D04

On the Relationship between the Spatial Distribution of Landslides in Nepal and APHRODITE's Orographic Precipitation Pattern

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Introduction

Rainfall triggers landslides worldwide, and understanding the relationship between local precipitation and slope failure is important in mitigating against disaster. The southern slopes of the Himalayas experience tremendous numbers of fatal landslides due to steep mountain slopes and heavy precipitation in summer monsoon season. Prediction of the monsoon over such mountainous terrain is challenging, but studies comparing landslide occurrence with ground-based precipitation measurements, provide important insight for landslide risk assessment.

Despite the importance, precipitation data over Himalayas has not been well distributed. The Asian Precipitation – Highly Resolved Observational Data Integration Towards Evaluation (APHRODITE) of water resources gridded data (Yatagai et al., 2012) is currently widely used for precipitation change in Himalayan region, however, expression of orographic rainfall is limited to the location of rain-gauges and world climatology (Hijiman et al., 2001). Among the many satellite sensors for measuring precipitation, the Precipitation Radar (PR) on board Tropical Rainfall Measuring Mission (TRMM) documented the precipitation pattern over the mountains. Heavy precipitation zone over the Himalayas dictated by the mountains, are shown by TRMM/PR climatology or gain-gauge adjusted TRMM/PR climatology (Yatagai and Kawamoto, 2008; cf. Fig.2 annual precipitation).

Petley has assembled global landslide records from online news reporting (Petley *et al.*, 2005; Petley, 2010; 2012) and shown a negative correlation between South Asian monsoon indices and landslide occurrence in Nepal (Petley *et al.*, 2007).

We show the spatial distribution of monsoonal precipitation over Nepal and location of fatal landslides.

Landslide Database

The fatal landslides database was assembled using systematic metadata online search tools identifying the location of a landslide to the precision of the corresponding news reporting, i.e. known to have occurred within a district, VDC or ward, but rarely is the location identified as a precise latitude/longitude coordinate.

Figure 1 shows the distribution of fatal landslides for the years 2004 – 2015.

Precipitation pattern and orography

Figure 2 shows annual climatological precipitation pattern estimated by using TRMM/PR and APHRODITE rain-gauge collection (Yatagai and Kawamoto, 2008). Two clear west-east oriented rain-bands are observed from the west to the east of Nepal. While, a strong zone (centered at 90E/27N) is observed in Bhutan. These heavy precipitation zones correspond to the mountain slopes of Great Himalaya (north band) and Mahabharat (south band).

Most fatal landslides occur during the summer monsoon season (June-September), corresponding with the time of heaviest precipitation. We compare the spatial distribution of landslides and rainfall during June-September in Figure 3.

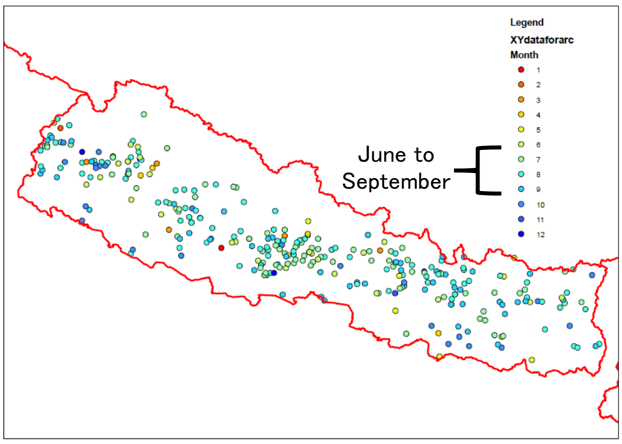

Figure 1. Distribution of fatal landslides for 2004-2015. Each point is one landslide. Color indicates month.

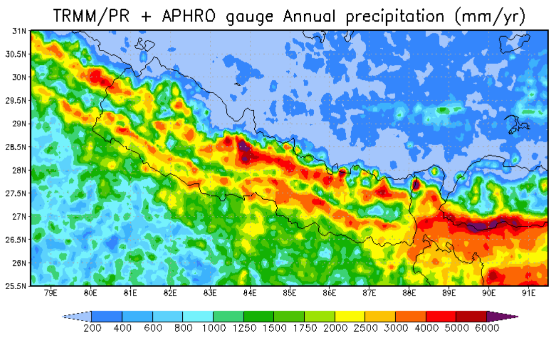

Figure 2. Climatological annual precipitation over Himalayas estimated by using TRMM/PR and rain-gauges.

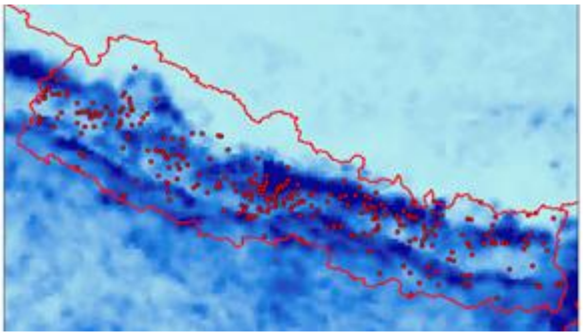

Figure 3. Distribution of fatal landslides during June-September (2004-2015) overlaid on precipitation (TRMM/PR + APHRODITE) for the summer monsoon. Each red dot is one landslide. The increasing darkness of the blue shade indicates increasing June-September climatological precipitation.

Precipitation pattern and landslides

Figure 3 shows a clear geographical correspondence of heavy precipitation zone and landslide fatalities. Heavy precipitation corresponds with the tectonically active Himalayan mountain chain, containing slopes prone to landsliding.

Figure 4A shows an example of APHRODITE's daily precipitation estimate from 25th June 2012; the white cross identifies the location of a landslide on this date. We used the above mentioned TRMM/PR+rain-gauge climatology interpolate daily observation data. No adjustment was made to account for differences in local time stamps when we made daily grid analysis. The Department of Hydrology and Meteorology, Nepal (DHM) measures rainfall in the morning (8:45AM local time) and stamp on the date. Then, APHRODITE data is based on that time, namely, it is accumulation from 8:45AM (3 UTC) of previous day to 8:45AM (3 UTC) to the stamped date. Meanwhile, landslide records are from 0:00 local time (14:45 UT) to 24:00 local time (14:45 UT). To overcome this, we considered precipitation on the day of the landslide and also on the day after the landslide Figure 4B. Maximum precipitation associated with the landslide on 25th June 2012 is shown on the 26th June precipitation estimate, highlighting the importance of considering the time period over which precipitation accumulation is measured. Detailed results are reported in other precipitation (Ando et al., P47).

Conclusion

We compared spatial distribution of monsoonal precipitation over the Himalayas and fatal landslides in Nepal using APHRODITE data. Higher precipitation values corresponded with the mountain chain, and greater numbers of fatal landslides. Ongoing research is investigating patterns of daily precipitation and landslide occurrence across Nepal.

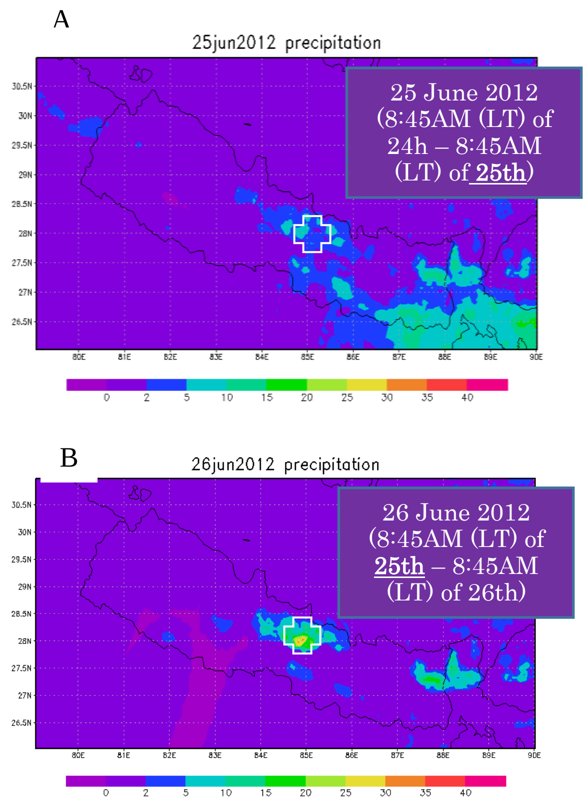

Figure 4. Daily APHRODITE precipitation (mm/day) for the date of Gorkha landslide (upper) and that of next day. White open cross shows the area of landslide.