Sustained observations of mesoscale and submesoscale surface circulation off the U.S. West Coast

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Collaborators:
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Coastal Ocean Observing System (COOS)

- HF radar, ADCP, Wave Buoys
- AUV, Glider, Floats
- Tide gauges
- Meteorological stations
- Newly developed instruments

Regional Coastal Ocean Observing System (RCOOS)

NANOOS: Northwest Association of Networked Ocean Observing System
SCCOOS: Southern California Coastal Ocean Observing System
Radio signals used in high-frequency radar

3-30 MHz (between AM radio and TV)
Wavelength ($\lambda_r$) : 10 ~ 100 (m)

Bragg backscattering
When the radar signals are backscattered in phase,

$$\lambda_w = \frac{\lambda_r}{2}$$
Phased array vs. Compact array

- Phased array
  - Parallel radar array
  - WERA, OSCR
  - Europe, US (FL, GA), Japan

- Compact array
  - Monopole + 2 dipoles
  - CODAR
  - USA (West/East), Korea, Japan

University of Hamburg, Germany

Point Loma, CA USA
HFR surface current maps off the USWC (Cascade maps)
Oceanic processes in time and spatial scales

(Tcholton 2001, Dickey et al, RG 2006)
Oceanic processes in time and spatial scales

Satellite sensors

Altimeters

HFR

100yr

10yr

1yr

seasonality

1month

1week

diurnal

1day

1hr

1min

1sec

Horizontal spatial scale

cm

1

10

100

1

10

100

km

100

1000

10000

1

10

100

1

10

100

1

10

100

Climate scale

Basin scale

ENSO

PDO

Mesoscale

Eddies, fronts, filaments

Submesoscale

Coastal upwelling

CTW

Rossby waves

Inertial/internal/solitary waves

Internal tides

Surface tides

Langmuir cell

Surface waves

Turbulence

Chelton 2001, Dickey et al, RG 2006
Subinertial alongshore surface currents

- Rotated currents following the shoreline
- Daily averaged alongshore surface currents.
- Seasonal California Currents.
- Phase speeds of 10 and 100 – 300 km/day
- Slower mode feature is found in southern CA and (intermittently) north.

(Kim et al, JGR 2011)
Subinertial alongshore surface currents

- 61 HFRs, 14 NDBC wind buoys hourly observations (2007 to 2008)
- Effective spatial coverage (blue; 6 km) and coastline axis (red; 25 km apart from shoreline)
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(Kim et al, JGR 2011)
- Hourly alongshore surface currents.
- High-frequency structure coherent with diurnal wind and tides.
- Poleward progression of convergence front.

(Kim et al, JGR 2011)
Streamlines (nearly closed polygons) are identified with winding angle method.

Co-centered streamlines are fitted into an ellipse.

If the center of ellipses in consecutive time steps is within a drifting range (e.g., 1.5 km) with the same rotation, ellipses are considered as a part of an eddy time series. The length of time series is called as persistency (Kim, CSR 2011).
Vorticity and size of identified eddies

- About 700 eddies are identified for each rotation.
- O(0.5-1) Rossby number at the center of eddies
- 5-20km diameter (L)
San Diego shoreline water quality sampling

Water quality

Rainfall

River flux
Lagrangian particle track model

- Objectively mapped surface currents
- Forward time integration
- Particle concentrations vs. water quality samplings
- ROC (Receiver Operating Characteristics) analysis

AOC = 0.72
Exposure map (2D PDF)

Exposure map normalized by # of particles at the source location.
(when each source is active)
Hyperion Discharge & oil spill experiment
Summary

- The operational USWC HFR network as a backbone of regional coastal ocean observing system (ROOS) provides the detailed aspects of coastal surface circulation and ocean dynamics at a resolution (km in space and hourly in time) of never before resolved.
- Observed surface currents contain responses to the low frequency, tides, wind forcing, and Earth rotation.
- HFR observations can be a useful resource to study surface circulation, eddies and interaction of energy at submesoscale, and ocean state estimates and can provide various environmental applications.