Design Projet 2025

Understanding Glacier and Landslide Dynamics with the help of aerial datasets in the Aletsch forefield

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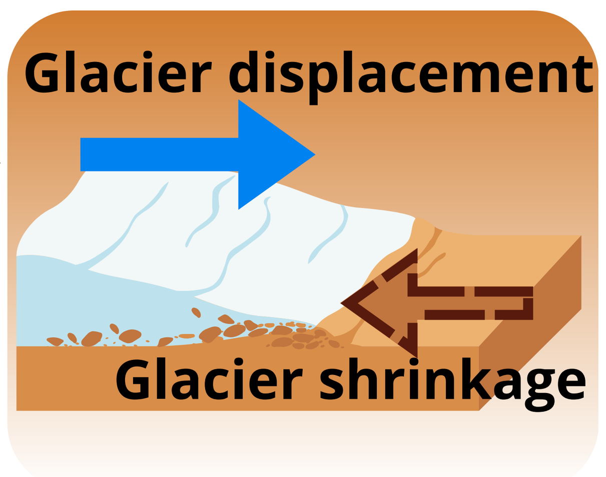
Context

The Great Aletsch glacier has been retreating in the last century due to climate change[1], leading to debuttressing and over-steepened valley flanks. IDMatch software uses DSMs (Digital Surface Models) and images to generate surface velocity fields. It has been developped by CREALP team some years ago[2].

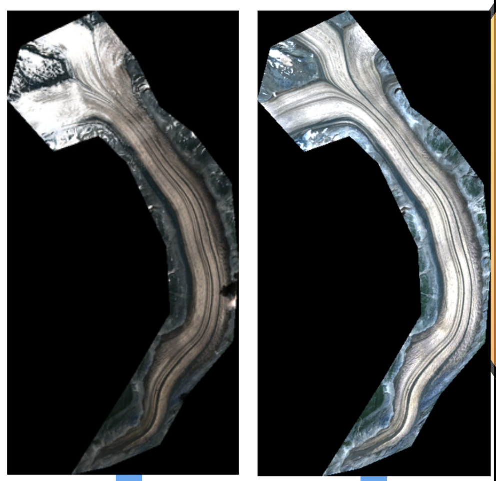


Objectives

- Develop a new Python tool for satellite data download (from Sentinel and Landsat satellites),
- Update and leverage IDMatch's code,
- Apply those tools to analyse the displacement of the Great Aletsch glacier.

Dataset

2023-06-25 2022-07-18

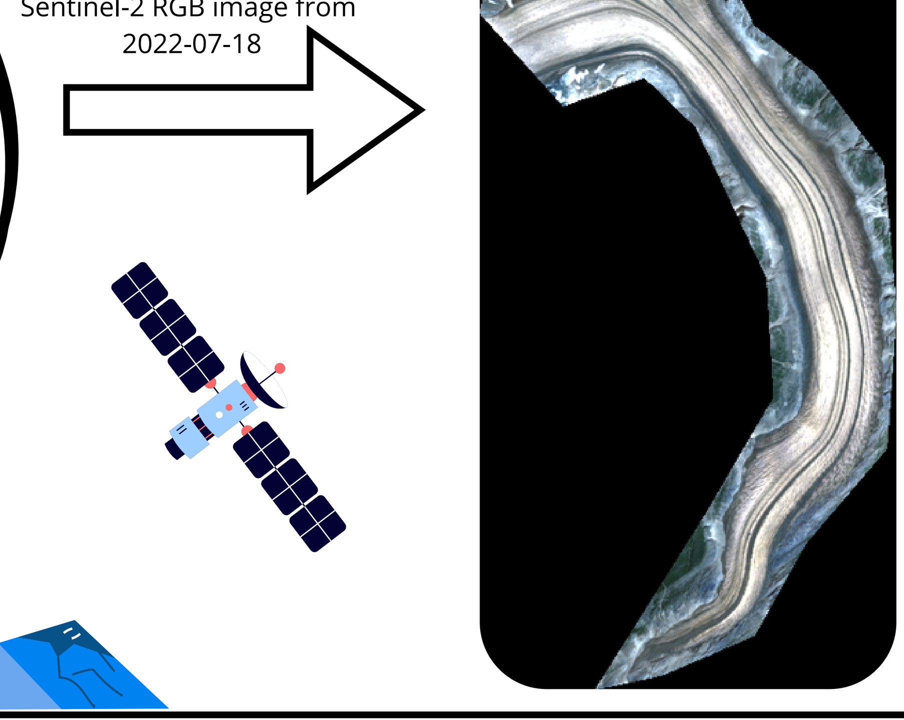


We used Google Earth Engine (GEE) and its Python API to write a code for satellite imagery download[3]. This code searches for images in GEE's datasets over a period of defined time and returns the less cloudy one with a 20 m resolution.

Digital Surface Models of the glacier extracted from Swisstopo[4] with a resolution of 10 m.

Inputs:
- Dataset name
- Dates
- Area of interest
- Bands (e.g. B4)
- Output format

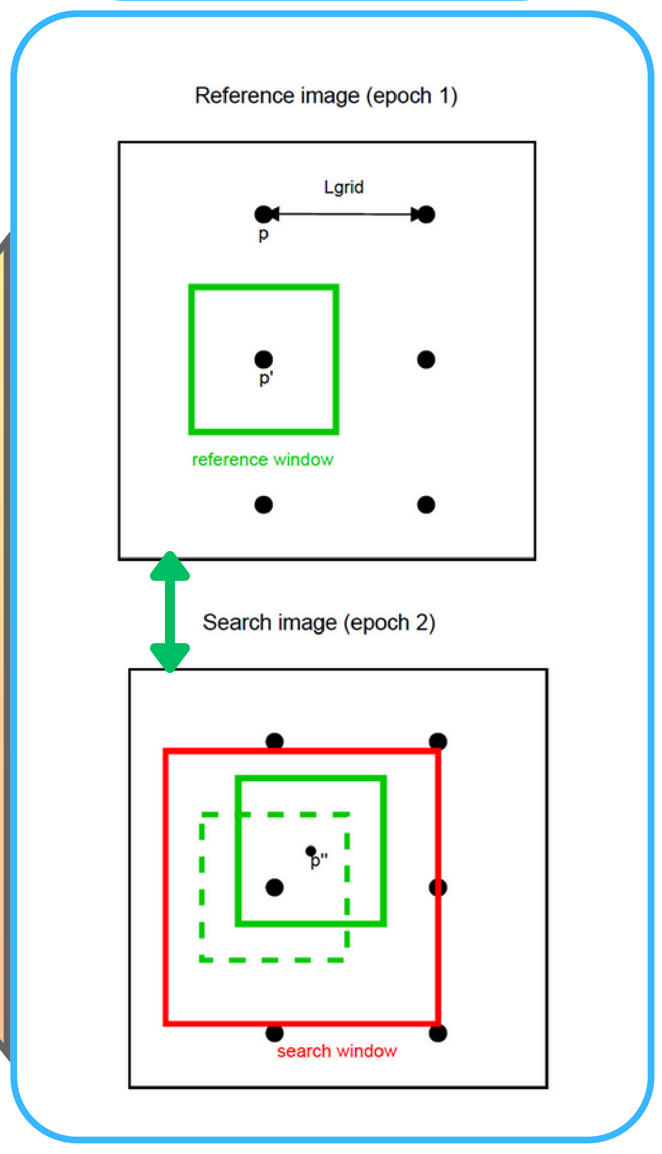
Sentinel-2 RGB image from 2022-07-18



IDMatch

CORE STEPS	Parameters	Variation of computation time when increasing the parameter	Sensibility on the ouput velocity field
1. IMPORT DATASETS	Input paths		
2. PRE-FILTERING	Pre-filters (F1-F5)		low
3. MATCHING	Matching method (M1,M2)		low
	Lgrid = space between the grid points	-	high
	pixel deviation = window size range	+	high
	number of window sizes	+	high
4. POST-FILTERING	post-filter window size		
	minimum number of matched points in the window		
5. OUTPUT VELOCITY FIELD	Results path		

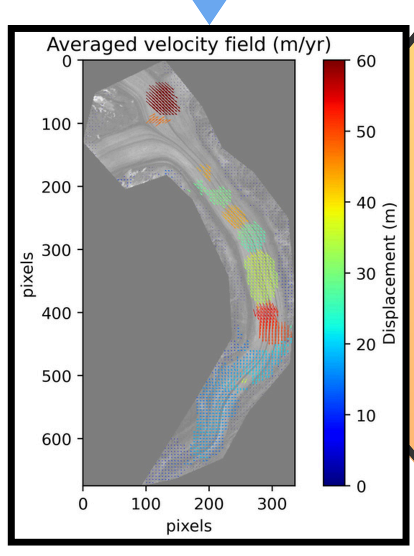
Matching algorithm



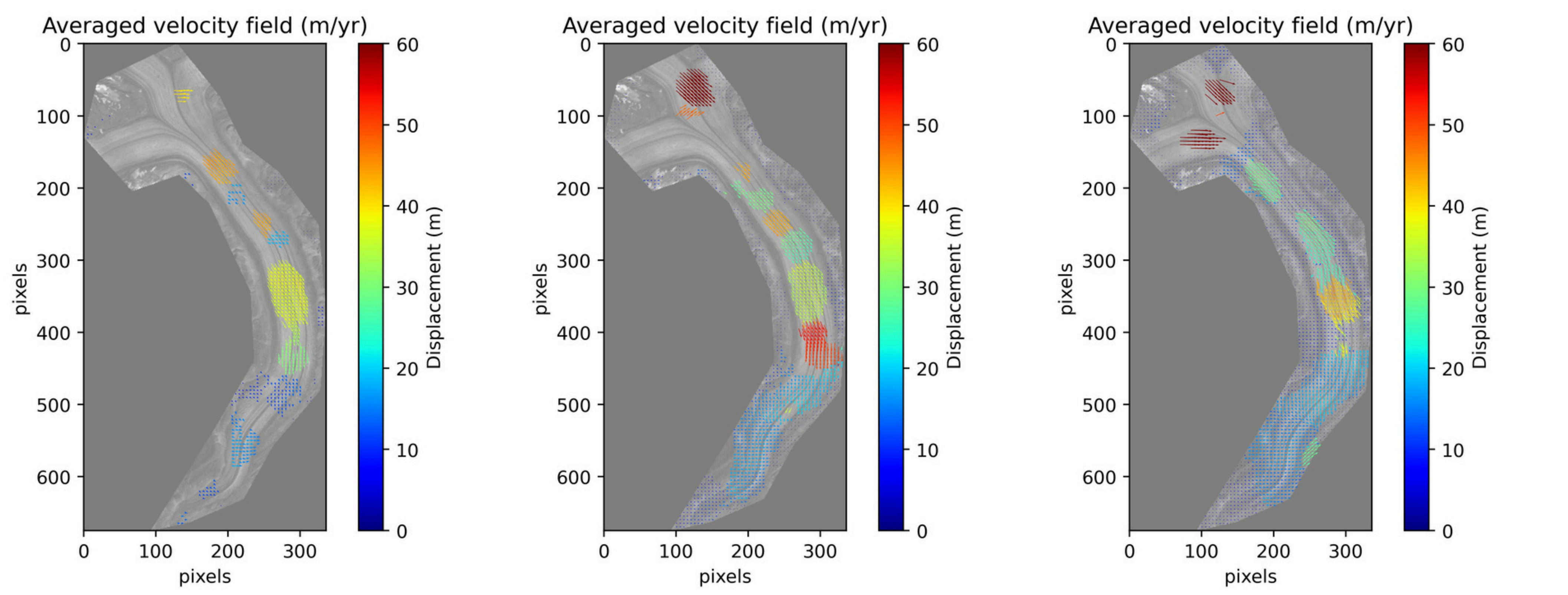
A template-based algorithm is applied between the reference window -around p'- and a subregion of the search window -around p"- to quantify the correspondence between the two areas. The displacement is then p'-p". It defines the magnitude and the orientation of the resulting velocity vectors.

Mean Great Aletsch glacier velocity :
- IDMatch[5] : 28 m/yr for velocities in [15,60] m/yr
- GLAMOS[6] : 36 m/yr

Results



We conducted a sensitivity analysis to find the best parameters for our study. It emphasized the importance of *pixel deviation*, *number of window sizes* and *Lgrid* parameters. Computation time was the main constraint limiting higher output resolution.



2 3 5

pixel deviation

Conclusion

This workflow provides an easy method to have a velocity field. It can be applied to diverse temporal and spatial scales -from decades to weeks- and to diverse geomorphological objects such as landslides or river banks. However, improvements can still be performed. For example, the code can integrate machine learning methods to automatically tune parameters and reduce computation time[7].

References

[1] Hock et al., (2019) IPCC special report on the ocean and cryosphere in a changing climate.
[2] Gindraux, S. (2019). The potential of uav photogrammetry for hydro-glaciological forecast
[3] https://github.com/Margaux-Ccd/Satellite_glacier.git
[4] Federal Office of Topography swisstopo (2025), SwissSurface3D Raster
[5] https://github.com/mmgl02/IDMatch.git
[6] GLAMOS (2024) Glacier Monitoring Switzerland
[7] Lagemann et al (2021) Deep recurrent optical flow learning for particle image velocimetry data

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