SLR target signature model improvements, plus co-locations with gravity measurements

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Emphasis of this work

* A strength of the LR technique is its longevity;
* Data at few cm-level of precision is available from launch of the LAGEOS in 1976
* But requirement now is for mm-level products, so:
* Can we improve satellite centre-of-mass models for all historical data, one of the key *accuracy* issues, impacting scale determination and GM;
* And, importantly, is the ground-segment technology going in the right direction to improve this issue for the present and the future

Satellite signature effects

* The satellite signature effect needs careful station/epoch-dependent treatment in order to refer range measurements to the centres-of-mass of the geodetic satellites
* Up to 10mm station-dependent differences for LAGEOS, 30mm for Etalon (Otsubo & Appleby, 2003)
* These effects are similar to the antenna phase-centre effects on GNSS satellites and receivers, as being addressed in IGS

Satellite signature effects

* ILRS stations' site logs are a valuable source of relevant information:
* Detectors, laser pulse-length, operational practices (return-energy regimes), etc.
* Used to derive time-series of CoM corrections and their uncertainties for each station for LAGEOS and for Etalon
    * - using the published models and comparison with LAGEOS-2 pre-launch tests for some station configurations

Satellite signature effects

* Results being evaluated; recent (Aug-Sep 2011) 7-day arc, 4-satellite solutions for coordinates and EOP show small improvement in post-fit WRMS at sub-mm level;
* Residual mean value changes ± 0.2mm
* Plus some suggestion that LAGEOS-2 solutions worse (Pavlis, AWG 2011)
* Plan more testing, release to ACs and AACs

Detail from CoM table for LAGEOS

Station	Time-span	detector info	CoM min, max, adopted (mm)
7838	01 04 2008 31 12 2050	20 MCP CSM	3.0 6 15 252 248 **250**
7838	01 07 1990 01 04 2008	100 MCP CSM	3.0 20 40 252 248 **250**
7839	01 01 1983 31 12 2000	300 PMT NC	3.0120150 245 241 **243**
7839	01 11 1981 08 10 2003	35 CSP NCM	2.2 3 9 255 250 **252**
7839	09 10 2003 31 12 2050	10 CSP NSF	2.2 3 9 255 250 **252**
7840	01 02 2007 31 12 2050	10 CSP CS	2.5 3 9 245 245 **245**
7840	31 03 1983 31 03 1992	100 PMT NCF	3.0 35 45 252 244 **248**
7840	31 03 1992 31 12 2050	100 CSP CS	3.0 6 15 246 244 **245**
7841	20 07 2001 31 12 2050	50 PMT CSF	2.5 10 18 254 248 **251**

Availability of CoM data tables

* In principle, complete for LAGEOS and Etalon for 1980s onwards;
* Some missing stations/epochs discovered during discussions within AWG;
* Some conflicts for stations with multi-configurations
  * Have implemented use of system configuration flags
* Almost ready to release data for Ajisai
* Starlette/stella under preparation
* Fortran code and two text files

Current trends in ILRS network development – improvement in CoM modeling?

* Ideal system for mm-level *accuracy* is:
* kHz rate, (short-pulse) laser;
* Very high-precision event timer;
* Working rigorously at single photon level of return:
  * In this configuration the return PDF is straightforward to model and CoM value well-determined
* how does reality fit this ideal?

Current trends in ILRS network development – improvement in CoM modeling?

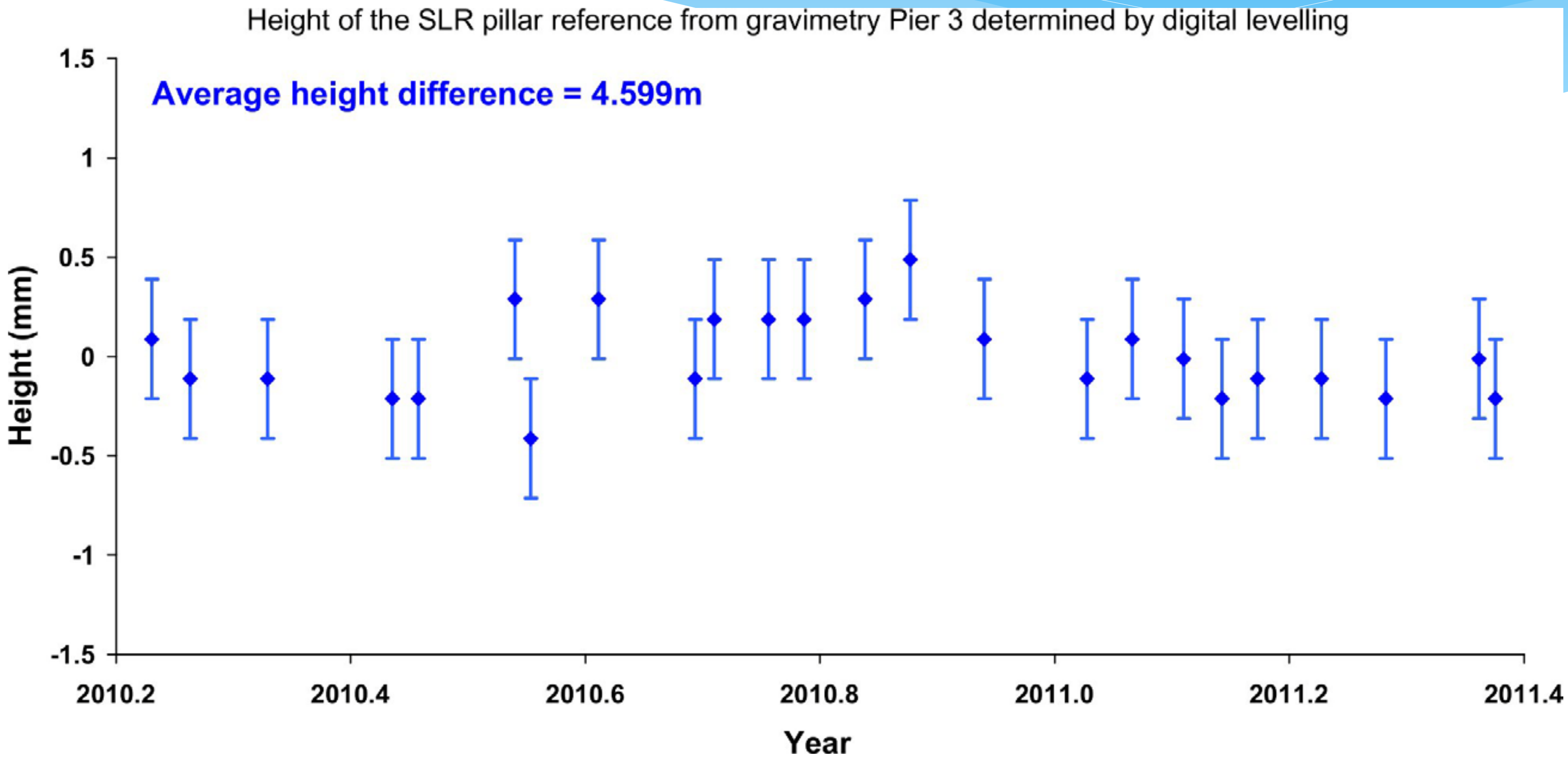
* NASA's NGSLR;
* current and growing numbers of ILRS systems upgrading to kHz;
* Confident that new systems can deliver mm-level accurate ranges
* plus major other existing stations do comply:
  * The NASA systems do work at high return signals, but ground-based CoM measurements were tuned to them:
  * Our models suggest CoM values of 249-251mm
  * Ground tests measured 251mm (Varghese, *et al*, 1992)

Value of close co-location and comparison with gravity values

* Comparison of space geodetic coordinates (heights) with gravity time-series from visiting or permanent FG-5 absolute gravimeter;
* Use space geodesy results to monitor site motion, gravity to monitor that motion plus loading signals
* E.g., at SGF Herstmonceux, UK
  * Weekly 24-hour mean value time series

* In addition, very important to monitor regularly on-site possible inter-technique (height) variations

Digital Levelling between AG monument and SLR pillar – first year's results

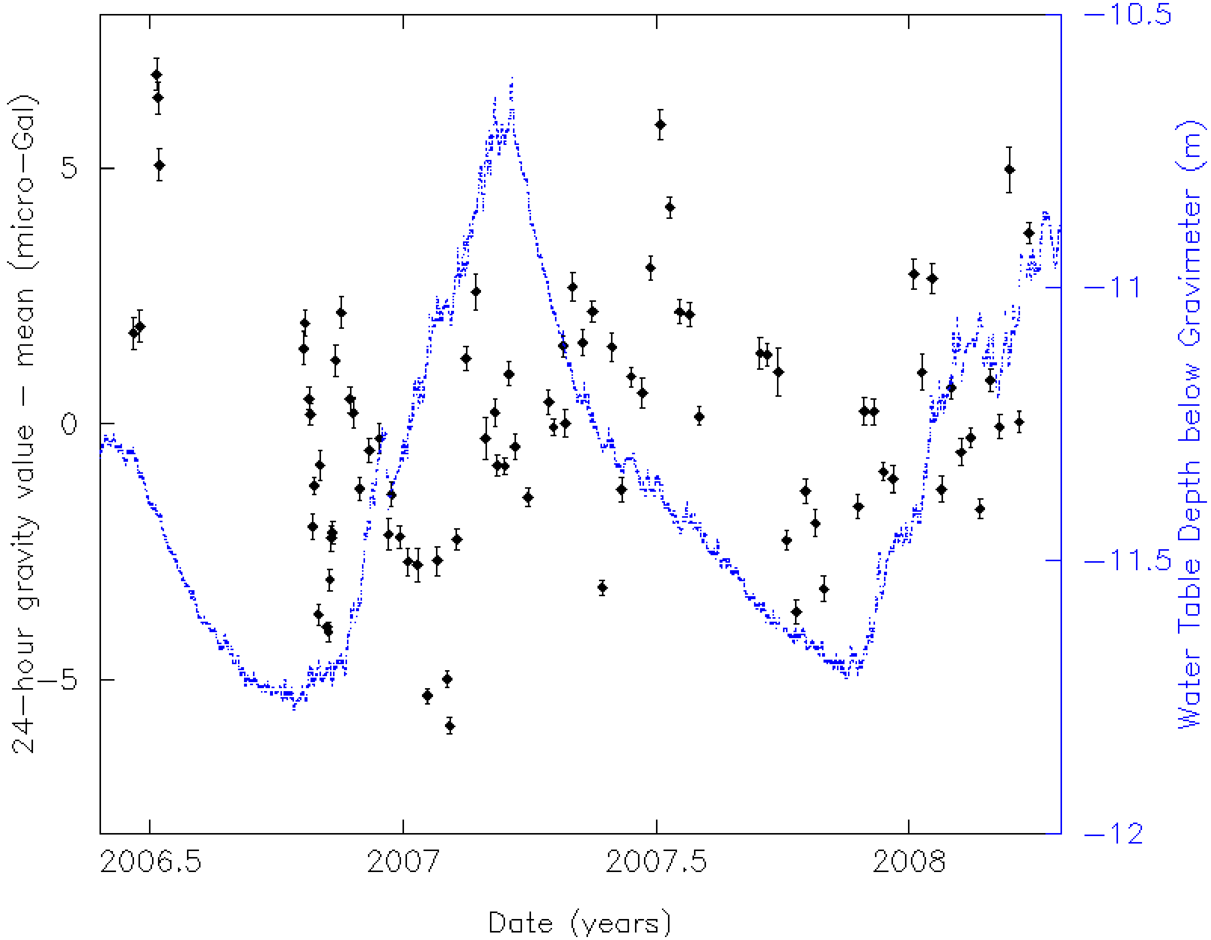


AG time-series

* Found AG series has negligible seasonal signal and little correlation with groundwater variations
* Likely forcing by rainfall – under investigation

* Also, models imply both small OL and APL signal for this site
* -> stable site, on compacted clay (Appleby, Smith *et al*, 2010).

Weekly gravity series (black), water table (blue)



* But: post-service ~4μGal (~15mm) probable ‘jumps’ in AG time-series
  * -> Important study into systematic AG effects
* Very important to monitor behaviour of AG at intervals via inter-comparison meetings (2-yearly, Luxembourg)

SLR heights vs height variation implied by AG

conclusions

* CoM corrections for LAGEOS and Etalon for all stations and for period 1980s onward completed
  * Software and text files to be released during Sept 2011
* New ILRS stations tending towards high-rate, lower energy
  * -> Less systematic problems wrt CoM values

* Valuable to use gravity measurements in conjunction with space geodetic solutions
* Potentially more complete understanding of site characteristics