Determination of the local tie vector between the VLBI and GNSS reference points at Onsala using GPS measurements

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Introduction

Geodetic co-location sites are important for the International Terrestrial Reference Frame (ITRF) to connect different space geodetic techniques. So-called local tie vectors between the technique specific reference points need to be known with high accuracy.

The Onsala Space Observatory (Fig. 1) is the geodetic co-location site with the longest VLBI observation history in Europe. The main instrument today is the 20 m radome enclosed telescope (Fig. 3) that is used for geodetic VLBI. A dedicated twin telescope for geodetic VLBI has been funded in 2012 and the installation is expected in early 2016. The observatory operates also other instrumentation in support of space geodesy and the ITRF:

- several GNSS antennas/receivers (e.g. Fig. 2)
- a superconducting gravimeter
- a seismometer
- several water vapour radiometers (WVRs)
- several tide gauges.

The local tie vector at Onsala

A determination of the local tie vector at Onsala with classical geodetic methods is difficult since (1) the telescope reference point at Onsala is not a physical point and thus cannot be observed directly but only with indirect methods, and (2) the telescope is enclosed in a radome [1]. Therefore, two GNSS-antennas were gimbal-mounted in 2013 on both sides of the telescope dish (Fig. 4, Fig. 5). GPS data were recorded during nine campaigns, both dedicated semi-kinematic ones, and standard VLBI-sessions (kinematic). The data were analyzed together with data from the ONSA site (Fig. 2) using the double-difference strategy. Absolute phase-centre variation (PCV) corrections were applied, with modifications for telescope azimuth orientation [4]. The antenna reference point in a geocentric system and the axis offset were determined by least-squares fitting of a mathematical model ([2, 3], Fig. 4).

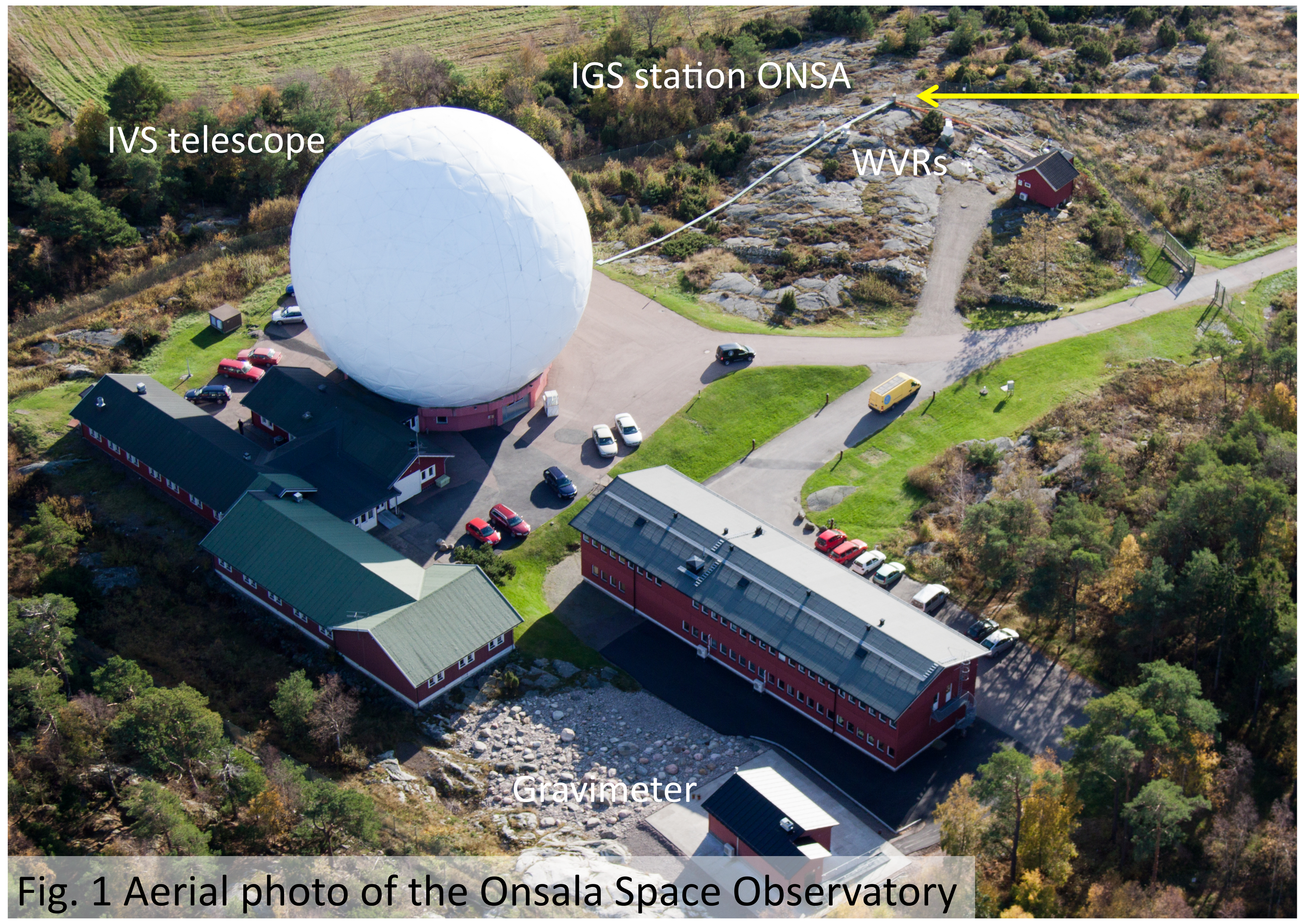


Fig. 1 Aerial photo of the Onsala Space Observatory

Fig. 2 The IGS antenna ONSA.

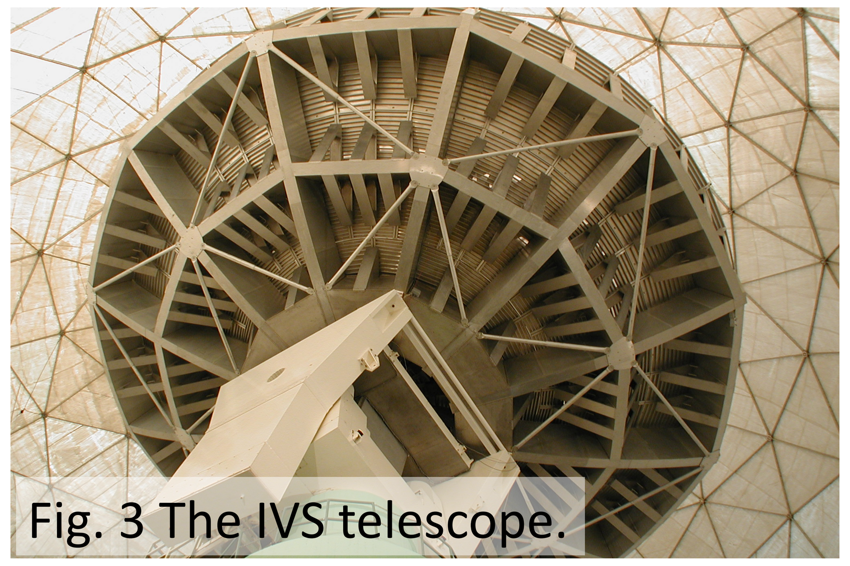
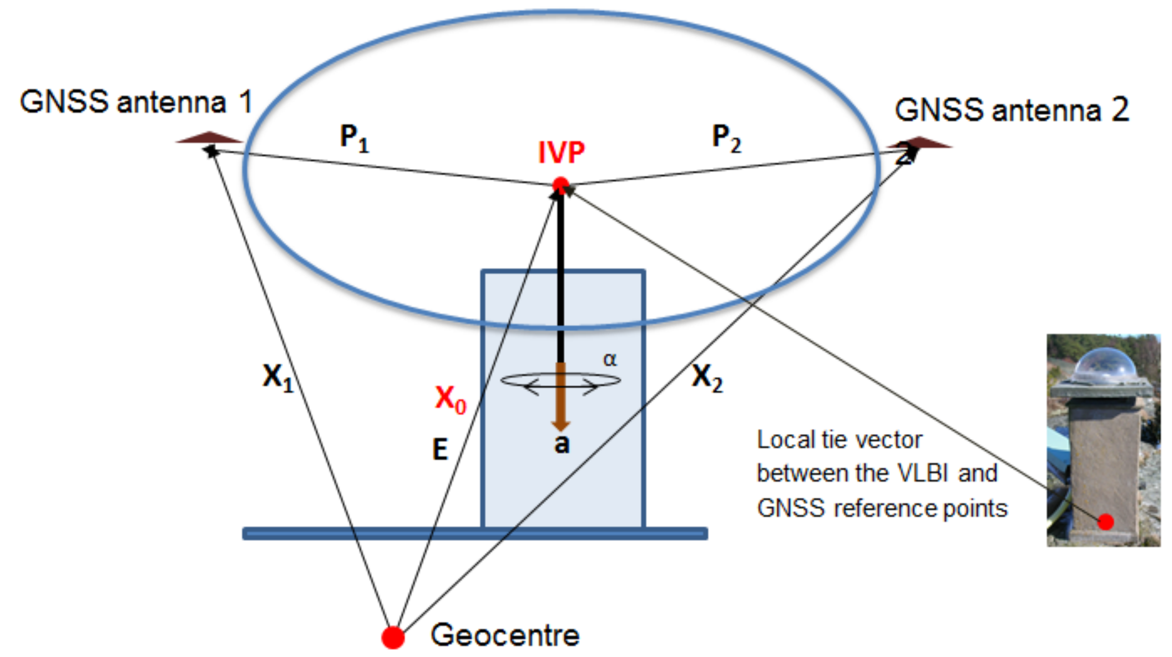


Fig. 3 The IVS telescope.



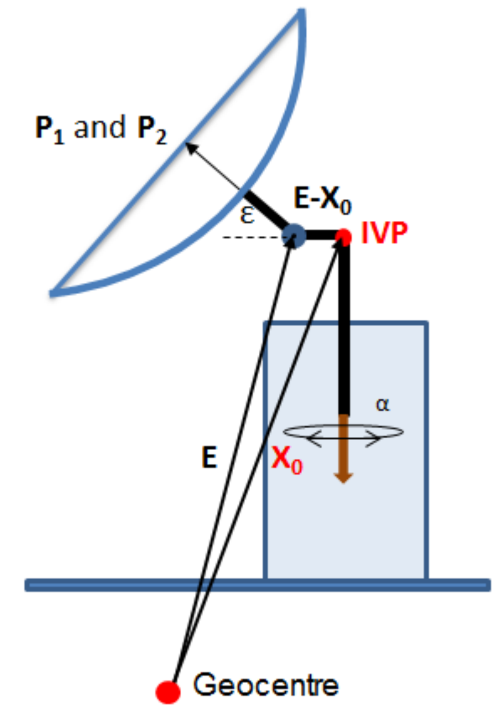


Fig. 4 A sketch of the model parameters and the local tie vector between the VLBI and the GNSS reference points [4].

Fig. 5 GNSS antennas.

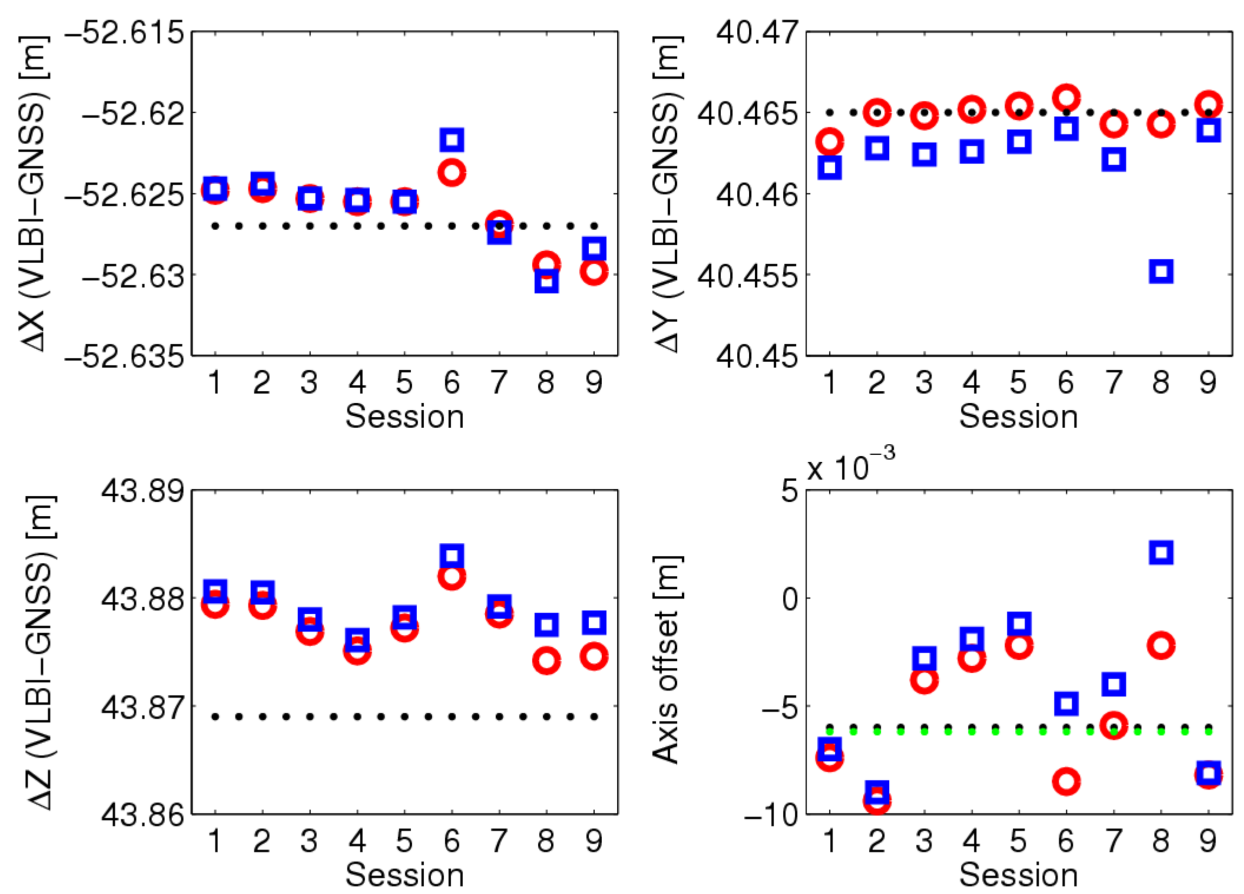


Fig. 6 Results for local tie vector and axis offset [4].

Results

The results for the local tie vector obtained from both semi-kinematic and kinematic campaigns agree with standard deviations of 2-3 mm (Fig. 6, Tab. 1). The baseline between the VLBI and GNSS reference point has a standard deviation of 1 mm but differs by 4 mm from the ITRF 2008 value (Tab. 1). The results for the axes offset agrees with the value previously determined from classical methods. The application of PCV corrections modified for the telescope azimuth orientation are important (red circles in Fig. 6).

Conclusions

The results indicate that the VLBI-GNSS local tie vector at Onsala can be monitored using this method continuously with an accuracy of a few millimetres.

Tab. 1 Results for local tie vector (VLBI-GNSS) and further model parameters [4].

	Session Date	ΔX^1 [m]	ΔY^1 [m]	ΔZ^1 [m]	Baseline [m]	Axis offset [m]	P_1 [m]	P_2 [m]
	semi-kinematic							
1	2013-07-09	−52.6248	40.4632	43.8794	79.5741	−0.0074	12.0590	12.0603
2	2013-07-10	−52.6247	40.4650	43.8793	79.5749	−0.0094	12.0600	12.0585
3	2013-09-21	−52.6253	40.4648	43.8769	79.5739	−0.0038	12.0632	12.0632
4	2013-09-22	−52.6255	40.4652	43.8751	79.5732	−0.0028	12.0604	12.0623
5	2013-09-23	−52.6255	40.4654	43.8772	79.5745	−0.0022	12.0583	12.0595
	Mean	**−52.6252**	**40.4647**	**43.8776**	**79.5741**	**−0.0051**	**12.0602**	**12.0608**
	Standard deviation	**0.0004**	**0.0009**	**0.0018**	**0.0006**	**0.0031**	**0.0019**	**0.0020**
	kinematic							
6	R1592 (2013/07/01-07/02)	−52.6237	40.4659	43.8820	79.5762	−0.0085	12.0666	12.0640
7	EUR124 (2013/07/04-07/05)	−52.6269	40.4643	43.8785	79.5755	−0.0059	12.0637	12.0615
8	RV101 (2013/09/11-09/12)	−52.6294	40.4643	43.8742	79.5749	−0.0022	12.0608	12.0623
9	R1604 (2013/09/24-09/25)	−52.6298	40.4655	43.8746	79.5759	−0.0082	12.0592	12.0601
	Mean	**−52.6274**	**40.4650**	**43.8773**	**79.5756**	**−0.0062**	**12.0626**	**12.0619**
	Standard deviation	**0.0028**	**0.0008**	**0.0037**	**0.0006**	**0.0029**	**0.0033**	**0.0016**
	Mean (total)	**−52.6262**	**40.4648**	**43.8775**	**79.5749**	**−0.0056**	**12.0614**	**12.0612**
	Standard deviation (total)	**0.0021**	**0.0008**	**0.0026**	**0.0010**	**0.0029**	**0.0027**	**0.0018**
	ITRF 2008	−52.6270	40.4650	43.8690	79.5708			
	Difference from ITRF 2008	0.0008	−0.0002	0.0085	0.0041			
	Local survey 2002				79.5685[2]	−0.0060		
	Local survey 2008				79.5678[2]	−0.0062		

References [1] Lösler, Haas, Eschelbach (2013) *J Geod*, 87(8). [2] Lösler (2009) *J Surv Eng* 135:131–135. [3] Kallio, Poutanen (2012) *IAG Symposia*, 136. [4] Ning, Haas, Elgered (2014) submitted to *J Geod*.