Landslides and climate changes: insights from Mediterranean test cases

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ABSTRACT

Although several significant landslide events have occurred in recent years around the world [1] ongoing and expected variations affecting the magnitude and frequency of weather-induced landslides has met limited interest of researchers and policy-makers mainly compared with interest in other geo-hydrological hazards (i.e. droughts or pluvial flooding) where the link with potentially climate change induced increases is widely debated [2,3]. Nevertheless, the Mediterranean area present several test cases in which the influence of changes in climate variables on the frequency and the magnitude of landslides is analysed [3]. The geomorphological, geological and climatic variability of Italy makes the analyses more challenging [4]. Currently, the most reliable and consolidated simulation chain to assess future variations in landslide activity entails the adoption of physically based climate simulations driven by assessments on future pathways of greenhouse gases provided by future socio-economic scenarios. Such data are used as input for landslide models. The current weaknesses in climate modelling prevent adopting "raw" data but require the adoption of post-processing statistical approaches known as "bias correction" procedures [5]. Such brief excursus highlights the relevance of a proper identification of source and magnitude of uncertainties associated to the main elements of the assessment of climate change impact on landslides. In this regard, the work tests, for each element of the simulation chain, several options to verify which the elements are characterized by higher uncertainty and to understand how it can affect direction and magnitude of trends. As test case, landslides affecting pyroclastic layers of Campania Region (Southern Italy), frequently interested by weather-induced events in the last years are considered [6]. They usually exhibit null/very low cohesion values while the suction contribution permits them to be stable also on slope steeper than the effective friction angle. However, rainfall-induced soil wetting can reduce resistance suction contribution inducing slope instability. The main features of such covers (e.g. high porosity or hydraulic conductivity intermediate between that of coarse and fine soils, 10^-6÷10^-7 m/s) entails that the triggering is regulated by joint actions of the water exchanges between soil and atmosphere for several months acting as antecedent/predisposing factors and a heavy rainfall event acting as trigger for slope movements [7]. In this regard, the test case results particularly interesting as the area is expected experiencing contrasting trends, beneficial (B) or detrimental (D) to slope stability: significant temperature increases (then more atmospheric evaporative demand, B), lower cumulative rainfall values in already drier periods (B) but increases in the wettest ones (D), less rainy days (B), more severe and more frequent heavy rainfall events (D). Although a general worsening in slope stability conditions is returned under all the different simulation chains, its expected severity highly vary in the different modelling configurations [8].

REFERENCES

[1] Froude, M.J. and Petley, D.N.: Global fatal landslide occurrence from 2004 to 2016, Nat. Hazards Earth Syst. Sci., 18, 2161-2181, https://doi.org/10.5194/nhess-18-2161-2018, 2018.

[2] Ciscar, J.C., Feyen, L., Soria, A., Lavalle, C., Raes, F., Perry, M., Nemry, F., Demirel, H., Rozsai, M., Dosio, A., Donatelli, M., Srivastava, A., Fumagalli, D., Niemeyer, S., Shrestha, S., Ciaian, P., Himics, M., Van Doorslaer, B., Barrios, S., Ibáñez, N., Forzieri, G., Rojas, R., Bianchi, A., Dowling, P., Camia, A., Libertà, G., San Miguel, J., de Rigo, D., Caudullo, G., Barredo, J.I., Paci, D., Pycroft, J., Saveyn, B., Van Regemorter, D., Revesz, T., Vandyck, T., Vrontisi, Z., Baranzelli, C., Vandecasteele, I., Batista e Silva, F., Ibarreta, D.: Climate Impacts in Europe. The JRC PESETA II Project. JRC Scientific and Policy Reports, EUR 26586ENO.C. Zienkiewicz and R.C. Taylor, *The finite element method*, 4th Edition, Vol. 1, McGraw Hill, 2014.

[3] Gariano, S.L., and Guzzetti, F.: Landslides in a changing climate. *Earth-Science Reviews* 162, 227–252, 2016.

[4] Picarelli, L., Comegna, L., Gariano, S.L., Guzzetti, F., Mercogliano, P., Rianna, G., Santini, M., Tommasi, P.: Potential climate changes in Italy and consequences for land stability, in: Ho, K., Lacasse, S., Picarelli, L. (Eds.) Slope Safety Preparedness for Impact of Climate Change, CRC Press, 151-198, 2016, ISBN 9781138032309

[5] Wilby, R.L.: Climate Change in practice Cambridge University Press, ISBN: 9781316534588, 2017.

[6] Pagano, L., Picarelli, L., Rianna, G., and Urciuoli, G.: A simple numerical procedure for timely prediction of precipitation-induced landslides in unsaturated pyroclastic soils. Landslides 7(3), 273–289, 2010.

[7] Rianna, G., Pagano, L., and Urciuoli, G.: Rainfall patterns triggering shallow flowslides in pyroclastic soils. Engineering Geology 174, 22–35, 2014.

[8] Rianna, G., Reder, A., Mercogliano, P., and Pagano, L.: Evaluation of variations in frequency of landslide events affecting pyroclastic covers in Campania Region under the effect of Climate Changes. Hydrology 4(3):34, 2017.