SCRIPPS INSTITUTION OF OCEANOGRAPHY

Observation of submesoscale eddies off southern San Diego using high-frequency radars

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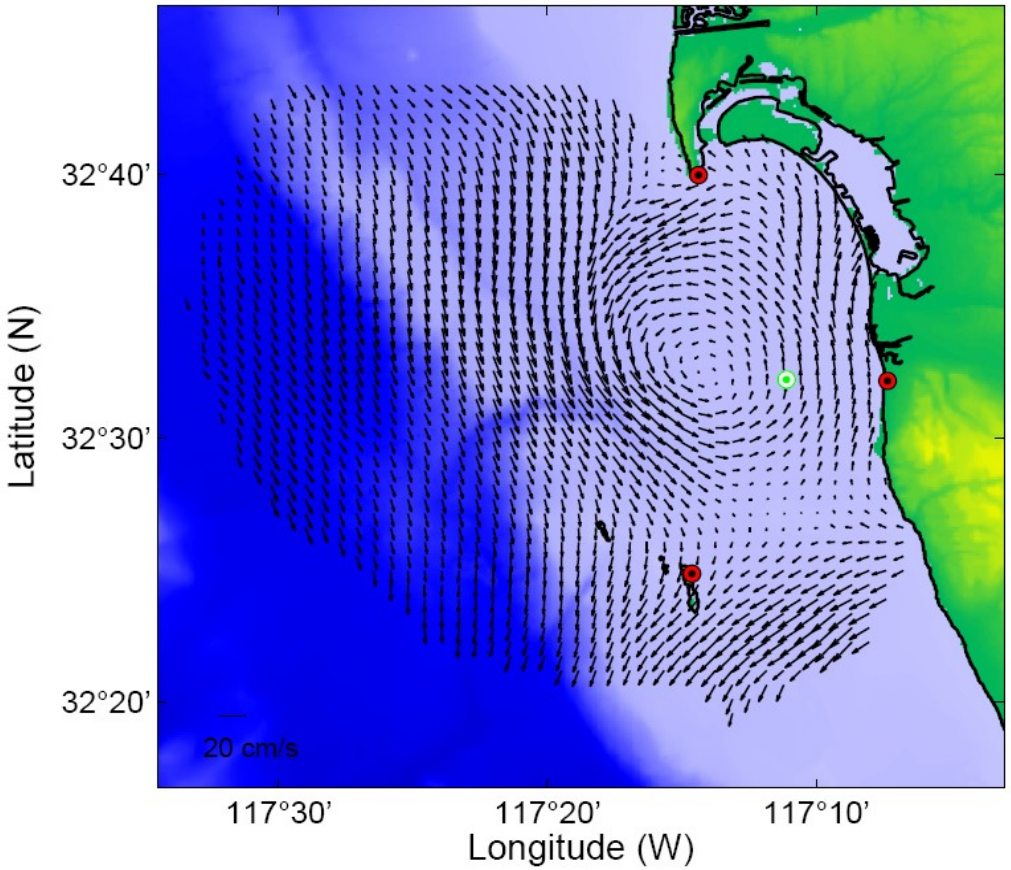
SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM

bp

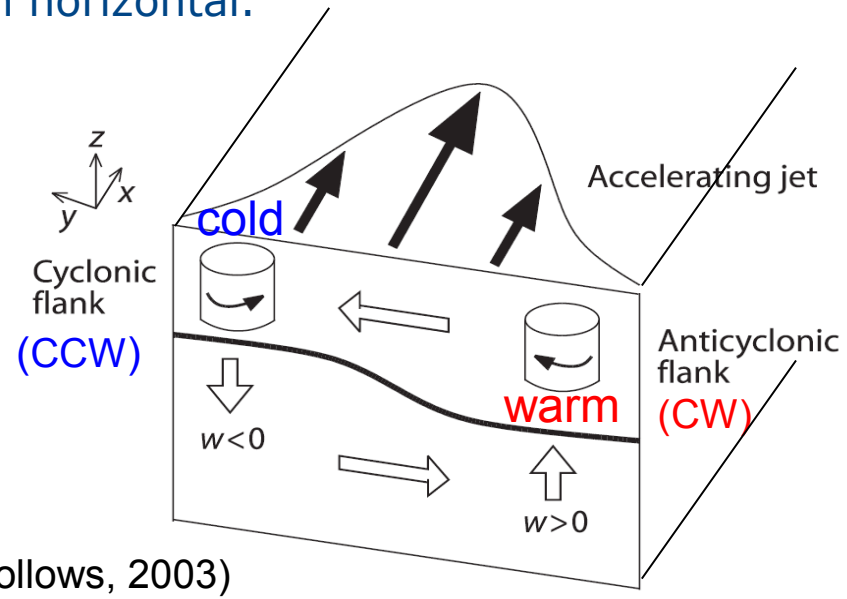
Motivation



- High-resolution surface current observations
  - Hourly and 1-6 km spatial resolution.
  - Derivation of useful products (e.g., kinematic and dynamic quantities).
  - Observation of submesoscale eddies/fronts.

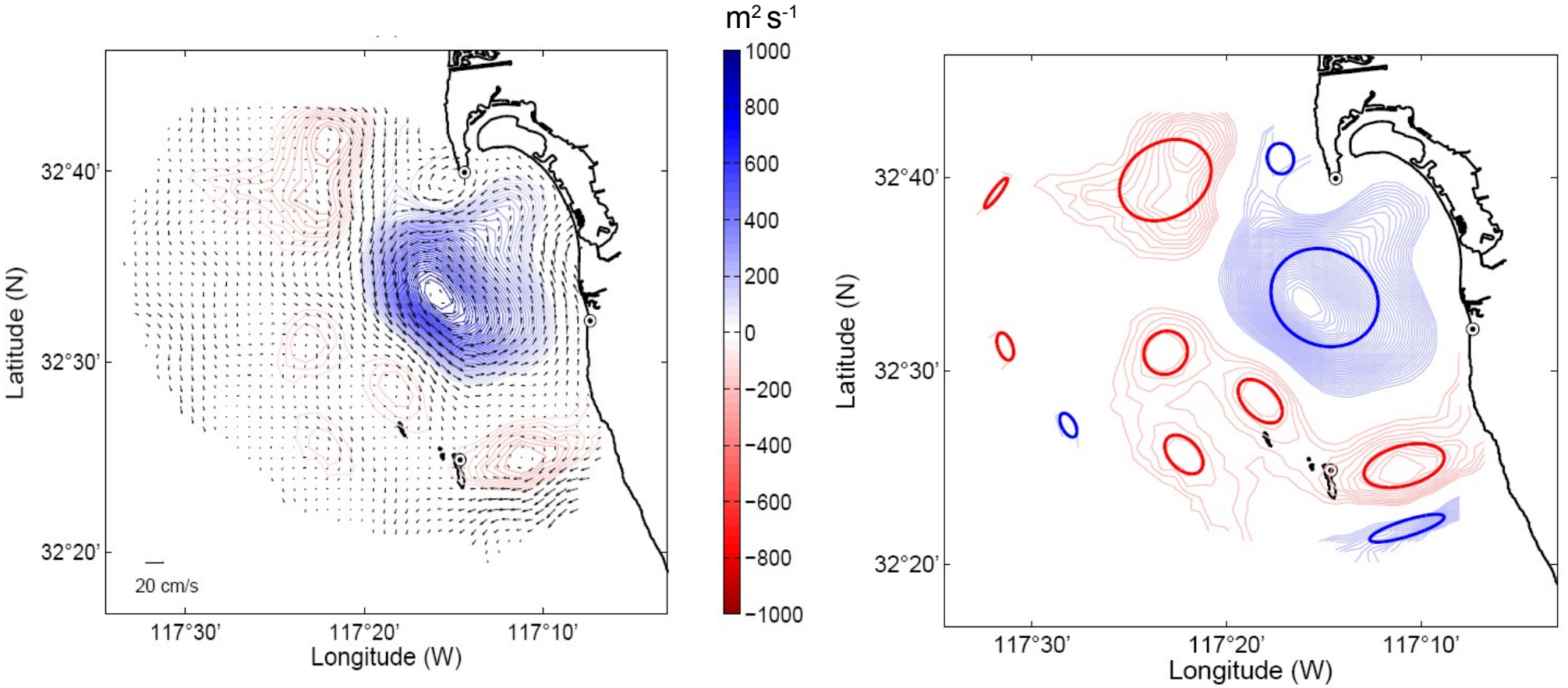
Rossby number.

cal front-scale circulation and high deformation ates in horizontal.



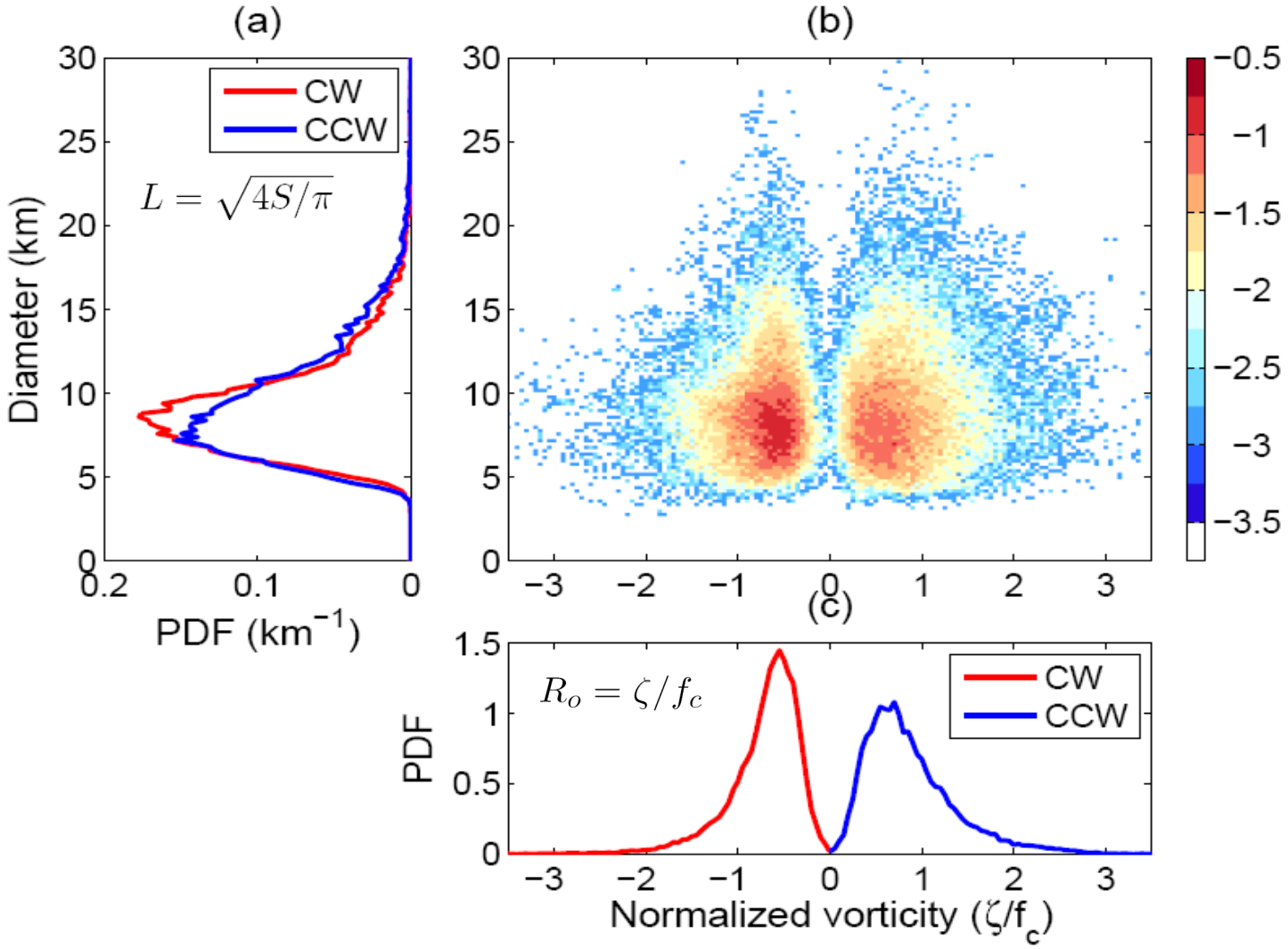
(Williams and Follows, 2003)

Eddy detection



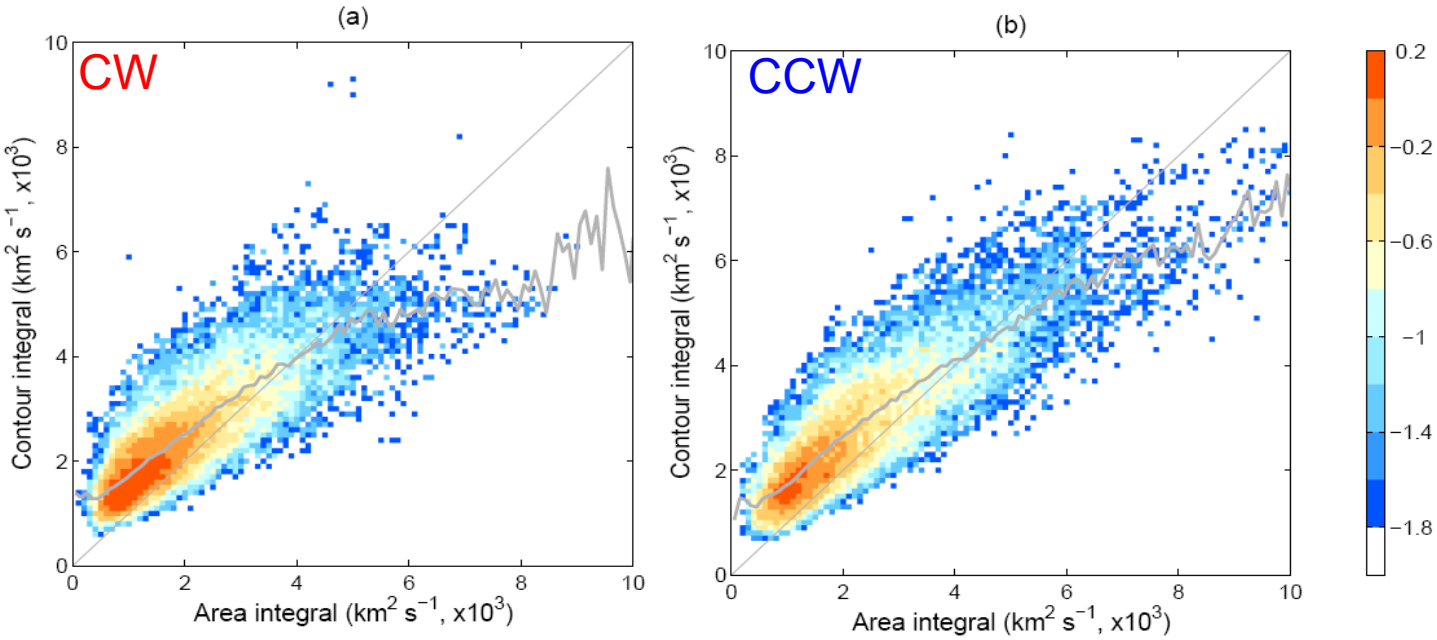
- Streamlines (nearly closed polygons) are identified with winding angle method.
- Co-centered streamlines are fitted into an ellipse.
- If the center of ellipses in consecutive time steps is within a drifting range (e.g., 1.5 km) with the same rotation, they are considered as a part of an eddy time series. The length of time series is called as persistency.

Rossby number and size

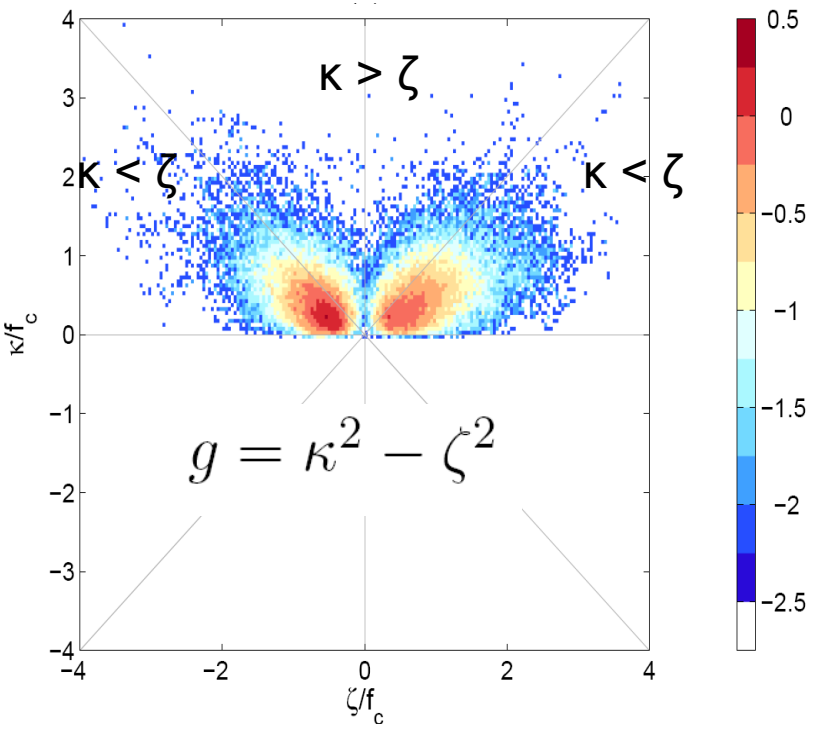


- O(0.5-1) Rossby number at the center of eddies
- 5-20km diameter (L)

Circulation & WO parameter



$$\Gamma \equiv \oint_C \mathbf{u}\cdot \mathrm{d}\mathbf{l} = \oint_C \mathbf{u}_\psi \, dl \approx \sum \mathbf{u}_\psi \Delta l,$$
$$\equiv \iint_S (\nabla \times \mathbf{u})\cdot \mathrm{d}\mathbf{S} = \iint_S \bar{\zeta}\cdot \mathrm{d}\mathbf{S}$$
$$\approx \bar{\zeta} S,$$



$$\zeta = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$$ vorticity

$$\kappa = \sqrt{\varrho^2 + \varsigma^2}$$ strain rate

$$\varrho = \frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}$$ shear deformation rate

$$\varsigma = \frac{\partial u}{\partial x} - \frac{\partial v}{\partial y}$$ stretching deformation rate

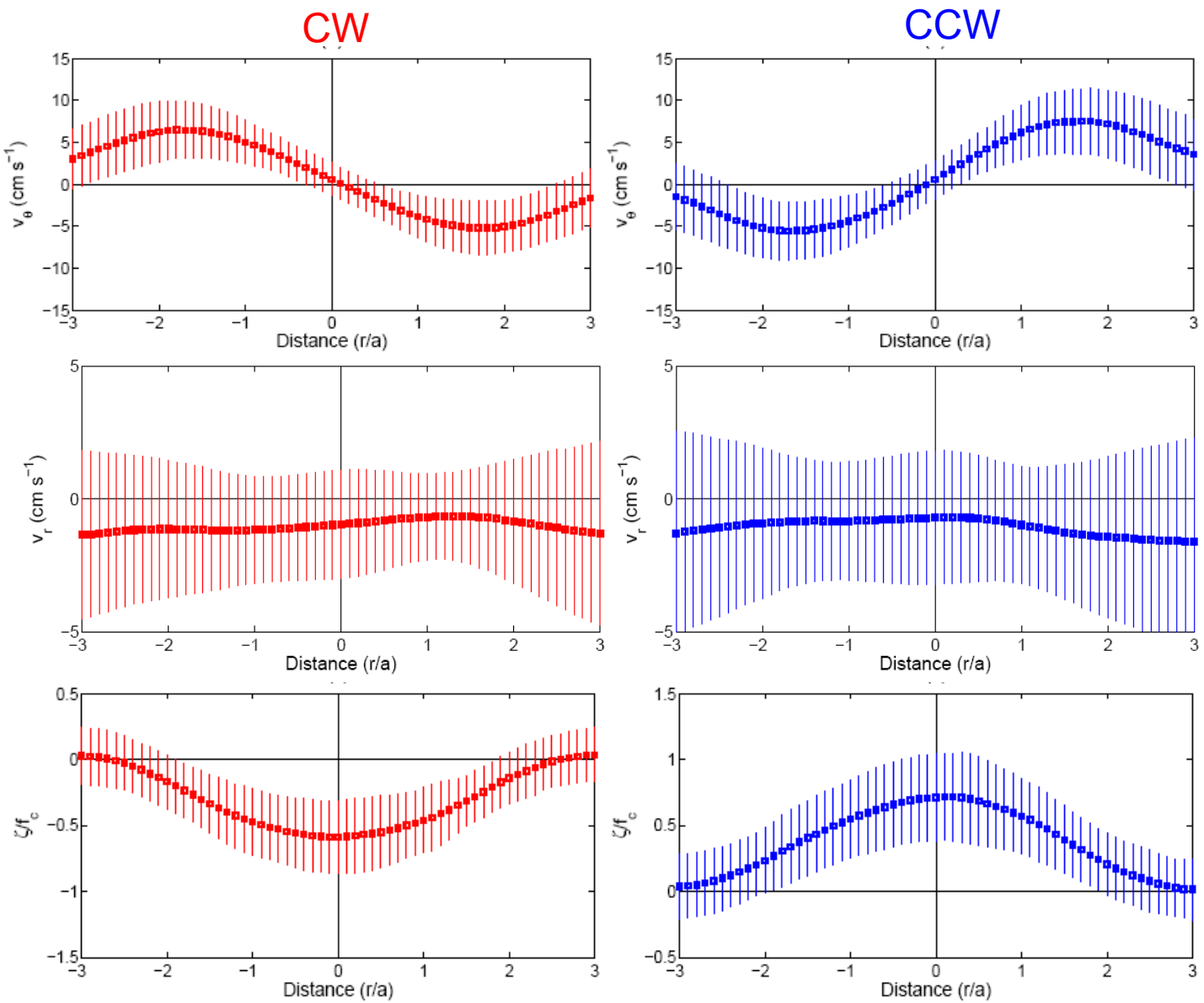
Weiss-Okubo criterion using deformation tensor
g > 0, strain-dominated region
g < 0, vorticity-dominated region

Horizontal structure

v_Θ
Tangential velocity

v_r
Radial velocity

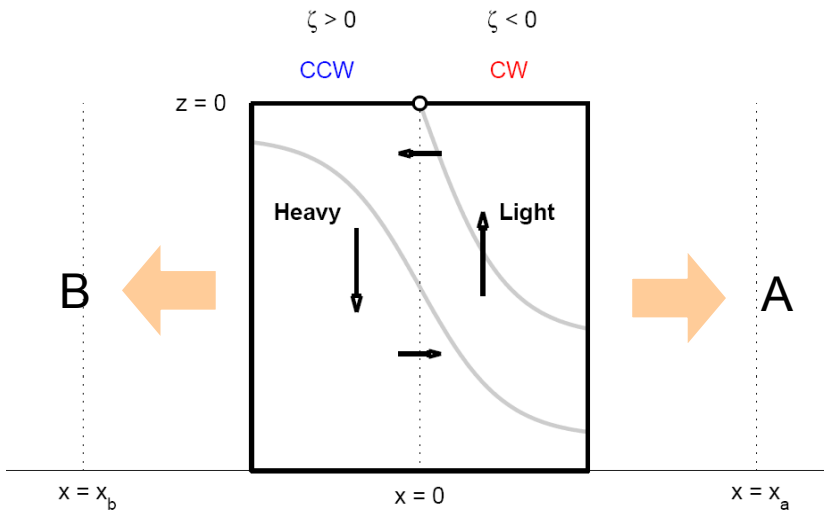
ζ/f_c
Rossby number

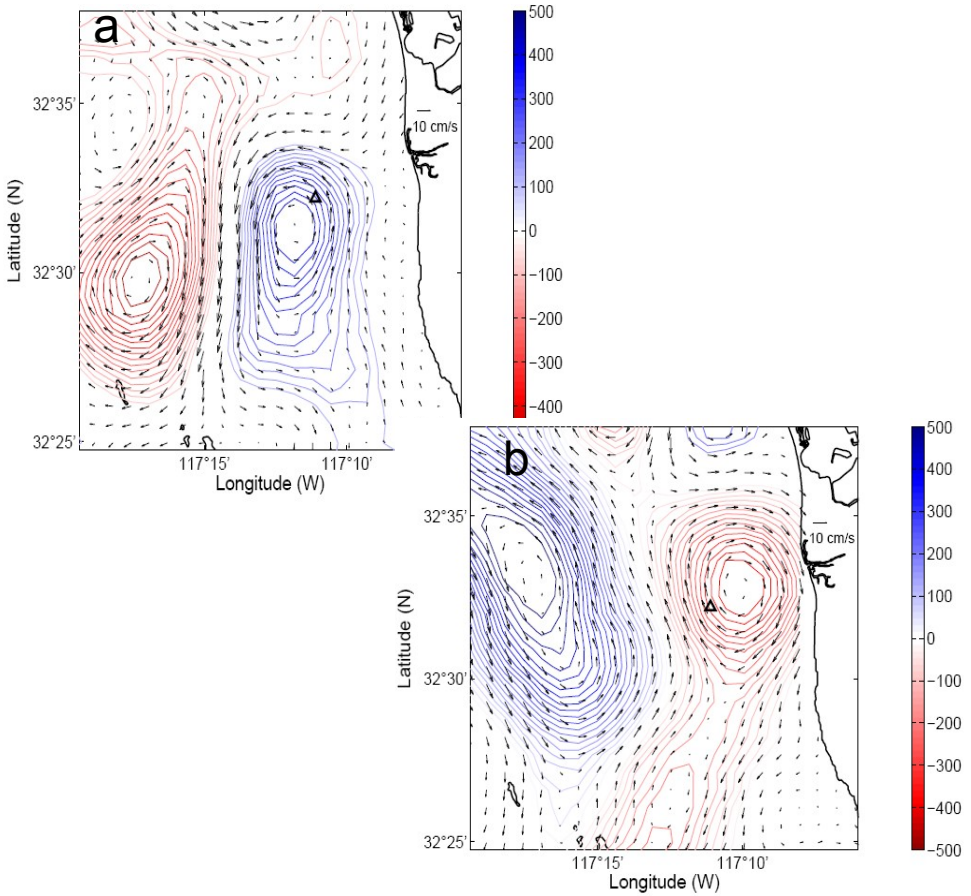


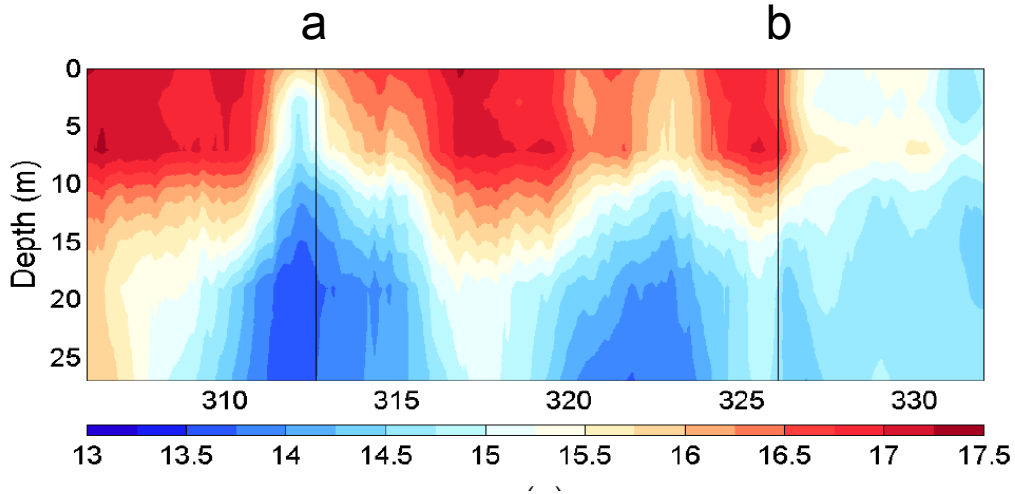
r/a: Relative distance on the major axis

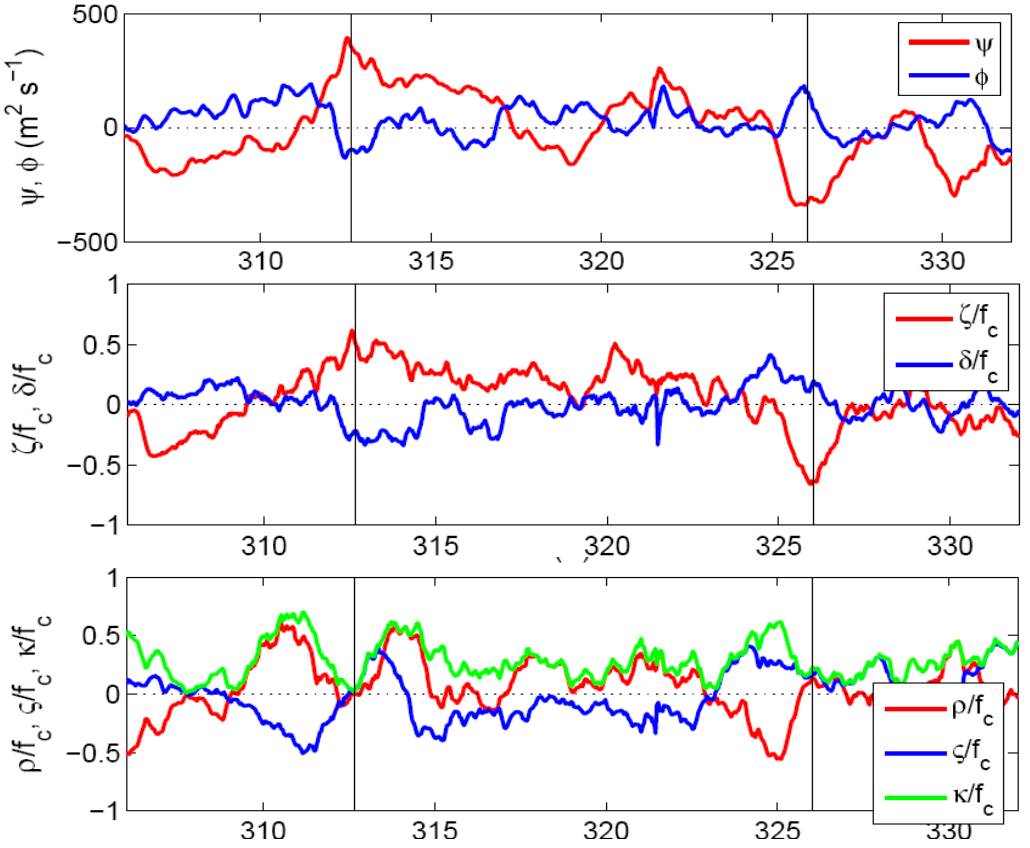
- V_Θ and ζ/f_c have similar shapes to the Taylor eddy.

Frontal-scale secondary circulation

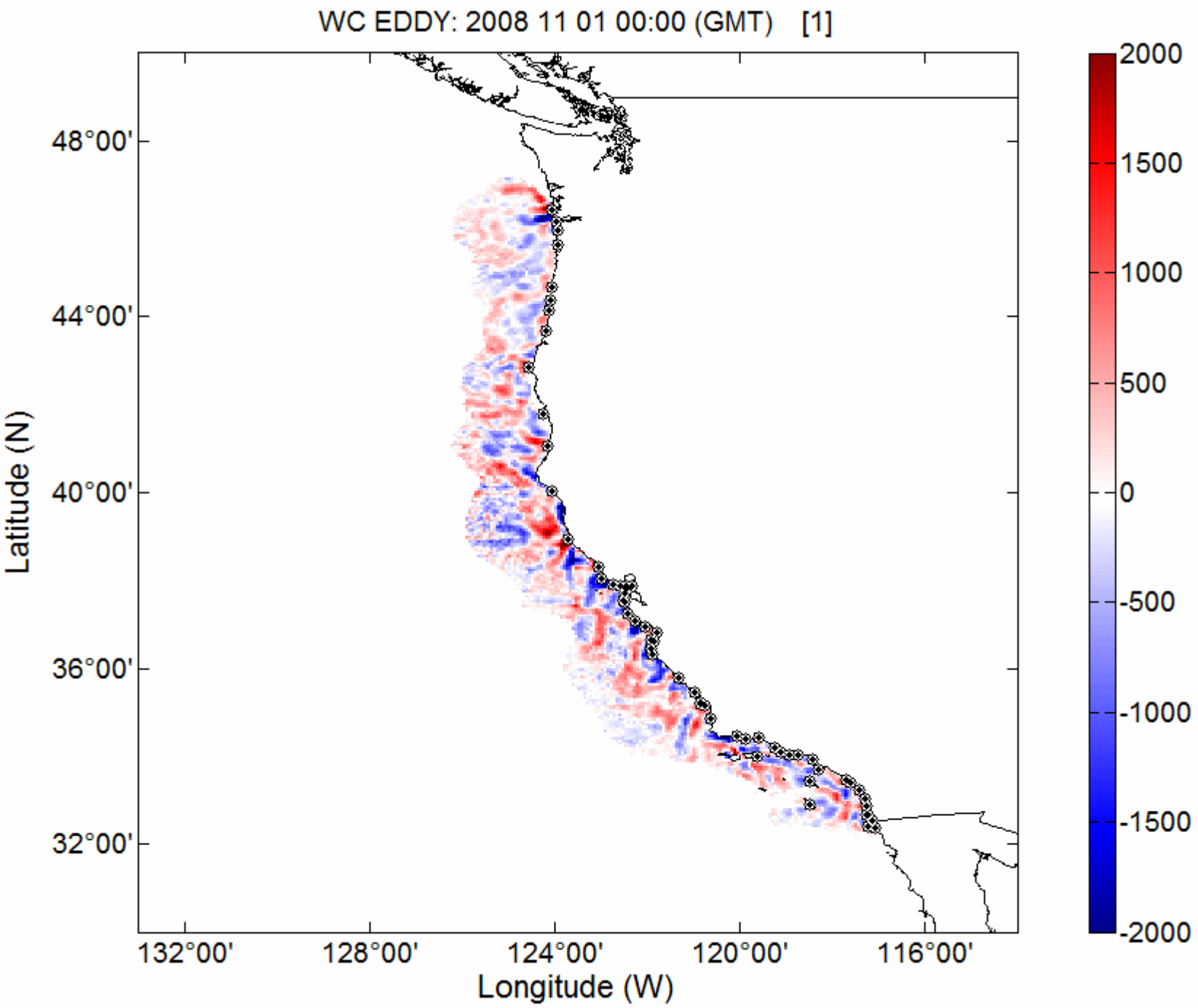








Submesoscale eddies on the USWC



Summary and discussion

- Direct estimate of kinematic and dynamic quantities from radial velocity maps of HF radars: stream function, velocity potential, divergence, vorticity, and deformation rates.
- Eddy detection using geometric criteria on co-centered streamlines -- winding angle.
- Submesoscale eddies off southern San Diego: Rossby number of O(0.5-1) and 5-20 km diameter
- Frontal-scale vertical circulation due to drifting eddies undulates thermoclines.
- A potential instrument to observe submeoscale eddies in coastal regions.

Thank you.