The contribution of the Twin Telescopes at Onsala and Wettzell to the VGOS System

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Introduction

The accuracy of geodetic VLBI is expected to be improved to 1mm in station position and 0.1mm/yr in station velocity with the realisation of the VGOS concept, developed by the International VLBI Service for Geodesy and Astrometry (IVS). It includes broadband observations with fast-slewing antennas and suggests to build twin telescopes to reduce the source switching interval and increase the number of observations. This work compares the results that can be achieved if the legacy Onsala 20m and the Wettzell 20m were replaced by twin telescopes following the VGOS concept. The CONT11 station network is used for these simulations.

Approach

The first day of the CONT11 campaign was scheduled by using standard S/X band observations with the participating stations in the CONT11 campaign and with the twin telescopes in Onsala (OTT) and Wettzell (WTT). Schedules were created with respect to different observing modes (see box 'Twin Telescopes') and the source based strategy, where 2 or 4 sources at a time (SAAT) are selected regardless of their effects on individual stations. Subnets are formed and all stations in one subnet observe the same source. (Sun; 2013)

Schedule name	Explanation
CONT11,2	original antennas, 2 SAAT
CONT11,4	original antennas, 4 SAAT
OTT, co, 2	OTT in continuous mode and 2 SAAT
OTT, co, 4	OTT in continuous mode and 4 SAAT
OTT, mu, 4	OTT in multidirectional mode and 4 SAAT
OTT & WTT, co, 2	OTT and WTT in continuous mode and 2 SAAT
OTT & WTT, co, 4	OTT and WTT in continuous mode and 4 SAAT
OTT & WTT, mu, 4	OTT and WTT in multidirectional mode and 4 SAAT

After scheduling, 25 days of observations were simulated by simulating a wet troposphere delays using station related turbulence parameter, clock errors with an ASD 1e-14 @ 50 min and white noise of 32 ps. The following parameters were estimated with a least squares adjustment

Parameter [Unit]	Interval
Clock offset [cm]	1h
ZWD [cm]	0.5h
NGR [cm]	6h
EGR [cm]	6h
EOP [mas/ms]	1/d
Station coord. [cm]	1/d

Participating stations in the CONT11 campaign (IVS; 2012)

Twin Telescopes

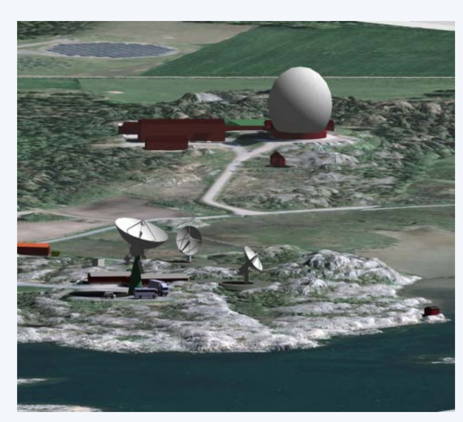
A twin telescope is a pair of identical VLBI telescopes in max 100 m distance, connected to the same clock and with accurately known local tie vector between the telescopes. Due to the short separation distance, the atmosphere above the telescopes can be assumed to be the same.

Observing modes:

A twin telescope has additional observing modes. In the multidirectional mode (mu), the two antennas are part of different subnets at the same time by observing separately different sources into different directions. To operate a twin telescope in this mode in a useful way the 4 SAAT strategy has to be chosen. In the continuous mode (co) one telescope observes and the other one already slews to the next radio source. This leads to a continuous observation without any temporal gaps.

Onsala Twin Telescope

The Onsala Twin Telescope (OTT) was proposed in 2011 and got accepted in 2012 by the 'Knut and Alice Wallenberg Foundation'. It is expected to become operationally in 2017 and will take over the observations of the legacy Onsala 20 m telescope (Haas, 2013).


courtesy of Rüdiger Haas, Chalmers

Wettzell Twin Telescope

The Wettzell Twin Telescope (WTT) made its first observations in 2014 and will be fully operational in 2015.
(Kronschnabl; 2014)

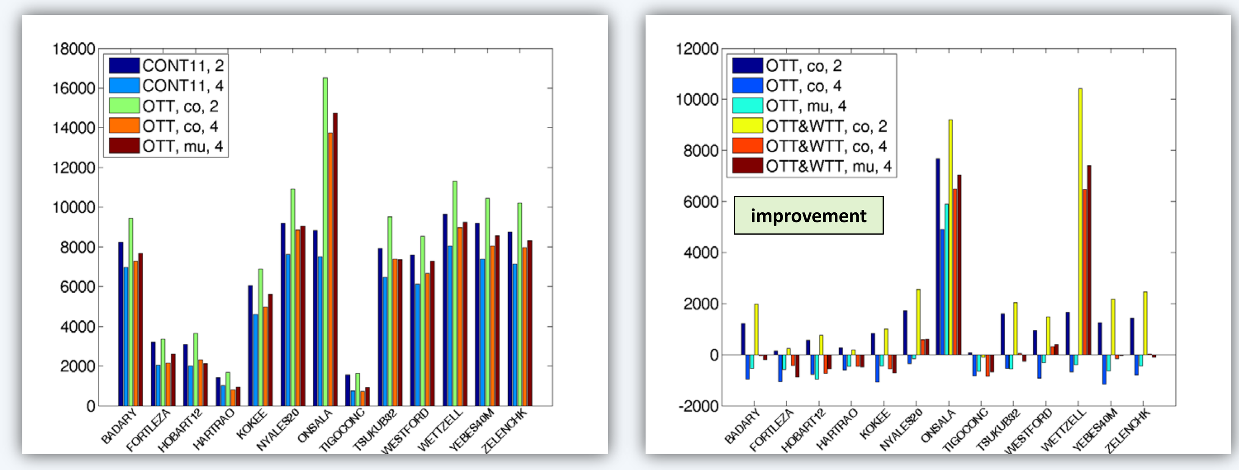

courtesy of Dr. Alexander Neidhardt, TUM

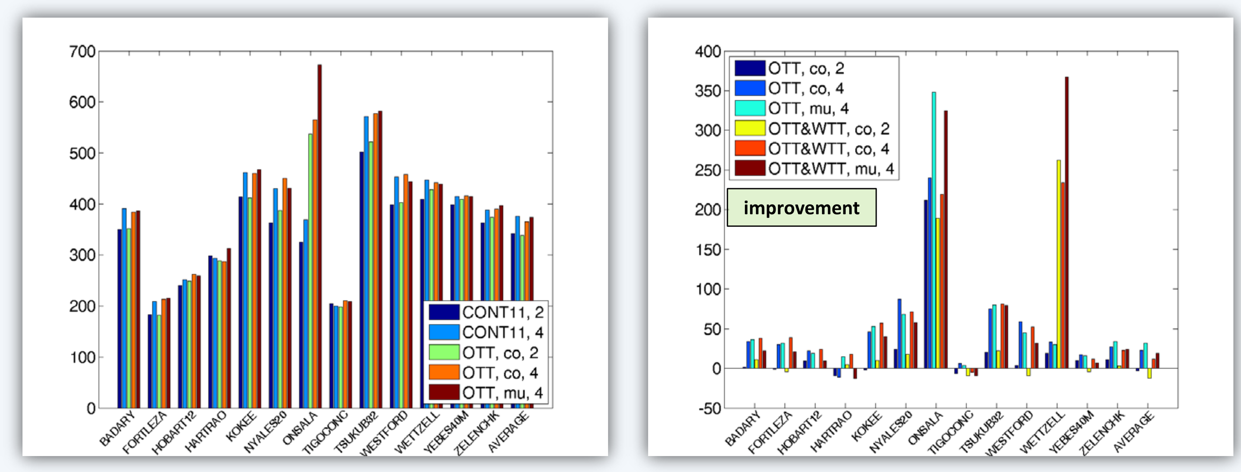
Conclusion

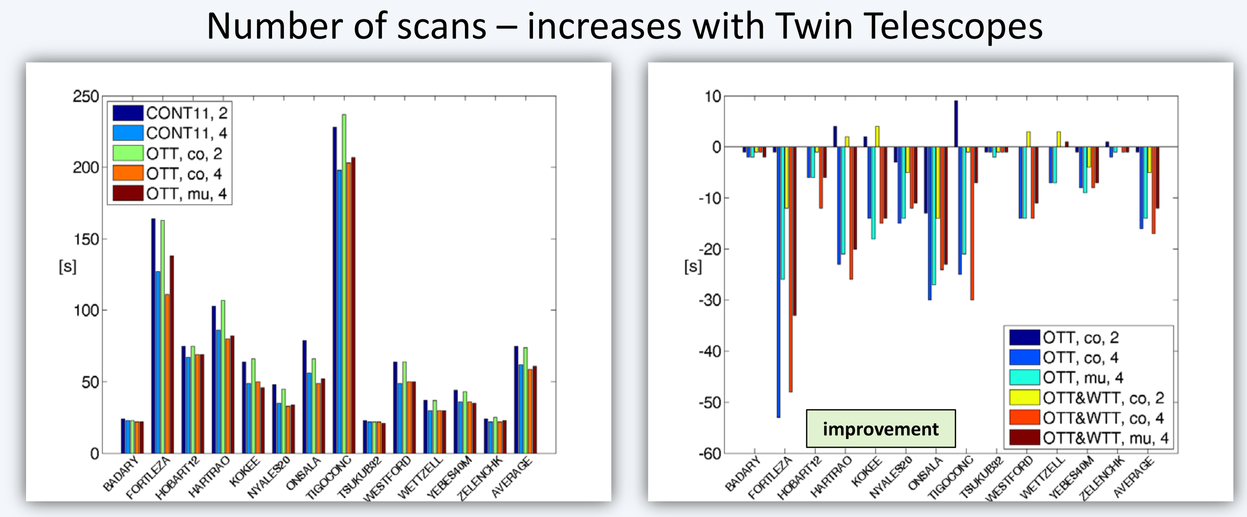
Replacing the legacy 20 m antenna in Onsala and/or Wettzell has different effects on the tested parameters. They depend on the observing mode (continuous or multidirectional) and the number of sources observed simultaneously (2 or 4). An analysis of the schedules shows more scans and observations at all sites with twin telescopes, but especially for the site with a twin telescope independent on the scheduling mode. Furthermore the average on-source time reduces at all sites with twin telescopes which leads to more scans during a session. This is an important goal in the VGOS concept.
For the analysed network using antennas of the CONT11 campaign, the improvements with a twin telescope in Onsala compared to the improvements with twin telescopes in Onsala and Wettzell are nearly the same. This leads to the conclusion that two twin telescopes close to each other do not improve parameters essentially. The baseline length Onsala-Wettzell is around 920 km and its accuracy improves by 1-2 mm with twin telescopes. A reason for these results could be the current status of scheduling, which still has to be optimized for Twin Telescopes in the coming years. Also broadband observations will be available in the next years to converge to the aim of 1 mm in station position.

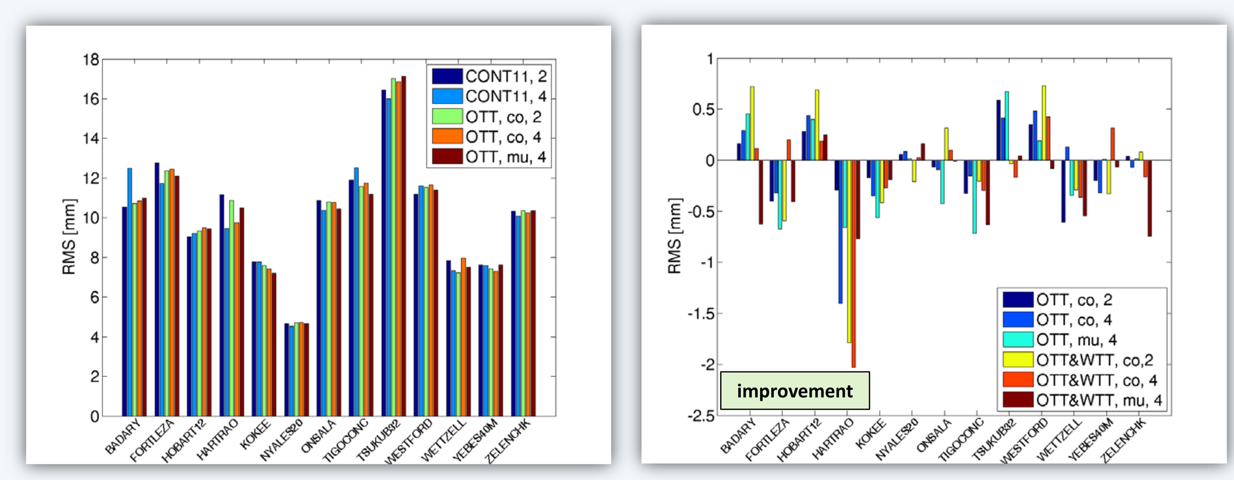
Results

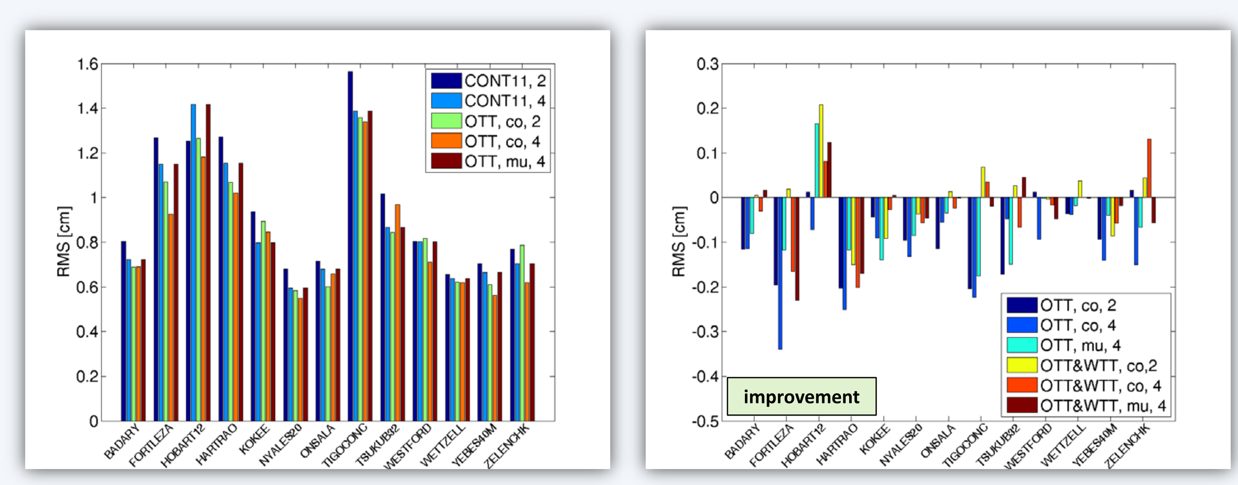
Absolute values **Relative to CONT11,2**

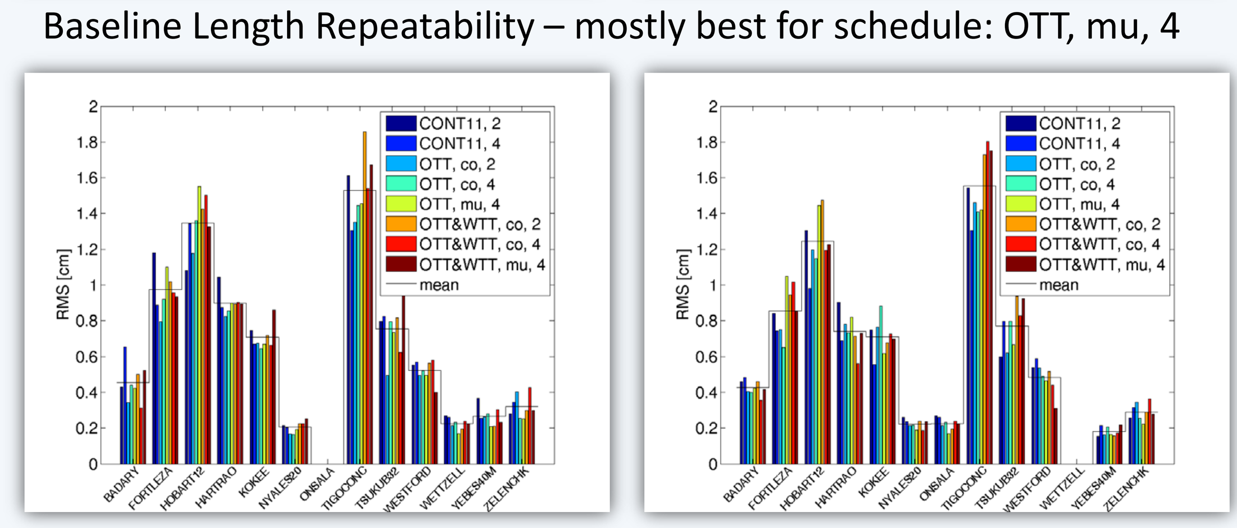

Number of observations – increases with Twin Telescopes

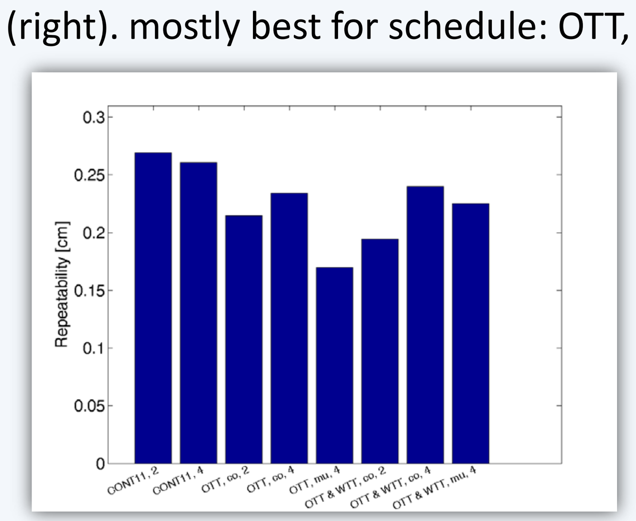

Number of scans – increases with Twin Telescopes


Average on source time – decreases with Twin Telescopes


RMS between estimated and simulated Zenith Wet Delay


Baseline Length Repeatability – mostly best for schedule: OTT, mu, 4


Baseline length repeatability for baselines with Onsala (left) and Wettzell (right). mostly best for schedule: OTT, mu, 4


Baseline length repeatability for baseline: Onsala – Wettzell