Performance of WPLTN Stations

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Abstract

There have been significant upgrades to WPLTN stations in the last year. Performance statistics for each station will be presented, which may highlight where further improvements could be achieved.

Introduction

The working and developing stations which constitute the Western Pacific Laser Tracking Network (WPLTN) include Tokyo, Simosato and Tanegashima (Japan), Shanghai, Beijing, Changchun, Yunnan, Wuhan and the CTLRS (China), Yarragadee and Mount Stromlo (Australia), Riyadh (Saudi Arabia), Maidanak (Russia), and most recently the new Chinese-supplied station at San Juan, Argentina. In 2006, as well as the commissioning of San Juan, Shanghai moved to a new site and significant upgrades came to fruition at Simosato and Changchun. San Juan has been accepted as a member of WPLTN, and Yarragadee has dual membership with WPLTN and the NASA network.

These developments have produced a noticeable increase in the productivity and quality of the network as a whole. It is therefore timely to review its performance and to compare it with the NASA and Eurolas networks. (This paper was actually presented at the WPLTN General Assembly.)

For the purposes of this paper, Yarragadee is included in WPLTN, TIGO in Concepcion (Chile) and the Ukraine stations in Eurolas, and Hartebeesthoek and Tahiti in NASA. Data are shown in four periods – three 28-week periods spanning 20 Feb 2005 to 2 Sep 2006, and the 4-week period 3-30 Sep 2006 leading up to the Workshop. In many ways the data displays emulate the ILRS Quarterly Global SLR Performance Reports, arranged differently.

Productivity

The numbers of passes summarized by network are shown in Fig.1 as percentages of the global totals. The increase since 2005 seems to be sustained, at the expense of the NASA network. Data were extracted from the weekly CDDIS SLR Data Reports.

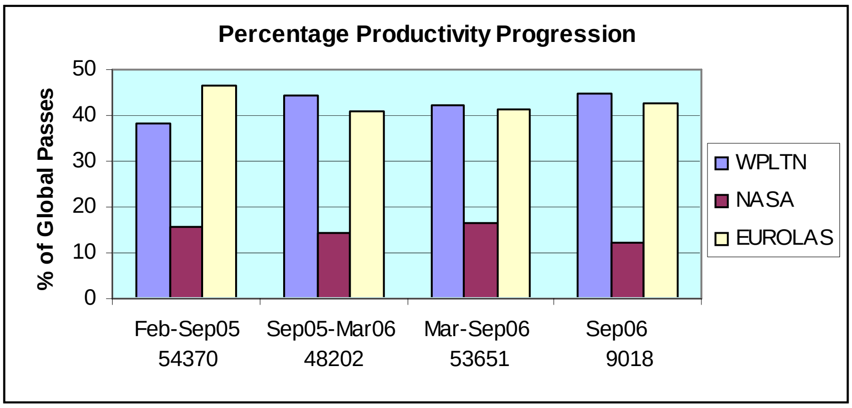


Figure 1*: Productivity comparison. The global totals of passes are on the bottom line.*

Fig.2 shows the numbers of passes per station per period, grouped by network.

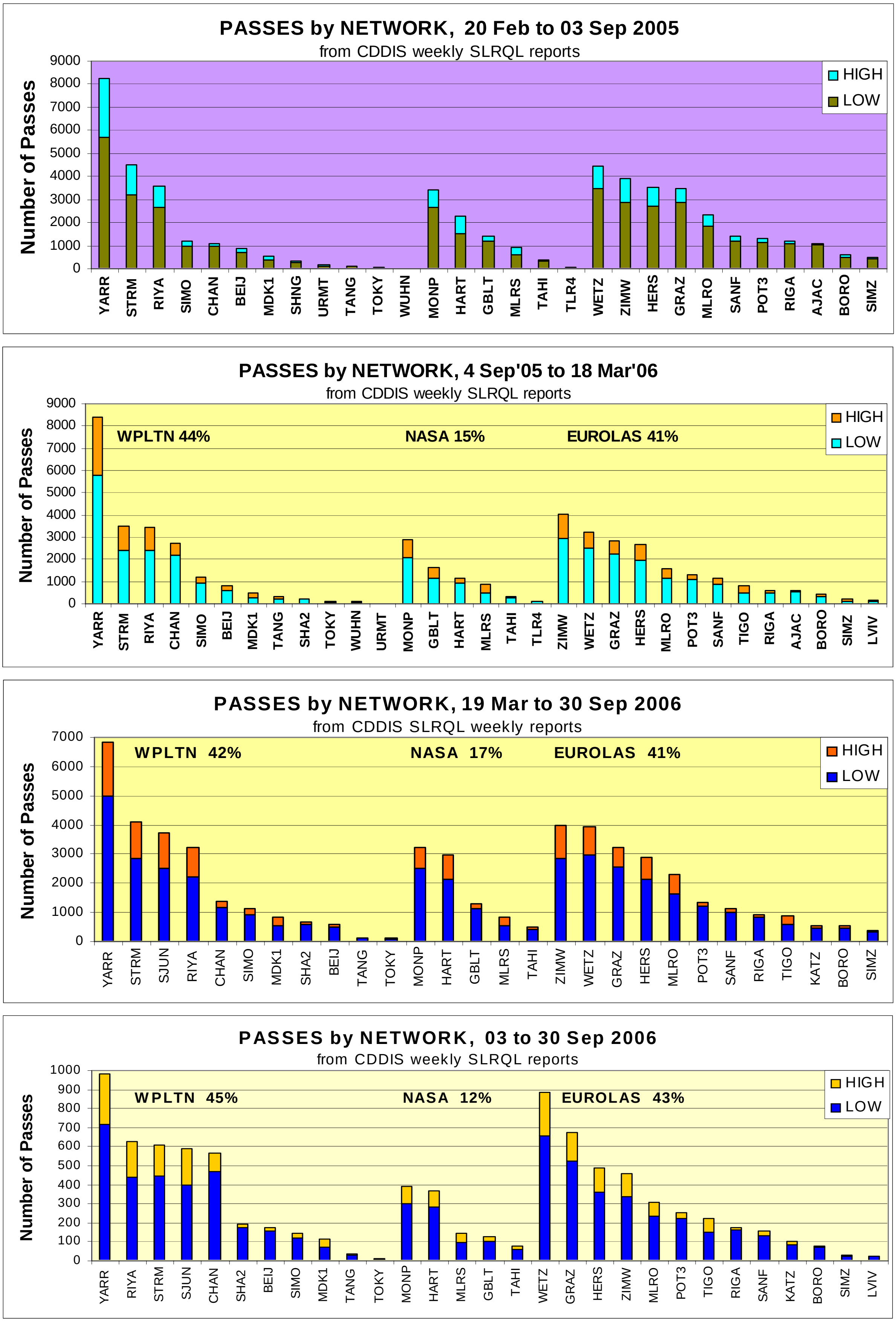


***Figure 2**: Numbers of passes per station in each of the four periods.*

Normal Points per Pass

This category reflects the observing efficiency of the stations, and is affected by skill in acquiring satellites and interleaving passes, as well as factors like aperture, laser power, sun avoidance, priorities, and bad weather. In general, low ratios mean more uncertainty in determining time bias, unless the normal points are very well distributed throughout a pass.

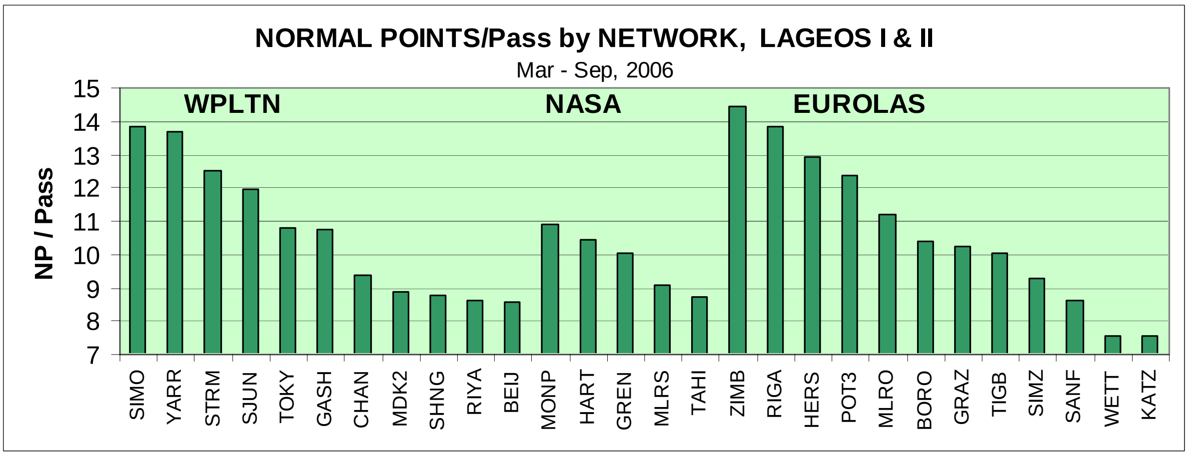


Figure 3*: Normal points per pass in much of 2006.*
Data from daily NICT Multi-Satellite Bias Analysis Reports.

The best of the WPLTN stations are comparable with Eurolas. Stations with low ratios – in all networks! – should aim to improve coverage during passes.

Normal Point Precision

For Fig.4, the average NP Precision values were calculated after removal of obvious outliers. Stations not shown were off-scale. The best stations achieve 2 mm, and 3 mm should be the aim. Clearly, several WPLTN stations and some from eastern Europe need to improve.

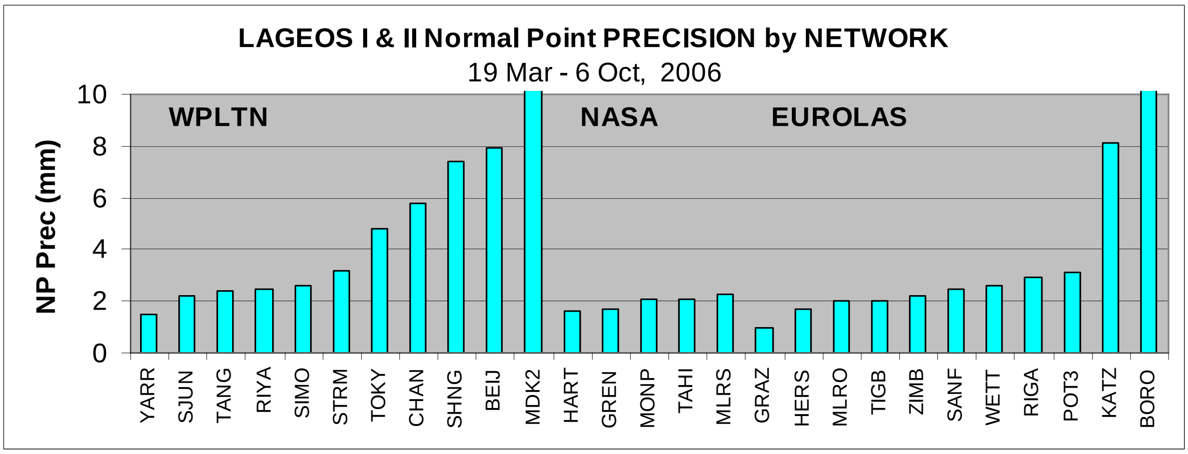


Figure 4*: Average Normal Point Precisions for much of 2006.*
Data from NICT reports.

Time series graphs for some of the stations are shown in Fig.5. Only passes containing at least 4 Normal Points are plotted. Graphs for Yarragadee, Stromlo and San Juan are given in the companion 'Southern Hemisphere' paper (Luck, 2006).

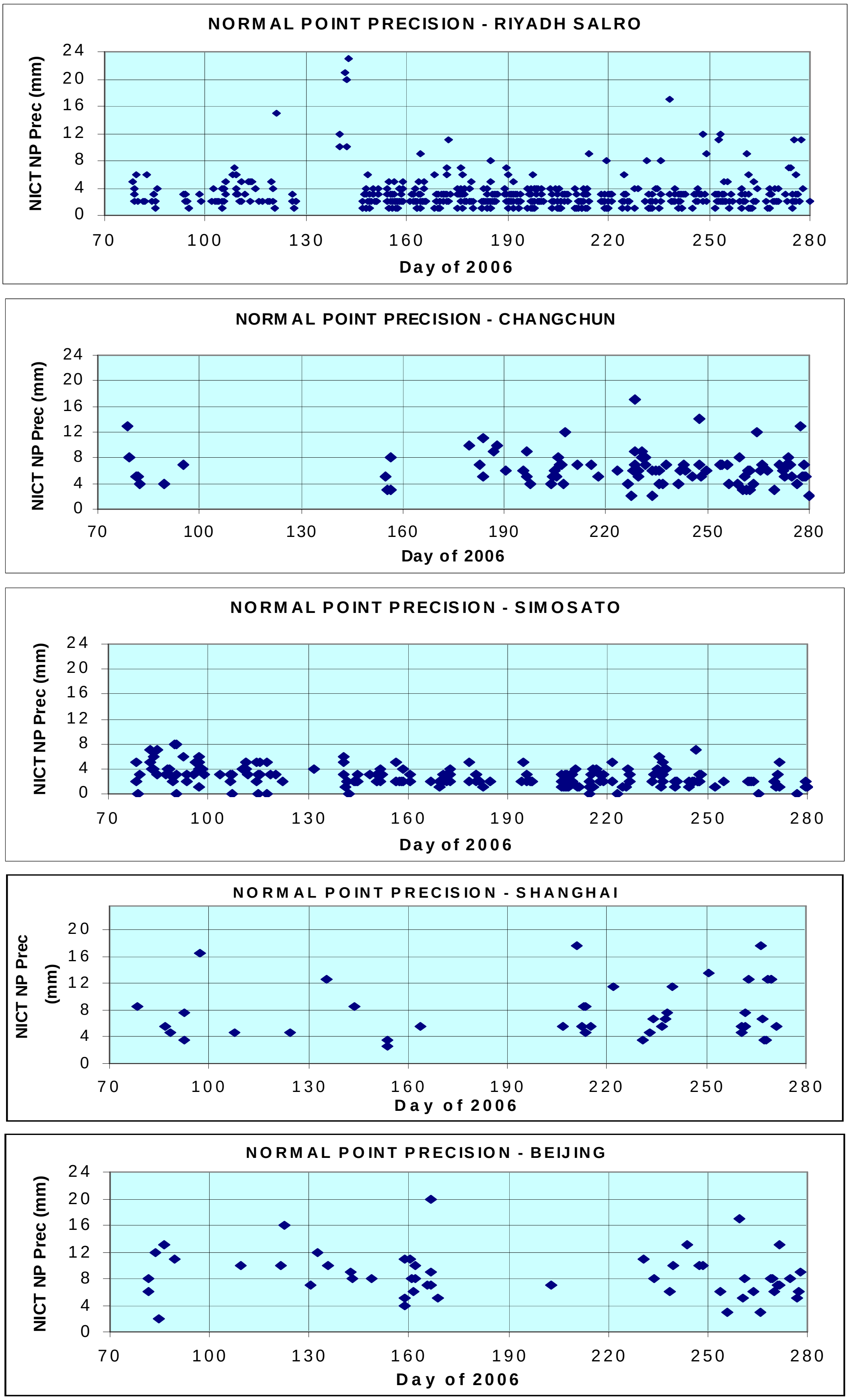


***Figure 5**: Normal Point precisions for selected WPLTN stations.*
Data from NICT reports. See also (Luck, 2006)

Accuracy – Range Bias and System Calibration

More important than the precision of the measurements is their accuracy, i.e. how closely the numbers obtained reflect the true distances. There is no perfect way to assess accuracy, so we use range biases, which in a sense give a station's range errors against a sophisticated average over all stations using the satellites' orbits as constraints; and we use ground-target ranging to measure the system delays that are applied to the range measurements. Both these methods have drawbacks. Range biases depend upon the set of station coordinates and the processing philosophy adopted by any particular Analysis Centre. For ground-targets, the distance from invariant point to target must be measured with millimeter accuracy, and preferably be checked frequently by a technique such as MINICO (Luck, 2005).

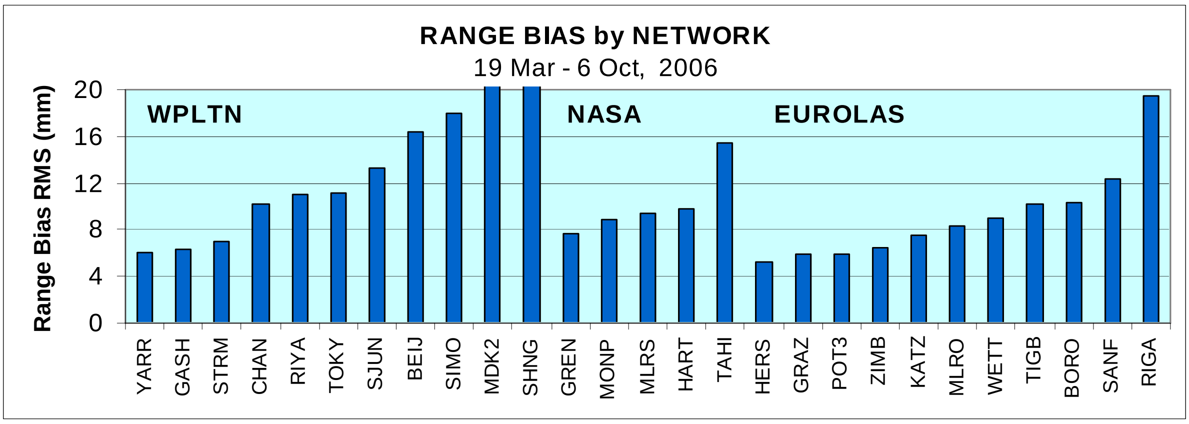


Figure 6*: Range bias RMS about mean values by station. Data from NICT reports.*

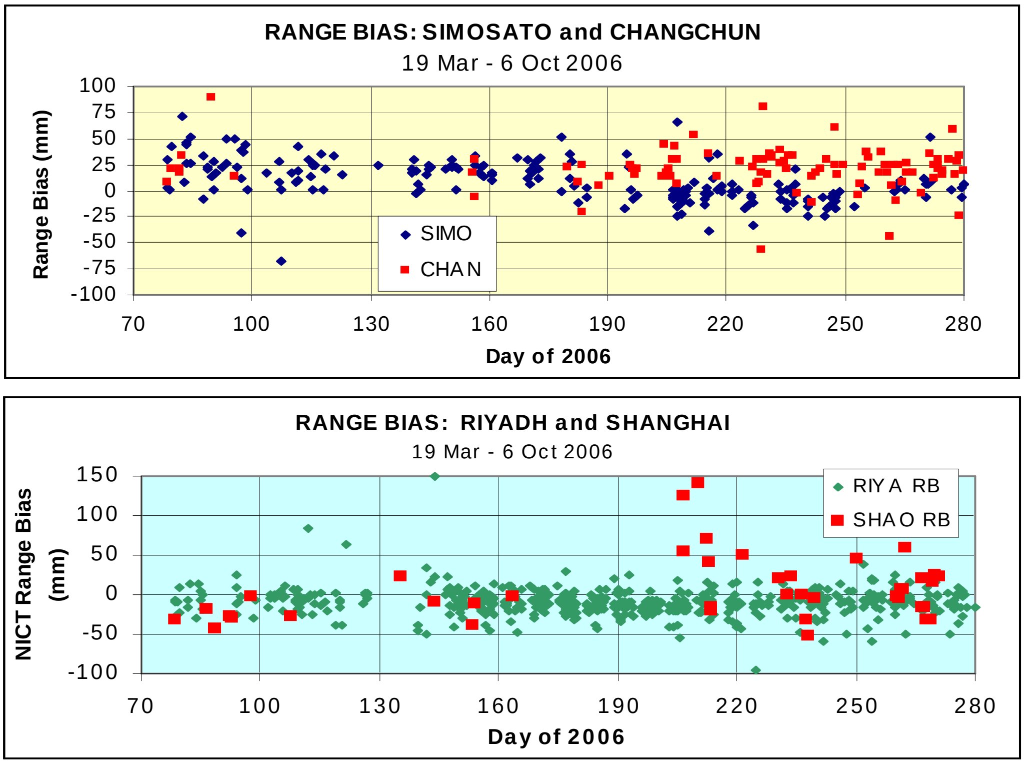


Figure 7*: Range bias time series for reasonably productive stations.*
Data from NICT reports.

RMS variations of LAGEOS I & II range biases about their station means for a period in 2006 are shown in Fig.6, and time series for some of them in Fig.7. Yarragadee, Stromlo and San Juan are shown in the companion "Southern Hemisphere" paper (Luck, 2006).

System Delays

In Fig.8, the average system delay for each station has been subtracted from its values to clarify the comparisons. Large jumps, which are perfectly valid, occurred during the period at Simosato and Riyadh, so in Fig.9 they are adjusted to their piecewise averages.

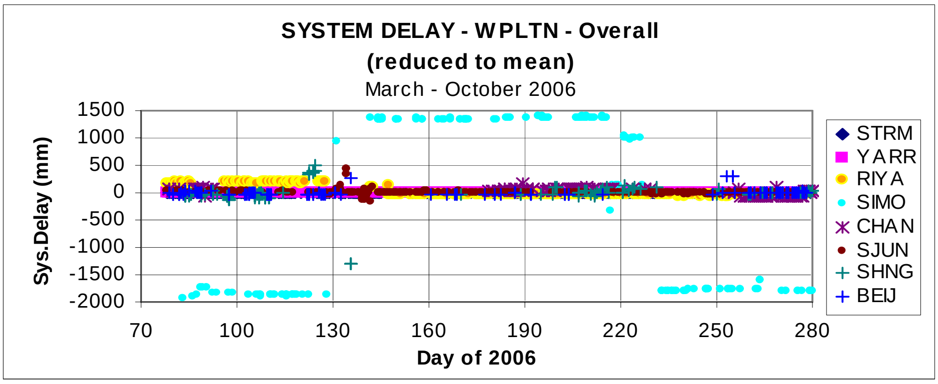
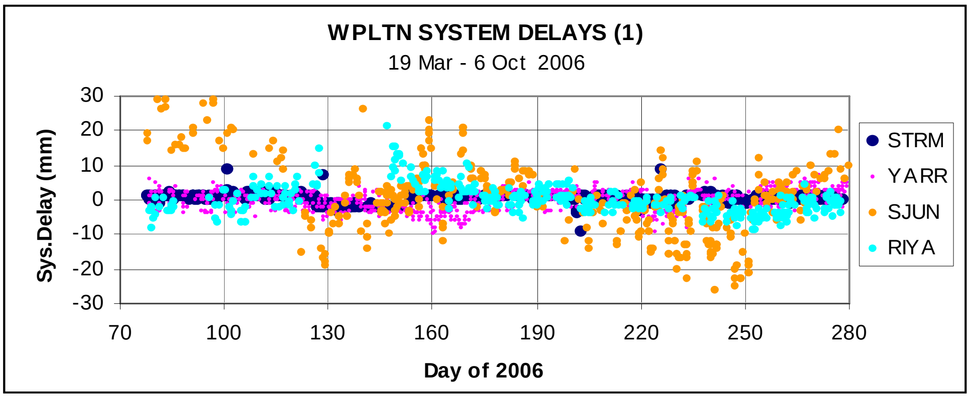


***Figure 8**: Relative system delays for productive stations. Data from NICT reports.*



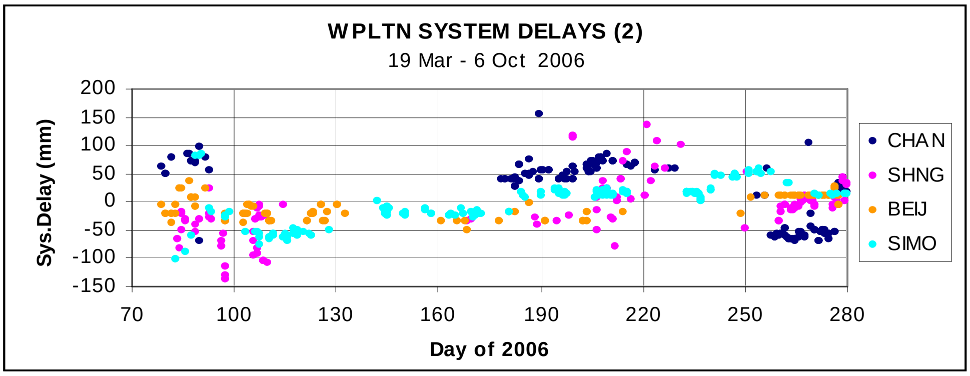


***Figure 9**: Relative system delays at different expanded vertical scales.*
Data from NICT Reports, AJISAI passes.

There is substantial scatter for most stations except Yarragadee, Stromlo and Riyadh, and drifts in several, most notably Riyadh and Simosato, which are even more worrying. Stations are strongly urged to investigate the causes of the scatters and drifts, because it is then likely that there are also large scatters and drifts within passes. Fortunately, there is little evidence of correlations between range bias and system delay (although if there were, it should be easily fixed).

Conclusions

The number of passes acquired by WPLTN stations has improved in the 12 months to October 2006, and now exceeds Eurolas. This is largely due to the commissioning of San Juan and upgrades at some other stations. Most stations now track GPS-35 &-36 successfully, at night. When stations like Changchun and San Juan achieve daylight tracking, the productivity ratios should improve even further.

The analysts prefer passes well tracked from observing horizon to observing horizon, or at worst that include segments near both horizons and at maximum elevation. NPs/Pass is a rough measure of how well this is achieved, but inspection of the NICT reports shows that sparse passes invariably fail to produce a Time Bias of decent quality, which indicates poor NP distribution. Fig.3 indicates that many stations (in all networks) need to improve this aspect of operations.

The quality of WPLTN stations, assessed by Normal Point precision and Range Bias RMS for LAGEOS I & II combined, is an area needing improvement, with only 5 stations showing NP precision better than 3 mm and 3 stations with Range Bias RMS below 8 mm. It is suggested that detailed attention to stabilizing system delays is needed at many stations.

And if you think that this paper is just stating the bleeding obvious, then I have found by long and bitter experience that that is exactly what is sometimes needed!

Acknowledgements

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References

[1] Luck, J.McK.: "*Five Target System Calibration*", Proc. 14th International Laser Ranging Workshop, San Fernando, Spain. Boletin ROA No.5/2005, pp.311-321 (2005)

[2] Luck, J.McK.: "*Performance of Southern Hemisphere Stations*", these proceedings (2006)