Capturing Mesoscale Features in Surface Currents

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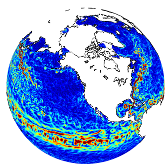
OSCAR Surface Currents

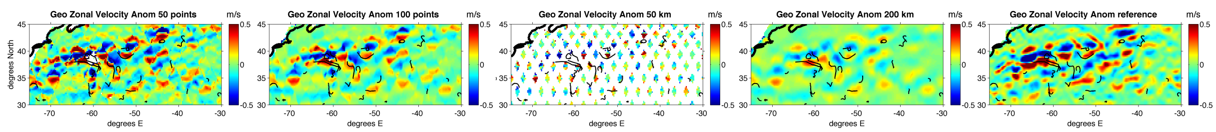


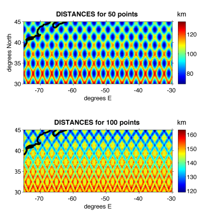
Ocean Surface Currents Analyses-Realtime processing system (OSCAR) is a satellite-derived global surface current database provided in near-real time based on geostrophy, Ekman dynamics, and thermal wind, assuming linear quasi-steady dynamics. OSCAR is produced at ESR by P.I. K. Dohan and hosted at podaac.jpl.nasa.gov. Surface currents are calculated from altimetry (AVISO MADT, www.aviso.altimetry.fr), ocean vector winds (SSM/I, QuikSCAT, ERA/I, and NCEP), and SST (Reynolds OI). The main research focus of OSCAR is in improving the wind driven component, funded by NASA as part of the International Ocean Vector Winds Science Team.

OSCAR successfully captures the surface currents in highly geostrophic regions with larger-scale and relatively slowly evolving eddies, such as in the Gulf Stream (timescales of evolution on the order of days), typically with r>0.75 correlation with drifters. When compared with global surface drifters, though, velocity standard deviations are underestimated by 20-50% in OSCAR over much of the oceans. This is in part due to missing dynamics in the simple model for OSCAR although some of the loss of signal is also due to the use of level 4 gridded fields rather than using level 2 fields directly. We have been using local polynomial fitting mapping methods to investigate the mesoscale and sub-mesoscale signal in both altimetry and ocean vector wind fields. An important feature of local polynomial fitting over optimal interpolation methods is the order of fit: a first-order (linear) fit calculates gradients as part of the mapping. **How much of the missing signal is due to the removal of "noise" in existing gridded products, and how much can be recovered with alternate gridding methods?**

New Gridding Algorithm for SSH and Derivatives

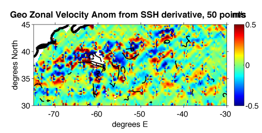
Traditional Optimal Interpolation methods for gridding intentionally remove the small-scale noise, i.e. the mesoscale signal. Here we explore local polynomial fitting: at each point the surface is Taylor-expanded, and using data within some radius we seek to estimate not only the unknown surface, but also its derivatives up to some order. We start with the linear fit algorithm developed by Lilly and Lagerloef used for Aquarius level 3 salinity maps and use the Integrated Multi-Mission Ocean Altimeter Data for Climate Research V.2 (Beckley 2010) along track geo-referenced Sea Surface Height Anomalies (SSHA) from Topex/Poseidon, Jason-1 and OSTM/Jason-2. The radius for points can be set by either a fixed radius, or a fixed number of neighboring points with a variable radius.





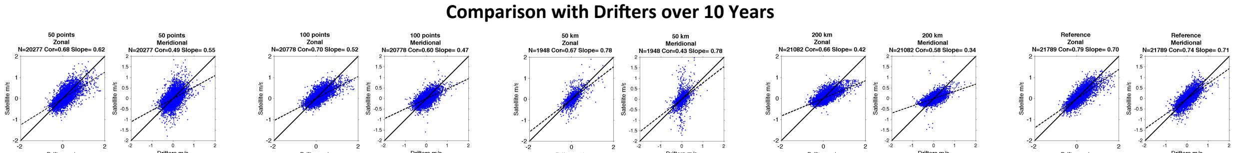
- Sample gridded Gulf Stream zonal geostrophic velocity anomaly results using the derivatives of SSHA obtained during the gridding process SSHA using data from a complete 10 day cycle, centered on 03-Jan-2012. The zonal OSCAR geostrophic anomaly for 01-Jan-2012 is shown for reference.
- Four test cases using both a fixed numbers of points and a fixed radius are shown to demonstrate the differences in signal variability that can be achieved. Reference dataset is AVISO SSH MADT allsat (merged absolute dynamic topography) on 01-Jan-2012 with 20-year mean removed (for convenience for now: used in OSCAR). Note that only the Jason class altimeters are used for the test cases.
- For fixed point cases the radius distance varies depending on density of tracks, as shown on the left.

Advantage in Direct Calculation of Geostrophic Velocity



- Velocities as calculated from gradients of the 50 point SSHA field. By using a first order fit, velocities can be calculated during the gridding process so that mesoscale information can be retained in the velocity signal without resulting in spurious noise.
- Another advantage is near coasts: the variable radius choice allows for gridding closer to coasts.

Comparison with Drifters over 10 Years

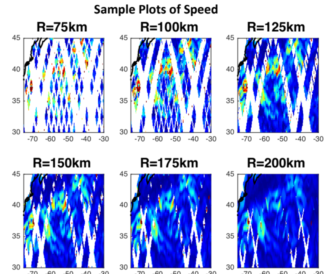


- Scatter plot comparisons of satellite-based velocities against drifter velocities (5-day binned), for data mapped in the Gulf Stream area (above) for the years 2003:2012. The full velocities are completed using OSCAR mean geostrophic and Ekman components. Dashed line=best-fit line through data, solid line=1:1 line. The satellite velocities underestimate drifters, progressively more so with smoother data.

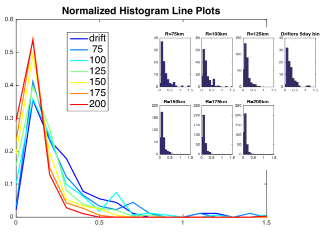
Loss of Detail with Increasing Mapping Radius

- On the right are sample images of the gridded velocities with fixed radius for R=75km to 200km for Jan 10, 2009. There is increased coverage for the gridded product but at the expense of accuracy and detail. The are is the same Gulf Stream area as above, distorted aspect ratio.
- As the radius is increased, the resulting velocities lose amplitude, as shown in the histogram plots where, in this example, 3 months of gridded data (Jan-Mar 2009) are compared to drifter velocities.
- The statistics as they vary with R, calculated from the 3-month drifter matches (done as in the scatter plots above) are shown on the bottom right.
  Skill = 1-std(drifter-satellite)/std(drifter).

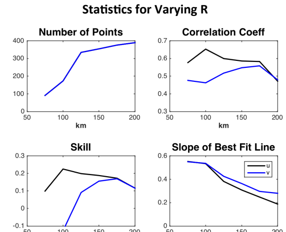
Sample Plots of Speed



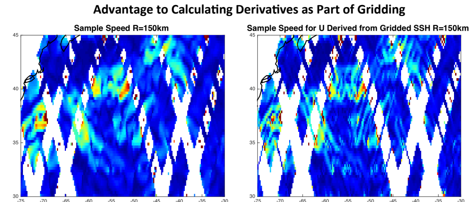
Histograms of Speeds



Statistics for Varying R



Advantage to Calculating Derivatives as Part of Gridding



- Another example of the advantage to gridding derivatives of SSH directly from the level 2 data. Although quite noisy and still preliminary, the results of the direct gridding do not show the same spurious edge effects as the velocities calculated from gridded SSH for the same R.

Future Directions

This work on this project in still in the beginning stage. Over the next 2 years we will be developing this algorithm to explore eddy signatures in altimeter signals. The results shown here are a first look at the features observed in the TP/J1/J2 combined signal. The goal is to map not just SSHA but its derivatives and information about the mesoscale, in particular eddy statistics, as part of the gridding process.

Reference:

Beckley, B.D., N.P. Zelensky, S.A. Holmes, F.G. Lemoine, R.D. Ray, G.T. Mitchum, S. Desai, S.T. Brown, Assessment of the Jason-2 Extension to the TOPEX/Poseidon, Jason-1 Sea-Surface Height Time Series for Global Mean Sea Level Monitoring, Marine Geodesy, 33(S1): 447-471, 2010, Supplemental Issue on OSTM/Jason-2 calibration/validation, Vol. 1