**Second review of Asadi et al.**
**"Probabilistic Spatio-temporal Seasonal Sea Ice Presence Forecasting using Sequence to Sequence Learning"**

The manuscript has improved considerably, both in terms of presentation of text, methods (model description, experiment description, skill scores), results, figures and due to new content. The discussion section was extended and includes good new aspects, and additional sections were added in which the proposed Seq2Seq models are compared to ice charts and S2S forecasts. This puts the proposed method in context to other commonly used data products and is a valuable addition.

Unfortunately, I find the new sections (7.2.3, 8, 9, and partly 10) more difficult to read than other sections. First of all, there are many little mistakes like typos, double words, inconsistencies, missing references, wrong figure numbers etc.. I've tried to point some (not all) of these issues out in the list below, but I think these sections need to be revised carefully by the authors. These sections would benefit not only from fixing the little mistakes, but also from an additional attempt to improve readability of the text. The other sections were easier to read for me.

Regarding the revised documents, I noticed that the document with tracked-changes does not match the revised manuscript (without tracked-changes). From the properties of the pdf files I could see that the tracked-change-document was older, hence I did this review based on the non-tracked-change document and line numbers are referring to this. Nevertheless, I would wish that I would not need to spend time to check for such inconsistencies.

I'm also confused to see that some of my earlier proposed corrections have apparently not been processed (especially regarding typos in the Reference section.) It's completely OK to not implement my *suggestions* if you don't like them. But I couldn't find an indication in the author-reply document whether you have overlooked the proposed *corrections* or whether you just intend to implement them sometime later. Therefore, I refer to them again.

General
##################

A) Good that you found the inconsistency of the ERA5 landmask and the landmask used for SIC.

B) In line 78 you mention that you use hourly data at 12:00 for each day. Was it a deliberate decision to not use daily averages? I would assume that the models could maybe do a better job if they used daily averages. For example, air temperature at 12:00 will very often be higher than the daily average and presumably ice conditions correlate more with the daily value than the 12:00 value. For wind speed I guess there is a similar problem: Strong winds during nighttime would have an impact on the sea ice conditions (used for training), but the input data for wind cannot reflect this. There is nothing wrong using 12:00 data, I'm just wondering if the model could do better if daily data were used.

C) I like that the text refers to figure numbers more often now. However, please double-check if the correct figure numbers are used throughout the manuscript. I did find some mistakes.

D) 321-323
Why do you replace an unusual break-up date by a freeze-up date? Wouldn't this make the mistake even bigger? Couldn't you instead extent the allowed break-up range to include all possible break-up dates?

E) Why is the comparison to ice charts a subsubsection while the comparison to S2S is a full section? Spontaneously, I would rather suggest to make one section for the evaluation of the spatial full-domain forecasts and another section for the evaluation of forecasts at point locations. In any case, just give the section-layout another thought.

Abstract
###############

If there is space left, I would suggest to mention the most important 1-2 results.

Introduction
################

17 "have included"
Could also be written in present tense.

17 "(Drobot et al., 2006),"
Remove comma

21 "by Zhang et al. (2008) in which"
I would use a comma before "in which"

25
The sentence "A comparison..." comes quite suddenly - I don't see a connection to the previous statements. Did you delete this introducing sentence on purpose? "The majority of studies on sea ice prediction and forecasting focus on the pan-Arctic domain"

50, 51
Are you aware that you use "spatio-temporal" in the title and in the abstract but "spatiotemporal" otherwise?

51
Also here: "sequence to sequence" in the title but "sequence-to-sequence" otherwise. Did you choose to do it like this on purpose?

485 Bushuk
The given DOI number "10.1022/2017/GL073 155" does not work. It should be "10.1002/2017GL073155"

Data
####################

71-72 "When ... ERA5 the SIC..."
"When ... ERA5, the SIC..."

77 "network.Recalling"
Missing space?

80 "was set to zero." and 84 "was set to the average"
Consider to use "we set ..." instead of passive past tense to make it more clear what was found in ERA5 and what was done by you.

3 Study Region
################

Figure 1
Great to have this map now! If you want to optimize it, you could plot the red dots on top of the grey landmask. In Python and matlab the plotting order can be set with the option "zorder".
Additionally, the titles (port names) of the six subplots could be placed more consistently, e.g. flush-left.

Caption of Figure 1 "model grid point near Quaqtaq"
Looking at the subplots for all ports (Churchill, Inukjuak and Quaqtaq) I don't see how/why Quaqtaq is a special case. All model grid points seem to be located in the water region. (And considering that you are working with a sea ice model, that makes a lot of sense.)

4 Forecast model architecture
###############################

98/99 "video captioning (...), speech"
"video captioning (...), and speech"

103 "the number days"
"the number of days"

105 'and “Augmented Model”'
' and the(?) "Augmented Model"'

116
Would be helpful to mention that one only needs to look at the black part of Figure 2a for the Basic model.

Caption of Figure 2
- Add a space in "architecture(a)"
- Not coming from the ML field, I don't know what an "adder" is. But if/as this is not critical for understanding the basic principle of your model, it's ok for me to not go into more detailed explanations here.

5 Description of Experiments
##############################

146
space missing after "operationally,"?

148, 149, 155 etc.
It seems the concept of "model weights" has not been introduced/explained. I also don't see it in Figure 2.

157-159
I find these sentences confusing. Isn't the "For example"-sentence saying the same as the sentence starting with "The model for year 11"? The figure helps a lot to understand what you want to say :-) Would it maybe be easier to use year numbers like 1995 and 1996 instead of 11 and 12?

Figure 3
- "Train" in the legend for the blue color means "Training" I guess.
- I know "testing" is a term in ML, but it could be confusing that you call the green color "Test" while you talk about "prediction" in the text.
- Just a little detail, but it makes me feel unsure:
At the moment the figure indicates that weights from the combination of Train-1995 and Val-1996 are used both for Train-1996 and Val-1997. Can you double-check if this is what you want to say? I get the impression that the Weight-arrow should come or end in a colored box instead of the white box?

174 "points"
Is this the same as pixel?
Ah, no, it's not. Can you connect the next sentence, which explains N, better? And then use "pixel" in line 175.
Suggestion:
"... N is the total number of points considered. For monthly scores, N is the product of the number of pixels in the spatial domain, ..."

180
Two times "binary accuracy" in this sentence. Maybe change to "... impact the resulting score."

184 "grid location"
Consider to use "pixel" again?

184 "points in the spatial domain"
pixel or point?? I thought N was the number of points.

186 "the average of 'ERA5' sea ice presence"
Why did you drop to mention ERA5? I find it is an important information.

190 "extracting"
Not sure I understand where you extract from. I thought you would just need to "run" the April-model to get the 90-day forecasts.

191 "test data in Fig 3"
This is confusing to me: The arrow in Fig 3 indicates that the green Test-data originate from the trained/validated model. I thought this is the forecast output not the ERA5 observation data.

7.1.1 Monthly averaged results
################################

196 "each value"
"the value", because there is only one value for each (i,j).

197 "(a) and (b) of Fig 5"
Figure 4? And why not (c), as mentioned in the sentence before? Maybe can be left out?
"For example, the value at index (i,j) of each panel represents..."

200-201 "This continues... April 1-30"
I suggest to remove this sentence and instead show the example for index (2,1).

201 "Panel 1b)"
Fig 4a?

202
Suggestion: Start the sentence with "Fig 2 (a,b,c) show that the binary accuracies ..." to help the reader find where we are.

206, 207
If "Basic AND Augmented models" then Fig 4d and 4e.

207 "early lead times"
"short lead times"?

208-209
Do you talk about Fig 4f now? "Improvements" is ambiguous.

225 "early lead days"
"short lead times"

Figure 6
It would be nice if the aspect ratio of x and y axis was 1, so that the dashed line would be at 45 degree.
(I have pointed this out last time already and you have marked it as "Modified", but I don't see any modification...?)

7.1.2 Spatial maps of sea ice presence
########################################

243
I still can't see where in the northern part of the domain the Basic model has higher ice presence probability than the Augmented model.

7.2.1 Freeze-up and Break-up Accuracy
#####################################

256 "is in incorrect"
"is incorrect"

Section 7.2.1 basically describes a new skill score, and hence it would actually fit well into section 6. Can you move it there to give a full overview about all used metrics in section 6?

7.2.2 Freeze-up and Break-up in comparison with ERA5 data
#################################################

261 "lead days The"
Add "."

263 "Fig 9b"
"Fig 8b"?

Figures 8 and 9
Add a space between the subfigure number and the subfigure caption
(I have pointed this out last time already and you have marked it as "Modified", but I don't see any modification...?)

261-263
This sentence is misleading. It sounds like you compare the pattern of the Basic model with the pattern of the Augmented model. But I assume you are actually comparing both models to the Climate Normal?

267
Why in past tense?

264, 265 vs. 269, 261, 263, caption of Fig 10, 290
Inconsistency in use of "lead day" and "lead days". (I didn't check the whole document if there are more cases.)

273 "((c) and (d))"
(Fig 10c,d)

284 "influx of freshwater inflow"
Couldn't "influx" be removed?

287 "Quataq"
"Quaqtaq"

292 "CIS"
Has this abbreviation been introduced already?

Captions of Figures 11 and 12
Is it possible to use a proper "+/-"sign?

302-303 "as for break-up as for freeze-up"
Still not quite... ;-) Now there is one "as" too much.

7.2.3 Ice charts
##################################

Section title: Do you want to make the wording of 7.2.2 and 7.2.3 more similar?

307 "described section in"
"described in section"

310-311 & 312 "CIS charts"
"ice charts"

311 "assimilation"
I don't think this term can be used here.
"Ice charts are compiled by ice analysts who manually combine information from different sources like ..."

313 and elsewhere "ERA-5"
Be consistent: "ERA5" or "ERA-5"

The description of the CIS ice charts and Ice Atlas should actually go to section 2 "Data", shouldn't it?

318 "2 metrics"
How is this now different to what we have seen in the previous section? Is the "Accuracy" you mention here the same as before?

319
How exactly do you get a forecast from an Atlas?

324
Refer to Table 1?

Table 1
Missing full stop at the end of the caption.
Sounds like the selected sites are shown in the Ice Atlas.

Table 2
Explain "MAE" in the caption and give the unit (days).

8 S2S System
###################################

Should the introduction of the S2S data go to section 2 "Data"? Or at least be mentioned there for people who go to "Data" to look up info about used datasets.

Figure 13
Could you add the month names to the subfigure caption (like "a) May" instead of "a)")?

Caption of figure 13
Move the second full stop from the end to the beginning of the last sentence.

368 "(false negative, FN)"
Use math font for "FN"

Figure 14
Binary accuracy was defined as (TP + TN )/N, which is a scalar quantity for the whole domain. Also false positive rate and false negative rate are scalar quantities, one number for the whole domain, if I understand correctly. I miss an explanation how you can plot those quantities as a map. Maybe you show probability of false negatives (without "rate")? And something like probability of correct prediction/hit instead of binary accuracy?

Caption of Fig 14 and 15
Needs improvement/more details.

370, caption of Fig 14/15, General reminder
Inconsistent use of "lead day 30", "30 lead days"

370-371 "maps showing ... are shown."
One "show" should be enough.

370
For people who don't read the paper in a linear way, can you quickly repeat what observations (="truth") you use to calculate the hits, FP and FN.

371 "July 1 to July 30th"
Either "1st" or "30"

372 double "are"

379 "that"
"than"

383 and 390 and 393 "proposed approach"
Better stick to "Basic and Augmented models". At least use plural form. Or Seq2Seq models?

385 and elsewhere
When you refer to "portion of domain", do you mean Hudson Bay or the whole model area? In my view, Kivalliq is pretty much in the center of the domain (latitude 61N out of 52N to 70N). [I just realize: Maybe this could also be an explanation for my comment about line 243?]

391 grammar correct?

9 Discussion
########################

393 "spatial-temporal"
spatio-temporal

393-394
Reference to a figure?

396
Your manuscript does not have a Figure 1d.

398-402
Quite lengthy text with potential to be shortened.

409 "enforce"
This word sounds weird to me in this context. Maybe more something like "incorporate/draw on knowledge from the climate normal"? (But I'm not a native English speaker...)

412 "Fig 13 and 14"
and 15?

421 "they"
their

10 Conclusion
######################

434 "in advance"
Isn't lead time always in advance?

434-435
Suggestion: "The Basic model uses eight input variables from the ERA5 dataset for the 3 days prior to the forecast start day."

435 "basic model"
"Basic model"

435 "where it"
"which"

436 "climate variables ... over the forecasting period"
You mean Climate Normal? But this is historical data, so then it cannot be used 'over the forecasting period'. Can you clarify the text?

437 "climate normal"
You improved the consistent use of capitals a lot. However, this paragraph seems to be an exception...

438, 207, 225, 396
I still find "short lead times" better than "early lead days".

438 "probability assessment by calibration analysis"
I don't quite know what you are trying to refer to.

442 "lead day"
"lead time" (You also wouldn't say "Air temperature is decreasing with meter." but "Air temperature is decreasing with height.")

444 "operational"
I guess you are thinking about dynamical forecasting here. A statistical approach like yours could also be "operational".

Paragraph 444-452
The content of this paragraph is pretty good but the sentences are a bit unconnected. Maybe it can be improved by starting the paragraph with the last sentence with a structure something like this: "The model is demonstrated in hindcast mode here, but it is intended to be used for forecasting. We do not envision this to be difficult .... Using different input data requires fine-tuning of the weights, but this is a quick process and only takes around 15 minutes .... Producing a forecast only takes 10 seconds which is much less than with commonly used dynamical forecast systems. This clearly demonstrates the advantage of the Seq2Seq approach. ... " Or so.

448 "different reanalysis"
A reanalysis product is produced by re-running the atmospheric model (including assimilation) in hindcast mode in a more consistent way than it is possible to do for the "analysis product" (which is used as initial conditions for real forecasts). Hence, reanalysis products are usually only available with a considerable delay (months). Therefore I don't see that you could run your model in forecast mode based on reanalysis data as input.

Paragraph 452-462
Good point with the coarse resolution which limits usability for mariners. My understanding is that dynamical forecast models have difficulties to go to higher resolutions for long predictions because the computational costs are so high. But as computational efficiency seems to be the big advantage of your approach, I wonder: Could your Seq2Seq-model be trained with high-resolution atmosphere/ice data (e.g. from an analysis product of a regional atmosphere-ice-ocean model) and with this be able to produce high-resolution sea ice predictions in a computationally cheap way?

462 "et al"
"et al."

Code and data availability
##################
What about the ice charts and Ice Atlas? (I don't know if they need to be mentioned if they are not available.)

This link returns "Page not found".
https://cds.climate.copernicus.eu/cdsapp/dataset/reanalysis-era5-single-levels?tab=overview

In general for links I would expect info about when the page has been accessed last.

468 "Vitart et al."
Only two authors, therefore "Vitart and Robertson"

469 "available"
"is available"

469 Reminder to replace the place-holder.

Acknowledgments
####################
I thought Copernicus had some rules about what to write as acknowledgments when one uses data from CDS. ERA5 was downloaded from CDS, wasn't it?

References
##################

Please check the corrections I've provided in the first review. A few of them are still not implemented.

Missing page numbers and misspelled Danish letter in Dybkjær:
Tonboe, R. T., Eastwood, S., Lavergne, T., Sørensen, A. M., Rathmann, N., Dybkjær, G., Pedersen, L. T., Høyer, J. L., and Kern, S.: The EUMETSAT sea ice concentration climate data record, The Cryosphere, 10, 2275–2290, https://doi.org/10.5194/tc-10-2275-2016, 2016.

Missing volume number and missing initial letter for second author:
Vitart, F., Robertson, A.W. The sub-seasonal to seasonal prediction project (S2S) and the prediction of extreme events. npj Clim Atmos Sci 1, 3 (2018). https://doi.org/10.1038/s41612-018-0013-0

Missing references to Gignac et al. (2019) and Dirkson et al. (2019) (line 414-415)
Also add full stop after "et al" in line 414-415.