Divergent Eddy Heat Fluxes in the Kuroshio Extension at 143°-149°E

Stuart P. Bishop*, D. Randolph Watts, Kathleen A. Donohue

Graduate School of Oceanography, University of Rhode Island, 215 South Ferry Road, Narragansett, RI 02882
*bishop@geo.uri.edu

Overview

The Kuroshio Extension differs from the Gulf Stream in that it has a shallower thermocline and it flows over a much deeper subthermocline layer. As a result, meander growth and decay processes are driven by internal mesoscale perturbations. The largest down- and up-gradient eddy heat fluxes are driven by remotely-generated deep eddies and ring interactions with the Kuroshio Extension.

I. Introduction

Kuroshio Extension System Study (KESS)

- Mesoscale-resolving array of 46 current and pressure equipped inverted echo sounders (CPIES).
- Located east of Japan in region of highest KEX.
- Provides 3-D maps of geostrophic velocity and temperature for 16 months (Donohue et al. 2010)².
- This poster presents eddy heat flux estimates from the KESS observations.

Motivation

1. Eddy-mean flow interactions:
   - Eddies release mean potential energy of baroclinic jet.
   - Eddies act as an eddy force on the mean flow.

II. Eddy Heat Flux

- The eddy heat flux is the depth-averaged density, \( \rho'' \), times the specific heat at constant pressure, \( C_p'' \), times the temporal correlation between the geostrophic currents, \( \mathbf{u}' \), and the temperature field, \( T' \).

CPIES Absolute Geostrophic Currents

\[ \mathbf{u}' = \mathbf{u}_\infty + \mathbf{u}_p' \]

- Absolute geostrophic currents are the vector sum between a vertically aligned current in thermal-wind balance called the baroclinic current, \( \mathbf{u}_\infty \), and a weakly depth-dependent reference current called the barotropic current, \( \mathbf{u}_p' \), measured at 350 m.

CPIES Mapped Eddy Heat Flux

\[ \rho'' C_p'' \left( \mathbf{u}' \cdot \nabla T' \right) \]

- Divergent eddy heat fluxes in the Kuroshio Extension exhibit decadal variability within 1000 km of Japan coast (Qiu and Chen 2005)³.

IV. Spatial Structure of Divergent Eddy Heat Fluxes

- Vertically-integrated Eddy Heat Flux
  - a) 16 month: asymmetry along mean path
  - Down-gradient upstream of trough
  - Up-gradient downstream of trough
  - b) “Stable” regime: 16 months – mostly down-gradient.
  - c) “Unstable” regime: 10 months – similar to 16 month mean with asymmetry along mean path.

Poleward Eddy Heat Transport

- d) Peaks near 35°N at 0.04 PW

V. Vertical Structure

- a) Deep cyclone begins crossing jet.
- b) Poleward heat flux associated with joint development between deep cyclone and upper geopotential height anomaly.
- c) Strong poleward heat flux.
- d) Joint development reaches a maximum as deep cyclone passes almost completely south of jet.

VI. Temporal Variability

- a) Time series at 400 m
  - Deep cyclones crossing jet.
  - Strong poleward eddy heat flux.
  - Joint development between upper and deep continues.
  - Axes of jet steepens into a trough.

- b) Poleward eddy heat flux associated with joint development between deep cyclone and upper geopotential height anomaly.

- c) Strong poleward heat flux.

- d) Joint development reaches a maximum as deep cyclone passes almost completely south of jet.

Figure Legend

- Jet axis: Thick black contour
- 30-50 day band-pass filtered upper geopotential height anomaly (0.1 cm)
- Dark grey: positive
- Light grey: negative
- 30-50 day band-pass filtered bottom pressure anomaly: color coded
- Eddy heat flux vectors at 400 m.

VII. Summary

1. Divergent eddy heat fluxes in the Kuroshio Extension are driven by weakly depth-dependent currents.

2. 16 month mean divergent fluxes change alongstream from down-gradient to up-gradient at the mean trough.

3. Fluxes are vertically coherent with extrema exceeding 500 kW m⁻² between 200-500 m.

4. The mean spatial structure arose from episodic mesoscale phenomena: cold-core ring formation, ring-jet interaction, and remotely-generated deep eddy-jet interactions.

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