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A Sentinel-1 InSAR study for monitoring landslide movement in the Rules Reservoir

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The Rules Reservoir is located in the Guadalfeo River to the south of Sierra Nevada (Betic Chain, SE Spain). This reservoir has a storage capacity of 117 hm3 and it supplies water to the populations, subtropical crops and greenhouses in the coast of Granada. The construction of the reservoir presented difficulties due to the instability of the substrate. Such instability is still active and it has been evidenced by several studies but not in great detail. We have analysed the area by means of InSAR techniques to confirm the existence of ground displacement due to landsliding. We produced a surface velocity map and displacement time series in the reservoir surrounding slopes by processing 139 radar images of the Sentinel-1 (A and B) satellite on ascending orbits from 10 March 2015 to 20 September 2018. A methodology developed in the CTTC (Centre Tecnològic de Telecomunicacions de Catalunya) was used to process the images and measure the surface displacements.

The identified areas with the greatest displacement rates were mainly two: (1) the south end of the Rules Reservoir Viaduct, with velocities ranging from 2 to 2.5 cm/year; and (2) the central part of the western hillside of the reservoir, with velocities around 3 cm/year. The pillars, on which the unstable part of the Rules Reservoir Viaduct rest, stand on a slope where a landslide was already identified and delimited. The observed movement demonstrates that the structural measures applied in this part of the viaduct have not totally mitigated the instability of the slope. In the case of the western hillside of the reservoir, the displacement is associated to a large landslide, not documented up to date. This slope a priori does not show clear morphologies to map an active landslide but this new InSAR results may help in the delimitation of a sliding body.

In both cases, the phyllite rocks may be the main conditioning factor for the observed landsliding due to the general instability observed in the slopes formed by these materials. Moreover, we infer that the acceleration and reactivation of the landslides could have an anthropic origin due to the continuous changes in the water level of the reservoir.

The presented results show how Sentinel-1 images can be used in the monitoring of the slopes that surround reservoirs and bridges. This is an important application to avoid disasters such as the Vaiont or San Francis dam failures. On the other hand, the results also give an example of bridge monitoring through InSAR techniques that can represent essential data to manage the deformation caused by landslides on this structures.