Review of: IcePAC – a Probabilistic Tool to Study Sea Ice Spatiotemporal Dynamic: Application to the Hudson Bay area, Northeastern Canada"
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The paper presents an interesting and useful tool, IcePAC, which uses historic sea ice concentration data to model the predictability of differing sea ice conditions throughout the Hudson Bay System across the annual cycle. The tool provides an interesting way of looking at the phenology of sea ice in Hudson Bay, and is something that would be very useful for the maritime industry that operates in Hudson Bay.

While the tool is interesting, I think the authors need to provide some more context on the Hudson Bay ice cover, discuss the limitations of the passive microwave datasets, and directly discuss where this tool could be applicable. Potential users of the IcePAC tool are briefly listed on Lines 41 to 46, but there could be some more direct applications provided. There is an existing maritime shipping industry in Hudson Bay that would benefit from a tool like this, so some discussion of the shipping season, increased shipping in the shoulder seasons and the users of marine shipping (marine re-supply, Port of Churchill and mines) would help to frame the application of the tool.

Major Comments:

Within the introduction the discussion of Hudson Bay should focus less on freshwater and the oceanography of the Bay and more on the actual ice cover. After all this is purely a tool for sea ice. The limited discussion on the ice cover of Hudson Bay can also be expanded upon. Specifically I would suggest adding reference to the recent work of *Landy et al.,* (2017) who looked at sea ice thickness and its spatial patterns in the Bay, and add in discussion of the polynyas in Hudson Bay. It's these polynyas that drive the variability in ice cover during winter shown in Figure 6, so they are an important factor. Additionally several papers have now highlighted trends towards earlier breakup, later freeze-up and a longer open water season within the HBS (*Hochheim and Barber*, 2014; *Andrews et al.,* 2018). Provided the timing of these seasonal changes is an integral part of the IcePAC tool they should be discussed.

Within the methods there needs to be discussion of the errors and known limitations of passive microwave derived fields of sea ice concentration, particularly in coastal areas and during the melt season. Also the OSI-430 dataset needs to be introduced and contrasted from the OSI-409 dataset. Are the differences in Figure 6 purely due to different processing techniques of the SIC datasets? In terms of coastal influence, it is presented as a limiting factor for site OFB and is likely a factor for your coastal sites (CAI, CBI and CCD). This would also be a good place to compare the known differences between SIC derived from passive microwave sensors and

the CIS charts; see *Agnew and Howell* (2003) and *Tivy et al.,* (2011) for more information.

In terms of the coastal and offshore comparison sites, why did you choose these 6 locations? One issue is that site OFB is outside of Hudson Strait so it is not actually within the HBS that you define in the methods, and since the data from this point prove to be unreliable perhaps you can move this site to the mouth of Hudson Strait. This would also be a very useful site for the maritime industry as Hudson Strait is the access point for the entire HBS. I am also not sure that OC (Churchill) should be considered an offshore location. Perhaps the selection of these sites can be revised to locations that are of particular interest to eventual users of this tool (e.g. the re-supply and shipping industry).

Additionally the paper needs a thorough edit for grammar and sentence structure. There are some awkwardly worded sentences.

Minor Comments:

Title: I don't think you need to add "Northeastern Canada" to the title, and you can simply say "Application to Hudson Bay".

The term "meltdown" is used in place of "melt" throughout the paper. Please change this terminology.

"Sea ice dynamics" implies sea ice ridging, rafting, transport, motion, etc. Therefore I think the authors need to find a better way to refer to the variability in spatiotemporal patterns of sea ice. I'd suggest using the statement on Line 56 ""…analyse the dynamics of SIC in the HBS…".

L45: Elaborate and provide references on the statement "Given the increase in activity noticed in the Arctic…" Are you referring to shipping, mining, tourism, etc?

L48: "resolution" not "resolutions"

L48 to 52: This is an oversimplification of the CIS. The ice atlas does provide climatological conditions but weekly ice charts area available and do provide more detailed information. I understand that the atlas doesn't represent anomalous conditions, but this text should be revised.

L58 to L66 and throughout: You can just refer to Hudson Bay, Hudson Strait, Foxe Basin and James Bay, no need to include "the…" before all of them.

L73: "A complete freeze-up in late December. An annual maximum in extent is usually achieved in April…" Once the HBS is completely frozen over, the spatial extent of sea ice can no longer increase. This needs to be revised.

L74 to 75: "the meltdown is driven from the shores towards…" I'd suggest replacing "driven" with "progresses".

L84 and throughout: I'd suggest replacing "images" with "data", and specifically it is the passive microwave dataset that starts in 1978.

L94: remove “sea ice concentration”, you have already defined SIC and can use it throughout the paper.

L107: change “answers” to “meets”

L130 to 131: How are the three different ice states defined? From my other comment re: Figure 3, this is never referred back to within the paper so it may be extraneous information that isn’t required.

L190: RMSE has not been defined as an acronym.

L237 to 240: When discussing the variations in and out of the predicted range of SICs, the three factors listed should be discussed in the introduction or methods. There is notable natural variation in SIC within the HBS, this should be discussed in the introduction. What are “highly improbable events” in the ice cover? As mentioned elsewhere, the errors in OSI-409 and -430 need to be thoroughly discussed in the methods section so they can be interpreted here.

L313: Change “under scrutiny” to “analyzed” and provide an actual year for when the CIS started monitoring the ice in HB, instead of just saying “many decades”.

L320 to 325: To compare the PMW derived IcePAC tool with the CIS there needs to be a more thorough discussion of the ice charts. Yes Radarsat has very high resolution, but ice types are grouped into polygons using the egg code which provides SIC in tenths, so the 15% limit for freeze-up and melt gives rise to an inherent difference. Furthermore, Radarsat was launched in 1996 so there is a limitation in the accuracy of ice chart data from pre-1996. It is also worth noting that historically ice charts were only produced monthly, so direct assessment of freeze-up and break-up week needs to be discussed as a limitation of the ice atlas.

L342: change “are bringing” to “provide”

Section 5 Conclusions: Building on my previous comments, it would be suitable in the conclusions to included a statement about the applicability of this tool to marine transportation or coastal engineering as a predictive tool.

Figures and Tables:

Figure 1, 4, 7 and 8 should be rotated so that North is upwards.

Figure 1: Partially cuts off Foxe Basin, which is considered part of the HBS within your work. Additionally, I have suggested adding either Igloolik or Hall Beach to Figure 9C, so Figure 1 will need to be expanded to include either of these communities.

Figure 3: Within the associated text you need to provide a definition for how ICE, MIZ and OW are defined. Is there a SIC threshold and if so how is SIC in 1992 greater during the OW period than the MIZ period? Furthermore, the ICE, MIX and OW classifications are not used throughout the rest of the paper, so I’m not sure what they actually add to the paper. You could probably cut this section and this figure.

Figure 4: What are the blue areas within the ice cover in 4A? If they are errors within the dataset perhaps you can smooth over them or present them as NaN, instead of blue and implying 0% SIC within a highly concentrated ice cover.

Figure 5: A minor note, but following the box "IF Q = SIC_{max}" the next step is the same whether the answer is "Yes" or "No". Therefore these two steps can be flipped to more accurately reflect the procedure.

Figure 6: A minor note, but within the legend SIC is presented as a %, whereas on the axes it is presented as a proportion (0 to 1.0 at 0.1 increments).

Figure 9: the y-axis in 9A should be changed to emphasize the difference across the probabilities. In the text you refer to a 1-week change in melt timing from 25% to 10% but within the figure this change is not evident. I would suggest removing the white space and limit the y-axis to weeks 20 – 50. For 9C, why not do all of the communities in the HBS? And if not all, either Hall Beach or Igloolik should be added to provide some context for Foxe Basin, which has a short ice-free season.

Table 1: This table is never referred to in the text. I understand it supports the text in section 4.2 but it needs to be interpreted.

Suggested papers:

Agnew T., S. Howell (2003), The use of operational ice charts for evaluating passive microwave ice concentration data, *Atmosphere-Ocean*, 41:4, 317-331, DOI: 10.3137/ao.410405

Andrews, J., D. Babb, D. Barber, (2018) Climate change and sea ice: Shipping in Hudson Bay, Hudson Strait, and Foxe Basin (1980–2016). Elem Sci Anth, 6: 19. DOI: https://doi.org/10.1525/elementa.281

Hochheim, K.P., D. Barber (2014), An Update on the Ice Climatology of the Hudson Bay System, *Arctic, Antarctic, and Alpine Research,* 46, 1, pp: 66-83, doi:10.1657/1938-4246-46.1.66

Landy, J.C., J.K. Ehn, D. Babb, N. Theriault, D. Barber (2017), Sea ice thickness in the Eastern Canadian Arctic: Hudson Bay Complex and Baffin Bay, *Remote Sensing of Environment,* 200, 281-294, doi: 10.1016/j.rse.2017.08.019.

Tivy, A., S. E. L. Howell, B. Alt, S. McCourt, R. Chagnon, G. Crocker, T. Carrieres, and J. J. Yackel (2011), Trends and variability in summer sea ice cover in the Canadian Arctic based on the Canadian Ice Service Digital Archive, 1960–2008 and 1968–2008, J. Geophys. Res., 116, C03007, doi:10.1029/2009JC005855