Dependence of OSCAR Surface Currents on Scatterometer Winds

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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.
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
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.
- 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 < 10 m/s
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 < 20 m/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 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

1–day base Binned
Zonal velocity
N=2217 Cor=0.41 Sk=0.09 RDS=0.64
Slope= 0.16451

1–day base Binned
Meridional velocity
N=2006 Cor=0.31 Sk=0.04 RDS=0.83
Slope= 0.055621

1–day base Binned
Zonal velocity
N=101 Cor=0.53 Sk=0.12 RDS=0.23
Slope= 0.61315

1–day base Binned
Meridional velocity
N=94 Cor=0.55 Sk=0.11 RDS=0.77
Slope= 0.13146

5-Day

1–day base Binned
Zonal velocity
N=2217 Cor=0.32 Sk=0.05 RDS=0.62
Slope= 0.13876

1–day base Binned
Meridional velocity
N=2006 Cor=0.13 Sk=0.01 RDS=0.80
Slope= 0.028103

1–day base Binned
Zonal velocity
N=101 Cor=0.50 Sk=0.10 RDS=0.80
Slope= 0.10616

1–day base Binned
Meridional velocity
N=94 Cor=0.37 Sk=0.06 RDS=0.80
Slope= 0.076539
Relative difference between drifters and 1-day OSCAR as a function of wind speed.

Median of points in black.
OSCAR is a quasi-steady solution.

Ekman currents are generated by vertical gradients in the wind-generated surface stress.

\[
\frac{\partial u_E}{\partial t} + ifu_E = \frac{\partial \tau}{\partial z}.
\]

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

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

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:

- \( \beta \) 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.
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.