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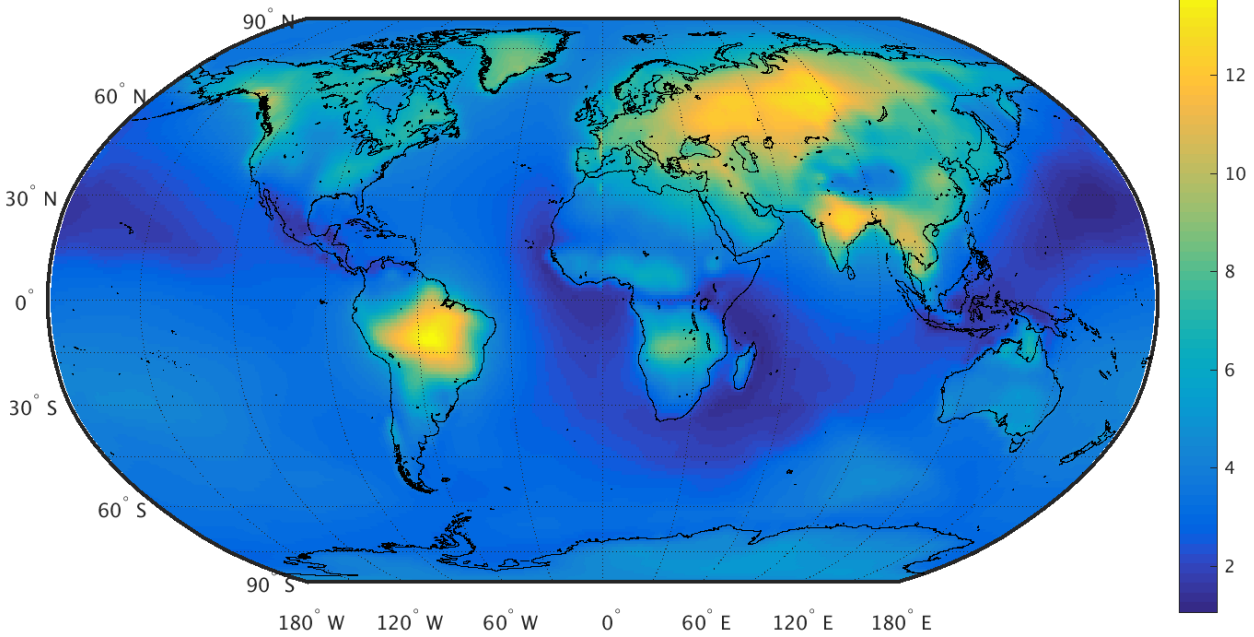
On the impact of reducing global geophysical fluid model deformations in SLR data processing

M. Weigelt and D. Thaller

Motivation

- Non-tidal mass redistributions lead to displacements of the Earth surface
- Limiting factor for ITRF realizations
- Loading models for atmosphere, (non-tidal) ocean, and hydrology are available

GGFC annual amplitude: up component



Models (gridded data)

Atmosphere	Time resolution	Spatial resolution	Models
GGFC (Luxemburg)	6h	2.5°	NCEP
NASA GSFC	6h	2.5°	NCEP
TU Vienna (v4)	6h	1°	ECMWF
Uni Strasbourg	3h-6h	0.5°	ECMWF + IB ECMWF + MOG2D ERAinterim + IB
IMLS	3h-6h	1°	MERRA GEOS-507 GEOS-511 GEOS-FP GEOS-FPIT
GFZ	3h	0.5°	ECMWF reanalysis ERA-40 + ERA-Interim + operational ECMWF

Models (gridded data)

Non-tidal ocean	Time resolution	Spatial resolution	Models
GGFC (Luxemburg)	6h	2.5°	ECCO1 / JPL
NASA GSFC	12h	1°	ECCO1 / JPL
Uni Strasbourg	12h-24h	0.5°	ECCO1 / JPL ECCO2 / JPL
IMLS	6h	1°	OMCT

Hydrology	Time resolution	Spatial resolution	Models
GGFC (Luxemburg)	1 month	2.5°	GLDAS / NOAH 1°
NASA GSFC	1 month	1°	GLDAS / NOAH 1°
Uni Strasbourg	3h-6h	0.5°	GLDAS / NOAH 0.25° ERAinterim
IMLS	6h	1°	MERRA GEOS-FPIT GLDAS / NOAH 0.25°
GFZ	24h	0.5°	LSDM (v1)

Forming sets of (institute-wise) models

- Blocks of models per institution

REF	GGFC	NASA	Strasbourg	IMLS
-	NCEP	NCEP	ERAinterim	MERRA
-	ECCO	ECCO	ECCO	OMCT
-	GLDAS	GLDAS	ERAinterim	MERRA

- Choice is based on assumption of consistent computation
- No mass conservation in any of the selected sets
- Bias and trend removed (from data period 2000-2011)

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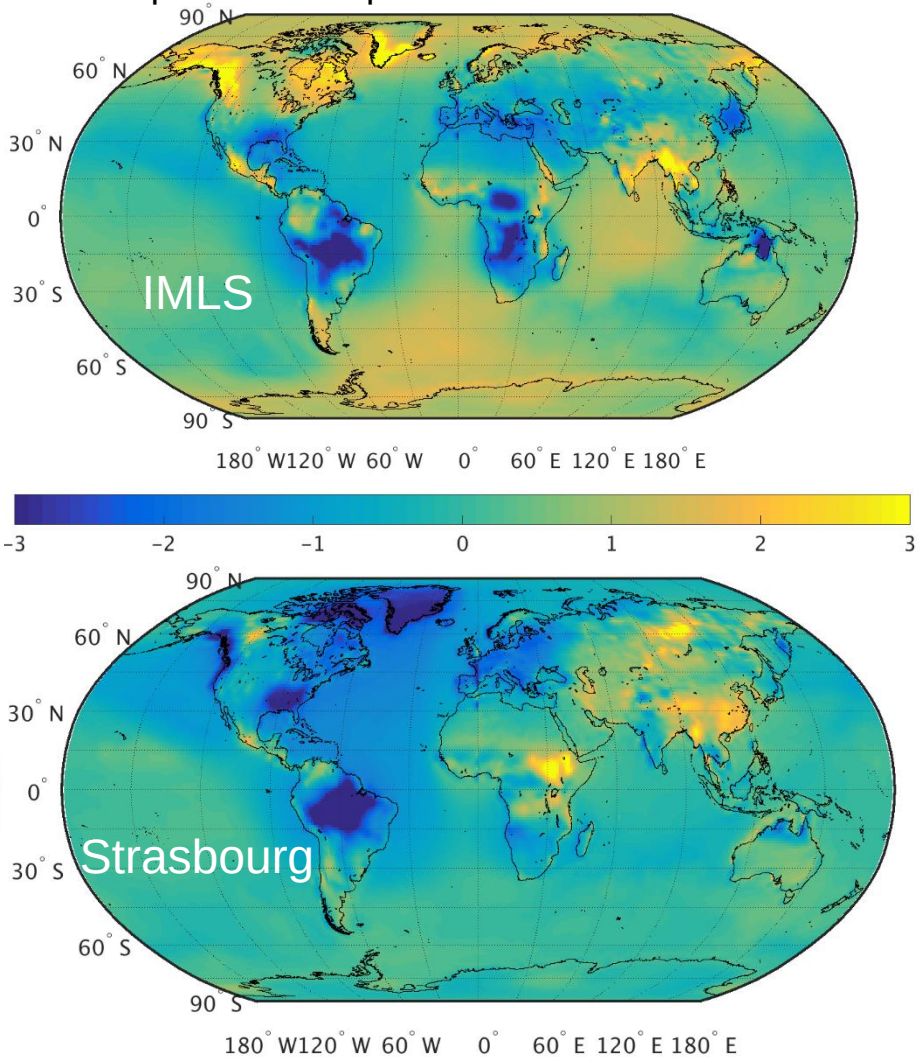
Comparison: annual amplitude of the up-component

More than 25% difference
in signal strength observable

Possible reasons:

- driving models
- spatial (and temporal) resolution
- handling of regions
- loading calculation

Up: annual amplitude relative to GGFC



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Impact on SLR data processing

SLR data processing

Observed satellites:	LAGEOS 1/2
Time period:	14 years (Jan. 2000 – Dec. 2013)
Sampling:	weekly (Sun.-Sat.)
Software:	Bernese GNSS Software with SLR development v5.3
Loading grids:	Spatial interpolation to 1°x1° Temporal interpolation to 6h Consistent AOHD modeling (SH analysis of the gridded data)
SLR network:	58 Stations

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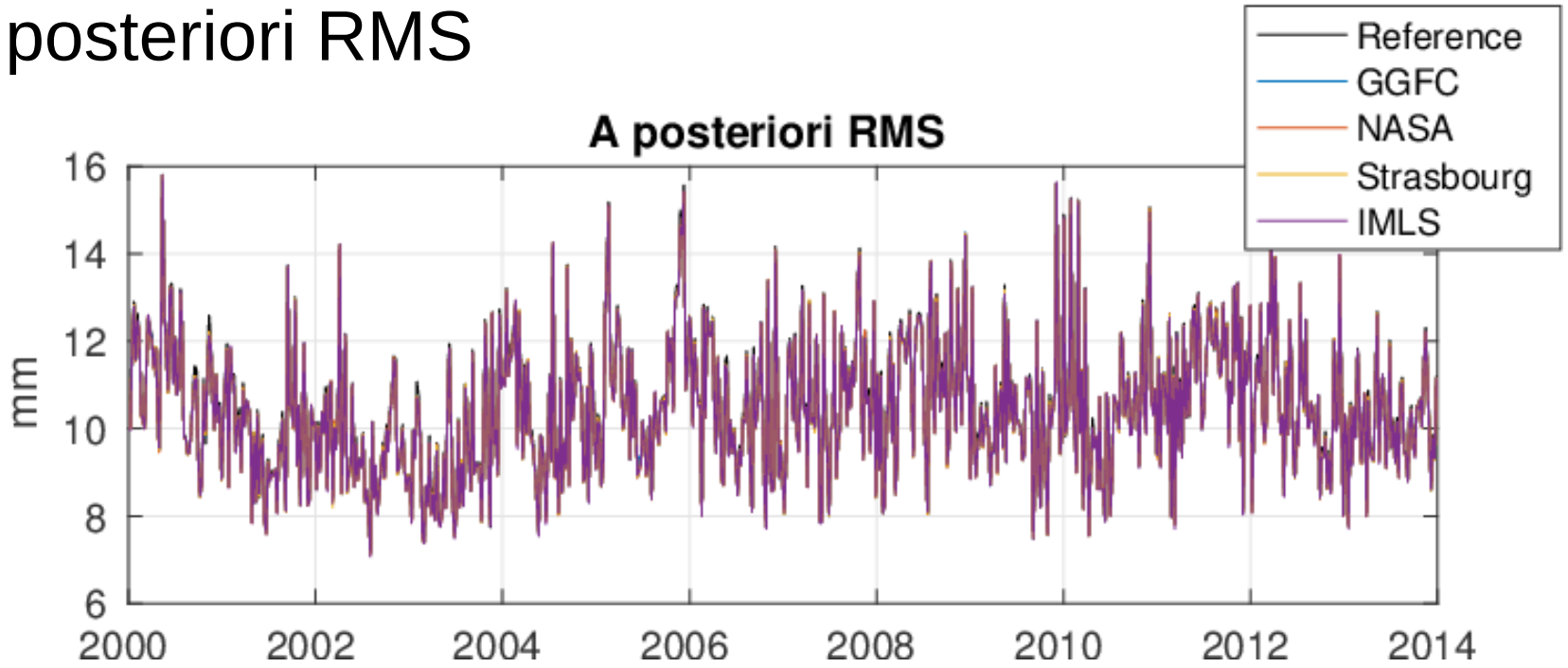
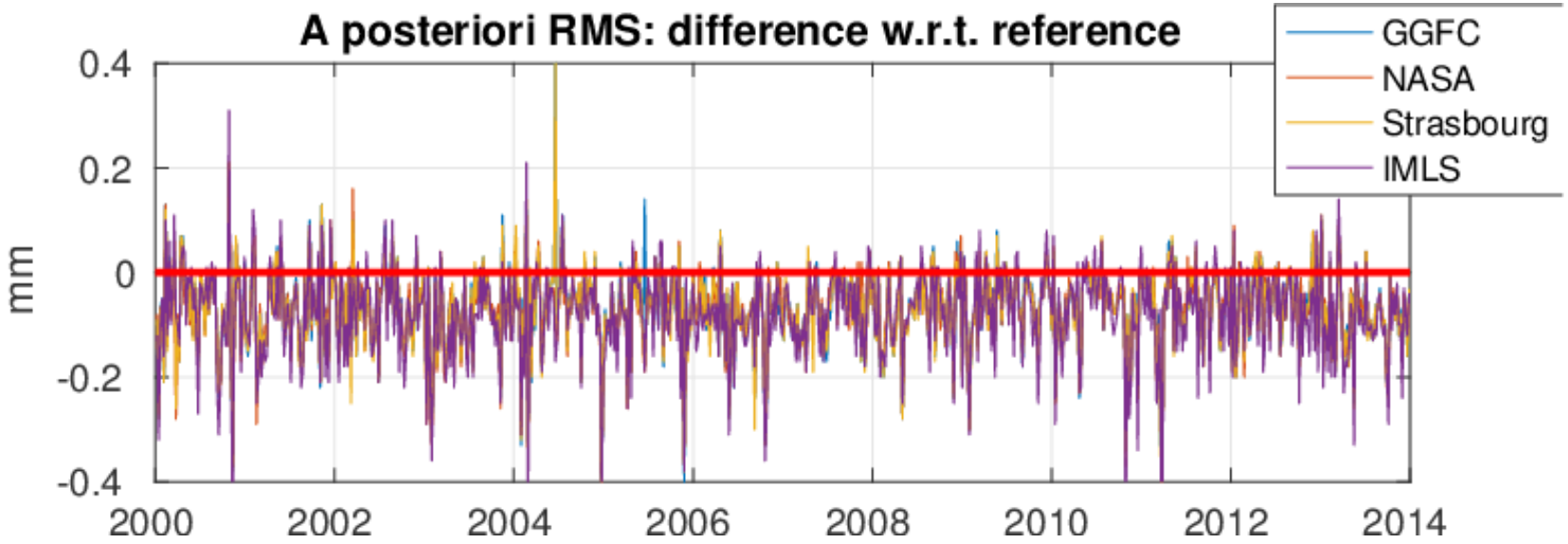
A posteriori RMS



Model:	Mean [mm]	Std [mm]	Max [mm]	Min [mm]
Reference	10.511	1.540	15.810	7.200
GGFC	10.443	1.545	15.790	7.130
NASA	10.442	1.548	15.800	7.110
Strasbourg	10.441	1.545	15.780	7.130
IMLS	10.433	1.549	15.800	7.070

A posteriori RMS



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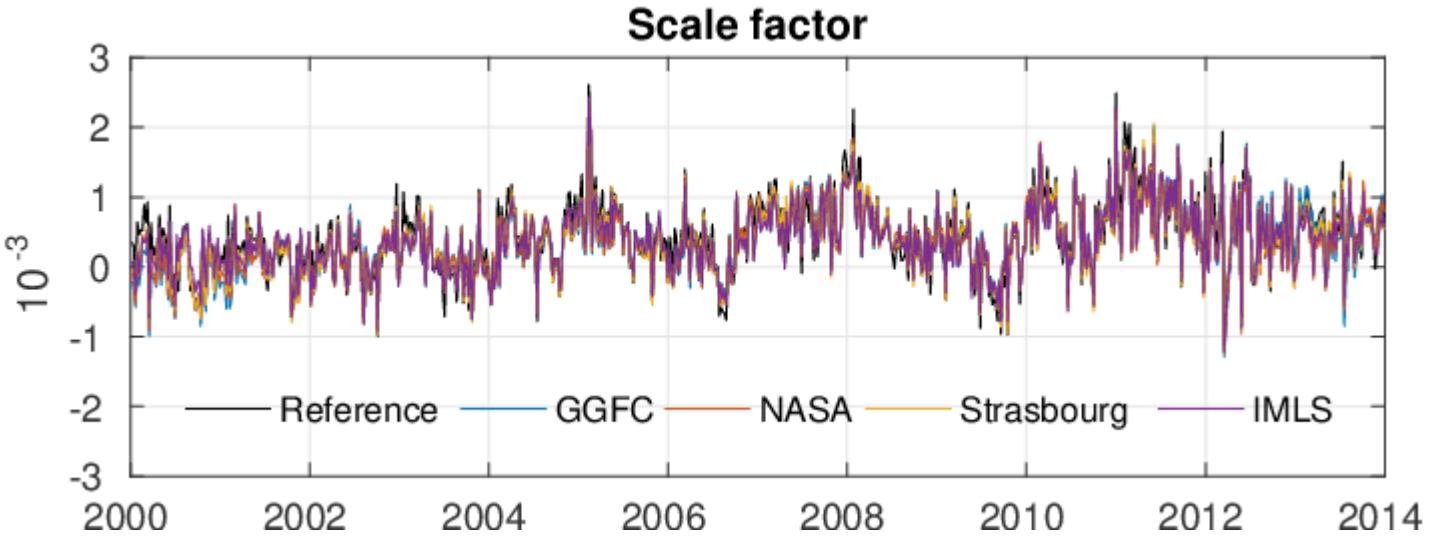
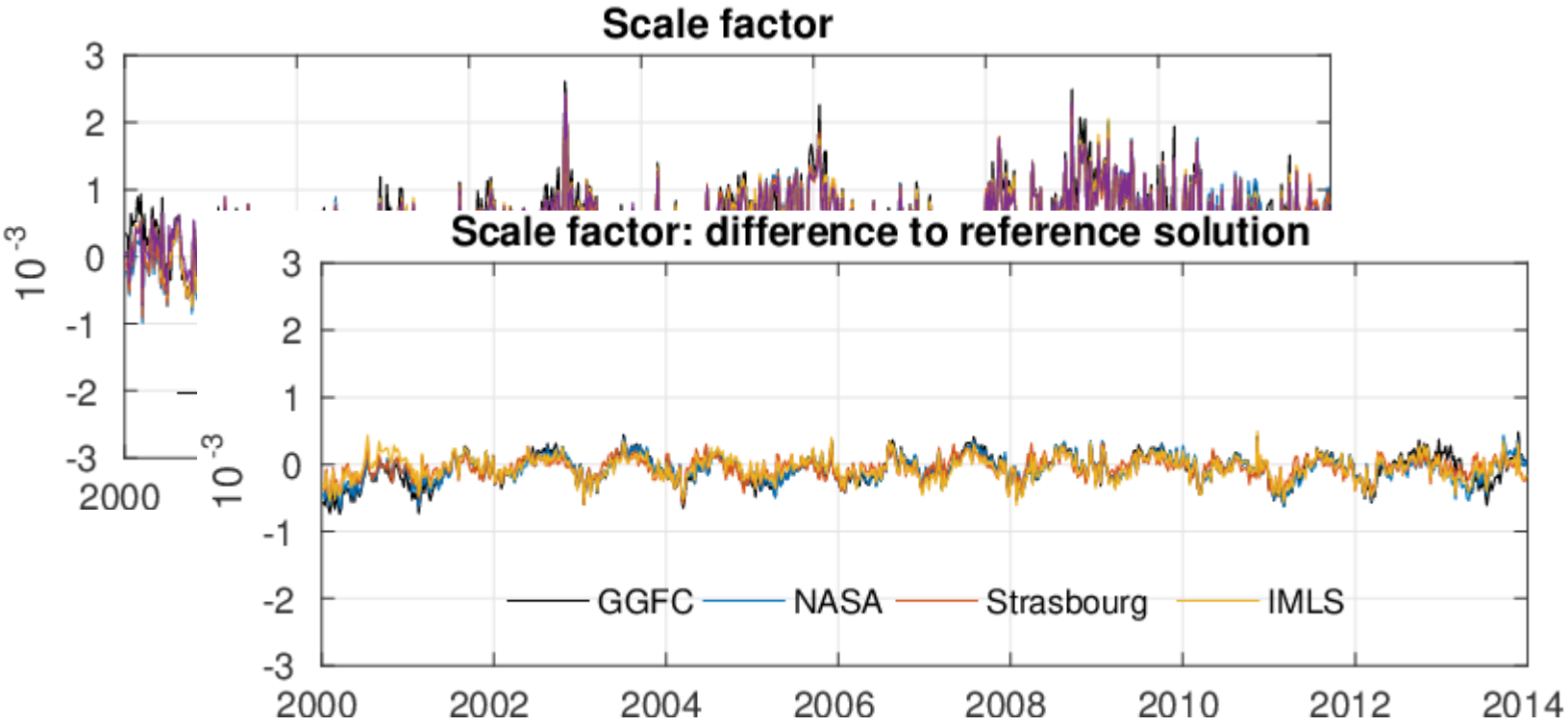
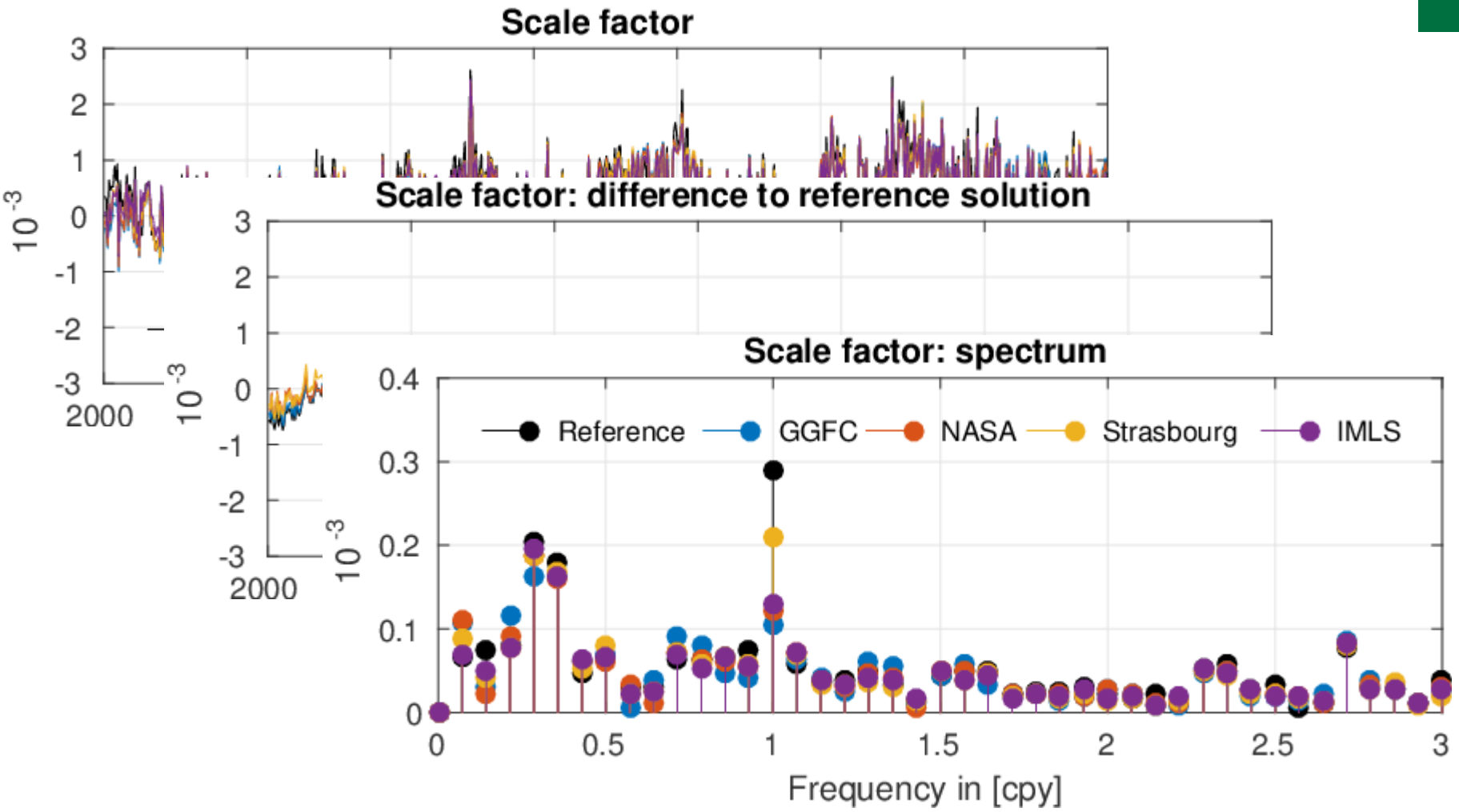
Scale w.r.t. SLRF2008



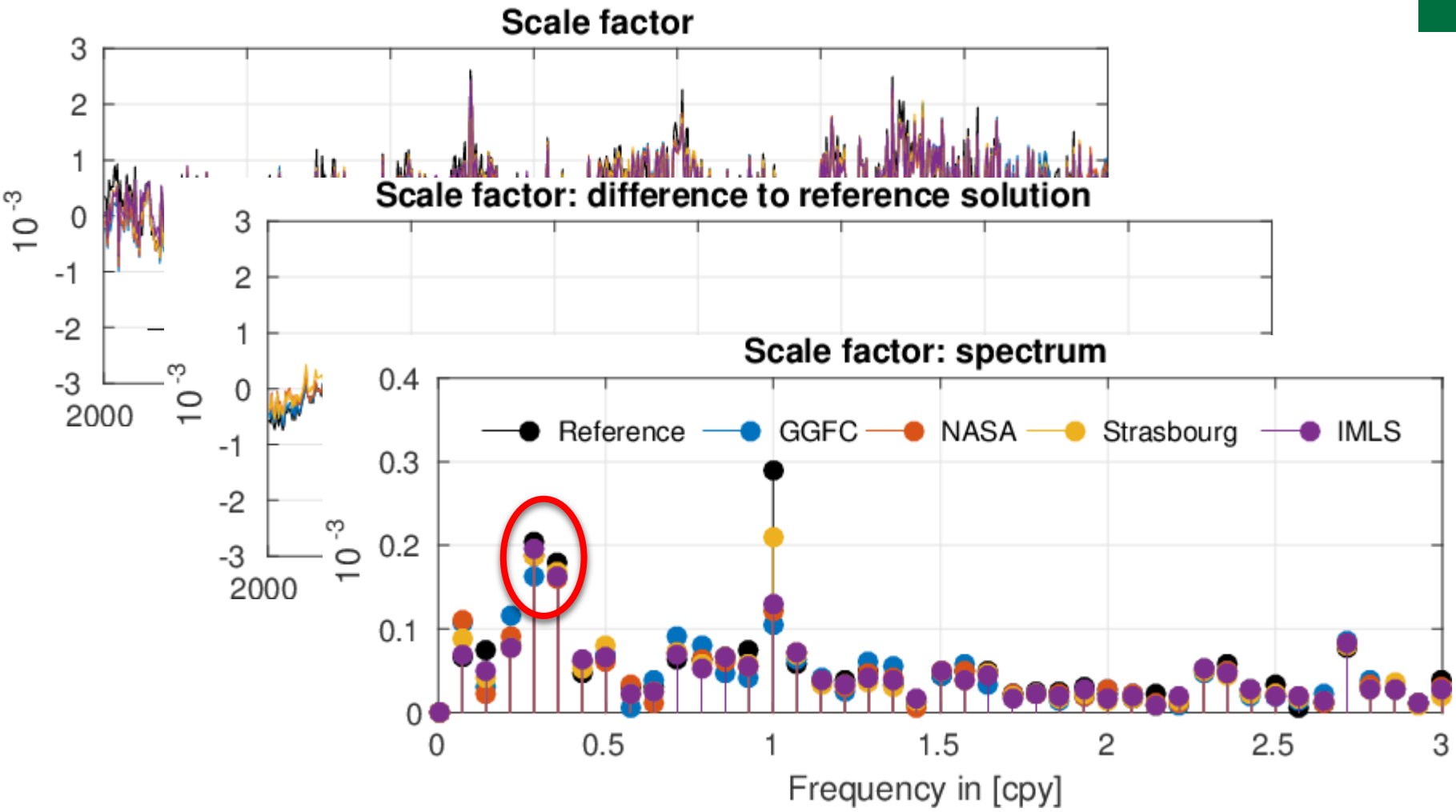
Scale w.r.t. SLRF2008



Scale w.r.t. SLRF2008



Scale w.r.t. SLRF2008



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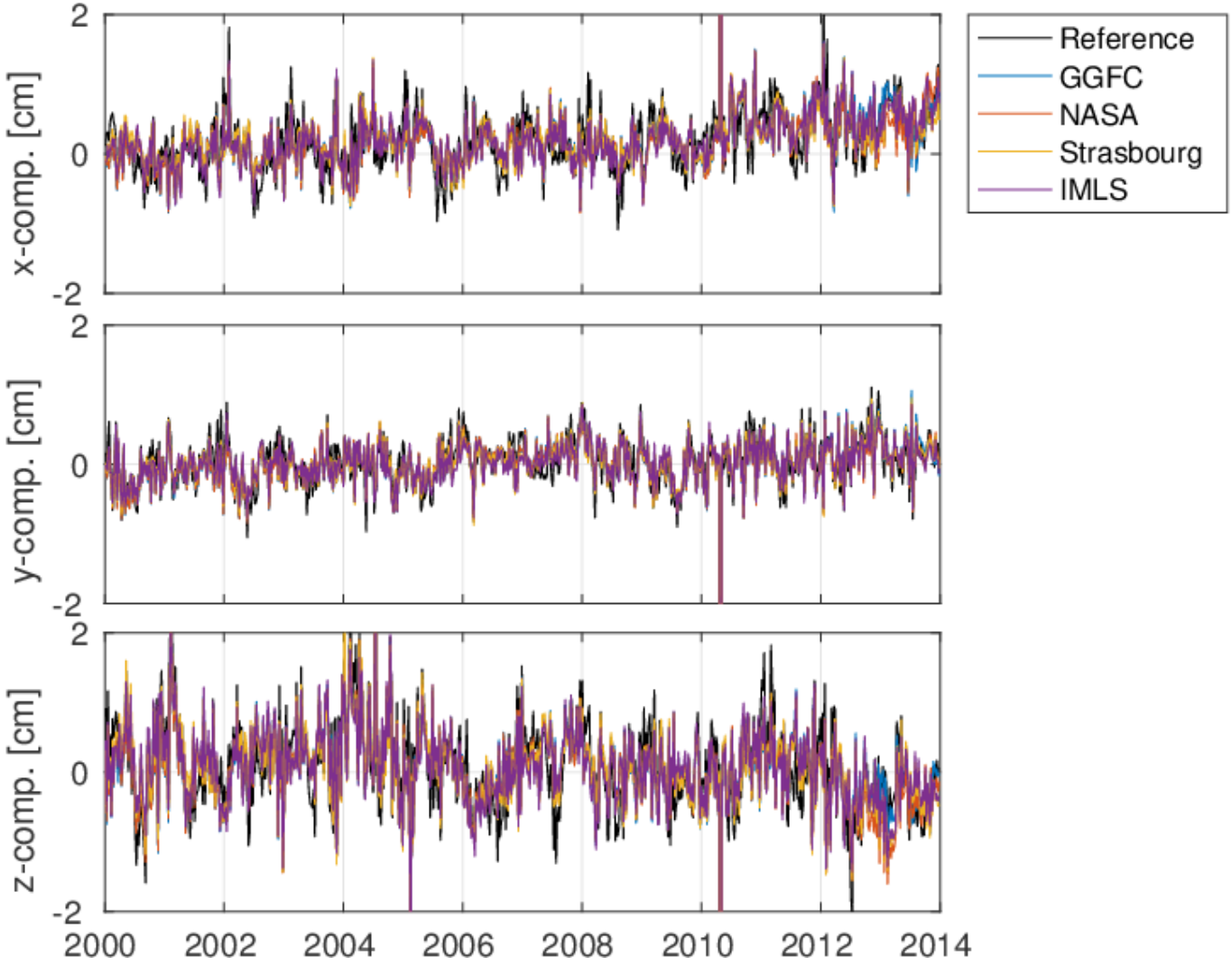
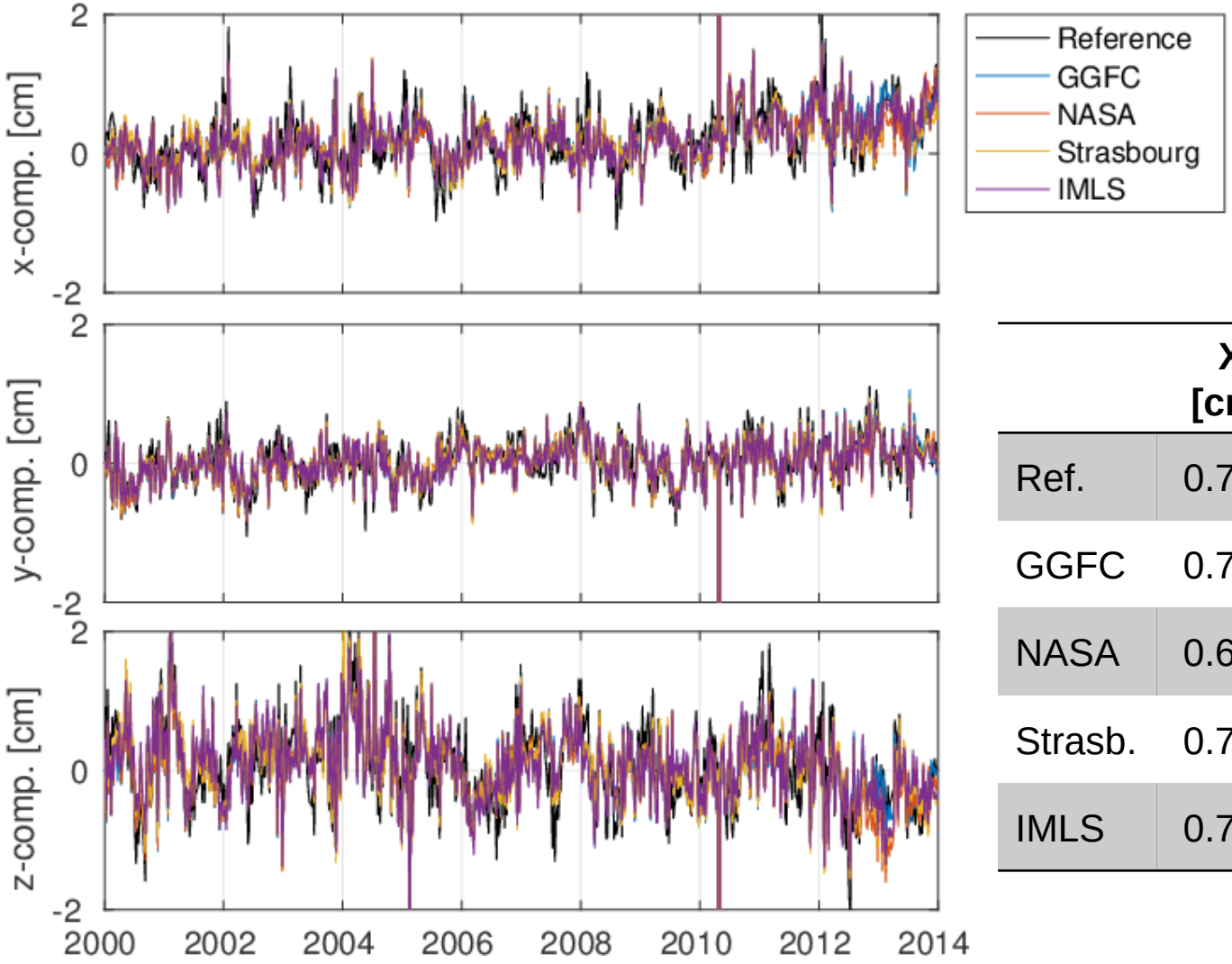
Geocenter

Geocenter coordinates

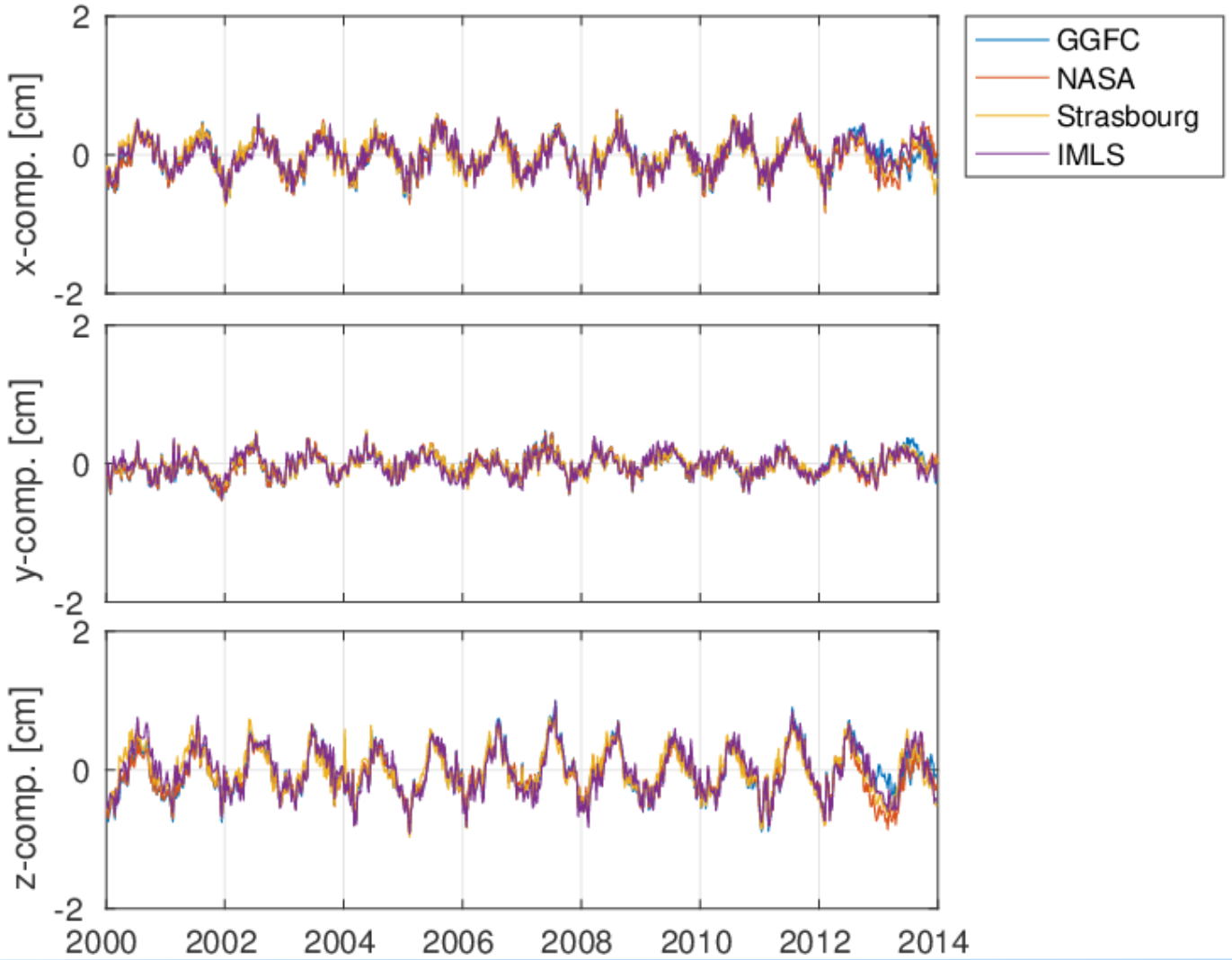


Geocenter coordinates

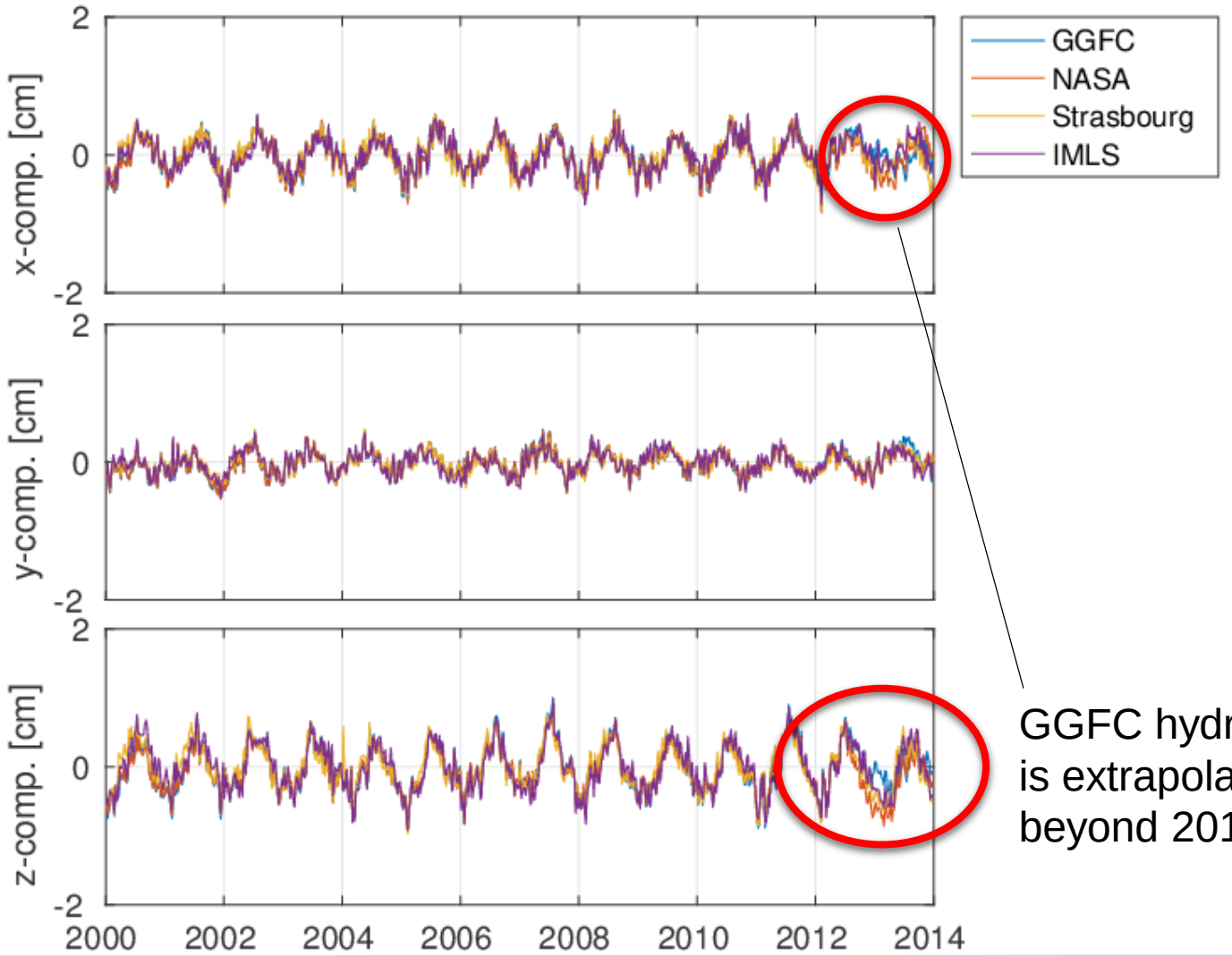


	X [cm]	Y [cm]	Z [cm]
Ref.	0.747	0.548	0.761
GGFC	0.701	0.524	0.685
NASA	0.694	0.519	0.701
Strasb.	0.705	0.519	0.701
IMLS	0.702	0.516	0.695

Geocenter coordinates – difference to reference

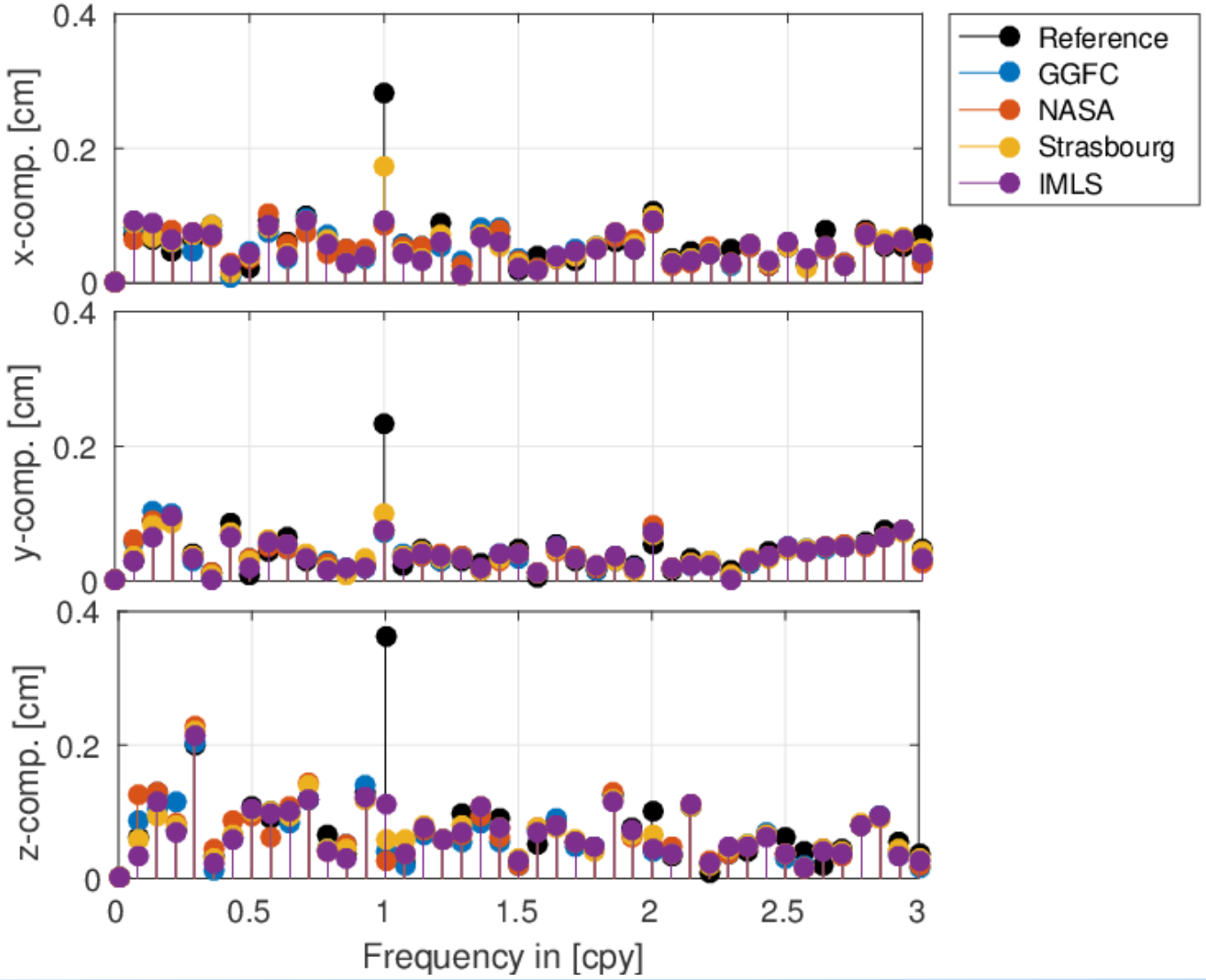


Geocenter coordinates – difference to reference

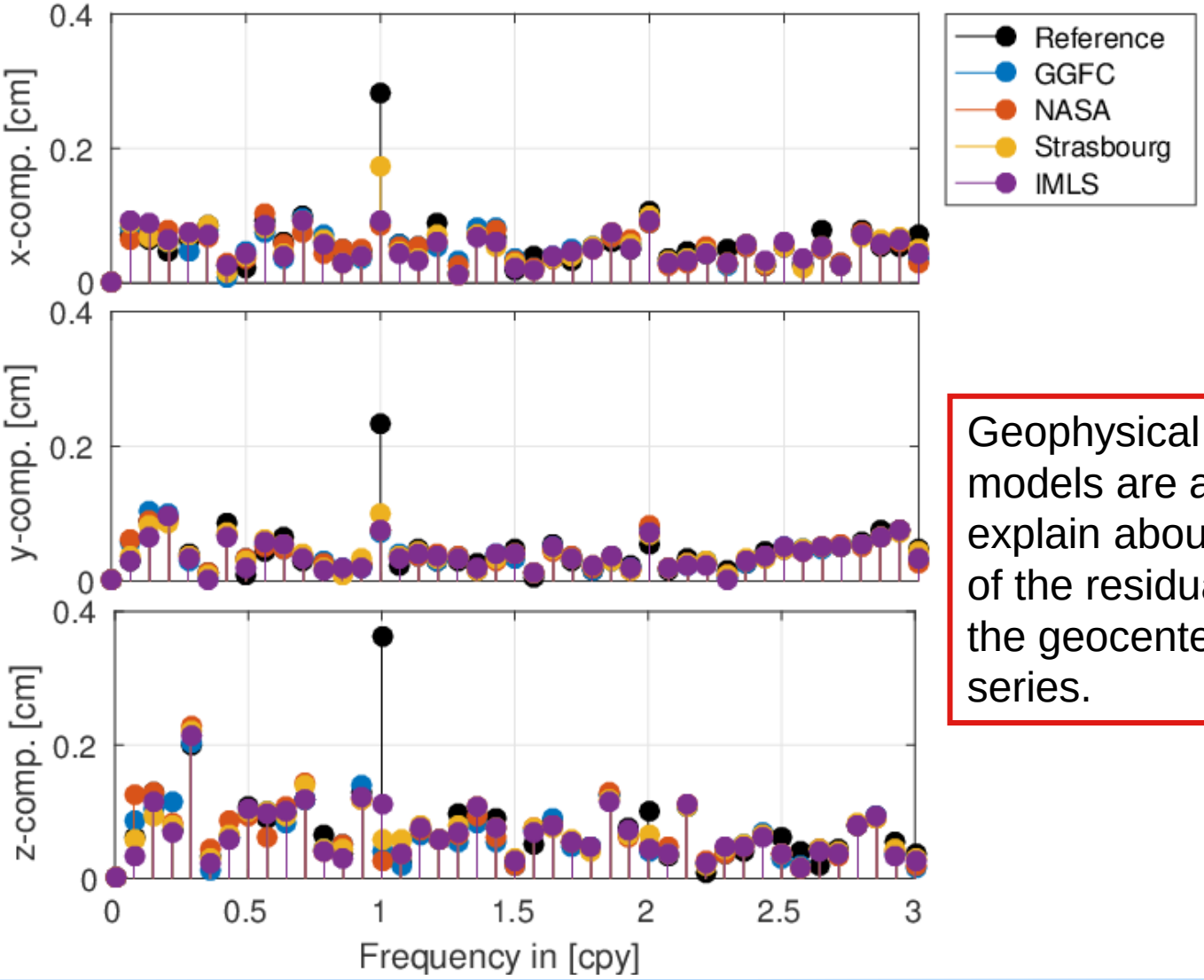


GGFC hydrology is extrapolated beyond 2012

Geocenter coordinates – filtered time series



Geocenter coordinates – filtered time series



Geophysical Fluid models are able to explain about 10% of the residuals in the geocenter time series.

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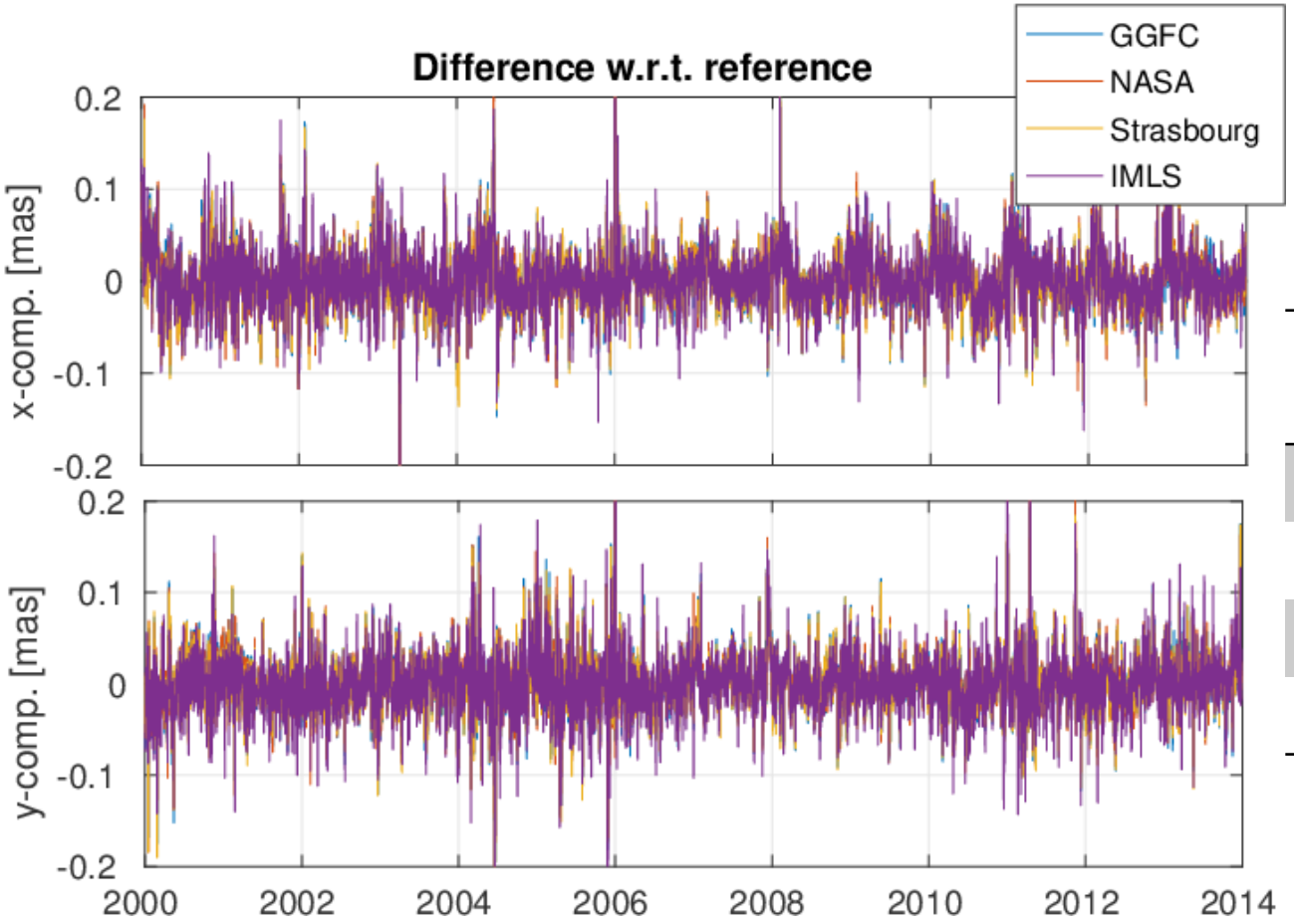
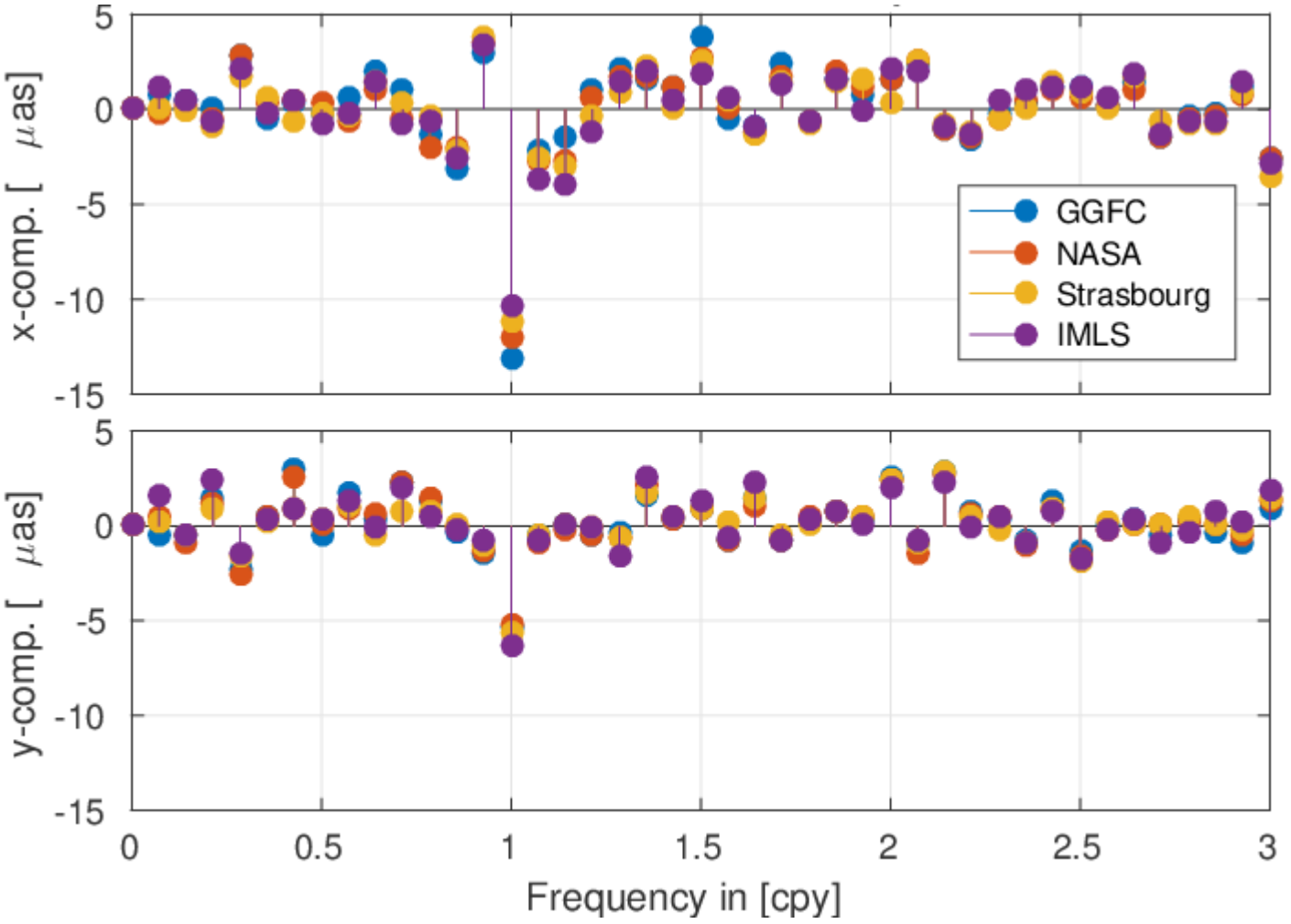
Earth orientation parameters

Polar coordinates

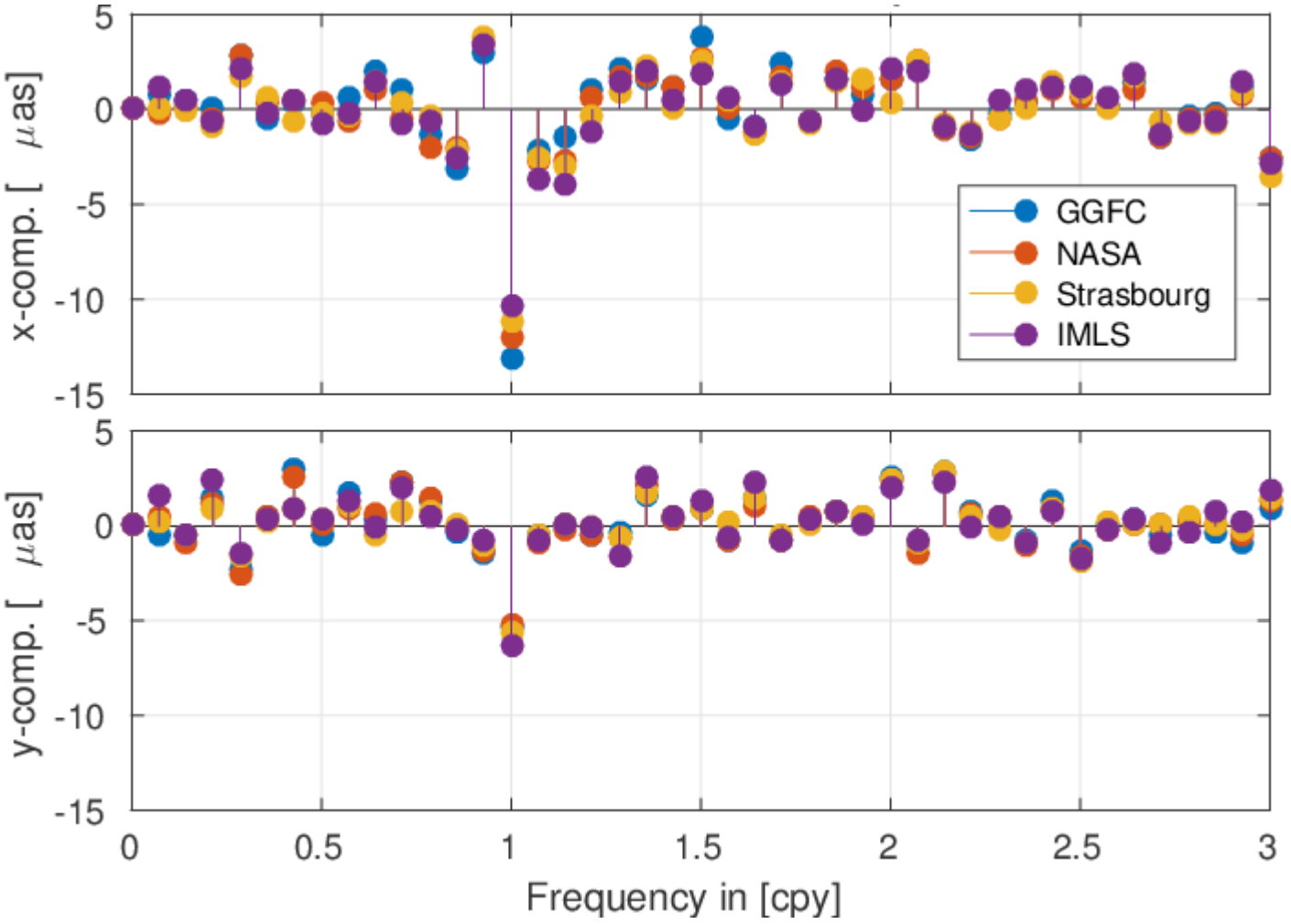


	X [µas]	Y [µas]
GGFC	30.41	30.93
NASA	29.53	29.60
Strasb.	30.31	30.68
IMLS	32.59	34.58

Polar coordinates – difference of spectrum

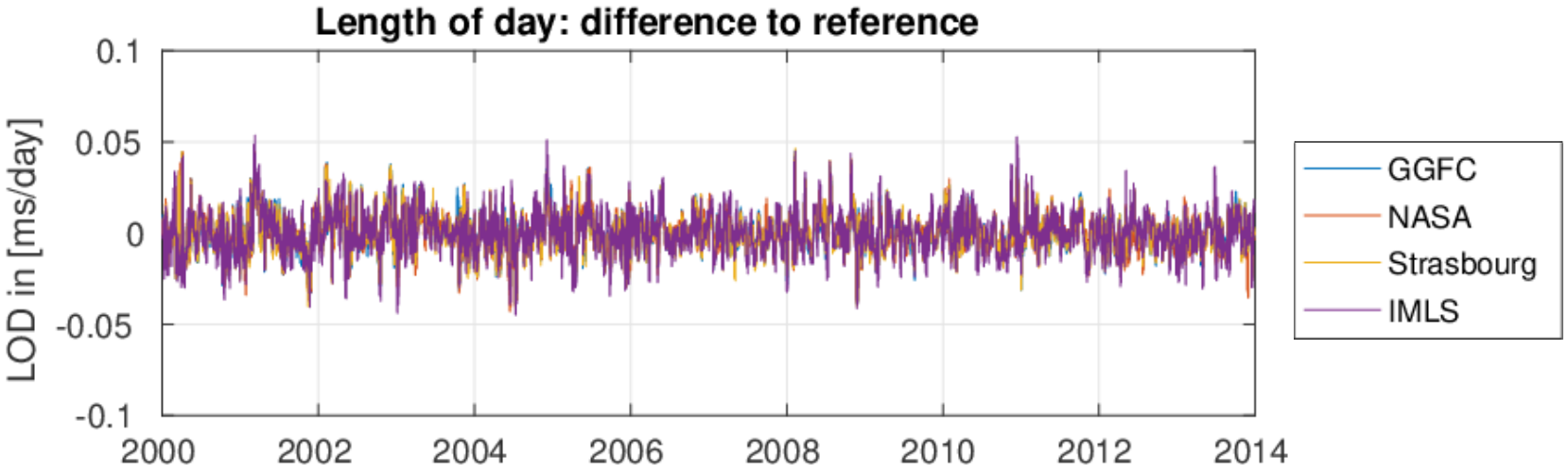


Polar coordinates – difference of spectrum



20 – 45% of the variations in the polar coordinates can be explained by the annual signal in the geophysical models.

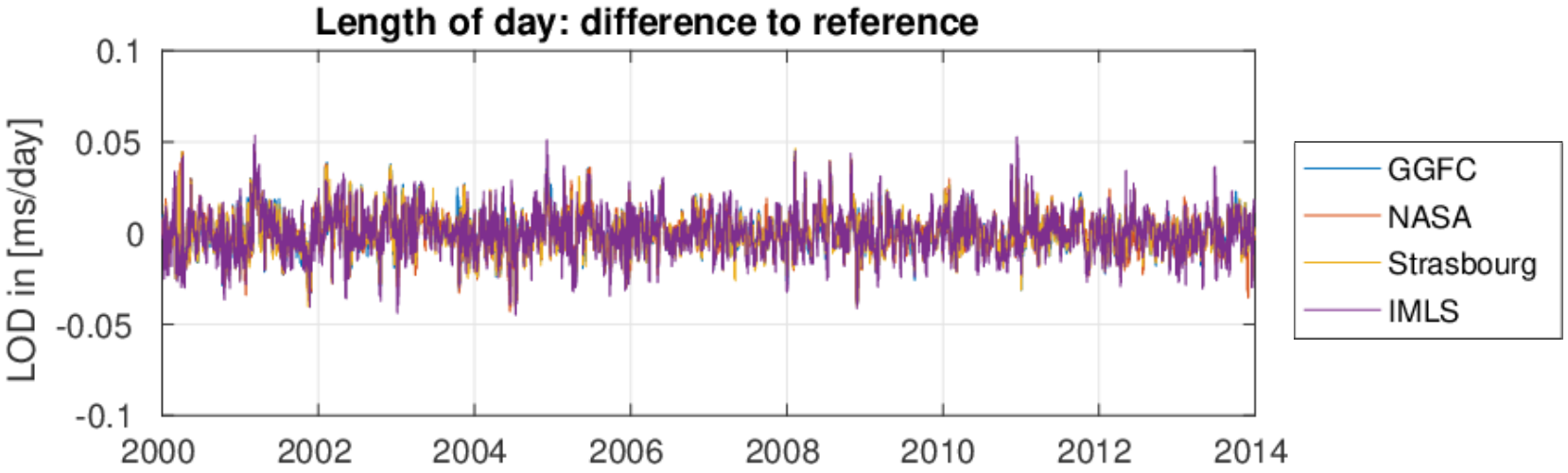
Length of day



- Impact of loading models is below 50 µs/day.
- No significant difference between the models.
- No noticeable impact

	RMS [µs]
GGFC	10.46
NASA	10.50
Strasb.	10.66
IMLS	12.41

Length of day



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Signal RMS: ~ 946 µs/day

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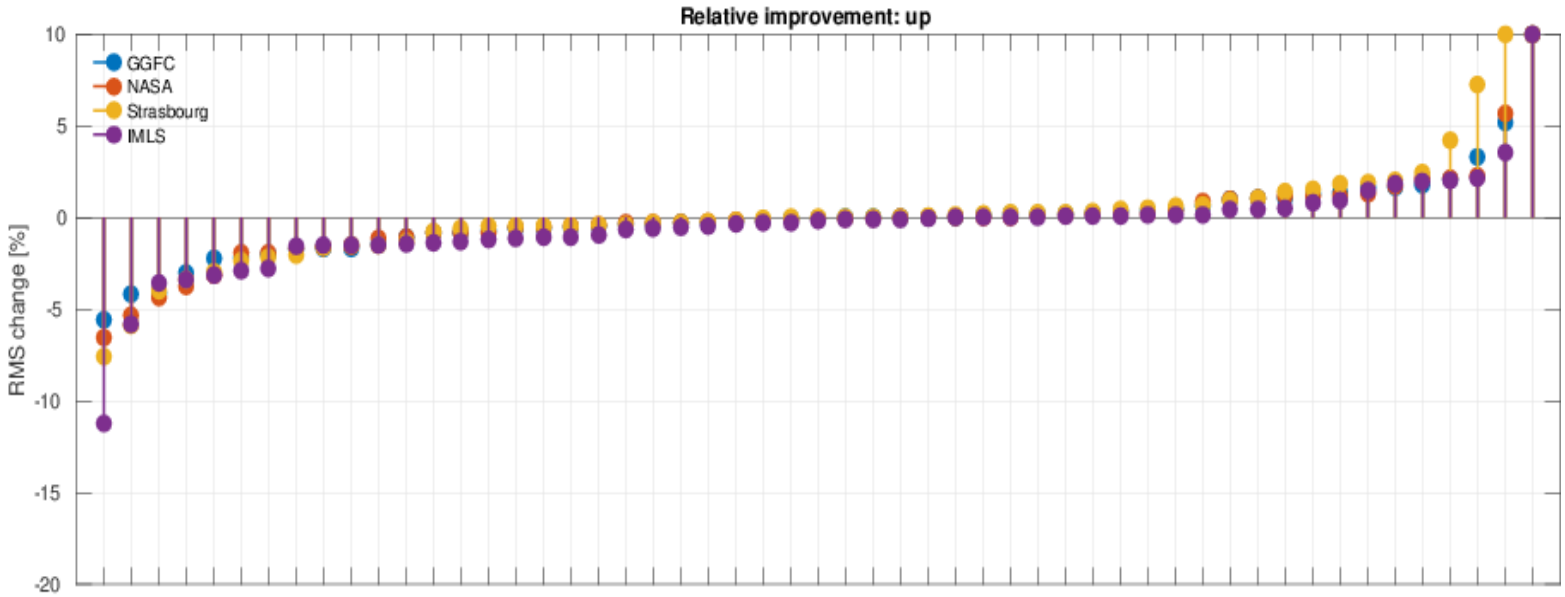
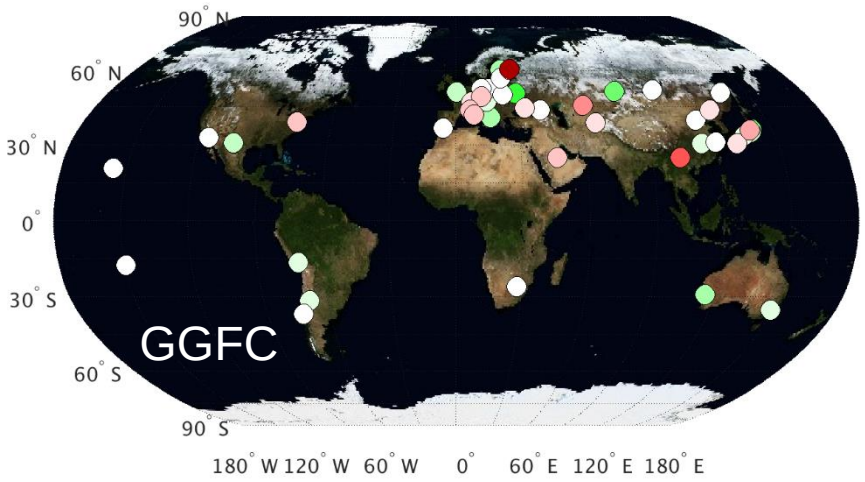
Station time series

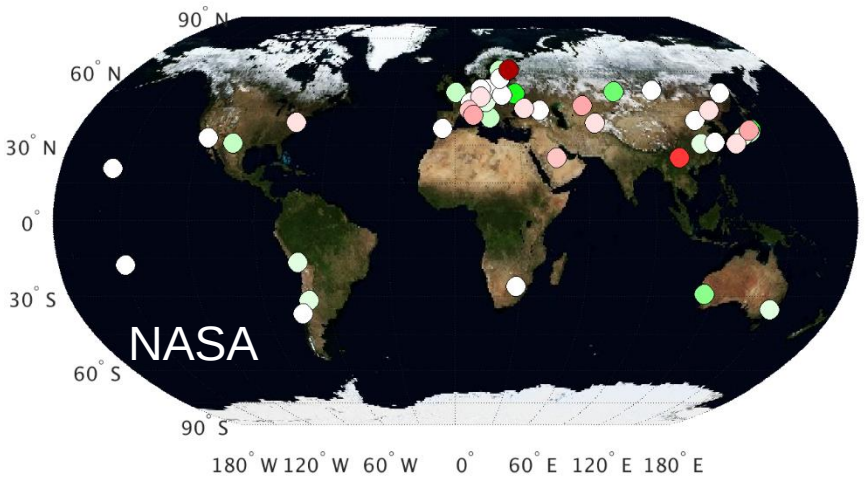
RMS change of station time series

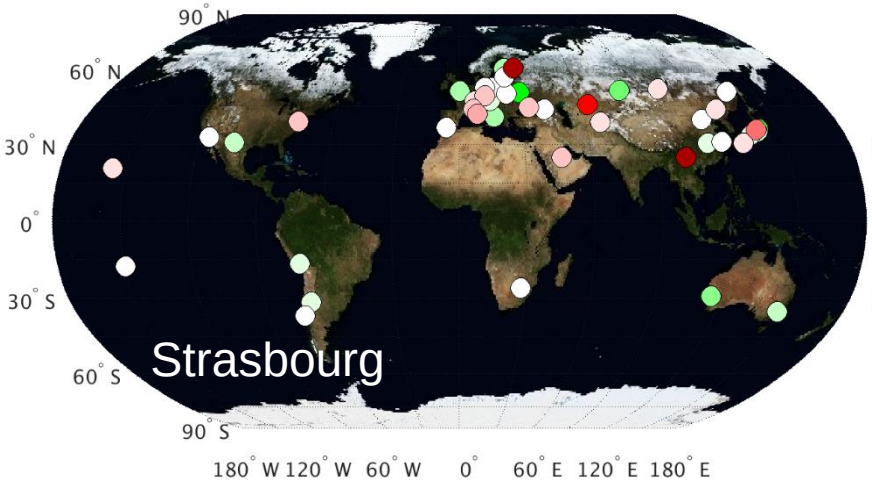


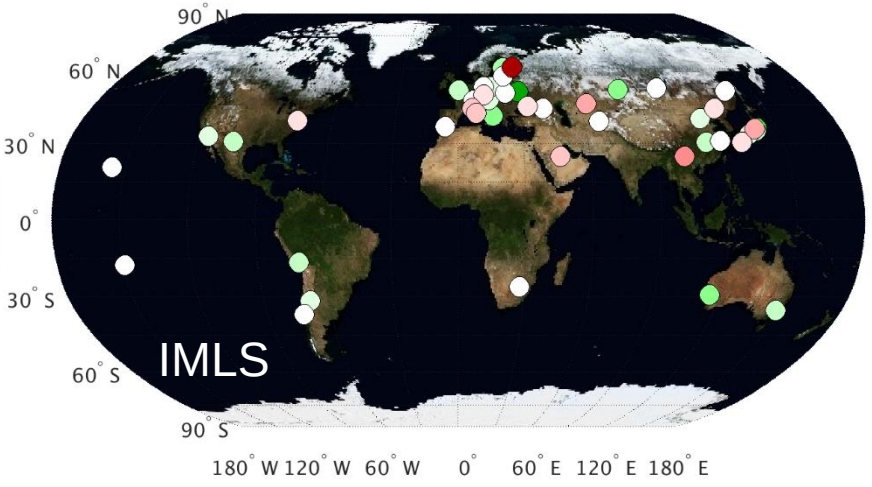
Model	% max. decrease	% max. increase	% of stations with improv.	% of stations with degrad. of < 1 %
GGFC	5.6	19.6	50.9	26.4
NASA	6.5	14.1	58.5	20.8
Strasbourg	7.6	16.9	47.2	32.1
IMLS	11.2	26.7	60.3	26.4

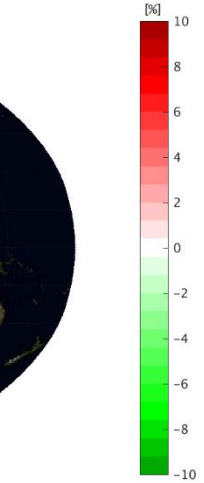
Change in RMS coordinate time series

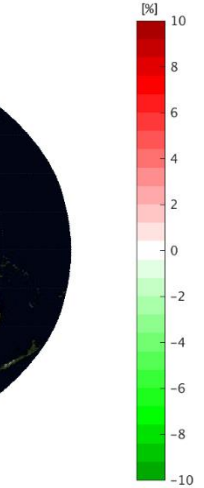












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Conclusions

Conclusions

- Geophysical models reduce almost exclusively the annual signal component.
- Geophysical models
  - explain about 10% of the variability in the geocenter motion,
  - explain 20 - 45% of the variability in the polar motion,
  - have no significant impact on length of day and
  - reduce the station RMS for about 50% of the stations.
- No model combination is outstanding in the performance.
- Urgent need for consistent modelling of all compartments.

Thank you for your kind attention!

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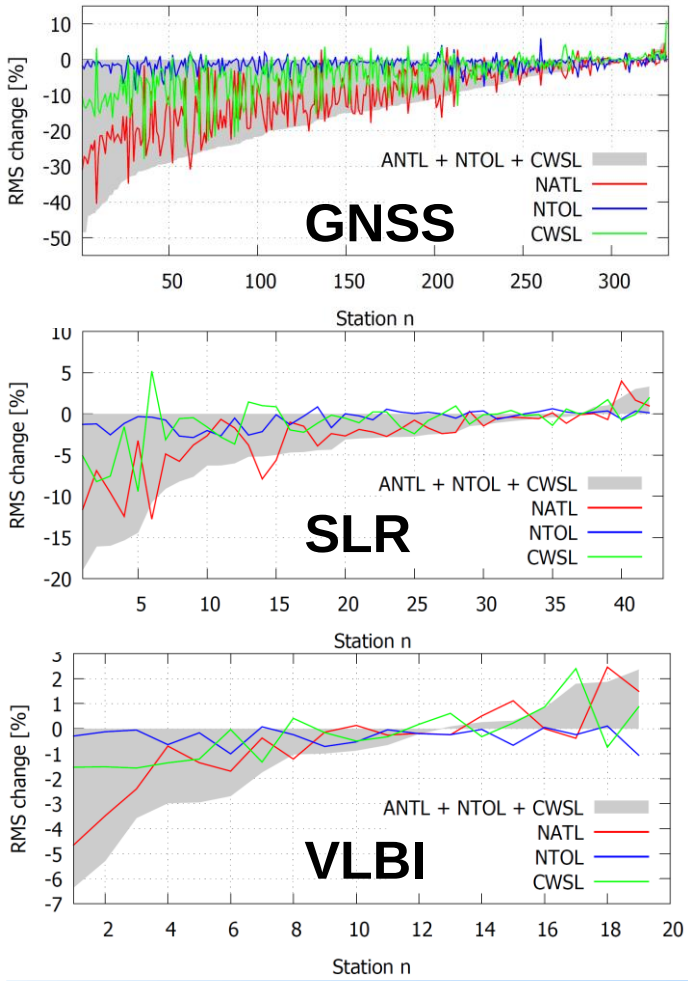
Visit our website:
www.referenzsysteme.de

BACKUP

RMS change wrt. ref. solution (up)

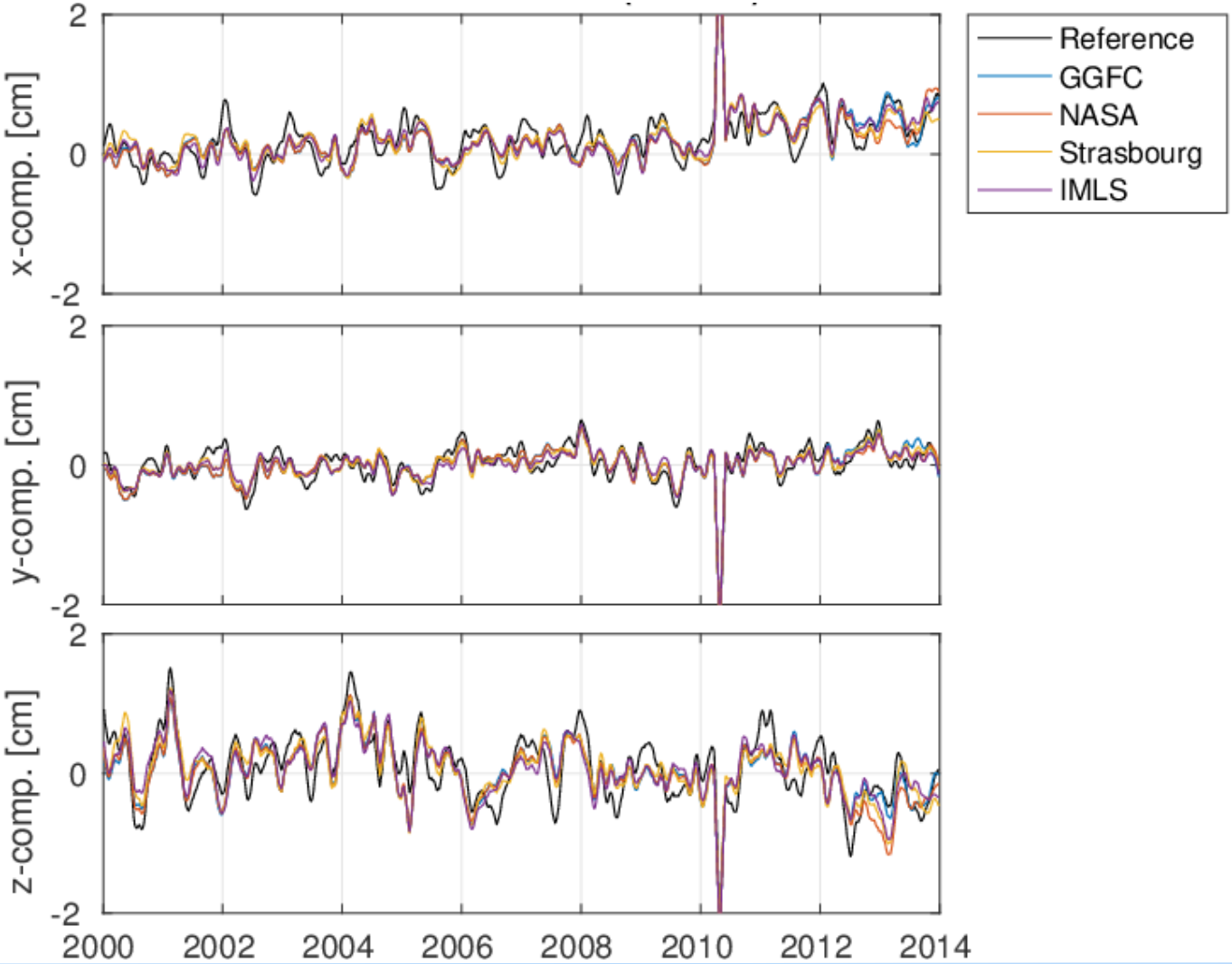


	max. increase [%]	max. decrease [%]	Median [%]	% of stations with improv.
GNSS	11.1	-32.0	-8.8	93.1
SLR	3.3	-19.0	-2.9	88.4
VLBI	2.3	-7.4	-0.9	65.0

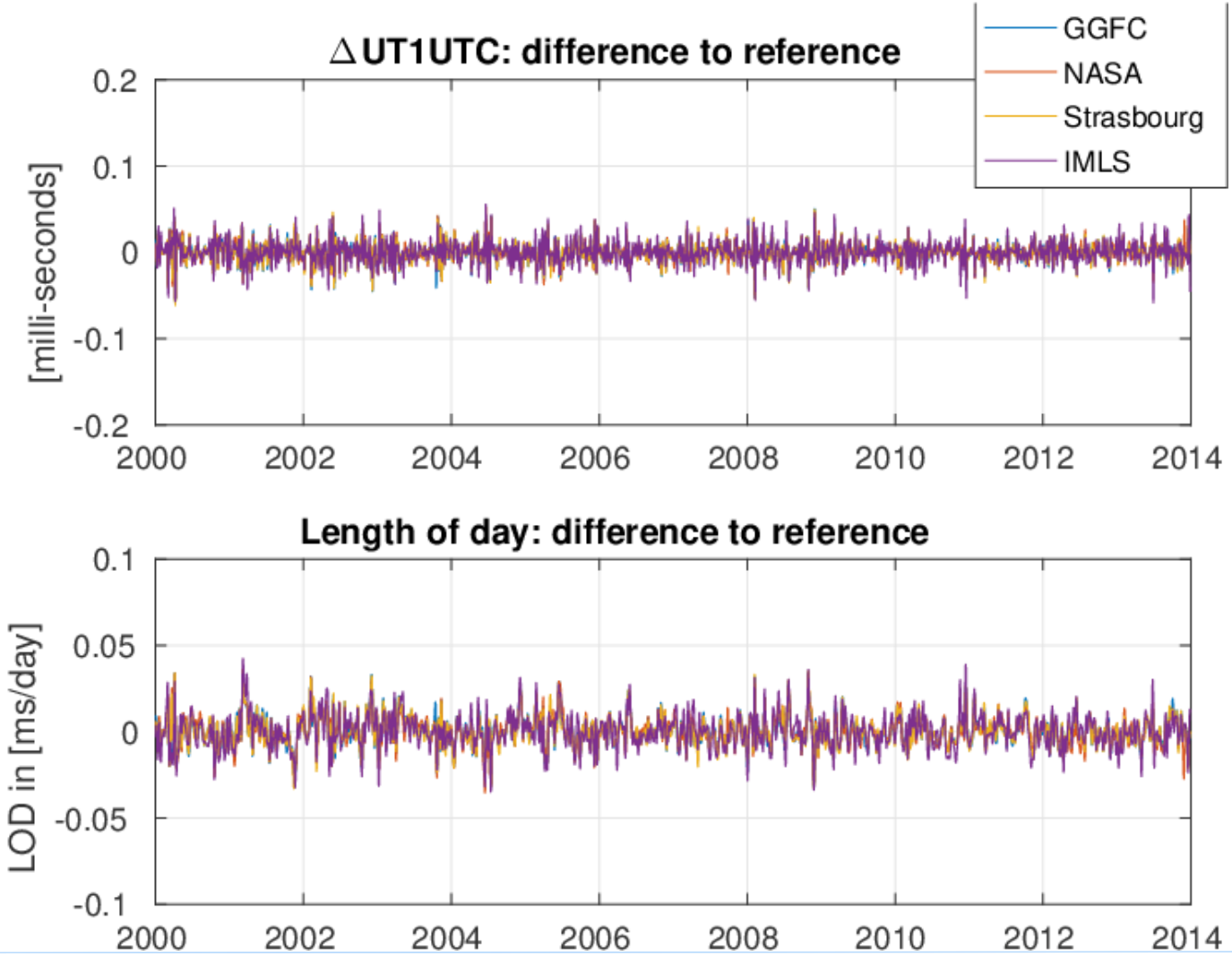
% of stations with improvement

	NORTH	EAST	UP
GNSS	93.1	68.4	93.1
SLR	83.7	79.1	88.4
VLBI	80.0	75.0	65.0

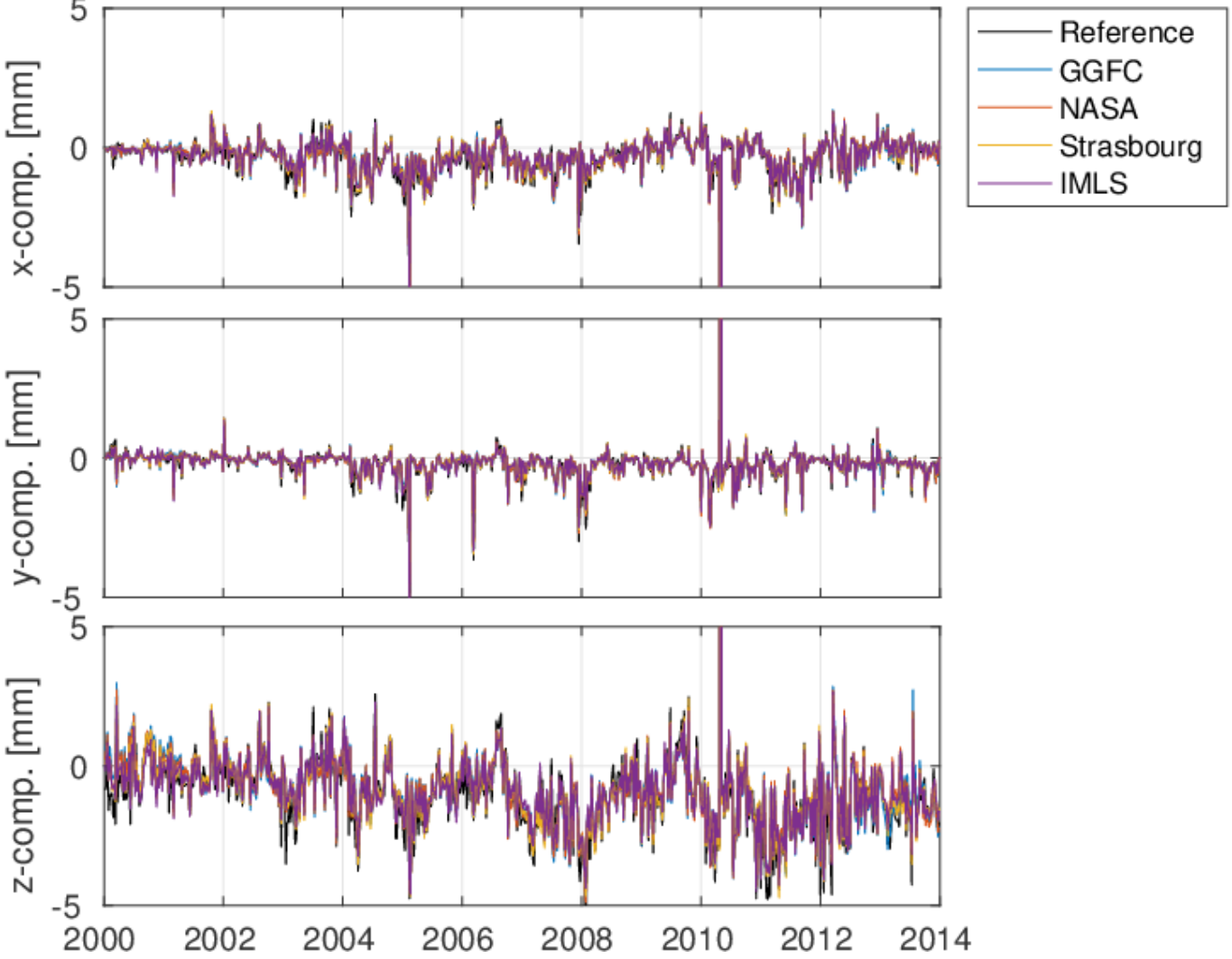
Geocenter coordinates – filtered time series



LOD and ΔUT1UTC - filtered



Translation parameters w.r.t. SLRF2008



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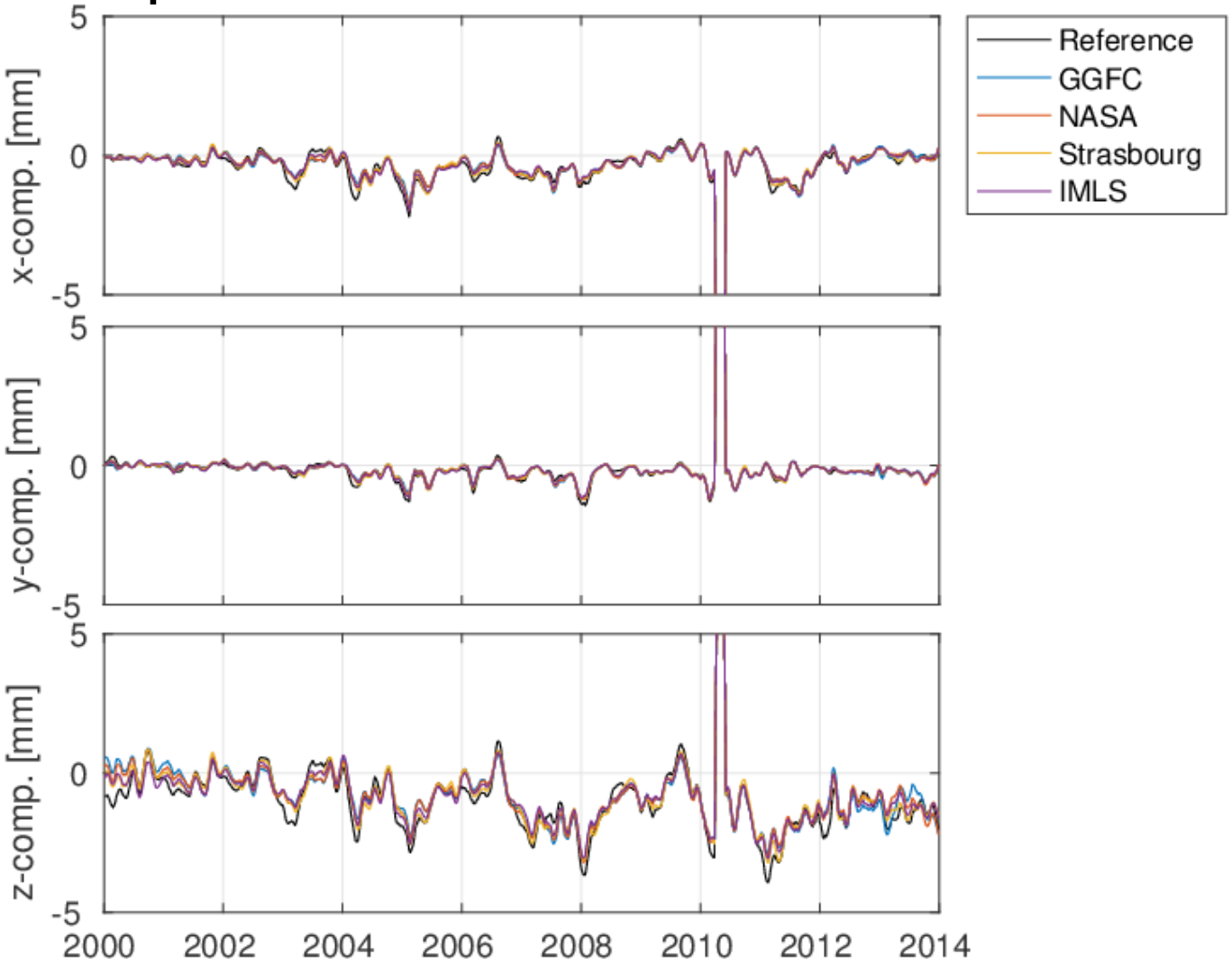

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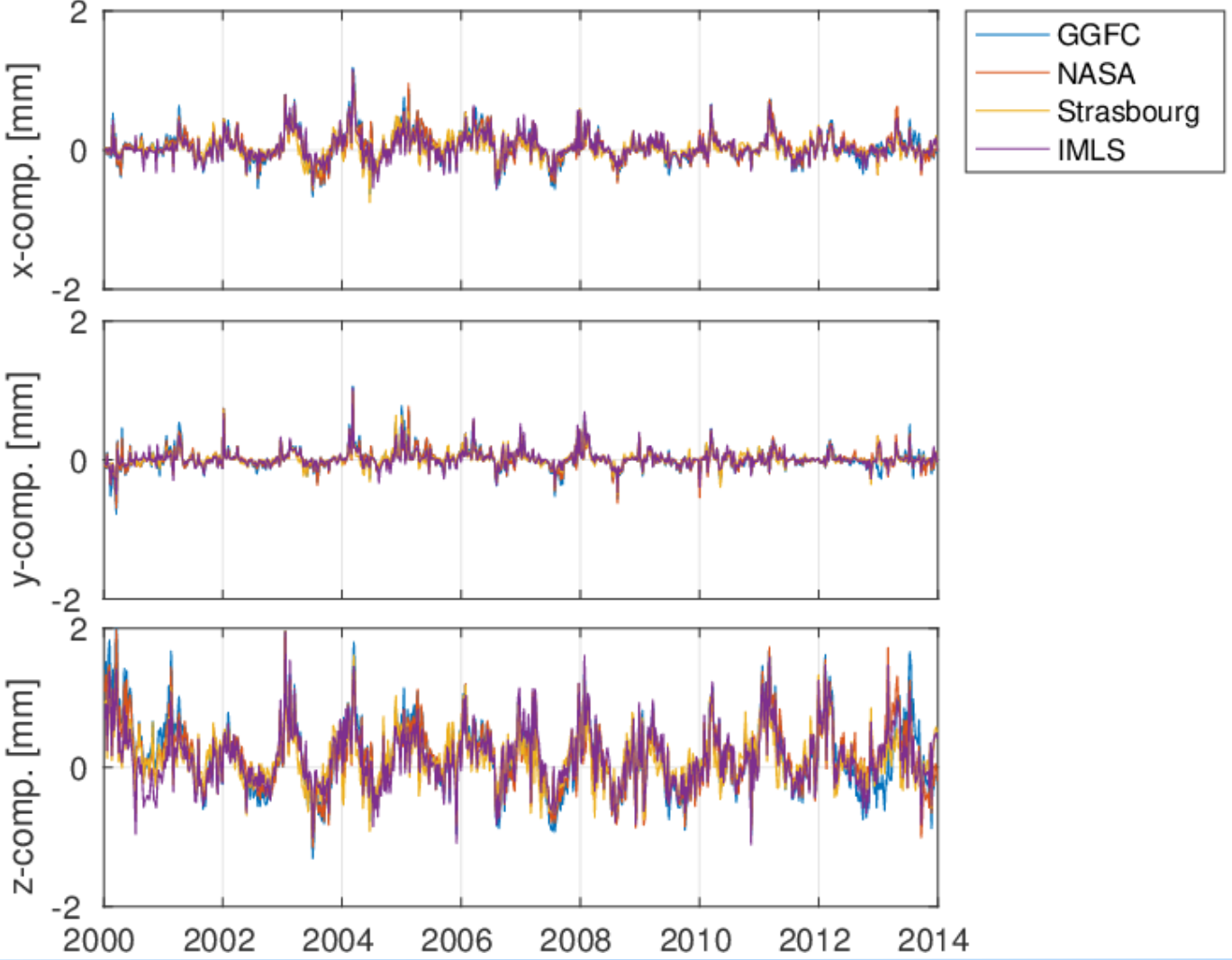
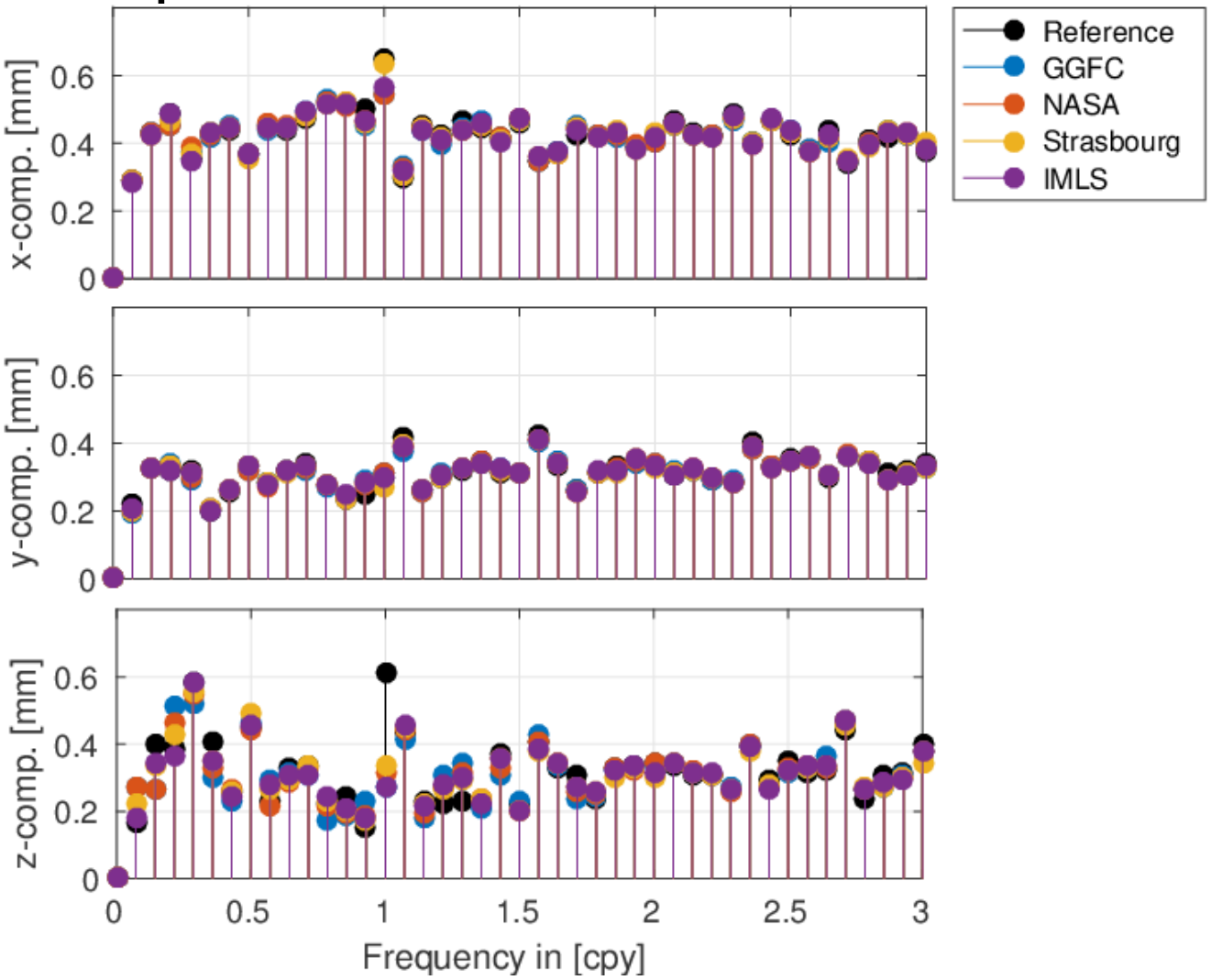
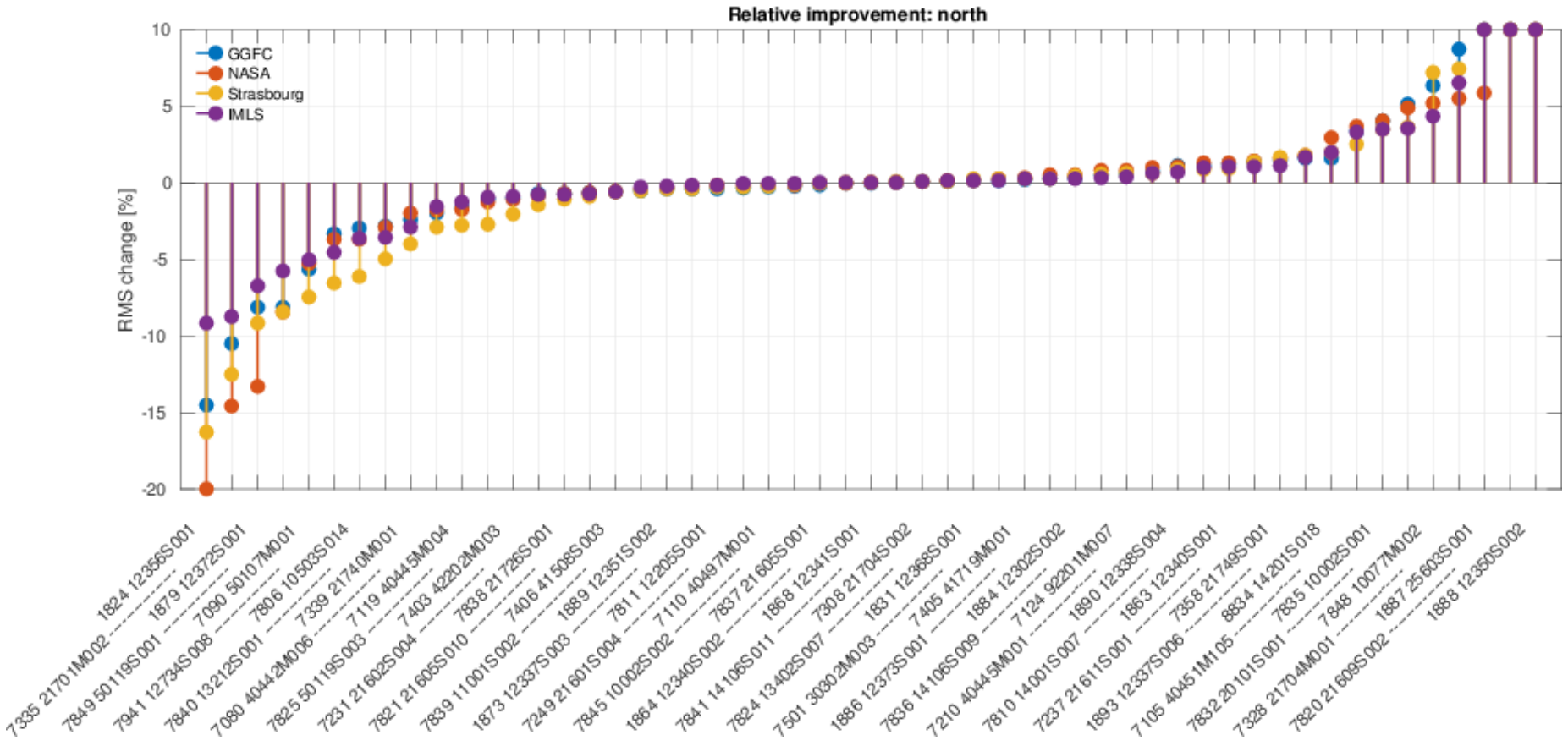


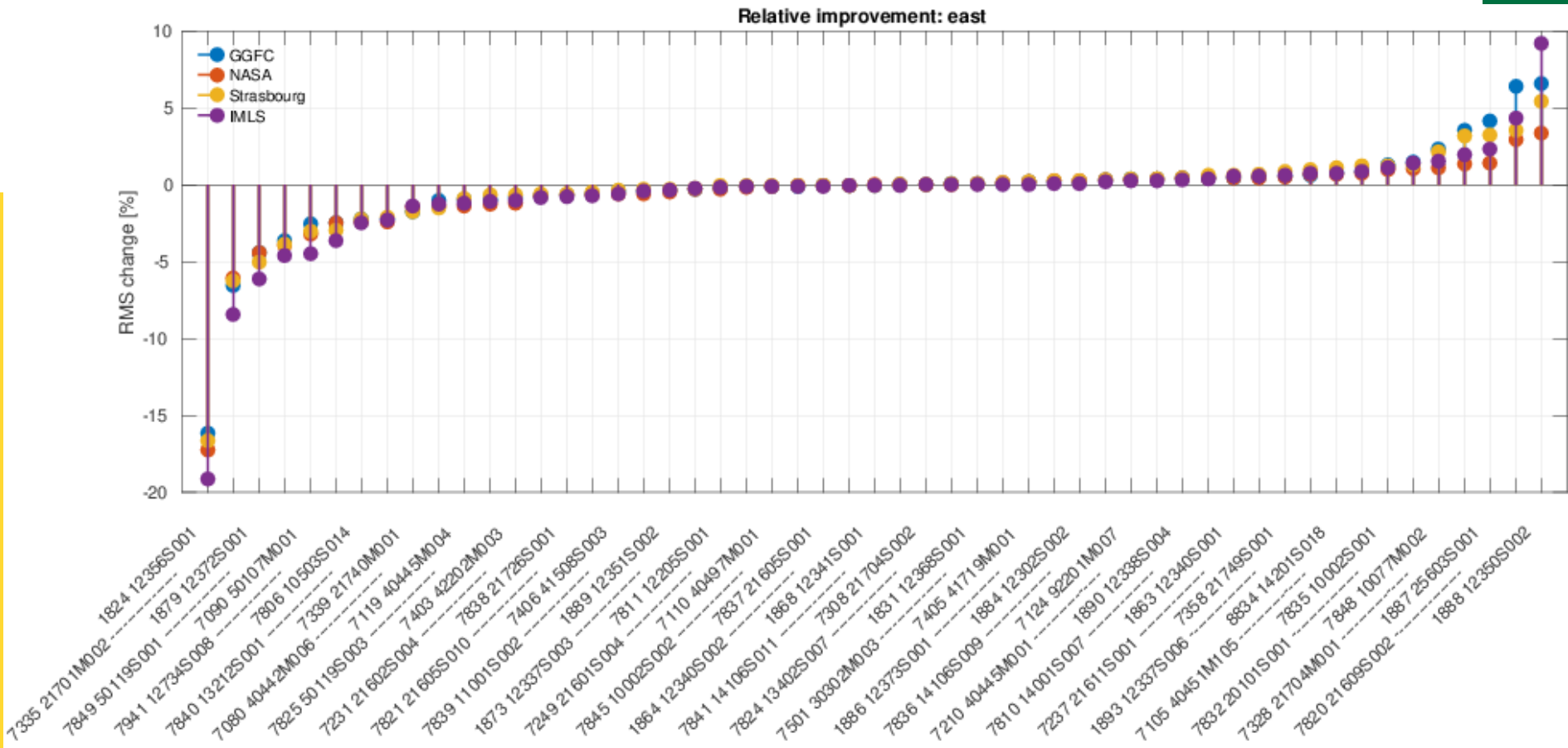
Translation parameters w.r.t. SLRF2008



North


Relative improvement: north
GGFC
NASA
Strasbourg
IMLS
RMS change [%]
10
5
0
-5
-10
-15
-20
1824 12356S001
7335 21701M002
1879 12372S001
7849 50119S001
7090 50107M001
7941 12734S008
7606 10503S014
7840 13212S001
7339 21740M001
7080 40442M006
7119 40445M004
7825 50119S003
7403 42202M003
7231 21602S004
7838 21726S001
7821 21605S010
7406 41508S003
7839 11001S002
1889 12351S002
1873 12337S003
7811 12205S001
7249 21601S004
7110 40497M001
7845 10002S002
7837 21605S001
1864 12340S002
1868 12341S001
7841 14106S011
7308 21704S002
7824 13402S007
1831 12368S001
7501 30302M003
7405 41719M001
1886 12373S001
1884 12302S002
7836 14106S009
7124 92201M007
7210 40445M001
1890 12338S004
7810 14001S007
1863 12340S001
7237 21611S001
7358 21749S001
1893 12337S006
8834 14201S018
7105 40451M105
7835 10002S001
7832 20101S001
7848 10077M002
7328 21704M001
1887 25603S001
7820 21609S002
1888 12350S002

East



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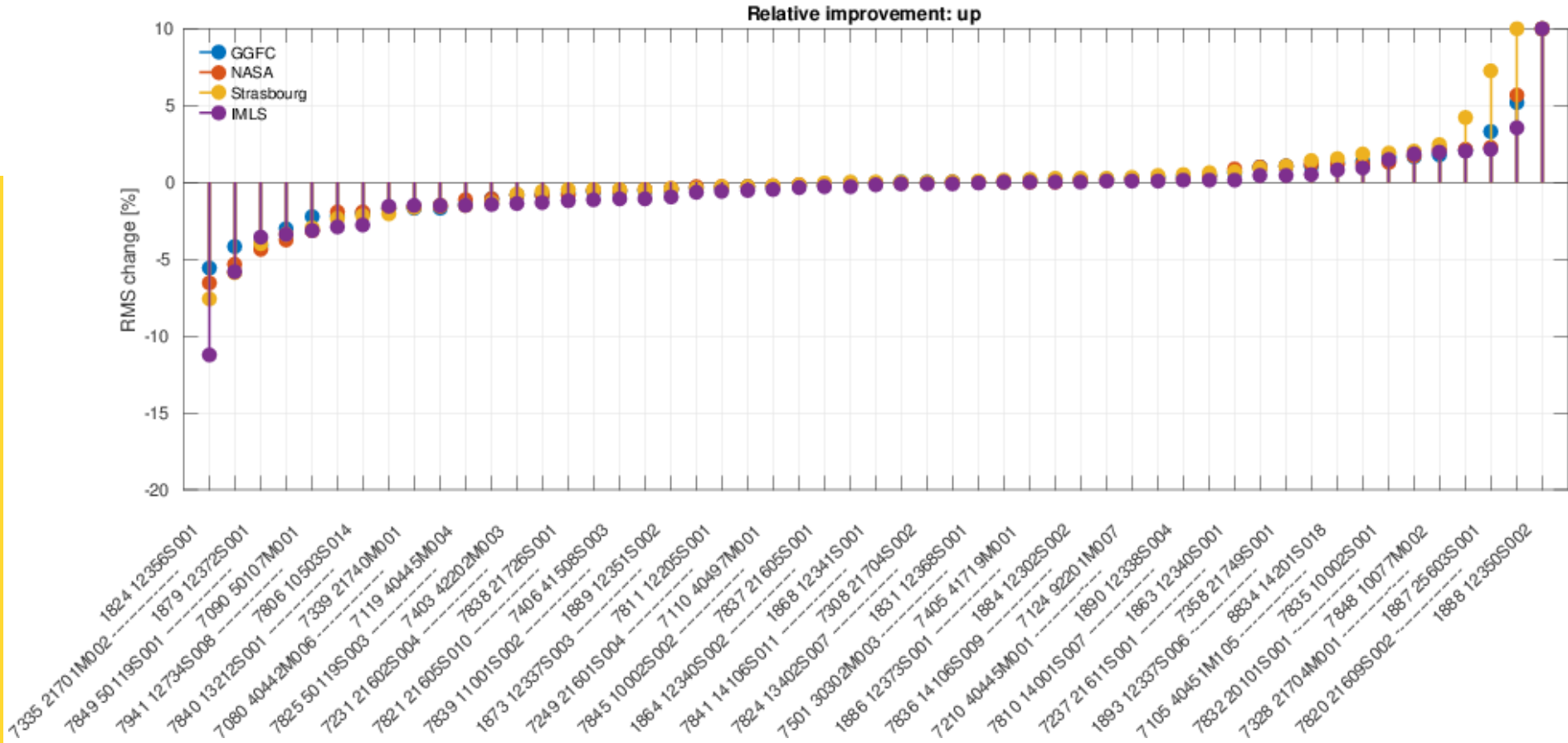
Up


Relative improvement: up
GGFC
NASA
Strasbourg
IMLS
RMS change [%]
10
5
0
-5
-10
-15
-20
1824 12356S001
7335 21701M002
1879 12372S001
7849 50119S001
7090 50107M001
7941 12734S008
7806 10503S014
7840 13212S001
7339 21740M001
7080 40442M006
7119 40445M004
7825 50119S003
7403 42202M003
7231 21602S004
7838 21726S001
7821 21605S010
7406 41508S003
7839 11001S002
1889 12351S002
1873 12337S003
7811 12205S001
7249 21601S004
7110 40497M001
7845 10002S002
7837 21605S001
1864 12340S002
1868 12341S001
7841 14106S011
7308 21704S002
7824 13402S007
1831 12368S001
7501 30302M003
7405 41719M001
1886 12373S001
1884 12302S002
7836 14106S009
7124 92201M007
7210 40445M001
1890 12338S004
7810 14001S007
1863 12340S001
7237 21611S001
7358 21749S001
1893 12337S006
6834 14201S018
7105 40451M105
7835 10002S001
7832 20101S001
7848 10077M002
7328 21704M001
1887 25603S001
7820 21609S002
1888 12350S002