



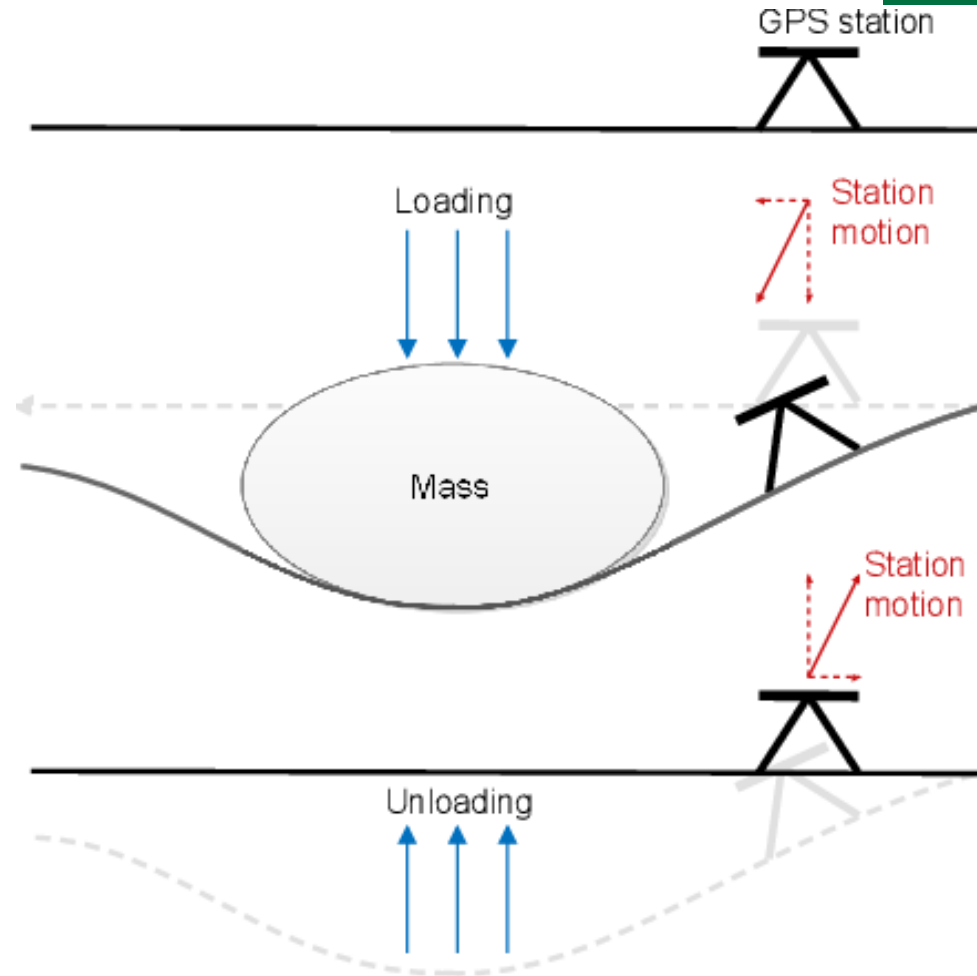
Federal Agency for
Cartography and Geodesy

SLR parameter estimation under the influence of mass redistributions

Matthias Weigelt and Daniela Thaller

Motivation

- Elastic response of the Earth surface due to mass re-distributions
- Displacements derived from various models and various groups available
- Questions:
 - What are the differences?
 - What is the impact on the solutions?



Available (gridded) models

Atmosphere	Time resolution	Spatial resolution	Models
GGFC (Luxembourg)	6h	2.5°	NCEP
NASA (GSFC)	6h	2.5°	NCEP
TU Vienna (v4)	6h	1°	ECMWF
EOST (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

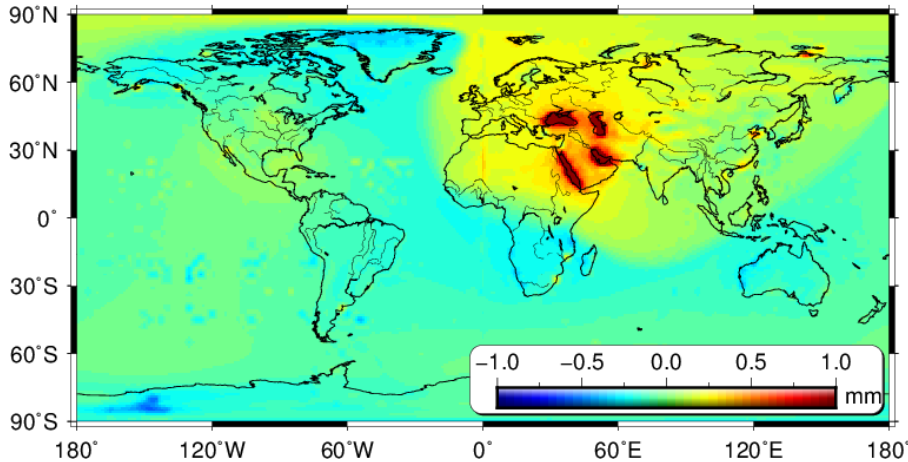
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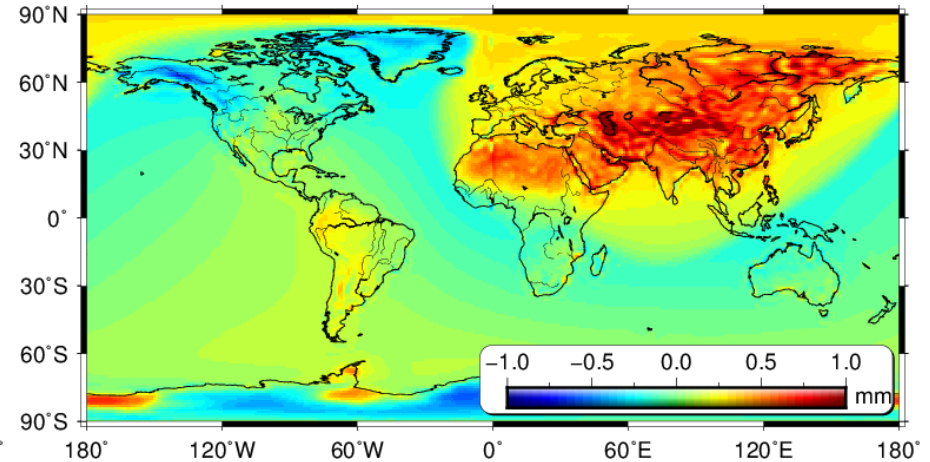
Spatial comparison (annual components/up)

- GGFC serves as reference (spatial interpolation to 1°)
- Differences are on the level of 20% of the total signal

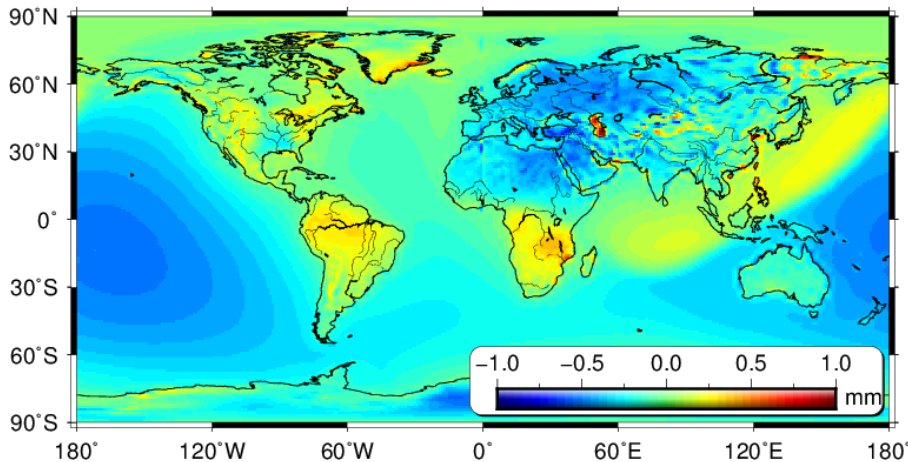
NASA–NCEP vs. GGFC–NCEP



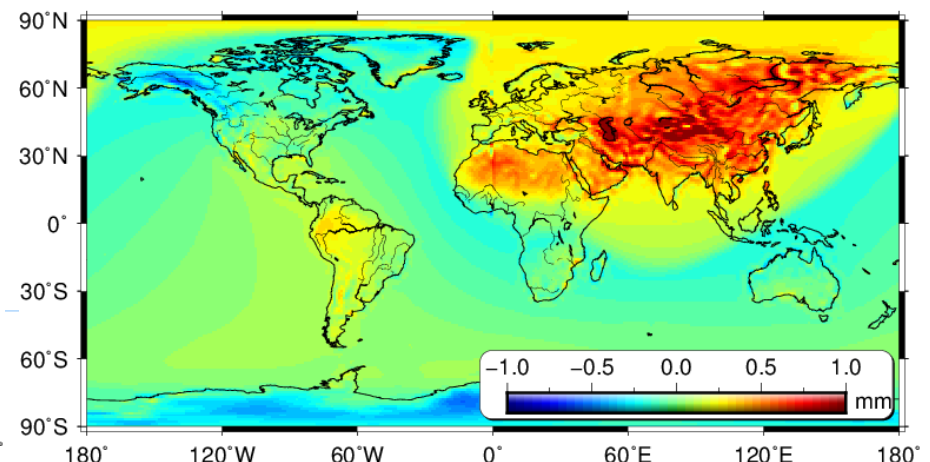
EOST–ERAinterim vs. GGFC–NCEP



IMLS–Merra vs. GGFC–NCEP



GFZ–ECMWF vs. GGFC–NCEP



Available (gridded) models (cont.)

Ocean	Time resolution	Spatial resolution	Model
GGFC (Luxembourg)	6h	2.5°	ECCO1 (JPL)
NASA (GSFC)	12h	2.5°	ECCO1 (JPL)
EOST (Strasbourg)	12h-24h	0.5°	ECCO1 (JPL) ECCO2 (JPL)
IMLS	6h	1°	OMCT
GFZ	3h	0.5°	MPIOM

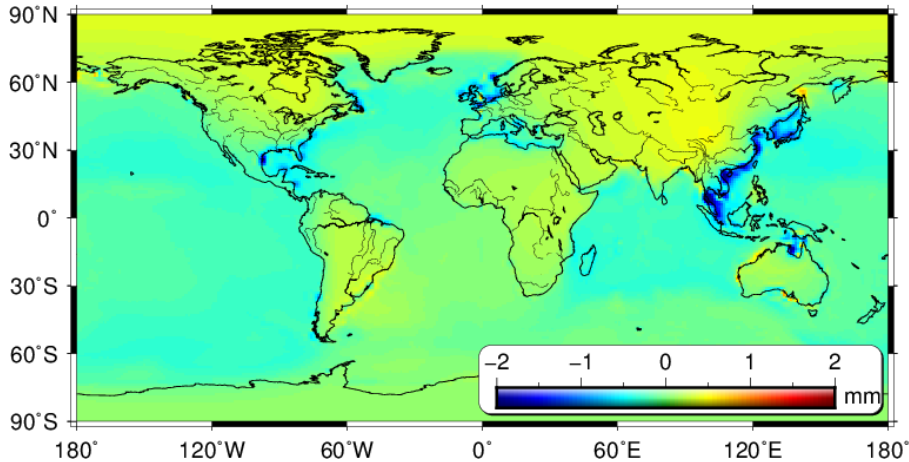
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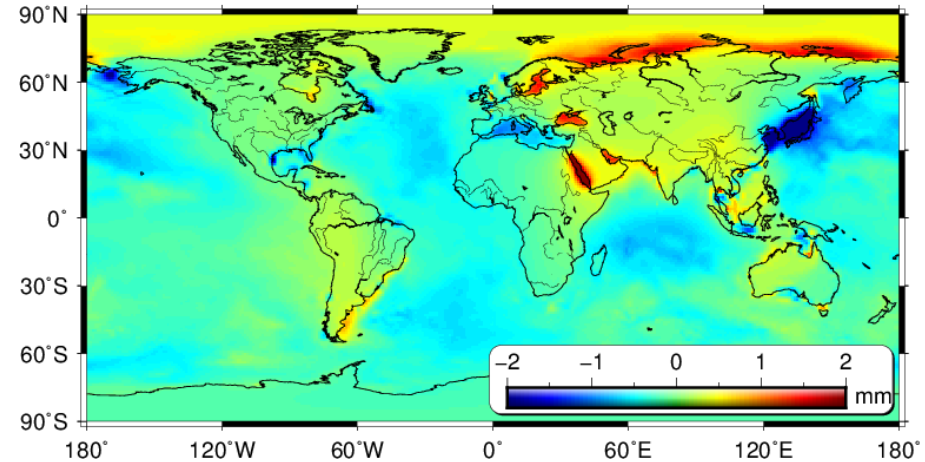
Spatial comparison (annual components/up)

- GGFC serves again as reference (spatial interpolation to 1°)
- Differences are on the level of up to **50%** of the total signal

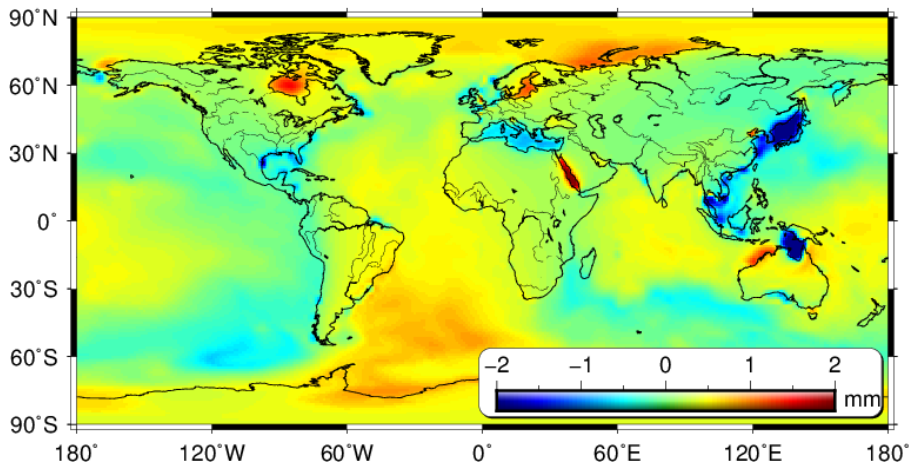
NASA-ECCO vs. GGFC-ECCO



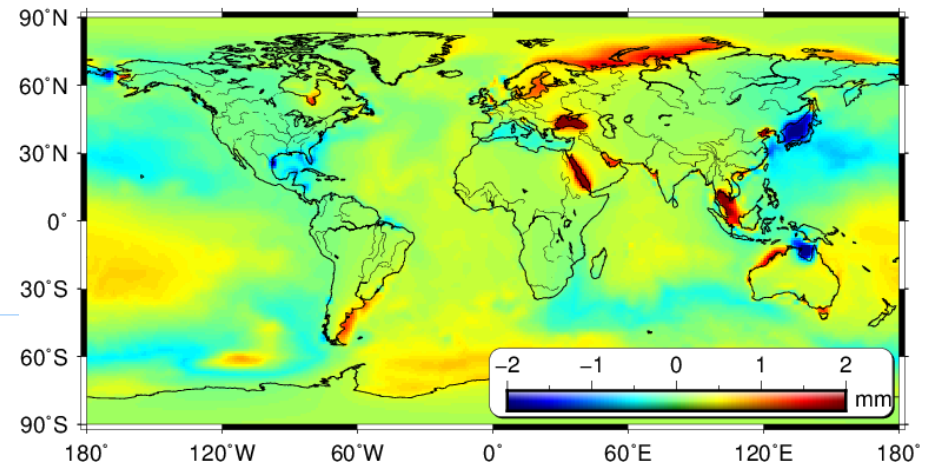
EOST-ECCO vs. GGFC-ECCO



IMLS-OMCT vs. GGFC-ECCO



GFZ-MPIOM vs. GGFC-ECCO



Available (gridded) models (cont.)

Hydrology	Time resolution	Spatial resolution	Model
GGFC (Luxembourg)	1 month	2.5°	GLDAS/NOAH 1°
NASA (GSFC)	1 month	2.5°	GLDAS/NOAH 1°
EOST (Strasbourg)	3h-6h	0.5°	GLDAS / NOAH 0.25° ERA interim
IMLS	6h	1°	MERRA GEOS-FPIT GLDAS / NOAH 0.25°
GFZ	24h	0.5°	LSDM (v1) LSDM (v1.2)

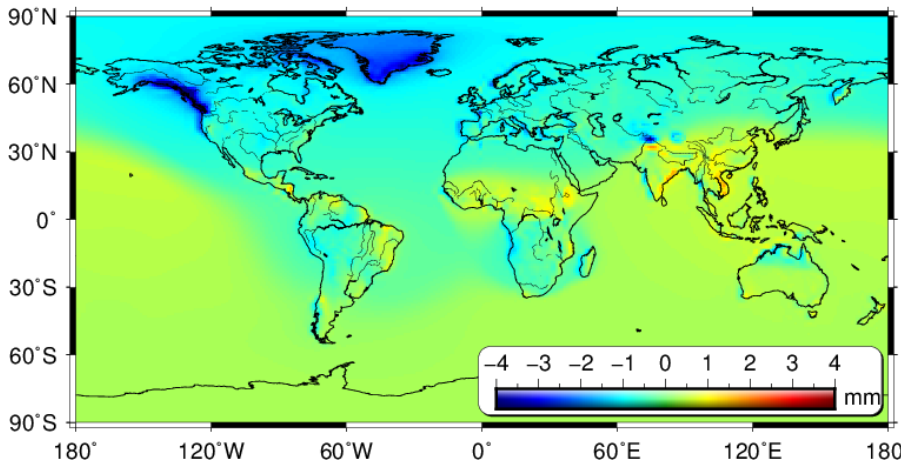
Available (gridded) models (cont.)

Hydrology	Time resolution	Spatial resolution	Model
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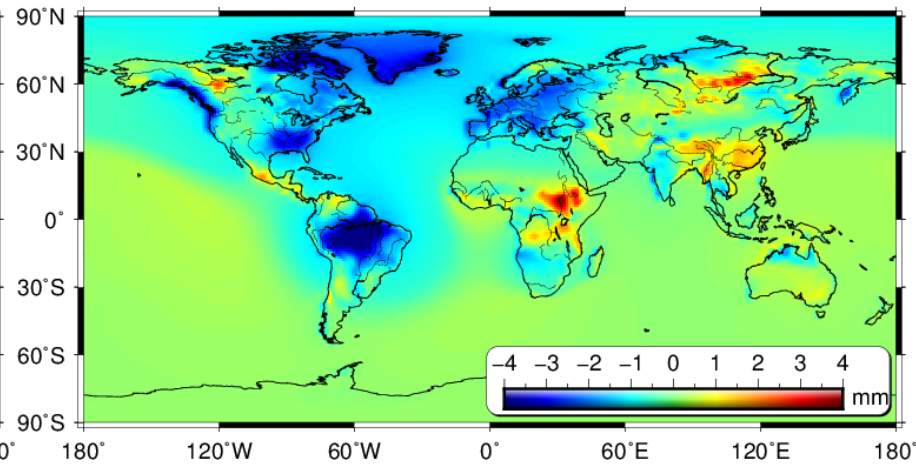
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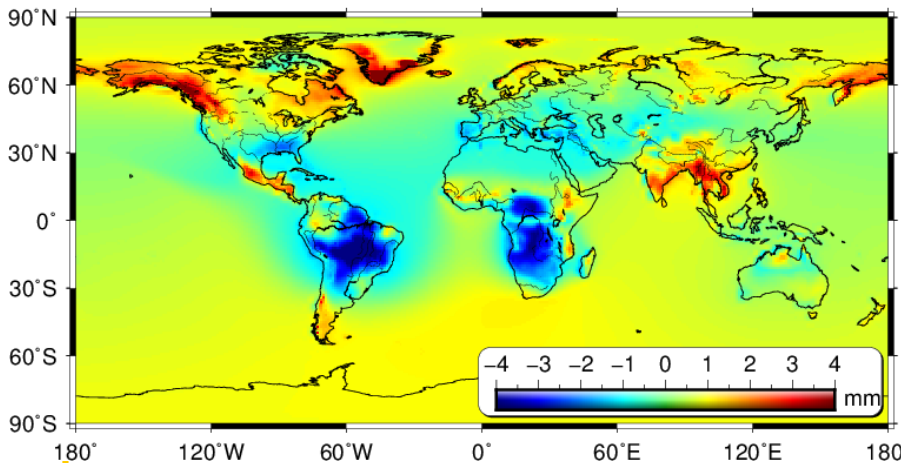
NASA-GLDAS vs. GGFC-GLDAS



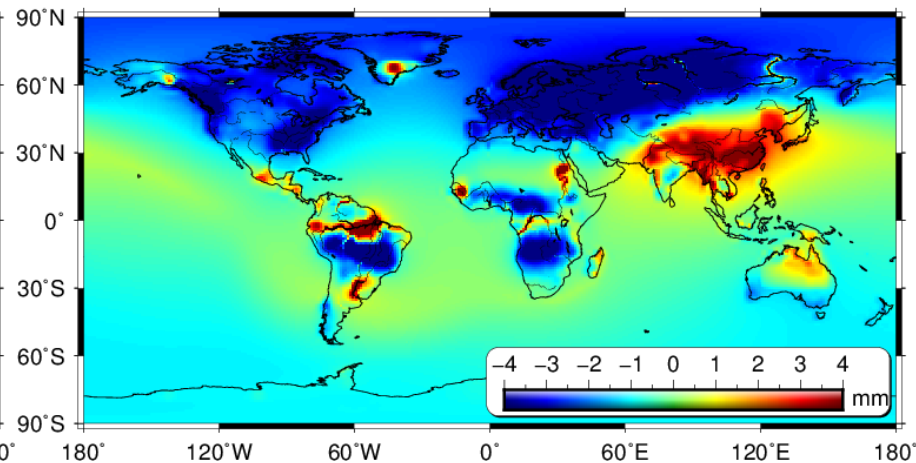
EOST-ERAinterim vs. GGFC-GLDAS



IMLS-Merra vs. GGFC-GLDAS



GFZ-LSDM vs. GGFC-GLDAS



Impact on SLR parameter estimation

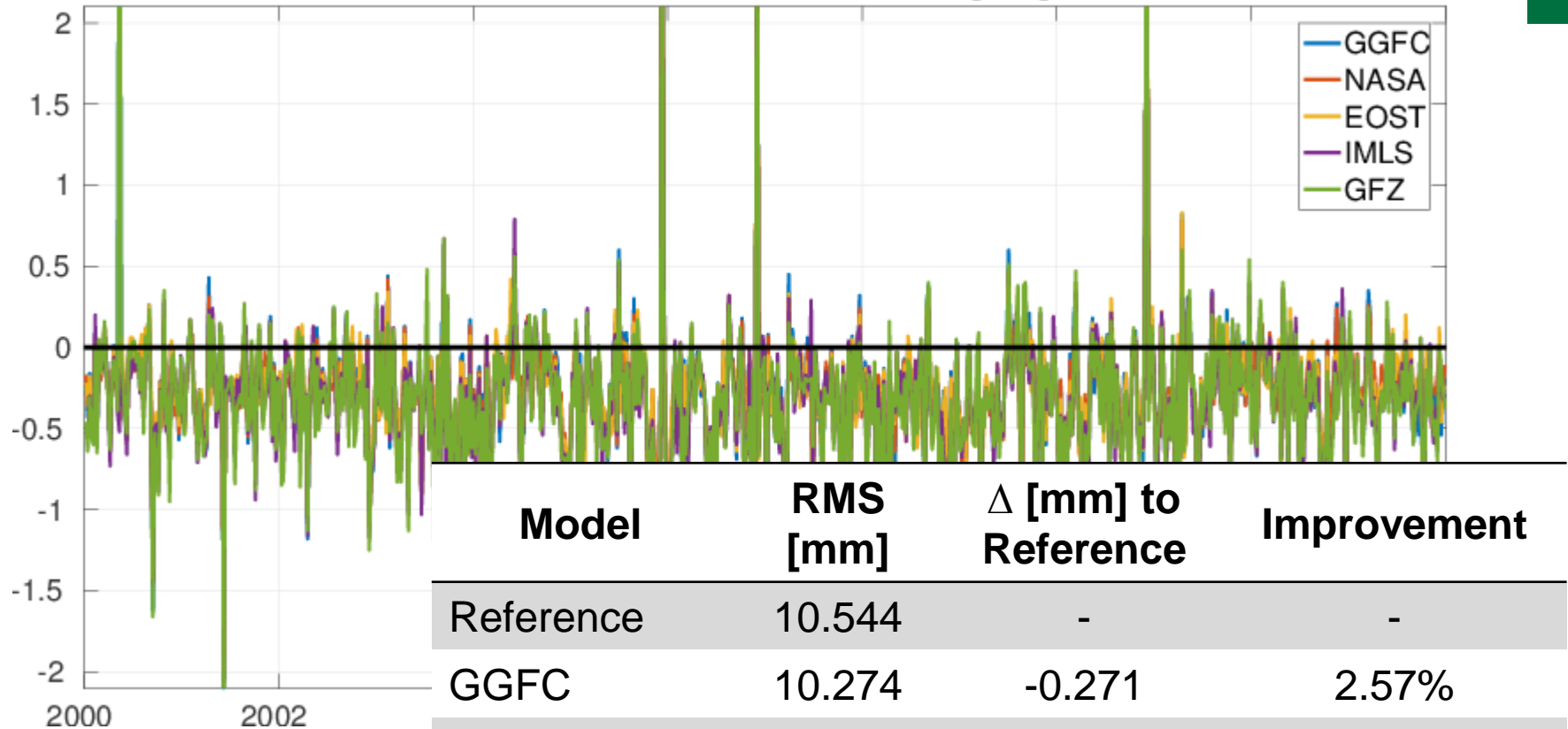
SLR data processing

Observed satellites: LAGEOS 1/2
Time period: 14 years (Jan. 2000 –Dec. 2013)
Sampling: weekly (Sun.-Sat.)
SLR network: 58 stations
Software: Bernese GNSS Software with SLR development v5.3
Loading grids: Temporal resolution of 6h

GGFC	NASA	EOST	IMLS	GFZ	Reference
NCEP	NCEP	ERA interim	MERRA	ECMWF	-
ECCO1	ECCO1	ECCO2	OMCT	MPIOM	-
GLDAS	GLDAS	ERA interim	MERRA	LSDM	-

A posteriori RMS

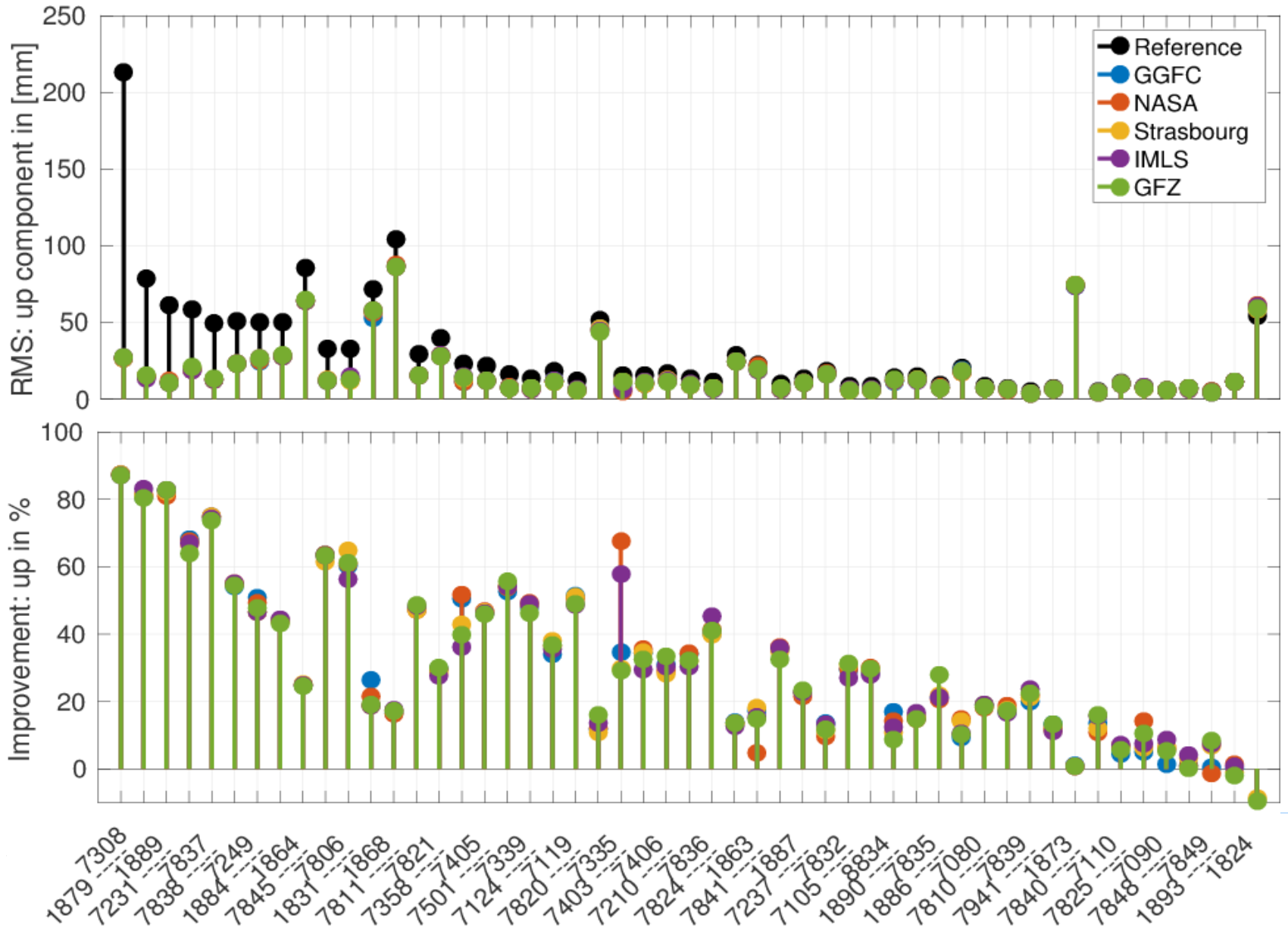
RMS difference w.r.t Reference in [mm]



Model	RMS [mm]	Δ [mm] to Reference	Improvement
Reference	10.544	-	-
GGFC	10.274	-0.271	2.57%
NASA	10.267	-0.278	2.63%
EOST	10.268	-0.276	2.62%
IMLS	10.224	-0.321	3.04%
GFZ	10.229	-0.316	2.99%

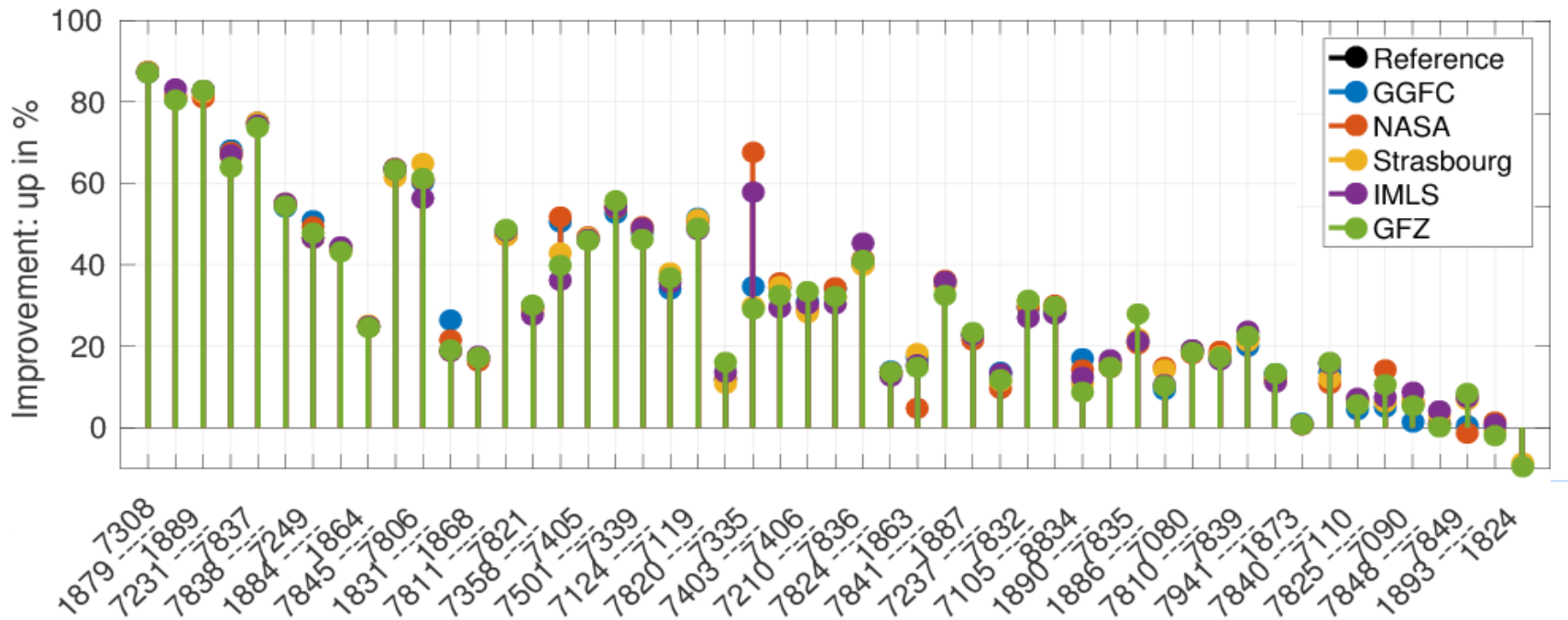
Station coordinates (up-only)

51 stations

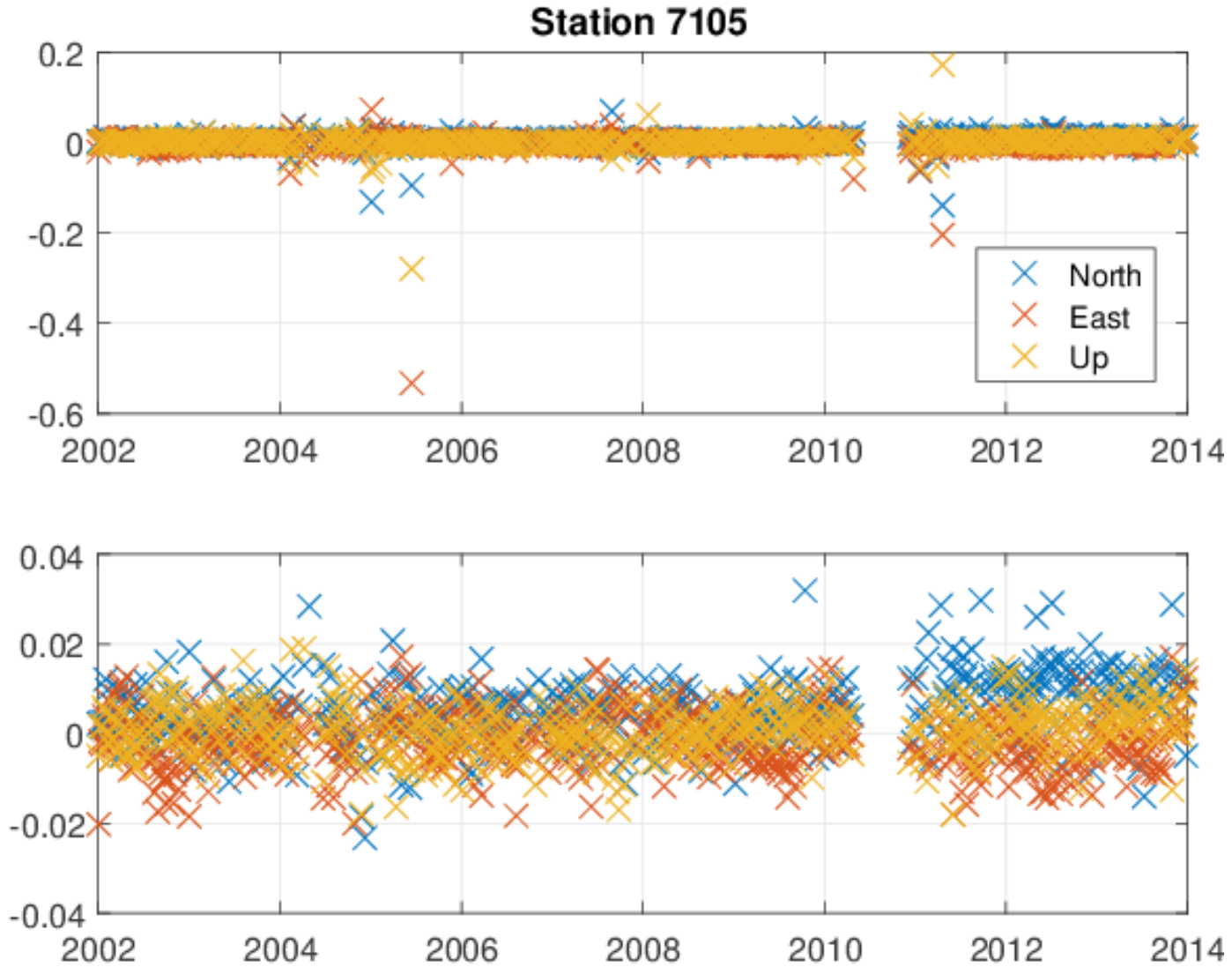


Station coordinates (up-only)

Model	max. increase in %	max. decrease in %	Average improvement in %	Stations with improvement in %
GGFC	87.49	12.58	31.11	98%
NASA	87.43	12.76	31.75	96%
EOST	87.47	08.72	31.00	96%
IMLS	87.12	11.42	31.39	98%
GFZ	87.13	09.64	30.97	96%

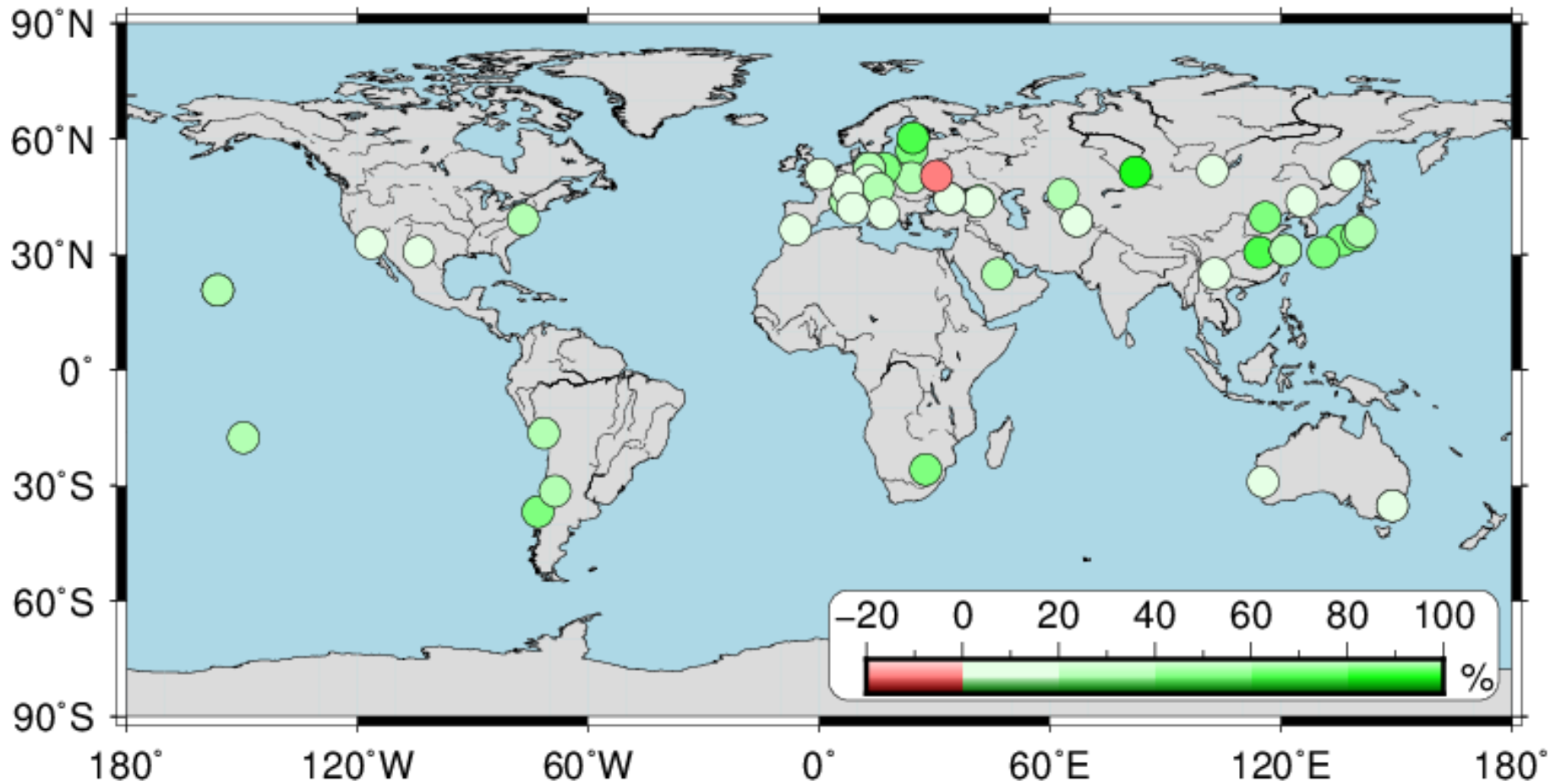


Station coordinates (up-only)



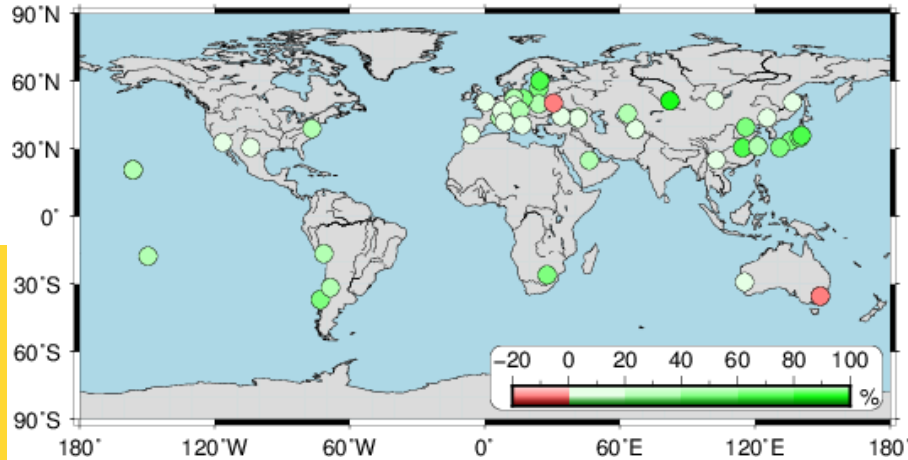
Station coordinates (cont.)

Station improvement: GGFC

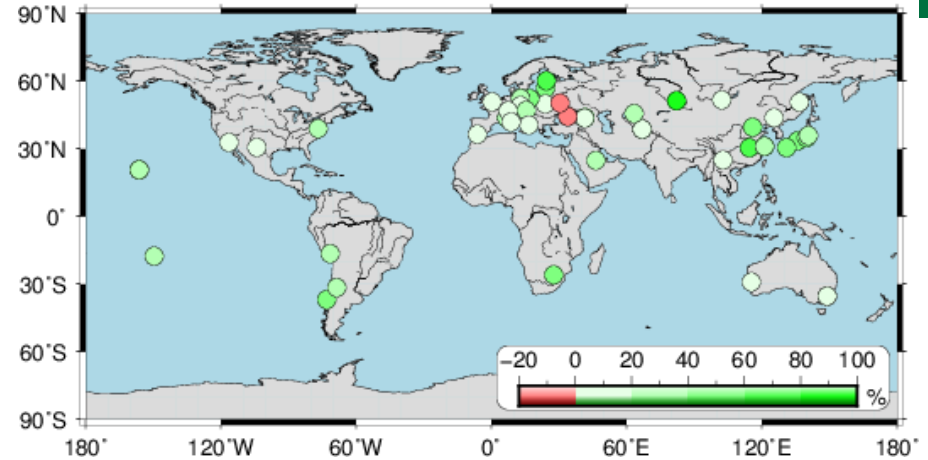


Station coordinates (cont.)

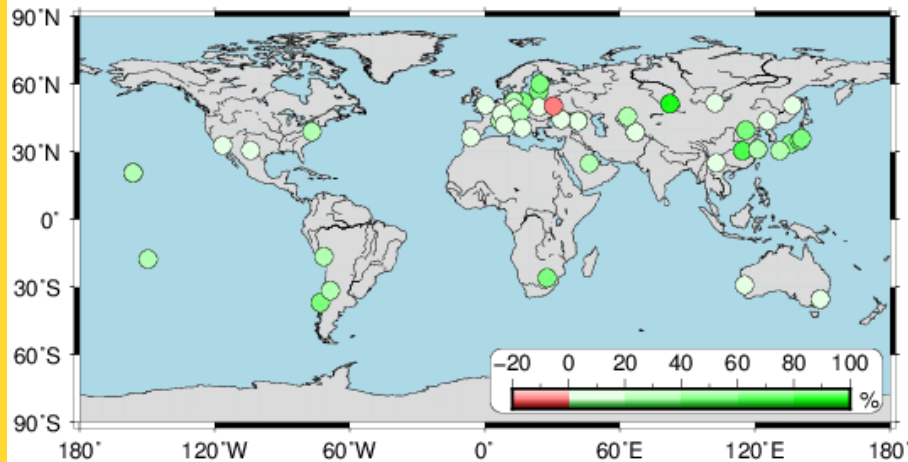
Station improvement: NASA



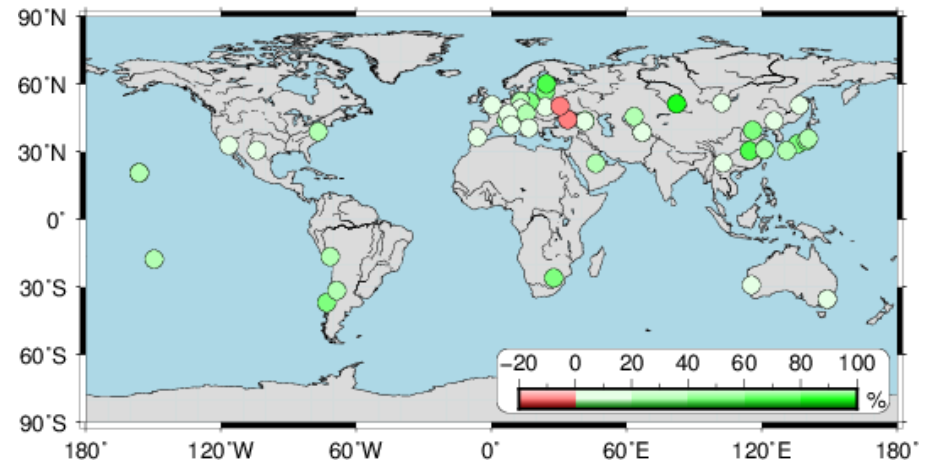
Station improvement: EOST



Station improvement: IMLS

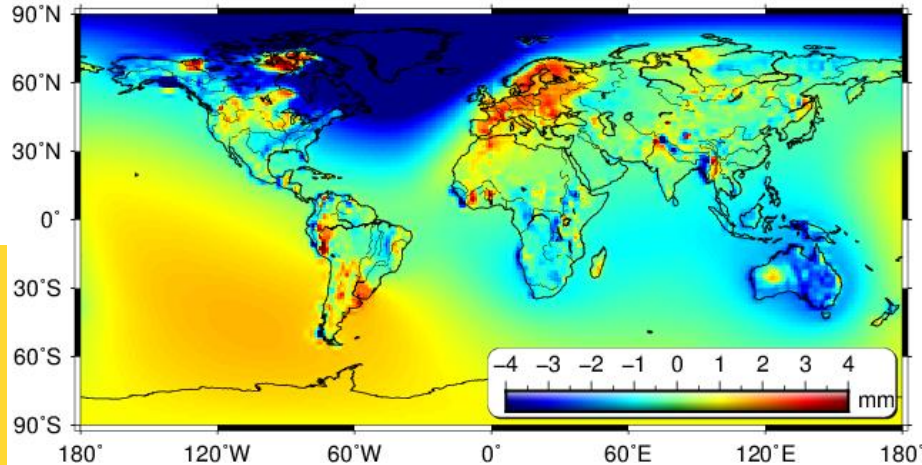


Station improvement: GFZ

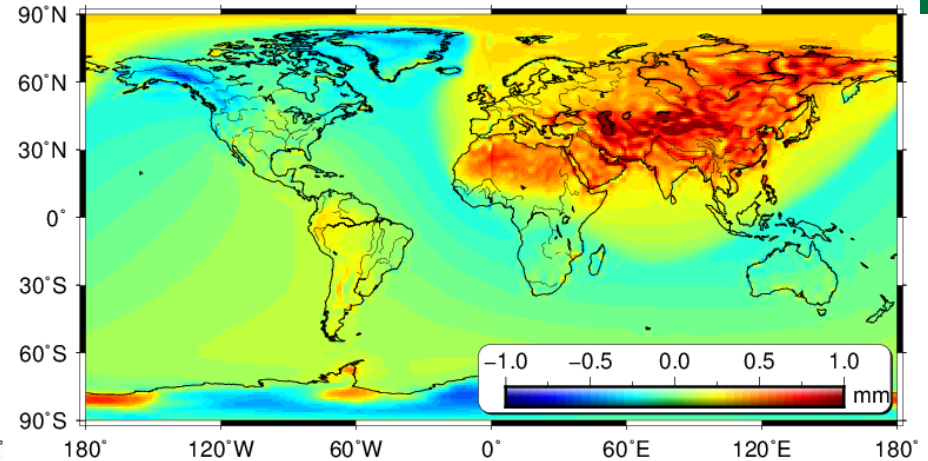


Station coordinates (cont.)

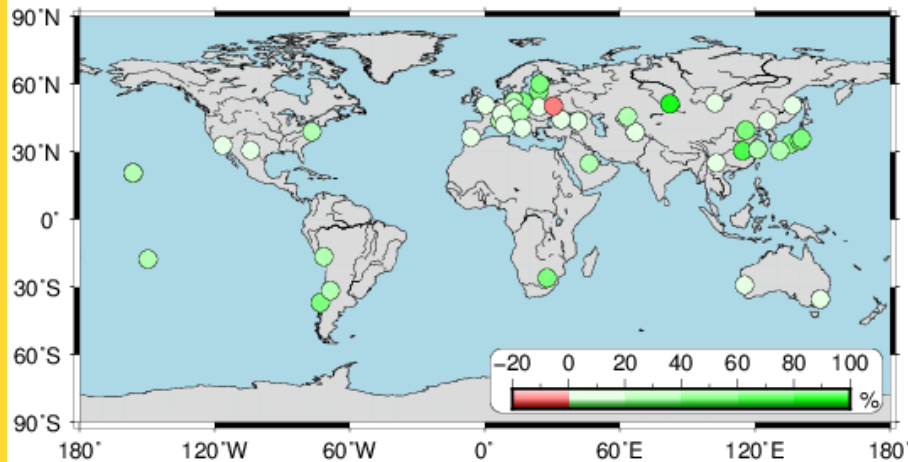
NASA-GLDAS vs. GGFC-GLDAS



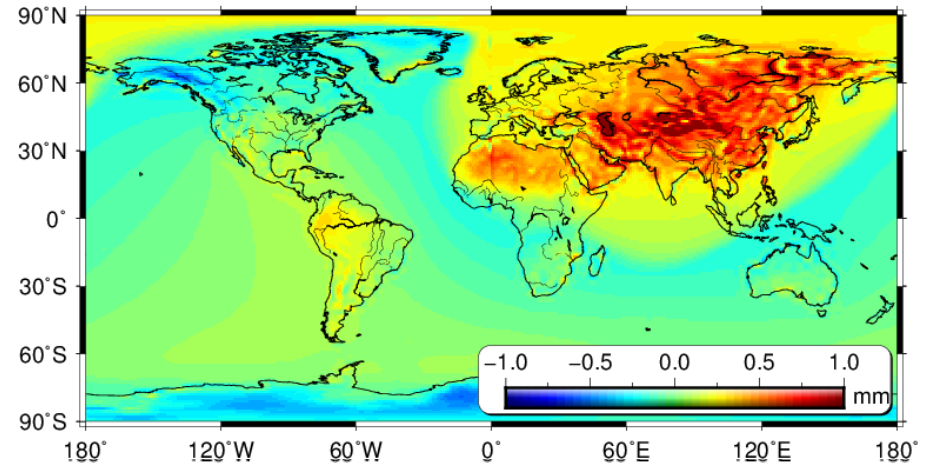
EOST-ERAinterim vs. GGFC-NCEP



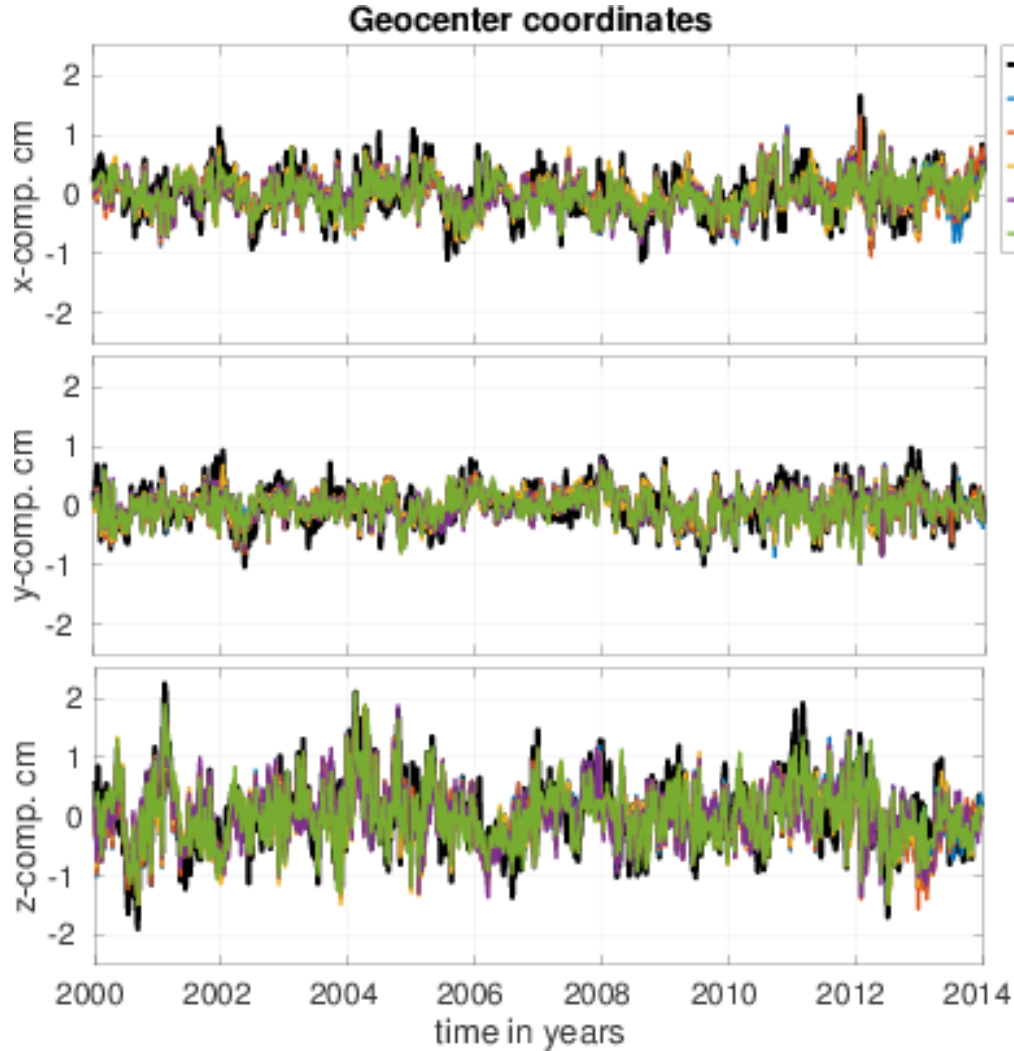
Station improvement: IMLS



GFZ-ECMWF vs. GGFC-NCEP

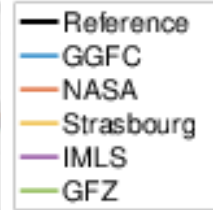
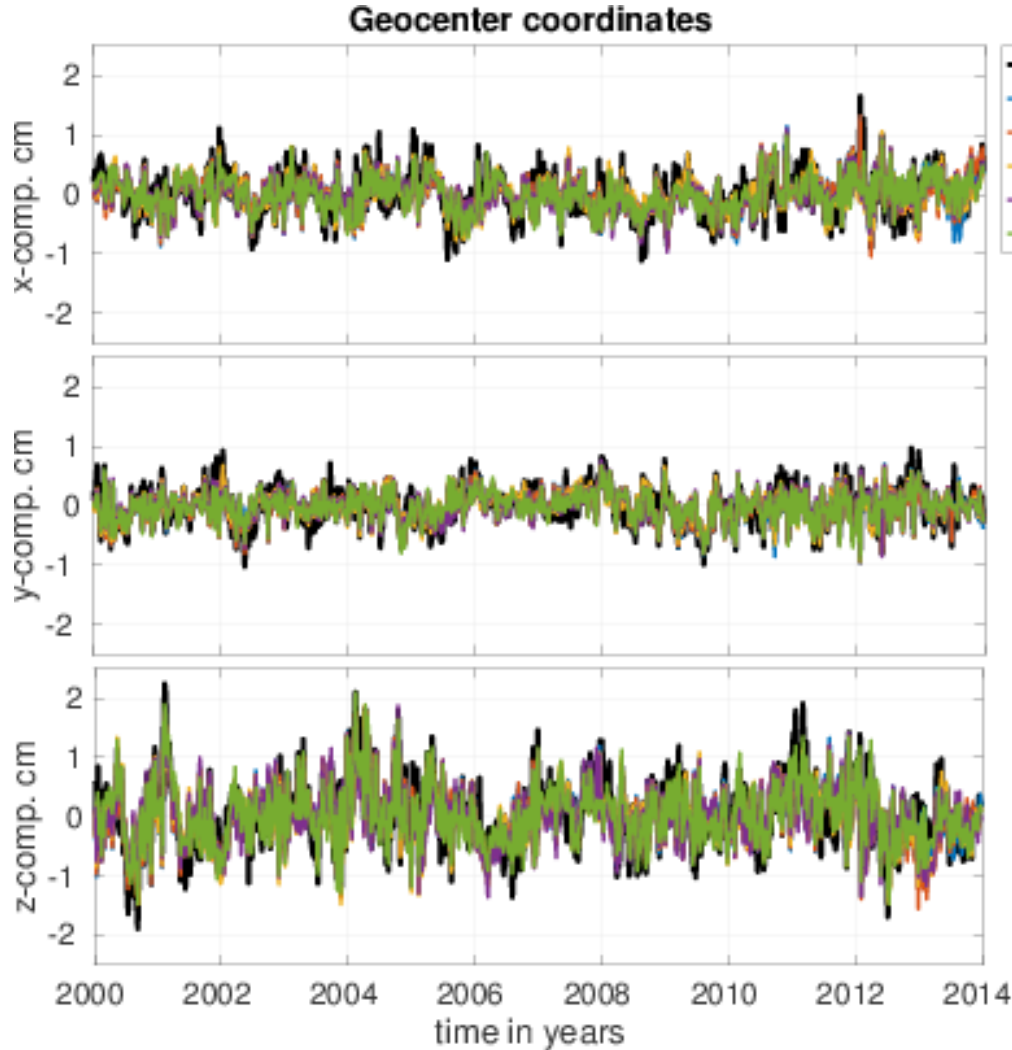


Geocenter: time series



Model	X [cm]	Y [cm]	Z [cm]
Ref.	0.386	0.323	0.605
GGFC	0.294	0.257	0.498
NASA	0.297	0.253	0.508
EOST	0.308	0.251	0.512
IMLS	0.298	0.244	0.503
GFZ	0.299	0.244	0.528

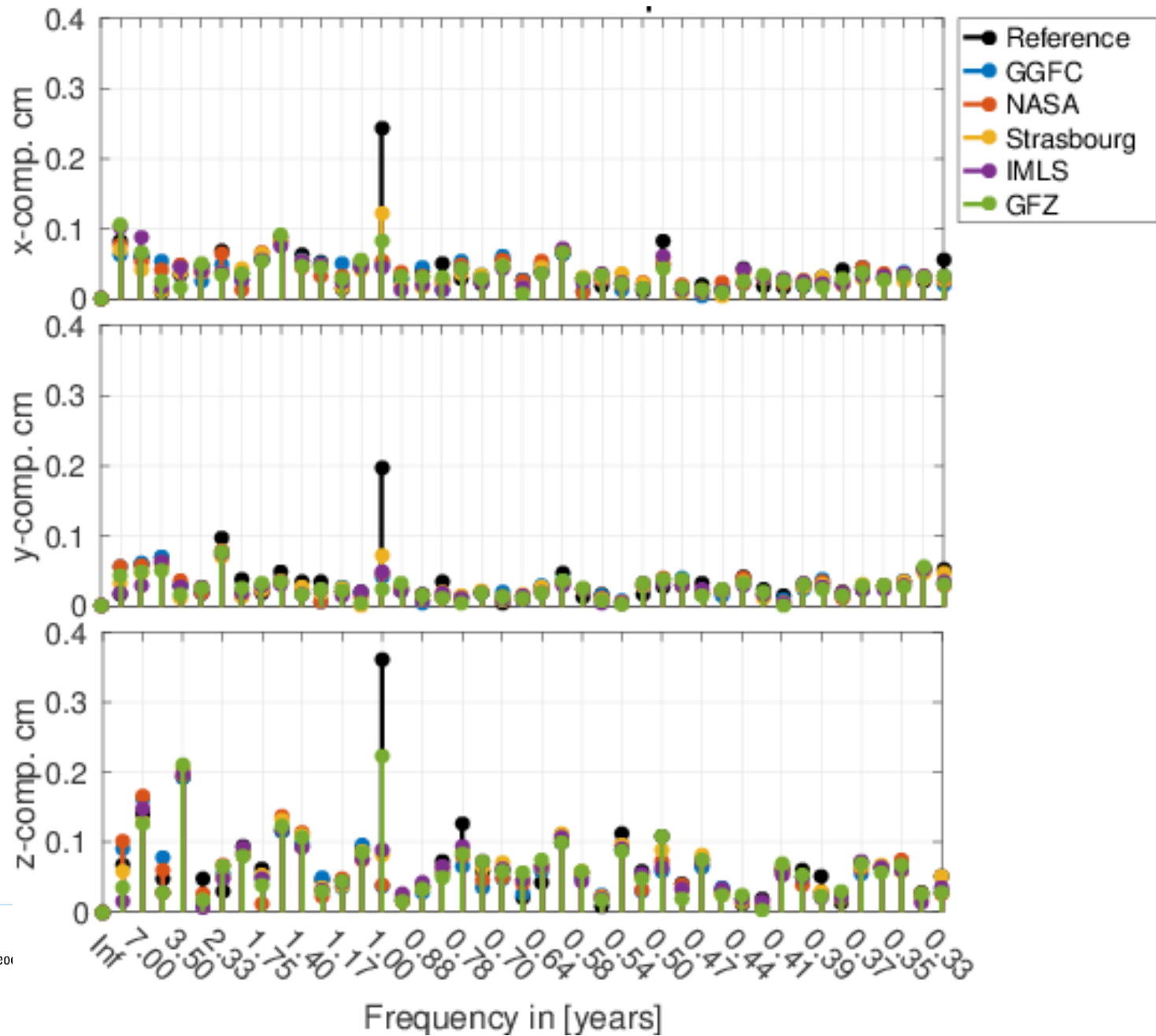
Geocenter: time series



Geophysical Models explain about 20% of the signal.

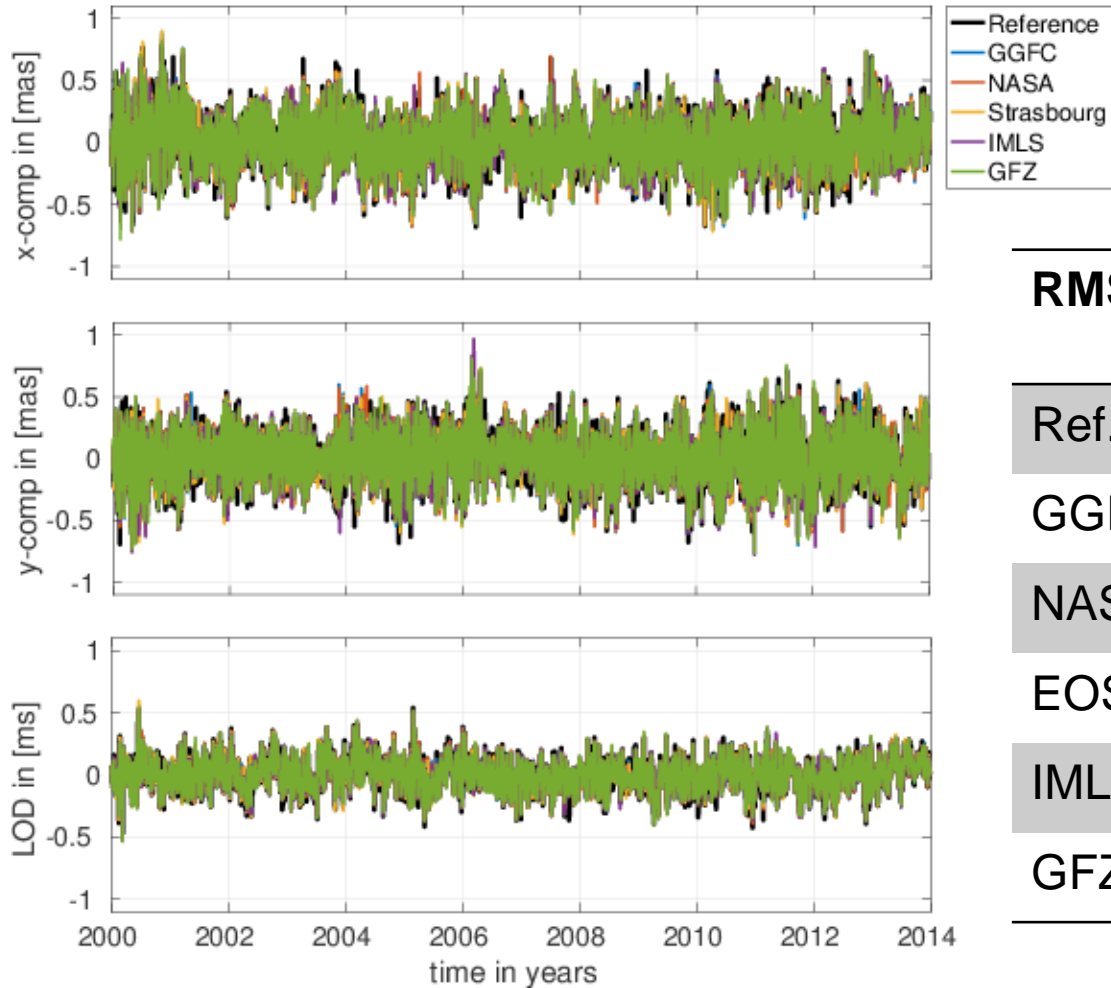
Rel. Impr.	X [%]	Y [%]	Z [%]	AVG [%]
Ref.	-	-	-	-
GGFC	23.8	20.7	17.7	20.6
NASA	23.0	21.7	16.0	20.3
EOST	20.0	22.3	15.5	19.3
IMLS	22.7	24.3	17.0	21.3
GFZ	22.5	24.5	12.8	19.9

Geocenter: spectrum



Earth orientation parameters

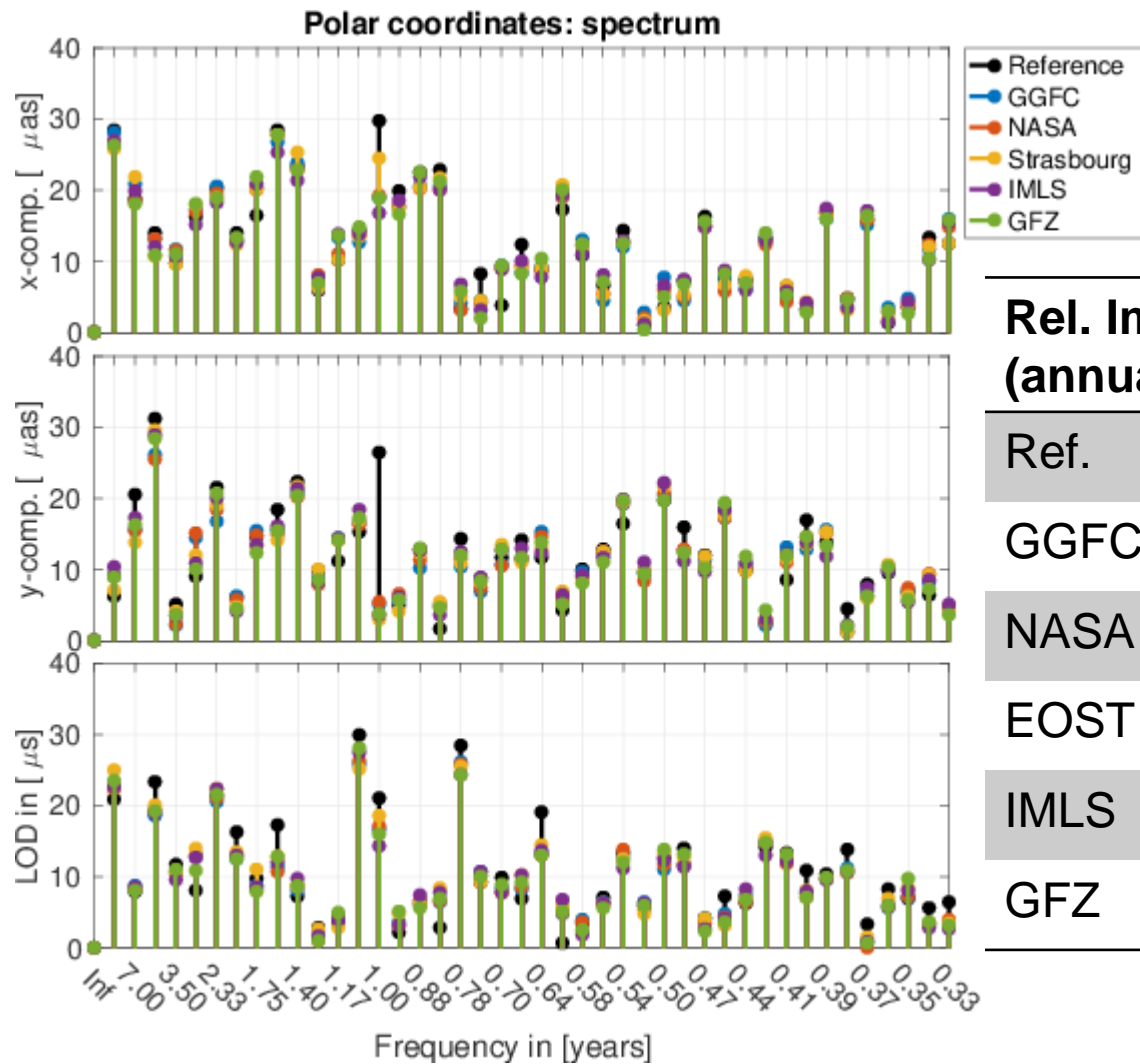
Polar coordinates



Statistics with respect to the IERS C04 (2008) time series

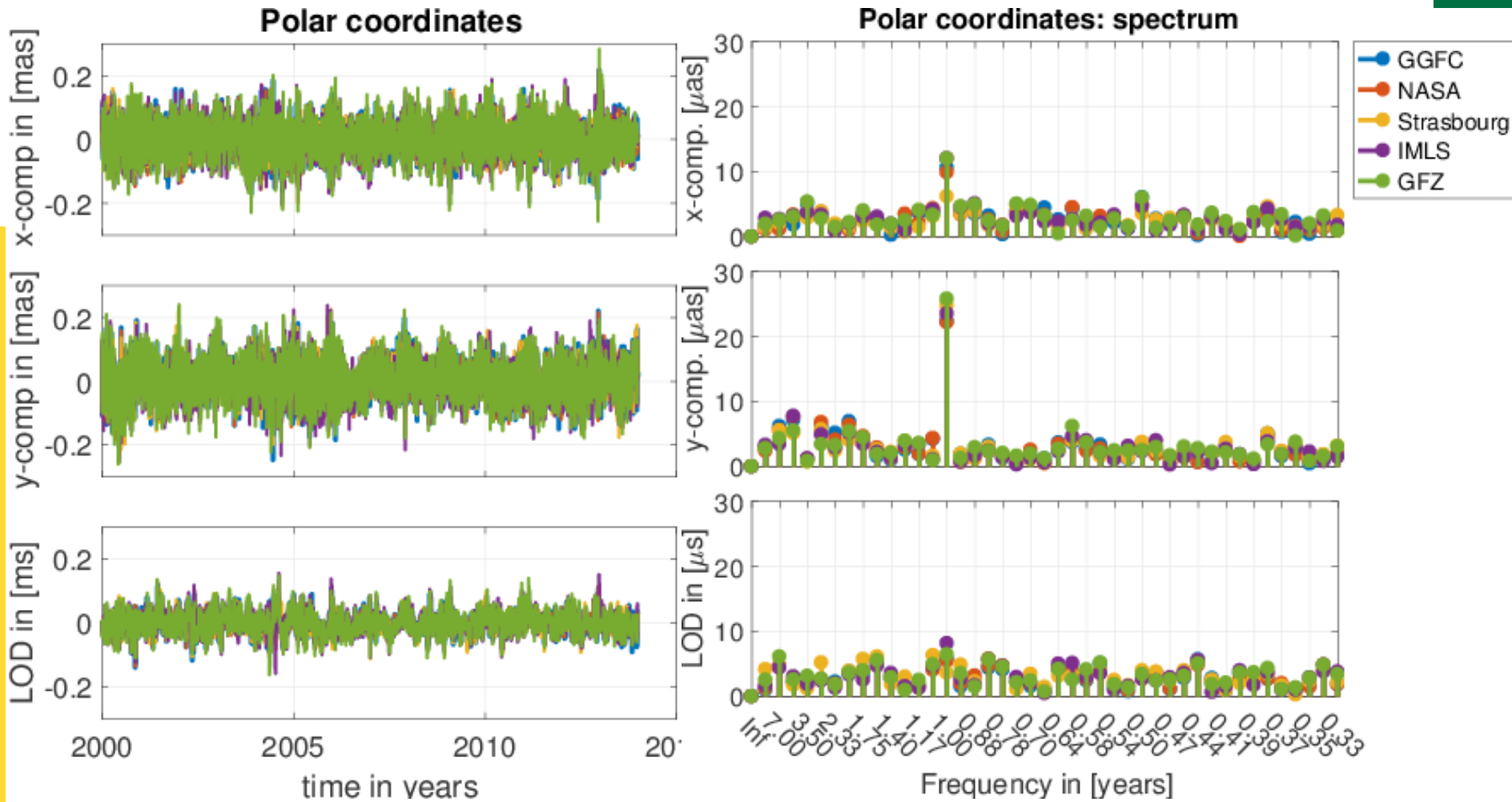
RMS	X [μas]	Y [μas]	LOD [μs]
Ref.	182.7	179.5	127.6
GGFC	176.5	173.6	121.0
NASA	177.1	174.6	121.5
EOST	176.2	174.9	122.5
IMLS	174.7	174.7	120.0
GFZ	175.7	173.6	121.3

Earth orientation parameters



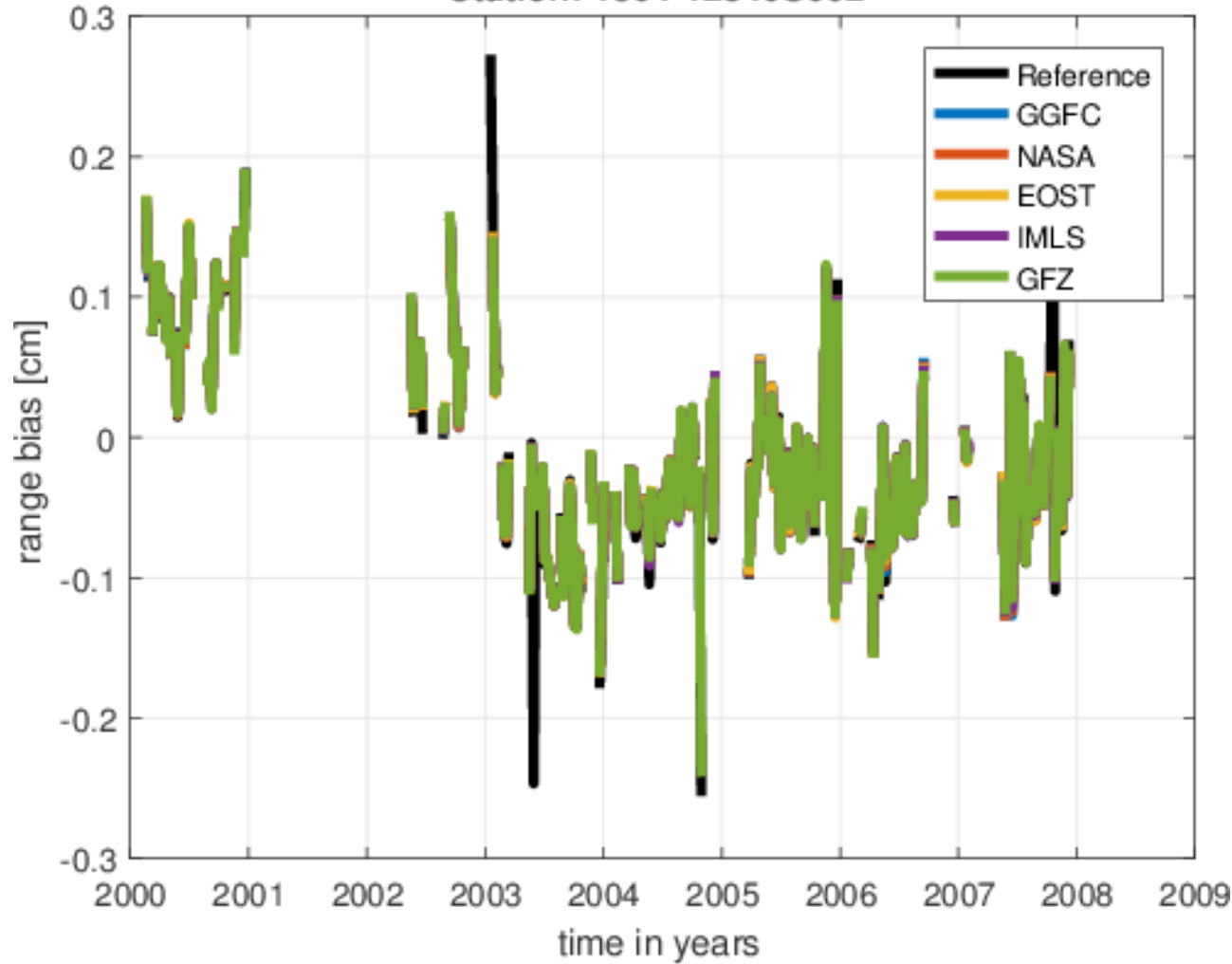
Rel. Impr. (annual)	X [%]	Y [%]	LOD [%]
Ref.	-	-	-
GGFC	35.9	80.7	21.3
NASA	34.7	79.4	18.7
EOST	17.2	88.6	11.7
IMLS	43.3	85.9	31.9
GFZ	36.3	86.2	24.2

Earth orientation parameters (relative to reference solution)



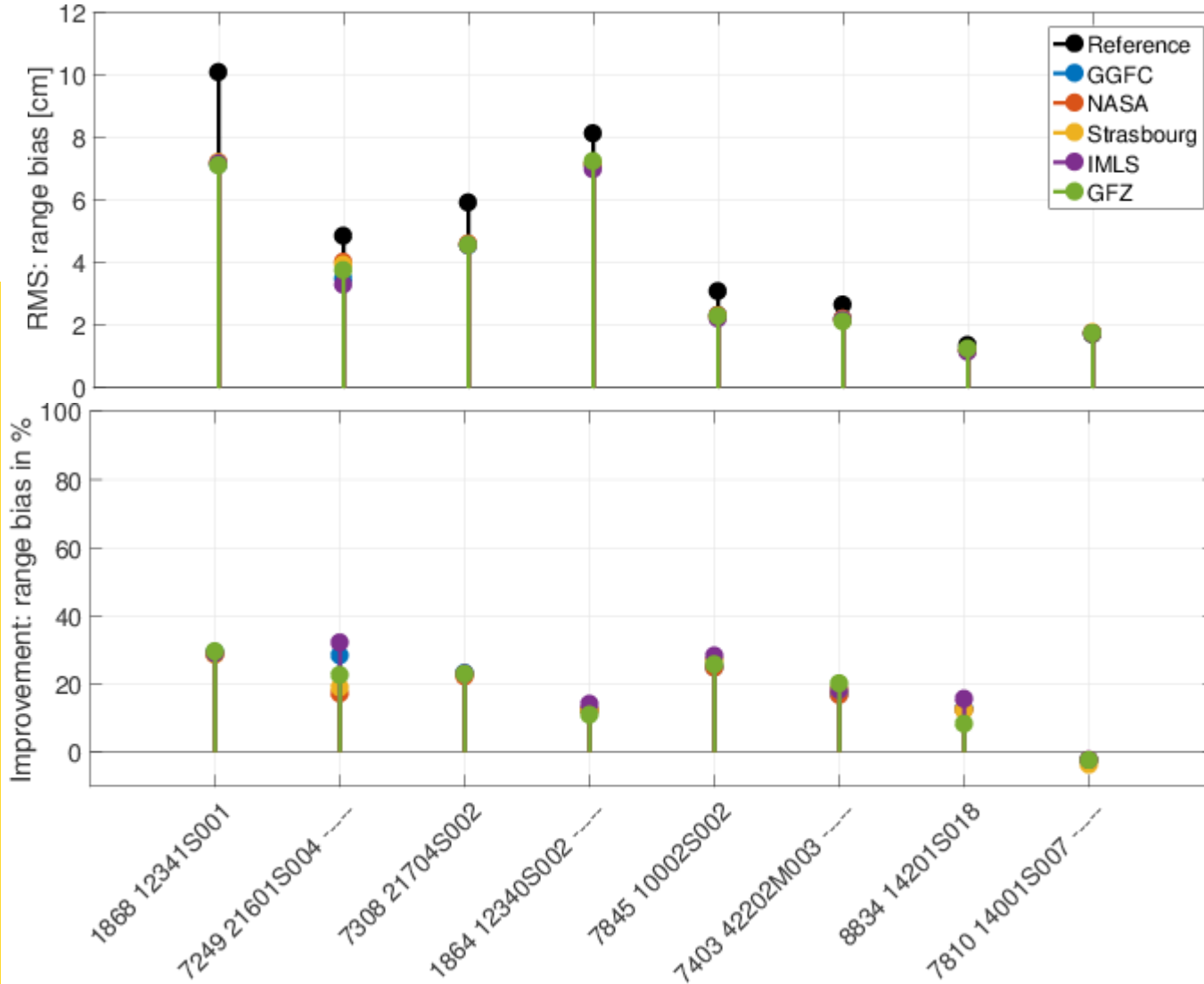
Range bias for station MAIL – Maidanak, Uzbekistan

Station: 1864 12340S002



Reduced peaks of the range bias time series when using loading models

Range bias



Average relative improvement w.r.t. reference

Rel. Impr.	[%]
GGFC	18.2
NASA	16.5
EOST	17.1
IMLS	19.7
GFZ	17.2

Conclusion

- Geophysical models significantly improve all estimates
 - nearly all station coordinates with up to 87% (outliers!)
 - 20% of geocenter signal can be explained primarily due to a reduction of the annual signal.
 - likewise reduction of the annual signal in the EOP
 - range biases reduce when applying loading models
- No model combination is outstanding
 - tendency of better performance of high temporal and high spatial models
- Models still do not include mass conservation
 - best attempt by GFZ as models are consistently forced but mass conservation not yet included

Thank you for your kind attention!

Contact:

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