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FOR REFERENCE: WESTERN PACIFIC GEOPHYSICS MEETING CALL FOR PAPERS AND SESSION DESCRIPTIONS, SEPTEMBER 19, 1995

Satellites Work in Tandem to Improve Accuracy of Data

Global observation of the oceans by satellite altimetry entered a new era with the European Space Agency ERS-1 and U.S./French TOPEX/POSEIDON missions, which were launched in July 1991 and August 1992, respectively. For the first time, two altimetric satellites were flying simultaneously. TOPEX/POSEIDON (TP) is an optimized altimetric mission dedicated to the precise observation of the large-scale oceanic circulation. ERS-1 is a multimission satellite. It carries a Synthetic Aperture Radar (SAR), a wind scatterometer, an along-track scanning radiometer and a radar altimeter.

The TP and ERS-1 altimeters provide complementary space-time sampling of the oceanic circulation but they do not obtain data with the same accuracy. The accurate determination of the satellite geocentric position, and specially its radial component, is a basic requirement for accurate determination of the sea level. The radial component of the TP orbit is determined to within 3 cm, while ERS-1 orbits are only determined to within 15 cm. However, since TP and ERS-1 are flying simultaneously, the more precise TP data can be used to correct the ERS-1 orbit error [*Le Traon et al.*, 1995a].

To correct the ERS-1 orbit error, a method based on a minimization of crossover differences over the whole globe is used. A crossover difference is the variation in measured sea surface height at a crossover point between two satellite arcs. The difference is mainly due to orbit error if the ocean topography does not change too much between the two arc dates. The differences between TP and ERS-1 arcs (TP-E crossover differences) and between two ERS-1 arcs (E-E crossover differences) are jointly minimized in the method.

The method was recently applied to the full ERS-1 35-day repeat cycle mission, which flew concurrently with TP, from October 1992 to December 1993 [*Le Traon et al.*, 1995b]. To be consistent with TP orbits, which use the Joint Gravity Model-2 geopotential model, ERS-1 JGM-2 orbits are used. For all processed cycles, the root mean square (rms) E-E crossover difference before orbit error correction is 18 cm for time lags below 5 days. The rmsTP-E crossover difference is 15 cm.

The orbit error correction provided a very efficient reduction of E-E crossover differences. For time lags of less than 5 days, the rms of corrected E-E crossover differences is always below 7.5 cm for each processed cycle, a value close to that obtained with TP data. The correction also provides a very efficient reduction of TP-E crossover differences, which are always below 7 cm rms.

The mean TP-E crossover difference before orbit error correction also provides an estimation of the difference between the ERS-1 and TOPEX instrumental range biases. This relative bias is about 26 cm. Assuming a 15 cm TOPEX bias, this means that ERS-1 measures too short by about 41 cm. This result is in excellent agreement with ERS-1 bias estimates.

The ERS-1 satellite exactly repeats its ground track pattern every cycle (every 35 days). The observed temporal variations of the sea level along the satellite tracks are due to both orbit errors and changes in the ocean surface topography. The rms Sea Level Variability (SLV) deduced from uncorrected ERS-1 measurements is shown in Figure 1. The variability is computed relative to the mean over cycles 6 to 18. In low-energy areas, where the oceanic signal is small, the SLV is typically 10 cm. Except in high-eddy energy areas, the signal is dominated by orbit error. Once the orbit error correction is applied, the SLV in low-eddy energy regions is reduced to 4–5 cm (Figure 2). The gain in variance is about 85 cm^2, which corresponds to an orbit error of about 9 cm rms. Since most of the orbit error due to geopotential model errors cancels out in repeat-track differences, this represents only a fraction of the total orbit error, in particular the part due to atmospheric drag model errors. The rms of the total orbit error is actually estimated to be 14 cm. Figure 1 also shows a few tracks with large orbit errors. These larger orbit errors are the result of satellite maneuver problems, which the near real time JGM-2 ERS-1 orbit calculation does not fully overcome. Remarkably, these tracks can be fully corrected using TP data.

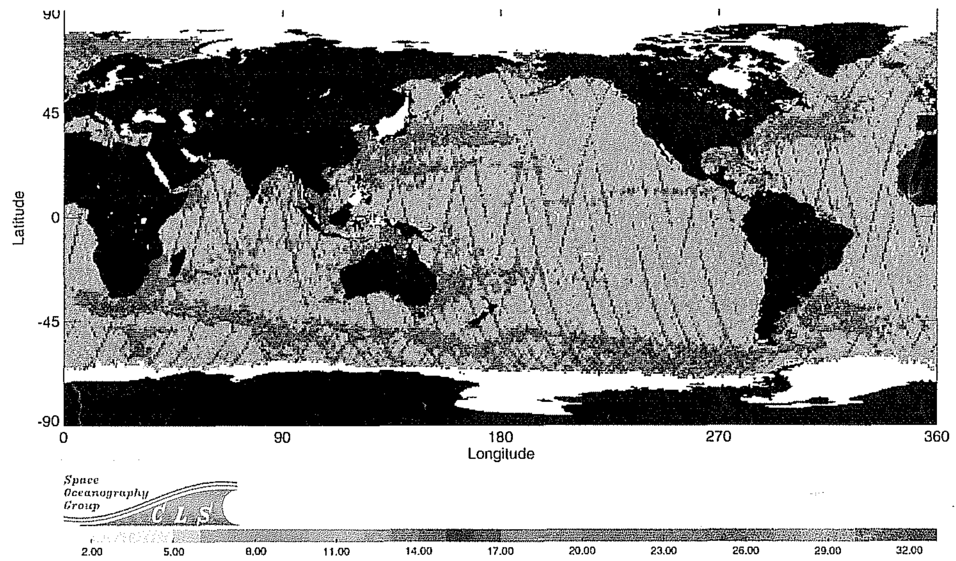

Fig. 1. Rms of sea level variability in centimeters for ERS-1 cycles 6 to 18 with the JGM-2 orbits. Except in high-eddy energy areas—for example, the Gulf Stream, Kuroshio, Brazil/Malvinas Confluence area, and the Antarctic circumpolar current—the signal is dominated by orbit error.

The corrected ERS-1 rms SLV is in excellent agreement with TP SLV [*Le Traon et al.*, 1995b]. Contrary to conventional orbit error reduction schemes, this result is achieved without removing the large-scale oceanic signal. The corrected ERS-1 data can thus be used to analyze the low-energy areas and the large-scale oceanic signals which, otherwise, are masked by the orbit error.

Satellites (cont. on page 389)

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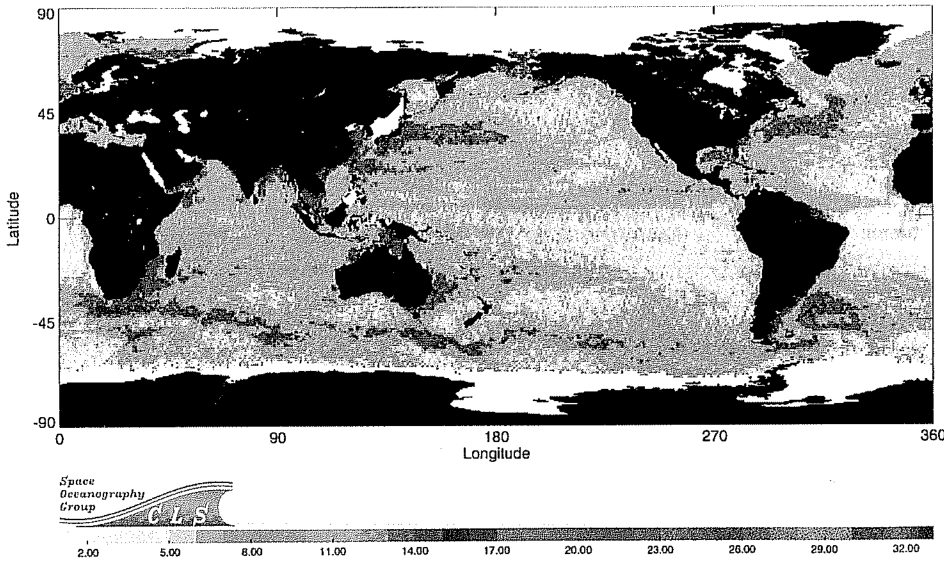

Fig. 2. Rms of sea level variability in centimeters for ERS-1 cycles 6 to 18 after correction with TOPEX/POSEIDON data. The root mean square is only 4–5 cm in low-eddy energy areas.

Corrected Data Sets Available

The corrected ERS-1 data set is distributed on CD-ROM by AVISO, the French TP processing and archiving center, to the scientific community; it consists of a reduced Geophysical Data Record, which provides the sea-surface height with all altimetric corrections applied, and a file of Sea Level Variability. Similar files for TP are also distributed. In the future, the long-term and precise monitoring of the sea level and oceanic circulation will require homogeneous times series of sea level from Geosat, TOPEX/POSEIDON, ERS-1, ERS-2, ENVISAT, Geosat Follow-On and TOPEX Follow-On data. This study is a first step toward this very challenging goal.

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