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Real-time Rockfall Detection System with Automatic Road Closure and Reopening using Doppler Radar Technology at the Ruinon Landslide, Italy

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Transportation corridors in mountain regions are often situated at the bottom of narrow valleys. Changing slope stability conditions can put these routes at critical risk. Slope stabilization works (e.g., rock scaling, blasting) or structural protection measures (e.g., rock sheds, reinforced embankments, tunnels) are not always feasible or may not be cost-effective due to low average daily traffic or the expected event size. Route SP29 is the main connection road to Santa Catarina, a popular tourist resort in the Frodolfo River Valley, Lombardy, Italy. The Ruinon landslide is a major slope instability involving approximately 30 million m³ of rock and debris and causes repeated rockfalls that can reach as far as the road.

We present a Doppler radar system for real-time rockfall detection and immediate road closure in case of an event. The rockfall radar permanently monitors the landslide area from the opposite side of the slope with a range of more than 1 km to the upper scarp. Radar technology works reliably regardless of visibility, i.e. in rain, fog or snowfall as well as at night. After an initial calibration period in summer 2020, we activated automatic road closure and reopening in case of a rockfall event; upon detection of rockfall in a defined region of interest, the radar system automatically switches the traffic lights to red. If the rock fall event reaches a defined zone near the road or the road itself, it remains closed and requires manual reset after site inspection with webcams at the radar site and the traffic lights. If the rockfall event remains above the road, then the radar system automatically releases the road again after 90 seconds. Automatic notifications about the status are sent to authorized user via email and SMS. In addition to the deployment of the alarm system using Doppler radar, the embankment along the endangered road section was reinforced and raised. These combined measures of protection structures and alarm system aim at maximising the opening hours of the street while providing the highest possible level of protection. Between July (installation) and December 2020, 60 rockfall events caused a road closure, with the road being automatically reopened by the system in approximately 85% of cases.