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Interactive
Comment

Interactive comment on "Inferring the zonal distribution of measured changes in the meridional overturning circulation" *by* A. M. de Boer and H. L. Johnson

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In this note, the authors seek to provide an alternative interpretation to the recent results of Bryden et al (henceforth BLC) published in Nature. A critical argument in their comment is that the geostrophic assumption made by BLC implies Sverdrup balance in the linear part of the meridional section considered by the authors. I would be comfortable with this assertion if one could assume the flow to be steady, but obviously, the whole point of BLC's study is to address transient variations in the MOC, which suggests that one should also make sure that in discussing BLC's results, such possible transient effects are not overlooked. Evidence for transient effects is evident in the data, as attested by the large variations in isopycnal depths found by BLC over time. Furthermore, another important issue in interpreting BLC's results that has been raised by many scientists is whether they could be contaminated by seasonal and interannual variability; for instance, some scientists at NOCS have suggested a possible role for baroclinic Rossby waves. As is well-known, such waves are geostrophic at leading order, and therefore consistent with BLC's assumptions, but obviously they are not in Sverdrup balance. The vorticity balance for such waves is

$$\nabla \cdot (fu) + \partial_t \omega = 0 \tag{1}$$

where f is the Coriolis parameter, u is the horizontal velocity field, and ω is the relative vorcity of the waves. The vorticity balance is obviously linear, and therefore should hold in the linear regions of the meridional section. In classical QG theory, one can approximate the relative vorticity in terms of the pressure field P as follows:

$$\omega \approx \frac{1}{\rho_0 f} \Delta P \tag{2}$$

where ρ_0 is the reference density made in the Boussinesq approximation. It follows that the vorticity balance can therefore be written, using classical arguments,

$$-f \frac{\partial w}{\partial z} + \beta v + \frac{1}{\rho_0 f} \Delta P_t = 0 \tag{3}$$

which reduces to the classical Sverdrup balance discussed by the authors in the case where $P_t = 0$. Integrating this equation over depth, between the level of no motion and the basis of the Ekman layer, as done by the authors, one finds that:

$$-f w_E + \beta V_g + \frac{1}{\rho_0 f} \int_{z_r}^{0} \Delta P_t dz \tag{4}$$

so that their equation (4) becomes in fact:

$$V_g = \frac{f w_E}{\beta} - \frac{1}{\rho_0 \beta f} \int_{z_r}^{0} \Delta P_t dz \tag{5}$$

According to this equation, one sees that the geostrophic transport no longer depends solely on the wind stress, and that there remains a possibility for V_G to vary over time even if the wind does not, especially given that the meridional sections considered by BLC should be regarded as snapshots in time. I believe therefore that the authors should at least discuss the above possibility in interpreting BLC's results, which suggests that changes in the MOC are not necessarily to be related only to change in the western boundary currents.

Interactive comment on Ocean Sci. Discuss., 3, 1653, 2006.