Axis offset estimation of VLBI telescopes

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ABSTRACT

Axis offset models have to be applied for VLBI telescopes whose pointing axes do not intersect. In this work we estimate the axis offsets for all VLBI antennas in a global adjustment of suitable IVS 24-hour sessions (1984.0 - 2014.0) with the Vienna VLBI Software (ViVeS). In particular, we focus on the two telescopes of the Hartbeesthoek Radio Astronomy Observatory in South Africa. For the older 26m telescope we compare the axis offset value before and after the bearing repair in 2010. A comparison with axis offset estimates from other geodetic techniques, like GNSS or conventional local survey is made. Furthermore, we assess the influence of differences in the axis offsets on the estimated geodetic parameters, such as station coordinates or Earth orientation parameters.

THEORY

Antenna axis offsets (AO) change the position of the receiver w.r.t. the incoming wavefront. It contributes to a time delay \( \tau_{AO} \) dependent on the unit vector \( \mathbf{s} \) in the radio source direction and on the unit vector in the direction of the fixed axis \( \mathbf{l} \) (Sovers et al., 1998; Nothnagel, 2009):

\[
\tau_{AO} = \frac{1}{c} \cdot \Delta \mathbf{O} \cdot \mathbf{s} - \mathbf{a} \cdot \Delta \mathbf{l}
\]

The projection of the axis offset onto the time delay value depends on the mount type of the telescope:

- **Equatorial (Polar) Mount**
  - for primary axis directed North-South:
    \[
    \tau_{AO} = \frac{1}{c} \cdot \Delta \mathbf{O} \cdot \mathbf{s} - \mathbf{a} \cdot \Delta \mathbf{l}
    \]
  - for primary axis directed East-West:
    \[
    \tau_{AO} = \frac{1}{c} \cdot \Delta \mathbf{O} \cdot \mathbf{s} - \mathbf{a} \cdot \Delta \mathbf{l}
    \]

HARTRAO 26M AND 15M TELESCOPES

In October 2008 the bearing of the polar shaft of the 26m telescope failed. In August 2010 the telescope took part in its first post-repair geodetic VLBI observing session.

**Axis offset of the 26m telescope (summarized in Combrinck (1997)):**
- 6.706 mm standard value (JPL, 1961)
- 6.695 ± 3 mm conventional survey (M. Newling, 1993)
- 6.693 ± 2.5 mm VLBI (C. Ma, 1995)
- 6.692.5 ± 1.5 mm VLBI (M. Enuklis, 1995)
- 6.695.6 ± 2.3 mm HartRAO GPS solution (1995)
- 6.698 ± 1.8 mm VLBI (C. Ma, 1996)
- 6.697 ± 1.8 mm VLBI (M. Enuklis, 1996)
- 6.69 ± 2.5 mm local tie survey (Michel et al., 2005)
- 6.692 ± 0.5 mm our estimate - before the repair (1986 - 2008.8)
- 6.707 ± 0.8 mm our estimate - after the repair (2010.6 - 2014.0)
- 6.703 ± 0.5 mm our estimate (1986 - 2014.0)

In October 2012 the 15m telescope started its observations within the IVS schedules.

**Axis offset of the 15m telescope:**
- 1.495 mm
- 1.494 ± 0.2 mm (A. Combrinck, 2007) from the first IVS sessions (GSFC, D. Gordon and S. Bokitin, 2012)
- 1.494 ± 0.2 mm VLBI (GSFC, D. McMillan, 2014)
- 1.495 ± 0.3 mm our estimate

SUMMARY

- Axis offset is projected onto time delay with the cosine of the elevation angle, therefore a correlation with tropospheric delay or clock parameters can occur.
- We compared our estimates of the axis offsets with the latest values (Jan 2014) provided by D. McMillan (GSFC Group). At some stations the differences reach up to 1 cm.
- We focused on the telescopes HartRAO 26m and 15m. The estimated axis offset at the 26m telescope before and after the bearing repair in 2010 differs by 8.1 ± 1.3 mm.

REFERENCES


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