

In this document, the authors provide answers to the two reviews of paper tc-2018-127.

Lavergne, T., Sørensen, A. M., Kern, S., Tonboe, R., Notz, D., Aaboe, S., Bell, L., Dybkjær, G., Eastwood, S., Gabarro, C., Heygster, G., Killie, M. A., Kreiner, M. B., Lavelle, J., Saldo, R., Sandven, S., and Pedersen, L. T.: Version 2 of the EUMETSAT OSI SAF and ESA CCI Sea Ice Concentration Climate Data Records, The Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-127>, in review, 2018.

We thank the two anonymous reviewers for thorough comments on our manuscript, and many suggestions to improve both the content and the language.

Anonymous Referee #1

Summary:

This paper describes a new version of the OSISAF sea ice concentration product and the ESA sea ice CDR. The products are derived from passive microwave data. The new version includes several enhancements from the Version 1 OSISAF product. Comparisons with independent estimates show good agreement. The new version provides a consistent record of sea ice concentrations for the scientific community.

General Comment:

The manuscript provides a thorough introduction of the new versions. The description of the algorithm and processing, including enhancements from Version 1 is clear and detailed. The initial evaluation results look reasonable and given that it builds on the previous version and thorough earlier validation, they are quite sufficient to provide high confidence in the quality of the product. The Level 4 filtered product is particularly beneficial for users who wish to have a “clean” concentration estimate and this is an excellent improvement from Version 1. I have only a few minor comments that the authors should address before publication.

Thank you for your positive appreciation of our manuscript. Your comments are very valuable and are addressed below.

(One further general comment: it would be helpful for readability to either indent new paragraphs and/or skip a line between paragraphs.)

This is done in the revised manuscript.

Specific Comments (by page and line number):

P2, L9: while the albedo specifically depends on concentration, it is not only concentration: snow melt state and particularly melt ponds substantially affect albedo even for 100% concentration.

We agree and have changed the wording to now read “For example, the albedo of the polar oceans is strongly influenced by sea-ice concentration”

P4, L24-25: I find the (resp. XXXX) style awkward to read and somewhat confusing. I would just write out each in sequence rather than using parenthesis, but this may just be a preference by me.

We changed this sentence to read: “Although not identical, the spatial resolution of the channels needed for the SIC algorithms is similar for the three coarse resolution sensor series (SMMR, SSM/I, and SSMIS) with about 70x45 km instantaneous Field-of-View (iFoV) diameters for the 19 GHz frequency channels, and 38x30 km for the 37 GHz ones (Table 2)”.

P6, L1: “daily composited fields of SIC” – how is the compositing done? Is it simply drop-in-the-bucket?

We use a weighted average with Gaussian spatial weights, and equal weights in the temporal domain. This is added to section 3.6 where gridding and daily compositing was briefly covered.

P10, L12-20: What are the uncertainties in the NWP fields and the RTM? While the dynamical tiepoints and the double-difference approach may negate much of the influence, I do wonder how effective the correction is if the NWP data and/or the RTM have high uncertainties? This feeds into my next comment below.

The quality of RTMs and NWP fields indeed play a role in the effectiveness of the T_B correction. In our experience however, the T_B correction always yields more accurate SIC fields over open water when correcting for wind speed, and water vapour. As others we do not correct for Cloud Liquid Vapour (L) which is not reliable in NWP data (see next comment).

P10, L28: the use of the NWP fields is novel and I like the physical approach. However, L is not reliable from NWP. Isn't L one of the largest if not generally the largest source of emission, at least over open water. So not being able to correct for that really limits the effectiveness of the NWP correction, doesn't it? The use of weather filters in the Level 4 fields eliminates this, which is good, but the quality of the Level 3 fields must be limited, right?

The use of NWP fields and RTM-based correction schemes is one of the specificities of the OSI SAF approach, and was introduced in Andersen et al. (2007). So far, Cloud Liquid Water (CLW, symbol L in the paper) in global NWP field has rarely been found to be reliable enough for correcting T_B . One factor is probably that the modelled fields are not at the same temporal and spatial scales as the satellite data.

Although CLW is not used, the correction based only on 10m wind speed and water vapour is still quite efficient (see for example the offset of 1% to 1.5% standard deviation in Figure 8). Correcting T_B for WS and WV leads to a 35% reduction in T_B variance at 18/19 GHz and 22% reduction in T_B variance at 37 GHz. This subsequently leads to a 35-45% reduction of SIC variance for standard algorithms (ESA SICCI PVASR p151-159). The noise associated to CLW is rather localized on small geographical domains, and is indeed taken care of by the weather filter (and maximum extent climatology) at Level-4. As in previous version of the CDR (Tonboe et al. 2016), the Level-3 product files indeed present some remaining noise, more pronounced in the case of high CLW. Noticeably: the statistics of the remaining noise is integrated in the uncertainty fields: not correcting for CLW leads to higher product uncertainties.

P13, L17: It might be worth considering showing an example of the “ice curve”. I can generally visualize, but a figure would perhaps better illustrate it.

Yes, this is added to Figure 3, and discussed in section 3.4.3.

P13, L20-26: I’m not sure I understand Figure 5. It appears to show an increase in open water concentration near the ice edge due to the correction (e.g., in Barents Sea and Davis Strait regions). Is that correct? Wouldn’t that reduce the quality if the correction essentially added ice to open water regions?

You are referring to the “open water” region of Figure 5 left panel (outside the 15% SIC contour). This part of the plot was actually not described nor discussed in the text, something that was clearly missing and triggers your comment (also from Reviewer #2).

Figure 5 (left and center panels) shows the effect of the total correction, including both the correction due to the ice curve (described in this section 3.4.3), and the effect of the RTM-based atmospheric correction (section 3.4.1). The ice curve correction has most of its impact in high-concentration regions (inside the 70% SIC contour) while the atmospheric correction has most of its impact over open water regions (outside the 15% SIC contour). Outside the 15% SIC contour, it is correct that Figure 5 (left) shows increase in SIC after correction. This was confirmed by plotting similar maps for other months. This is because the SIC before correction SIC_{ucorr} is mostly slightly negative there, and the correction step brings it closer to 0%. This is linked to the way our OW tie-point is tuned. As explained in section 3.4, the OW tie-point is tuned dynamically against open ocean cases that are outside a maximum ice extent climatology, thus potentially more representative of “open ocean” Tie-point than the conditions closer to the edge. Prior to atmospheric correction, the open-water tie-point is thus “warmer” than the T_B conditions closer to the edge, thus the uncorrected SICs are slightly negative there. After correction, our OW tie-point is re-tuned and is more representative of T_B close to the ice edge, hence the increase (reds in Figure 5). The net effect is a reduction in variability over ocean (blues on Figure 5, center panel) which indicates that the atmospheric

correction step on average does a good job reducing weather-induced noise over the open ocean.

Your comment prompted several edits: in section 3.4.1 we added that the effect of the RTM-based correction is largest over open water, and very limited over sea-ice. in section 3.4.3, we stated the “ice curve” correction has most impact over consolidated ice, and little effect over open water. Then we started that Figure 5 shows the combined effects of both correction. We also reworked the description of Figure 5 to first address the “ice curve” correction (including the discussion with ice-age on right panel), before addressing the atmospheric correction (including addressing your specific comment above). This results mostly in a re-arranging of text for improved readability. Thank you for this comment.

P16, L3: This should be discussed further – why is the gridded land-spillover correction still needed after the swath correction? How much coastal contamination remains after the swath correction. If the swath correction is not sufficient on its own, is it worth doing – i.e., would the Cavalieri correction work just as well without the swath correction? I guess the basic question is whether there is a benefit to doing both corrections or is the Cavalieri correction just as good? If so, then why do the swath correction?

We believe there is a benefit of combining the two approaches: first perform a physically based correction, then a statistical-based correction/filtering. We have however not studied in details if the statistical method alone could have done a good enough job alone, and cannot answer your (very valid) questions above. We added the following text in section 5.2 “Outlooks” when discussing algorithm improvements.

Other steps in the processing chain can further be improved upon, e.g. the land spill-over correction schemes. In section 3.6 we described how land spill-over was corrected in two steps, first through a physically-based algorithm on swath T_B data (adapted from Maass and Kaleschke, 2010), followed by a statistically-based correction of gridded SICs (adapted from Cavalieri et al. 1999). Several reasons can have led to the swath-based correction to not be enough. For example, the method relies heavily on accurate geolocation of the T_B measurements, however its uncertainty for the SSM/I and SSMIS instrument is known to be large (Poe et al. 2008), and is not corrected for in the current version of the FCDR (R3) we used (Fennig et al. 2017). We used approximated iFoVs weighting functions instead of eFoVs (see section 2.1) when convolving antenna pattern with the land mask, thus neglecting the effect of the measurements integration period. Finally, strategies to avoid gridding land-contaminated FoVs when building Level 3 maps might help in the future. It will also be beneficial to use high-resolution SIC maps from coastal regions (e.g. from navigational ice charts) to tune the various thresholds embedded in the statistically-based correction. To improve further on the land spill-over correction will be an objective for upcoming versions of the CDRs.

P16, L31: "basic isotropic schemes" is not very specific. Is it a bi-linear interpolation?
It is a interpolation with gaussian weights of the distance. This is now specified in the text.

P19, L17-23: I can understand that the ERA-Interim fields are not as good earlier in the record and thus the correction for SMMR is not as good. However, there is a noticeable step-change between SMMR and SSMI in Figure 8. Did ERA-Interim undergo a step change in terms of data sources or other processing quality at the same time? If not, then it seems like it's not ERA-Interim (or at least not only), but rather something else causing the step change. Perhaps it's related to the change in frequency from 18 GHz for SMMR to 19.3 GHz for SSMI?

This is a very good point, also made by Reviewer #2. We added a sentence discussing the impact of 18.0 GHz Ku-band.

Concerning the quality of ERA-Interim in the SMMR era: the main ERA-Interim reference is Dee et al. 2011, but it only describes the "1st production stream" of ERA-Interim (post 1989). A second stream covering 1979-1989 was added at a later stage, but there are no publications. We contacted the ECMWF team, and obtained a personal communication that can give some insight. We modified the manuscript P19 to read: "Another plausible explanation would be that the re-analysed fields for wind speed and water vapour from ERA-Interim are less accurate in the SMMR era than in the SSM/I and SSMIS era. We note that clear-sky radiances from SSM/I and SSMIS were directly assimilated in ERA-Interim over the ocean (Dee et al. 2011), but not SMMR radiances (Paul Poli, personal communication). This can especially have an impact in the SH, where other sources of conventional observations are scarcer".

P21, L4: One thing not discussed is the potential impact of satellite crossing times on the retrievals. I assume the dynamic tiepoints should handle these discrepancies, but it might be worth mentioning.

The dynamic tuning of tiepoints and OWF threshold work with samples gathered at an hemispheric scale, and over a [-7:+7d] sliding time window. This technique can thus not handle intra-daily differences -arising from one region to the next- that are due to not observing the surface at the same time. It can however mitigate the potential impacts due to different missions observing at different times (if any). We added the following sentence when describing how OWFs are tuned and applied at Level-2 (P12): "To compute OWFs at Level 2 can also help mitigate the potential impacts of changes in satellite crossing time between different missions".

P25, L12: Why not produce a 12.5 km or 10 km resolution AMSR-E and/or AMSR2 product, i.e., using the same channels (19, 37 GHz) as for SMMR-SSMI-SSMIS, but obtaining a higher spatial resolution for the period of 2002-present? It seems like this

would be more beneficial than at least the 25 km SICCI. I can see a benefit of using the 6V channel for the 50 km product, but that isn't in the 25 km SICCI.

This is an excellent question. The channels we use for AMSR-E and AMSR2 have the following iFoVs (reproduced from Table 2).

iFoV	18.7GHz	36.5GHz
AMSR-E	16x27 km	9x14 km
AMSR2	14x22 km	7x12 km

They all have a 10x10 km spacing. The diameters given here are those of the 3dB ellipses of the main lobe of the antenna pattern. Considering in addition that eFoVs are larger (mostly in the across track direction), we approximate that the eFoV diameter for the 18.7GHz channels are about 25km, while the eFoVs of 36.5GHz are about 15km. These two resolution are then merged into a SIC algorithm (that uses one 18.7GHz channel, and two 36.5GHz channels). What is the spatial resolution (eFoV) of the computed SIC? Probably somewhere between 15km and 25km, but in any case larger than 10km (the spacing) or 12.5km (half the grid spacing used for OSI-450).

The choice of a grid spacing for SIC products is very much based on “feelings” and historical reasons. Because the SSM/I brightness temperature daily maps were originally provided on a polar stereographic 25km grid, the NOAA/NSIDC SIC CDR is also on a 25km grid, and OSI-450 as well. This is probably too fine a spacing as we discuss in our section 4.3. The choice of 25km grid for the SICCI product based on 19 and 37 GHz channels from AMSR-E and AMSR2 is potentially too conservative (not by much), but this choice was made to ease uptake by users (only one spacing to refer to).

Your comment prompted the following revision:

A sentence was added section 4.3: “The true resolution of the SICCI-25km CDR might be slightly better than 25x25 km, but this grid spacing was retained to ease uptake by users, and comparison with OSI-450.”

A sentence was added section 5.2 (Outlooks) when discussing needs for further research efforts: “Finally, research is needed to assign a true spatial resolution to SIC fields computed from combinations of n T_B channels, themselves at different spatial resolutions. Some knowledge is embedded in our parametrization of smear, but it is currently not enough to e.g. choose and fully justify a grid spacing for SIC data records.”

Minor Comments (by page and line number):

P3, L17: use “in” instead of “entering”

P3, L26: use “share” or “provide” instead of “keep”

P16, L26: use “contrasts with” instead of “is conversely to”

P24, L3: “aiming at most complete” to “aiming to produce the most complete daily maps possible”

P25, L11: use “allowed, e.g., consistent processing of SIC CDRs. . .”

P26, L18: use “on the order of. . .”

P27, L1-2: use “the impact that melting and melt-ponds have. . .”

P27, L10: use “could be investigated if selecting. . .”

P28, L24: use “aim to have the best temporal consistency. . .”

Thank you, all your suggestions were implemented.

Anonymous Referee #2

This paper gives a thorough, informative and detailed description of three important new climate data records of sea ice concentration. The science in the paper is comprehensive. I therefore only have suggestions for minor improvements (though there are quite a few) - mostly for clarifications to the text. The paper is clear and easy to read, despite a number of minor grammatical errors which are detailed below.

Thank you for your positive evaluation of our manuscript. Your “quite a few” suggestions for minor improvements were processed thoroughly and led to an improvement of our text and figures. Thank you for having taken the time.

Minor comments

Page 2 line 1: Is this the observation uncertainty in assimilation for models? Unclear, need to elaborate

We have added a sentence to clarify this statement: “This is because both the bias correction of large-scale climate models and the extrapolation of observed relationships between forcing and sea-ice coverage can only be carried out robustly if observational uncertainty is sufficiently small.”

line 32: quantify what you mean by “coarse resolution”

Done: “coarse resolution (30-60 km)”.

Page 3 line 4: quantify what you mean by “medium resolution” line 19/20 & 22 (and throughout): Why only an “initial evaluation”. Reading on shows that you have done

more than just a cursory evaluation which is what this wording implies. Suggest reword.

Done: “medium resolution (15-25 km)”.

“initial” is here meant as “a first set of evaluation results”. More evaluation is underway, that will be published at a later stage. Since both reviewers estimate that the evaluation presented in this manuscript is enough for a publication, we will remove “initial”. That more evaluation will come in later publications is already announced in our Outlooks section.

Page 4 line 2: Suggest mentioning data gap in AMSR data earlier, perhaps when introducing Table 1. line 4: Suggest “documented in Table 2” should be “documented in the comments in Table 2”. Would also be useful to have a full list of outages, perhaps a link to this in another document? Line 10 (and Table 2): “width of the polar observation hole” is not given, it’s the bit that’s viewed rather than the hole, also not a width as it’s an angle, suggest rename this column line 23: Not sure that spatial resolution of SMMR is “somewhat similar” to SSM/I and SSMIS, suggest reword line 26: Clarify difference between sampling and resolution line 32: Consider showing eFoV in Table 2.

P4L2: this would require discussing acronyms earlier, we feel it is not worth the rewriting since the information comes shortly after. L4 done, we refer to the Product User Guides (PUGs) for extensive list of missing dates. L10&T2: done. L23 done (removed “somewhat”). L26: done (add sentence “The dimensions of the iFoV and eFoV are referred to as the resolution of the channels. The sampling is how close in space the FoVs are acquired. Most channels are thus oversampled.”). L32: unfortunately there is no authoritative source for eFoVs across all the instruments. iFoVs is what is generally documented (e.g. at WMO OSCAR database).

Page 5 line 4/5: Clarify if L1 data for SMMR, SSMI/S, SSMIS line 5: Add a line on what is an FCDR and what reprocessing has it undergone. Overlaps? Calibration? QC? line 6: add what period AMSR-E data covers line 9: more information needed on “resolution-matched”

P5L4: done. L5: done (add sentence “In the FCDR, the T_B are re-computed from Antenna Temperatures (TA) , screened and corrected for known artefacts like solar intrusion, and intercalibrated between missions.”) L6: done, L9: done. The sentence is edited to read : “For both AMSR-E and AMSR2, the T_B are available both at their nominal resolution (documented in Table 2), and post-processed at lower resolution matching those of other channels (e.g. the 36.5GHz T_B at the resolution of the 6.9GHz channel). We use the nominal resolution of the T_B channels, not the resolution-matched ones.”

Page 6 line 1: what type of grid? EASE? Line 2: what are the necessary steps? Can reference later on in paper if necessary lines 5-8: suggest moving these lines to page 5 line 32, after “flags”. Would flow better. Line 18: clarify these numbers are sea ice fraction line 23: needs citation for BRI more accurate than BPM at high concentrations line 28: Figure 3 illustrates for AMSR-E data, example from Comiso (1986) is for SMMR. Need to clarify that these can be applied to other instruments.

P6L1: Yes. The type and definition of grids is covered later in the text. L2: the sentence was simplified to “The Level 4 (L4) chain fills the gaps, apply extra corrections, and format the data files that will appear in the CDR.”. L5-8: done, L18: done, L23: same references as the sentence before, so we merged the two sentences. L28: the reference to SMMR was not needed and was removed.

Page 7 lines 4/5: show ice signatures on plot (mentions in text to left and right but not that clear) line 8: text says D-A, use A-D for consistency. Also A,D in figure 3 and D,A in figure 4, make consistent.

Well spotted. We made this consistent.

Page 8 line 4: What is the magnitude of the ice concentration change between algorithms for this example? Line 10: show $\theta = 90$ on figure

The improvement is only few tens of %s RMSE, but can be more significant in other conditions. We specified the [-90;90] range for Figure 4.

Page 9 line 5: Have you also used a sliding window? Wording implies not, if it is suggest adding “similarly” before sliding. Why was the window changed from +-15 to +-7 days? Line 13: Why can this be assumed? Expand. Line 15: and SMMR, SSM/I, SSMIS? Also remove “than”. Line 15/16: suggest moving sentence beginning “Recent investigations...” to line 13, before “It is assumed...”

P9L5. Done. We add a sentence: “Our sliding window is made shorter so that tie-points react more rapidly to seasonal cycles, e.g. onset of melting.” L13, L15, L15/16: all done by a refactoring: “As in Tonboe et al. (2016), the CI training sample is based on the results of the NASA Team (NT) algorithm (Cavalieri et al., 1984): locations for which the NT value is greater than 95% are used as a representation of 100 % ice. Recent investigations, e.g. during the ESA CCI Sea Ice projects confirmed that NT was an acceptable choice for the purpose of selecting closed-ice samples.”

Page 11 First paragraph: This is confusing as it sounds like different RTMs for each instrument but is it actually different optimisations? Reword. Line 10: quantify what is meant by “rather large” line 27: Is there a citation for the ATBD document itself? From line 20: As not using GR2219v suggest editing this section as don’t need to describe in detail or give previous examples.

P11: we re-worded to avoid confusion of different RTMs. L10 done (“sometimes up to 50%”) L27: we are not aware of a citation for the ATBD. L20: we kept the text as-is.

Page 12 line 1: Would be helpful to use a different symbol other than T to avoid confusion with temperature line 26: Implies that <10% will be removed anyway, even if GR3719v < T. If so need to clarify this in text. Note also in this section that GR3719v is also used for AMSR despite different channels. Also in this section, it is not really clear how the threshold values for the Gradient Ratios are selected, needs clarification.

P12, L1. In retrospect we agree that another symbol could have been chosen, but T is also ok as a symbol for Threshold. We kept T. L26: your observation is correct, and we added a justification for adding a test to SIC<10% (“In addition, GR3719v contains information on sea-ice type (Cavalieri et al. 1984) and it is desirable the filter should work equally for first-year and multiyear sea ice.”). Concerning the need for clarification, the dynamical tuning of the OWF is described with several sentences already, we made the link to Figure 3 clearer. We changed one of them to be better described by Figure 3: “First, the coordinates for the point J are computed: J falls where the SIC=10% isoline (thick blue line) crosses the (blue, dotted) line between the OW signature point H and a point at the right-most end of the line A-D. Then, the GR3719v value corresponding to J is computed, and used as a threshold T”.

Page 13 line 1: If you say it's visible, need to show on a figure line 12: Would be useful to show in a figure for visualisation line 13: “u” in italics is given as “U” on figure 4, needs to be consistent line 26: Why is there an increase in concentration due to the atmospheric correction (with reduced standard deviation) in figure 5? line 29: Are the contours specifically for 2015? Need to elaborate.

P13L1: We show it on Figure 5 introduced in the next paragraph., L12: Yes. The need for visualization is expressed by both reviewers and we agree. We added such a visualization on Figure 3 (black curve). L13: U is a direction sustained by unit vector u. We made this clear in the caption for Figure 4. L26: Both reviewer asked the same question. We added an explanation in section 3.4.3.

See also our answer to a similar point made by Reviewer #1: “Outside the 15% SIC contour, it is correct that Figure 5 (left) shows increase in SIC after correction. This was confirmed by plotting similar plots for other months. This is because the SIC before correction SIC_{corr} is mostly slightly negative there, and the correction step brings it closer to 0%. This is linked to the way our OW tie-point is tuned. As explained in section 3.4, the OW tie-point is tuned dynamically against open ocean cases that are outside a maximum ice extent climatology, thus potentially more representative of “open ocean” Tie-point than the conditions closer to the edge. Prior to atmospheric correction, the open-water tie-point is thus “warmer” than the T_B

conditions closer to the edge, thus the uncorrected SICs are slightly negative there. After correction, our OW tie-point is re-tuned and is more representative of T_B close to the ice edge, hence the increase (reds in Figure 5). The net effect is a reduction in variability over ocean (blues on Figure 5, center panel) which indicates that the atmospheric correction step on average does a good job reducing weather-induced noise over the open ocean.”

L29: yes, the contour are for january 2015, this was added in the text.

Page 14 line 2: confirm if this is the standard deviation of the differences, or the standard deviation over January for each pixel, then the difference of these (latter is as worded) line 8: Would be useful to see impact of ice curve correction and atmospheric correction separately on figures line 26: clarify footprint mismatch is between different channels

P14L2: This is indeed the second option: “the standard deviation over January for each pixel, then the difference of these”. L8: we cannot show the impact of the two separately. However, and as now clearly noted in the manuscript as a response to Reviewer #1 comments: the RTM-based correction has most effect at low concentration (outside the 15% contour in Figure 5), and the ice curve correction at high concentration values (inside the 70% contour). Thus, although we cannot have separate figures, the effect of the two corrections are clearly separated in space. L26: done: changed “footprints mismatch” to “the mismatch between footprints at different channels”.

Page 15 lines 1&3: need to explain “3 dB footprint” or remove lines 2/3: also mention AMSR products line 10 and paragraph: Needs more information on how K was calculated line 21: land spill-over effects are critical for users in that missing data around coasts causes problems and has to be dealt with. Where you have removed data, have you done any filling?

P15L1&3: removed “3dB” as unnecessary. L10: the following text was added: “The MODIS images are first classified as water/ice at full resolution. Two sets of coarser resolution SIC fields are then prepared: 1) the foot-print simulator is applied to prepare a synthetic sea-ice concentration field at the resolution of the PMR channels, and 2) the high-resolution classified pixels are binned into regular grid cells, e.g. at the target resolution of the CDR (e.g. 25x25 km). The mismatch between the two fields is what we call the smearing uncertainty, and is parametrized against proxies such as (MAX-MIN) 3×3 .” L21: contrarily to the operational SIC product by OSISAF, we do not have a stripe of missing data along the coastline. We rather correct the coastal SICs for land spill-over. For this version of the datasets, we combine a swath-based correction scheme, with a statistically-based one. The land spill-over is much reduced with respect to earlier versions, but more work is needed (and planned) on these aspects.

*Page 16 line 3: Does this improve things compared to Cavalieri et al. (1999) alone?
line 6: Year for Donlon paper should be 2012. Also, not to change in the paper but
note that I believe the mask has been updated for the SST CCI v2 processing. Line
15: "New Scotland" should be "Nova Scotia", no need to translate as still same in
English lines 15&16: State whether you have done anything different in processing to
get ice over inland regions and fresh water, either here or elsewhere in paper line
29&30: Clarify that you are not filling in missing days, e.g. in the SMMR period etc.
Are you filling around coasts?*

P16L3: It does improve wrt to Cavalieri et al. (1999) alone, we added a paragraph in the Discussion section (5.2): "Other steps in the processing chain can further be improved upon, e.g. the land spill-over correction schemes. In section 3.6 we described how land spill-over was corrected in two steps, first through a physically-based algorithm on swath T_B data (adapted from Maass and Kaleschke, 2010), followed by a statistically-based correction of gridded SICs (adapted from Cavalieri et al. 1999). Several reasons can have led to the swath-based correction to not be enough. For example, the method relies heavily on accurate geolocation of the T_B measurements, however its uncertainty for the SSM/I and SSMIS instrument is known to be large (Poe et al. 2008), and is not corrected for in the current version of the FCDR (R3) we used (Fennig et al. 2017). We used approximated iFoVs weighting functions instead of eFoVs (see section 2.1) when convolving antenna pattern with the land mask, thus neglecting the effect of the measurements integration period. Finally, strategies to avoid gridding land-contaminated FoVs when building Level 3 maps might help in the future. It will also be beneficial to use objective high-resolution SIC maps from coastal regions (e.g. from navigational ice charts) to tune the various thresholds embedded in the statistically-based correction. To improve further on the land spill-over correction will be an objective for upcoming versions of the CDRs."

Donlon paper: done. Thank you for the update on the SST CCI land mask, we will act upon this for next version. L15&16: We added this information at the end of section 4.3: ("Ice resulting from freezing of fresh and brackish waters does not have the same emissivity as that from sea water. The retrieval of ice area fraction in these conditions would call for dedicated tie-points (e.g. Ghaffari et al. 2011), which we did not implement here. In addition to the difficulty of computing dynamic tie-points over such small areas, it is unclear if such dedicated tie-points would make a large difference in the end, because of the combination of many error sources in these close water bodies (land spill-over, thin sea-ice, larger atmospheric influence, etc...). A layer in the status_flag variable indicates fresh and brackish water bodies.")

Fully missing days: we added the sentence "Days with fully missing input data (e.g. every other day in the SMMR period) are not created by interpolation, and the files are missing."

Page 17 Evaluation of the data: Have you simply looked through the data? Issues where processing has gone wrong, or the data looks strange have previously been an issue for OSI SAF CDRs. It would be very helpful for users not to have to do this QC. Line 7: add what the ERA-Interim data is used for in the processing line 28: colour scale is blue-red, not blue-yellow-red line 29: Is noise just characterised as below 10%? line 33: suggest move “as nominally returned by the SIC algorithm” to line 27 after “raw_ice_conc_values”

P17: The data was thoroughly looked at. We hope no artefacts are left. The situation should also be improved wrt OSISAF v1 thanks to using QCed FCDR as input (instead of an archive of operational data stream). L7 ERA-Interim: Done. L28: done, L29: no, “noise” characterises that the true SIC is 0% (unless close to the edge), before the OWF is applied. L33: done.

Page 18 line 16: what about summer?

Good question. The following sentence was added: “During summer, sigma_algo is larger by few percents, and the increased variability inside the ice pack yields higher sigma_smear, leading to larger sigma_tot.”

Page 19 line 23: SMMR uncorrected is also better than for SSM/I and SSMIS, particularly in the NH. Why? Line 30: in winter? Line 31: need to give seasonal figures

P19, L23: Indeed, SMMR uncorrected is also better than SSM/I and SSMIS. This is due to the center frequency of the Ku-band channel (18GHz) being farther away from the water vapour absorption line (22GHz) than the SSM/I channel (19.3GHz). 18GHz is less influenced by water vapour. This explanation was added in the manuscript.

L30 and L31: the offset between SICCI-50km and the others is mostly constant in all seasons.

Page 20 line 4: “internally consistent” - do you mean consistent over time? Line 5: Can't tell from figure 8 that it's the smallest possible. Suggest reword “and smallest possible retrieval noise” to “and a small retrieval noise” line 14: change “thus after the OWF is applied” to “thus after all the filters including the OWF are applied” for clarification line 17&18: as the range changes are they stable with time? Also need to give separate summer and winter values and incorporate line 20 in the discussion. Also separate summer and winter values line 21. line 27: might be worth adding that this is addressed as future work later in the paper line 33: Need to elaborate on how this could cause an increase over time

P20L4&5: clarified as suggested. L14: done as suggested. L17&18 We added a values for summer and winter. L33: this is an hypothesis, and is now clearly marked as such. The mechanism would go via improving atmospheric correction via better

re-analysis field, that would lead to stronger separation of the projection plane in (19v,37v,37h) and the (19v,37v) OWF plane. We changed the sentence to: “The departure of the optimal SIC data plane from the OWF plane (by convention at $\theta=0^\circ$, see right-hand side panel in Figure 4) could be the cause for the slight increase of the 1%-percentile curves of OSI-450 during the time period (via an improvement of the reanalysis data entering the atmosphere correction step over time), and the different value obtained with SICCI-25km”.

Page 21 lines 17&18: Why 2 months in summer and 3 months in winter?

The motivation doing so is the temporal duration of sea-ice conditions being close to the annual sea-ice extent minimum and maximum. This period lasts longer in winter than summer. We also chose to limit the comparison to these months because the climatological ocean mask varies least during these time periods and allows us to put the locations of the reference 0% sea-ice concentration as close as possible to the maximum extent of sea ice. This way we make sure to perform the evaluation in "polar"-type waters and atmospheric conditions.

line 23: Give the T2m threshold (if not mentioned elsewhere?)

The T2m threshold is +5C, this is now added in the text.

line 25: “skewed a bit” – could quantify the skewness, or reword to “slight negative skew” or similar, and elsewhere.

Reworded.

Line 27,28,29: should refer to Figure 12, not Figure 10.

To refer to Figure 12 instead of 10 is correct. Done.

Values given are not the same as on Figure 10, unclear. Line 33: In winter it looks fairly similar though.

This was a rounding issue in the figure text. Figure 10 (and 12) are now revised to show the same values as in the text.

Page 22 line 3: reference “(Figure 12)” after “100%”

The reference to Figure 11 at the end of the sentence is actually covering quite well the information given on this sentence, not changed.

line 4: should be Figure 12, not Figure 11

Indeed, this was changed.

line 7: Suggest replace “less good” with something like “poorer, but still acceptable”. Suggest cut the last sentence of this paragraph as is a repetition.

We replaced "less good accuracy" by "slightly larger bias", and removed last sentence.

Line 12: The total uncertainty is described as “standard error” on Figure 12, need to reword this.

This is now better captured in the caption of Figure 12: black error bars are for plus/minus one standard deviation of the standard error, while blue error bars are for plus/minus one standard deviation of the total uncertainties.

Paragraph around line 20: Elaborate on why uncertainties for SICCI-50km are smaller than for the other two datasets.

The following sentence was added: “These results are in agreement with those introduced in section 4.2.1 and are mainly explained by the frequency channels used in the three CDRs: 18.7 GHz for SICCI-25km, instead of 19.3 GHz for OSI-450 (less noise contribution from atmospheric water vapour content), and 6.9 GHz for SICCI-50km (smaller sensitivity to atmosphere and surface snow and sea-ice property variations).”

Line 25: For high sea-ice concentration range they are slightly underestimated, especially for OSI-450.

Indeed. We reworded the sentence to: “Thus, the results summarized in Figure 12 indicate that the uncertainty tot provided with the three CDRs are slightly underestimated, especially for OSI-450, for the high sea-ice concentration range (SIC = 100%), and are slightly overestimated for the low sea-ice concentration range (SIC = 0%).”

Page 23 line 1: Confusing wording. Ground truth locations are not outside expanded maximum ice climatology?

This was reworded as: “For SIC = 0%, the ground-truth open water locations are selected just outside the maximum sea-ice climatology, while we used an expanded version of this climatology for the selection of the open water training data samples (sections 3.3 and 3.6)”

Line 17: Reword “it is also designed to remove” as “it also has the effect of removing”, as this is a side-effect of the filter, rather than a planned part of the design. Line 24: replace “these wavelengths” with “the wavelengths of the PMR channels” for clarity.

P23L17: done as suggested. L24: done as suggested.

Page 24 line 3: Unclear what is meant by “at most” in this context line 13: add “AMSR-E and AMSR2” before “channels” for clarity. Line 21: add “variable” after “raw_ice_conc_values” for clarity. Line 29: Expand “ECV” acronym here

P24L3: reworded. L13: done. L21: done, L29: done.

Page 25 line 5: change “two components” to “two algorithm components” for clarity line 10: add section number after “Outlook” line 16: add “data” after “AMSR2” line 23: add “channel” before “frequencies” for clarity. Lines 26&31: add “closed” before “sea ice”

P25L5: done, L10: done, L16: done L23: done, L26&31: done

Page 26 lines 18-19: The level itself is not stable, though always remains below 15% - needs rewording. Also not accurate to say “well below 15% SIC threshold” for SICCI50km. Lines 23&24: Confusing wording: “maximum 1%” and then “a couple of percent” - needs rewording.

P26L18/19: we reworded but still find that this is quite stable over >30 years.
L23&24: fixed (kept couple of percent).

Page 27 line 20: expand SIE acronym line 24: Add some more information on plans to implement improvements for CDRs into operational processing chains (a few lines).

P27L20: done. L24: done, but on the page after (when discussing ICDR).

Page 28 line 6: expand EO acronym (and use acronym on line 7) line 23: URL for CMEMS is “marine.copernicus.eu” (there is a typo)

P28L6: done. L23: done (thanks!)

Page 29 lines 2&3: Confusing wording – is it the first satellite or the first satellite with MWI? Reword. Line 14: Add “channel” before frequencies for clarity. Line 15: This implies users should combine the products (which they shouldn’t if they want a consistent product). Clarify that different products are available for different user needs. Lines 25-27: how can this be used? Users will treat uncertainties provided with data as the observation uncertainty

P29L2&3: We reworded: “The first satellite of the European Polar System Second Generation (EPS-SG) series to carry a Microwave Imager (MWI) is scheduled for launch in 2023.” L15: interesting question. Users can combine information they retrieve separately from the three datasets. They can also attempt the combination of the products, but have to take into account the difference in spatial resolutions, which requires more advanced techniques that we could use here. We did not modify the text. L25/27: based on our evaluation of the observation uncertainties, users 1) are confident that our uncertainties mostly correspond to the statistical observed error, and 2) our uncertainties are slightly too large over open water, and users can thus decide to shrink them a bit if relevant for their application.

Page 30 Line 7: Would be useful to provide URLs for the data archives. Line 18: Update this, says “[Indicate subset used]” References in general: Provide URLs if available for Technical Reports etc. Some DOIs have come out as links and others not.

P30L7: Rather than the URLs, we provide the DOIs (when available) that allow link to documentation. The list of references was thoroughly checked.

Figures and tables: Some acronyms are in figure and table captions before being introduced in the text. Suggest defining in captions.

Figure 1: Add section number for Outlook.

Done

Figure 2: Add that L2 SIC is also swath, L3 is a single daily averaged file. Define acronyms used in figure in caption

Done

Figure 3: Title should be “AMSR-E” (currently “AMSR”). Labels in the figure need to be closer to the points (or colour coding would help). In figure caption, give section numbers where BFM and OWF are described in the text. “mean water signature” should be “mean open water signature”

Done

Figure 4: Left plot: Label “BRI”, “BPM” and “BFM” on plot. Add theta label on plot. “u” in caption is labelled “U” on plot, make consistent. Axis labels should also match convention in caption, e.g. “37H” rather than “h37”. Right plot: “Freq. Mode” should be “BFM”, “Bristol” should be “BRI”. Add “theta” symbol to “Rotation angle” axis label. As noted in the text and figure caption, the original figure is from Smith et al. (1996), so that we cannot change the labels on the arrows. The other suggestions are implemented as text in the caption to Figure 4.

Figure 5: Centre panel: Difficult to see any detail using this scale, needs to be shortened. Doesn’t have to be the same as left panel as showing different variables

Done.

Figure 6: a) Need to show 0% as white (or similar) for SIC plots so can see detail around ice edge. b) Would also be helpful to plot `ice_conc minus raw_ice_conc_values`.

- a) We tried your suggestion, but it gives the impression that the SIC fields have missing value (instead of 0% SIC). We did not observe it added much information in the ice edge region. Readers interested in such details would probably open the netCDF files and inspect this more closely, while we aim here at a high-level feel of what is in the variables. We did not change figure 6.
- b) `raw_ice_conc_values` holds non-masked values iif `ice_conc = 0%` (in places the OWF was triggered) and `ice_conc = 100%` (in places `ice_conc_raw_values` is larger than 100%). Thus, a plot of “`ice_conc minus raw_ice_conc_values`” would be very similar to our plot of “`raw_ice_conc_values`”. Because it is the first time users are presented with

such “raw” ice concentration values, we feel it is more important to illustrate them what they find in the file. We did not add or change on Figure 6.

Figure 7: Need to show 0% as white (or similar) so can see detail at low uncertainties.

There are no grid cells with exactly 0% in sigma_algo (left) and thus sigma_tot (right). There are some 0% values in sigma_smear (center) but as in Figure 6, using white for them gives the impression that the sigma_smear field has missing values. Readers interested in such details would probably open the netCDF files and inspect this more closely, while we aim here at a high-level feel of what is in the variables. We did not change Figure 6.

Figure 8: Figure legend - datasets should be capitalised for consistency
Done.

Figure 9: Figure legend - datasets should be capitalised for consistency. If SICCI-25km and OSI-450 lines were thinner (like SICCI-50km) it would be easier to see the lines for both hemispheres.

Capitalization done. We did not change the line width as NH lines were too difficult to read. As per your suggestion, we added some description of the NH and SH curves in the text with discussing Figure 9.

Figures 10, 11: Specify that the sea ice concentration is uncorrected. Numbers in parentheses are in front of the season, not behind. Unclear - “Numbers below the season denote the mean SIC plus/minus one standard deviation” - there’s only one number so how can this be plus/minus? Also Figure 11: The SH plots are “bumpier” than the NH plots – add comments on this.

The sea-ice concentration are corrected but not filtered (the OWF and 100% thresholding are not applied). This is now specified in the legend to both Figures. The description of the numbers appearing in the plot area was revised. The SH plots are “bumpier” simply because of the reduced number of data pairs, as indicated in the plot area.

Figure 12: Standard error is not mentioned in the text.
This is now done.

Table 1: Give months in the time period. Worth adding that grid is EASE grid.
Caption: “entering” should be “entered in”.
Done

Table 2: Start date for DMSP SSM/I has an error (“090”), check table for other errors
Done, thank you.

Technical corrections

General comments: Throughout, need to ensure there is a space between numbers and their units.

Done.

Throughout have used “...” or “etc...”, should probably just be “etc.” or sometimes “e.g.” but check journal style guide.

We will check when editing final version.

Have referred to e.g. F10, F11 satellites, suggest using full name (include DMSP) at the start of the paper for clarification.

Done (introduce DMSP acronym early in the text).

Specific comments: Some of the following are corrections of grammatical errors, and some are rewording suggestions to improve the readability of the paper.

Thank you very much for compiling all these suggestions!

Page 2 line 4: “allow” should be “allows” line 5: “are” should be “is” line 6: “to understand” should be “for understanding” line 11: “are” should be “is”, “have” should be “has” line 28: unclear what you mean by “possibly” in this context, if it’s the possibility that filtering can be applied needs rewording.

Implemented all suggestions. We reworded “possibly filtered” to “access to filtered as well a raw values”.

Page 3 line 17: remove “up-front” here, reads a bit strangely in this context. Also, “entering” should be “entered”

Done.

Page 4 line 3: “some” should be “a” line 4: “more” should be “most” line 6: give section number for Outlook. Line 20/21: “Such wavelength” should be “Such a wavelength” line 23: replace “needed for” with “used in” line 25: add “(Table 2)” after “channels” line 31: “diameters” should be “diameter”

Done.

Page 5 line 1: I think “One” should be “Two”, also change “swath” to “swaths” line 2: change “orbit” to “orbits”, “extent” to “extents” line 5: expand CM-SAF acronym line 7: “directly accessed directly” should be “accessed directly”, “Japan space agency” should be “Japan Aerospace Exploration Agency” line 15: “contribution” should be “contributions” line 18: “ERA-Interim” should be “ERA-Interim reanalysis” line 20: “ERA-Interim prior” should be “ERA-Interim data prior” (or similar), “early period with”

should be “earliest period of” line 24: “from” should be “of”, “for” should be “in” line 27: “operated to process” should be “for” line 32: “(L3) collects” should be “(L3) chain collects”

Done.

Page 6 line 3: “apply” should be “applies”, “format” should be “formats” line 5: “similarly” should be “similar” line 29: define OW (given above in context of algorithm but worth defining here again), same for CI line 30.

Done.

Page 7 line 1: “TB in point” should be “TB at point”, similarly “lines in point” should be “lines at point” line 2: “and geometric” should be “and a geometric” line 6: remove “originally”, “describes” should be “describe” line 20: “onto” should be “on” line 25: “cope for” should be “cope with”

Done.

Page 8 line 1: would read better as “Figure 4 (right panel) also shows that the optimum...” line 16: “space” should be “spaces” lines 19/20: replace arrows with “ “ line 26: “section so” should be “section has so” line 32: “by Eq. 1” should be “using Eq. 1”

Done.

Page 9 line 20: “was” should be “has been”, comma before “which” line 21: “varies” should be “vary”, “follows” should be “follow” line 25: “yield highest” should be “yield the highest” line 26: “yield departure” should be “yield a departure” line 27 and 28: “departure” should be “departures”

Done.

Page 10 line 3: add commas both before and after “the uncorrected SIC value” line 7: “re-analysis” should be “re-analyses” line 20: Add “For Tb_nwp” at the start of the line line 22: Add “For Tb_ref” at start of sentence before “Theta_instru” line 26: remove “for F10” (already mentioned in this sentence) line 29: “for being” should be “to be”

Done.

Page 11 line 3: “allows” should be “allowed” line 9: “ones” would read better as “datasets”. Also, having introduced the acronym WFs should use on this line instead of “Weather filters” (also on line 20). Line 14: no hyphen in unaffected line 18: suggest changing “so far did not adopt” to “have so far not adopted”, also “from” should be “in” line 19: change “by using adhoc status flags” to “on an adhoc basis by using status flags” (as the flags themselves are not adhoc) line 22: “re-used” should be “reuse” (or “have reused”) line 23: Suggest add “For example,” before Spreen et

al. Line 25: "to" should be "with" line 26: "with" should be "for", "for which" should be "where", suggest changing "threshold is 0.053" to "threshold is set to 0.053"

Done.

Page 12 line 2: "intersect" should be "intersects" line 6: missing close bracket after (AD), also "illustration how" should be "illustration of how" line 7: "into" should be "in" line 11: add "and" before "the varying effects" line 12: suggest replace "not remove" with "avoid removing" line 13: "show" should be "shown" lines 16,17: "T" should be in italics line 20: "naming" should be "name" line 22: change "is set to" to "will" as this is an unintended consequence line 23: suggest changing "we rather refer to such filters as 'Open Water Filter'" to "we refer to such a filter as an 'Open Water Filter'", also suggest "add" changed to "include" line 24: "are" should be "is" line 27: "Noticeably" should be "Notably" line 28: "attached a" should be "attached to a", also change "as to if the OWF detected it" to "corresponding to OWF detection"

Done.

Page 13 lines 1&2: "high concentration range" should be either "a high concentration range" or "high concentration ranges" line 5: remove "likewise" line 10: change "best appear" to "are best shown" line 11: "T" in $B_{CI}(T)$ should be bold lines 14&15: "constantly" should be "consistently" line 28: "Laptev and Kara Sea" should be "the Laptev and Kara Seas" line 29: would read better to remove "old" after "2 years", also "on right panel" should be "on the right panel"

Done.

Page 14 line 6: "north for Canadian" should be "north of Canadian" line 8: remove "that what" line 9: change "and" to "which" after "section 3.4.1," line 19: "data is assimilated" should be "data are assimilated" line 21: "those" should be "that" line 28: "algorithm to retrieve" should be "algorithm for retrieving"

Done.

Page 15 line 1: suggest change "relevant to discuss" to "relevant for discussion of" line 4: "Earth surface" should be "the Earth's surface" line 7: remove "that is" line 9: "cells" should be "cell" line 20: remove "shortly" line 21: suggest change "presenting less" to "have undergone little" line 28: "details" should be "detail" line 30: suggest change "among others" to "including" line 31: remove "is computed" line 32: change "the antenna pattern functions are approximated" to "the approximation of antenna pattern functions" line 33: "from central" should be "from the central"

Done.

Page 16 line 1: "for contribution" should be "for the contribution" line 4: "were" should be "have been" line 5: "where" should be "were" line 7: "as input" should be "as the input" line 13: "were" should be "was", suggest change "base" to "basis", "pixel"

should be “pixels” line 18: “in SH” should be “in the SH” line 19&20: change “where to select the Open Water training samples” to “where the Open Water training samples were selected” line 26: “conversely” should be “converse”, suggest “CDR of” should be “CDR method of”

Done.

Page 17 line 14: “of SICCI-25km” should be “of the SICCI-25km” line 22: “file” should be “files” line 27: “Bottom” should be “The bottom” line 29: “corresponds” should be “correspond” line 32: “by OWF” should be “by the OWF”

Done.

Page 18 line 6: “indicate” should be “indicates” line 14: replace “are covered by” with “cover” line 18: Suggest replace “several” with “three”, “One” with “The first” line 19: “its” should be “their” line 25: no hyphen in intermediate

Done.

Page 19 line 9: “albeit” should be “despite” line 12: “from” should be “for” line 15: “from” should be “for” line 16: “improve much” should be “much improve” line 18: “parametrization” should be “parametrizations” line 21: “from with” should be “for”, also “were” should be “where” line 25: “sensibly” - do you mean “ostensibly”?

Done.

Page 20 line 9: remove “at best” and add “ideally” before “preserving” line 19: reword “very little few jumps are” to “very little change is” (or similar) line 23: could remove “lowest” and “highest” as it’s already clear this is the range

Done.

Page 21 line 10: remove comma after “but” line 14: “details” should be “detail” line 21: “East Antarctic” should be “the East Antarctic” (or “East Antarctica”) line 23: remove “being”, suggest replace “by too” with “with” lines 29&30: suggest move “than for the other two CDRs” after “more” on line 29 line 30: “e.g.” should be “i.e.” line 31: add “for all three CDRs” after “2%”. lines 32&33: suggest change “less good than that” to “poorer than”

Done.

Page 22 lines 5&6: change “Arctic” to “the Arctic”

Done.

Page 23 line 3: Suggest reword “can be picked” to “may be selected” line 4: Suggest reword “and to the least at the location of the ground-truth estimates used in the section” to “where the ground-truth estimates used in the section are located” line 5:

Change “More developed” to “A more developed”, “as wetter” to “as a wetter” line 6: Change “We finally” to “Finally, we” line 12: “in large extent” needs to be reworded, perhaps replace with “generally” or “to a large extent” line 13: Capitalisation of “Passive Microwave” varies, be consistent line 15: “on combination” should be “on a combination”, also need to define acronym “PMR” line 19: “take” should be “pay” line 20: “in field” should be “in the field”, also use “OWF” acronym for consistency line 21: “are pertaining” should be “pertain” line 25: Remove “distinguishing between” and add “to be distinguished” to end of sentence.

Done.

Page 24 line 1: “aims” should be “aim”, also “from interested” should be “from the interested” line 6: replace “was” with “were” twice line 17: “is ‘spilling’ ” should be “ ‘spills’ ”, also “appear” would be better than “look” line 19: “foot-print” sometimes has a hyphen, sometimes not, needs to be consistent line 20: “instrument” should be “instruments” line 29: “improvement” should be “improvements”

Done.

Page 25: line 7: “on March 1985” should be “in March 1985” line 8: add “dataset” before “only”, also add “on” before “09 July” lines 9&10: change “achieving” to “to achieve” line 11: suggest reword “algorithms allowed e.g. to consistently process SIC” to “algorithms also allowed consistent processing of SIC” line 14: change “15 years record” to “15-year record” line 18: change “will” to “would” line 20: change “had met” to “would meet” line 33: add “the” before “coarsest”

Done.

Page 26 lines 3&4: Confusingly worded: “seasonal cycle of sea-ice and snow properties during summer”. Should this be sea ice extent? (Also be consistent throughout about whether to use a hyphen in sea ice or not) line 15: “than” should be “as” line 17: Suggest remove “For all practical purposes” line 29: Remove “namely” line 33: remove “that”

Done.

Page 27 line 1: “impact of melting” should be “impact that melting” line 3: Suggest change “more efforts” to “further effort” line 4: Remove “same” and “that was” line 10: “if to selecting” should be “if selecting” line 12: “dimension” should be “dimensions” line 17: “the sea ice cover, sea ice area” should be “of sea ice cover, and sea ice area” line 27: “exploring” should be “exploration” line 28: “channels” should be “channel”, “that” should be “than” line 30: Suggest change “could not be better embedded by SIC” to “could be better embedded in SIC” line 32: “Filter” should be “Filters”

Done.

Page 28: line 2: Suggest adding “still” after “can” line 24: Change “at best” to “to achieve” line 33: “passed” should be “past”

Done.

Page 29 line 5: Add “However,” before “Because” (as shouldn’t start a sentence with because) line 17: “product contains” should be “products contain” as there is more than one product. Line 19: Replace “on the hand a” with “ease of”, “product” should be “products” line 20: remove “of all products”, “is” should be “are”, “has” should be “have” line 25: “this provides” should be “this paper provides” (or similar)

Done.

Page 30 line 6: “making” should be “make”

Done.

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