Harvest calibration site off California

# First results of Jason-1

## data product validation


P. Vincent[1], S.D. Desai[2], J. Dorandeu[3], B. Soussi[3], M. Ablain[3], P.S. Callahan[2]
(1) Cnes, France, (2) Nasa/JPL, USA, (3) CLS, France
Patrick Vincent - E-mail: patrick.vincent@cnes.fr


Data from the validation phase of the Jason-1 mission have been comprehensively reviewed.

Project teams at JPL and CNES, working with the Space Oceanography Division at CLS [Dorandeu et al., 2002; Vincent et al., 2002], have systematically validated distributed data. Further, analyses by Principal Investigators and Co-Investigators involved in the work of the Jason-1 CALVAL group have extended the scope of analyses conducted by the project team and a carried out a thorough review of geophysical performance.

In addition to the usual statistical analyses, measurement of differences at crossover points, repeating ground track analyses, comparisons of geophysical corrections for each individual satellite, and combined analyses of Jason-1 and Topex/Poseidon data (T/P) were performed from the outset. These combined analyses took advantage of the ideal conditions provided by having the two satellites flying just 73 seconds apart, on the same orbit, to measure differences between data from the two missions very closely. They also identified possible refinements to algorithms for both missions.

A full review of all results obtained is obviously beyond the scope of this article. The reference data mentioned here aim to give users a clear picture of the main performance characteristics. Most analyses were based on Jason-1 Interim Geophysical Data Records (IGDRs) processed during calibration phases. Updated information can be found on AVISO and PO-DAAC websites.

### 1. Measurement timing

Timing accuracy of altimetry measurements is key to the system's overall error budget. The current level of accuracy is two microseconds, well within the 10-microsecond specification for near-real-time products.

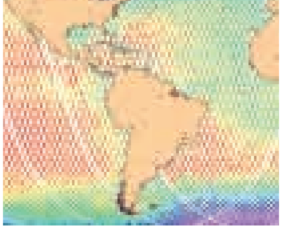
### 2. Instrument noise in range measurements

For the Poseidon-1 (T/P) and Poseidon-2 (Jason-1) altimeters, the noise in range measurements is identical, of the order of 1.6 centimeters for a significant wave height (SWH) of two meters and a sigma0 of 11 dB.

Analysis of high-data-rate data from the Topex altimeter (10 Hz) and from the Poseidon-2 altimeter (20 Hz), after waveform retracking, yielded two interesting results [Zanifé et al, 2002]:

- After waveform retracking by the ground segment, both instruments exhibit comparable noise levels of 1.6 centimeters on the Ku-band range measurement for an SWH of two meters and a sigma0 of 11 dB.

- Before waveform retracking, Topex altimeter data from the onboard tracking algorithm (included in GDR and MGDR products) and Poseidon-2 data from the onboard tracking algorithm exhibit the same features, with no white noise, which fits the tracking algorithm theory used for both altimeters.



## 3. Spectral analysis of measurement differences between Jason-1 and T/P

This analysis, conducted by Fu [2002], took advantage of the fact that because the satellites are trailing one another very closely they acquire measurements over the same point in quick succession. In this configuration, variations between T/P and Jason-1 measurements should show up as a white noise. Any other type of noise would raise issues to be resolved.

Regarding SWH measurement differences, the large-scale signal is of very low amplitude, of the order of 0.1 m. Regarding the difference in the backscatter coefficients, a red spectrum is present at all scales. However, the root-mean-square (rms) of these differences is only about 0.1 dB, which is not an issue.

Regarding differences in sea surface height (SSH) measurements by the two altimeters, the spectrum is red at wavelengths longer than 500 kilometers. While variations in the quality of orbit data may be a causal factor for wavelengths above 10,000 kilometers, this is not so for the portion of the spectrum between 1,000 and 5,000 kilometers. Here, the rms of the difference is of the order of one centimeter. The correlation with the SWH can therefore be interpreted as a sign that the two instruments are behaving differently or an indication that there are algorithm effects involved that need to be explained. We should note that the impact of these factors is negligible for most ocean applications using Jason-1 data. However, it is an issue when considering the large-scale ocean circulation, for example.

## 4. SWH

The cycle-to-cycle distribution of SWH measured by Jason-1 has a bias of 8.9 centimeters with respect to the Topex distribution. The standard deviation of the difference between the two measuring systems is of the order of 20 centimeters. The differences with respect to the WAM model are of the order of 38 centimeters for Jason-1 [Lefèvre et al, 2002]. The dispersion diagram of the difference between Topex SWH and Jason SWH as a function of Topex SWH exhibits a gradient that we need to explain: this point must be addressed alongside issues already raised by the spectral content of the differences, as described above.

## 5. Sigma0

After applying an a priori bias of –1.7 dB on the sigma0 of the Jason-1 Ku-band signal (to derive a wind parameter in line with that obtained from T/P), there is a residual bias of 0.13 dB between the Topex and Jason-1 distributions. The standard deviation of the Jason-1/Topex differences is 0.15 dB (figure 1).

## 6. Dual-frequency ionospheric correction

There is a bias of 0.3 cm between the dual-frequency ionospheric correction distributions of Jason-1 and Topex.

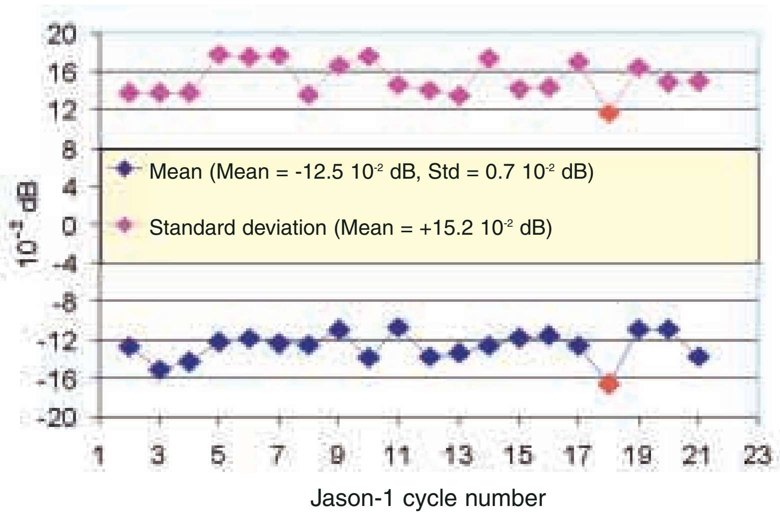



**Figure 1. Mean and RMS of sigma0 differences between Topex/Poseidon and Jason-1 (Units are dB) (On the "Mean" curve, blue diamonds are Topex measurements , while the red one refers to Poseidon-1 )**

D. Chambers and other investigators have underlined the need to filter the dual-frequency ionospheric correction for Jason-1 before using the data in geophysical products, as is the case for Topex.

## 7. SSH

Comparisons of sea surface height (SSH) have been made on T/P and Jason-1 data rendered as uniform as possible, using geophysical and sea-state bias corrections. Broadly speaking, analysis of differences at crossover points yields an overall standard deviation of the order of 7 cm for Jason-1, compared with 6.5 cm for Topex/Poseidon. This shows that there is still room to improve Jason-1 products, for example by working on the quality of orbit data and the sea-state bias law. Analysis using the repeating ground track method confirms that Jason-1 data are of very good quality (figure 2). In regions of low ocean variability, the standard deviation of the signal is only 4 cm, just like T/P.

Moreover, cross-calibration of Jason-1 and T/P in terms of SSH is a key factor, although not the only one, for obtaining uniform long time series of data.

An important finding of the cross-calibration exercise conducted by several investigators is that the high degree of accuracy sought for the relative bias between the two missions is closely dependent on the quality of the sea-state laws and ground retracking algorithms.

Medium-term and long-term activities seeking to achieve more reliable estimation of relative bias include efforts to optimize sea-state laws, refine ground waveform retracking for both missions, and explain how differences in SSH between Topex and Jason-1 are related to SWH. As an indication, the average preliminary relative bias figures discussed at the SWT Meeting in October 2002 are of the order of 11.5 cm. Since then, on-site experiments in Harvest and Corsica yielded a bias of 13 cm in the Jason-1 SSH data [Bonnefond et al, 2003]

## 8. Real-time products

Real-time Operational Sensor Data Records (OSDRs) are wind-wave products aimed chiefly at users working in marine forecasting.

However, altimetric range measurements can be used operationally to determine SSH, provided that the user performs the usual geophysical corrections and use the 10-cm class real-time DORIS orbit (DIODE

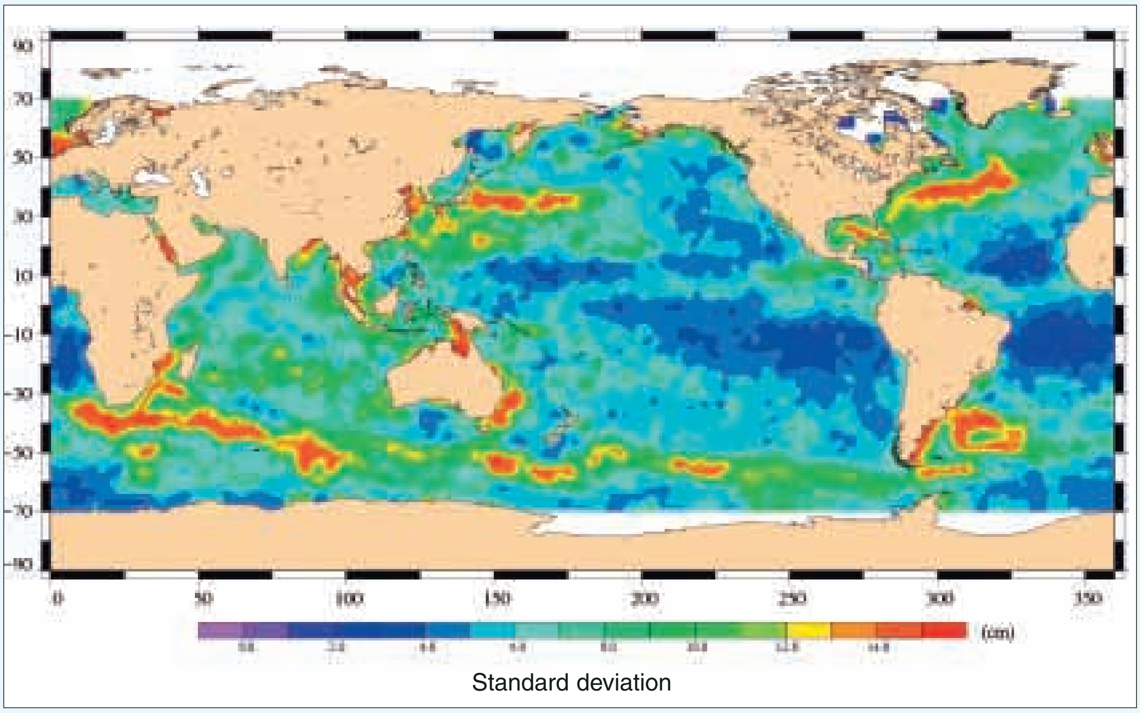



**Figure 2. RMS of sea level anomalies computed from 21 cycles of Jason-1 IGDR data (units are cm)**

navigator). For example, K. Withmer [2002] has shown how Jason-1 OSDR products are making a significant contribution to real-time oceanography activities.

Likewise, S.D. Desai and B.D. Haines [2002] have shown that it is feasible to create very accurate SSH products (better than 5 cm) within five to nine hours, by merging OSDR products with real-time orbit data accurate to 2.5 cm rms from TRSR measurements and by performing all necessary geophysical corrections.

Lastly, the use of Jason-1 IGDR products for two kinds of near-real-time applications—SSALTO/DUACS (CNES/CLS) and OSCAR [Lagerloef et al., 2002]—is another good example. The first of these is providing multisatellite altimetry products for climate research; the second, near-real-time surface currents in the Tropical Pacific.

## Conclusion

To conclude this brief overview of the main results from the Jason-1 science validation phase, in the words of S. Nerem in the abstract [2002] of his presentation at the SWT Meeting in New Orleans: "Preliminary evaluation of sea-level change measurements made during the coincident 21 cycles shows that the interim data from Jason-1 is of nearly the same quality as T/P, and there is every reason to expect that the final data will be of the same quality or better". Work underway into altimetry waveform retracking, sea-state bias, atmospheric tides, aliasing of the high-frequency spectrum of ocean variability in altimetry measurements, and other areas is set to bring significant advances in Jason-1 data quality.

**Corsica calibration site**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