Impact of a consistent realization of the ITRS and ICRS on source positions

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Abstract

So far, the realizations of the ITRS and ICRS are performed separately by different processing centres. The ITRS is realized from a combination of the four space geodetic techniques VLBI, SLR, GNSS and DORIS. Since VLBI is unique for observing extragalactic radio sources, only this technique is used for the realization of the ICRS. Due to the individual computation, the two realizations (ITRF and ICRF) are not fully consistent. Inconsistencies exist with respect to the datum and the geometry of the VLBI station network and with respect to the related Earth Orientation Parameter (EOP) time series.
Full consistency for the two realizations can be reached if they are computed simultaneously together with the EOP in a common adjustment by combining the four space geodetic techniques. We compute such a TRF-CRF solution using long time series of homogeneously processed data of VLBI, SLR and GNSS until 2007.
Even, if the positions of the radio sources are observed by VLBI only, an impact of the consistent realization of ITRS and ICRS on the Celestial Reference Frame (CRF) has to be expected. It is shown, that the impact is twofold: on the one hand, the combination of the station networks has a systematic but not significant effect on the CRF, on the other hand, the combination of the EOP series leads to changes in the positions and standard deviations of primarily sources observed in regional sessions only.

Simultaneous realization of ITRS and ICRS

ITRS and ICRS can be realized consistently by a simultaneous adjustment of both frames and the linking EOP as shown in Figure 1. The datum of the CRF-TRF solution is realized taking into account the types of conditions applied for the individual realizations performed today (see Figure 1).

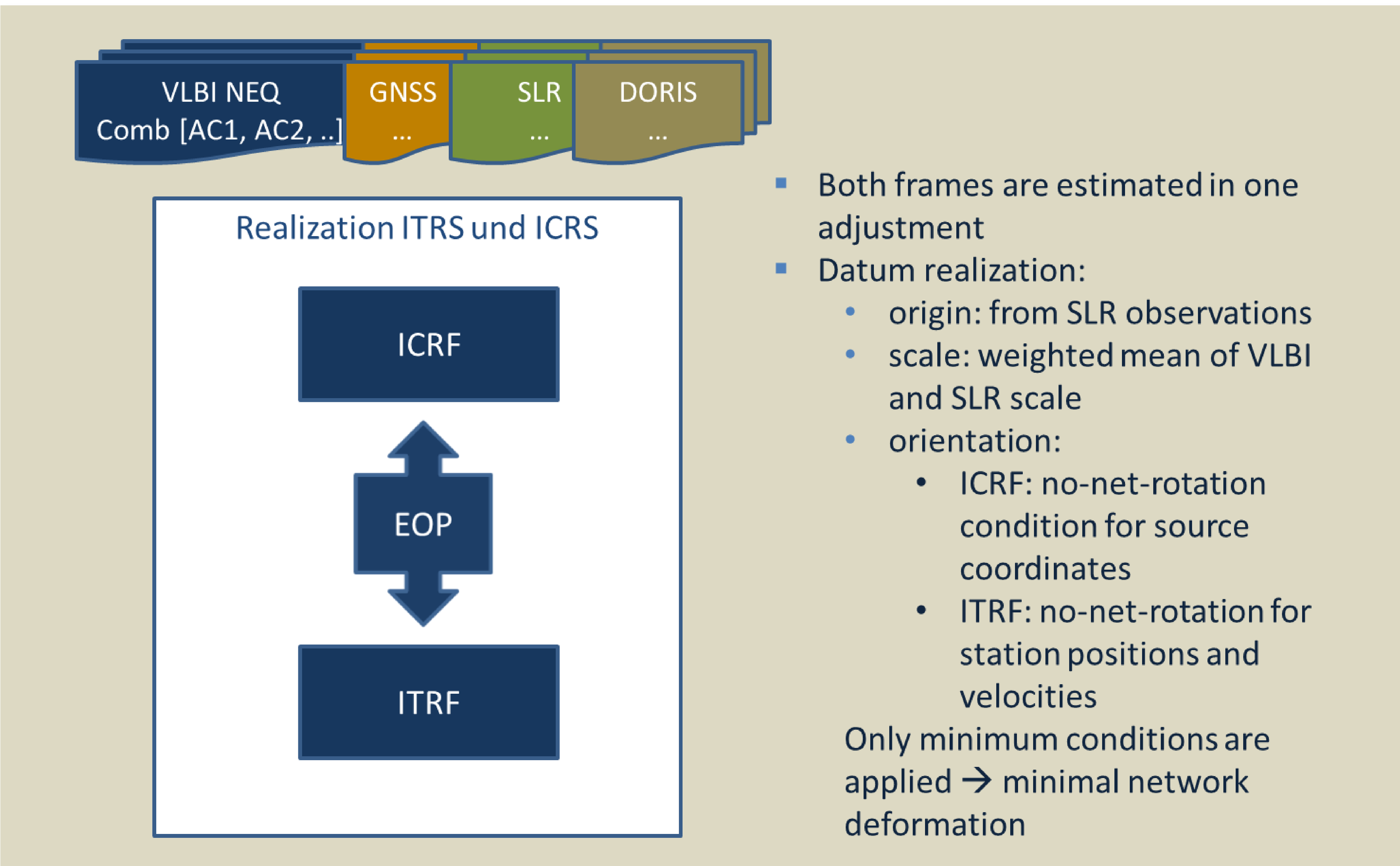


Figure 1: Simultaneous realization of ITRS and ICRS.

What can be expected from a simultaneous adjustment?

- Consistency between all parameters
- Improvement of station coordinates and EOP due to the combination (see ITRF, IERS C04 series)
- Effects on the CRF (source positions and their standard deviations) due to the combination of station coordinates and EOP (hypothesis: the CRF can benefit from a simultaneous adjustment)

CRF-TRF solution

The CRF-TRF solution computed at DGFI is based on time series of normal equations (NEQ) resulting from the analysis of VLBI, SLR and GPS observations, respectively. The NEQ are constraint-free regarding the datum parameters. Table 1 gives an overview about the input data. Table 2 gives a summary of the geodetic parameters which are solved directly (≈ 45.000) or indirectly (datum parameters) in the CRF-TRF solution.

Table 1: Input data used for the CRF-TRF solution

	Period	Resolution	Institution
VLBI	1984-2007	session-wise (24 h)	combined: IGG+DGFI
GPS	1994-2007	daily	GFZ
SLR	1993-2007	weekly	DGFI

Table 2: Parameters included in the CRF-TRF solution: "x" means that the parameter is provided by the space technique, "(x)" means that only information about the parameter rates is provided.

						Indirect Parameters	
	Station coord.	Source coord.	Pole	Nuta-tion	UT1-UTC	Origin	Scale
VLBI	x	x	x	x	x		x
GPS	x		x	(x)	(x)		
SLR	x		x		(x)	x	x

Figure 2 shows the distribution of radio sources included in the solution. The blue-coloured sources are observed by global VLBI station networks, the magenta-coloured ones are observed in VLBA Calibrator Survey Sessions (VCS sessions) by the VLBA station network (see Figure 3) solely. More than 50% of the CRF sources are VCS sources.

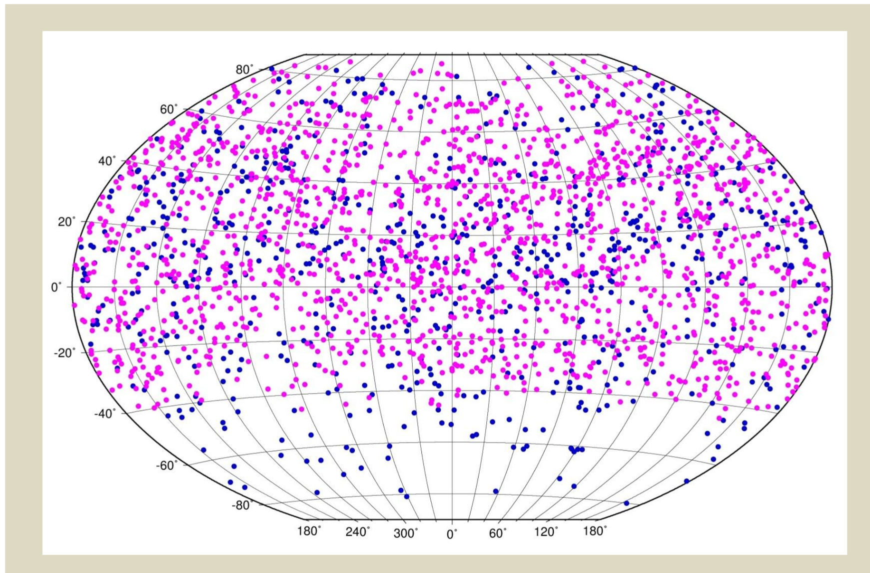


Figure 2: Distribution of radio sources:
- *Blue: sources observed by global station networks*
- *Magenta: sources observed by VLBA Calibrator Survey (VCS) sessions only*
- *Number of sources:*

	this solution	ICRF-2
Total	2967	3414
VCS	1657 (56 %)	2197 (64%)

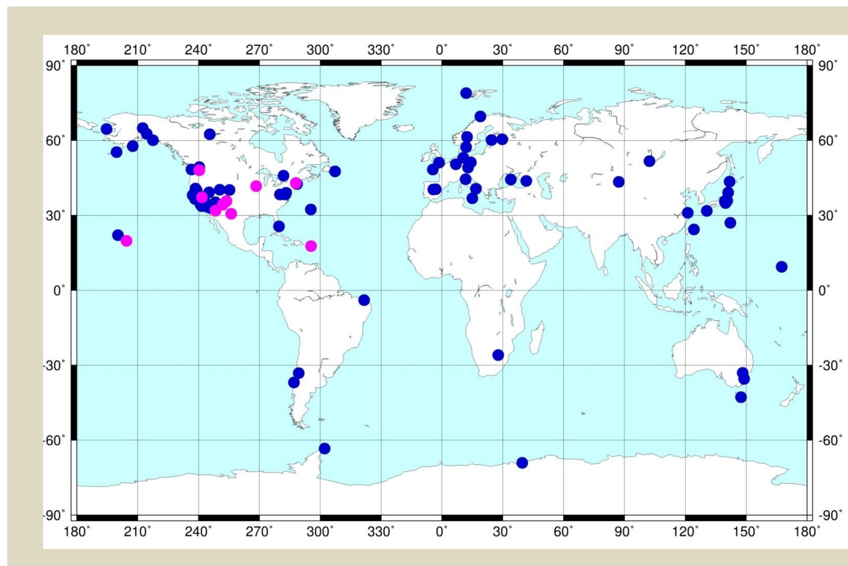


Figure 3: VLBI station network. Blue: stations of global VLBI networks, Magenta: stations of the VLBA network.

Effect of combination on the CRF

Effect of the combination of the EOP series

The effect of the combination of EOP on the CRF is shown in Figure 5. The VCS sources show larger shifts than the non-VCS ones. In right ascension (RA) even a systematic behaviour for some of the sources between declinations of -40° and +30° comes out. In order to study the effects in more detail, we combine the EOP step by step (pole only; pole and ΔUT1/LOD; pole, ΔUT1/LOD and nutation/rates). The results are shown in Figure 6. We found that the combination of LOD is related to the signature in right ascension.

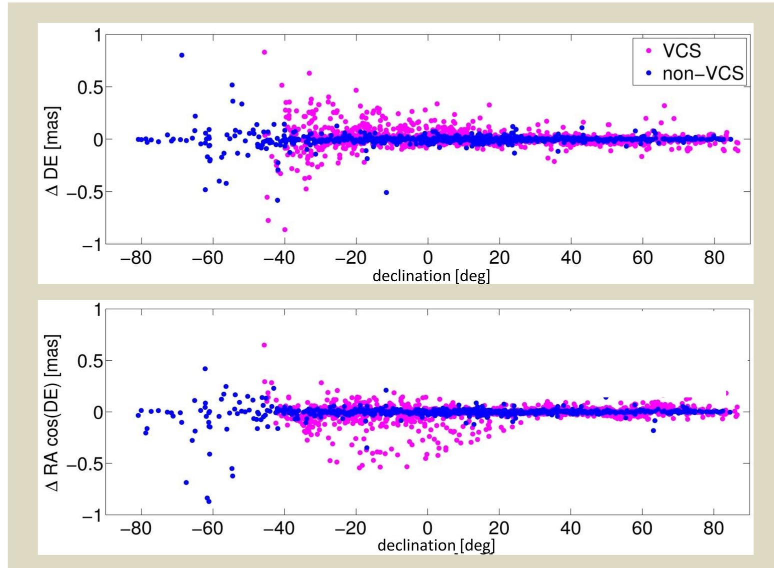


Figure 5: Declination and right ascension of the CRF-TRF solution w.r.t. a VLBI-only CRF

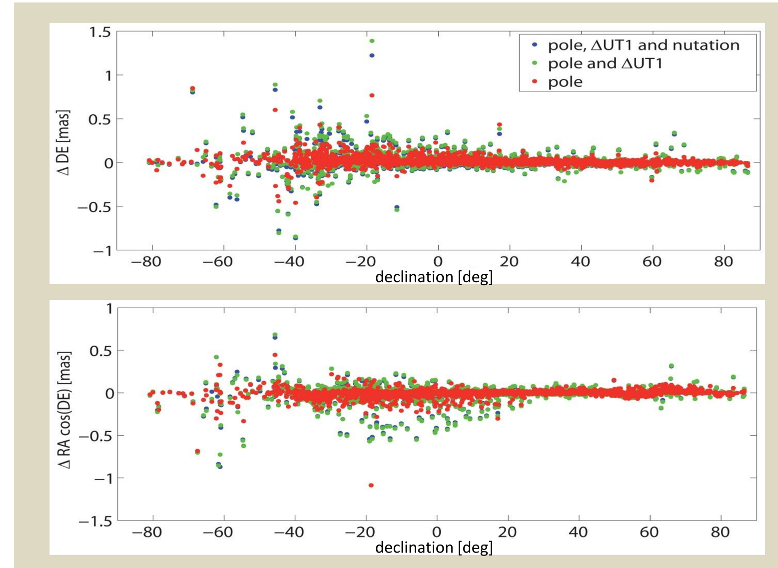
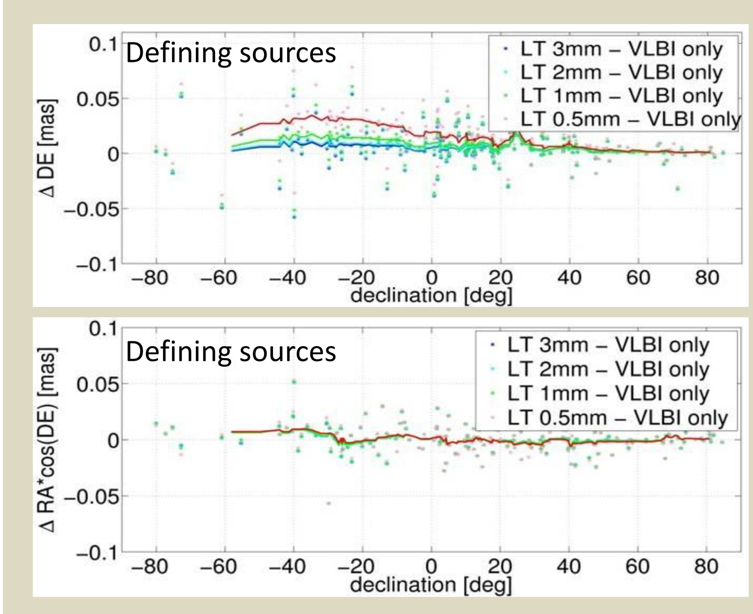


Figure 6: Declination and right ascension of three CRF-TRF solutions (step by step EOP combination) w.r.t. a VLBI-only CRF

Effect of the combination of station coordinates

The combination of the station networks has also a systematic but very small effect on the declination of source coordinates. The effect was studied applying different standard deviations for the local ties (LT) of 3mm down to a very small value of 0.5mm. Considering all sources the effect cannot be detected because the overall noise is too large, but taking into account the defining sources only, it becomes visible (see Figure 7).



Deformation of station network caused by the combination of the station networks. In particular stations at co-location sites on the southern hemisphere show changes in station position due to the combination of a few Millimetres. A relation to the systematics in the southern CRF is obvious.

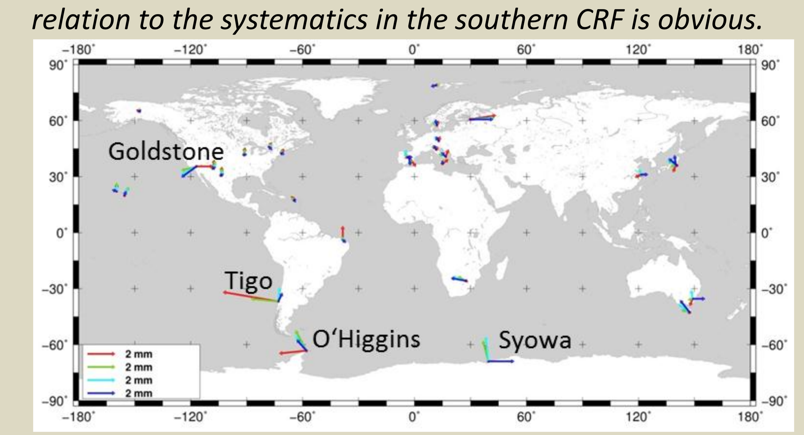


Figure 7: Left: Declination and right ascension of four CRF-TRF solutions (LT introduced with different standard deviations) w.r.t. a VLBI-only CRF. Right: Deformation of VLBI station network.

Summary

A simultaneous realization of ITRS and ICRS provides full consistency between all estimated parameters (TRF, CRF and the EOP). The combination of different space geodetic techniques causes changes in the CRF. While the effect of the combination of the station networks is negligible, the EOP combination leads to systematic differences of up to 0.5mas in the right ascension of some VCS sources. The standard deviations of all sources decrease in the combination but in particular for the VCS sources.

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