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The impact of the AuScope VLBI observations and the regional AUSTRAL sessions on the TRF

The world's busiest antennas

From contributing to about 40-50 IVS sessions in 2012, over 70-80 in 2013, the AuScope VLBI antennas in Hobart (Hb), Katherine (Ke), and Yarragadee (Yg) are each scheduled for about 170 sessions in 2014. Besides supporting almost every IVS-R1/R4 session, the AUSTRAL observing program has been increased tremendously (Fig. 1). This includes continuous AUST campaigns over 15 days in 2013 and 2014, as well as 48h weekend sessions additional to the traditional AUSTRAL experiments.
For the year 2015, the AuScope antennas are scheduled for 241 observing days, supporting ~120 AUSTRAL sessions (including two 15 day continuous campaigns), 89 IVS R1/R4 sessions and 25 other IVS sessions.

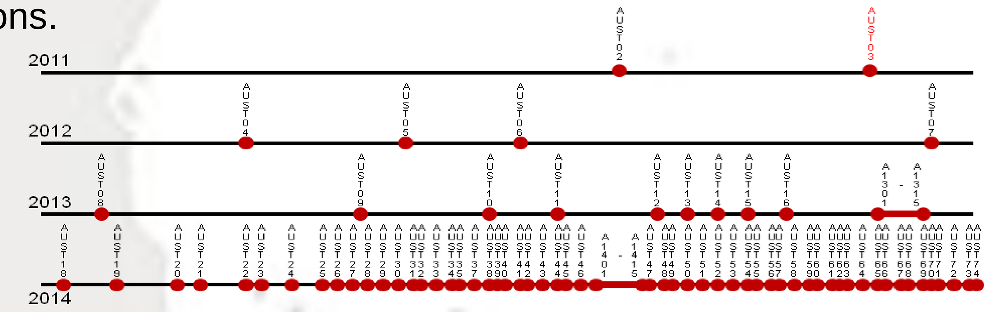

Figure 1: Calendar of the AUSTRAL sessions.

Introduction

SINCE 2013, THE CONTRIBUTION OF THE AUSCOPE VLBI ANTENNAS TO REGULAR IVS SESSIONS HAS SIGNIFICANTLY INCREASED, LEADING TO A CLEAR IMPROVEMENT IN SOUTHERN BASELINES. ADDITIONALLY, MORE THAN 60 DEDICATED AUSTRAL VLBI SESSIONS HAVE BEEN OBSERVED. THESE INCLUDE ANTENNAS IN AUSTRALIA, NEW ZEALAND AND SOUTH AFRICA. WE GIVE AN OVERVIEW OF THE AUSTRAL OBSERVING PROGRAM, SUMMARISE THE RESULTS SO FAR, AND PRESENT OUR FUTURE PLANS.

Pre-VGOS scheduling

As a prototype for the VGOS system[1], the AUSTRAL antennas are small but fast antennas. The reduced sensitivity is compensated by an increased recording rate of 1 Gbps. In Figure 2 we show simulated baseline length wrms using various schedules, antenna capabilities, and measurement noise. We find that the 1Gps recording let us expect much better results than the traditional 256 Mbps. The positive effect of a system upgrade to broadband receivers is also clearly visible.
The scheduling is done at Vienna University of Technology using the VieVS software. Steady improvements led to a top of 30 scans per hour per station from AUST30 onwards (Fig 3).

[1]VLBI2010 Global Observing System

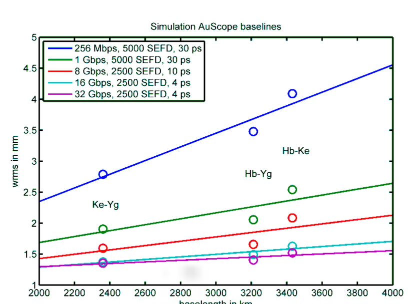

Figure 2: Simulated wrms in baseline lengths for schedules using different receiver and recording capabilities.

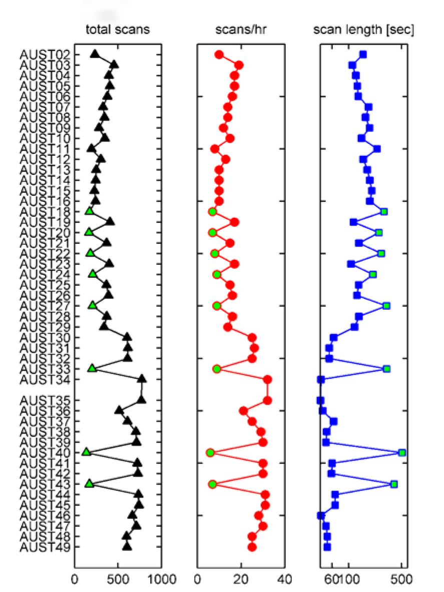

Figure 3: Average number of scans per station, scans/hour, and scan length in the AUSTRAL sessions. Astro-experiments are marked green.

Pre-VGOS operations

We remotely control all three Australian antennas form the UTAS campus in Hobart using the e-Control software. This is a first step towards the VGOS goal of shared antenna control enabling global 24/7 observing.

Each AuScope antenna produces ~17TB of data per week. This leads to constantly new developments in the areas of data storage, transfers (shipping and e-transfer), and disk module logistics.

Improved southern baselines

Analysing one year (2013) of standard global VLBI sessions (IVS R1/R4), we find that southern and north-south baselines are significantly less precisely determined than northern ones (Fig. 5). In simulations we identified the fewer number of observations per baseline to be the main reason for this imbalance.
Since mid 2013, the AuScope antennas contribute with all three instead of previously only one antenna to the IVS rapid sessions. As shown in Fig. 5, this clearly improved the performance of southern and mixed baselines.

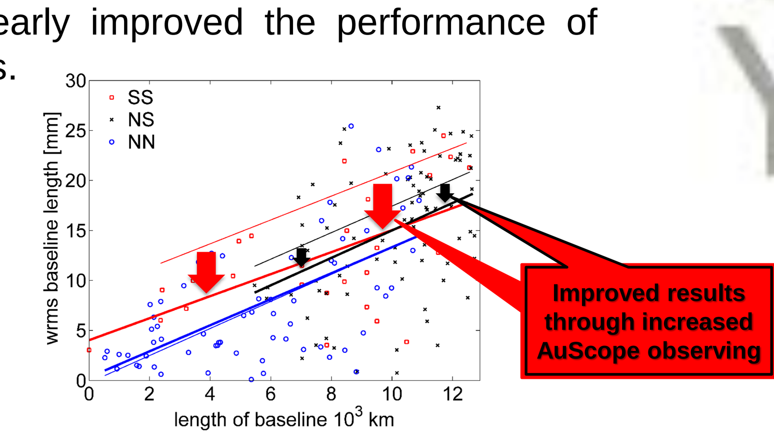

Figure 5: Baseline length repeatabilities (wrms) of IVS rapid (R1/R4) sessions for 7/2013-12/2013. We distinguish between southern (SS), northern (NN), and mixed (NS) baselines. The thick lines are fitted linear trends for each type of baselines. The thin lines are the trends for the first half of the year (1/2013-6/2013).

Summary

THE CONTRIBUTION OF THE AUSTRALIAN AUSCOPE VLBI ANTENNAS TO GLOBAL IVS EXPERIMENTS HAS SIGNIFICANTLY IMPROVED THE REPEATABILITIES OF SOUTHERN AND NORTH-SOUTH BASELINES.

THE DEDICATED AUSTRAL EXPERIMENTS SERVE AS A TEST BED FOR THE FUTURE VGOS OBSERVING WITH STEADY DEVELOPMENTS IN OPERATION AND DATA LOGISTICS.

AUSTRAL GEODETIC RESULTS IN TERMS OF BASELINE LENGTHS ARE CONSISTENT WITH (AND SLIGHTLY BETTER THAN) STANDARD IVS PRODUCTS AND PROVIDE VALUABLE DATA FOR FUTURE REALISATIONS OF THE TERRESTRIAL AND CELESTIAL REFERENCE FAME.

Results

- **62 AUSTRALs analysed** — *up to AUST45, incl. AUSTCont*
- **R1/R4 from 2011/1-2014/11** — *standard weekly IVS experiments*
- **Cont14** — *incl. all AUSTRAL antennas*

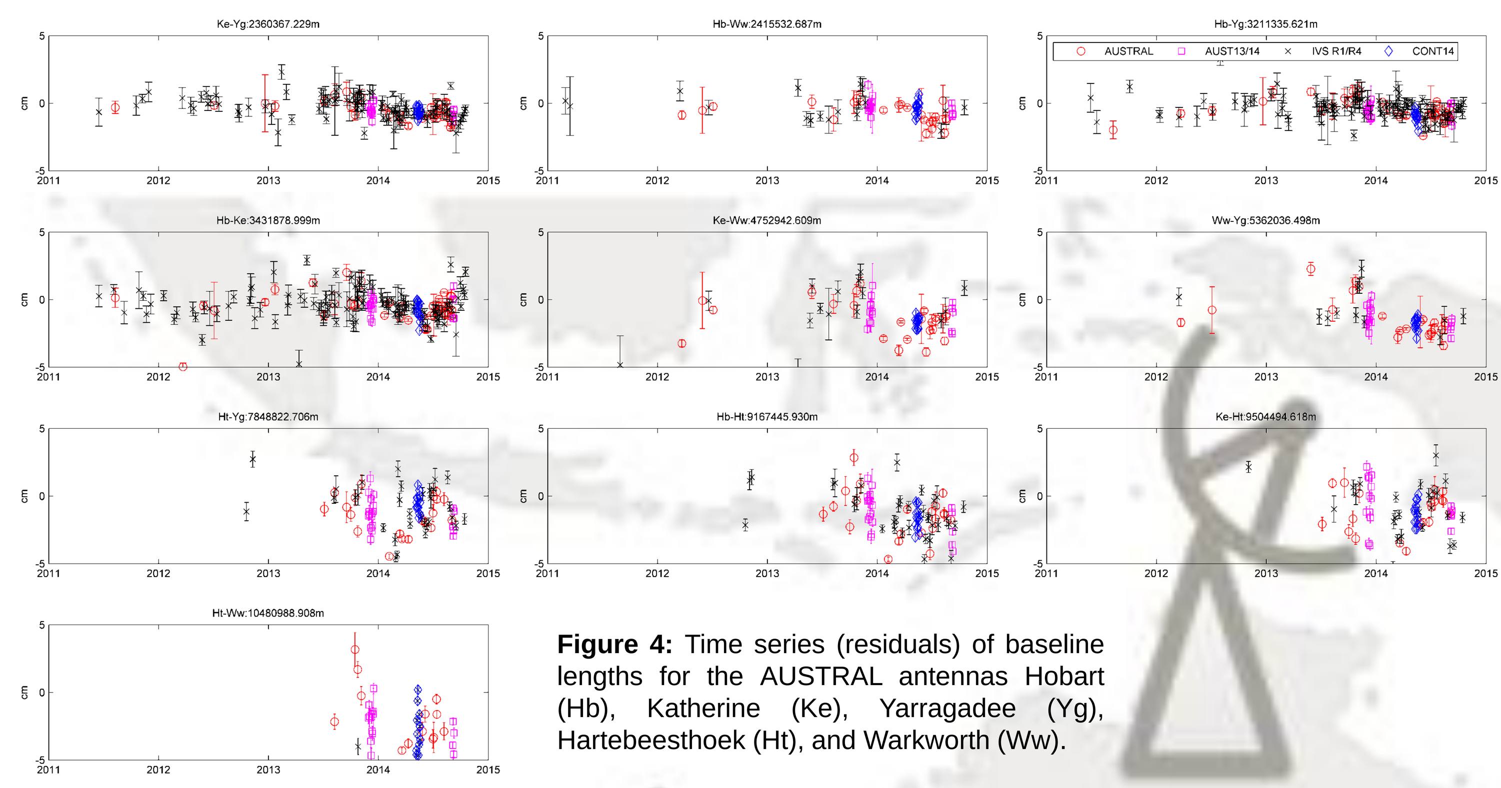

Figure 4: Time series (residuals) of baseline lengths for the AUSTRAL antennas Hobart (Hb), Katherine (Ke), Yarragadee (Yg), Hartebeesthoek (Ht), and Warkworth (Ww).

Baseline lengths

- *Baselines are in accordance with IVS results (Fig. 4).*
- *Improved repeatabilities for AUSTRALs vs. IVS rapids (Tab. 1).*
- *Dense time series reveal unknown systematics (e.g. Hb-Ke).*

baseline	length	AUSTRALS	R1/R4	Cont14
Hb-Ho	296 m	-	9.5 mm	1.7 mm
Ke-Yg	2360 km	5.5 mm	7.9 mm	3.3 mm
Hb-Ww	2416 km	7.2 mm	10.4 mm	5.1 mm
Hb-Yg	3211 km	6.0 mm	7.4 mm	4.3 mm
Hb-Ke	3432 km	7.4 mm	10.5 mm	6.4 mm
Ke-Ww	4753 km	9.9 mm	17.0 mm	3.6 mm
Ww-Yg	5362 km	9.9 mm	13.7 mm	4.5 mm
Ht-Yg	7849 km	9.3 mm	11.2 mm	6.6 mm
Hb-Ht	9167 km	13.4 mm	16.4 mm	8.0 mm
Ht-Ke	9504 km	14.3 mm	15.2 mm	8.0 mm
Ht-Ww	10481 km	16.6 mm	-	14.6 mm

Table 1: Baseline length repeatabilities (wrms) as determined in the AUSTRALs, R1/R4 sessions, and Cont14.

Hb ... Hobart 12M
Ho ... Hobart 26M
Ht ... Hartebeesthoek 15M
Ke ... Katherine 12M
Ww ... Warkworth 12M
Yg ... Yarragadee 12M

Better and better

AUSTRAL results are still improving (Fig.6). Thanks to improved scheduling after AUST30, due to more frequent observations with four and five station networks and less failures during observations.

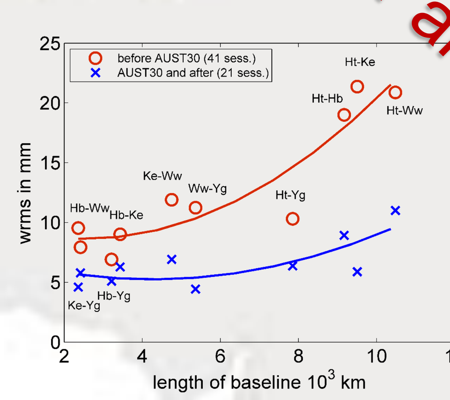

Figure 6: Baseline length repeatabilities of the AUSTRAL sessions before and after a change in the scheduling strategy.

CRF

Within the AUSTRAL program, special astrometry sessions are performed once per month. The goal is astrometry of radio sources of the ICRF2 with limited number of S/X observations and flux appropriate for observing with 12m radio telescopes. We also look for new sources (Tab. 2).

✓ ... detected   x ... not detected / bad observations

source	type	Aust18	Aust20	Aust22	Aust24	Aust33	Aust40	Aust43
0002-478	ICRF2 defining						✓	✓
0048-427	ICRF2 defining						✓	✓
0122-003	non-defining	✓	✓	✓	✓	✓	✓	✓
0107-610	ICRF2 defining	✓		✓				
0230-790	ICRF2 defining	✓	✓	✓	✓	✓	✓	✓
0312-770	non-defining						✓	✓
0743-673	single X-band	✓	✓	✓	✓	✓	✓	✓
0758-737	single X-band	✓	✓	✓	✓	✓		
1030-590	single X-band	x	x	x	x	x	x	x
1336-237	VCS	✓	✓	✓	✓	✓	✓	✓
1352-632	non-defining						x	
1511-360	single X-band						✓	✓
1531-352	non-defining	✓	✓	✓	✓	✓	✓	✓
1707-376	single X-band	x	x	x	x	x		
1842-289	VCS	✓	✓	✓	✓	✓	✓	✓
1922-224	non-defining						✓	✓
1933-400	ICRF2 defining	✓	✓	✓	✓	✓	✓	✓
2030-689	non-defining	✓	✓	✓	✓	✓		
2354-117	VCS	✓	✓	✓	✓	✓	✓	✓
2355-534	ICRF2 defining	✓	✓	✓	✓	✓	✓	✓

Table 2: Selection of radio sources observed in the AUST-Astro experiments. They are intended to improve the observational history of sparsely observed ICRF2 sources (defining, non-defining, and VCS) as well as to identify new sources which have never been observed with S/X band before and whose position is known form single X band observations.

Outlook

- **Many more sessions to analyse and observe in 2014/15**
  AUST-74 until the end of 2014, AUST-CONT14, two AUST continuous campaigns in early 2015.
- **AuScope goes VGOS**
  Hb, Ke, and Yg will be upgraded with a broadband feed & 16 Gbps sampler/recording system until end of 2015.
- **Dynamic observing**
  Ongoing developments for improved operations with real time correlation & quality control.
- **Sibling Telescopes**
  Twin-Experiments with the legacy-VGOS antenna pairs in Hobart and Hartebeesthoek (Fig. 7).
- **Source structure studies**
  Continuation of source structure studies with broadband/phase delay observations.

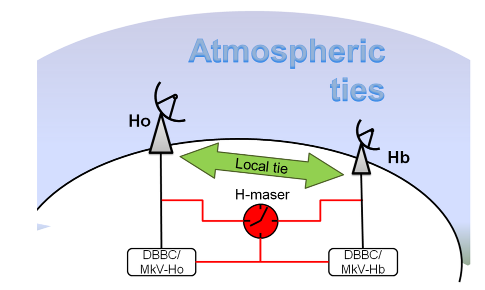

Figure 7: Observations with sibling telescopes: improved analysis through atmospheric ties and common clock parameters.

AGU FALL MEETING
San Francisco | 15–19 December 2014

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