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Using satellite soil moisture and rainfall in the Landslide Hazard Assessment for Situational Awareness system

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The Landslide Hazard Assessment for Situational Awareness system (LHASA) gives a global view of landslide hazard in nearly real time. Currently, it is being upgraded from version 1 to version 2, which entails improvements along several dimensions. These include the incorporation of new predictors, machine learning, and new event-based landslide inventories. As a result, LHASA version 2 substantially improves on the prior performance and introduces a probabilistic element to the global landslide nowcast.

Data from the soil moisture active-passive (SMAP) satellite has been assimilated into a globally consistent data product with a latency less than 3 days, known as SMAP Level 4. In LHASA, these data represent the antecedent conditions prior to landslide-triggering rainfall. In some cases, soil moisture may have accumulated over a period of many months. The model behind SMAP Level 4 also estimates the amount of snow on the ground, which is an important factor in some landslide events. LHASA also incorporates this information as an antecedent condition that modulates the response to rainfall. Slope, lithology, and active faults were also used as predictor variables. These factors can have a strong influence on where landslides initiate. LHASA relies on precipitation estimates from the Global Precipitation Measurement mission to identify the locations where landslides are most probable. The low latency and consistent global coverage of these data make them ideal for real-time applications at continental to global scales. LHASA relies primarily on rainfall from the last 24 hours to spot hazardous sites, which is rescaled by the local 99th percentile rainfall. However, the multi-day latency of SMAP requires the use of a 2-day antecedent rainfall variable to represent the accumulation of rain between the antecedent soil moisture and current rainfall.

LHASA merges these predictors with XGBoost, a commonly used machine-learning tool, relying on historical landslide inventories to develop the relationship between landslide occurrence and various risk factors. The resulting model relies heavily on current daily rainfall, but other factors also play an important role. LHASA outputs the probability of landslide occurrence on a grid of roughly one kilometer over all continents from 60 North to 60 South latitude. Evaluation over the period 2019-2020 shows that LHASA version 2 doubles the accuracy of the global landslide nowcast without increasing the global false alarm rate.

LHASA also identifies the areas where the human exposure to landslide hazard is most intense. Landslide hazard is divided into 4 levels: minimal, low, moderate, and high. Next, the number of persons and the length of major roads (primary and secondary roads) within each of these areas is calculated for every second-level administrative district (county). These results can be viewed through a web portal hosted at the Goddard Space Flight Center. In addition, users can download daily hazard and exposure data.

LHASA version 2 uses machine learning and satellite data to identify areas of probable landslide hazard within hours of heavy rainfall. Its global maps are significantly more accurate, and it now includes rapid estimates of exposed populations and infrastructure. In addition, a forecast mode will be implemented soon.