climate change initiative

→ PERMAFROST

Integrating S1 and CSK InSAR-based information for an improved regional characterization of rock glacier dynamics

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permafrost cci

Motivation

The kinematic classification of rock glaciers across valleys/regions is often conducted using **Sentinel-1 (S1)** wrapped interferograms:

ADVANTAGES

1) Reliable frequency of acquisitions → ensures interferogram redundancy
2) Freely available
3) Able to detect up to **metric** annual rates of surface deformation along LOS

LIMITATIONS

1) Coarse spatial resolution
2) Inconsistent detection of **cm/yr** and **slower** annual rates of surface deformation along LOS
3) Inconsistent detection of features flowing **north** and **south**

→ A population of **kinematically-undefined** rock glaciers

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Can **integration** with another SAR constellation improve the **kinematic reliability** and **completeness** of a rock glacier inventory?

Is Cosmo-SkyMed (CSK) an option?

Technically, considering its reliable frequency of acquisitions, complementing S1 with CSK should warrant:

1) **higher spatial resolution** in the delineation of moving areas
2) Consistent detection of **<cm/yr** surface deformation along LOS

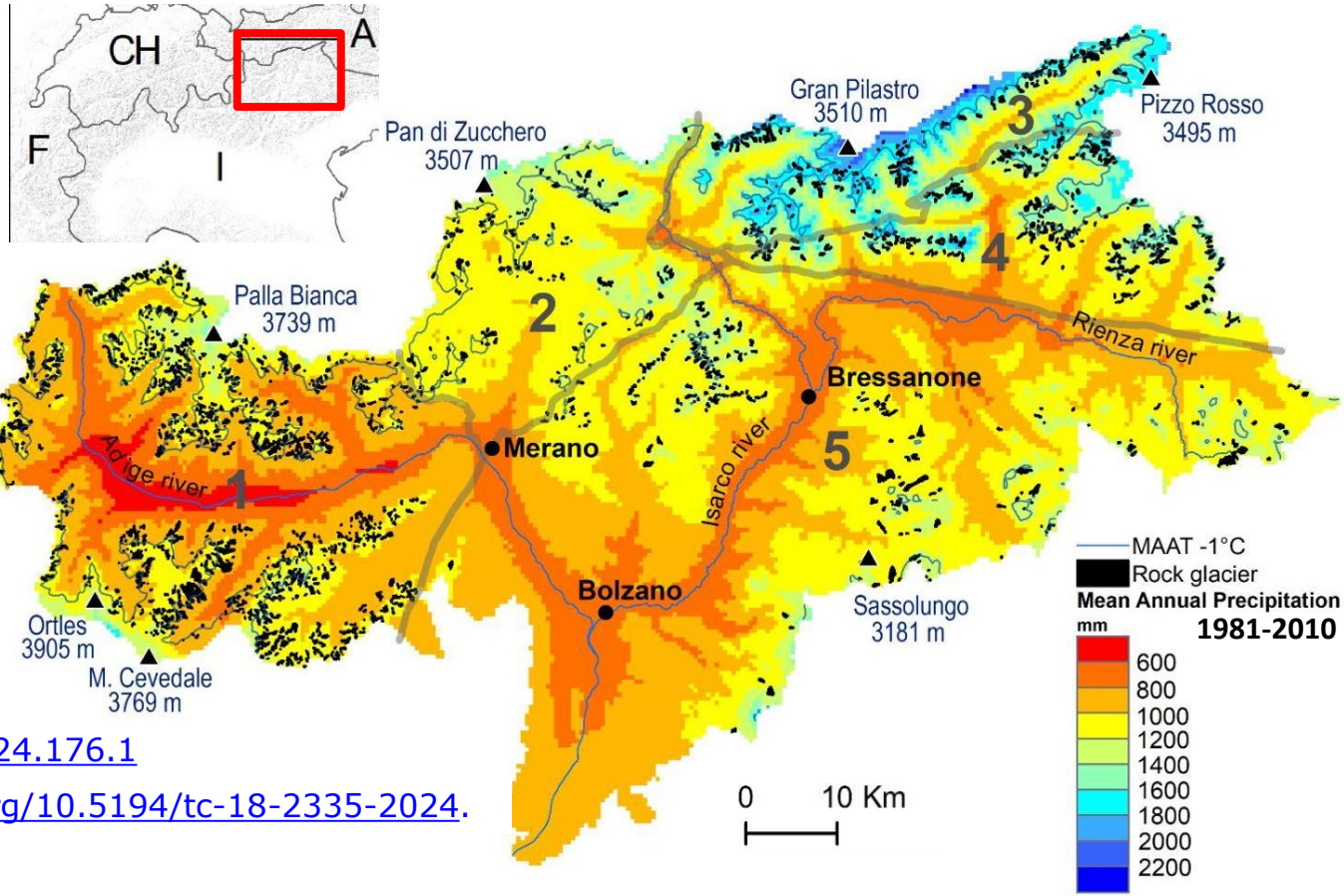
→ Ultimately **reducing** the number of **kinematically undefined** rock glaciers

Sentinel-1		Cosmo-SkyMed
C	Band	**X**
0.056 m	Wavelength	**0.031 m**
2.8 cm	One-phase cycle	**1.6 cm**
6 to 12 days	Min. Revisit period (constellation/satellite)	**1 to 16 days**
35 deg	LOS avg angle	35 deg
2.33 x 14.07 m	Scene pixel size	0.93 x 2.21 m
15 m	Interferogram pixel size	**5 m**

Study area: western South Tyrol

Where RG density is 2 to 10 times higher than elsewhere in the region: **1.1 #/km²**

n = 2796 region-wide



Scotti et al. 2024
https://doi.org/10.52381/ICOP2024.176.1

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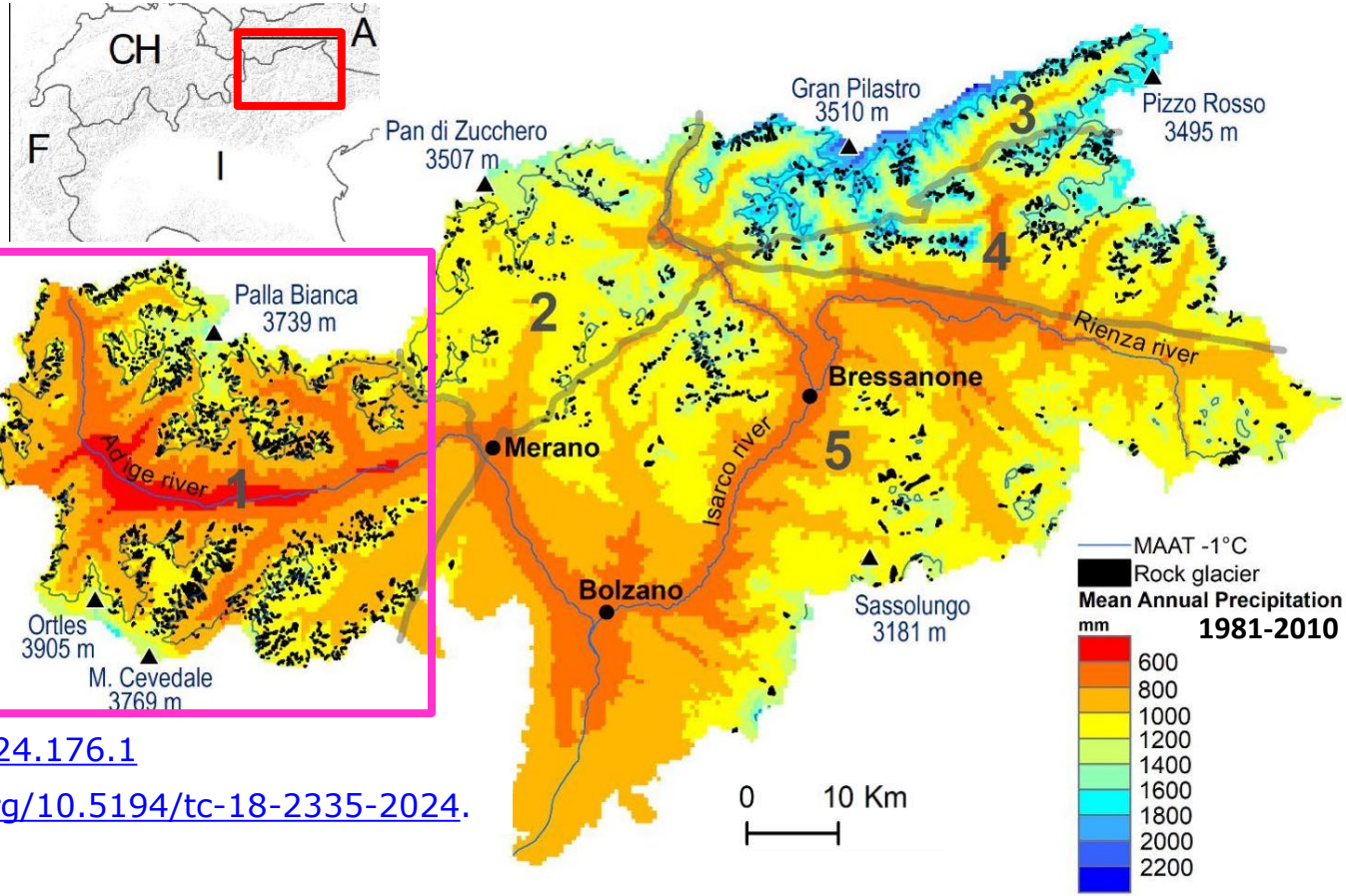
n = 2796 region-wide
n = 1642 in western ST



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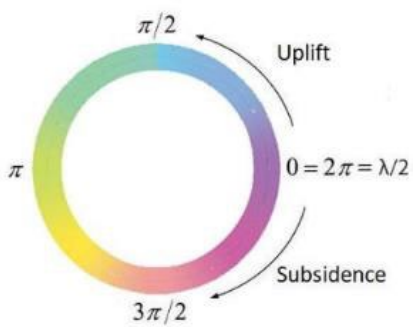
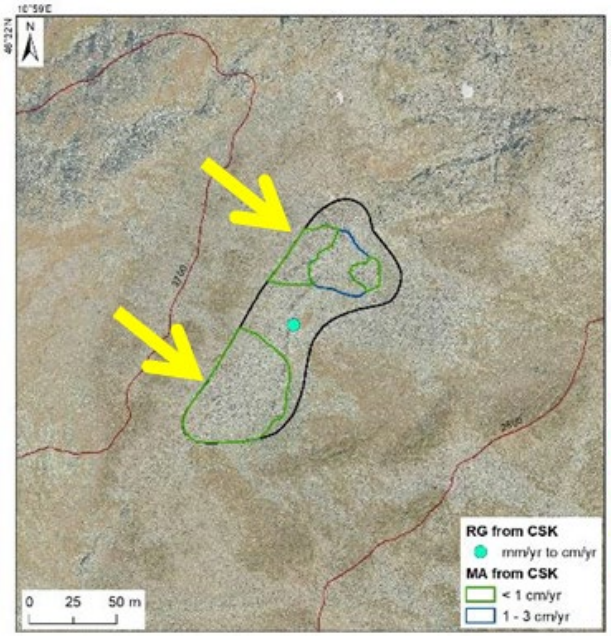
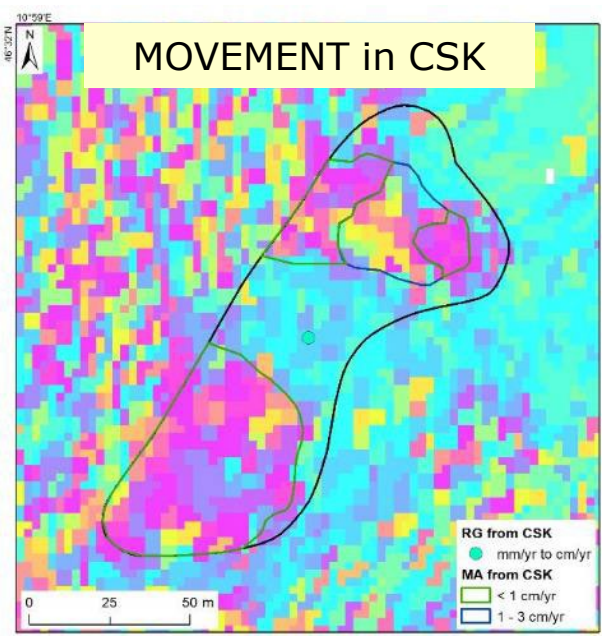
Indeed CSK detects surface deformation < cm/yr

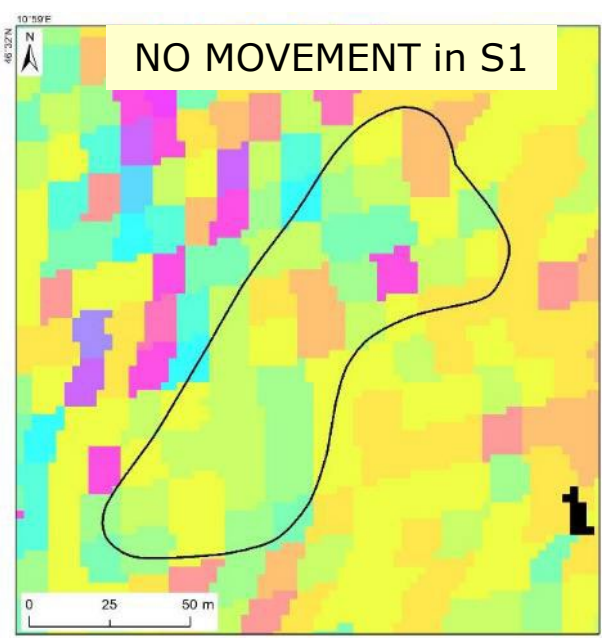
South Tyrol, Italy



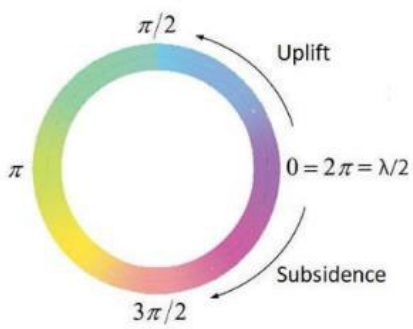
1-year interferograms





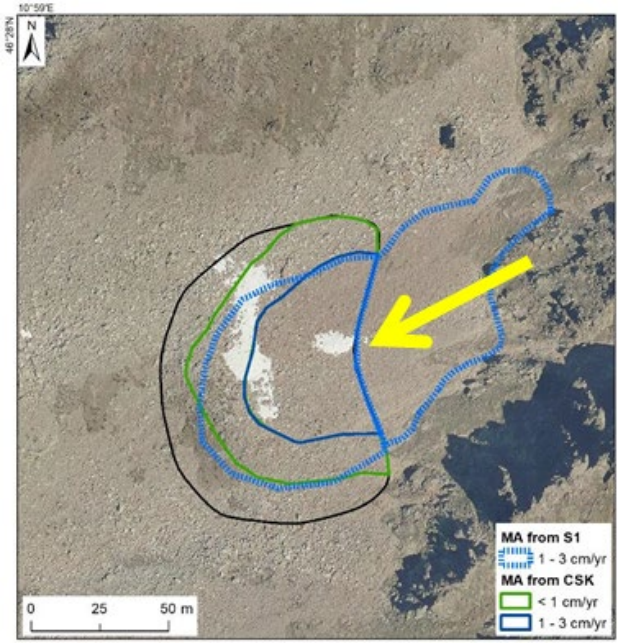


Enhanced spatial and kinematic resolution afforded by CSK

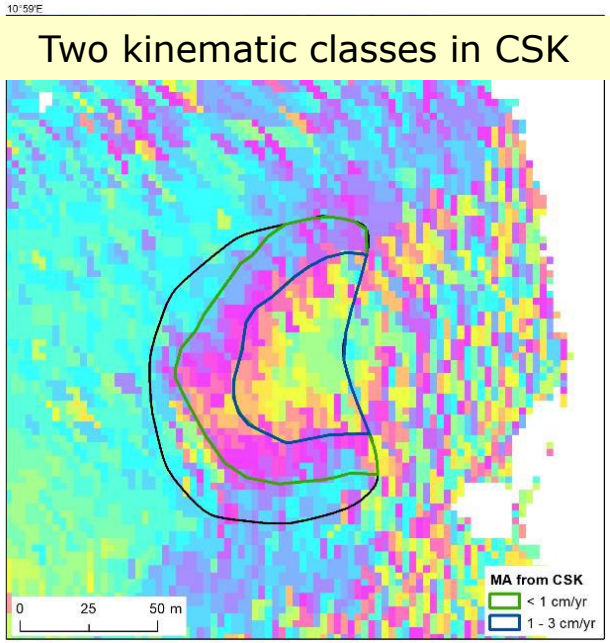


South Tyrol, Italy

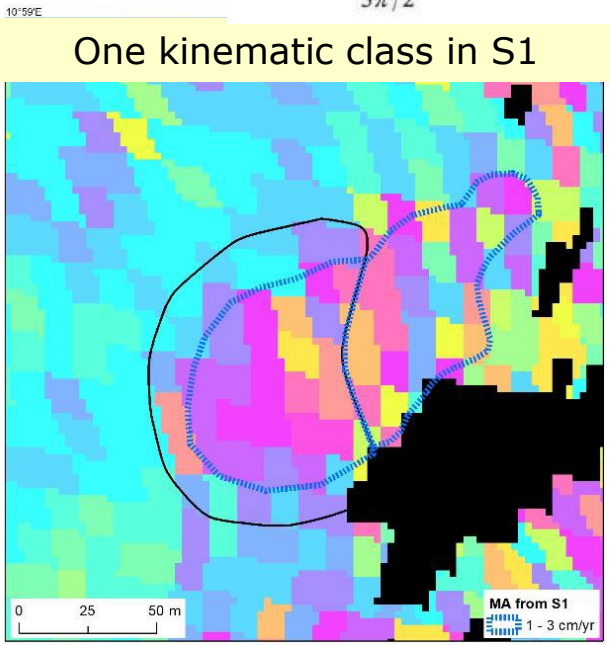
1-year interferograms



Two kinematic classes in CSK



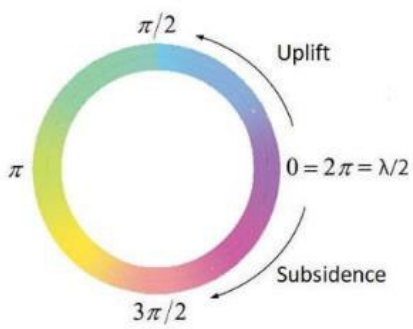
One kinematic class in S1



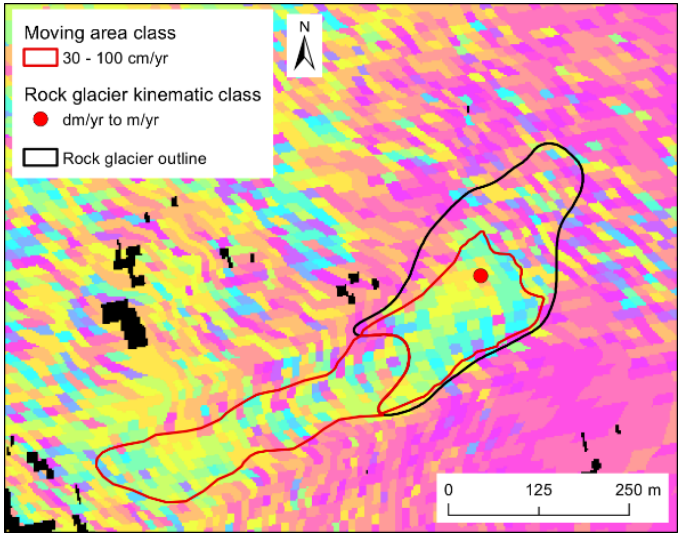
Detection of fast moving rock glaciers afforded by S1

South Tyrol, Italy

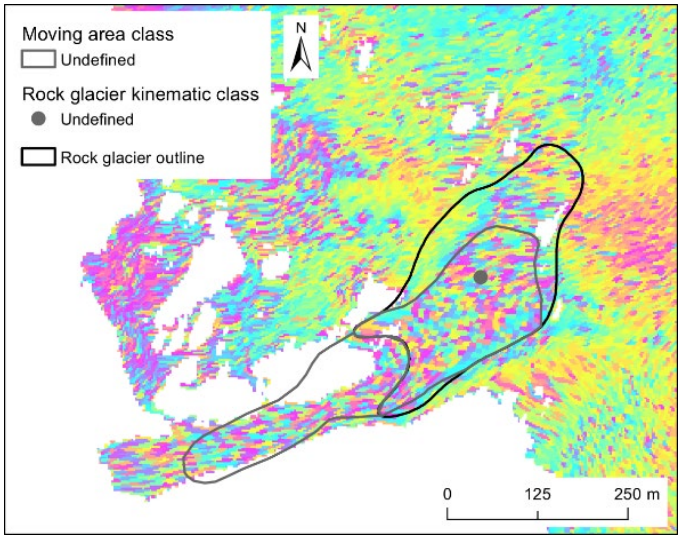
→ Scenarios of RG front advance & sediment supply to a debris-flow channel



S1: 6 days (detectable fast MA)



CSK: 16 days (decorrelation)



Valley scale: S1

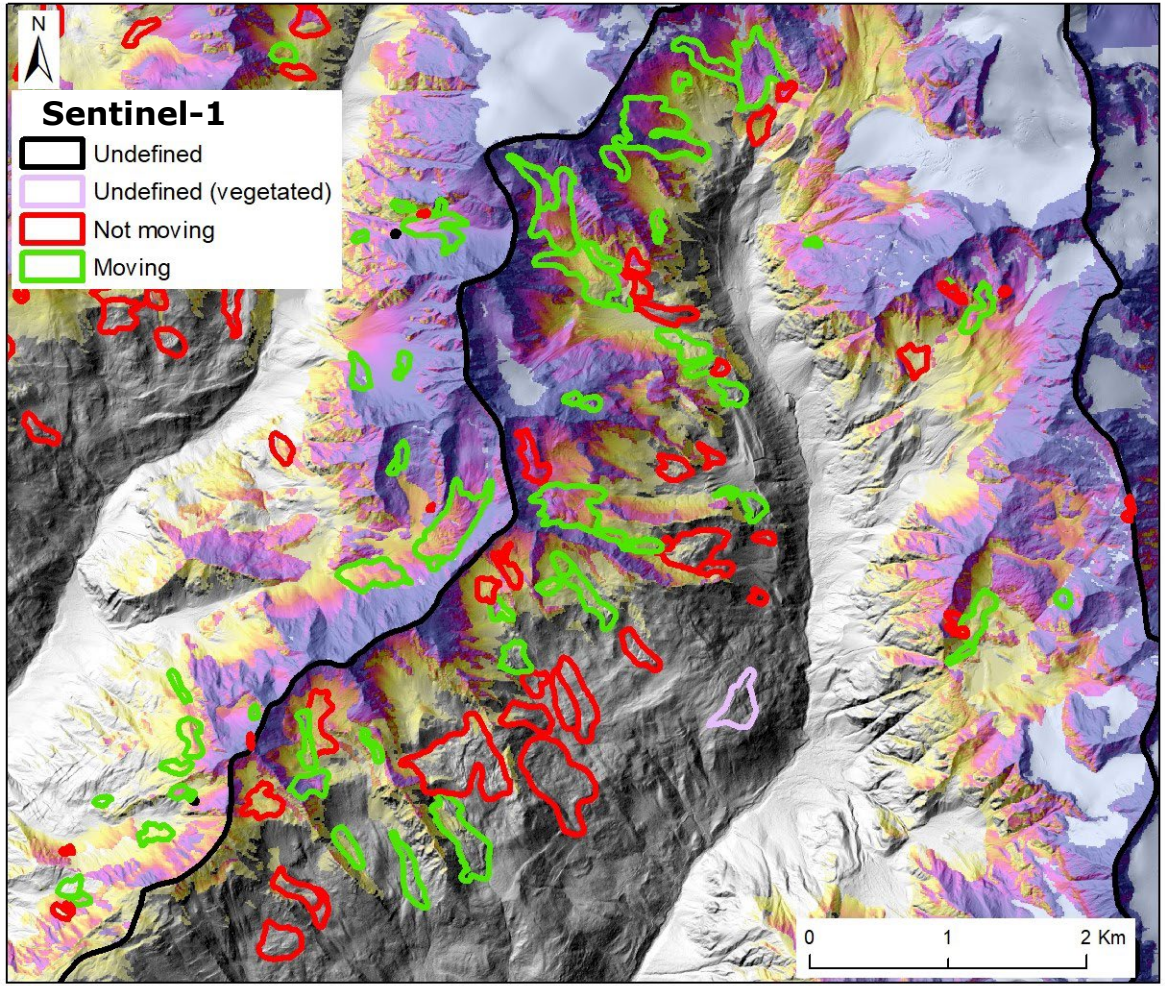
Blue: Permafrost in nearly all conditions

Purple: Permafrost mostly in cold conditions

Yellow: Permafrost only in very cold conditions

PERMANET permafrost index map

The spatial distribution of **moving** and **not moving** RGs does not follow an intuitive altitudinal gradient
→ see **red polygons** near the ridge crest



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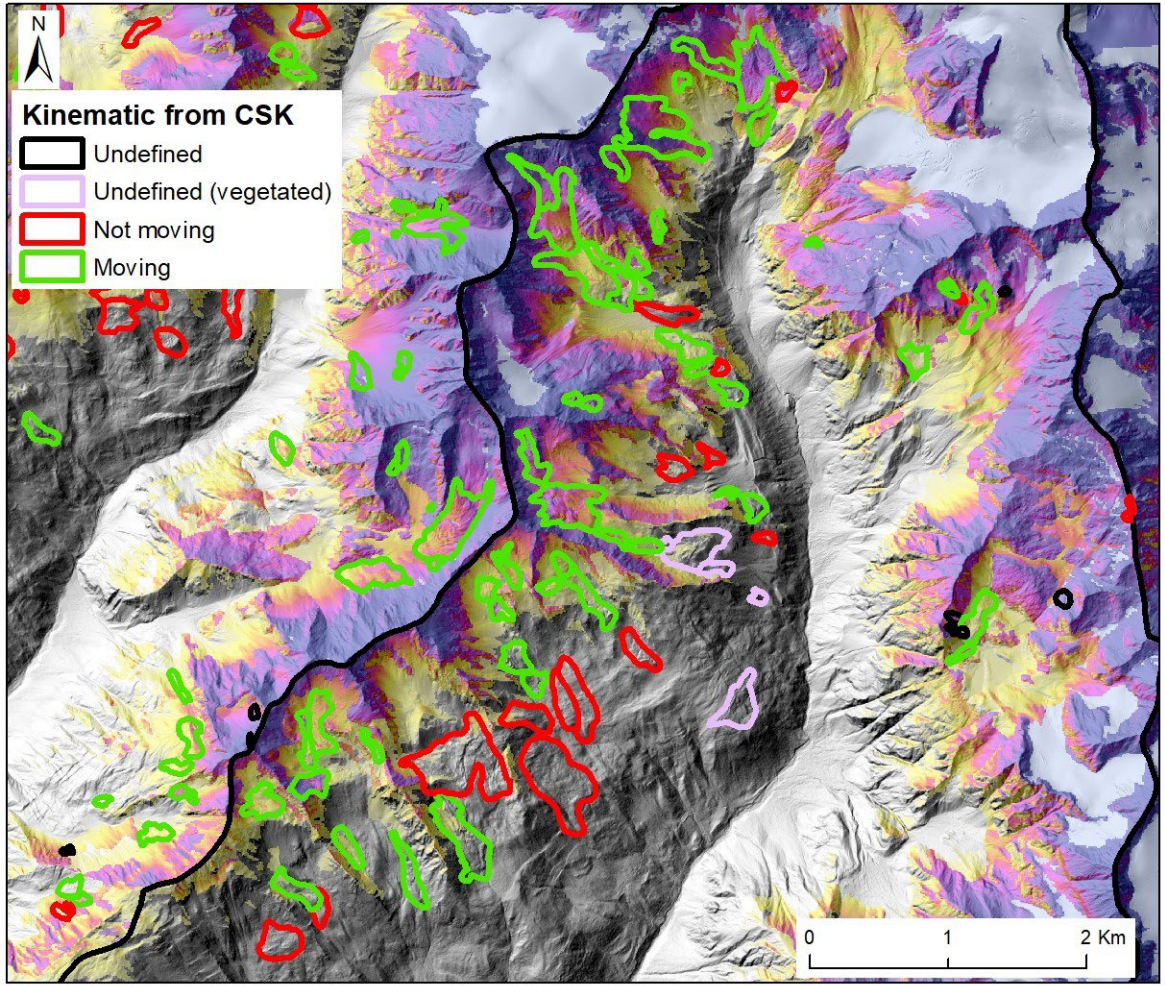
PERMANET permafrost index map

CSK detects **moving** RGs at high elevations (gap filling):
→ elevation-dependent pattern
→ S1 underestimates the occurrence of **moving** RGs in the landscape



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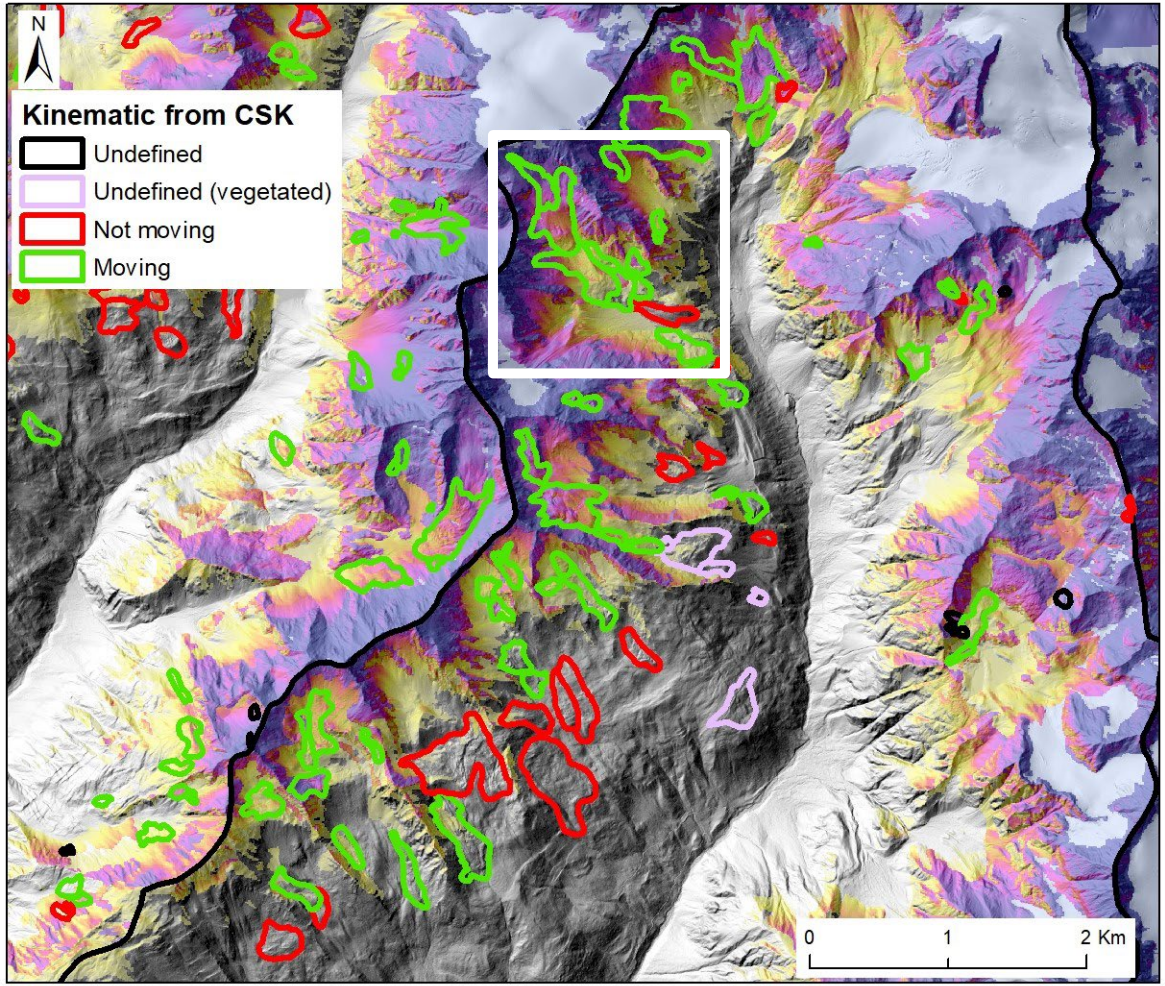
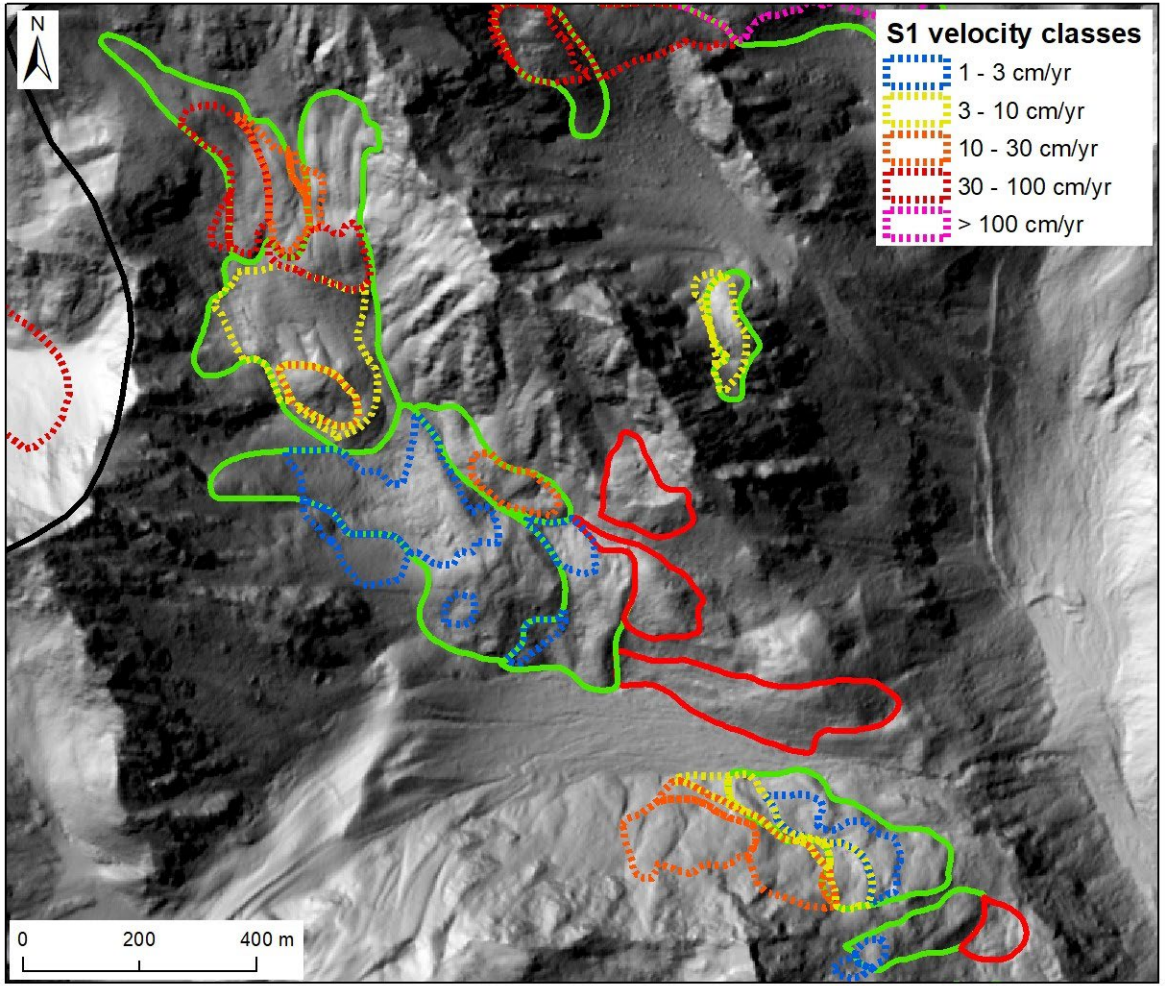


Moving areas (Sentinel 1)



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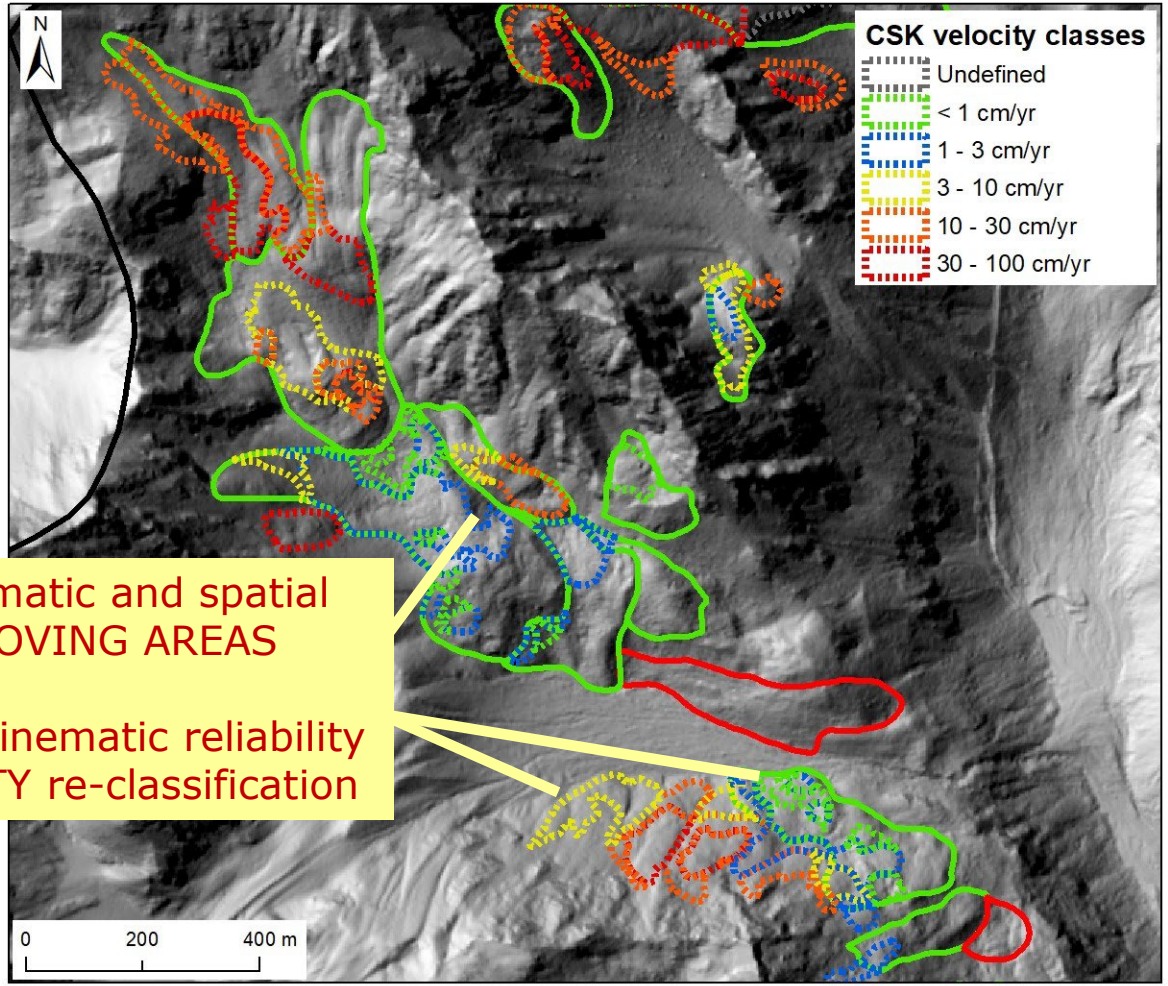
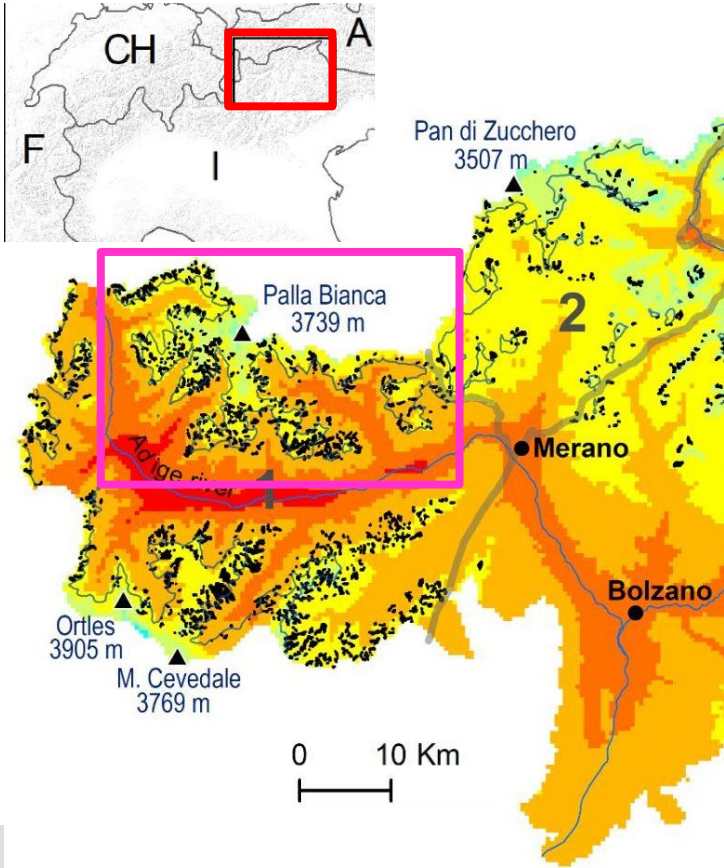


Improved kinematic and spatial resolution of MOVING AREAS lead to:
(1) increased kinematic reliability
(2) RG ACTIVITY re-classification

The added value of S1-CSK integration

In the Northern Venosta area: n = 708

1) **S1-CSK agreement** in 574 RGs (81%)
2) **CSK detects** 84 moving RGs (12%) <u>undetected</u> by S1
3) **S1 detects** 19 moving RGs (2.7%) <u>decorrelated</u> in CSK
4) **Undefined** RGs are lowered from 61 to just 24 (3.4%)



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