Secular Trend in Global EKE using Accurately Resolved Mesoscale Currents
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Abstract
Using a novel difference operator to resolve mesoscale currents, a secular trend in the global mean eddy kinetic energy (EKE) trend over the first ten years of T/P has been found over the history of TOPEX/POSEIDON. The operator optimally maintains the large deviations in the along-track height measurements as a high pass filter. To mitigate the enhancement of this noise, the heights must first be filtered, and further reduction of the noise is possible with longer difference operator lengths. We have developed an optimal difference operator which, in a single operation, both optimally reduces the noise and computes the derivative.

Consider a standard finite difference operator of size N:

\[ \Delta \frac{d}{dx} = \frac{1}{h} \left[ -\frac{1}{2} \frac{y_{n+1} - y_{n-1}}{2h} + y_n \right] \]

That computes the change in height with respect to time, weighting each term. The maximum uncertainty of such a calculation is given by:

\[ \sigma = \frac{1}{\sqrt{N}} \left( \frac{1}{h} \right) \]

In order to minimize the white noise, we must minimize the combination of the height uncertainties by finding the optimal weight. By differentiating with respect to each weight and setting the result equal to zero, we find the minimum \( \sigma \) for the noise of measurements used. The most straightforward way of writing the minimization problem is to use the method of undetermined multipliers by Lagrange.

The length of the mesoscale is small in comparison to correction scales eliminating the need to apply corrections when one is interested in slopes only over short spatial scales. More accurate short-scale slopes can be computed without applying corrections (using only height minus range measurements) as long as the spatial scale of the derivative operator is smaller than the length scales of the correction. This allows for the use of high-rate data for increased spatial resolution of mesoscale currents. As shown by Chelton, the mesoscale is determined locally by the baroclinic Rossby radius of deformation of the local wind. An optimal filter with a half-power location equal to twice the Rossby length can accurately resolve mesoscale features globally.

Verification
In order to confirm that the optimal difference operator can accurately resolve geostrophic currents, a comparison against an independent measure is required. Near real-time surface currents and surface altimetry data from the Northern Central California COBRA Project managed by Lake Washburn at the University of California, Santa Barbara Channel are used in comparison. On this date, the bottom of the Santa Barbara Channel are calculated and compared with other methods. Although surface currents from COBRA contain Ekman flows (short from the geostrophic approximation used in altimetry), the correlation between COBRA and the other methods is high. However, the operator allows for this fine-scale analysis.

References

Future Work
EKE results must be confirmed by computing the statistical significance of the data and trend. Eddy statistics: eddy momentum flux, velocity variance, and eddy momentum convergence can be computed accurately by the operator by considering the statistical significance of increasing energy in an attempt to explain rising EKE values.

With the addition of the Wide-Swath Ocean Altimeter (WSOA), the ability to measure vorticity will be at least feasible, but further developing the operational processor into a two-dimensional operation, will be very accurate. The ability to generate accurate, global vorticity maps will greatly help our understanding of global circulation and mesoscale energy.

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