Validation of components of local ties

Susanne Glaser[1,2], M. Fritsche[1,3], K. Sośnica[4], C. J. Rodríguez-Solano[5], K. Wang[6], R. Dach[4], U. Hugentobler[5], M. Rothacher[6], R. Dietrich[1]

[1]Technische Universität Dresden, [2]now at: Technische Universität Berlin, [3]now at: GFZ German Research Centre for Geosciences, [4]Universität Bern, [5]Technische Universität München, [6]ETH Zürich

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Outline

1. Introduction

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Reference frame as the realization of a reference system

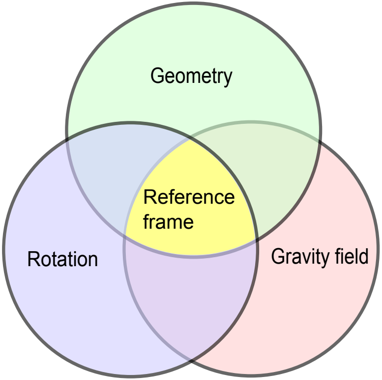

Figure: Reference frame as the connections of the three pillars of geodesy, according to IAG (2014)

Combination of different geodetic space techniques

GPS

DORIS

SLR

VLBI

Combination strategy

Combination of the different techniques

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- Local ties at co-located sites

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  - Inhomogeneous data base
  - IERS Working Group on Site Survey and Co-location

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- Pole coordinates as global ties (Seitz et al., 2012)

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  - IERS Working Group on Site Survey and Co-location
- Pole coordinates as global ties (Seitz et al., 2012)
- Our approach: combination of the pole coordinates and the degree-1 surface load coefficients (Blewitt, 2003), common origin of GNSS and SLR

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Data

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GNSS

- daily normal equation systems 1994 - 2010
- GPS and GLONASS
- 334 stations

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GPS, GLONASS and SLR

from a homogeneous reprocessing (Fritsche et al., 2014)

Station network

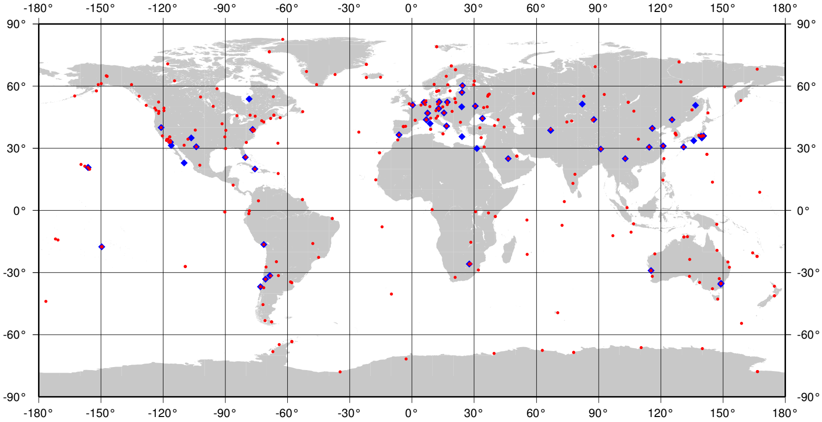

Figure: Globally distributed GNSS (red) and SLR (blue) stations

Preliminary analysis at station positions time series of all stations

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- Station events (jumps)
- Core stations for the definition of the geodetic datum

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- Elimination of position outliers
- Station events (jumps)
- Core stations for the definition of the geodetic datum
  - Selection according to the length and accuracy of the station position time series and the global distribution
  - Similar to IGS and ILRS solutions

Pole coordinates

Pole coordinates

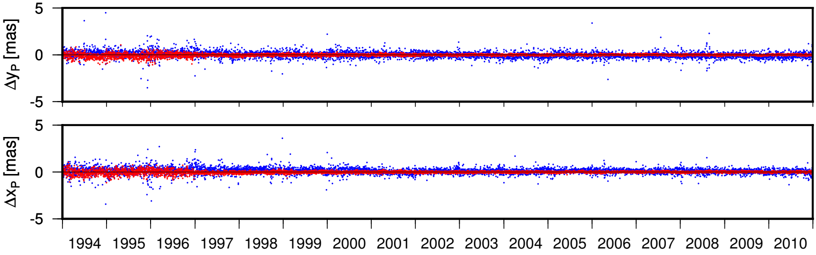

Figure: Differences Δx_P, Δy_P of estimated and "IERS 08 C04" pole coordinates

Offset, Trend	GNSS-only		SLR-only	
Δx_P	-0.04 mas	0.00 mas/a	0.14 mas	0.00 mas/a
Δy_P	-0.06 mas	0.00 mas/a	0.11 mas	0.00 mas/a

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$$\begin{aligned} \mathbf{N} &= w_{GNSS}\mathbf{N}_{GNSS} + w_{SLR}\mathbf{N}_{SLR} \\ \mathbf{n} &= w_{GNSS}\mathbf{n}_{GNSS} + w_{SLR}\mathbf{n}_{SLR} \end{aligned}$$

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$$\begin{aligned} w_{GNSS} &= 1 \\ w_{SLR} &= \frac{s^2_{GNSS}}{s^2_{SLR}} \cdot \frac{N^{mean}_{GNSS}}{N^{mean}_{SLR}} = 0.81 \end{aligned}$$

based on Thaller (2008)

Definition of the geodetic datum

Combination strategy

- Combination of the pole coordinates of GNSS and SLR
- Combination of the degree-1 surface load coefficients
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- Origin: GNSS and SLR observations
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  - NNR around the X, Y, Z axis for GNSS
  - NNR around the Z axis for SLR

temporal change: NNR around the X, Y, Z axis for GNSS

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$\rightarrow$ minimum constraint solution

Estimation of components of the local ties

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Strategy

- a priori positions and velocities
  - $\Delta\mathbf{X}^{LT} = \mathbf{X}^{LT}_{SLR} - \mathbf{X}^{LT}_{GNSS}$
  - same velocities for the LT stations

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Result

$$\delta \mathbf{X} = (\mathbf{X}^{est}_{SLR} - \mathbf{X}^{est}_{GNSS}) - \Delta \mathbf{X}^{LT}$$

Local Ties

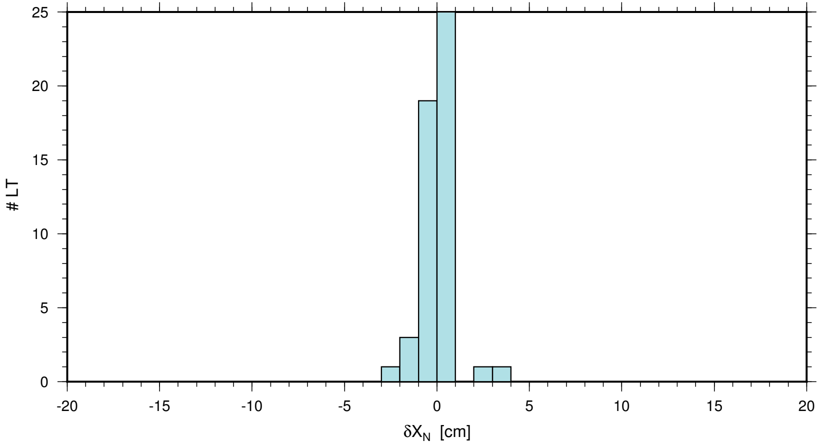

Figure: Histogram of differences δX_N [cm] in the north component of estimated and measured local ties.

Local Ties

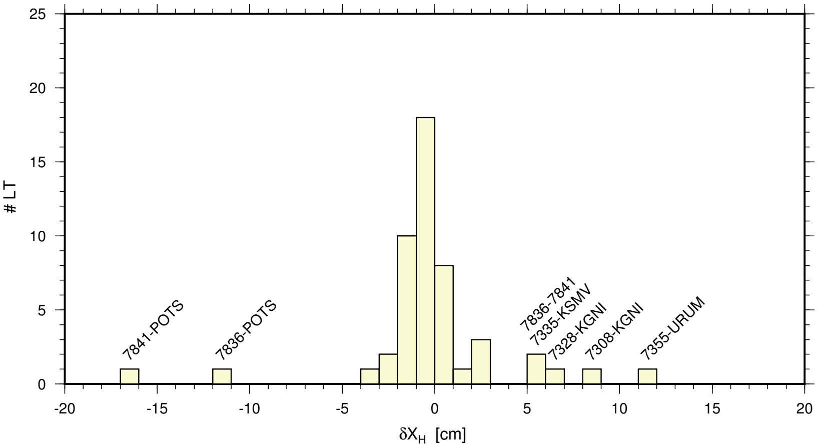

Figure: Histogram of differences δX_H [cm] in the height component of estimated and measured local ties.

Effect of the measured local ties

Effect of the measured local ties

Using a 14-parameter Helmert transformation

- between the single-technique solutions
  - GNSS: $\mathbf{X}^{est}_{GNSS}$
  - SLR + LT: $\mathbf{X}^{est}_{SLR} + \Delta\mathbf{X}^{LT}$

Transformation parameters of a 14-parameter Helmert transformation

GNSS				SLR + LT	
T_X	[mm]	$\dot{T}_X$	[mm/a]	1,76	-0,38
T_Y	[mm]	$\dot{T}_Y$	[mm/a]	-16,51	0,39
T_Z	[mm]	$\dot{T}_Z$	[mm/a]	3,20	-0,14
R_X	[masec]	$\dot{R}_X$	[masec/a]	0,031	-0,012
R_Y	[masec]	$\dot{R}_Y$	[masec/a]	0,382	-0,007
R_Z	[masec]	$\dot{R}_Z$	[masec/a]	-0,147	0,005
m	[mm/km]	$\dot{m}$	[mm/km/a]	-0,00064	-0,00025

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- **Differences** between estimated and measured local ties: 88% in north, 52% in height component below 1 cm.
- **Translation** in direction of Y and **rotation** of the network around Y by using all measured local ties.

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- **Combination** of GNSS and SLR with **minimum constraint** conditions.
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- **Translation** in direction of Y and **rotation** of the network around Y by using all measured local ties.

$\rightarrow$ Combination of different geodetic space techniques to realize a global terrestrial reference system in the framework of GGOS.

Thank you very much for your attention.

susanne.glaser@tu-berlin.de

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Definition of core stations

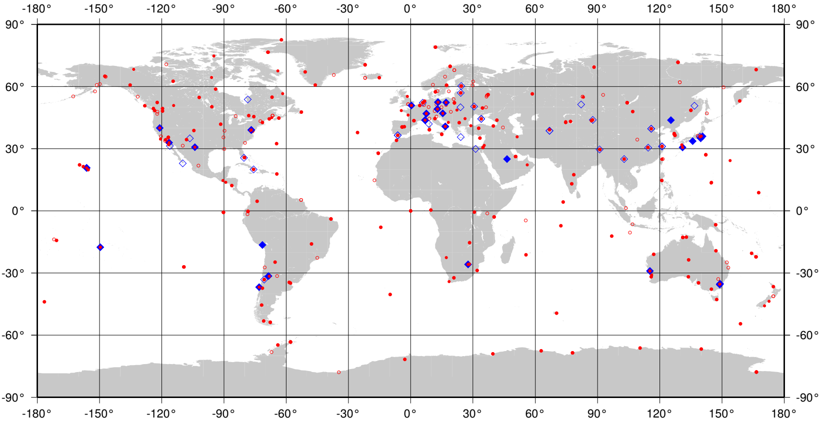

Figure: Definition of core stations (filled symbol) of the GNSS (red) the SLR (blue) network

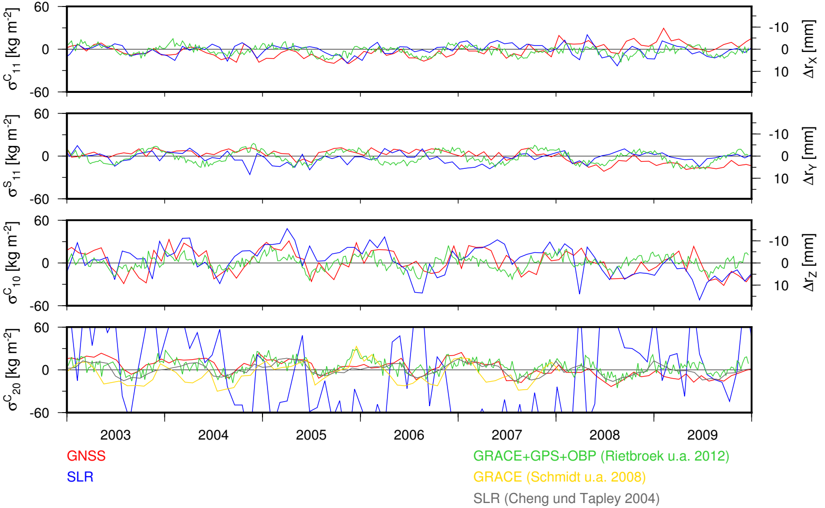

Figure: Surface load coefficients and difference of CF w. r. t. CM

Modeling of surface loads (Blewitt, 2003)

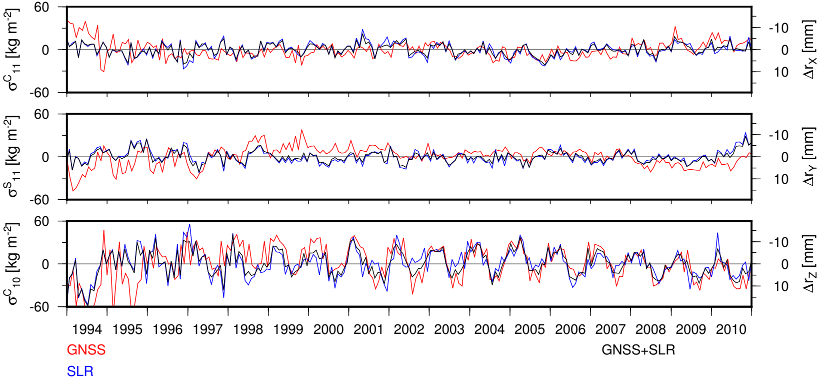

Figure: Degree-1 surface load coefficients $(\sigma^C_{10}, \sigma^C_{11}, \sigma^S_{11})$ (left) and differences $[\Delta \mathbf{r}_{CF}]_{CM}$ (right)

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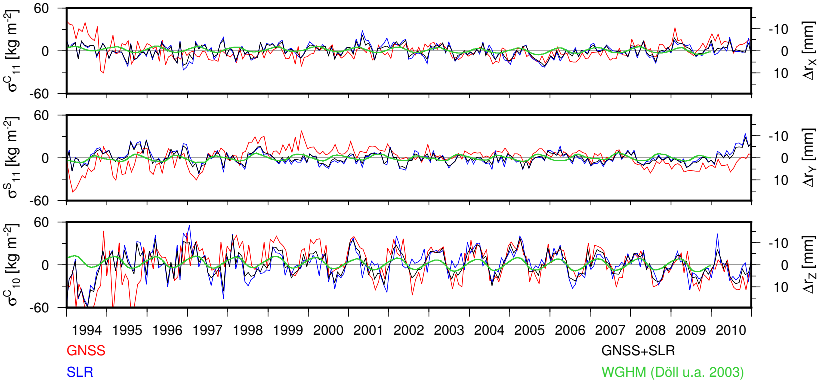

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