The circulation of the deep Bering Sea and exchanges with the North Pacific – a high-resolution model perspective

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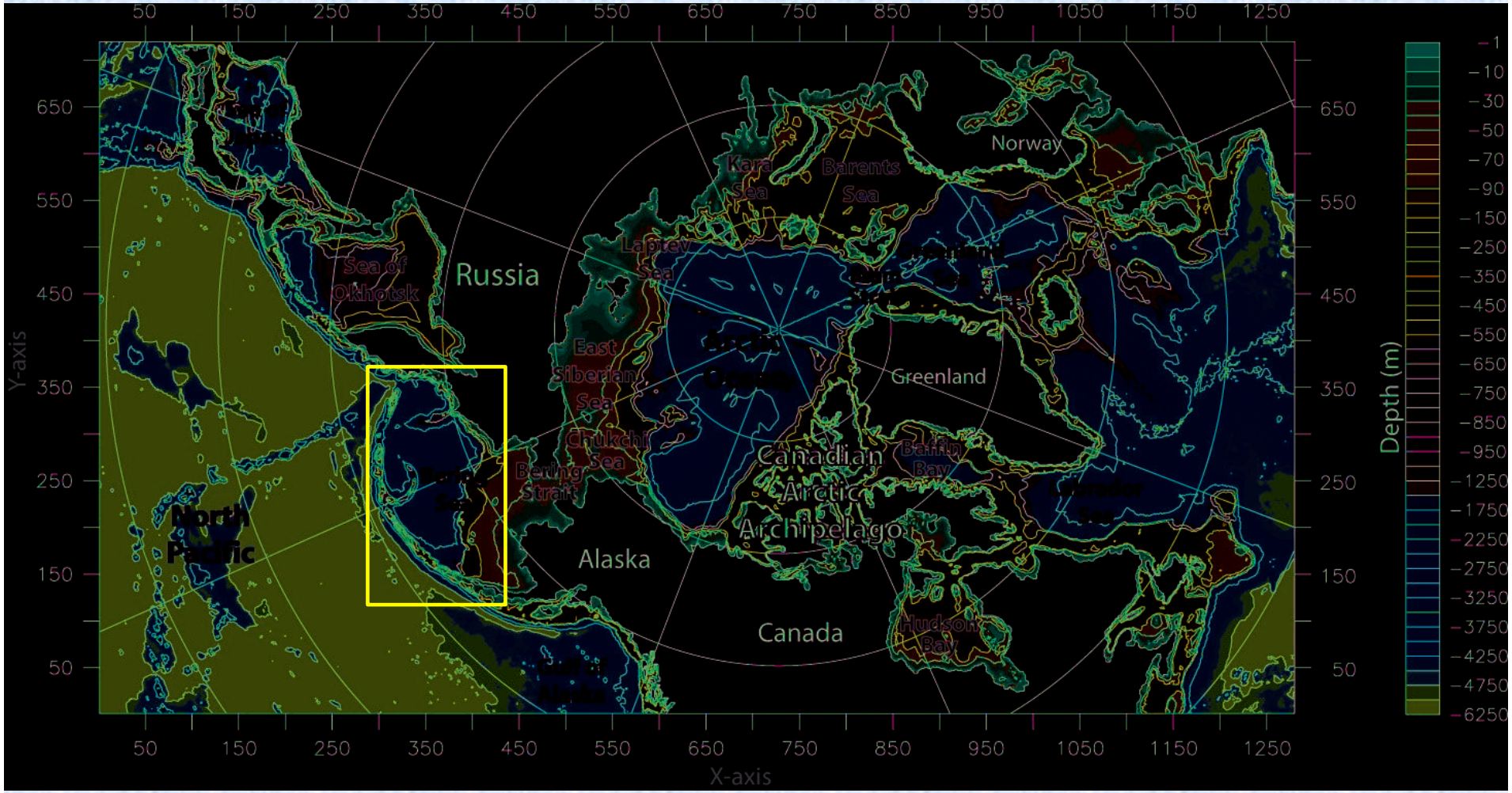
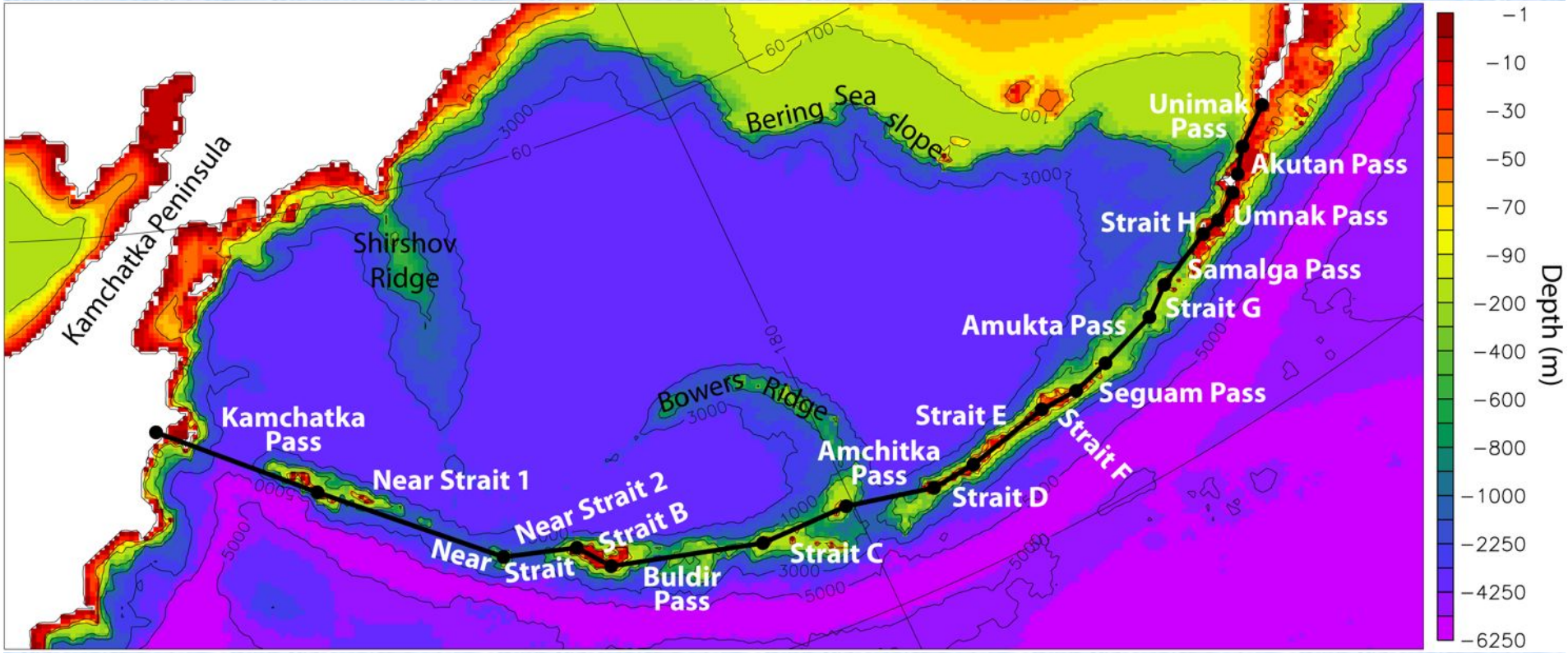
State of the Arctic, March 2010, Miami, Florida

1/12° ice-ocean model domain



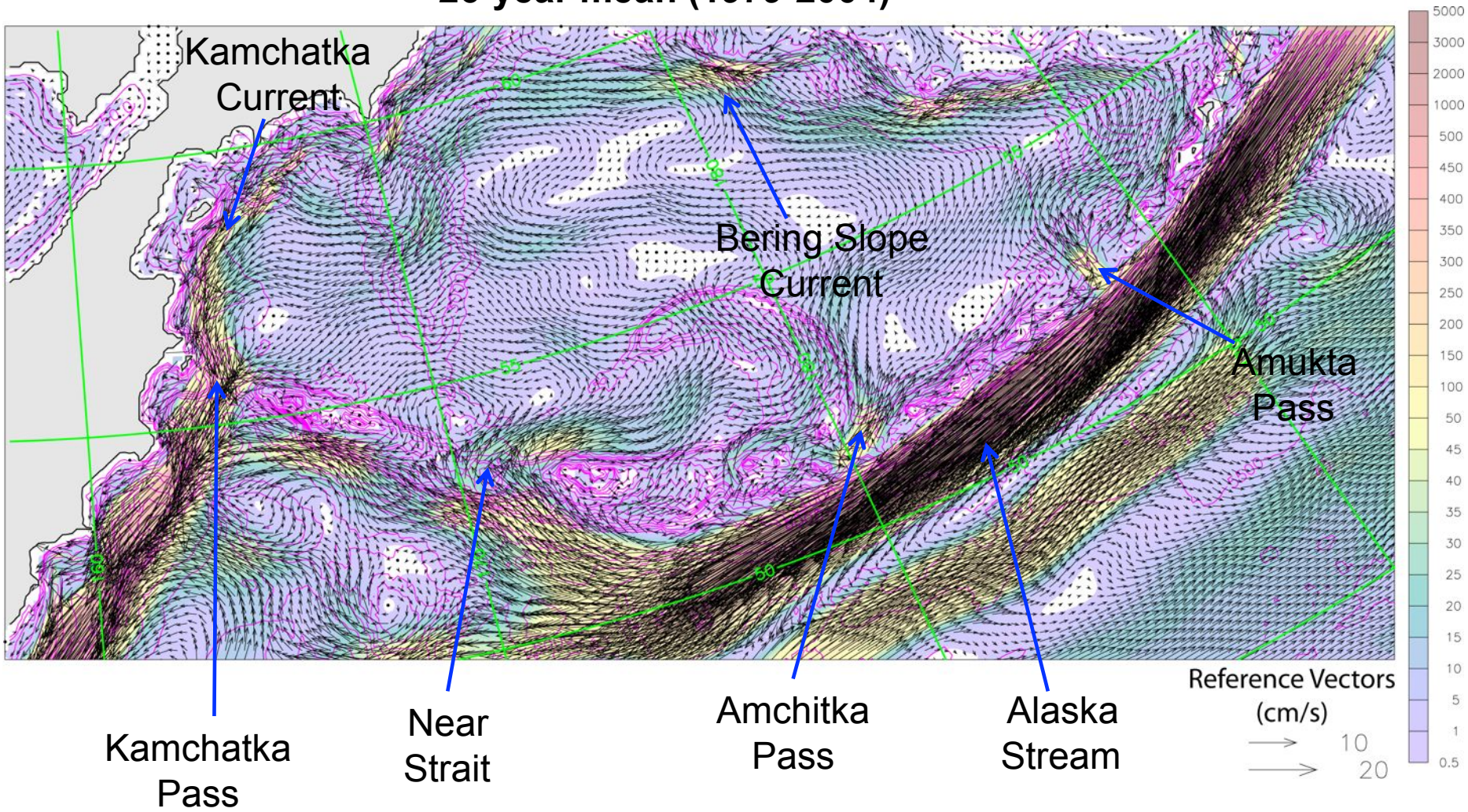
- ~9 km horizontal resolution, 45 vertical layers
- ECMWF daily atmospheric forcing
- integration from 1979-2004

Region of Interest
bathymetry and place names

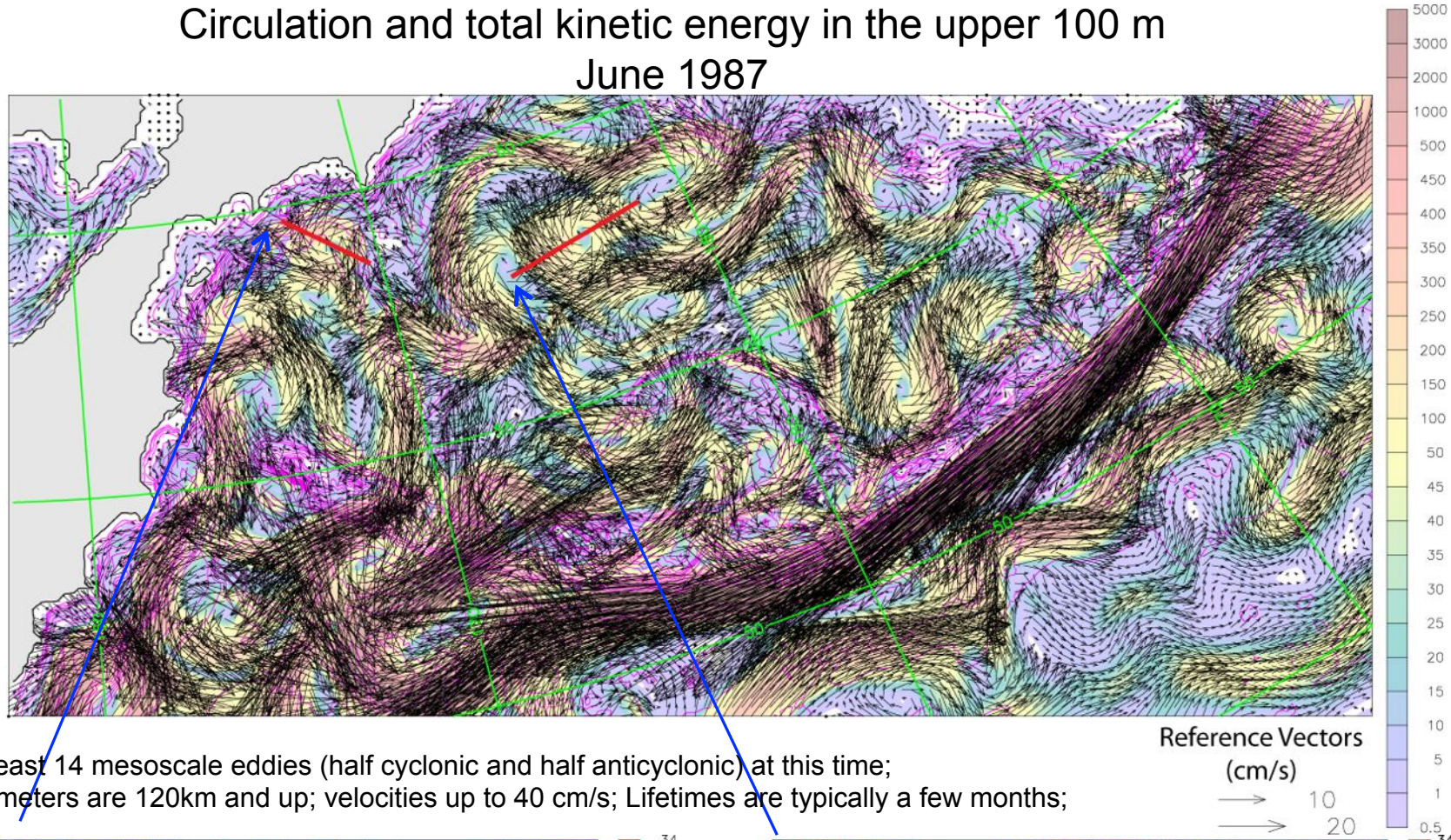


Circulation and total kinetic energy in the upper 100 m

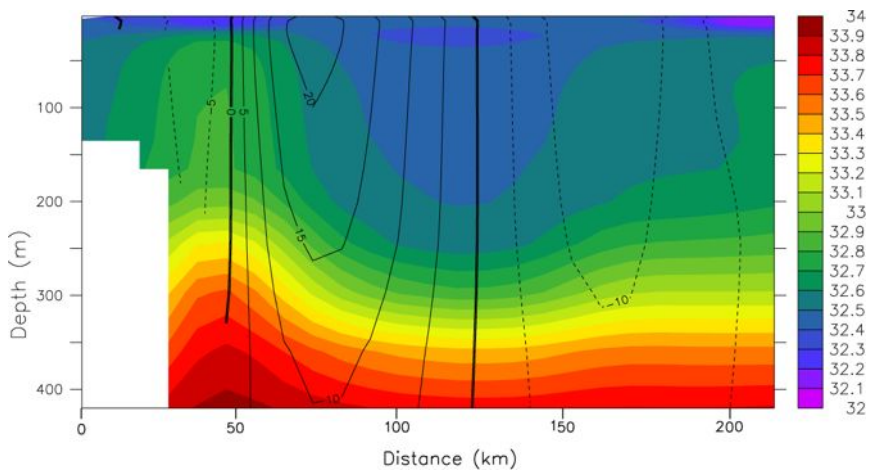
26-year mean (1979-2004)

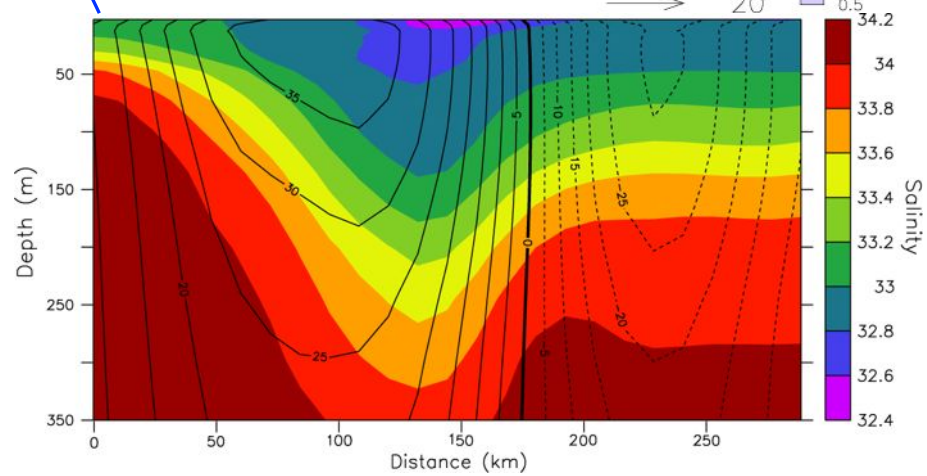


Circulation and total kinetic energy in the upper 100 m
June 1987



At least 14 mesoscale eddies (half cyclonic and half anticyclonic) at this time;
Diameters are 120km and up; velocities up to 40 cm/s; Lifetimes are typically a few months;



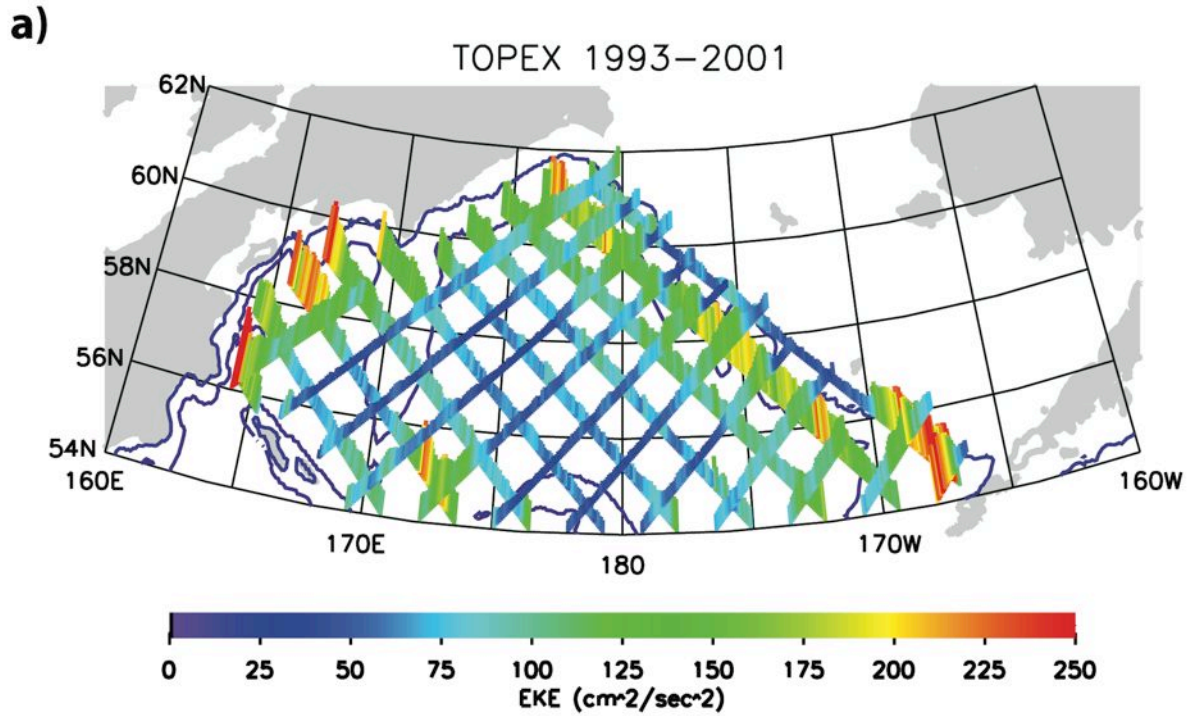


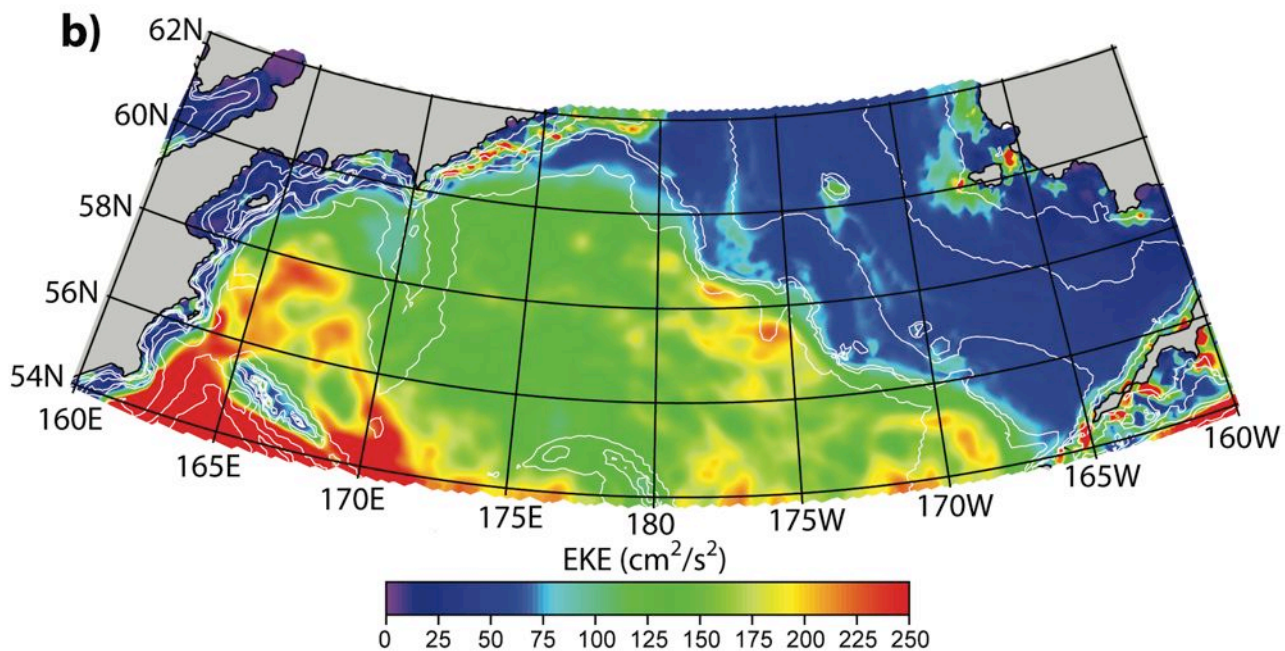
Eddy Kinetic Energy (1993-2001 10-daily mean)

- similar distributions for modeled and observed fields
  - TOPEX-derived estimates likely underestimate the true values because altimeter-derived velocities are computed from the along-track slope of SSHA

- low EKE in the basin interior

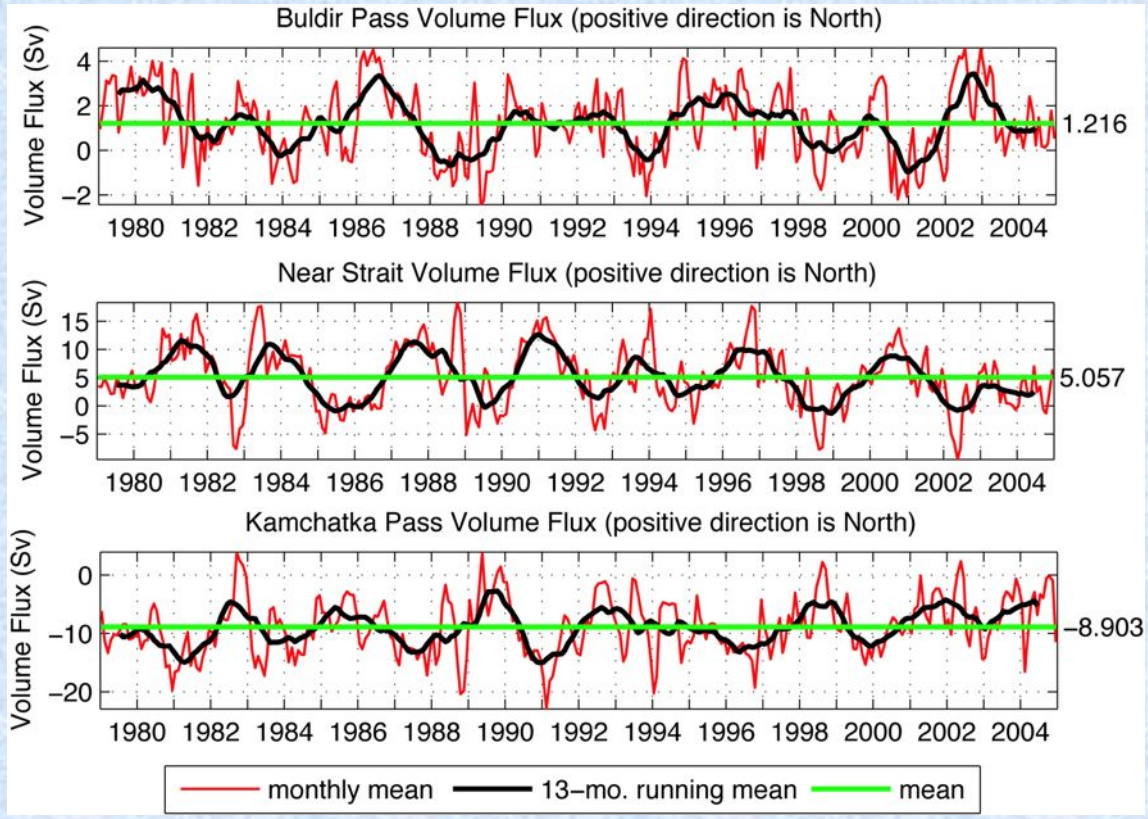
- high EKE along southern part of Kamchatka coast, along the shelf break, near Zhemchug Canyon





Monthly mean volume flux through large western passes

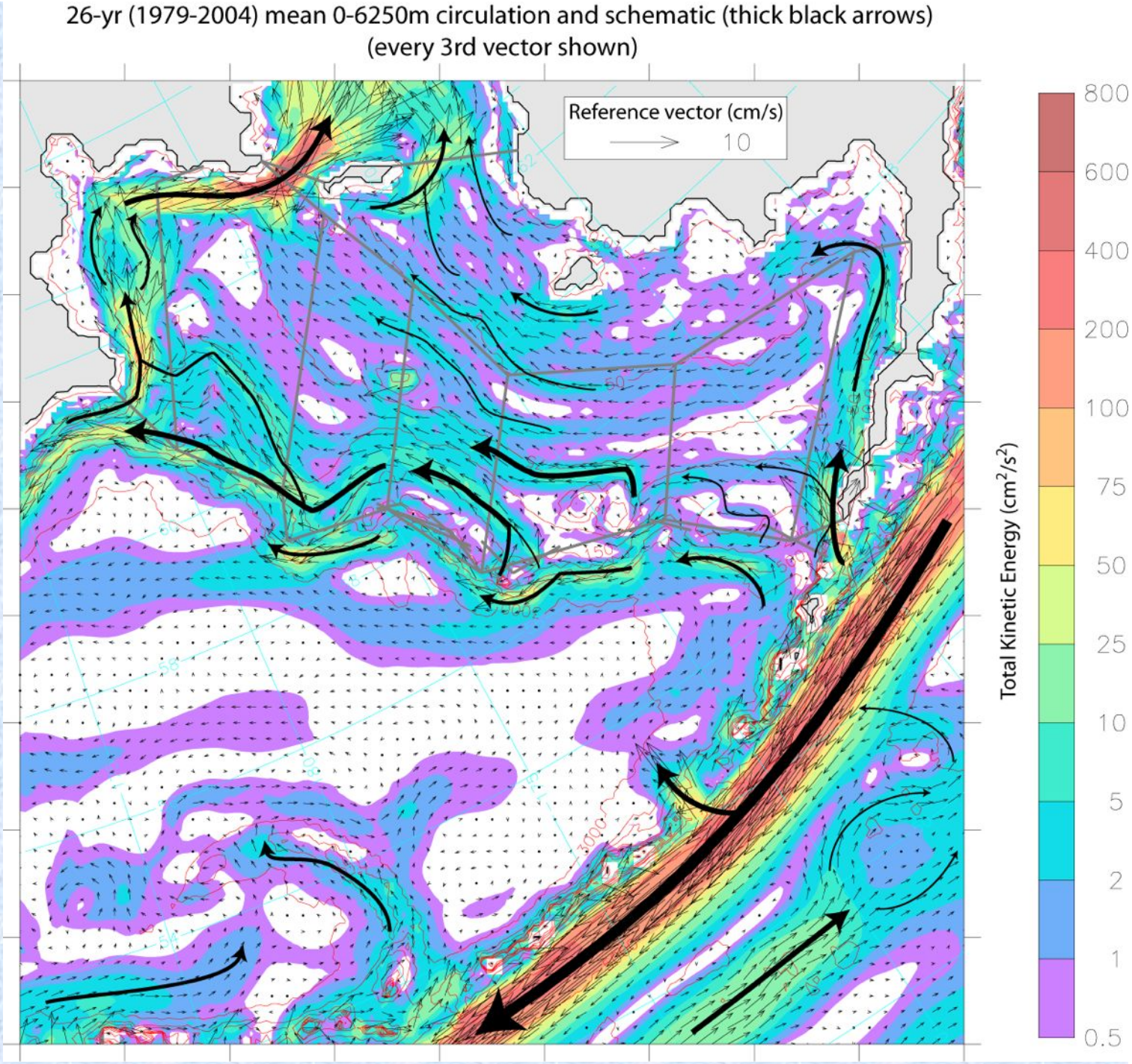
correlation coefficient (Near Strait and Kamchatka) = -0.77 for monthly means and -0.79 after removing annual cycle (both are significant at 1% level)



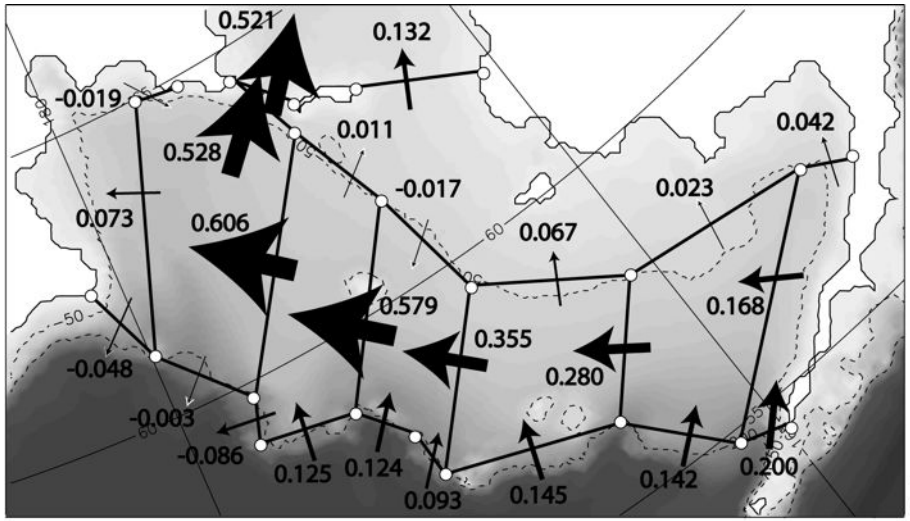
Pass/Strait	Buldir	Near	Kamchatka
Model	1.2	5.1	-8.9
Stabeno and Reed, 1993	~1	~5	-6.8 (Aug. 1991)
Arsen'ev, 1967; Ohtani, 1970, Huges et al. 1974, Favorite, 1974		3.7 - 26	
Verkhunov and Tkachenko, 1992			-11
Pantaleev et al., 2006 (summer only)			-24

Total Kinetic Energy

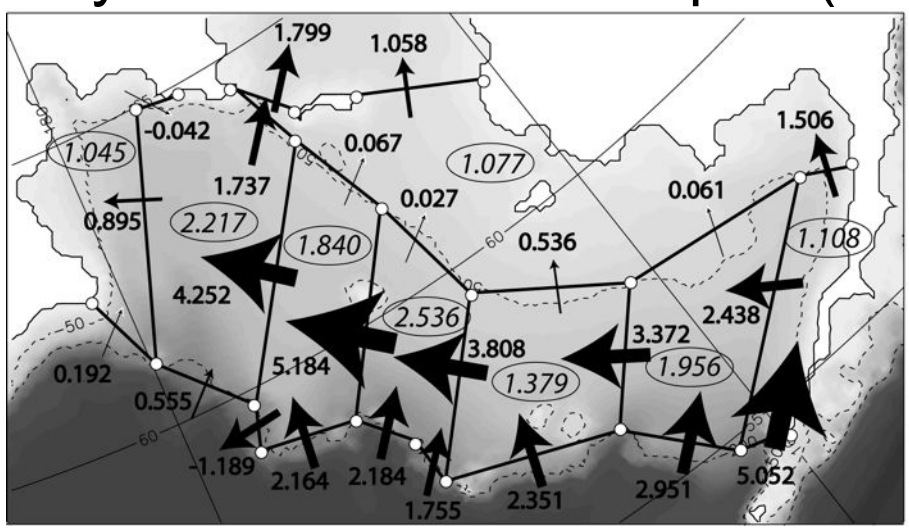
- long-term mean current speeds
- no North-South split of BSC at Cape Navarin
- observational support
- coastal current along Siberian coast

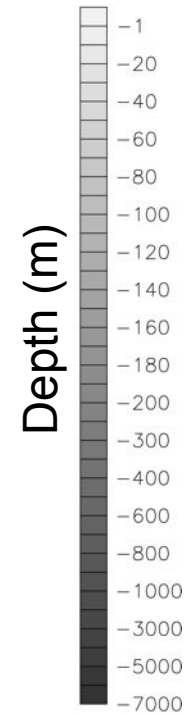


26-year mean volume transport (Sv)



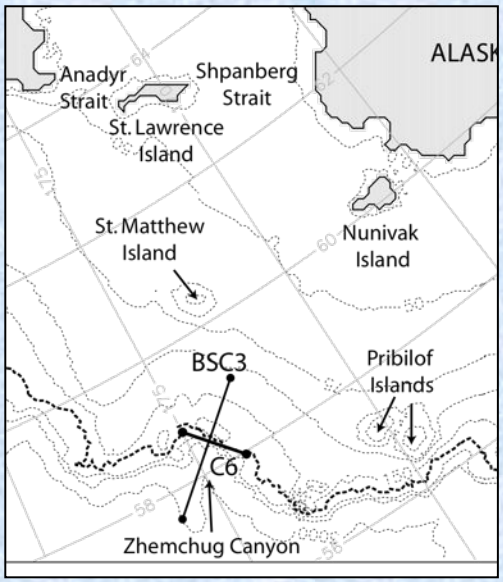
26-year mean heat transport (TW)

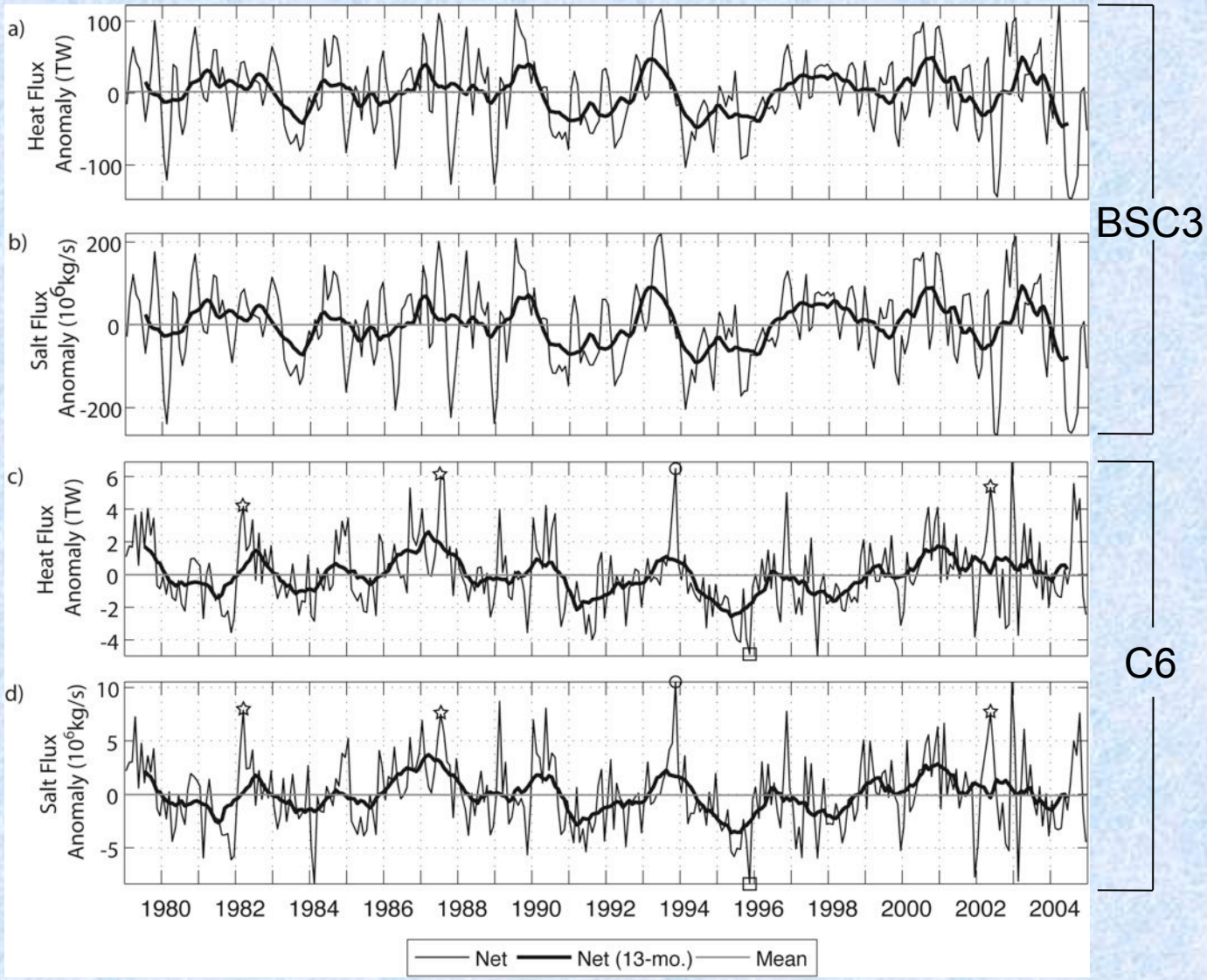




Across 200m isobath:	Across 50m isobath:	Across AS & SS:	Across Bering Strait:
19.1	3.9 (20.6%)	2.9 (15.0%)	2.4 (12.5%)

Time series of monthly mean heat (A, C) and salt (B, D) flux anomaly



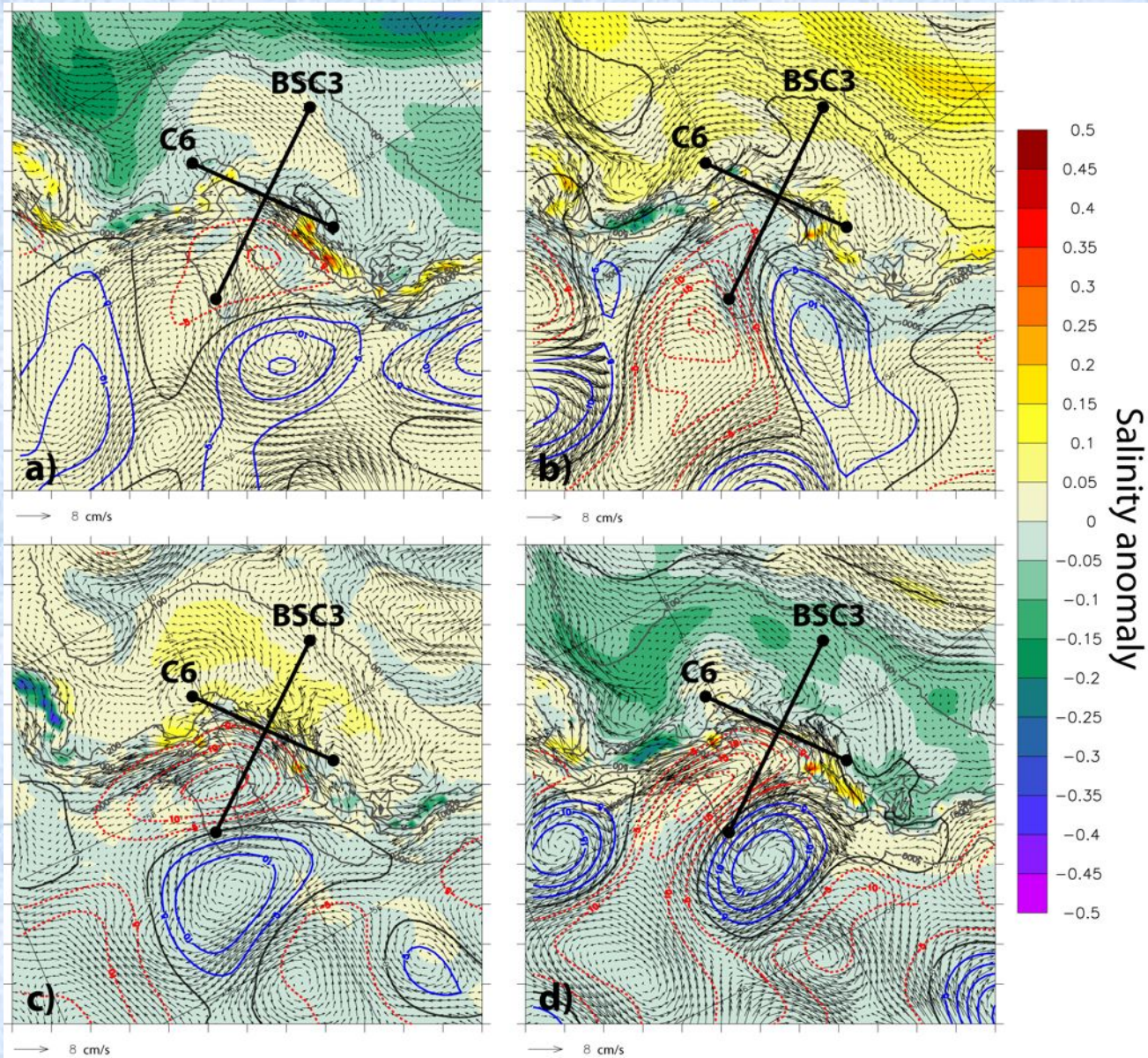


Time series of monthly mean heat (A, C) and salt (B, D) flux anomaly across BSC3 (A, B) and the Zhemchug Canyon section (C6; C, D). The thin black line represents monthly mean values, while the thick black line represents a 13-month running mean and the horizontal gray line represents zero. The circles and squares represent the salt and heat flux maximum (November 1993) and minimum (November 1995), respectively, through the Zhemchug Canyon. The stars represent local peaks in the heat and salt flux anomaly through the Zhemchug Canyon associated with eddies shown in the next slide.

Bottom-water salinity anomaly and SSHA near Zhemchug Canyon

4 time periods correspond to maxima in the time series of heat and salt fluxes across C6

associated with cyclonic eddies in the BSC

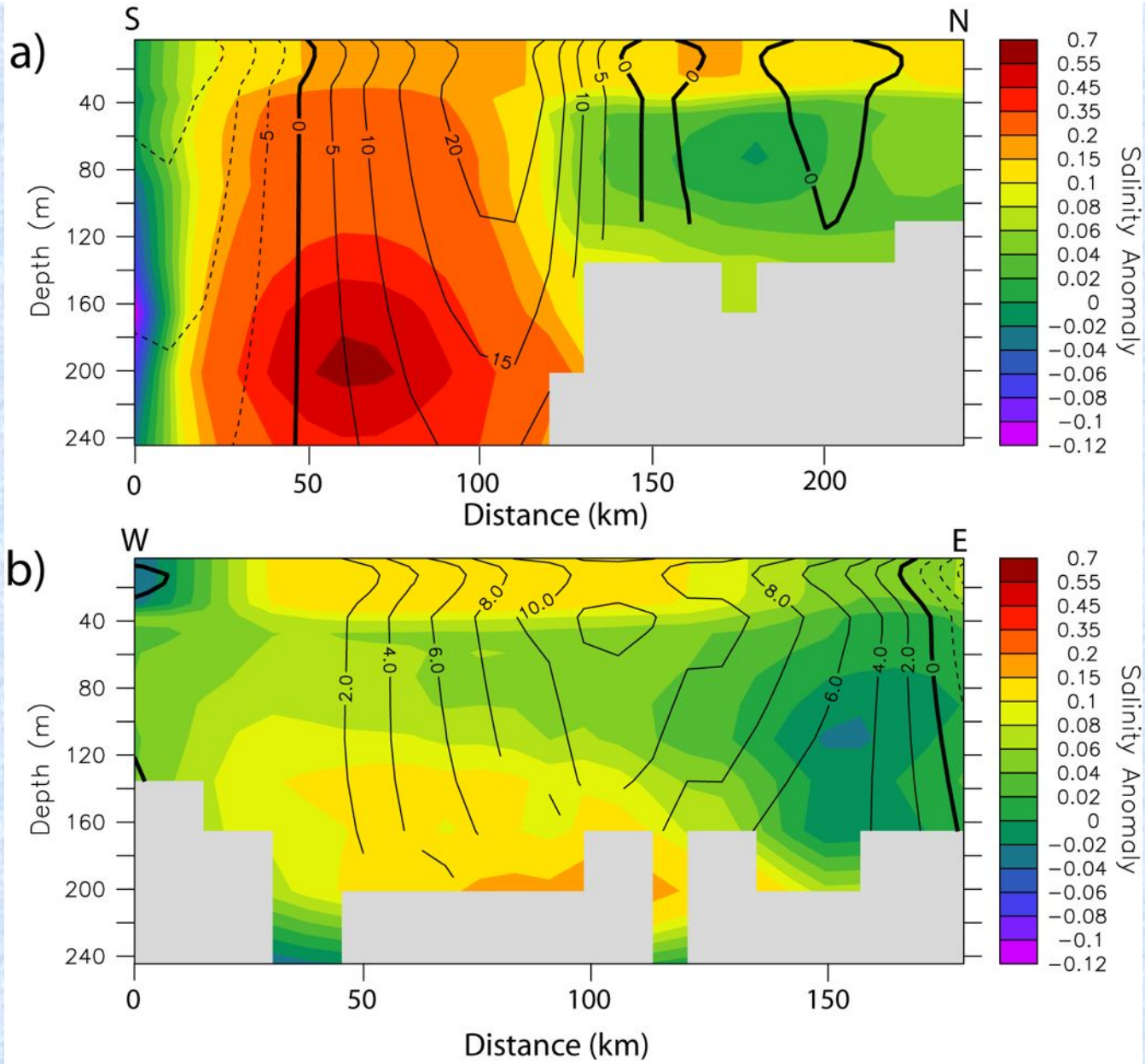


Bottom-water salinity anomaly and sea surface height anomaly contours (blue is positive and red is negative; contour interval of 5 cm) during (A) March 1982, (B) July 1987, (C) November 1993, and (D) May 2002 in the vicinity of the Zhemchug Canyon. The vectors represent monthly mean velocity over the entire water column during each respective month.

Cross-sections of salinity anomaly and velocity

- relatively salty water is upwelled onto the central Bering Sea shelf due to the cyclonic eddy

- could be important for nutrient concentrations on the shelf

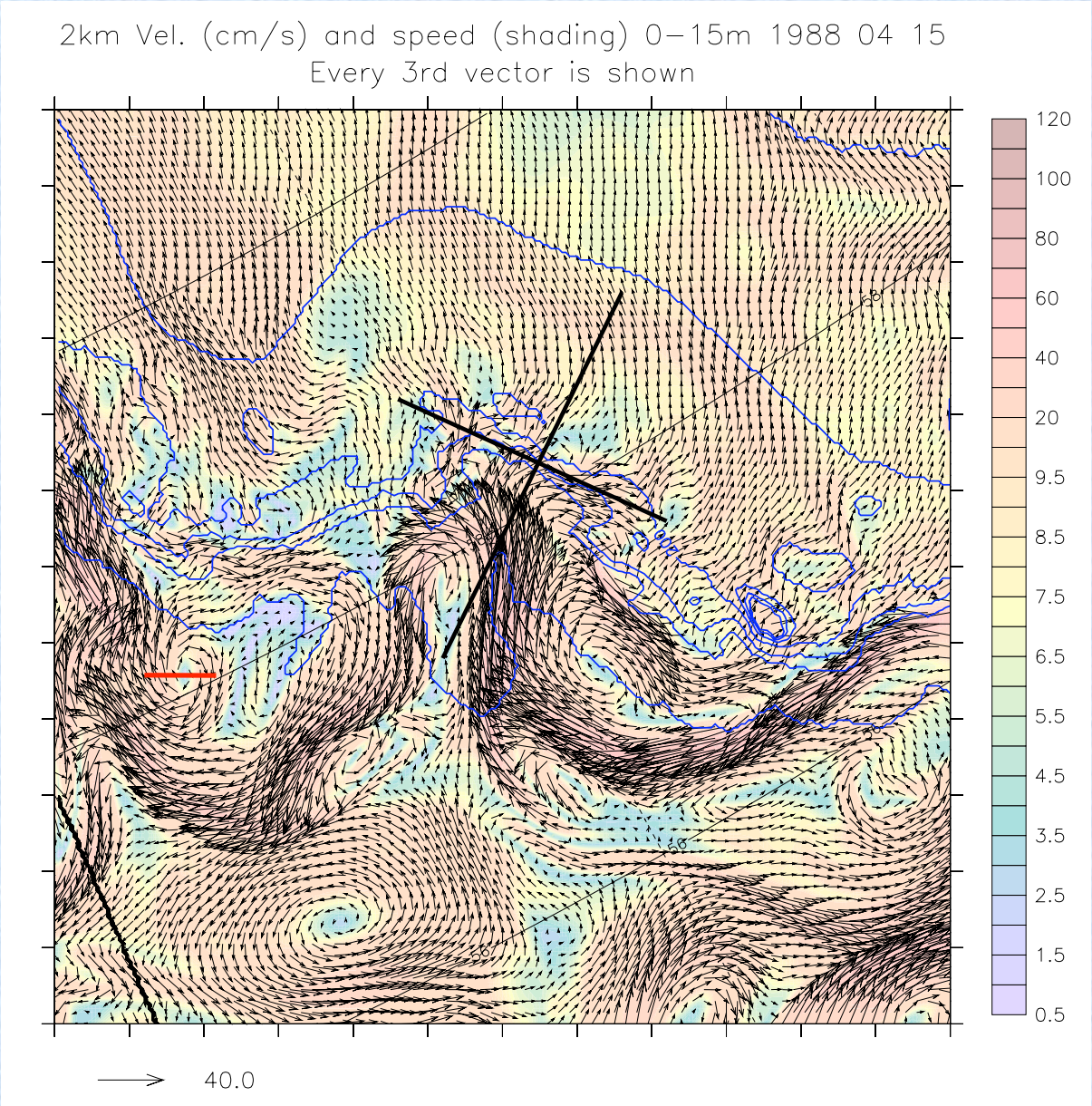


Vertical section of velocity (contours; cm/s) and salinity anomaly (shading) (A) along the Zhemchug Canyon (section BSC3) and (B) across the Zhemchug Canyon (section C6) during November 1993.

Results from the new 2-km model output

- eddies with smaller diameters are present (red line is 46 km)

- cyclonic feature is creating strong (up to 50 cm/s) cross-isobath flow onto the shelf at Zhemchug Canyon



Summary

• model realistically represents the circulation and exchanges between the northern North Pacific and the deep Bering Sea

• oceanic dynamics in this region are dominated by mesoscale circulation/eddies

• mesoscale features are important in shelf-basin exchange in the Bering Sea, especially in canyons

• those features will likely affect biological productivity via nutrient supply

• eddy-resolving models are necessary to account for:
  • narrow passages along Aleutian Islands
  • shelf-slope bathymetry (e.g. canyons)
  • mesoscale eddies and topographically-controlled flow

Clement Kinney et al., 2009 DSRII; Maslowski et al., 2008 JGR; Clement Kinney and Maslowski, 2008 Chinese Journal of Polar Science; Clement et al., 2005 DSRII; Maslowski et al., 2008, Ocean Modeling in an Eddying Regime, Geophysical Monograph Series, and Clement Kinney et al., in prep.

- Please see poster for more results -