Estimation of Elevation Dependent Deformations of a Parabolic Reflector of a Large Radio Telescope

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ABSTRACT:

The main reflector of the Effelsberg 100 m radio telescope of the Max Planck Institute for Radio Astronomy is affected by an elevation dependent deformation due to gravitation. A survey campaign with a laser scanner was performed in order to detect the surface deformations of the mirror which lead to a change in focal length. Knowledge about an elevation dependent variation of the focal length is essential for VLBI applications because it directly impacts the time-of-flight measurements. Due to the fact that the laser scanner was mounted head down on the sub reflector it was possible to scan nearly the whole surface. The measurements were performed at seven different elevations between 90° and 7°. In order to estimate the deformation, the surface is parameterized by an implicit model of a best fit rotational paraboloid. The orthogonal distance regression allows an estimation of the focal length of the paraboloid. The associated adjustment process presented here is a two step modification of a classical nonlinear least squares approach: First, it is based on a linearization of the functional model directly on the estimated paraboloid itself, represented by the observed coordinates' orthogonal contacting points on the surface. Second, the distances between the observed coordinates and the corresponding calculated orthogonal contacting points are minimized. Results have shown that these modifications in the present case add up to a focal length estimation more robust towards changes in position and orientation of the paraboloid in space. An analysis of the estimated focal length at different elevations shows a significant elevation and consequential gravity dependent variation. The focal length decreases together with the elevation with a magnitude of about one centimeter.