

Ocean Sci. Discuss., referee comment RC1
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Comment on os-2021-60

Hjálmar Hátún (Referee)

Referee comment on "Weakening and warming of the European Slope Current since the late 1990s attributed to basin-scale density changes" by Matthew Clark et al., Ocean Sci. Discuss., <https://doi.org/10.5194/os-2021-60-RC1>, 2021

Review: Clark et al., 2021

I will upfront reveal my identity (my name is Hjálmar Hátún). I have been thinking/writing about topics associated with the material presented in this paper, and my comments will (naturally) be subjective. I will even refer to some of our papers (although I do not know if a reviewer is supposed to do this).

General impression

This is a nice study, and trying to determine the effect of a changing North Atlantic on the Slope Current is an interesting and important theme. It is timely to address the overlooked topic.

I therefore think it is a pity that large potentials are unused here, and I will be frank and start by suggesting some major adjustments. And I will not provide a detailed review at this first stage, but would be happy to do this at a later stage.

The discussion on eastward flows in the North Atlantic Current has a long history (which the present study does not appear to acknowledge). Already in 2002, Pingree (2002) linked this to the meridional gradient in sea surface height (SSH), as revealed by satellite altimetry. He discussed increased SSH gradient/transport during NAO+ years (e.g. 1994-1995 and 1999-2000). He (and a large volume of following literature) has

associated such interannual changes to the NAO index and variability in the wind stress curl field over the NE Atlantic.

After this, SSH data (observed and simulated) have been utilized by myself and many others, to discuss this dynamics in a broad and longer context (Hátún and Chafik, 2018, and reference therein). For example is the calculation of the so-called gyre index closely linked to variability mentioned by Pingree (2002), and likely to your eastward transport records based on hydrography. Your analysis on these transports is interesting, and does provide new information/knowledge. Just try to better weave it into the existing volume of knowledge. This includes paying more attention to the interannual fluctuations that you present (Figure 6 and 7). Your study is clearly motivated by identifying drivers behind ecosystem fluctuations along the European continental slope (ECS). We have previously linked these pulses to many ecological aspects in the NE Atlantic (e.g. Hátún et al., 2017, 2016; Jacobsen et al., 2019), and a growing body of evidence shows that this type of variability does also characterize the ECS (Pätsch et al., 2020). You have the evidence, utilize it better.

Garcia-Soto et al. (2002) and Pingree (2002) discuss the conditions along the ECS in relation to the relatively narrow slope currents from the south (Bay of Biscay). This topic should be better handled in your work. For example does Pingree (2002) claim that the North Atlantic Current strength and the mentioned poleward flow are out of phase. Weak NAC (aka NAO-) is related to stronger flow of warm and saline waters from Spanish waters – also referred to as Navidad events/years (Garcia-soto, 2002). This seems to be at odd with your perspective (although I follow your argument that NAC waters are being continuously recruited to the slope, north of the Porcupine Bank). This aspect must be better handled.

I will below suggest some more specific changes to your work. If you are will to roughly follow this path, I can provide a more detailed review during the next round.

Fig. 1 does nice illustrate the entrainment of water to the boundary north of Ireland, and no northward bound boundary current south of the Porcupine Bank. Your particle tracking figures, however, suggest near-slope patterns further south. Would velocity quiver maps on a shallower level maybe reveal any influx from the Bay of Biscay?

Figs. 2-4:

You can state the association between T and S, and the tight linkage between T and SSH in the text, and only show the density field (Fig. 4). The T-S-density relations are well known between oceanographers, and the T and S figures are not strictly needed. And as suggested below, provide a better figure, which includes a relevant geographic domain, and averages over relevant periods.

I would also include altimetry data here. It would (i) validate the chosen in situ hydrography data product, (ii) produce an independent eastward transport record, and (iii) enable you to put your analysis in much better context – and link to the existing literature.

I would only show the GODAS-based Hovmöller diagram in Fig. 5. You say that there is mutual agreement between the GODAS-based and the EN4-based. I think there are large differences between them (although basic major features are comparable). You also describe some limitations with the EN4 dataset (pages 10 and 11). And my impression of the hydrographic signal at $\sim 60^\circ\text{N}$ (which is based on many years of experience and many data sources), is that the GODAS product probably is more reliable for your purpose. Suggestion, skip EN4. It would enable you to produce a clearer figure, and convey a clearer message.

I would merge Figures 6 and 7 into one two-panel figure with the GODAS-based time series. It is reassuring that the EN4-based series show similar variability, and this could be mentioned with words/correlations.

It is good to see the transport change in T-S space (Fig. 8). You could, however, zoom in on a narrower TS window, which would enable a better/clearer figure. The TS-transport figure based on ORCA12 (Fig. 9) is actually very different from the GODAS-based figure (Fig. 8). GODAS shows a major decrease around $5\text{--}6^\circ\text{C}$, 35.0 (which must be close to Subpolar Mode Water), which is not reproduced by the ORCA model. Suggestion: Stick to GODAS – skip Fig. 9.

Fig. 10. Yes the transports are much larger at the northern section (admixture of NAC-derived water, right?), and there is a somewhat worrisome decline in this transport (in line 255, you mention an almost-steady northward transport of 2 Sv after 1995, while I see a continuing decline, also after 1995). While I guess that you already have tested this thoroughly, are you still confident that you capture the entire slope current, with this model extraction? If yes, which current is then presently feeding the Faroe-Shetland Channel?

The results from your particle tracking analyses are nice. Keep.

I hope that I have been too frank. I really hope that your work will become a part of the literature, because it is needed. If you (and the editor) think that my suggestions are too drastic, I would be ok with being revoked as an editor. Otherwise, I look forward to reading a reworked version J

Figures

(I wrote this, before the text above. You can maybe use it as guidance)

Figure 1: Remove the header "Velocity quiver at 245 m" from each panel, and this common information in the caption. Remove the y-axis information on the right panels, and the x-axis information/labels in the upper panels, enlarge each panel, which removes too much void space between them.

Figures 2-4: Remove " S/T/density decadal mean anomaly, and "205 m" from each title. This information is already in the caption.

You lose out in insight and smear out valuable signal, by strictly averaging over these decades. For example, the 1990s was a contrasting period, with dense waters until the mid-1990s, and much warmer/lighter waters after. The average over these contrasting states is not so meaningful. I am aware of our wish to stay objective, but you have explainable reasons for selecting contrasting periods (e.g. early 1990s and early 2000s), in order to portray spatial hydrographic structures over the North Atlantic. Also pay attention to the (short term) interannual signal (mentioned above).

Add some selected isobaths (e.g. 1000m, 2000 m and 3000 m) to these plots. In order to discuss these patterns against previously published key patterns in the North Atlantic (e.g. the spatial sea surface height mode, which is associated with the gyre index), you might want to include a broader meridional window (e.g. 35-65°N, although you only calculate transports over the 45-60°N latitudinal range). Maybe use a bit narrower color ranges, in order to emphasize the obtained patterns.

Figure 5:

Maybe use a bit narrower color ranges, in order to emphasize the obtained patterns.

The obtained Hovmöller diagrams based on GODAS and EN4 are actually rather dissimilar (mentioned above).

Figure 6:

Remove "Geostrophic eastward transport", from the titles. This info is provided in the caption.

Figure 7:

Remove "total eastward transport", from the titles. This info is provided in the caption.

Figure 11-13

Just keep the y-axis information on the left panels, and the x-axis info on the upper panels. Enlarge the panels, which would remove the excessive white spaces in these figures.

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