Spatial mapping of time-variable errors in Jason-1 and TOPEX/POSEIDON surface topography measurements

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Summary

Fitting ocean models to altimeter seasurface height (SSH) measurements requires knowledge of instrument noise (radar noise, sea state bias, path delay corrections, and orbit errors) and ``representation'' errors related to SSH signals not computed in the models (e.g., tidal, pressure-driven and eddy signals). Comparisons between the independent TOPEX/POSEIDON (TP) and Jason-1 altimetric missions when they were in identical orbits show that point-by-point the data are consistent within the mission specifications of about 3 cm rms, but large-scale dependences exist in the data differences, and these are both poorly known and capable of introducing major errors into oceanic state estimates. Here we focus on the time-variable component of the spatially dependent errors. The analysis reveals errors ranging from 2 cm in the tropics to 4 cm at mid and high latitudes and roughly consistent with a dependence of instrument noise on significant wave height. Analysis of the representation errors suggests that, over the deep ocean, uncertainties associated with the simplifying assumption of an inverted barometer response to pressure loading are larger than the remaining errors in modeling the large-scale tides. Over extensive regions, however, errors associated with eddy signals missing in coarse resolution models can dominate. Obtaining a more quantitative estimate of the latter errors remains a challenge. Time-mean errors involved in estimates of mean dynamic topography (altimetry-geoid) are not addressed here but are also not well understood and might be larger than formal geoid errors.

Instrument noise

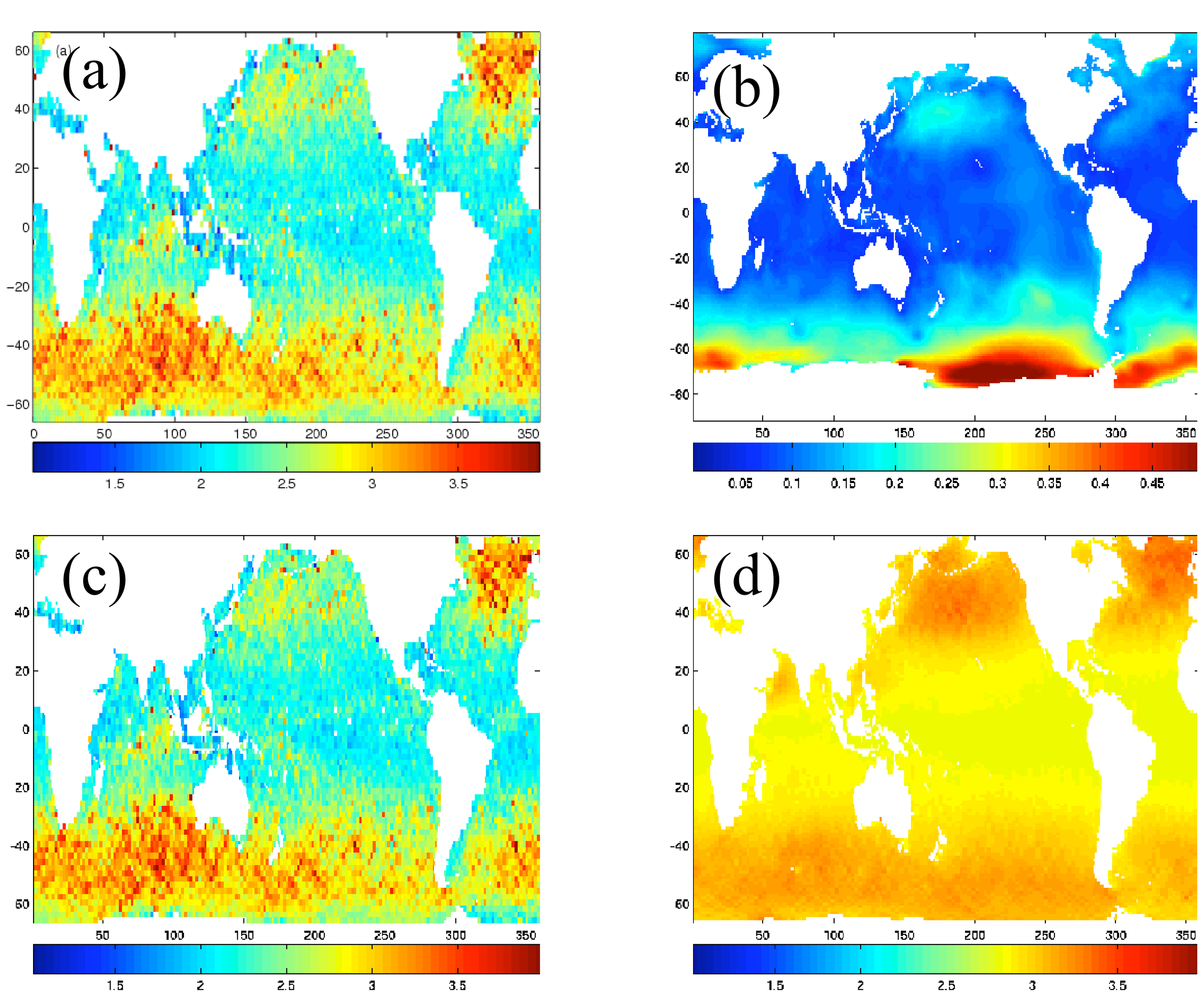

Figure 1. Standard deviation (cm) of estimated instrument noise based on 1Hz measurements.

(a) Unexplained differences between TP and Jason-1 series, computed for 20 cycles of the tandem mission and then averaged in 2x2 degree boxes (based on Along-Track-Gridded Sea Surface Height Anomaly product provided by PODAAC at JPL)
(b) Error associated with the dry tropospheric correction, which is not included in (a), from estimated errors in surface atmospheric pressure
(c) Total instrument noise calculated as the root-sum-square of values in (a) divided by $\sqrt{2}$ and (b)
(d) Altimeter noise computed by modeling radar noise as linearly related to significant wave height, sea state bias errors as 1% of the standard deviation of significant wave height, and constant values from *Chelton et al. (2001)* for wet tropospheric and ionospheric correction errors and orbit error

Representation error

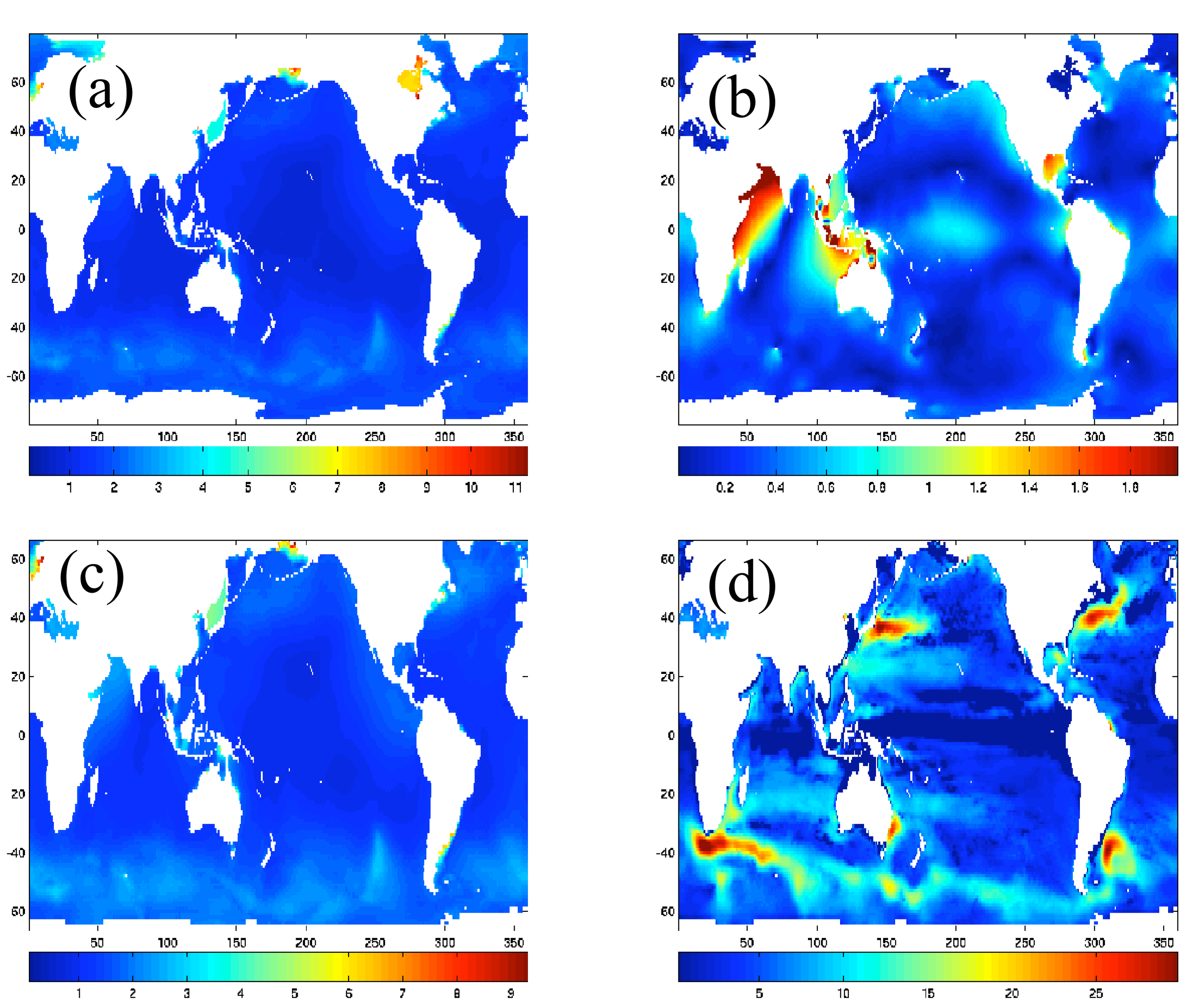

Figure 2. Various representation error terms in the MIT-AER ECCO estimates. All values in cm.

(a) Standard deviation of dynamic signals forced by atmospheric pressure
(b) Amplitude of the S_1 tide forced by the respective climatological air tide
(c) Standard deviation of the total error associated with dynamic signals forced by atmospheric pressure as represented in (a) and (b)
(d) Standard deviation of ``eddy'' error based on comparisons of 1/8 degree and 1 degree ocean models and TP observations

Combined (instrument+representation) error

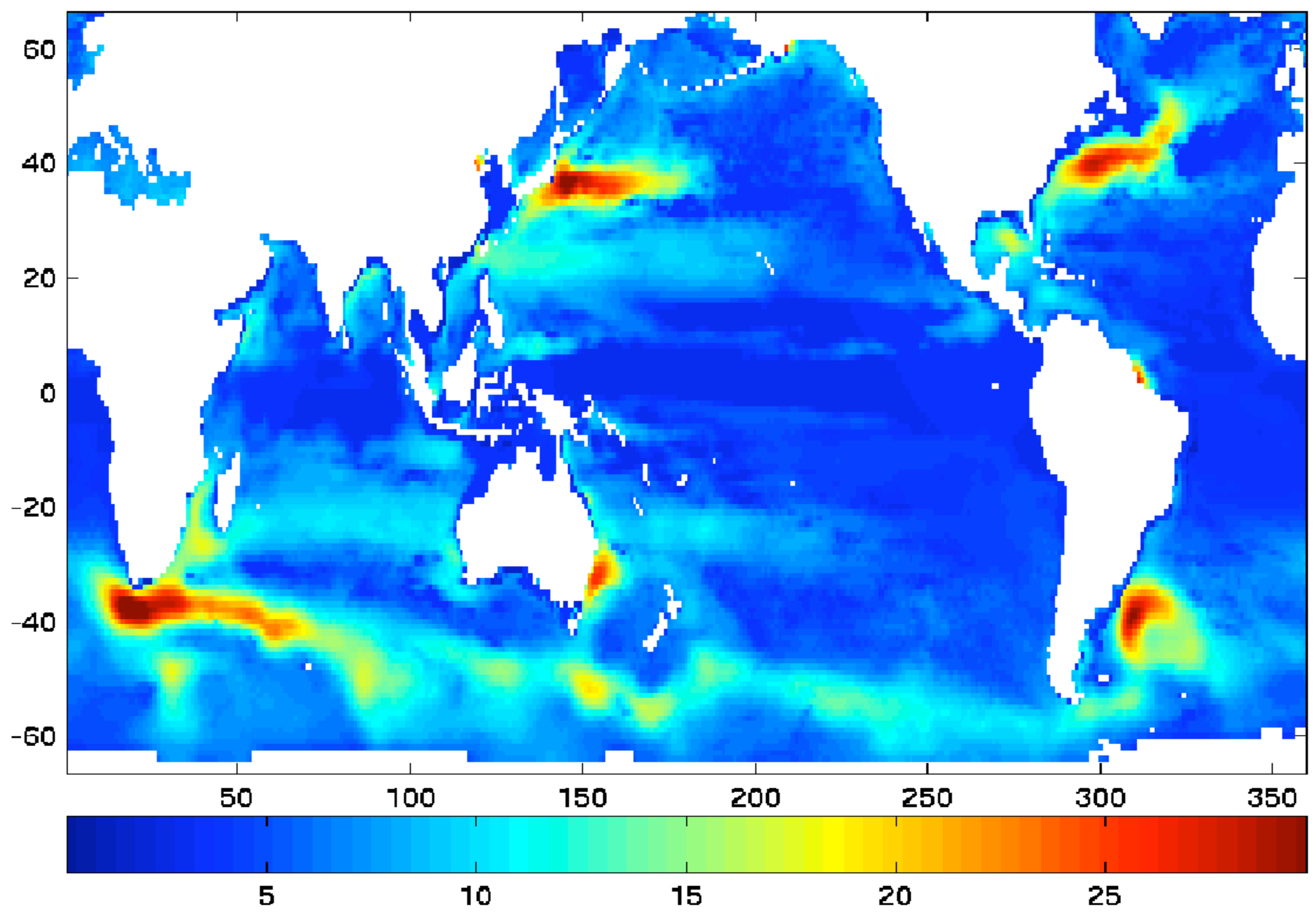

Figure 3. Standard deviation (cm) of total error (instrument noise+constant tide error of ~1cm+inverted barometer and dynamic signals from atmospheric pressure effects+eddies), and our best current estimate of the spatial structure of the altimetric errors. This pattern, reduced by 10% to account for data smoothing effects, is now used in the MIT-AER ECCO state estimation runs and corresponds to the diagonal of the error covariance matrix for the time-dependent altimetry. Off-diagonal elements have not yet been estimated. The figure can also be interpreted as an estimate of mesoscale variability in the ocean, as that component dominates.

References

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