Sub-centimeter SLR precision with the SLRF2005/LPOD2005 network

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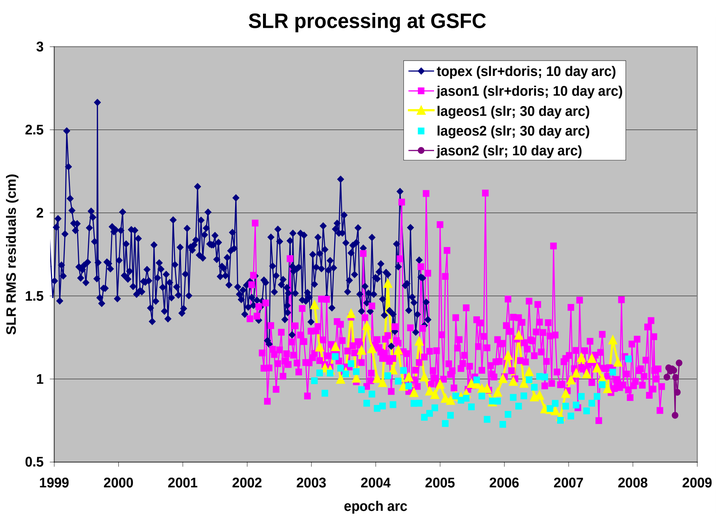
ABSTRACT

Satellite Laser Ranging (SLR) offers the only unambiguous sub-centimeter range measurement to orbiting satellites. This capability finds many applications in addition to precision orbit determination (POD), which include a unique absolute measure of orbit accuracy, accurate altimeter range calibration, accurate definition of the Earth's center of mass, the most accurate definition of the geocentric gravitational coefficient (GM) and scale of a terrestrial reference network. Achieving sub-centimeter precision requires appropriate modeling of the satellite laser retro-reflector array (LRA) coupled in some cases with appropriate modeling of the satellite-dependant station detector characteristics, a highly accurate terrestrial reference frame, and appropriate attention to possible bias modeling of individual stations. We have processed Jason1, Lageos1/2, and TOPEX SLR tracking using the latest and most accurate POD models which include a GRACE-based static gravity, time varying gravity, and the highly accurate ILRS update of the rescaled ITRF2005 SLR complement, SLRF2005. SLRF2005 has been again updated with subsequent recommendations for the rescaled ITRF2005, LPOD2005. Our analysis evaluates individual SLR station performance and systematic signals as observed from all four satellites. Several baseline stations are identified having significant biases, which if untreated could lead to degradation in current levels of POD accuracy, and possibly bias the results for other applications of the SLR measurement.

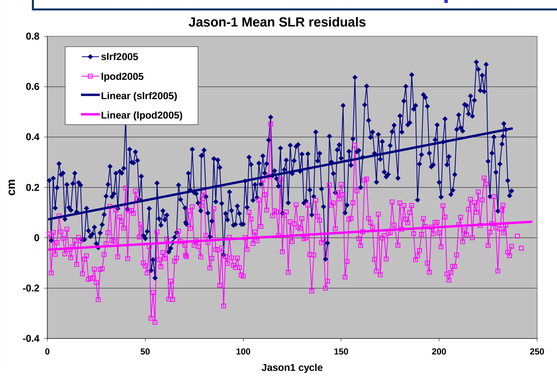
A priori SLR processing performance

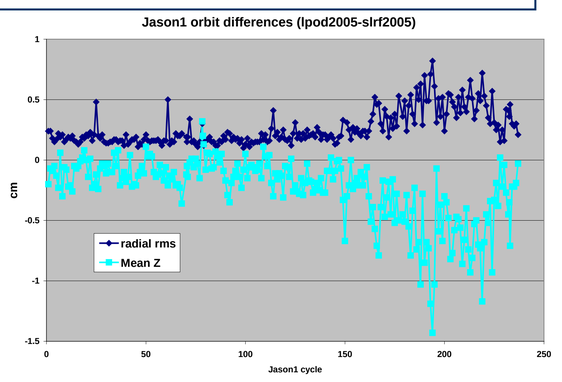


Consistent POD models across satellites include:

Reference frame and displacement of reference points	
SLR	SLRF2005 + LPOD2005 (version 6)
DORIS	DPOD2005
Earth tide	IERS2003
Ocean loading	Got4.7 all stations
Tidal CoM &EOP	Got4.7; VLBI high frequency terms
Gravity	
Static	Eigen-Gl04s
Time varying	Linear C20-dot, C21-dot, S21-dot (IERS2003) + 20x20 annual terms from GRACE
Atmospheric	ECMWF, 50x50@6hrs
Tides	Got4.7 (ocean); IERS2003 (Earth)
SLR measurement	
Biases	Consistent with SLRF2005/LPOD2005
LRA/CoM (mm)	TP: model, JA1/2: -49, L1/2: -251 / -245(RGO)

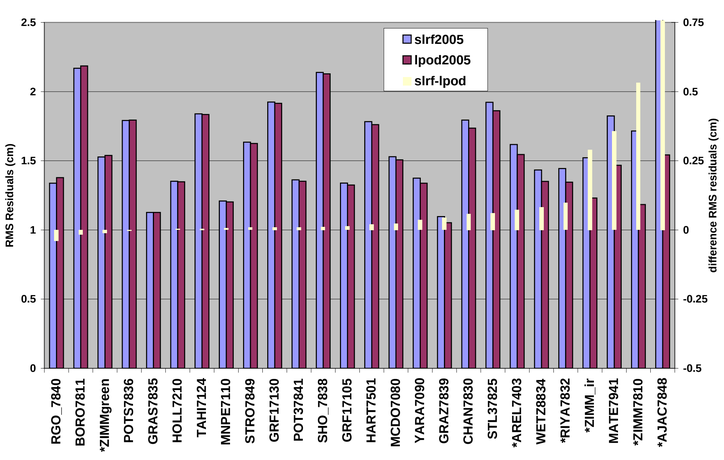
The increase in SLR mean residuals indicates an increase in station bias or position error. This has a significant effect on the cm-level Jason-1 orbit. Much of the error has been removed using the LPOD2005 upgrade to SLRF2005, and a revised station bias strategy. Maintaining such orbit accuracy requires on-going vigilant maintenance of a bias treatment plan for individual stations.

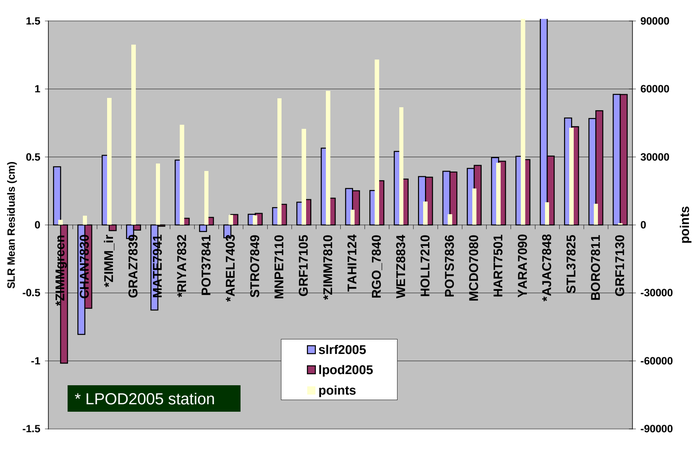




LPOD2005 solution

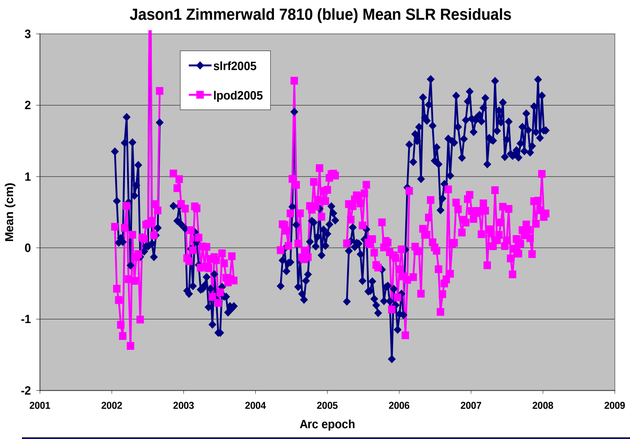
As shown below LPOD2005 improves station performance and reduces mean residuals over Jason-1 cycles1-237

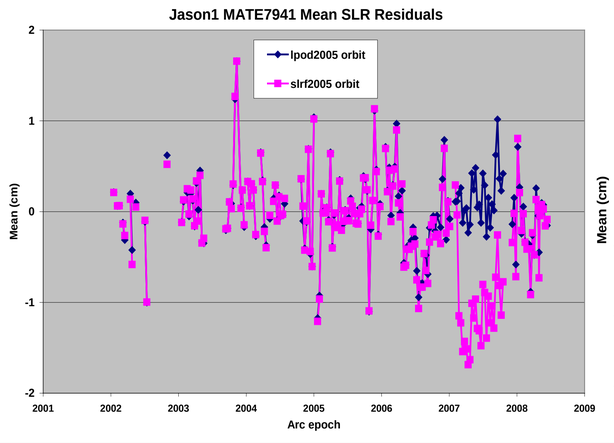


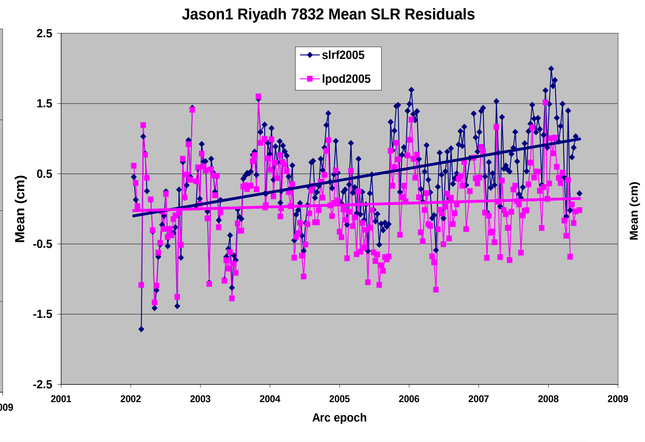


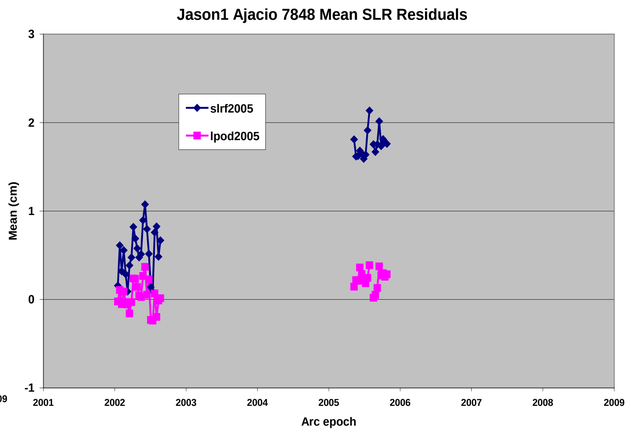
Jason-2 tests over cycles 1-10 confirm the Jason-1 results

Jason2 LPOD2005 evaluation SLR-only cycles 1-10	slr (cm) mean	slr (cm) rms	xover rms (cm)
slrf2005	**0.075**	**1.032**	**5.734**
lpod2005 (v10)	**0.000**	**0.930**	**5.693**



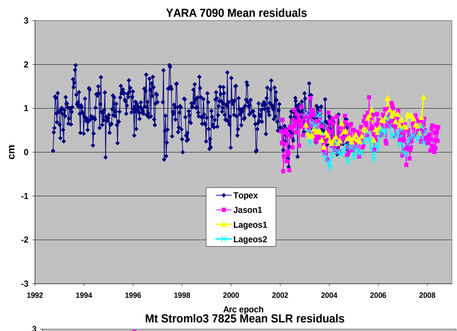


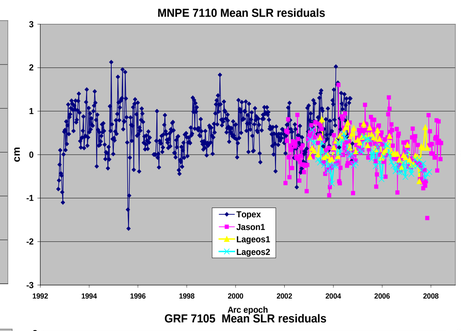


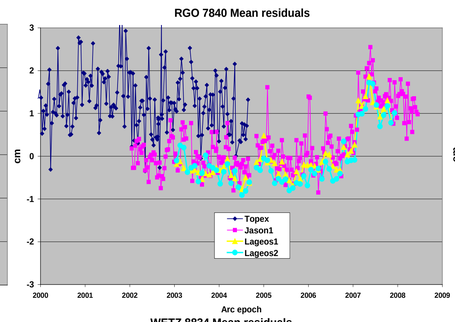


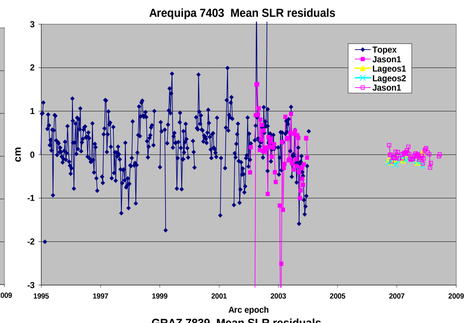
SLR mean residuals for primary stations

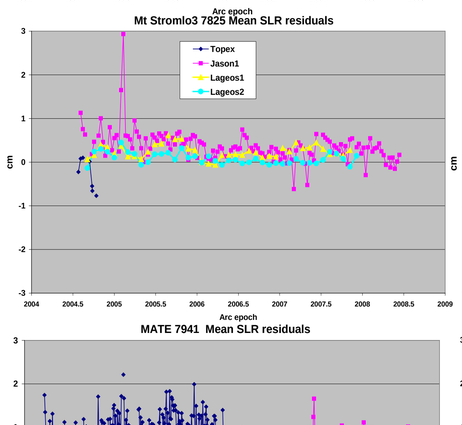
The mean residual patterns shown below indicate the bias strategies for several primary stations may have to be revised. Trends suggest position velocity error.

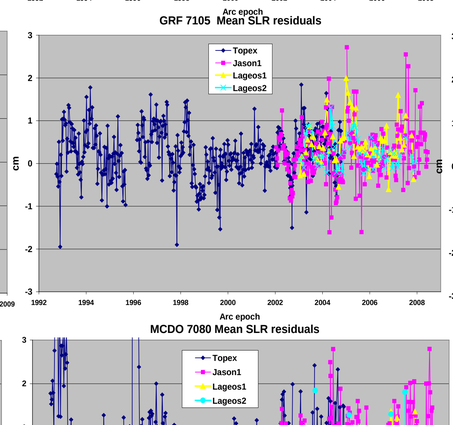


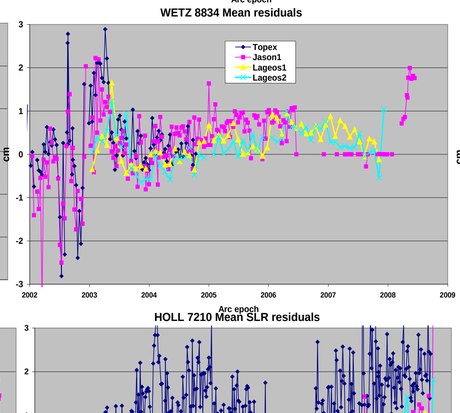


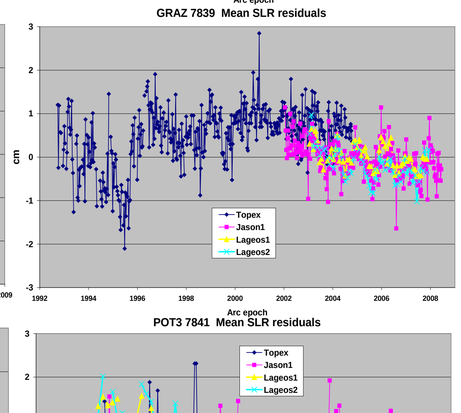


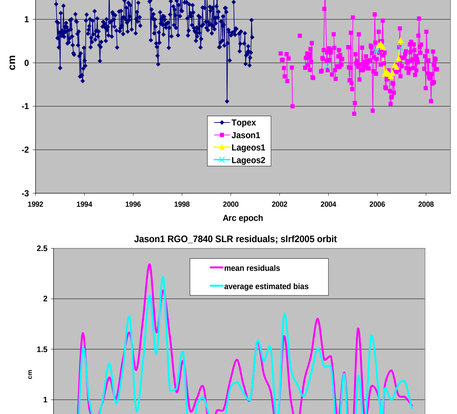


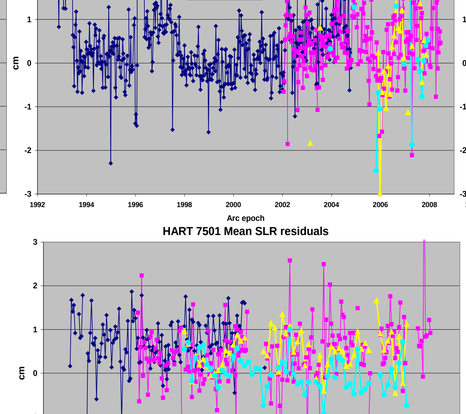


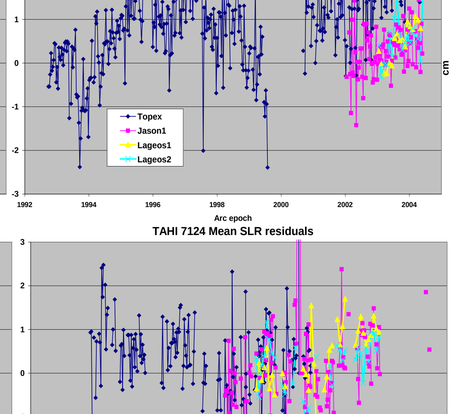


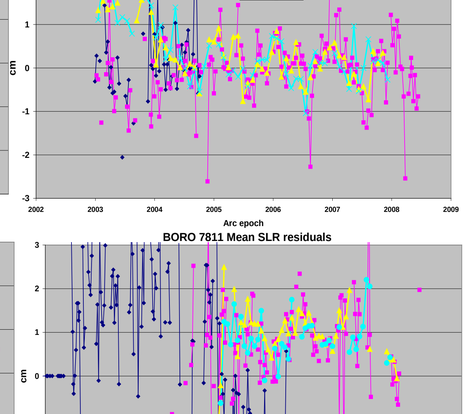


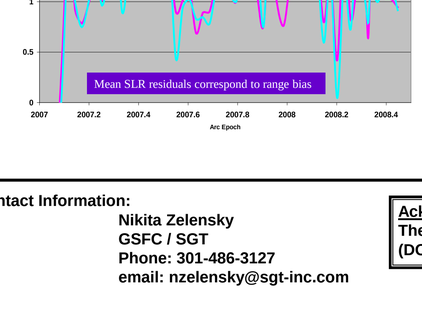


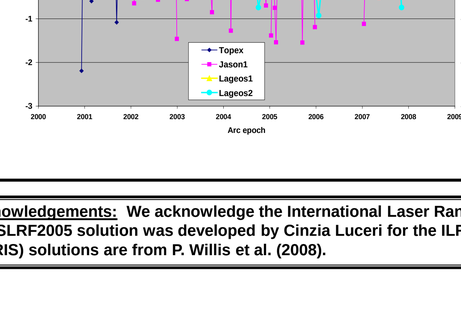


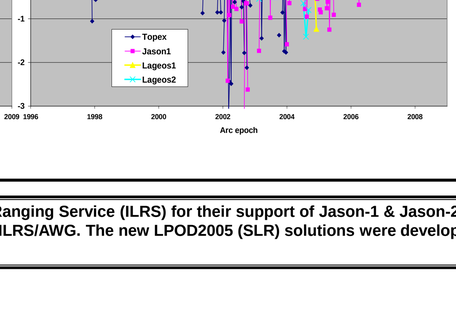


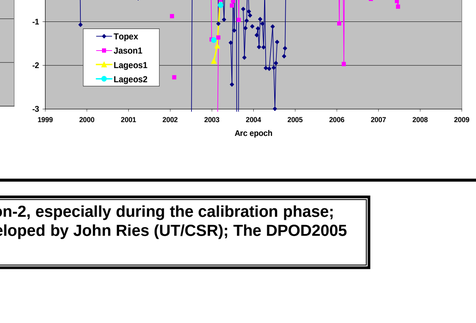




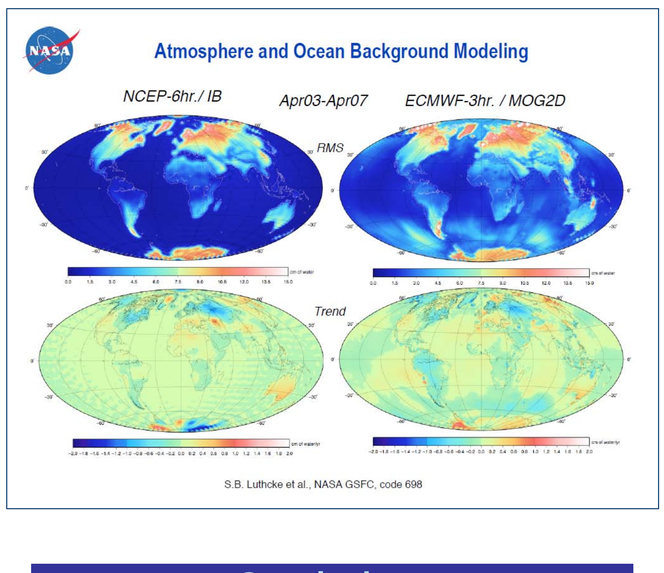








Summary



Conclusions

- SLR processing now at the 1-cm level for Jason and Lageos, and 1.5-cm for Topex
- At this level differentiating between station biases and position /velocity error is difficult, but critical for further improvement.
- SLRF2005 offers a comprehensive station set, a significant improvement over the ITRF2005-SLR scaled station set.
- LPOD2005 significantly improves primary stations Zimmerwald, Riyadh, and Ajacio.
- Herstmonceux shows a 1.2 cm bias beginning about Feb 12, 2007. Recent data from Wettzell, Haleakala, Mcdonald, and Tahiti show possible trends in the mean residuals.
- Should POD standards for the next ITRF require a common bias strategy and atmosphere time-varying gravity modeling?

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