Periglacial slope dynamics on the southern Qinghai-Tibetan Plateau revealed by FLATSIM InSAR time series

Hugo Watine*†[1], Simon Daout[1], Jérôme Lavé[1], Marie-Pierre Doin[2], Philippe Durand[3], and Flatsim Working Group

[1]Centre de Recherches Pétrographiques et Géochimiques – Institut National des Sciences de l'Univers, Université de Lorraine, Centre National de la Recherche Scientifique, Institut National des Sciences de l'Univers : UMR7358, Centre National de la Recherche Scientifique : UMR7358 – France

[2]Institut des Sciences de la Terre – Institut de Recherche pour le Développement, Institut National des Sciences de l'Univers, Université Savoie Mont Blanc, Centre National de la Recherche Scientifique, Université Gustave Eiffel, observatoire des sciences de l'univers de Grenoble, Université Grenoble Alpes – France

[3]Centre National d'Études Spatiales – Centre National d'Etudes Spatiales - CNES (Toulouse, France) – France

Résumé

The Peikucuo catchment, located in the southern Qinghai-Tibetan Plateau (QTP), is characterized by a high-altitude periglacial landscape with limited precipitation. Seasonal thawing and refreezing of excess ice in frost-sensitive materials of the active layer lead to cycles of ground heave and subsidence, which, on slopes, induce the slow downslope movement of soil known as solifluction. This process plays a significant role in shaping periglacial landscapes and may contribute substantially to soil and rock debris transport along hillslopes. The QTP, like the Arctic, is highly sensitive to climate warming, and recent studies have reported an apparent acceleration of solifluction and ground subsidence. Spatial geodesy techniques such as Multi-Temporal Synthetic Aperture Radar Interferometry (MT-InSAR) offer the opportunity to monitor the spatial distribution, dynamics, and temporal evolution of these slow-moving processes.

Here, we applied a post-processing approach to MT-InSAR data from the FLATSIM service (FormaTerre LArge-scale multi-Temporal Sentinel-1 InterferoMetry) over a sub-region around Peiku lake. For each ascending and descending track, we implemented a specific workflow to improve interferogram unwrapping, filtered displacement time series to remove long-wavelength geodynamic signals, and performed a temporal decomposition to extract surface velocities, seasonal cycles, and their evolutions. Finally, by inverting results from both viewing geometries, we estimated slope-parallel and slope-normal motion components. This method allowed us to cross-correlate measurements with morphometric parameters, quantify the impact of slope-normal heave-subsidence cycles on downslope solifluction activity, and analyze the recent evolution of these surface processes.

Our method effectively isolated and quantified frost-heave and downslope processes, showing

*Intervenant

†Auteur correspondant: hugo.watine@univ-lorraine.fr

that solifluction movements are significant and widespread across different terrains in the QTP. However, approximately 94% of the identified areas with downslope velocities exceeding 5 mm/year occur within permafrost areas, suggesting that the presence of permafrost is a critical factor for sustaining rapid slope dynamics across the region. Furthermore, high-velocity zones show low slope-normal seasonal amplitudes, suggesting that solifluction is primarily driven by basal shearing and shallow diurnal freeze-thaw cycles, likely due to limited frost-susceptible layer thicknesses. Additionally, we observed increasing frost-heave amplitudes and irreversible subsidence, indicating ongoing permafrost degradation which may, in turn, increase hillslope erosion through solifluction processes.

Mots-Clés: InSAR, Solifluction, Flatsim, Permafrost, Tibet