Summary

This paper presents an approach to calculate swath-to-swath (S2S) sea ice motion vectors from passive microwave imagery. Via comparisons with buoys, this approach is shown to be more accurate that the standard daily map products that composite brightness temperatures over a 24-hour period. The S2S are improved because the TB values are instantaneous instead of a "blurred" average and the time between images is exact as opposed an average time of all passes, which also "blurs" the motion estimates. The methodology is promising for the future CIMR mission, which will have wider swaths to obtain more motion vectors and higher spatial resolution for greater accuracy.

General Comment

Swath-to-swath sea ice motion vectors has been a long-discussed idea, so it is great to see it successfully implemented here. The methodology is sound and it appears to be viable to do operationally. The paper is well-written and the results are convincing.

We thank the reviewer for his positive comments.

I have a couple general comments. First, there is discussion of the packaging of the fields in Section 5, but it's still not totally clear how this would happen. I can understand the baseline approach, where there are fields for each of the overlaps and the times. But also discussed is the generation of daily maps. I agree that this would be useful and would probably be most convenient for most users. But it's not clear how this would be created. You would have motions for time periods of ∼100 minutes to over 24 hours. How would the different time separations be combined? The ice motion will vary between the periods, so simple interpolation/extrapolation may not work. The easiest thing would be to use the repeat orbit overlaps from each day – then there would be 24 hours between all vectors. But, of course, this leaves out many vectors. Maybe there could be some kind of weighting scheme to optimally combine vectors over different time intervals into an optimum cohesive daily map.

These are very exciting thoughts and we might be investigating such merging methodologies in future studies. We do not feel confident expanding on this aspects in the present manuscript though. Still, we modified two sentences in the Discussions section to bring some elements of your comment:

As with the other parameters to be observed by CIMR, a Level-3 sea-ice drift product should be prepared that optimally combines e.g. a day's worth of S2S products (having very different time durations) into a complete map of e.g. ~24 hours sea-ice motion vectors. To the best of our knowledge, such merging algorithms do not exist.

Another thing that came to mind while reading is the potential utility for summer motions. It's understandable to focus first on winter, but summer is not mentioned until Section 5. There are well-known limitations to using PM TBs for summer – most notably the surface melt and (especially for 89 GHz) greater water vapor levels. The S2S approach seems like it would be potentially quite helpful. First, the exact time of S2S will remove some error because ice is more dynamic in the summer, and potentially improve accuracy of the more sensitive lower frequency channels. For example, 18.7 GHz S2S may obtain better summer motions than daily composites. On the other hand, I wonder if the instantaneous S2S fields might cause some problems for the 89 GHz channels because water vapor can change rapidly and the "smearing" of the daily composite TBs may filter out some of that variability that could cause errors. It would be great to have a summer example in the paper, but I think keeping the focus tighter on the winter case studies makes sense here. But I think some brief discussion of the limitations of PM for summer motions, e.g., in the Introduction, and a little more discussion in Section 5, would be helpful.

Since the other reviewer (and editor) also pointed out that an investigation of the summer conditions would strengthen the paper, we decided to include this in revising the manuscript. As already mentioned in the manuscript, a major limitation to today's ice motion retrieval during summer is the relatively coarse resolution of the 18.7 GHz imagery channels of the AMSR2 sensor. Adopting an S2S versus DM approach might help, but the step-change will be the spatial resolution at CIMR, which we cannot test at present. This is even more true for lower frequencies (10.6 GHz or 6.9 GHz). We will include an analysis of summer sea-ice drift from AMSR2 18.7 GHz (DM vs S2S) in the revision of our manuscript.

A few other minor comments are noted below. These are addressable in my view with minor revisions.

Specific Comments (by line number):
43: "short-lived" is ambiguous here. It may suggest something that lasts only a few weeks, but buoys can last at least a few years. That's short compared to long-term climate monitoring, but longer than what I would call "short-lived".

Agreed, see below.

44: "scattered with vast distances between them" can be described more simply as "sparse". Perhaps rephrase this whole sentence to something more like: "Buoys have a limited lifespan before they exit out of the Arctic or the ice melts; this and limited opportunities for deployment result in sparse spatial coverage of the Arctic."

We follow your suggestion and revise as: "Nevertheless, buoys have a limited lifespan before the sea-ice floe they seat on melts, or they drift out of the Arctic, or they suffer technical issues; this and limited opportunities for deployment result in sparse spatial coverage."

76-77: I don't see a reason to abbreviate "Section" here – it's more readable without the abbreviation.

The author's guidelines from EGU TC read: The abbreviation "Sect." should be used when it appears in running text and should be followed by a number unless it comes at the beginning of a sentence.

81: Is there a specific citation recommended? At the least the website should be given, but if at all possible a formal citation (with date of access for a website) should be used.

*This was the Global Portal System (G-portal) (*https://gportal.jaxa.jp/gpr/*), and we now specify it in the text and the acknowledgments section.*

Table 1: I would recommend giving the diameters of both dimensions of the sensor footprints, e.g., A x B, rather than the average. It provides better information and it looks like there is room to fit these in.

Showing the two diameters (A x B) would also be our preferred solution. However, because CIMR is still in the design phase, these numbers are not known at this stage. For CIMR, we must thus *keep these requirements on the arithmetic mean. We suggest to add (AxB) for AMSR2. We modify Table 1 and its caption:*

Band	L	C	X	Ku	Ka	W
Center Frequency [GHz]	1.4	6.9	10.7	18.7	36.5	89.0
AMSR2 -[km]	-	49 (35 x 62)	33 (24 x 42)	18 (14 x 22)	9 (7 x 12)	4 (3 x 5)
CIMR -[km]	<60	15	15	5	<5	-

Table 1: Spatial resolution (~~computed as the~~ arithmetic mean of the minor and major diameters of the instantaneous field-of-view ellipse, and the two diameters for AMSR2) of selected microwave frequencies of the AMSR2 and CIMR missions. AMSR2 also records at 7.3 and a 23.8 GHz, those will not be on-board CIMR. "-" indicates a microwave frequency is not recorded by the mission. The values for CIMR are the mission requirements from Donlon et al. (2020), those for AMSR2 are from the Observing Systems Capability Analysis and Review (OSCAR) tool of the World Meteorological Organization. The CIMR mission being under development, the actual diameters of the ellipses are not known at time of writing. See also Lavergne (2018) for a graphical representation of these values.

360-365: This would seem to argue towards using only (or primarily) the repeat orbits for the S2S instead of all overlaps, right? Or at least limiting to overlapping orbits that have orientations that limit the geo-location error effect?

*Indeed, which is why we noted in the text that "the retrieval of accurate sea-ice drift vectors from individual swaths puts stringent requirements on the geo-location accuracy of passive microwave missions **if all swath overlap pairs should be processed**".*

We do not think it is necessary to bring more information at this point, since we so far only explored a very specific type of geo-location error (systematic offset in flight direction) while other types of geo-location errors (e.g. along the scan direction) will result in other characteristics of the bias.

405: I would note though that more advanced techniques, such as Backus-Gilbert, do take account of the antenna pattern of the sensor and the measurement response function (MRF). So, it should be better than simple interpolation. Another approach that uses MRF for weighting is Brodzik et al., https://doi.org/10.5067/MEASURES/CRYOSPHERE/NSIDC-0630.001.

Yes, we re-formulated as "However, more advanced gridding techniques (e.g. Backus-Gilbert) could also be challenged by the lack of sufficient overlap between neighboring 89 GHz Field of Views".

418: minor grammar suggestion, ". . .often leads to increases in the noise level."

Implemented.

Figure 9: Why does there appear to be more vectors on the Atlantic side of the Arctic than the Pacific side? I would expect the pattern to essentially be symmetric, but in the East Greenland, Barents, and Kara Seas, there are more vectors than at the same latitudes in the Beaufort, Chukchi, East Siberian, and Laptev Seas.

This is a good question that we had to investigate in more details. The larger amount of S2S vectors in the "European" sector of the Arctic is a consequence of the orbit cycle of CIMR. The last orbit to *start in a 48 hours period [D@00utc to D+2@00:00 utc] also extends in the following day, and leads to a region of the Arctic (and Antarctic) to be covered by one more swath. This results into additional swath overlaps, and thus S2S vectors. Furthermore, the feature is not fixed in space, and will transit all around the pole in the 29 days/412 orbit cycle of CIMR.*

When revising the paper, we will re-assess Fig. 9 and the way we count the last orbit in the 48 hours period. This might lead us to re-doing Fig. 9 and obtain a more symmetrical coverage. We will in any case comment in greater details the link to the orbit cycle.

444: typo, "...larger than discussed here..."

Implemented.