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Ocean Surface Velocities from Space - looking behind the scenes

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Concerning my work:

I use satellite altimeter data - Sea Surface Height (SSH) data - to infer large scale geostrophic surface velocity anomalies to verify ocean models and to conduct basic research to understand the upper ocean flow field in general. I deal with velocity anomalies instead of absolut velocities, as from satellite altimetry only the time varying part of the velocity field can be captured with respect to a temporal mean. One could provide the missing mean part using an accurate mean dynamic topography, and compute a mean velocity field from that.However, very accurate estimates are just about to be released with the new gravity satellite missions. The velocity data originates from the Jason-1 - TOPEX/POSEIDON (JTP) tandem mission and covers the 3-year time period from 09/2002 until 09/2005 where the altimeter satellites Jason-1 and TOPEX/POSEIDON (successor of J-1) were flying next to each other with a separation of about 1.4° in latitude and thus allowed to calculate not only one velocity component in cross track direction, but the complete velocity field. The opportunity to study each velocity component on its own without the necessity to assume isotropy and without prior gridding of the Sea Surface Height fields (SSH), yields an important increase in knowledge to the general behavior of the ocean circulation. This is turning the two altimeter satellites TOPEX/POSEIDON and Jason-1 into a space born near real time current meter.

I am especially interested in the seasonal cycle of the surface flow field and of the eddy kinetic energy (EKE), which is the energy that can be attributed to the turbulent flows of the ocean. Further, I investigated the geostrophic velocity fields to deepen the knowledge of their frequency and wavenumber spectra and to understand the Probability Density Functions (PDF) of the geostrophic velocities and their spatial distributions.

Concerning uncertainties:

For the description and interpretation of a dataset errors play a crucial role. However, an error calculation is not straigth forward and most likely consists of different error contributions.
To specify the formal uncertainties of the resulting velocity estimates, I used a formal error propagation approach. The resulting errors of zonal geostrophic velocity anomalies for the zonal and meridional flow component clearly display a pronounced latitudinal dependence, leading to enhanced errors due to a decreasing Coriolis parameter in low latitudes and due to a decreasing track spacing approaching the poleward turning latitudes.

Another latitudinal dependence arises due to the calculation procedure of the geostrophic velocity estimates that can be seen as a systematic error of the JTP tandem mission velocities.
Furthermore, and in the same order of magnitude as the systematic error, errors of geostrophic velocity estimates are slightly enhanced in areas of large variability associated with western boundary currents where the standard deviation of the SSH measurements dominates the resulting velocity error.

Further and most interestingly, when talking about wavenumber spectra of geostrophic velocity estimates from JTP, an error is introduced when calculating the wavenumber spectra in along-track and across-track direction. This error is originating in the two-dimensional spectra of SSH and the sample characteristic of the satellite measurements. We recently discovered this error, that very carefully has to be taken care of when discussing the distribution of energetic scales in the ocean.

Using this as an example, alltogether, it is crucial to know the errors of a variable in order to finally be able to draw the right conclusion.