AuScope VLBI Project and Hobart 26-m Antenna

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Abstract

This is a report on the activities carried out at the three AuScope VLBI observatories and the Hobart 26-m antenna. In 2012 the three AuScope 12-m antennas at Hobart (Hb), Katherine (Ke), and Yarragadee (Yg) completed their first full year of operations as an array. The Hobart 26-m antenna (Ho) continued to make a contribution to IVS, providing overlap with the Hb time series. In total the AuScope antennas and the Hobart 26 m observed for 146 antenna days in 2012.

In this report we also briefly highlight our research activities during 2012 and our plans for 2013.

1. VLBI Facilities

As part of AuScope (www.auscope.org.au), the University of Tasmania (UTAS) operates the AuScope VLBI Array (Lovell et al., 2013), three radio telescopes on the Australian continent (Figure 1), located near Hobart (Tasmania), Yarragadee (Western Australia), and Katherine (Northern Territory). Newly derived telescope coordinates are presented in Table 1. The AuScope telescopes closely follow the International VLBI Service VLBI2010 specification for the next generation of telescopes for geodesy (Petrachenko et al., 2009) or provide an upgrade path to meet the specification where it is not currently possible to do so.

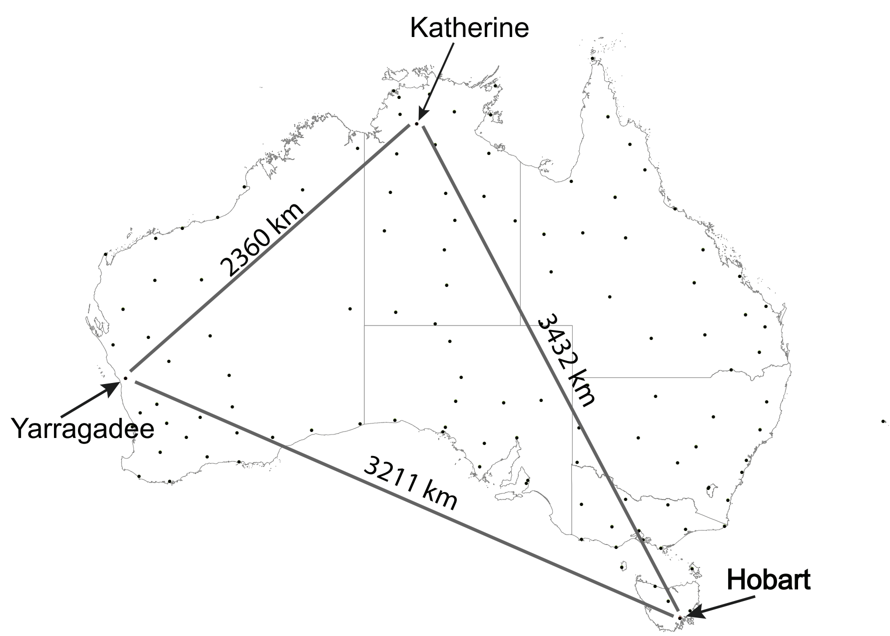

Figure 1. The geographical distribution of VLBI and GNSS infrastructure for AuScope. The locations of the new 12-m telescopes are labeled, and the new GNSS sites are indicated by filled dots.

Table 1. Calculated positions for the three AuScope VLBI antennas at epoch 2012.0, ITRF2005 datum (Lovell et al., 2013). The first uncertainty represents the average formal error in an individual measurement. The second uncertainty corresponds to weighted scatter about the best estimate.

Hobart 12 m (Hb)	
No. Sessions	82
Latitude (d m s)	$-42\,48\,20.0621 \pm (0.0006, 0.0012)$
Longitude (d m s)	$147\,26\,17.3070 \pm (0.0006, 0.0012)$
Height (m)	$40.967 \pm (0.019, 0.036)$
Katherine 12 m (Ke)	
No. Sessions	24
Latitude (d m s)	$-14\,22\,31.6679 \pm (0.0006, 0.0004)$
Longitude (d m s)	$132\,09\,08.5439 \pm (0.0007, 0.0006)$
Height (m)	$189.262 \pm (0.021, 0.017)$
Yarragadee 12 m (Yg)	
No. Sessions	14
Latitude (d m s)	$-29\,02\,49.7226 \pm (0.0012, 0.0006)$
Longitude (d m s)	$115\,20\,44.2576 \pm (0.0013, 0.0013)$
Height (m)	$248.236 \pm (0.040, 0.029)$

The new Hobart telescope (Hb) is co-located with the existing 26-m telescope (Ho) to preserve the more than 20 year VLBI time series at the site. Midway between the 26-m and 12-m telescopes is the HOB2 GNSS installation which has been a core site of the International GNSS Service (IGS) since its conception. A hut capable of housing a mobile gravimeter is also co-located on the site. The Yarragadee telescope (Yg) provides a far western point on the continent and is co-located with multiple existing geodetic techniques including SLR, GNSS, DORIS, and gravity. The Katherine site (Ke) is new and provides a central longitude, northern site. The telescope at Katherine is co-located with a new GNSS site that forms part of the AuScope GNSS network.

Each AuScope VLBI observatory is equipped with a main reflector that is 12.1 m in diameter. The telescope specifications include: 0.3 mm of surface precision (RMS), fast slewing rates (5 deg/s in azimuth and 1.25 deg/s in elevation), and acceleration (1.3 deg/s/s). All three sites are equipped with dual polarization S- and X-band feeds with room temperature receivers covering 2.2 to 2.4 GHz at S-band and 8.1 to 9.1 GHz at X-band. System Equivalent Flux Densities (SEFDs) are 3500 Jy in both bands. Data digitization and formatting is managed by the Digital Base Band Converter (DBBC) system, and data are recorded using the Mark 5B+ system. Each site is equipped with a Hydrogen maser time and frequency standard.

All three observatories were designed and constructed to be remotely controlled and monitored to keep operating costs at a minimum. Operation of the AuScope VLBI array is being carried out from a dedicated operations room on the Sandy Bay campus of the University of Tasmania.

2. Staff

Staff at UTAS consist of academics, Professor John Dickey (director), Dr. Simon Ellingsen, Dr. Christopher Watson, and Professor Peter McCulloch. Dr. Jim Lovell is Project Manager for the AuScope VLBI project. Dr. Jamie McCallum, Dr. Stas Shabala, and Dr. Anthony Memin are Australian Research Council Super-Science Fellows who are carrying out research aimed at improving geodetic solutions in the southern hemisphere. Mr. Brett Reid is the Observatory Manager whose position is funded by the university. In addition we have an electronics technical officer, Mr. Eric Baynes. For operation of the observatories during geodetic observations we rely heavily on support from astronomy PhD and postgraduate students. Logistical and maintenance support at Katherine is provided by Mr. Martin Ephgrave and at Yarragadee by Mr. Randall Carman and team at the MOBLAS5 SLR station.

3. AuScope VLBI Project Status

The Hobart telescope began IVS observations in October 2010 with Yarragadee and Katherine joining in May and June 2011 respectively. 2012 was the first full year that all three telescopes participated in IVS sessions.

The AuScope VLBI array is currently funded for operations at the level of 70 observing days per year until the end of 2014. The Hobart 26-m antenna will continue to participate in IVS sessions at the level of six days per year to assist in the maintenance and enhancement of the Celestial Reference Frame in the southern hemisphere.

4. Geodetic VLBI Observations

In 2012 the AuScope and Hobart 26-m antennas participated in 72 IVS sessions for a total of 146 antenna days of observing. A summary of the sessions is presented in Table 2.

Table 2. AuScope and Hobart 26-m antenna participation (number of days) in IVS sessions in 2012.

Session	Antenna			
	Ho	Hb	Ke	Yg
APSG		1	1	
AUSTRAL		4	4	4
CRDS	1	6	3	3
OHIG		3		
R1	5	18	17	15
R4	5	16	18	19
T2		1	1	1
Total	11	49	44	42

5. Research Activities

5.1. Source Structure

A key area of research over the past year has involved investigating the effects of quasar structure and evolution on geodetic solutions. In particular, we have begun using the IVS flux density data to track quasar evolution. Some promising metrics have been obtained for assessing the effects of quasar evolution on source position stability as evaluated by geodetic software. We plan to develop this work further in the coming year, with the ultimate goal of helping schedulers decide which quasars should be included in a given IVS session. Other related projects include a better calibration of the IVS flux density data, and simulation-based evaluation of the effects of quasar evolution on geodetic measurements.

5.2. Non-tidal Deformation

Taking into account the deformation of the Earth due to a range of well-known geophysical processes is required to accurately resolve VLBI solution parameters including EOPs and station coordinates. Models describing the dominant tidal signals (solid Earth tides, pole tide, and ocean tide loading) are routinely employed following the International Earth Rotation and Reference Systems Service recommendations. However to achieve greater accuracy at the millimeter level, non-tidal deformations must also be considered.

To this aim we investigated the effect induced by high-frequency non-tidal ocean loading at 18 Australian geodetic GPS sites. We found that correcting for this effect improved the daily geodetic observation scatter by up to 15% in 61% of the studied vertical coordinate time series (mean improvement about $6-8\%$). Another project has involved the investigation of hydrologically induced deformation which has a highly spatially correlated regional signature. The temporal variability in surface gravity, as deduced from the Gravity Recovery And Climate Experiment (GRACE) data, will help to extract the seasonal signal that will be compared to the geodetic time series. We aim to assess the improvement in station coordinates and the impact on other parameter estimates when including these non-tidal deformations in VLBI solutions.

5.3. Antenna Structural Deformation Study

In order to realize the full potential of the telescopes and achieve positional accuracy at the millimeter level, several sources of systematic error must be understood and mitigated. One such error source is structural deformation of the telescopes themselves, particularly due to the effects of thermal expansion. In 2013 we will embark on a high precision survey of the Hobart 12-m telescope in order to provide an insight into the structural behavior of the telescope. We will use the Australian Geophysical Observing System (AGOS) robotic telescope monitoring infrastructure, including a Leica TDRA6000 total station and an array of temperature sensors deployed over the telescope to study how the structure responds to the diurnal temperature cycle. We will compare our observations with modelled estimates obtained through computer modelling of the telescope with the final aim of establishing a corrective model for the AuScope telescopes to mitigate the effect in our geodetic analysis.

References

[1] Petrachenko, B. et al., 2009, "Design Aspects of the VLBI2010 System. Progress Report of the IVS VLBI2010 Committee". NASA/TM-2009-214180, June 2009.

[2] Lovell, J. E. J. et al., 2013, "The AuScope Geodetic VLBI Array", Journal of Geodesy, accepted.