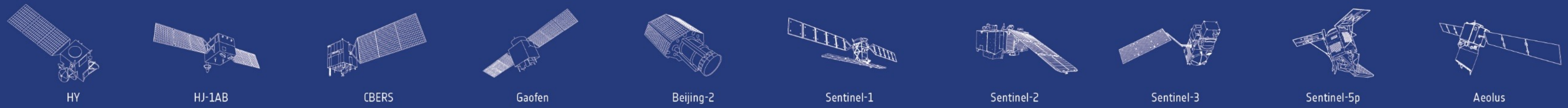

2023 DRAGON 5 SYMPOSIUM

3rd YEAR RESULTS REPORTING

11-15 SEPTEMBER 2023

PROJECT ID. 59295

MONITORING AND INVERSION OF KEY ELEMENTS OF CRYOSPHERE DYNAMIC IN THE PAN THIRD POLE WITH INTEGRATED EARTH OBSERVATIONS AND SIMULATION

<SEP 13TH>

ID. 59295

PROJECT TITLE: MONITORING AND INVERSION OF KEY ELEMENTS OF CRYOSPHERE DYNAMIC IN THE PAN THIRD POLE WITH INTEGRATED EARTH OBSERVATIONS AND SIMULATION

PRINCIPAL INVESTIGATORS: : PROF HUI LIN (CHINESE SIDE), JIANGXI NORMAL UNIVERSITY

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CO-AUTHORS: LI GANG, CHEN XIAO, CHEN ZHUOQI, FENG XIAOMAN, MAO YANTING, YANG ZHIBING.

PRESENTED BY: GANG LI , SUN YAT-SEN UNIVERSITY, CHINA

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Dragon 5 3rd Year Results Reporting

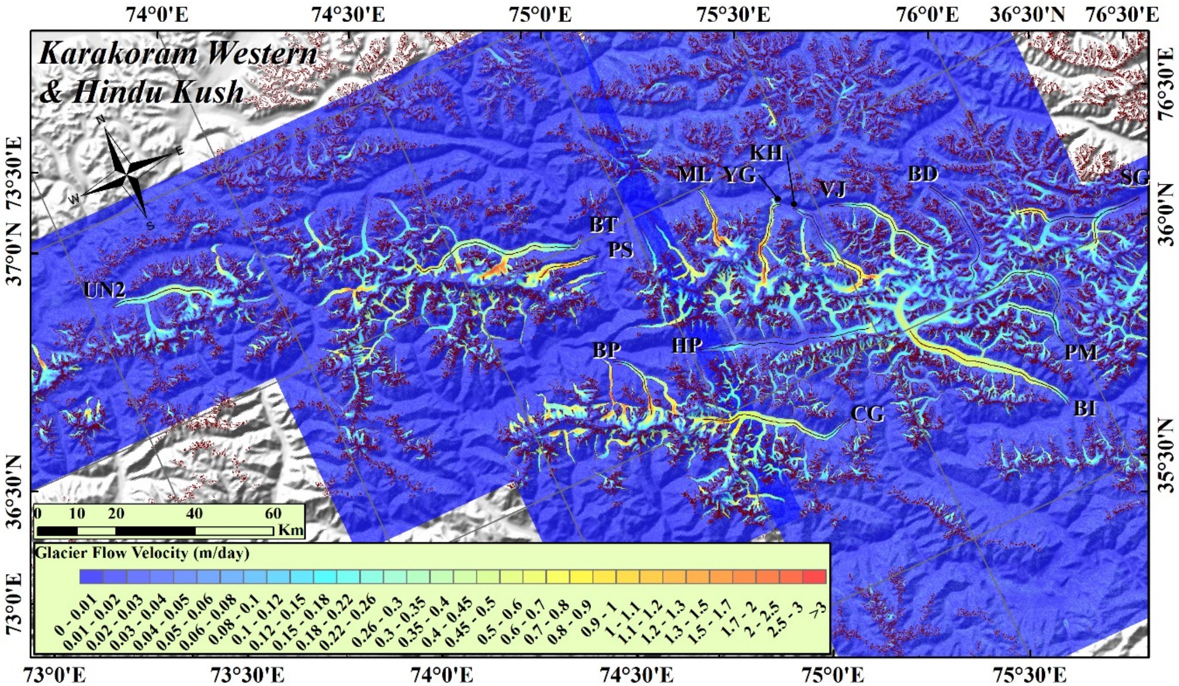
- Inform on the project's objectives
- Detail the Copernicus Sentinels, ESA, Chinese and ESA Third Party Mission data utilised after 3 years (complete slide 4)
- Detail the in-situ data measurements and requirements
- Provide details on field data collection campaigns and periods in P.R. China or other study areas
- Inform on the results after 3 years of activity
- Inform on the project's schedule, planning & contribution of the partners for the following year
- Report on the level and training of young scientists on the project achievements, including plans for academic exchanges
- Report on the peer reviewed publications (nr. of papers, journal name and publication title) after 3 years of activity

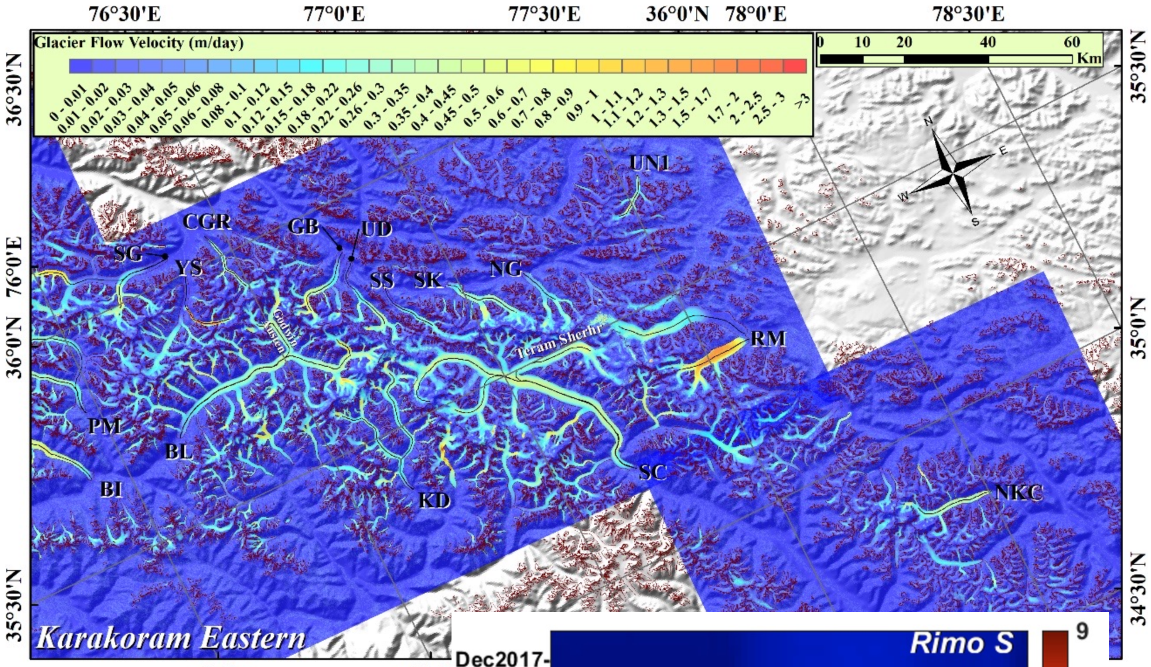
Project Objects

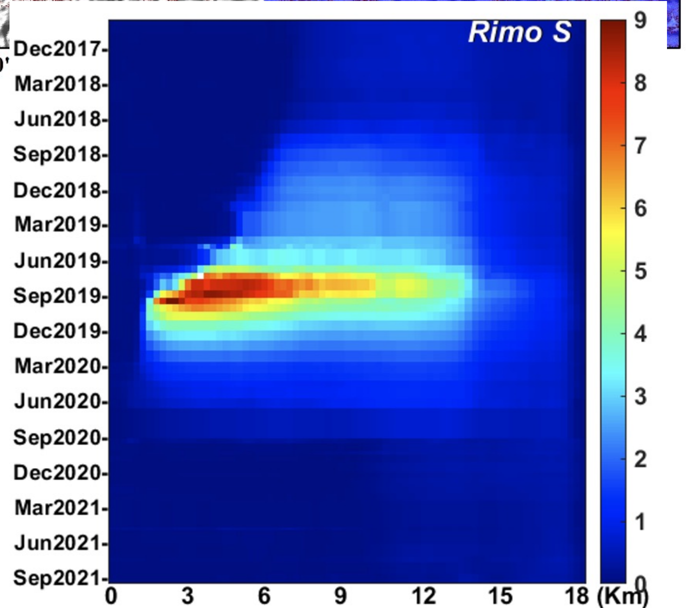
The main objective of this project to investigate glacier and frozen ground dynamics in the Pan Third Pole (PTP) in an integrated Open Virtual Geographic Environment (OVGE) system by the synergistic use of multi-mission remote sensing datasets, ground measurements and by developing physical and/or empirical models.

1, Develop algorithms and methods that employing new generation of European, Chinese and TPM satellites
2, Modify and develop physical and/or empirical models that employ satellite data and Forecasting future fate of the glaciers and frozen ground in the PTP.
3, Evaluating quality of earth observation data from ESA, China and TPM.

Glacier velocity at Karakoram derived by S2

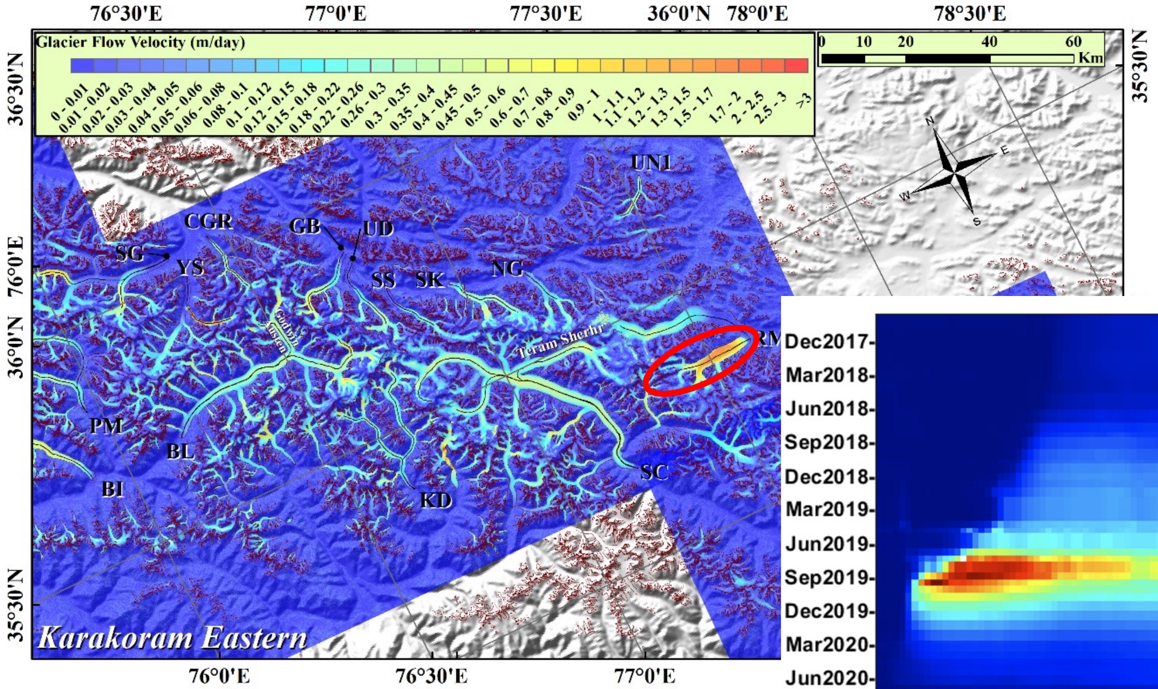


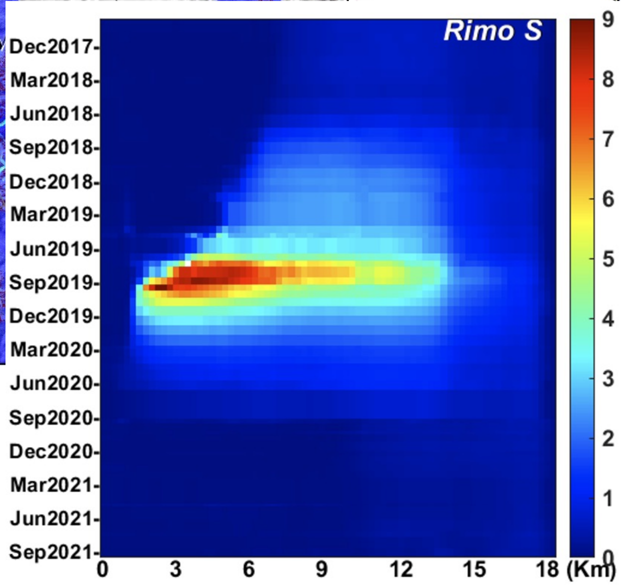


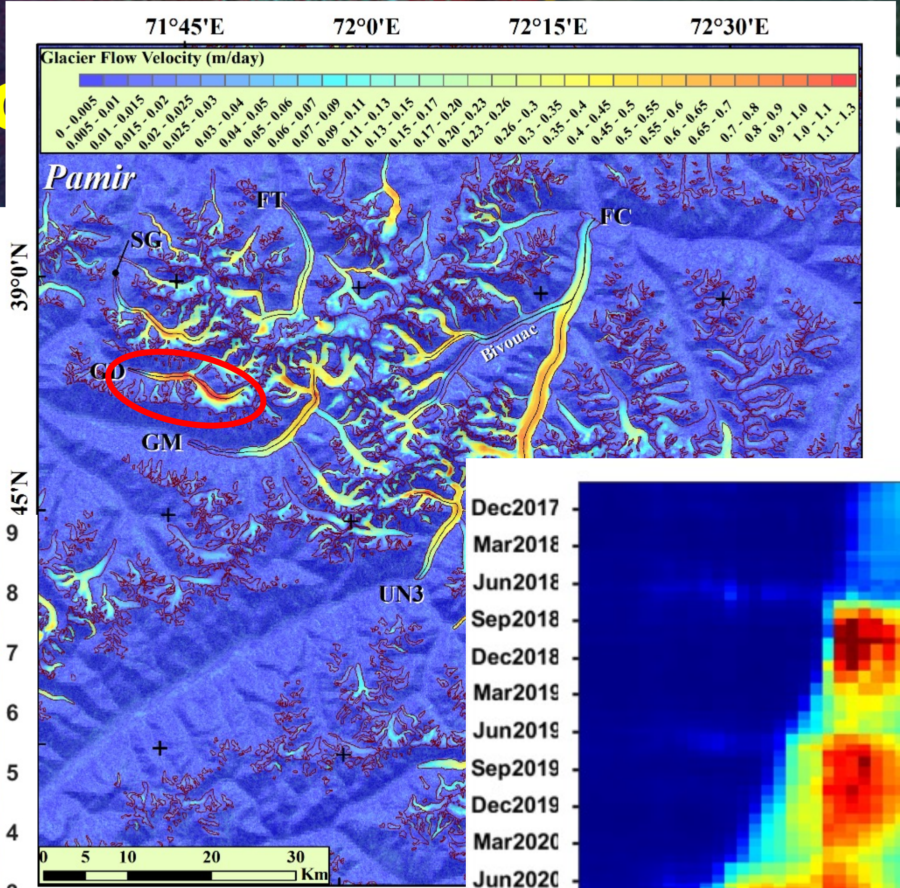


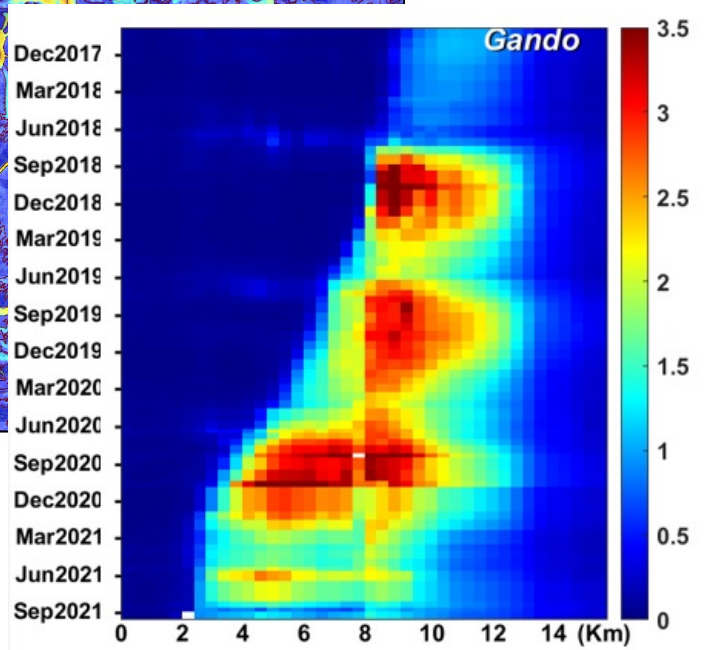
During Oct 2017 to Sep 2021, plenty of surged glaciers start and/or end their surging phases. Rimo south glacier experienced a full surging phase during our study period and last for about two years, the maximum speed exceeded 9m/day. Several other glaciers are also be identified as surge type.

Glacier velocity at Karako









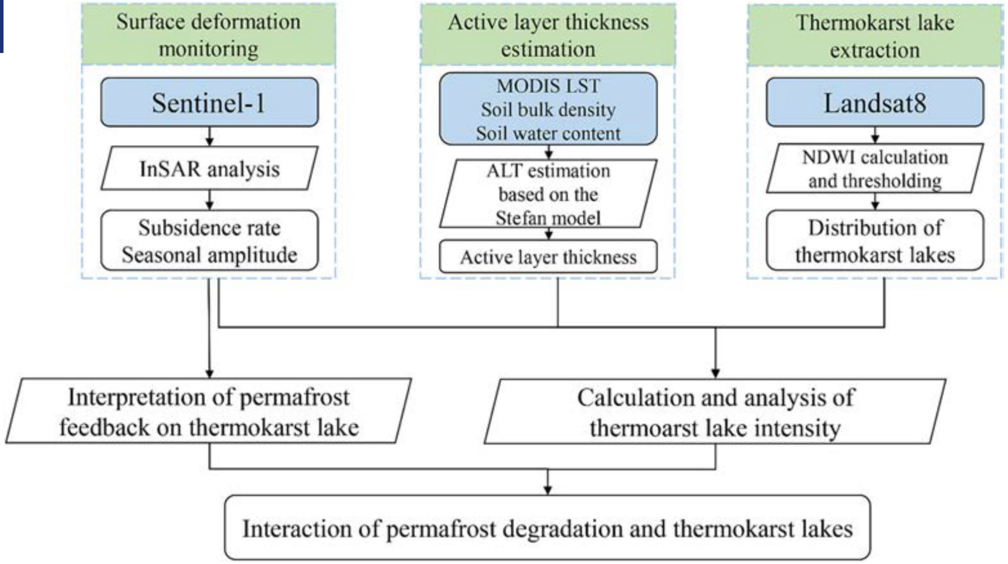
Two types of surging glaciers were identified. The first type exhibited a short surging phase of just one or two years without seasonal variation, such as Rimo's southern tributary. The second type shows glacier front that advances and exhibits much higher summer end speeds than during stagnation, such as Gando at Pamir.

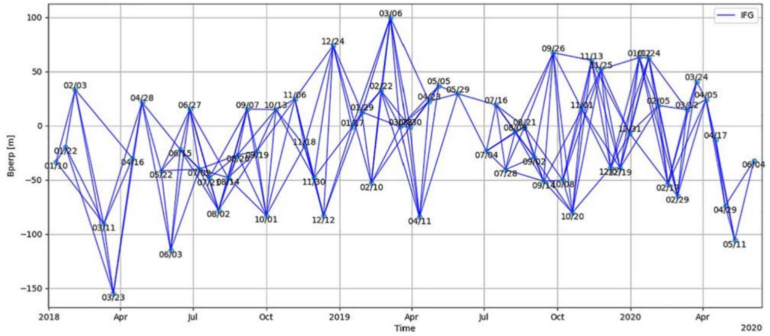
Permafrost dynamic at Beiluhe, QTP

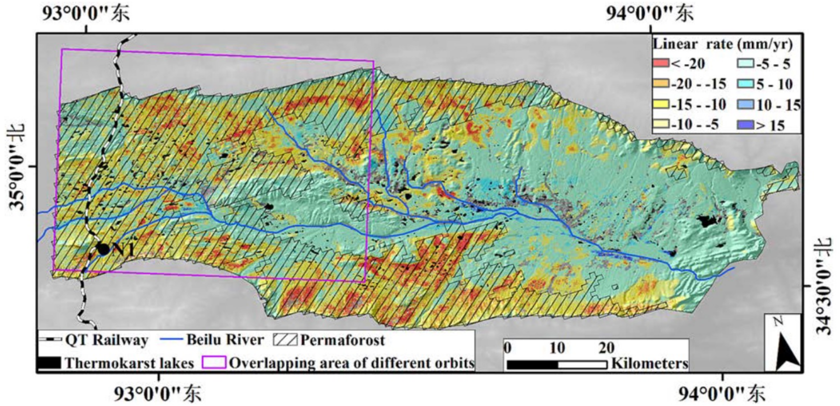
Permafrost dynamic

↕

Thermokarst lake







Methods:

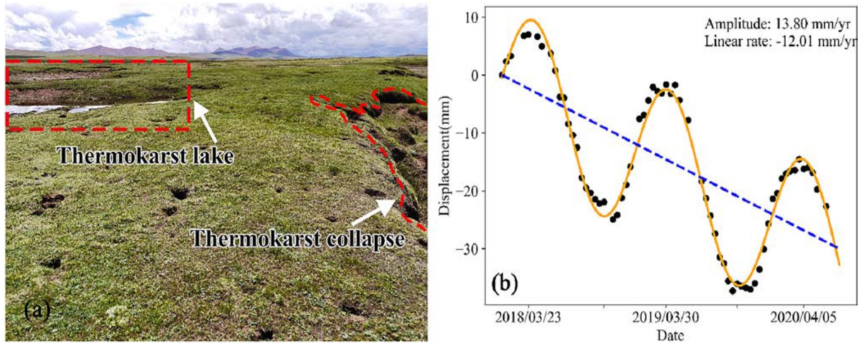
S1 derived deformation time series: spatial-temporal variation of surface deformation in the Beiluhe Basin in north QTP. Subsidence 5mm/s, amplitude >10mm/year

MODIS LST to derived active layer thickness(ALT). 2.1m to 3.5m

Landsat (why not S2) to derive thermokarst lake.

Found:

Permafrost degradation was concentrated in the areas with a high density of thermokarst lakes. The density of thermokarst lakes was positively correlated with the linear subsidence rate and the seasonal deformation amplitude.

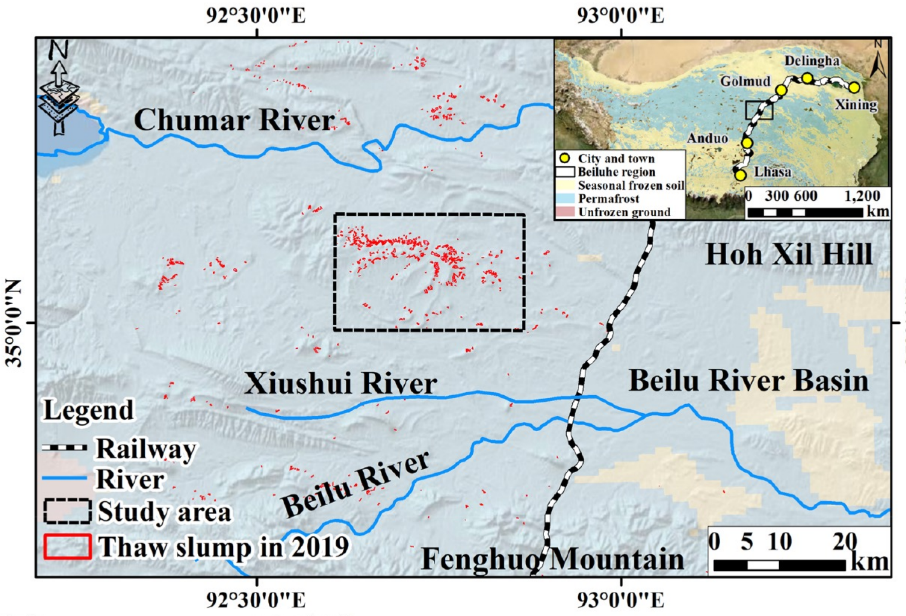


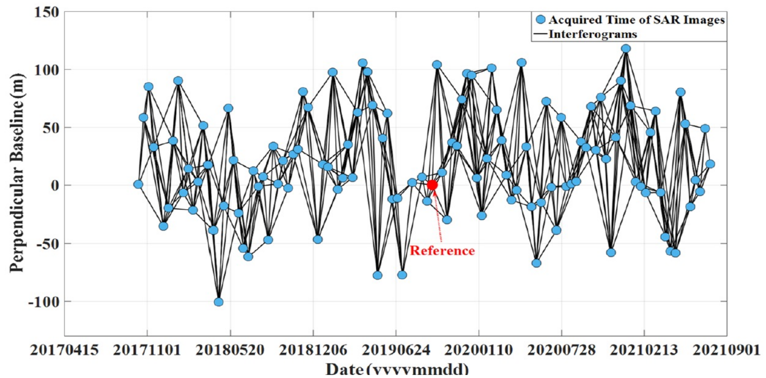
Ref to: Xu, Zhida**., Jiang, Liming*.,** et al. (2023). Interaction of permafrost degradation and thermokarst lakes in the Qinghai–Tibet Plateau. *Geomorphology*, *425*, 108582.

Permafrost dynamic at Beiluhe, QTP

MT-InSAR to S1 images, Retrogressive Thaw Slumps (RTS热熔滑塌) detection at QTP

S1, SBAS → Deformation TS & Optical, RTS inventory → Potential RTS



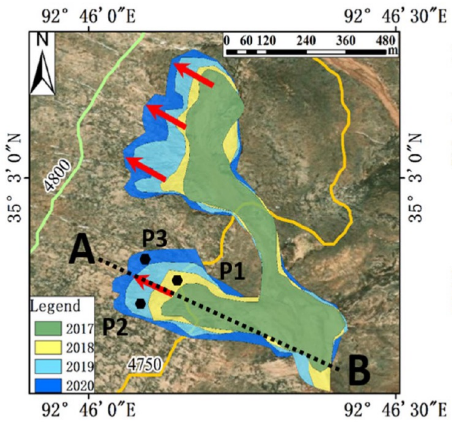


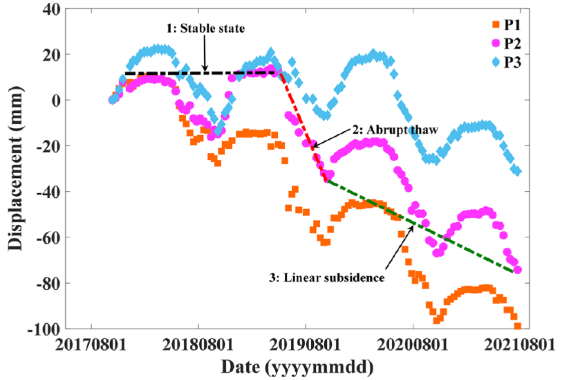
Data & Method:

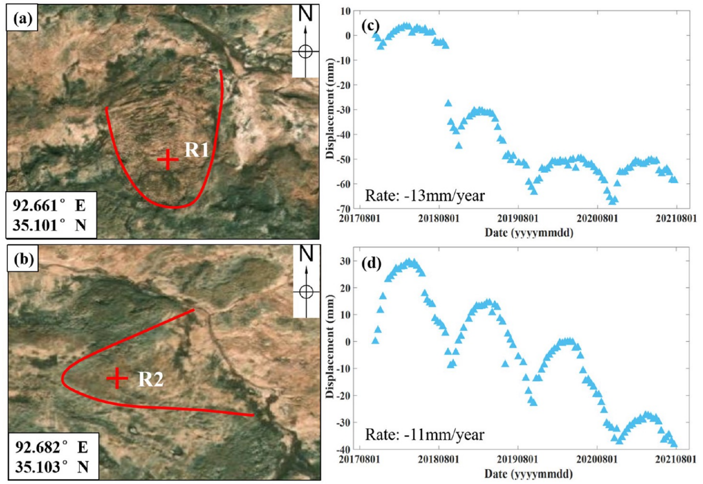
112scenes of S1 from 2017 to 2021 to derive deformation at Beluhe region using MT-InSAR

Found:

Deformation rates of RTSs from -35 to 20mm/year stable, abrupt thaw, and linear subsidence.





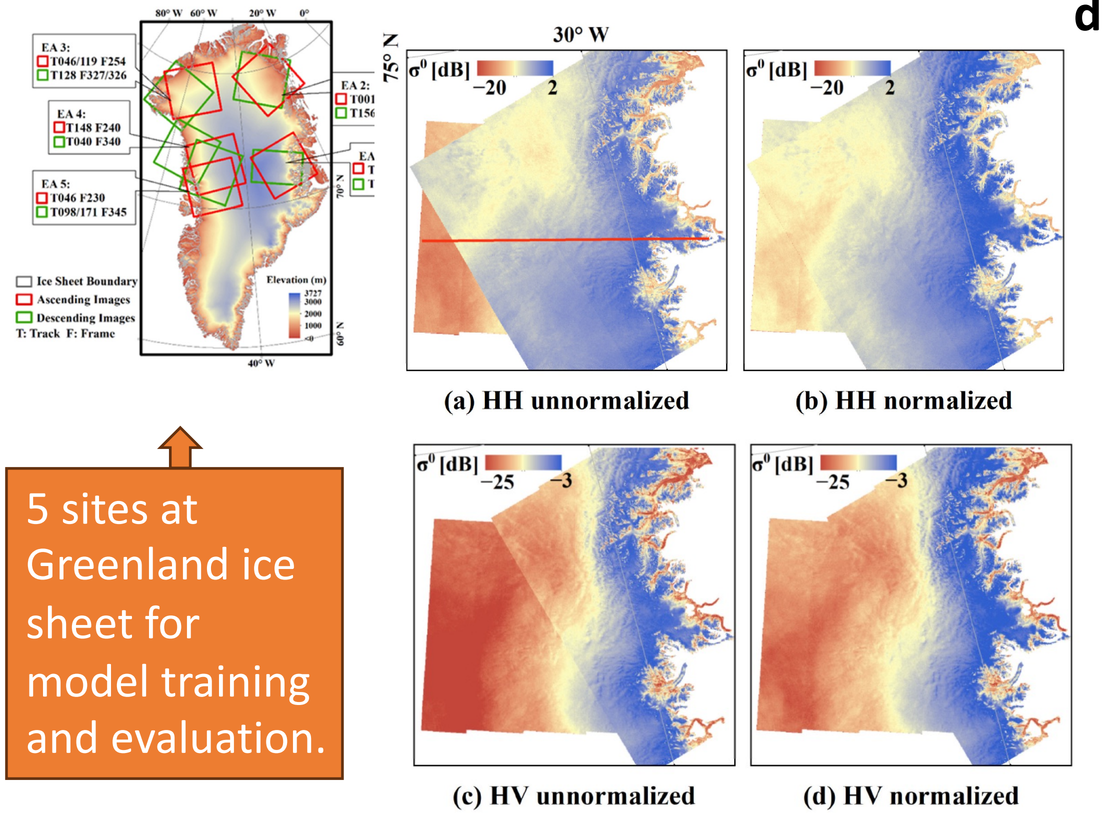


retrogressive thaw slump (RTS) variation.

Ref to Jiao, Z., Xu, Z., Guo, R., Zhou, Z., & **Jiang, L*.** (2023). Potential of Multi-temporal InSAR for Detecting Retrogressive Thaw Slumps: A Case of the Beiluhe Region of the Tibetan Plateau. International Journal of Disaster Risk Science, 1-16.

Incidence angle normalization of S-1

Ascending and descending images obtained within 24 hours.



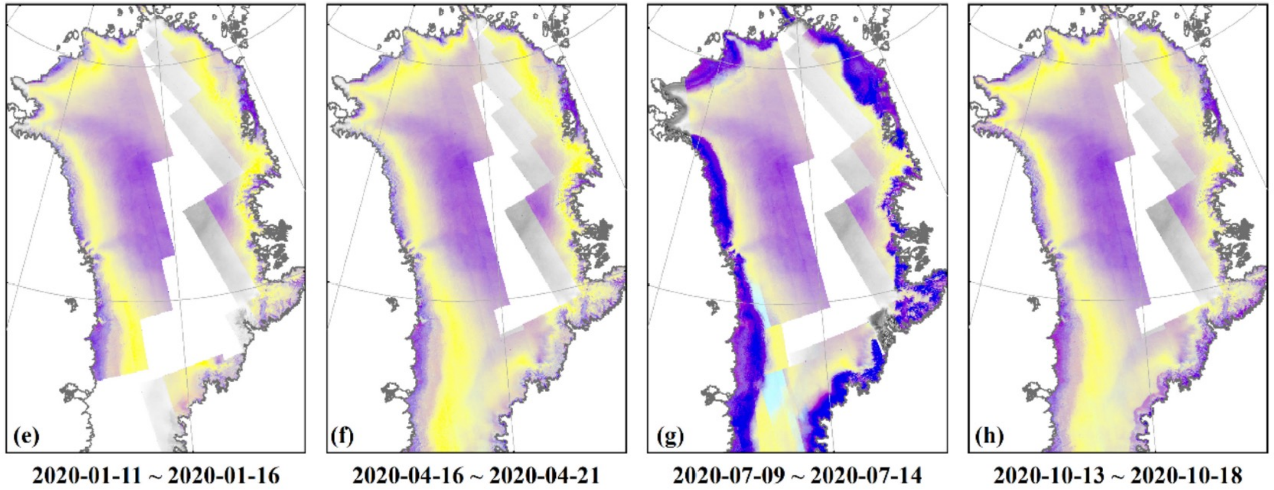
5 sites at Greenland ice sheet for model training and evaluation.

SAR images normalized to a certain incidence angle can better served for melting detection.

We introduced an algorithm that presumes that backscatter coefficient (in dB)differences is linear to incidence angle differences.

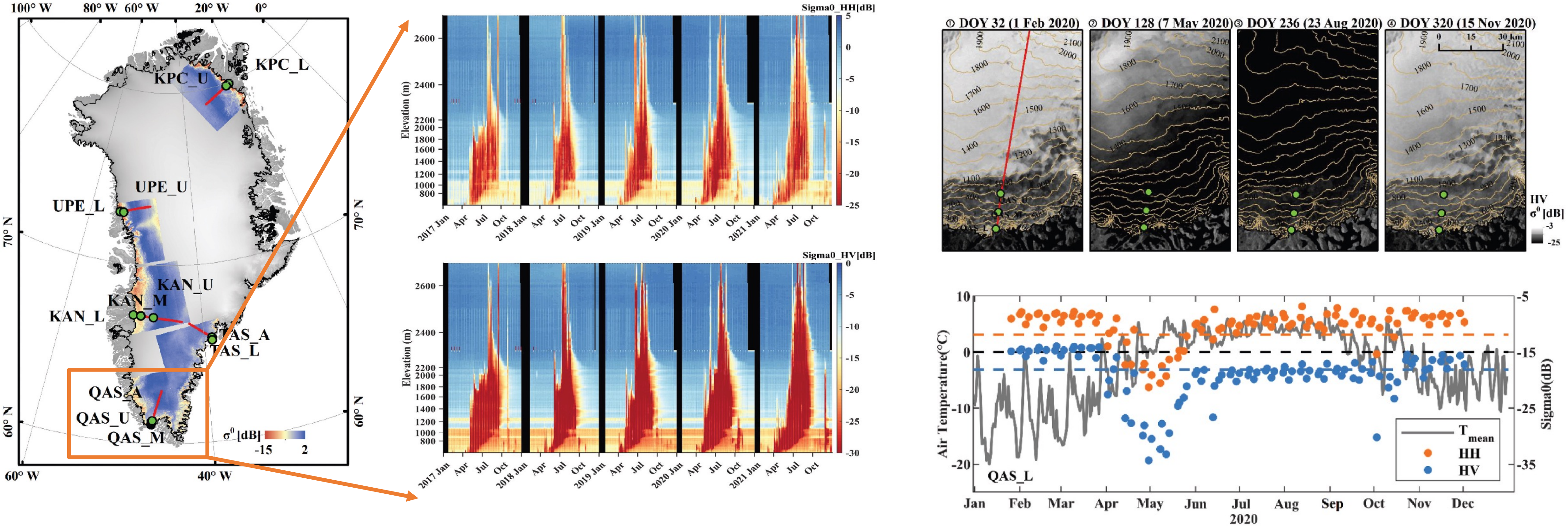
$$\sigma_a^0 - \sigma_d^0 = \frac{d\sigma^0}{d\theta} * (\theta_a - \theta_d) + r \ \ [\mathrm{dB}]$$

Coefficient: depends on surface feature, which is modelled lon, lat, height and acquisition dates.



Ref to: Chen, X., Li, G., Chen, Z., Ju, Q., & Cheng, X. (2022). Incidence Angle Normalization of Dual-Polarized Sentinel-1 Backscatter Data on Greenland Ice Sheet. *Remote Sensing*, *14*(21), 5534.

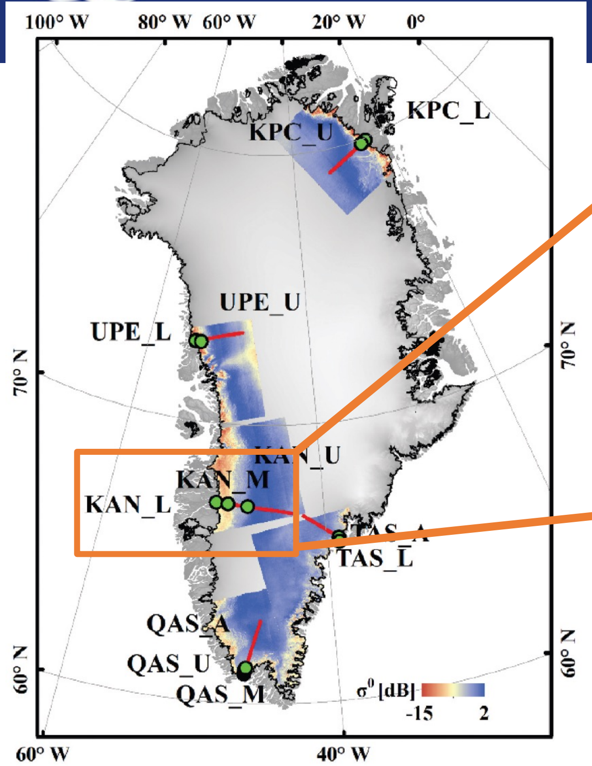
Greenland Surface melting detection using S-1

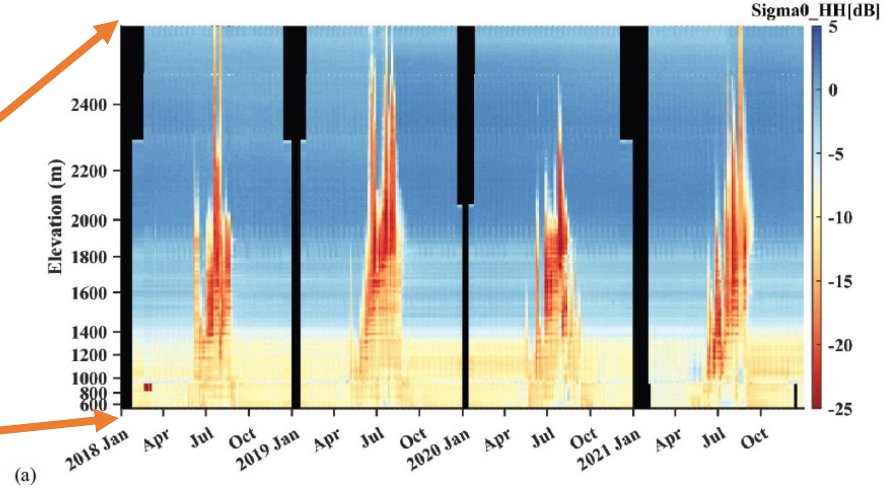


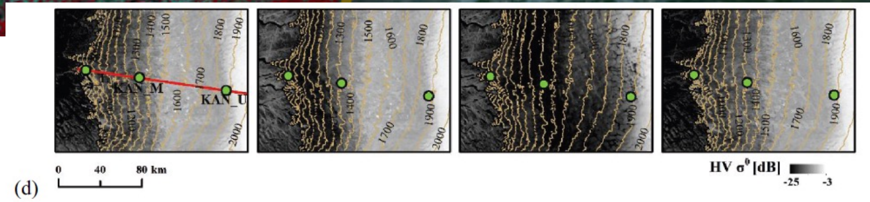
Method: 6-day repeat S1 images are employed for detecting the surface melting, referring to AWS sites temperature.

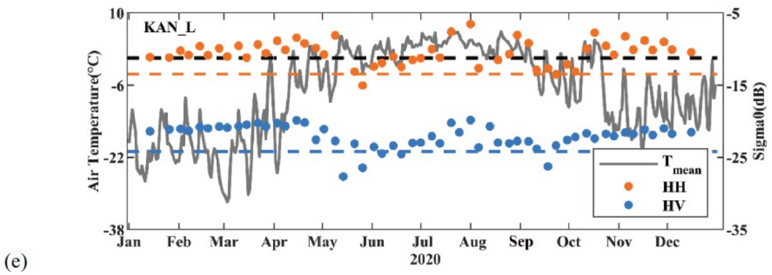
Found: The wet snow radar zone shows clear backscatter coefficients decreasing during the melting seasons, but the bare ice radar zone behaves more complexly during the melting seasons.

Greenland Surface melting detection using S-1

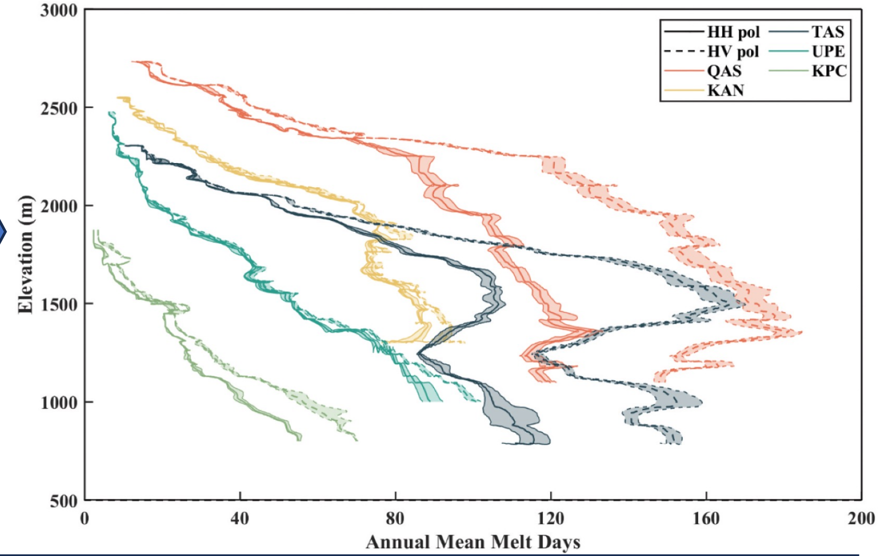








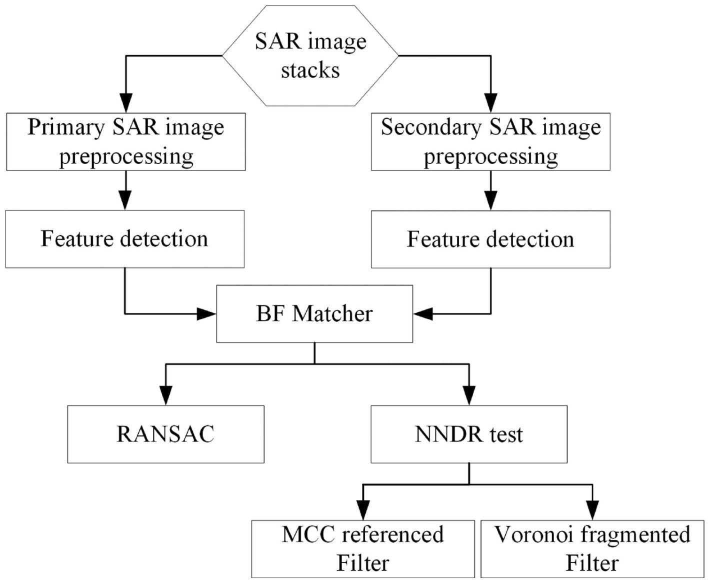
Melting days detected by S1 at 5 profiles



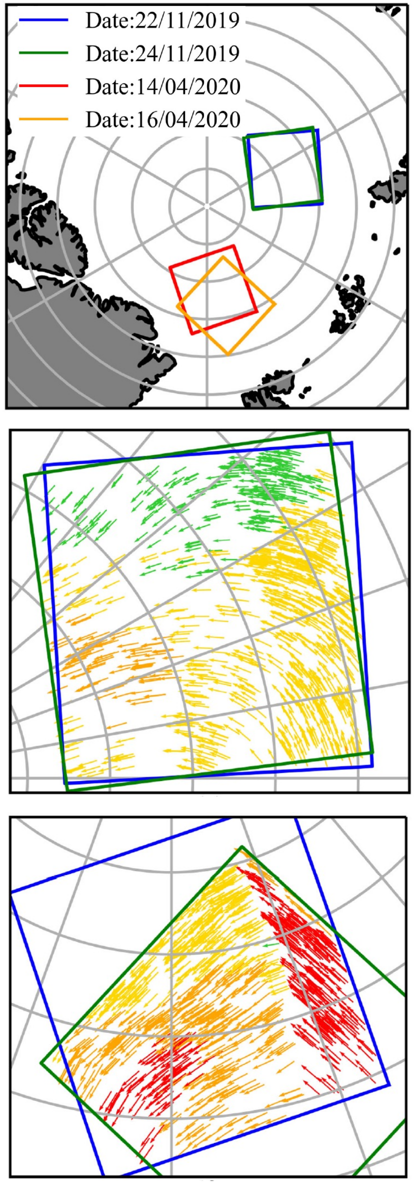
Near KAN, at upper wet snow or percolation zone, melting patter is clear to backscatter coefficient dropping. At lower wet snow zone, and or bare ice zone, the correlation between mean Air temperature and backscatter coefficient are more complex.

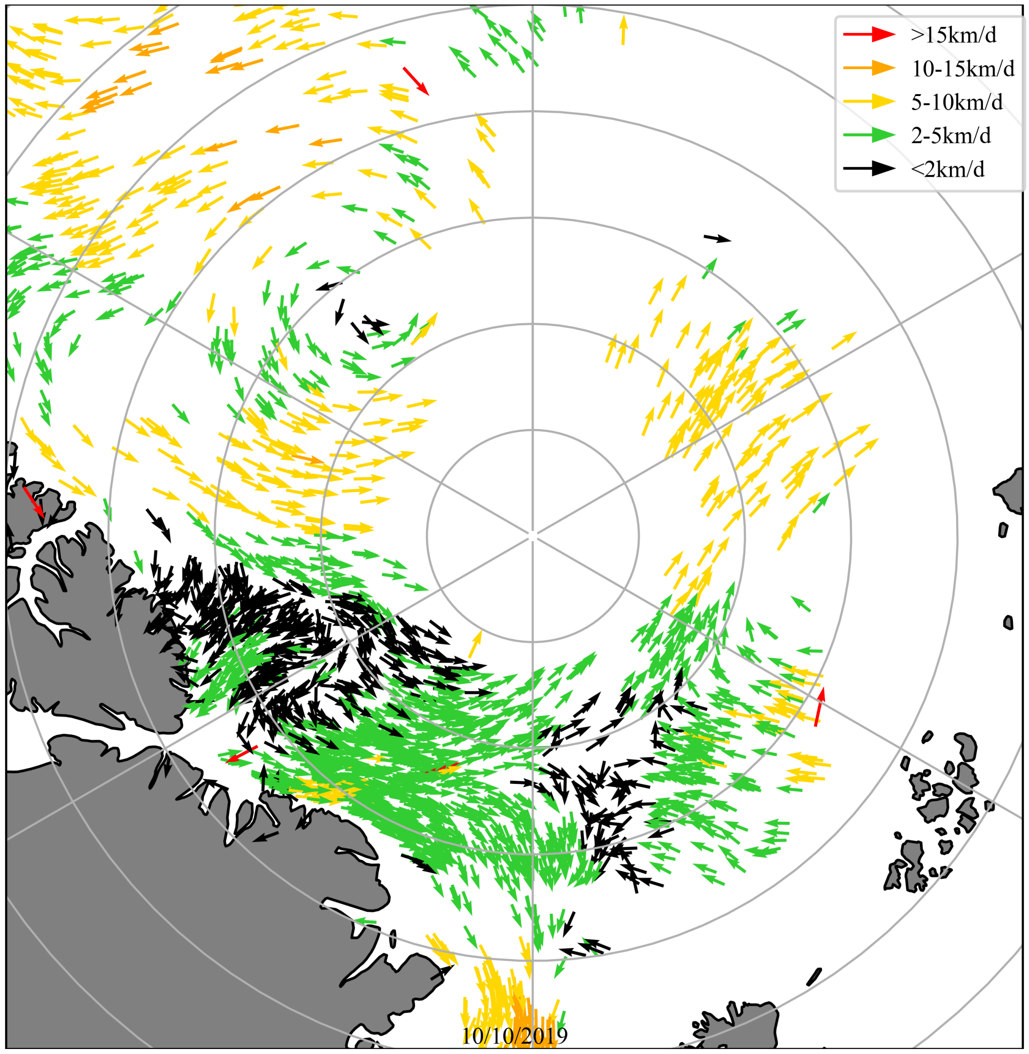
Ref to: Li, G., Chen, X., Lin, H., Hooper, A., Chen, Z., & Cheng, X. (2023). Glacier melt detection at different sites of Greenland ice sheet using dual-polarized Sentinel-1 images. *Geo-spatial Information Science*, 1-16.

Sea ice motion detection using S-1 feature tracking



working flow of derive sea ice motion vector with Sentinel-1 Imagery





Daily sea ice motion derived by Sentinel-1 in Oct,2019

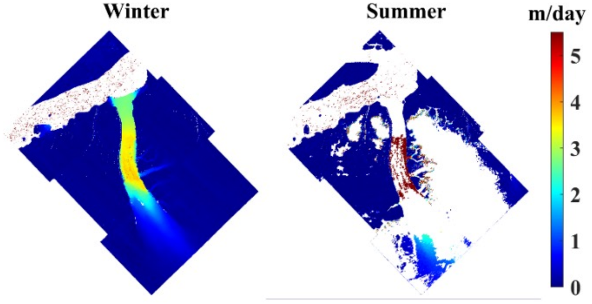
Ref to:1, 李超越, 李刚, 王雪, 鞠琦, 陈卓奇.基于特征匹配的采用Sentinel-1影像提取海冰漂移矢量算法研究[J/OL]. 遥感学报, 2022, 0.DOI: 10.11834/jrs.20222238.

2, Chaoyue Li; Gang Li*, Zhuoqi Chen, Xue Wang, and Xiao Cheng. Matching Vector Filtering Methods For Sea Ice Motion Detection Using SAR Imagery Feature Tracking. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2022, 15: 6197-6202.

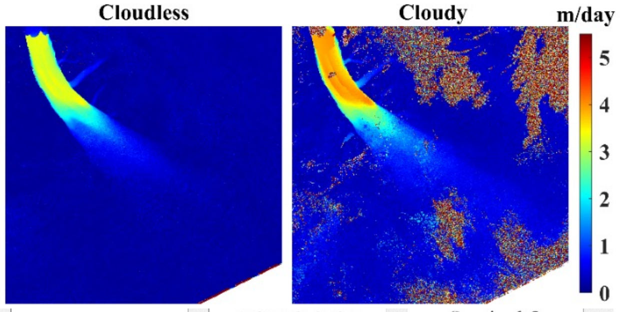
Glacier motion detected combined by S1 & S2

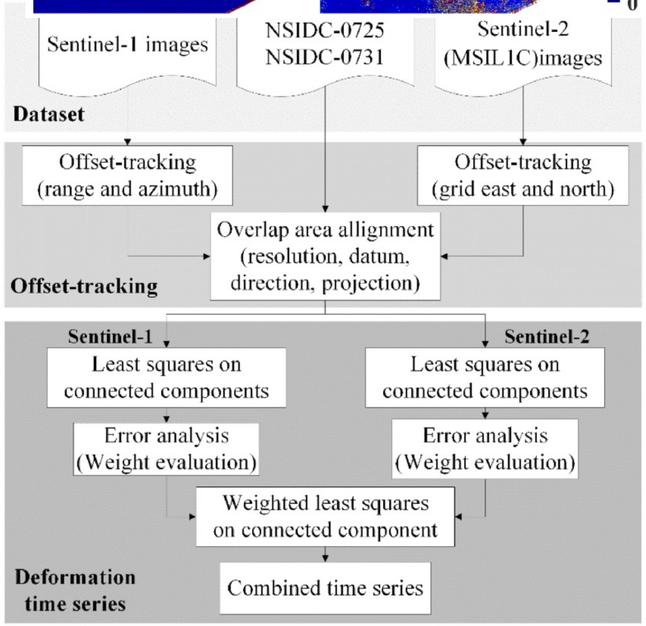
Why combining S1 and S2 for glacier velocity?

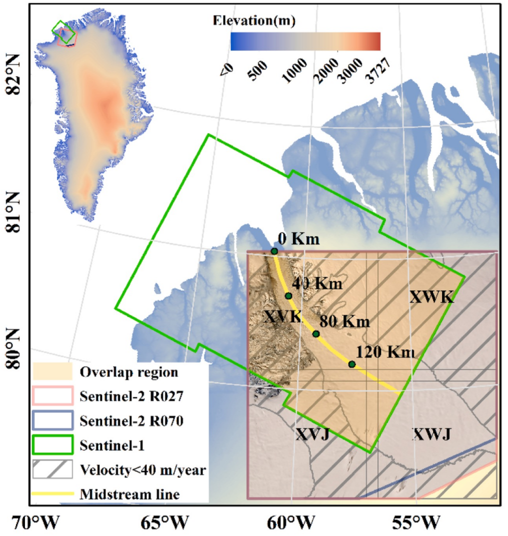
RADAR



Optical

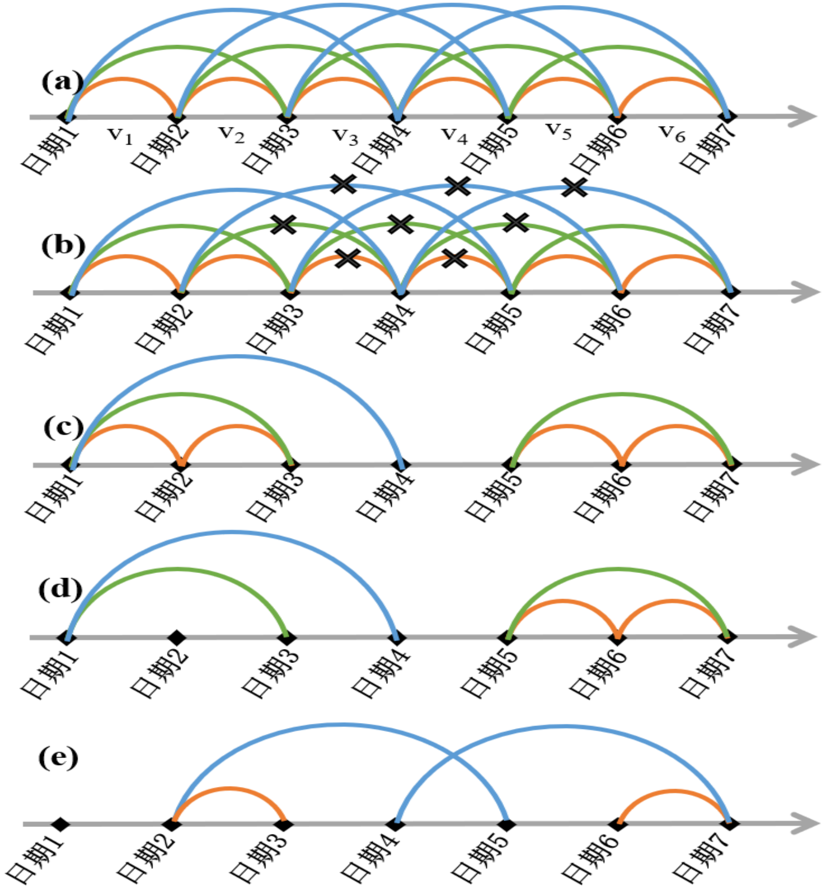






Study site,
Petermann @ GrIS

A 2-step least squares method based on connected component



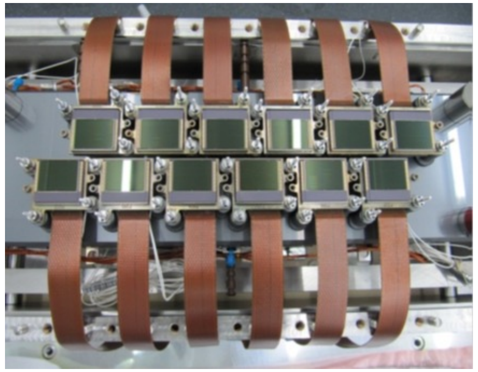
After removing the gross errors, the equation can be rank deficit. But after solving within connected component, there will be no such problem.

Glacier motion detected combined by S1 & S2

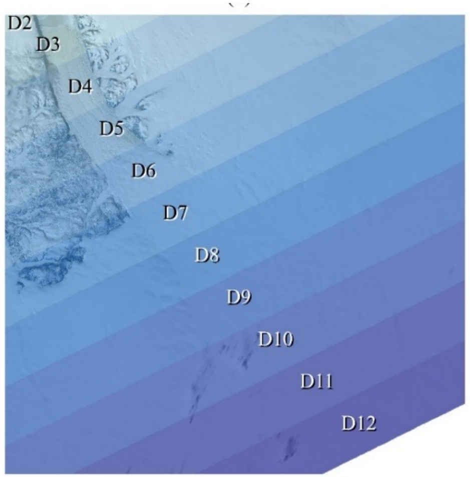
Mosaicking different (12) detectors of MSI is not perfect for Sentinel-2. The output of offset-tracking requires correction before the time-series analysis step.

Here we regard the region <40m/year as stable area on ice sheet, and presume its velocity does not change. The mosaicking errors are evaluated and removed from the offset-tracking output.

S-2 MSI sensor

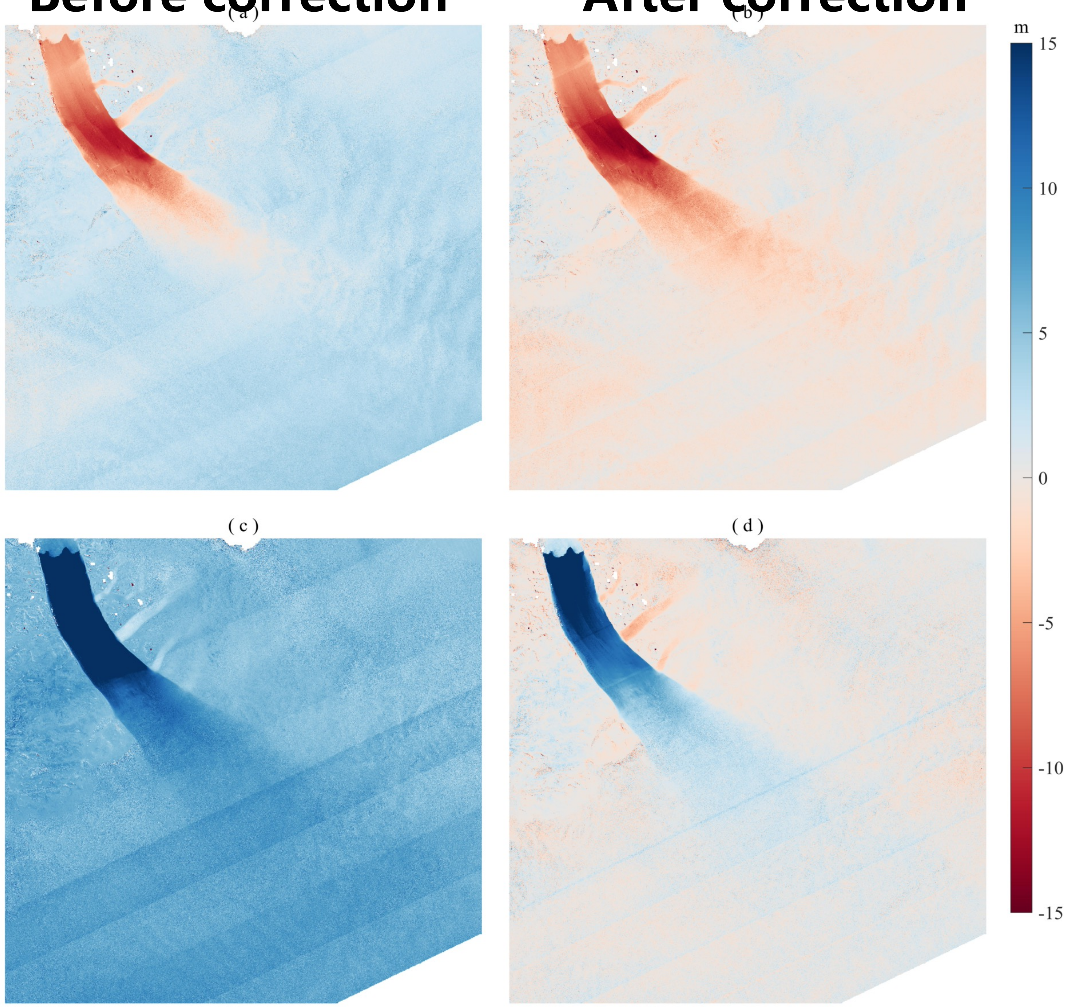


S-2 detector footprint



Before correction

After correction



Sub-pixel mosaic error results in jumps in the offset-tracking outputs

Glacier motion detected combined by S1 & S2

S1 Summer

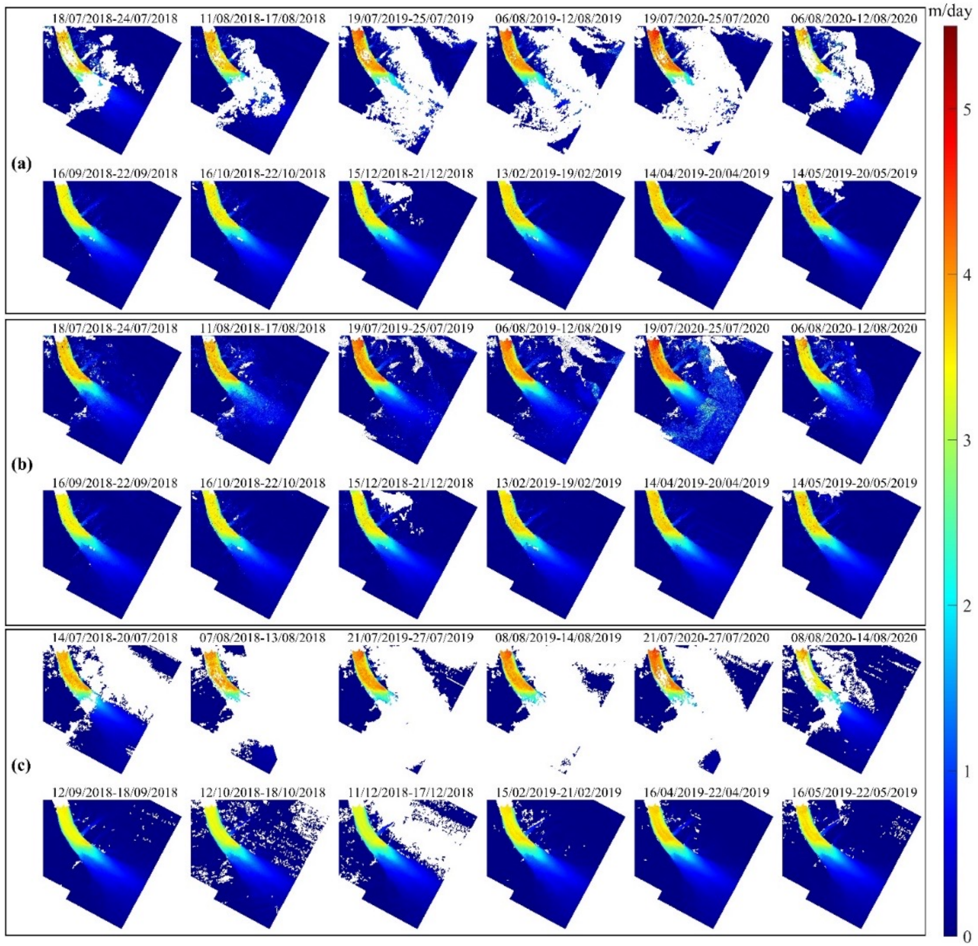
S1 Spring, autumn, winter

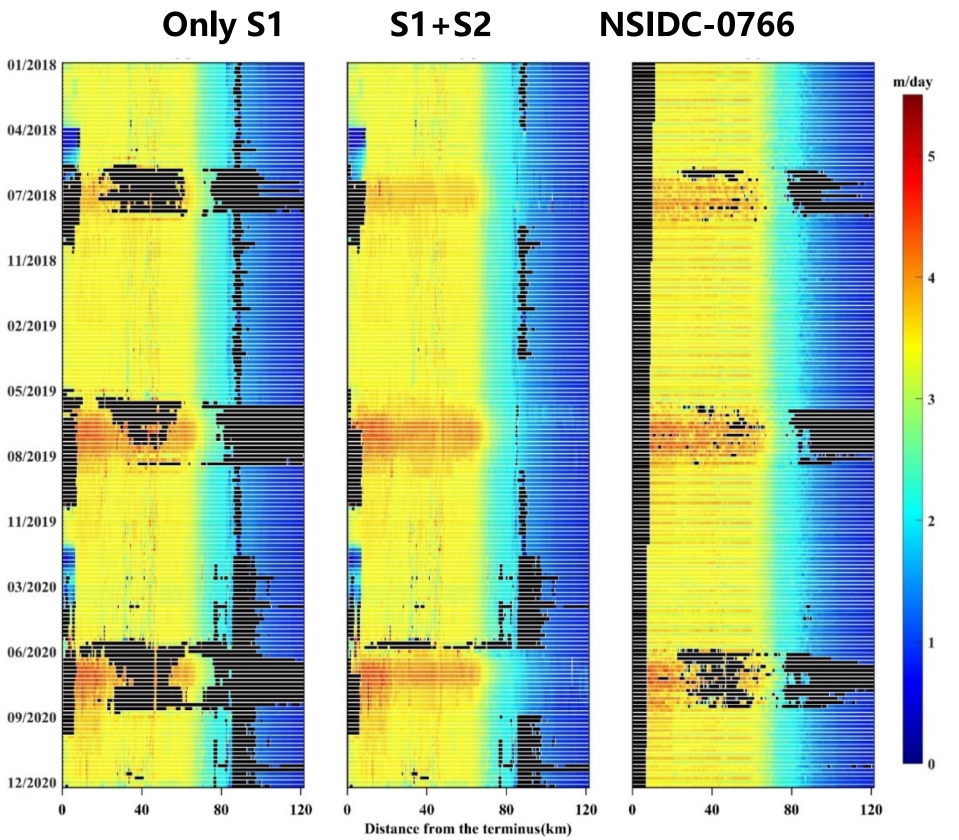
S1+S2 Summer

S1+S2 Spring, autumn, winter

NSIDC-0766 Summer

NSIDC-0766 Spring, autumn, winter





Combining S1 and S2 can deriving a spatial and temporal continuous velocity fields time series for Greenland Ice Sheet.

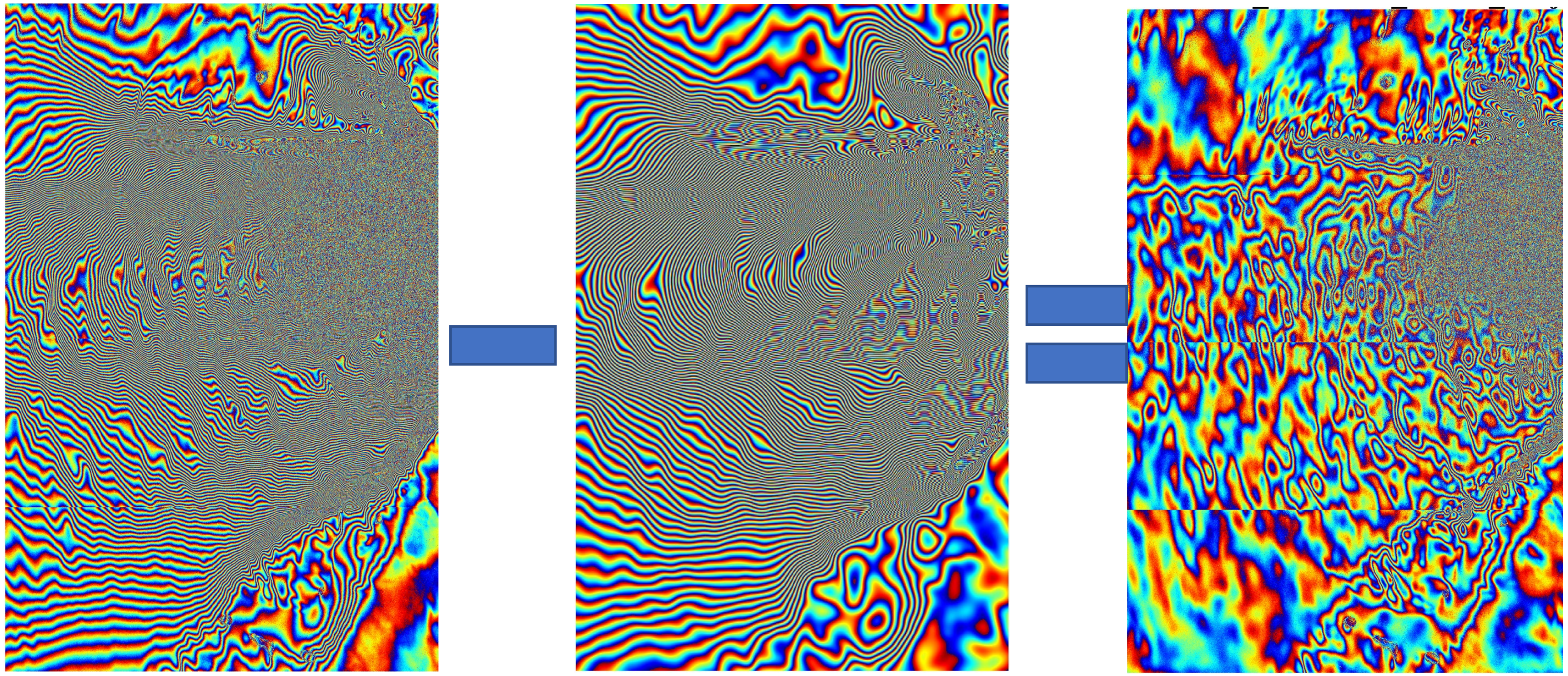
Ref to: Gang Li; Yanting Mao*; Xiaoman Feng; Zhuoqi Chen; Zhibin Yang; Xiao Cheng, Monitoring ice flow velocity of Petermann glacier combined with Sentinel-1 and -2 imagery. International Journal of Applied Earth Observation and Geoinformation, 2023, 121: 103378.

Glacier motion detection with S1 InSAR

Benefitted by 6-day repeat cycle of S1, coherence is not a big issue for InSAR applying on ice sheet. But still other issues to address, including (not limited to) phase unwrapping, TOPS induced phase jump between adjacent burst.

Object:

To get a wrapped interferogram with lower phase gradient for a easy phase unwrapping

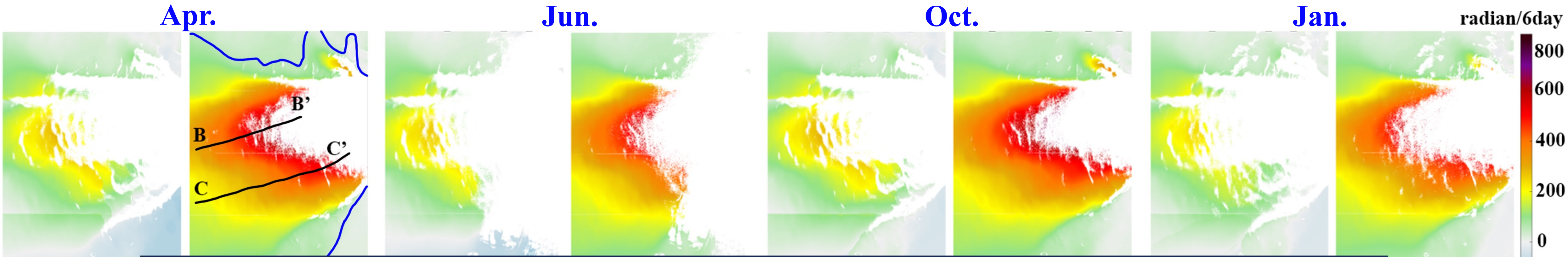


Original D-InSAR, high gradient

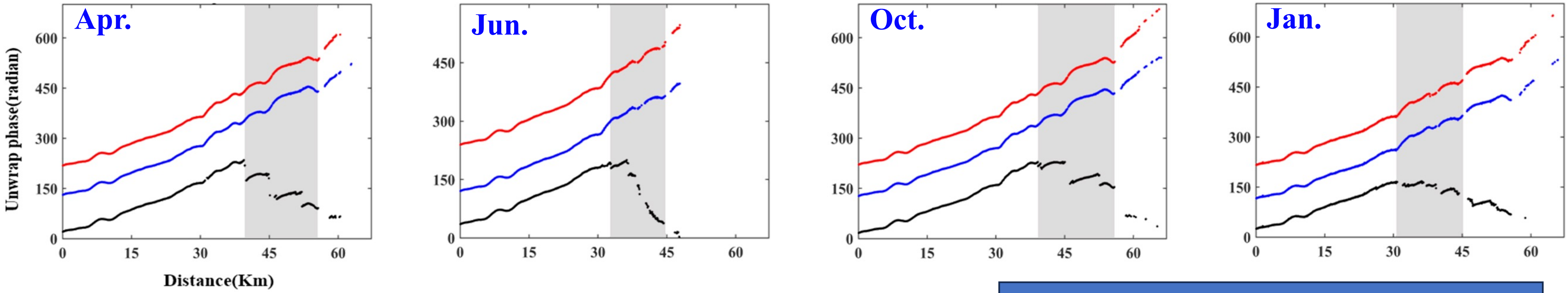
Phase estimated with slant range offset-tracking, high gradient

Re-differential D-InSAR, low gradient, easy to unwrap

Glacier motion detection with S1 InSAR



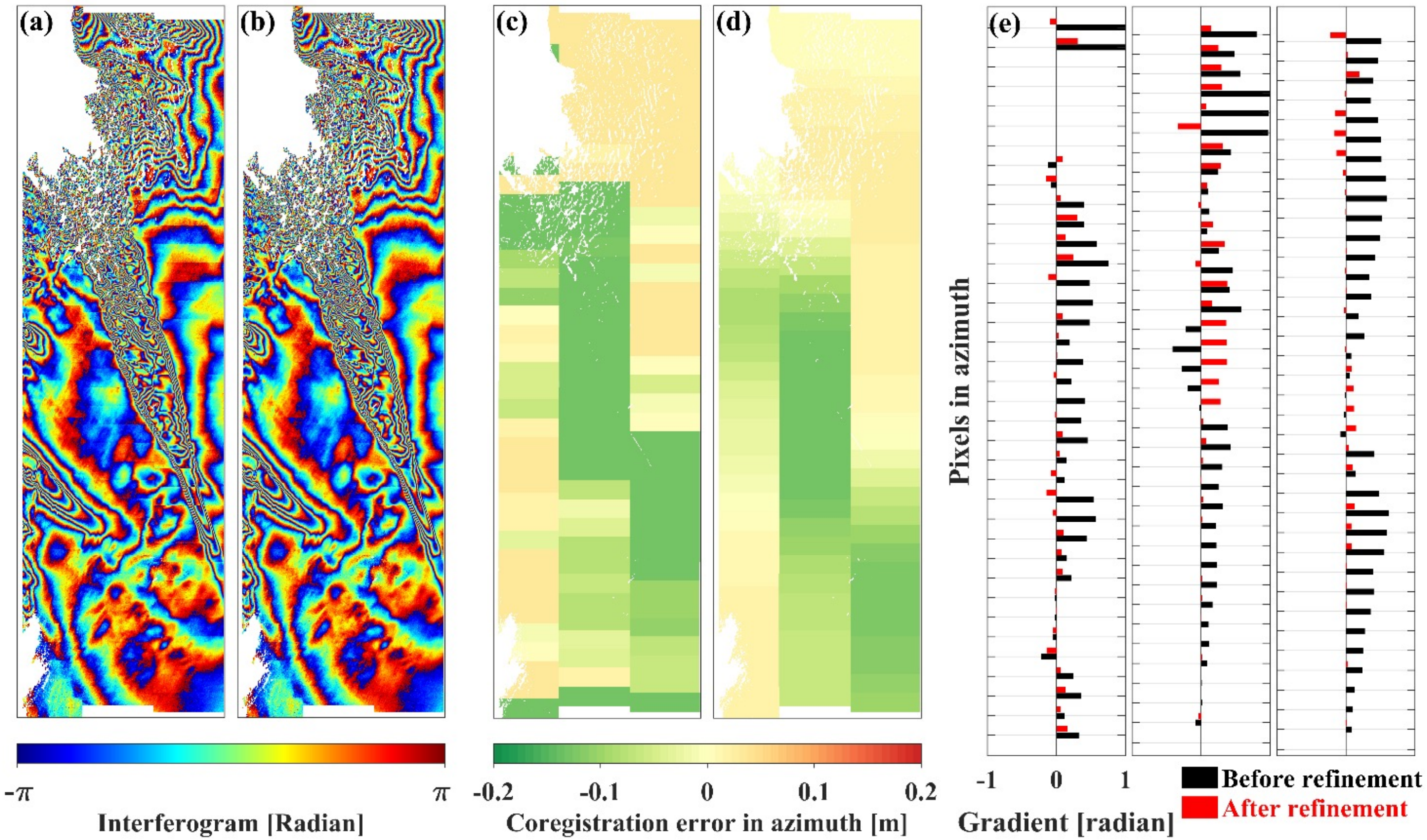
Original D-InSAR unwrap results (left) and unwrap results (right) with this method.



Red: this method, D-InSAR subtract slant offset-tracking
Blue: this method, D-InSAR subtract monthly average simulated fields
Black: original D-InSAR unwrapping results.

This method extent S1 D-InSAR capacity of monitoring deformation from 1.4m/6days to 3.6m/6days.

Glacier motion detection with S1 InSAR



$$\Delta\varphi_{ramp} = 2\pi f_{DC}(\Delta_{motion} + \Delta_{mis\_err})$$

In most studies, motion in azimuth direction does not required to be considered as 2pi=130cm deformation.
But glacier motion in polar region is another story. Here historic monthly or annual flow rates is employed.

Phase gradient at burst edge has been effectively reduced if considering the azimuth motion.

Evaluation the azimuth co-registration error basing on a mean (azimuth) velocity fields

Ref to: Xiaoman Feng; Zhuoqi Chen; Gang Li*; Qi Ju; Zhibing Yang; Xiao Cheng. Improving the capability of D-InSAR combined with offset-tracking for monitoring glacier velocity. *Remote Sensing of Environment*, 2023, 285: 113394.

EO Data Delivery

Data access (list all missions and issues if any). NB. in the tables please insert cumulative figures (since July 2020) for no. of scenes of high bit rate data (e.g. S1 100 scenes). If data delivery is low bit rate by ftp, insert “ftp”

ESA /Copernicus Missions	No. Scenes
1. Sentinel-1	>8000
2. Sentinel-2	>1000
3. Sentinel-3	20
4.	
5.	
6.	
Total:	>9000
Issues:	

ESA Third Party Missions	No. Scenes
1. nan	
2.	
3.	
4.	
5.	
6.	
Total:	
Issues:	

Chinese EO data	No. Scenes
1. nan	
2.	
3.	
4.	
5.	
6.	
Total:	
Issues:	

Chinese Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution including period of research
Yanting Mao	Sun Yat-sen University	Monitoring ice flow velocity of Petermann glacier combined with Sentinel-1 and -2 imagery	Develop the method of combining S1 and S2 offset-tracking results to derive velocity fields for polar glaciers. 2021.9 - now
Zhibin Yang	Sun Yat-sen University	Precision comparison of different offset-tracking methods at sub-pixel level for glacier velocity study	Evaluate different algorithms in terms of offset-tracking precision at sub-pixel level. Developing the correction method for the fast running software. 2021.9 - now