Improvements to the Wind Driven Component of the OSCAR Surface Current Product

Kathleen Dohan, Gary S. E. Lagerloef, and John T. Gunn

Earth & Space Research
Seattle, Washington

Introduction

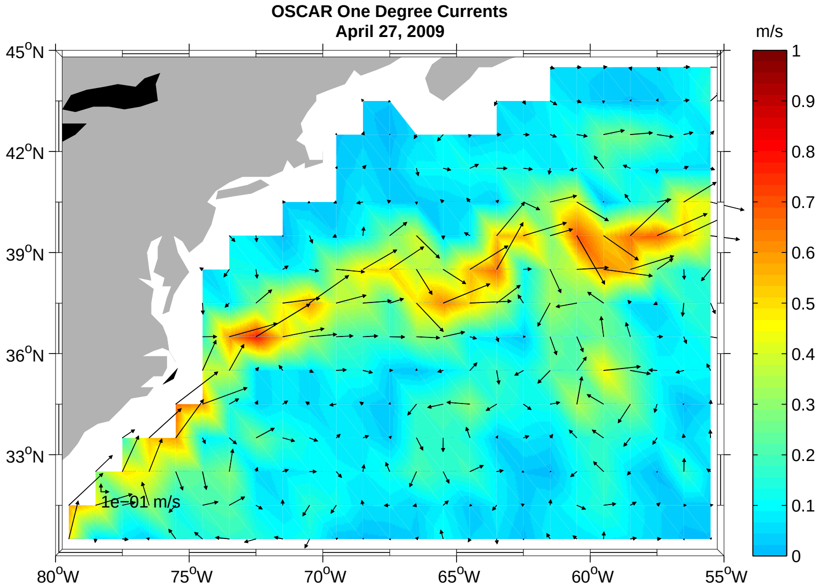
Ocean Surface Currents Analyses Realtime processing system (OSCAR) is a satellite-derived surface current database based on a combination of quasi-steady geostrophic and locally wind-driven dynamics (Bonjean and Lagerloef, 2002).

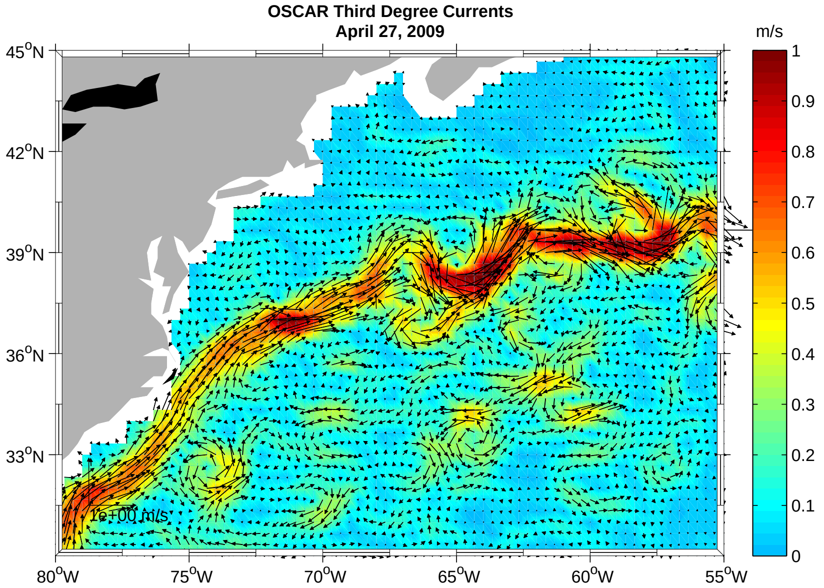
- The geostrophic term is computed from the gradient of surface topography fields (AVISO/CLS).
- Wind-driven velocity components are computed from an Ekman/Stommel formulation with variable viscosity using QuikSCAT winds (FSU/COAPS)
- with a thermal wind adjustment using satellite SST data.
- Data available at http://www.oscar.noaa.gov.

Introduction

- State of the improvements to the currently available OSCAR system.
- Examination of the wind-driven component
  - Vertical eddy viscosity parameterization as a function of the wind
- Future directions.

OSCAR Latest Developments

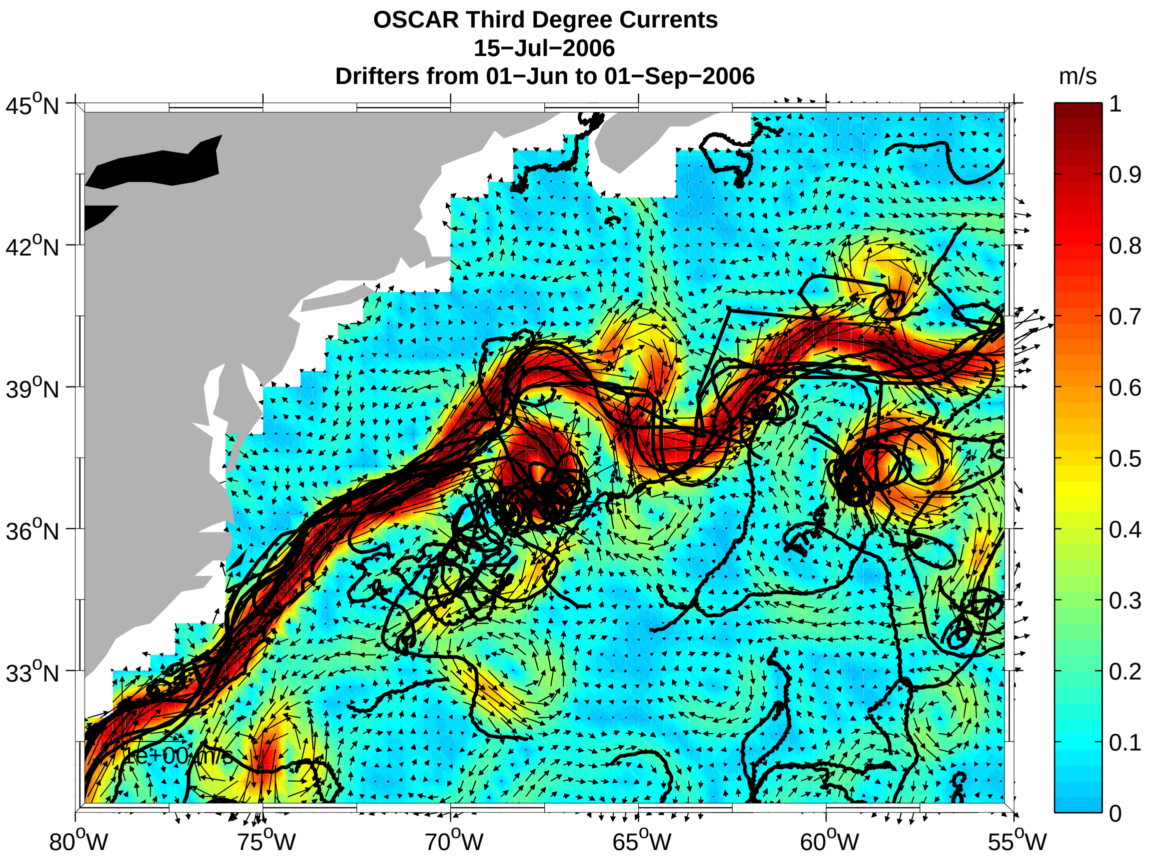




Developments to OSCAR: increased grid spacing from one degree to 1/3 degree

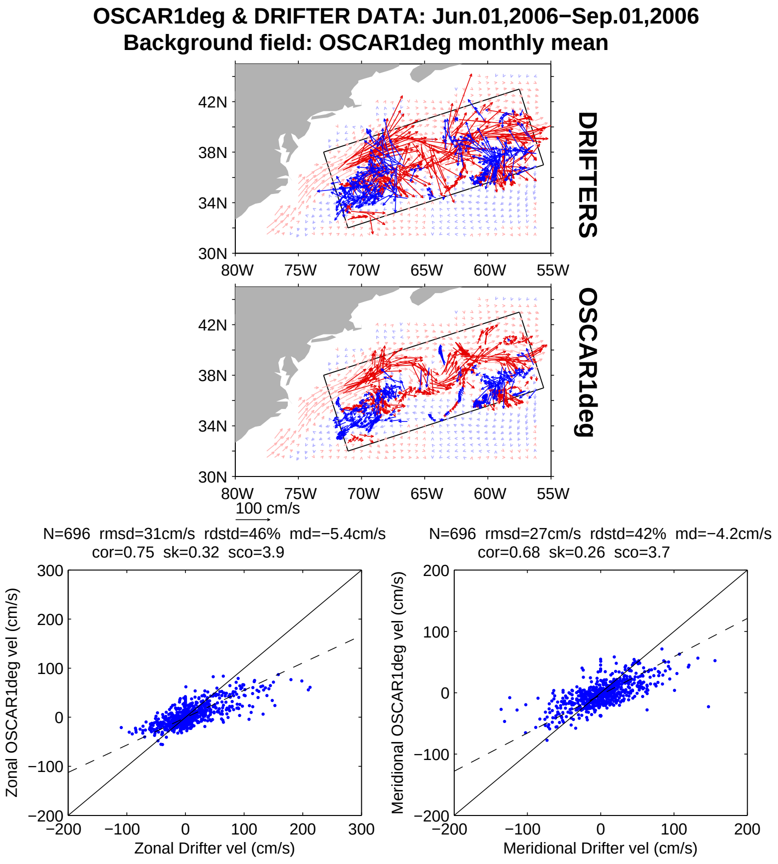
- SSH gradient calculation for geostrophic component revised to suit 1/3 degree grid with extensive Cal/Val
- Larger coverage of data towards coasts
- Improved model in equatorial region
- Fewer spuriously large values (mostly along coasts).
- Available through ftp at ftp://ftp.esr.org/pub/datasets/SfcCurrents/ThirdDegree/ and soon through http://www.aoml.noaa.gov/phod/dac/drifter_climatology.html.

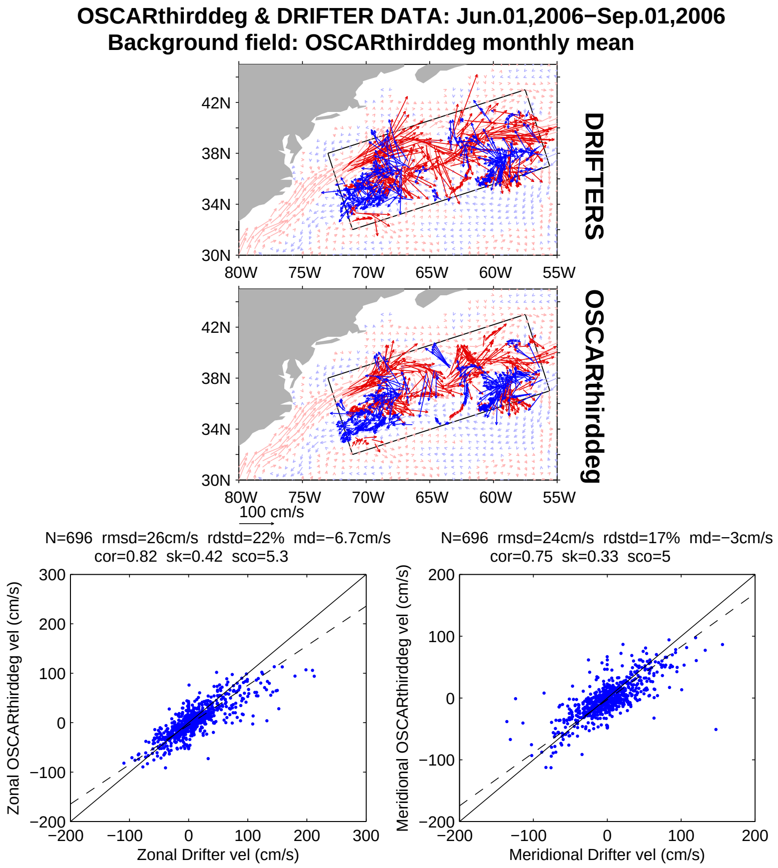
Comparison with Drifters Gulf Stream



- Currents are interpolated onto the drifter locations (which have been averaged over 1 day). Zonal and meridional currents *vs* drifter velocities.

Comparison with Drifters Gulf Stream





Calculating Surface Currents

Quasi-linear steady flow in a surface layer with turbulent mixing parameterized by a constant vertical eddy viscosity. Frontal model: buoyancy force θ is a function of SST horizontal gradients only. Surface layer velocity $\bar{\mathbf{U}}$ by averaging over the top 30m.

$$ if\bar{\mathbf{U}} = -g \bigtriangledown \zeta + \frac{h}{2} \bigtriangledown \theta + \frac{\tau - A\frac{\partial \mathbf{U}}{\partial z}\,|_{-h}}{h}. \tag{1}$$

Stommel model boundary conditions

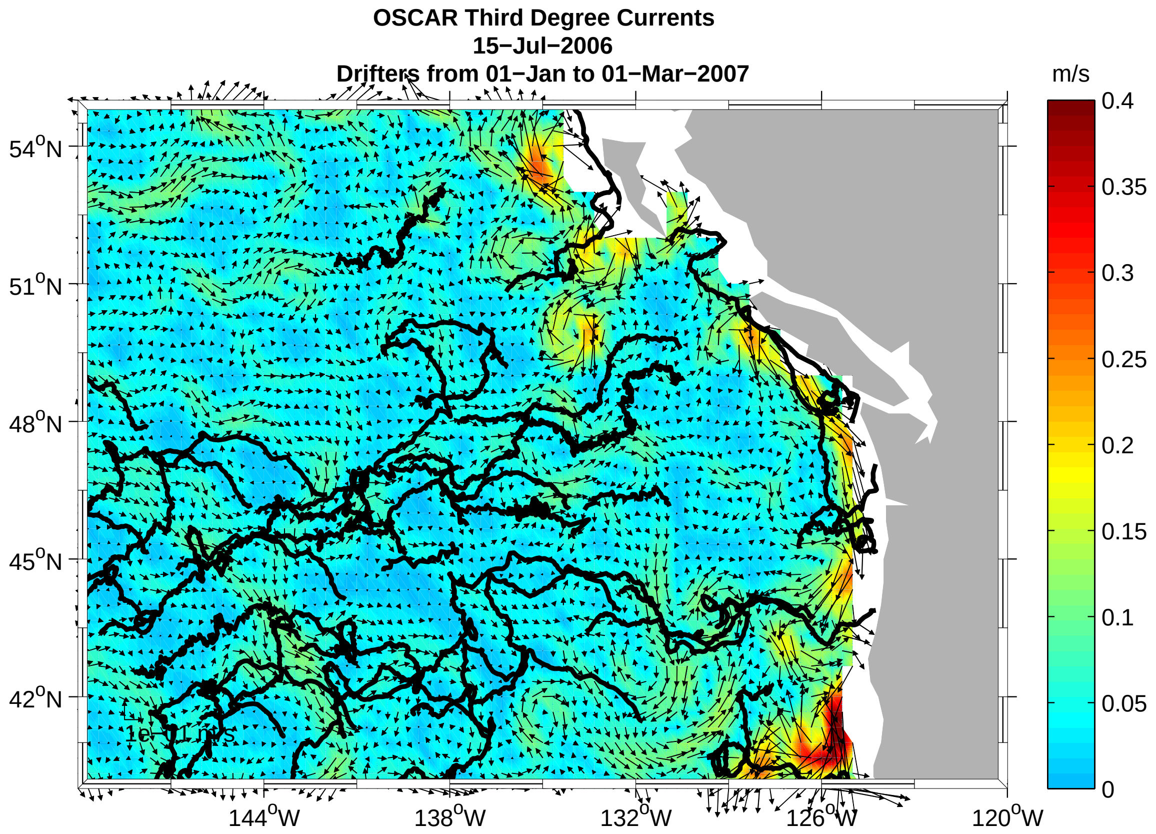
$$ \frac{\partial \mathbf{U}}{\partial z}(z=0) \quad = \quad \tau/A \tag{2}$$

$$ \frac{\partial \mathbf{U}}{\partial z}(z=-H) \quad = \quad 0 \tag{3}$$

where: $\mathbf{U} = u + i * v$, τ is surface wind stress, $h = 30m$, ζ is SSH, θ is SST and A is a vertical eddy viscosity, calculated as a function of wind

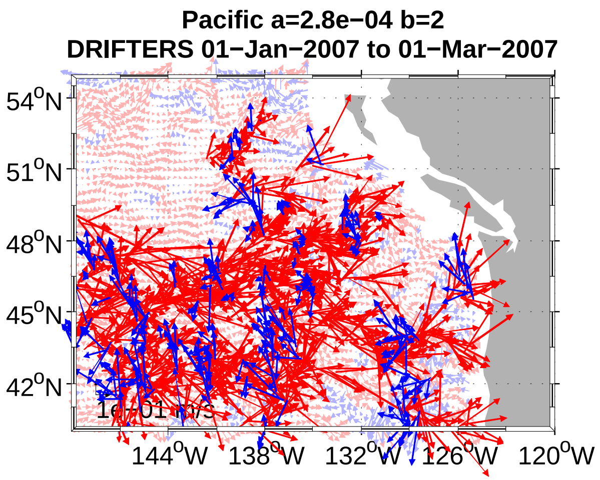
$$ A = a(\frac{|\mathbf{W}|}{W_0})^b. \tag{4}$$

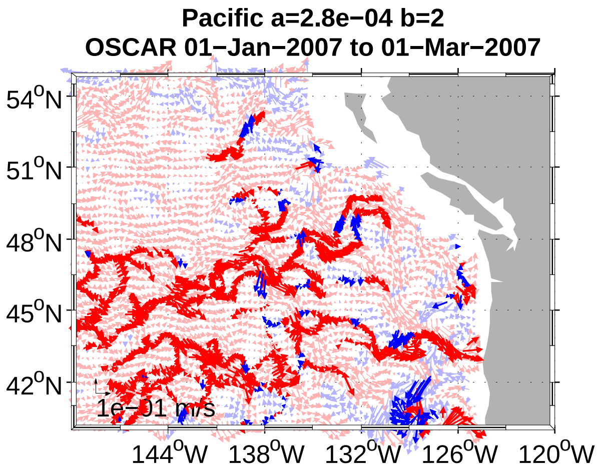
Pacific Sample Region

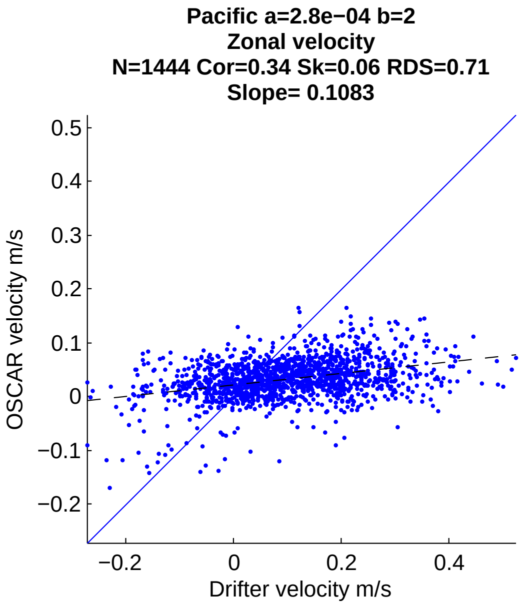


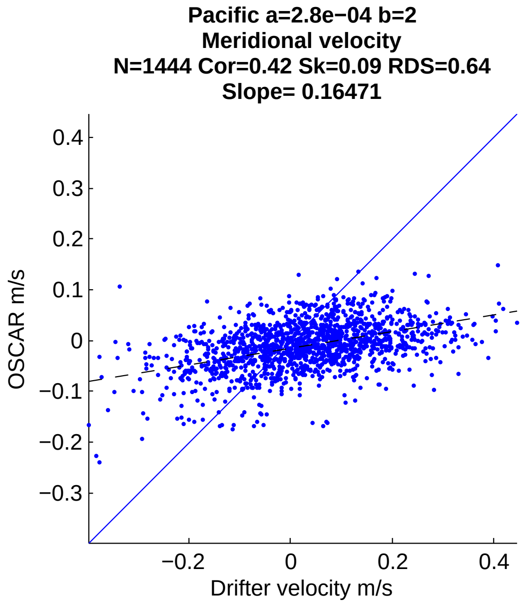
- Currents are interpolated onto the drifter locations (which have been averaged over 1 day). Zonal and meridional currents *vs* drifter velocities.
- Sensitivity to the parameter value a has been tested, with attention to different dynamical regimes. Coefficient a is varied from 1e-06 to 1e-03. Exponent b is varied from 2 to 2.2. Depth-scale H is varied from 30m to 150m.

Pacific Sample Region Comparison with Drifters



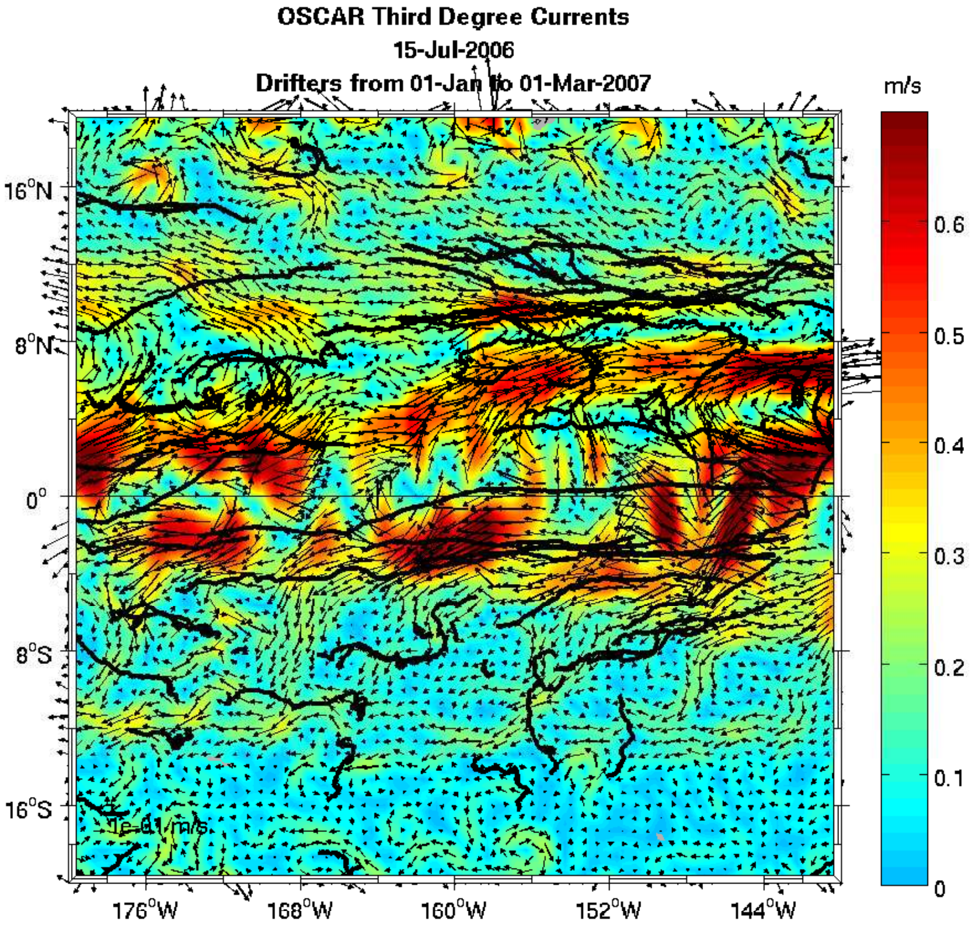






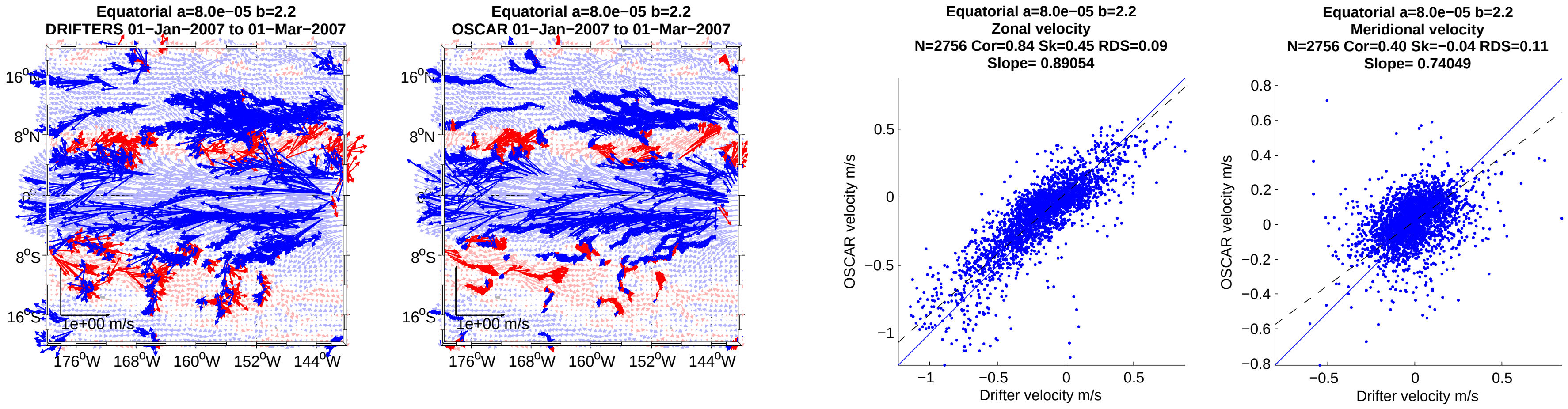
- Well underestimating the magnitude of currents in the open basins: 1 degree winds, 10 day smoothing
- Optimal values for a varies between 8×10^{-5} and 5×10^{-4} with little variation.
- Correlations steadily increase from January to August (0.3 to 0.6).

Equatorial Sample Region



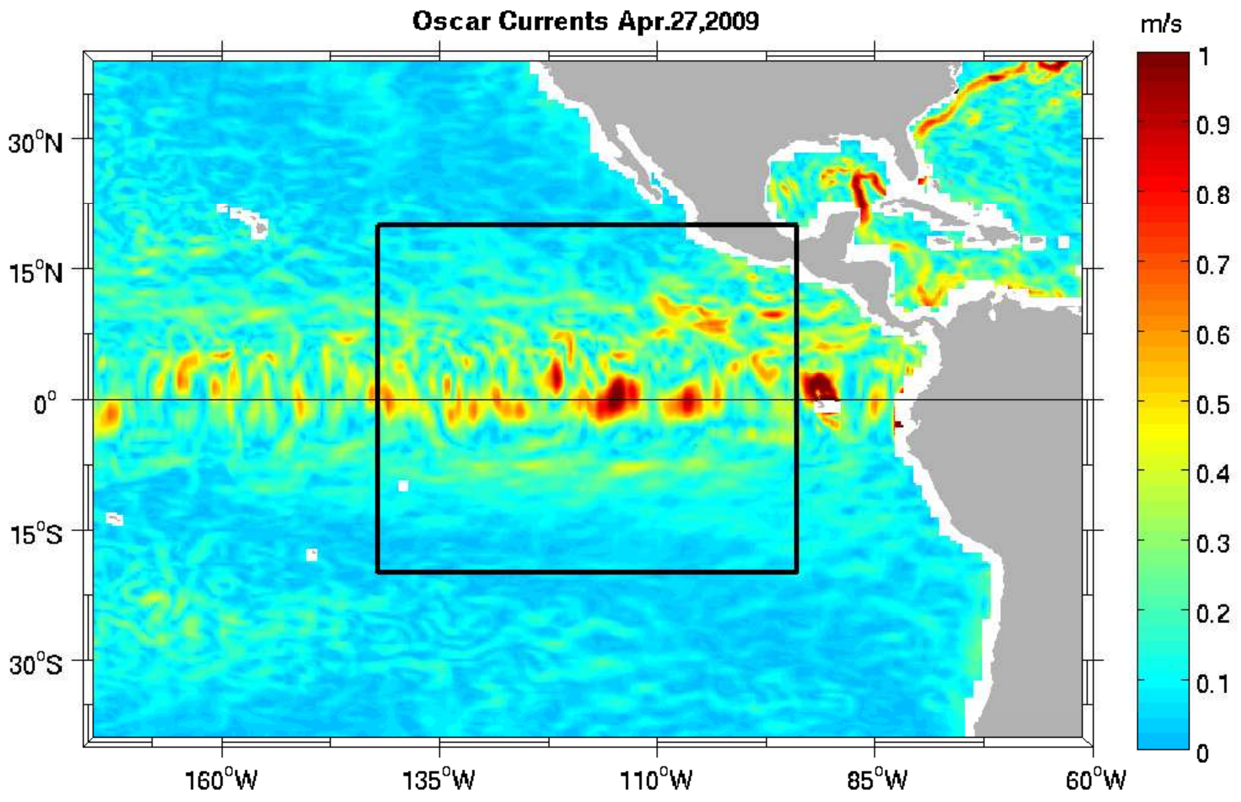
- Currents are interpolated onto the drifter locations (which have been averaged over 1 day). Zonal and meridional currents *vs* drifter velocities.
- Sensitivity to the parameter value a has been tested, with attention to different dynamical regimes. Coefficient a is varied from 1e-06 to 1e-03. Exponent b is varied from 2 to 2.2. Depth-scale H is varied from 30m to 150m.

Equatorial Sample Region Comparison with Drifters



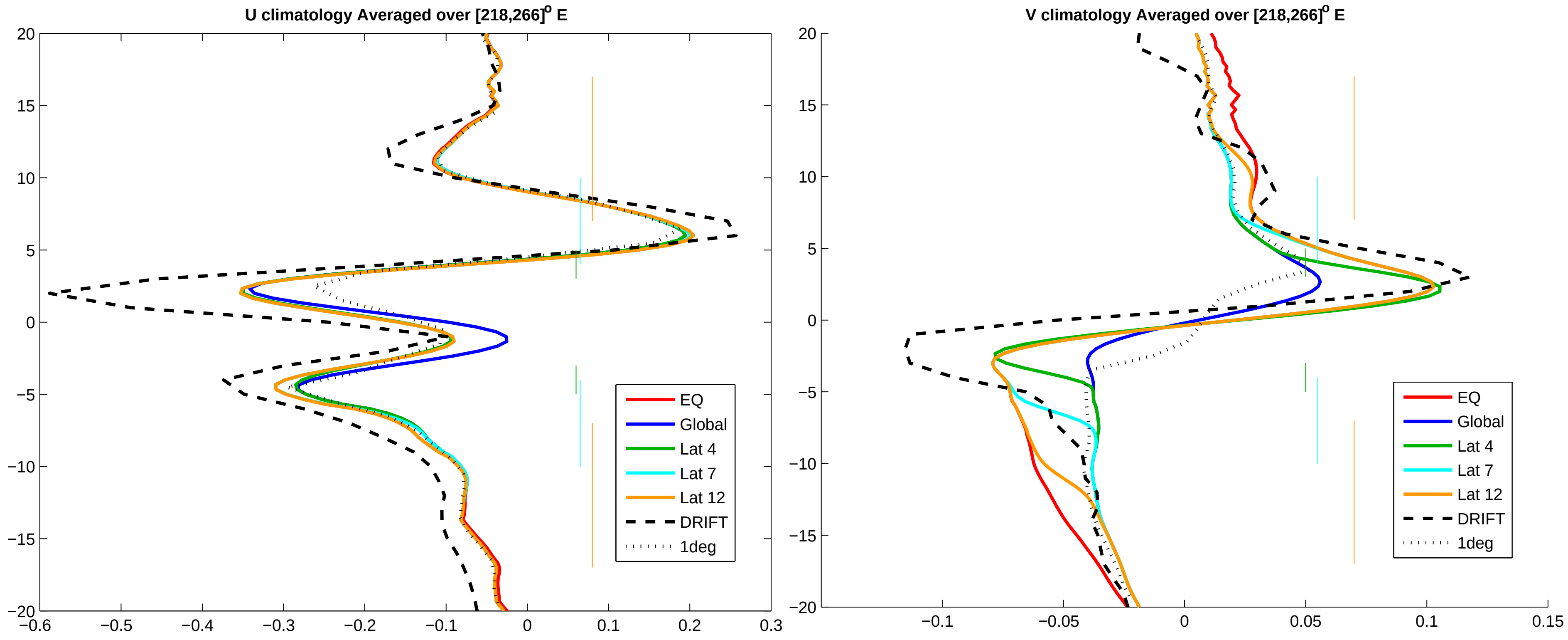
- Optimal choice for a consistent with 8×10^{-5} m^{2}s^{-1} in Santiago-Mandujano & Firing (JPO 1990).
- Little variation with a and b, except in amplitude of meridional: slope ranges from 0.52 - 1.55.

Equatorial Region Climatology



- Climatological means are compared to drifter climatology using seasonal and regional climatologies along the equatorial region. Sample region and results shown here.

Equatorial Region Climatology



- Parameter values are blended from $a = 8 \times 10^{-5}$ m^{2}s^{-1}, $b = 2.2$ at the equator to 2.85×10^{-4} m^{2}s^{-1}, $b = 2$ for a global value.

Summary

- OSCAR surface currents compare well with drifter velocities in regions of strong SSH gradients: boundary currents, zonal equatorial component, ACC.
- Amplitudes are underestimated outside the above regions, with lower velocity correlations.
- Wind-driven velocities are fairly insensitive to the value of the eddy viscosity, except for meridional amplitude around the equator.
- Mid-latitudes show a seasonal trend in drifter comparison.
- Wind-driven velocities are insensitive to the depth value H.
- Mooring analyses are inconclusive, with varying optimal viscosity values for equatorial region, season, and statistical quantity calculated.

Future Work

- Improve the wind-driven turbulent mixing scheme
  - vertically varying eddy viscosity - e.g. law of the wall versus slab
  - incorporate ARGO mixed layer depths
  - vary models according to dynamical regions
- Incorporate faster timescales in wind driven OSCAR component
  - Include time-dependent dynamics in OSCAR to include high-frequency wind-driven currents
  - Separate by timescales the geostrophic from the wind-driven components
  - 1 day winds
  - Examine inertial motions in drifter datasets
- Extend OSCAR capability to nowcast and forecast
- **Gulf Stream movie**