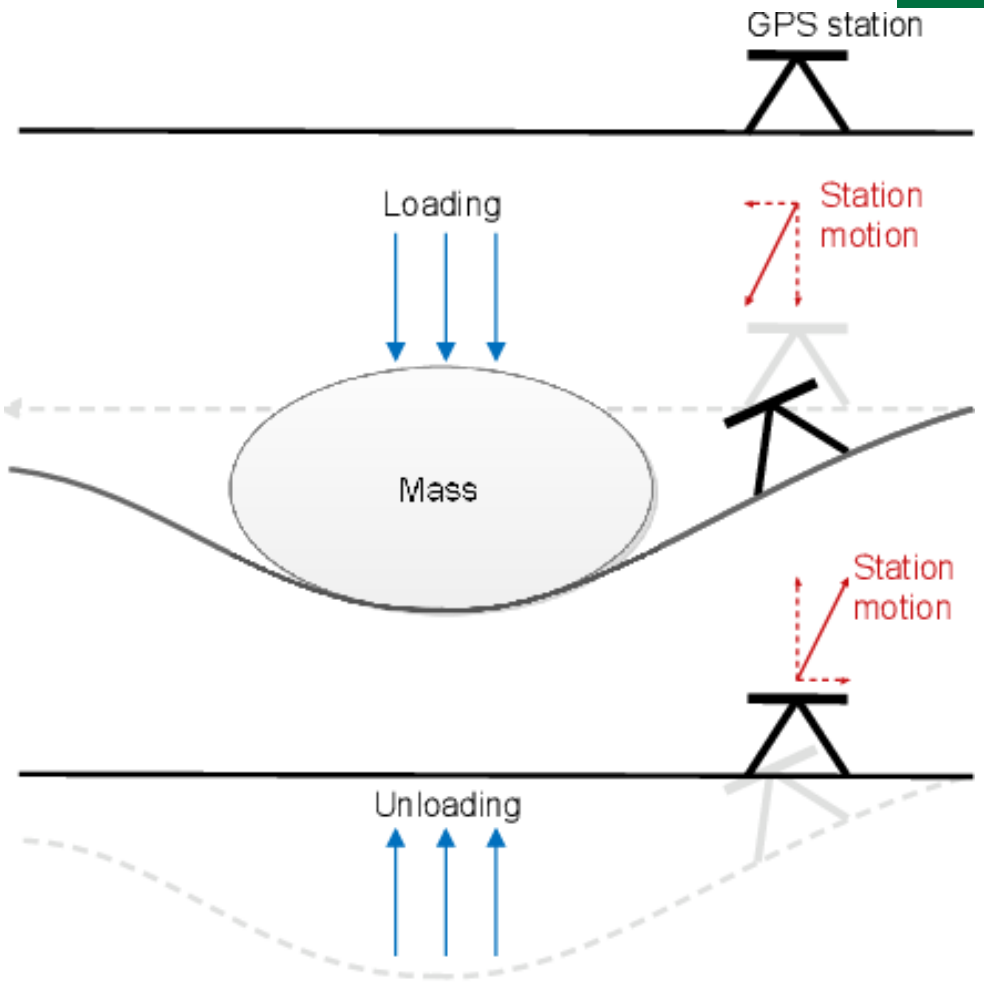
Federal Agency for
Cartography and Geodesy

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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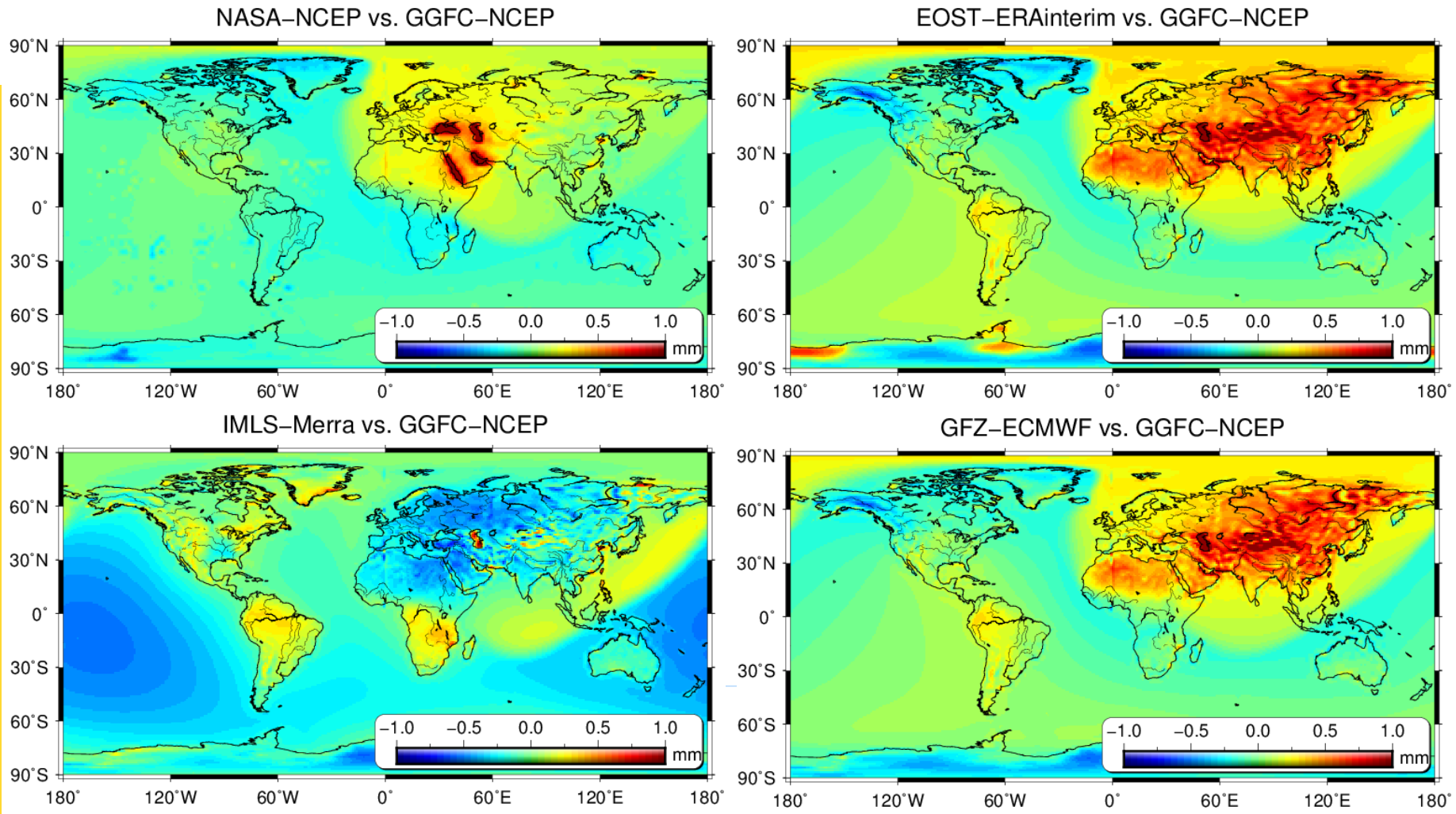
Spatial comparison (annual components/up)

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



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

Available (gridded) models (cont.)

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IMLS	6h	1°	**OMCT**
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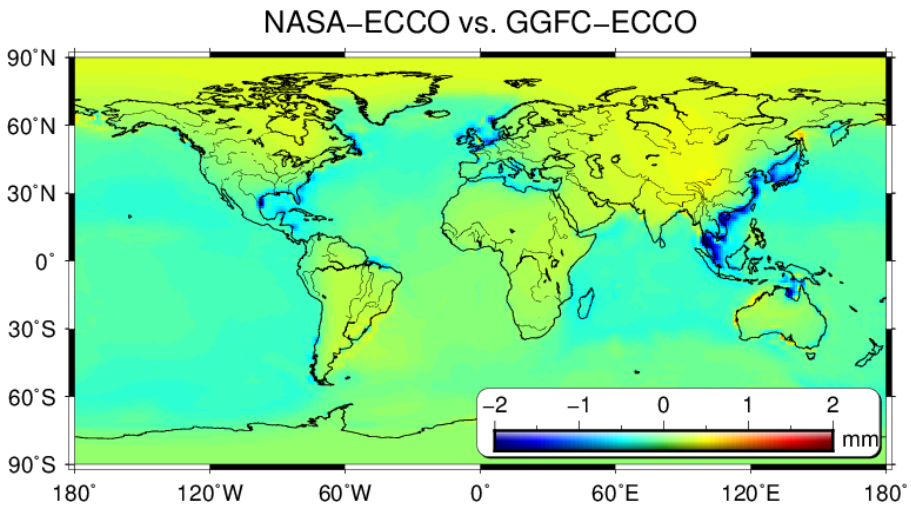
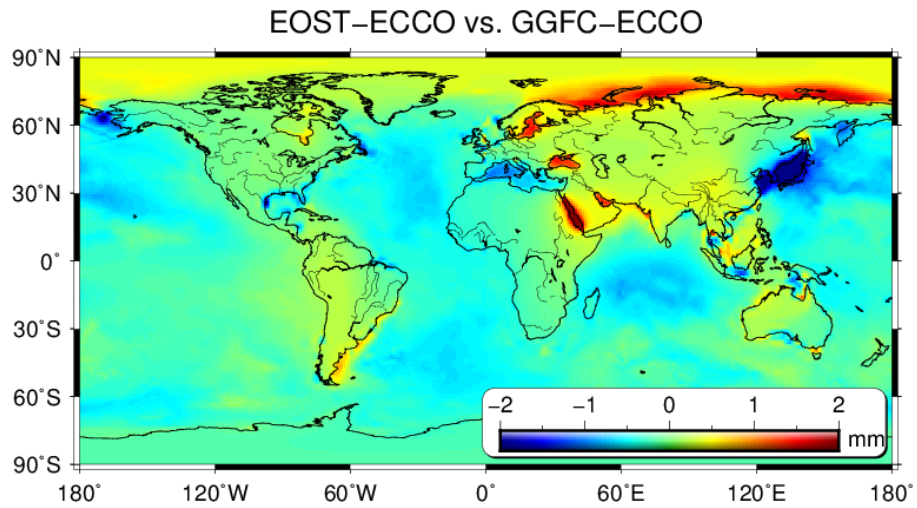
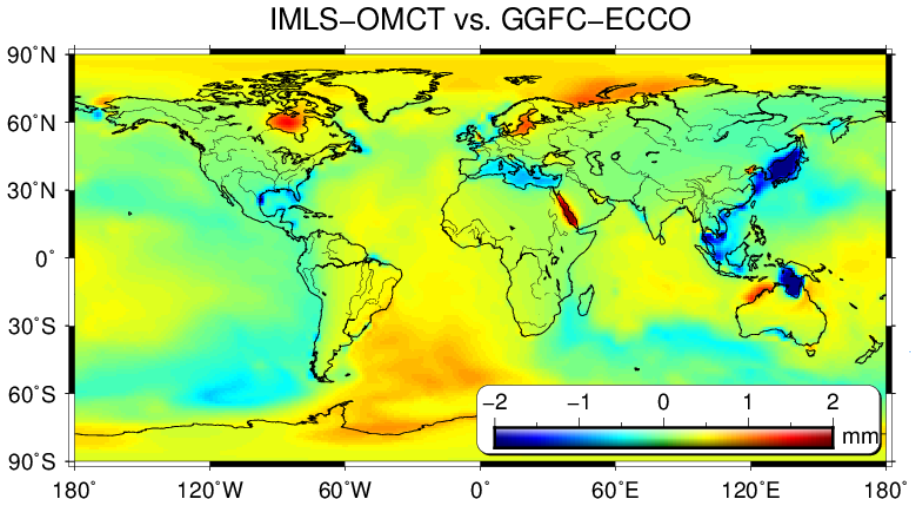
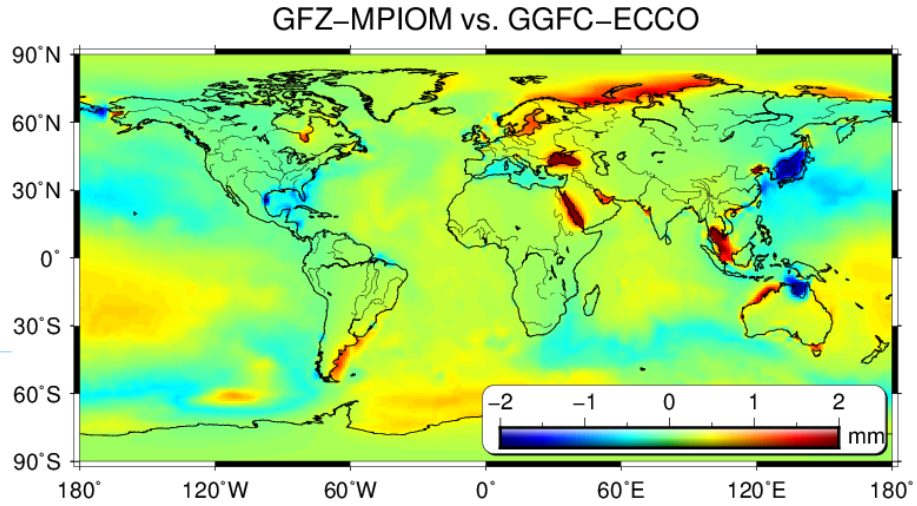
Spatial comparison (annual components/up)

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









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
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°
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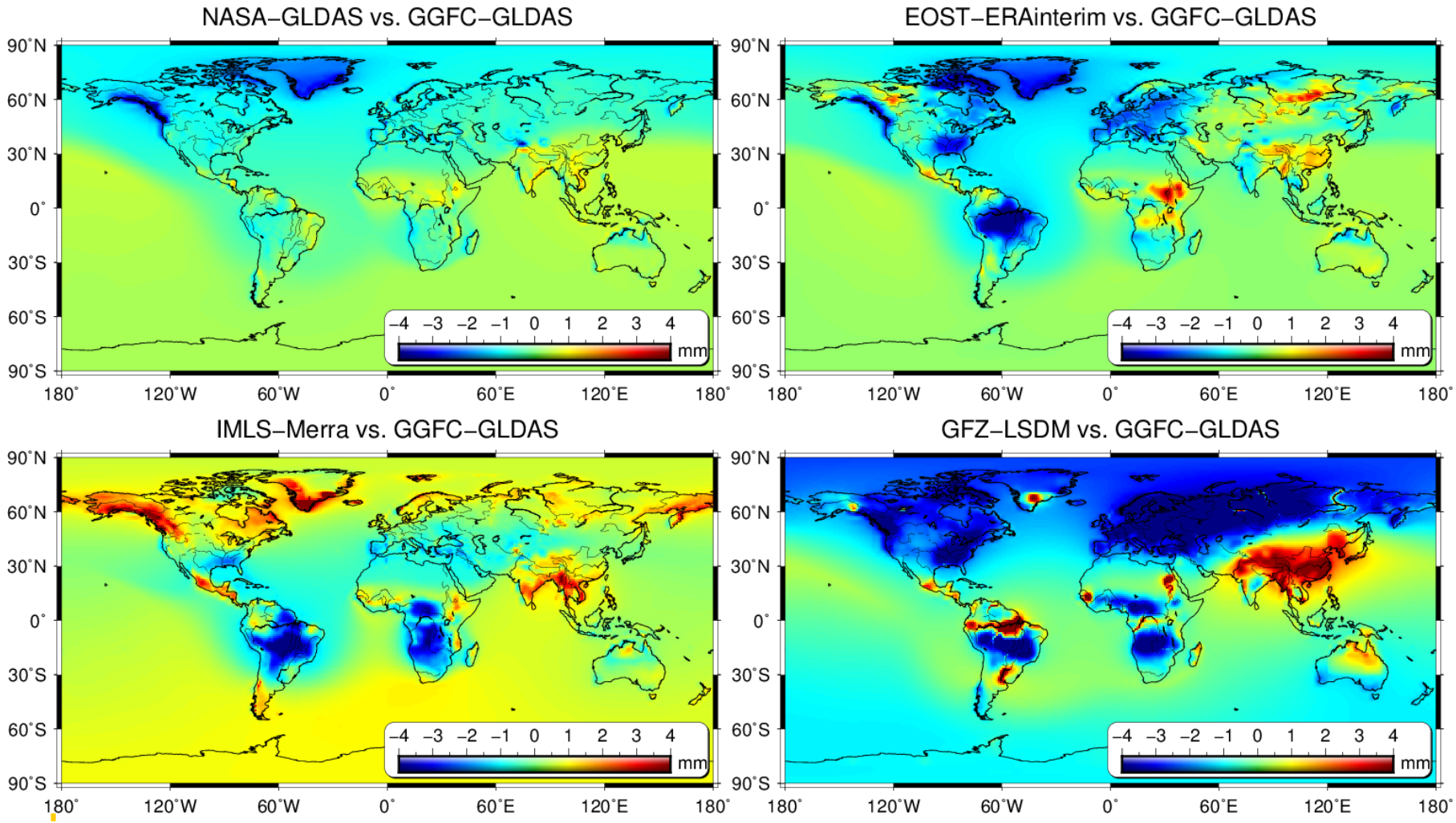


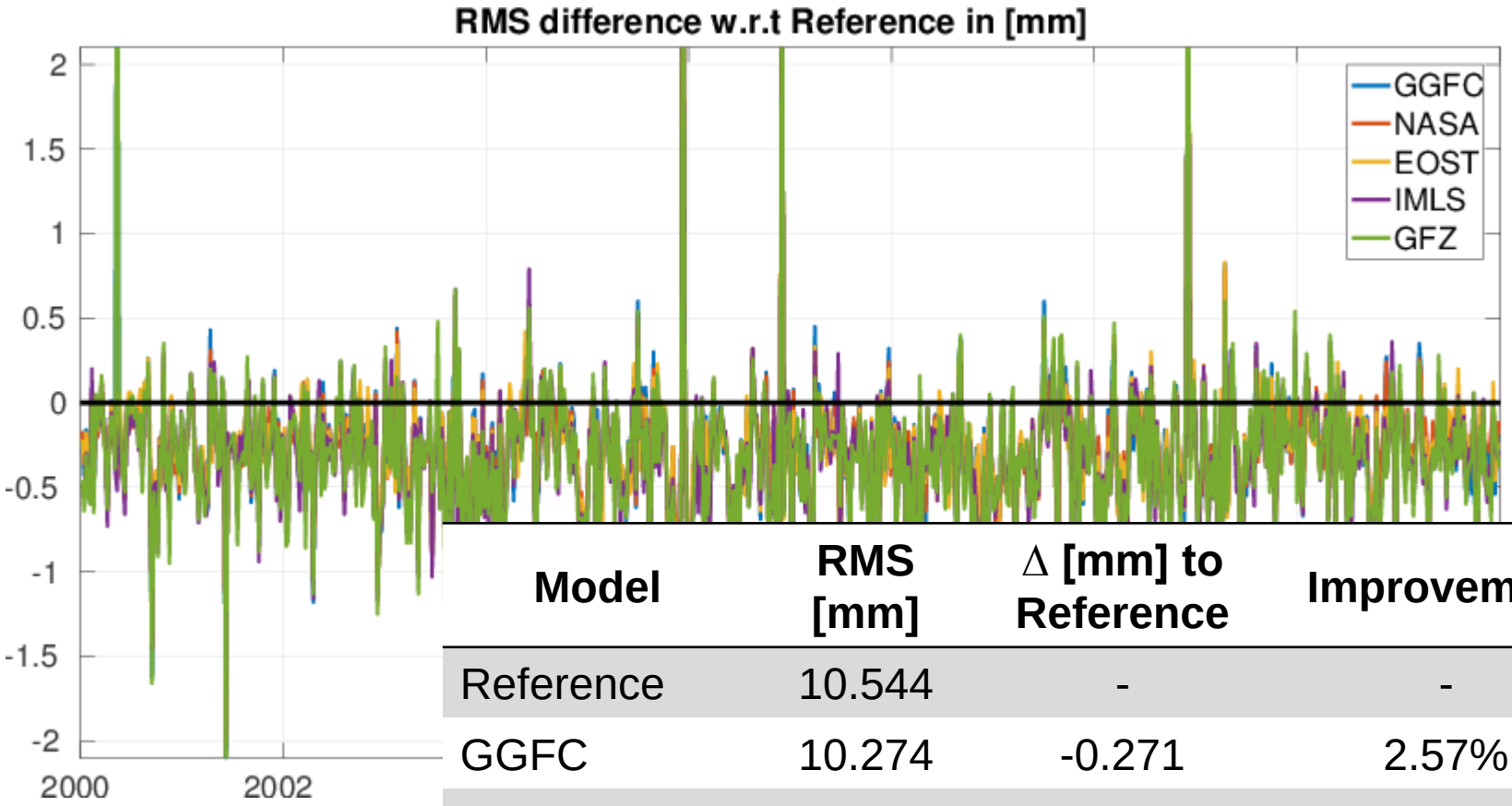
Impact on SLR parameter estimation

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	-

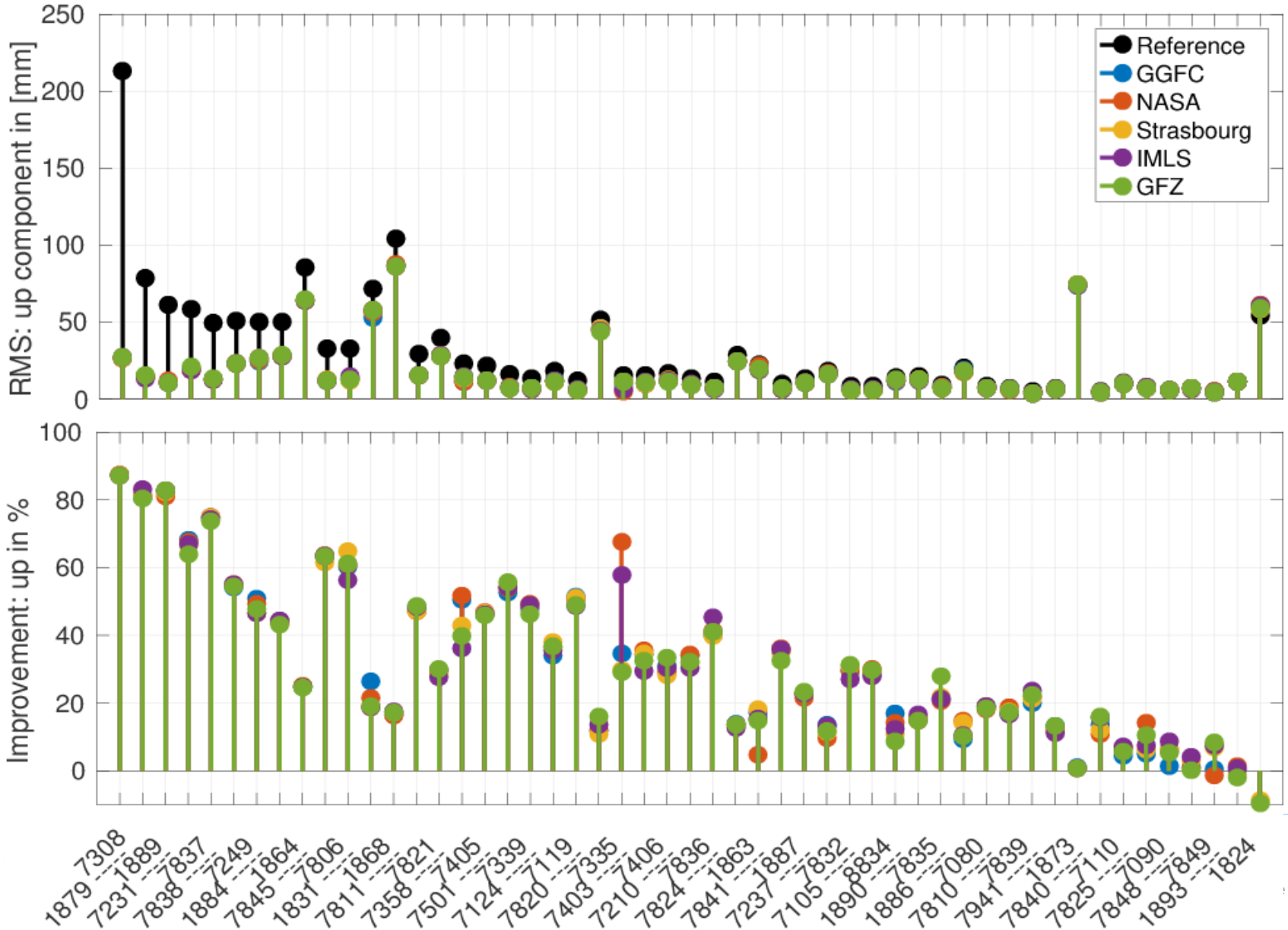
A posteriori RMS



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%

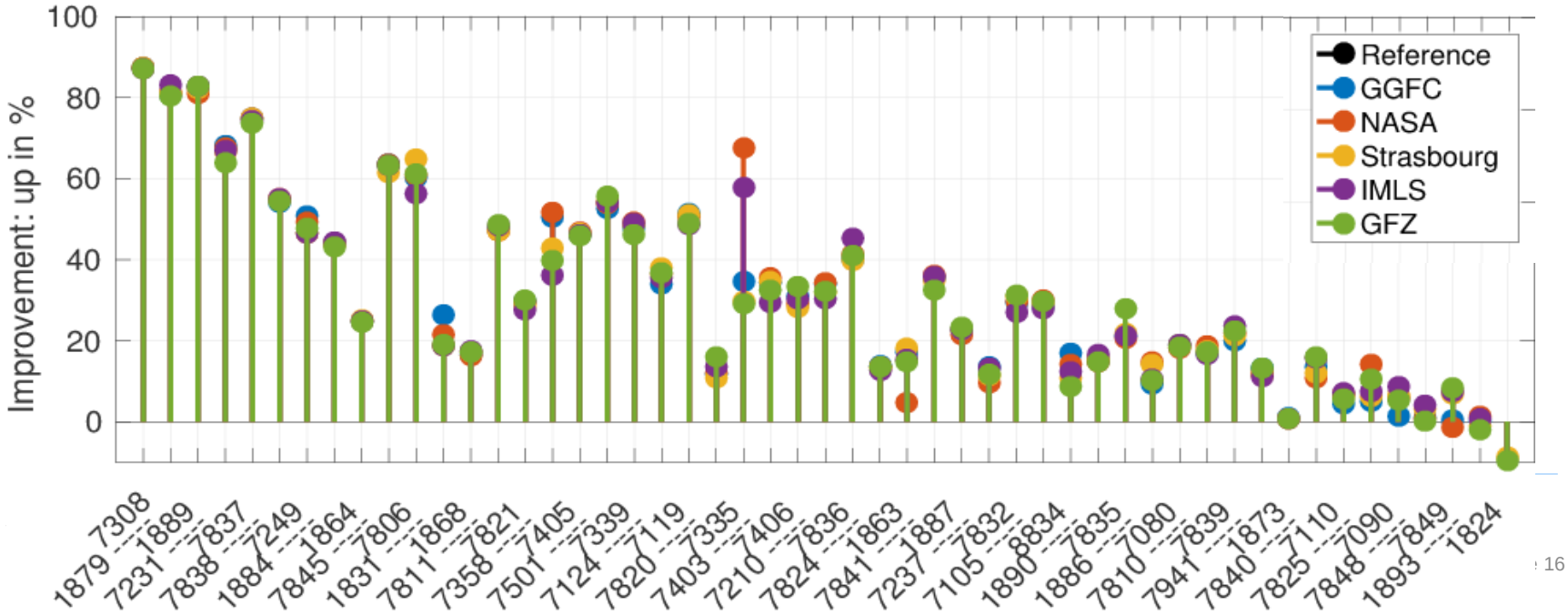
Station coordinates (up-only)

51 stations

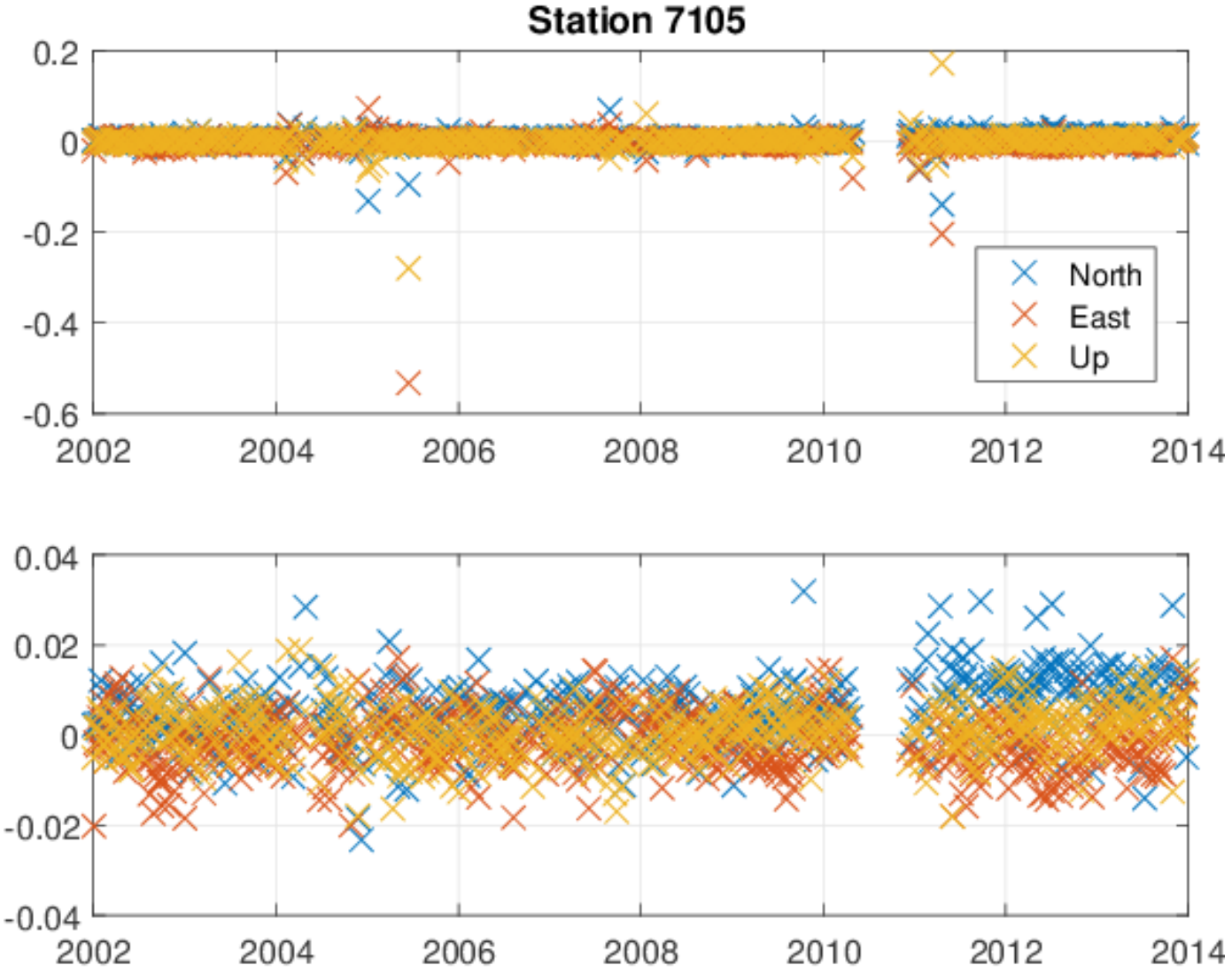


Station coordinates (up-only)

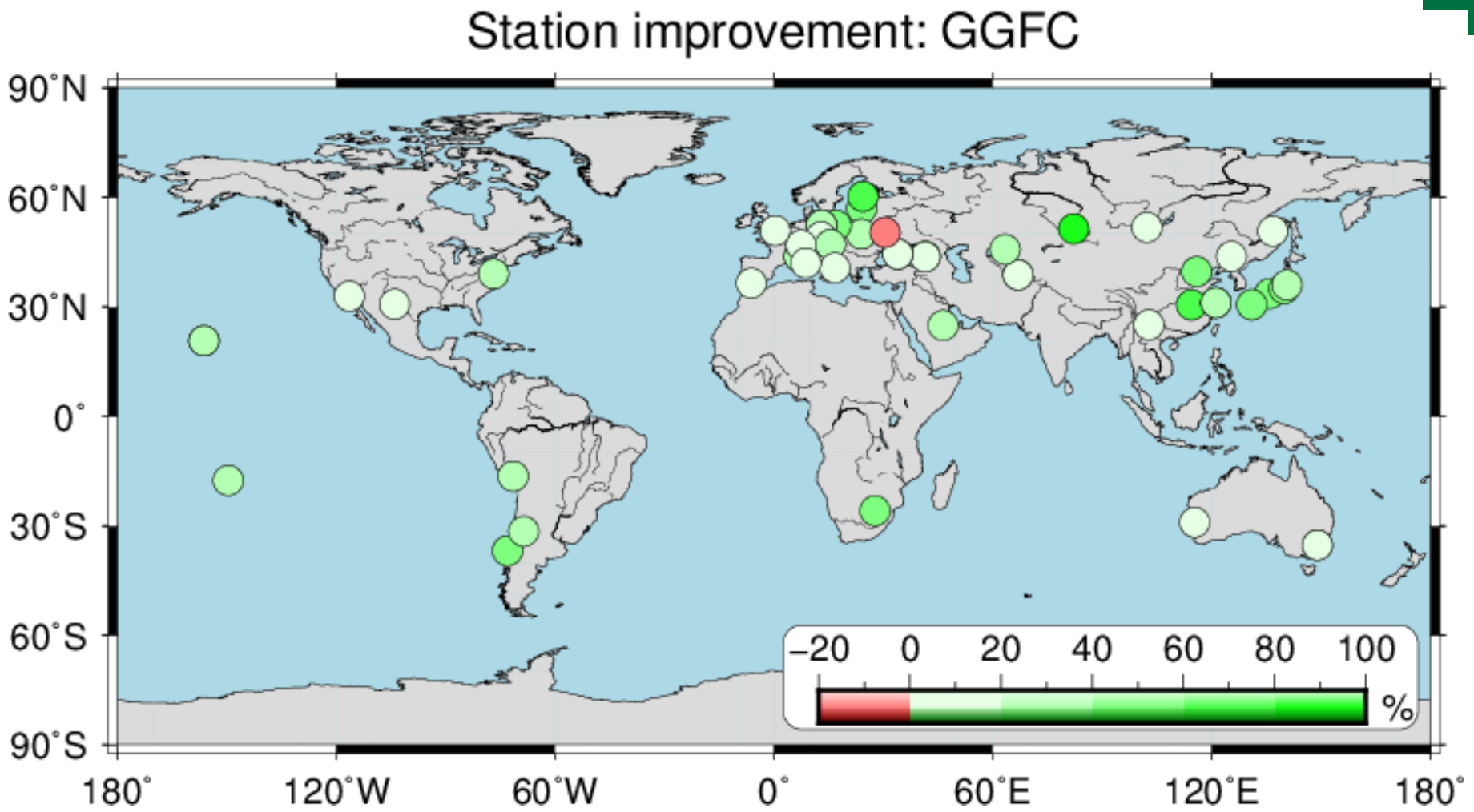
Model	max. increase in %	max. decrease in %	Average improvement in %	Stations with improvement in %
GGFC	87.49	12.58	31.11	98%
NASA	87.43	12.76	31.75	96%
EOST	87.47	08.72	31.00	96%
IMLS	87.12	11.42	31.39	98%
GFZ	87.13	09.64	30.97	96%



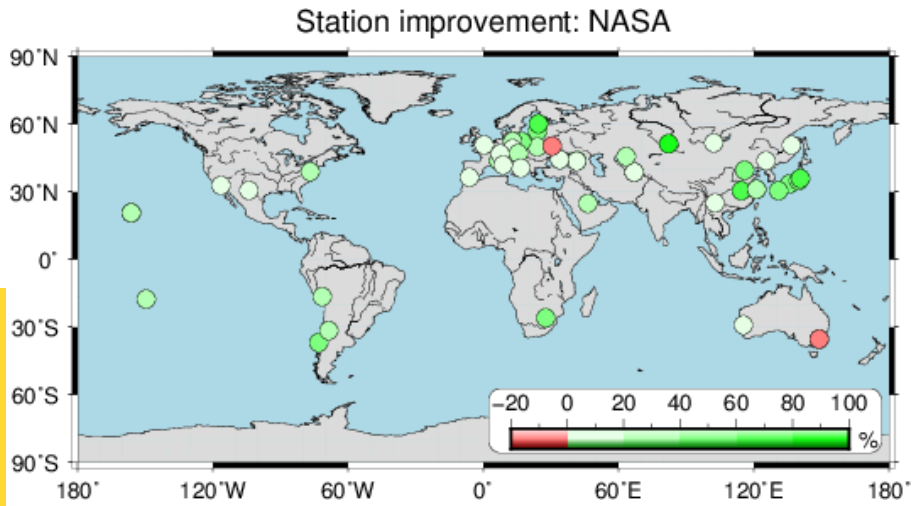
Station coordinates (up-only)

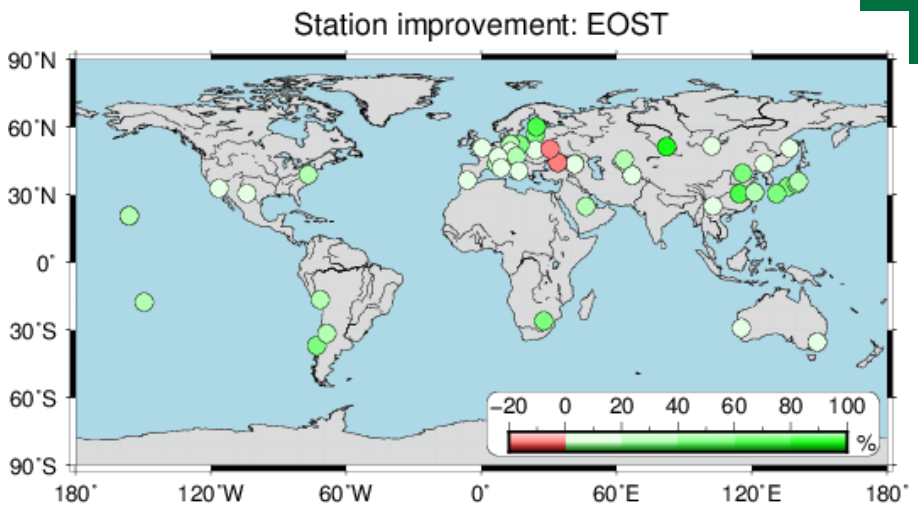


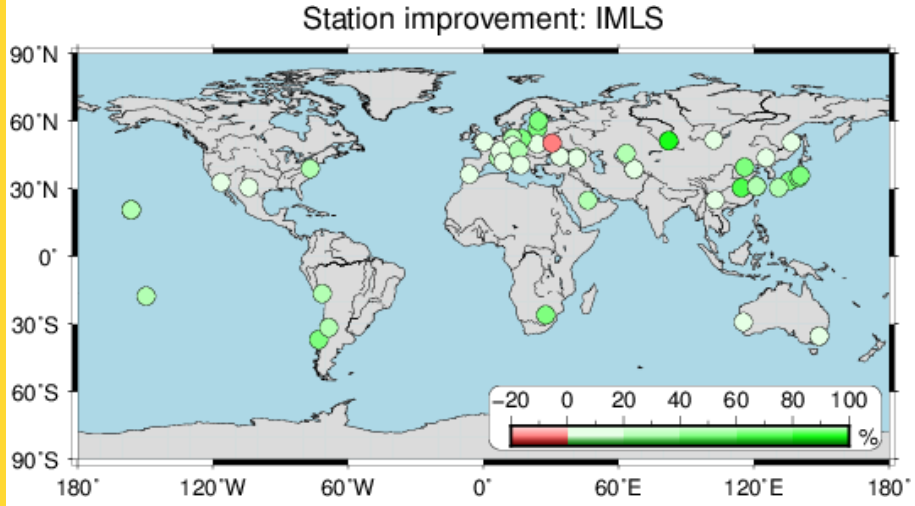
Station coordinates (cont.)

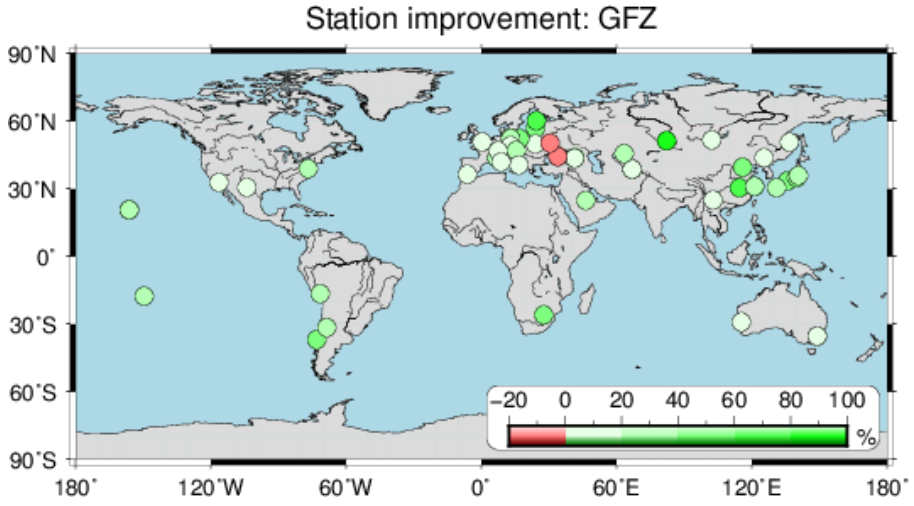


Station coordinates (cont.)

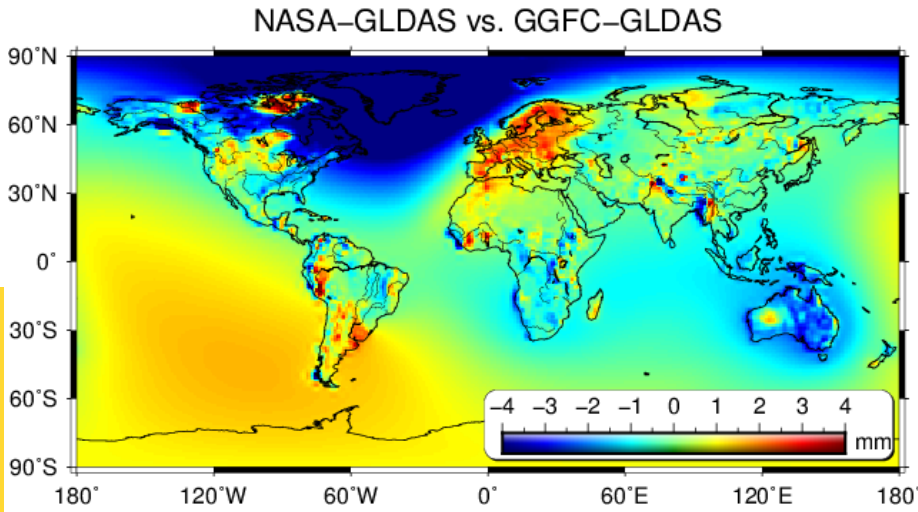


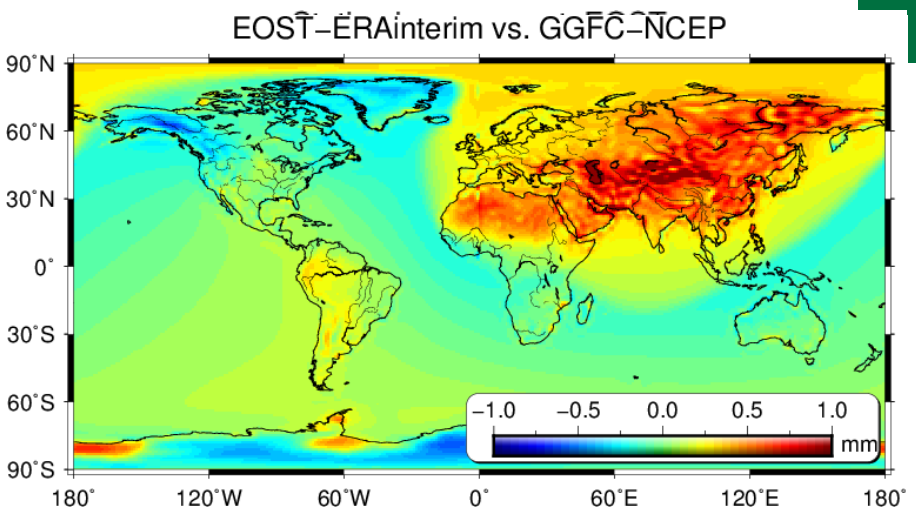


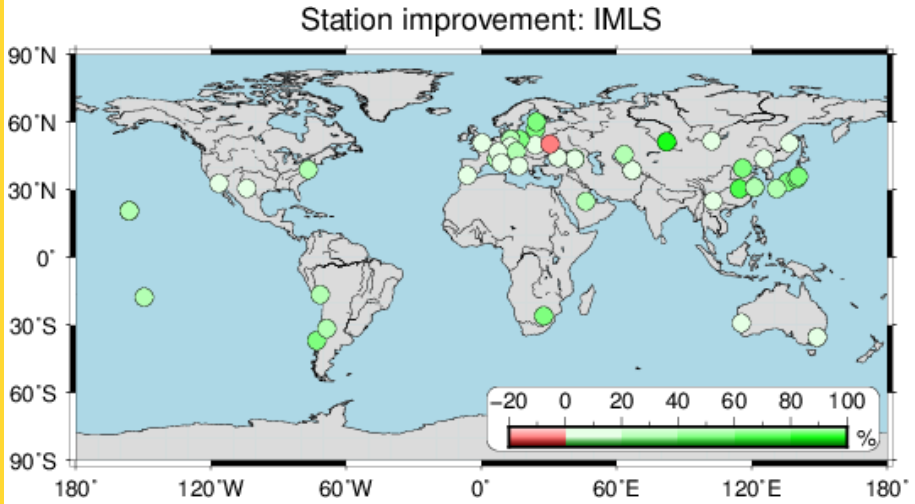


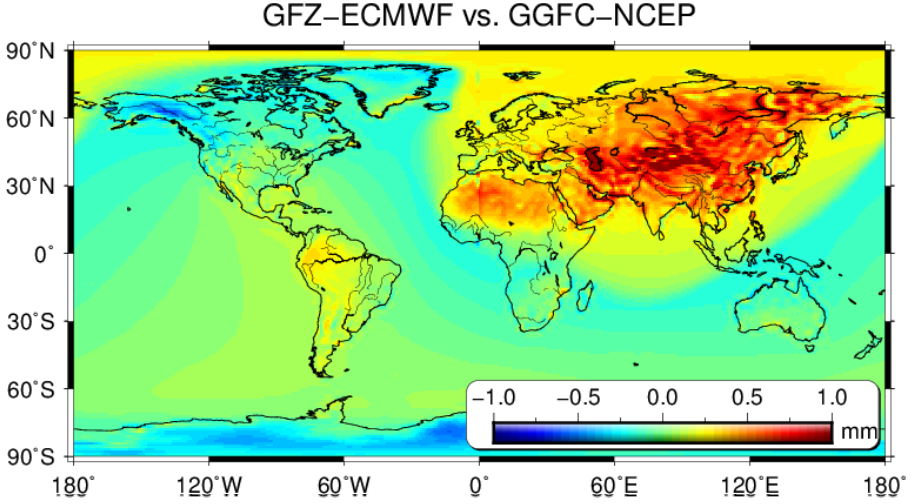


Station coordinates (cont.)

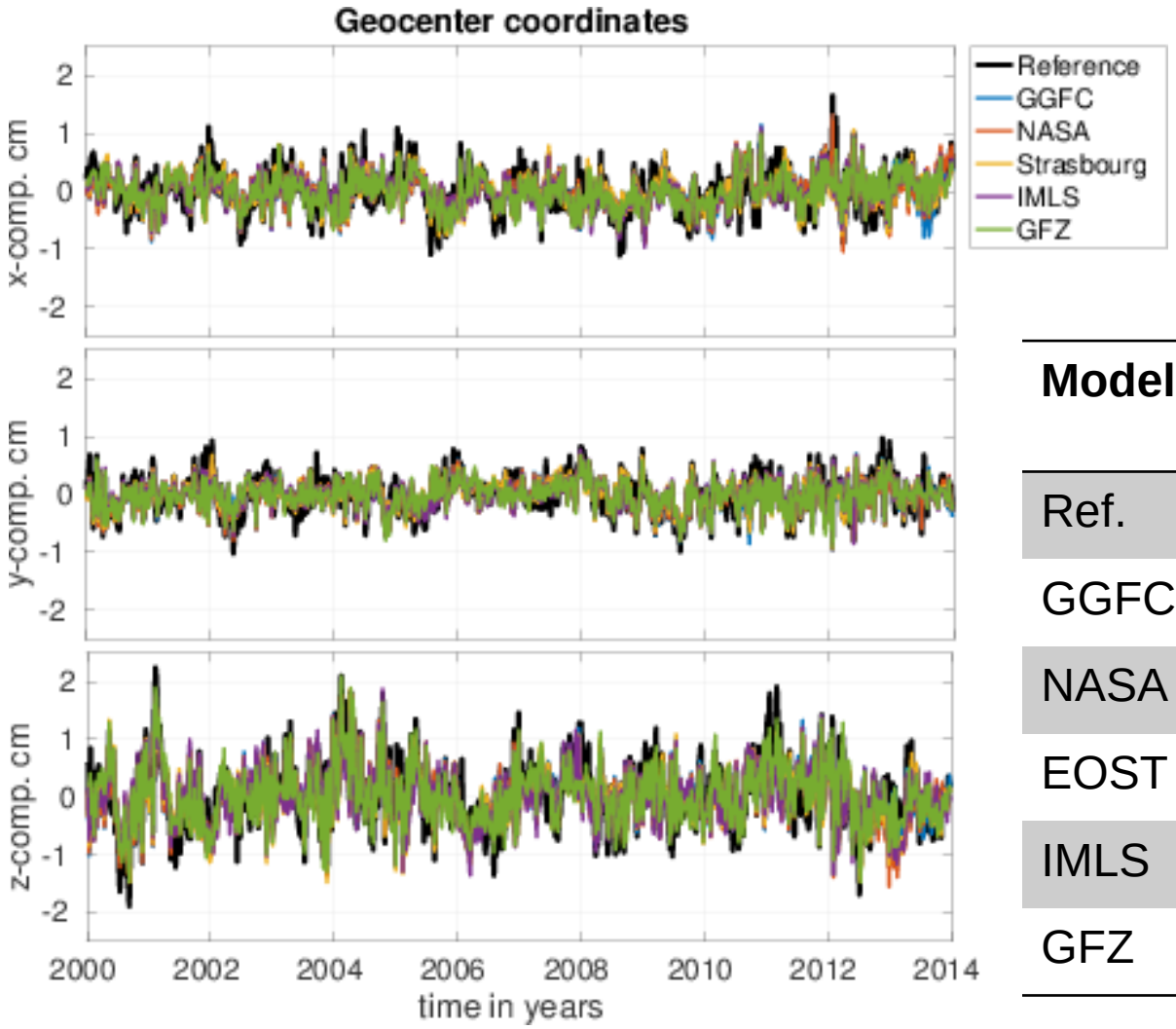






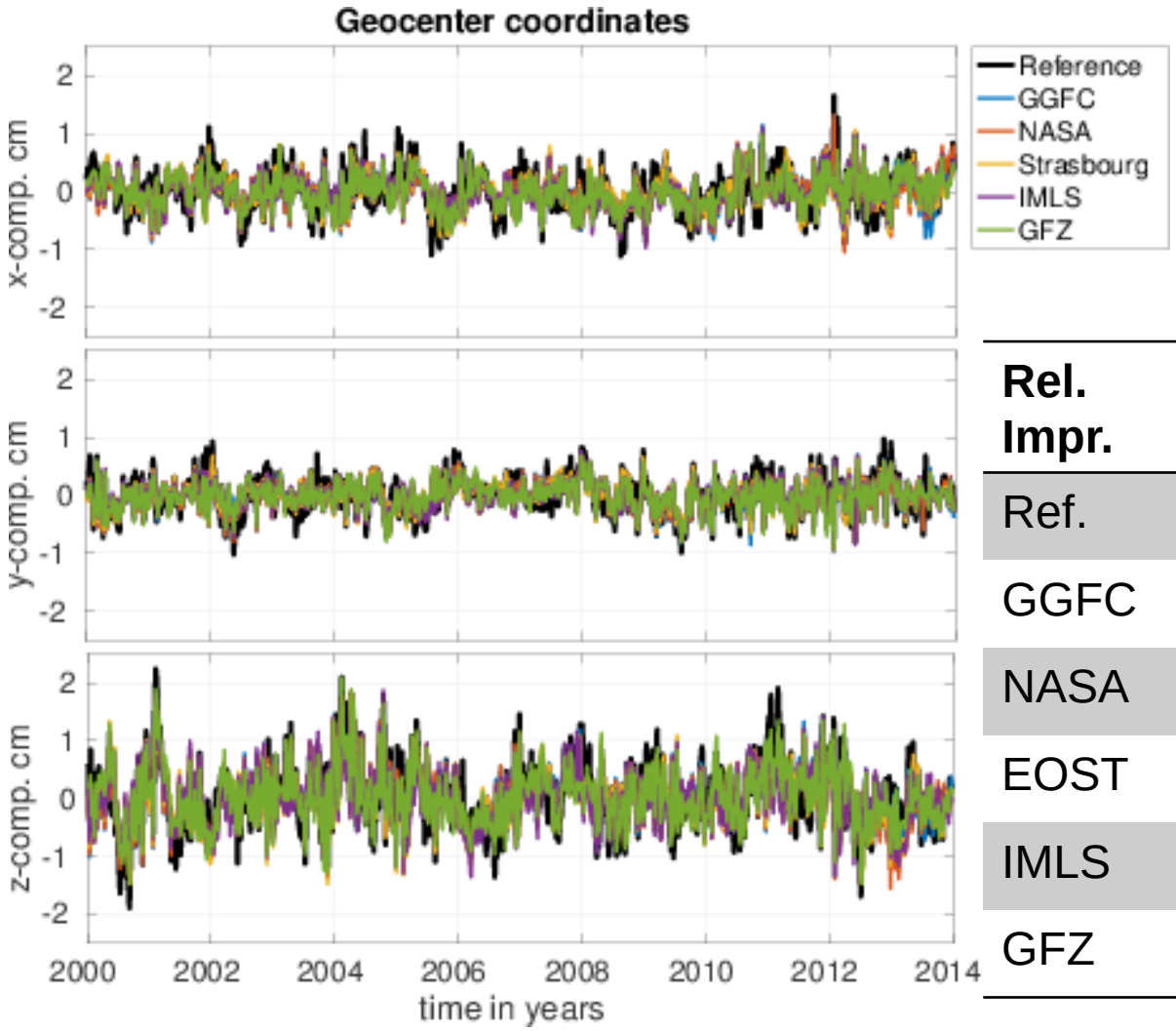


Geocenter: time series



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

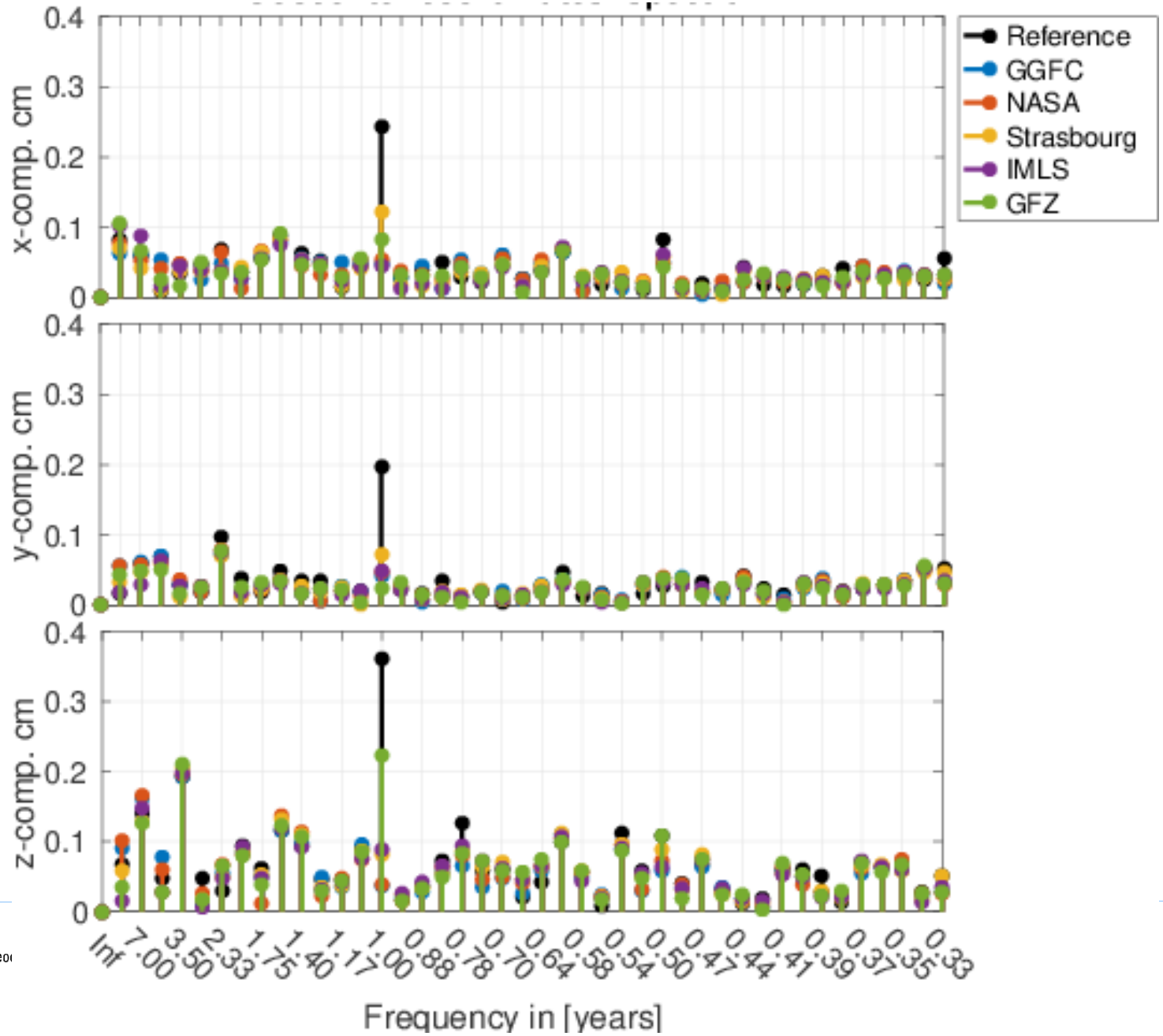
Geocenter: time series



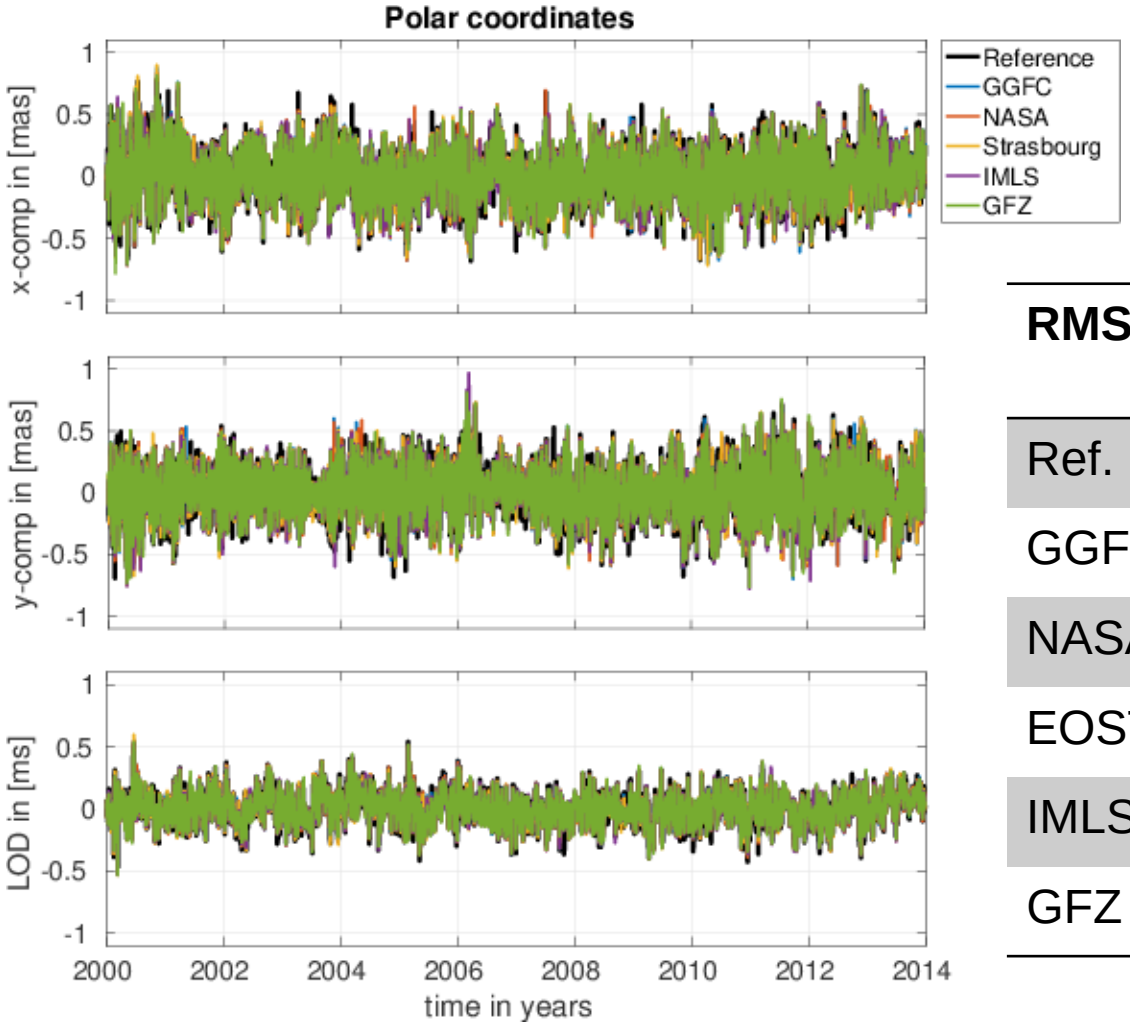
Geophysical Models explain about 20% of the signal.

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



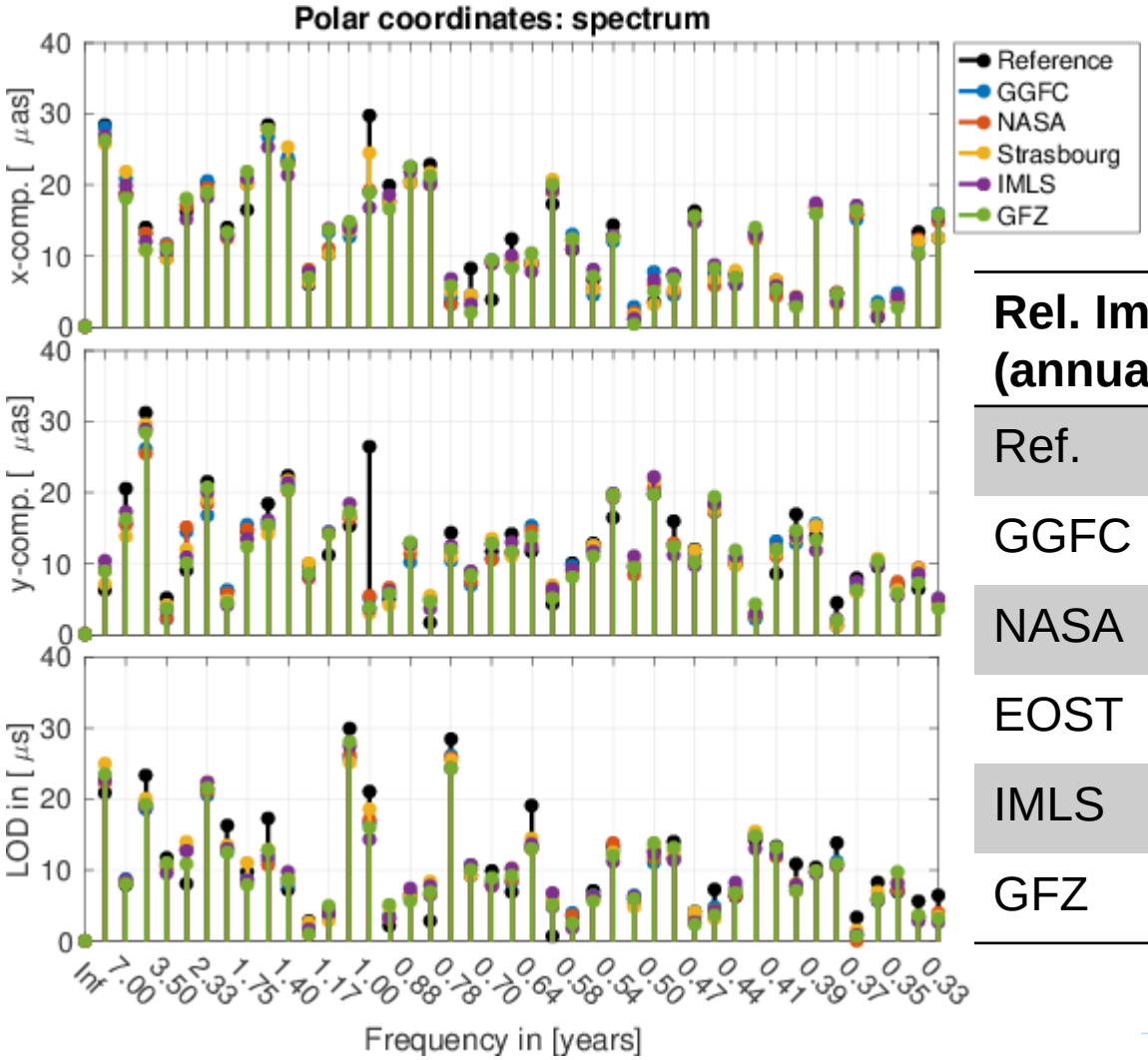
Earth orientation parameters



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

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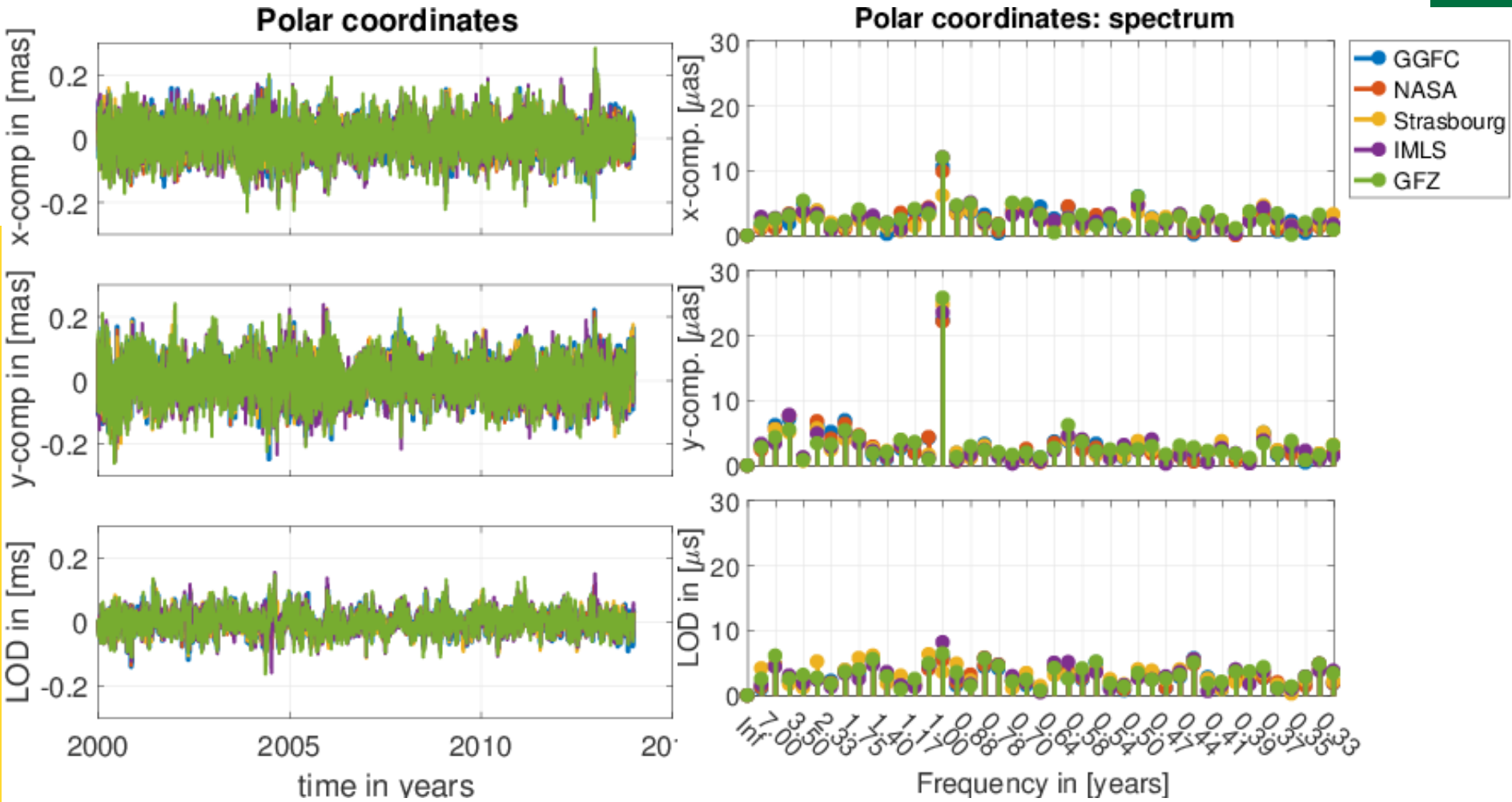
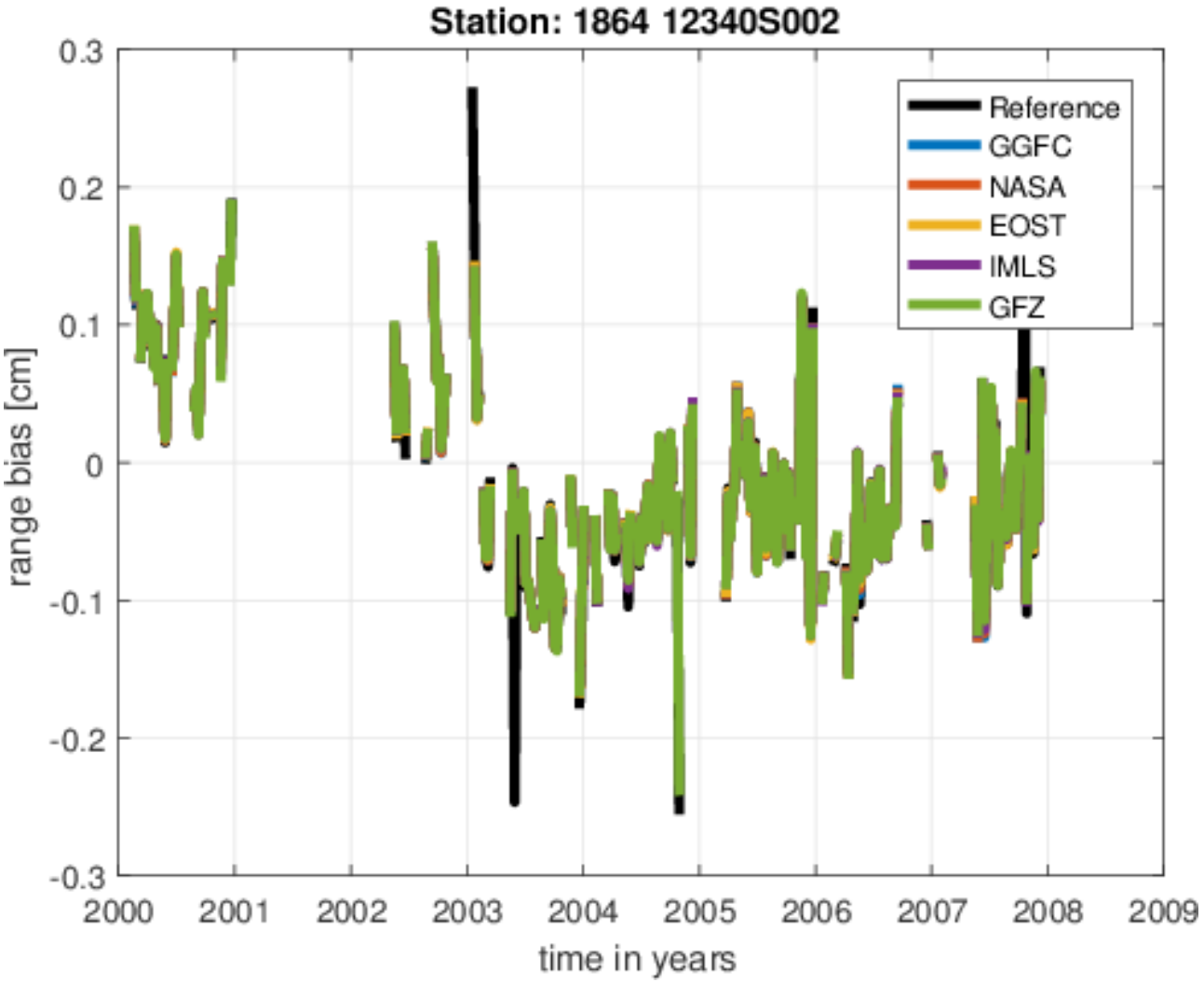
Earth orientation parameters (relative to reference solution)

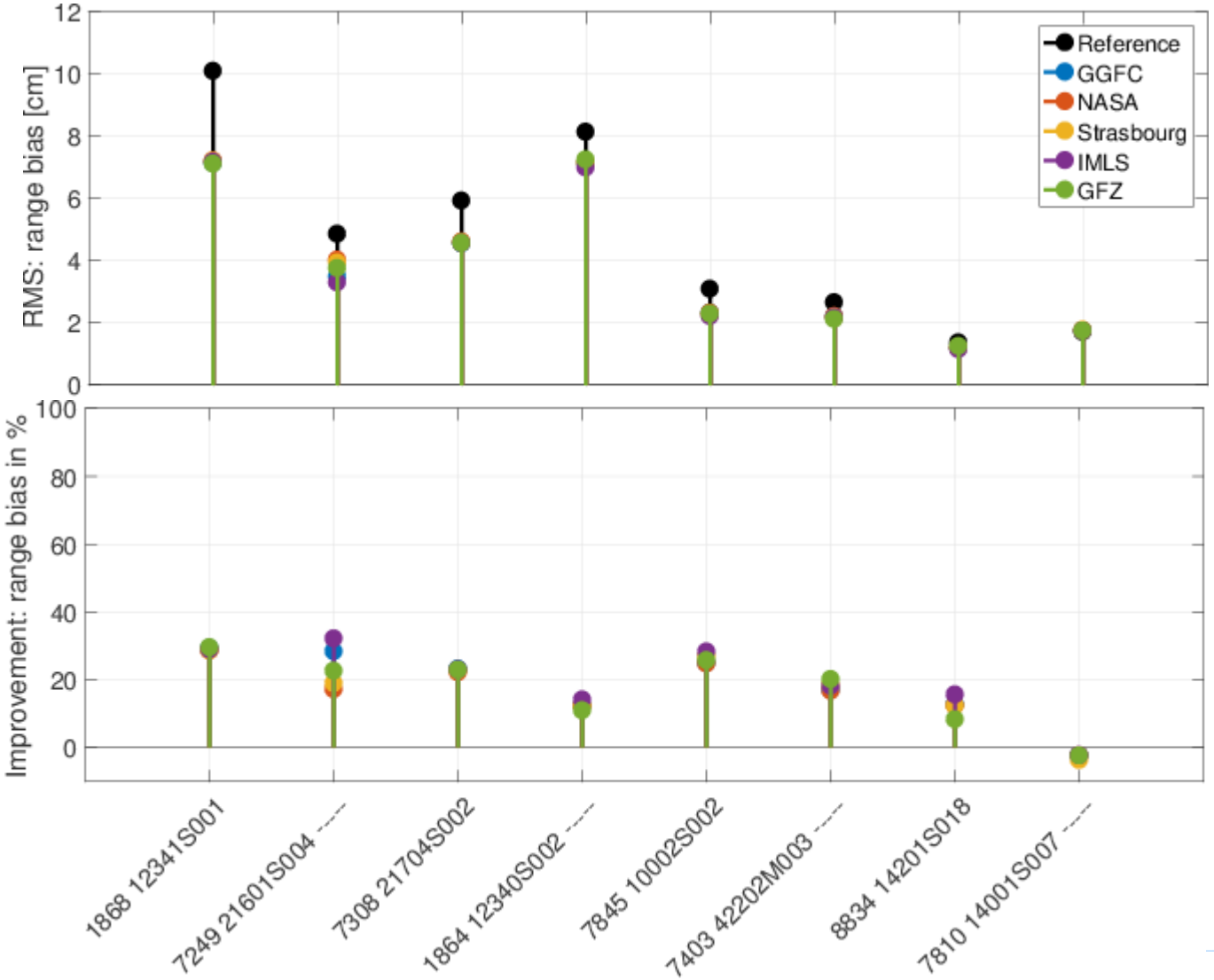


Range bias for station MAIL – Maidanak, Uzbekistan



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

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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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