RESPONSE TO EDITOR'S/REVIEWER'S COMMENTS

We would like to thank the editor and reviewers for sparing their valuable time in reading our manuscript and providing valuable comments/suggestions which have helped us to improve earlier version of the manuscript. In view of the comments/suggestions, we have revised our manuscript, hope our manuscript will be acceptable to the Referees and to the Editor. The suggested changes are highlighted (with green colour) in the manuscript.

Reply to the points raised by the Reviewer (RC1)

General comments

The study presented demonstrates a commendable use of English. There is major room for improvement in the presentation of the figures. Overall, the chosen subject matter is captivating.

Nevertheless, problems of basic methodological elements weaken the study considerably.

For this reason at this point I would propose a major revision.

Answer: We are thankful to the reviewer for reading the manuscript and suggesting revision.

Specific comments

The authors employ the InSAR technique. The theoretical part of the SAR methods adopted are clearly explained and in detail. However, at first the authors focus on the Tibet 2020 earthquake (Mw5.7), which caused significant deformation detectable by InSAR, as evident from the fringes displayed in the wrapped interferogram in Fig. 3D. However, starting from the second event studied (Leh earthquake, Mw5.3), the magnitudes are too low to be reliably detected by InSAR. Additionally, subsequent minor events with magnitudes ranging from 4.1 to 4.5 and varying depths of 35, 49, or even 74 kilometers, further challenge the feasibility of using InSAR for surface deformation monitoring. Consequently, it becomes apparent why the wrapped interferograms for these events are not presented -except for the Mw5.7 Tibet 2020 earthquake. Thus, the approach utilized to measure surface deformation for the second event (Leh earthquake, Mw5.3, depth: 10 kilometers) could be questionable, and for all subsequent events, it is deemed unsuitable.

Answer: In this work, we attempt to capture surface and glacial deformations due to earthquake events of various magnitude and hypocentre depth. The idea is to check the capability of the C-band radar interferometry technique to capture seismic deformation of glacial bodies and ground surface.

It is true that the detectability of reliable deformation reduces with decrease in earthquake magnitude and increase in hypocentre depth. Therefore, in order to capture the reliable seismic deformation, we have considered deformation of the regions with co-seismic coherence ≥ 0.6. Our results align with the general understanding of earthquake deformation detectability and also with the results presented by Li et al., 2022, as explained in the manuscript.

In fact, for the earthquake events of lesser magnitudes, the detection of reliable seismic deformation is questionable, as in the case of the 2017 Sikkim Earthquake (M_w 4.2), 2018 Sikkim Earthquake (M_w 4.4) as well as 2020 and 2021 Nepal Earthquakes (M_w 4.1).

The wrapped and unwrapped interferograms for every earthquake event considered in this study is presented in the supplementary file along with the shake maps, isoseismal contours and focal mechanism (available for whichever earthquakes in the USGS Earthquake Catalog and Global Centroid

Moment Tensor (CMT) Catalogue respectively). Those results support these conclusions, but also identify other features, as discussed in the paper.

The authors make assumptions regarding the influence radius of the smaller events, their methodology could potentially be considered to lack sufficient data to ensure reliable results. However, what is more crucial is the absence of estimations for the expected deformation of each event. I consider, that it is imperative for the authors to develop forward surface displacement models, potentially based on formulations such as those of Okada. This missing element is of significant importance. Such models could be constructed using the focal mechanisms of the events or -for more detailed results- on slip distributions, if available. Understanding the anticipated surface deformation based on the event source is paramount, allowing for a comparison with observed patterns to ascertain whether the glaciers are following expected trends or displaying deviation.

Answer: We would like to thank the reviewer for the valuable suggestion. As isoseismal contours and shake maps with Modified Mercalli Intensity (MMI) scale are available online for earthquake events with much higher magnitudes, understanding seismic deformations for comparatively moderate and lower magnitude earthquakes become difficult. Similarly, focal mechanisms are available online for higher magnitude earthquakes only. In particular, for the earthquake events which are triggered at high-altitude Himalayan regions where glaciers are present, such information is unavailable. In this context, C-band radar interferometry can act as an effective tool in studying earthquakes which are triggered near remotely located high-altitude glacial bodies.

The USGS shake maps, isoseismal contours and focal mechanisms for 2020 Tibet earthquake (Mw 5.7), 2020 Leh earthquake (Mw 5.3) and 2017 Thang earthquake (Mw 5.2) and shake map for 2021 Joshimath earthquake (Mw 4.5) is presented in the supplementary file.

We first tested the proposed methodology for the 2020 Tibet Earthquake (M_w 5.7), which was studied extensively for surface deformation. Later, we utilized the method for other earthquakes of varying magnitudes and hypocentre depths.

Technical corrections

1. Add the wrapped and unwrapped interferograms for all the events.

Answer: The wrapped and unwrapped interferograms for all the earthquake events studied in this work are presented in the supplementary material.

2. Add the available shakemaps in the figures, or in the supplementary material.

Answer: The shakemaps and isoseismal contours are presented in the supplementary material.

3. Add a global map where you can show the area of interest. Also since you refer to them, add the Indian and Eurasian plate boundaries, Tibetan plateau Himalayan frontal thrust etc. All that is mentioned in the text, would be better to be shown in the figures too.

Answer: We thank the reviewer for the suggestion. Figure-1 has been modified with a global map, Indian:Eurasian plate boundaries and tectonic lineaments.

4. According to gacos.net, when using GACOS, all the following papers should be cited:

- Yu, C., Li, Z., Penna, N. T., & Crippa, P. (2018). Generic atmospheric correction model for Interferometric Synthetic Aperture Radar observations. Journal of Geophysical Research: Solid Earth, 123(10), 9202-9222.

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- Yu, C., Li, Z., & Penna, N. T. (2018). Interferometric synthetic aperture radar atmospheric correction using a GPS-based iterative tropospheric decomposition model. Remote Sensing of Environment, 204, 109-121.

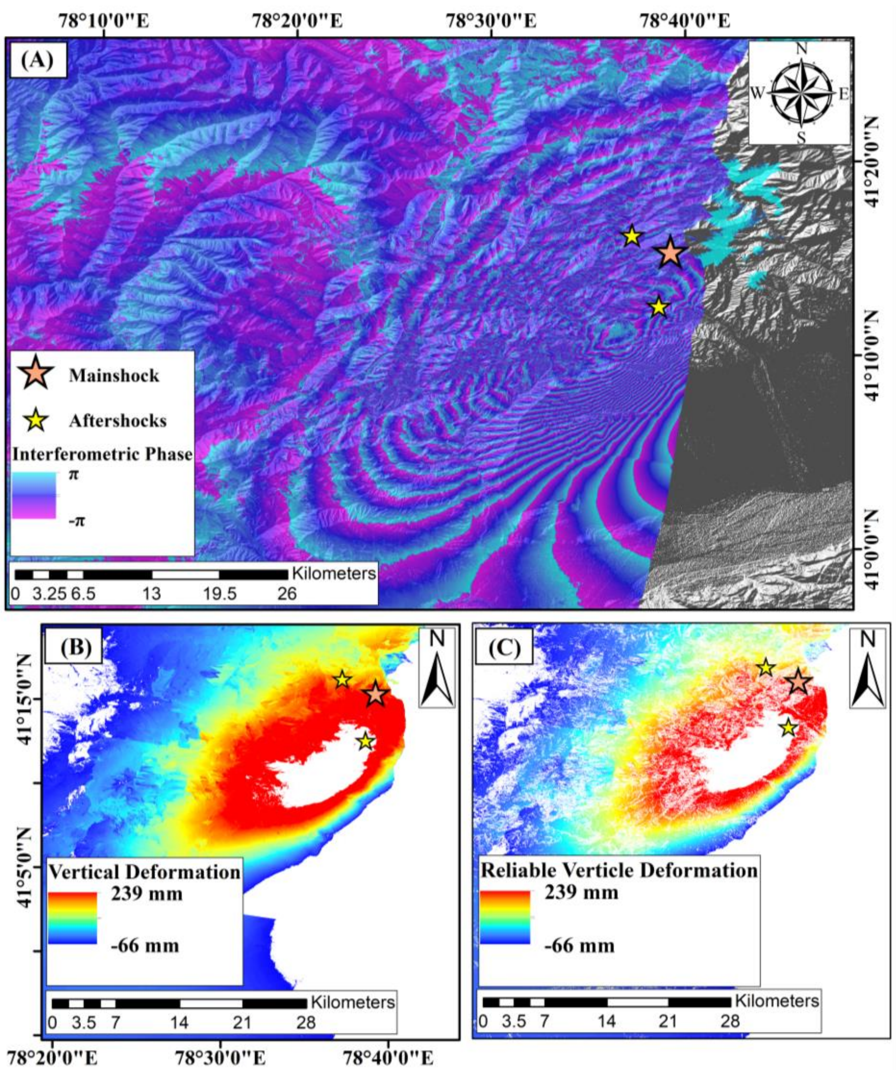
- Yu, C., Penna, N. T., & Li, Z. (2017). Generation of real-time mode high-resolution water vapor fields from GPS observations. Journal of Geophysical Research: Atmospheres, 122(3), 2008-2025.

Answer: Suggested papers have been cited.

5. Add the focal mechanism of all the events in the corresponding figures.

The focal mechanisms for 2020 Tibet earthquake (Mw 5.7), 2020 Leh earthquake (Mw 5.3) and 2017 Thang earthquake (Mw 5.2) are presented in the supplementary file.

6. In section 4.2 around line 245 you mention: "…regions close to the epicenter location show positive vertical displacement for the 2020 Leh earthquake, with negative vertical displacements moving away from the epicenters." This is an example where you should present what you measured and which is the theoretically expected deformation pattern.



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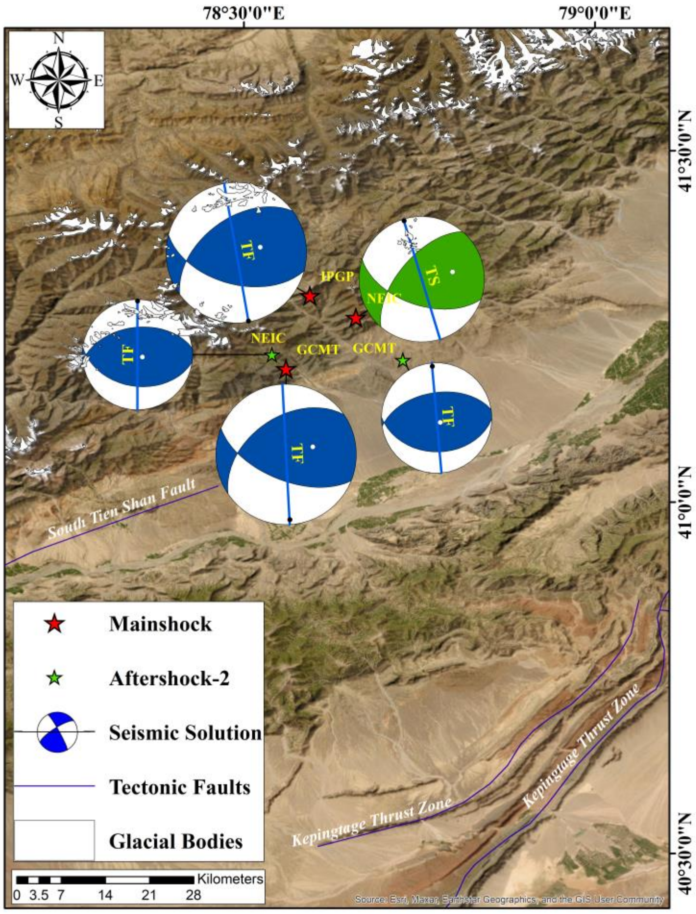
Answer: We thank the reviewer for the suggestion. In case of the 2020 Leh Earthquake, we observed upliftment near epicentre that later transforms to subsidence as moving away from the epicentre. We have checked for various other earthquakes including the recently occurred 2024 China Earthquake sequence which includes a mainshock (Mw 7.0) at a hypocentre depth of 13 km and two aftershocks (Mw 5.8 and 5.5) at a hypocentre depth of 10 km in the Tien Shan mountains' fold and thrust belt shows similar observation (as shown in the map above). Both the earthquakes have occurred due to thrust faulting as understood from the focal mechanism and beach ball map of 2024 China Earthquake (given below). The focal mechanism and beach ball map for 2020 Leh earthquake is shown in the supplementary file.

Earthquake	Event ID	Latitude (°)	Longitude (°)	Depth (km)	Nodal Plane-I			Nodal Plane-II			M_w	Source
					Strike-I	*Dip-I*	*Rake-I*	*Strike-II*	*Dip-II*	*Rake-II*		
		41.2628	78.6594	22	108.39	55.86	144	220.51	60.96	39.94	6.7	NEIC
Mainshock	636644404	41.294	78.594	22	105	53	127	234	50	51	7.1	IPGP
		41.19	78.56	16.1	112	60	127	235	46	44	7	GCMT
Aftershock	641513987	41.2023	78.7264	10	91.12	38.32	97.7	261.34	52.09	83.95	5.1	NEIC
		41.21	78.54	23.2	98	42	101	262	49	80	5.5	GCMT



7. Figure 5A. Why is there such a sharp discontinuity?

Answer: This discontinuity is likely the result of phase unwrapping errors associated with the topography. This is a good example of why we masked out those areas with coherence less than 0.6, resulting in Figure 5B, which shows areas of more reliable results.

6. Provide a citation for the SRTM DEM.

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Answer: The following citation has been included in the manuscript for the SRTM DEM:

Rabus, B., Eineder, M., Roth, A. and Bamler, R., 2003. The shuttle radar topography mission—a new class of digital elevation models acquired by spaceborne radar. ISPRS journal of photogrammetry and remote sensing, 57(4), pp.241-262. https://doi.org/10.1016/S0924-2716(02)00124-7

FINAL COMMENTS

I find the arguments of the authors intriguing: the presence of metamorphosed glacial ice over the ground surface leads to seismic amplification and the effects of earthquake events on glaciers can be notably more significant than their impact on the surrounding terrain. But as previously mentioned, the analysis falls short in terms of robustness. The methods adopted in this manuscript are not suitable for most of the part of the study that the authors present.

However, considering that the subject is interesting, I would invite the authors to present an improved version of it, after a major revision.

Answer: We agree with the reviewer that the results are intriguing. While it is regrettable that there is not more complete seismic information available in the region, we believe that these first results are of value to the community and that future work will better elucidate the mechanisms and dynamics. We have included this discussion in the conclusion.