



# Twenty years of rock glaciers and periglacial slope movements analysis in the Bas-Valais (Swiss Alps)

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## Abstract

Investigations conducted for two decades on the periglacial belt of the Bas-Valais (Swiss Alps) give a detailed overview of Alpine slope movements at a regional scale. Rock glacier inventories have first been carried out over this area in the late 1990's using aerial images and field mapping. SAR Interferometry (InSAR) has then been used to characterize moving objects related to various types of mass wasting phenomena (rock glaciers, landslides, etc.). Since then, the inventories have been regularly updated using the more recent very-high resolution SAR data. In the last 15 years, terrestrial geodetic survey (DGPS, Total station, Lidar, etc.) deployed over more than 20 sites became precious source of measurements. This study intends to combine all the results and to provide a global overview of the rock glacier and periglacial slope movements evolution during the past 20 years.

**Keywords:** rock glaciers; landslides; inventories; InSAR; terrestrial geodetic survey; mountain permafrost.

## Introduction

For twenty years, large efforts have been carried out to analyze the evolution of slope movements over the periglacial belt of the Bas-Valais (Swiss Alps). In this study, existing data such as rock glacier inventories, terrestrial geodetic data (DGPS) and inventories of slope movements using InSAR are jointly used to produce a detailed overview of the evolution of rock glacier dynamics over the area of interest.

### Rock glaciers and mass movements inventories

Rock glacier inventories have first been carried out over this area in the late 1990's using aerial images and field mapping (Delaloye and Morand, 1997; Lambiel and Reynard, 2003). InSAR with high-resolution satellite radar data of the ERS-1/2 SAR and JERS-1 sensors of the 1990's with acquisition time intervals from 1 day to several years was then considered to compile a detailed overview of complex slope movements (Barboux et al., 2014). About 1500 moving objects related to various types of mass wasting phenomena (rock glaciers, landslides, etc.) with displacement rates from a few

centimeters to several meters per year were identified. Classification of the process types and validation of the spatial extent was done using optical imagery. Results were then considered in the set-up of in-situ monitoring sites (Delaloye et al., 2010).

The inventories are now regularly updated using the more recent very-high resolution SAR data. The new TerraSAR-X and CosmoSkyMed SAR data for instance, (spatial resolution  $\sim 3\text{m}$ ), permit to better spatially characterize the displacement rates. In addition, Sentinel-1, with acquisitions available every 6 days, is suited to characterize changes of surface motion over time (Caduff *et al.*, 2017). More sophisticated processing approaches, like Persistent Scatterer Interferometry (PSI), Short Baseline Interferometry (SBAS) or offset-tracking (Strozzi *et al.*, 2002; Barboux *et al.*, 2015), are also used to quantitatively detect points moving with velocities below a few cm/yr, below several dm/yr and more than 1 m/yr, respectively.

### In-situ measurements

In the last 15 years, terrestrial geodetic survey (DGPS, Total station, etc.) became precious sources of data. DGPS measurements have been performed on more