THE IMPORTANCE OF MINICOS

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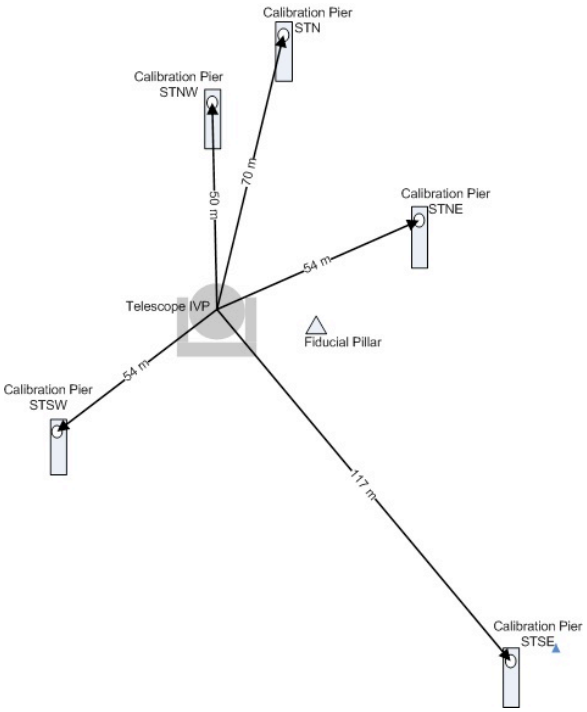
INTRODUCTION

Mt Stromlo SLR station is one of very few stations that have been taking multi-target calibration measurements over a significant period of time and including at least four targets suitably arranged around the SLR tracking telescope system reference point(SRP). A set of measurements obtained from such targets over a short time interval is referred to here as a mini-colocation calibration or MINICO. Previous reports on this technique (Luck, 2004, 2006) necessarily included only relatively short periods of measurements.

A recent re-analysis of about 10 years of Minico data, together with associated tie survey results, has been undertaken and some of the results presented in this paper. As a technique for assessing the stability of the SRP, the results clearly demonstratethat the Minico method can identify signals at 1mm level, and particularly trends in the movement of the SRP and/or individual calibration targets. The significance and interpretation of such signals is perhaps not so obvious.

Since the accuracy, as well as the precision, of SLR data is directly related to the measurement of the system delay, it will be particularly important for improving the accuracy of SLR data to monitor the SRP and calibration pier stability, allowing improvements to the accuracy of system delay measurements. Minico calibration is an important technique in doing this, and stations are encouraged to install sufficient calibration targets to support such measurements.

1. Layout of External Calibration Piers at Mt Stromlo



Calibration Pier STNE

Calibration Pier STN, STNW and SLR station in the background.

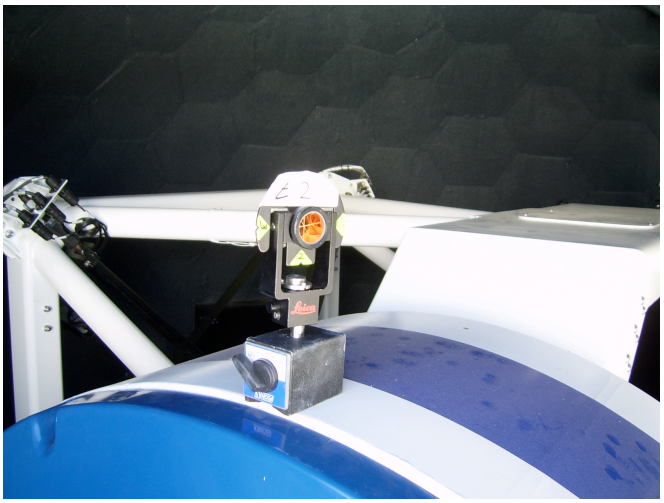
Calibration Pier STSE

Calibration Pier STSW

2. SURVEYS

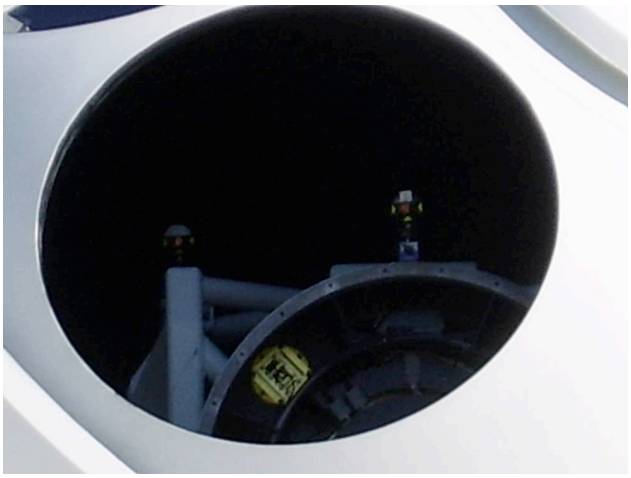
Once a network of monuments, including calibration targets, GNSS, SLR, DORIS, VLBI and other instruments, have been constructed, an initial local tie survey must be conducted to establish the reference point connections. The survey distance of the prime calibration target of an SLR system is particularly important for routine system delay measurements. After the initial survey, local tie surveys should then be conducted on a regular basis, say once every two years after the initial survey.

Survey of all calibration targets and fiducial points in local tie network



Survey of the telescope IVP. Targets are installed on the gimbal and trusses for measurements at various azimuths and elevations (cf Ruddick and Woods, 2013).

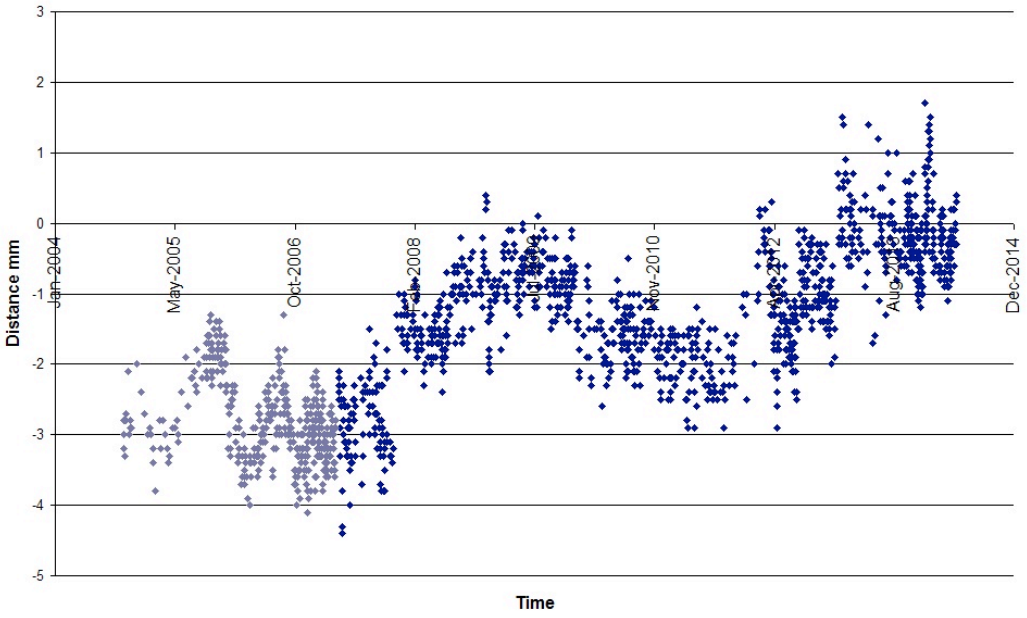
Survey of spigot reference point on calibration pier STN.



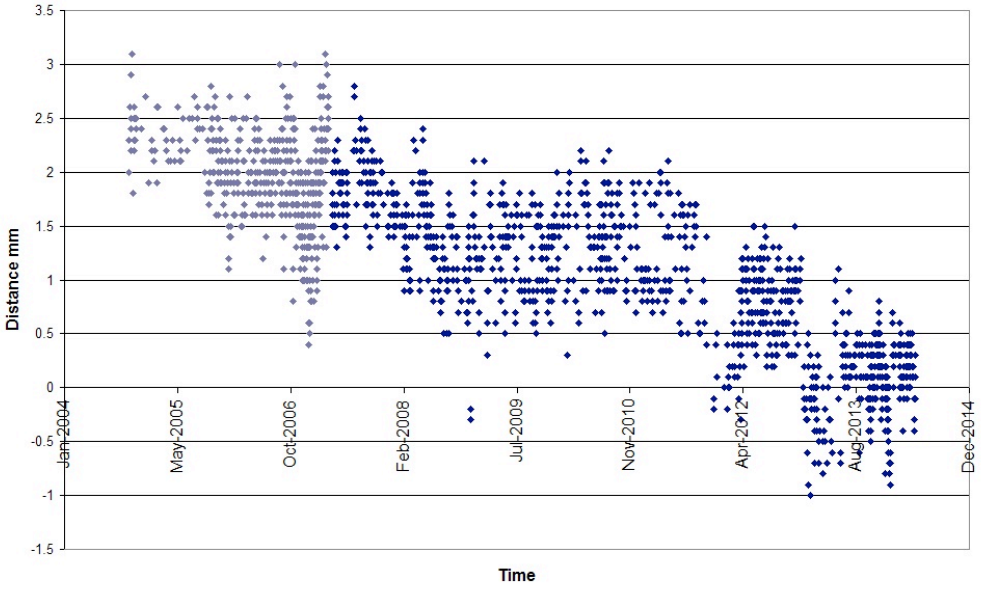
Telescope targets are surveyed from external fiducial pillars so must be visible as the telescope azimuth and elevation axes are rotated.

3. IDENTIFY IVP STABILITY

While the IVP is a fixed point in space as telescope varies in azimuth and elevation, it is not necessarily a fixed point in space over time. This may depend on the stability of the telescope mount in the shorter term and on movements in the location of the associated monument due to geological motions over the longer term. Stability of the IVP can be monitored over time from determination of IVP coordinates using a Minico least squares solution (Luck 2004).



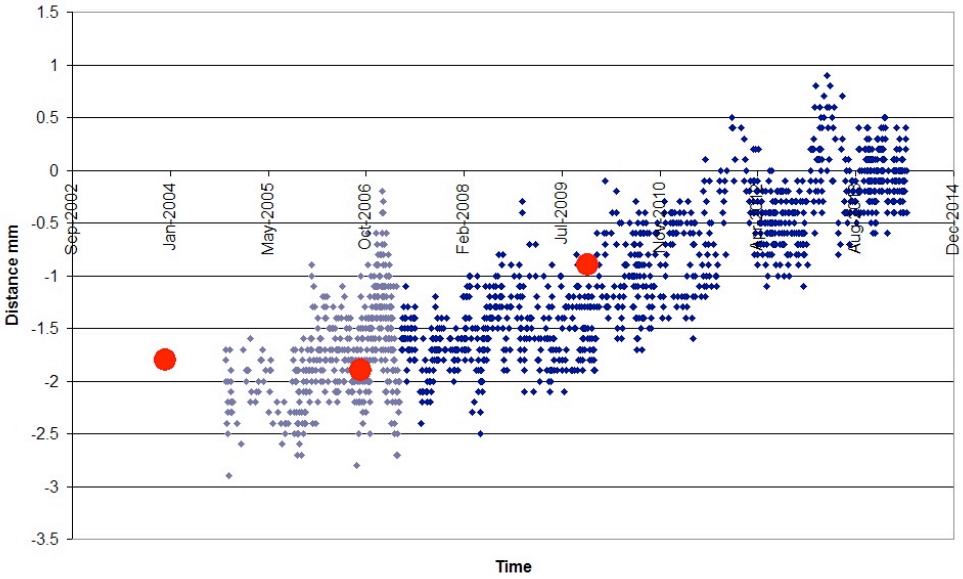
Variation in IVP easting coordinate



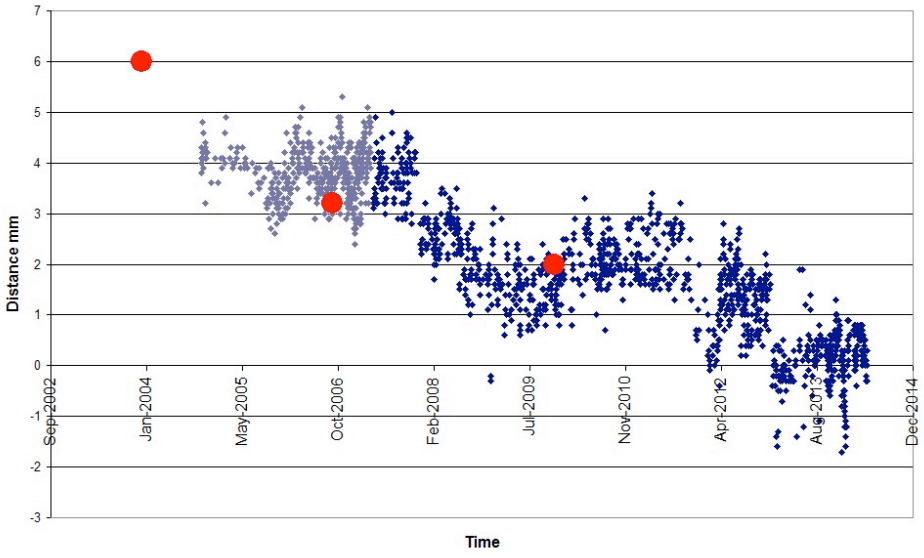
Variation in IVP northing coordinate

4. ANALYSE CALIBRATION TARGET RESIDUALS

The Minico least squares solution for IVP coordinates allows calculations of changes in IVP to calibration target ranges. This allows an assessment of the stability of calibration piers themselves.



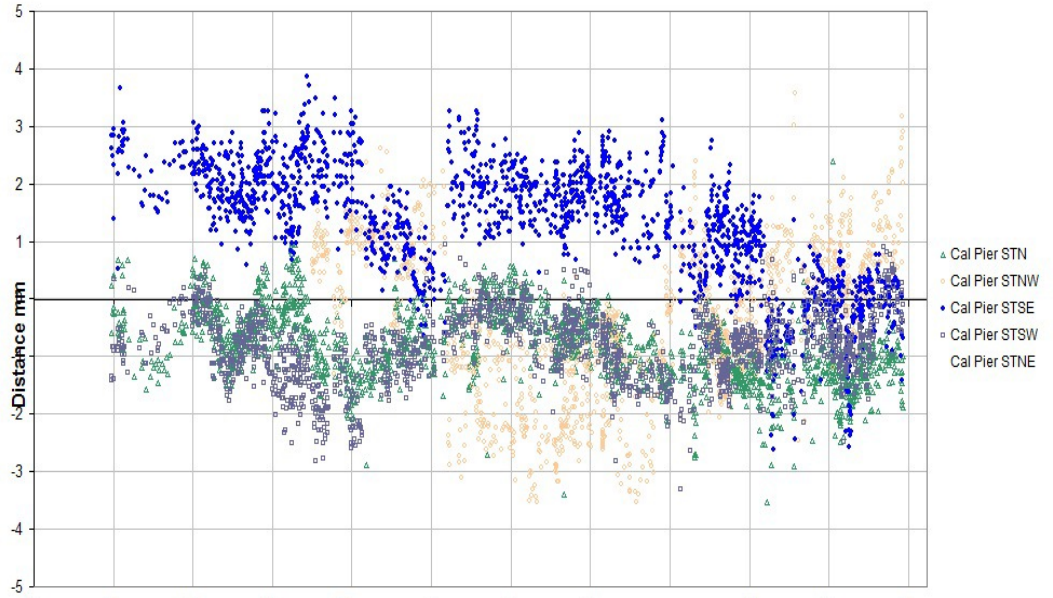
Variation in Calibration Target STN Residual. Red dots are survey values – 69.593m.



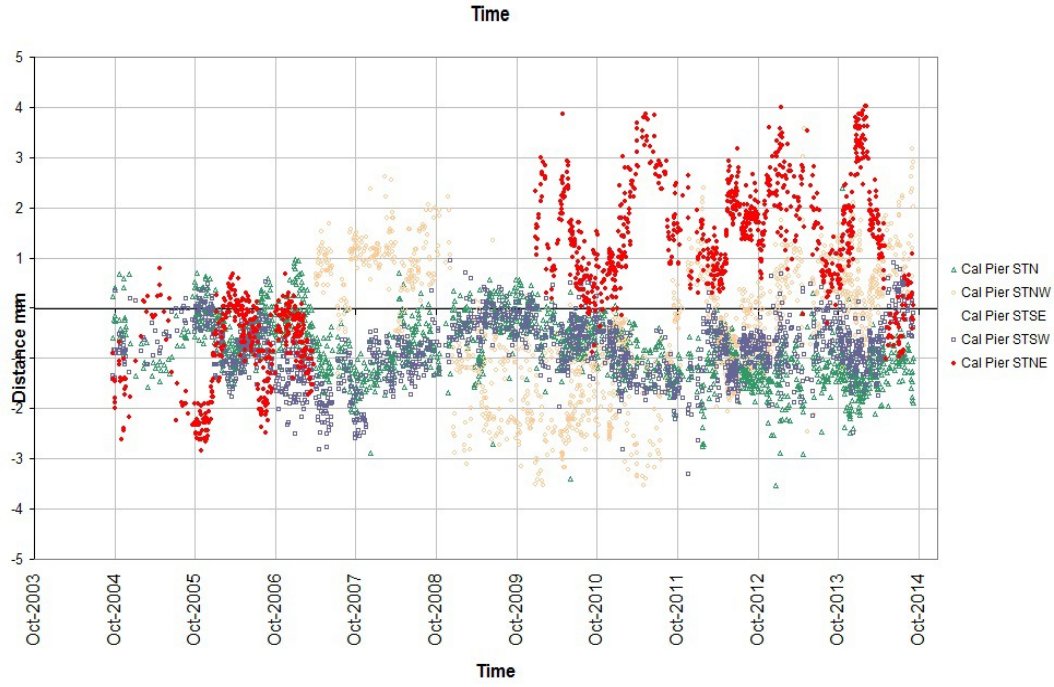
Variation in Calibration Target STSE Residual. Red dots are survey values – 117.217m.

5. IDENTIFY UNSTABLE CALIBRATION TARGETS

An alternative to the Minico least squares solution, system delay values may be determined by averaging data from all available targets. If most piers are stable (ie "good" targets) then residuals from less stable piers will stand out and be easily identified. This example identifies the stability of calibration pier STSW as being suspect. Recent data from calibration target STNE is also identified, but this is due a known issue (recent inability to survey the target accurately).



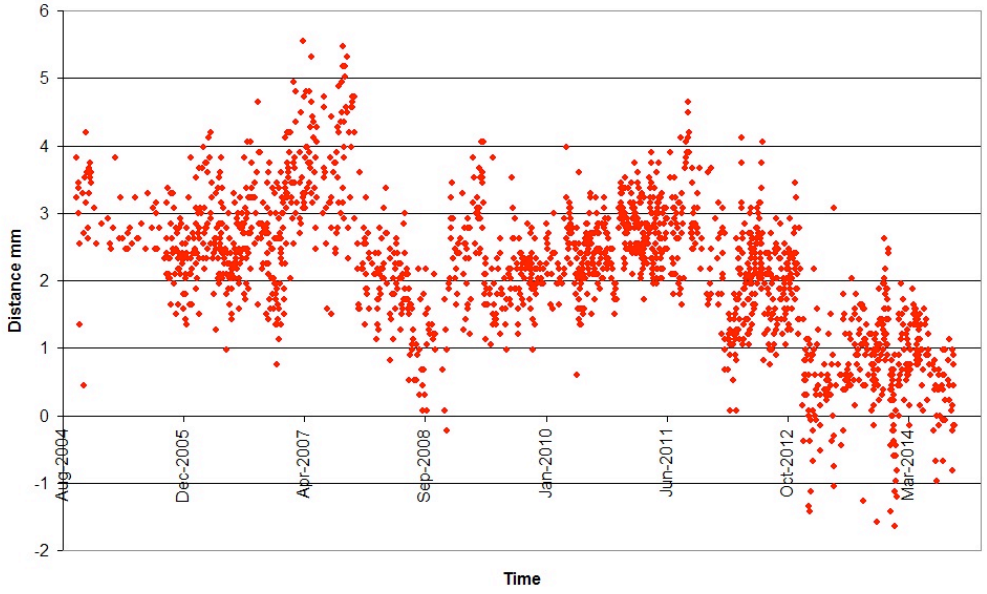
Variation of residuals of all calibration targets (excluding STNE) using averaged system delays.



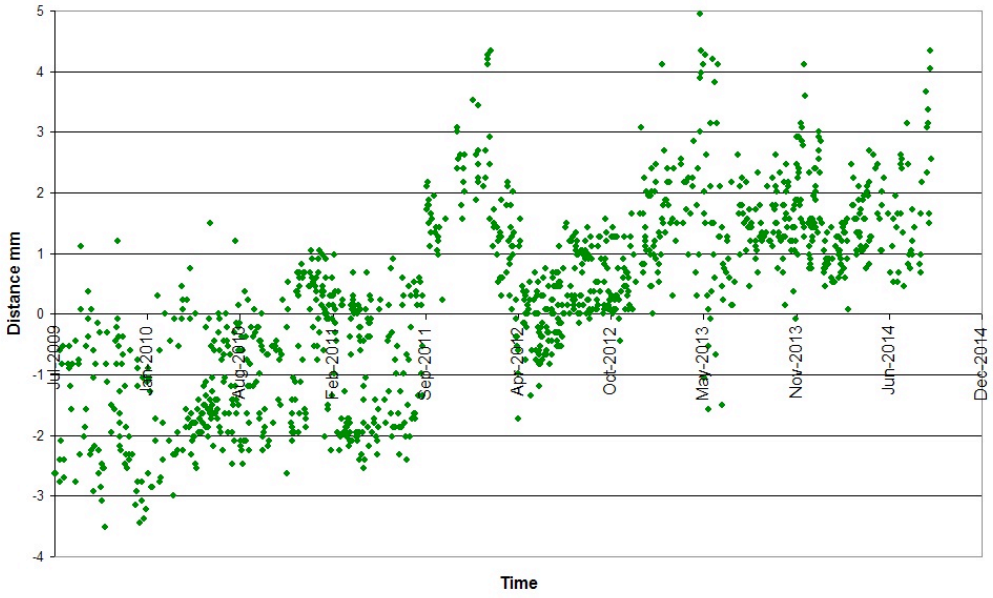
Variation of residuals of all calibration targets (excluding STSE) using averaged system delays

6. ANALYSE STABILITY OF INDIVIDUAL CALIBRATION TARGETS

Use of averaged system delay values determined from selected "good" piers allows independent analyse of individual calibration target movements over time.



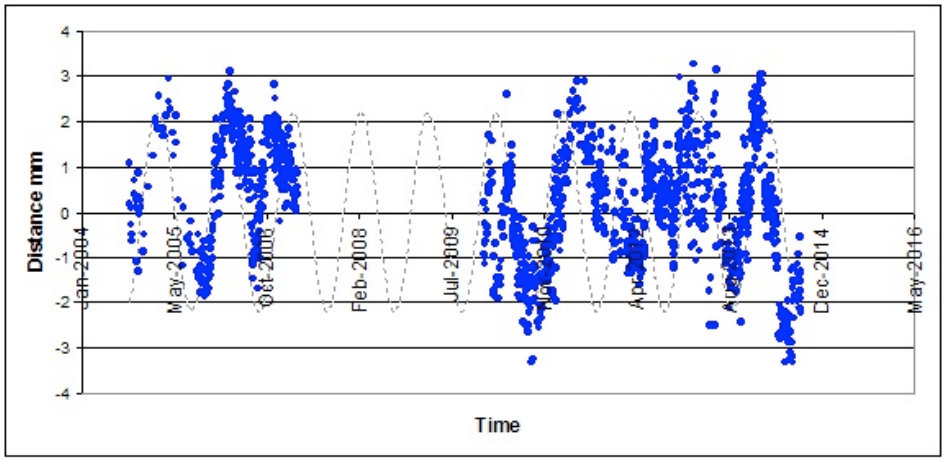
Variation in Calibration Target STSE Residuals determined from estimated system delays.



Variation in Calibration Target STNW Residuals determined from estimated system delays.

7. IDENTIFY UNUSUAL SHORT TERM STABILITY PATTERNS

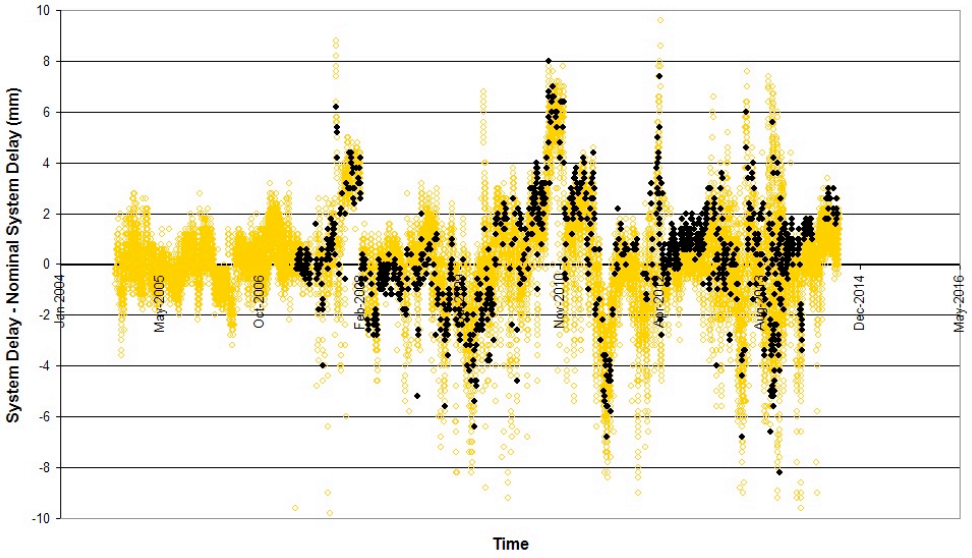
Minico analyses may identify unusual patterns in IVP or calibration target movements that may be associated with particular events or natural phenomena. This plot suggests that one cal target at Mt Stromlo continues to be subject to roughly annual cycles.



Variation in calibration target, STNE residuals overlaid on an annual cycle.

8. CHECK SYSTEM DELAY

The Minico least squares solution provides an measure of the system delay that is independent of any individual calibration target - useful for confirming the adequacy of system delay measurements.



A comparison of system delay values obtained from routine ranging to primary calibration pier STN (yellow crosses) and minico values obtained from 4 calibration piers (black dots). In both cases system delay values are offset by the current nominal system delay value.

9. CONCLUSIONS

The benefits of having calibration data from multiple targets and associated minico solutions are;

- They provide a means to monitor any movement of the IVP over time;
- They can indicate movement in individual calibration targets;
- It calibrates the system delay range used in regular single calibration target measurements, giving greater confidence in these measurements;
- If internal calibration target data is available, it can be extended to calibrate the internal calibration target offsets homogeneously with the external calibration target measurements giving greater accuracy than by other means.

Sub-mm accuracy of ranging measurements requires sub-mm accuracy of system delay. Telescope and primary calibration target must therefore be sufficiently stable. Survey of calibration targets alone cannot achieve required accuracy due to measurement error, low frequency of measurements and the effects of time. Hence it is important to install multiple calibration targets and conduct regular Minico measurements to monitor errors in system delay due to imperfect stability of calibration targets and the IVP.

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10. BIBLIOGRAPHY

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