NH030 - Landslide Life Cycle: From Hazard Analysis to Risk Assessment

# Do better satellite precipitation algorithms improve landslide hazard assessment?

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## Abstract

Satellites make it possible to estimate precipitation in near real time. Given the challenges of achieving global coverage by other means, these data are used widely. However, few systems for landslide hazard assessment rely on satellite precipitation estimates. This could be due in part to perceptions of accuracy, although latency, spatial resolution, and other factors may also be important. We test whether recent changes to data streams from the Global Precipitation Measurement mission (GPM) have improved its potential for use in landslide prediction. Specifically, we examine data produced by the Integrated Multi-satellitE Retrievals for the GPM (IMERG) algorithm, which was upgraded to version 7 this year. IMERG relies upon other algorithms, including the Goddard Profiling Algorithm (GPROF) and the GPM Combined Radar-Radiometer Algorithm (CORRA). Many changes have been made during the switch from IMERG version 6 to version 7. These include upgrading CORRA and GPROF to version 7, to improve the accuracy of precipitation in frozen, mountainous, and coastal areas. The measured intensity of some storms has been enhanced with a new algorithm, the Scheme for Histogram Adjustment with Ranked Precipitation Estimates in the Neighborhood. Combined with many others, these changes to IMERG should improve its utility for landslide hazard assessment in a variety of contexts.

To test this idea, we retrain the global Landslide Hazard Assessment for Situational Awareness (LHASA) model twice—first with data from IMERG version 6B and second with 7B. Since current daily rainfall is the most important variable in determining outcomes predicted by LHASA, it should reflect changes made to that input. First, we grid the landslides at a daily, thirty-arcsecond resolution. This serves as the response variable. At each of these sites current and antecedent rainfall are extracted, along with antecedent snow mass and soil moisture, slope, and PGA. In addition, one million grid cells are selected at random points to represent conditions under which landslides (probably) do not occur. After merging these data, we hold back 20% of the dataset for validation purposes and train a machine-learning model with the rest. We assess both the model's overall ability to identify landslides and its ability to predict specific large landslide disasters.

## Is IMERG version 7 better correlated with gauge data in the southwestern USA? Yes

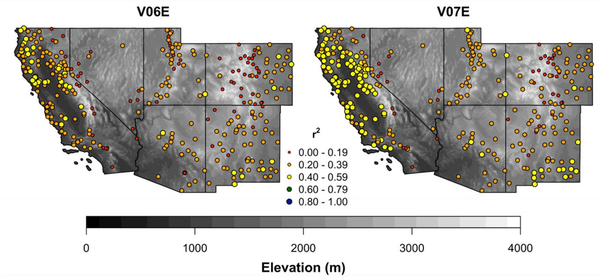



**Figure 1:** Maps of elevation with point size and colors representing the r-squared of the relationship between daily gauge precipitation and early-run IMERG V06 (left) and V07 (right). The correlation to the reference is strongest in California and weaker inland. The newer algorithms seem to have improved results in much of California and Utah.
Aggregated across all the gauges, the r-squared is 0.28 for V06 and 0.38 for V07—a notable improvement across this region, although far from perfection.

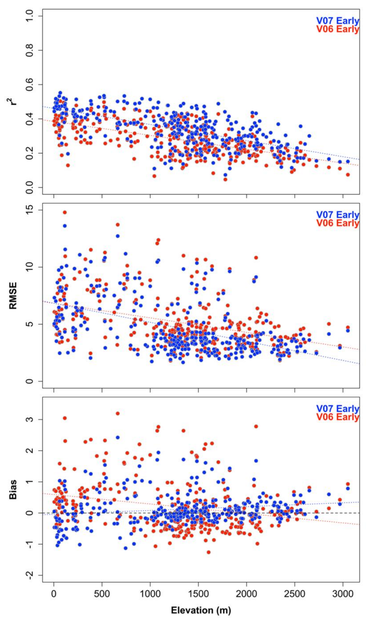



**Figure 2:** Scatterplots of r-squared, root mean square error (RMSE), and bias versus elevation for early-run IMERG version 06B (blue) and 07B (red) relative to each ground station. The fitted linear regression for each relationship is shown as dotted lines on each time series. The correlation decreases with altitude in both products. IMERG version 07B has generally improved errors and biases across the full range of elevations. This could improve predictions of debris flows in this region.

## Acknowledgements

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## Is estimated rainfall higher in IMERG version 7 before and during landslide events? Yes

### Is antecedent rainfall higher? Yes

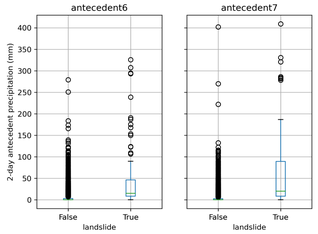



**Figure 3:** This boxplot compares rainfall over the 2 days prior to known landslide events (labeled "True") and random times and locations (labeled "False"), as estimated by the IMERG late run version 06B (left) and 07B (right). Outliers are shown as circles. Data are a stratified random sample (n=10,000) of the earth's land surface from 60 degrees North to 60 degrees South over the years 2015-2021.

### Is current rainfall higher? Slightly

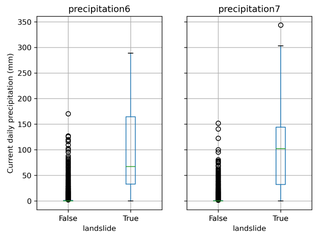



**Figure 4:** This boxplot compares daily rainfall accumulated on the date of known landslide events (labeled "True") and random times and locations (labeled "False"), as estimated by the IMERG early run version 06B (left) and 07B (right).

### Is current rainfall higher after rescaling? Slightly

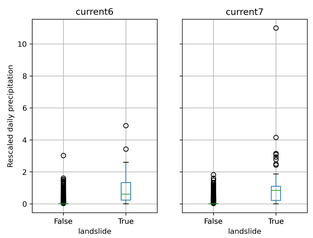



**Figure 5:** This boxplot shows daily rainfall accumulations divided by the 99th percentile of historical daily rainfall in the same grid cell known for landslide events (labeled "True") and random times and locations (labeled "False"). The percentile is calculated after fitting a lognormal distribution to daily rainfall estimates from IMERG early run version 06B (left) and 07B (right). This variable is used by LHASA to predict rainfall-triggered landslides at the global scale.

## Modest overall improvement

The algorithmic improvements behind IMERG version 7 have improved precipitation estimation before and during landslide events. In addition, the LHASA model has benefited from these changes. However, the increases are quite small, if statistically significant. Nevertheless, none of the cases shown here represent a degradation of performance in either satellite precipitation estimation or landslide hazard assessment. Therefore, potential users of satellite precipitation products are encouraged to assess these data for suitability in specific locations or applications.

## Does LHASA make better predictions globally? Slightly

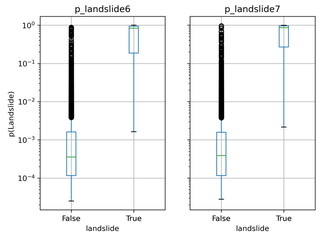



**Figure 6:** Plotted on a logarithmic scale, this boxplot compares predictions made by LHASA for known landslide events (labeled "True") and random times and locations (labeled "False"), based on rainfall estimated by the IMERG late run version 06B (left) and 07B (right). Outliers are shown as circles. Data are a stratified random sample (n=10,000) of the earth's land surface from 60 degrees North to 60 degrees South over the years 2015-2021.

A version of the LHASA model was retrained using each rainfall product, holding all other variables and parameters equal. The overall distribution of outcomes is very similar, although specific data points differ in outcome. Both models have an AUC of 0.98 and an accuracy of 99%.

## Does IMERG version 7 show heavier rainfall in Rio de Janeiro, Brazil on February 6, 2019? Yes, but…

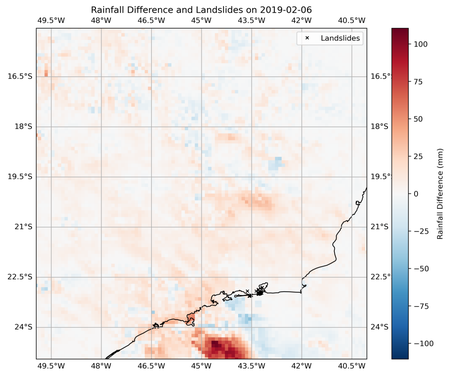



**Figure 7:** This map shows the difference between daily rain estimates from the IMERG early run product. Red indicates higher values in version 07B, and blue indicates higher values in version 06B. Although v7 shows a substantially more intense rainfall event, the change is primarily located offshore, with little difference between the products at any recorded landslide. The figure plotting function was generated by Claude 3.5 Sonnet.

## Does IMERG version 7 show heavier rainfall near Thrissur, India on August 16, 2018? Slightly

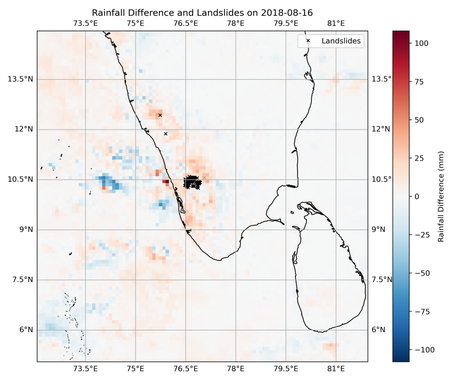



**Figure 8:** This map shows the difference between daily rain estimates from the IMERG early run product. Red indicates higher values in version 07B, and blue indicates higher values in version 06B. Version 7 does show more rain at the locations of historical landslides, but the median increase is 7 mm.

https://www.landslides.nasa.gov/

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