Observational inferences of lateral eddy diffusivity in the halocline of the Beaufort Gyre

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Key points
- Eddy diffusivity in the Beaufort Gyre (BG) ranges from 100 – 500 m²/s near the surface, decaying rapidly with depth across the halocline
- Eddy-induced upwelling largely compensates downward Ekman pumping
- Lateral eddy diffusivity plays a zero-order role in the freshwater budget

Eddy diffusivity in the limit of vanishing residual mean

The 2003-2012 climatology of Ekman pumping (λ) (color) and geopotential height D computed from the 2003-2012 World Ocean Atlas climatology (black contours). Thick dashed lines show mean ice concentration.

Observations of Ekman pumping and isopycnal slopes

We then estimate horizontal eddy diffusivity from temperature, salinity and velocity profiles obtained from four Beaufort Gyre Observing System (BGOS) moorings. A mixing length framework is employed as described by Cole et al. (2015). The mixing length, 3, and horizontal diffusivity, KD, are estimated as:

\[ \lambda = \frac{\text{vertical stratification}}{\text{mean horizontal velocity}} \]

where 3 is the temperature along a density surface, u is the horizontal velocity vector, and 3 a mixing efficiency (Trenkle, 1972; Armi and Stommel, 1983; Naveira Garabato et al., 2011; Abernathey and Cessi, 2014). The mixing efficiency is taken to be 3 = 0.16 (Wunsch, 1999; Klocke and Abernathey, 2014). Primed quantities denote a fluctuation from the mean temperature and velocity. The mixing length at timescales larger than one year was removed. The timescales are chosen to exclude higher frequency variability primarily in the velocity observations, and to represent the mesoscale dynamics of the system. Overbar denotes a temporal average over all years. The spatial gradient of the mean temperature field, V\text{mean}z, is estimated along density surfaces from MIMOC

(Shmidt et al., 2013) at a 100 km scale. The calculations are performed independently on each density surface and for each mooring.

A range of mixing lengths, velocity fluctuations, and diffusivities were found at the four moorings. Mixing length values range from less than 50 to near 200 km. Velocity fluctuations decayed by more than a factor of two between 70° and 300 m in depth, and then remained constant at approximately 0.02 m/s. Both mixing length and velocity fluctuations are small in comparison to other regions (Cole et al., 2015).

Hydrographic section of potential density (referenced to the surface) at 75°N (see gray dash-dotted line in left panel), computed from the World Ocean Atlas climatology.

Eddy diffusivity inferred from the BG moorings


Profiles of (left) mixing length and (right) magnitude of velocity fluctuations. The black thick line denotes the mean among the four moorings.

References


