Centre of mass values for precise analysis of LAGEOS, Etalon and Ajisai 1980-2013

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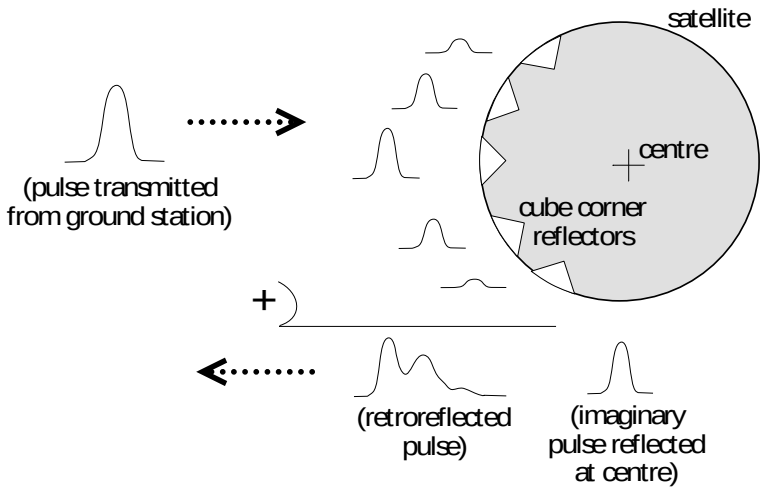
Outline

- Previous work * developed generic centre of mass values that take account of station hardware;
- More recently tables of values for LAGEOS and Etalon and software were released and tested by Analysis Working Group
- New table for Ajisai now available
- Some comments on results for all three satellites

* Otsubo & Appleby, JGR, 2003

Station- and epoch-dependent CoM values

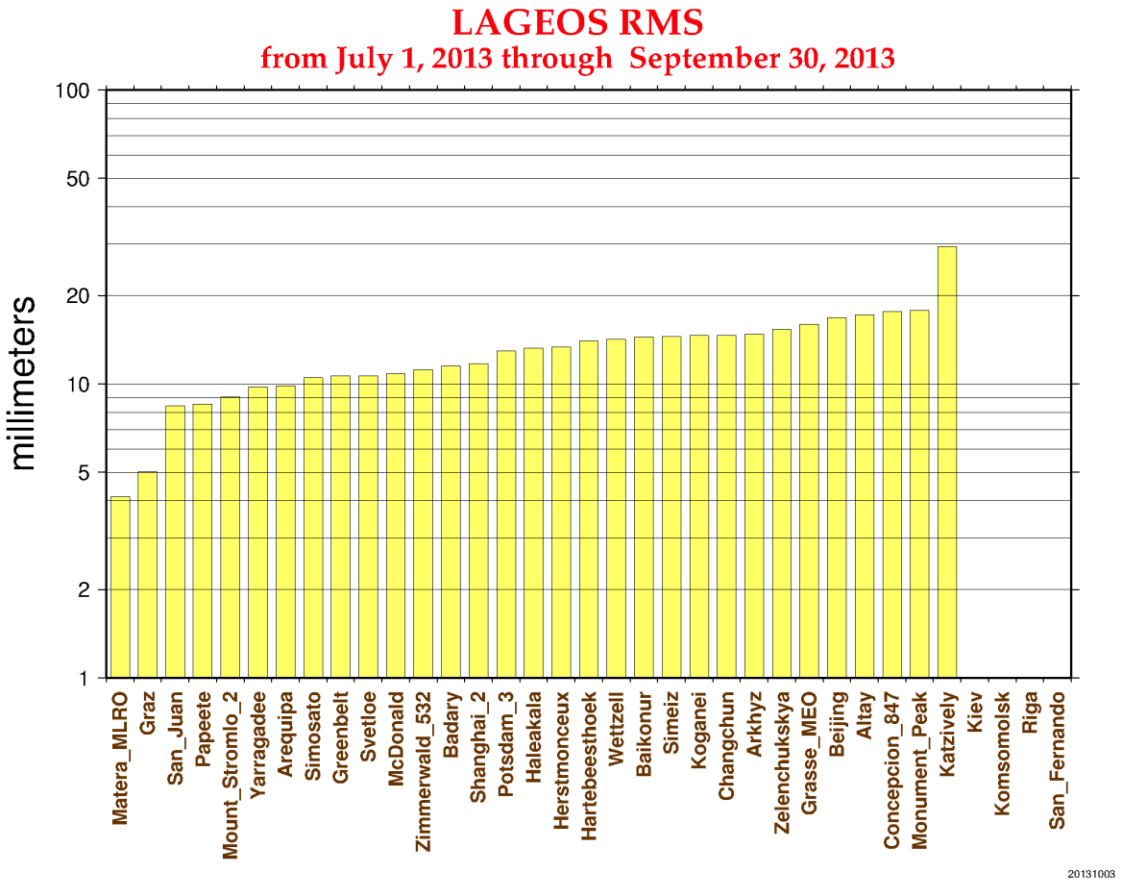


- Appropriate CoM value **and its accuracy** depends upon:
- System detection hardware (SPAD, MCP, PMT)
- Return energy level (multi-, single- or mix-)

Station- and epoch-dependent CoM values

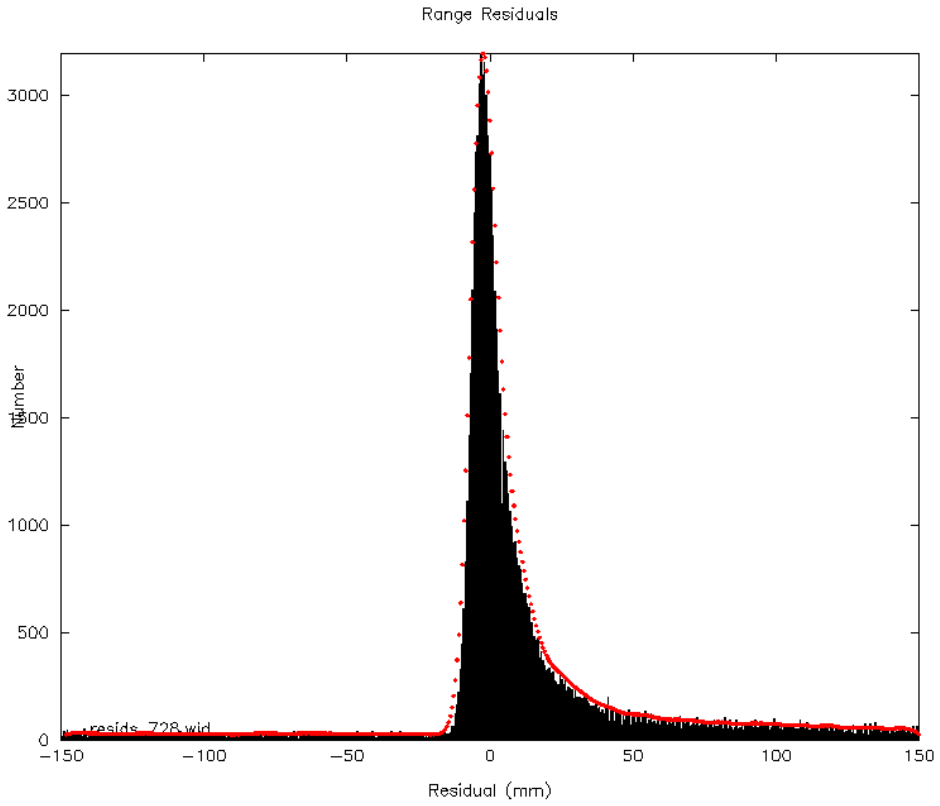
- Taking these generic, system-dependent results;
- Using up-to-date Site-log information **and change records** for all stations from ~1980 onwards as a **critical resource**
- Estimated CoM values and error estimates:
- In general, single-photon return allows determination of most **accurate** CoM value, **even if** single-shot **precision** is low(er):

Single-shot precision (RMS, mm) of LAGEOS ranges



A good proxy for system **type** (single, multi ph.), **not** (necessarily) a good indicator of **accuracy of range or determination of CoM correction**

e.g. High accuracy CoM for LAGEOS single-photon kHz data at SGF Herstmonceux



Model (red) fits very well. Implied CoM value from model is 245 ± 1 mm. Results (R Neubert, 2012) for upgraded Potsdam kHz system are identical (245 ± 1 mm). Single-shot precision **only 15mm** in each case.

Station- and epoch-dependent CoM values

- For the multi-photon MCP (e.g., NASA) systems, model implies value of ~250mm, close to ground-measured, 'standard' 251
- However:
  - If logfile suggests that return energy variable or even unknown,
  - Larger (~10mm) **uncertainty** placed on model CoM value.

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	3.0	120	150	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 07 2011	50	PMT CSF	2.5	10	18	254	248	**251**
7841 01 08 2011	31 12 2050	10	CSP CS	2.2	3	9	246	244	**245**

Data files for LAGEOS and Etalon and Fortran code are available to extract CoM for analyses

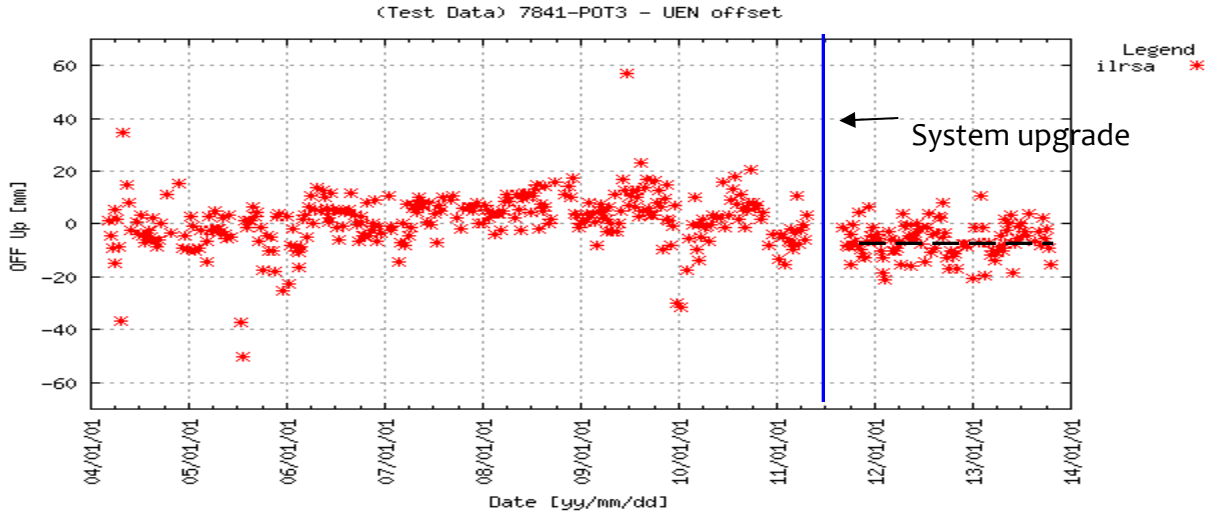
Testing the CoM tables during POD

- Tests were carried out by the ILRS ACs on the LAGEOS and Etalon tables via weekly solutions
  - For six months only
  - SGF AC results reported (EGU 2012, Frascati 2012)
- Effect on the quality of the reference frame quite marginal according to AWG & SGF work:
  - difference in scale, driven by more careful use of CoM values, is only 0.03ppb

Testing the CoM tables during POD

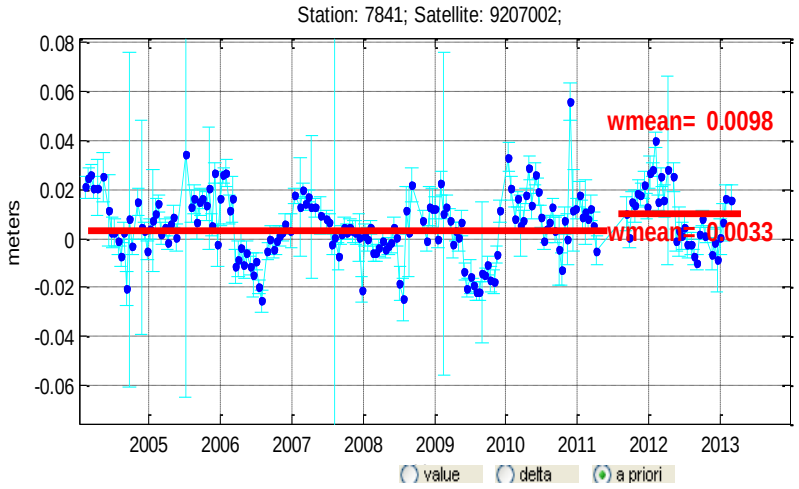
- But in detail, for some specific stations, effect is important and clears up some apparent data anomalies:
- e.g. Potsdam 7841, following a system upgrade to 2kHz:
- Time series of station height shows apparent drop in height of 7 or 8 mm (C. Luceri, 2013)
- 6mm of that is explained by use of CoMs 251 and 245mm for PMT and SPAD respectively, pre- and post-upgrade:

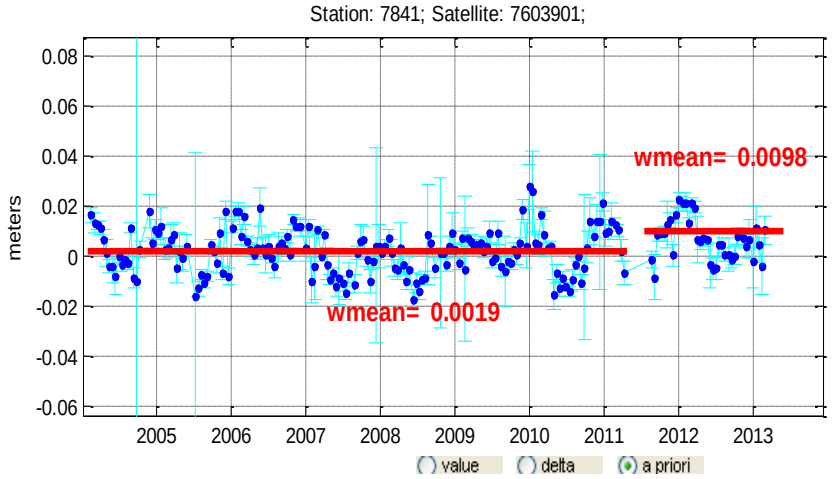
7841 - POTS : discontinuity



Δh = -8mm

RB = +7mm





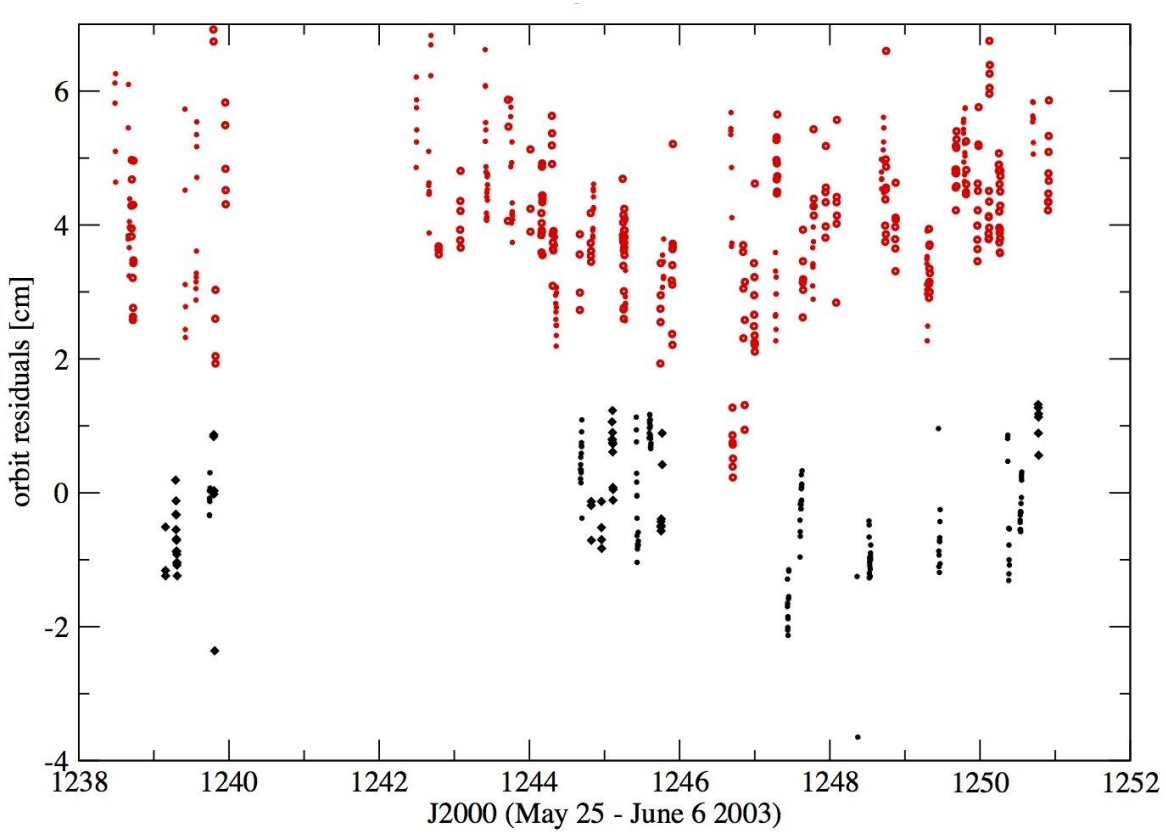
C Luceri, 2013

RB = +8mm

7841 20 07 2001 31 07 2011 50 PMT CSF 2.5 10 18 254 248 **251** 1
7841 01 08 2011 31 12 2050 10 CSPA CS 2.2 3 9 245 245 **245** 1

CoM table entries

But: Of course cannot attribute large effects to CoM effects



Range residuals from LAGEOS for a station that has two modes of operation – choice of two detectors. **Plot from H Mueller**

Ajisai

- Work has been extended to Ajisai
- 2150 mm diameter satellite, CoM variation of ~45mm
- Same treatment regarding station configuration, return-level, etc., as for LAGEOS and Etalon, from the published generic results
- Table of values produced, and read-software updated
- Will be available at EDC and CDDIS, along with LAGEOS and Etalon:
- e.g. http://ilrs.dgfi.badw.de/index.php?id=6

Detail from CoM table for Ajisai

7328	01	04	1997	01	01	2050	35	CSPA	NSM	2.5	8	151023 985**1004**
7335	01	04	1997	01	02	2001	35	CSPA	NSM	2.5	8	151023 985**1004**
7337	01	01	1997	31	03	2001	35	CSPA	NSM	2.5	8	151023 985**1004**
7339	01	04	1997	13	10	2001	35	CSPA	NSM	2.5	8	151023 985**1004**
7355	28	12	1999	31	12	2050	30	CSPA	NC	2.5	15	301023 985**1004**
7356	28	12	1999	31	12	2050	30	CSPA	NSM	2.2	15	301023 990**1007**
7357	30	06	2002	31	12	2005	40	CSPA	NC	2.5	8	151023 985**1004**
7358	25	03	2002	31	12	2050	50	MCP	NC	3.0	1	510251015**1020**
7403	10	07	1992	31	12	2050	200	MCP	CFM	3.0	5	1010171009**1013**

Testing the CoM tables during POD

- For the new Ajisai CoM values:
- Used in-house SATAN code as per main AC work, with fixed ITRF2008
- 7-day and 3-day arcs tested for August 2013, with and without (ILRS default is 1010mm) site-specific CoM values
- At best, marginal improvement of ~1% in post-fit residual RMS

LAGEOS/Etalon/Ajisai CoM conclusions

- Important to model as well as possible:
  - Direct impact on TRF scale, a major output from geodetic SLR
- Must consider (small) CoM effects in context with those of some poor site-ties and systematic range measurement error issues
- A more comprehensive comparison for 1980 onwards will be underway soon via AC contributions to ITRF2013
  - Big changes in network hardware in early decades
  - Important to track CoM changes – systematic
- Also it would be very useful to have similar results for Starlette, Stella and LARES…


Thank you