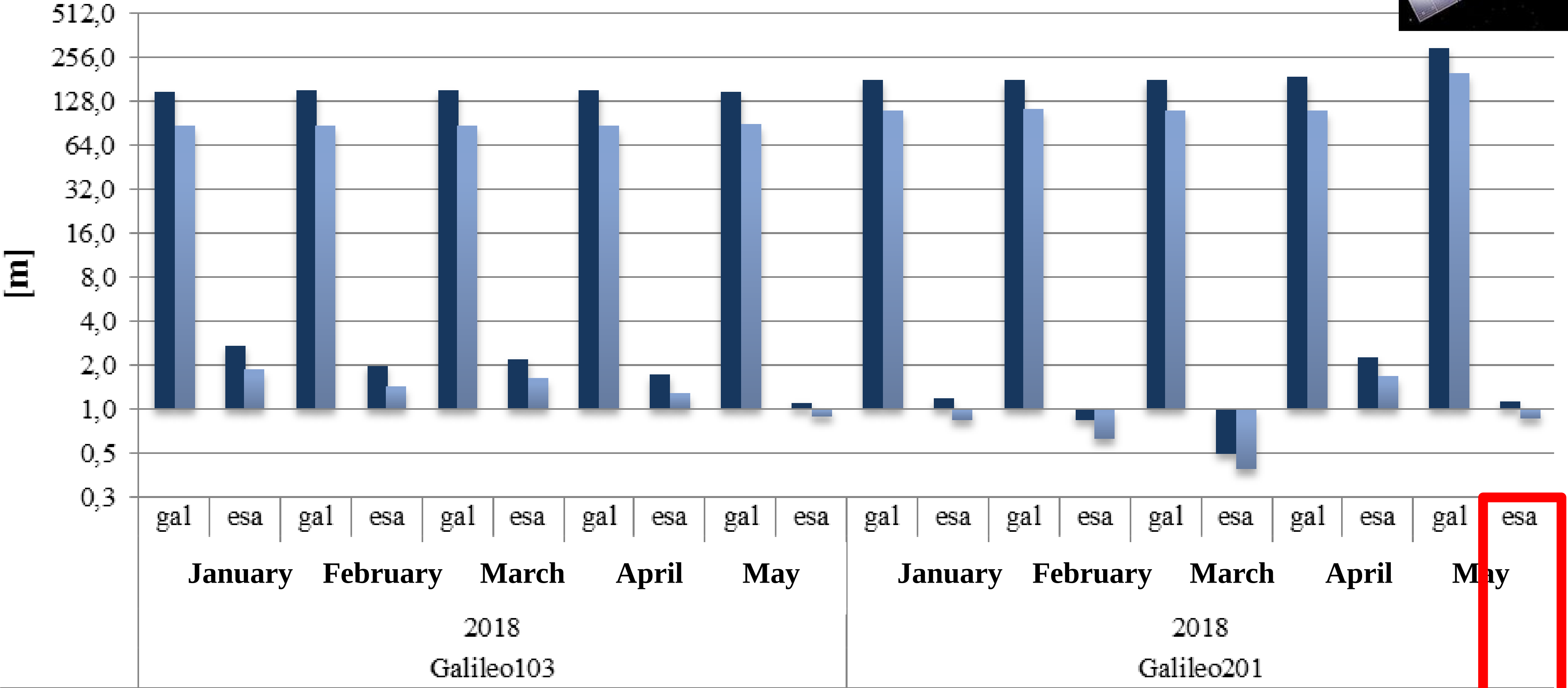
	sgf	hts	sgf	hts	sgf	hts	sgf	hts	sgf	hts
RMS 3D	7,3	16,6	9,1	11,9	5,2	4,6	2,9	2,6	6,4	6,8
STD 3D	4,6	10,5	6,0	7,8	3,4	2,8	1,9	2,0	4,1	4,5

Quality of the orbit predictions – Galileo





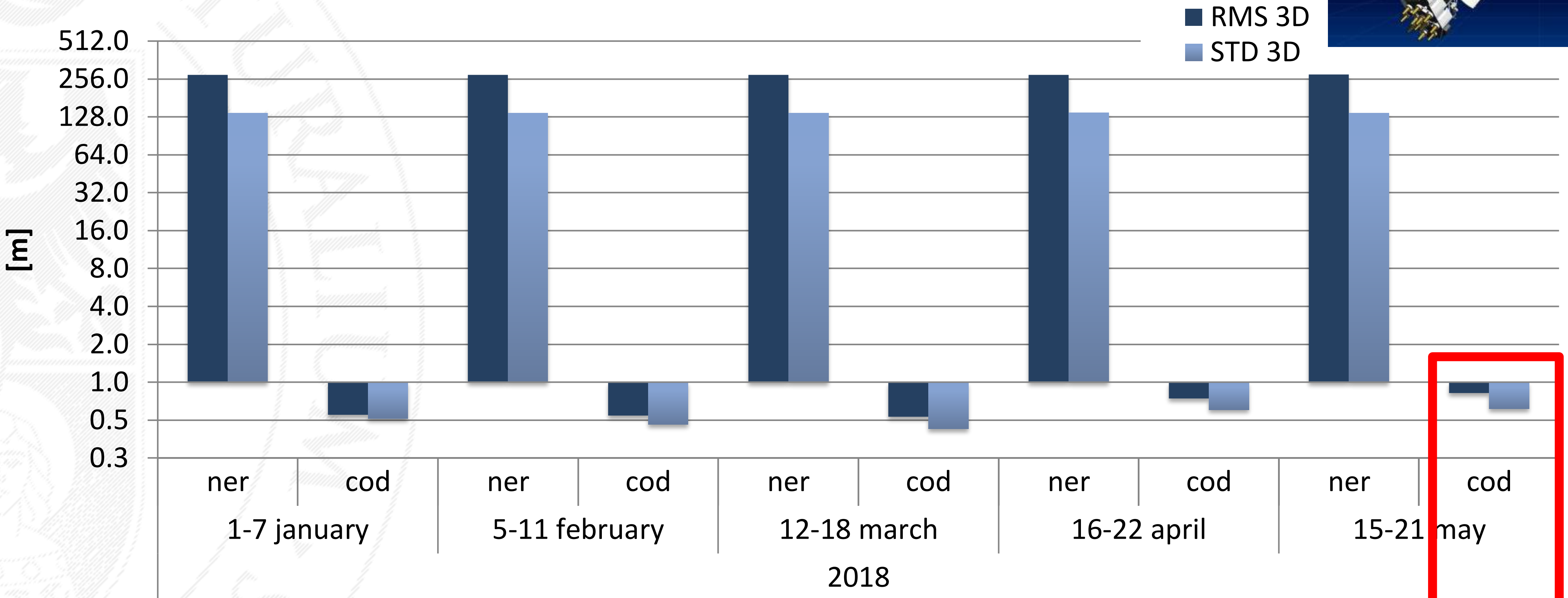
Quality of the orbit predictions – Galileo



	Galileo103 2018 January gal	January esa	February gal	February esa	March gal	March esa	April gal	April esa	May gal	May esa	Galileo201 2018 January gal	January esa	February gal	February esa	March gal	March esa	April gal	April esa	May gal	May esa
RMS 3D	151,5	2,7	152,6	2,0	153,8	2,2	153,0	1,7	151,6	1,1	182,6	1,2	181,9	0,8	182,1	0,5	189,8	2,3	302,3	1,1
STD 3D	87,9	1,9	88,1	1,4	87,5	1,6	88,3	1,3	88,5	0,9	111,8	0,8	112,8	0,6	111,4	0,4	110,1	1,7	198,2	0,9

GAL - Galileo Control Centre, ESA - European Space Operations Centre

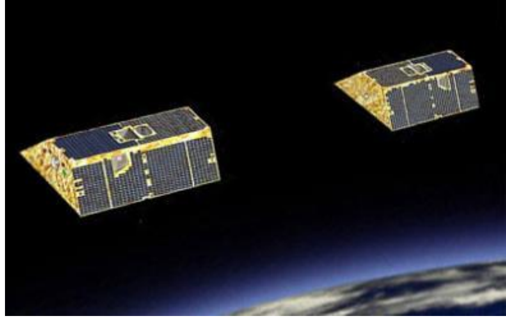
Quality of the orbit predictions – GLONASS



	ner 1-7 january	cod 1-7 january	ner 5-11 february	cod 5-11 february	ner 12-18 march	cod 12-18 march	ner 16-22 april	cod 16-22 april	ner 15-21 may	cod 15-21 may
RMS 3D	276.4	0.6	276.6	0.5	276.4	0.5	276.4	0.7	278.1	0.8
STD 3D	137.8	0.5	137.9	0.5	137.9	0.4	138.3	0.6	137.6	0.6

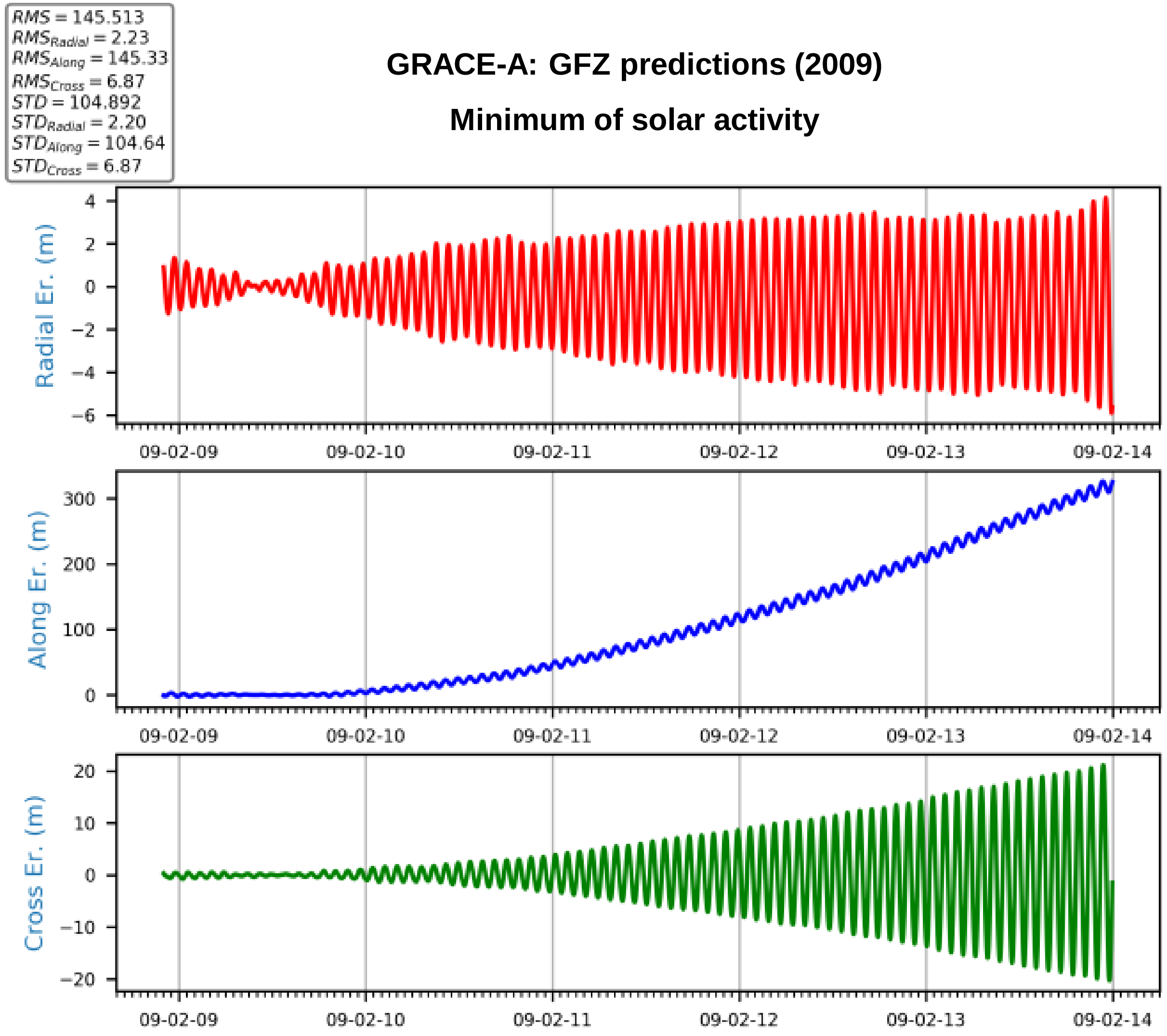
NER - NERC Space Geodesy Facility, COD - Center for Orbit Determination in Europe

Quality of the orbit predictions – GRACE



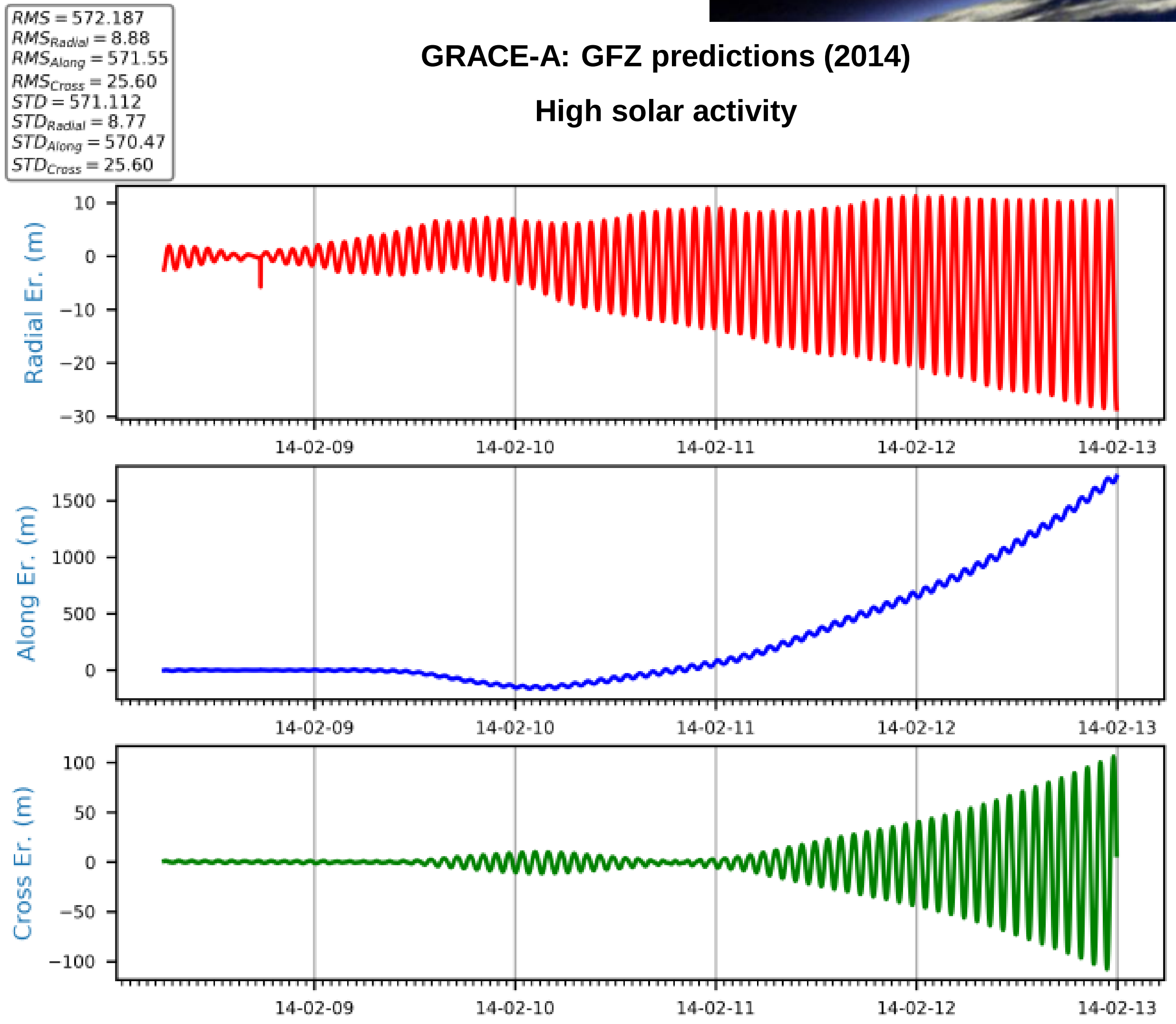
GRACE-A: GFZ predictions (2009)

Minimum of solar activity

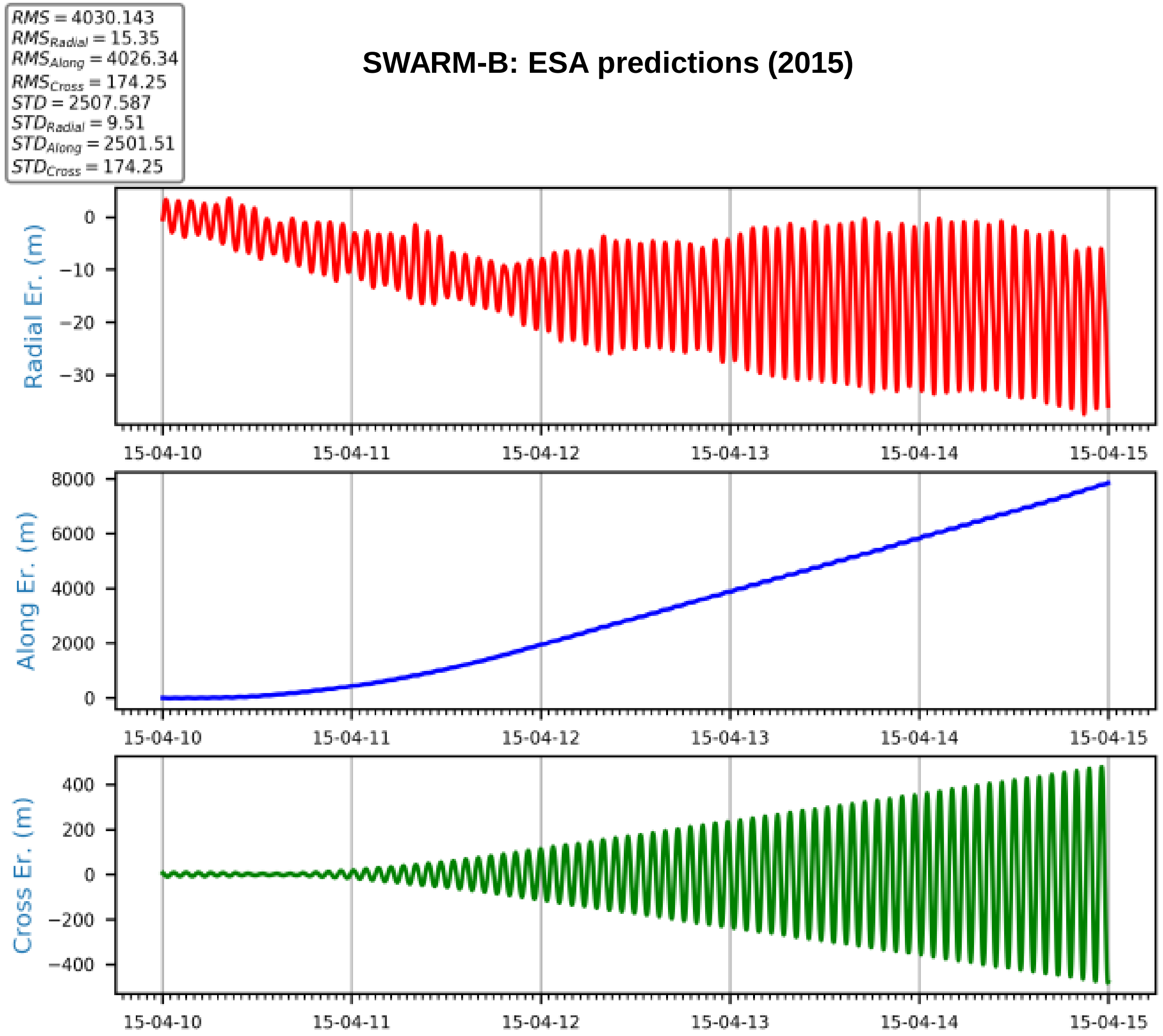


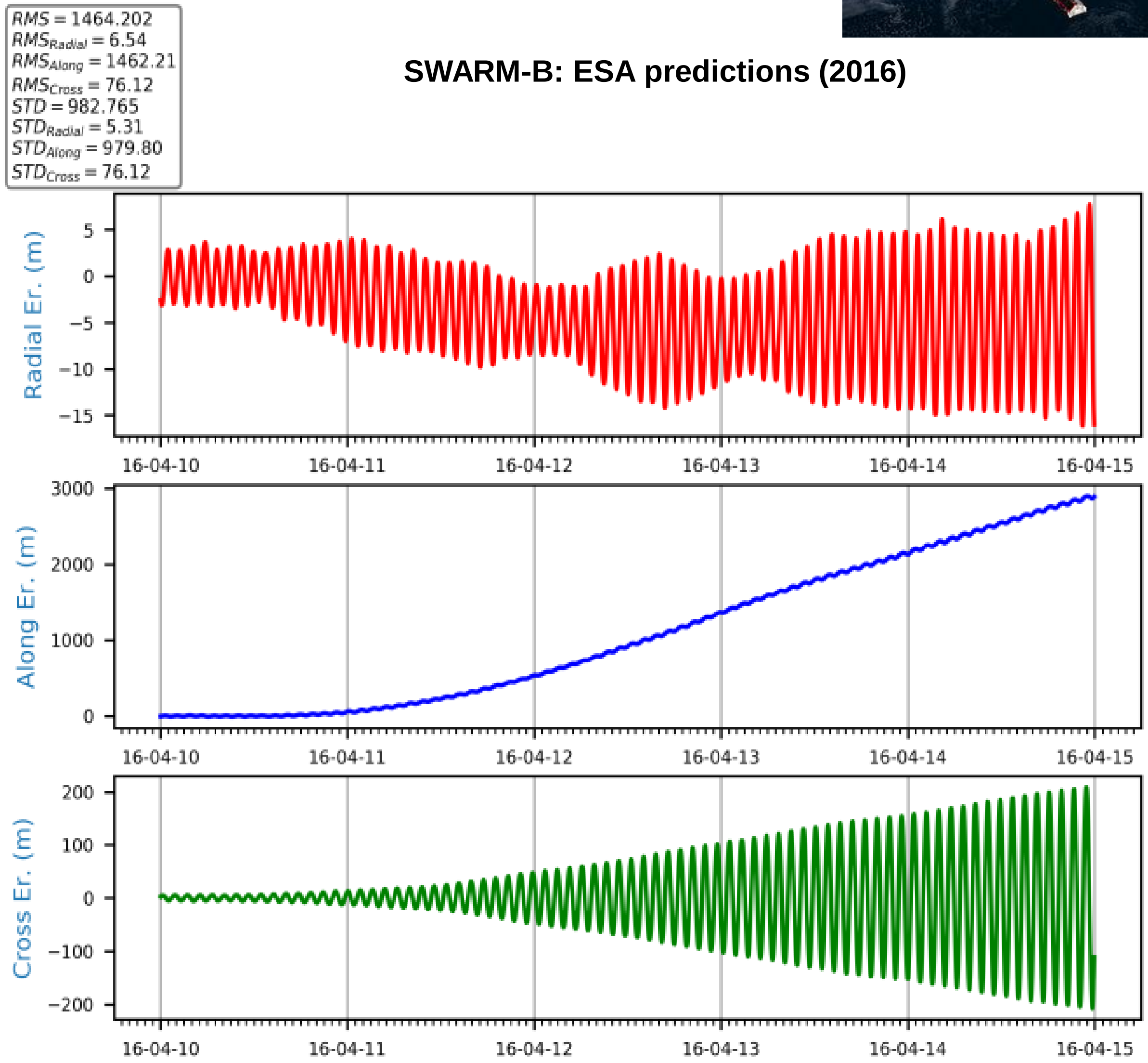
GRACE-A: GFZ predictions (2014)

High solar activity



Quality of the orbit predictions – SWARM





Best prediction centers & 3D Quality of predicted orbits

Geodetic satellites: Accuracy of 0.3-100m

Galileo and GLONASS: 0.5-2.0 m (!)

BeiDou and QZSS: 50-100 m

LEO: frequent updates needed

Satellite	Prediction Centers	RMS 3D [m]	STD 3D [m]
Etalon1	SGF (or JAX)	1.1	0.8
LAGEOS1		0.4	0.3
LAGEOS2		0.5	0.4
Larets	MCC (or SGF)	95.3	60.4
Starlette	SGF	6.2	4.0
Stella		25.7	17.6
Galileo103	ESA/COD	2.0	0.9
Galileo201		1.2	0.9
GLONASS	COD	0.6	0.5
BeiDou-i3	SHA[1]	64.6	53.3
BeiDou-M3		71.3	48.0
QZS-1	QSS[1]	110.0	100.1
GRACE-A	GFZ[1]	832.8[2]	229.8[2]
Swarm-B	ESA[1]	1109.9[2]	813.2[2]
Swarm-C		2879.8[2]	2095.7[2]

[1] For these satellites, the prediction files are published only by one center.
[2] For the year with reduced solar activity.

Thank you for your attention

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