

ABSTRACT

Glacier velocity monitoring is an important subject in earth science research and global environmental management. The optical image cross-correlation method is an effective way to obtain glacier flow velocity. In this study, we utilized high spatial and temporal resolution Sentinel-2 MSI (MultiSpectral Imager) satellite imagery and applied an improved method to estimate glacier velocity and then analyzed the dynamics of the Yanong Glacier in southeastern Tibetan Plateau. The Co-registration of Optically Sensed Images and Correlation (COSI-Corr) method was used to estimate glacier surface flow velocities over different time periods. It was observed that both too short and too long time intervals between image pairs can affect the accuracy of velocity estimate. In addition, due to the monsoon climate, the study area was frequently covered by clouds during the summer (early May to late September), resulting in limited availability of usable satellite images. The latter applies to both a nadir viewing space-born sensor system and to slant illumination causing shadows on the target glacier. To address these challenges, we implemented an optimized image pair selection scheme and a redundant measurement method to improve the accuracy of velocity retrievals. Finally, using Sentinel-2 MSI remote sensing images from 2020 to 2024 and the improved glacier velocity retrieval method, we successfully obtained reliable estimates of velocity time series of the Yanong Glacier.

INTRODUCTION

Glaciers are sensitive indicators of climate variability, and their movement patterns are changing in response to climate warming. Monitoring glacier surface velocity is crucial for understanding the relationship between glacier motion and mass balance, as well as climate variability, and provides a scientific basis for studying glacier dynamics and mitigating glacier-related hazards. The southeastern Tibetan Plateau is rich in maritime glaciers with clear dynamic features, including the response to seasonal atmospheric forcing. The extensive datasets provided by satellite observations allow large-scale and long-term monitoring of glacier velocity. COSI-Corr is a common approach for obtaining the flow velocity of glaciers. However, glaciers are moving slowly, and their surface morphology changes over time. It is important to select optical image pairs with appropriate time intervals to maximize the correlation of multi-temporal images and the quality of the retrieved flow velocity.

OBJECTIVES

- 1) Extracting glacier flow velocity time series of the Yanong Glacier in the southeastern Tibetan Plateau.
- 2) Find optimal time intervals for extracting glacier velocity using the optical image cross-correlation method.

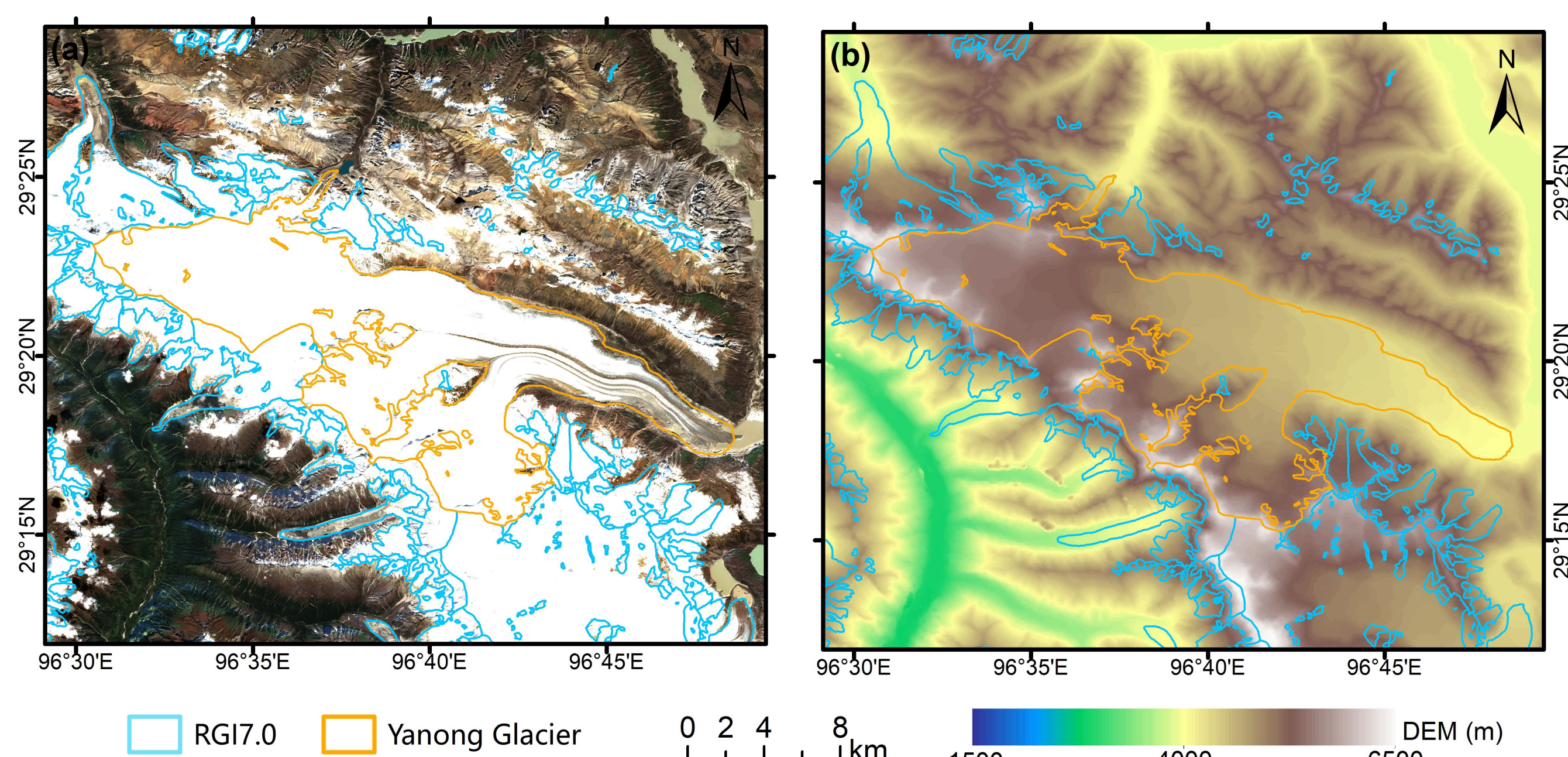


Fig.1 Overview of the study area.

- (a) True color image of Yanong Glacier on October 22, 2022 (Sentinel-2 MSI imagery);
(b) SRTM DEM and boundary of Yanong glacier

METHODS

- 1) Eliminate images with large cloud cover and snow cover.
- 2) Select optimal image pairs with appropriate temporal baseline
- 3) Apply COSI-Corr method to extract glacier flow velocity.
- 4) Use post-processing techniques such as bilateral filtering to remove outliers and noise.
- 5) Get flow velocity time series of the Yanong glacier.

RESULTS

1) Optimal time intervals for optical image cross-correlation

- a) If time interval is too short, the displacement of glacier is too small (less than the spatial resolution of the image) to be determined accurately, given the spatial resolution of applied image data. (Fig.2)
- b) If time interval is too long, the surface morphology of glaciers is likely to have changed, thus losing the correlation between image pairs. (Fig.3)
- c) There is very little available data from May to September, when the time interval between image pairs needs to be longer
- d) The appropriate time interval is between 45 and 120 days.

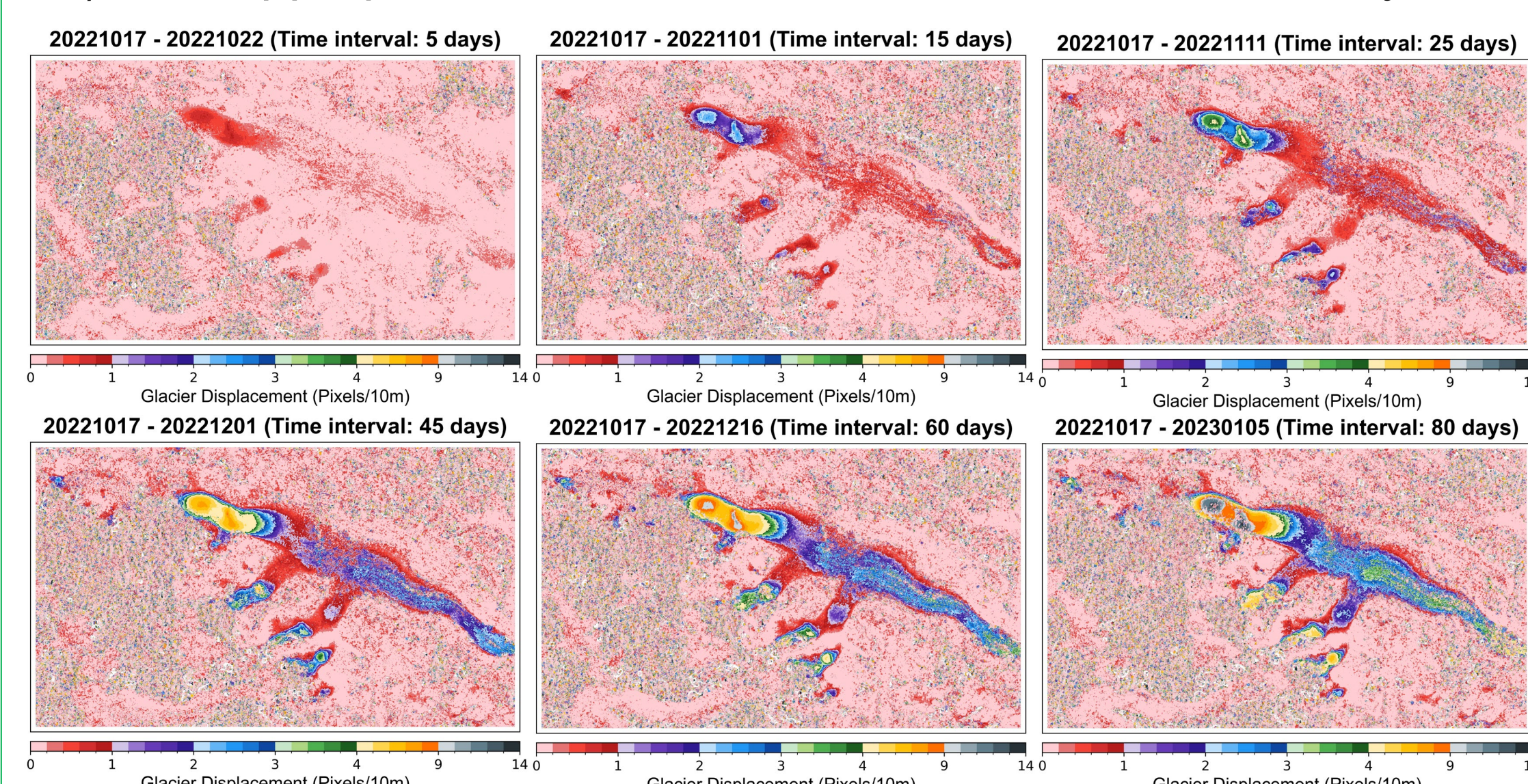
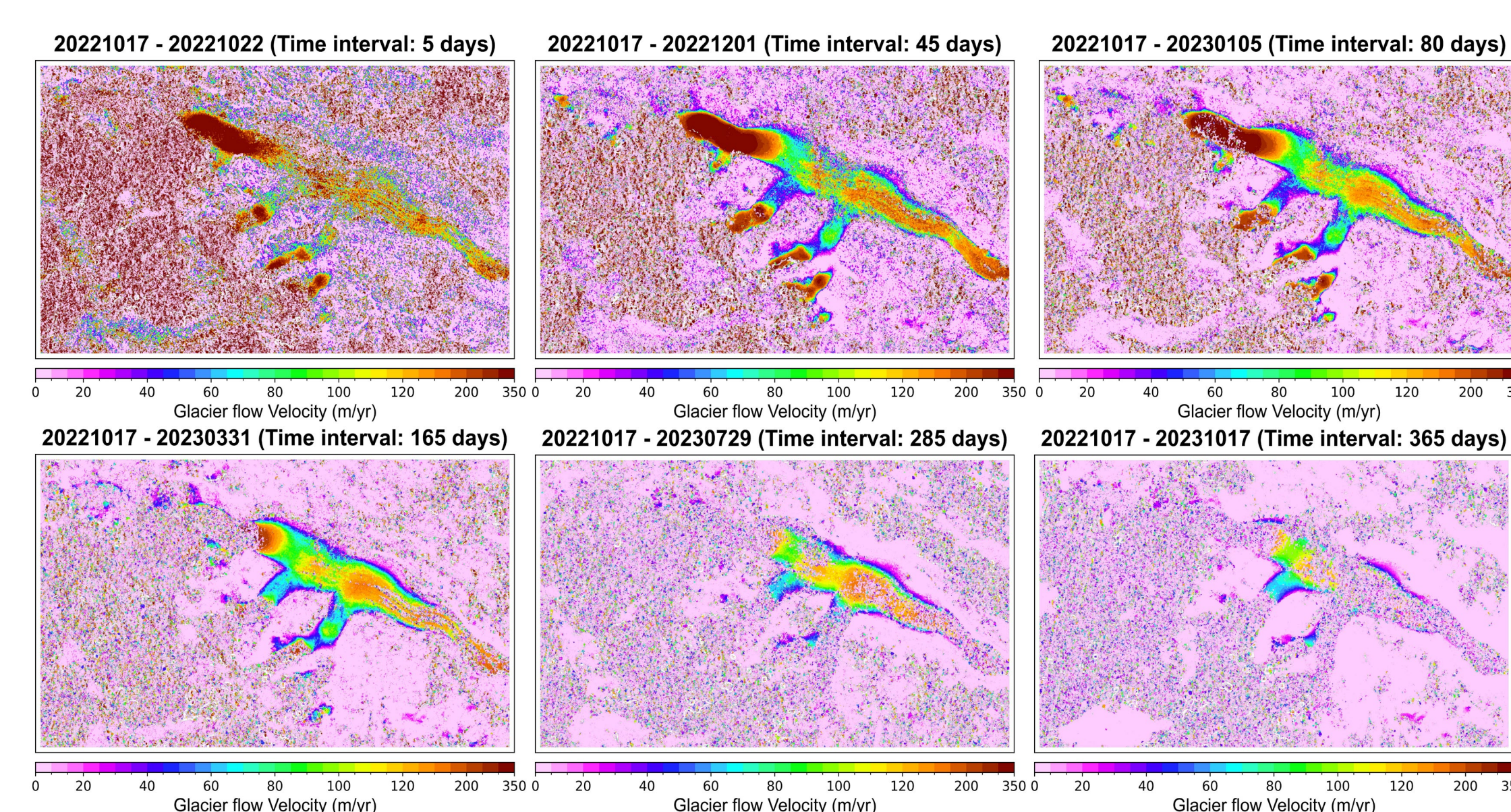


Fig.2 The glacier displacements obtained by using image pairs with different time intervals and the COSI-Corr method

Fig.3 The glacier flow velocities obtained by using image pairs with different time intervals and the COSI-Corr method



2) Why low correlation?

Surface changes of glaciers; Snow Cover; Cloud Cover (Fig.4)

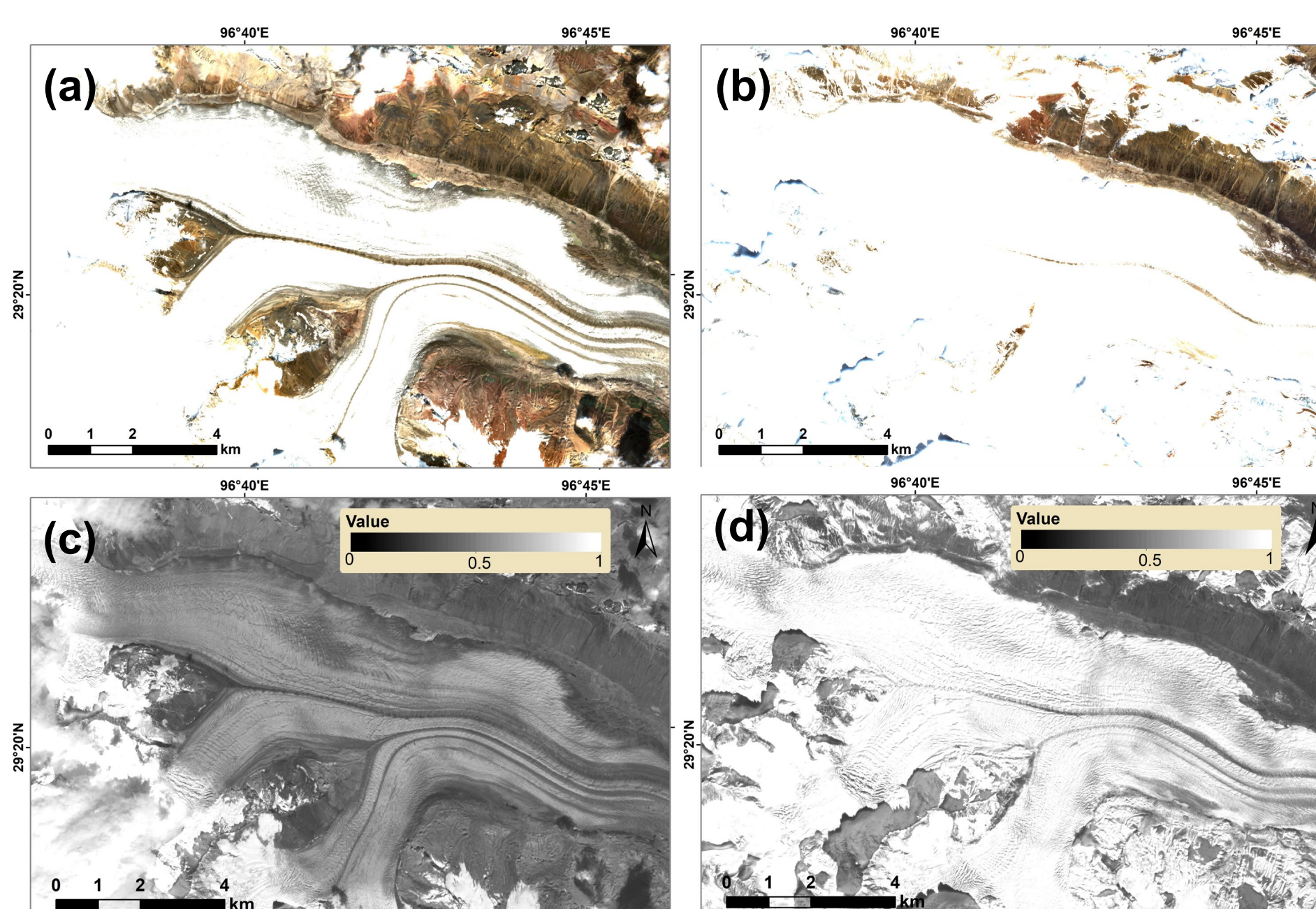


Fig.4 The correlation of image pairs loss due to snow cover and cloud cover

True color image on October 17, 2020 (a) and December 11, 2020 (b); Near-infrared band value on October 17, 2020 (c) and December 11, 2020 (d)

CONCLUSION

We developed an improved method for estimating glacier velocity and applied on the Yanong glacier to get more accurate flow velocity time series. Results show that the appropriate time interval for image pairs used in optical image cross-correlation is between 45 and 120 days. Outliers in time series often have a relatively low correlation coefficient, mainly due to the influence of cloud cover, cloud shadow and snow cover.

References

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