ERROR IN GRIDDED SEA SURFACE HEIGHT PRODUCTS

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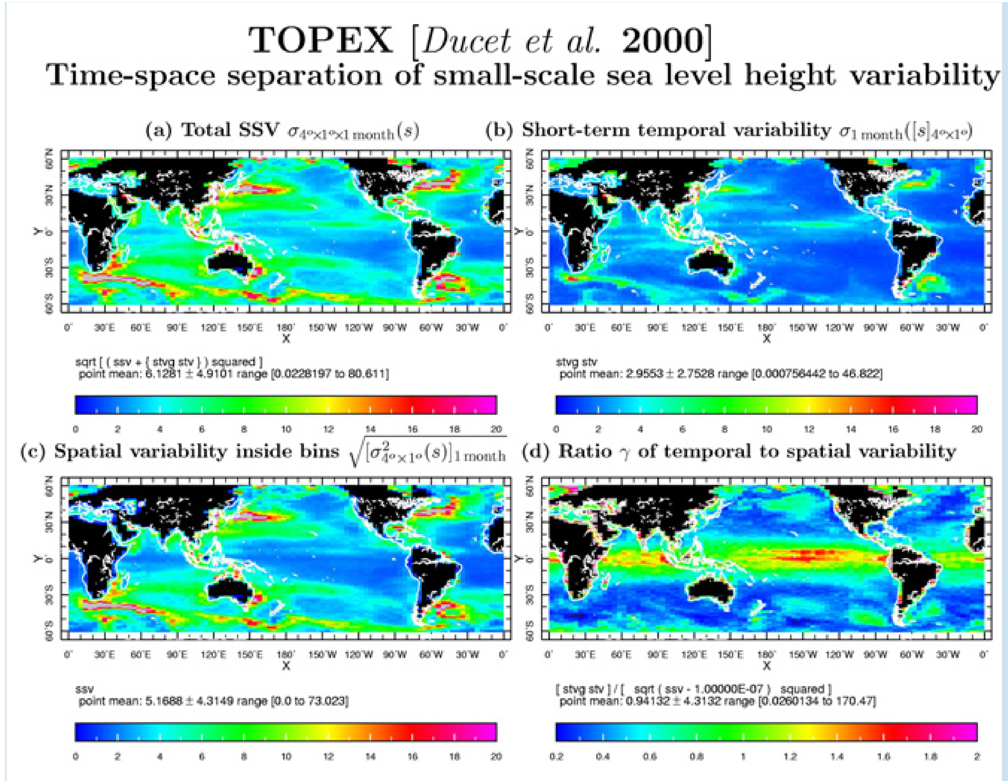
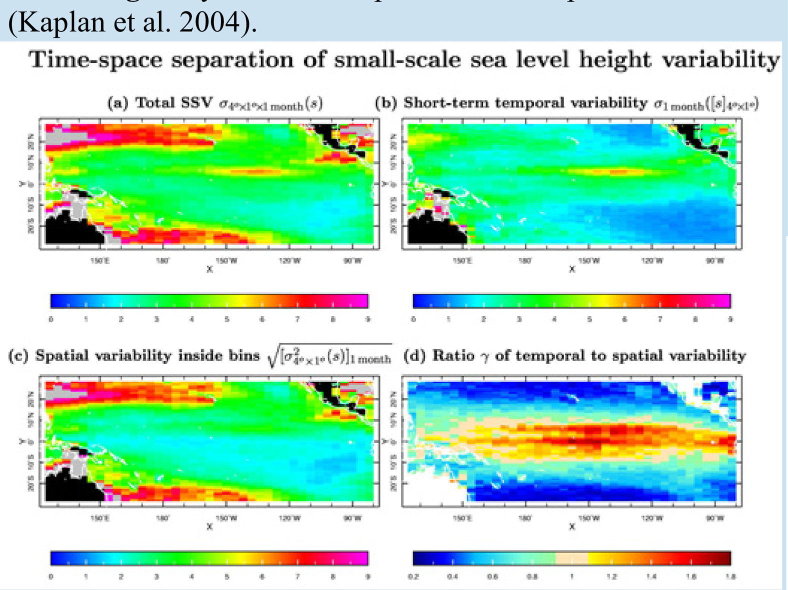
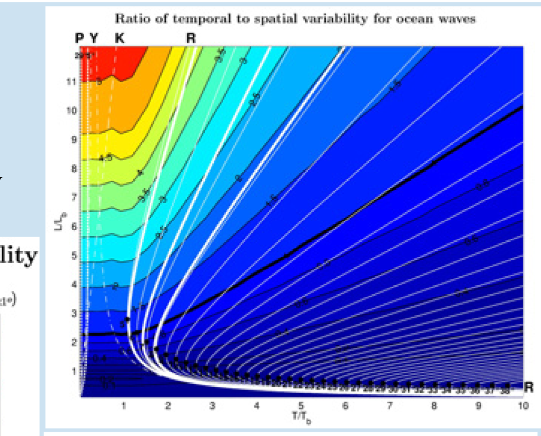
SUMMARY

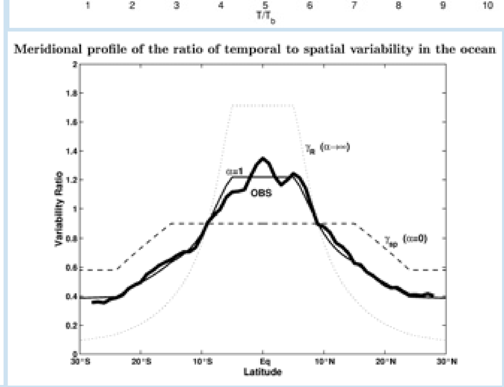
Variability in nature exists on all spatial and temporal scales, including those smaller than the resolution of model and observational data sets. Imperfect parameterization of the small-scale variability (SSV) in models and incomplete sampling of it by observational systems creates model and observational error on the resolved scales of variability. The SSV in sea surface height plays a major role in defining the error pattern of wind-forced ocean simulation and satellite altimetry assimilation products. The statistical modeling of the SSV in sea surface height suggests that in the tropical Pacific the major portion of this variability can be explained as a dynamical ocean model response to the SSV (and error) in the wind. Areas of high error which are not associated with local wind SSV are those of high shear and current instabilities in the ocean. Most GCMs underestimate the wind-driven sea surface height SSV even if driven by wind forcing with well-represented SSV and, as a result, underestimate variability on signal scales as well. Data assimilation procedures usually interpret observed data as if they could be expressed in terms of the averages over model grid box areas despite in reality the observations are either pointwise values (for in situ data) or averages over certain footprints (for remote sensing data). Therefore the difference between observations and model values ought to reflect the influence of the small-scale variability (SSV) of the observed physical field, because this variability is getting averaged differently by the model grid and by the observational system. The statistical details of the SSV, e.g. its standard deviations and temporal-to-spatial SSV ratios, helps model data error. Intercomparison of altimetry data with tide gauge values helps to verify or tune error model for the spatial and temporal scales currently unresolved by altimetry data.



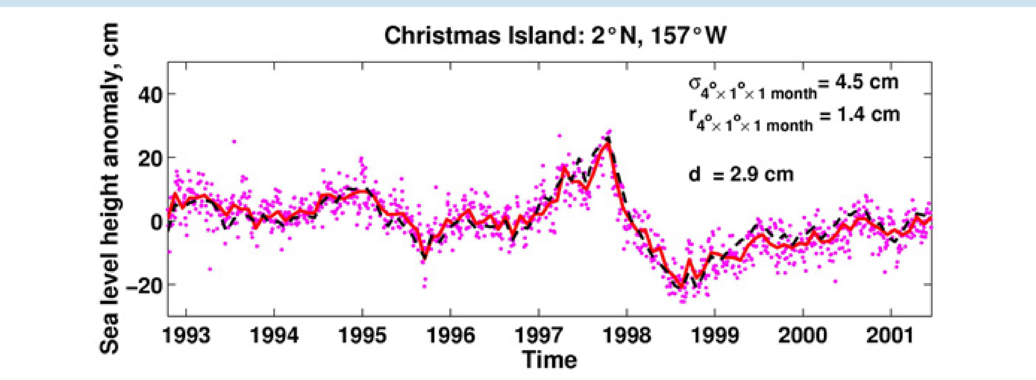
On the left: Separation of small-scale and short-term variability in the global altimetry fields.
Below: same as on the left but zoomed in to the tropical Pacific Ocean.
On the right: dynamical interpretation of the patterns below (Kaplan et al. 2004).

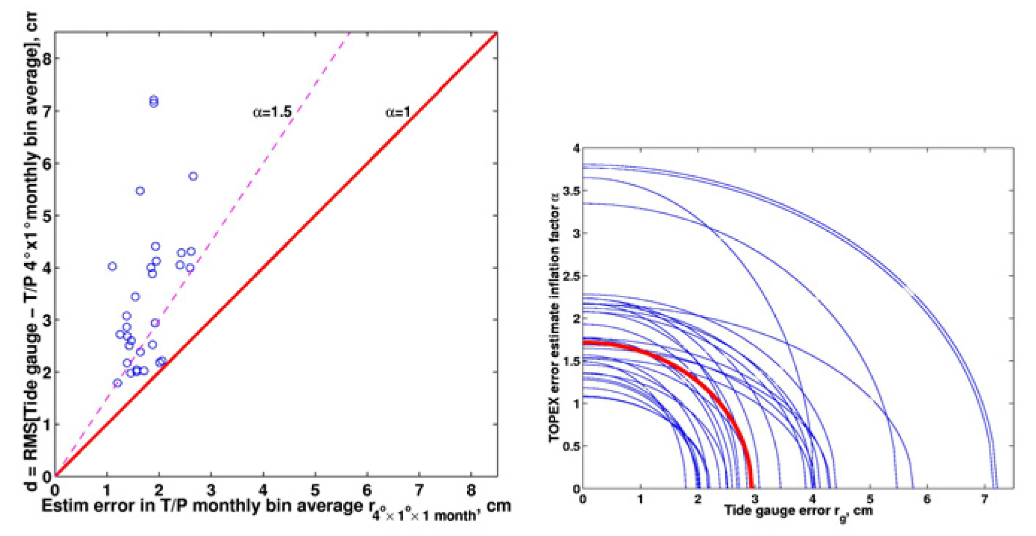




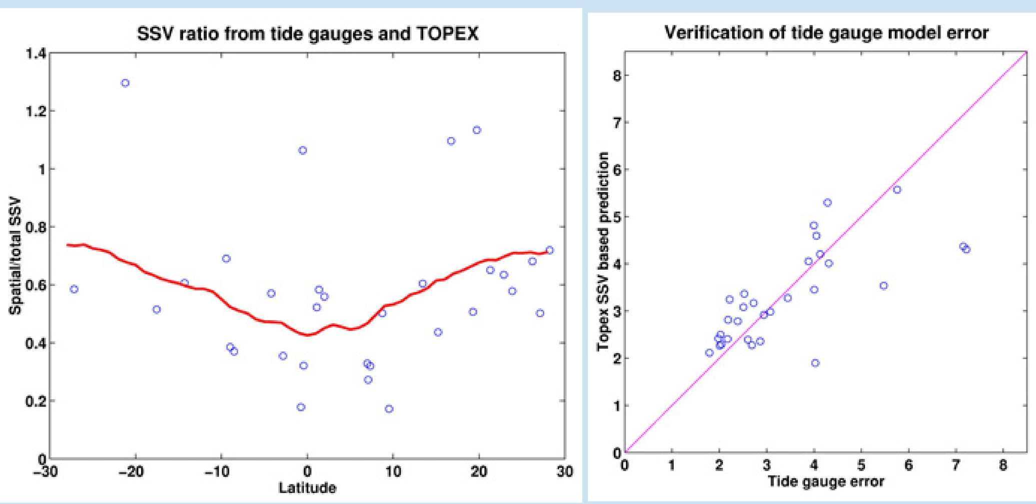


ERROR MODELS FOR ALTIMETRY AND TIDE GAUGES

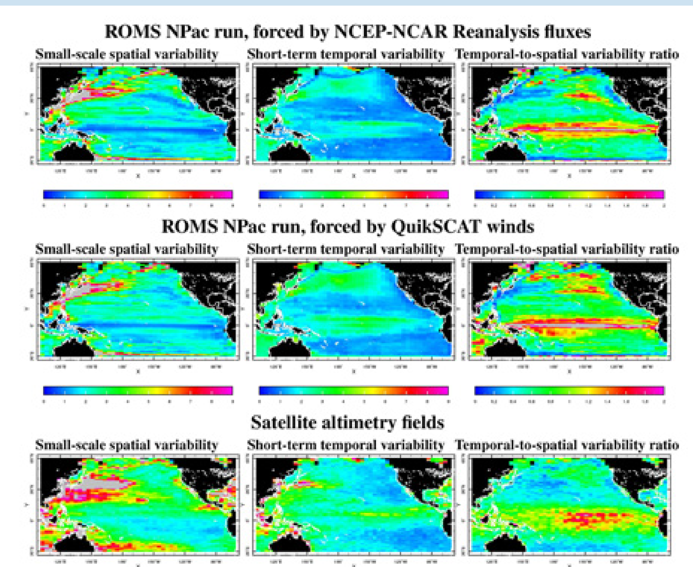




Validation of T/P error estimates by comparison with the tide gauge records, October 1992 -- March 2001.
Above: the top panel compares monthly tide gauge sea level height anomalies at Christmas Island (dashes) with altimetric measurements from the corresponding gridbox (centered at 2N and 158W) of *Cheney et al.* [1994] T/P product. Dots show values from individual altimetry passes, and the solid line shows their monthly averages for this gridbox. Temporal RMS values of the intrabox variability sigma inside the gridbox, the sampling error estimate r for the gridbox mean, and the RMS difference between the gridbox and tide gauge monthly means d are indicated as well. In the lower left panel, circles are differences between 31 tide gauges and T/P bins. Differences would fall along the solid line if the only errors were the ``optimistic'' estimate of T/P errors. The dashed line inflates these optimistic estimates by a factor of 1.5. In the lower right panel, thin lines show constraints on the inflation factor alpha and tide gauge error r for individual tide gauges. The thick line shows the median constraint.
Below: left panel compares the portion of purely spatial small-scale variability in the total intrabin SSH variations for tide gauges (circles) and altimetry; right panel uses altimetry estimates of spatial and temporal variability to predict the RMS difference between altimetric values and tide gauge measurements.

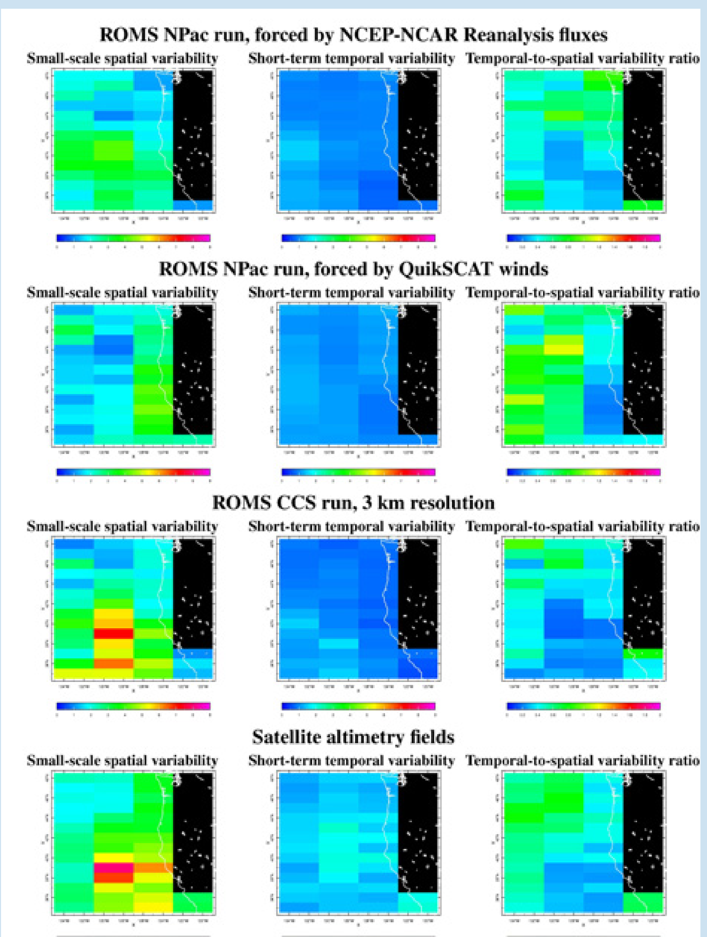


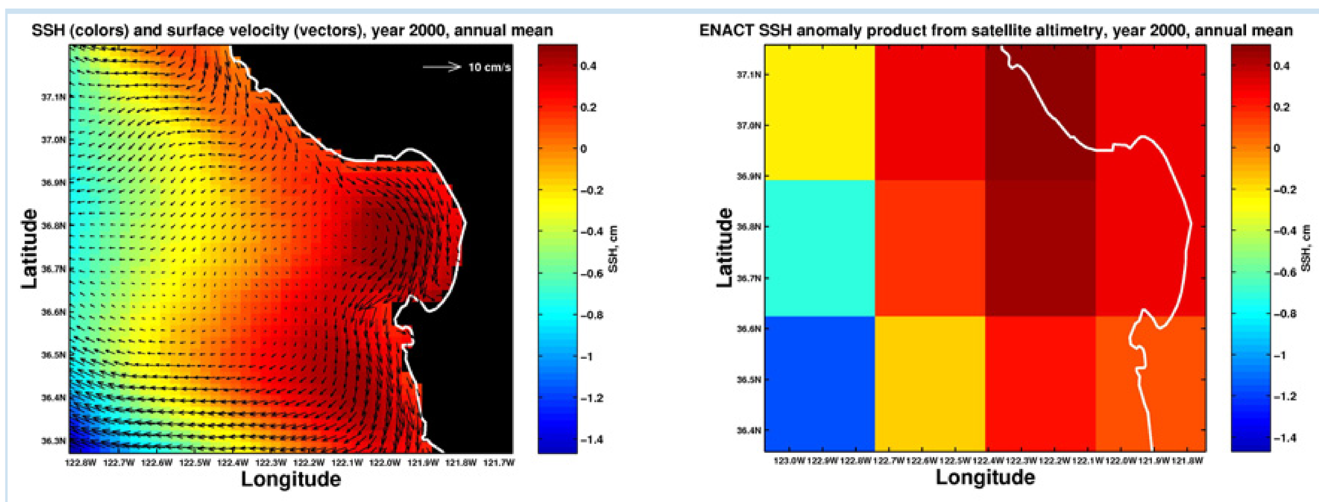
Small-scale and short-term SSH variability in ROMS

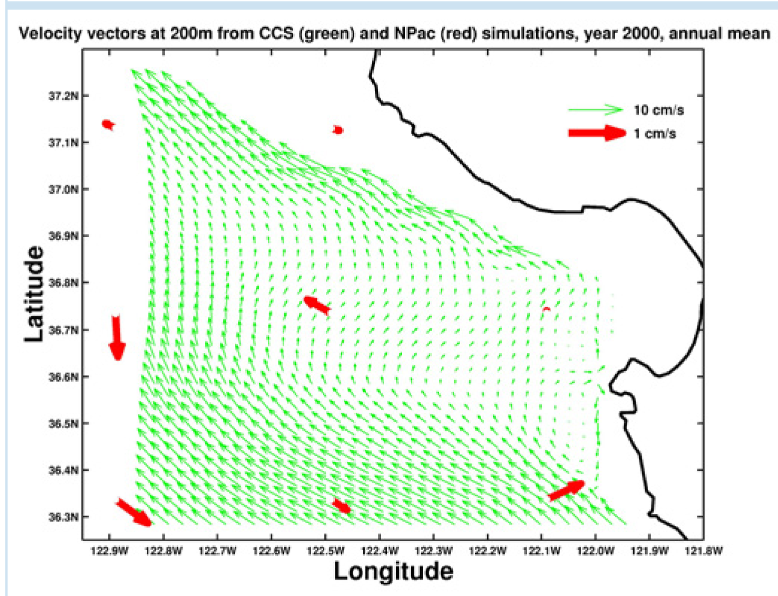


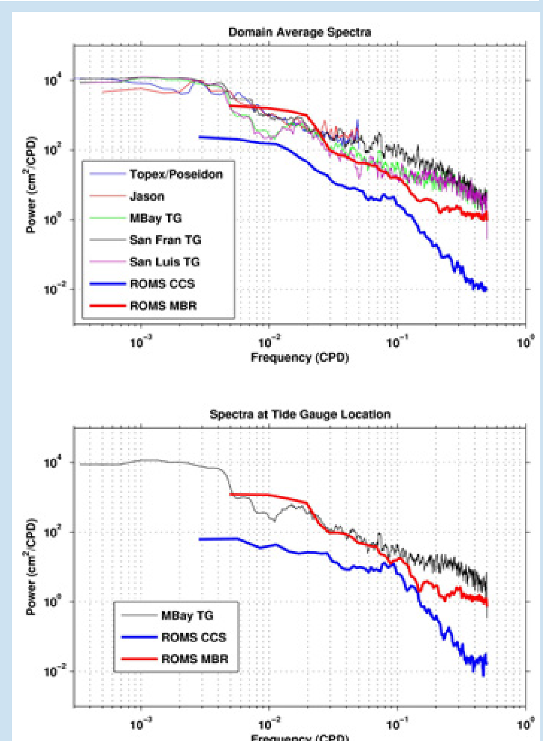
Above: Small-scale spatial variability inside 4 degree by 1 degree boxes, temporal variability (standard deviations of these box means computed within 1 month intervals, and their ratios. Shown are ROMS NPac run forced by Reanalysis fluxes and by QuikSCAT winds (Curchitser et al. 2005) and Ducet et al. (2000) blended analyses of Topex/Poseydon and ERS-1,2 satellite altimetry. All statistics are averaged for for the QuikSCAT run period of 2000-2002.

Below: Same as on the left but constrained to the area and period (year 2000) of California Coastal Current System ROMS simulation with 3 km spatial resolution (Powell et al. 2006), which is also shown.

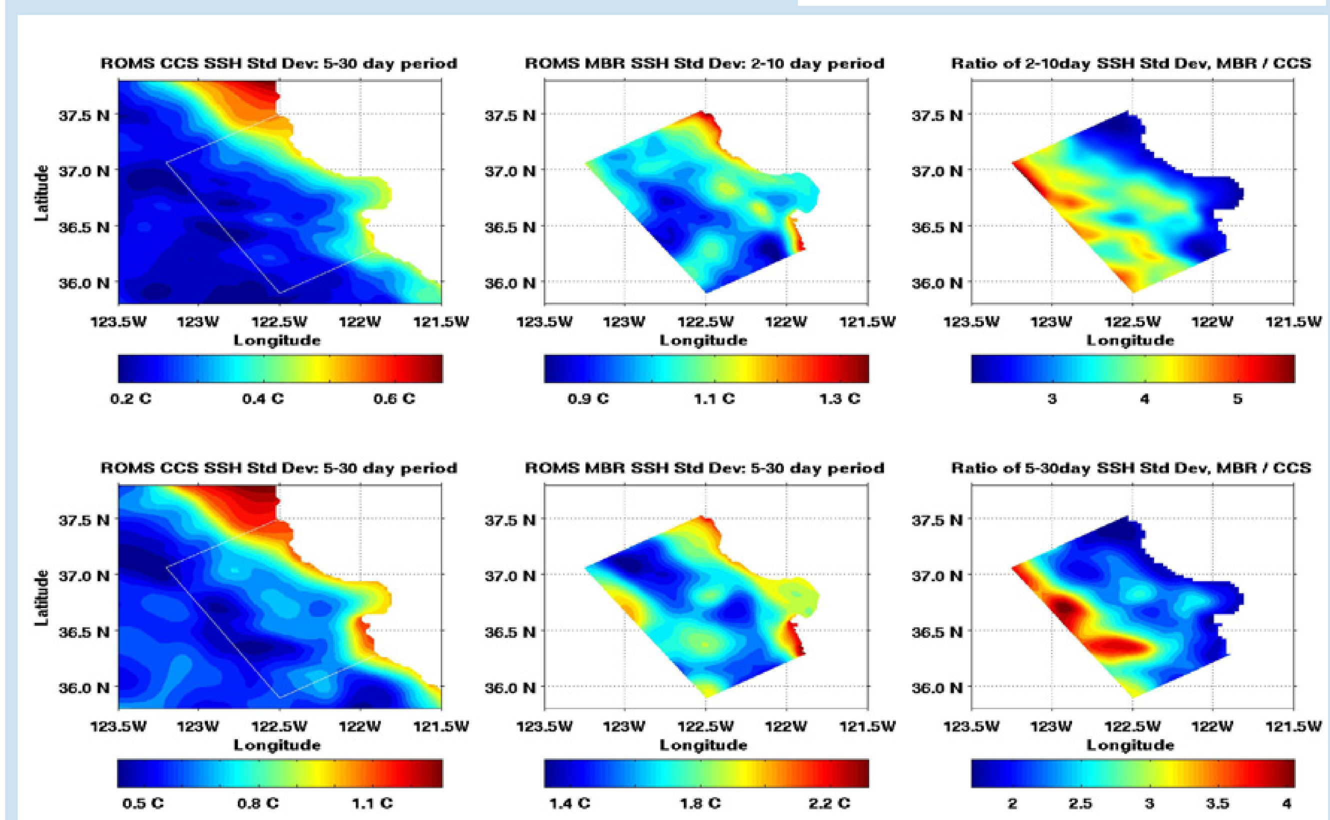


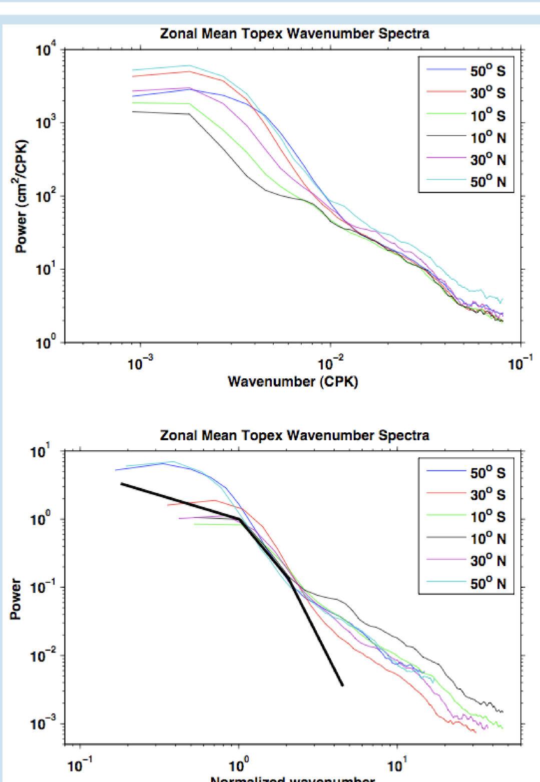


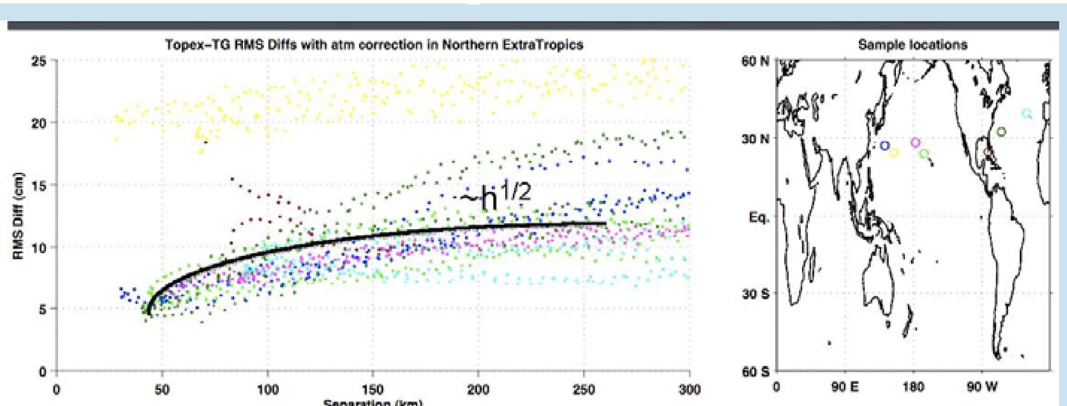




Analysis of ROMS simulations for Monterey Bay area







Structure function $D(h) = 1/2\ \overline{[s(x+h)-s(x)]^2}$

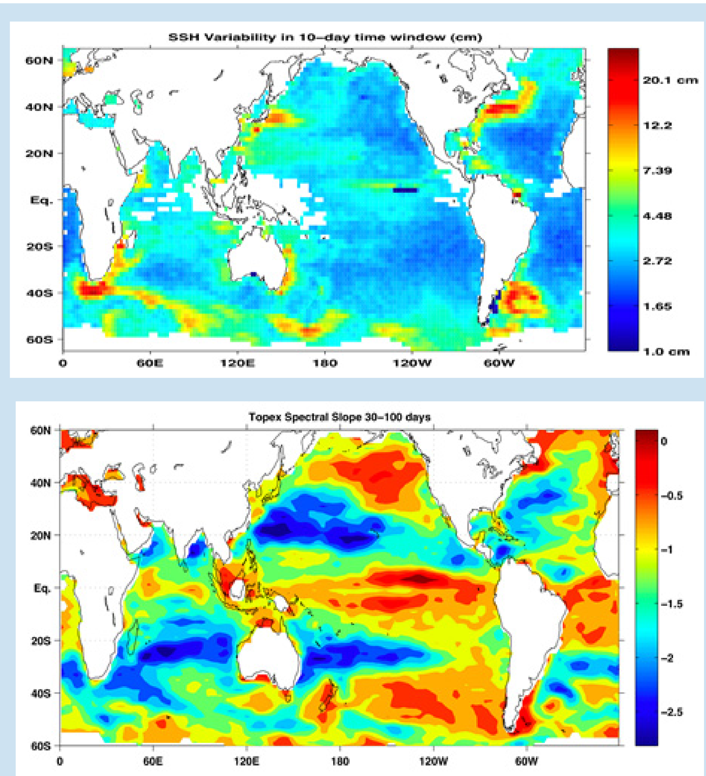
Where if $P(k) \sim k^{-n}$ and $D(h) \sim h^p$

Then $n = p + 1$

Thus a slope of -4.6 at high wavenumbers implies p of 3.6, or 1.8 for $D(h)^{1/2}$, represented by RMS differences above.
The scatterplot however, seems inconsistent with 1.8 exponent and more consistent with ½.

On the left: Verification of earlier spectral slope estimates using AVISO data and differences between daily tide gauge values and altimetry estimates.

On the right: Estimates of temporal error std (top panel) based on 30-100 day empirical slope (bottom panel) and assumed spectral slope of -2 at higher frequencies.



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