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Towards GGOS Station(s) in New Zealand

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Abstract. *The accuracy of positioning and dynamic measurements can be greatly improved when two or more geodetic techniques are used from the same geographic locations. The Global Geodetic Observational System (GGOS) was created in 1990s in order to combine existing methods of geodetic observations and take advantage from joint use of these techniques. At the moment New Zealand has one geodetic observatory which has features of a GGOS station – Warkworth, which combines VLBI, GNSS and gravity stations. Preliminary geodetic results from Warkworth are presented and the opportunity for establishing the second GGOS station (in New Zealand's South Island) is discussed.*

AUT Radio Telescopes

Auckland University of Technology operates two large modern radio telescopes — see the panorama of the Warkworth Observatory in the top centre. AUT's 12-m radio telescope is a modern fully steerable fast slewing antenna of Cassegrain design (Gulyaev et al., 2008). The radio telescope is equipped with a dual-band (S/X) dual-polarization feed system designed for astrophysical and geodetic research. This radio telescope is collocated with the GNSS station, one of base stations of the IGS (see Figure above).

The 30-m radio telescope (on the right in the panorama and in Figure below) is currently using C-band and X-band uncooled receivers (Woodburn et al. 2015).

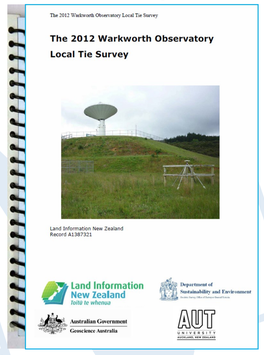
Equipped with a Hydrogen maser clock and 10 Gbps fibre optics data link via REANNZ network, these radio telescopes allow New Zealand to contribute to modern international geodetic VLBI and eVLBI research and services.

Geodetic VLBI, astrometry and the Earth Science

Development of the New Zealand VLBI service for geodesy is one of the central tasks in sustaining the New Zealand Geodetic Datum 2000 and maintaining its link to the International Terrestrial Reference Frame (ITRF).

Aims of space geodesy research conducted at IRASR include:

- Integration of VLBI into NZ space geodesy research and practice;
- Development of NZ geospatial link between VLBI and GNSS techniques for definition and maintenance of the NZ Geodetic Datum;
- Integration into the AuScope programme (Australia) to jointly study the structure and evolution of the Australian tectonic plate;
- Development of GGOS components of the NZ station, such as GNSS and gravimetry services collocated with VLBI;
- Establishment of the second GGOS station in the New Zealand's South Island;
- Contribution to GGOS study of the Pacific and Australian tectonic plate relative motion;
- Development of foundation for establishment of a GGOS station in Antarctica, possibly operated jointly by NZ (Scott Base) and the USA (McMurdo Station) scientists and engineers.



Geodetic results with the 12-m radio telescope

The Warkworth 12-m radio telescope is integrated into the Australian AuScope programme, whose primary goal is to study the structure and evolution of the Australian continent. Location of the NZ 12m radio telescope at the Eastern edge of the Australian tectonic plate allows extending this task to study dynamics and evolution of the Australian Plate as a whole.

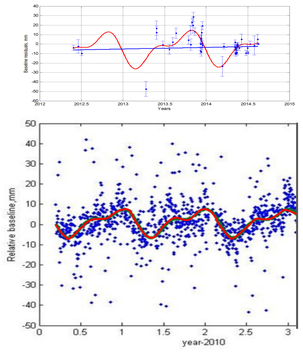


Figure: *Baseline Warkworth—Katherine. Top: VLBI time series. Bottom: GNSS time series. Red line: fitting of two signals — annual and semi-annual.*

First geodetic results with the 12-m radio telescope included its precise positioning via geodetic VLBI (Petrov, et al. 2012) and geodetic local tie survey of the radio telescope and the collocated GNSS station (Gentle, et al,2013), which was repeated in February 2015.

Monitoring of baselines between three AuScope radio telescopes and Warkworth 12-m started recently. The first results of this monitoring were reported by Plank et al. (2014). For comparison, baselines between collocated GNSS stations were also determined. Figure below/left shows the baseline Warkworth—Katherine for both GNSS stations and VLBI radio telescopes. Though accuracy of individual VLBI measurements is a few times worth than for GNSS, the dispersion of measurement points is comparable for GNSS and VLBI. As the result, the rate of change of baselines can be measured with comparable accuracy, and seasonal signals (annual and semi-annual) can be compared and studied.

Establishment of Gravity station in Warkworth

In 2015 a gravity station was established near the 12-m radio telescope in Warkworth. Measurements were conducted with an absolute gravimeter provided by the Land Information NZ and the NZ Geological and Nuclear Sciences Institute.

First geodetic results with the 30-m radio telescope

The New Zealand 30-m radio telescope facility is located near Warkworth, New Zealand. It was built in 1984 as a telecommunications antenna (the Earth Station) to be used by the New Zealand Post Office, later by Telecom New Zealand. In 2010 it was transferred to the Institute for Radio Astronomy and Space Research for conversion to a radio telescope. The conversion was accomplished in 2014 (Woodburn et al., 2015).

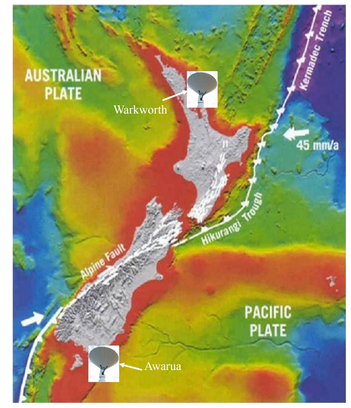
The first geodetic VLBI session was conducted in late 2014. The position of the telescope was determined with uncertainties estimated as 100 mm for the vertical component and 10 mm for the horizontal components (Petrov et.al. 2015).

The geocentric coordinates of the telescope and the corresponding velocities were determined as follows (Petrov et al. 2015):

X = −5115425.60 ± 0.08 m
Y = 477880.30 ± 0.02 m
Z = −37670428.10 ± 0.06 m
dX/dt = −4.6 ± 1.5 mm/yr
dY/dt = −2.9 ± 0.5 mm/yr
dZ/dt = −38.9 ± 0.5 mm/yr
The telescope axes offset was found to be 2.61 ± 0.06 m

Future development

A plan for construction of a new geodetic radio telescope in Awarua (South Island) is under development. The southern observatory, when/if constructed, has a potential to become the second GGOS station in New Zealand. Placed on the Pacific Plate, it will allow monitoring baseline Warkworth-Awarua, as well as baselines AuScope—Awarua. One more geodetic VLBI station in the Southern Hemisphere will contribute towards more homogeneous distribution of International VLBI Service (IVS) stations between hemispheres, therefore contribute to improvement of the ITRF solution.



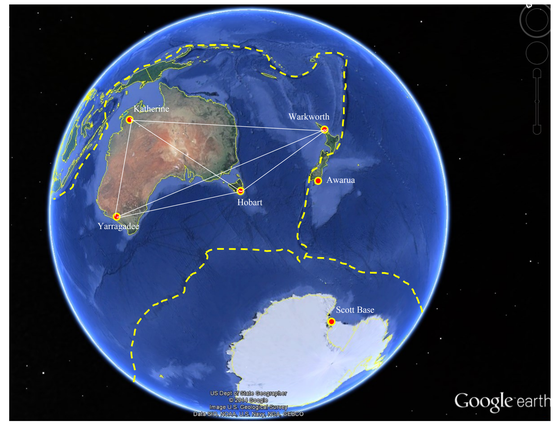


Figure: *Shows locations of existing and potential GGOS stations in the Australasia—Antarctica region. Boundaries between tectonic plates—Australian, Pacific and Antarctic— as well as the triple point are shown schematically.*