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Rockfall monitoring of a poorly consolidated marly sandstone cliff by TLS and IR thermography

Caroline Lefeuvre, Antoine Guérin, Dario Carrea, Marc-Henri Derron, and Michel Jaboyedoff
Université de Lausanne, ISTE, Switzerland (lefeuvrecaroline05@gmail.com)

The study area of La Cornalle (Vaud, Switzerland) is a 40 m high south-west facing cliff which is also part of a larger landslide (Bersier 1975 ; Parriaux, 1998). The cliff is formed by an alternation of marls and sandstones. The thicknesses of sandstone layers range from 0.5 to 4 meters. The rockfall activity of this cliff is high, with an average of one event per day. The aim of this study is to better understand the links between rockfall activity, cliff's structures, and weather and thermal conditions.
The 3D surface evolution of the Cornalle cliff is monitored approximately every month since September 2012 using a Terrestrial Laser Scanning (TLS) data in order to get a monthly inventory of rockfall events. Since November 2013, a weather station located 150 meters away from the cliff collects data such as temperature, humidity, atmospheric pressure, rain and solar radiation every 15 minutes. Furthermore, we also fixed a thermic probe in the sandstone at 10 cm deep which measures temperature every 10 minutes.
A detailed analysis has been performed during a short period (01/29/2016-04/08/2016) and pointed out a correlation between daily rainfall and rockfall. We found that a fall occurred the day or the day after a cumulative daily rainfall of at least 10 mm/day.In parallel to this monthly monitoring, the northwest part of La Cornalle cliff (the most active part) was monitored for 24 consecutive hours in July 2016 (from 12:30 to 12:30) using infrared thermography and crackmeters with a precision of 0.01mm. We collected a series of thermal pictures every 20 minutes, and measured the opening of a crack in sandstone layers every hour.
We observed that marls are more affected by external changes of temperature than sandstones. Their surface temperature rises (resp. falls) more with an increase (resp. decrease) of external temperature than sandstones.
Crackmeters measured an opening of the crack with an increase of the rock temperature and the opposite displacement (crack closing) happened with a decrease of temperature. The maximal amplitude of cumulated displacements measured is 0.15 mm. In terms of uncertainty, note that until 30% of the measured displacement can be related to instrument thermal dilatation.
Finally, a multilayer model of daily thermal variations, including air temperature, solar radiation, rock temperature and thermal imaging is in development to assess the effect of temperature on unstable blocks and fracture opening, as demonstrated recently by Collins and Stock (2016).

References

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