Reviewer 2

In this study, freshwater contents of the various sub-basins of the Baltic Sea from the BALMFC CMEMS reanalysis data 1993-2020 were calculated following the method by Boyer et al. (2007). The authors investigated trends in freshwater content per sub-basin and vertically in the water column, as well as seasonal climatologies of freshwater content. In the discussion, trends were attributed to river discharge, net precipitation and sea ice volume changes.

Reanalysis data are well suited for the analysis of the ocean conditions and the detection of trends in three dimensions and for the calibration and evaluation of ocean circulation models. However, reanalysis products are generally not good for attribution studies because quantities are not conserved due to the assimilation methods used. As Baltic Sea models often have large biases in salinity due to artificial numerical diffusion (Burchard and Rennau, 2008), data assimilation results in artificial sources and sinks in salinity. Hence, any attribution analysis and discussion of causes of detected changes are difficult.

We agree with the reviewer that data assimilation does not conserve salt (and heat). Therefore, in this study we described the ocean conditions, i.e. freshwater content of the Baltic Sea and its subbasins. We did not provide salt balance estimation of the Baltic Sea, because the salt balance could be violated due to data assimilation, if the salt transport through the Danish straits is not accurately simulated.

In the revised manuscript, we will provide more in depth analysis. Keeping in mind that data assimilation is used in the reanalysis product, we will provide analysis of the dynamics and discuss emerging discrepancies and inconsistencies in relation to previous studies.

Furthermore, the authors considered only river discharge and net precipitation data while wind fields were not analyzed although several previous studies claim that the seasonality in juvenile freshwater propagation or multi-decadal variability in freshwater content are controlled by the wind (the latter at least partly).

Generally, westerly winds force inflow of saline water and easterly winds force outflow of brackish Baltic Sea water. We agree that juvenile freshwater propagation between the Baltic Sea subbasin is controlled by the wind. In the context of the whole Baltic Sea, the wind fields control saline water inflows to the Baltic Sea, and therefore FWC. In Fig. R2 we plot a time series of fresh water content and the annual accumulation of 10m zonal wind anomaly. In the revised manuscript, we provide transports between the subbasins and their relationships with wind fields.

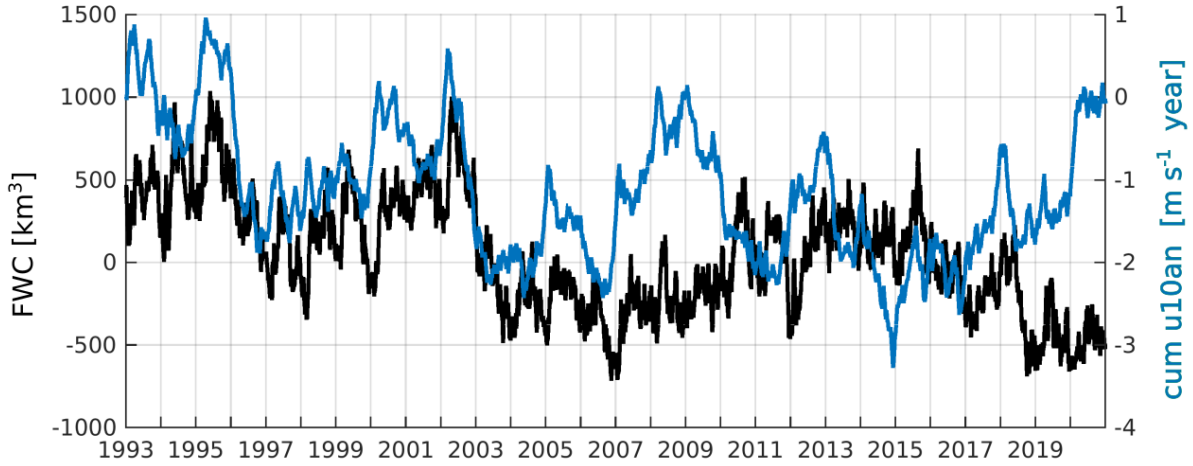

Figure R2. The time series of fresh water content and the annual accumulation of 10m zonal wind anomaly.

The provided explanation that melting sea ice could have contributed to the observed positive trends in freshwater content is wrong. In contrast to the Arctic Ocean, in the Baltic Sea multi-year sea ice does not exist. Averaged over one year, the freshwater extraction and freshwater supply is balanced.

We agree that FWC stored in sea ice is totally released every year. On the other hand, seasonal formation of sea ice affects FWC in the water on an annual scale, if the volume of ice and freshwater stored in the ice is not taken into account in calculation of the FWC in the fixed volume of water. The latter is usually the case in the calculation of the salinity (and FWC) in the ice covered water column. Annual mean FWC is calculated by averaging daily FWC over the year. If the sea ice is formed, then some amount of freshwater is “removed” from the water and “stored” in ice. When the daily volume of ice is larger then more freshwater is stored in the ice. As a consequence, annual mean FWC is smaller when accumulated daily ice volume is larger and vice versa.

In the seasonally ice-covered seas, the ice coverage acts as temporal internal freshwater storage. In a closed water basin without any other sources and sinks, annual mean FWC and accumulated daily ice volume reverse relationship. Therefore our results of the negative trend in annual ice volume and positive trend in FWC in the Bothnian Bay are consistent.

We will provide a detailed explanation of the effect in the revised manuscript.

The first part of the introduction suggests a relevance of the study for the impact of climate change. However, previous studies found a pronounced multi-decadal variability in salinity and freshwater content of the Baltic Sea (e.g. Winsor et al., 2001). Hence, trends during the rather short period of existing reanalysis data (1993-2020) only describe the natural variability and cannot be used for the analysis of systematic changes.

The first part of the introduction provides a global background for this study. Our study consists of a time series of almost 30 years. The 30-year period is considered sufficient for climate change studies although longer periods are preferable. We will discuss our results in the context of a multi-decadal variability

in salinity and freshwater content of the Baltic Sea (e.g. Winsor et al., 2001; Lehmann et al., 2022).

Lehmann, A., Myrberg, K., Post, P., (...), Lips, U., Bukanova, T., 2022. Salinity dynamics of the Baltic Sea, Earth System Dynamics, 13(1), pp. 373-392.

Methodologically, the study has gaps. Significance levels of trends are not provided. For me the rationality of the correlation analysis for the understanding of the observed variability is not clear. What have you learned?

We will provide significant levels of the trends in revised manuscript. We have provided some of the significant levels of trends. The correlation coefficients are calculated because we see similar and opposite changes in the time series of FWC in different basins. Physically, the changes between the subbasins of the Baltic Sea could be correlated. We will provide extended dynamic analysis in the revised manuscript.

Furthermore, the manuscript suffers from missing references (e.g. Winsor et al. 2001) and phrases that need to be revised (e.g. line 47, line 170).

We correct the reference list and we will revise the text of the manuscript.

In summary, the study in the current version is rather descriptive and does not provide any new insights into the causes of observed trends and variability in freshwater content. Hence, I recommend rejection.

We agree that a major part of the study has been descriptive. The reanalysis data used for the period 1993-2020 and this period is not covered by any of the previous publications. The FWC of the whole Baltic Sea and all main subbasins is described. Previous studies were mainly limited to the central Baltic Sea, either the Gulf of Finland included or not. The seasonal climatology is novel. None of the previous studies have used 3D climatological fields for the reference salinity, but constant values or averages over the shorter periods.