Response to Editor on "Co-registration and residual correction of digital elevation models: A comparative study"

Comment received: 13 Sep 2023

Key:

Editor comment (black)

Response (blue)

First of all I appologise for the long time needed to get back to you. This was due to an illness which lasted several weeks and prevented me from working.

The manuscript has further improvedas as did the discussion section. However, I am still missing a discussion "along with the current literature" which I specifically demanded. Moreover, some statements is the discussions are to vague. Some parts of the discussion are also relevant for the conclusions.

The discussion section has been revised to include relevant literature.

Our work focuses on the analytical (i.e., the terrain information based) methods only, given that previous studies (Paul et al., 2015; Vacaflor et al., 2022) have already shown that the NK method is more recommended for glacier research than other DEM co-registration methods, such as the grid search method, the LS3D method, and the subwatershed-based method.

The RT method has not been investigated by the cryosphere community, and there is no previous literature to discuss the difference between the RT and NK methods.

In addition to the NK method, the NH method (Noh and Howat, 2014) is the only one analytical algorithm that has been previously used in glacial studies. The theoretical connections between the NH and RT methods have been discussed in the revised manuscript. The NH method has not been widely adopted by other researches, possibly because its equations are quite long and tedious (see the Equation S4 in the supplement). We recommend the RT method rather than the NH method, because the two methods are basically equivalent to each other (i.e., both based on a 3-D similarity transformation, rather than the shift used in NK method), while the former is much easier to implement in programming.

References:

Paul, F., Bolch, T., Kääb, A., Nagler, T., Nuth, C., Scharrer, K., Shepherd, A., Strozzi, T., Ticconi, F., Bhambri, R., Berthier, E., Bevan, S., Gourmelen, N., Heid, T., Jeong, S., Kunz, M., Lauknes, T. R., Luckman, A., Merryman Boncori, J. P., Moholdt, G., Muir, A., Neelmeijer, J., Rankl, M., VanLooy, J., and Van Niel, T.: The glaciers climate change initiative: Methods for creating glacier area, elevation change and velocity products, Remote Sens. Environ., 162, 408–426, https://doi.org/10.1016/j.rse.2013.07.043, 2015.

Noh, M. and Howat, I. M.: Automated Coregistration of Repeat Digital Elevation Models for Surface Elevation Change Measurement Using Geometric Constraints, IEEE Trans. Geosci. Remote Sensing, 52, 2247–2260, https://doi.org/10.1109/TGRS.2013.2258928, 2014.

Vacaflor, P., Lenzano, M. G., Vich, A., and Lenzano, L.: Co-Registration Methods and Error Analysis for Four Decades (1979–2018) of Glacier Elevation Changes in the Southern Patagonian Icefield, Remote Sens., 14(4), 820, https://doi.org/10.3390/rs14040820, 2022.

One example: You write "However, as shown in Section 4, the performance of the NK method is usually suboptimal because only the shift-induced errors are considered. When the precision of DEM co-registration is of great importance, the RT method is recommended for glacial studies to replace the widely used NK method." What does usually mean? Are there cases where the NK performance is optimal, can you citer related studies? The precision is usually of high importace. When would you recommend the RT method? There might be studies to cite in order to show the great importacne of the co-registration. The statement thet RT method is recommended should be repeated in the conclusions.

The word “usually” means “under normal circumstances” or “with high probability”. It has been removed in the revised manuscript, because it is not an exact expression. A hypothesis testing approach has been used for deciding whether the precision of the RT method is better than the NK method. The statistical result shows that the null hypothesis cannot be rejected at the p=0.05 level.

We recommend the RT method to replace the NK method in glacial studies without any preconditions. This statement is supported by both experimental results (from a statistical viewpoint) and theoretical analysis (the performance of the NK method is limited by ignoring scale- and rotation-induced errors). The RT method has been widely used in photogrammetry and remote sensing studies, but it has not been investigated by the cryosphere community. So, there is no relevant literature to support our conclusions directly.

One example about the vague statement: "Sinusoidal functions usually takes multiple trials, and the performance is sometimes limited by their predefined models." What does "usually" and "sometimes" mean? Here, references to other studies might also help.

The word “usually” has been removed in the revised manuscript. The residual signals induced by satellite attitude jitter often appear at several frequencies, and the numbers are not constant for different DEM sources but depend upon sensors and data pre-processing techniques (before DEM generation). A fixed number of sinusoidal functions cannot be universally suitable for various data sources. A better choice is to fit 1–n (e.g., n=6 in Girod et al., 2017) sinusoidal functions separately and select the best fitting result.

The residual signals in many DEM pairs do have an exact mixed sinusoidal shape, but some do not. The parametric regression method with a predefined model “sometimes” cannot obtain a very high precision fitting result.

References:

Girod, L., Nuth, C., Kääb, A., McNabb, R., and Galland, O.: MMASTER: Improved ASTER DEMs for Elevation Change Monitoring, Remote Sens., 9, 704, https://doi.org/10.3390/rs9070704, 2017.

These are two examples but there are more, so please try your best to improve the discussion accordingly. If done propperly I am happy to accept the paper.

Please do not hesitate to ask in case you have any question.

I am looking forward to your revised version and promise a rapid handlig of the revision in order to avoind further delays.

Thanks for your detailed review.