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Interactive comment on "Variability of the transport of anthropogenic CO_2 at the Greenland–Portugal OVIDE section: controlling mechanisms" *by* P. Zunino et al.

Anonymous Referee #2

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This study uses the transport calculations along the OVIDE section by Mercier et al. 2013 to infer transport rates of anthropogenic carbon. The same method has been applied in Perez et al. (2013) to a subset of the data. Here, all realizations of the OVIDE section are used, and the role and importance of the MOC (diapycnal component) and the isopycnal component of the Cant transport are investigated. The paper clearly deserves to be published in Biogeosciences after appropriate revision.

General comments:

At a first glance, the method with the division of the transport into a net, iso- and diapycnal component seems to be reasonable. If looking at the details, however, I am not so

convinced whether this approach is really optimal for the inetrpretation of Cant transports. My objections are the following: For calculating the MOC, the use of isopycnal coordintes is probably the best one can do. Things become different when looking at the so called isopycnal component: In the paper by Böning and Herrmann (1994), this component was defined in z-coordinates and interpreted as a 'gyre' component. This means for the case of the OVIDE section, that warm and Cant rich surface water is transported northward with the North Atlantic Current (NAC), whereas in the Irminger Sea cold and Cant rich surface water is transported southwards. The surface waters of the Irminger Sea have higher densities than the surface waters within NAC. Thus, when using isopycnal coordinates, the northward Cant transport related to the NAC occurs completely in the diapycnal (overturning) component (Fig. 5C), whereas the southward transport related with the surface waters of the Irminger Sea occurs in the isopycnal component (Fig. 4C). This means that horizontal and isopycnal transports are not the same, which the authors do not seem to be aware of (e.g. p.16105, l. 21, 'the horizontal or isopycnal transport ...').

Another result of the decomposition of the Cant flux is the large northward diapycnal flux in the overflow waters, contrasted by a large southward isopycnal component. The high value if TCant_diap for the deep waters are the result of a negative value of <v> (the southward flow of overflow waters mainly over the nothwestern part of the OVIDE section) combined with a negative valu of <Cant> in the deep waters. The authors state that the overflow waters at 60°N are poor in Cant because of entrainment/dilution (p. 16113, l. 25). However, for me it seems that the negatie value of <Cant> in the deeep waters is mainly caused by the old AABW in the eastern part of the section, whereas the overflow waters in the northwestern part have intermediate Cant values (see Fig.2). This means, that the (western) core of negative velocities and the (eastern) core of negative Cant anomalies are not colocated, and the large positive value of <Cant><v> for the deep waters is just an artefact. This artefact is compensated by the large negative value of Tcant_isop for the deep waters, so the total transport is correct. In the light of this, one cannot simply interprete the term Tcant_diap as 'transport of Cant linked to the diapycnal circulation that accounts for the light to dense water mass conversion' (p. 16110, l. 4), as the overflow waters, which form the lower limb of the diapycnal circulation, clearly transport Cant southward (i.e. TCant_diap for the overflow waters should be negative), but here they have a positive contribution to TCant_diap due to the above mentioned reasons. (For the heat transport, this effect is much smaller, as the temperature difference between overflow waters and old AABW is relatively small in contrast to their large difference in Cant concentration). In the paper by Mercier et al. (2013), a similar decomposition is done for the heat flux, but there the potential temperature is only devided into two compnents, <theta> and theta', there is no theta0 substracted. If Cant would also only be decomposed into <Cant> and Cant' without substracting Cant0, <Cant> would be positive everywhere, and TCant_diap for the overflow waters would become negative. I would strongly recommend to redo the calculation of TCant_diap and TCant_isop without the substraction of Cant0.

Role of Tnet

The authors mention in the paper a northward volume transport of about 1 Sv over the OVIDE section (p. 16110, l. 2). The paper by Mercier et al. (2013) gives numbers between 2.2 Sv and -0.3 Sv, and these values seem to be used in this work. Otherwise the variability of TCant_net shown in Fig. 3 would not pe possible. This variablity of TCant_net of about 50 kmol/s is not neglible compared to the variability of the total transport of Cant (between 200 kmol/s and 400 kmol/s), but it is almost not mentioned in the paper. Another concern is, how reliable the estimations of Tnet are. Lherminier et al. (2004) give a value of 0.1 +- 2.5 Sv for the net volume transport ofer the OVIDE section in 2004. If this error is applicable to all realizations of the section, all net transports are not significantly different from zero.

Variability of MOC on shorter time scales

The paper by Mercier at al.(2013) constructs a MOC index from altimetry and ARGO, and this MOC index has a seasonal amplitude of 4.3 Sv. Given that, how characteristic

are the Cant fluxes calculated in this paper for the period between the cruises? A discussion of that topic is completely missing.

Specific comments

p. 16109, l.5

it is not mentioned that V0 and Cant0 have to be substracted before calculating <v> and <Cant>.

p. 16109, l. 10, Eq.(4)

The overbar over 'rhoV0Cant0' is missing.

p. 16112, l. 21-23

'... on a given isopycnal in the WEB and the IAP, the surface layers are less rich in Cant than in the Irminger Sea (Fig.2).' This is somehow misleading, as the surface waters in the eastern part have even higher Cant values than in the Irminger Sea. The surface waters in the Irminger Sea have the same density as intermediate waters further east, and these are indeed lower in Cant, but this is not a comparison between surface waters. This is more correctly formulates in the discussion section (p. 16119, l. 8-10).

p. 16113, l. 4/5 and l. 24-28

in l.4/5 it is stated that the waters (in the Irminger Sea) of the upper and lower lobe have a high concentration of Cant. In l. 24-28, about the waters of the lower lobe the opposite is said, i.e 'these deep and bottom waters are quite diluted when arriving at 60°N, ... resulting in a negative Cant anomaly'. In my opinion the deep waters in the Irminger Sea have an intermediate Cant concentration, i.e. lower than the surface waters, but higher than the old AABW in the eastern part of the OVIDE section, see my general comments.

p. 16119, l. 11-14

'... supporting the idea that deep convection in the Irminger Sea (Bacon et al. 2003; Pickart et al. 2003) reached depths down to 1000 - 1500 m in the 2000s.' Both cited publications deal with data from the 1990s, so their results belong to the 1990s, not to the 2000s.

p. 16119, l. 18

Why does the LSW yield a minor contribution to the TCant_isop? In my opinion the main reason is the fact that the main formation area of LSW, the Labrador Sea, is south of the OVIDE section. A net northward flow of LSW over the OVIDE line cannot penetrate over the sills to the Nordic Seas, so this Cant has to be stored in the area between the OVIDE line and the sills towards the Nordic Seas. Obviously, this storage rate is not very large.

'the Tcant' is often written in the paper; I would use Tcant without article (but I am not a native speaker).

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