

Non-linear station motions in the DGFI realization of the ITRF2014

M. Seitz, M. Bloßfeld, D. Angermann, R. Schmid

Deutsches Geodätisches Forschungsinstitut der
Technischen Universität München (DGFI-TUM)

E-mail: manuela.seitz@tum.de

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DTRF2014 solutions

- ITRS realization 2014 by DGFI-TUM
- Based on **combination of normal equations** (NEQs) of individual techniques reconstructed from SINEX files
- For the first time, **non-tidal loading (NT-L) signals are considered**
- Solutions computed:
 - ❑ **conventional solution**: without non-tidal loading corrections
 - ❑ **corrected solution**: corrected a posteriori for non-tidal atmospheric (NT-ATML) and hydrological (NT-CWSL) loading (models provided by GGFC) → still under construction!

This talk:

- How are the NT-L corrections applied a posteriori at the NEQ level?
- What is the impact of NT-L corrections on parameters of the single-technique DTRF2014 solutions?

DTRF2014 input data

Space geodetic techniques:

	Service	Solution type	Resolution	Time span	
VLBI	IVS	Free NEQ	Session-wise	04/80 - 12/14	35 years
SLR	ILRS	Loosely constrained solution	Before 1993.0: 15 days After 1993.0: weekly	12/82 - 01/15	32 years
GNSS	IGS	Minimum constraint solution	Daily	01/94 - 02/15	21 years
DORIS	IDS	Minimum constraint solution	weekly	01/93 - 01/15	22 years

Local ties and loading data:

	Provided by ...	Format
Local ties	<ul style="list-style-type: none"> - Co-location sites, surveying teams - Collected and prepared by Z. Altamimi 	SINEX
Non-tidal atmospheric, hydrological (and oceanic) loading data	<ul style="list-style-type: none"> - GGFC of the IERS <ul style="list-style-type: none"> • Atmospheric: based on NCEP model • Hydrological: based on GLDAS model • Oceanic: not used (time series only from 1994) 	Free format



Non-tidal loading (NT-L) corrections

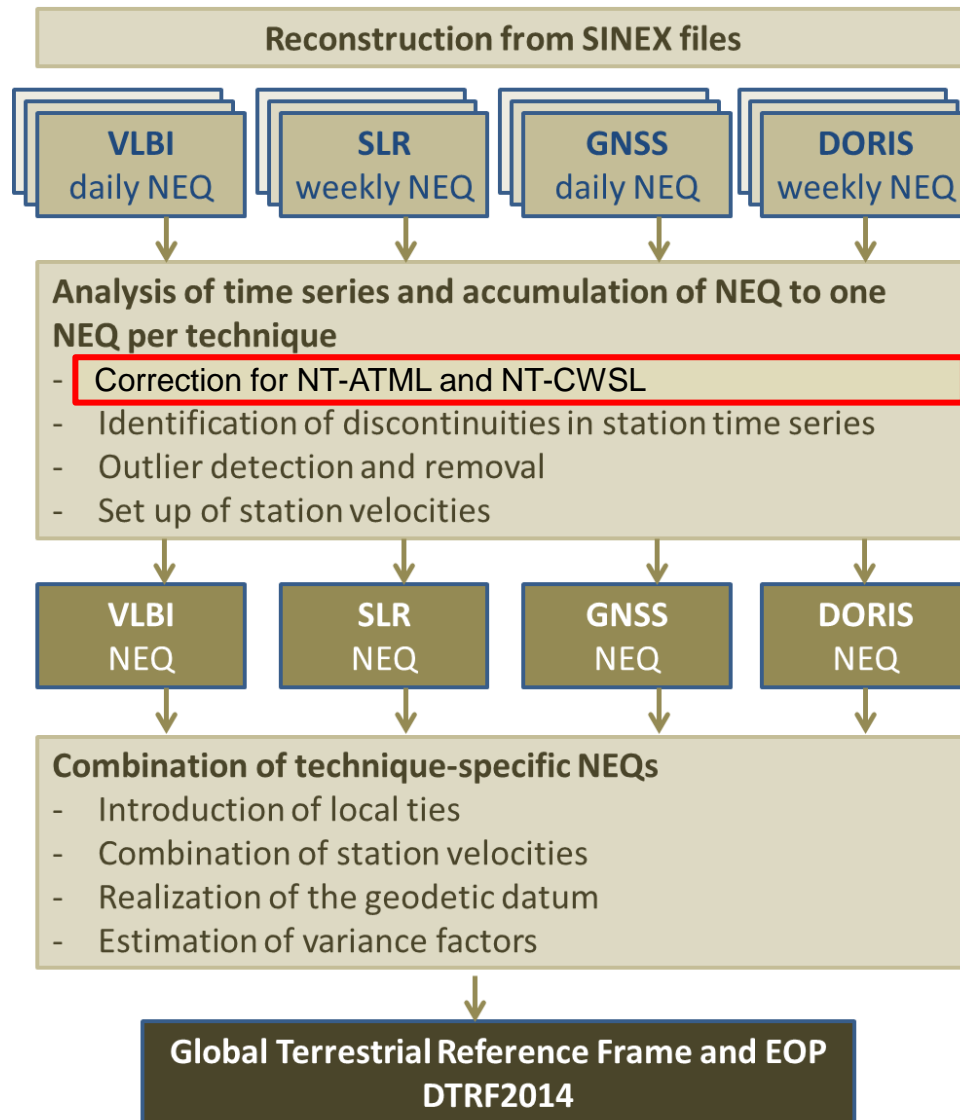
Frame of NT-L corrections

- NT-L corrections are provided in [mm] in a local horizontal frame (NEU)
- Transformation of $\delta[NEU]_{load}(CM)$ to $\delta\mathbf{x}_{load}(CM) = \delta[XYZ]_{load}(CM)$

Expected impact on DTRF datum parameter time series

- $\delta\mathbf{x}_{load}$ is related to the Earth's CM \rightarrow CF-CM is applied through model
 - CF-CM variation is a significant part of NT-L corrections
 - SLR NEQs are related to CM; if corrected for $\delta\mathbf{x}_{load} \rightarrow$ impact on SLR-derived weekly translations
 - impact of $\delta\mathbf{x}_{load}$ on other techniques is smaller since they are not sensitive to CM
- Impact on scale should be small except for effects induced by transformation network (due to inhomogeneous distribution of transformation stations)
- Impact on orientation is minimized by NNR condition

NT-L correction applied a posteriori at NEQ level



- $\delta \mathbf{x}_{load} = \delta \mathbf{x}_{NT-ATML} + \delta \mathbf{x}_{NT-CWSL}$
- Computation of mean $\delta \mathbf{x}_{load}$ per day/session/week
- NT-L corrections are applied before accumulation of NEQs

$$\tilde{\mathbf{N}} = \mathbf{N}$$

$$\tilde{\mathbf{y}} = \mathbf{y} + \mathbf{N}\delta \mathbf{x}_{load}$$

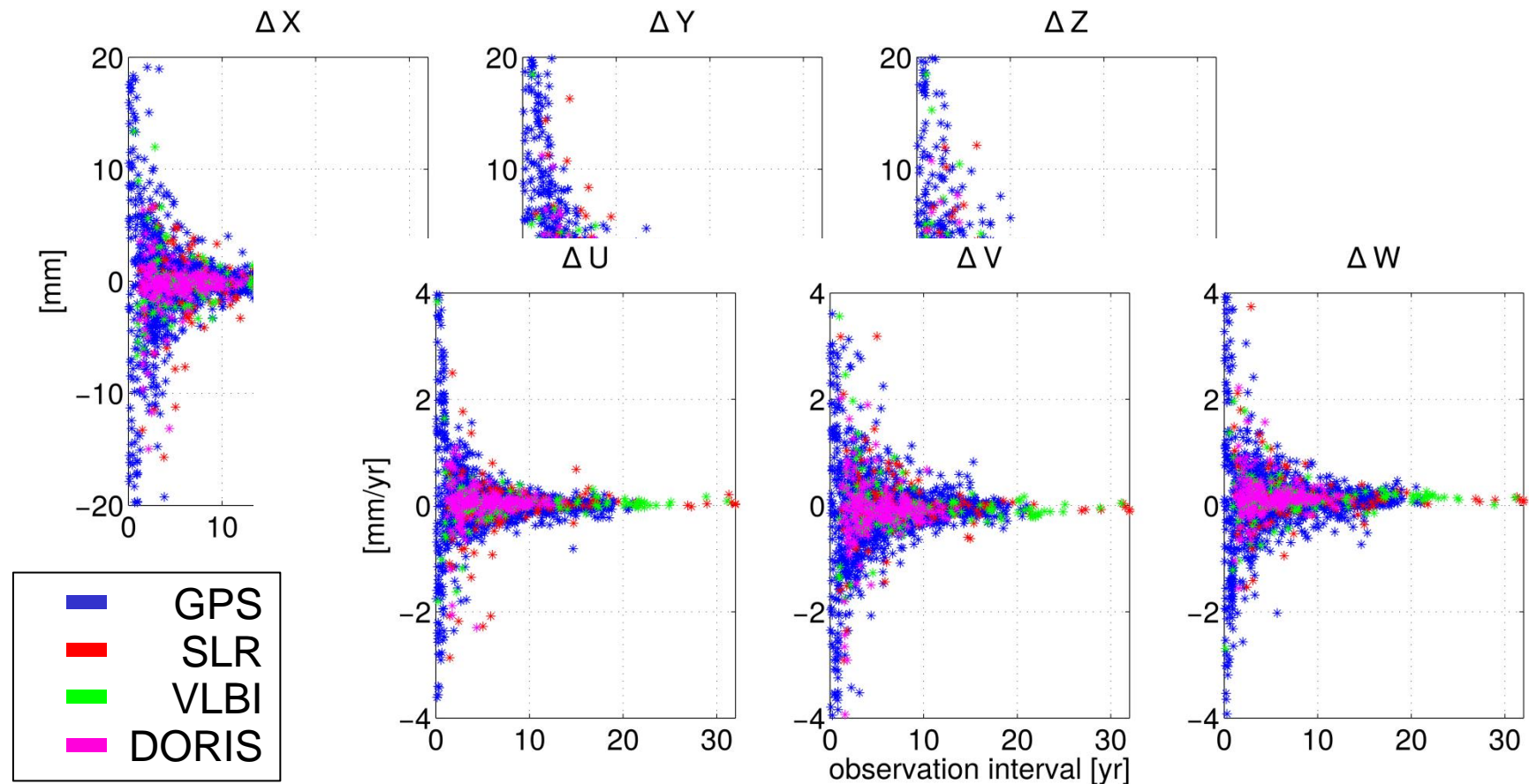
$$\tilde{\mathbf{l}}^T \tilde{\mathbf{P}} \tilde{\mathbf{l}} = \mathbf{l}^T \mathbf{P} \mathbf{l} + \delta \mathbf{x}^T (2\mathbf{y} + \mathbf{N}\delta \mathbf{x})$$

$$\tilde{\mathbf{x}}_0 = \mathbf{x}_0$$

- only $\tilde{\mathbf{y}}$ and $\tilde{\mathbf{l}}^T \tilde{\mathbf{P}} \tilde{\mathbf{l}}$ change, NEQs remain unchanged

Impact on technique-specific solutions

- Impact of NT-L corrections on station coordinates and velocities



- Stations with short observation intervals are affected most
- Can NT-L corrections help to consider short-interval velocities for the TRF?
- Improvement or degradation of the TRF?

Impact on technique-specific solutions

- Validation of NT-L corrections using SLR-GPS local ties (LTs) at stations with large impact on velocity
- 3D difference of technique-specific TRFs w.r.t. LT at measurement epoch

➤ GPS-SLR LT at Borowiec

	LT (1994.0)	3D(conv.)-LT	3D(corr.)-LT
X	+25.767 m	+14.4 mm	+10.6 mm
Y	-72.908 m	+5.0 mm	+5.7 mm
Z	-0.324 m	+14.0 mm	+12.3 mm

➤ GPS-SLR LT at Cagliari

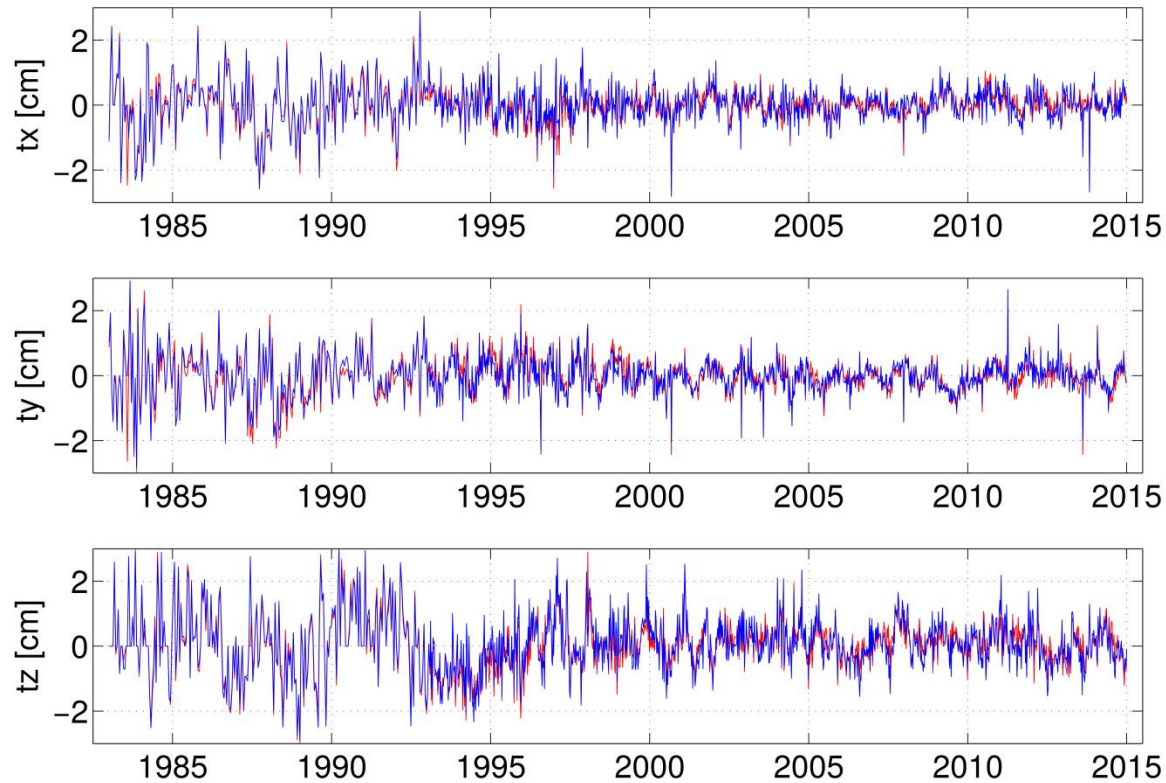
	LT (1995.4)	3D(conv.)-LT	3D(corr.)-LT
X	+19.036 m	+6.1 mm	+1.9 mm
Y	+23.844 m	-7.9 mm	-8.8 mm
Z	-40.947 m	-4.5 mm	-3.5 mm

➤ GPS-SLR LT at Wettzell

	LT (2002.1)	3D(conv.)-LT	3D(corr.)-LT
X	+3.824 m	-4.2 mm	-3.0 mm
Y	+68.202 m	+1.8 mm	+2.2 mm
Z	-15.518 m	+0.2 mm	+0.3 mm

Impact on technique-specific solutions

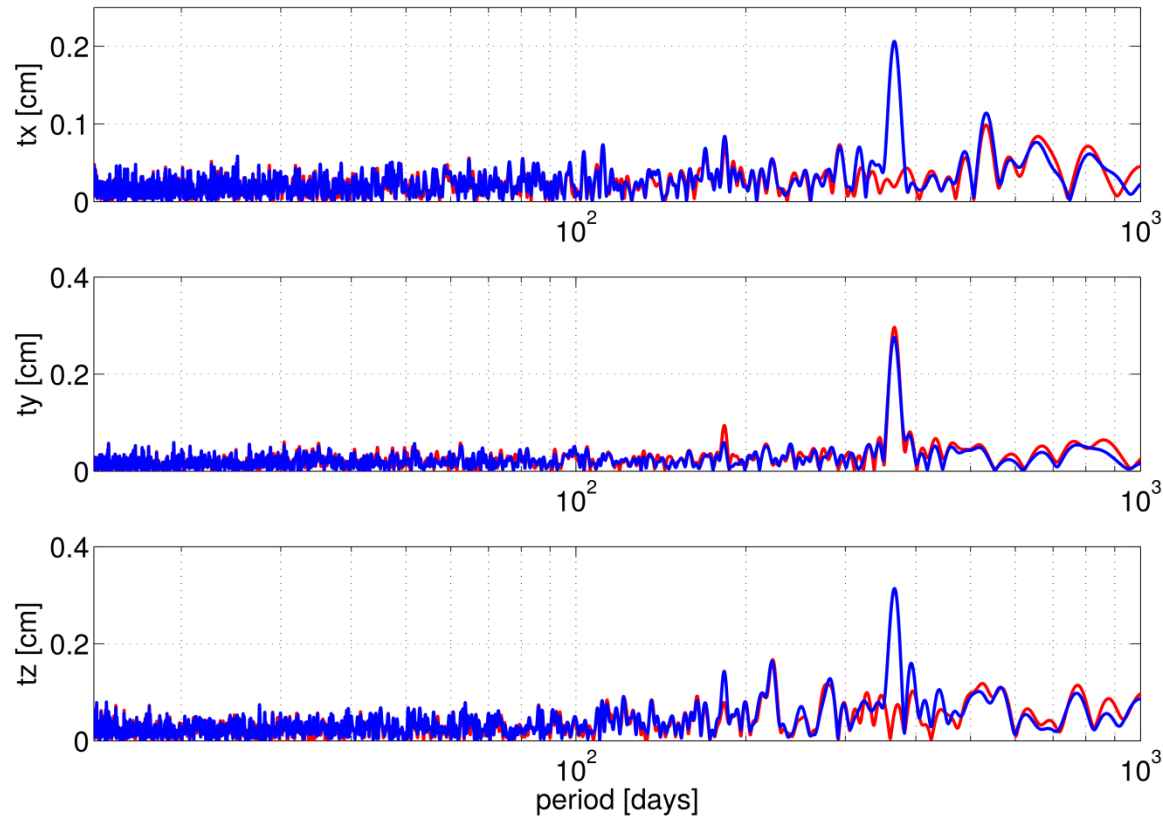
- transformations of weekly (**conv./corr.**) SLR-only w.r.t. long-term SLR-only TRF



WRMS [mm]	Tx	Ty	Tz
conventional solution	3.38	3.48	5.61
corrected solution	3.31	3.72	5.52

Impact on technique-specific solutions

➤ spectra of transformations

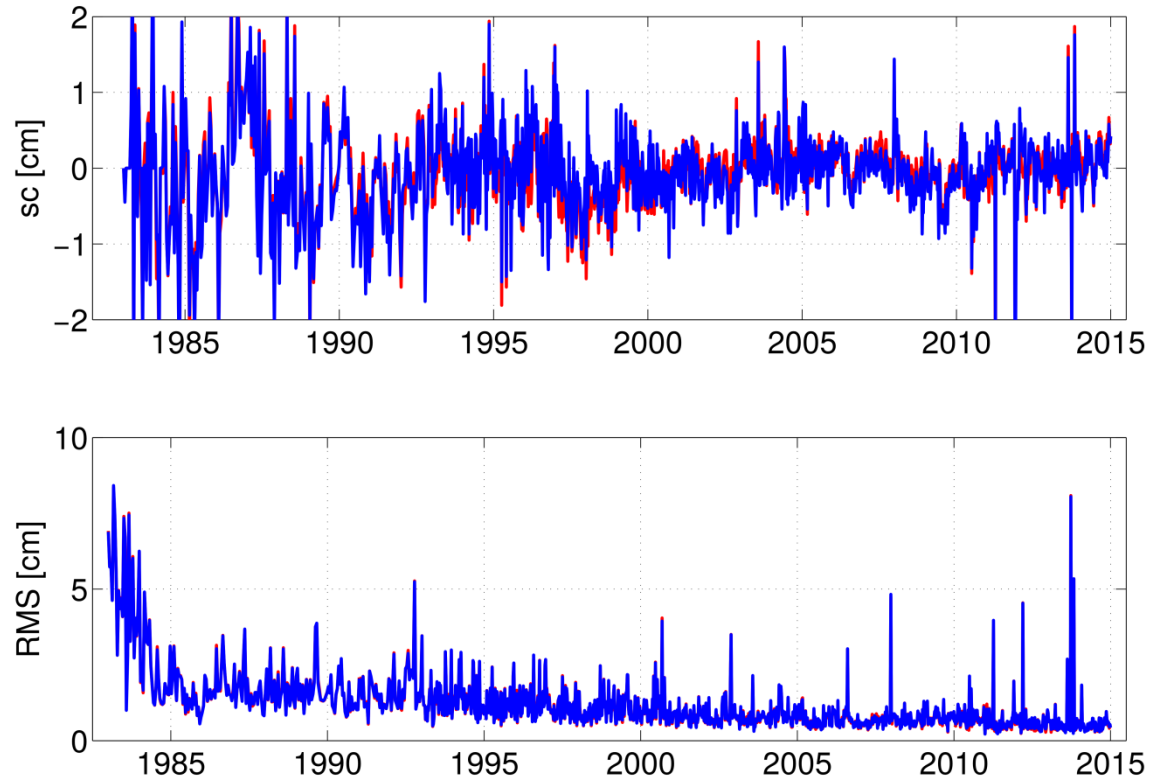


WRMS [mm]	Tx	Ty	Tz
conventional solution	3.38	3.48	5.61
corrected solution	3.31	3.72	5.52

➤ CM-related NT-L corrections cause significant change in SLR origin

Impact on technique-specific solutions

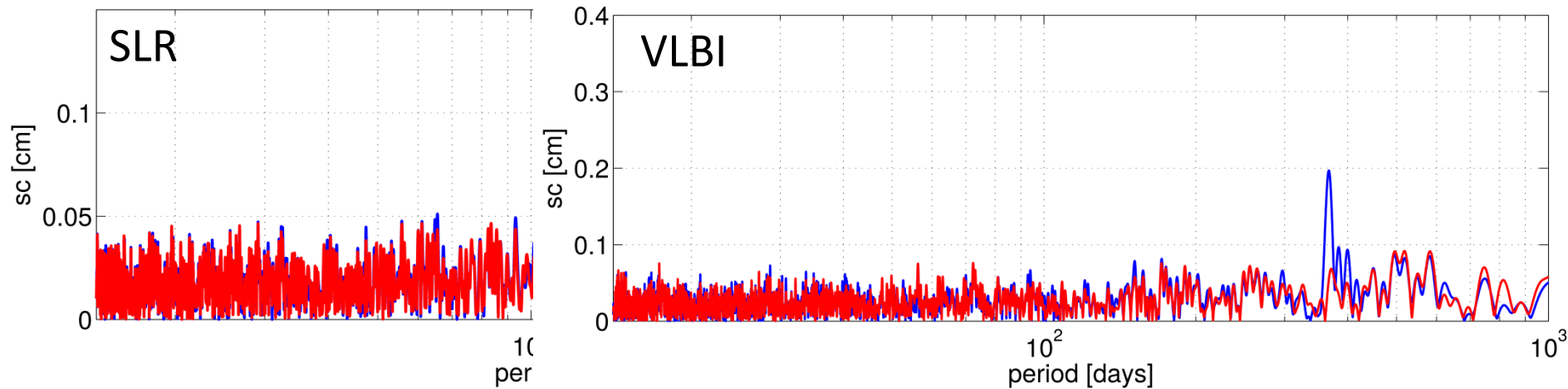
- transformations of weekly (**conv./corr.**) SLR-only w.r.t. long-term SLR-only TRF



WRMS [mm]	Tx	Ty	Tz	Sc
conventional solution	3.38	3.48	5.61	3.03
corrected solution	3.31	3.72	5.52	2.95

Impact on technique-specific solutions

- spectra of transformations



- scale change might be caused by transformation network
- seasonal signal is also affected in VLBI scale time series
- only small reduction of WRMS due to high scatter of time series

WRMS [mm]	T _x	T _y	T _z	Sc
conventional solution	3.38	3.48	5.61	3.03
corrected solution	3.31	3.72	5.52	2.95

Impact on technique-specific solutions

- Does scatter of station position residual time series decrease?

mean WRMS of SLR stations [mm]	north	east	height
conventional solution	15.16	13.80	16.60
corrected solution	13.91	13.63	16.17

mean WRMS of DORIS stations [mm]	north	east	height
conventional solution	10.87	16.46	12.95
corrected solution	10.94	16.50	12.85

mean WRMS of VLBI stations [mm]	north	east	height
conventional solution	3.71	3.47	10.86
corrected solution	3.79	3.56	10.74

→ GPS: still processing...

- SLR residuals improve in all components
- no distinct improvement in N/E, slight improvement in H
- residuals seem to be dominated by other than loading effects

Summary: improvement due to NT-L corrections?

- NT-L corrected solution finished for SLR, DORIS and VLBI contribution
- Impact mostly on stations with short observation intervals
- Validation of NT-L-induced velocity improvements via LT comparisons
 - Discrepancy between 3D-differences of single-technique solutions and LT measurements are getting smaller
 - Possible introduction of more LTs
- Significant impact of NT-L corrections on datum parameters which are implicitly realized in NEQs
 - SLR origin (T_y needs further investigation) and scale
 - VLBI scale
- Impact of NT-L corrections on residual time series is not distinct
 - Only for SLR, WRMS(NEU) is decreased
 - WRMS(H) is decreased for SLR, DORIS and VLBI

How to get the DTRF2014?

- ❑ **Final DTRF2014 solution will comprise:**
 - **SINEX files** for all techniques
 - **Station position residual time series** which enable the user to correct the DTRF2014 positions to the true position at epoch
 - **Loading time series** applied in DTRF2014 computation
 - **SSC and EOP files**
 - Publication will be announced in IERS mailing lists

- **DTRF2014 paper:** in preparation

In PANGAEA

Data Publisher for Earth &
Environmental Science

<https://doi.pangaea.de>

Thank you very much for your attention!

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Email: manuela.seitz@tum.de

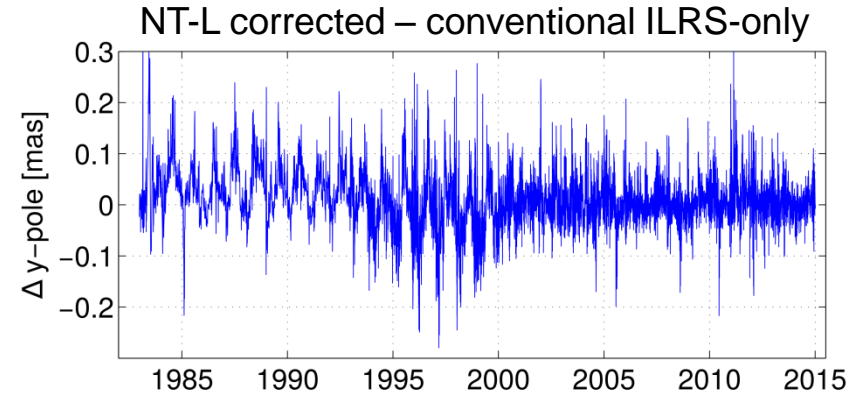
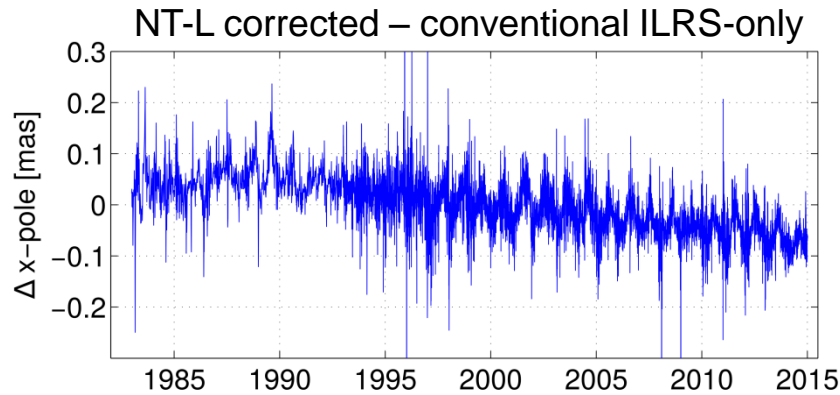
The final solution of the DTRF2014 will be published soon at the **PANGAEA** data base!

For further information, please have a look at www.dgfi.tum.de



Impact on technique-specific solutions

- Changes of ILRS-only EOP due to NT-L corrections



ILRS-only WRMS w.r.t. IERS 08C04	x-pole [mas]	y-pole [mas]	LOD [ms]
conventional solutions	0.214	0.208	0.032
corrected solutions	0.202	0.207	0.032

- Seasonal signal in difference time series of pole coordinates (also in other techniques)
- Seasonal signal w.r.t. IERS 08C04 is decreased in both components