The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2018-290-RC2, 2019

The Cryosphere Discussions

Interactive comment on "On the multi-fractal scaling properties of sea ice deformation" *by* Pierre Rampal et al.

Anonymous Referee #2

Received and published: 6 March 2019

General comments: This paper aims at validating the basic behavior of deformation rate in the neXtSIM sea ice model which is based on the Maxwell-Elasto-Brittle rheology, focusing on the scaling properties in space and time. The model domain was the whole Arctic Ocean and the coarse graining method was used for scaling analysis with the drifters' data in the model. For validation data, the Lagrangian displacement data produced from RADARSAT Geophysical Processor System (RGPS) were used. Through scaling analysis, it was shown that the multi-fractal properties can be reproduced for the first time in the numerical sea ice model. Besides, the statistical properties of the first, second, and third moments of deformation rates at temporal scales of 3 days to 96 days and spatial scales of 7.5 km to 700 km were shown to be mostly consistent with the observations. In conclusion, since the fundamental properties were

Printer-friendly version

Discussion paper

validated, they suggest that the neXtSIM model could be used as a proper tool to further study the physical meaning of the processes related to deformation. Considering that it is still a big challenge to reproduce the rapid thinning trend of ice thickness distribution in the Arctic Ocean in the numerical sea ice model and the need to improve the deformation processes in the model has been recognized for a long time, the topic of this paper is timely, and the results of this paper will provide insightful implications. Overall, I feel that this paper is an elaborate and nice work, and this approach is indispensable to improve our understanding of the dynamic behavior of sea ice. Therefore, I believe this work will contribute to the development of sea ice dynamics, especially for the parameterization of the model, related to the deformation. My comments, which might come from the lack of my knowledge about mathematics, are limited to minor points as follows:

1) Regarding the description of exponents, α and β (Eqs. 4 and 5), could you please explain more about why these exponents can be expressed as a quadratic equation of the moment parameter (q)? To be honest, I could not follow the subsequent paragraph (P5L4-11) completely. To my understanding, multi-fractal means the geometric properties that contain various dimensions of fractals. If this is correct, why can the curvature of the exponents as a function of q be an indicator of multi-fractal which discriminates from mono-fractal? In my mind, if I could accept this concept, the manuscript would have become much more understandable to me. 2) Regarding the methodology of analysis, it is stated that you used the coarse-graining approach (P10L12). Is this the method described after P11L12? If so, it might make it readable when you insert "(shown later)" at the end of the sentence (P10L12). Besides, regarding the statement, "Only the trajectories that are common to both the simulation and RGPS dataset are considered in the calculation of the deformation and their statistics" (P10L22-24), I am a bit concerned whether this approach might affect the results by setting a bias in the calculation. I mean the data consistent with observations might have preferentially selected. If you can add some description about how much fraction of data were discarded by this method and show that this selection did not affect the result

significantly, it would be appreciated. 3) Regarding the interpretation of the scaling analysis (Fig.5&6), it is stated that "We find that the estimated spatial scaling exponent, β, decreases with increasing T (Figure 5 and 6, left panels)" (P15L15-16). To my understanding, β corresponds to the slopes of the graphs. As far as looking at the left panels, however, the slopes appear not to be significantly different for all the values of T (3 days to 96 days) at least for q = 1. When looking at right panels, there certainly be a decreasing trend with the increase of T for q = 2 and 3. Thus, unless there is a physical meaning in the decreasing trend of β with the increase of T, it might be one idea to focus on the decrease of the multi-fractality of the spatial scaling with the increase of T. The similar discussion may apply for the last paragraph in section 4.2 (P17L11-21). Besides, the additional description about the physical implications of the decrease of the multi-fractality would be appreciated if it is possible.

Specific comments: *(P2L19-20) "Rothrock and Thorndike, 1984; Matsushita, 1985" & "Rothrock and Thorndike, 1980" are missing in the reference lists. *(P3L7-8) "Coon et al. (2007)" should be "(Coon et al., 2007)" *(P12L18) Is there any meaning in the selection of 30 degrees? *(Figure 1&2) Considering the order of appearance in the manuscript, it would be preferable to exchange Figure 1 and 2. *(P15L4) I think "0.2" should be "-0.2". *(Figure 8) It is stated that "The dashed lines are extrapolation for the smallest scales" in the caption. However, I could not see the dashed lines. Besides, "L=7.5km", which appears in the upper left corner of the figure, is misleading. Please take it if not necessary.

That is all. Faithfully yours.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2018-290, 2019.