

ITRF2004 computations at DGFI

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ITRF2004: New concept

- Input: Time series of station positions
(daily: VLBI; weekly: SLR, GPS and DORIS)
and daily Earth Orientation Parameters
- Requested data (types of solicited solutions):
 - A: Intra-technique combined solutions from TCs
 - B: Individual solutions from ACs
 - C: Solutions combining various techniques at the obs. level
- Constraint categories:
 - Free normal equations
 - Loosely constrained solutions
 - Solutions with minimum constraints
 - Solutions with removable constraints

ITRF2004: Input data

(Status October 7, 2005)

- Combined set of time series per technique (TCs)
 - GPS (NRCan): 1996-2004 (updated until July 2005)
BUT: EOPs before June 1999 not available
 - VLBI (GIUB): 1984-2004 (new version ready)
 - SLR (ASI): 1993-2004 (new version in Nov. 2005)
- Individual solutions from ACs
 - DORIS (3 ACs: IGN, LCA, INA) 1993-2004
 - VLBI, SLR, GPS: some AC submissions (for validation ?)
- No multi-technique solution at obs. level submitted
- Co-location tie vectors (recently updated by IGN)
- Discontinuity tables for station positions provided by TCs

Computation methodology at DGFI

- General concept: Combination of normal equations and common adjustment of station positions, velocities and EOPs
- Software: DOGS
- Processing procedure:
 - Validation and pre-processing of input data (e.g., datum characteristics, rank defect analysis, constraints removal, ...)
 - Time series analysis and accumulation of epoch normal equations per technique
 - Intra-technique combination in the case of DORIS (IDS ?)
 - Combination of different techniques (e.g., local tie implementation, weighting, equating station velocities, applying minimum datum)
 - ITRF2004 solution (positions, velocities and EOPs)

Status of ITRF2004 computations at DGFI

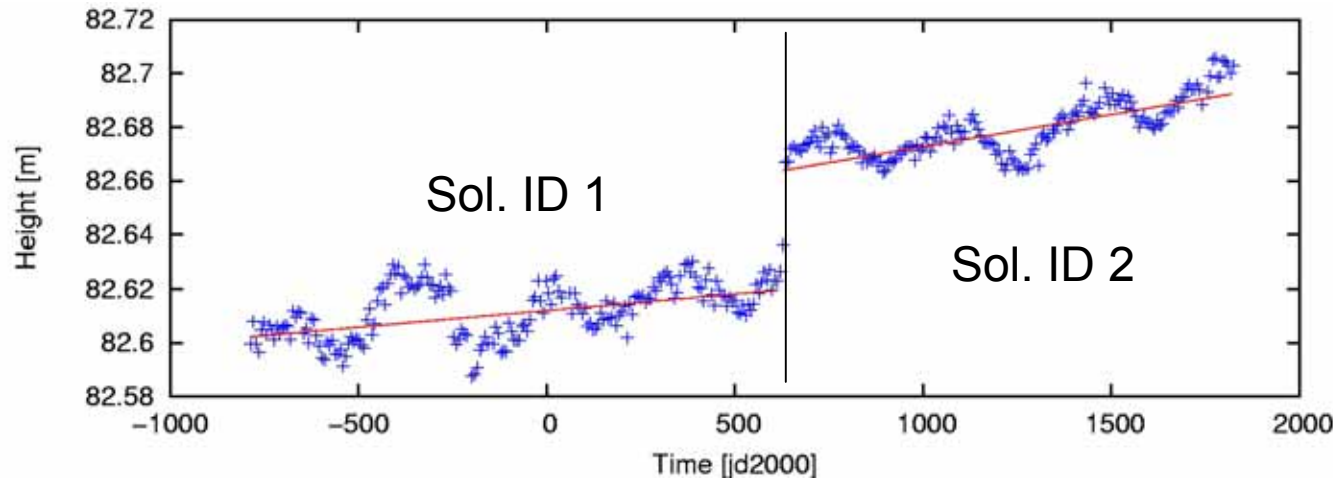
- Analysis of ITRF2004 input data (feedback to TCs)
- Time series analysis and accumulation per technique
 - GPS: Combined solution ready (data until end of 2004)
comparisons with IGN and NRCan
 - VLBI: Test computations, new input data will be provided by IVS
 - SLR: Test computations, new input data will be provided by ILRS
 - DORIS: Accumulation of individual solutions and intra-technique
combination under work
- Inter-technique combination: Test computations, advanced
methods are developed for ITRF2004 solution

GPS intra-technique combination

- Input: Weekly SINEX solution files (positions and daily EOPs)
- Reduction of a priori datum by setting up Helmert-transformation parameters (translation, rotation and scale)
- Accumulation of weekly (**singular !**) normal equations (using the table with discontinuities from the IGS)
 - Poorly observed GPS stations are excluded (data < 2.5 years)
 - Analysis of time series solutions, e.g., to identify additional jumps
- Combined GPS solution with positions, velocities and daily EOPs (velocities for different solution numbers are not equated)

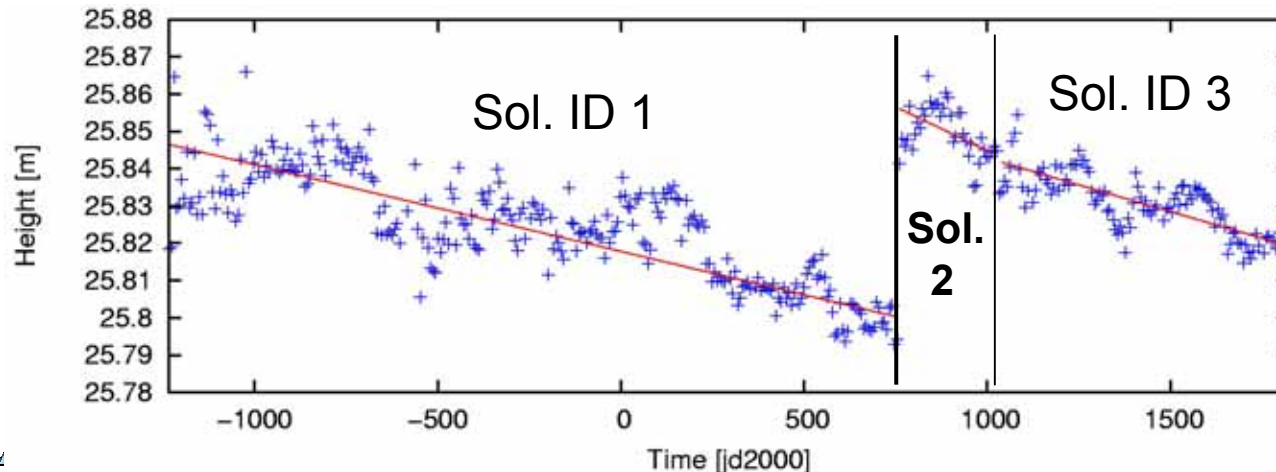
GPS position time series and velocities

Expl. 1: Position time series of GPS station HOFN, Iceland



Sol. ID	Velocities [mm/yr]
1	4.5 ± 1.4
2	8.7 ± 1.1
$\Delta 2-1$	4.2 ± 1.8

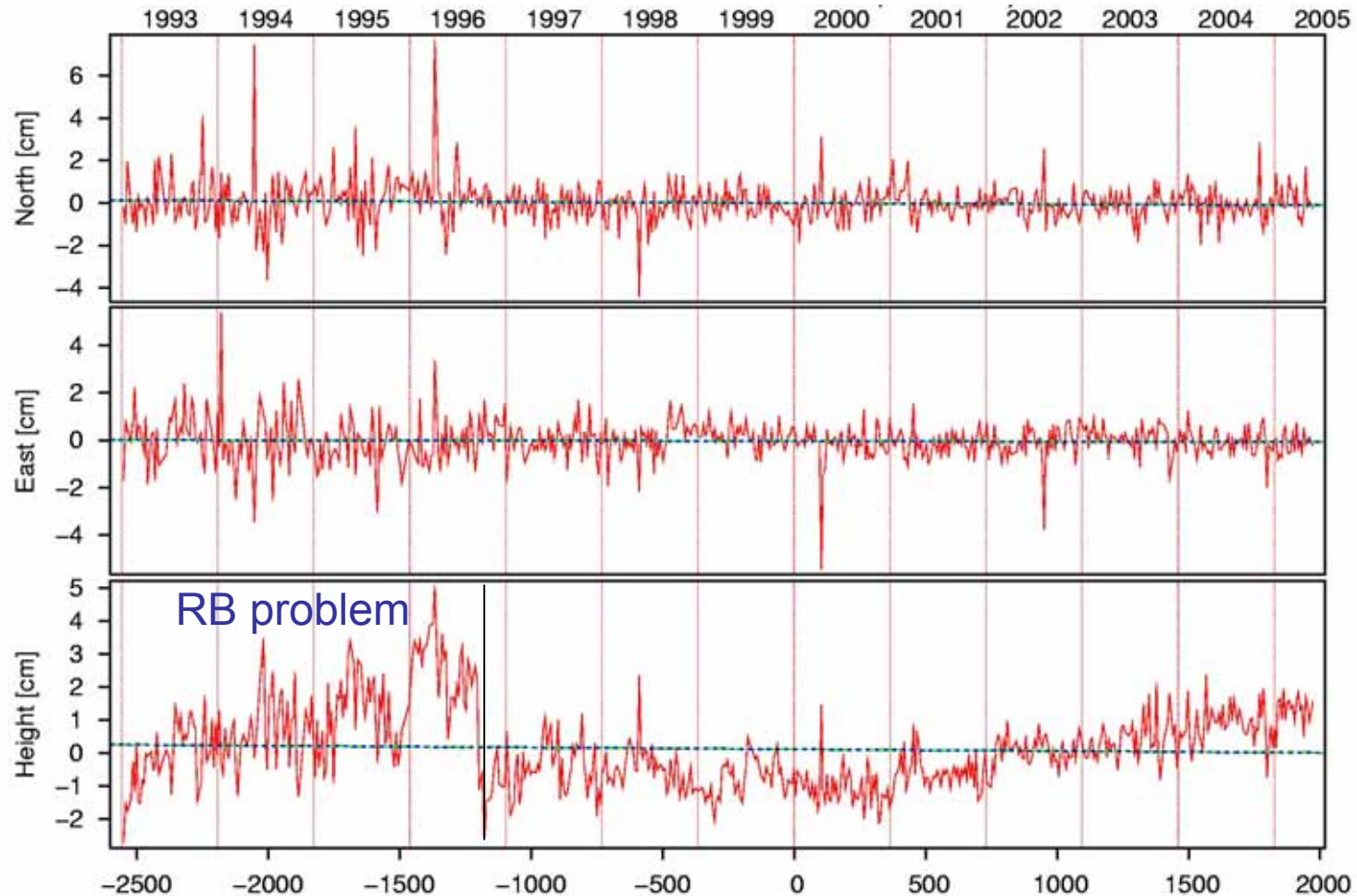
Expl. 2: Position time series of GPS station WUHN, China



Sol. ID	Velocities [mm/yr]
1	-8.5 ± 1.5
2	-17.0 ± 12.5
3	-10.5 ± 3.1

SLR: Combined ASI solutions (v3)

Example: Position time series of SLR station Graz, Austria



Weighting of techniques

- Variance component estimation within inter-techn. combination
- Alternative method: Using the time series solutions per technique
 - > Repeatability of station position estimates

Technique	TC / AC	North [mm]	East [mm]	Height [mm]
GPS	IGS	0.22	0.26	0.64
VLBI	DGFI	0.53	0.52	1.5
DORIS	IGN/JPL	2.7	3.7	2.5
SLR	DGFI	3.1	3.6	2.7

VLBI: daily session solutions, other technique solutions are weekly

ITRF2004 inter-technique combination

- **New approach:** Simultaneous estimation of the TRF and EOPs
- EOPs serve as a „global tie“ between different techniques
 - eliminates 4 degrees of freedom (rotation about x and y, and their rates)
 - stabilize the inter-technique combination
- EOPs provide valuable information to validate local tie selection (see Poster Krügel et al.: Improved consideration of local ties in inter-technique combinations)



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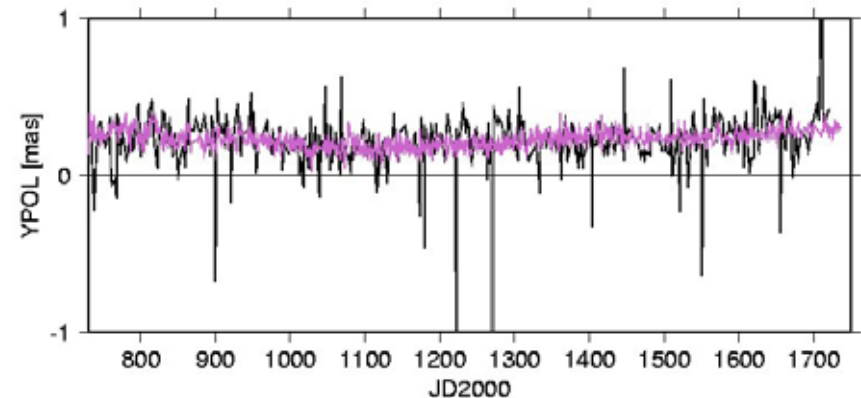
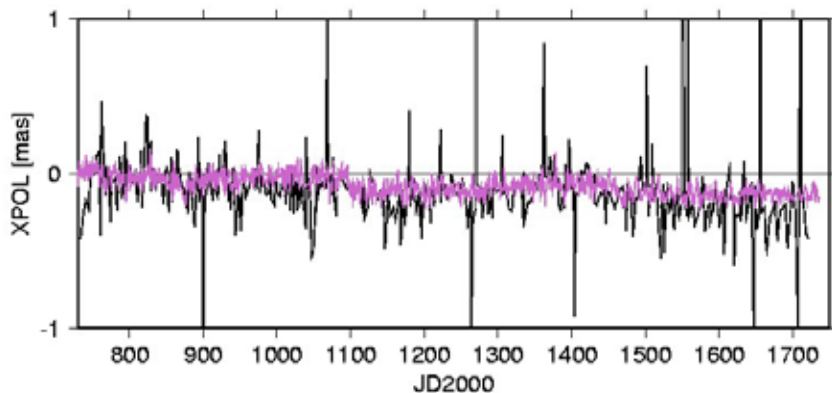


Validation of local ties using EOPs

Example: Combination of GPS and VLBI solutions

Solution type	Pole offsets [mas]	
	xp	yp
Single techn. solutions	-0.090	0.143
17 ties used	0.057	0.085
9 good ties used	0.004	0.035

	xp [mas]	yp [mas]
RMS_{GPS}	0.06	0.05
RMS_{VLBI}	0.18	0.17
Offset	0.004	0.035



Comparison of GPS solutions among ITRS Combination Centers

RMS differences for station positions and velocities

(subset of about 65 IGS reference frame stations without discontinuities)

ITRS CCs	RMS differences Positions [mm]			RMS differences Velocities [mm/yr]		
	Latit.	Long.	Height	North	East	Height
DGFI – IGN	0.70	0.62	1.89	0.34	0.32	0.56
DGFI - NRCan	0.89	0.84	1.22	0.39	0.38	0.46
IGN – NRCan	0.91	0.83	1.56	0.38	0.42	0.54

Comparison of GPS solutions (II)

Comparison of EOPs between IGN and DGFI

Parameter	Offset	RMS Difference (Offset removed)
xpole	9.7 μas (0.3 mm)	2.8 μas (0.09 mm)
ypole	3.2 μas (0.1 mm)	4.1 μas (0.13 mm)
xpole rate	0.0 $\mu\text{as/yr}$	1.6 $\mu\text{as/yr}$
ypole rate	0.0 $\mu\text{as/yr}$	1.6 $\mu\text{as/yr}$

Conclusions

- New strategy has major advantages
 - Consistency between TRF and EOPs
 - Insight into individual space geodetic solutions
 - Identification and resolving remaining problems
 - Parameterization of non-linear site motions
- But, the new procedure has to be well established and requires a perfect data and information flow among the groups involved (e.g., CB, TCs, ACs, CCs)
-> ITRF2004 e-mail exploder ?
- First results are promising, e.g, comparisons among ITRS Combination Centers (IGN, NRCAN, DGFI)
- To finalize the ITRF2004 solution, it is important that the official ITRF2004 input data for all techniques become available very soon

Some open questions

- How to handle different solution IDs on a station ?
 - Equating station velocities (statistical tests !)
 - Introducing new positions (only in the case of significant jumps)
 - Realistic standard deviations are necessary !
- What are the requirements for stations to be included in the final ITRF2004 solution (e.g., data > 2.5 years) ?
- Time span of data to be included ?
 - GPS: 1996 – 2004 (update until July 2005,
EOPs since June 1999)
 - SLR: 1993 – 2004
 - VLBI: 1984 – 2004 (2005 ?)
 - DORIS: 1993 – 2004
- How to generate the official ITRF2004 (ITRF2005 ?) from the three ITRS Combination Center solutions ?



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