

## **Review of the manuscript: “Observed bottom warming in the East Siberian Sea driven by the intensified vertical mixing.”**

This manuscript argues that intense wind-generated cyclones over the shallow shelf (less than 40 m deep) in the East Siberian Sea mix the entire water column and are responsible for warming of more than 3 deg C at the bottom of the ocean, having important implications for the submarine permafrost. The study is based on a combination of reanalysis and in situ observations. The manuscript is well written, and the figures are relevant. However, although of great interest, the manuscript lacks actual proofs that: 1) the warming at bottom is caused by wind-driven mixing. 2) this warming observed at only one station lasts long enough and can be observed on a significant spatial area to have a significant impact on the permafrost. I suggest major revisions for this manuscript. My comments are found below.

**Abstract:** it is impossible by reading the abstract to know what the new findings are and what is ‘old’ knowledge. Please rephrase by highlighting what is new in this work.

1.11: ‘worrying trend’: very subjective word that should be avoided in an abstract.

L.12: ‘high wave’: is it surface or internal waves?

1.13: ‘enormous heat downward’: please quantify

1.14: ‘remarkable warming...’: how is the warming at depth observed?

1.15: ‘undoubtedly suffer more extreme heatwaves’: any evidence of that?

### **Introduction:**

1.20: CH<sub>4</sub> is methane: please indicate in full letters

1.22: indicate the value of the freezing point temperature.

1. 23: how does the cold layer acts as a barrier to reduce methane emissions?

1.27-28: ‘abrupt near-bottom warming’: it is not clear for me if it has been shown before (then a reference should be added) or if it is part of the results of this manuscript (then it should be deleted from the introduction). Please clarify.

1.29: ‘up to 3 months’: please add ‘after the wind event’.

1.29: ‘warm bottom waters’: are they still at 3 degrees above the freezing point, or have they cool down? Please clarify

1.31: ‘reaching 2 deg C during 2012/2013’: please add a reference.

1.34: ‘wind forcing, and tides become dominant roles’: reference?

1.36: ‘cause significant impacts on the thermal condition’: is there impact only on the thermal conditions or also on the haline conditions? Please clarify.

1.41: maybe expeditions/campaigns rather than fieldwork.

1.42: ‘uniformly mixed and the bottom water temperature reaching nearly 3 deg C’: this has already been said earlier in the introduction. And again: is that new results or is that part of a previous study? Please clarify.

1.43-44: ‘This paper reports this extreme mixing event and the related processes’: Is that new result then? From reading the introduction it felt like this was not new result. The processes linked to the extreme mixing should be better explained and there should be better evidence in the manuscript about these processes. See my comments below.

1.44: ‘long-term trend’: is it based on mooring time series or on observations?

Please add a paragraph with the plan of the manuscript.

### **Data and methods**

1.49: which year is the expedition?

1.52: add ‘respectively’ after the temperature and salinity accuracies.

Please add a reference or a link to the CTD data, and some information about the calibration of the CTD.

1.56: 'heat flux': is it surface heat flux in the atmosphere? Please clarify.

1.60: please provide more information about the vertical resolution of the model.

How good is the reanalysis on the shelf? Has it been compared with in situ observations? From my knowledge, there is no assimilation of SST under the sea ice, so it might be worth checking how good (or not) the reanalysis is on the ESS.

1.64: Why is the sea surface temperature not from the reanalysis?

1.71: what does the 'rich vertical structures' mean? Please reformulate.

1.73: 'The wavelength': which wavelength is lambda referring to? Is it the one of the internal waves? Surface waves? Please clarify. In general, I find this section confusing. The authors should help the reader to understand why these notions (mixed layer depth, wavelength and ocean heat content) are being introduced, and how they will be used in the rest of the study.

1.79: What is the unit of Q? Same applies for the wavelength.

1.82: How do you define the bottom layer? The definition of the mixed layer is explained at the beginning of this section but not the definition of the bottom layer.

1.87: how many km<sup>2</sup> is 20% of the total area of the studied region?

1.88: where does the wave data come from? Please clarify.

## Results

Section 3.1 Please reference more frequently to the different panels of the figures.

1.115: Where is station LA77-35?

1.118: 'was driven by the windy weather condition': we don't have proof of that with what is shown now in the manuscript. Why couldn't it be the tidal forcing too? There is only one station showing the warming at depth, it could indeed be because of 'perfect timing' with the location of the wind event, but it could also be caused by tidal forcing in my opinion. More evidence and explanations should be brought up, or the conclusions should be tuned down.

L.125: 'lower than the previous two': please quantify.

1.134-135: Please explain more the theory behind this process.

1.136: what is the 'mid-shelf'? please define

1.137: 'with 30 to 60 m depths Increased to about 70m': I don't understand this sentence. Please clarify.

1.156: 'higher than the net solar radiation': please quantify

1.158: 'enhanced diapycnal mixing': Do you have any proof of that? No turbulence measurements are shown in this manuscript.

1.162: how is the heat loss computed from the net surface heat flux? This should be part of the method section.

1.164: 'with the same cooling rate was about 14000 km<sup>2</sup>': any evidence of that?

A general comment of section 3.3: the authors argue that 'the area with the significant cooling most likely experienced the same extent bottom warming induced by intensified vertical mixing' (1.164-165). At the same time, there is no sign of warming in the other stations of the section, that are within this area I believe (relatively close to the other stations). How is that possible?

1.185: 'since 2007': which season is considered here?

1.185-186: Have the authors tried to fit a regression line between the sea ice extent and the number of days with heavy winds and high waves? Is that significant?

1.187: 'high waves gradually increased': add a reference to the corresponding figure.

## Discussion and conclusion

1.202-204: This first sentence seems a bit out of the context, as there is no single mention of methane in the result section. Please reformulate.

1.220-222: Again, this is a strong statement, and there is no evidence of that in the manuscript. Please reformulate and nuance this statement.

1.228-229: I am surprised that the warming could remain for at least 2-3 months when it is not observed in the stations in the surrounding. Please elaborate.

### Figure 1:

- Panel a: How is the trajectory estimated. Add some names (i.e. ESS; Canada; Groenland)
- Panel c and d: it is hard to know where we are on the section compared to panel b. Please add some station names on the section too. Also: why is the section shallow, then getting deep and then shallow again? This is not clear, I thought it is a cross-shelf section so I would expect it to only gets shallower or deeper.
- What is the x-axis of panel b, c and d
- Add labels to the colorbars in panel c and d
- Caption: a) 'from 9 to 12': of which month? What is the box and what is the line? Be clearer. B) 'Observation station locations': what does that mean? Please reformulate. What is the big red dot in the section?  
c) Help the reader by indicating which section is east and which one is west. 'The horizontal coordinate is time': in days? 'The blue rectangular box': isn't it supposed to be red?

In general, I found this figure interesting and useful for the paper, but it gets complicated ad panel c and d mix eularian and lagrangian processes. It will be useful for this figure but also for the rest of the manuscript to try to disentangle the spatial and the temporal component.

### Figure 2:

- Why is the colored background different in both figures? 'From September 11 to 12': what is shown from September 11 to 12? Is it then averaged over the time period? Is that from the reanalyses?
- Add the scaling arrow in all the panels and make it white.
- Line 148: it should be only d, there are no black lines in figures e and f.

### Figure 3:

1.179: Add in section data and methods how the geostrophic currents are estimated.

1.177: 'the red asterisk': shouldn't it be the red dot?