Precision Surveys at Australian Geodetic Observatories

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1 Introduction

Precision geodetic site surveys are routinely carried out by Geoscience Australia at all of the significant co-located Australian geodetic sites to determine accurate terrestrial connections between each observing system. The terrestrial connections are the 3-dimensional vectors and their associated variance covariance information, aligned to the International Terrestrial Reference Frame (ITRF), between a primary monument and other significant reference marks at each site. These co-located geodetic observing sites in Australia (see Fig. 1 and 2) include:

- Yaragadee (SLR/GPS/DORIS/GLONASS/Absolute-Gravity);
- Mount Stromlo (SLR/GPS/ DORIS/GLONASS);
- Orroral (SLR now obsolete, was 27km from Tidbinbilla);
- Hobart (VLBI/GPS/Absolute-Gravity);
- Tidbinbilla. (VLBI/GPS);
- Darwin (GPS/GLONASS);
- Davis, Antarctica (GPS/GLONASS/Tide-Gauge).

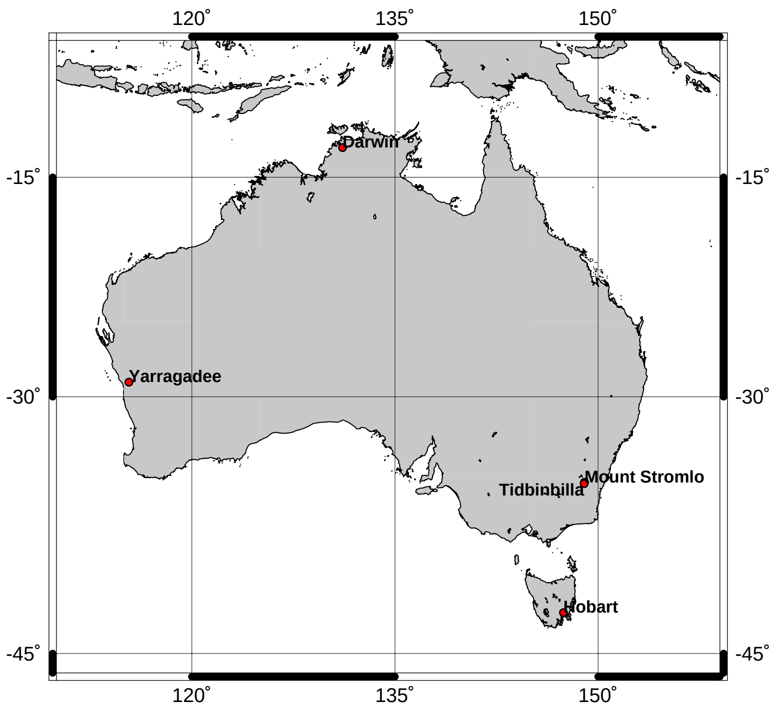

Figure 1: Co-located Geodetic Sites, Australia.

Figure 2: Co-located Geodetic Sites, Australia. Top Left Yaragadee. Top Right Mount Stromlo. Centre Hobart. Bottom Tidbinbilla.

The Geoscience Australia terrestrial survey connection between observing systems at each of these sites are generally determined using a combination of GPS, total station and precise levelling observations.

While not directly related to co-location for terrestrial reference development Geoscience Australia is also involved in the site survey of a number of GPS to tide gauge connections in Australia and the region. These include Hillarys in Western Australia, Burnie in Tasmania, Macquarie Island and Mawson, Casey, Davis in the Australian Antarctic Territory. In addition Geoscience Australia through the Australia Agency for International Development (AUSAID), is involved in the site survey of a number of GPS to tide gauge connections throughout the South Pacific including stations at Samoa, Cook Islands, Fiji, Tuvalu, Tonga, Manus Island, PNG, Kiribati, Vanuatu, Nauru and Micronesia, see Fig. 3. With further stations planned for Marshall Islands, Palau, Niue, and the Solomon Islands. Tide gauge connections include multi-day GPS connection between GPS Station and the Tide Gauge Bench Mark (TGBM); an orthometric levelling connection as well using Total Station Levelling (TSL).

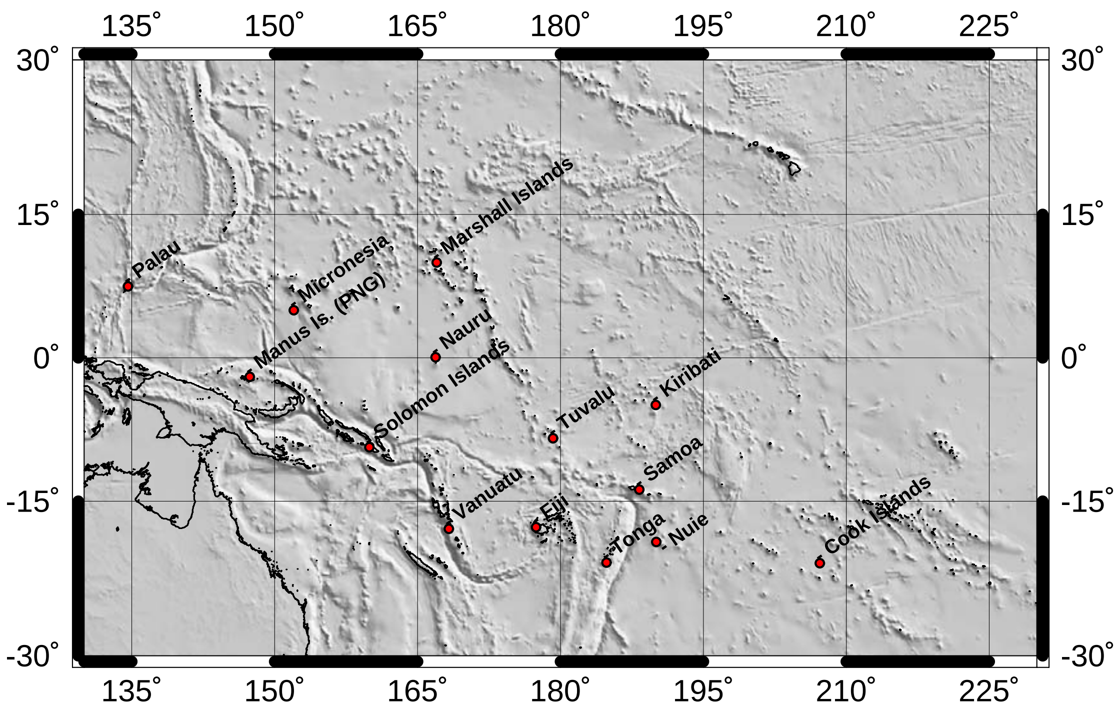

Figure 3: South Pacific Sea Level and Climate Monitoring Project GPS Network.

2 Planning and Strategies

The survey of precise geodetic facilities should

- Be timed for optimum survey observations, i.e. timing the survey when weather conditions are neutral to minimise atmospheric effects;
- Allow for several days down time, particularly on Satellite Laser Ranging (SLR) or Very Long Baseline Interferometry (VLBI) systems;
- Be planned to avoid critical tracking campaigns;

- Plan the placement of marks on the telescope/antenna to optimise observations for the determination of axes (in the case of indirect reference point determination), i.e. optimise the target trajectories and the radius of the trajectories; and
- Place instrument stand-points to satisfy survey accuracy demands (as determined by network simulation if necessary).

Forced centring is used to eliminate the introduction of setup errors wherever possible. A Leica Zenith Nadir precise optical plummet is used for all tripod setups, to ensure near zero plumbing errors. Additionally, wherever possible concrete pillars are used for instrument standpoints. This ensures setup stability during the often long observation periods when observations are taken to the antenna or telescope systems.

3 Equipment and Equipment Calibration

Geoscience Australia primarily uses a Leica TCA2003 (total station) for precision surveys, see Fig. 4. This instrument has an angular measurement (horizontal and vertical) precision specification of 1 second of arc and a distance measurement precision specification of 1 mm plus 1 part per million. However a laboratory calibration revealed that the specifications were somewhat pessimistic and the actual precision were angular measurement (horizontal and vertical) precision of 0.6 second of arc and a distance measurement precision of 0.5 mm plus 0.4 part per million. The use of motorization and automatic target recognition (ATR) in the Leica TCA2003 reduces observer errors. Geoscience Australia uses Leica precision prisms with Tribrach and carriers (including plate bubble) and a zenith nadir plummet for centring tripods where they are required; a fixed height prism pole (see Fig. 5) for Total Station Levelling (TSL) and a invar staff for instrument heighting.

Figure 4: Left Leica TCA2003 Total Station. Right Leica Precision prisms with Tribrach and carriers (including plate bubble).

Figure 5: Fixed height prism pole for Total Station Levelling (TSL).

Geoscience Australia's Leica TCA2003 (total station) was purchased with the factory calibration option. In addition an annual comparison with a standard baseline (linked to the Australian National Standard) is made. At the time of survey internal angular calibrations are estimated. The calibration of prism / reflectors is made following the standard methodology over a calibration baseline. Comparison with GPS is also undertaken. The invar staff used was factory calibrated initially (when purchased) and is calibrated biennially.

4 Monumentation and Network Design

The choice of station monumentation is highly dependant on site conditions, however,

- Ideally instrument standpoints are stable bedrock anchored pillars;
- Pillars should have reference marks to monitor local deformation; and
- Survey marks should have an unambiguous reference point.

Ideally the survey network design should link instrumentation through a highly over determined braced quadrilateral network design. For SLR and VLBI systems with reference points unable to be directly observed Geoscience Australia uses an approach for estimating the observation reference point using an indirect technique of coordinating targets on the measurement systems during specific rotational sequences of the observing system. The axes of rotation are then used to define the reference point of the instruments.

In the case of GPS antennas the Antenna Reference Point (ARP) of the GPS is coordinated directly, see Fig 6. While for DORIS antennas direction observations are made symmetrically to each side of the antenna case then averaged and intersected with further observations made from at least one other standpoint.

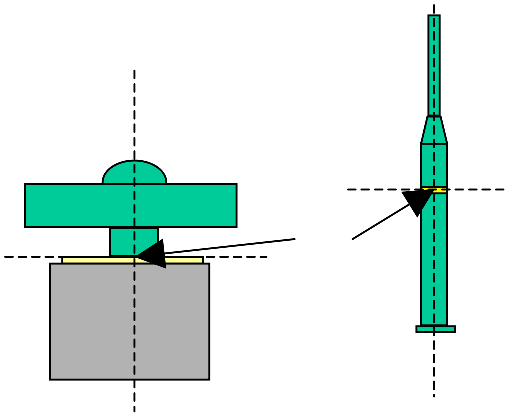

Figure 6: Reference point of GPS and DORIS.

5 Additional Issues

The accurate measurement of observing instrument trunnion axis height has been addressed by the use of observational sequences to a level staff (Rueger and Brunner, 1981) situated on a bench mark of known height. In surveys to date poor performance of the tape reflectors on distance and angular measurement have become apparent and there use is no longer recommended for high precision surveys. Another effect yet to be fully quantified is the unknown effect of refraction on lines which have a temperature gradient. In the future the potential use of laser scanning or terrestrial photogrammetry to determine VLBI antenna deformation will be explored.

6 Final Comments

Precision surveys are currently undertaken at the one millimetre level although monument design and stability remain an issue. Repeat surveys are completed every two years to monitor network and system stability.

References

Rueger J.M., and Brunner F.K., The Australian Surveyor, June 1981, Vol. 30, No. 6.