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Ocean Science Discussions

Interactive comment on "Large-scale forcing of the European Slope Current and associated inflows to the North Sea" *by* Robert Marsh et al.

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Anonymous Referee #1

General Comments:

The manuscript investigates the driving forces of the European Slope Current and also the related inflow of Atlantic water into the northwestern North Sea. In this study, a well-selected combination of observational data and model results is employed. These data are integrated by means of innovative analytical methods, leading to new insights into the acting mechanisms. The overall impression is that the paper is carefully written in a clear and concise way. I just have some minor comments, which are given below. Therefore, altogether, I could recommend the manuscript for publication after a minor revision.

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Discussion paper

Response: We thank the reviewer for supporting and thoughtful comments.

Changes in the manuscript: The manuscript will be revised in accordance with the comments below, alongside more extensive revisions in response to Referee 2.

Detailed Comments:

(1) Page 3, line 19: ". . . are usED"

Response: Noted

Changes in the manuscript: To be corrected

(2) Page 3, Section 2.2, model hindcast: It remains unclear, why ORCA12-N01 data are used at all. If ORACA12-N06 covers a longer period, I do not understand why you do not solely use this data set. Moreover, you must provide more support that a spatial resolution of approx. 10 km and a temporal resolution of 5 days are sufficient to describe the relevant processes related to the slope current variability.

Response: The ORACA12-N06 hindcast was not available until after the long-established ORCA12-N01, and the offline trajectory calculations were until recently only possible with locally archived data (ORACA12-N06 data are archived remotely).

Changes in the manuscript: In Sect. 2.2, we will discuss the extent to which spatial and temporal resolutions are appropriate to a study of the Slope Current dynamics and variability thereof.

(3) Page 6, line 4: The argument that the number of drifters is limited does not really hold, since it would be possible to start the simulated particles exactly at the same time and place as in the drift experiment. Furthermore, the argument that sub-mesoscale processes hamper a proper comparison between observed and simulated tracers is in contradiction with the statement made in section 2.2, i.e., that eddy-resolving model data are employed.

Response: In our statement, we mean that we routinely simulate 630 particle trajectories across a broad depth range representative of the Slope Current (per release), compared to 21 drifters that were drogued to drift with currents at 50 m in the Shelf Edge Study (SES) of LOIS. It would be possible to simulate specifically this number of particle trajectories, with start locations and times as in SES and drifting with currents at the same depth, and we will attempt this. However, the results may not add useful insight, not least because the ocean is chaotic at the mesoscale, so only in statistical terms (i.e., with a larger number of trajectories) are drifts in the ORCA12 hindcast representative of those in the real world. The purpose of Fig. 1 and Sect. 3.1 is to demonstrate that representation of the Slope Current in the ORCA12-N01 hindcast is broadly realistic in terms of pathways and timescales. Regarding sub-mesoscale processes and the point made in Sect. 2.2, we should clarify that ORCA12 resolves only mesoscale processes (10-100 km), but cannot resolve sub-mesoscale processes (1-10 km) such as inertial currents, frontal instabilities, etc.

Changes in the manuscript: In Sect. 3.1, we will clarify the purpose of showing model trajectories alongside drifter tracks, and explain more clearly why we would not expect agreement. We will clarify the distinction between resolved mesoscale and unresolved sub-mesoscale processes. If useful results are obtained with new trajectory calculations (for the same start locations and time as SES, drifting with currents at 50 m), we may show these in place of the current particle trajectories in Fig. 1c,d.

(4) Page 8, line 16: Please clarify how hs and H are defined and give a reasoning why you distinguish between shelf and deep ocean. Actually, the Slope Current, which is in the focus of this study, is located at the transition between these two regions. Which equation holds in these transition areas?

Response: Following Simpson and Sharples (2012), we introduce hs and H in Sect. 3.3.1, following the development of Equation (5) for the meridional sea surface slope in relation to water depth and the meridional density gradient. The reasoning for a distinction between the shelf and deep ocean is in the context of (5), which predicts the scenario presented in Fig. 14, with a steeper (downward to the north) slope in the deep ocean compared to the shelf, central to our understanding of the Slope Current. Given that the Slope Current is found at a water depth intermediate between hs and H, we would expects an intermediate meridional sea surface slope, but the key issue regards the growing difference between on and off shelf sea surface height with progression to the north, hence strengthening the associated geostrophic flow in the Slope Current.

Changes in the manuscript: We already provide this reasoning for hs and H in the manuscript. On revision, we will review the clarity of this reasoning.

(5) Page 8, line 25: Related to the previous comment, I do not see why H is always much larger than hs.

Response: H is always much larger than hs by definition, as H is the depth of the deep ocean while hs is the depth of the adjacent shelf sea.

Changes in the manuscript: No change necessary

(6) Page 12, line 4: The argument here is extremely questionable. If the number of particles entering the North Sea is well correlated with the Slope Current, there is no reason to assume that the definition of the Slope Current is not adequate, when it is correlated with salinity anomalies, since these should also be directly affected by the inflow of Atlantic water.

Response: Referee 2 raises related points, and we expand on that response here. Contrary to the understanding so far established, we should not neglect variations in salinity, including contributions to Atlantic inflow excluded from our definition of the Slope Current. We can address changing salinity in the model via the salinity along each trajectory (already calculated), and we will further seek observational evidence for any changes.

Changes in the manuscript: We will develop and substantiate statements in Sect. 3.4 that relate to the Slope Current influence on North Sea salinity, due to changes in both transport or salinity, distinguishing between “anomalous volume transport of mean salinity” and “mean volume transport of anomalous salinity”.

(7) Page 13, line 3: Again, I question why ORCA12-N01 data are used at all, if the ORCA12-N06 data are more reliable as stated here, and cover even a longer period as mentioned earlier. To my opinion, this is unnecessary and just confuses the reader.

Response: We do not claim that ORCA12-N06 data are more reliable, only that there is a good agreement in SSH variability between hindcasts over the period of overlap (see Fig. S9). As explained in an earlier response, the ORACA12-N06 hindcast was not available until after the long-established ORCA12-N01, and the offline trajectory calculations were until recently only possible with locally archived data (ORACA12-N06 data are archived remotely). While it may seem desirable to repeat the trajectory calculations with ORACA12-N06, these involve considerable effort and would severely delay manuscript revisions, while not substantively changing the conclusions of this study. We anticipate further studies of Slope Current variability that will involve the use of new and longer hindcasts. We chose to use ORCA12-N06 for the analysis in Sect. 3.5, as it is relatively straightforward to obtain model SSH data for direct comparison with the tide gauge data over the longer period.

Changes in the manuscript: At the end of Sect. 2.2, we will further clarify why we chose to use the new ORCA12 hindcast.

(8) Page 14, line 23: “Changes OF inflow ....”

Response: Noted

Changes in the manuscript: To be corrected

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