

## **Sea ice cover in Isfjorden and Hornsund 2000-2014 by using remote sensing**

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### **Summary**

A new dataset of sea ice cover for two fjords in Svalbard (Isfjorden and Hornsund) is established using radar and visible remote sensing data from multiple products for the period 2000-2014. Remote sensing data are used to manually identify the areal coverage of “fast ice”, “drift ice” and “open water” in the Fjords. The timeseries of percentage of the fjords covered by ice is examined in relation to an index referred to as “days of fast ice coverage” (DFI), which is the cumulative fractional ice covered area for a given year and fjord. A similar progression of ice cover is found for both Isfjorden and Hornsund, with both fjords appearing to exhibit a substantial reduction in sea ice cover after 2006. The authors examine such changes in relation to oceanic and atmospheric changes discussed in relevant literature.

### **General Comments:**

This study seems to represent quite a bit of effort with regard to collecting and analyzing multiple satellite products to produce a record of sea ice changes in these fjords. The dataset is also potentially very useful for relating sea ice changes to climate and ocean changes. I feel that the study should be published. However, I have identified some issues, discussed below, which I consider to be relatively major:

- (1) The manuscript mainly focuses on presenting the dataset, without presenting an analysis of reasons for observed fluctuations in ice cover. I feel the paper could be more effective if the authors include observations of sea surface temperature, average wind speed, or other observations that can provide some insight into the observed changes in the fjords.
- (2) The discussion section sometimes draws conclusions relating observed sea ice changes to changes in ocean circulation that are not necessarily supported by the data presented. Including ocean and atmospheric data in the analysis would help to better place the results in context of the discussed literature.
- (3) The authors do not discuss the impact of mixing and matching different products in the analysis. In particular, what is the impact of different resolutions on the results? It seems that a lower resolution product might give different estimates of sea ice cover. For example, an entire 500 m grid box from MODIS could be classified as 100% ice-covered when an analysis of ASTER data could reveal that it is perhaps 60% covered by ice. The authors should attempt to quantify the impact of these effects and include a discussion of this in the methods section.
- (4) The shift from 2005 to 2006 from relatively high to relatively low ice cover occurs just as the shift from visible data to SAR data occurs. It seems possible that such a shift could influence the timeseries, but this has not been discussed. The possible impact of the inclusion of SAR data should be analyzed and discussed.
- (5) Errors are discussed in the data section, but not discussed anywhere else in the paper. The influence of errors on interpretation of results should be mentioned in the results and/or discussion sections. Errors should be quantified where possible.

## Specific Comments

1. **Title:** I think a clearer title would be “Sea ice cover in the Isfjorden and Hornsund Fjords, Svalbard (2000-2014) from remote sensing data” or perhaps, “A new sea ice cover record for the Isfjorden and Hornsund fjords (2000-2014) from remote sensing data”
2. **P. 4044, Line 6:** Change ‘ open “water” ’ to ‘ “open water” ’ here and throughout the manuscript.
3. **P. 4044, Line 8:** Briefly define “fast ice”
4. **P. 4044, Line 15:** Change “concept” to “index”. I don’t think “days of fast ice coverage” is an appropriate name for this index. (See later comments).
5. **P. 4045, Line 1:** Change “the fjords” to “two fjords”
6. **P. 4045, Lines 1-2:** It would be helpful if the authors could add a map of the study region, showing the locations of the two glaciers.
7. **P. 4045, Lines 23-26:** After “2490 km<sup>2</sup>” add “(as defined from 2013 Landsat 8 images)” and remove “(areas defined with ArcGIS and Landsat 8 images from 2013)” on lines 25-26.
8. **P. 4046, Lines 1-4:** Suggest revising the sentence to: “Previous studies have investigated sea ice conditions in Hornsund during the winter seasons of 2005 through 2011 (...”
9. **P. 4046, Lines 4-7:** Do these two sentences refer to all of the cited studies or just some of them? Please clarify in the text.
10. **P. 4046, Line 12:** Is the “main hypothesis” the main hypothesis of AWAKE-2? Please clarify.
11. **P. 4046, Line 25:** Change “index” to “index, the days of fast ice (DFI) index,”
12. **P. 4047, Lines 16-23:** Please specify the resolution of the radar products.
13. **P. 4047, Line 24 – P. 4048, Line 5:** Please provide more specifics about the products used, including the names of the individual products, and references and/or links for each of the products, and their resolution.
14. **P. 4048, Line 16,18:** What is meant by “ice situation”? Please replace with something specific.
15. **P. 4048, Line 19:** This section should be moved to occur within or following the methods section for better flow of the text.
16. **P. 4049, Lines 4-5:** Are the changes in area on the order of 1 percent, 10 percent, 1-10 percent? Please provide a number.
17. **P. 4050, Line 1:** Please provide further description as to how the sea ice expert distinguishes between fast ice, drift ice, and open water.
18. **P. 4050, Lines 5-6:** It would be interesting to see how different products may be used to produce a single estimate.
19. **P. 4053, Lines 22-25:** Suggest changing “more sea ice” to “relatively high sea ice cover”, and “less sea ice cover” to “relatively low sea ice cover”.
20. **P. 4054, Lines 12-15:** The time series does not show the influence of the forcing event on thermodynamics, it only shows changes in sea ice cover. Rather the sea ice timeseries and previous work seems to suggest that the change in circulation has an influence on the sea ice cover. Also, the forcing that occurs on a “timescale of weeks” is not discussed in the previous sentence. Please discuss the forcing event.

21. **P. 4055, Lines 2-5:** Again, without any ocean data, I don't think it is possible to draw the conclusions from Figs. 2 and 3 that sea ice-cover is less influenced by AW intrusion. Also, I am not sure I really see variations on shorter timescales at Hornsund. It is difficult to draw that conclusion from the limited length of the timeseries.
22. **P. 4055, Line 9:** It is not clear what supports the statement that Hornsund can be used as such an indicator.
23. **P. 4055, Line 12:** What does "will be" refer to? Is this part of the AWAKE-2 project?
24. **P. 4056, Line 9:** "Warm water as a major" ... ?
25. **Figures 2 and 3:** I suggest changing the legend to read "DFI (short season)" from "DFI" for clarity.

#### **Technical Corrections:**

1. **P. 4044, line 18:** Change "end of sea ice" to "end of the sea ice".
2. **P. 4044, Line 24:** Change "with Greenland Sea" to "with the Greenland Sea".
3. **P. 4045, Line 8:** Change "It is a strong contribution" to "The WSC contributes strongly"
4. **P. 4045, Line 18:** Remove comma after "This means"
5. **P. 4045, Line 29:** Change "considering" to "for".
6. **P. 4046, Line 11:** Add a comma after "ice".
7. **P. 4047, Line 11:** Change "concerned." to "used." or "utilized."
8. **P. 4047, Line 14:** Change "put" to "placed".
9. **P. 4047, Line 15:** Change "during sea ice is present" to "when sea ice was present."
10. **P. 4048, Line 19:** Change "estimate" to "estimates".
11. **P. 4049, Line 13:** Change "Method" to "Methods".
12. **P. 4049, Line 19:** Suggest changing "cut into pieces" to "subdivided".
13. **P. 4049, Line 27:** Suggest changing "put on top of" to "superimposed on". Also change "cut by" to "divided by"
14. **P. 4050, Line 2:** Change "can be both" to "can result from both"
15. **P. 4052, Line 22:** Change "express strong variations between different years." to "indicate strong variations from year to year."
16. **P. 4055, Line 16:** Change "growths" to "growth".
17. **P. 4055, Line 21:** Change "by using" to "using"
18. **P. 4056, Line 16:** Change "systems" to "system"
19. **Figure 1, caption:** change "analysis of sea ice expert" to "analysis by a sea ice expert".
20. **Figures 2 and 3, caption:** change "sea ice expert" to "a sea ice expert".