

The role of heat wave events on the occurrence and persistence of thermal stratification in the southern North Sea

Review

The manuscript aims to investigate the contribution of marine heatwaves (MHW) to thermal stratification in the North Sea by using ocean-wave coupled numerical experiments performed during a 8-year period.

Comparing with observations (in-situ and remote-sensing), they observed large stratification events in the summers of 2014 and 2018, when large surface-to-bottom differences in water temperature co-occurred with high air temperatures.

They argue that in absence of turbulent mixing high air temperatures lead to high SST and intensified stratification, triggered also by the long memory of seawater compared to air to low temperatures in the cooling season (e.g. January-April).

Thermal stratification and MHWs show a well-defined dependency in areas, along the Danish coast, which were not well characterized in the literature as one of the density stratification regimes in the North Sea.

The vertical structure of stratification (R_i) shows the water depth as the factor modulating the sensitivity of the stratification to the summer heatwave (max values observed in the middle of the water column).

The work is well developed and well placed within the framework of the scientific open issues about the effect of extreme climate events. The authors use robust analysis and provide an exhaustive physical interpretation of all the results obtained, which address the goals of the study. The publication is recommended.

Here follow some suggestions, which could help improve certain parts of the manuscript.

General Comments

1. The sensitivity of ocean-wave coupling is addressed in supplementary materials (SM), but either a dedicated Appendix on the wave-induced processes included in the coupling, or an additional Figure in SM on the sensitivity to the wave-induced turbulent mixing, could help the reader to fully understand the results (e.g. Lines 270-275).
2. The quality of the graphics and Figure captions could be improved (look at specific comments).

Specific Comments

Introduction

Line 17: the reference IPCC, 2012 should be updated to AR6

Line 26: "In the North Sea ..." - rephrase.

Line 55: "who showed..." – rephrase.

Line 56 "Considering the interface ..." – rephrase.

Section 2

Line 99: Check the reference GEMORAR, 2019

Line 102: omit "for the location".

Section 3

Line 158-159: rephrase. Something like: “The results were further compared with satellite data. Figure 4 shows an annual variation in the modelled and remote sensed SST at the NSB III platform location in 2018.

Line 194: multi-year mean.

Section 4

Line 232: “...the number of days when the water ...”

Line 265: “...down to the bottom”: it is hard to distinguish max Ri values at the bottom, and the statement is in contrast with the sentence at Lines 267-268. Consider rephrasing.

Line 277-295: It could be shorter and move to the conclusions.

Comments about Figures

Figure 2:

The bottom panel should be either described in the manuscript or removed.

Caption

“Bottom panel: the differences ...”.

Figure 3

The text in the caption should be improved.

Figure 4

The text in the caption should be improved.

Figure 6

Check the unit (see palette). The text in the caption should be improved describing clearly what is displayed on the background. It is hard to distinguish between dashed and solid black lines.

Figure 9

What about the solid line? See relevant comment for Figure 6.

Figure 10

See previous comments.