Geoscience Australia Analysis Center Report

Oleg Titov

Abstract This report gives an overview of the activities of the Geoscience Australia IVS Analysis Center during 2021—2022.

1 General Information

The Geoscience Australia (GA) International VLBI Service (IVS) Analysis Center is located in Canberra within the National Geodesy Section, National Positioning Infrastructure Branch, Space Division of Geoscience Australia.

2 Activities during the Years 2021–2022

Several celestial reference frame (CRF) solutions were prepared using the OCCAM 6.3 software. The latest solution was released in December 2022 (`https://ivs.bkg.bund.de/data_dir/vlbi/ivsproducts/crf/aus2022b.crf.gz`). VLBI data consisting of 4,313 daily sessions from May 1993 to September 2022 were used to compute this solution. This includes 5,332 radio sources having three or more observations. Positions of 57 radio sources including four radio stars were estimated as daily parameters. The total number of observational delays used in this solution is 12,893,362. Earlier VLBI data between 1980 and 1993 were not used for this solution due to poor quality of astrometric parameters.

Geoscience Australia

GA Analysis Center

IVS 2021+2022 Biennial Report

Station coordinates were also estimated using No-Net-Rotation (NNR) and No-Net-Translation (NNT) constraints. The long-term time series of the station coordinates were used to estimate the corresponding velocities for each station. The tectonic motion for the Gilcreek VLBI site after the Denali earthquake was modeled using an exponential function typical of post-seismic deformation [1].

The adjustment was made by least squares collocation, which considers the clock offsets, wet troposphere delays, and tropospheric gradients as stochastic parameters with apriori covariance functions. The troposphere gradient covariance functions were estimated from GPS hourly values.

Four radio stars (HR1099, UX Ari, the Vela pulsar, and LSI+61 303) within our galaxy were detected with geodetic VLBI. They display a significant proper motion with a magnitude of 10–100 mas/y and an annual parallax of 5–100 mas. All other radio sources are extragalactic objects at the cosmological distance, so their proper motion and parallax are known to be zero, and the expected positional variations due to change of intrinsic structure do not exceed 3–5 mas. Only three outstanding positional changes were detected in 2016 with the Second Epoch Very Long Baseline Array (VLBA) calibrator survey [2]. For example, radio source 1524 – 136 has shifted more than 100 mas between 1997 and 2014. But it was treated as a “stable” radio source in the recent ICRF3 catalog published in 2018 because its early observations in 1997 were ignored [3].

Nonetheless, we found that more reference radio sources show an unprecedented change in their apparent positions (up to 200 mas) on time scales from several years to several decades using new observations released after 2018. This is predictably linked to the evolution of the intrinsic source structure and brightness distribution, although the scale of these positional changes is far beyond the common astrometric instabilities. Four objects (3C48, CTA21, $1144+352$, and $1328+254$) were reported ([4]), and about 50 other objects are under analysis.

A potential impact of such positional instability on the statistical quality of future astrometric catalogs may be severe, should the number of the radio sources with large offsets soar during the next decade. As all the offsets were found with recent observations made in the post-ICRF3 era, this means that any radio reference frame source may suddenly demonstrate an abrupt change in its coordinates. This seems more likely for the sources with complex, extended core–jet structure at the scale of 10–100 mas or, even more, with multiple compact components in VLBI images. Therefore, a higher number of radio sources with similar positional offsets could be found with future VLBI observations.

Acknowledgments

This report has been published with the permission of the CEO, Geoscience Australia.

References

1. Titov O., Tregoning P., 2005, JGeod, 79, 196. doi:10.1007/s00190-005-0459-9
2. Gordon D., Jacobs C., Beasley A., Peck A., Gaume R., Charlot P., Fey A., et al., 2016, AJ, 151, 154. doi:10.3847/0004-6256/151/6/154
3. Charlot P., Jacobs C. S., Gordon D., Lambert S., de Witt A., Böhm J., Fey A. L., et al., 2020, A&A, 644, A159. doi:10.1051/0004-6361/202038368
4. Titov O., Frey S., Melnikov A., Lambert S., Shu F., Xia B., González J., et al., 2022, MNRAS, 512, 874. doi:10.1093/mnras/stac038