

# Review of “The Risk of Synoptic-Scale Arctic Cyclones to Shipping” by A. Vessey et al.

## General comments

Vessey et al. describe recent trends in ship traffic within the Arctic Circle, and measure the risks they face due to severe weather.

The article contains a clear description of the aims of the investigation, its wider context, data and methods used, and explanations of results. It delivers new information on the dangers posed by severe weather to Arctic shipping, of particular benefit to those with exposure in this sector. However, the article has significant shortcomings, and I recommend a major revision before publication.

I ask the authors to address the following weaknesses in a revised version of the manuscript: (i) a significant number of grammatical mistakes, (ii) inconsistencies in the values of quantities quoted in the text (often percentages are wrong by a factor 100, and other data in discussions do not match plotted values in figures), and (iii) the proxy of severe weather (*a ship within 3 degrees of the location of the maximum wind or wave height above a threshold which itself is within five degrees of an analysed cyclone centre*) is unnecessarily complicated, and introduces avoidable error in identifying the true shipping hazard, namely roughness of the sea state at a ship's location.

## Major comments

1. While the general standard is good, there are many mistakes in the grammar. Some of the more significant errors have been listed in the section ‘Minor Comments’. The authors are asked to proofread the entire manuscript for grammatical errors, and meet journal standards.
2. The pdf file has an unusual size of 180 MB and some Apps struggle to load and display a file of this size. A reduction of file size would be useful for the audience. My guess is that Figures 2a-d might be of huge size, because they contain plots of more than 300,000 unique ship tracks. If this guess is correct, then converting them to a different file format may help, or moving Figures 2a-d to Supplementary Information might be suitable?
3. All quoted data values in the text need greater inspection by the authors. There is an unusual number of inconsistencies between data values in the text and values plotted in Figures. Some mismatches have been in the ‘Minor Comments’ section below, but I encourage the authors to comprehensively review this aspect of their manuscript.
4. There is potential to improve the Introduction.
  - a) The opening paragraph of the Introduction describes how sea-ice is declining hence the Arctic is becoming more accessible to shipping. The authors may wish to give a more complete description of Arctic changes in the opening paragraph, before focussing on benefits to shipping. For example, add a sentence or two on its negative aspects both locally

(people, wildlife, adapted to colder climate) and on mid-latitude climate – implicated in colder Siberian winter, and droughts/wildfires/floods in mid-latitude summer, e.g. Coumou et al. (2018). Further, the authors may wish to revise their opening statement to reflect how global warming is considered to be the *main* driver of sea-ice decline. (Multidecadal variability in the climate system may play a minor role.)

- b) The Introduction contains multiple references to information in Table S1. The fact that data in Table S1 is central to this discussion suggests it is more appropriately placed in the main manuscript, either as a Table, or as a map with routes (with polar stereographic map projection).
- c) My understanding is that the analysis of shipping damage data from the Arctic Council is a key contribution, and an extra paragraph on this dataset in the Introduction would help the reader.

5. Revision to analysis methods. The authors use the concept of an intersection of Arctic cyclones containing maximum winds/wave heights above a threshold, with the locations of ship tracks, to identify incidents due to severe weather. This contrasts sharply with the simpler method of identifying severe conditions based on wave height along the ship track. ERA5 provides all the data required to identify wave height at all locations of a ship track. Could the authors explain why winds are used together with wave heights in a study of ship damage? Do strong winds cause damage, per se? (I thought it was the sea state that damaged modern vessels, but not an expert.) Further, could the authors explain the benefits of including the identification of cyclones here? The definition of severe weather as a ship within 3 degrees of significant winds or waves seems like a proxy for wave height, but given that wave height is available, why use cyclone tracking?

### Minor comments/corrections

1. lines 18-19: the sentence beginning ‘In September 1980...’ provides an indication of the sea-ice decline using September data for 1980 and 2012. I suggest expressing the decline in terms of annual mean Arctic sea-ice over the past 40 years, using data from NSIDC, and expressed in % change (decline) per decade, to create a more robust and representative measure of the decline.
2. line 21: the word ‘however’ is not appropriate since there is no contrasting information in this sentence.
3. the Arctic Circle is defined throughout as 66.3°N, whereas the standard definition is 66°34'N, or approx. 66.6°N (e.g. <https://www.pmel.noaa.gov/arctic-zone/faq.html>).
4. line 75: “combined” should be combine?
5. line 80: grammar error in “has been somewhat been addressed”
6. lines 94-96: the description of the sections in the manuscript is not accurate. For example, the summary is given in Section 10, rather than Section 4.
7. line 139: error in grammar

8. line 169: "Incident south of..." should be "Incidents south of..."
9. line 171: "to match the temporal scale" could be replaced by "to match the spatio-temporal scale"
10. line 175: "southern quadrant" – either southern half, or southwest quadrant ('southern' is not a quadrant)
11. line 197: error in representing the degrees symbol (a superscript '-1')
12. lines 201-202: "This is similarly showed by" to "This is similarly shown by"
13. lines 204-205: do the authors have any insight into the extent that the increasing number of observed ships is caused by the increasing use of transponders (lines 67-68)? Is it possible to distinguish all large ships over 300 tonnes, or passenger ships, and identify their trend?
14. Could the scale in Figures 2e-2h be extended to include low values of track density close to the pole?
15. lines 225ff : should references to Figure 2e – f be replaced by Figure 2e – g?
16. line 242: reference to a "Table S1.1" needs corrected.
17. lines 244-248: the numbers in the text do not match with the plotted values in Figure 3b.
18. line 261: "only 0.001% of all ships" – inaccurate: 248 incidents among 176,961 ships = 0.14%.
19. line 273: reference to Figure 1, should be Figure 4a?
20. lines 276-279: all the quoted percentage values in the text do not match with the values plotted in Figure 4b, and appear to be wrong.
21. Figure 5: could the authors include dashed lines in the horizontal and vertical in both plots, to help the reader define the values of data?
22. line 295-301: multiple references in text to Figures S3 and S4, whereas the Supp Info labels them as Figures S5 and S6.
23. lines 307-309: the quoted figure of 18 incidents in the text does not match with (a) the plotted values in Figure 8d which sum to 5 incidents, and (b) the numbers quoted in line 327.
24. line 308: the quoted percentage is incorrect: 18 incidents in 246,690 intersections = 0.007%
25. line 311: the 334,944 ship tracks mentioned in the text does not match the total number of ship tracks in the legends in Figure 2a-d.
26. line 311: closing parentheses is missing after 'Figure 2'.
27. lines 314-319: Figure 8a-b indicate three times more Arctic cyclones defined by wave height, versus near-surface wind speed, whereas the data in Figures 6 and 7 indicate there are slightly more Arctic cyclones using wind speed, than wave height. Could this confusion be explained in text?
28. line 336: "only very small"

29. line 343: “As there is are a”

30. line 356: the reference to tables S2 and S3 here seems inappropriate. The two tables are provided as evidence that the most intense cyclones produced no damage incidents, but the tables contain data for all cyclones, not the five most intense.

31. line 376: the percentage of incidents to intersections is quoted as less than 0.0001%, but it is actually 0.007%, as mentioned earlier.

32. line 378: “but there number” should be “but the number”

33. lines 378-379: the “number of shipping incidents has remained fairly stable between 2010 and 2016” is not consistent with Figure 4a showing the number of incidents growing.

34. lines 385-389: the quoted number of shipping incidents per year, and the trend in the percentage, do not match with the data presented in Figure 4a-b.

35. line 411: the percentage is wrong: 248 incidents with 176,961 ships is 0.14%.

36. line 419: the quoted percentage is wrong.

## **Reference**

Coumou, D., Di Capua, G., Vavrus, S. et al. The influence of Arctic amplification on mid-latitude summer circulation. Nat Commun 9, 2959 (2018). <https://doi.org/10.1038/s41467-018-05256-8>