The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-126-RC1, 2020

The Cryosphere Discussions

Interactive comment on "Brief Communication: Mesoscale and submesoscale dynamics of marginal ice zone from sequential SAR observations" *by* Igor E. Kozlov et al.

Wilken-Jon von Appen (Referee)

wjvappen@awi.de

Received and published: 11 June 2020

The manuscript reports on the use of consecutive (separated by 48 minutes) SAR images of the sea ice distribution in the marginal ice zone of Fram Strait. A method is described to extract the ice velocity at a resolution of hundreds of meters or several cm/s. In the described low ice concentration regions, the ice velocities likely correspond to the ocean velocities underneath. The authors demonstrate that this method can be used to obtain mesoscale and submesoscale oceanic dynamics at unprecedented resolution. This is of high interest both for sea ice physics and physical oceanography as the dynamics of the MIZ depends on both and can only be understood by considering

both. The brief communication is well-written and succinct. I have no major issues with the manuscript, but would like the authors to clarify a few things. That should be straightforward to do. The minor points below should likewise be easy to address. Therefore I recommend minor revision.

Main points:

1. The manuscript impressively demonstrates how well the method works in this one example. However, it would be good to know how usable this method is in general. It would be great if the authors could provide the answers to the following questions in an additional paragraph.

How much effort is it to obtain the velocity vectors for an individual image pair? If it is a lot of work: Can you share the software code such that researchers can run it for their own individual time/location of interest? If it is not much work: Can you make this method operational and provide to others the velocity vectors at all times/locations where appropriate image pairs from Sentinel 1A/B exist?

When can this method be used? What is the range of sea ice concentrations where it applies? Are there differences between seasons in the detail/precision/ease with which the method can be used? E.g. maybe in July (melt season) there is less texture on the sea ice that the satellite could pick up than in September (start of refreezing). Are there influences of weather on the method (e.g. clouds, fog)?

2. The example presented here is from September 2017 in the marginal ice zone in Fram Strait. My high resolution shipboard in-situ study of a submesoscale filament (von Appen et al GRL 2018) was from July 2017, i.e. 3 months earlier. Is there a reason you chose the later time? A direct comparison between the in-situ and the remote sensed data could benefit both methods and reveal more information on the ocean than to consider them separately. I'm not suggesting to change the example presented here, but it might be nice to follow up by also using the method on the July 2017 example, hence also the motivation for the questions under point 1. above.

3. The grammar in the manuscript needs careful editing. Especially articles (a/the) are often missing. I point out a few (but by no means all) of these instances below. I'm not sure whether this should be done now or will take place anyways after acceptance by the journal's copy editors.

Minor points:

l1 title consider "dynamics in the marginal"

l7 "New possibilities for . . . over the marginal . . . are demonstrated"

l8 "within 70-85°N or 70-85°S"

l14 "oceans has been rapidly"

l23 Can that melt rate also be expressed as m/day in the vertical?

l39 Can you give a number what "relatively low concentrations" means (see main point 1 above)?

l45 "independent of"

l51 "has recently become"

l88 "the velocity detection threshold in this case would be 0.03 m s-1" I think it is not just the threshold, but also the precision of your method. I.e. you can only determine the velocity to be 0.03m/s, 0.06m/s, 0.09m/s, and so on. Or am I misunderstanding this?

l93 Did you mean 1150kmˆ2? Otherwise the area would only be 2km long (multiplied by 60km width).

l105 "meaning" How does the second statement (reflects underlying circulation) follow from the first statement (3-5m/s)? Maybe you should state that the winds were very weak or something like that.

l126 ". . . von Appen et al (2018) where velocities of +-0.5m/s were observed with a

vessel mounted acoustic Doppler current profiler."

l130 "in opposite directions"

l148 "one sees very"

l162 "0.02 mˆ2 sˆ-2", i.e. same units as on l149

l165 "instability, of"

l173 "flows which are very effective at producing"

Fig1b Mark box for Fig1c

Fig1c Mark box for Fig2. Otherwise Fig2 would not be georeferenced.

Fig2 Mark box for Fig3. Also consider adding a vector showing the wind direction and a scale vector for 1m/s ocean velocity.

Fig3 Consider to also show strain in a subplot. Also add the "A, C1, F1" letters and the F1 arrows to all subplots to make a comparison easier.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-126, 2020.

Interactive comments on the paper "Mesoscale and submesoscale dynamics of marginal ice zone from sequential SAR observations" submitted by Igor E. Kozlov et al, 2020.

Overall quality:

The paper brings to the attention an interesting ability to examine the mesoscale to submesoscale dynamics in the marginal ice zone using the MCC method on a number of Sentinel-1 A/B SAR acquisitions at short revisit times.

Hitherto the MCC has been frequently applied to optical- and altimeter-based satellite data for studies of mesoscale dynamics in coastal regions. In this paper, the novelty relates to the use of the MCC method to a series of Sentinel-1 SAR image acquisitions in the marginal ice zone, demonstrating promising results.

The paper is fairly well structured and written, with the inclusion of very good figures.

Scientific issues:

The paper title should preferably be modified to read: Mesoscale and submesoscale dynamics in the marginal ice zone from sequential SAR observations.

The abstract is perhaps too brief. The importance for model validation should be mentioned in consistence with the Discussion and conclusion section.

The submesoscale dynamics are also recognized to have intense, narrow bands of vertical motion. The authors need to address this issue in regard to the application of the MCC method whereby only the estimation of horizontal motion is discussed. For instance, could patterns evolve as influenced by the vertical motion, rather than the horizontal motion. The marginal ice zone is periodically also known to have bands of strong wind induced upwelling that would also influence the subsequent dynamics.

Moreover, the data are collected in September. This is related to the time of year of minimum sea ice extent and concentration. The summer sea ice melt is also nearing an end. Does this set up a shallow mixed layer regime in the MIZ that favors the presence of these mesoscale to submesoscale structures? If so, is there a seasonal variability to these SAR image expressions? It could be good to have this commented and/or addressed.

When Sentinel-1 is mentioned for the first time be more precise; e.g. Sentinel-1 is the European Radar Observatory for the Copernicus joint initiative of the European Commission (EC) and the European Space Agency (ESA).

Technical/editorial corrections:

Line 7: Abstract: …..retrieval in the …….
Line 8: remove…..made……
Line 9: replace….obtaining …with ….estimation of….
Line 11: ….strong sea ice concentration and vorticity…
Line 14: ….polar ocean has rapidly grown during….
Line 16: …major source of uncertainties in the….

Line 22: ….remove……cyclonic….
Line 23:……ice edge melt rate of….
Line 29:…..large vertical velocities that can entrain….
Line 51: Be consistent in the use of naming convention. Sentinel-1, rather than S-1, is my preference. The former is used in all Figure captions, while it is a mix in the text (although line 51 say…hereafter S-1….
Line 62: …..remove…..from…..
Line 63/64: daily basis over region of particular interest, such as the European Arctic Ocean (Fig. 1.a) with 43 S-1 A/B acquisitions available….
Line 66: …by overlapping SAR scenes.
Line 67: ..SAR data , O(100m), ensure a unique….
Line 68: To demonstrate the potential we analyze….
Line 69:….the warm Atlantic Water (AW)…..
Line 76: ….SAR images has several steps:…
Line 94: and display a large number…..
Line 101: …with model results reported by…..
Line 103: …….for surface current estimation using the MCC method.
Line 113:…..evolves into the large anticyclonic…
Line 128/129: This sentence should be improved. Avoid expressions like…..its movement direction…..
Line 146/147: ….for eddies A ($\xi \approx 0.07$ f) and C ($\xi \approx 0.3$ f) yields a larger Rossby number than for….
Line 163: …use same unit for EKE in text and Figure Maybe also color scale in the figure could be extended to identify values of 0.3 m^2/s^2.
Line 164:….EKE values were attributed to the complex…
Line 173: ….of anticyclonic flows that are very effective……
Line 174: … use……. relative vorticity ……..instead of ……vertical vorticity…..
Line 184: …….data to resolve small-scale processes of the complex….
Line 186: ……features may importantly enhance the vertical…..
Line 187: ice and influence sea ice melt, upper ocean stratification,…

Figure captions:

Line 254: ….showing the coverage of Sentinel-1 A/B SAR image acquisitions…
Line 261 (Figure 2): ….Sentinel-1 A/B images acquired on …
Line 262: …..the SAR image and b) map of the horizontal velocity (speed in color)
Line 266: relative vorticity normalized by the Coriolis