TOPEX

The TOPEX data are from the Merged Geophysical Data Records (MGDRs) and have been modified to include the Wallops internal calibration, new tide models, TMR path delay corrections, and updated sea state bias models.

To make comparisons with Jason more compatible, we replaced the (M)GDR ocean and load tides with those from GOT99.2 model [Ray, 1999] and the equilibrium long-period ocean tides with those used for the Jason GDRs (P. Callahan, personal communication).

Two modifications to the wet troposphere path delay are necessary. Keihm et al. (2000) discovered a drift in one channel of the TOPEX Microwave Radiometer (TMR), which caused a noticeable drift in comparisons between T/P SSH measurements and the global tide gauge network [Mitchum, 1998]. We have applied a correction for this drift based on global means [Keihm et al., 1998], which, in terms of SSH is

$$\mathrm{SSH_C} = \mathrm{SSH_M} + \begin{cases} (1.2\ \mathrm{mm/year})(t-1992.75), & t < 1997.0 \\ 5.2\ \mathrm{mm} & t \geq 1997.0 \end{cases}$$

where t is the year, $\mathrm{SSH_M}$ is the SSH from the TOPEX (M)GDRs with all major corrections applied, and $\mathrm{SSH_C}$ represents the SSH corrected for the effect of the TMR drift. We also include a TMR yaw correction to account for a slightly greater path delay when the satellite is in fixed rather than sinusoidal yaw. This TMR yaw correction, available on the GDR Correction Product Version C, accounts for the 15-hour thermal transition between yaw states (Zlotnicki and Callahan, 2002).

Chambers et al., 2003 estimated new models (here called T-CSR) for each of the two different TOPEX altimeters (TOPEX-A and TOPEX-B) that have operated during TOPEX/POSEDION mission. The T-CSR SSB model for TOPEX-B is significantly different than the model provided on the (M)GDRs, which was estimated using only TOPEX-A data. A 1.5 mm bias between TOPEX-A and TOPEX-B has been applied. We have not applied any retracking corrections or corrections to the ionosphere path delay that result from changes to the sea state bias model.

The inverted barometer used is NOT the value from the TOPEX MGDR-B, but is calculated using the 6-hour pressure values from the European Centre for Medium-Range Weather Forecasts (ECMWF).

Inverted Barometer = –9.948*(atmospheric_pressure – global_average_pressure)

The global_average_pressure is interpolated from values determined at 6-hour intervals from CNES. The file containing the average values is obtained from CNES/CLS (ftp://ftp.cls.fr/pub/oceano/calval/pression/moy_globale_spatiale.txt).

Jason

The Jason-1 data are from the Geophysical Data Records (GDRs). We replaced the GDR orbits with JPL GPS reduced-dynamic precise orbits [Desai and Haines, 2003]. The reduced dynamic orbits are thought to be accurate to better than 10 mm rms, in part because the reduced dynamic technique can compensate for residual gravity errors.

To correct for time-varying biases in the wet troposphere path delay, we apply a globally averaged bias for each cycle. This bias has been determined from the differences in the Jason Microwave Radiometer and the ECMWF model wet troposphere path delays from the GDRs.

A relative bias of 154 mm has been removed from the Jason-1 SSH data to bring them into agreement with the T/P SSH data. See our calibration paper [Leuliette et al., 2004] for more information.

Global mean sea level

We chose to reference TOPEX and Jason SSH anomalies on the common ground-track to an along-track mean computed using data from the original TOPEX/POSEDION mission. A cross-track gradient correction was estimated using the JPL along-track mean sea surface model. This model was derived by computing adjustments to the GSFC00.1 global mean sea surface model using sea surface height data from the TOPEX altimeter. The cross-track gradient component was not adjusted and was therefore effectively a fit to the cross-track gradients defined by the GSFC00.1 model along the T/P ground track. (S. Desai, personal communication).

Spurious data have been removed with a restriction of SSH anomalies to be < 1 meter. Global mean sea level was computed from the corrected SSH anomalies using a simple equal-area weighted average [Wang and Rapp, 1994].

The inverted barometer does not have much apparent effect on the global mean sea level, because the ocean as a whole is not compressible.

Trend Error Estimation

With the current set of corrections to T/P data, the tide gauge calibration for T/P is reasonably "flat," and thus we no longer consider it necessary to correct the altimetry using the calibration values. Nevertheless, we consider the calibration valuable in accessing altimeter measurement errors and develop error bars for the sea level change estimates. At present, the gauges indicate that the drift error is consistent with zero, but only to a precision of about 0.4 mm/year. Hence, the estimated bias error due to the altimeter drift is 0.0 ± 0.4 mm/year. The calibration error could become much better, because the error model is almost entirely driven by errors in the land motion estimates used for each of the tide gauges [Mitchum, 2000]. Including improved land motion estimates from GPS and DORIS measurements should reduce the uncertainty in the altimetric rates.

A random-phase bootstrap sample of the residuals was used estimate the random trend error due to the scatter of the T/P and measurement errors. This form of bootstrapping is robust when the residuals are serially correlated, as is the case for mean sea level [Ebisuzaki, 1997]. This random error is estimated to be ±0.14 mm/year. Combining the calibration error with the random error in quadrature produces a final trend error of $\sqrt{(0.14)^2 + (0.4)^2} \approx 0.4$ mm/year.

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