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Interactive comment on "Arctic Ocean geostrophic circulation 2003-2014" *by* Thomas W. K. Armitage et al.

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I would like to make a comment on the importance of the derived eddy kinetic energy (EKE).

While capturing only large-scale eddies, the EKE estimates provide first-of-a-kind global evidence of eddy variability on a gyre-scale, which makes it a crucial dataset for the advancement of our understanding of BG and freshwater variability.

A recently developed theory explicitly links FWC, halocline depth, and geostrophic currents to eddy dynamics. In particular, Manucharyan and Spall 2016 suggest that lateral freshwater fluxes due to eddies are counteracting the Ekman-driven freshwater accumulation. As a result, a characteristic isopycnal slope, s, that is linearly proportional to geostrophic currents and should scale as

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Discussion paper

$s \sim tau / (rho\ f\ K)$, (1)

where tau is the surface stress, rho - density of the ocean, f - Coriolis parameter, and K is the isopycnal eddy diffusivity. Idealized BG simulations suggest that a realistic halocline can be achieved if K is in a range of 100–500mˆ2/s, with lower values in the interior of the gyre and higher values near its coastal boundaries (see Figure 3a in Manucharyan et al, 2016). However, due to the scarcity of data, we currently lack global observational evidence to confirm these values of diffusivities, thus leaving the theory as a hypothesis.

Nonetheless, eddy diffusivity parameter K can be estimated based on a mixing length theory that has been tested in other world oceans (Holloway, 1986). In particular, Klocker and Abernathey (2014) suggest an unsuppressed eddy diffusivity can be calculated as

K=gamma u_rms Lmix, (2)

where Lmix is the mixing length that is of the order of the Rossby deformation radius Rd, the characteristic eddy velocity u_rms is taken as u_rms=sqrt(EKE), and gamma$\sim$0.35 is an empirically estimated efficiency coefficient that stays nearly constant for a wide range of flows. For the sake of making a rough estimate the diffusivity (and compare it to idealized simulations), (2) can be rewritten as

K=0.35 sqrt(EKE) Rd. (3)

Estimating sqrt(EKE) at about 0.1 m/s near coastal boundaries and about 0.05 m/s in the interior of the gyre (Figure 7 of the manuscript under review), we find that these values are consistent with idealizes BG simulations (see Figure 2b in Manucharyan et al, 2017). Taking Rd = 15 km in the BG (Nurser and Bacon, 2014), and using Eq. (3) we get the following range for K = 250–500 mˆ2/s which are also consistent with idealized BG simulations of Manucharyan et al, 2016 (see Figure 3a).

Note, that because of the limitation of constructing under-ice SSH data, the satellite

EKE estimates capture only large scale eddies. However, in the Arctic Ocean, a significant inverse cascade is expected to occur based on f-plain geostrophic turbulence theory (Larichev and Held, 1995). It is also expected that eddies with scales much larger than the local deformation radius should be dominant contributing to eddy buoyancy fluxes (see Figure 1 in Larichev and Held, 1995). This view is consistent with the idealized simulations of Manucharyan and Spall (2016) that resulted in eddies that are about 100km in scale.

In conclusion, the satellite EKE and K estimates based on large-scale variability could be adequate, and present a foundation for adjusting these values in climate models to improve the mean state and variability of the Beaufort Gyre.

It would be beneficial for the Arctic observational and modeling community if the authors comment in their manuscript on the relation between geostrophic currents and eddy dynamics.

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