We thank both reviewers for taking the time to consider our manuscript in detail. The comments provided have been very helpful and we believe that this has greatly improved the quality and readability of our revised manuscript.

We are pleased to provide our detailed response to the review comments which outlines the actions we have taken to incorporate these into our revised manuscript.

| **Carey et al. MS No.: esurf-2018-73** | |
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| **Comment** | **Response and actions** |
| **Reviewer 1** | |
| A short description of the apparatus in the form of a sketch would be interesting for the reader who is not familiar with this apparatus | Agreed. We have included an additional Figure to introduce the shear box (Figure 3). |
| I doubt whether the figures are all necessary to explain the moving pattern of the samples. | Agreed. We have reviewed the figures used throughout the paper. Where feasible we have included symbols and modified colours. We have also reduced the number of figures presented for the laboratory experiments as suggested. |
| Figures are not well explained, difficult to read with complex codes and colours which cannot be read by colour blind reader | Agreed. As above we have made significant modifications to figures where feasible. |
| An important omission of the paper is the fact that the reader has no insight of the landslide measured in the field. For example, the hysteresis in the movement pattern with a rising and falling groundwater table. | Agreed. There has been significant work undertaken to measure and the movement behaviour of the landslide in the field. To better inform the reader we have separated Figure 1 into 2 figures.<br>Fig 1 - Provides the study location maps for the landslide, the monitoring equipment and sampling sites.<br>Fig 2 - Focuses on the monitoring results using Piezo PZA and UTK1 GPS cumulative horizontal displacement. We have also plotted piezo UTK3 for comparison, as this has the longer time series and shows a similar pattern to PZA. |
| Conclusion in the paper are very clear. Are not all the results a confirmation of what was found by former research. I ask the author to be more specific on that. | Agreed. We have added some text to provide a clear link back to the previous research to show how the lab results corroborate the previous findings. |
| I want that the authors make a clear link with the results measured in the field. | Agreed. As discussed above we have included additional monitoring data (Figure 2) and provided closer collation between the site and laboratory measurements. |
| Supplement comments: | |
| Page 1. What is GNS | This is the trading name of our institute and consistently used in all our publications. No modification made. |
| Page 2, Line 24. To Date - Until today | Agreed. Text modified (page 2 line 26). |
| Page 3, Line 5. 'along with numerical modelling of potential ground displacements during earthquakes' - | We model the static stability of the landslide using the different recorded piezometric head levels in order to calibrate the movement, pore-pressures, material shear |

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| Not numerical modelling of potential displacements with groundwater?<br>So I understand that the combination of lab experiments with field monitoring data is rather unique. | strengths and landslide geometry. Some additional explanation has been provided (Page 3, line 5 and page 3, line28 – page 4 line3). A note has also been added to the Figure 11 caption. |
| Page 3, Line 10. How do you know that it is a reactivated landslide? Was there a dormant period When? Some history if that is available. | Agreed. We have modified "reactivated" to "active" in the text (Page 3, line 11). |
| Page 3, line 18. I cannot see that in 1c Figure unclear for me Text and legend difficulty to read | Agreed. We have included this in our new Figure 2. |
| Page 3, Line 21. Figure 1d difficult to understand. | Agreed. We have included this in our new Figure 2. |
| Page 4, Line 3. So K is a stress (Force /m2) and not an acceleration which of course is physically related to Force/m2 | Ky is the acceleration needed to cause the landslide mass to start moving. This acceleration x landslide mass = the shear force, which is needed to exceed the resisting force to make landslide movement start to accelerate. We have modified the text to define Ky more clearly and have put a reference in that describes Ky (Page 4 line 11 to 19) |
| Page 4, Line 6. < should be = | Agreed. This has been rectified in the modified text. (Page 4, line 11 to 19). |
| Page 5 line 11. UTD first mention. | Agreed As noted later this experiment is not used in the proposed model. We have therefore removed this from the paper. (Reference removed Page 5 line 25). |
| Page 5 line 11. 'initial confining pressure should this be initial normal pressure | Agreed. We have revised to normal effective stress. (Page 5 lines 25, 26 and 28). |
| Page 5, Line 33 'and pore water pressure response of the sample were measured' where can I see this? | The sample response is shown in the results section. We have included (see section 4) at the end of this sentence. Page 6, line 17) |
| Page 6, Line 10. How can you have permanent constant displacements with a fluctuating Ky/Kmax ? | Ky is constant per test. Each Ky/Kmax value relates to an event (in this case a load cycle) and the estimated permanent displacement of the mass in response to that event (cycle). Even though the acceleration (force) and displacement varies through each test-cycle we adopt the maximum acceleration (which we vary between tests but is kept constant during a given test) and use this to represent Kmax, and the accumulated total displacement, per cycle. This is the same as in the numerical simulations, where Ky is constant, but the acceleration acting on the mass during the earthquake varies, but we simply adopt the maximum acceleration acting on the mass as Kmax (as described by Makdisi and Seed, 1978).<br>In the landslide, Ky will vary mainly as a function of the pore-water pressures acting within the slide surface clay and overlying landslide mass. For the dynamic simulations, Massey et al. (2016) adopted piezometric "base levels", which are the mean maximum piezometric head levels |

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| | recorded on the landslide at the onset of each period of pore-water pressure induced landslide acceleration.<br>We have added additional text to clarify this (Page 7 lines 1 and 2). |
| Page 6, Line 12. The relationship between Ky/Kmax and displacement is determined by the viscosity Could you verify that? | We believe that the relationship between ky/kmax is determined by the shear strength of the clay material forming the thin (10-20 mm) slide-surface of the landslide and the pore-water pressures at the time of the earthquake, which would determine what Ky would be needed to cause landslide movement to accelerate. Ky is not constant and will change in response to changing pore-water pressures. Kmax is a function of the earthquake acceleration applied to a given mass. In this case the well-defined landslide geometry defines the mass, and we have varied the earthquake accelerations based on the records we've used as inputs to the modelling.<br><br>We recognise that many authors have used viscosity functions to better describe and in some cases predict the motion patterns of these types of landslide assuming that once motion is triggered the landslides move as visco-plastic flows, rather than rigid-plastic frictional slip, e.g. Iverson (1985), Angeli et al., (1996); Corominas et al., (2005); van Asch et al., (2008); Ranalli et al., (2009). However, Results from SEM analysis of the Utiku and Taihape slide-surface clays (reported by Massey, (2010) and Massey et al., (2013), showed that the clays contain many discrete shear surfaces (slickensides). To generate such slickensides requires Mohr-Coulomb slip.<br><br>Engl et al (2014) simulated movement of the Utiku landslide using a viscosity model. They found that although the model could simulate the periods of accelerated movement caused by increases in pore-water pressures, it could not simulate the arresting process, as the landslide decelerated even though pore-water pressures remained high, at values that were higher than those that initiated the movement (Massey et al., 2013).<br><br>It is our opinion that displacement of the landslide occurs due to Mohr-Coulomb slip along any number of shear surfaces within the slide-surface clay. |
| Page 6, Line 19 You mean initial shear stage | Agreed. Corrected (Page 7, line 5). |
| Page 6, Line 2 6ut it is very strange that the cohesion remains so high after a number of initial shear stages !! | Agreed. It is noted in the literature however that clay rich materials can have a curved envelope so steepening at lower effective stresses. It is possible therefore at the stress states we are producing an artificially high c' using a straight line. We have modified text accordingly (Page 7, line 13 to 15). |

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| Page 7, line 26. Explain the difference in a and b Especially 6a: graphs difficult to read especially when you are colour blind. | Agreed. We have modified Figure 6 (now Figure 7). We have removed the displacement graph an illustrate this behaviour with displacement rate only. See Figure 7. |
| Page 7, line 33 BP was held stable and measured PWP continued to rise. I do not see that Very unclear graphs for me<br>Explain why because in the earlier stage the drop in displacement rate was not so fast? | Agreed. These graphs have been improved as discussed above. (See Figure 7). |
| Page 8 equation 1 - I am not so happy with this expression v is related to these effective stresses but not equal. | Agreed. This has been symbol has been changed (Page 9, line 4) |
| Page 8, Line 16. the normal effective stress is not constant but decreasing with groundwater rise. | Agreed. This has been clarified in the text (Page 9, line 6). |
| Page 8, Line 17. This is an extra increase in pore pressure related to the rate of change Can we translate that in an excess pore pressure component which depends on the rate in groundwater rise and permeability which dissipates when the at constant water level? | This is an interesting idea although we do not have sufficient data from our experiments to explore this in this paper. No modification made. |
| Page 8 Conceptual Model figure 7. This schematic concept is based on the experimental results given in Fig 6 b-c So I do not see what the other figures 4 and 5 have contributed to this concept | Agreed. Figure 4 and associated section has been removed from the manuscript. |
| Page 8, Line 29. Fig 8 should be Fig 7 | Agreed. Revised. Now Figure 8 |
| Page 9, Line 13. The codes for the different graphs in these figures must be"decoded" so that the reader can easily understand what kind of graph he is looking at. | Agreed. We have tried to improve these graphs |
| Page 9, Line 14. Difficult to read graph 8c | Agreed. Graphs have been improved |
| Page 9, Line 23. (Fig 8f and 8i –In my opinion they exceed the failure envelope What kind of experiment? Difficult to read these graphs. | Agreed. Graphs have been improved |
| Page 10, Line 6 'Our results suggest that the materials that form the Utiku | This statement has been removed. The key point is that the c/phi of the material does not change with strain. Statement removed. (Page 10, line31,31). |

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| landslide are not susceptible to liquefaction.' Explain a bit more. | |
| Page 10, Line 15. 'numerical simulations from Massey et al.' A bit more about these numerical simulations. Define strain, which is normally defined as Dx/x or Dx/Dz. Why do you use strain here instead of displacements? | Agreed. Strain is Dx/x – strain used because it is not possible to compare displacement from to 10mm wide sample to the entire landslide mass in a meaningful way.<br><br>Text updated to clarify (Page 11 , line 5) |
| Page 11, Lines 4-8. Interpret behaviour as creep – where do we see this? I think you should refer to some figures. | Agreed. Graphs referred to. (Page 11, lines 28 and 32) |
| Page 11, Line 11. Shear surface do you mean failure envelope? | Agreed. Correction made. (Page 12, line 4) |
| Page 11, Line 19-26. For me it is a bit disappointing that we have here no more detailed information of the moving pattern of the Utiku landslide. which we can compare with the moving patterns of the lab experiments. | Agreed. Links to the observed behaviour in the landslide and laboratory now included (Page 11 line 31 to 32) |
| Page 12, Line 1. Does brittle failure always give catastrophic landslides? | We have removed this initial statement from the conclusions as sample UTD has been removed from the manuscript. |
| Page 12, Line 10-11. Consistent with ground motion records- We did not see these records | Agreed. More detailed ground monitoring records have been included (see Figure 2) |
| Page 12, Line 10-11. Displacement rates increase rapidly with distance normal to failure envelops - Can this lead also to catastrophic failure? | This is probably the case, but we do not have sufficient data to support this at this stage. No modification made. |
| Page 12, Line12. Numerical simulations - No idea how these were performed | Agreed. Text has been modified (Page 13 lines 4 to 7) |
| Van Ash correct to Van Asch? | Agreed. typo corrected |
| Reviewer 2 | |
| A few minor corrections: | |
| Page 3 line 10 – I would classify the Utiku landslide as compound rather than translational. | Agreed. "or compound" after "translational". |
| Page 5 line 20 – samples TUB and UTC were subjected to different patterns OF pore water pressure | Agreed. Typo corrected. |
| Page 7, line 6. In both samples further increase in back pressure | Agreed. Typo corrected. |
| Figure 2 Special dynamic shear box not specialist. | We are not sure that Special We now refer to the 'Dynamic Back Pressured Shear box approach' |