This paper introduces a new method for obtaining information on sea ice dynamics from floating ice tethered buoy location data. The theory is introduced and implemented on n3 separate buoy data sets. The study presents an interesting and worthwhile inclusion to current methods of analysing sea ice drift. Comparisons are successfully made in the paper that show notable improvements overt existing polygon methods of analysing sea ice drift and dynamics. However, I find the paper somewhat lacking in results and technical information and this greatly hampers the interpretation of the results presented. I am confident that after addressing the following issues it will be fit for publication. See major points below followed by specific points.

A more detailed description of the usability of this method is needed. This could well be a useful method for the community to explore sea ice dynamics, but certain features of the method and results are still unclear to me.

First is the dimensionality of the results. The figures give results in units of d-1, so it seems that TSE metrics are equivalent to standard strain measurements. How do the units given in the results scale in comparison to Itkin (2017) and other measurements? Are the TSE scales and strain measurements of comparable magnitude? Is TSE most comparable to divergence, how does it respond to shearing across the trajectory? A few toy examples of this method, such as included in the appendix will aid this paper. For example, it is currently unclear to me what TSE we expect for a large coherent ice cover, under no deformation, but under acceleration. What TSE do we expect for a divergent flow? How does it respond under rotation or with a flow field experiencing shear or curl? These examples will aid the interpretation of particularly figure 2, where the TSE and triangle methods show different behaviour. What is happening to the ice during these periods?

The second is that the method relies on the magnitude of the tangential vector to the buoy trajectory. Does this mean that directional information is included within the TSE results, or is it purely a scalar? Does this link into the analysis between the TSE and polygon methods on L 199? The context of figure 1 is difficult to understand. This may be due to the difficulty in interpreting the method and theory presented, but consider adding to this figure the deformation results of Itkin (2017), if comparable. The figure captions all need expanding upon.

Thirdly a greater description of \bar{TSE} is required. This is given as the “hyperbolicity strength” but this definition does not explain to me why this value is positive definite. The equational form and results suggest that this metric gives a longer time scale measurement of stretching, but only for divergence with no expression of compression. In figure 2 it is compared to the strain rate magnitudes, so is it a measure of the total magnitude of change in stretching?

Fourth, the buoy deformation results in figure 2 are unexplained and uncited. Are these the first publication of the triangle based deformation measurements from MOSAIC? If so they need much more documentation than currently included here and possibly a figure or two to allow these results to be adequately interpreted. If not then a further description of the previous publication is required. How reliable are the results? What are the successes of these results?
Related to this issue: a separate data section is required. This needs to include all descriptions of the data used and the previous results repeated in this study. Currently this information is within the introduction, method and results and is difficult to follow.

L 14 a more up to date reference for this is desirable.

L 15 -16. Does this feedback come directly from Serreze and Francis? A little more expansion on how they discovered and documented is needed. The current description is too brief to show the importance of ice dynamics.

L 28-29 this sentence doesn’t fit the flow of the paragraph. Consider moving it before the description of SAR data.

L 35 This paragraph will benefit from an expanded definition of a Lagrangian coherent structure, in particular why this perspective results in the difficulties in using ‘gridded sea ice displacement fields’ mentioned later.

L 46 What characteristics of a LCS make it a hyperbolic LCS? And what makes sea ice applicable to a hyperbolic LCS? Additional arguments and descriptions of Haller et al. 2021 could be incorporated.

L 50 Does the period have the ‘much larger influence’ or is it the identification that has it? ‘Much larger influence’ than what?

L 63 ‘the the’ -> ‘that the’

L 63, 64 I find that this sentence does not give enough background on Haller et al. 2021 to allow for any understanding of the following equations. Please include a sentence each, with terms, on ‘material stretching’, ‘hyperbolicity strength’ and ‘initial material tangent vector’. At the moment the reader is required to also read a large part of Haller et al. 2021 in order to understand these equations. It is also unclear what is represented in the two equations.

L 69 My interpretation of the appendix does not show that this is “verified”. If I indeed it is only likely that sea ice drift is slowly varying, then this needs to be stated as such.

L 78 including a definition of a “steady flow” will benefit this section.

L 87 Again a definition of hyperbolicity in this context will aid the understanding here.

L 90 Can you add in this paragraph a description on the units of the two equations and TSE? A further description of how this relates to usual deformation units and how to interpret the two values would be of help (you may want to put this elsewhere).

L 91 A citation is needed here.

L 95 - 97 What is meant by this sentence? Will this technique be used later, or is it a note on the context of TSE methods and the use of existing stress vs train rheology methodologies?

L 112 It is not immediately obvious why equations 6-9 are included as they are not referenced. Consider removing them. Do they apply directly to the example A3? If so put them there too. The following paragraph gives a detail dsicussion on the limitations of polygon based approaches, these extra questions don’t bring anything useful here.

L 123 An example of such a long time series is needed here.

L 149 An extra summary sentence here showing plain words rational for this technique would be beneficial.

L 169 how is the slowly varying nature of sea ice drift relate to these storm periods? Is it more or less likely that the slowly vary criterion holds?

L 175 I’m not sure why the beginning part of this sentence is needed, as the second part of it does not logically follow. It’s fine that the diagnostic has a time window, and this description is a sensible choice.

L 179 here may be good place to refer to equations 6-9, if they are needed at all.

L 186 a quick summary of the Itkin cleaning method would be a beneficial addition here.

Figure 1. This caption requires extensive expansion. All lines need to be defined. It is currently impossible to interpret this figure without extensive reading in the text. The figure needs to be interpretable from the caption alone assuming a knowledge on the papers aims and method. Addional lines at d-1 = 0 will allow

L 217 - 221 Has this data been analysed by this method previously? If so citations and a summary of results is required. If not then this paper needs expansion as a presentation of these new results too. A least a discussion of previous use of these results or method is required.

L225 please refer div, D back to the equations previously and change the labels on the plot to directly match the text. Using 2a, 2b will help too. Please also add from an improved method why TSE is compared to div, and \bar{TSE} to total D.
L 240 which source do these numbers come from? The polygon of triangle based methods? What numbers come from the other method? Can the two methods be dimensionally compared in this way? Is there any method that allows for the integral of all deformation and TSE over the period discussed?

L 241 Is this value significant? Which line plot does it come from? Do all significant deformations have a higher value?

L 242 Is shear plotted anywhere? How do we interpret shear against the TSE metrics?

Figure 2. Caption needs expanding. (a-d) are referenced in the text but do not appear. What is the black line in b and d? A scale is required for the colourbar.

L 258 Please comment on how the spacing of the buoys and the time handling of this data (linear sampling) affects the dimensionality of the calculated TSE in comparison to high time resolution data from the other sources.

L 259 Shown in black where?

L 267 In the line plot I see that at the beginning of the period the TSE is distributed about zero, and then towards these events the spread of values reduces to oscillating peaks. Is this what you mean?

L 270 Red is positive TSE? So equivalent to net divergence?

L271 high positive or negative values?

L 275 This paragraph will be aided by a previous discussion of what TSE we expect for certain dynamics events. For the accelerating ice described here, what TSE is expected? For constant but rotating flow as described at the end of this paragraph what idealised TSE is expected?

Figure 3 You have chose not to include \bar{TSE} int his plot. Can you explain why? Please use a divergent colour scale for the divergence, with white at zero and different colours for positive/ negative TSE.

L 281 This paper has provided not explantation I could interpret so far on how TSE provides insight in to “distant fracture events”. Please expand, as this is a useful contribution if true.

L 285 I have seen the deformation events captured in the new technique, but nothing on prediction. Perhaps the wrong word to use here.

L 291 “predicted” again this is the wrong word I think. Captured or similar is more accurate.

L 296 “Buildup of stress” is this your hypothesised stress state prior to the break up, or does the TSE measure stress? Are there other measurements of stress during this period that can back up this claim?

L298 Again is this a hypothesis of what internal stresses are expected within the pack? If these assessments of ice stress are speculation, please be very clear about this, or remove them.

L 317 This is the first mention of the technical methodology used in this study. Please include this information earlier in the study also. A data section detailing the exact values taken from the buoy data is needed.

Appendices

L 362-365 Can you comment on how figure A1 suggests that the slowly varying criterion is met, but not conclusively? I see from figure A1 that $|vt|/|a(t)| < 1$ in most cases (positive tail greater than 10^0), but not strictly or $<< 1$. Is this correct? Does that mean that the data presented suggests that sea ice is, in general, slowly varying, but not strictly so? Can you comment on the cases where $|vt|/|a(t)| > 1$, when do such cases occur?

L 394 A summary sentence for this example, repeating, and expanding upon the introduction to the appendix would be helpful here.