Response to reviewer #1

"An improved sea ice detection algorithm using MODIS: application as a new European sea ice extent indicator", by Joan A. Parera-Portell, Raquel Ubach, and Charles Gignac

Dear reviewer #1,

First of all thank you for your comments and suggestions, which will surely help improve the current manuscript. Here it is a detailed answer for each of your **major comments**:

1) I think you are right, there are many references to Gignac et al. (2017) that could be avoided. I also agree with the excessive use of "we" in the introduction. However, I would like to clarify that we are not the IceMap250 team: we independently tested IceMap250 and developed IceMap500 with Dr. Gignac as a collaborator. Thus, answering to one of your specific comments, we dropped the 250 m downscaling for various reasons: I) simplicity, II) reduced processing times, III) problems with MODIS Aqua band to band registration reported by various authors, and IV) spectral integrity of the imagery (since no downscaling is applied).

2) In my opinion, the most important feature of IceMap500 is the way it diminishes the effect of the NISE footprint, which really hinders the mapping of the sea ice edge (see Fig.2 in the manuscript). Therefore its major benefit is the increase of mapped area respective to MODIS MOD29/MYD29 sea ice extent products and IceMap250 itself, which nonetheless has a higher resolution. The maps generated by IceMap500 covering the coastline or the ice edge are very detailed and consistent in this sense and, as you say, it should be further explained and exemplified. In this regard, in Figure A are shown two different monthly composites centered in different regions where the resolution of other sea ice extent datasets might be too coarse.

The maps in Figure A are also useful to explain the derivation of our monthly extent maps from monthly sea ice presence likelihood maps, as readers might wonder why the two do not perfectly match when overlaid. As said in the Methodology section, pixels where sea ice presence is >0 % and <10 % are discarded because such observations might not be reliable enough (0 % is water). In practice, what happens is that usually by eliminating such observations one gets a small NoData buffer zone along the ice edge. We then take advantage of the pixels set as water (remember that the sole goal of the VIS mask is to detect open water) and fill the gaps using an Euclidean distance allocation algorithm. This way we get a clearer and smoother sea ice edge, which nonetheless does not completely ignore the information carried by pixels where likelihood <10 %.

3) Yes, September 2013 is an interesting case and it can further demonstrate the accuracy of IceMap500 when detecting fragmented ice. Figure B compares the Sea Ice Index (SII) and IceMap500 monthly maps corresponding to Sept. 2013, which I think would be a useful addition to the manuscript. What we found is that IceMap500 classifies way more ice due to the presence of fragmented ice and ice floes, which are not seen in the SSI due to the monthly mean sea ice concentration not exceeding 15 % within those cells (remember that the cell size is 25 km). Therefore, differences do not only come from the coarser resolution of the SSI, but also from the different ways in which the SSI and IceMap500 obtain the monthly extent: while the SSI calculates extent from the monthly mean concentration,

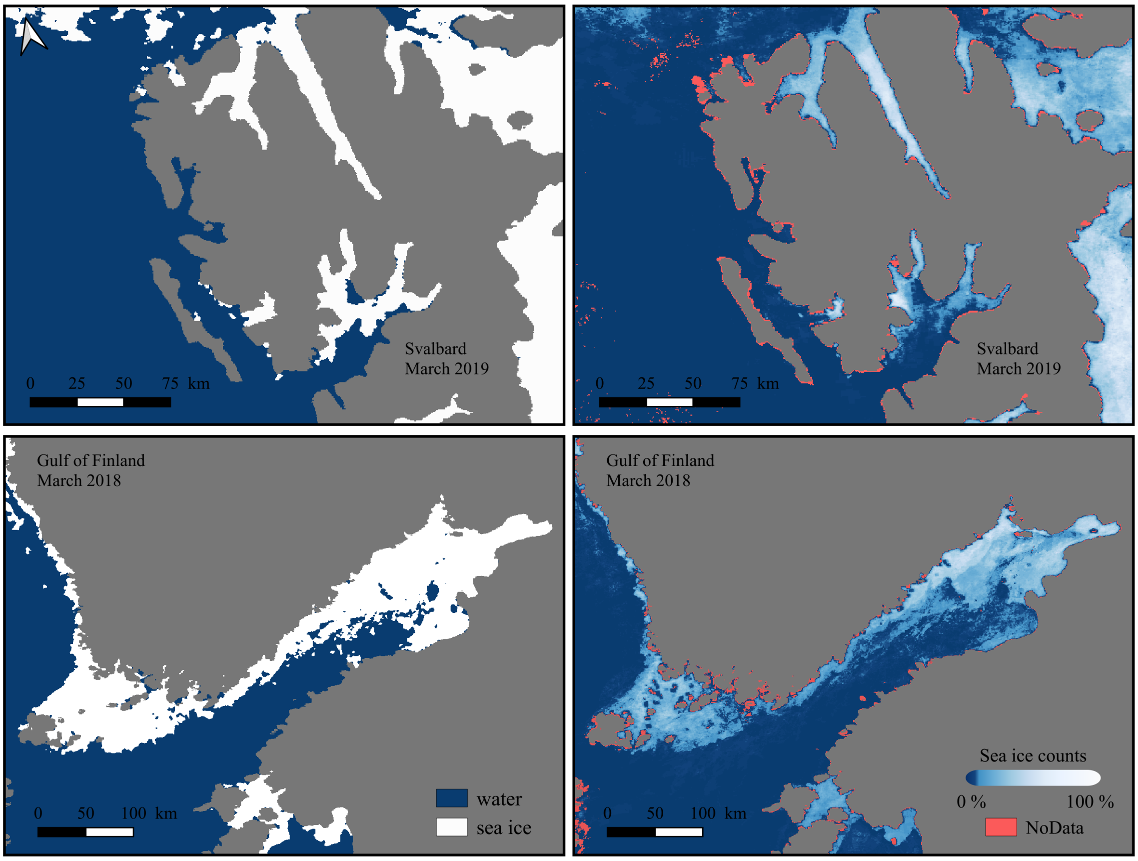

Figure A: IceMap500 monthly extent maps covering different regions of the Arctic and Baltic seas. In the right panels the monthly sea ice presence likelihood is shown.

the IceMap500 monthly maps may be better understood as the maximum sea ice extent achieved during that month (considering the 10 % sea ice presence likelihood threshold).

4) Indeed, processing time is a major concern regarding any computer algorithm and the manuscript would benefit from including details on this matter. The time required to generate a sea ice extent map for a given scene depends on many factors, including how many pixels there are inside the study area, the amount of clouds and nighttime areas, the number of pixel samples used to calculate the Jenks breaks and the time that NASA's HDF-EOS to GeoTIFF Conversion Tool takes to project the original hdf files. I have run IceMap500 on multiple computers, from laptops to desktop PCs but, to illustrate the processing time, consider Figure C. This is a fairly large scene with both surface classes, sea ice and water. Currently, on a desktop computer under Linux Mint 20.1, 2.67GHz $\times$ 4 processor and 12 Gb RAM IceMap500 takes about 230 s to create the map seen in Fig. C (excluding the data download time). A full daily map covering our study area (16 scenes) took 50 min to process. Of course, the processing time would become smaller with more powerful machine specifications .

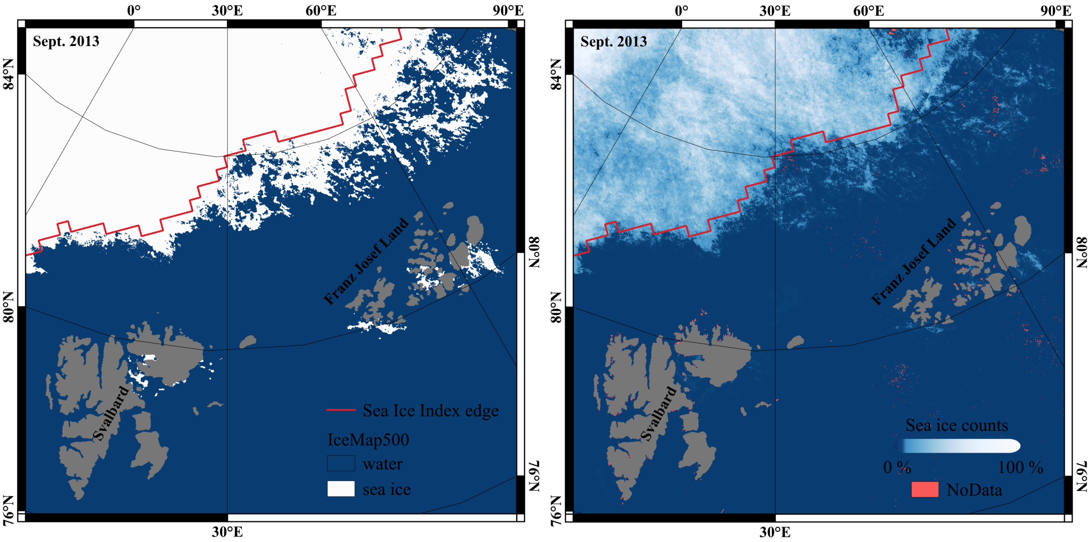

Figure B: Comparison between IceMap500 monthly map and the Sea Ice Index (September 2013). In the right panel the monthly sea ice presence likelihood is shown.

Finally, I would like to thank you for your text corrections and to answer some of your **specific comments**:

l.3: The reference to IceMap250 will be dropped, as it has been also suggested by reviewer #2.

l.14: Indeed this sentence is unclear and will be rewritten. What it really means is that the areas that we compare are not accounting for the error in the trend lines.

l.32: We will, as you suggest, provide more background about sea ice remote sensing.

l.40-45: see my general comment n.1. We will fix the text so it becomes more clear to the readers.

l.231: You are right, an introductory text should improve the transition between sections. We will probably also add subheadings so the structure of the discussion becomes more clear.

l.300: The agreement between the NSIDC's SSI and IceMap500 depends on the number of pixels that are classified as sea ice in both datasets, i.e. where both datasets agree there is sea ice. Plainly put, if there is an agreement of 90 % this means that the SSI and IceMap500 overlap on the 90 % of sea ice pixels. The other 10 % are pixels that are classified as sea ice only by either one of the maps. The difference in spatial resolution is not compensated, as the sole goal of this agreement analysis is to show the consistency of IceMap500. What is seen in Figure 8 is that agreement in March is very stable, only slightly oscillating around 90 %. This suggests that besides the difference in resolution, there are no significant differences between IceMap500 and the SSI, even considering the different monthly extent calculation approach. Instead, in September the mean agreement decreases while its variability greatly increases, so there is something more going on: sea ice is considerably more fragmented, which makes the effects of the resolution and the extent calculation to be much more important (see Figure B).

Figure 9: We plan to include a graphic comparison with other sea ice products. The figure will surely include a more zoomed in comparison with the SII, as you suggest.

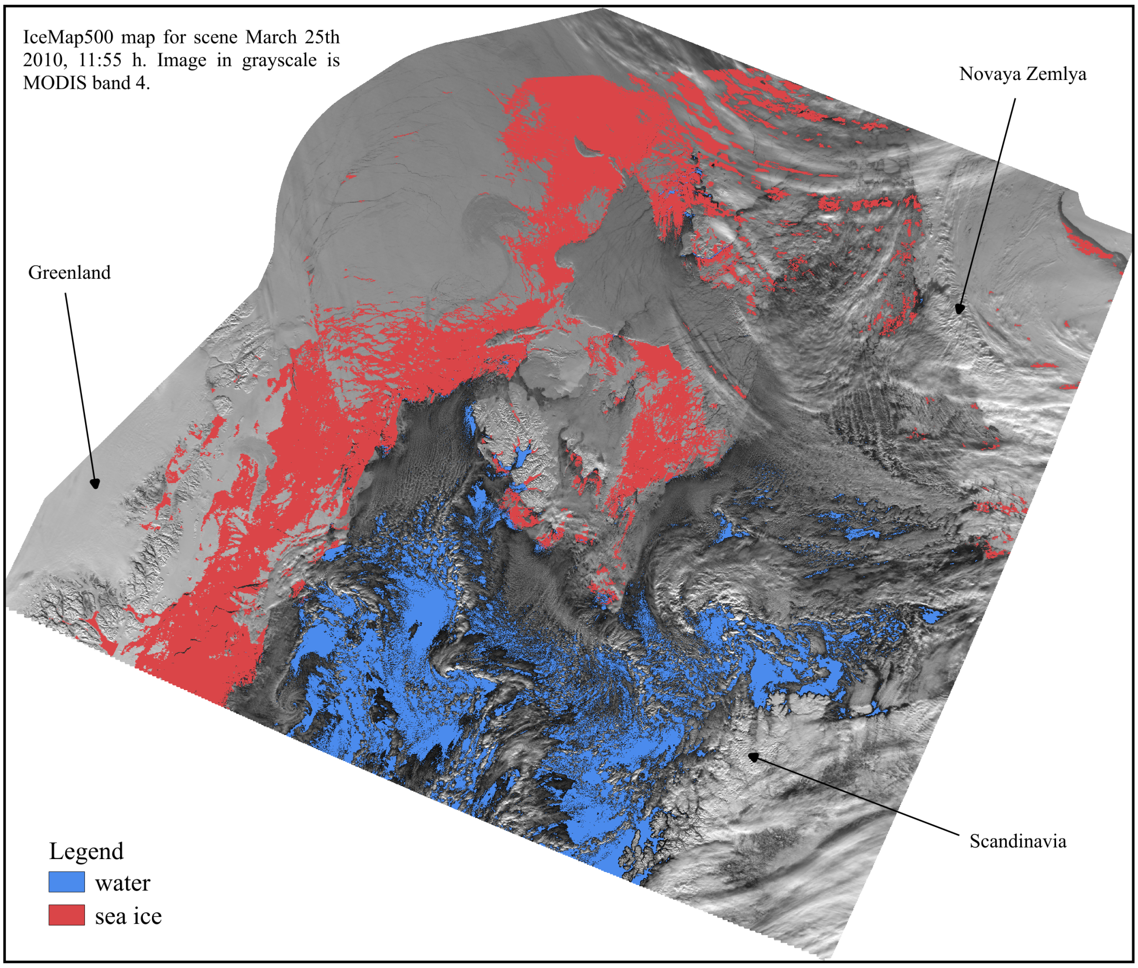

Figure C: Single classified swath example (Arctic).