

The Cryosphere Discuss., referee comment RC2  
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## Comment on tc-2021-335

Anonymous Referee #2

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Referee comment on "Contribution of ground ice melting to the expansion of Selin Co (lake) on the Tibetan Plateau" by Lingxiao Wang et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-335-RC2>, 2022

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The manuscript "Contribution of ground ice melting to the expansion of Serling Co lake on the Tibetan Plateau" by Lingxiao Wang et al. is an interesting and original paper that aims to quantify the water volume contribution to the impressive change in water volume of Seling Co lake in Tibet. The work is original as it uses the ground deformation in areas within the watershed and prone to changes in ground ice volume to deduce the water release by ground ice melting. Three years of Sentinel-1 data from end of 2017 to end of 2020 have been processed by multi-temporal InSAR SBAS technique, leading to a decomposition between seasonal deformation associated mainly to freeze-thaw cycles and a three year trend that is mainly interpreted as decadal ice lense melting (for subsidence) or formation (for uplift). In situ core drillings support the existence of ice rich layers or ice lenses at depth between 2 and 8m, where seasonal deformation or pluri-annual subsidence is observed. Interpretation of GPR results also confirm the existence of ice in the same areas.

The paper is overall well written, present new and interesting data and an original way of quantifying the effect of permafrost degradation on lake level change. The endohoreic nature of this watershed area is also allows to test assumptions or models involved in water cycle quantification. It should be accepted for publication after addressing some comments below, that together lead to a major revision.

### 1- InSAR processing and results

\* Ansari, de Zan et al. have shown that including only **very short temporal baseline interferograms leads to strong biais**, mostly in the form of a pluri annual subsidence. While my experience is that this bias appears mostly in crop areas, and should not be strong in this area of Tibet, it must be shown here that it is not the case (and I really believe that in Tibet you don't have such biais, or at least that what you see is real). The difficulty here is that freeze-thaw cycles lead to decreased coherence and high fringe gradient, such that interferograms with temporal baseline larger than 2 months are difficult to unwrap. You may find some methodology of how to overcome this in Daout et al., 2017 paper. A stack of numerous 1 year interferograms could also do the trick,

provided that you can unwrap them.

\* **Unwrapping** : Given the difficulty to unwrap permafrost related InSAR signals, you should show a few examples of 24 days interferograms in an appendix together with their unwrapped counterparts. Can you please use network misclosure (Lopez quiroz et al., 2009) during network inversion to quantify the amount of possible unwrapping error ? Please cite the Minimum Cost Flow algorithm used here.\* The time series shown in the paper, with respect to the reference point quite far away, appear extremely smooth in time, where atmospheric contribution of two points 100km apart should, even in Tibet at its very high elevation, be of at least a cm up to a few cm. Please explain what smoothing you used (I guess embedded in MintPy).

\* The discussion of possible **uplift and hence permafrost aggradation** could be improved. First of all, one can see on Figure 6 an E-W and N-S trend in velocity in areas not affected by permafrost, the trend resulting in apparent uplift on the NE corner. Deramping here should be evaluated on pixels not affected by permafrost (otherwise the ramp that is removed is affected by subsidence). A display of the seasonal amplitude and velocity field of the whole study area could help assess this trend. On Fig5, inserting panels with zooms on the amplitude and trend plus the location of time series would help the reader. The patterns associated with uplift could then be visualised in correspondance with the optical image. If the uplift is due to permafrost aggradation, it should also have a seasonal component as ice freezing only happens in winter/spring. Please note that sedimentation cannot lead to uplift, as it only destroy coherence. InSAR only follows the displacement of targets that remain coherent between successive acquisitions.

\* The footprint of the two tracks, the satellite heading and LOS direction should be shown on a figure. Please put also the LOS direction on the amplitude and velocity maps, even if you assume vertical displacement (which is decent here). Please state line 155 if you processing ascending or descending tracks.

\* The **uncertainty on velocity maps is completely wrong** and should be recomputed or deleted (it is at best of the order of a mm/yr for an evaluation with 100 dates spread over 3 years, and with a reference point located at distance of about 100km). The evaluation cannot be made on smoothed time series unless you consider then temporally correlated noise. It does not then include possible biais or unwrapping error, but that's fair enough.

## 2- Other comments:

\* Coring was performed in autumn. Please indicate implication: end of thaw period. Is this why you can conclude from coring that you can measure the depth of the active layer or top of permafrost table ? Active layer is by definition evolving through time. Please clarify your methodology here. A sketch of expected permafrost or active layer features with depth would be welcome as I am not sure I really understand the relation between Table 2 permafrost table and "dev of ground ice" columns.

\* Assumption is here done that total settlement is due to ice melting at the top of the permafrost table. Can you discuss a possible contribution of ice / water present in the soil porosity ? Would then settlement be less per unit of ice melting, at least in a drained setting?

\* Line 372-376: Replace text by a figure showing a density plot of seasonal amplitude versus velocity.

\*paragraph 4.2.3 : show a zoom of velocity and amplitude map in areas of drillings and GPR, with annotated core numbers

\* Figure 9 : the unit is strange. I suggest to drop the figure as I guess it is simply the velocity multiplied by pixel size. The unit shuld stay as a velocity as it is a volume per unit size per unit time.

### **3- Comments on various parts of the manuscript**

\* The ratio of lake surface to watershed area is about 5.4 %, such that a water level increase of 0.2m/yr corresponds to at least 1cm/a of water collected uniformly over the whole watershed area (neglecting evaporation). With permafrost prone areas covering only a fraction of the watershed (ratio of lake surface to permafrost areas in watershed of 0.18), 4 cm/a of ice melting collected uniformly over the permafrost areas in watershed would be necessary to explain lake level rise. Giving these ratio in the introduction could be useful to the reader to understand the water balance at stake for Serling Co lake.

\* Please give a very short description of the pema frost models (extension and ground ice) of Zhao and Sheng 2019 and Zou et al., 2017. I guess it is mostly based on a thermal model and much less on observations. The type of soil is also important: bedrock at the surface cannot host ice I suppose.

\* line 92-93: "long-term subsidence ....melting": Please rephrase, not very precise

\* Figure 1: enlarge text, numbers, reference point (a cross should be better). Add S-1 footprints in a larger area.

\* Table 4 : give date in YYYYMMDD format

- \* Line 222: " Every SAR image was coregistered ... acquisitions". It is not clear. I guess what is meant is that all interferometric pair processing was done independently from each other (without a stack processing that would result in a stack of co-registered image). It is a bit misleading so may be rewrite this paragraph starting with explaining that each ifg processing was done independently from each other.
- \* line 238: weighting by the inverse of phase variance : variance in space ? over what area ? whole interferogram ?
- \* line 239: Please cite the other studies that are referenced here
- \* line 271 : mosaicking is performed after projection on vertical, so delete here.
- \* line 274 : "Thus, the observed ....direction": delete
- \* line 275: add "assuming no horizontal displacement"
- \* line 288 : "long-term ... elevation": replace with cumulated settlement
- \* line 294 /299 : if a threshold on velocity, it must be in velocity unit (2.5 mm/yr), so separate thresholds on amplitude and on velocity
- \* line 391 : " This sensitivity ....SLC04": drop, repetition.
- \* line 394: "surface permafrost" : unclear
- \* line 397 : SLC03 is repeated twice
- \* Fig8: suggestion to put text or symbol or graph of found ice in cores on each panel to facilitate the reading.