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Impact of rainfall and snowmelt on unstable slope destabilisation using wavelet analysis (Séchilienne, French Alps)

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Increase of pore water pressure in hillslopes after rain events is one of the main triggering factors of deep seated landslides. To our knowledge, few investigations have been carried out yet to understand relationships between precipitation amount and unstable slope destabilization on long time series (> several years). Wavelet analysis has become a powerful technique to investigate the variability of hydrological response (rainfall-discharge relationships). Decomposing a time series into time-frequency space, this method localizes power variations within a time series. It is ideal for analyzing non-stationary signals and identifying short- to long-term periodic phenomena. In this setting, we hypothesis that wavelet was a pertinent tool to characterize precipitation-displacement relationships on unstable slopes. Using wavelet analysis, this work aims to characterize the impact of precipitation on unstable slope displacement in a mountainous area where snowmelt is an important component of the annual water balance. The study site is the Séchilienne deep seated unstable slope located in French Alps. The unstable slope is monitored at a daily rate since about 20 years, by several displacement stations and a meteorological station which allows estimating rainfall and snow melt amount. A strong spatial heterogeneity for displacements intensity and direction with zones more active than others is observed. We applied wavelet analysis on the two recharge components (i.e., rainfall and snowmelt) and on two displacement stations in order to compare the spatial variability of recharge influence in the two main slope destabilization zones. The main results show that rain and snowmelt components have a different influence on the destabilization, and that only the most active zone is sensitive to recharge variations. We showed that there was an evolution of slope displacement, especially in the last 4 years with a strong velocity increase. In the most active zone, displacement was affected slightly at a short time scale (< several months) by main rainfall events, and was highly impacted by snowmelt at an annual scale. In the last four years, snow melting was more important due to a pluri-annual series of cold winter. From this date, rainfall impact on the destabilization begun to be significant, meaning that a threshold may have been reached after series of harsh winter allowing rainfall recharge to play also a role in the destabilization. Consequently, from this analysis one may suppose that snow melt is the main key process driving destabilization of the unstable slope. Finally, this study highlights the effectiveness of wavelet analysis in characterizing destabilization of complex unstable slopes with a naturally high level of non-linear hydrological behaviour.