An Improved Coastal Ocean Surface Current Product: Merging Altimetry and MCC-Derived Velocities

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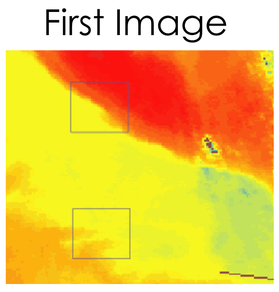
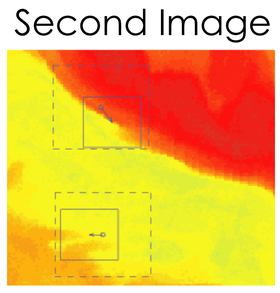
The Maximum Cross Correlation (MCC) Technique

Velocities are estimated by tracking feature displacements in successive 1 km thermal infrared and ocean color satellite images. The first image is divided into subwindows (solid boxes) that are cross correlated with all possible subwindows in the search area (dashed boxes) of the second image. The location that produces the maximum cross correlation (second image, solid boxes) indicates the most likely displacement of the feature. The velocity vector is the displacement divided by the time separation of the two images.

First Image



Second Image



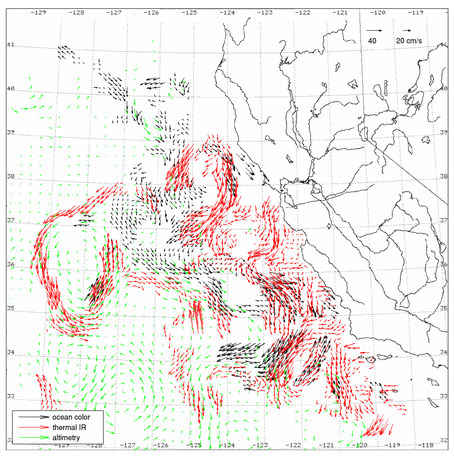
The spatial and temporal MCC velocity coverage is limited by clouds and isothermal/isochromatic sea surface conditions. The MCC method can be applied to thermal IR and ocean color satellite imagery, and the resulting velocities can be merged, to increase the overall velocity coverage [1].

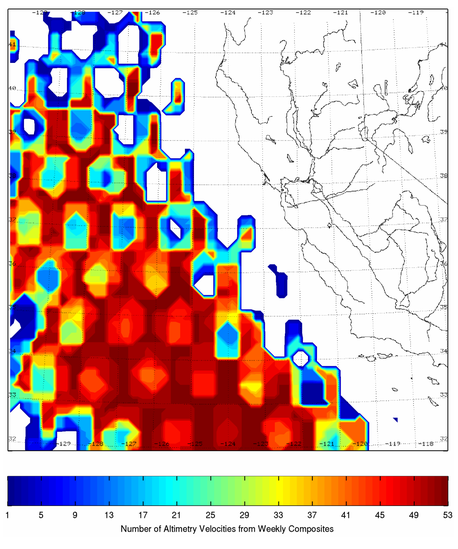
For this study, MCC velocity fields are derived from all available AVHRR thermal IR imagery and MODIS and SeaWiFS ocean color imagery from 2003 for the California coastal region.

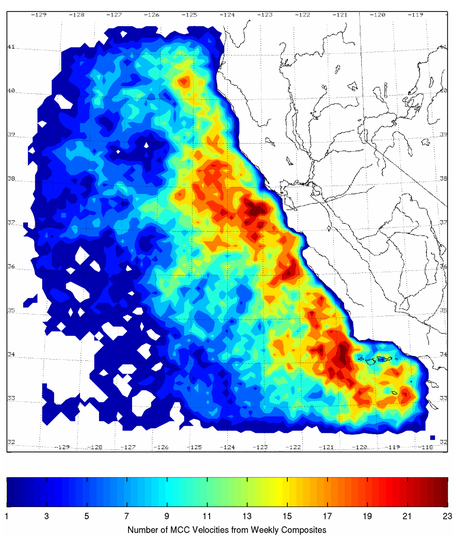
Comparison of Altimetry and MCC Velocities

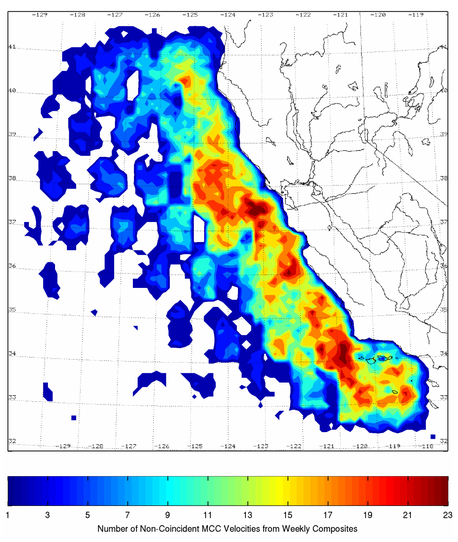
Weekly MCC velocity composites are created corresponding to the altimetry OI fields. Coincident altimetry and MCC velocities have a correlation coefficient of ~0.78, a magnitude RMS error of ~10.3 cm/s, and a directional RMS error of ~51°. The agreement between altimetry and MCC surface velocities is quite good, suggesting the two products can be merged together.

The altimetry velocities are concentrated off-shore, with very limited coverage along the coast. The MCC velocities are concentrated along the coast, with limited coverage off-shore. Merging these two products will produce an improved velocity product with significantly increased coverage.





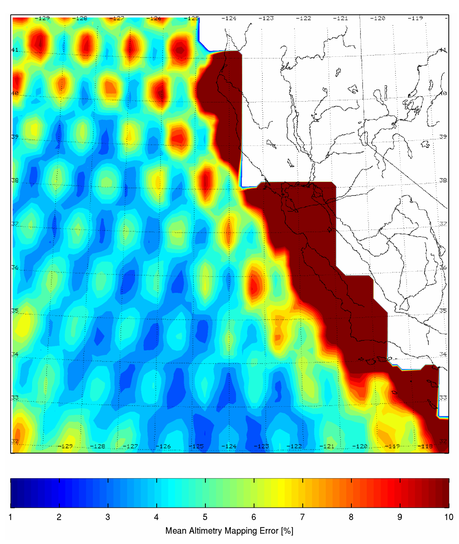




Altimetry-Derived Ocean Surface Currents

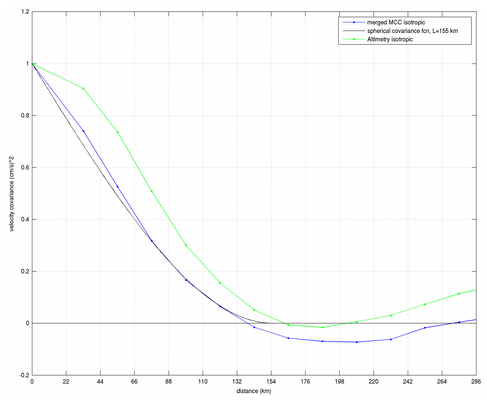
The altimetry surface currents used in this study are derived from absolute dynamic topography fields generated from sea surface height data acquired from all available satellite altimeters. Multi-mission cross-calibration ensures accurate information by removing residual orbit error [2] and long wavelength error through an optimal interpolation (OI) scheme[3].

The altimetry OI velocity fields, and associated formal mapping error fields, are generated on a weekly basis by Ssalto/Duacs and distributed by AVISO with support from Cnes. To eliminate unreliable artifacts of the OI, velocities are removed where the mapping error is greater than 5% of the signal variance. Notice that the highest mapping error is located close to the coastline.



Optimally Interpolating Altimetry and MCC Velocities

Altimetry and MCC velocities are merged using an OI scheme based on a spherical covariance function that models the MCC autocovariance, thereby preserving its' spatial length scale. Merged altimetry and MCC seasonal OI fields display complex coastal dynamics that are unresolved by altimetry alone.



Spherical Covariance Function

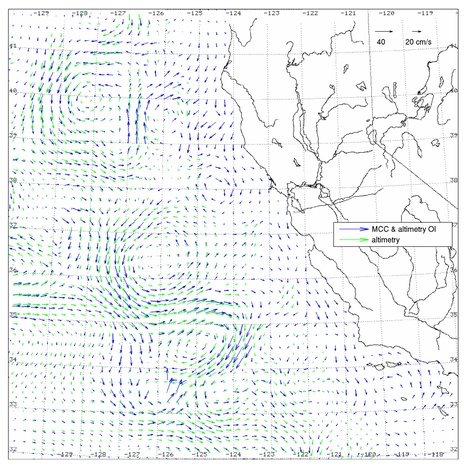
$$\textbf{covariance} = 1 - \left[1.5\frac{d}{L} - 0.5\left(\frac{d}{L}\right)^3\right] \quad \textbf{for } d \le L$$

$$\textbf{covariance} = \mathbf{0} \quad \textbf{for } d > L$$

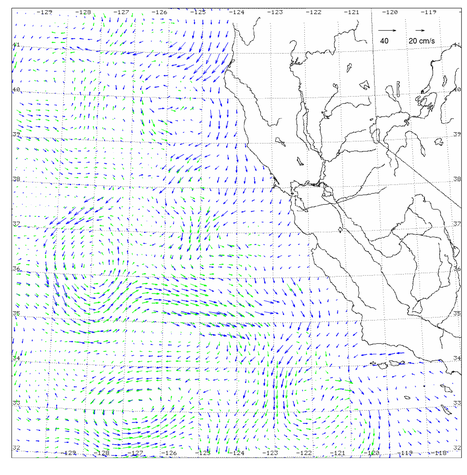
$d = \textbf{distance}$

$L = \textbf{length scale} = \mathbf{155\,km}$

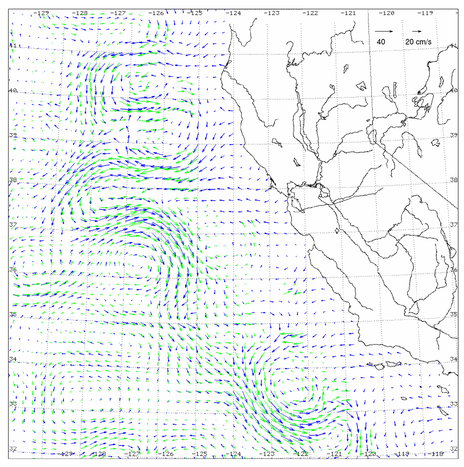
Winter 2003



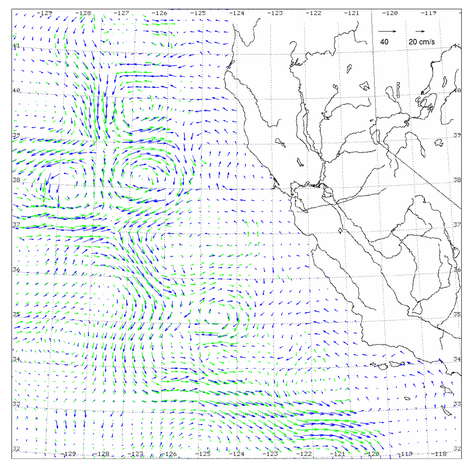
Spring 2003



Summer 2003

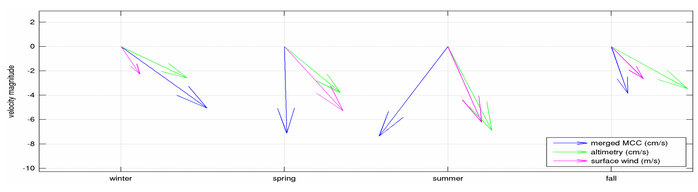


Fall 2003



Ongoing and Future Work

Quantify the ageostrophic component of MCC velocities, and improve the method used to merge them with Altimetry. Produce a total velocity product?



References

[1] R.I. Crocker, D.K. Matthews, W.J. Emery, and D.G. Baldwin, "Computing coastal ocean surface currents from infrared and ocean color satellite imagery," *IEEE T.G.R.S.*, vol. 45, no. 2, pp. 435-447, 2007.
[2] P.-Y. Le Traon and F. Ogor, "ERS-1/2 orbit improvement using TOPEX/ POSEIDON: the 2 cm challenge," *J. Geophys. Res.*, vol. 103, pp. 8045-8057, 1998.
[3] P.-Y. Le Traon, F. Nadal, and N. Ducet, "An improved mapping method of multisatellite altimeter data," *J. Atmos. Oceanic Technol.*, vol. 15, pp. 522-534, 1998.