Dependence of OSCAR Surface Currents on Scatterometer Winds

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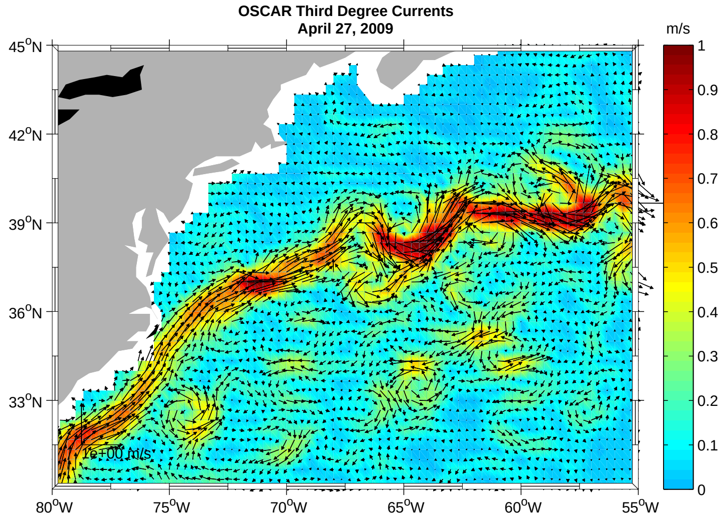
Introduction

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).

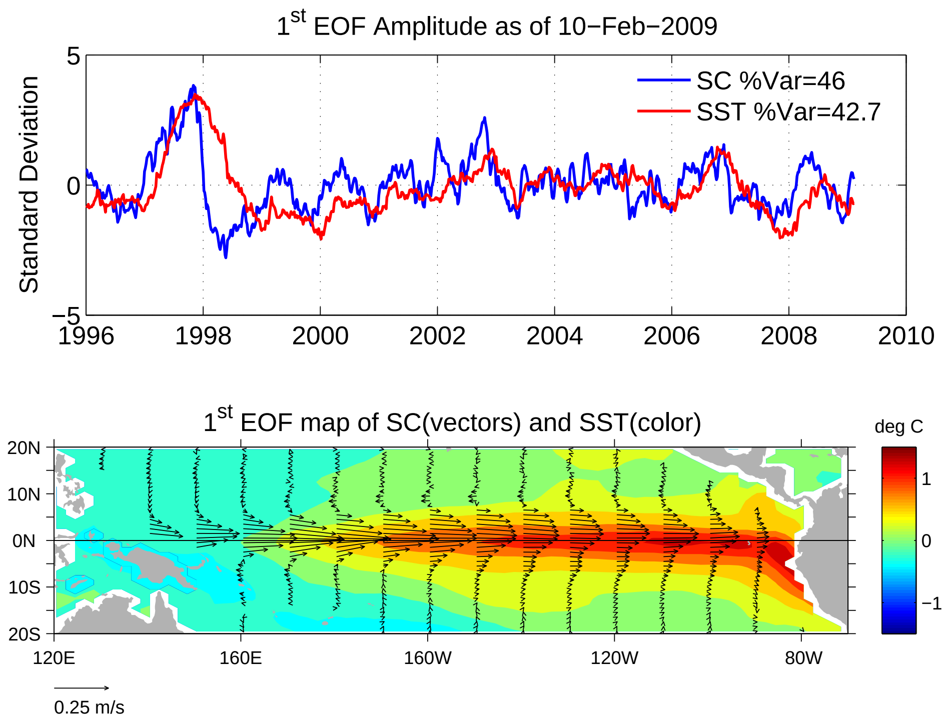
- The geostrophic term is computed from the gradient of surface topography fields (AVISO/CLS).
- Wind-driven velocity components are computed from an Ekman/Stommel formulation with variable viscosity using QuikSCAT winds (FSU/COAPS)
- with a thermal wind adjustment using Reynolds SST data.
- Data available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

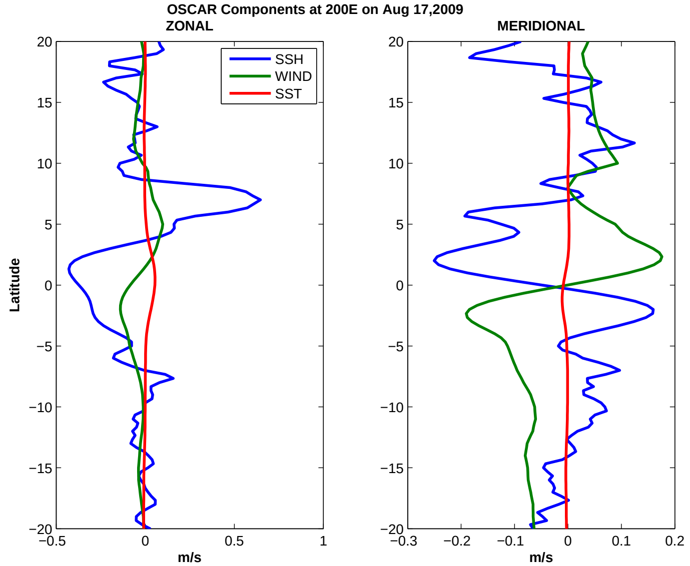


Introduction

- Climate application of OSCAR
- Examine the performance of the wind-driven component of OSCAR with:
  - Wind speed
  - Temporal wind resolution
- Main area for improvement
  - Time dependent term: near inertial oscillations

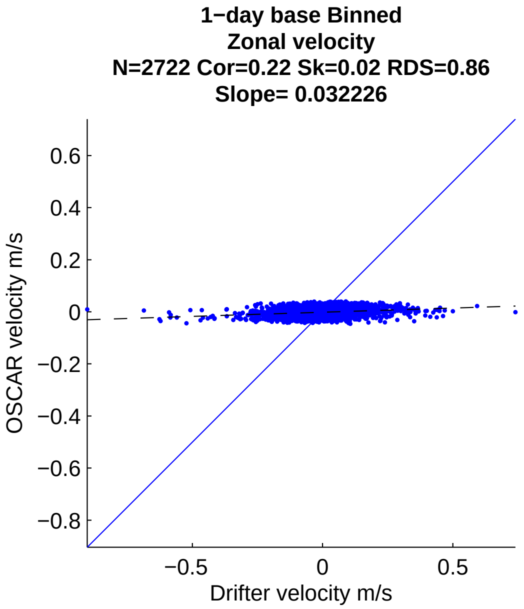
Surface currents and ENSO indices

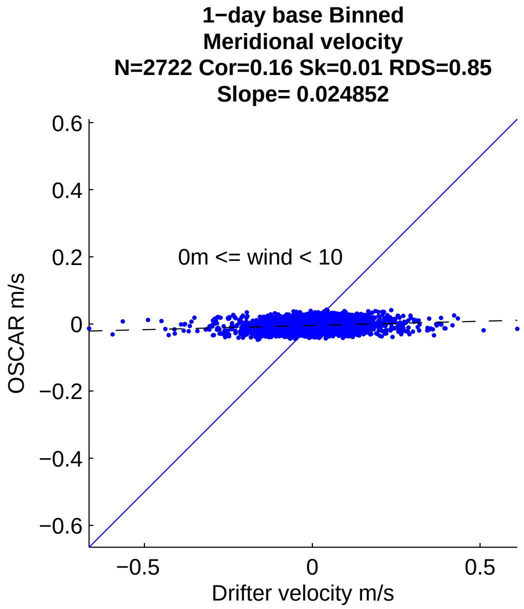


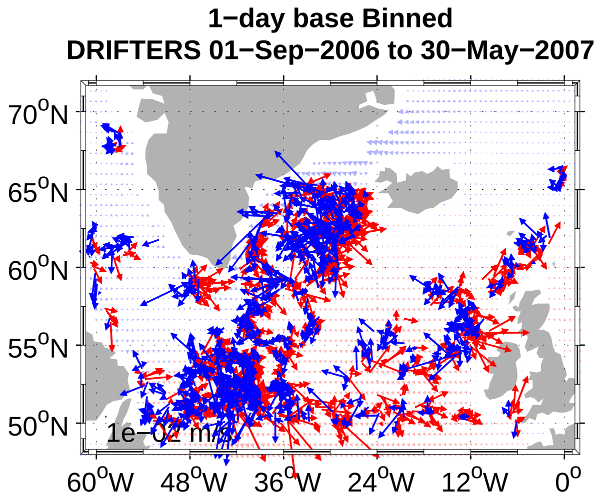


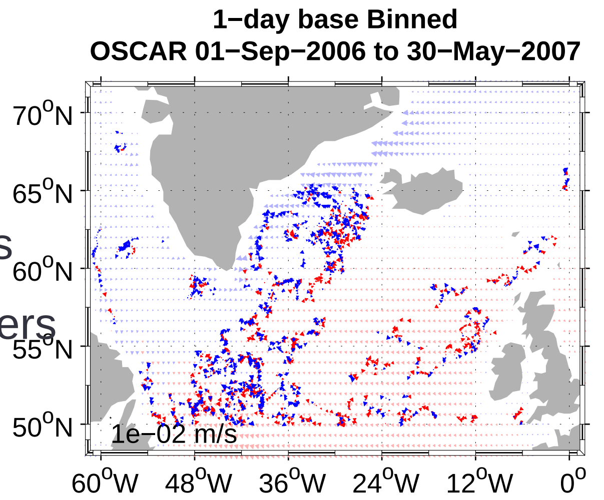
- First principal EOF of surface current (SC) and SST anomaly variations in the Tropical Pacific.
- Top: Amplitude of the EOFs normalized by their respective standard deviations. Bottom: corresponding EOF structures.
- Surface current anomalies in the tropical Pacific typically lead SST anomalies by several months.

High Wind Speed Performance



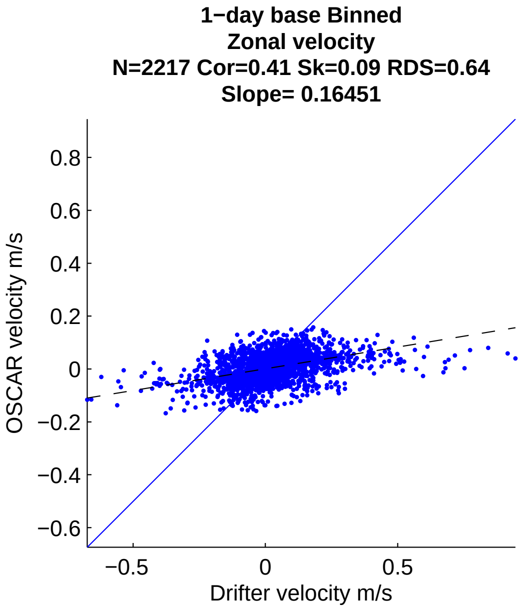


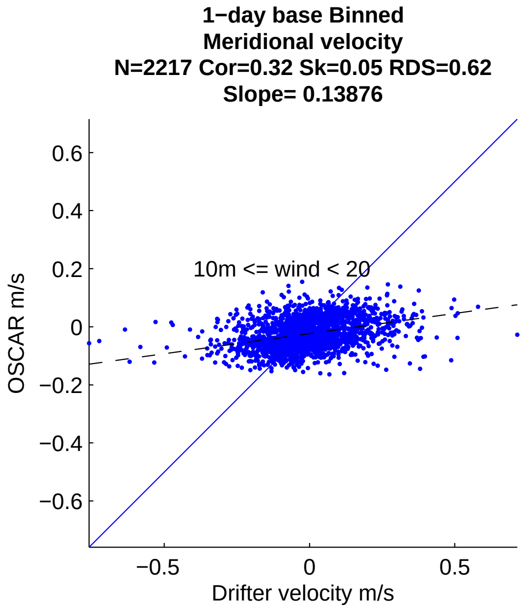


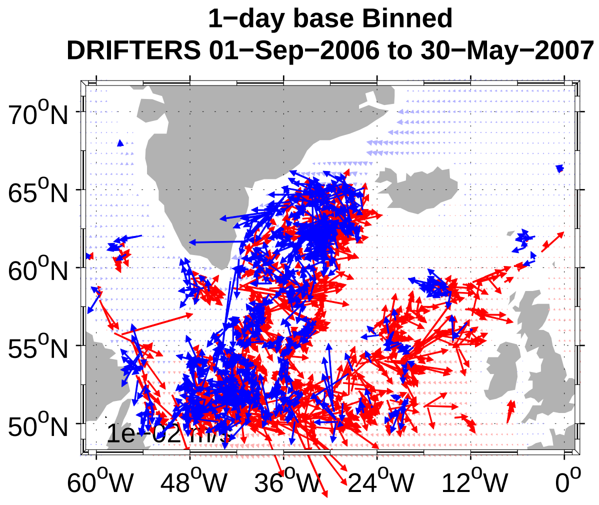


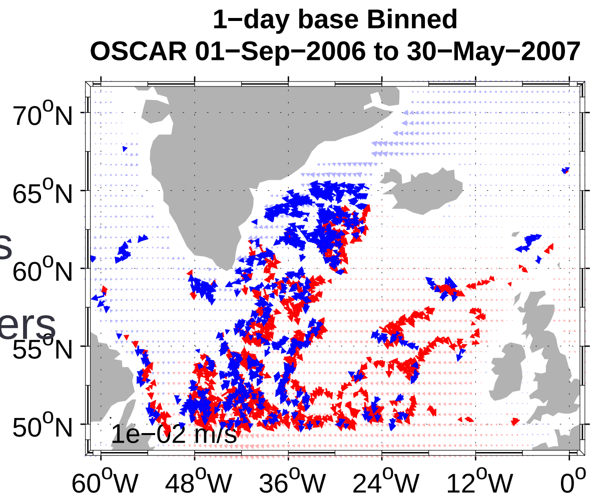
- Comparison with drifters in area experiencing higher winds
- 1-day wind-driven currents compared to 1-day binned drifters
- Over 9-month period
- 0 m/s <= Wind Speeds < 10m/s

High Wind Speed Performance



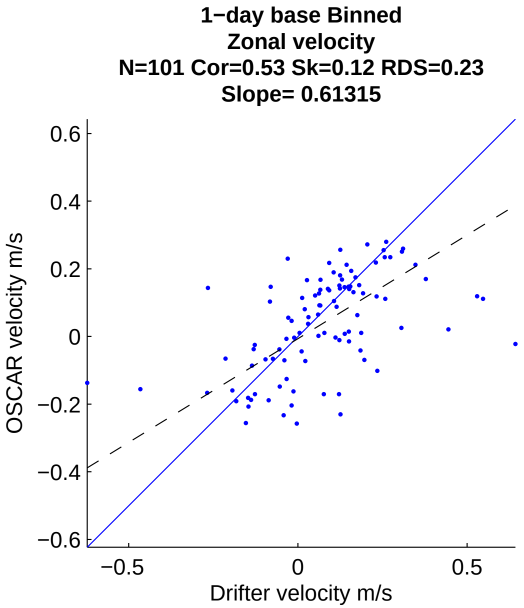


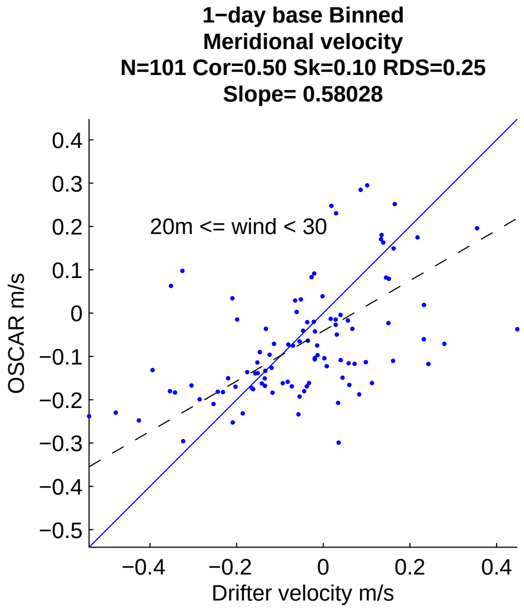


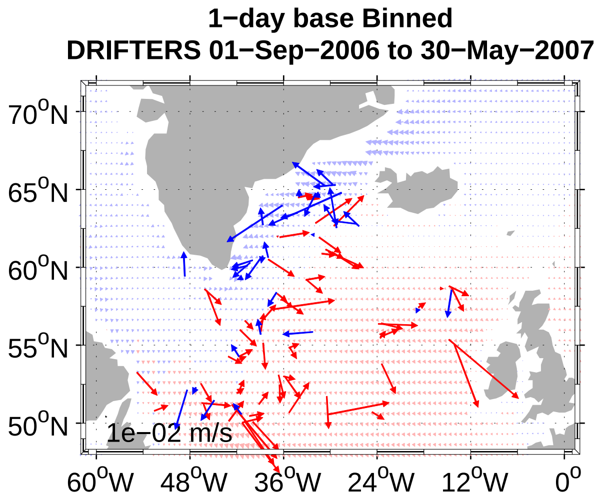


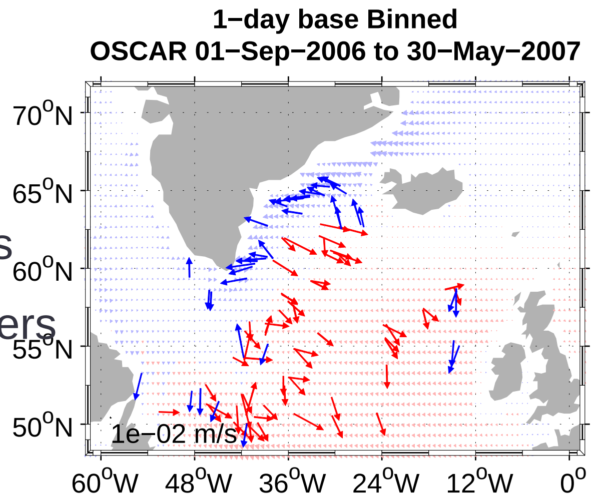
- Comparison with drifters in area experiencing higher winds
- 1-day wind-driven currents compared to 1-day binned drifters
- Over 9-month period
- 10 m/s <= Wind Speeds < 20m/s

High Wind Speed Performance





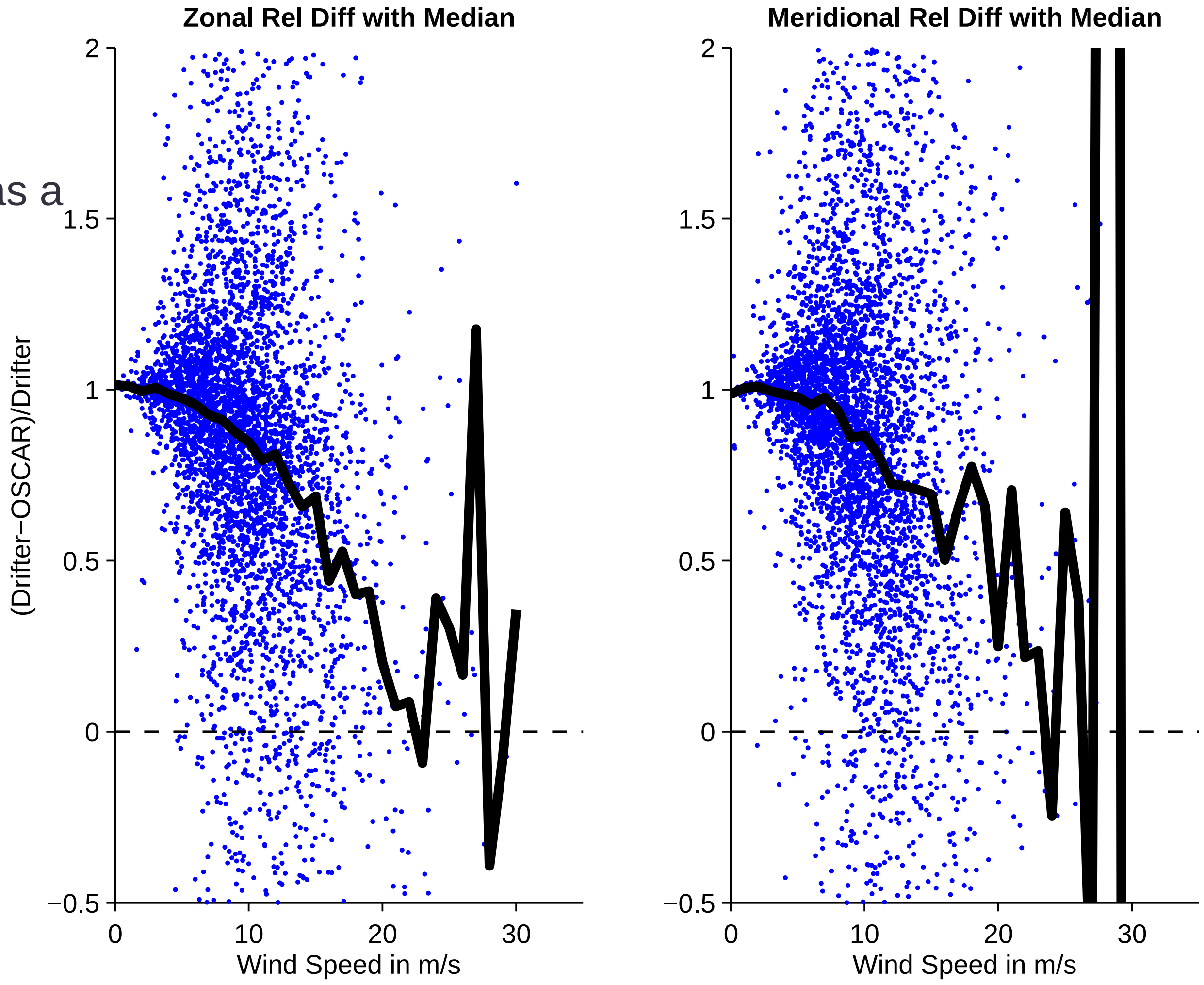




- Comparison with drifters in area experiencing higher winds
- 1-day wind-driven currents compared to 1-day binned drifters
- Over 9-month period
- 20 m/s <= Wind Speeds < 30m/s

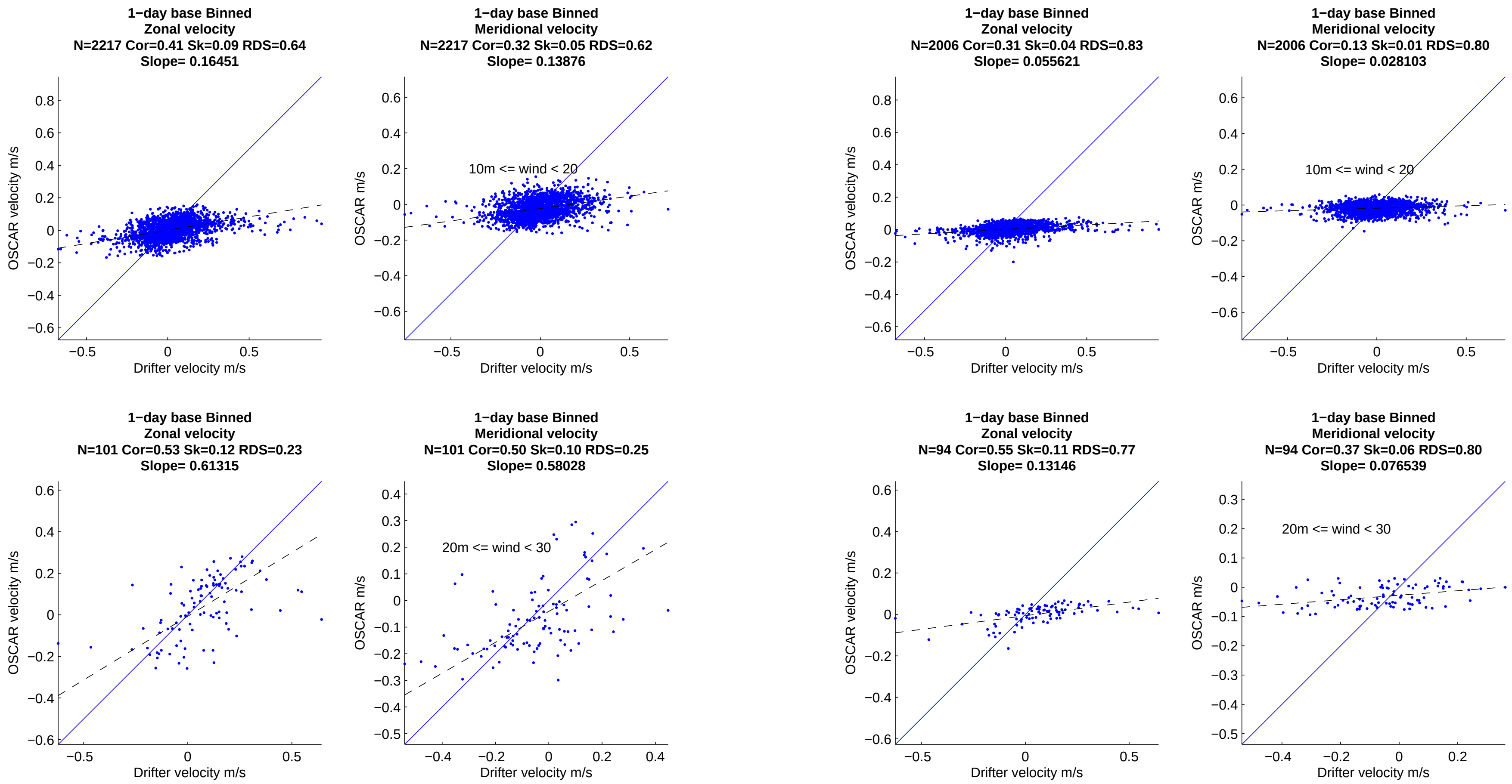
Relative Error

- Relative difference between drifters and 1-day OSCAR as a function of wind speed.
- Median of points in black.



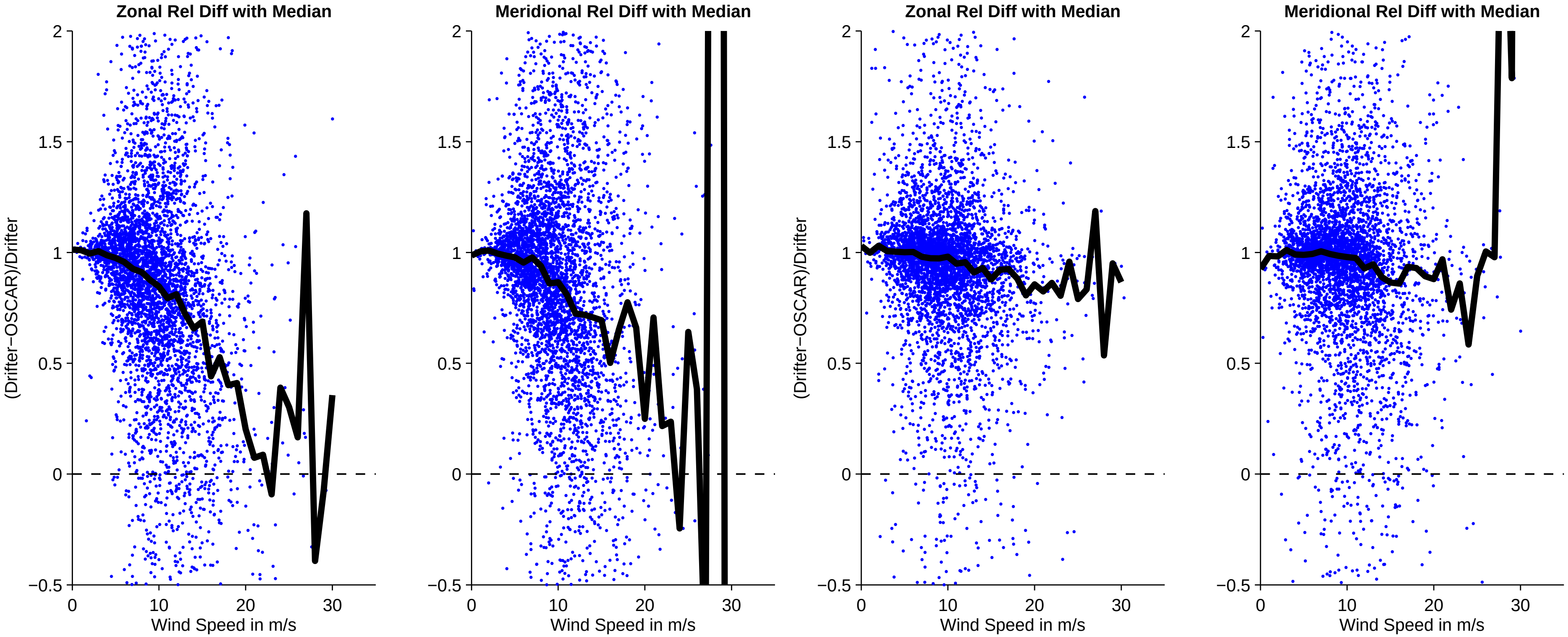
1-Day vs 5-Day Winds

1-Day | 5-Day



Relative Error

1-Day 5-Day



- Relative difference between drifters and 1-day OSCAR as a function of wind speed.
- Median of points in black.

Missing Physics: Near-Inertial Oscillations

- OSCAR is a quasi-steady solution.
- Ekman currents are generated by vertical gradients in the wind-generated surface stress.

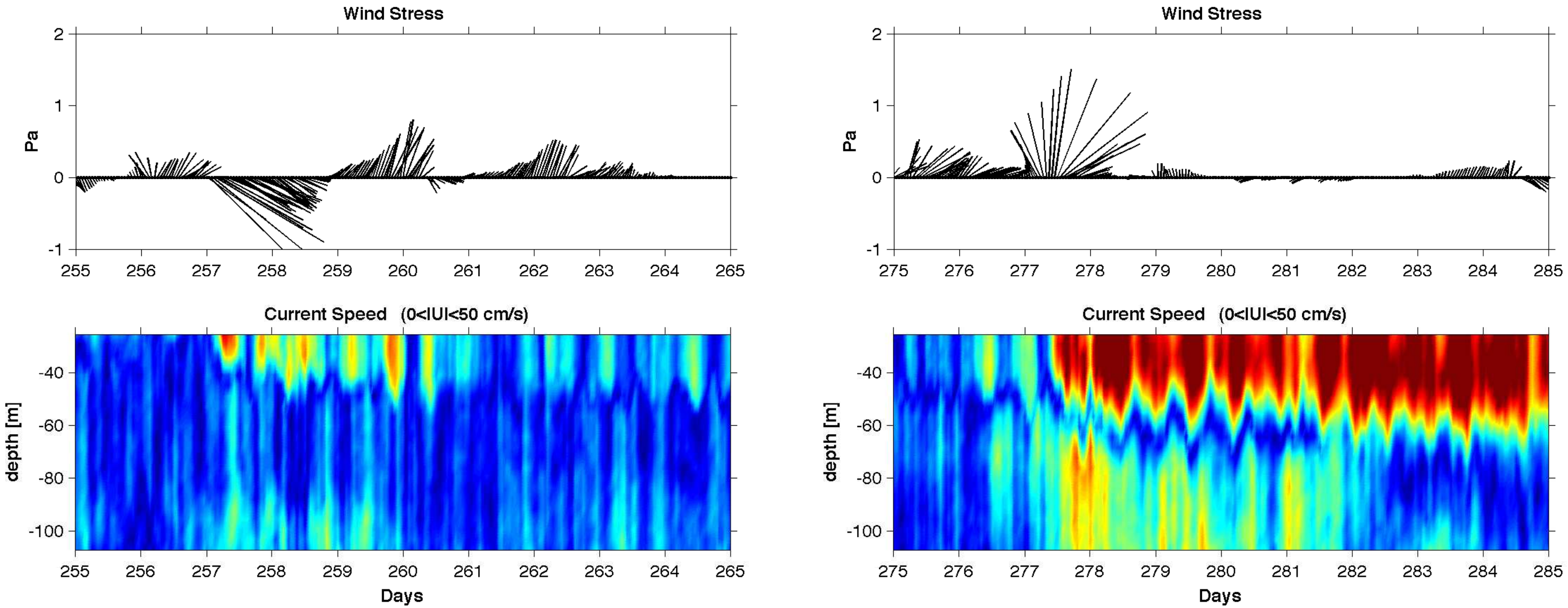
$$\frac{\partial \mathbf{u_E}}{\partial t} + if\mathbf{u_E} = \frac{\partial \tau}{\partial z}.$$

- Integrate over the mixed layer depth (slab layer) gives the solution

$$\mathbf{U_E} = -i\frac{\tau}{\rho}(1 - \exp(-ift)).$$

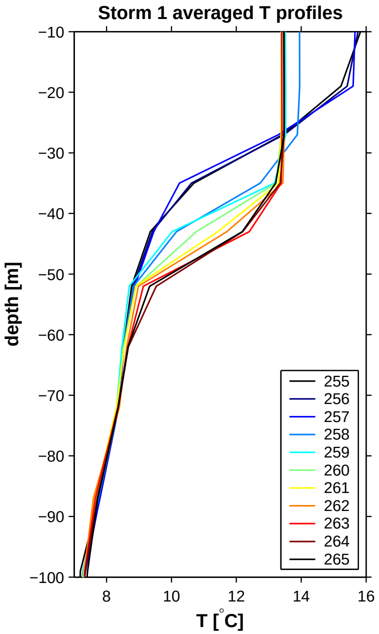
- Steady current to the right of the wind and an anticyclonic inertial oscillation.
- Pure inertial oscillations have zero vertical group velocity and infinite horizontal extent. Propagation via:
  - β effect = variation in Coriolis with latitude causes de-correlation and finite horizontal extent
  - interactions with eddies
  - small-scale storms.

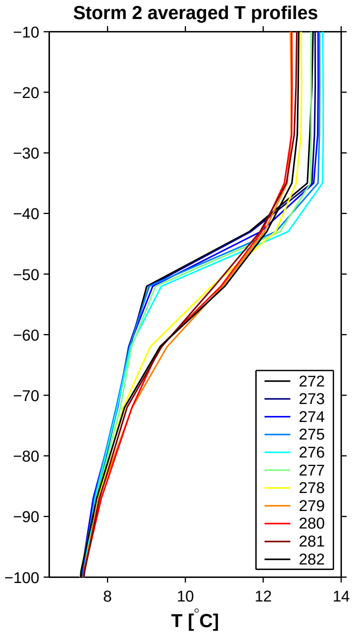
Example: Near-Inertial Oscillations

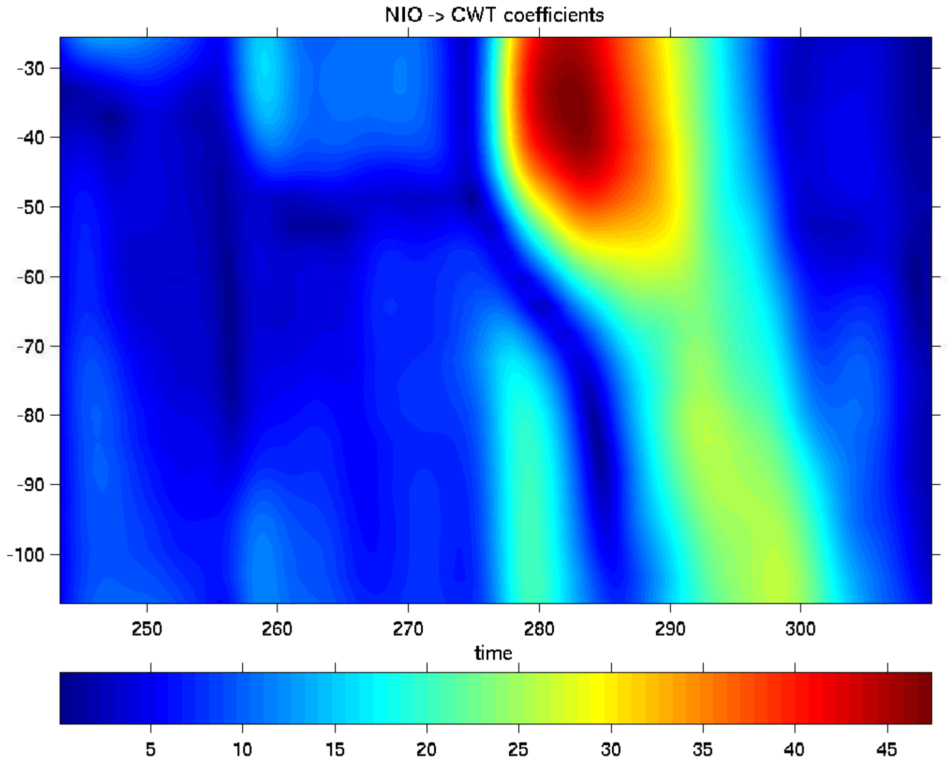


- Mooring data (Ocean Storms; Dohan and Davis 2009, JPO). Hourly winds. Two storms similar magnitude.
- Strong near-inertial oscillations in second storm due to resonant turning of wind direction, lasting well after strong winds.

Significance to Climate

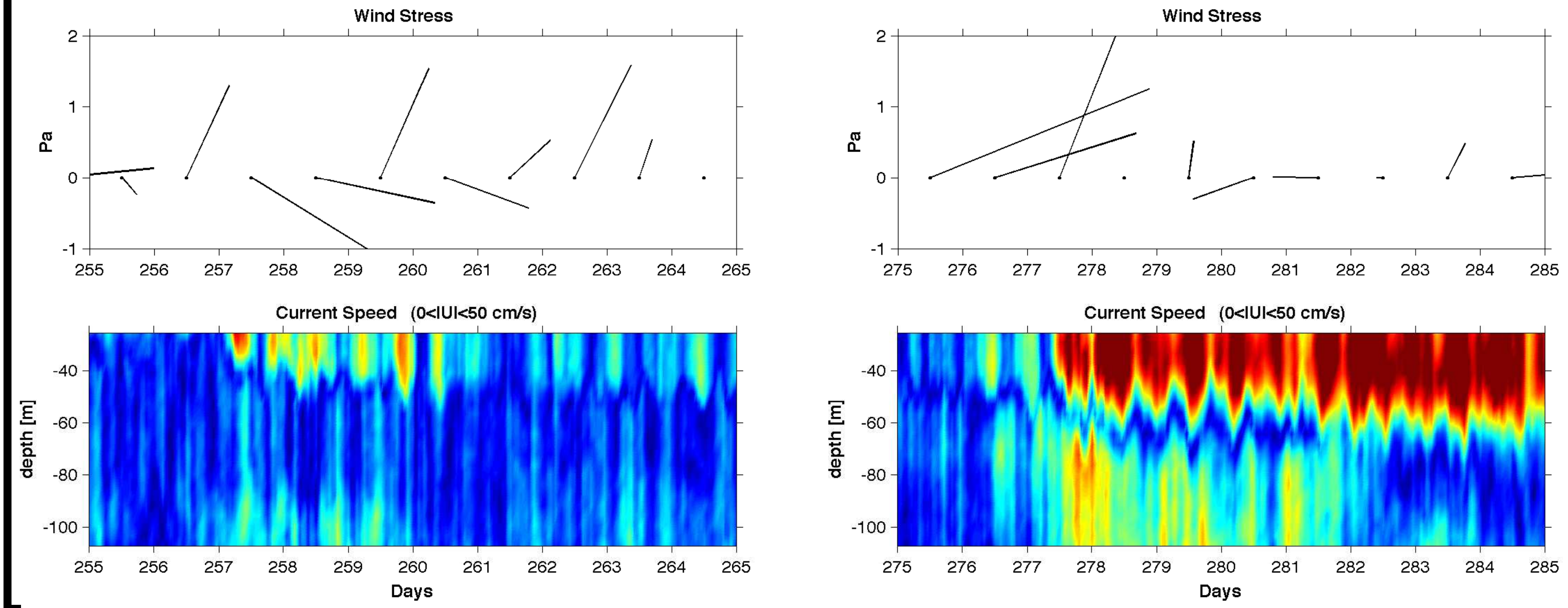






- Mixing
  - Shear-driven mixing within the upper thermocline.
  - The major source of internal waves in the deep ocean from the surface mixed layer.
- Wind-driven momentum transfer to the interior ocean.

Near-Inertial Oscillations: Wind Resolution



- Example of winds on a daily grid.

Summary

- High Winds and OSCAR
  - OSCAR performance improves with higher winds.
  - Inconclusive whether there is a very high-wind degradation seen in OSCAR.
- Resolution in time
  - 1-day winds show improved performance over 5-day
  - **High enough temporal resolution together with more dynamics than steady Ekman will be necessary to capture near-inertial oscillations (NIO).**
- Resolution in space
  - Currents will improve with higher spatial resolution. Also necessary component of NIO.
- Other sources of drifter/OSCAR divergence
  - Geostrophic velocity subtracted from drifters does not include filamentary features.
  - Drifter slip in high winds.
  - Eddy viscosity parameterization, constant in vertical.

Energy Budgets

- Munk and Wunsch (1998) estimate 2.1 TW of mixing is necessary to maintain the abyssal stratification. Wunsch and Ferrari (2004): 0.6 TW from winds, 0.9 from tides.
- Estimates of the power input from the wind from NCEP winds using a slab model is around 0.5 TW (Alford, 2003).
- GCM studies indicate smaller values of 0.1 TW (Furuichi et al., 2008,Zhai et al., 2009).
- Primitive equation models find seven times more dissipation when moving from daily wind forcing to 3 hour wind forcing (Klein et al. 2004).
- A big missing link is a detailed knowledge of the wind structure
  - ocean circulation models
  - abyssal stratification
  - climate predictions.