

The most recent DGFI-TUM realization of the ITRS: DTRF2014

Mathis Bloßfeld, Manuela Seitz, Detlef Angermann, Ralf Schmid

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

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Change and for Precise Navigation in Space“

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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)

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 constr. sol.	Before 1993.0: 15 days After 1993.0: weekly	12/82 - 01/15	32 years
GNSS	IGS	Minimum constr. sol.	Daily	01/94 - 02/15	21 years
DORIS	IDS	Minimum constr. sol.	weekly	01/93 - 01/15	22 years

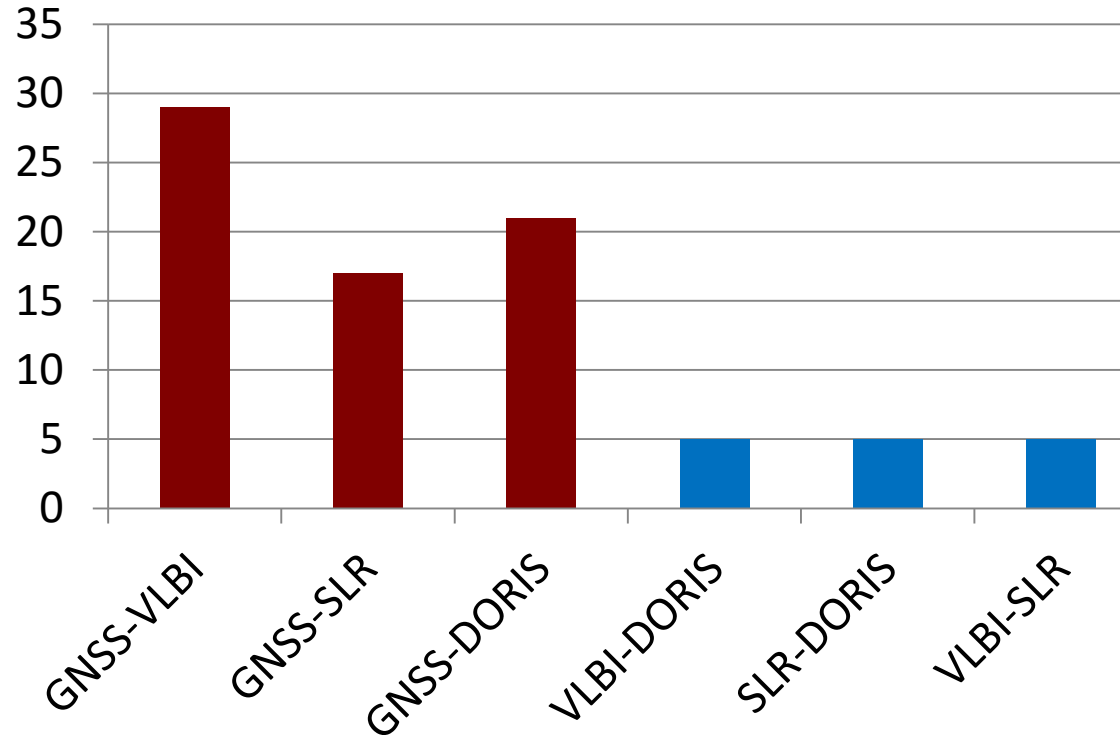
Local ties and loading data:

	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

DTRF2014 – multi-technique combination (constraints)

Number of colocation sites used in DTRF2014 for introducing local ties: 82

	VLBI	SLR	DORIS
GNSS	29	17	21
VLBI		5	5
SLR			5



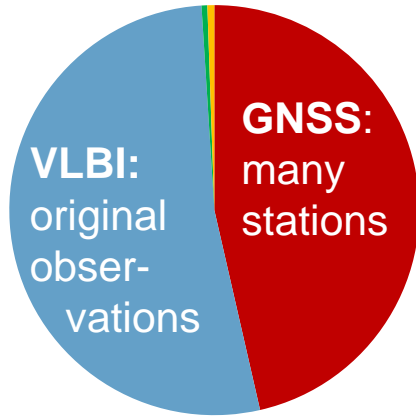
- GNSS is essential for the combination of all techniques!
- Local ties are selected using a threshold of 15mm for 3D-discrepancy

Number of equalized velocities (considering solution numbers): 381

- Velocities are equalized using a threshold of 2 mm/yr

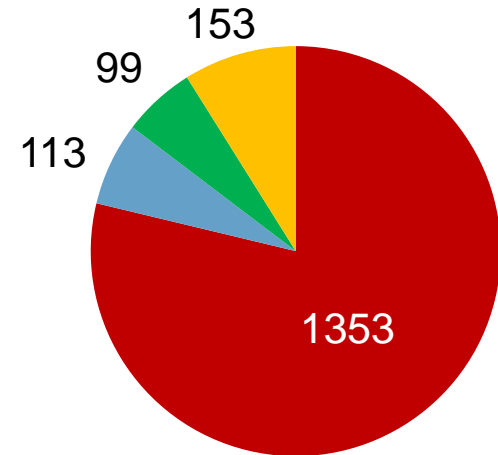
DTRF2014 – solution statistics

Number of observations: 167,686,139

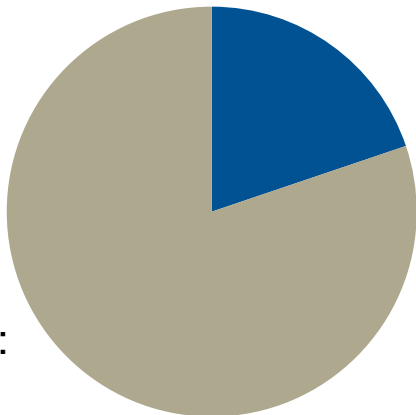


- GNSS
- VLBI
- SLR
- DORIS

Number of sites: 1718

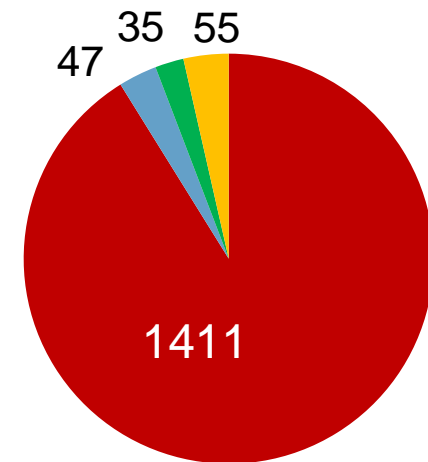


Number of unknowns: 80,335



- Station coordinates
- EOP

Number of discontinuities: 1548



Size of NEQ:
49.2 GB

Non-tidal loading (NT-L) corrections

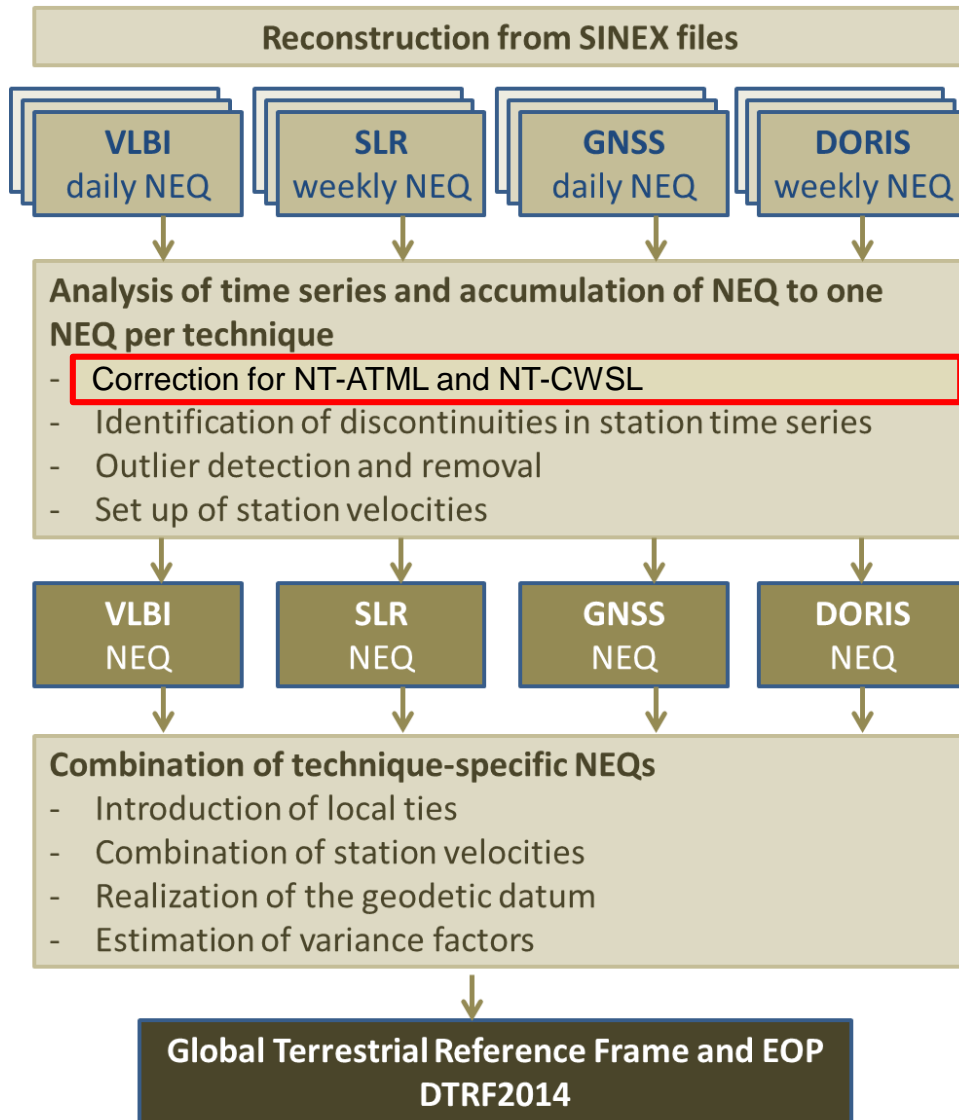
▪ Frame of NT-L corrections

- 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 → 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 $\delta\mathbf{x}_{load}$ → 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 corrections applied a posteriori at NEQ level



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

$$\tilde{N} = N$$

$$\tilde{y} = y + N\delta x_{load}$$

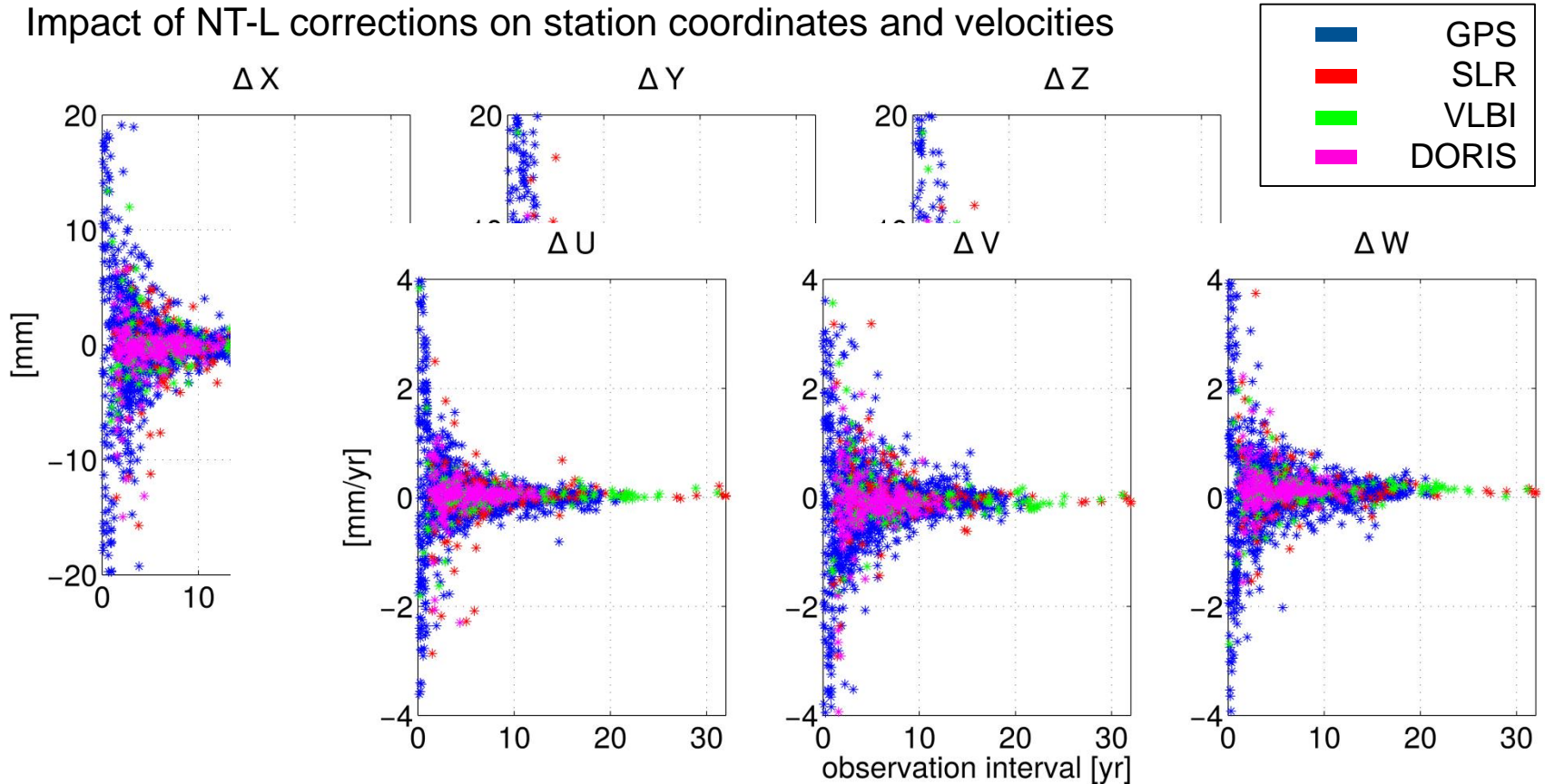
$$\tilde{l}^T \tilde{P} \tilde{l} = l^T P l + \delta x^T (2y + N\delta x)$$

$$\tilde{x}_0 = x_0$$

- only \tilde{y} and $\tilde{l}^T \tilde{P} \tilde{l}$ 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

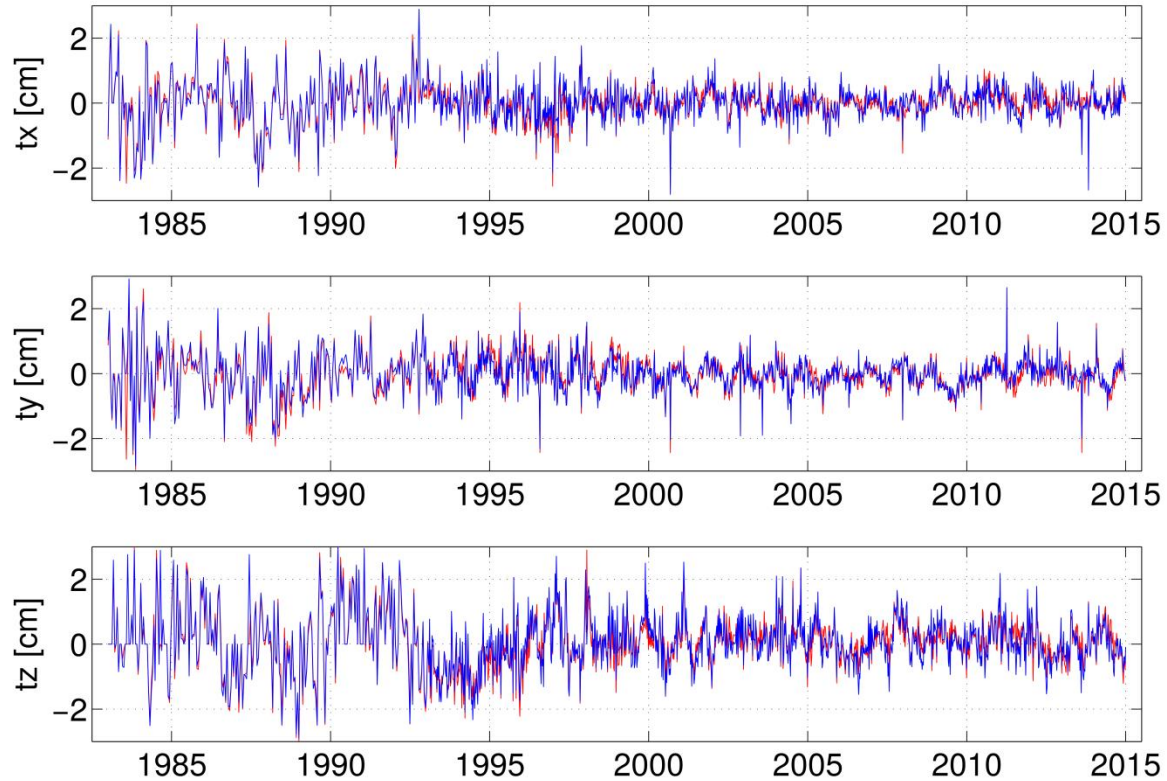
	LT (1995.4)	3D(conv.)-LT	3D(corr.)-LT
X	+19.036 m	+6.1 mm	+1.9 mm
Y	+23.844 m	-7.9 mm	-8.8 mm
Z	-40.947 m	-4.5 mm	-3.5 mm

- 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

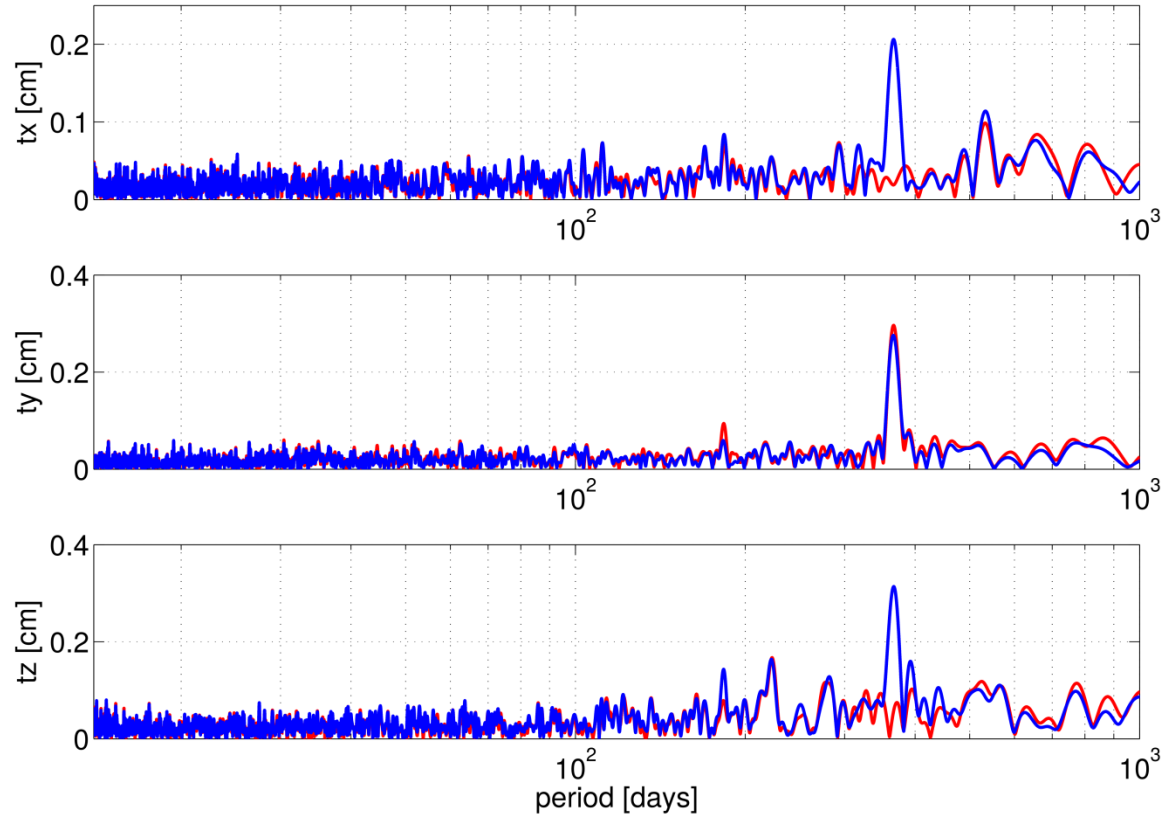
- transformations of weekly (**conv./corr.**) SLR-only w.r.t. long-term SLR-only TRF



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

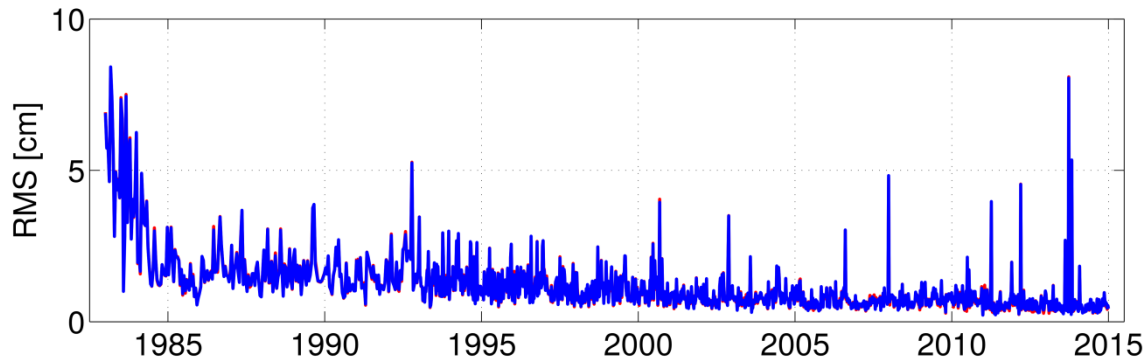
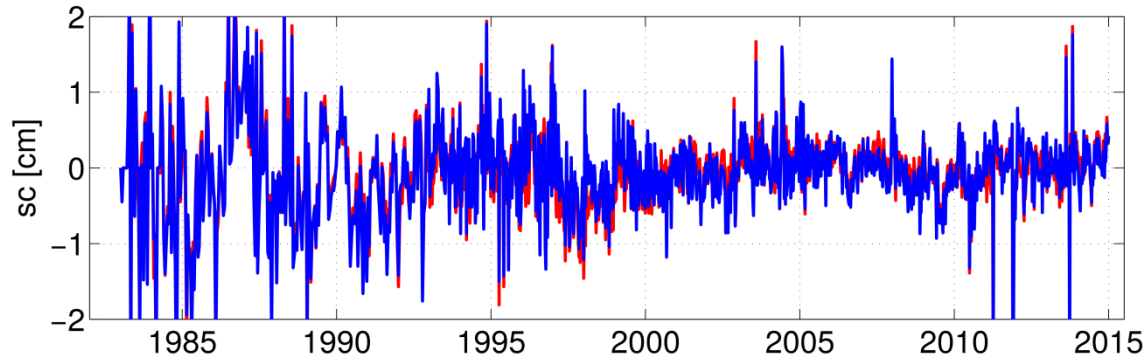
➤ spectra of transformations



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Impact on technique-specific solutions

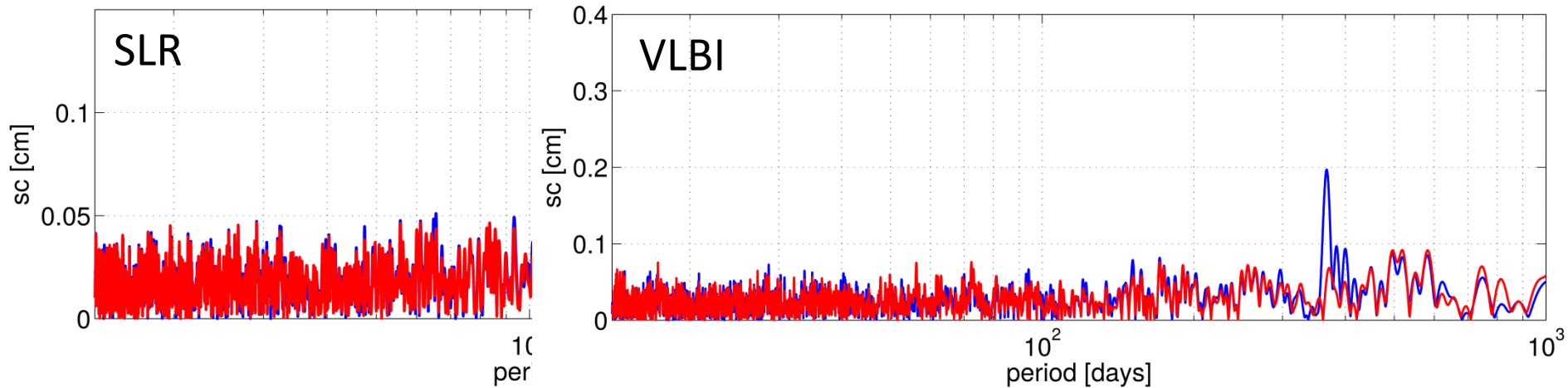
- transformations of weekly (**conv./corr.**) SLR-only w.r.t. long-term SLR-only TRF



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

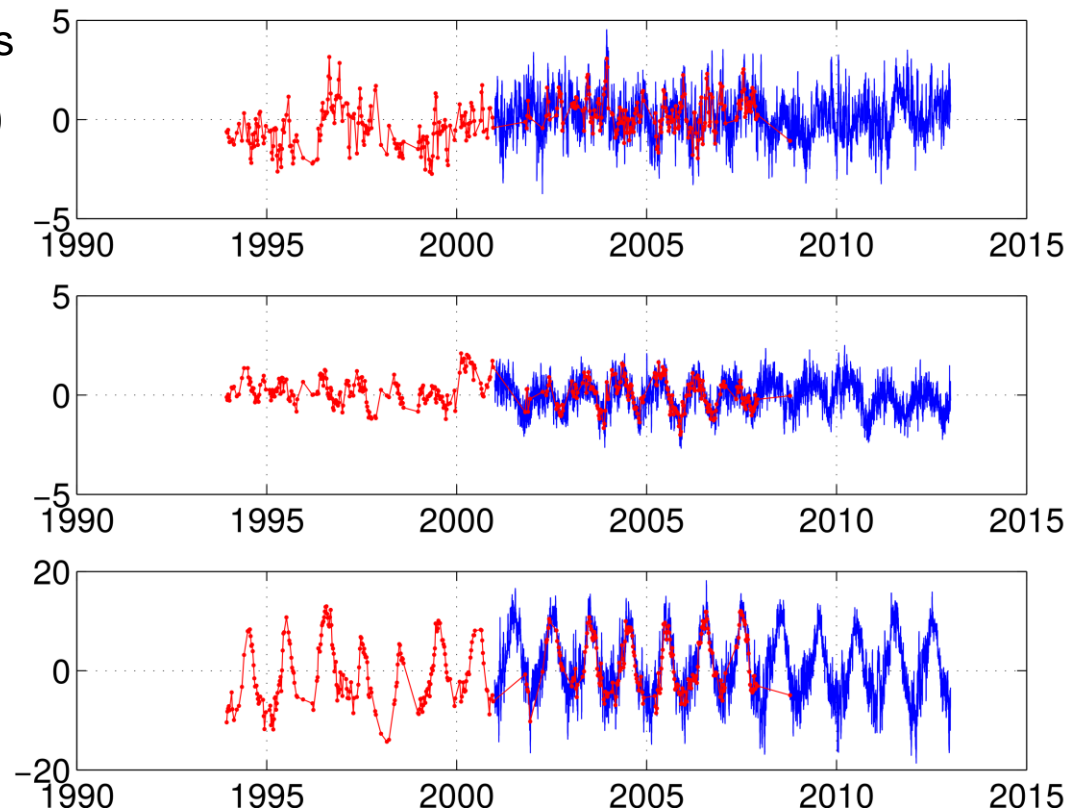


- scale change might be caused by transformation network
- seasonal signal in SLR and VLBI scale time series is reduced
- only small reduction of WRMS due to high scatter of time series

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

- Why is annual amplitude in y-translation not reduced by the NT-L correction models?
 - Error in correction models of GGFC? Wrong transformation ($\delta[NEU]_{load}(CM)$ to $\delta x_{load}(CM) = \delta[XYZ]_{load}(CM)$)?
 - Example: correction time series of SLR-station Maidanak (Rus)
 - Correction models show good agreement!
 - Is the annual variation in y caused by the neglected NT-OCNL?



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

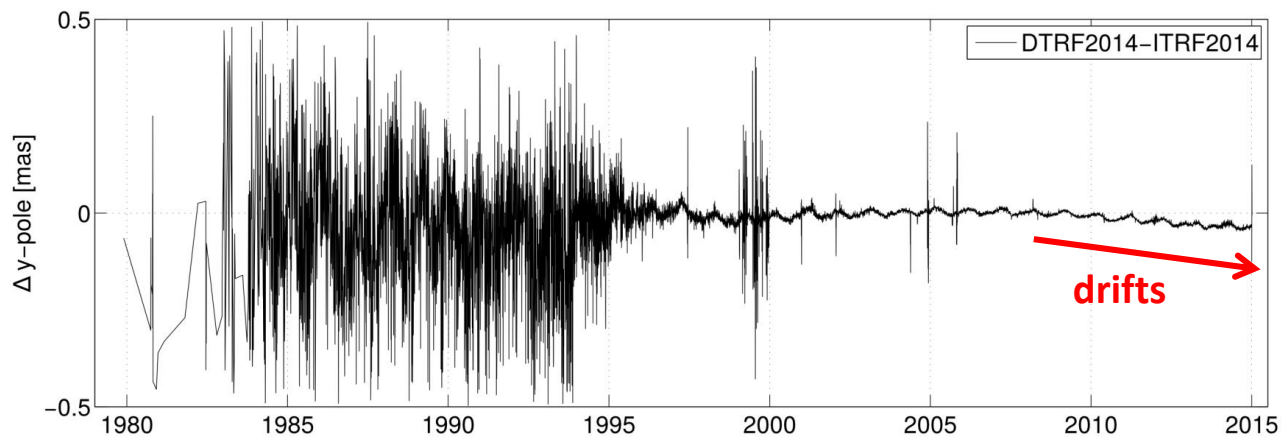
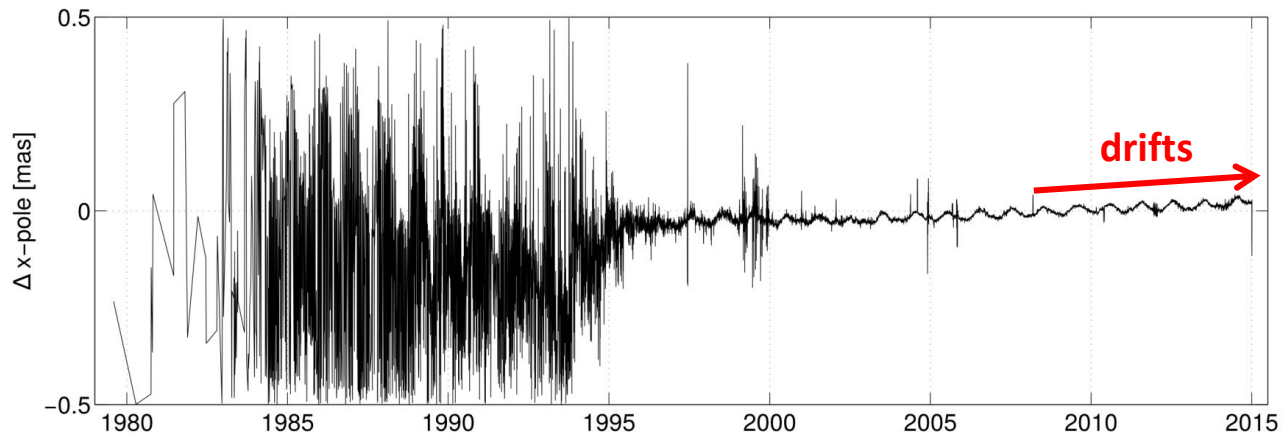
mean WRMS of VLBI stations [mm]	north	east	height
conventional solution	3.71	3.47	10.86
corrected solution	3.79	3.56	10.74

→ GPS/combined solution: already computed; detailed analysis pending

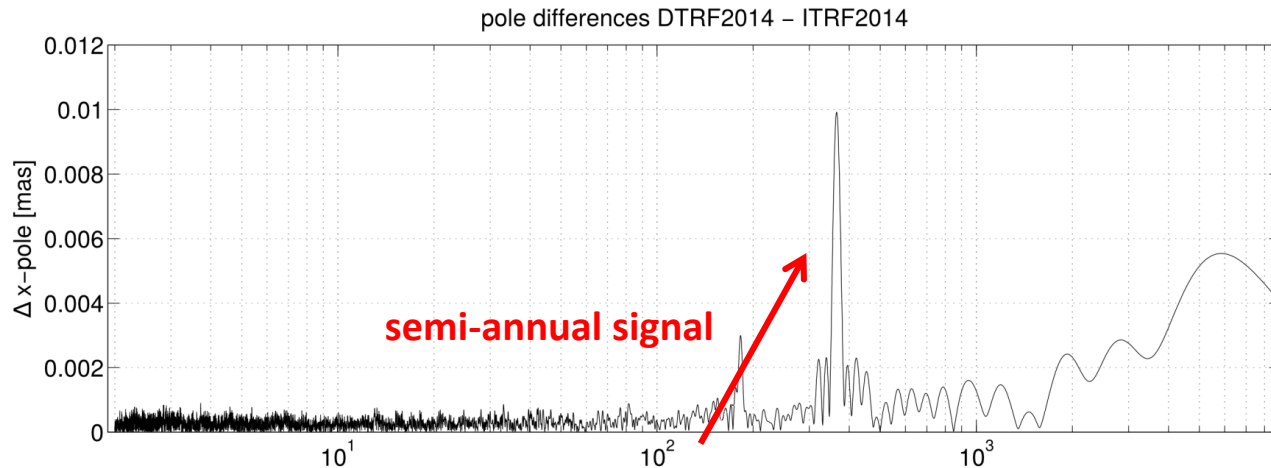
- SLR residuals improved in all components
- no distinct improvement in N/E, slight improvement in H
- residuals seem to be dominated by other than loading effects

Impact on consistently estimated EOP

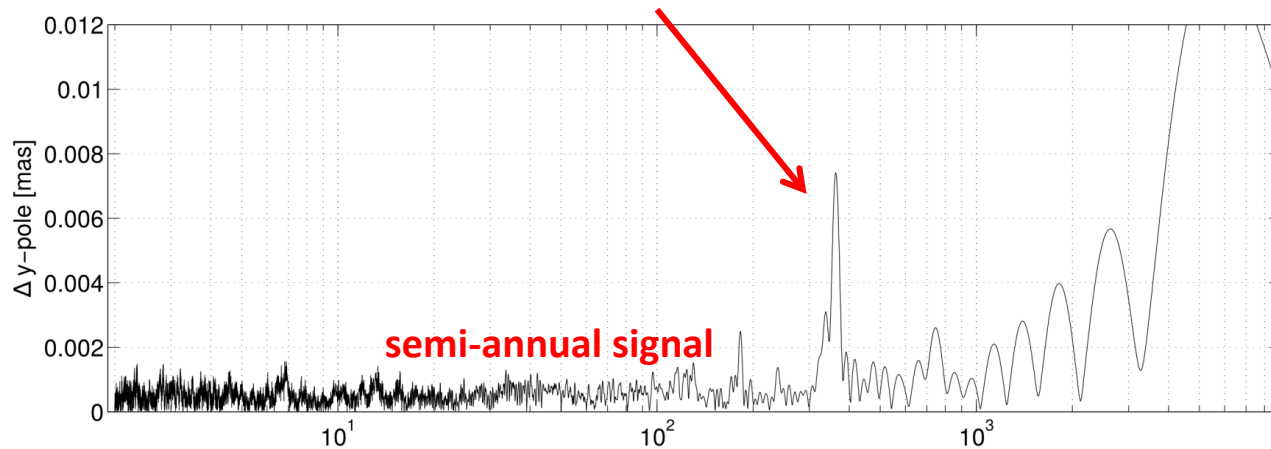
- DTRF2014 (conventional) – ITRF2014 (annual/semi-annual signals corrected)



Impact on consistently estimated EOP



annual signal can be seen in the difference time series



- Difference caused by different treatment of non-linear station motions (expected to be smaller if NT-L corrections are applied)

Conclusions

- NT-L corrected solution finished for all solutions; SLR, DORIS and VLBI already validated
- Impact mainly 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 implicitly realized datum parameters
 - SLR origin (Ty affected by NT-OCNL neglect?) and scale
 - VLBI scale
- Impact of NT-L corrections on residual time series is not distinct
 - Only for SLR, WRMS(NEU) is decreased
- Systematic effects in pole coordinates due to different treatment of non-linear station motions

How to get the DTRF2014 solution?

❑ 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

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Thank you very much for your attention! Any questions?

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