Intermission and tide gauge comparisons of CryoSat-2, SARAL/AltiKa and Jason-2

Eric Leuliette, Amanda Plagge
NOAA/NESDIS Laboratory for Satellite Altimetry
Gary Mitchum
University of South Florida

With thanks to Remko Scharroo and Richard Ray

NOAA

Laboratory for Satellite Altimetry
NOAA-NESDIS-STAR

Outline

① Test of some Jason-1 GDR-E standards

– Crossover analysis of Jason-1, Jason-2, SARAL/AltiKa, and CryoSat-2

② Intermission differences between Jason-2 and CryoSat-2

– Test of the “59-day” problem

③ Tide gauge comparisons of Jason-2 and the TX/J1/J2 reference series

① GDR-E Standards

Jason-1 GDR-E standards available for testing in RADS:

- New tide models (GOT4.10 and FES2012)
  - GOT4.10 swaps J1+J2 for TX
    - Improved S2 tide solution w.r.t. to bottom pressure gauges
  - Used the "full" FES2012 solution
  - The GOT4.10 load tide is used for both GOT4.10 and FES2012.
- New sea state bias models (Tran et la. 2012)
  - Separate (but similar) models for Jason-1 and Jason-2
- New mean surface models (DTU2013)
  - Corrected DTU2013 (October 2014)

Not available (yet):

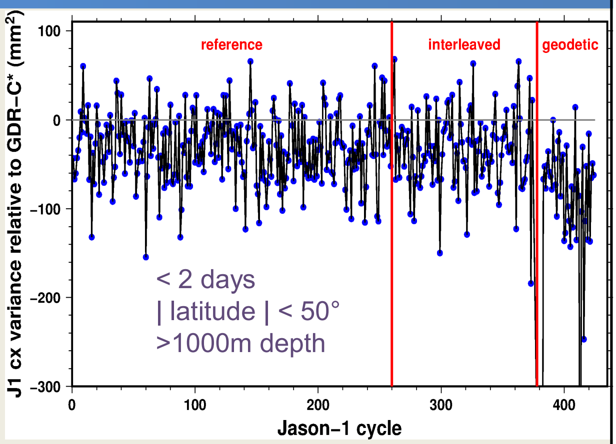
- New orbits
- New JMR wet tropospheric path delays

RADAR ALTIMETER DATABASE SYSTEM

① Jason-1 crossovers

Jason-1 reduction in variance Tran SSB/GOT4.10 tides/DTU13 MSS relative to GDR-C+GDR-D orbits:

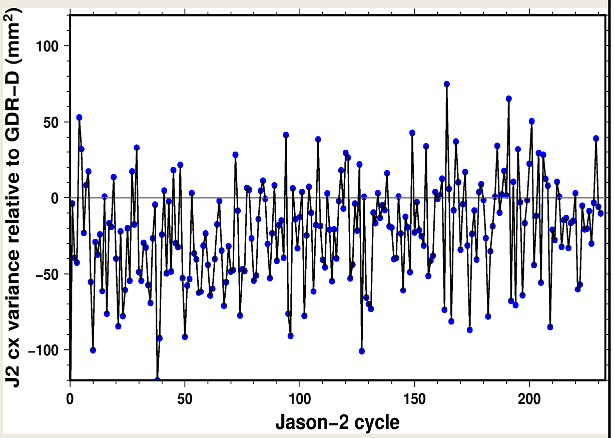
- 37 mm² (2.4%)
- Reference: 35 mm² (2.2%)
- Interleaved: 33 mm²



Jason-1 crossovers (st dev cm)		Ref	Inter	Geodetic
Jason-1 GDR-C (+GDR-D orbits)	3.95	3.94	3.99	3.92

① Jason-2 crossovers (cycles 1 to 225)

Jason-2 crossovers	(st dev cm)
GDR-D	3.76
Tran/FES2012/DTU13	3.84
Tran/GOT4.10/DTU13	3.72

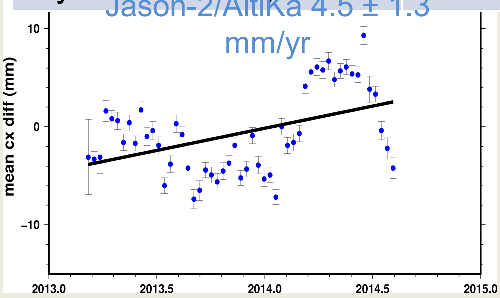


Tran SSB/GOT4.10 tides/DTU13 MSS reduces the variance by 28 mm² (2%).

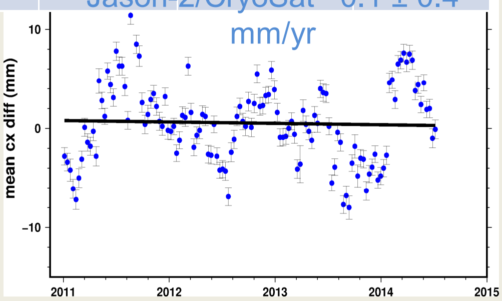
① Jason-2 crossovers with AltiKa and CryoSat

Crossovers with Jason-2	St. dev. (cm)		St. dev. mean/cycle (mm)	
	GDR	“GDR-E”	GDR	“GDR-E”
SARAL/AltiKa	4.23		4.3	
CryoSat-2 (2011-)	4.27	4.20	4.8	4.5

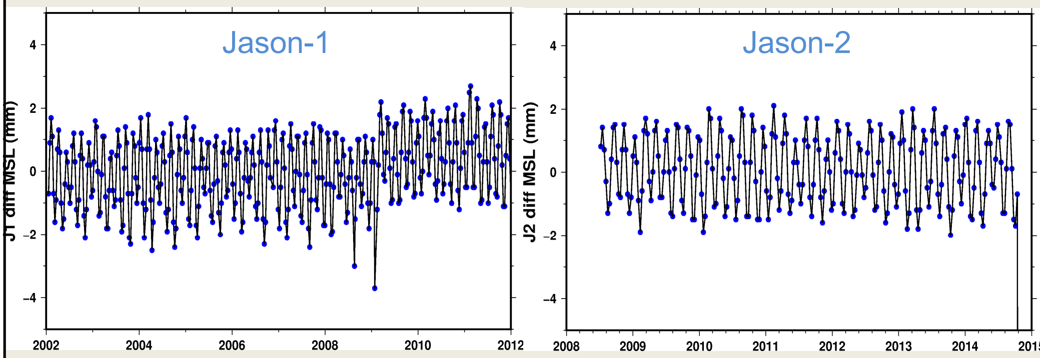
Jason-2/AltiKa 4.5 ± 1.3 mm/yr



Jason-2/CryoSat –0.1 ± 0.4 mm/yr



① Change in global mean sea level

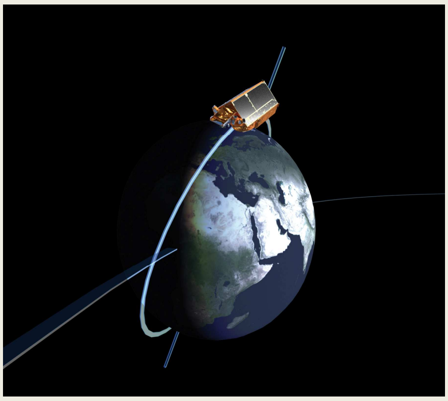


Tran SSB/GOT4.10 tides/DTU13 MSS
Jason-1 reduction in GMSL variance: 4 mm^2 (3.5%)
Jason-2 reduction in GMSL variance: 6.4 mm^2 (9%)

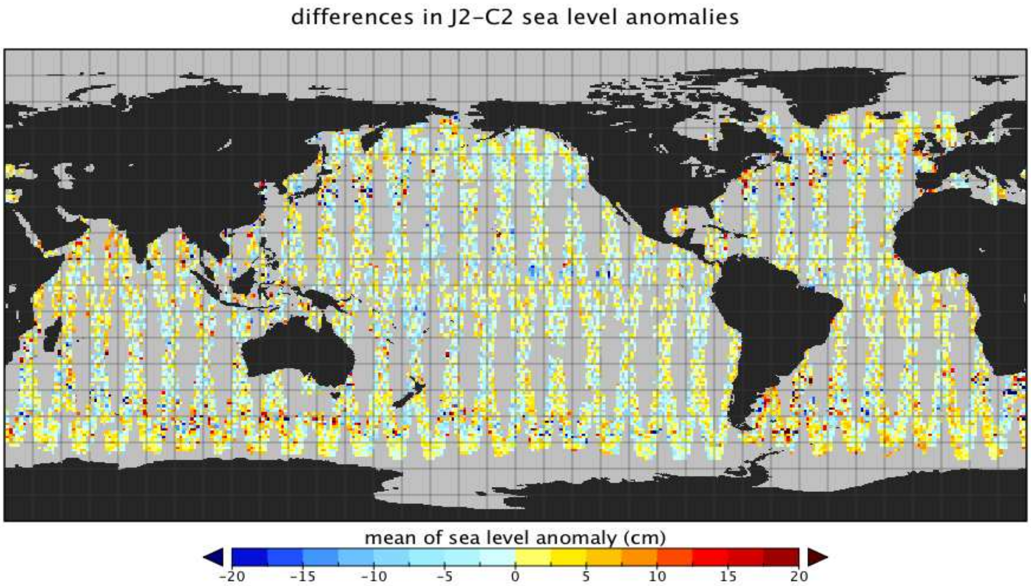
GOT4.10 reduces the variance mainly at 59-days
DTU13 MSS makes a slight change the bias during the geodetic phase

② CryoSat-2 and Jason-2 intermission differences

Previous ESA altimeter missions (ERS-1, ERS-2, Envisat) were in sun synchronous orbits and thus alias the solar tides to zero frequency. Their sampling of solar-forced phenomena does not change over time (other than once per orbit).



Because CryoSat is not sun-synchronous, its orbit plane makes a half revolution with respect to the Earth-Sun line in about 244 days. We can use it to explore the 59-day errors in TOPEX/Jason data.



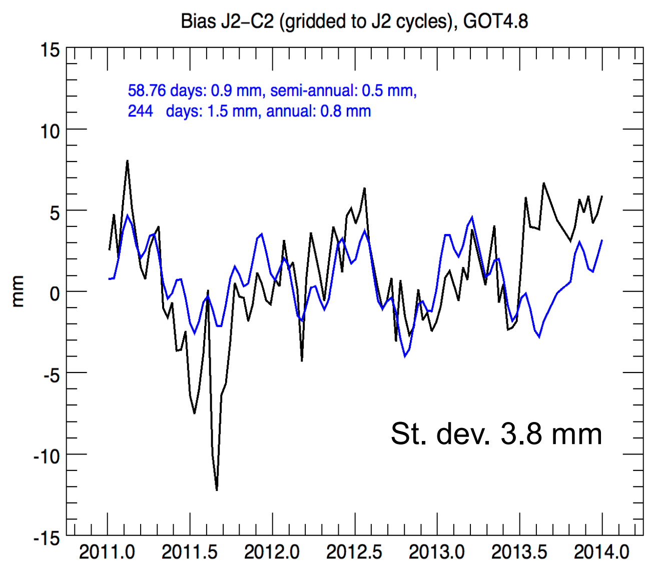
The Jason-2 orbit repeats every 10 days. One such 10-day period is shown here (J2 cycle 91). The areas sampled by CryoSat during 10 days move with each 10-day cycle. Differences are computed in 1x1˚ boxes and then these boxes are area-weighted averaged to give the global mean sea level difference estimated every 10 days.

② J2-C2 global mean sea level difference, GOT4.8 tide model applied

Black: observed data.

Blue: periodic model with annual, semi-annual, 59-, and 244-day cycles.

The 59- and 244-day terms have RMS amplitudes of 0.9 mm and 1.5 mm, respectively, when using the GOT4.8 model.

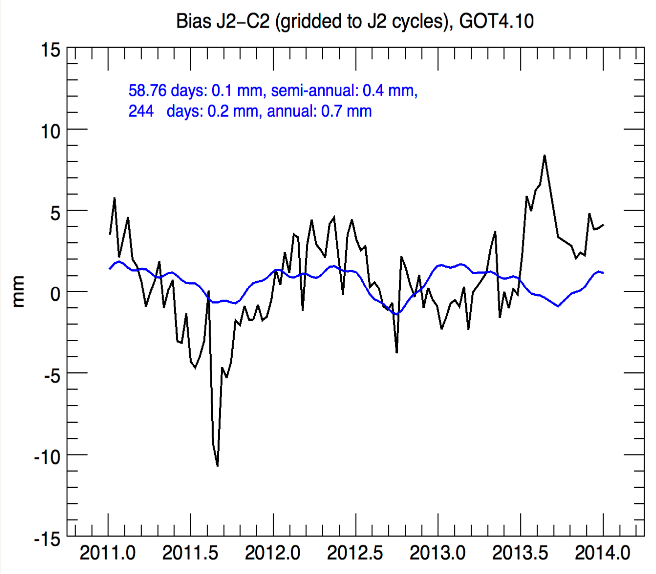


② J2-C2 global mean sea level difference, GOT4.10 tide model applied

Black: observed data.

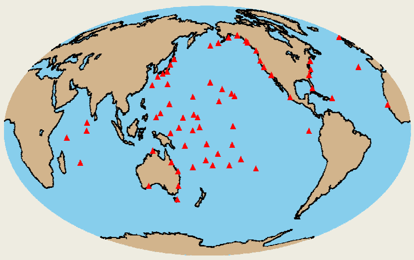
Blue: periodic model with annual, semi-annual, 59-, and 244-day cycles.

The 59- and 244-day terms have RMS amplitudes of 0.1 mm and 0.2 mm, respectively, when using the GOT4.10 model. The variance of the J2–C2 residuals are reduced by 27%.



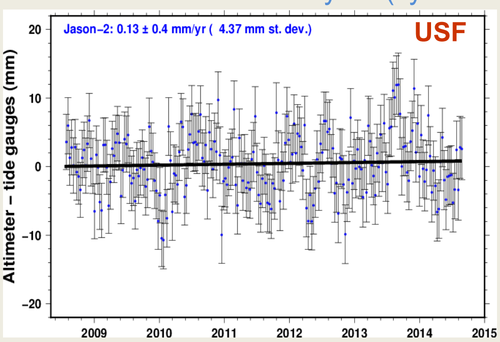
③ Jason-2 tide gauge comparison

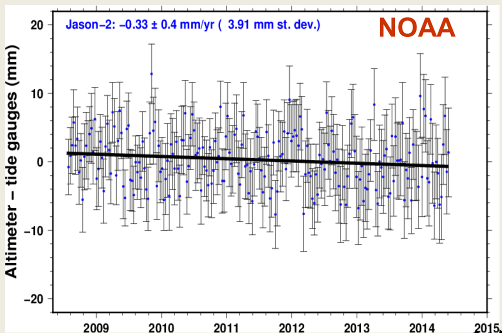
We've made two estimates of the drift in Jason-2, comparing J2 with a network of tide gauges using separate implementations of the method described in Mitchum [1998;2000] at USF and NOAA.



USF: +0.13 ± 0.4 mm/year (cycles 1 to 226)

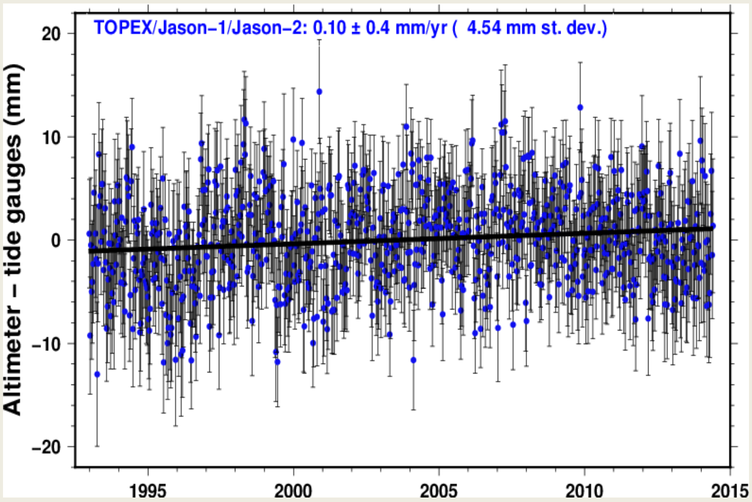
NOAA: –0.33 ± 0.4 mm/year (cycles 1 to





③ Reference series tide gauge comparison

NOAA implementation of Mitchum method for the 22-year reference series: drift of +0.10 ± 0.4 mm/year.



Summary

- Applying Tran SSB, GOT4.10 tide, and DTU13 MSS corrections from GDR-E standards to Jason-1 and Jason-2 significantly reduces the variance of differences in crossovers.
- Jason-2/CryoSat-2 (RADS) differences show no significant drift; Jason-2/AltiKa differences show a seasonal signal.
- Applying a Jason-only tide model, like GOT4.10, to Jason and CryoSat-2 reduces inter-satellite differences and eliminates most spurious 59-day variations in Jason-2 and 244-day CryoSat in global mean sea level.
- Two different implementations of the Mitchum tide gauge comparison show no significant drift in Jason-2.