TOPEX/Poseidon and Jason-1 Satellite Altimeters: Absolute Calibration in Bass Strait, Australia

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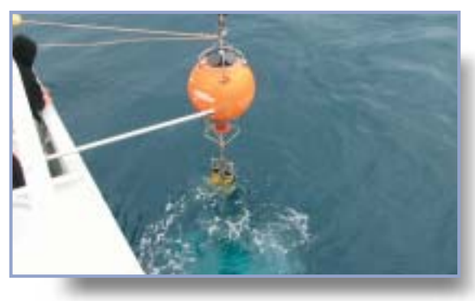
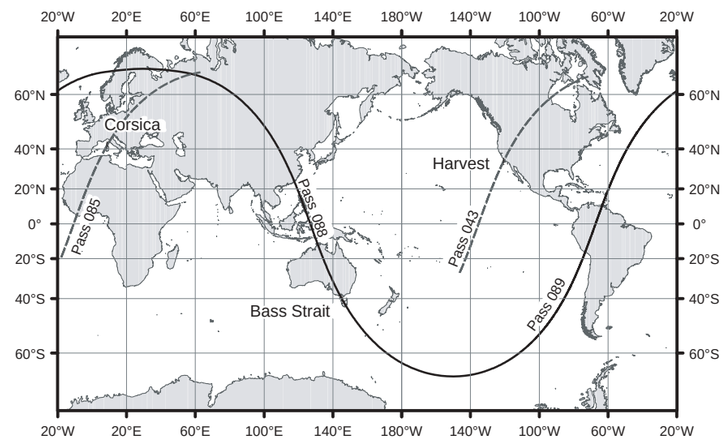
Introduction

The joint NASA/CNES TOPEX/Poseidon (T/P) and Jason-1 satellite altimeters are invaluable for a wide range of oceanographic and climatological studies. They have become the tool of choice for the study of global sea-level change.

Maintaining continuity between altimeter missions requires careful calibration using in situ measurements. The Bass Strait calibration site is the sole in situ calibration site for T/P and Jason-1 in the Southern Hemisphere.

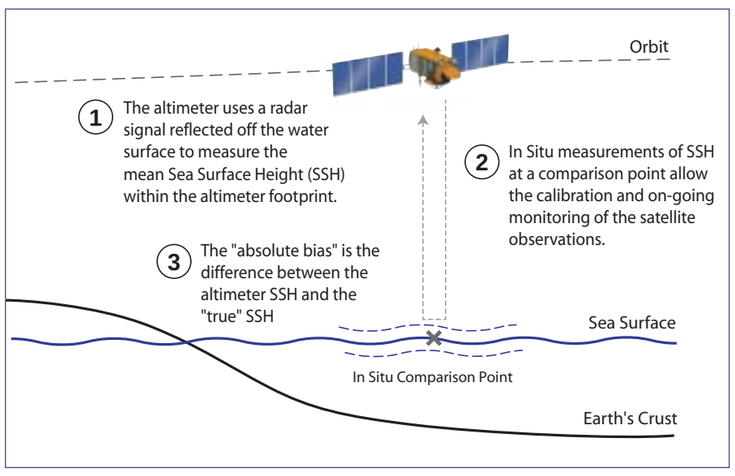




The Bass Strait (Burnie) calibration site has been running since T/P's launch in August, 1992. The NASA site is at Harvest oil platform offshore from California and the CNES site is at Corsica.

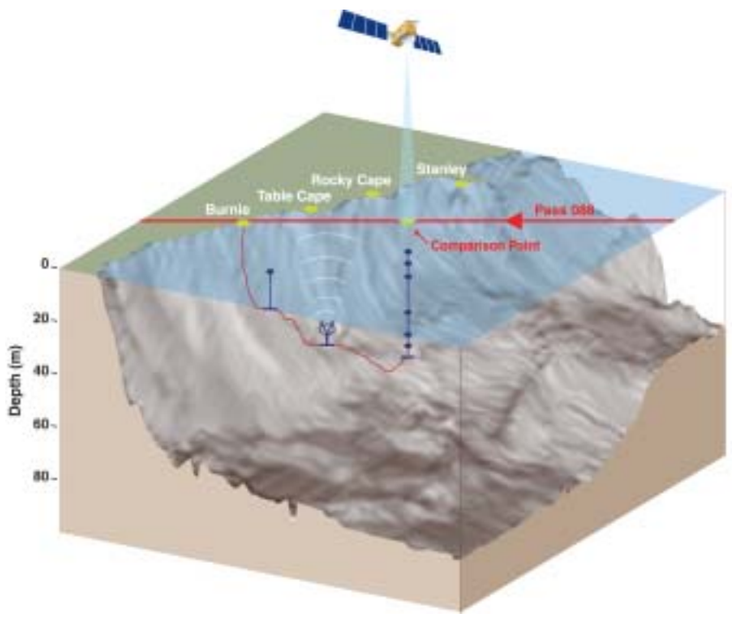
Methodology

During the calibration phase of the Jason-1 mission (January through August 2002), Jason-1 was positioned on an identical ground-track to T/P, leading by approximately 70 seconds. The satellites pass over the same ground track every cycle (10 days) and measure Sea Surface Height (SSH) from an altitude of around 1340 km, precise to 30-35 mm.



To calibrate the altimeter-derived measurement, SSH is measured using ground based observations in Bass Strait:

- A coastal tide gauge (located at the Burnie wharf from 1992),
- Two GPS buoys (deployed episodically at the comparison point approximately 40 km north-west from Burnie),
- Three land based GPS reference stations, and
- Oceanographic moorings (deployed Dec 2001-Sept 2002)

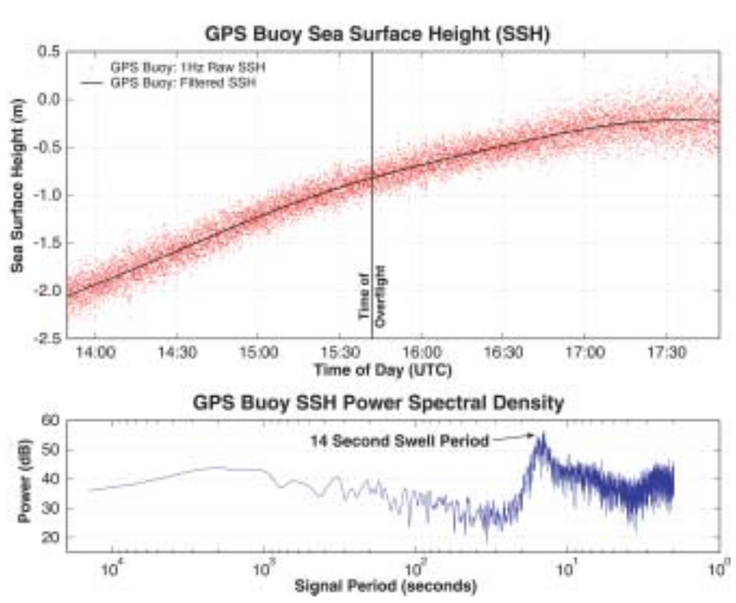


Data Processing

The altimeter data are from the standard Geophysical Data Record for both T/P and Jason-1. Corrections are made for various factors (e.g. atmospheric water vapour) which affect the radar pulse return time.

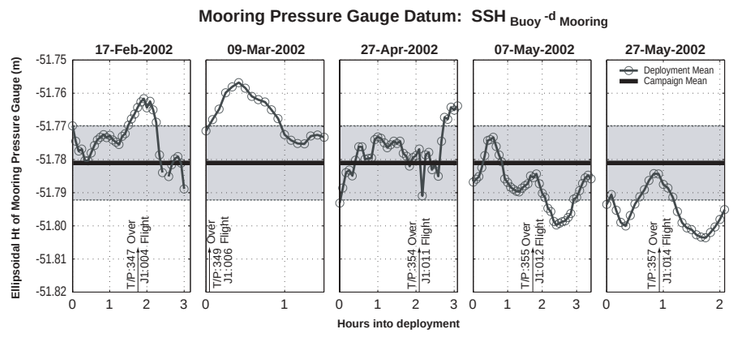
The GPS analysis involves two main processing stages:

- Absolute positioning of the GPS reference stations and regional network in the ITRF2000 reference frame using GAMIT/GLOBK software.
- Kinematic positioning of the GPS buoys every second using MIT's TRACK software. Independent GPS buoy solutions allow quality control of the SSH time series. Five buoy deployments, each 3 to 4 hours duration were completed.



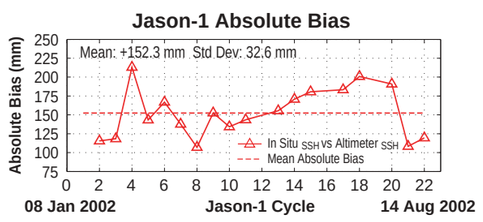
The heavy bold line through the GPS SSH estimates (upper panel) shows the filtered SSH, highlighting the underlying tidal signal. The spectra of the 1 Hz data (lower panel) indicates ocean swell.

A continuous SSH time series is calculated using measured bottom pressure, water density profiles and atmospheric pressure. The absolute vertical position of the Mooring SSH is defined by comparison with the GPS SSH time series.



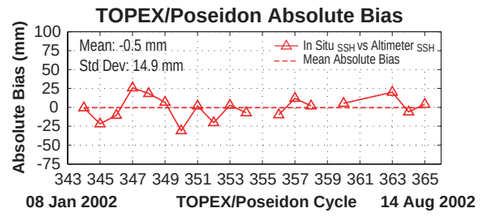
Results of the GPS solutions, relative to the mooring-derived SSH. The solid horizontal line is the mean over all deployments and the heavy grey lines show the mean of all four solutions (2 GPS buoys and 2 GPS reference stations) for each deployment. The shaded section shows ±1 standard deviation (11 mm).

Our bias estimates are:



Jason-1
Sea Surface Height Bias:
+152 ± 13 mm

The bias (SSH offset) estimates were calculated for the calibration phase (Jason-1 cycles 1-22). The Jason-1 bias appears to be more variable than the T/P bias. Using only common cycles, the relative bias is +150 ± 11 mm. Uncertainties have been calculated from a formal error budget.



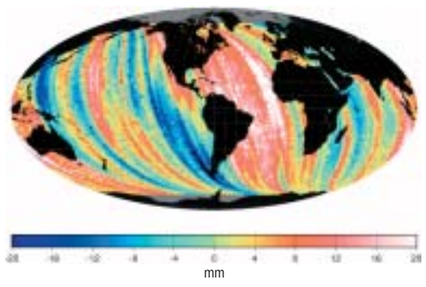
TOPEX/Poseidon
Sea Surface Height Bias:
0 ± 14 mm

Geographically Correlated Error

Results over Jason-1 cycles 1-60 (to August 2003) reveal differences depending on the choice of orbit (+148 mm for the GDR orbit and +131 mm for the Jet Propulsion Laboratory (JPL) GPS orbit). This difference is due mainly to differences in the underlying gravity field models (JGM-3 and GGM01S).

Conclusions

The use of GPS buoys combined with an oceanographic mooring array provides a unique calibration technique for determining absolute altimeter bias. The limiting error sources are the systematic error in the GPS reference station analysis, followed by uncertainty of the altimeter SSH estimates.



Geographically correlated orbit errors (Jason-1 GDR orbit – JPL GPS orbit). Only descending passes shown. Figure from Haines *et al.*, 2004, included with permission.

The significant bias (~150 mm) present in the Jason-1 data remains unexplained.

After considering geographical differences associated with orbit computation, bias estimates from Harvest and Bass Strait agree to within estimated uncertainties. Bias estimates from the Corsica site are slightly lower, but still within the formal uncertainties.

Careful calibration of altimeter missions is essential for sea-level studies, particularly those involving the computation of regional to global mean sea level and associated trends.

References

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Haines, B., Bar-Sever, Y., Bertiger, W., Desai, S., and Willis, P. (2004). "One-Centimeter Orbit Determination for Jason-1: New GPS-Based Strategies." *Marine Geodesy*, 27(1-2).

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Poster design by Louise Bell