An Update from Harvest: New Results from TOPEX/POSEIDON, Jason-1 and Jason-2

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Harvest Platform



- NASA Prime Verification Site for High-Accuracy (Jasonclass) Altimetry
 - Open-ocean location along 10-d repeat track (by design)
 - 10-km off coast of central California
- Continuous monitoring for over two decades
 - 365 T/P overflights spanning 10 years (1992–2002)
 - 259 Jason-1 overflights spanning 7 years (2002–2009)
 - 268 Jason-2 overflights and counting... (2008–).

Experiment status

- Refurbished NOAA water level systems in 11/2014.
- New NOAA radar gauges installed in 06/2015.
 - Co-located with CU lidar system
 - Electrical conduit pending.
- New GPS station installed 01/2015.
 - Supplements existing site (operation since 1992).
 - Antenna located at old WVR site.

New this year

- Additional Jason-2 (GDR-D) results.
- New results for Jason-1 (GDR-E) and TOPEX (retrack).
- Updated GPS time series (including new station)
- Regional calibrations for SARAL/AltiKa







Platform Harvest Geodetic Height From 23 Years of Continuous GPS Monitoring







New Permanent GPS Station at Harvest Simultaneous

Observations over 25-m Baseline Provide Continuous Calibration



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Replace TOPEX MGDR Data with Retracked (skew01) Data

T/P: Skew01 (Callahan et al.) + repro. orbits (Lemoine et al.) and wet trop. (Brown et al.); Jason-1: GDR-E; Jason-2: GDR-D





Periodograms of SSH Bias Time Series







Wet Path Delay: Radiometer vs. GPS





JMR/AMR correction (Brown) interpolated directly to platform TCA (vs. t–5 s for std. correction)



Harvest: Ku-Band Ionosphere Calibration Using JPL GPS Ionosphere Maps





1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016





- Begin with uncorrected Ku- and C-Band Ranges
 - GDR-D and GDR-E for Jason-1 and -2 respectively
 - Compensate for troposphere using standard (GDR) approach
- Estimate SSH bias, drift and local SSB & iono. on each frequency simultaneously
 - SSB model (local to Harvest) is a simple percentage of SWH from nearby buoy ("BM1")
 - Epoch of 2009.0 (for defining bias)
 - Ionosphere is a scaling of TECU from GIM (GPS-based): theoretical values are 2.2 (Ku) and 14.3 (C).

	Jason-1 Ku-Band	Jason-1 C-Band	Jason-2 Ku-Band	Jason-2 C-Band
SSH Bias (mm)	+21 ± 7	+8 ± 11	+19 ± 12	+80 ± 20
SSH Drift (mm/yr)	+0 ± 1	+0 ± 2	–2 ± 1	-37 ± 3
Local SSB (%)	3.4 ± 0.2	4.3 ± 0.3	3.2 ± 0.3	3.7 ± 0.7
lono. (mm/TECU)	2.0 ± 0.2	13.0 ± 0.3	1.2 ± 0.2	12.7 ± 0.6
Number	206	204	212	206
Postfit σ (mm)	30	47	32	85



Regional Calibration: SARAL/AltiKa Results



- Regional calibration approach developed for Harvest by Cancet et al.
 - Use neighboring inter-satellite crossovers.
 - Successfully demonstrated for ENVISAT.
- For SARAL, direct (PCA) approach used.
 - Des. pass 226 only 18 km from platform (open ocean).
 - Gradient from avg of CLS201 & /DTU13 MSS







Summary



- Current (GDR-D) Jason-2 SSH slightly biased (low confidence).
 - +19 \pm 15 mm, including error in platform vertical
- Current (GDR-E) Jason-1 SSH biased high.
 - +40 \pm 15 mm, including systematic error from platform vertical.
 - Significant reduction vs. GDR-C (+94 \pm 15 mm)
 - Further reduced to +16 \pm 15 mm if Jason-2 MLE4 SSB used.
- TOPEX/Poseidon systems unbiased. (Uncertainties include error in platform vertical.)
 - T/P ALT-B: +8 ± 15 mm
 - T/P ALT-A: +11 ± 16 mm
 - T/P POS: -11 ± 17 mm
- SARAL/AltiKa bias estimates from 20 open-ocean passes (PCA ~ 18 km).
 - SSH bias of -37 ± 9 mm (formal error)
- No signs of significant SSH drift
 - Estimated drift \leq 1 mm yr⁻¹ range for all measurement systems except TOPEX Side A.
 - Estimated drift for TOPEX Side A ~2 mm yr⁻¹ (but higher uncertainty in land motion from early GPS).
 - Retracked (skew 0.1) Side A data show anomalous shift in ~1996 (not present in MGDR data).
 - Uncertainties (including land motion) close to 1 mm/yr for longest time series (Jason-1 & 2).
- Good consistency with GPS for EPD corrections
 - Both Jason-1 GDR-E and Jason-2 GDR-D
 - Enables evaluation of PD directly over platform
- Jason-1 GDR-E ionosphere 6-mm stronger than corresponding GDR-C correction
 - Increases discrepancy with Jason-2 GDR-D ionosphere from 5 to 11 mm.



Evolution of Bias/Drift Estimates



BIAS (mm)	Lisbon 2010	San Diego 2011	Venice 2012	Boulder 2013	Konstanz 2014	Reston 2015
Jason-2	+176	+176	+15	+22	+21	+19
Jason-1	+87	+89	+94	+96	+94	+40
ALT-B	+10	+14	+12	+11	+10	+11
Poseidon-1	-5	+6	+0	-0	-11	-11
ALT-A	+7	+18	+11	+8	+9	+8

DRIFT (mm/yr)	Lisbon 2010	San Diego 2011	Venice 2012	Boulder 2013	Konstanz 2014	Reston 2015
Jason-2	+8	+2	+5	+6	+3	-0
Jason-1	-2	-2	—1	-0	-1	+0
ALT-B	-3	-4	-2	-1	-1	-1
Poseidon-1	+1	-0	-0	+0	-0	-0
ALT-A	+4	+2	+2	+2	+2	+2

• Impact of improved models for platform subsidence (from GPS measurements) is significant.

• Tide-gauge errors also contribute