

# Monitoring ice flow velocity of Petermann glacier combined with Sentinel-1 and -2 imagery

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## Abstract

Synthetic Aperture Radar (SAR) images are commonly used to monitor glacier flow velocity at Greenland Ice Sheet (GrIS). However, offset-tracking with SAR imagery in summer usually show poor quality because the rapid ice surface freezing-melting cycles, while optical images are less sensitive to this phenomenon.

In this study, we combine Sentinel-1 and -2 images to create the glacier velocity time series for the Petermann glacier, located in the northern GrIS.

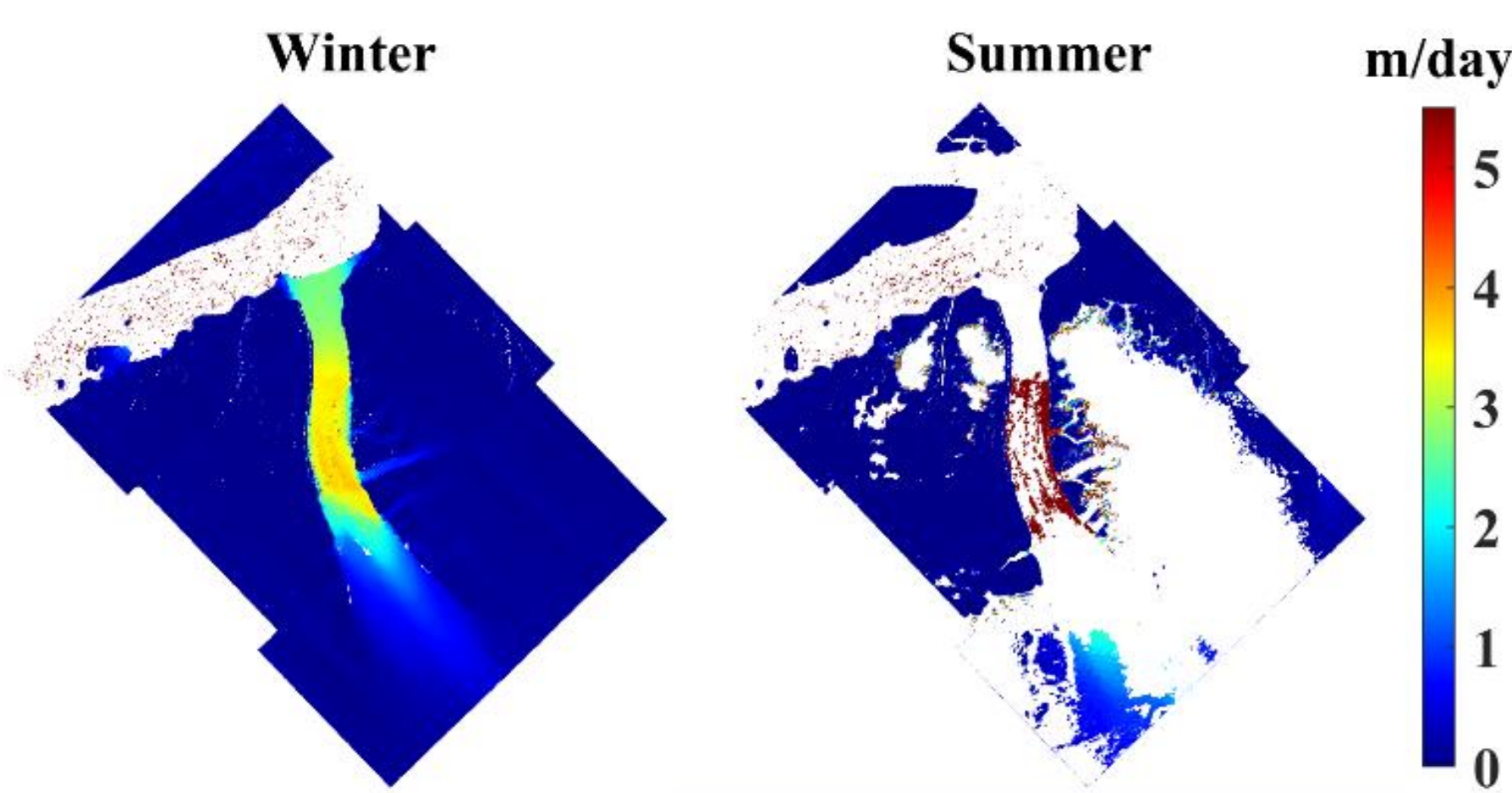
1. Offset-tracking: deformation fields with SAR and optical sensors separately.
2. Time series: the least squares method based on connected components for Sentinel-1 and -2, separately.
3. Combined time series: a weighted least squares method, where weights are evaluated according to last step.

This research finds that the fusion of Sentinel-1 and -2 offset-tracking results improves the completeness of the ice movement time series for polar glaciers.

## Introduction

### Sentinel-1

- ☺ Full-time observation.
- ☹ **Summer** glacier rapid freezing and thawing -poor tracking effect

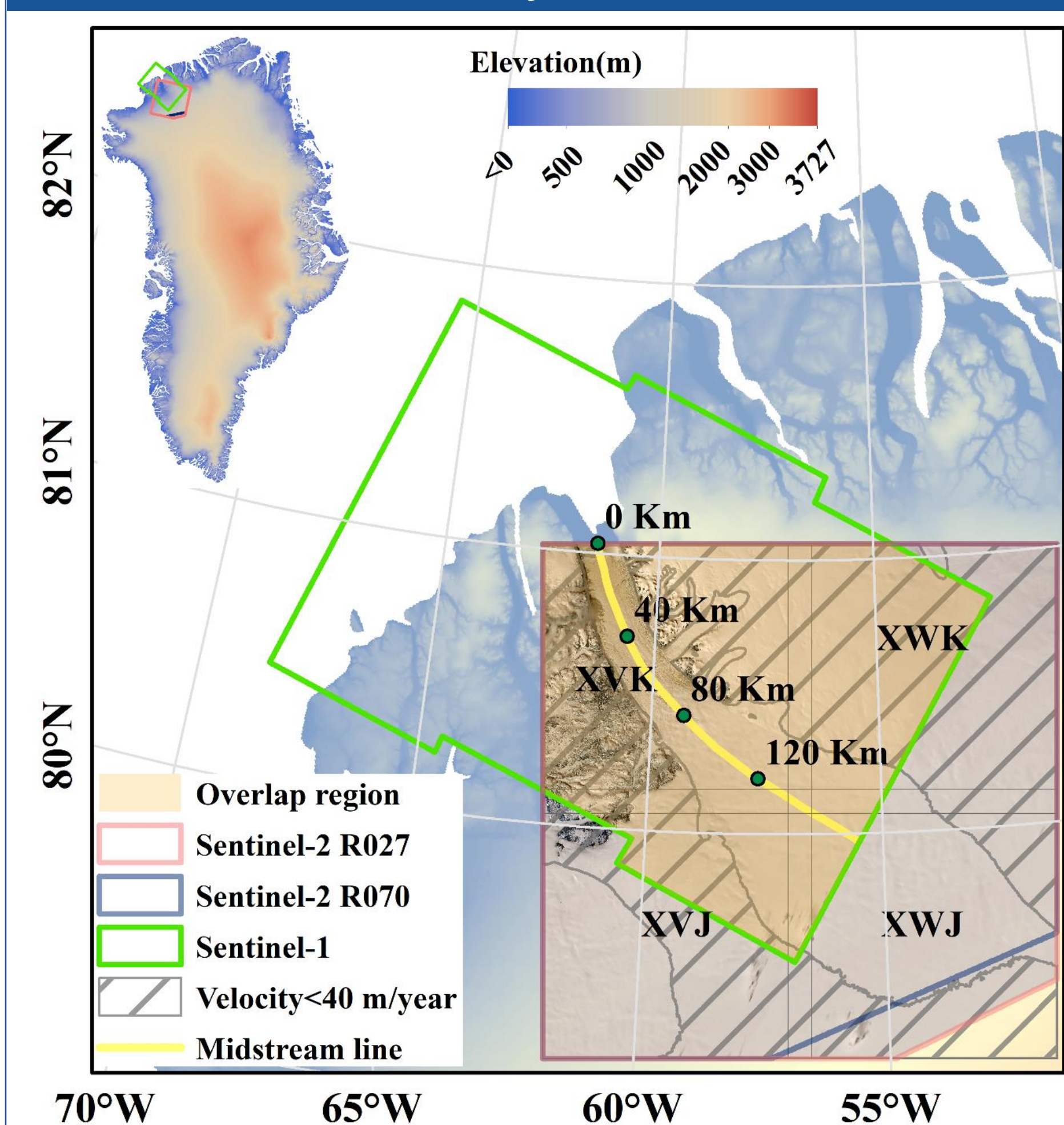


### Sentinel-2

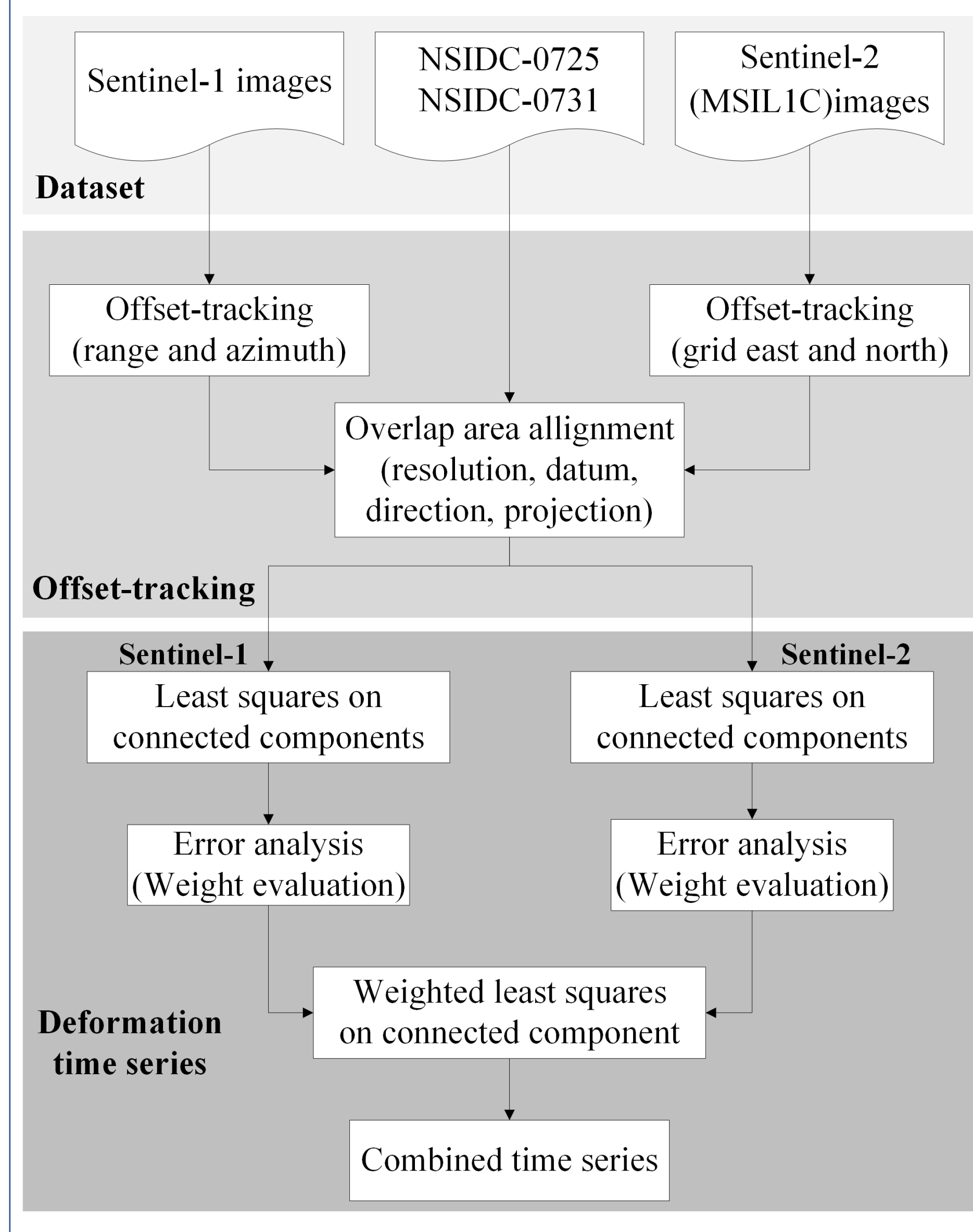
- ☺ Summer cloud-free imagery.
- ☹ **Cloud cover, polar night...** -poor tracking results

**Combining Sentinel-1&-2:** More complete glacier flow velocity time series.

## Study area



## Method

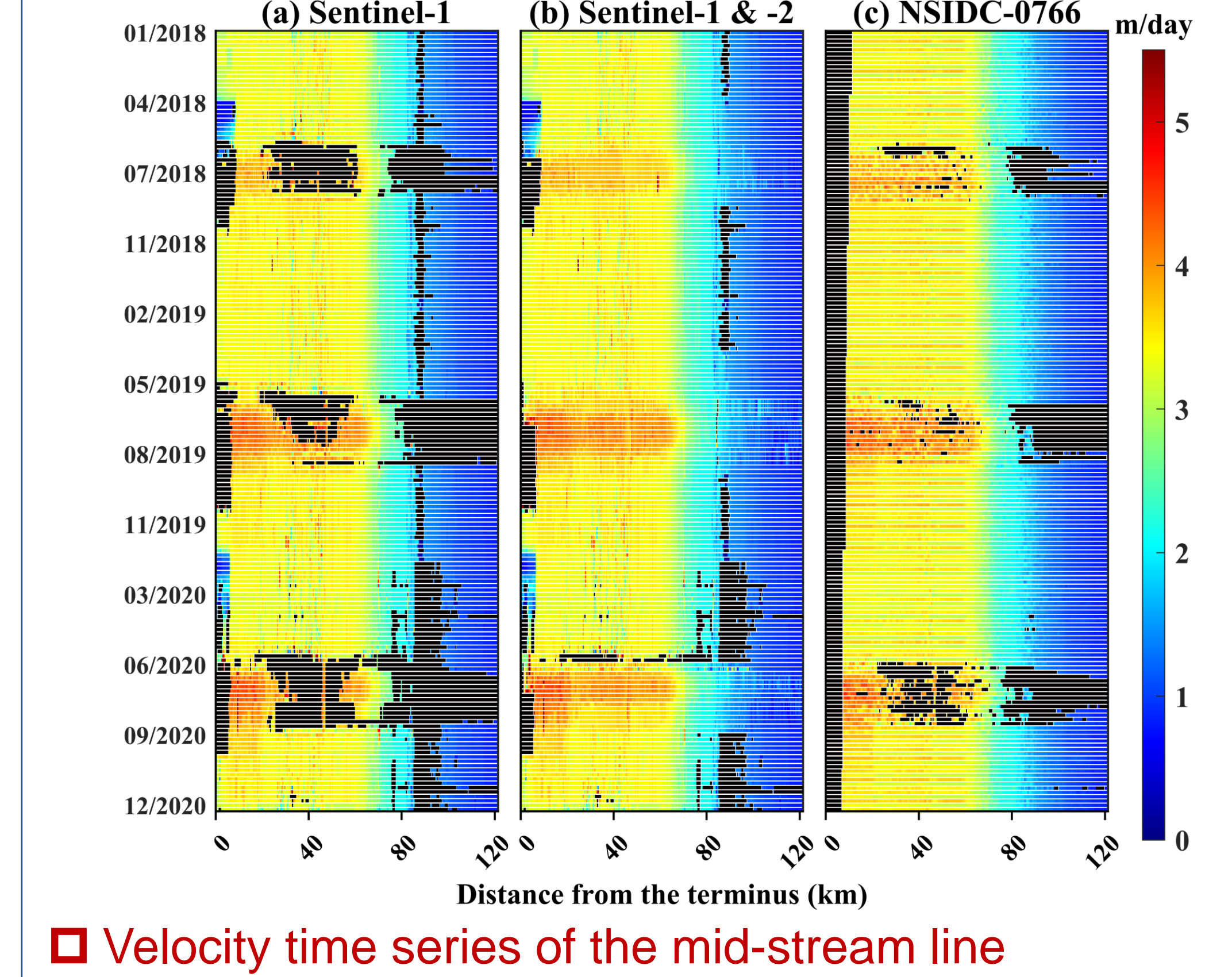


## Least squares

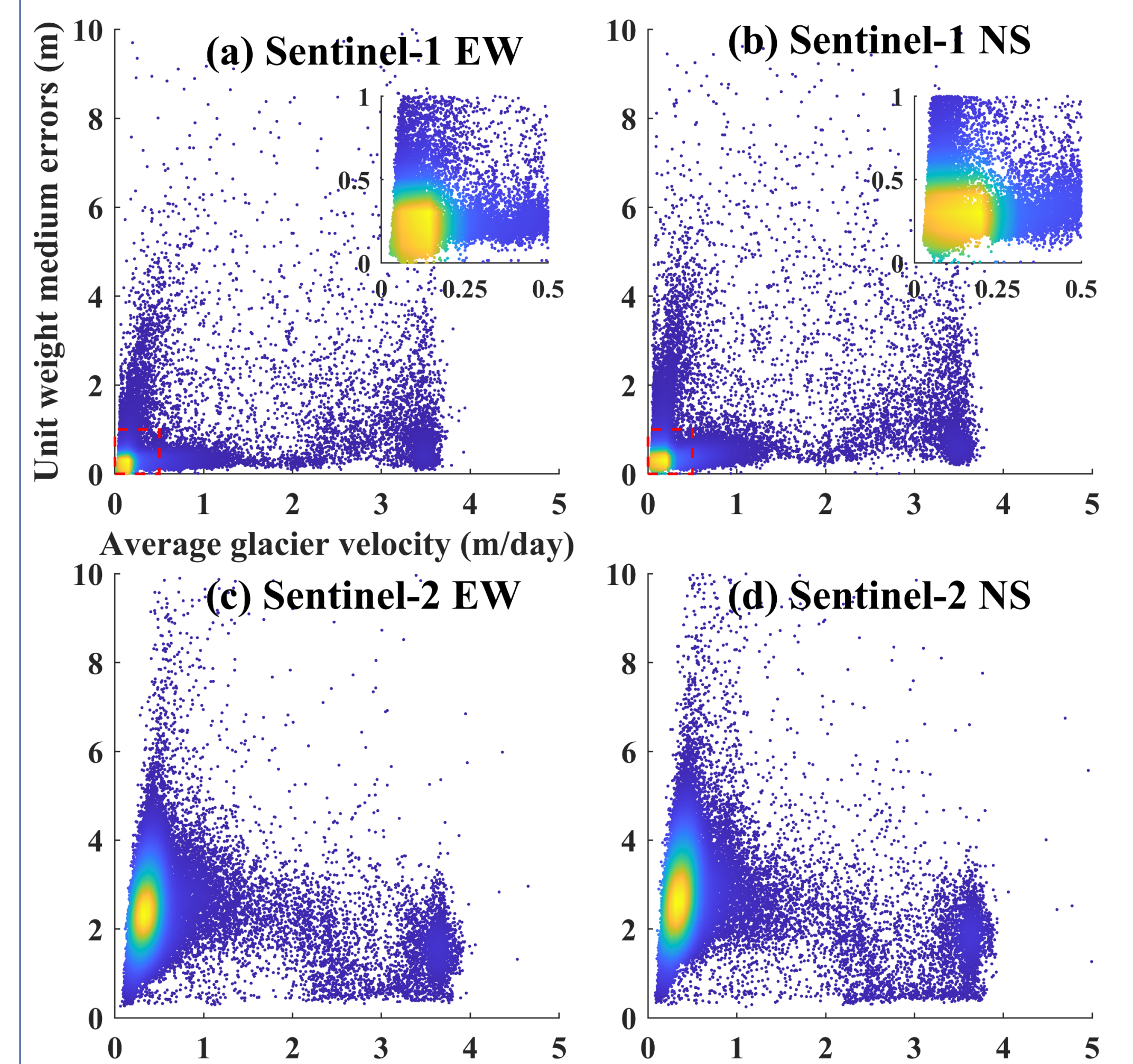
### based on connected component

- ① Deformation fields: each Sentinel image with its 1st, 2nd, and 3rd subsequent acquisitions
- ② Outlier removal
- ③ Connected components identification
- ④ Each connected component is solved with the least squares method separately.

## Precision analysis



## Precision analysis



☐ Scatter plots of least squares for Sentinel-1 and Sentinel-2 offset-tracking. Each point indicates a connected component.

## Conclusions

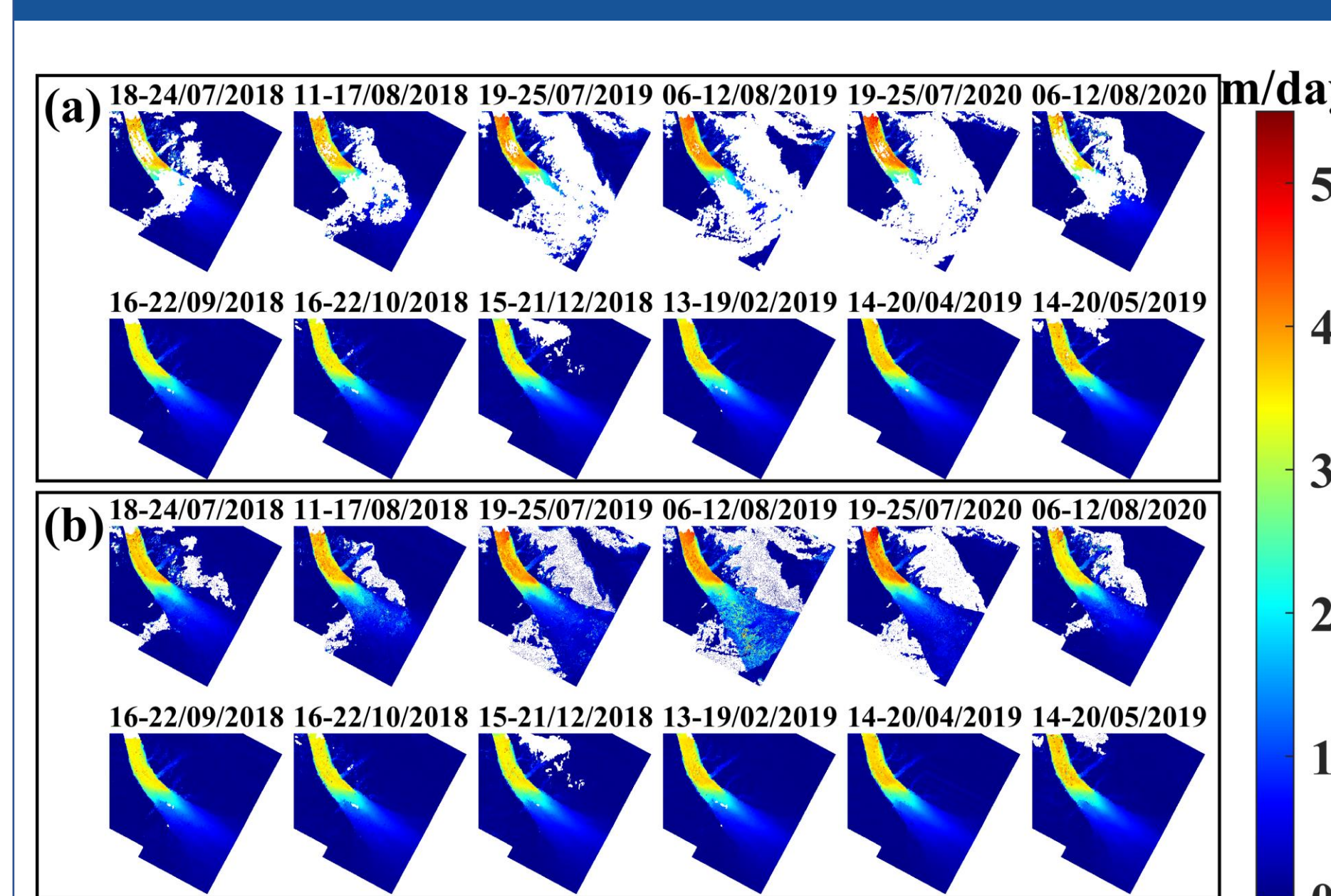
This study focuses on the Petermann Glacier where the offset-tracking of Sentinel-1 and -2 are merged to create a three-year timeline of glacier flow velocity.

- **Deriving ice sheet flow velocity with combining Sentinel-1 and -2**
- Sub-pixel mosaicking errors among different detectors of Sentinel-2 must be considered for offset-tracking between images of 2A and 2B.
- A much **better precision of Sentinel-1** imagery offset-tracking than the Sentinel-2's on ice sheet.
- Sentinel-2 **fills the summer gap** of Sentinel-1 derived glacier flow time series for the Petermann glacier.
- **Petermann's flow velocity**
- **Quicker flow rates in summer** than in other seasons at the glacier tongue.
- Flow velocity difference found at ~ 20 Km up to the terminus during August to December **suggests significant crevasse advection.**

## Major Reference

- Li, G., Mao, Y. \*, Feng, X., Chen, Z., Yang, Z., & Cheng, X., 2023. Monitoring ice flow velocity of Petermann glacier combined with Sentinel-1 and -2 imagery. International Journal of Applied Earth Observation and Geoinformation, 121, 103374.
- Sundal, A. V., Shepherd, A., Nienow, P., Hanna, E., Palmer, S., & Huybrechts, P., 2011. Melt-induced speed-up of Greenland ice sheet offset by efficient subglacial drainage. Nature, 469(7331), 521-524.

## Results



☐ Comparison of the derived velocity maps.

(a) only with Sentinel-1 in summers (the 1st row) and other seasons (the 2nd row).

(b) same as (a) but integrating Sentinel-1 and -2.