Thank you for taking the time to review our manuscript. We have responded to your comments below.

General comments:

Slowly-varying condition of sea ice drifting is the main basis for the application of TSE method. Then, is the TSE method applicable to all sea ice concentration scenarios and reasonable for all cases with different ice-wind ratios? That is, how the internal stress of sea ice affects the method. It is suggested that the author strengthen the discussion in this respect and increase the influence of sea ice concentration on the TSE calculation results.

Thank you for bringing this to our attention. We have further expanded our methods section to explain what exactly TSEs are calculating. We also have added an appendix section that shows the derivation of TSEs and relates them to Shear and Divergence in a analytic model example. TSE calculations are affected by sea ice concentration in much the same way as array-based estimates of rate-of-strain metrics. Once we are no longer dealing with a continuum of ice, such as when ice is transitioning to free-drift, we are no longer representing ice deformation, but calculating motion in a ice-ocean mixture. We have added to our MOSAiC example what happens when sea ice concentration drops and our cluster of buoys is no longer correlated.

As the author said, the speed of sea ice motion is very dependent on the sampling frequency (See also Lei et al., 2021). Then, the three groups of buoy data used in the paper should have different sampling frequencies. What is the impact?

At lower sampling frequencies, we might lose high frequency oscillations in the ice. For TSE calculations, this effect would be negligible. For \bar{TSE}, this oscillation effect would be cumulative and could indicate much higher degree of absolute hyperbolicity (cumulative stretching and compression). For example, a low sampling frequency might miss tidal oscillations, whereas higher frequency would be able to identify this effect on the ice. We now explain in the data section how the choice of sampling frequency is derived from the data source or comparisons with previous experiments.

In essence we are trying to approximate a continuous integral, and the sampling period is defining the discrete sum we are using to approximate that integral. I appreciate the concern of the reviewer with respect to sampling rate, but this calculus problem is well studied, and unfortunately unavoidable with discrete data. Obviously, higher sampling rate is better if there are not additional errors included. Changes from subsampling depend on the interpolation approach.

In addition, when judging the slowly-varying nature of the sea ice flow, daily satellite remote sensing products are used. Although the author already mentioned its influence, I think it is necessary to give the degree of influence quantitatively.

Unfortunately, we cannot ascertain the impact of a daily output of the ice product until a comparable higher resolution ice product is available. To quantify the slowly-varying nature of the flow (as in the appendix), we need to calculate spatial and temporal derivatives, which is only available with a gridded motion product. Our understanding of the slowly-varying nature of sea ice would benefit from a concerted modeling study where we can vary the sampling frequency, which is now suggested in the text.

Special comments:

- **Unit 20: "Obtaining local or regional information on the state of sea-ice can thus give an indication of future sea ice melt rates and potential weather impacts"**

-- the Connector for sea-ice is not necessary. "future" is better change to summer because it is mainly about the seasonal scale.

Thank you. This has been changed to summer.

- **Unit 80: "With these consideration in mind, we focus on mid-winter and early spring ice dynamics prior to minimize extensive fracturing of the ice cover"**

-- Does this mean that this method is not applicable in the sea ice marginal ice zone or the area with low ice concentration in summer.

Trajectory stretching exponents measure the degree of stretching of a specific initial vector in a material as it evolves over time. If the material is discontinuous (such as in the marginal ice zone), you would no longer be measuring deformation of just the material, but stretching of a motion vector of these mixed continuua. This is the same as quantifying shear or divergence in the marginal ice zone. Values no longer represent shearing of solely the ice, but quantify a deformation motion in the ice-ocean continuum. Please also refer to our response to general comment #1.

Unit 155: Here is a paper (Lei et al., 2022) talks about the timing of sea ice mass balance at the MOSAiC DN. Although this is a process analysis of thermodynamics, I think seasonal thermodynamic processes are helpful for supporting the analysis of their kinematic and dynamic processes.

Thank you for your suggestion. We will integrate this reference in the next version of the manuscript.

Unit 180: ", LKF formation", Abbreviations are not defined.

Corrected, thank you.

Unit 280 "We find that TSEs successfully identify signifificant local material deformation tangent to individual sea ice buoy trajectories"

-Sea ice deformation has obvious localization characteristics (Lei et al., 2021). The deformation given based on TES method should only identify the deformation and

fragmentation along the sea ice trajectory. Therefore, for a designated area (e.g., MOSAiC DN region), to obtain the localization characteristics of sea ice deformation, it is still necessary to build a high-density buoy array, even if the TES measurement method is used.

Thank you. We have added a comment in the conclusions that it is still necessary to use a high-density buoy array to characterize sea ice deformation with rate-of-strain invariants, and to localize trajectory stretching at high resolution:

"To obtain rate-of-strain invariants for sea ice deformation, it is still necessary to use a high-density buoy array. Such an array also reveals gradients of trajectory stretching and further enhances precise stretching localization with TSEs."

Unit 295 "TSEs accurately predicted the onset of major storms"

Can you give the physical mechanism to explain this prediction. It is generally believed that sea ice deformation occurs during or after storms.

Thank you for pointing this out. We have clarified the sentence in line with the general consensus as follows:

"Specifically, large TSE values coincided with major storms in the N-ICE2015 experiment"

Data availability, The MOSAiC drifter data: The MOSAiC GPS buoys were jointly provided by colleagues participating in MOSAiC, so appropriate acknowledgements are necessary. Because there were many providers involved, or sea ice team members can be used instead.

Thank you. The acknowledgements recognize Angela Bliss for her work in preparing and providing the MOSAiC buoy data.

References:

Lei, R, et al. 2022. Seasonality and timing of sea ice mass balance and heat fluxes in the Arctic transpolar drift during 2019–2020. Elem Sci Anth, 10: 1. DOI: https://doi.org/10.1525/elementa.2021.000089.

Lei, R., Hoppmann, M., Cheng, B., Zuo, G., Gui, D., Cai, Q., Belter, H. J., and Yang, W.: Seasonal changes in sea ice kinematics and deformation in the Pacific sector of the Arctic Ocean in 2018/19, The Cryosphere, 15, 1321–1341, https://doi.org/10.5194/tc-15-1321-2021, 2021.