

Improving the reliability of InSAR time series in periglacial environments using FLATSIM products

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Abstract:

The Tibetan Plateau is characterized by extensive periglacial landscapes. In such environments, seasonal freezing and thawing of the uppermost ground layer result in cyclic surface movements driven by expansion and contraction associated with water phase changes. On slopes, the regolith cover responds to these freeze–thaw cycles, generating slow downslope mass movements (mm/yr) known as solifluction. With ongoing climate warming, ground freezing conditions are evolving, impacting these processes and potentially leading to slope destabilization through rapid failure. Remote sensing provides an opportunity to monitor such movements using InSAR. Based on Sentinel-1 acquisitions, the CNES–ForM@Ter FLATSIM products offer a unique opportunity to monitor and map these processes on a large scale.

However, in such environments, rapid changes in soil moisture and ground heave can lead to unwrapping errors when the unwrapping path crosses areas with high phase gradients, potentially inducing 2π ambiguities in the unwrapped phase. Moreover, rapid variations in soil moisture introduce a systematic phase component, particularly in short temporal baseline interferograms, which biases SAR time series. Here, we present the processing strategies we use to mitigate these two issues, in order to minimize phase aliasing and biases in InSAR time series over periglacial terrains using FLATSIM products. The first correction is applied prior to the critical phase unwrapping step, where a seasonal deformation model, derived from the raw FLATSIM product, is subtracted from the interferometric phase to reduce phase variability in areas with strong phase gradients. After unwrapping the reduced phase, the seasonal model is added back to each interferogram to reconstruct the full unwrapped signal. To mitigate bias, short temporal baseline interferograms are excluded, and the remaining interferograms are weighted by their temporal baseline during the time-series analysis. Overall, this strategy enhances the reliability of InSAR time series in periglacial environments, providing robust data for monitoring periglacial dynamics and their evolution across the Tibetan Plateau.