Author Response to reviewer: S. Segoni

Response to Main Comments:

1- We greatly appreciate this comment and the point made by the reviewer. We have added some additional text at the beginning of Section 5 (Discussion) to encapsulate this important point.

The objective of this system is to estimate potential landslide activity over a very broad area in near real-time using input data that has very few points (relative to the area considered) as well as variable accuracy. These challenges restrict the usage of this model to the appropriate context: a situational awareness tool that flags potentially affected areas for further investigation rather than a direct tool for issuing warnings or declaring impacts. Results of the evaluation suggest that when the finest spatial buffers and temporal windows are considered for the 2014 validation dataset, the true positive rate for the moderate hazard model is between 43 and 58% for the Hispaniola and Central America datasets respectively (Table 2). However, as the search criteria are expanded, even slightly, results are more promising. The high hazard model has a relatively low probability of predicting landslides, due to the fact that many landslide reports in the GLC are not recorded on the same day as extreme rainfall events. Given the limitations of the data available for evaluating this system as well as for calibration of its components, we feel that results of the LHASA model nevertheless encourage its use as a regional situational awareness tool for potential landslide activity.

2 – We have added a discussion of the landslide typologies considered in this analysis in Section 2.2.

Another uncertainty stems from the landslide types presented in this catalog. The GLC includes mass movements that are reported to have been triggered directly by rainfall (including debris flows, mudslides, rock falls, etc.), all of which we herein refer to as landslides. While it is often impossible to differentiate between landslide types from a media report unless detailed descriptions or a photo is included, we believe that the majority of landslides that are used to calibrate and evaluate the LHASA model are rapid, shallow movements of soil, rock, and other debris. The size of each landslide is often even more difficult to determine in most cases, but the reported landslides often occur above roads and tend to be narrow, long runout debris flows. These assertions are based on review of GLC event entries as well as previous work in this region (Bucknam et al., 2001; Cepeda et al., 2010a; Devoli et al., 2006, 2008).

We have also outlined the main types of landslides we feel would be most likely to be represented by LHASA in a paragraph at the end of Section 3.4:

Given the triggering variables, surface information and landslide catalogs considered within LHASA, we posit that LHASA model is more successful in resolving the potential conditions for landslides with a mix of soil, rock and other debris, ranging from moderate to shallow depths and occurring at moderate to high velocities. This assertion is mostly due to the main types of landslides observed within the study area as well as from the fact that currently we do not consider other triggering variables such as earthquake occurrence, anthropogenic triggers (mining, construction, etc.), etc.

3 – We appreciate the recommendations of the cited citations. We have reviewed these publications and included them within the manuscript in two relevant locations.

4 – We have reviewed recent literature on regional rainfall threshold analyses as well as other topics and have updated the references accordingly.

Response to Minor Comments

5 – We have added additional text in Section 3.4 to describe the qualitative difference between moderate and high landslide hazard nowcasts. We hope that with additional data in the future we will be able to provide more quantitative descriptions of these classes:

The "high hazard" nowcast is designed to represent the extreme triggering conditions under which landslides have a higher probability of occurrence; whereas the "moderate hazard" nowcasts represent a lower probability of potential landslide activity. With additional data future work will seek to assign more probabilistic values of landslide potential to each of these hazard classes.

6 – The range of thresholds tested is described in Section 3.4, and a figure showing the variation in model success has been added. 7 – We have updated the text to include additional references in section 3.4:

Previous decision tree models considering precipitation and antecedent values have been derived at the city level and apply the trade-off between rainfall and past rainfall infiltration to create an alert framework (Aleotti, 2004; Godt et al., 2006) or at a regional (sub-national) scale considering accumulated precipitation and specifying a critical rainfall threshold (Lagomarsino et al., 2013; Martelloni et al., 2012; Segoni et al., 2014).

8 – We have clarified the meaning of "optimizing the predominant thresholds for these instances" in Section 3.4 with the below text:

The moderate hazard nowcast was calibrated by varying the ARI and daily rainfall thresholds, then determining the model's success for the Central American catalog. Due to the computational burden, the calibration process involved a representative sample of the thresholds between the 50th and 95th percentiles for both ARI and daily rainfall records, not every possible set of thresholds.

9 – We have amended the text at the end of Section 3.5 to be clearer:

To quantify how the predictions respond to different levels of accuracy of the GLC, we varied the spatial area from 0 to 25+ km around each of the landslide points as well as varied the temporal window considered around each landslide reported date/time by 1, 3 and 7 days. This provided a way to better quantify the probability of detection more realistically since the uncertainty in both the location and the date of the validation landslides was variable.

10 – This is a good point and we have added some text to the end of Section 4.3 to address this comment:

Another potential approach could consider dividing the study area into geomorphologically similar regions and re-calibrating the rainfall and ARI thresholds at sub-regional scales, allowing the rainfall thresholds and even susceptibility bins to be adjusted. However, this approach requires robust landslide inventory data for calibration and would need to assume that all areas had consistent and sufficient data points. We may consider this approach should new datasets become available or we apply this model over a different study area.

11 – We have made the change in the text from soil moisture to antecedent precipitation index.

12 – We have added a sentence in the text to explain the computational requirements to run the LHASA model:

The LHASA regional system is currently run on the Heroku Cloud Application Platform (Heroku, 2015) with limited computational resources required for generating regional, daily nowcast products.

13 – We make reference to future planned activities for the LHASA system including additional testing and evaluation over new study areas in several places in the text. We have a prototype model currently running over the Nepal region and are working on additional study areas at present. There are not any performance upgrades planned currently but hope to advance the model to make upgrades when new data becomes available.

14 – We are planning to run the model retrospectively over the entire TRMM record (2000-2015), at which point we hope to identify any potential systematic biases that may help us to constrain or improve the algorithm. At present, however, we are limited by the validation dataset (only available from 2007-2015) and we have already mined all relevant reports from 2007-2015. It is possible that events for 2015 may provide some additional information which we could use to improve the model, but this may be difficult to base on just 1 year of data.

15 – We have added FPR values to a new Table 3 to better explain model performance under varying spatial and temporal windows. As we have observed in this paper, FPR remains low at most reasonable rainfall thresholds, while TPR varies significantly.

16 – The figure has been changed

17 – The figure has been changed so landslides are now represented as circles