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Realisierung des terrestrischen Referenzsystems

D. Angermann, M. Krügel, B. Meisel, H. Drewes

Deutsches Geodätisches Forschungsinstitut, München
E-Mail: angermann@dgfi.badw.de

ITRF – Introduction and Overview

- IERS Terrestrial Reference Frame Section, IGN Paris generated a series of ten realizations (ITRF88, ..., ITRF2000)
- IERS Structure (since 1.1.2001, related to ITRS products):

  - ITRS Product Center (IGN, Paris)

  - ITRS Combination Centers (DGFI, IGN, NRCan)
- Strategy (up to now):

  Combination of **multi-year solutions** of different space techniques containing station positions and **constant** velocities
- Latest official IERS realisation: ITRF2000 (Altamimi et al., 2002)
- TRF realisation 2003 of DGFI (Angermann et al., 2004)

IERS Terrestrial Reference Frame Realizations

	Stationen	Lösg.: VLBI	SLR	GPS	DORIS	Gesamt
ITRF 88	120	5	6	-	-	11
ITRF 89	113	6	8	-	-	14
ITRF 90	120	4	7	-	-	11
ITRF 91	131	5	7	1	-	13
ITRF 92	155	5	6	6	-	17
ITRF 93	160	6	4	5	-	15
ITRF 94	209	6	1	5	3	15
ITRF 96	290	4	2	7	3	16
ITRF 97	309	4	5	6	3	18
ITRF 2000	477	3	9	6 + 8*	3	21 + 8*

*: regionale GPS Lösungen

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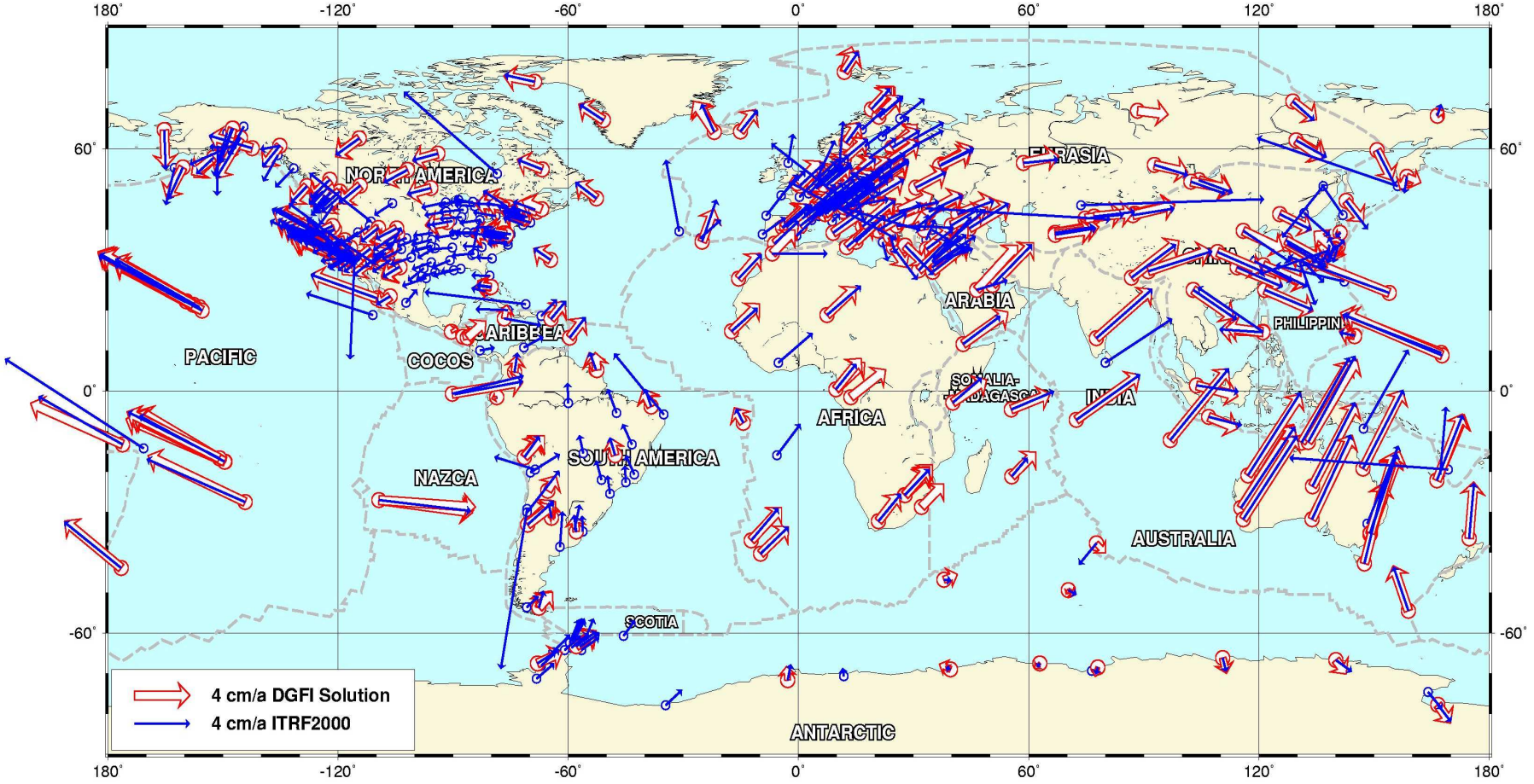
ITRF 2000 – Some remarks

- ITRF2000 (http://lareg.ensg.ign.fr/ITRF/ITRF2000):
  - 21 global solutions (VLBI, SLR/LLR, GPS, DORIS)
  - 8 regional GPS solutions (e.g. EUREF)
  - 477 sites with positions (1997.0) and constant velocities
- Combination of multi-year techniques‘ solutions by simultaneously estimating Helmert-transf. parameters
  Problem: (unremoved) constraints in the solutions !
- Realization of ITRF2000 datum
  - Origin (geocentre): SLR
  - Orientation: NNR condition w.r.t. past ITRF‘s (BIH, 1984)
  - Scale: VLBI and SLR
  - kinematic datum: geophysical model NNR NUVEL-1A

TRF computation at DGFI

- Analysis and validation of input data (multi-year solutions)
  - VLBI: DGFI, GIUB, GSFC, SHA
  - SLR: CRL, CSR, DGFI, JCET
  - GPS: combined IGS solution (NRCan, Ferland)
  - DORIS: IGN, GRGS
- Generation of unconstrained normal equations
- Combination with DGFI software DOGS-CS
  - Intra-technique combination (VLBI, SLR, DORIS)
  - Inter-technique combination (e.g. local tie implementation, equating velocities at co-location sites, datum definition, ...)
- Combined solution: TRF realization 2003

Station velocities of DGFI solution compared to ITRF2000



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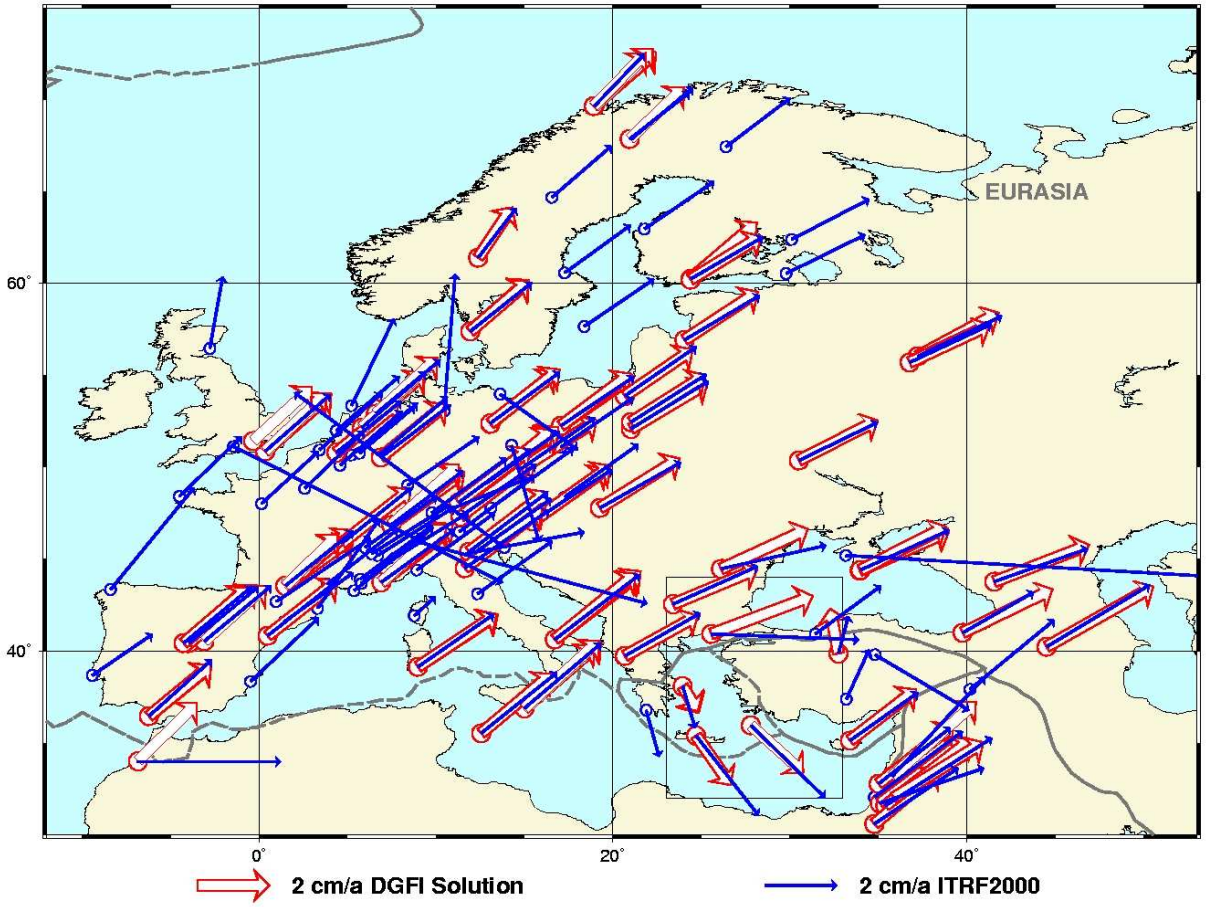
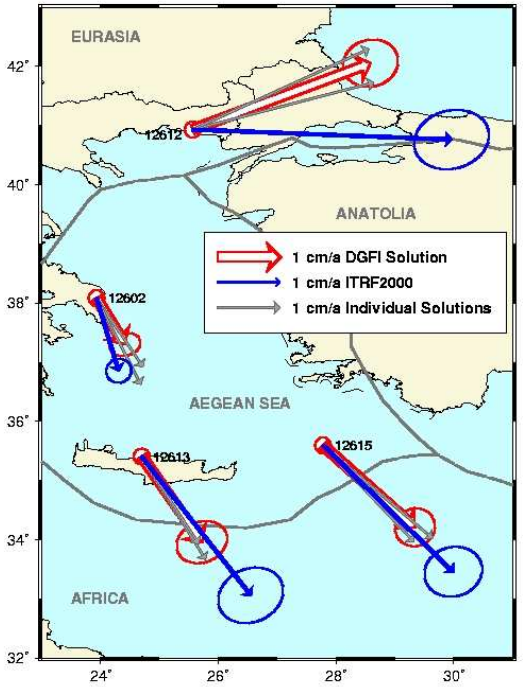
Horizontal station velocities (Europe)
ITRF2000 – TRF (DGFI2003)





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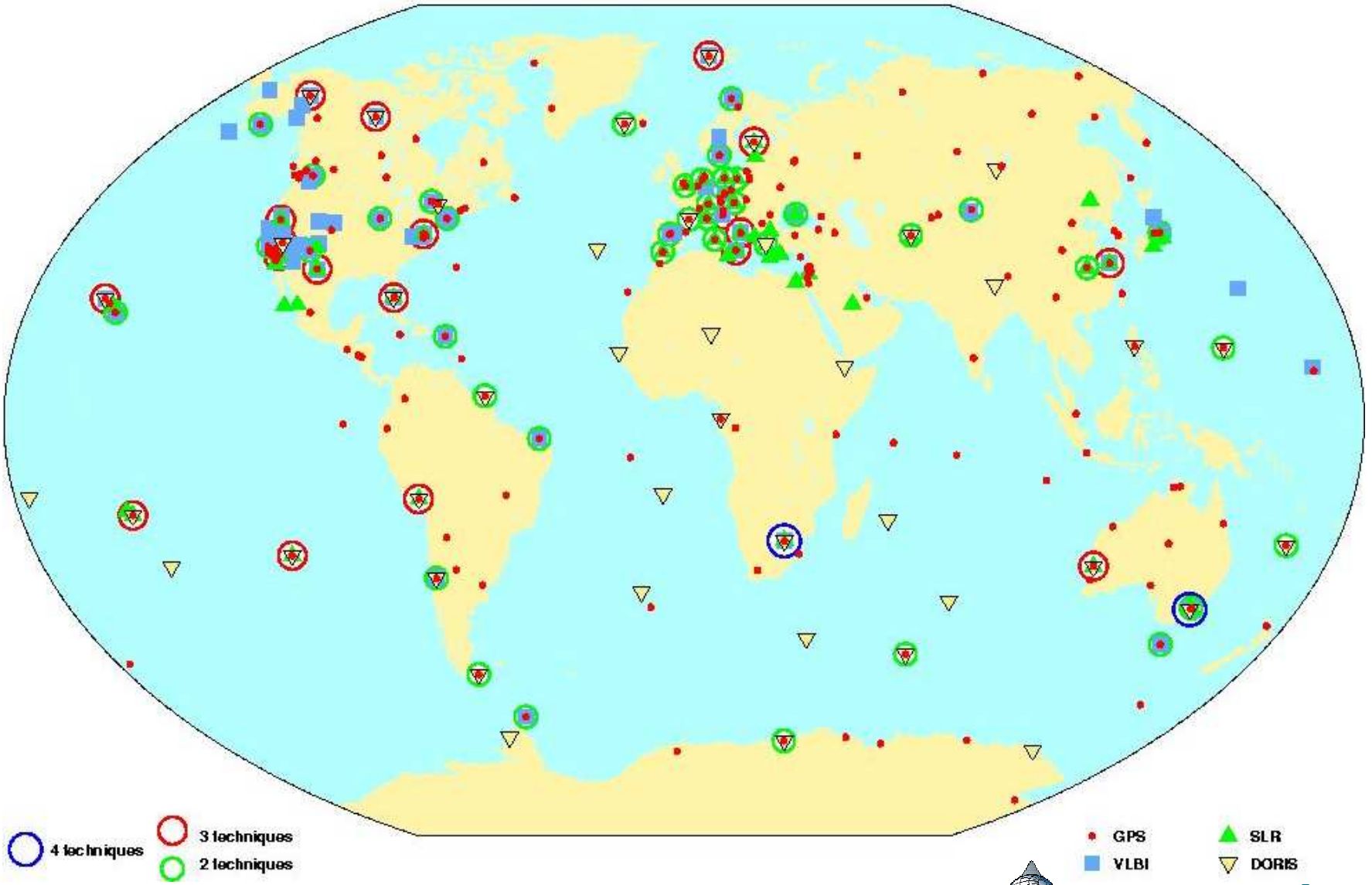
Comparison: ITRF2000 – TRF (DGFI2003)

3-D differences for 369 common stations
(VLBI, SLR, GPS, DORIS)

Δ Positions:	
< 1 cm	= 57 %
1 – 5 cm	= 35 %
> 5 cm	= 8 %

Δ Velocities:	
< 2.5 mm/a	= 55 %
2.5 – 10 mm/a	= 36 %
> 10 mm/a	= 9 %

Co-location Sites



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TRF validation: Comparison at co-location sites

		GPS – VLBI	GPS – SLR	SLR – VLBI	P/R/L – DORIS
# co-locations (missing local ties)		33 (5)	28 (6)	11 (2)	24 (1)
3-D pos. differences local ties – TRF sol.	< 5 mm	8	6	1	-
	5 – 20 mm	10	8	2	3
	> 20 mm	10	8	6	20
3-D vel. differences of co-located techn.	< 1 mm/yr	5	2	1	-
	1 – 5 mm/yr	17	19	3	10
	> 5 mm/yr	11	7	7	14

Source: TRF computation 2003, DGFI

Possible reasons for discrepancies at co-location sites, e.g.:

- Systematic biases between techniques
- Remaining inconsistencies of datum definition
- Local site effects (e.g. different motions of co-located instruments)
- Errors (uncertainties) in local tie measurements

→ Separation of these effects is difficult !!!

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Comparison at co-location sites

Results for „high quality“ co-location sites: Differences between space geodetic solutions and local tie measurements

Co-location sites	Techniques	Differences between ties and solutions [mm]			Differences in velocities [mm/yr]		
		Δ φ	Δ λ	Δ h	Δ φ	Δ λ	Δ h
Wettzell, Germany	GPS-VLBI	-0.0	-0.8	3.7	0.2	0.0	0.8
Mauna Kea, USA	GPS-VLBI	-1.5	-4.8	1.3	-0.1	-0.7	1.9
North Liberty, USA	GPS-VLBI	-1.7	-2.9	-2.0	-0.8	-0.5	2.2
Potsdam, Germany	GPS-SLR	2.8	1.7	-2.8	0.2	-0.0	0.3
Graz, Austria	GPS-SLR	3.6	-0.2	1.8	-0.0	-0.4	0.8
Yarragadee, Austr.	GPS-SLR	-1.2	0.6	-3.1	0.8	-0.9	0.5

Deficiencies / Recommendations

- TRF input data: problem with **unremovable constraints**
  ➔ Submission of **unconstrained normal equations**
- **Systematic biases** between techniques and solutions are a major error source in TRF computations
- Non-linear site motions (e.g. seismic effects, seasonal variations) are in conflict with **constant** station velocities
  ➔ Analysis of site position time series

➔ **Refined approach** for TRF computation required

Summary / Outlook

- Current TRF realizations do not reflect the high accuracy of the space geodetic observation techniques
- Biases between techniques and not considered non-linear site motions are major error sources
- Analysis of time series and first TRF computation (1999-2004) based on „weekly“ input data (Präsentation: B. Meisel)
- IERS Call for submission of long time series of weekly (daily) SINEX files with positions and EOPs (draft version !)
  1. ITRF2004 computation by ITRS Combination Centres
  2. IERS Combination Pilot Project (ITRF + EOPs + ICRF)