Performance and consistency of different satellite altimeter systems assessed by means of global multi-mission crossover analysis

Denise Dettmering and Wolfgang Bosch

Deutsches Geodätisches Forschungsinstitut (DGFI)
Centre of Geodetic Earth System Research (CGE)
München, Germany
email: dettmering@dgfi.badw.de
Content

Multi-mission crossover analysis (MMXO)

Results for selected mission

Jason-2 GDR-D

Jason-1 Geodetic Mission (GM)

Saral/Altika

HY-2A

Conclusions
Method: MMXO

Basics
- single- and dual satellite crossover differences in all combinations
- using only crossovers close in time (Δt < 2 days)
- least squares adjustment of radial errors minimizing crossover and the along-track consecutive differences
- weighting of missions done by variance component estimation (VCE)
- TOPEX (later Jason1) taken as reference mission
- segmentation into 10-day cycles of reference mission plus 2 days overlap
- up to 120,000(240,000) crossovers (unknowns) per segment
- iterative solution with conjugate gradient algorithm

Results
- time series of radial errors per mission (w.r.t. reference mission)
- range bias (per 10 days period)
- geographically correlated error pattern
- differences in the realization of the origin of reference frame (first order harmonics)
- differences in the realization of the rotation axis (second order harmonics)
Input Data

- ERS-1
- ERS-2
- Topex
- Topex EM
- GFO
- Envisat
- Jason-1
- Jason-1 EM
- Jason-2
- Sral/Altika
- Envisat EM
- Sentinel-3
- Jason-1 GM
- Jason-3
- Cryosat-2
- HY-2A

Timeline:
- 1993
- 1995
- 1997
- 1999
- 2001
- 2003
- 2005
- 2007
- 2009
- 2011
- 2013
- 2015
Results: MMXO14

Range bias w.r.t. TOPEX

ESA Living Planet Symposium 2013, 13.09.2013
GDR-D data set

Range bias w.r.t. TOPEX

⇒ no systematics
⇒ range bias is reduced from 17.5 cm (GDR-C) to -0.5 cm (GDR-D)
GDR-C data set with GDR-D orbit

Range bias w.r.t. TOPEX

Jason-1 GM: 10.31 ± 0.17 cm

Jason-1: 9.73 ± 0.13 cm

Jason-1 EM: 9.72 ± 0.26 cm trend?

Jason-1 is reference mission

⇒ geodetic mission phase: offset in range bias of 6 mm
GDR-T data set

Radial errors w.r.t. TOPEX

- Jason-1 GM: $\pm 1.3$ cm
- Jason-2: $\pm 1.0$ cm
- Saral: $-6.7 \pm 1.3$ cm
- Cryosat-2: $\pm 1.3$ cm

$\Rightarrow$ similar noise level than other missions
**Saral**

Range bias w.r.t. TOPEX

- **IGDR:** offset of 1.7 cm wrt GDR, removed within cycle 4 (July, 11 2013)
- **GDR:** mean range bias of – 6.7 cm w.r.t. TOPEX
Center-of-Origin Realization

mean of #13 cycles:

- $ \Delta x$: $+1.0 \pm 1.3 \text{ mm}$
- $ \Delta y$: $+0.1 \pm 0.9 \text{ mm}$
- $ \Delta z$: $-1.8 \pm 2.2 \text{ mm}$

Systematic effects?
Relative differences in z-component between Saral and Jason-2

First mission phase: trend of appr. **-1.4 mm/cycle**
Since May 2013: offset of about **-5 mm** w.r.t. Jason-2
Geographically correlated errors

± 4.5 mm
IGDR Cycle 1...49 (Oct. 2011 to Aug. 2013)

Range bias w.r.t. TOPEX

⇒ Range bias with significant trends
⇒ Some cycles with strong time tag bias (about 55 ms)
Radial errors w.r.t TOPEX (July/Aug. 2013)

RMS of last 10 days: 1.8 cm
(J2: 1.0 cm / Saral: 1.3 cm)

⇒ Most recent results look promising!
Conclusions

- Approach for global relative calibration of altimeter missions
  - Easy detection of biases, drifts, systematics, ... coming from the instruments, the orbit or the geophysical corrections
  - Possibility to compute geographically correlated errors
  - Independent of orbit type

- Cross-calibrated mission data is mandatory for many applications with the need for long-term time series and high spatial and temporal resolution.

- Recent results for selected altimeter missions
  - **Jason-2 GDR-D**: stable results; small offset w.r.t. TOPEX; no systematics
  - **Jason-1 GM**: offset of about 6 mm w.r.t. other mission phases
  - **Saral**: early results are good, first IGDR Cycles show offset of about 1.7 cm w.r.t. GDR
  - **HY-2A**: be careful with IGDR L2 products; most recent cycles look promising
Questions?

Denise Dettmering and Wolfgang Bosch

Deutsches Geodätisches Forschungsinstitut (DGFI)
Centre of Geodetic Earth System Research (CGE)
München, Germany
email: dettmering@dgfi.badw.de
Saral

± 5.1 mm

± 6.0 mm