Reviewer 2
This manuscript describes a new processing setup for monitoring sea-ice motion at the pan-Arctic scale by taking advantage of satellite imagery from five C-band SAR satellite missions (Copernicus Sentinel-1 A&B, and the three missions from RCM). A first batch (10 months) of S1+RCM sea-ice motion data is prepared and evaluated qualitatively at pan-Arctic scales and regionally in the Canadian Arctic Archipelago. A comparison to two existing large-scale sea-ice motion dataset (from NSIDC and OSI SAF) reveals that the new S1+RCM data generally retrieves faster drift regimes, as well as more vectors in regions with intermediate concentrations and close to land. The paper provides a description of the processing setup, and conveys well the main message that the recent availability of operational SAR missions opens a new era for large-scale sea-ice motion mapping. The paper is convincing and can be published with some more work.

As I see it, two weak points of the manuscript at this stage are 1) the lack of dedicated quantitative validation of the new S1+RCM drift vectors, namely against trajectories from on-ice drifters, 2) the lack of a stand-alone Discussions section where the choices and assumptions made in the new processing setup and its uncertainties are justified and discussed.

Howell et al
We thank the reviewer for constructive comments that only serve to improve the quality of the manuscript and associated datasets.

Summary of the Major Changes:

1. We recast the manuscript to describe the Environment and Climate Change Canada Automated Sea Ice Tracking System (ECCC-ASITS) which is to provide routine SIM products from S1+RCM for operational needs at ECCC, the broader scientific community and maritime stakeholders. Accordingly, the datasets have been updated until October 31, 2021.
2. Generated a new pan-Arctic 6.25 km 3-day S1+RCM SIM product
3. Added validation section that compares vector displacement from S1 and RCM to buoys from the IABP
4. Refined the uncertainty of the S1+RCM SIM products based on the buoy analysis and the time separation of the image pairs for dry and wet ice conditions
5. Provided a 1-to-1 grid cell comparison of NSIDC and OSI-SAF SIM products to S1+RCM

Reviewer Comments
Major comments:
Validation against buoys:
The paper would be much stronger with a dedicated validation against buoy data at the pan-Arctic scale. Validation against buoy data is the de-facto standard for documenting the accuracy of sea-ice drift datasets (e.g. OSI SAF, NSIDC, Kwok 1998, etc…). In your case it would be particularly useful because validation of RCM SIM vectors (and thus geo-location, resolution, speckle) have never been assessed. You could also check the assumptions built into your uncertainty model (e.g. the scaling of the uncertainty on velocities by Delta_t, see discussion

below). I strongly suggest that a dedicated validation against buoy data is conducted and reported here, but leave it to the Editor to decide if this major revision is required or not.

Howell et al.,

Although comparison of the algorithm against buoy data has been done before, we agree it is important to re-assess with new sensors (although still at the same frequency). We attached the resulting comparison for against winter (April) and summer (August) buoys for 2-years for the reviewer's reference:

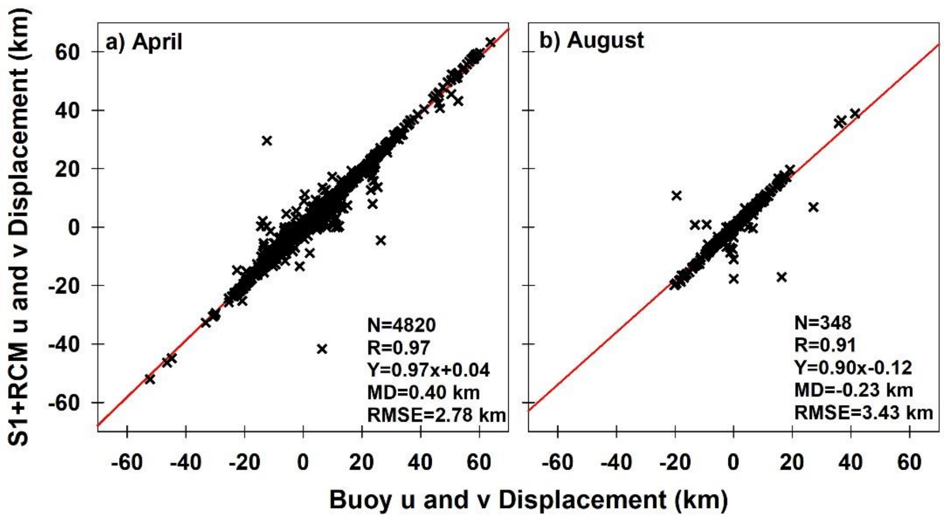

Figure 14. Comparison between ice motion vectors derived by the Komarov and Barber (2014) automated sea ice tracking algorithm from S1 and RCM SAR images and buoy data.

Based on the comparison we are develop to uncertainty estimates for dry and wet conditions as follows:

In order to estimate the SIM uncertainty from the ECCC's automated SIM tracking algorithm, we compared SIM displacement vectors from S1 and RCM to buoy positions from IABP during winter and summer time periods. For all S1 and RCM displacement vectors (derived from image pairs), the closest buoy trajectory was co-located to the start of each displacement vector position. The distance between the starting point of a given SAR ice motion tracking vector and the starting point of the corresponding buoy trajectory did not exceed 3 km. Fig 13. summarizes the results for dry winter conditions (April 2020 and 2021) and during the melt season (August 2020 and 2021). The ECCC automated SIM tracking algorithm performs very well during winter conditions with a root mean square error (RMSE) of 2.78 km and a mean difference (MD; bias) of 0.40 km. The RMSE is higher than the value reported by Komarov and Barber (2014) likely because more image pairs over a larger geographical area were used in this comparison as well as the spatial resolution was lower. Performance decreases during the summer with a lower number of vectors detected and an RMSE of 3.43 km.

Taking into considering the difference between the winter and the summer we assign two uncertainties to the S1+RCM SIM products for dry and wet conditions as follows. Consider a grid cell containing a set of N sea ice velocity vectors $\vec{V}_i$, where $i = 1,2,\ldots,N$. Each vector has the following uncertainty associated with the SIM tracking algorithm deriving the ice motion vector from two consecutive images:

$$\Delta V_i = \frac{S_0}{\Delta t_i}, \qquad (1)$$

where, Δt_i is the time interval (in days) separating two SAR images used to derive the considered ice velocity vector $\vec{V}_i$. s_o is the uncertainty in sea ice displacement (not speed) for dry ice conditions (2.78 km) or wet ice conditions (3.43 km). Note that s_o must be divided by Δt_i to come up with the ice velocity uncertainty. The average uncertainty for dry ($s_o = 2.78$ km) and wet ($s_o = 3.43$ km) ice conditions in each grid cell (N) is then determined using the following equation:

$$\sigma_{SIM} = \frac{1}{N}\sum_{i=1}^{N}\frac{S_0}{\Delta t_i} \qquad (2)$$

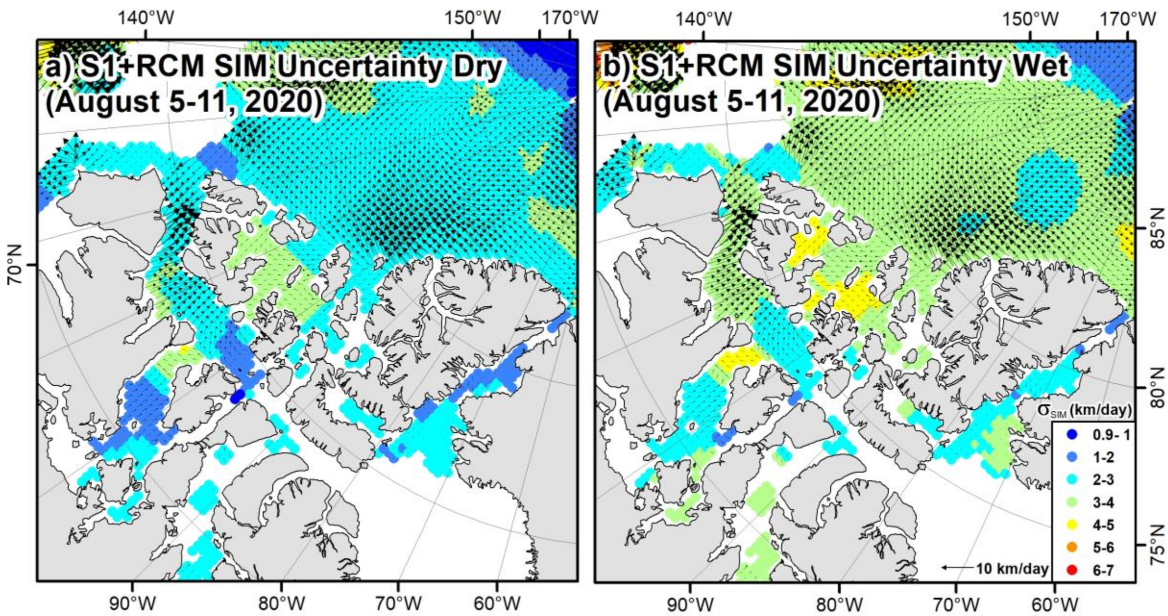

Figure 15. Spatial distribution of (a) dry and (b) wet S1+RCM SIM uncertainty for August 5-11, 2020

Reviewer #2

Sea-ice motion technique:

Section 3.2 is missing some details to fully characterize the processing. Some of the missing elements are:

* how old are the scenes allowed to be before they are not taken in the stack of scenes?
* In Fig. 5: we see that IMG1xIMG2, IMG2xIMG3, IMG3xIMG4, etc… are processed for SIM, but what about IMG1xIMG3, IMG1xIMG4, etc…? Considering these overlaps would dramatically increase the number of retrieved vectors and the sampling in the temporal domain. Please indicate if these additional overlaps are processed for SIM and, if not, add a discussion/justification why they were not considered (e.g. in a Discussions section).

Howell et al.

This is important to note. We have added the following to section 3.2:

It is important to note there is currently no “staleness” limit for images in a given sector. There are occasionally instances when long stretches of time (e.g., 7 days) occur between images pairs but this is mostly confined to the edge-sectors of the grid. Unfortunately, the computational capacity to take on the additional processing load of using the same image in multiple pair combinations is not currently available in the infrastructure being used.

Reviewer #2
* In Fig. 3: it is clear and well justified that S1 and RCM scenes are processed on their own (before the merging step). Are SIM vectors processed within the S1 and RCM missions? E.g. S1a with S1b, RCMa with RCMc, etc… Please add this information.

Howell et al.
The following statement has been added to:
S1A and S1B are freely mixed in the Sentinel processing chain as well as RCM1, RCM2 and RCM3 are mixed in the RCM processing chain.

Reviewer #2
* Fig 6 a) gives the impression that S1 has a complete coverage of the dark blue region at least once on every week. Is it really the case, or are there weeks were S1 leaves some holes in the weekly coverage? Could these [0-1] average density be in a different color to better appreciate the weekly coverage? Same for b).

Howell et al.
This is a very good suggestion and yes, it is very close that there is almost complete coverage by S1 once a week. We changed the legend of Figure 6 (now Figure 3) to a quantile to better illustrate the coverage.

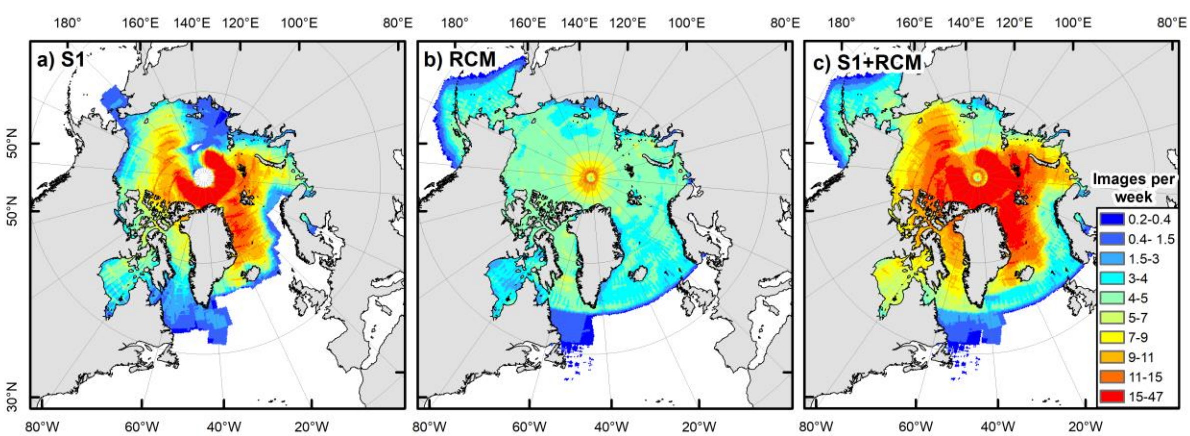

Figure 3. Image density per week for a) S1, b) RCM, and c) S1+RCM based on images from March 2020 to October 2021.

Reviewer #2
* L184: what is the justification for the cap at minimum 12 hours?
* starting L183: it is not immediately clear that you average the velocity vectors instead of the displacement vectors. Please clarify.

Howell et al.
i) We justified the 12 hour cap as follows:

We selected a 12 hrs cut-off because below 12 hrs the SIM resulted in less representative (usually higher speeds) with respect to the averaged product value (over 3 or 7 days). This was the primary observation from previous studies constructing a very high temporal resolution time series (e.g. Howell and Brady, 2019; Moore et al., 2021a). This is likely related to uncertainty, as vectors with lower time separation are more uncertain especially at sub-daily time intervals to be used for 3 or 7 days average SIM products

ii) We are averaging the velocity vectors and not the absolute speeds. This is now clarified in the methods.

Reviewer #2
Minor comments:
L49: The dataset based on passive microwave indeed have coarse resolution, that rather are in the range (50 – 100 km) than (12-25 km) as stated here. The OSI SAF is ~60km like the data from IFREMER/CERSAT, Kwok's is ~100km. NSIDC's 25km grid results from oversampling (see e.g. Table 2 of the NSIDC V004 User Guide).

Howell et al.
Changed.

Reviewer #2
L75: Did you use the multi-sensor OSI SAF product (multi-oi) or the single-sensor products (from AMSR2, SSMIS, etc…) Please provide this information.

Howell et al.
We used the multi-sensor low resolution 62.5 km gridded products (OSI-405). https://osisaf-hl.met.no/osi-405-c-desc

Reviewer #2
Fig 14: the labels and legends are hardly readable. Please enlarge the text.

Howell et al.
Figure 14 has been removed.

Reviewer #2
Conclusions: with "swath-to-swath" approach, SIM from passive microwave now achieves sub-daily temporal resolution (Lavergne et al. 2021). This will be extremely difficult to reach consistently and pan-Arctic from SAR constellations alone. Maybe the complementary of SIM estimation from SAR and "swath-to-swath" PMW would deserve a mention in the Conclusions.

Howell et al.
Good point. We have added this to the Conclusions as follows:

While groups like the Polar Space Task Group aim to improve or refine SAR coverage across the pan-Arctic over the annual cycle it is unlikely a purely SAR derived SIM product will be able to achieve daily or sub-daily consistently across the pan-Arctic. This has recently been achieved with passive microwave observations using a swath-to-swath approach (Lavergne et al., 2021). Therefore, it could be worth exploring the complimentary of SIM provided from passive microwave "swath-to-swath" and SIM generated from SAR.

Reviewer #2
Editorials:
L15: delete "able to be"
L18-19: OSI SAF, without "-" (in long form and acronym).
L49: "trade-off with respect to" → "drawback of" or "limitation of".
L73: replace "2020" with "this period".
L86: here and later in the section: "coarser spatial resolution levels". Consider changing "levels" with "images" for clarity.
L90. Lowest resolution → coarsest resolution
L135. "at _least_ 32,000 km2"
L250. Based _on_ the weekly image….

Howell et al.
All changed.