ITRS realization 2020: the new situation for scale realization

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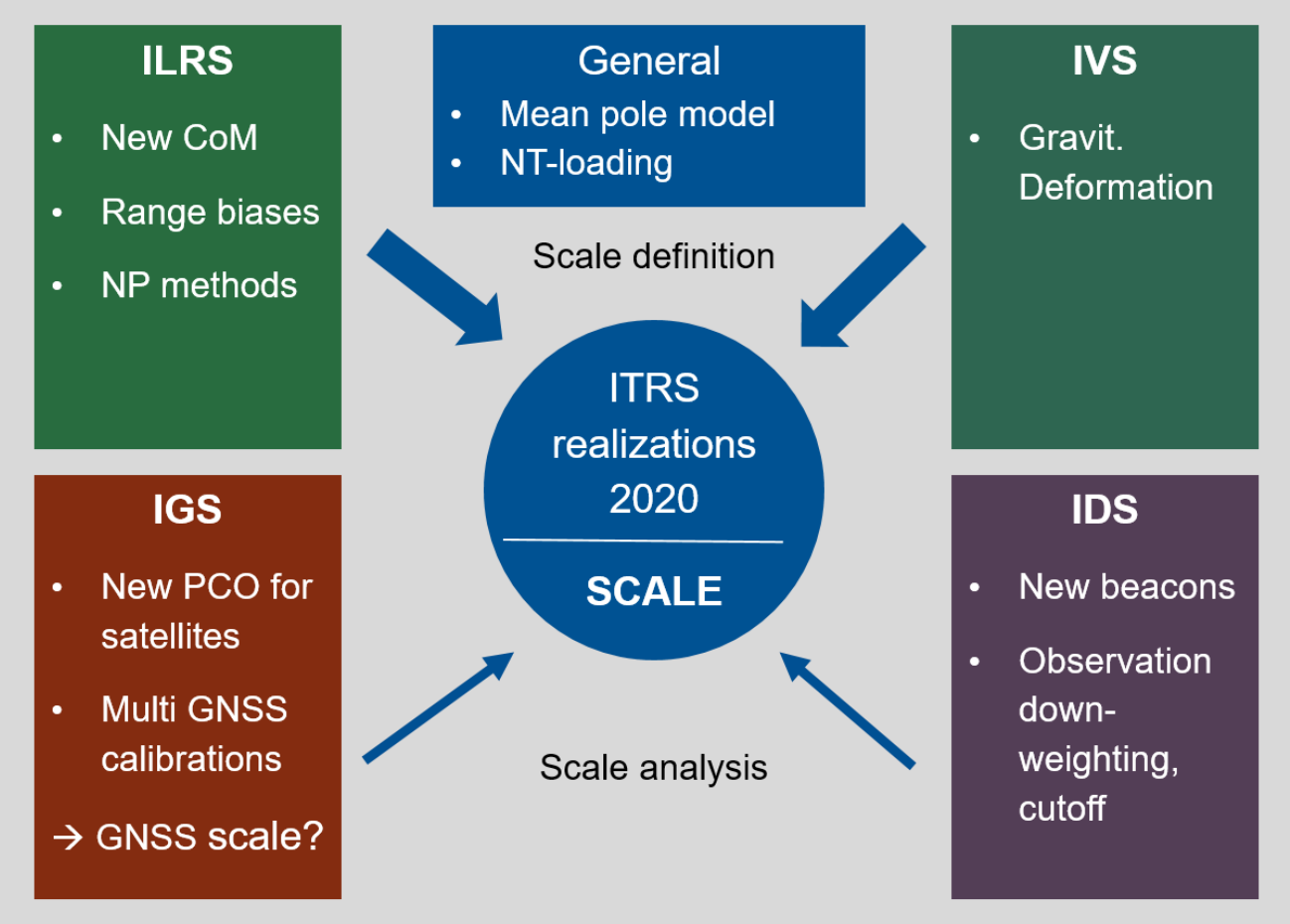
Introduction

- The **precision and accuracy of ITRS realizations** strongly depend on the **realization of the geodetic datum** (origin, scale and orientation).
- The scale and the origin are realized from the **intrinsic scale of VLBI and SLR** and the intrinsic origin of SLR normal equations / solutions, respectively.
- Changes in modelling and parameterization within the SLR and VLBI analysis directly impact the ITRS scale realization.

ITRS 2020 realization

- Reprocessing of full observation history of GNSS, DORIS, VLBI and SLR currently performed by the analysis centers of the respective IAG Services
- A lot of **changes in modelling and parameterization** are performed, **many are related to the scale** (see next slide).
- ITRS 2014 realizations: scale offset between SLR and VLBI? Still under discussion.
- A challenge for ITRS 2020 scale realization!

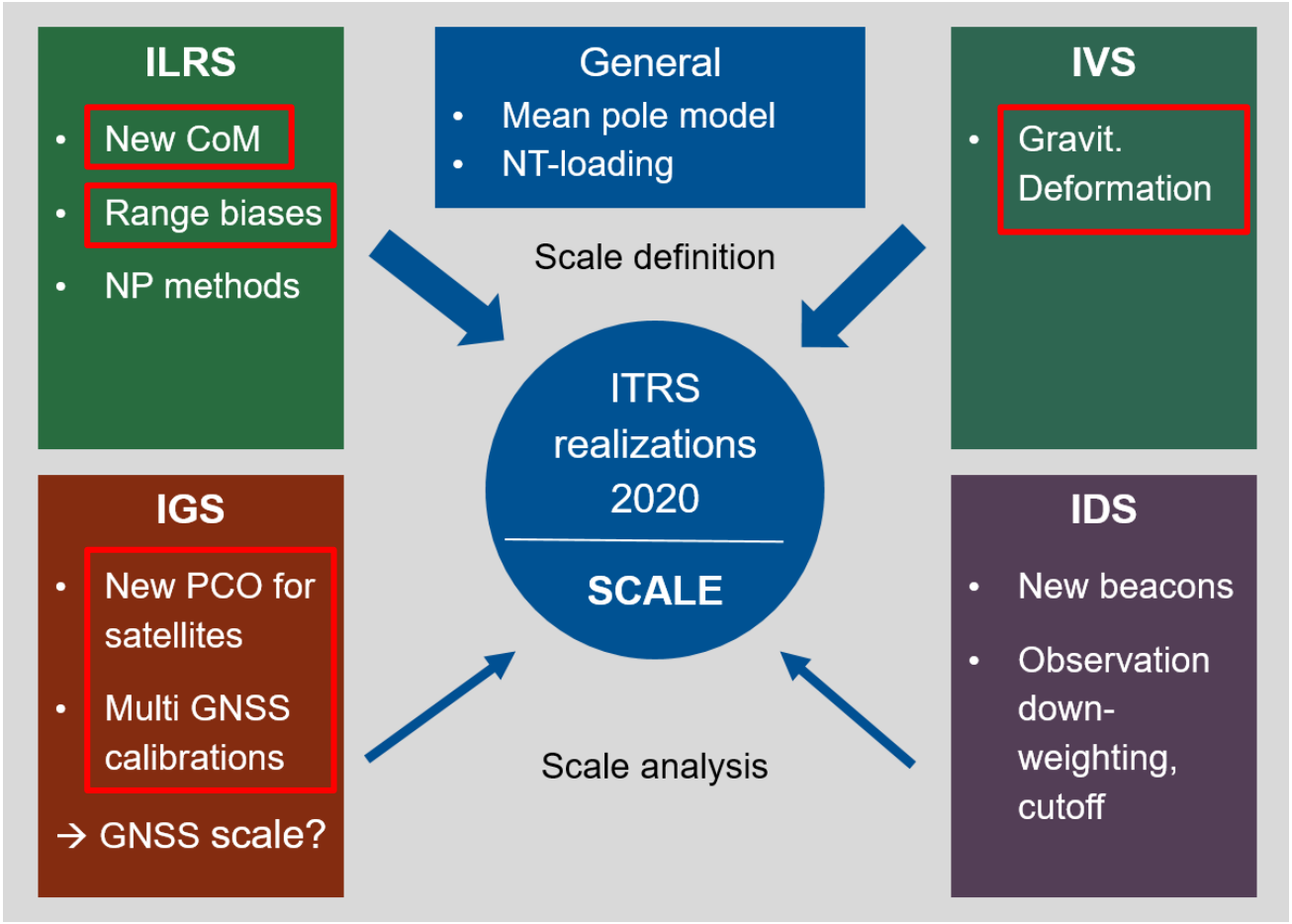
ITRS realization 2020: new models related to ITRF scale



- **Many model changes** will have an **impact on** the ITRS **scale** realization
- For many models the impact of the scale is **not well investigated yet**.
- ITRS 2020 scale realization will be a challenge (no consistency with ITRS 2014 realizations)

→ A careful step-by-step analysis of the individual contributions is necessary to understand the scale of the ITRS realizations 2020!

analyzed in this presentation



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- For many models the impact of the scale is **not well investigated yet**.
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Analysis of SLR, VLBI and GNSS series w.r.t. the scale

Input data

Technique	Time span	Solution series	Institution
VLBI	1984-2019	**dgf2018a** (~ITRS 2014 input) **dgf2020a** (~ITRS 2020 input)	DGFI-TUM
SLR	1993-2019	**v230a**: so far standard CoM corrections and set up for range biases (RB) **v230b:** new CoM model, so far standard RB set up **v231**: new CoM, RB set up for all stations and satellites *(input for the ILRS SSEM PP, intermediate SLR solution!)*	DGFI-TUM
GNSS	2000-2005 2014-2019	series according to IGS standards for ITRS 2020 input (preliminary solution)	CODE

VLBI scale analysis

Gravitational deformation (for six stations): change in station height


Effelsberg (by pixabay)

	Diameter [m]	Predicted height change [mm]	Estimated height change [mm]
EFLESBERG	100	114.3	118.70
GILCREEK	26	2.4	2.46
MEDICINA	32	8.9	8.87
NOTO	32	7.3	7.26
ONSALA60	20	-5.1	-4.92
YEBES40M	40	-49.5	-37.44

→ Estimated height changes agree well with the predicted ones *(J. Gipson, UAW 2019)*

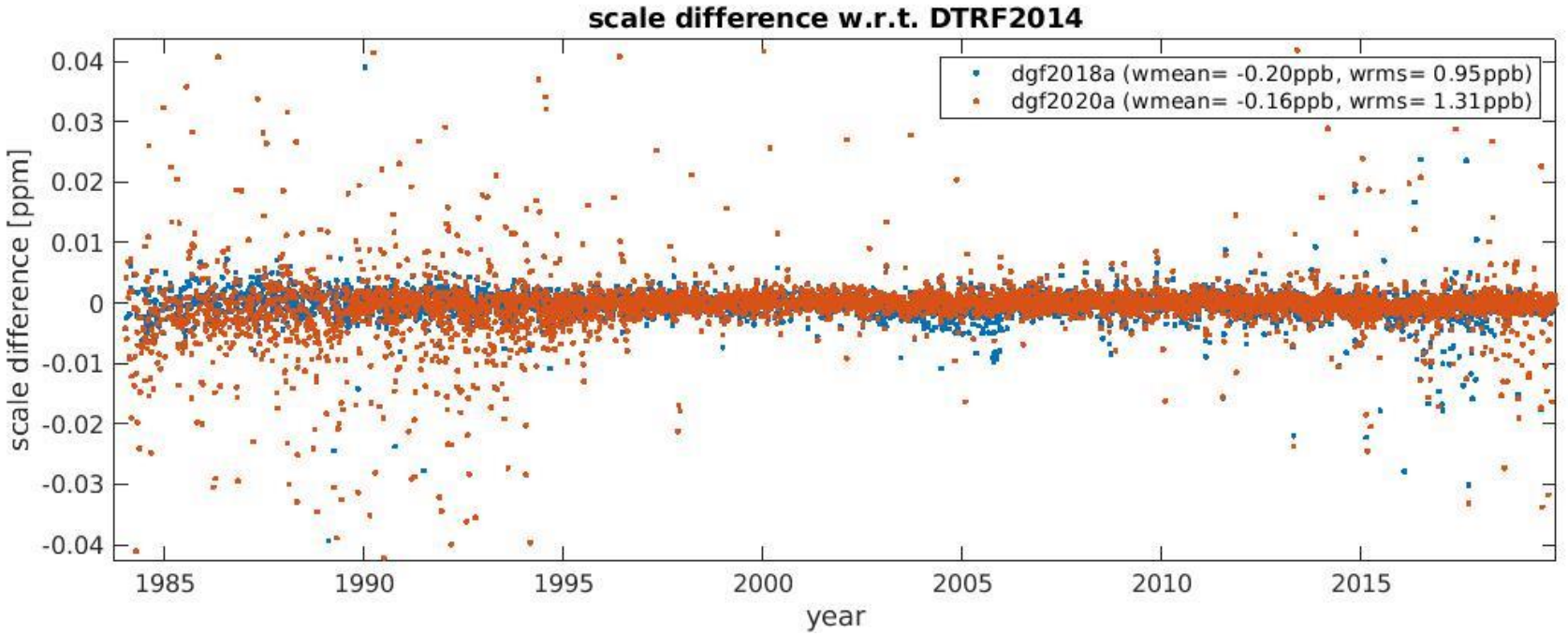
→ Stations are not included in NNR/NNT conditions nor in Helmert transformations

Further VLBI model changes

- new secular pole model
- HF EOP model
- atmospheric loading
- ICRF3
- tidal ocean loading

VLBI scale analysis

Scale difference w.r.t. DTRF2014 for dgf2018a and dgf2020a series



→ No significant scale offset of dgf2020a w.r.t. dgf2018a and DTRF2014

→ No significant scale change for VLBI expected

SLR scale analysis

Three SLR solution series are compared

(1) New CoM corrections *(J. Rodríguez, 2019)* and **new range bias set up**

- DGFI-TUMs contribution to the ILRS SSEM Pilot Project (an intermediate SLR solution used for the estimation of mean range biases which will be finally introduced)
- Range biases are set up for all stations and satellites. Range biases for E1/2 are combined

(2) New CoM corrections, present standard set up for range biases (range biases for selected stations only)

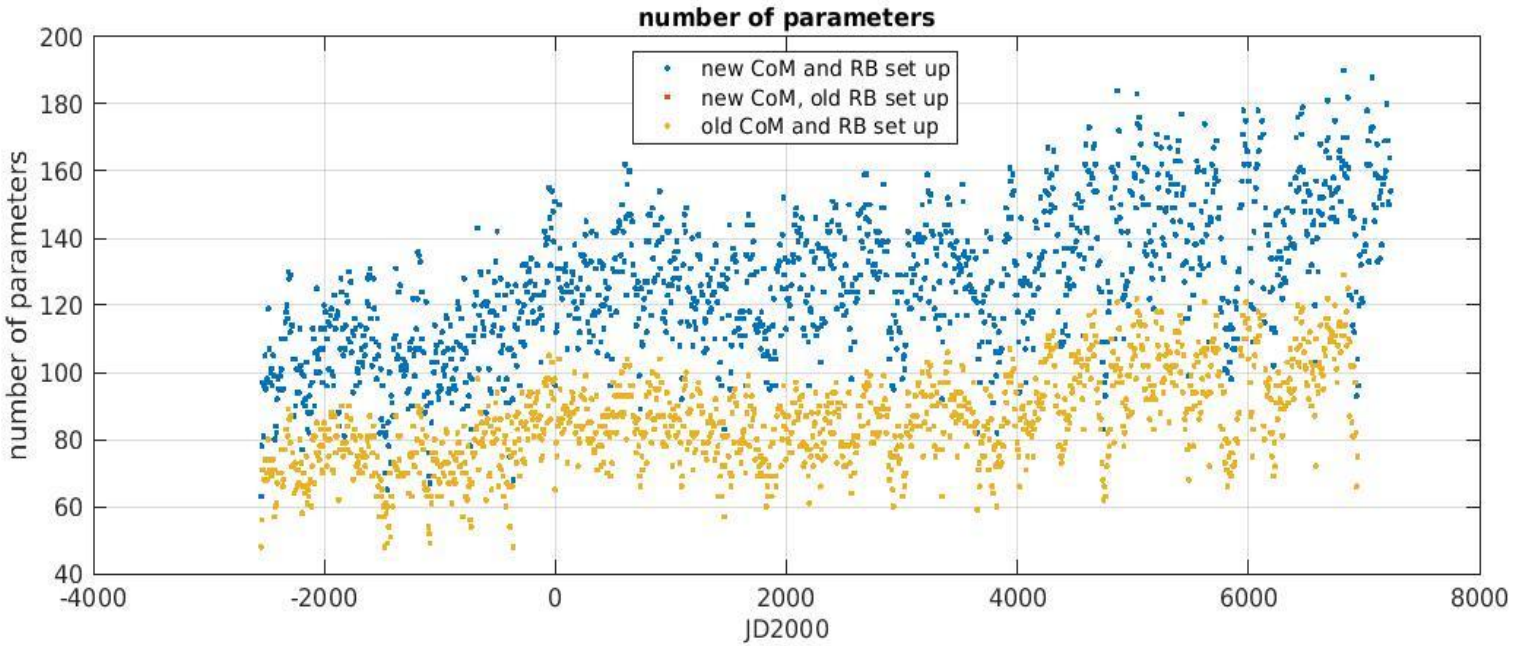
(3) Previous standard CoM corrections and range bias set up (so far standard solution)

Questions of interest:

- How stable is the solution (1) compared to the former standard SLR solution?
- Is the scale change dominated by the new CoM corrections or by the new set up of range biases?

SLR scale analysis

Number of parameters

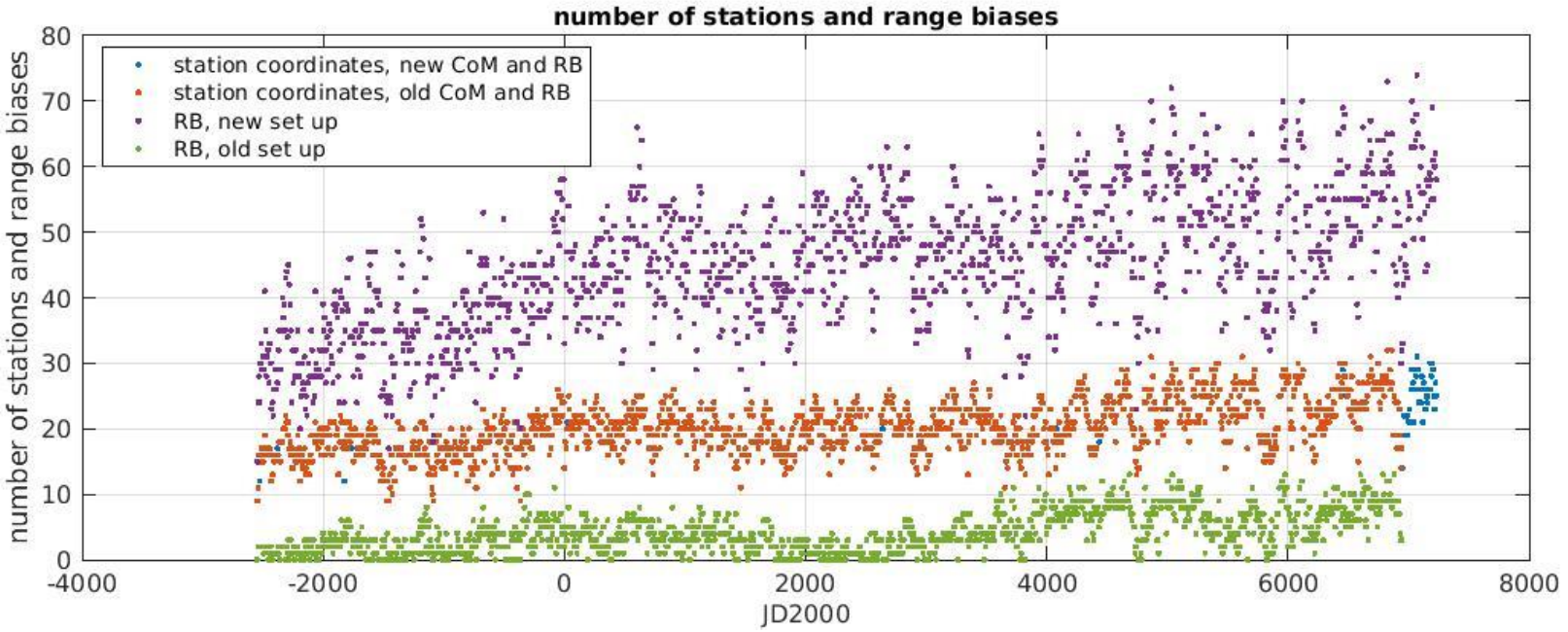


New CoM and RB set up
New CoM, previous RB set up
Previous CoM and RB set up

The number of parameters increased strongly!

SLR scale analysis

Solution characteristics: Number of stations and range biases

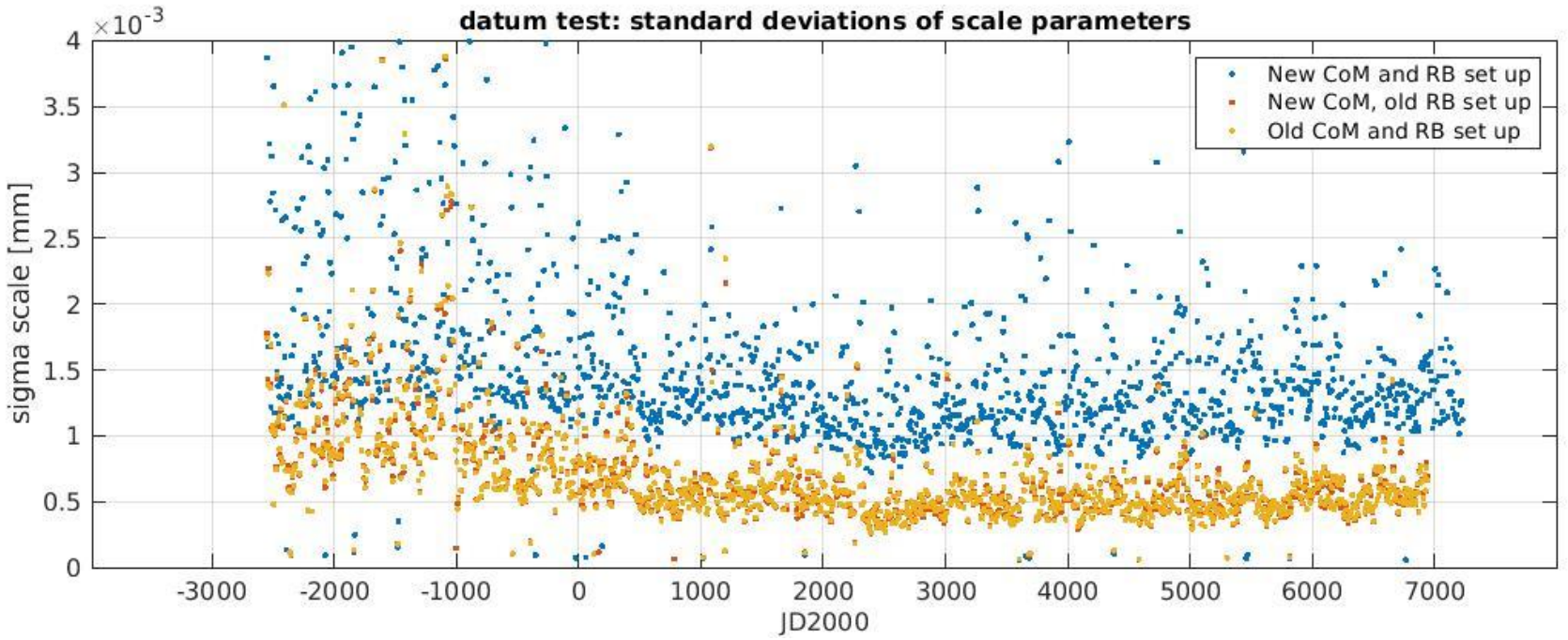


- stations: new CoM and RB set up
- stations: previous CoM and RB set up
- range biases: new CoM and RB set up
- range biases: previous CoM and RB set up

The relation between number of range biases and number of stations increased strongly!

SLR scale analysis

Solution characteristics: standard deviation of realized scale

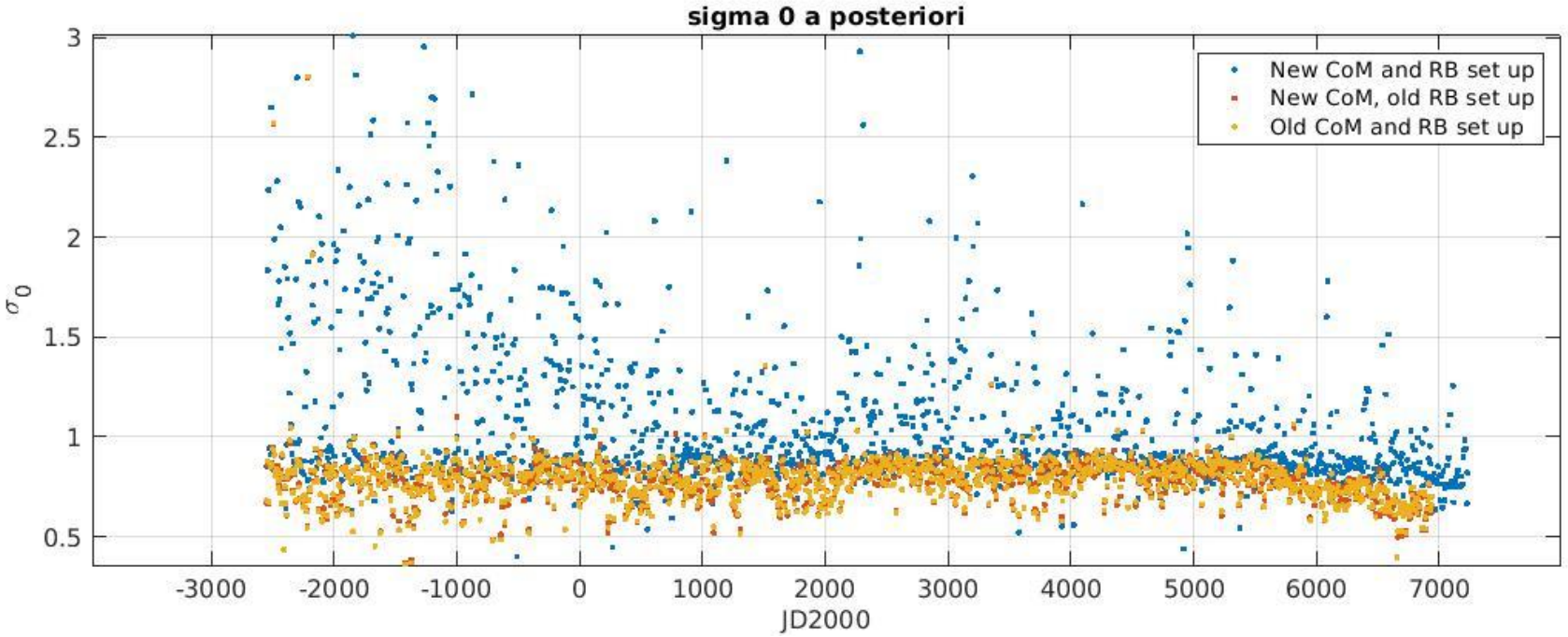


- new CoM and RB set up
- new CoM and previous RB set up
- previous CoM and RB set up

The standard deviation of the realized scale increased strongly (factor 2). The scatter of standard deviations increased as well.

SLR scale analysis

Solution characteristics: A posteriori sigma0

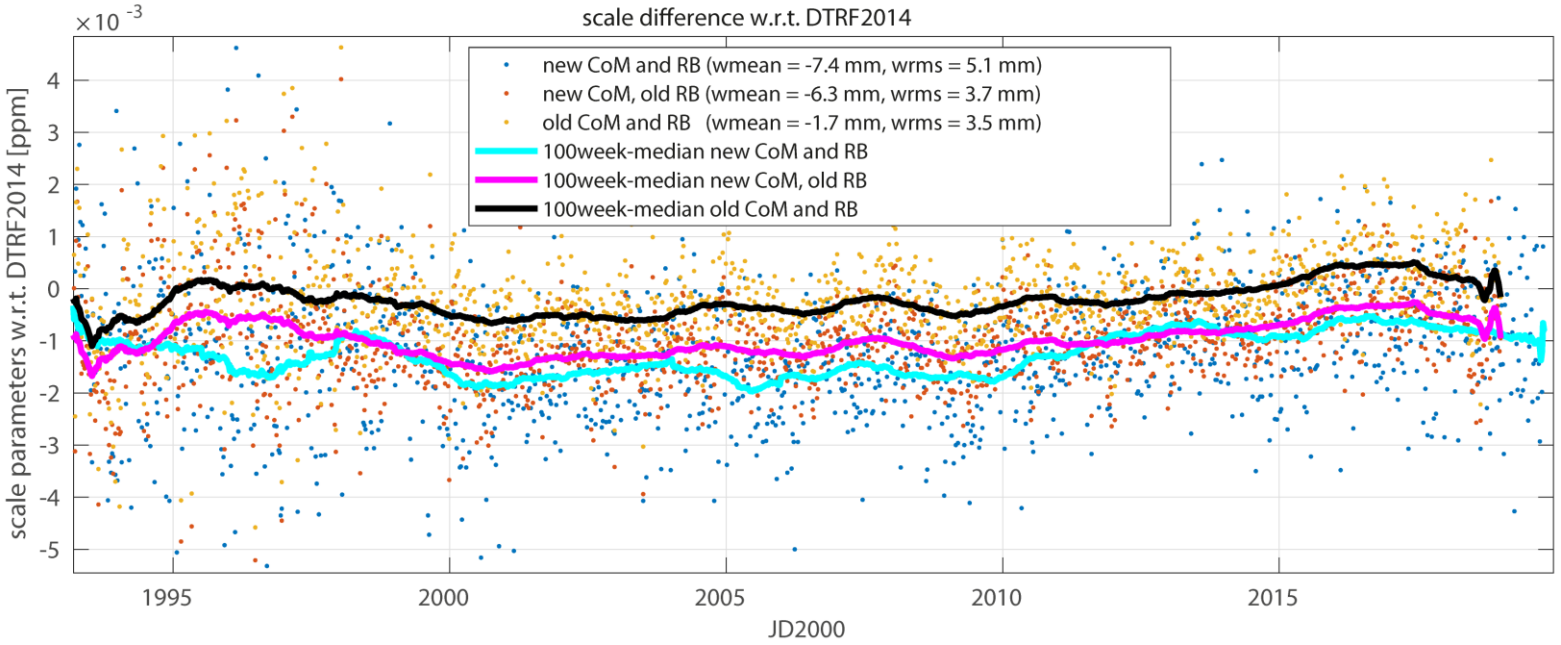


- new CoM and RB set up
- new CoM and previous RB set up
- previous CoM and RB set up

The a posteriori sigma of weekly solutions increased and shows a larger scatter.

SLR scale analysis

Scale difference w.r.t. DTRF2014

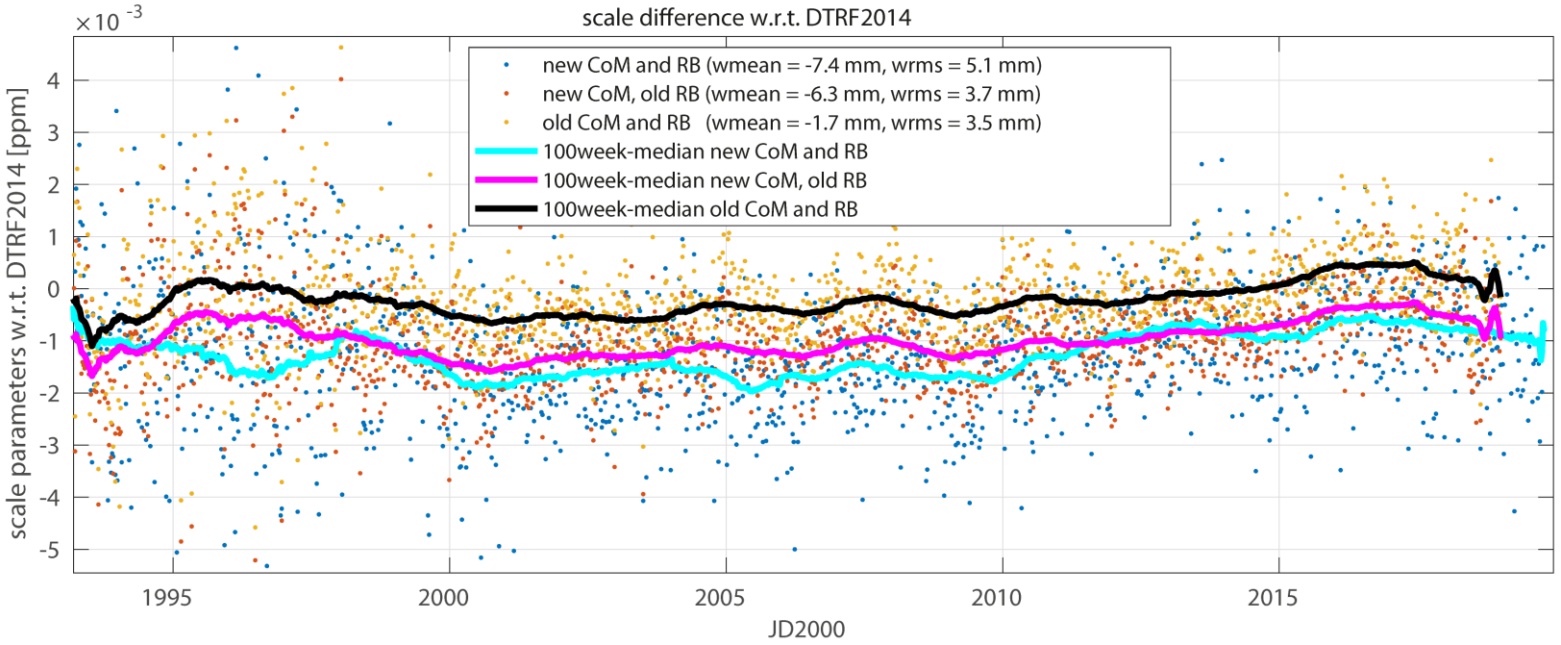


- new CoM and RB set up
- new CoM and previous RB set up
- previous CoM and RB set up
- 100w-median: new CoM and RB set up
- 100w-median: new CoM and previous RB set up
- 100w-median: previous CoM and RB set up

	wmean [mm]	wrms [mm]
New CoM and RB	-7.4	5.1
New CoM, prev RB	-6.3	3.7
Prev. CoM and RB	-1.7	3.5

SLR scale analysis

Scale difference w.r.t. DTRF2014



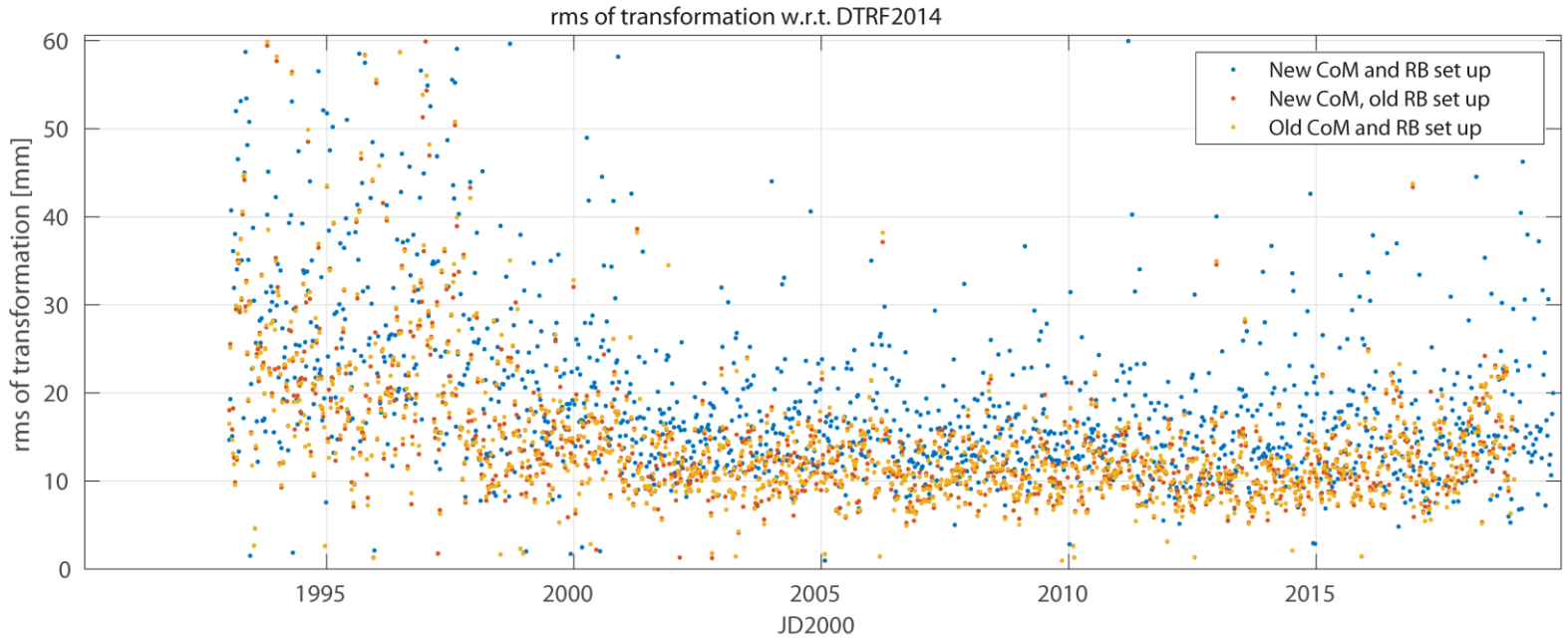
	wmean [mm]	wrms [mm]
New CoM and RB	-7.4	5.1
New CoM, prev RB	-6.3	3.7
Prev. CoM and RB	-1.7	3.5

Scale change: change of **CoM** corrections has the strongest impact.

RMS of transformation: **new range bias** set up has the strongest impact.

SLR scale analysis

RMS of Helmert transformation w.r.t. DTRF2014

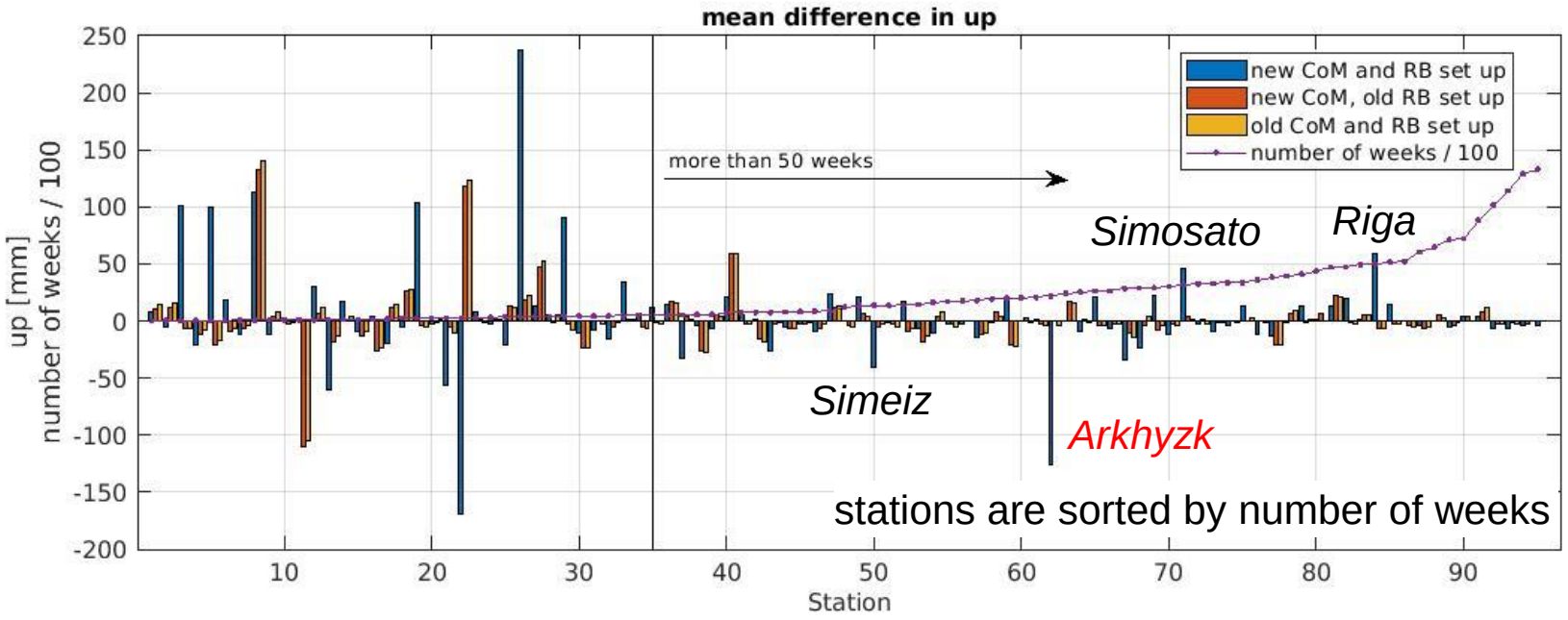


New CoM and RB set up
New CoM, previous RB set up
Previous CoM and RB set up

RMS of Helmert transformation w.r.t. DTRF2014 increased.

SLR scale analysis

Change of station heights apart from global scale change

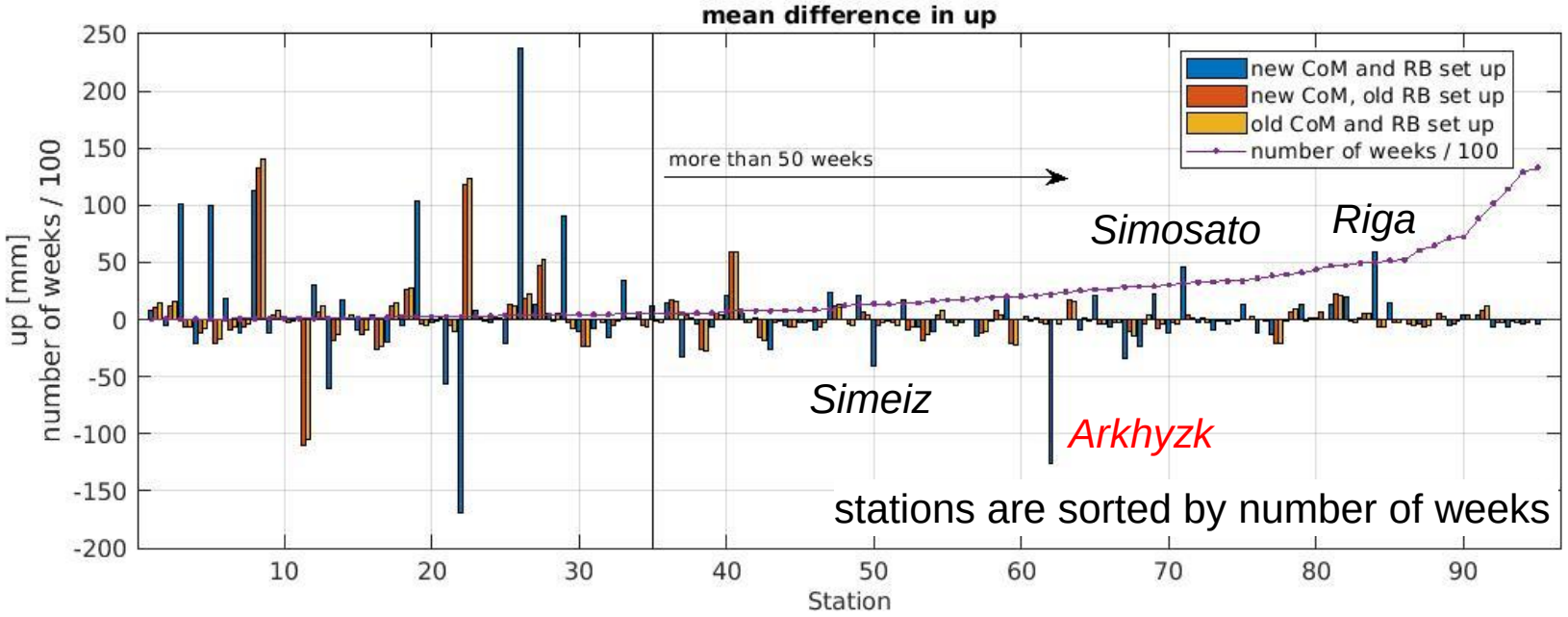


Partly large changes of individual station positions due to global range bias estimation (all components are affected, but station height most).

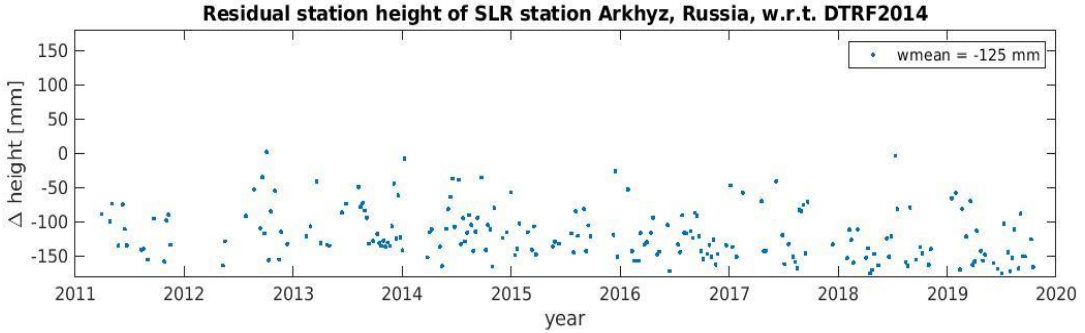
New CoM corrections do not have a large impact on individual station heights (apart from a global scale change).

SLR scale analysis

Change of station heights apart from global scale change



Arkhyzk: station height residuals w.r.t. DTRF2014 wmean = 125 mm



SLR scale analysis - Summary

SLR scale

- **scale offset** in particular affected by CoM corrections

offset w.r.t. DTRF2014:	CoM:	- 4.6 mm
	global RB estimation:	- 1.1 mm
	sum	- 5.7 mm

- **scale standard deviation** affected by global RB estimation but not by CoM corrections

Individual change of station height

Estimation of range biases for all stations and satellites leads to significant individual changes of stations heights for a lot of stations.

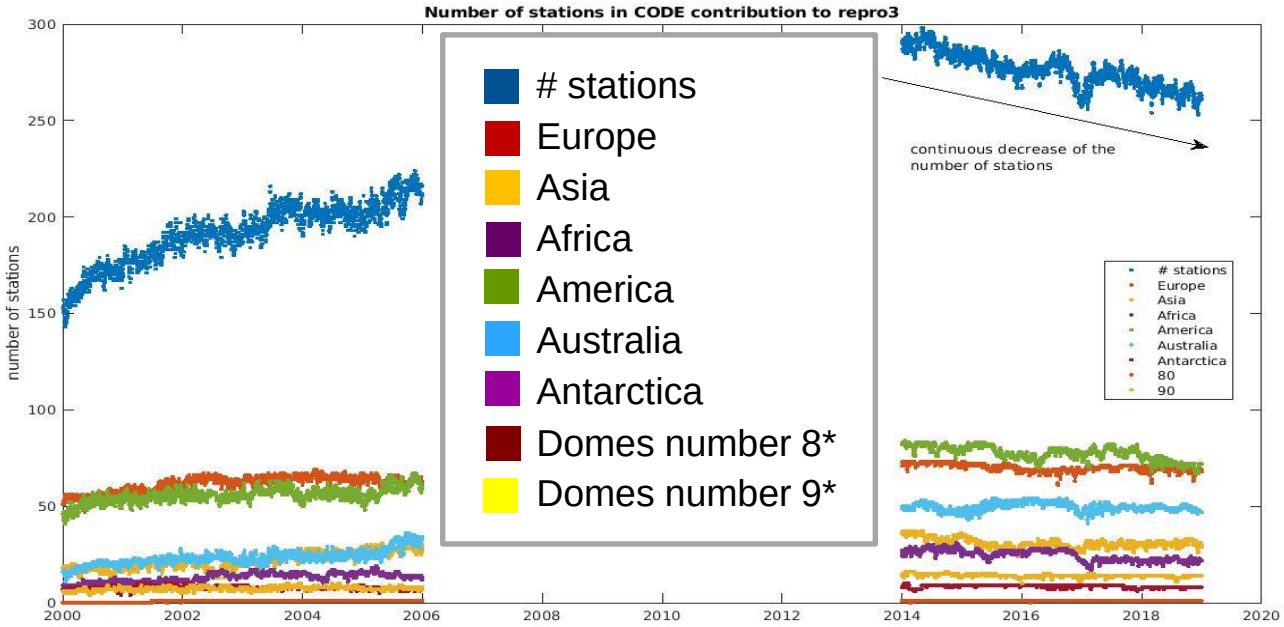
GNSS scale analysis

New antenna phase center corrections for stations and satellites

- Multi-GNSS calibration of station antennas
- New satellite antenna z-offsets for all satellites (GPS, GLONASS, Galileo) consistent to Galileo-intrinsic scale (→ assumption: GNSS can provide an independent scale for ITRS scale realization)

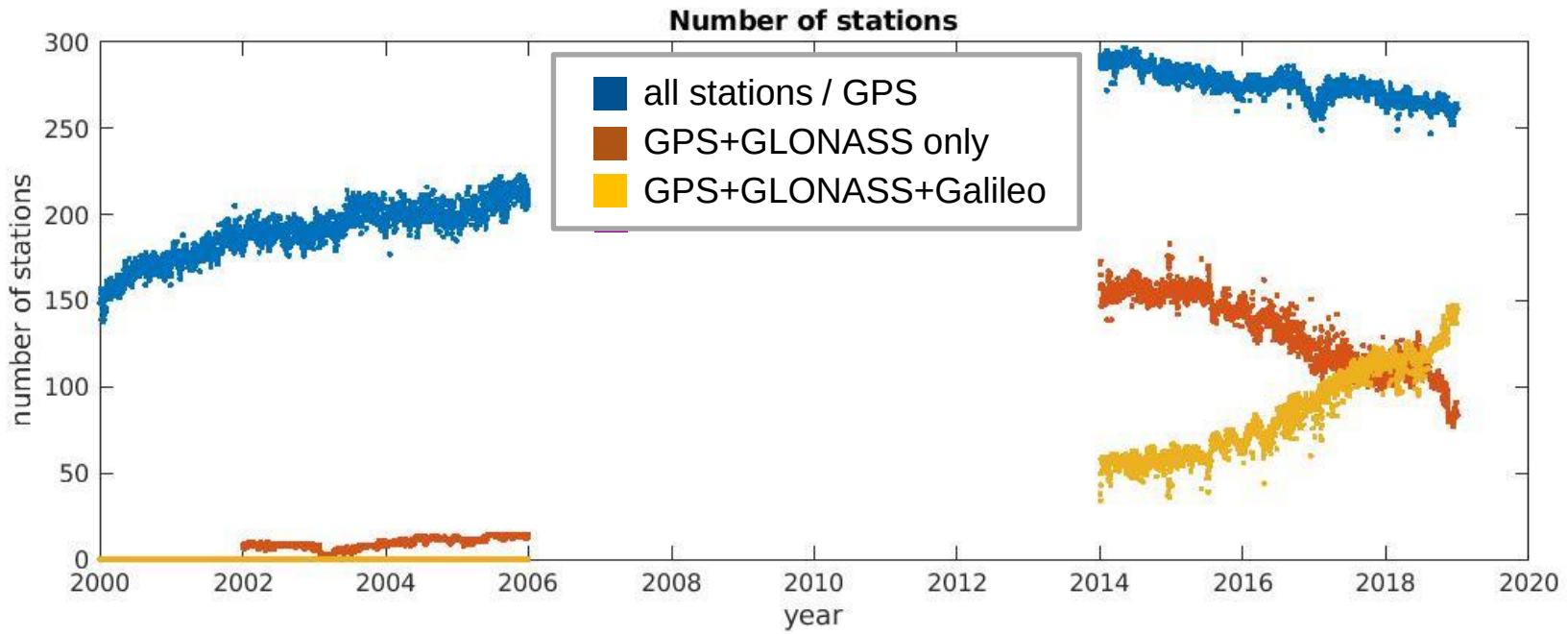
Number of stations

→ see also next slide



GNSS scale analysis

Number of stations observing the different GNSS constellations

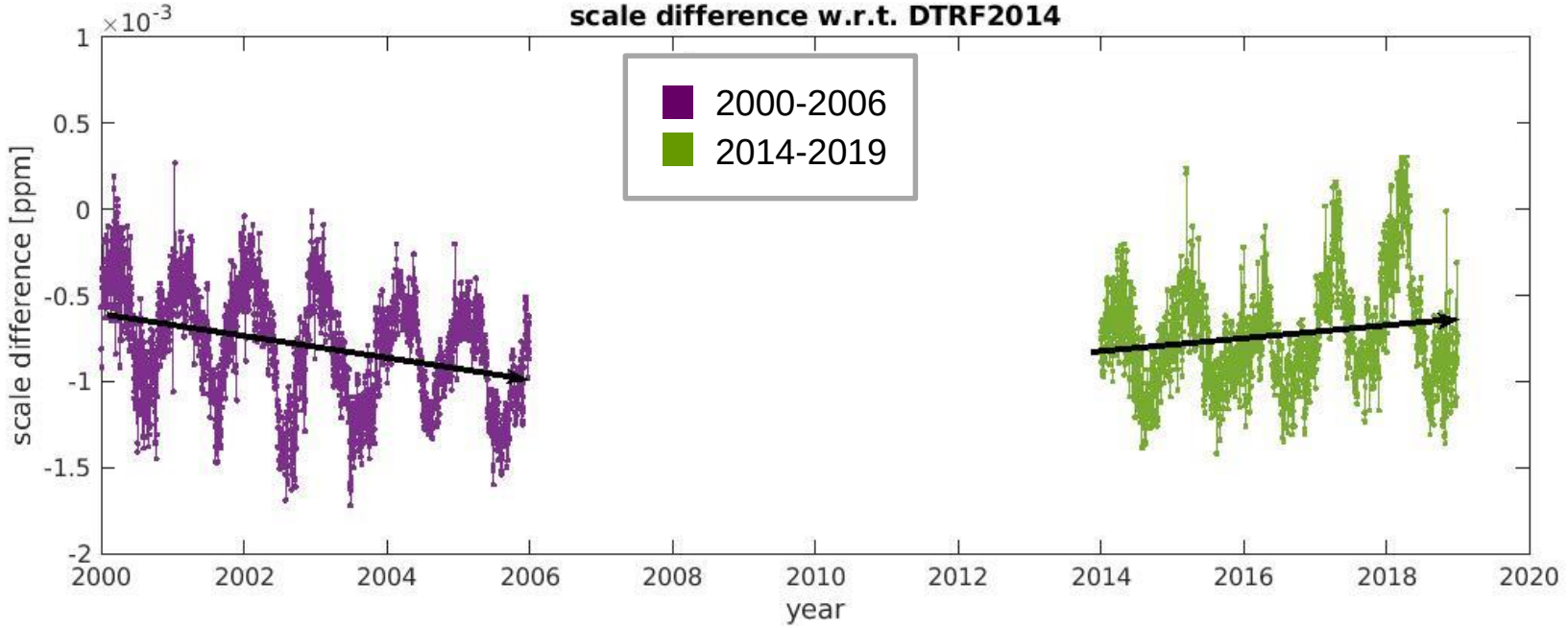


2000-2006: increasing number of stations

2014-2019: decreasing number of stations, increasing number of stations observing beside GPS also GLONASS and Galileo

GNSS scale analysis

Scale difference w.r.t. DTRF2014

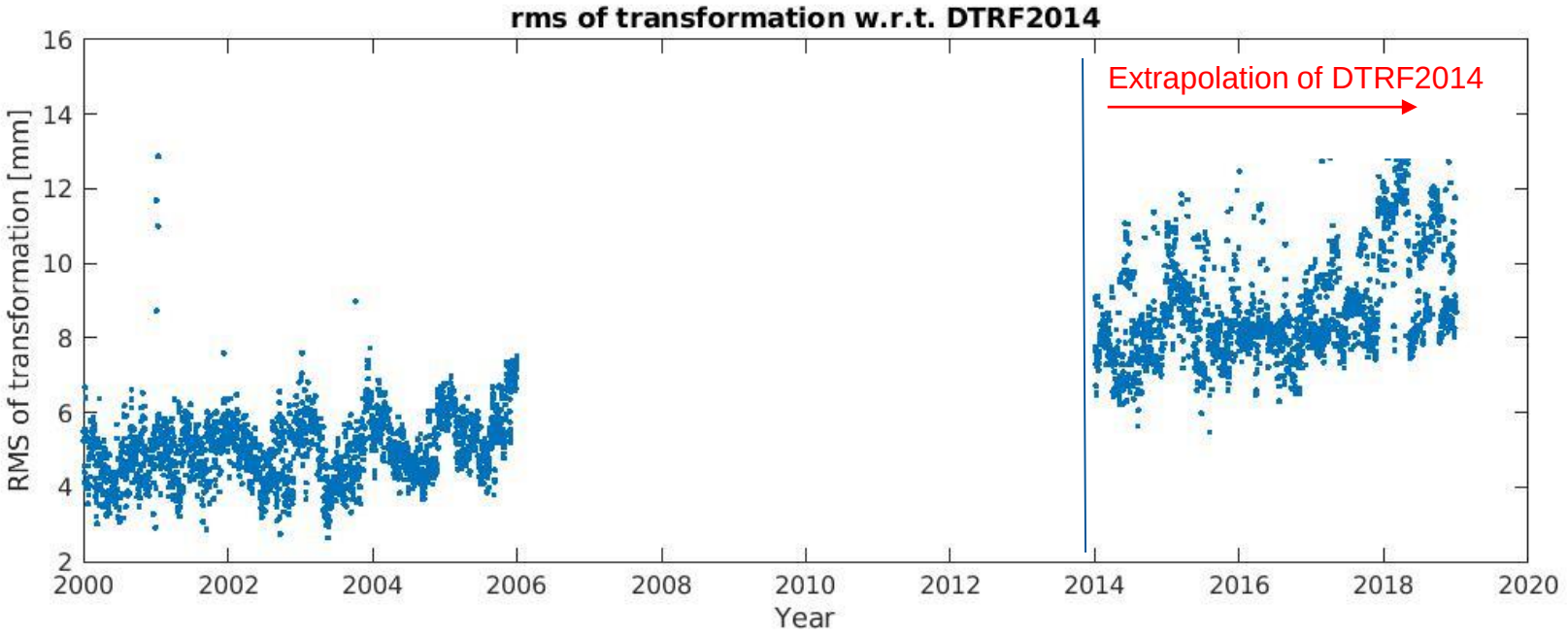


	All data	2000-2006	2014-2019
offset	- 5.0 mm	- 5.1 mm	- 4.8 mm
drift	0.0 mm/yr	- 0.45 mm/yr	+ 0.26 mm/yr

Scale offset: about - 5.0 mm
Scale drift: different trends for 2000-2006 and 2014-2019; 2006-2014 needed for a more detailed study.

GNSS scale analysis

RMS of Helmert transformation w.r.t. DTRF2014



- Significantly larger and continuously increasing RMS for the time span 2014-2019
- Two reasons might be responsible:
  - increasing extrapolation error of DTRF2014 and/or
  - changing GNSS network geometry due to an increasing number of multi-GNSS stations (see two slides before)

Summary

- Changes in modelling and parameterization lead to changes in the realized scales of the individual techniques
- **SLR**: a significant change in scale of about **– 5.7 mm** is expected due to changes in CoM corrections (- 4.6 mm) and new RB (-1.1 mm)
- **GNSS**: mean scale difference w.r.t. DTRF2014 of about **- 5.0 mm** due to the switch to Galileo scale
- **VLBI**: **no significant scale change** due to model changes
  - Now, for six stations gravitational deformation is applied.
  - However, these corrected stations are not used for NNR, NNT nor for Helmert transformations!
  - When applying gravitational deformation for all stations (future ITRS 20** realizations), it must be assumed that small scale changes can occur.
- **DTRF2020:** mean scale discrepancies of about ±5 mm are expected between SLR and VLBI as well as between GNSS and VLBI.

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