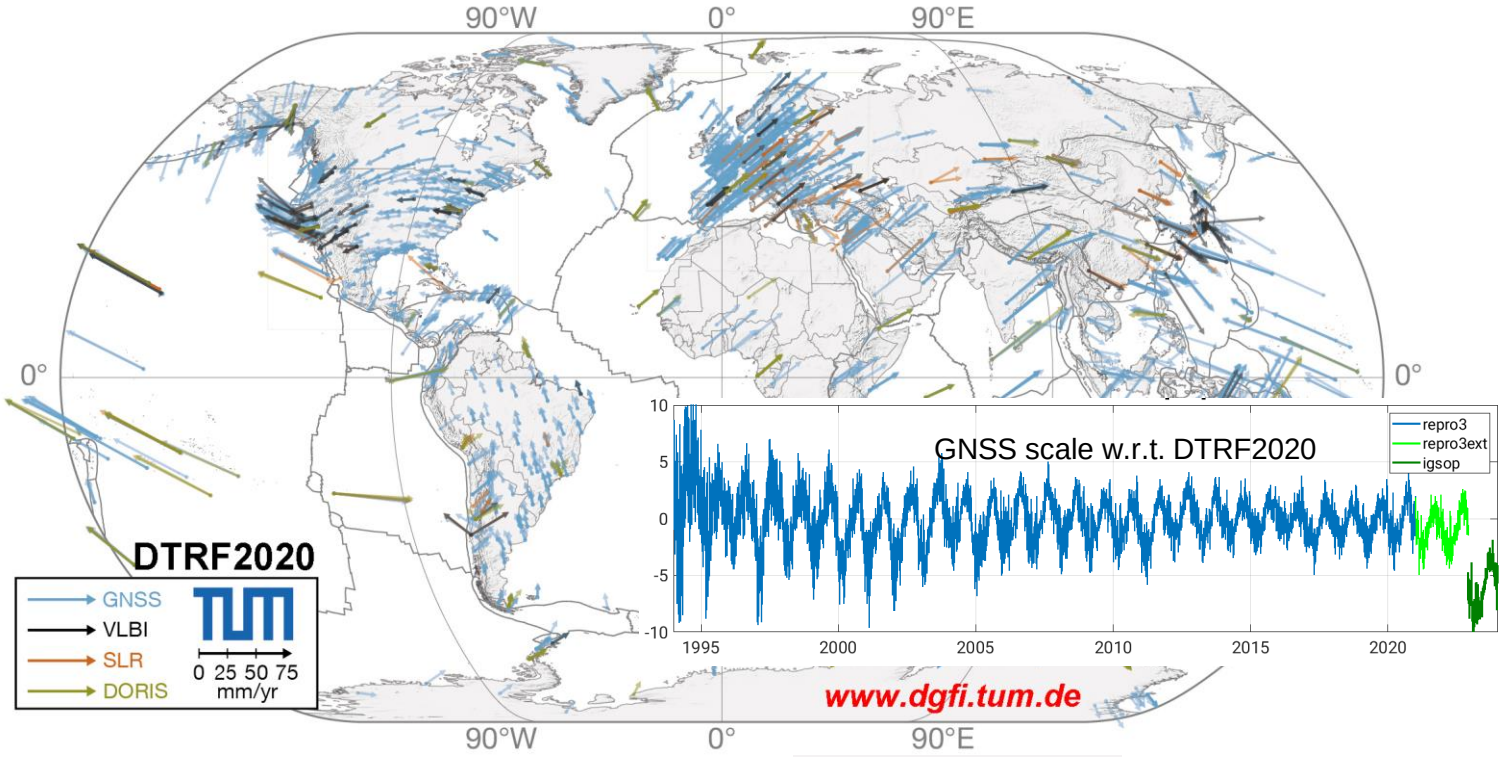
Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
Technische Universität München

DTRF2020 extension: GNSS scale and continuity issues

Manuela Seitz, Mathis Bloßfeld, Matthias Glomsda, Detlef Angermann, Laura Sánchez

Deutsches Geodätisches Forschungsinstitut,
Technische Universität München (DGFI-TUM)



Session 2: Building Global GNSS-Based Reference Frames

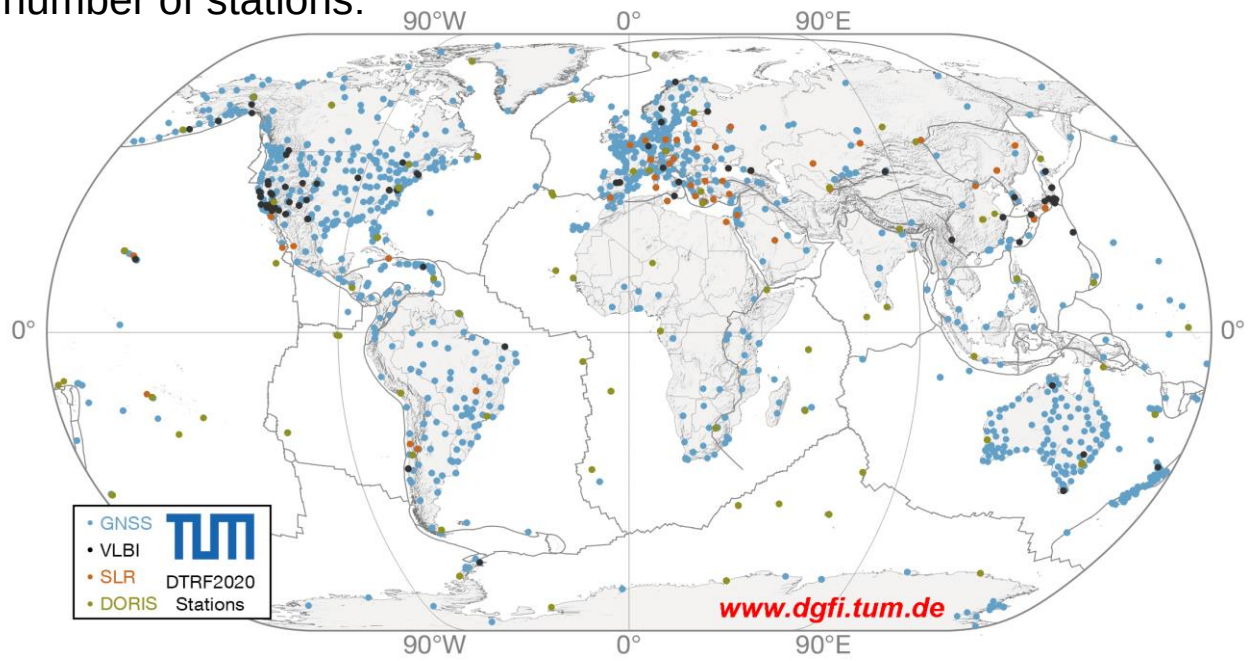
DTRF2020: ITRS realization of ITRS CC DGFI-TUM

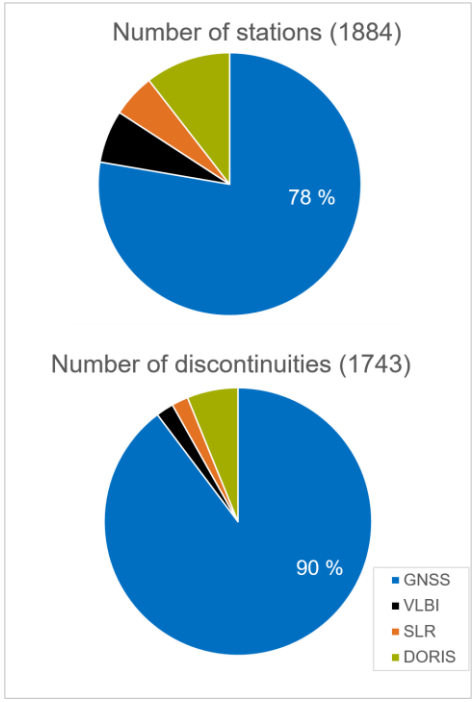
IGS contribution to DTRF2020

- repro3 series
- realizes an independent GNSS scale through disclosed Galileo and GPS III z-PCO values
- for other GNSS satellites PCOs are estimated consistently

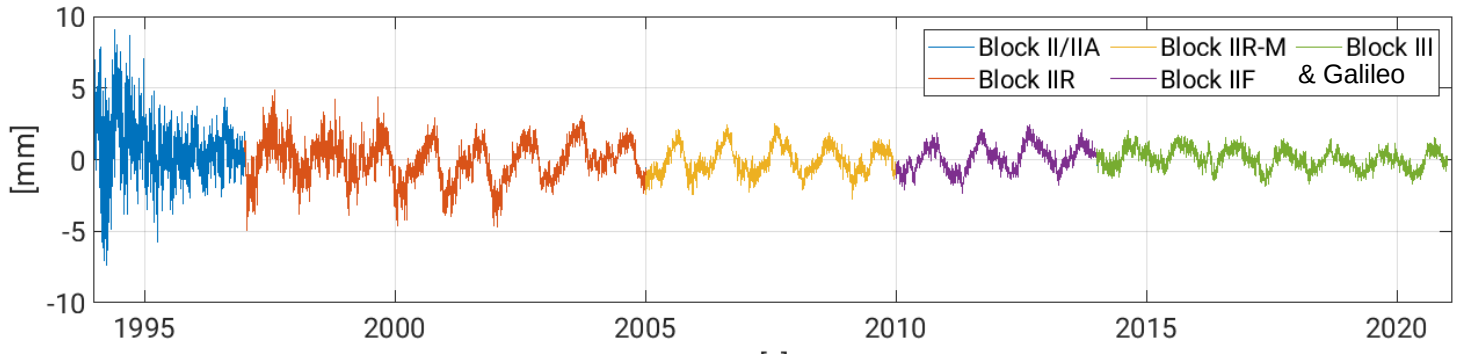
GNSS in DTRF2020

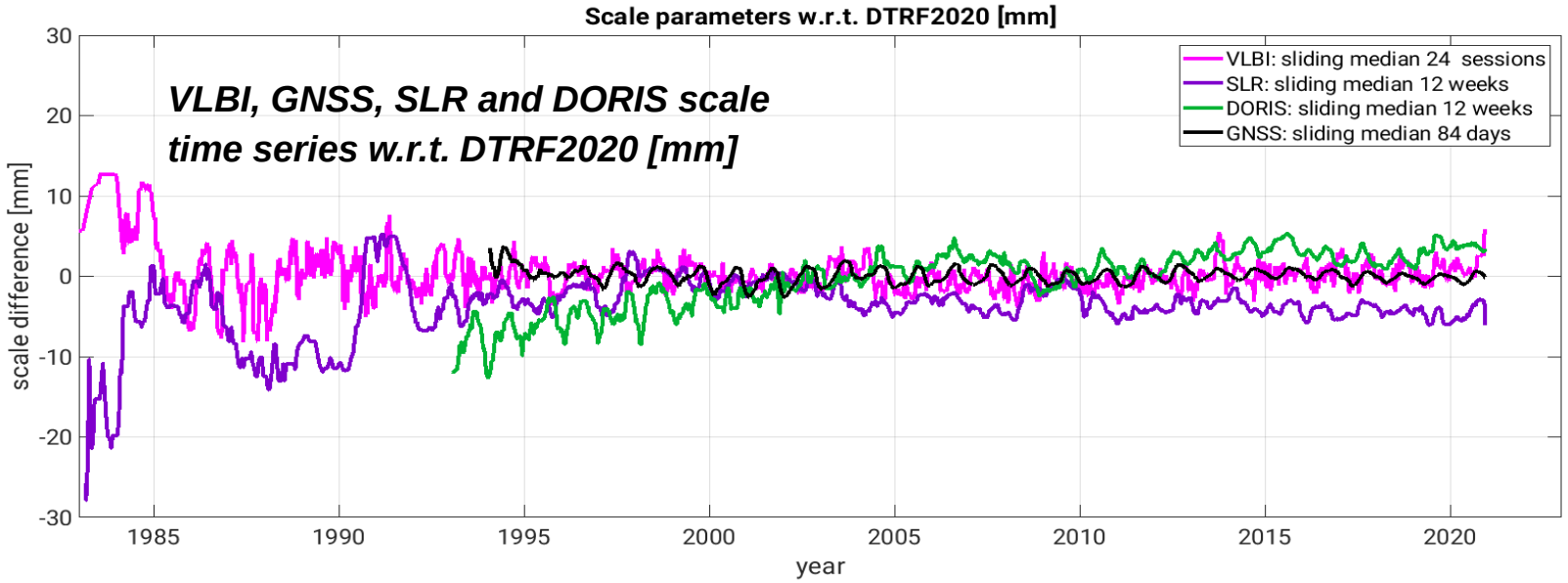
- DTRF2020 scale is realized from VLBI and GNSS scale
- GNSS provides by far the largest number of stations:





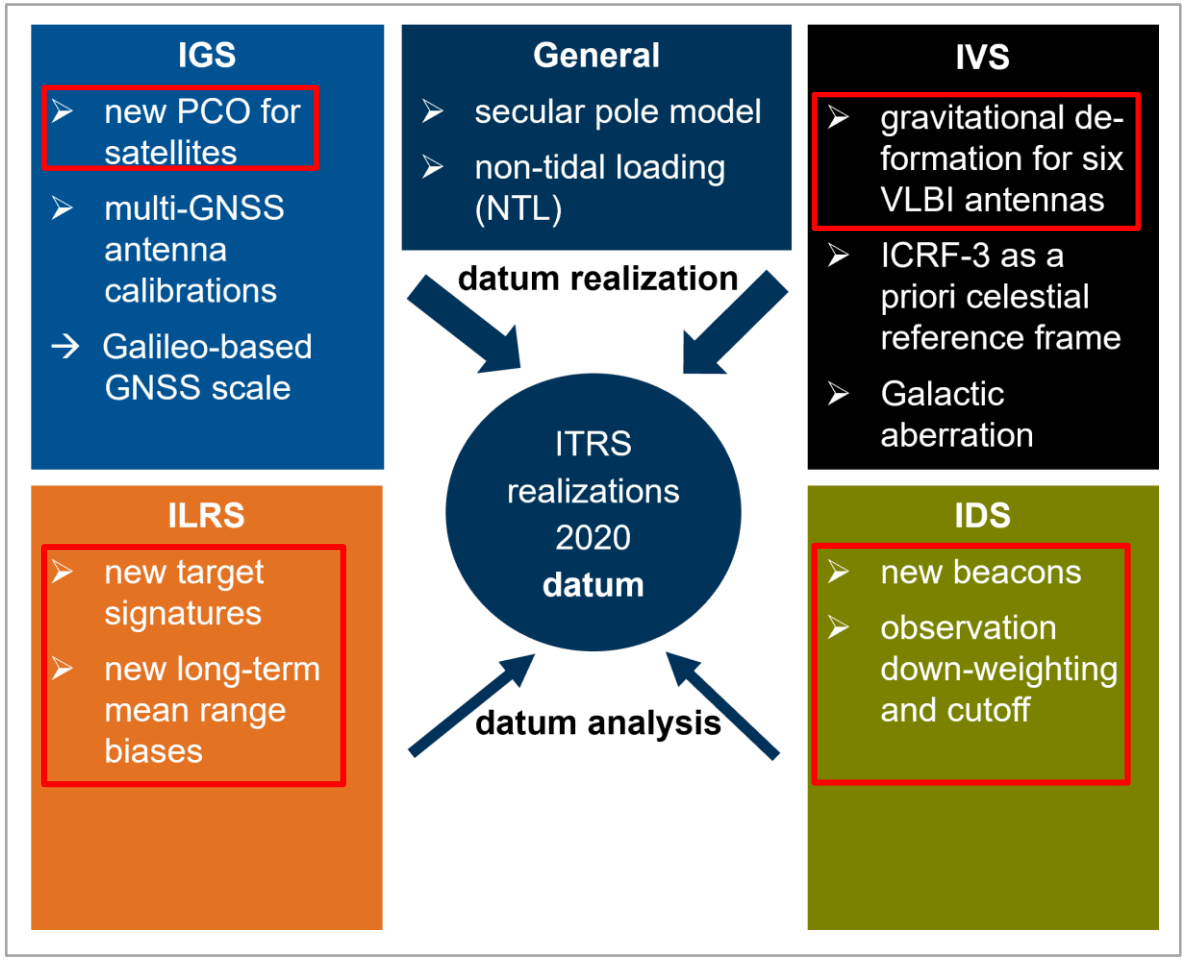
GNSS intrinsic scale time series (repro3)

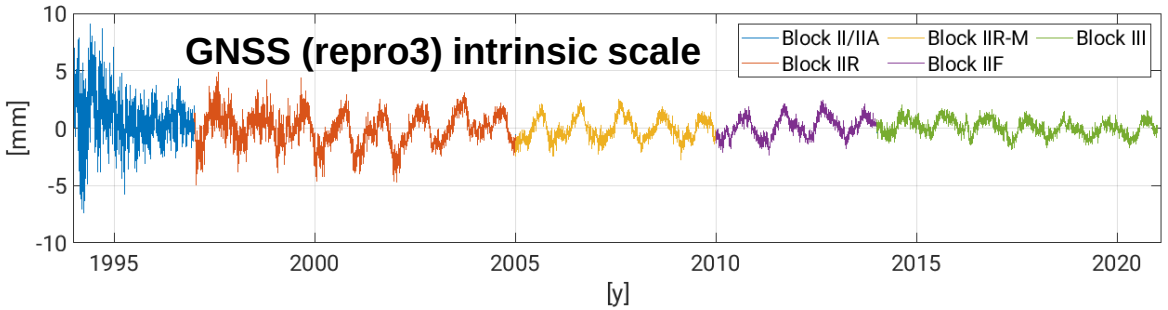


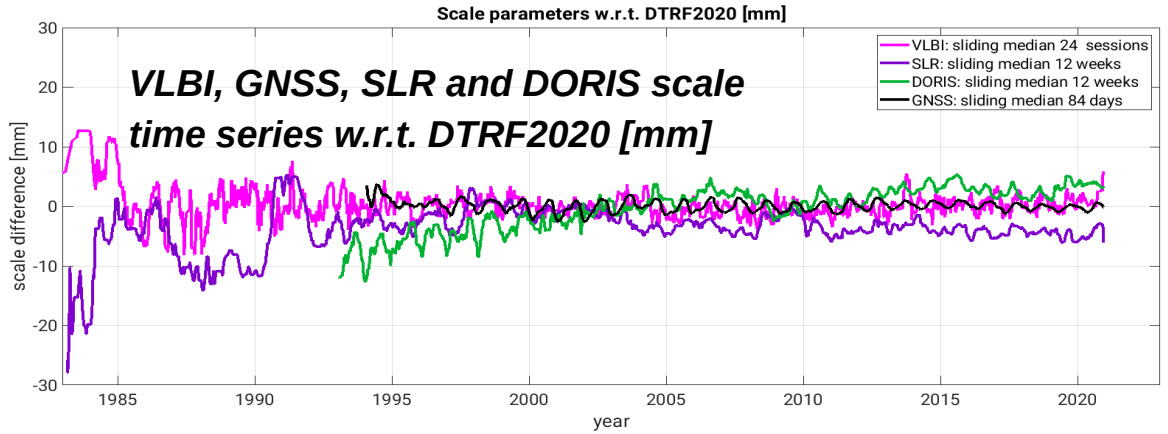


- Very stable scale time series → improving over time
- Reduction of NTL leads to a decrease of the annual amplitude in the GNSS scale time series from 2.6 mm to 1.0 mm
- The draconitic signal and its harmonics remain in GNSS scale time series
- Amplitude of the draconitic signal becomes smaller for new generations of satellites

What impacts the scale realization?







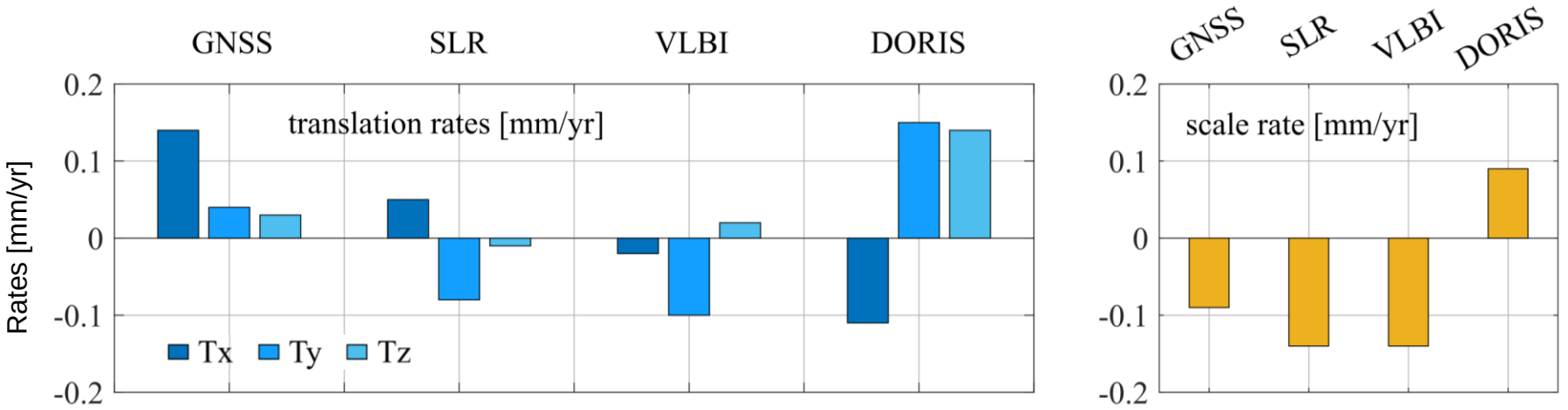
→ All technique scales are impacted by modelling

xTRF2020 – long-term stability

High long-term stability of ITRS realization means

realizing the linear development of datum parameters with very high accuracy, precision and consistency over many years (if possible over the full observation history of the contributing techniques of more than 40 years)

Translation and scale rates between DTRF2020 and ITRF2020



Scale realization:

DTRF2020	VLBI+GNSS
ITRF2020	VLBI+SLR

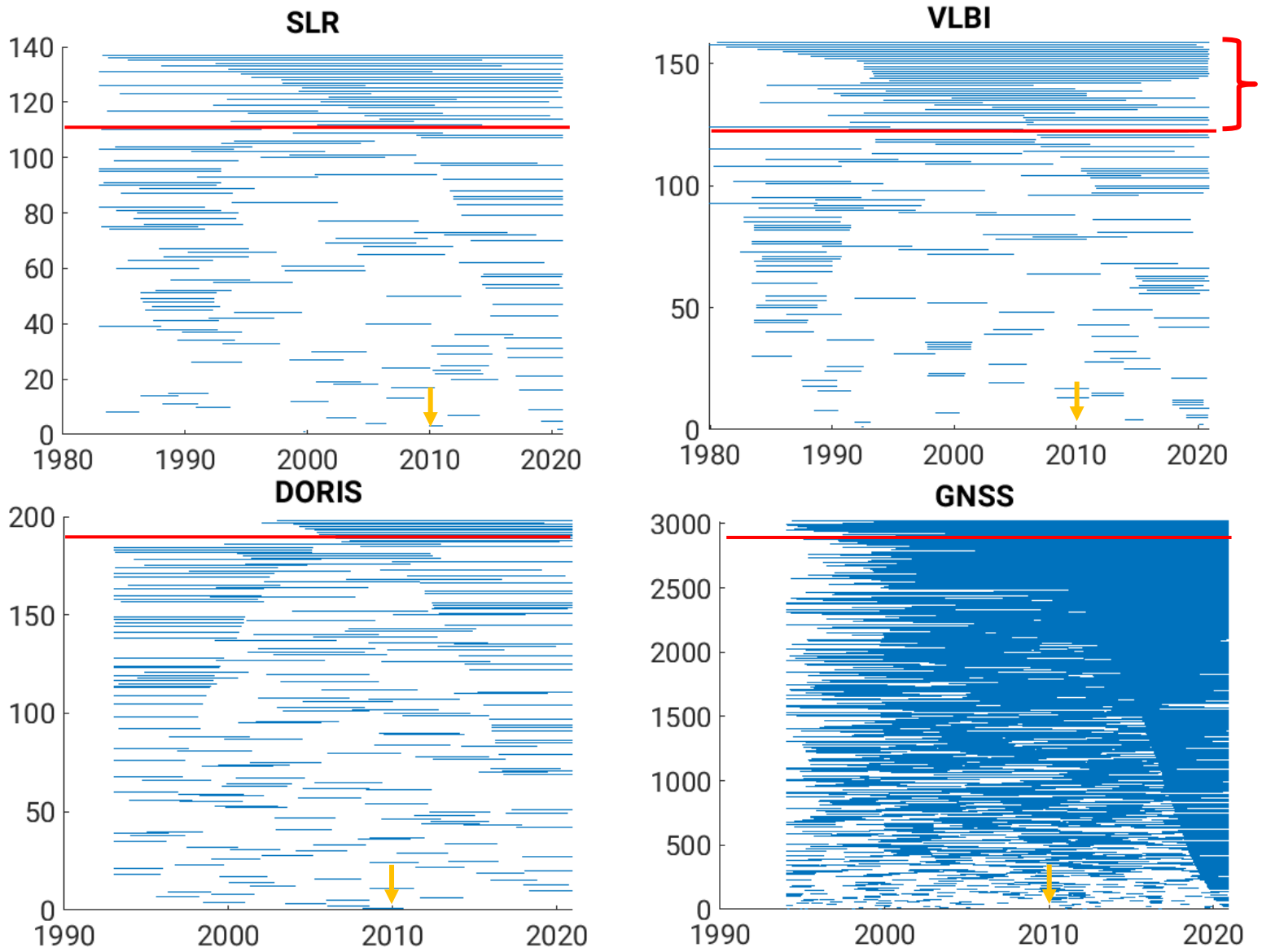
→ rates between 0.02 mm/yr and 0.16 mm/yr

GGOS requirements for datum realization

- 0.1 mm/yr

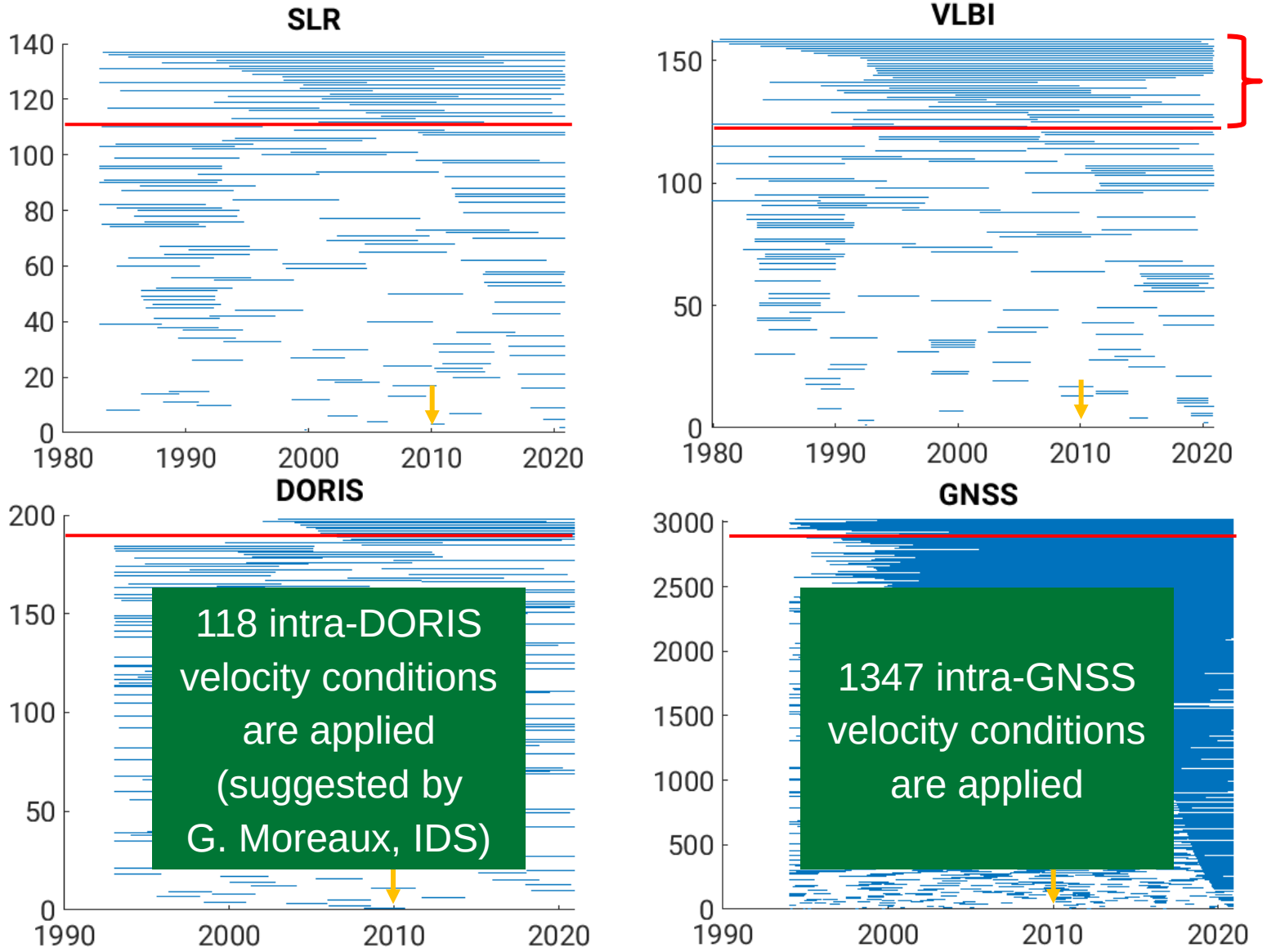
DTRF2020 – long-term stability

- Stations sorted by length of observation time span
- **SLR and VLBI provide a solid basis** of overlapping station observation time spans of **15 years and more**
- The large number of discontinuities leads to a **fragmentation of GNSS and in particular DORIS TRF**
- Drift changes in translation time series at **DTRF2020 reference epoch**
- **Long-term stability of TRF can be ensured only by a combination of station velocities** of
  - solution numbers (consecutive observation intervals) or
  - intra-technique co-locations
  - combination of the techniques



DTRF2020 – long-term stability

- Stations sorted by length of observation time span
- **SLR and VLBI provide a solid basis** of overlapping station observation time spans of **15 years and more**
- The large number of discontinuities leads to a **fragmentation of GNSS and in particular DORIS TRF**
- Drift changes in translation time series at **DTRF2020 reference epoch**
- **Long-term stability of TRF can be ensured only by a combination of station velocities** of
  - solution numbers (consecutive observation intervals) or
  - intra-technique co-locations
  - combination of the techniques



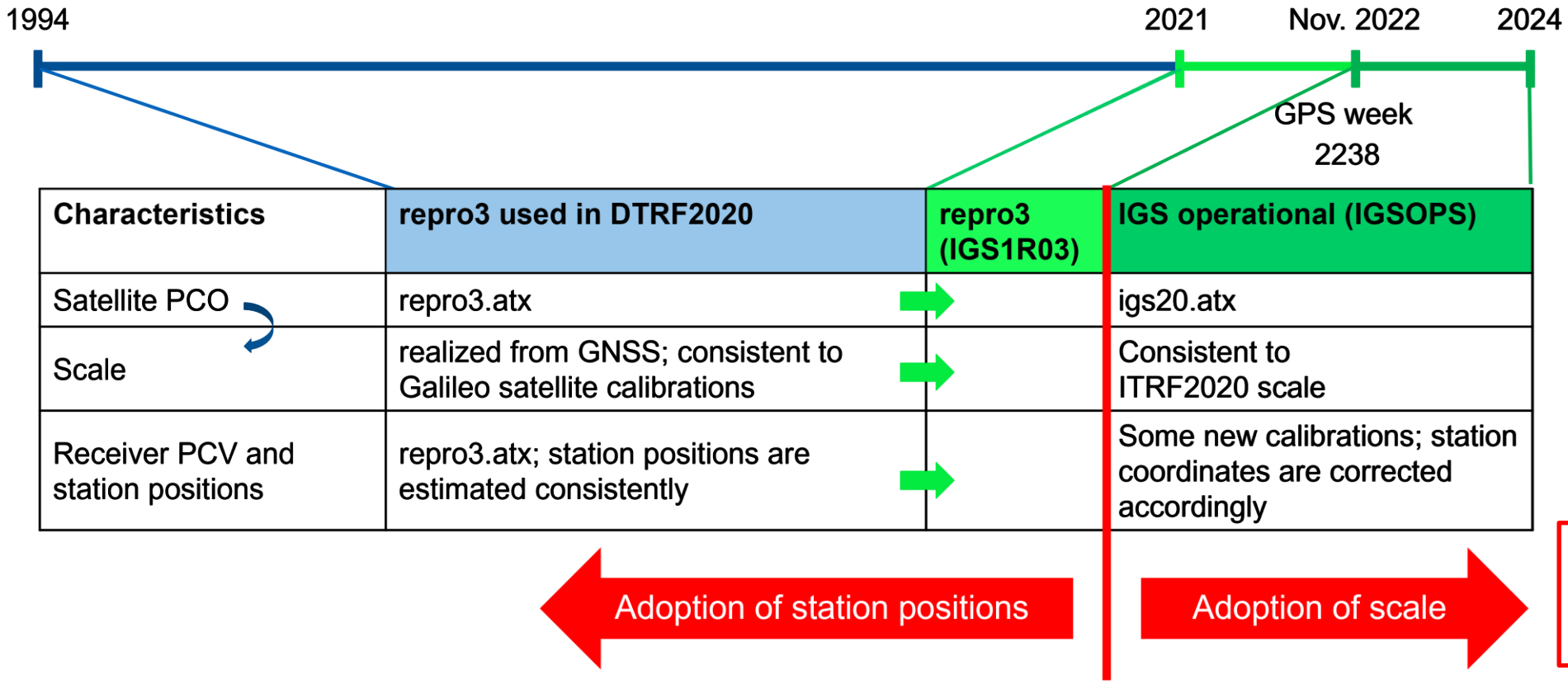
DTRF2020 update

- ITRS Center decided to update ITRF2020 by extending the solutions by 3 more years of data (2021-2024.0)
- **IGS provided** a time series in the beginning of 2024 **splitted into two parts** which differ w.r.t.
  - scale realization
  - ground antenna calibrations for about 150 stations and
  - number of contributing AC

Characteristics	repro3 used in DTRF2020	repro3 (IGS1R03)	IGS operational (IGSOPS)
Satellite PCO	repro3.atx		igs20.atx
Scale	realized from GNSS; consistent to Galileo satellite calibrations		Consistent to ITRF2020 scale
Receiver PCV and station positions	repro3.atx; station positions are estimated consistently		Some new calibrations; station coordinates are corrected accordingly

DTRF2020 update

- ITRS Center decided to update ITRF2020 by extending the solutions by 3 more years of data (2021-2024.0)
- **IGS provided** a time series in the beginning of 2024 **splitted into two parts** which differ w.r.t.
  - scale realization
  - ground antenna calibrations for about 150 stations and
  - number of contributing AC



Characteristics	repro3 used in DTRF2020	repro3 (IGS1R03)	IGS operational (IGSOPS)
Satellite PCO	repro3.atx		igs20.atx
Scale	realized from GNSS; consistent to Galileo satellite calibrations		Consistent to ITRF2020 scale
Receiver PCV and station positions	repro3.atx; station positions are estimated consistently		Some new calibrations; station coordinates are corrected accordingly

Adoption of station positions

Adoption of scale

- error-prone
- additional effort

What impacts the long-term stability ?

(+) long continuous observation histories

(-) discontinuities in station position time series incl. velocity changes

Common to all techniques: geophysical effects	Technique specific effects, caused by …		
	Instrumental changes	Model changes (e.g. PCV)	Processing changes (OSI), e.g. number of AC

Can we avoid/change/correct for discontinuities caused by the different reasons?

Past observations	No	No (or only partly by model changes, e.g. by new PCV models)	Yes: within reprocessings	Yes: within reprocessings
Future observations	No	Yes: careful and reduced changes		

Example on the next slide

60% of disc.

Impact of antenna changes and new antenna calibrations

Station position changes due to new receiver antenna calibrations

- Correction table provided by P. Rebischung
- ~280 stations are affected back up to year 2001
  → DTRF2020 has to be recomputed
- Correction is performed at NEQ level (daily)

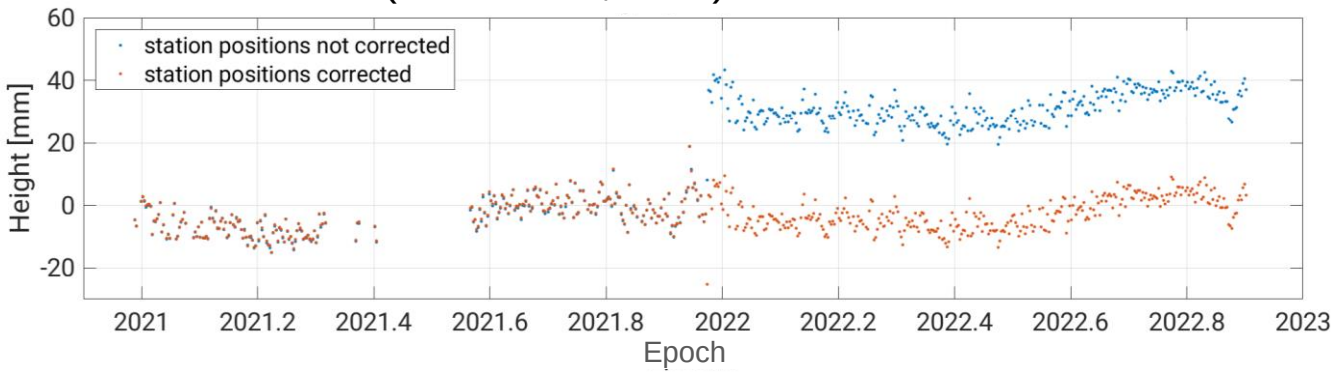
Examples (figures on the right):

- Station positions of CHCM and PTAA are corrected for new calibrations of the same antenna type: TRM115000.00+S / SCIT

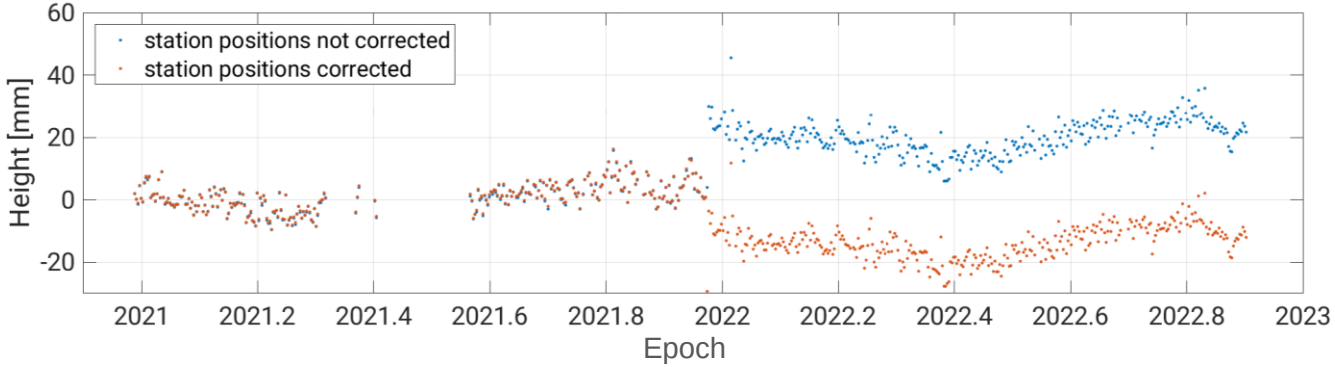
→ CHCM: discontinuity in height vanishes,
PTAA: smaller discontinuity with opposite sign

→ Number of discontinuities can be reduced, but not for all stations

Station: CHCM (Chimacum, USA)



Station: PTAA (Port Angeles, USA)



To ensure long-term stability of ITRF …

… effort needed at the different levels of analysis and combination

Station/observation level

- Reduced and careful equipment changes

Analysis level

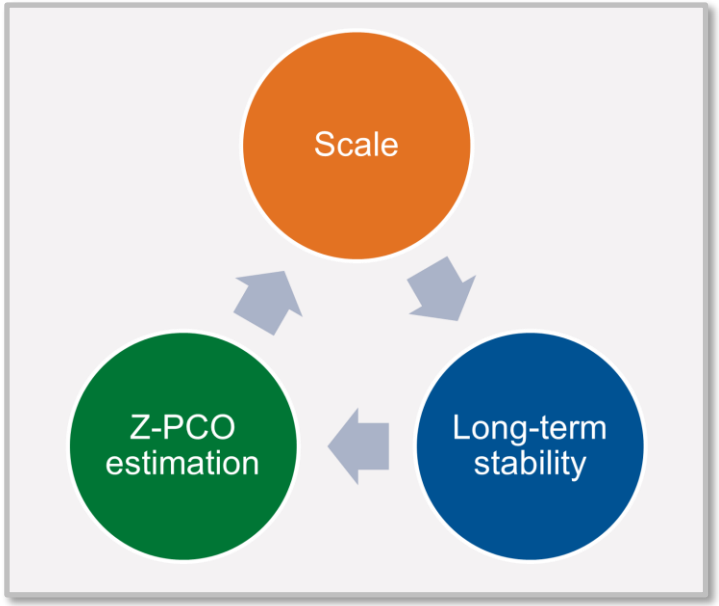
- Homogeneous models and parameterizations
- Constant number of ACs

→ long-term consistent input data series

Combination level

- In case of stable datum parameters (e.g., scale):
  - realize technique-specific TRF with the technique-own scale and set up only one scale offset and drift (if necessary) in ITRF combination

    → stabilization of technique-specific TRF contribution!



Long-term stability is required for a consistent scale realization and benefits at the same time from the GNSS own long-term scale information

Summary

- Discontinuities in station position time series (of all techniques) limit the long-term stability
- The proportion of artificial discontinuities is very high, in particular in case of GNSS (and DORIS)
- Reducing the number of artificial discontinuities is very important to realize the GGOS goal of 0.1 mm/yr for the ITRF
- Updating the xTRF solutions by extended series, not fully consistent with the previous,
  - induces additional discontinuities and
  - makes at the same time a partial reprocessing of the xTRF necessary anyway
  (as, e.g., in case of new receiver antenna calibrations)

→ Reprocessing of the full history of observation data through (at least a subgroup of) ACs by applying new models is necessary to ensure that long-term stability is not weakened for the ITRF update!

→ But, the reprocessing is a very large effort which cannot be managed by AC, TC and CC!

How to realize a more frequent ITRF computation without a loss of long-term stability?

From our (ITRS CC DGFI-TUM) point of view ….

- The analysis and processing of GNSS input data needs the largest effort, when computing a new DTRF solution.

→ The computation of a new DTRF is possible every 2-3 years if the number of GNSS stations would be limited to 250-300 fiducial stations, considering

- global distribution
- length of observation history
- quality of observations
- co-locations

→ It is worth to discuss on a xTRF computation every 2-3 years with a reduced number of GNSS stations