Earth Observation for monitoring CC impact on meteorological hazards in mountainous regions

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Introduction

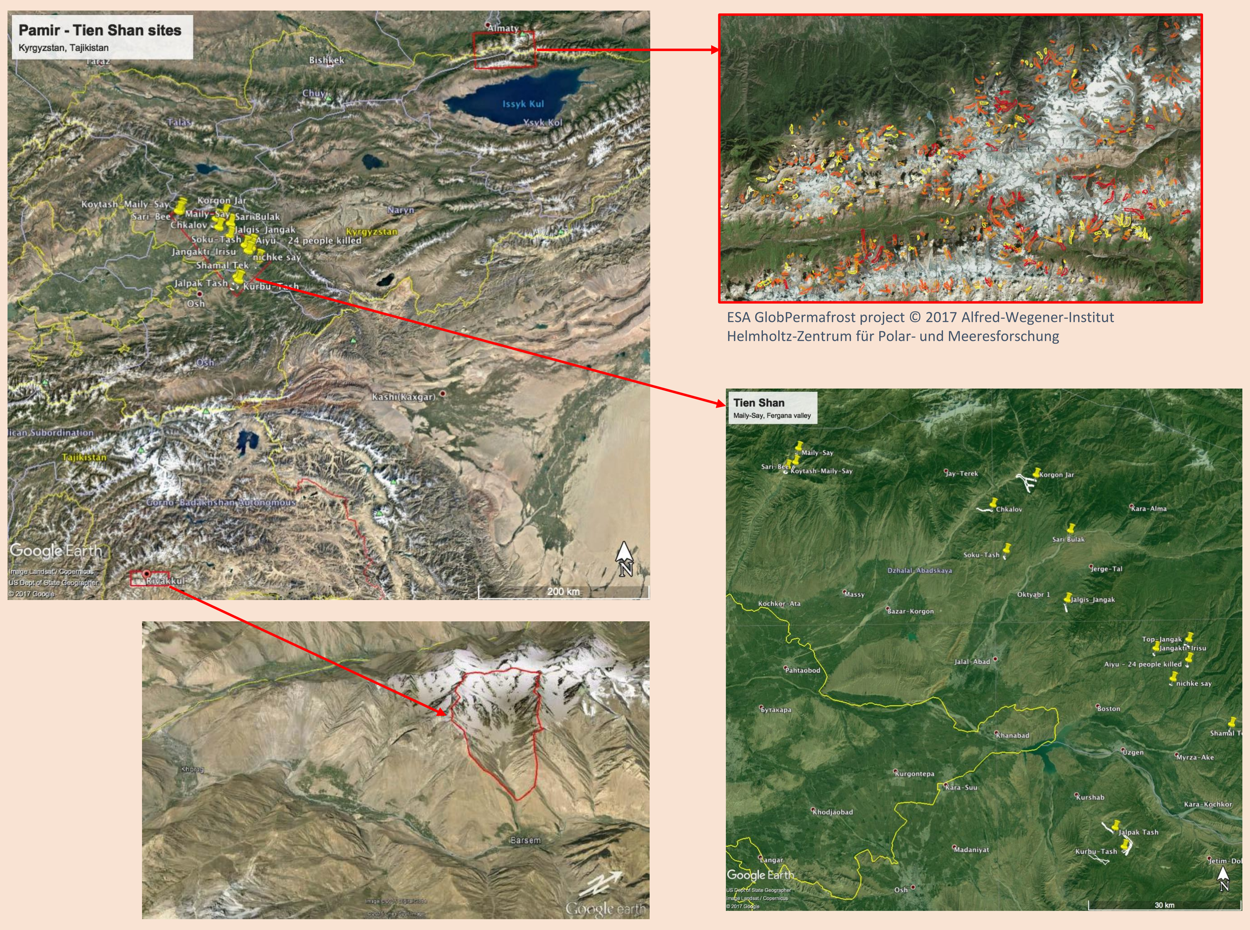
◆ **Motivation**

During the last few decades, it has been proven that **changes in climate** can affect the stability of natural and engineered slopes and have consequences on landslides (Gariano & Guzzetti, 2016). In particular, rock avalanches may be becoming larger because of rock-permafrost degradation (Coe et al., 2017).
However, still little is known about the **effects of climate** and its variation on slope stability, landslide hazards, and the related risk (e.g. Coe and Godt, 2012).

- ❑ How to monitor natural hazards evolution with EO data in relation to CC?
- ❑ What are the relationships between the natural hazard occurrence, particular meteorological conditions and CC?
- ❑ Which are ESA tools and products enabling answering these questions?

◆ **Study areas**

To investigate these issues four areas have been identified in hazard-prone developing countries of Asia. Two study areas are situated in the high and middle Kyrgyz Tien Shan mountains (Fergana valley and North Issykul lake), one area is located in the Pamir mountains (Gunt valley), another one will focus on the Himalayas (Southern Mt. Makalu). The methodology will also be tested in the European Alps, and more particularly in the South Tirol region were meteorological perturbations and climate change effects are also expected.



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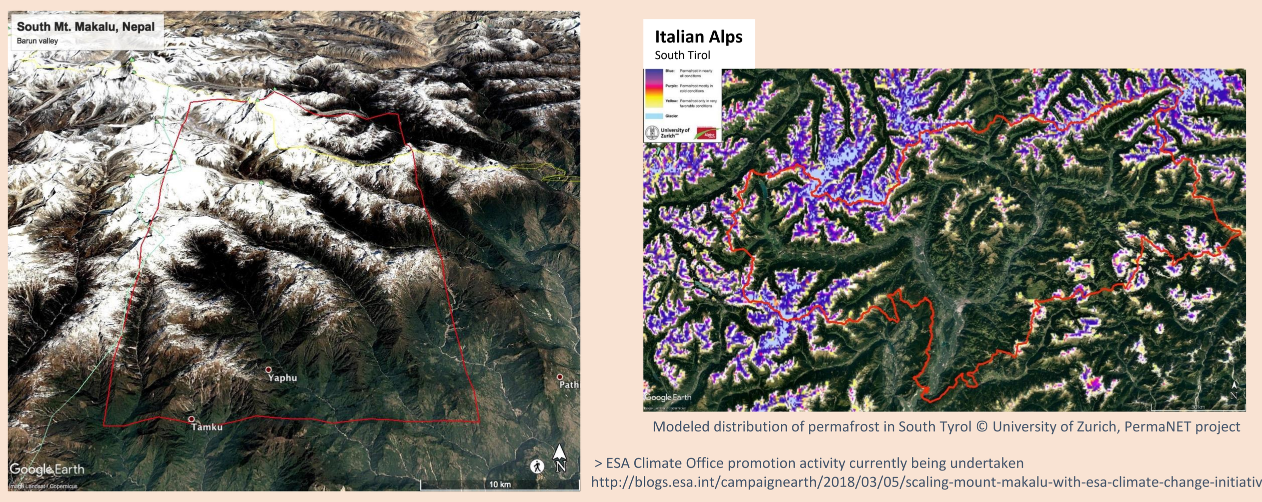


Modeled distribution of permafrost in South Tyrol © University of Zurich, PermaNET project

> ESA Climate Office promotion activity currently being undertaken http://blogs.esa.int/campaignearth/2018/03/05/scaling-mount-makalu-with-esa-climate-change-initiative/

◆ **Objectives**

- ❑ Collect long EO time series for monitoring geohazards in mountainous regions
- ❑ Detect peaks of hazard occurrence and activity
- ❑ Evaluate relationships between meteorological conditions known for triggering particular hazards
- ❑ Use climate data (CCI in particular) in a dynamic hazard assessment scheme

Materials and methods

◆ **Data for hazard(s) monitoring**

- ❑ Historical event databases, (multi-temporal if available) inventories
- ❑ C-band SAR: mainly ESR + ENVISAT + S1
- ❑ Optical: mainly LANDSAT + S2 (& HR images if available)

Monitoring type	Variable examples	EO data
Change detection	Rapid debris flow	Mainly optical
Surface deformation	Very slow moving landslide	Radar (interferometry)
Meteorological conditions	Temperature, precipitation, snow cover	Variable (RADARSAT, MODIS)
Terrestrial EVs-related	Soil moisture, glaciers and land cover	Variable (Copernicus prog)

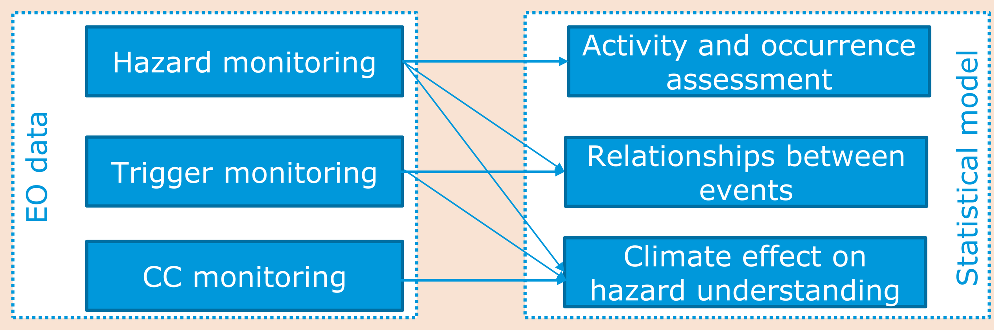
◆ **Data for trigger monitoring**

- ❑ Temperature: METEOSAT (possible from ESA GlobTemperature)
- ❑ Precipitation: Tropical Rainfall Measuring Missions (RMM) or RADARSAT, local rain gauge
- ❑ Snow cover: MODIS (or cci_snow)

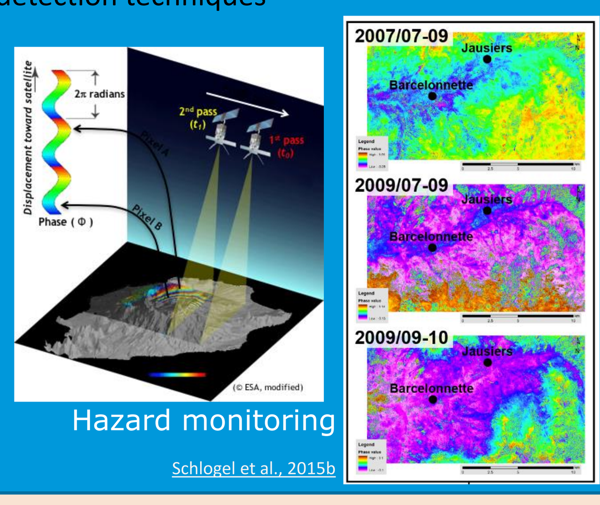
◆ **Data for environmental change monitoring and prediction**

soil moisture cci (since 80') | land cover cci (since 90') | glaciers cci (since late 90') | Climate observations IPCC

◆ **Methodology**

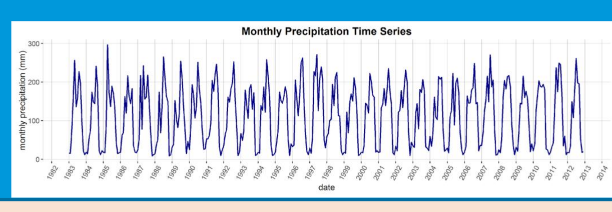


❑ Collect long EO time series to map and monitor hazard events with SAR interferometry and change detection techniques



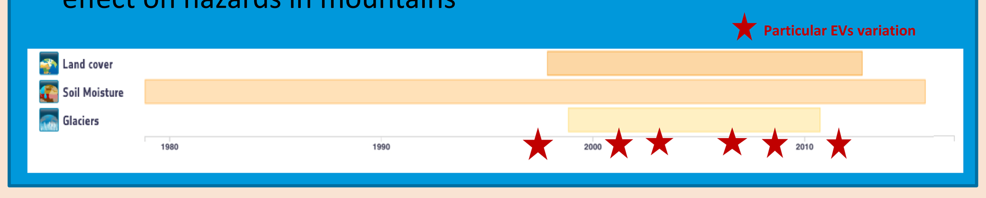
Schlogel et al., 2015b

❑ Hazard trigger assessment by independent correlation with rainfall, snow cover and temperature data and probability density function

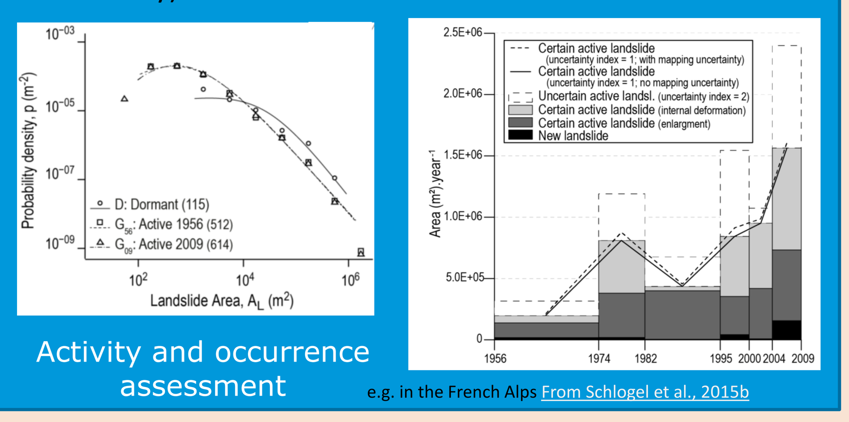


e.g. Single hazard index SPI, Standardized Precipitation Index

❑ Environmental change monitoring for improving hazard assessment and understanding real climate effect on hazards in mountains

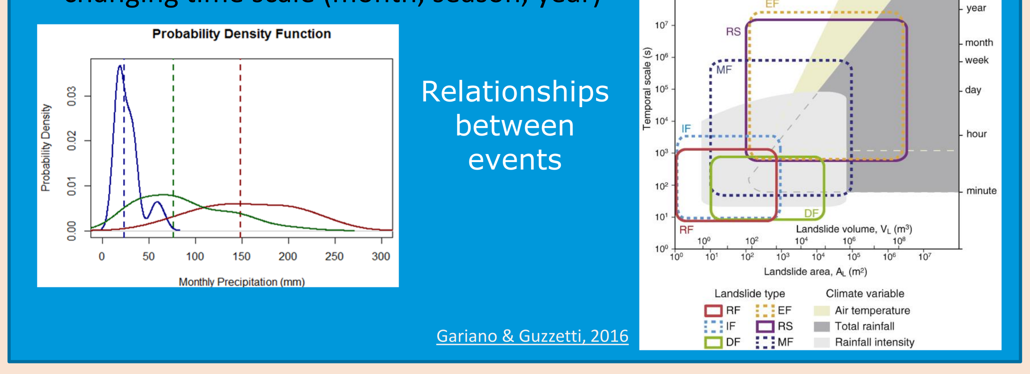


❑ Activity and occurrence assessment using historic data, or events catalogue (created by photo-interpretation, optical remote sensing analysis or field survey)



e.g. in the French Alps from Schlogel et al., 2015b

❑ Relationships between hazards and triggers by multi-parameter correlation changing time scale (month, season, year)



Gariano & Guzzetti, 2016

❑ Dynamic hazard modelling including changing parameters determining further hazard (if *more/less* events are expected) and with which *intensity*

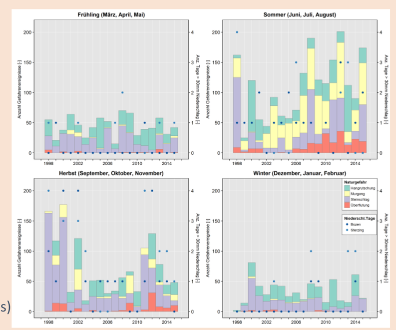
Climate effect on hazards understanding

Gariano & Guzzetti, 2016

Results

◆ **Seasonal multi-hazard activity in South Tirol province**

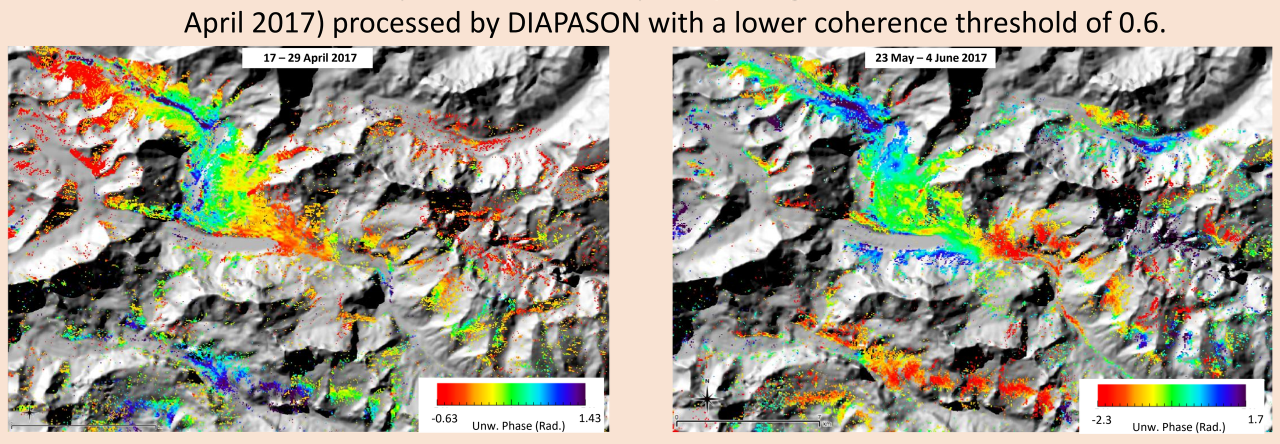
- ❑ Detection of active years according to particular meteorological hazards: 1998, 2000, 2007, 2012, 2015
- ❑ Most activity in summer and then autumn seasons, less activity in winter



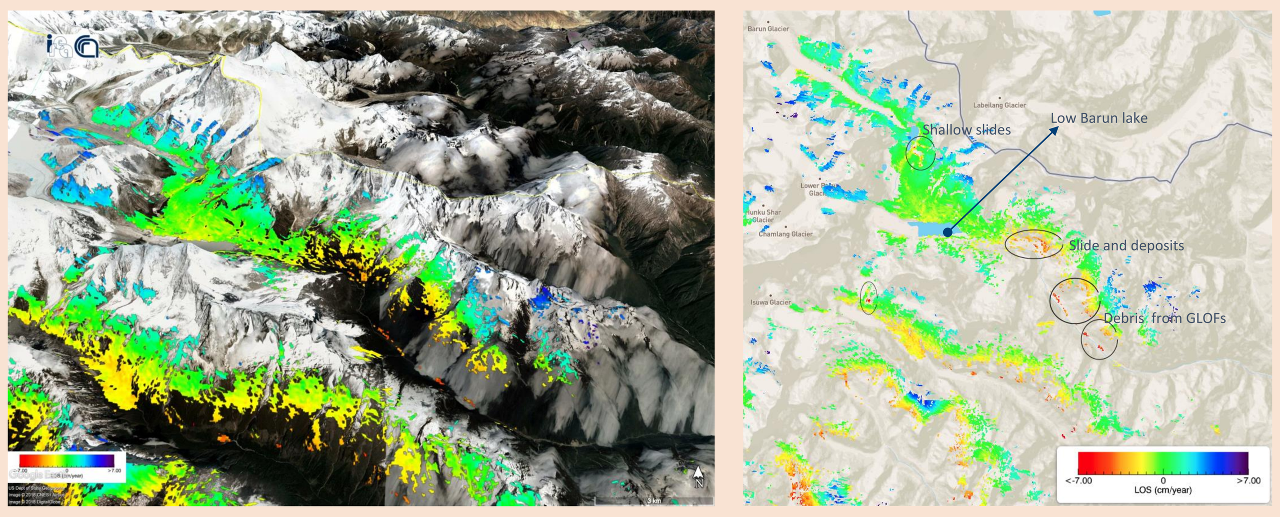
Schneiderbauer et al. (in press)

◆ **Differential SAR with DESC Sentinel-1 to monitor hazard in Barun valley, Himalaya**

- ❑ Deformation maps from two SAR pairs (during and after the main GLOF event in April 2017) processed by DIAPASON with a lower coherence threshold of 0.6.



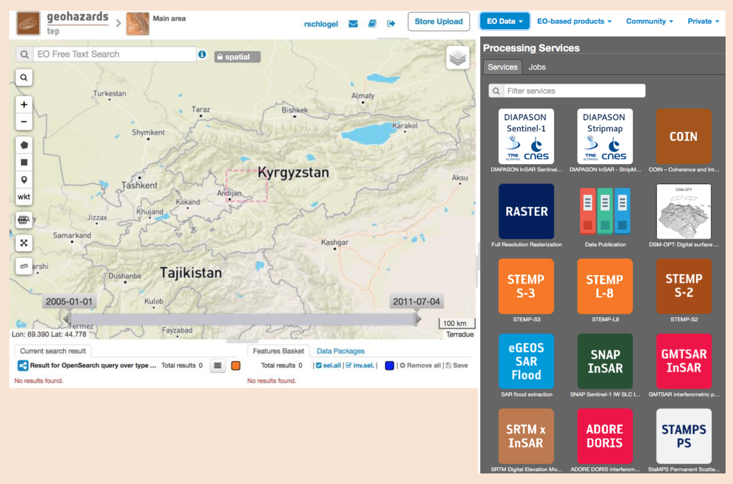
- ❑ Detection of active areas (hotspots) and periods according to magnitude differences from 26 SAR images from February to October 2017 processed using the P-SBAS technique with atmospheric correction



Discussion and outlook

◆ **Drawbacks**

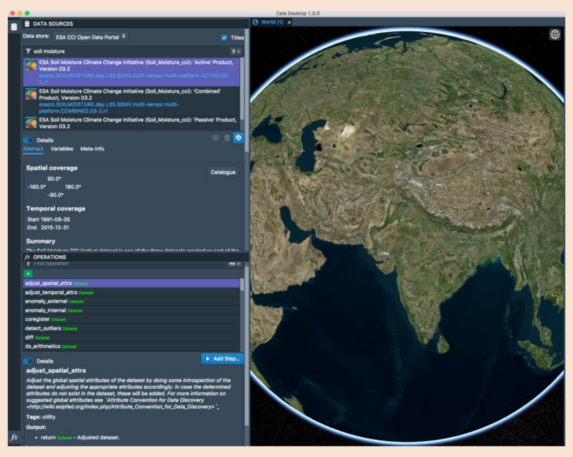
- ❑ ERS and ENVISAT data are barely available outside of Europe: incomplete results are expected for monitoring the evolution of in the magnitude of events
- ❑ Labelling different hazard events (e.g. GLOFs vs. debris flow and rock falls) from slope deformation detection
- ❑ Inventory completeness according to data availability, coverage and hazard event extent

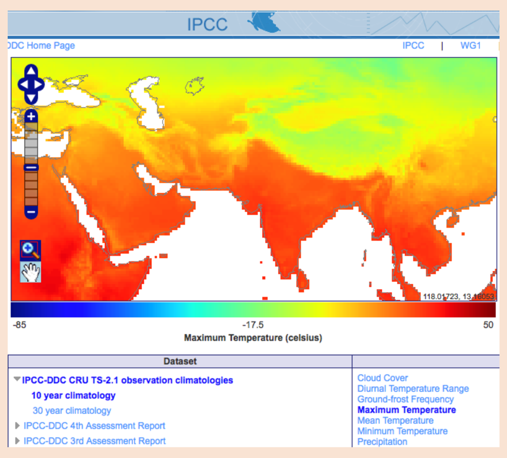


◆ **Hazard inventory collection for Kyrgyzstan and South Tirol areas, not available in Himalaya**

◆ **Further research activities**

- ❑ Database definition and preparation, reporting data limitations (availability and resolution)
- ❑ Recent hazard monitoring by EO at the **Himalayan** and **Kyrgyz** sites using ESA tools (e.g. TEP and Cate Desktop)





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