Permanent monitoring of the reference point at the 20m radio telescope Wettzell

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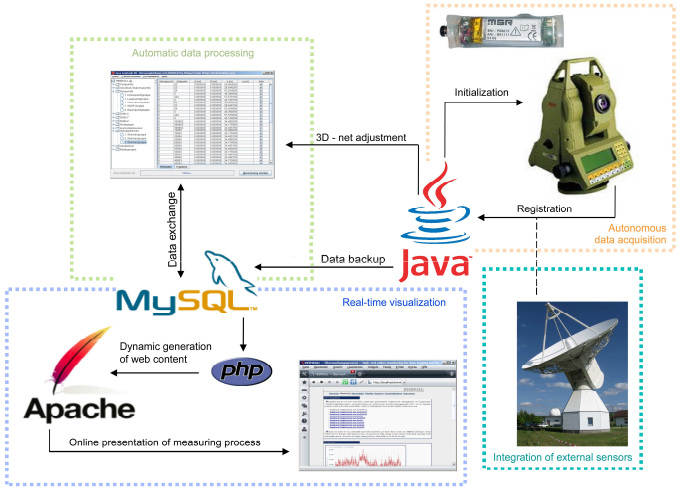
Abstract:

In the VLBI2010 agenda and in the framework of the Global Geodetic Observing System (GGOS) an automated monitoring of the reference points of different geodetic space techniques, such as Very Long Baseline Interferometry (VLBI), and therefore of the local-tie vectors at co-location stations are desirable in order to obtain the sub-millimeter level. For this reason a monitoring system was installed by the University of Karlsruhe to observe the 20-m radio telescope for VLBI at the Geodetic Observatory Wettzell from May to August. A specially developed software from the Geodetic Institute of that university collected data from automated tachymeter measurements, meteorological sensors, and sensors in the telescope monument (e.g., Invar cable data). A real-time visualization directly offered a live view of the measurements during the regular observation operations. Additional scintillometer measurements allowed refraction corrections during the post-processing. This project is one of the first feasibility studies aimed at determining significant deformations of the VLBI antenna due to, for instance, changes in temperature.



The used monitoring concept HEIMDALL

For the use case to realize a permanent monitoring system of the geometric reference point of the radio telescope at the Geodetic Observatory Wettzell, Germany a special software concept was designed by the Geodetic Institute Karlsruhe, Germany. The acronym of the basically in Java realized software HEIMDALL stands for **„High-End Interface for Monitoring and spatial Data Analysis using L2-Norm“** and is also the name of a god for protection in the old northern European mythologies. The myth says that he sees at day and night in the same high quality and that he can hear the grass growing. In Wettzell HEIMDALL was a **measuring laptop** connected to several sensors. Main instrument is a programmable **tachymeter TCA2003 from Leica** with an accuracy for distances of 1mm+1ppm and for angles of 0,15mgon. For the EDM corrections of the distances **meteorological data logger of the type MSR145W** were used. In addition four in the monument permanently installed **temperature sensors**, the **strain measurements** along the azimuth axis and the **telescope angles for azimuth and elevation** were registered. All collected data were saved in a MySQL database from where dynamic services offered a web presentation of the measuring processes. For refraction corrections during post-processing a parallel installed **scintillometer** offered momentum flux and heat flux data which are used to determine temperature gradients with Monin-Obukhov-Similarity-theory.

The observing concept

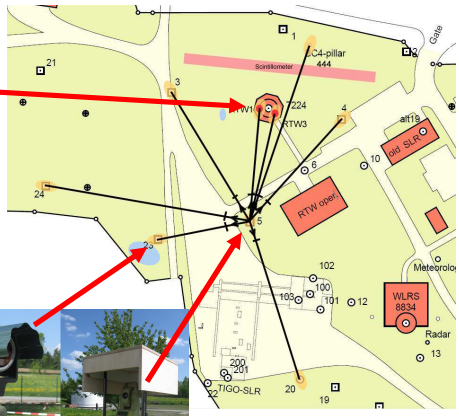
The observation time was **3 month** at all from mid of May to mid of August 2009. As the geometric reference point, which is the intersection of azimuth and elevation axis, is not directly usable, very small, externally mounted reflectors on the outside of the elevation cabin were installed. Therefore variations of the reference point can be derived indirectly from this rigid setup. The whole net was observed in 15 minutes intervals. **Seven supporting points** from the local surveying net on the area of the observatory offered the stable geometry to observe the **five object points on the telescope**. For a later 3D-adjustment the tipping axis and reflector heights of supporting net points were classically identified.

To offer a possibility for refraction corrections a **scintillometer** was installed permanently during the whole campaign. The correction is done during the post-processing. Therefore 1°C change can lead into a pretended lift of 0.8mm over a distance of 40m. This variation can be corrected by the setup. But the derived temperature gradients are used overall zenith angles, which reduces the effectiveness of this method.

Parallel operated, dedicated measurements of declinations with a **Nivel** and of distances with a **laser tracker** completed the setup.

Scintillometer with a laser distance of about 60m

Especially small reflectors on the telescope with a magnetic mounting equipment



Leica high-precision reflector GPH1P with a mounted roof to protect them from direct weather impact

Leica tachymeter TCA2003

The analysis and results

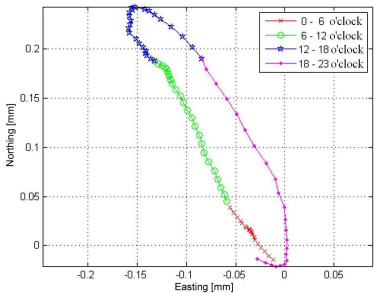
Changes of the reference point were investigated under different load situations, induced by different elevation positions, using a **high-precise tilt-meter „Nivel210“**. For these experiments the antenna was moved to 10 defined positions in elevation each time on 12 different azimuth angles. At each azimuth position the tilts were registered during the up and down path of the elevation. Additionally the whole experiment was repeated bringing the Nivel onto different height positions in the telescope tower. The registered data show significant deformations depending on different elevation positions. It shows that **the reference point moves it‘s position 0.05mm between 0° and 90° elevation**.

Nivel210 at reference point

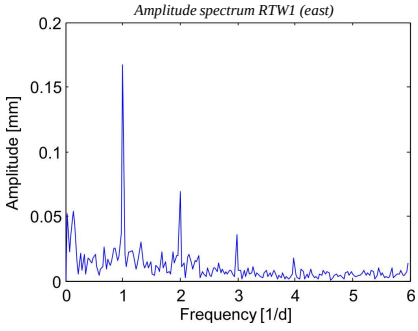
Using the adjusted data from the **tachymeter measurements** a daily, periodic variation for positions could be derived, which is superposed by a long-term trend. A fourier analysis allowed it to create a model, to transfer the results from the cabin surface to the internally located reference point. It showed that the **reference point moves its position in both axis of about 0.2mm over the period of one day**. For a reliable statement about the annual trend a longer observation campaign would be needed.

The permanent measurements at the Geodetic Observatory Wettzell showed, that changes in position could be detected due to load changes or insolation (temperature changes). Concerning to the variations defined within GGOS of about 0.1mm, the found results become more and more relevant. Similarly to the used height correction the usage of derived mapping functions could possibly increase the reliability of VLBI-results. Therefore future researches on that point are strongly recommended.

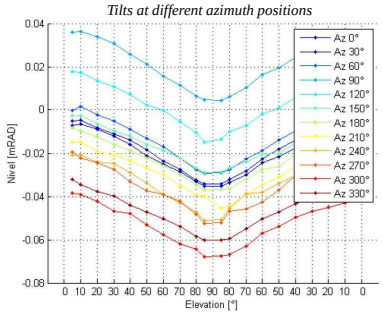
Estimated daily variation of the reference point



Amplitude spectrum RTW1 (east)



Tilts at different azimuth positions



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