

DTRF2014: the new DGFI realization of the ITRS

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*IGS Workshop 2016
Plenary 6: Reference Frame
2016-02-10*



DTRF2014

- **DTRF2014**: ITRS realization computed by DGFI-TUM
- Based on **combination of datum-free normal equations** of individual techniques reconstructed from SINEX files
- For the first time, **non-tidal loading signals are considered**
- **A conventional solution** (without non-tidal loading correction) was computed for validation purposes and **is presented in the following.**

Outline

- Input data and its analysis
- Solution statistics and datum realization of DTRF2014
- Internal and external validation of DTRF2014 (focus on DTRF scale)
- Summary and outlook

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 (data do not cover complete time span) 	free format

DTRF2014 – Parameters

Parameters contained in SINEX and used for DTRF2014:

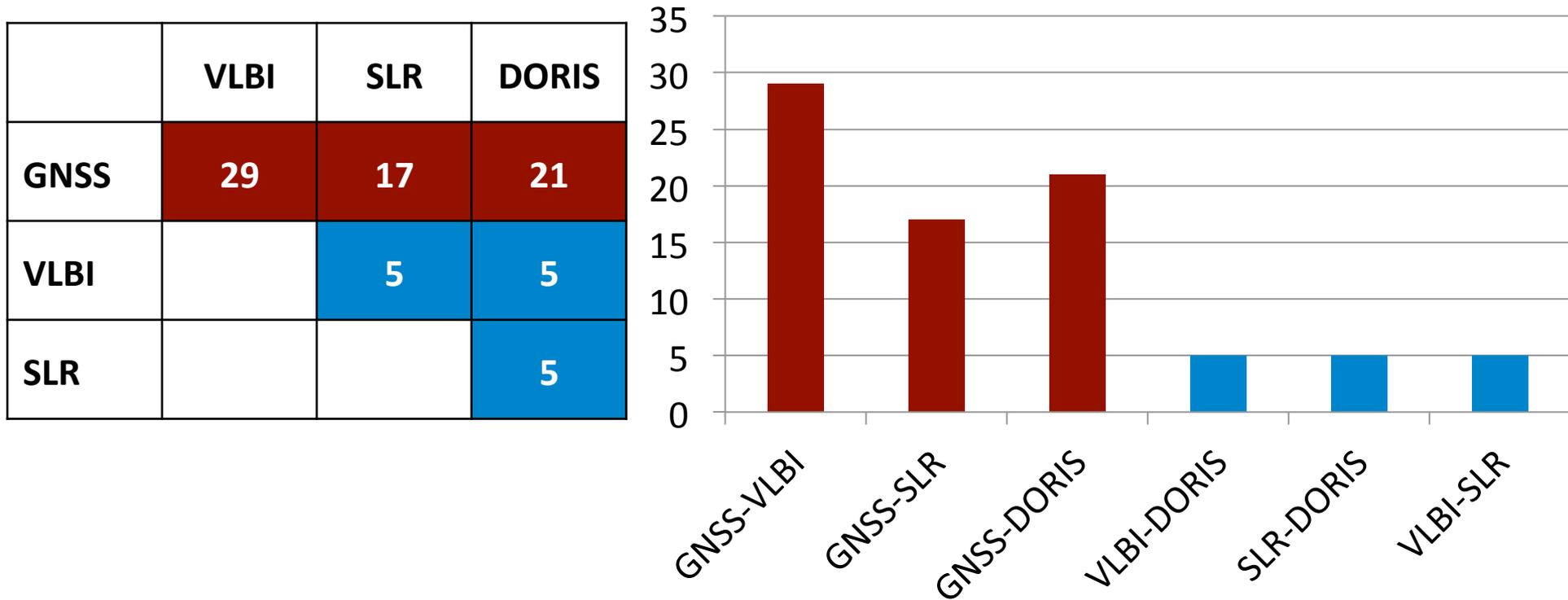
	Station positions	Station velocities	Geocenter coordinates	Daily EOP at noon epochs		
				Terrestrial pole	UT1	Celestial pole
VLBI	X			offsets & rates	UT1 & LOD	offsets
SLR	X			offsets before 1993.0: 1/3d after 1993.0: daily	LOD before 1993.0: 1/3d after 1993.0: daily	
GNSS	X		X	offsets & rates	LOD	
DORIS	X			offsets		
DTRF2014	X	X	reduced	offsets & rates	UT1 & LOD	offsets

Geodetic datum

- origin: realized by **SLR** (complete time series used)
- scale: realized by **SLR and VLBI** (complete time series used)
- orientation: no-net-rotation conditions (**GNSS subnetwork**) w.r.t. DTRF2008

DTRF2014 – Multi-technique combination (constraints)

Number of DTRF2014 local ties at co-location sites: 82 (373 altogether)



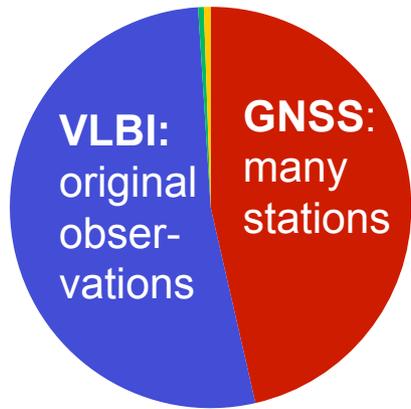
- GNSS are essential for the combination of all techniques!
- Local ties are selected using a threshold of 15 mm for 3D discrepancy

Number of equalized velocities (considering solution intervals): 381

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

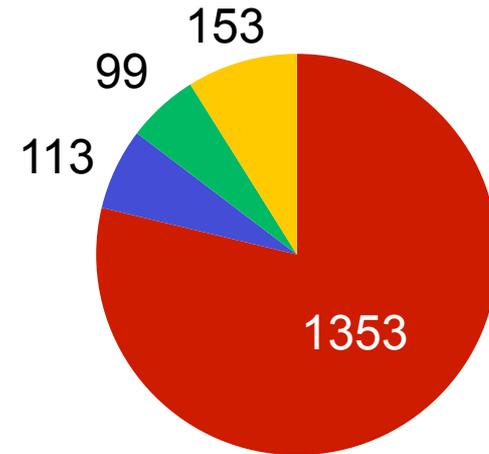
DTRF2014 – Solution statistics

Number of observations: > 167 million

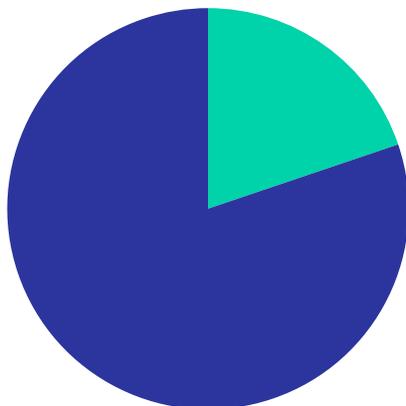


- GNSS
- VLBI
- SLR
- DORIS

Number of sites: 1718

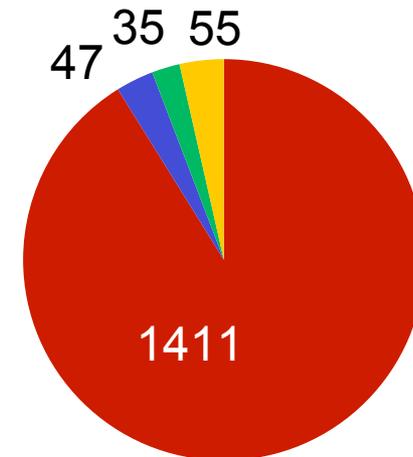


Number of unknowns: 80,335



- Station coordinates
- EOP

Number of discontinuities: 1548



Size of NEQ: 49.2 GB

DTRF2014 – Internal validation (1/2)

DTRF2014 vs. single-technique

Helmert transformation w.r.t. single technique solutions
 (aligned to DTRF2008, reference epoch 2000.0)

- DORIS not used for the datum definition

Offsets [mm] Rates [mm/yr]

	Origin			Scale	Orientation		
	Tx	Ty	Tz	Sc	Rx	Ry	Rz
SLR	0.1 ± 0.21 0.0 ± 0.04	0.6 ± 0.21 0.0 ± 0.04	0.9 ± 0.21 -0.1 ± 0.04	0.2 ± 0.21 0.0 ± 0.04			
VLBI				0.4 ± 0.09 0.1 ± 0.01			
GNSS					0.5 ± 0.02 0.0 ± 0.02	0.0 ± 0.02 0.0 ± 0.02	-0.2 ± 0.02 0.0 ± 0.02

No significant scale change for SLR or VLBI due to combination (< 0.1 ppb)

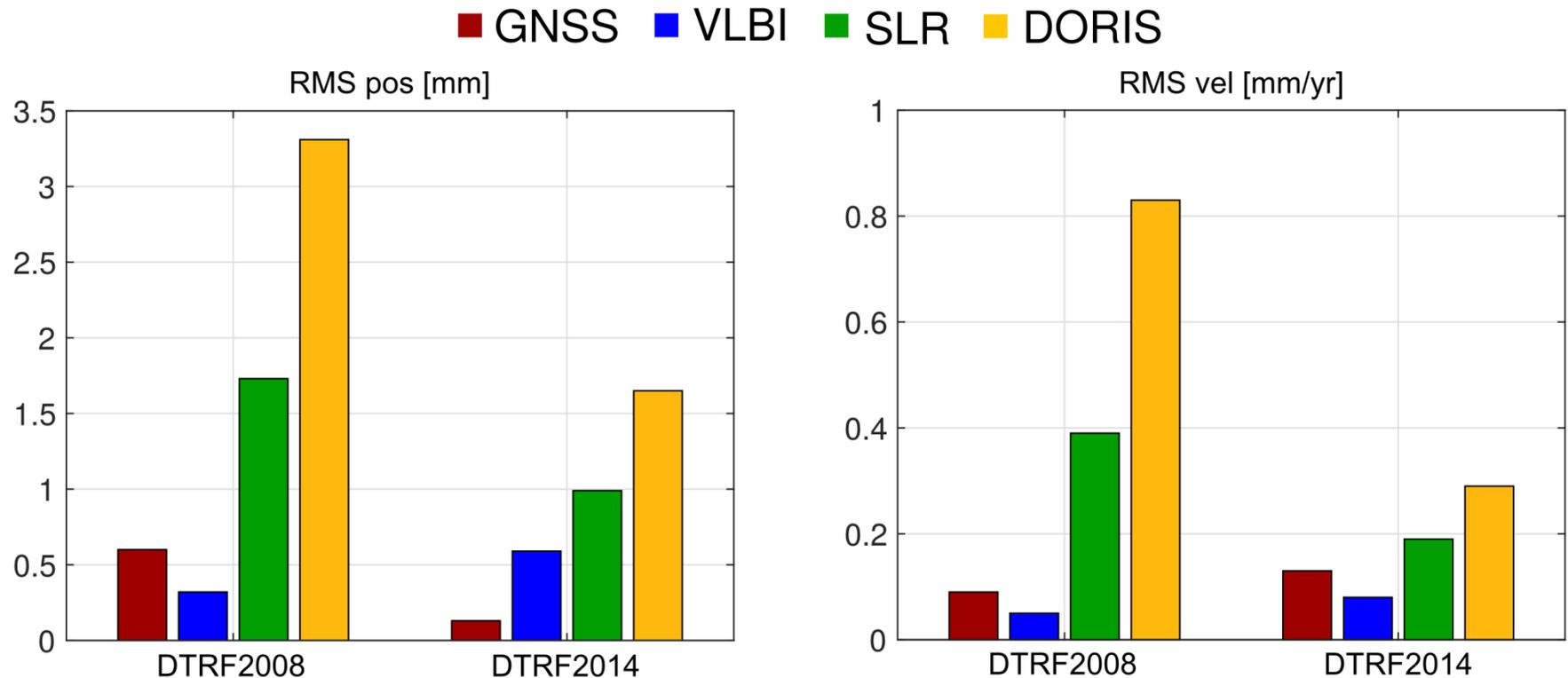
- indication for a good agreement between SLR and VLBI scale



DTRF2014 – Internal validation (2/2)

DTRF2008/DTRF2014
vs. single-technique

Helmert transformation w.r.t. single technique solutions
(aligned to DTRF2008, reference epoch 2000.0)



Deformation of network (RMS of Helmert transformation)

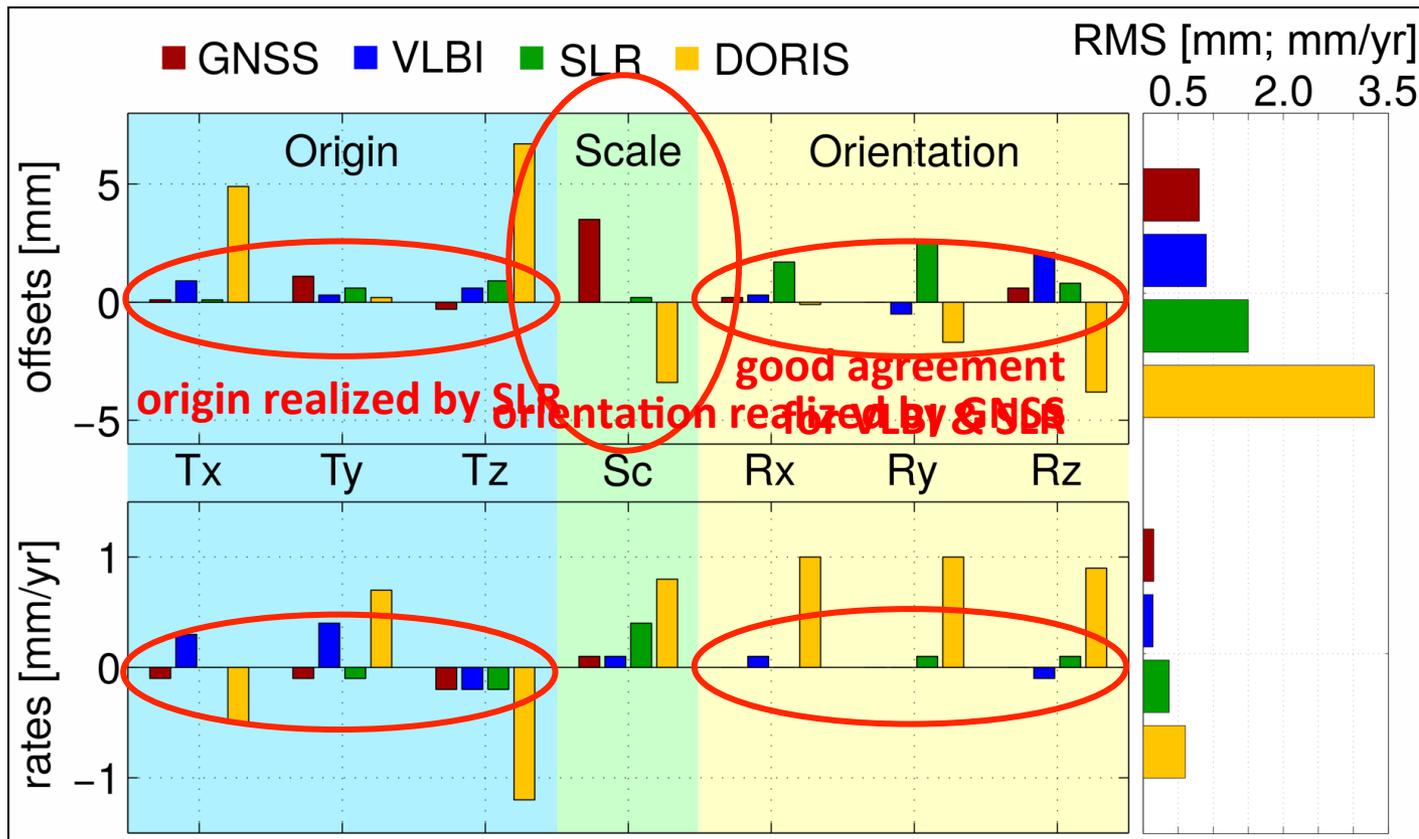
- The deformation caused by the combination is small for all techniques
- DTRF2014 shows smaller deformation than DTRF2008

DTRF2014 – External validation (1/2)

DTRF2014 vs. DTRF2008

Helmert transformation w.r.t. DTRF2008

(DTRF2014 orientation aligned to DTRF2008, reference epoch 2000.0)



Agreement with DTRF2008: GNSS < 1 mm (ignoring scale bias of 3.5 mm), VLBI/SLR < 2.5 mm, DORIS < 7 mm

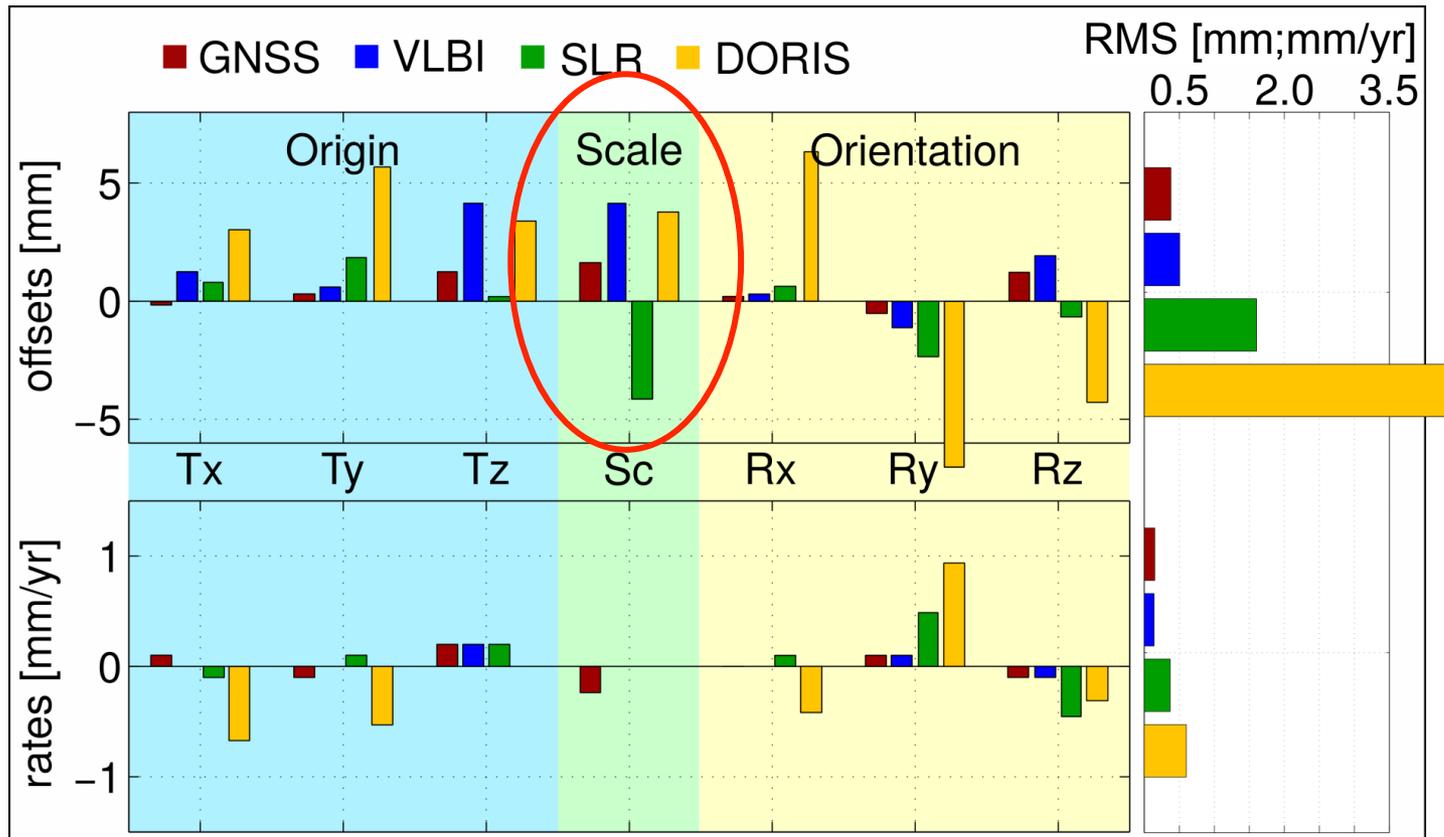
- Scale differences for GNSS (due to **albedo, antenna thrust?**) and DORIS: $\pm 3.4\text{mm}$

DTRF2014 – External validation (2/2)

DTRF2014 vs. ITRF2014

Helmert transformation w.r.t. ITRF2014

(DTRF2014 orientation aligned to DTRF2008, reference epoch 2000.0)



Agreement with ITRF2014: GNSS < 1.5 mm, VLBI/SLR < 3.5 mm, DORIS < 7.5 mm

➤ ITRF2014 scale difference between SLR and VLBI: 7 mm (about 1 ppb)

DTRF2014 – Open questions/suggestions to IGS

- Several ITRF2014 candidate stations do not meet TRF requirements
 - Stability of time series (high scatter, unstable monument, ...)
 - Availability of data (only few observations)
 - ITRS Combination Centers (CCs) need a lot of time to detect unsuitable stations
- Could the IGS provide a **list of stable and well-observed stations** which should contribute to the ITRF? Stations not meeting IGS standards could be reduced in the ITRF computation.
- Plenty of discontinuities (> 1400) split station position time series
 - Criteria for discontinuity significance?
 - High effort for ITRS CCs to set up discontinuity list
- Could the IGS maintain a **discontinuity list that is kept up-to-date** and that could serve as a basis for the ITRF computation?

DTRF2014 – Summary

- GNSS contribution essential for ITRS realization
 - Most inter-technique co-locations w.r.t. GNSS (about 80 %)
 - GNSS subnetwork used to realize the orientation (NNR condition)
- GNSS stations agree within 1.5 mm between different realizations and different Combination Centers
- GNSS TRF scale shows a bias of 3.5 mm between DTRF2014 and DTRF2008, probably due to albedo and antenna thrust (comparable to IGN results)
- **No significant scale bias between SLR and VLBI in DTRF2008/DTRF2014**

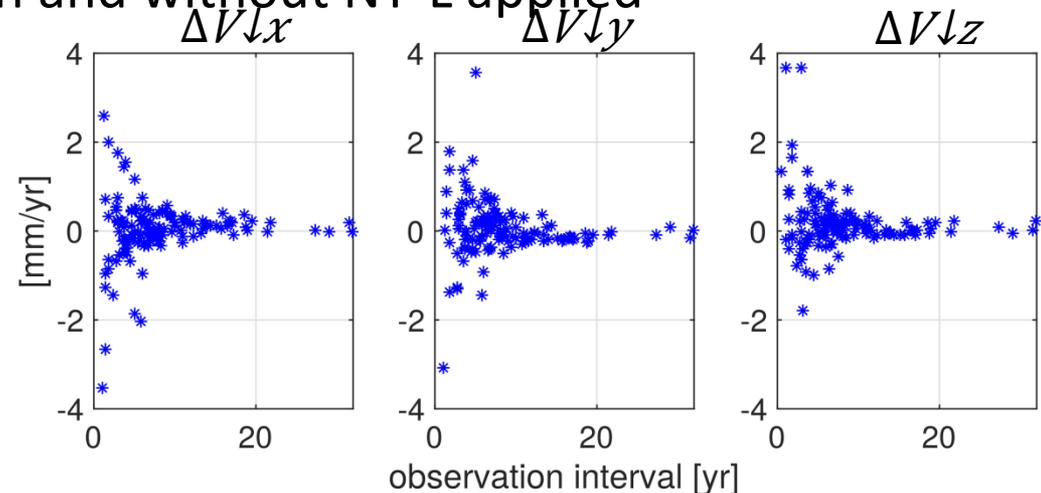
DTRF2014 – Outlook

Which DTRF2014 improvements can be expected from the consideration of non-tidal loading (NT-L)?

- General improvement of standard deviations (precision) for all parameters
- Benefit for the accuracy of station coordinates with short observation time spans (< 2.5 years)
- Decrease of the scatter (WRMS) of coordinate residual time series and EOP differences w.r.t. IERS 08 C04
- Example: **SLR-only solution** with and without NT-L applied

WRMS	x-pole [mas]	y-pole [mas]	LOD [ms]
without NT-L	0.1989	0.1919	0.0320
with NT-L	0.1970	0.1904	0.0319

w.r.t. IERS 08 C04



DTRF2014 – Outlook

Final DTRF2014 solution comprises:

- **Station coordinate (SSC) and EOP files**
- **SINEX files** for all techniques including EOP and the full variance/covariance matrix
- **Residual station position time series** that allow to derive the true position at epoch for all DTRF2014 stations
- **Loading time series** applied for the DTRF2014 computation

Validation of DTRF2014

- Further comparisons w.r.t. IGN and JPL solutions (stations and EOP)
- Manuela Seitz already provided SSC/EOP and SINEX files of conventional solution for validation (IAG Services)
 - Use of station coordinates and velocities (SSC, SINEX files)
 - In addition, use of consistently estimated EOP

The DTRF2014 and further information will soon be provided at
www.dgfi.tum.de

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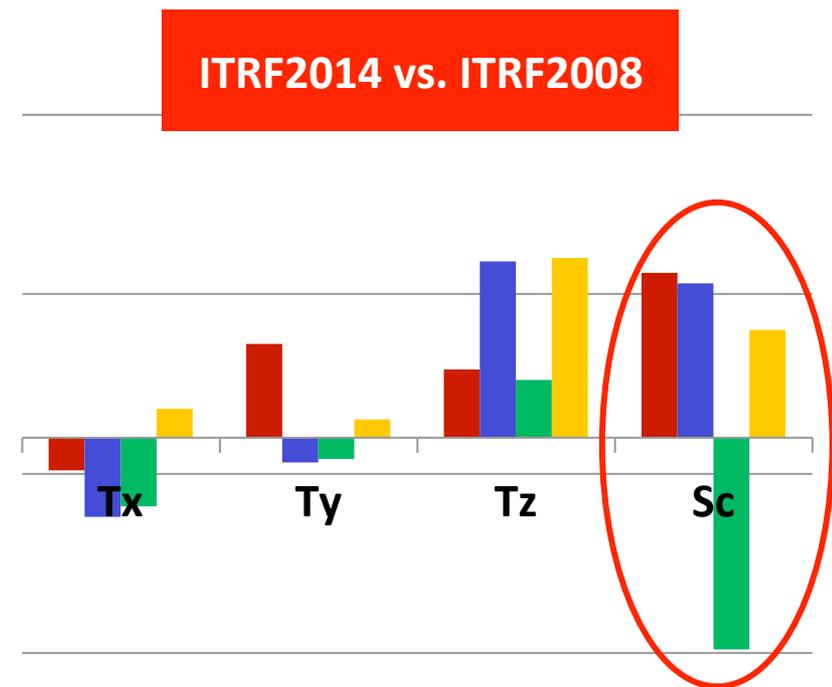
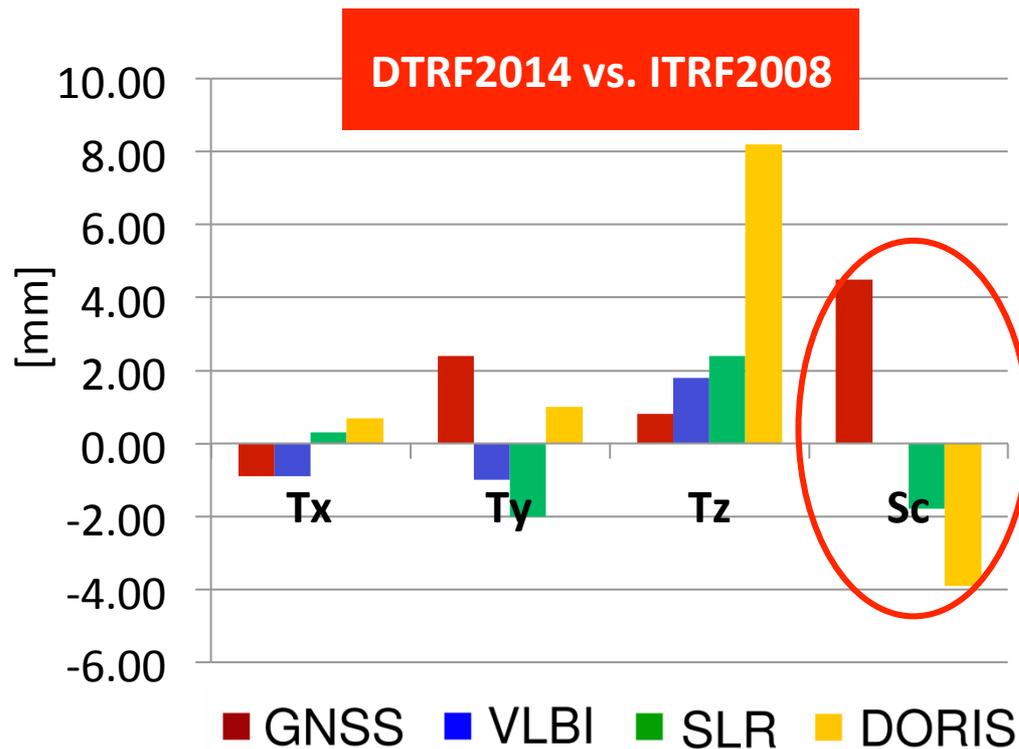
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DTRF2014 – external validation (3/3)

Helmert transformation w.r.t. ITRF2008

(DTRF2014 orientation aligned to DTRF2008, reference epoch 2000.0)



- DTRF2014 fits for some parameters better to ITRF2008 than ITRF2014
- Nearly no scale difference for DTRF2014 but for ITRF2014 w.r.t. ITRF2008!
- **This analysis shows that there is no significant scale difference between SLR and VLBI...**

DTRF2014 – Scale analysis

Helmert transformation w.r.t. DTRF2008

Three different comparisons to determine the agreement of the scale realized by SLR and VLBI

	Helmert transformation w.r.t. DTRF2008	Helmert transformation between SLR and VLBI via GNSS co-locations	Helmert transformation between VLBI and SLR via co-locations
VLBI subnetwork	-0.3 ± 0.16 mm 0.0 ± 0.04 mm/yr	0.3 ± 0.57 mm -0.2 ± 0.14 mm/yr (19 stations)	
SLR subnetwork	-0.3 ± 0.45 mm 0.3 ± 0.06 mm/yr	0.4 ± 0.61 mm 0.4 ± 0.11 mm/yr (13 stations)	
difference	0.0 ± 0.47 mm 0.3 ± 0.07 mm/yr	0.1 ± 0.78 mm 0.6 ± 0.17 mm/yr	0.7 ± 1.5 mm 0.5 ± 0.2 mm/yr (4 stations)

- The scale difference is small and not significant → VLBI and SLR scale can be combined.