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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Landslide displacement prediction using the GA-LSSVM model and time series analysis: a case study of Three Gorges Reservoir, China" *by* Tao Wen et al.

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Response to Reviewer's Comments The authors would like to thank the reviewer for the careful reading and constructive comments that have helped sharpen this manuscript. In this revision, all the comments of the reviewers have been carefully addressed. Specific responses to the review comments are listed below. The line numbers refer to those in the revised manuscript.

Anonymous Referee #1

1. Introduction: Pg 1_line 28 – Geological conditions here are referred to as an external

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factor influencing landslides. Geological conditions should be considered as an internal factor as is later suggested in the manuscript.

Response: Thank you for the careful reading. Indeed, geological conditions are considered as an internal factor in the manuscript. We have revised the manuscript accordingly. Please see Introduction: Pg 1_lines 35-36 in this revision.

2. Introduction: Pg 1_line 31-35 – These final sentences of the first paragraph should really be the start of the introduction as this sets out the general motivation for the study before linking this to the site.

Response: Thank you for the careful reading and constructive comment. We agreed with the reviewer. We have revised the text accordingly. Please see Introduction: Pg 1_lines 28-33 in this revision.

3. Introduction: Pg 2_lines 31-34 – I am not sure that this is needed I would suggest deleting this.

Response: Thank you for the comment. In this submission, we have revised the text accordingly. Please see Introduction: Pg 2_lines 35-36 in this revision.

4. Methodology: Pg 2_ lines 38-39 – I'm not sure I fully understand this point. Landslide displacement is caused by both internal and external factors but why does the lithology, geological structure and topography cause result in monotonic displacement through time? Also groundwater (pore water pressures) should be considered here. Most likely the ground water table remains high enough for ongoing movement to continue.

Response: Thank you for the careful reading and kind comment. To avoid the potential confusion, we have revised the text accordingly, with slight modification. Please see 2.1 Time series analysis of displacement: Pg 2_lines 41-46 in this revision.

The nonlinear evolution process of the cumulative displacement of landslides is controlled by primary factors such as geological conditions, and trigger factors such as rainfall and reservoir water level changes. The displacement of landslide sequence is an instability time series. Based on the time series analysis, total displacement of landslide can be broken down into different corresponding components according to the different influential factors. Total displacement of landslide can be divided into trend component displacement, which is affected by the periodic dynamic functioning of inducing factors such as rainfall, reservoir water level, groundwater. Trend component displacement nearly increases under large time scales, and periodic component displacement fluctuated increases under small time scales. The trend component revealed the long-term trend of the sequence, which is determined by the potential energy and constraint condition of the slope. Many landslides exhibit long-lasting, continuous movements under gravity loads that are affected by the creep property of slope materials (Desai et al. 1995). One of the important factors that influence the behavior of creeping slopes is appropriate characterization of the response of geologic materials and interfaces; in the case of creeping slopes, the latter can occur at the junction of the creeping mass and the essentially stationary (rock) mass below it. Landslide deformation is often characterized by creep, which generally need to undergo three stages, initial deformation, stable deformation and accelerated deformation stage. In the evolution scheme of three deformation phases of landslide, the landslide displacement generally increases monotonically with time.

Furthermore, we agreed with the reviewer that groundwater (pore water pressures) should be considered here. Groundwater, which is regarded as an active geologic agent, is one of the main factors that induces landslide instability. In the rising phase of reservoir water level, the groundwater level gradually increases, with a slight lag behind the increase in the reservoir water level. The groundwater remains high enough for ongoing movement to continue.

5. Methodology: Pg 5_lines 3-16 – This section This section introduces the GA computational model but largely explains this through its previous biological applications. It would be much easier for the reader to explain how this has been adapted for landslide studies.

Response: Thank you for the kind comment. We have revised the text accordingly.

We agreed with the reviewer that this section is not relevant to landslide, just introduces the GA model from the biological point of view. Thus, we deleted this section in the revision. About how this has been adapted for landslide studies, we had explained it in the introduction: Pg 2_lines 25-27.

6. Case Study: Pg 6_ line 29 – Why is landslide monitoring considered a qualitative approach to analyse landslide development. This is quantitative data.

Response: Thank you for the careful reading and kind comment. We have revised the text accordingly. Indeed, landslide monitoring is considered a qualitative approach to analyse landslide development. We are very sorry for that our mistake in spelling words. Please see Case Study: Pg 6_line 28 in this revision.

7. Case Study: Pg 8_lines 17-18 – This should be the other way around- the landslide stability decreased and the deformation increased.

Response: Thank you for the careful reading and kind comment. We have revised the text accordingly. Please see Case Study: Pg 8_line 20-21 in this revision.

8. Case Study: Pg 9_line 24 – Statement 'materials in the sliding mass are degraded by excess moisture and additional hydrodynamic pressure' is not correct. The excess pore water pressure reduces the mean effective stress at the landslide shear surface making it more susceptible to movement.

Response: Thank you for the careful reading and constructive comments. We agreed with the reviewer about the explanation. We have revised the text accordingly. Please see Case Study: Pg 12_line 23-24 in this revision.

9. Case Study: Pg 12_lines9-10 – How has the sliding force increased? Is it not the case that the confining pressure reduces with the lowering of the lake but the pore water pressure remains high so this change in stress state makes the slope more unstable?

Response: Thank you for the constructive comments. We have revised the text accordingly. Please see Case Study: Pg 12_line 5-13 in this revision for details.

Although the variation in reservoir water level was small before April 2007, the periodic displacement still exhibited small fluctuations due to the effects of rainfall and groundwater. This behavior could be explained in terms of stress changes within the landslide in that the rainfall events cause increased pore water pressures in the landslide shear zone which reduced the effective stress and increased instability. After April 2007, several distinct peaks can be observed in the periodic displacement-time curves during periods of decreasing reservoir water level. For example, the periodic displacement increased from May to July 2009 and from May to September 2012. However, when the reservoir water level increased from 145 m to 175 m, the periodic displacement gradually decreased. The main reason for the above conditions was that the rise of the reservoir water level increased the confining stress on the surface of the landslide and the hydrodynamic pressure, the direction of which was toward the interior of sliding body. Similarly, the lowering of the reservoir water level reduced the confining stress whilst pore water pressures were still high which would promote accelerated movement.

10. Case Study: Pg 12_line 12 – Is this an actual piezometer or standpipe installation or is this water observed within the inclinometer tube itself? If the latter is there any certainty as to where this has come from? If not an installed piezometer it could have come from the top cap of the installation and therefore may not be a reliable groundwater measurement.

Response: Thank you for the careful reading and constructive comments. We have revised the text accordingly. Please see Case Study: Pg 12_line 15-16 in this revision for details.

The water gauge used in this landslide was 730 type water level sensor, with the characteristics of measuring range as deep as 210 meters, high measuring accurancy and stable performance. The data acquisition and memory used NetL G-301 data storage device. At the head scarp of the landslide at an elevation of 181m, groundwater depth was measured by water gauge within inclinometer monitoring hole QZK3.

11. Figures Fig 4. The key is not explained. A clear key showing instrument type and borehole locations is needed Fig 5. As with figure 4 the key is not clear. Also the borehole and inclinometers should be drawn on to show their depth. Fig 8. Diagrams are hard to read. It would be better to display these as conventional inclinometer plots with depth on the y axis and displacement on the x axis.

Response: Thank you for the careful reading and constructive comments. We have revised the text accordingly.

About Fig. 4 and Fig.5, we have added the key for legend information accordingly. Please see Fig.4 and Fig.5 in this revision for details.

Furthermore, Fig 8. Diagrams is displayed as conventional inclinometer plots with depth on the y axis and displacement on the x axis. Please see Fig 8 in this revision.

References Furuya, G., Sassa, K., Hiura, H., Fukuoka, H.: Mechanism of creep movement caused by landslide activity and underground erosion in crystalline schist, Shikoku Island, southwestern Japan, Eng Geol, 53, 311-325, 10.1016/S0013-7952(98)00084-2, 1999. Desai, C. S., Samtani, N. C., Vulliet, L.: Constitutive modeling and analysis of creeping slopes, J Geotech Eng Trans ASCE, 121,43-56, 10.1061/(ASCE)0733-9410(1995)121:1(43), 1995. Sun, M., Tang, H., Wang, M., Shan, Z., Hu X.: Creep behavior of slip zone soil of the Majiagou landslide in the Three Gorges area, Environ Earth Sci, 16, 1-12, 10.1007/s12665-016-6002-x, 2016. Haq, A. N., Marimuthu, P., Jeyapaul, R.: Multi response optimization of machining parameters of drilling Al/SiC metal matrix composite using grey relational analysis in the Taguchi method, The Int J Adv Manuf Technol, 37, 250-255, 10.1007/s00170-007-0981-4, 2008.

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Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2017-87/nhess-2017-87-AC1-supplement.pdf

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