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## Reply on RC2

Diego Guenzi et al.

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Author comment on "Brief communication: Monitoring a soft-rock coastal cliff using webcams and strain sensors" by Diego Guenzi et al., Nat. Hazards Earth Syst. Sci. Discuss., <https://doi.org/10.5194/nhess-2021-155-AC2>, 2021

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**This brief communication presents an interesting monitoring approach, but the scientific presentation could be more sophisticated in general. A clear description of how the monitoring could be applied for predicting purposes specifically would be of interest to the reader. In some parts, a distinction between promoting and triggering processes could be advantageous.**

Thank you for your positive comment. We apologize about the limited scientific discussion presented in the manuscript, but this is related to the limited space available in a brief communication, so we focused on the presentation of the monitoring system and the interpretation of the results recorded so far. However, the monitoring system discussed here is based on the integration of advanced optical systems and traditional crackmeter devices. Currently, such integration of monitoring techniques allows detecting the failure mechanisms active in the study area, the rock volumes involved and the promoting factors which favor such processes. Moreover, it let us derive a quantitative assessment of the evolution of rock displacement trend over time, via the crackmeter measurements, which could be related to specific triggering environmental factors (i.e.: rainfalls, temperature, wave storms...). Therefore, prediction can be mainly pursued by means of the information gained via the crackmeter, although some precursory signs can be identified by means of the optical techniques, but, in the near future, computer-vision techniques applied to the digital images could be also used to derive information on the potential evolution of the rock cliff in near-real time.

A detailed discussion regarding the promoting and triggering factors related to the rockfalls active in the study area is reported in (Lollino et al. 2021). Promoting factors are supposed to be represented by the cliff geometry, the fracturing degree, the geostructural and lithological setup, the rock mechanical properties, whereas the triggering factors can be primarily identified in significant wave storms, but also rainfall events and temperature variations.

### **I 14 / 16 / 95 : you only use 1 crackmeter**

Yes, you are right. We modified the sentences you reported to use the singular. Moreover, we added a sentence at the end of the discussion to underline the reason of our choice of using a single crack meter ("The choice of using a single strain sensor is only due to the fact that we are experimenting a very low-cost monitoring system; in other cases, this system can be extended with as many crack-meters as needed").

### **I 17 / 29 : the precursor signal is a result of the triggered instability, not the other way round**

Thank you for your reporting: we modified both sentences changing “[...] that may trigger [...]” with “[...] that could be triggered by [...]”.

#### **I 24 : subclause needs rearrangement**

We modified the sentence: “Actually, brittle failures frequently occur along these cliffs [...]” has been changed to “Along these cliffs, brittle failures are frequent [...]”.

#### **I 32 / 37 / 61 : position of expression of time**

Thanks: we moved “in the last decades”, “in the last years” and “in real time” at the end of the corresponding phrases.

#### **I 36 : how is brittle failure characterized in rock of low mechanical strength?**

Laboratory testing carried out by the authors on rock samples taken from the study area (or of the same typology) has confirmed that even rock of low mechanical strength can exhibit brittle failure (Lollino & Andriani 2017, Perrotti et al. 2020).

#### **I 41f : is there literature on this topic?**

Thank you for your note: we added a few more references to better explain our sentence:

A) Intrieri E., Gigli G., Nocentini M., Lombardi L., Mugnai F., Fidolini F., Casagli N.: Sinkhole monitoring and early warning: An experimental and successful GB-InSAR application. *Geomorphology* 241, 304–314.

<https://doi.org/10.1016/j.geomorph.2015.04.018>, 2015

B) Allasia P., Godone D., Giordan D., Guenzi D., Lollino G.: Advances on Measuring Deep-Seated Ground Deformations Using Robotized Inclinator System. *Sensors*, 20, 3769.

<https://doi.org/10.3390/s20133769>, 2020

C) Herrera G., López-Davalillos J.C.G., Fernández-Merodo J.A., Béjar-Pizarro M., Allasia P., Lollino P., Lollino G., Guzzetti F., Álvarez-Fernández M.I., Manconi A., et al.: The differential slow moving dynamic of a complex landslide: Multi-sensor monitoring. In *Proceedings of the 4th World Landslide Forum, Ljubljana, Slovenia, 29 May–2 June 2011*

#### **I 54 : what means “regularly analysed”?**

For the sake of clarity, we removed “regularly”.

#### **I 56 : how did you use ICC?**

We have made our sentence clearer, modifying line 55/56 from “This can be achieved either manually or using artificial intelligence techniques (i.e. Image Cross-Correlation - ICC) [...]” to “This can be achieved either manually or using artificial intelligence techniques (i.e. Image Change Detection) [...]” and line 75/76 from “Based on such information and the application of ICC techniques [...]” to “Based on such information and the application of Image Change Detection techniques [...]”.

#### **I 73 / 84 / 104 : It is to expect that rockfall frequently happens during severe storms and bad weather conditions. How do you deal with that?**

You are absolutely right. Currently, we have started the procedures with the local authorities to have the possibility to connect our system to the public power grid but bureaucracy is terribly slowing us.

#### **I 79 : do you mean “anthropogenic”?**

Yes, thanks. We modified the wording.

#### **I 83 : how is the opening trend measured by the crackmeter used for predicting an imminent failure?**

First of all, we have to say that the data recorded with the crackmeter until now is not sufficient either to derive a clear displacement trend or to predict imminent failures. Moreover, the purpose of our monitoring system is to obtain an indication of a relationship between the displacement trend measured by the crackmeter and on-going cliff failures,

to be related with the information gained from the digital images. In other words, we are using optical images for monitoring rock cliffs where crackmeter measurements represent a sort of validation through conventional devices.

**I 96 : "a couple of years" = 2 years**

We changed "[...] a couple of years [...]" with "[...] the last two years [...]", to be clearer.