

Anonymous Referee #1

Received and published: 5 March 2020

This paper presents a consistent framework for estimating statistical errors of sea ice drift and ice deformation parameters derived from a set of GPS on-ice buoys or from sequential satellite SAR images. Throughout the case studies, the authors carefully examined various sources of errors and their estimates relevant to the both main types of sea ice drift observations. This paper will serve as a good reference for the future studies dealing with deriving kinematic parameters of sea ice and the corresponding statistical errors. The paper is well structured and written. I recommend it to publication, once the following comments are addressed:

Thank you. Our answers to your comments are marked in green.

In Section 3.4 the authors discuss deformation parameters retrieval for square grid cells in SAR images. However, many of the recent algorithms for retrieval of ice drift information from SAR images (e.g., Demchev et. al., 2017; Muckenhuber et al., 2016; Komarov and Barber, 2014) compute ice motion on a non-square grid, as usually the grid points are associated with distinctive ice features in SAR images. Could the authors extend their analysis (Section 3.4) from the “square” grid cells to “non-square” grid cells in SAR images? What is the most accurate approach to computing ice deformation parameters and associated errors from the SAR-derived ice velocities provided on non-square grid cells?

This is two separate questions.

1. Regarding non-square grid cells: see Section 2.5, in which uncertainties of deformation parameters are derived for a general polygonal region. These are based on the general formula for u_x (and the other velocity derivatives) given in equation (5), which is based on integration around the boundary of an arbitrary region. In Section 3.4 we simply specialized the results of Section 2 to square grid cells. We also added a paragraph providing a more general view on the problem of arbitrarily-shaped quadrangles at the end of Section 3.4.

2. Regarding “the most accurate approach to computing ice deformation parameters and associated errors from the SAR-derived ice velocities provided on non-square grid cells,” there are at least two factors to consider:

(a) Tradeoff between accuracy and spatial resolution. We can apply equation (5) for u_x (and the other velocity derivatives) over larger and larger regions defined by more and more boundary points to obtain more accurate estimates of the mean deformation, at the expense of reduced spatial resolution. In other words, one must balance the need for accuracy with the need for spatial resolution of the deformation field. This is mentioned in the second sentence of Section 3.6.

(b) Differentiability of the velocity field. The truncation error of equation (5) is of order $u_{xx}\Delta x^2$, i.e. second-order accurate: it is exact for velocity fields that are linear in x and y . Higher-order estimates for u_x could be derived, but they would not necessarily be more accurate because the ice motion may not be continuously differentiable to higher order, e.g. u_{xxx} and higher derivatives may not exist. Higher-order estimates would only be more accurate for sufficiently differentiable fields. We have added the above sentences to the end of Section 3.7.1.

Technical corrections:

Line 39-40. I suggest modifying:

“This means that drift and deformation errors do not only depend on the geolocation accuracy of satellite images but also on the reliability and robustness of the drift retrieval algorithm.”

to

“This means that drift and deformation errors do not only depend on the geolocation accuracy and spatial resolution of satellite images but also on the reliability and robustness of the drift retrieval algorithm.”

Done.

Line 76-77. “x” and “y” should not be in bold as they are scalars.

Was perhaps a problem when generating the PDF from Word

Line 141. “10km” → “10 km”

Done.

Line 457-467. Same as previous. Add spaces between numbers and units.

Done.

Equation (31). N should not be in bold.

Was perhaps a problem when generating the PDF from Word

Line 725. “RADARSAR” → ”RADARSAT”

Done.