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Meridional Eddy Heat Fluxes in the Kuroshio Extension System

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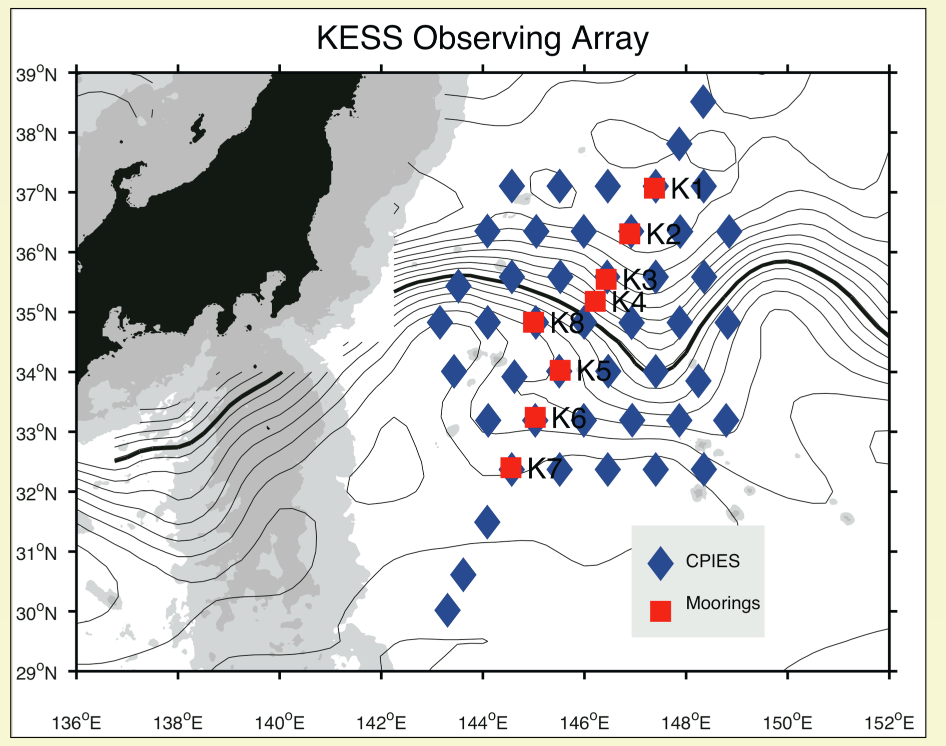
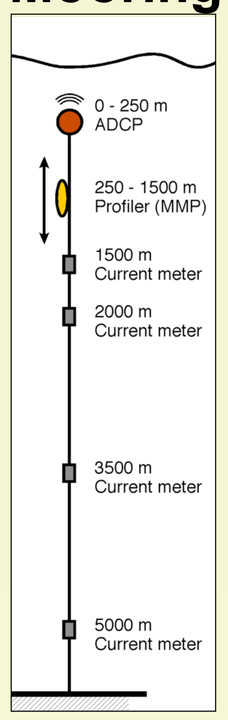
KUROSHIO EXTENSION SYSTEM STUDY





ARRAY OF CPIES -- used to map u,v,T,S, throughout water column. Tall moorings were co-located along central section.

* Designed to map the velocity and temperature structure daily with mesoscale resolution.
* Located in quasi-stationary meander crest & trough, where cross-stream fluxes were anticipated to be elevated.
* This poster presents the measured eddy heat flux in context.

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1. MERIDIONAL HEAT FLUX

Meridional Eddy Heat Flux Density:

$$q = \rho_0 C_p \overline{v'T'}$$

• Direct observations of q in the ocean are sparse and exhibit large spatio-temporal variability.

• Differential heating of the globe causes a net transport of heat (Q_{tot}) poleward by the ocean and atmosphere.

• Models predict at 36°N in the Pacific that total heat transport is due to eddies primarily associated with the Kuroshio Extension (Volkov et al. 2008 GRL).

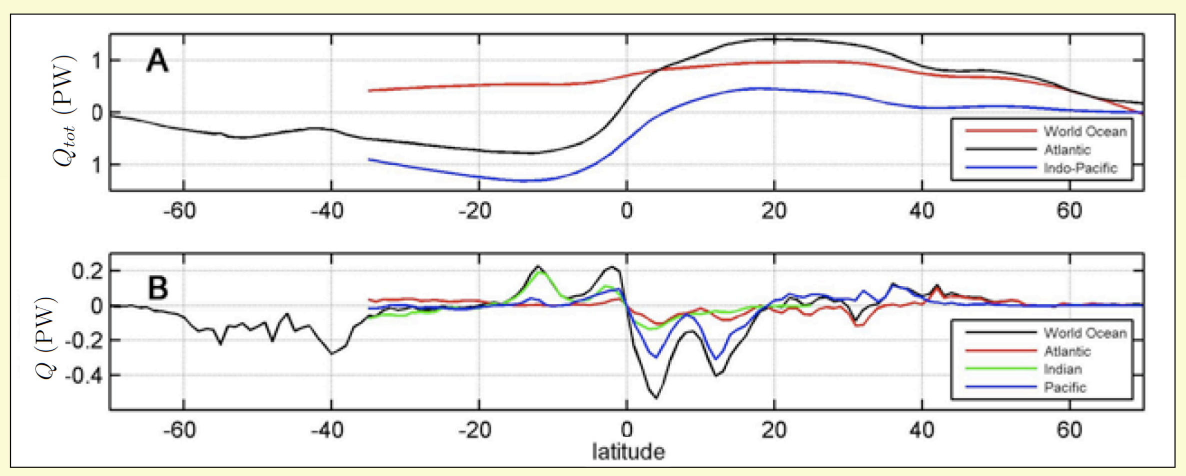
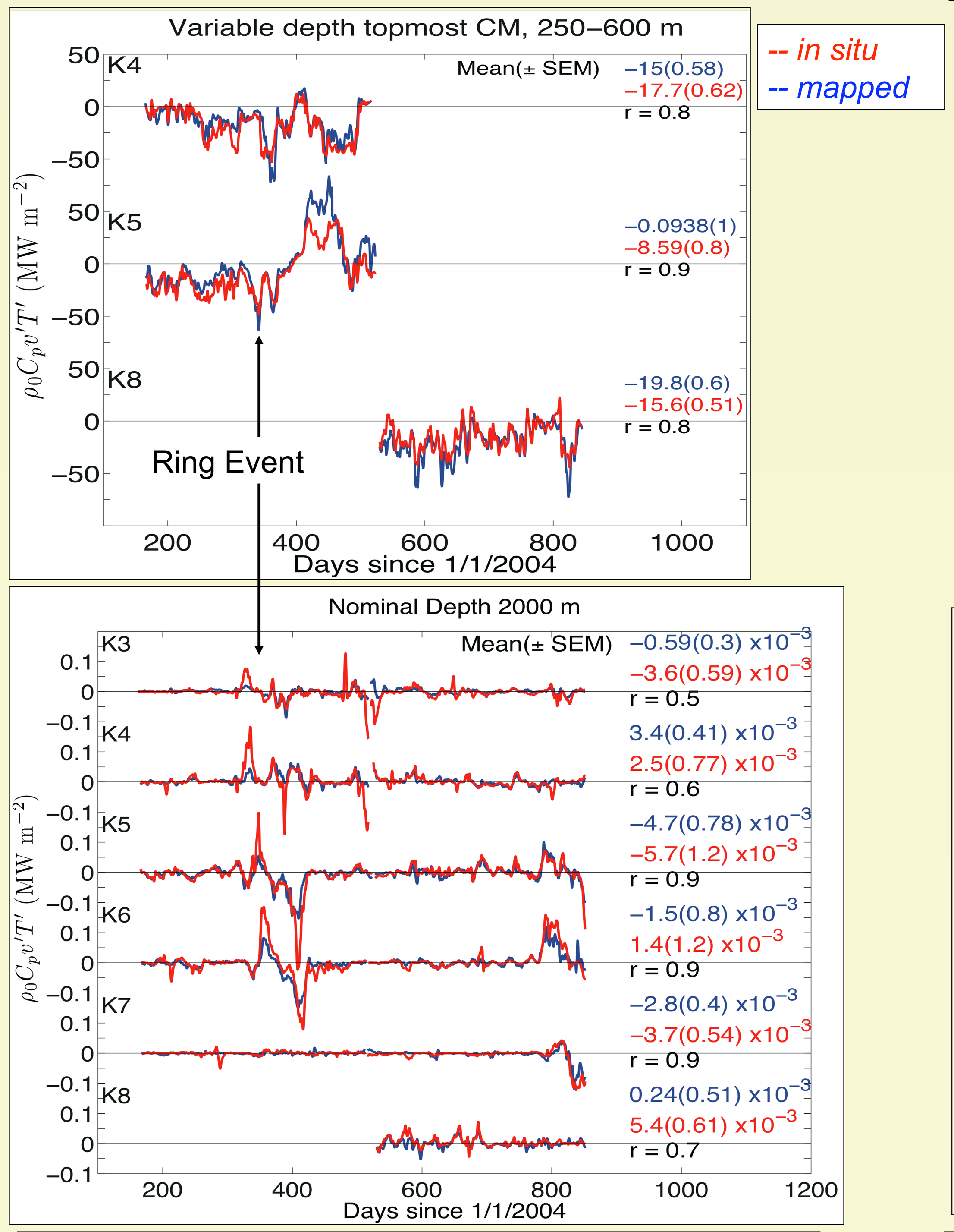


Figure courtesy of Volkov et al. 2008 GRL "Eddy-induced meridional heat transport in the ocean"

2. CAN CPIES QUANTIFY MERIDIONAL EDDY HEAT FLUXES?

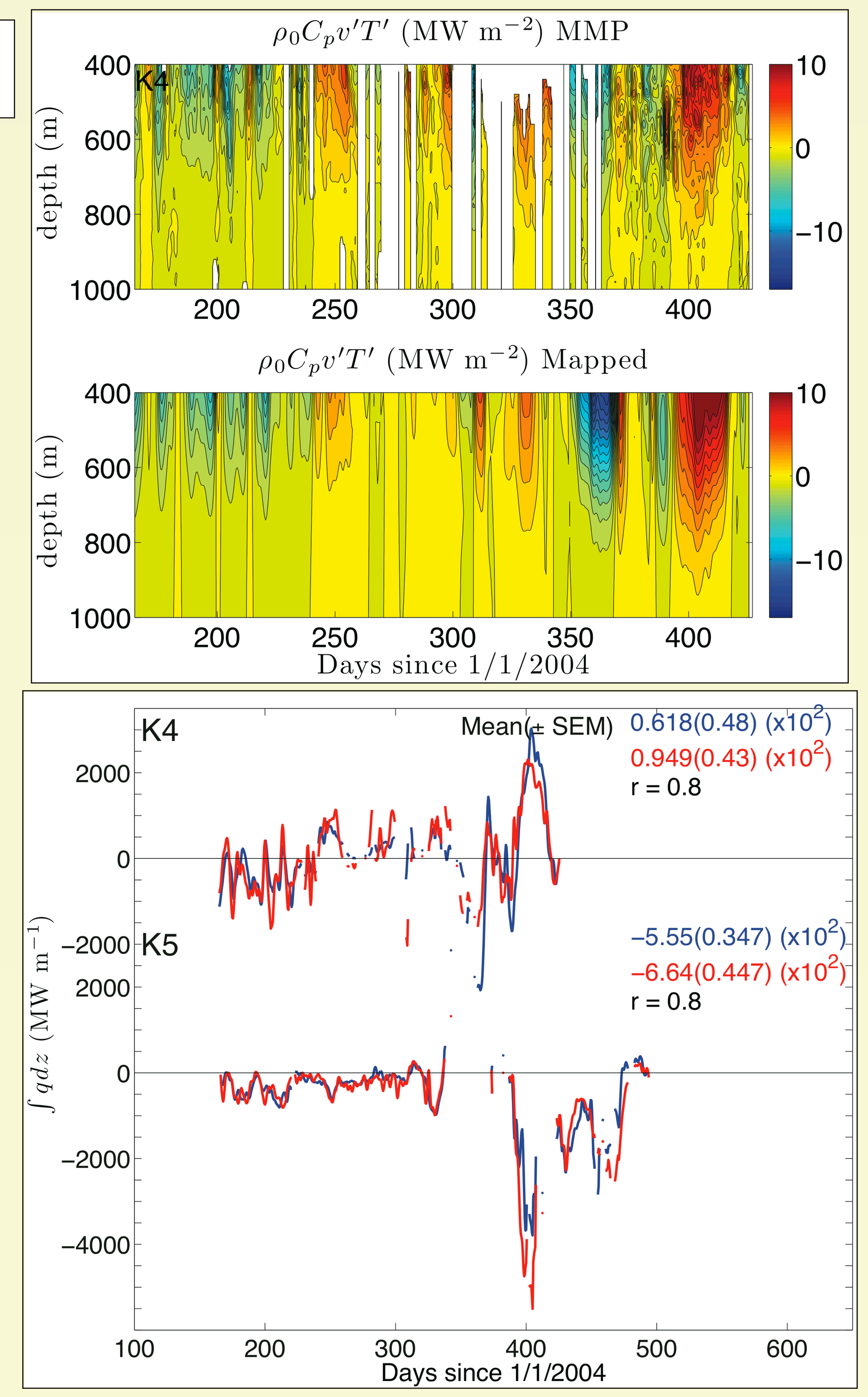
Upper & Lower Ocean *q* Comparisons



q Comparisons agree well for *in-situ* vs. mapped

- Magnitude and sign of mean
  - Most mean values agree within SEM
- Highly correlated r = 0.5-0.9

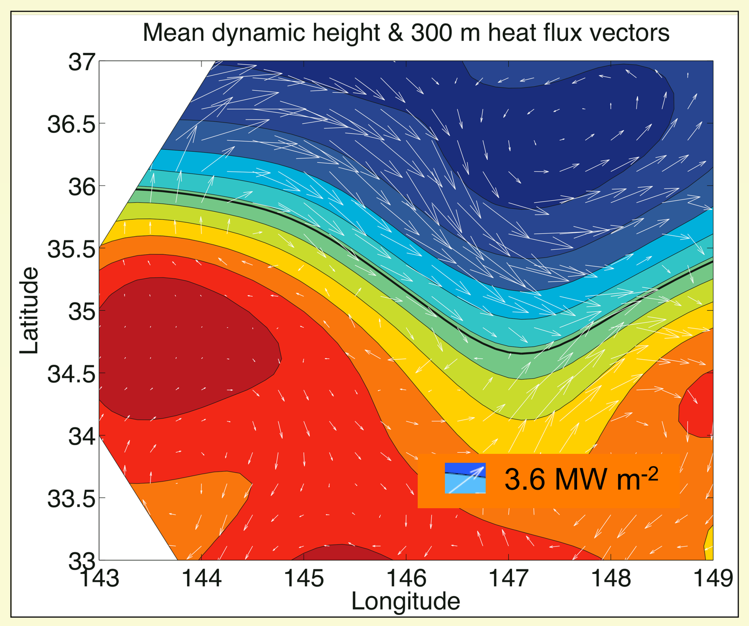
q & $\int qdz$ Thermocline Comparisons (Yr-1)



Vertically coherent q through the thermocline

- Vertically integrated q agree:
  - Magnitude and sign of mean
  - Highly correlated r = 0.8

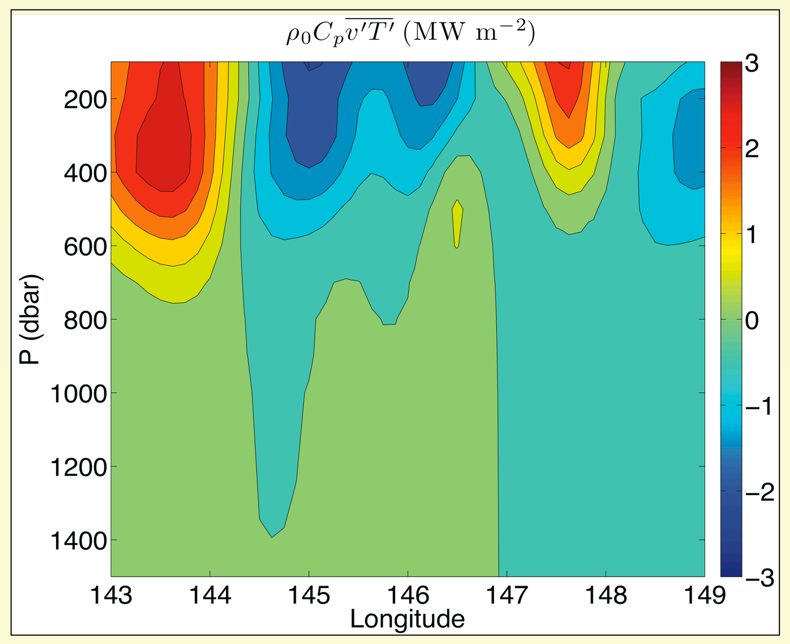
3. TOTAL MERIDIONAL EDDY HEAT FLUX

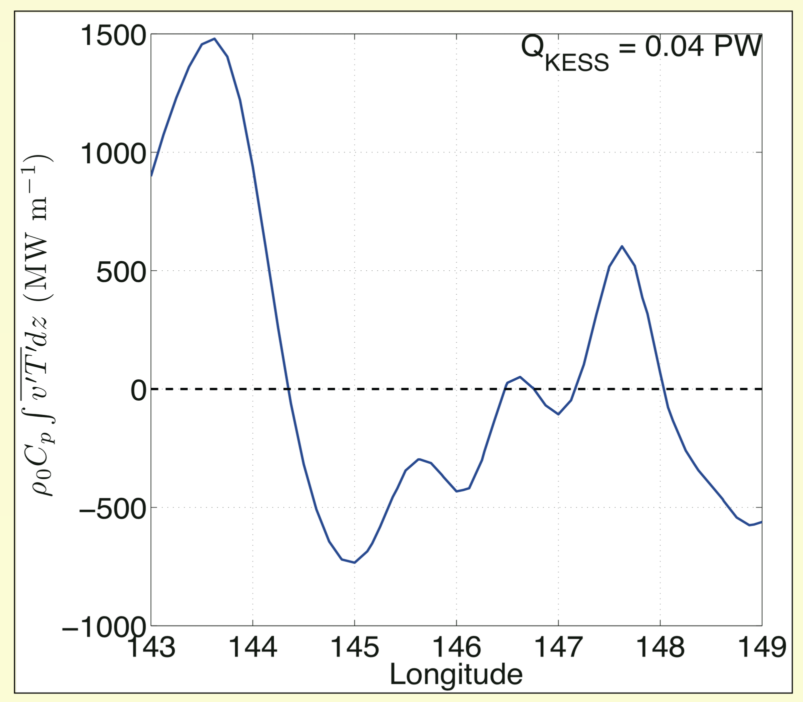


$$Q_{KESS} = \rho_0 C_p \int_{-H_2}^{-H_1} \int_0^L \overline{v'T'} \, dl dz$$

16 month mean meridional eddy heat flux across Kuroshio Extension axis (bold black contour figure to the left).

Integrated vertically (100-5000 m) and along the curved mean path (L ~ 700 km).





• The 16-month mean total meridional eddy heat flux (Q_{KESS}) is 0.04 PW.

• Q_{KESS} accounts for 40% of total in Kuroshio Extension region (O(0.1) PW, Qiu and Chen 2005).

• Q_{KESS} accounts for 27% of total in North Pacific at 36°N (0.15 PW, Volkov et al. 2008).

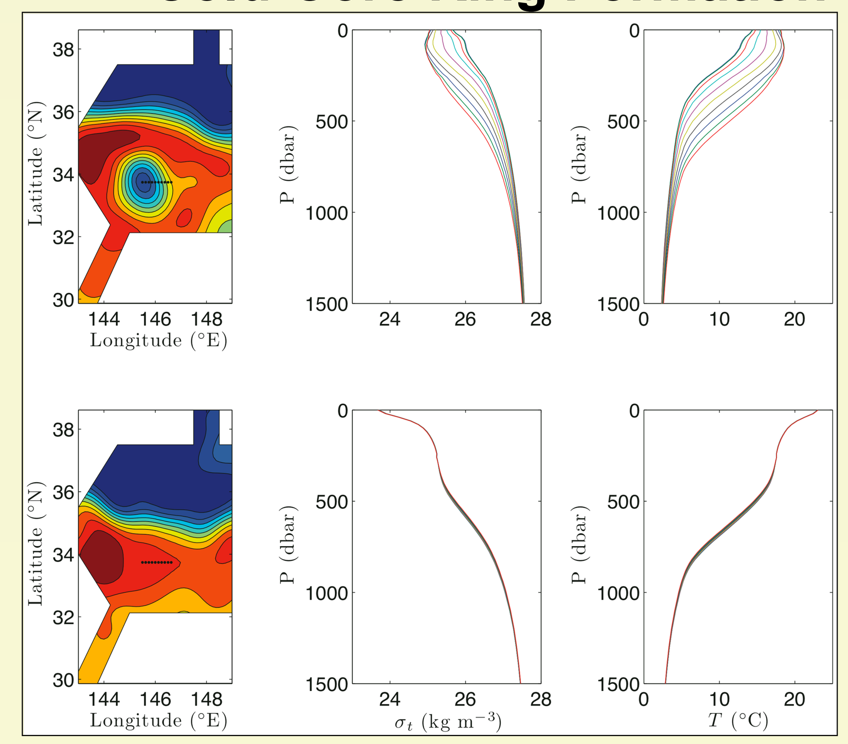
4. COLD-CORE RING HEAT FLUX

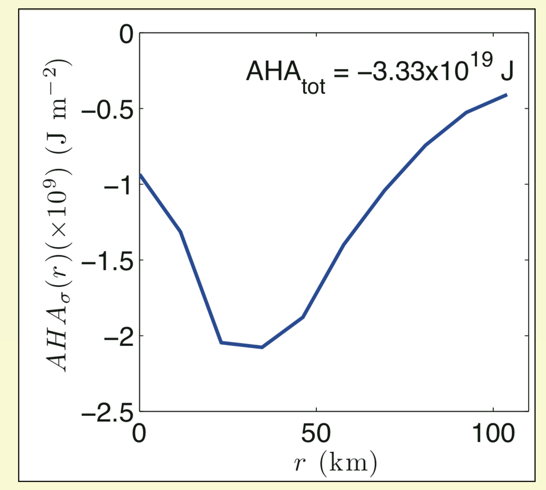
Available Heat Anomaly

$$AHA(r) = \rho_0 C_p h(r)[T_\sigma(r) - T_\sigma(ref)]$$

As defined in Morrow et al. 2004 JMR
h(r) thickness σ_t 26-27.6
T(r) vertical average of h(r) within ring
T(ref) vertical average of h(r) no ring

Cold-Core Ring Formation





Total Heat Anomaly

$$AHA_{tot} = 2\pi \int_0^R AHA(r) r dr$$

Assume ring is axisymmetric; AHA is integrated to the radius of max swirl speed (~80 km).

• Total heat anomaly associated with the cold-core ring is -3.33×10^{19} J

• During stable regimes (~1 ring per 4 years) Q_{ring} = 2.64×10^{-4} PW (<1% of Q_{KESS})

• During unstable regimes (~6 rings per 4 years) Q_{ring} = 15.8×10^{-4} PW (4% of Q_{KESS})

5. DISCUSSION & SUMMARY

* q magnitude is similar to other meandering jets, *e.g.*, Gulf Stream
* q values varied greatly, even changing sign along & across the Kuroshio
* q means are highly influenced by events
* Mapping a large region places the spatial & episodic heat flux variation in context
* Most of the eddy heat flux in KESS occurs leading into the first crest -- a substantial fraction of Pacific-wide flux at 36°N
* Cold-Core Rings account *on average* for a small fraction of the overall heat flux.