Reconstructing the 2015 Flash Flood event of Salgar

The Case of a Poorly Gauged Basin

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Introduction

During May 18 of 2015, two severe rainfall events generated a flash flood event in the municipality of Salgar (La Liboriana basin), located in the northwestern Colombian Andes. The flash flood resulted in more than 100 human casualties and significant economic losses.

We present a reconstruction of the hydrological processes that took place before and during this extreme event. We focus our work on exploring:

- Rainfall-soil moisture evolution and the role on the hydrological response of the basin.
- Shallow landslides reconstruction.
- Flash flood reconstruction with scarce data.

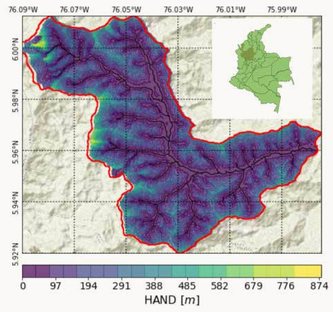

Figure 1. *Liboriana basin localization.*
Colors represent relative elevation respect to the drainage network

Materials

Region: La Liboriana is a small tropical watershed located between the Colombian west and central Andean mountain ranges. It has an area of 57km^2, with an elevation difference of 2300 meters. The affected urban area is at the outlet of the basin.

Data: We use ALOS-PALSAR DEM data (12.7m), radar data, and soil information.

Methods: We use the WMF model (https://github.com/nicolas998/WMF), radar-based QPE (from a Polarimetric C-band radar data Δt = 5min) and identification of convective and stratiform precipitation systems following Steiner (1995).

Also, we simulate flash floods and landslides with sub-models within WMF model.

Hydrological analysis

We analyze hydrological processes in relation to the soil features and rainfall structure. The model simulates runoff and sub-superficial flow separately, and it "marks" water from convective and stratiform systems following it throughout the basin.

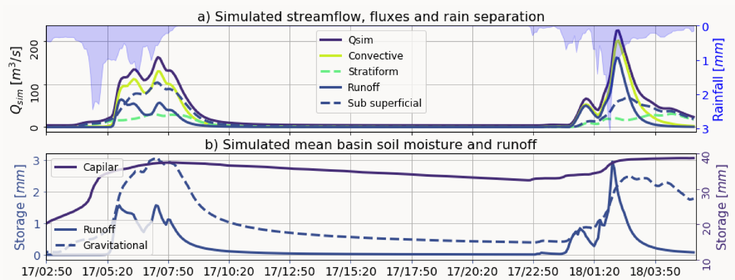

Figure 2. *Simulation results.*

Model

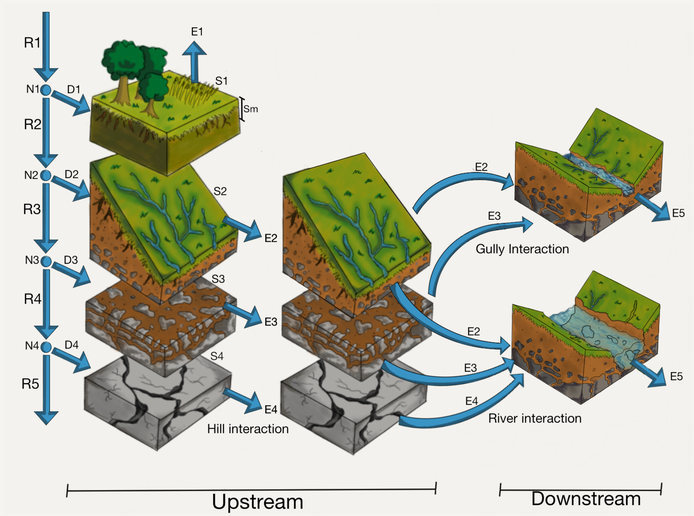

Figure 3. *Model description*

Landslides model

$$Z_{w,i}(t) = \frac{S_{3,t}}{W_c - W_{fc}} \quad (1)$$

$$Z_{i,crit} = \frac{\gamma}{\gamma_w} Z\left(1 - \frac{\tan\beta}{\tan\varphi}\right) + \frac{C`}{\gamma_w \cos^2\beta \tan\varphi} \quad (2)$$

At each time step, the model compares Zw,i vs. Zi,crit following Aristizábal et al. [2016]

Flashfloodsmodel

$$Y_i = \frac{Q_{i,sim}}{V_{i,sim} W_i} \quad (3)$$

$$Q_{i,sed} = Q_{i,sim} \frac{1+c_i}{1-c_i} \quad (4)$$

$$\hat{Q}_{i,sed} = \left(\frac{2}{5}\right) r_i (j\Delta y_{i,sed})^{3/2} S_{i,0} 0.5 \hat{A}_{i,sed} \quad (5)$$

For flash floods, we propose a 1D hydraulic model. The model extracts the cross profile from the DEM. And it solves the equations (3) to (5) by iterations over Y_i.

Spatio-temporal analysis

Spatio-temporal analysis: We group cells in function of their vicinity and travel time. For each group, we analyze capillary water and gravitational storage, as well as runoff and return flux.

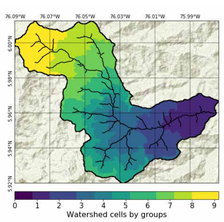

Figure 4. *Basin groups*

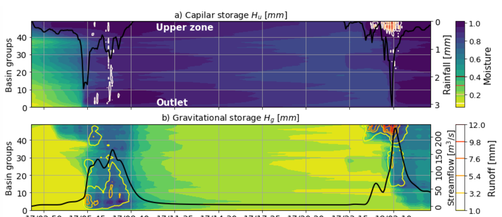

Figure 5. *Spatiotemporal evolution of the model states*

Capillary storage remains full in both events while gravitational storage descends faster. Precedent conditions and convective systems during May 18 increase return flux and runoff.

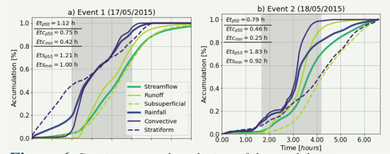

Figure 6. *Spatiotemporal evolution of the model states*

With a lag of 1.12h, event 1 accumulation rate is constant.

Event 2 has a delay of 0.79 hours.

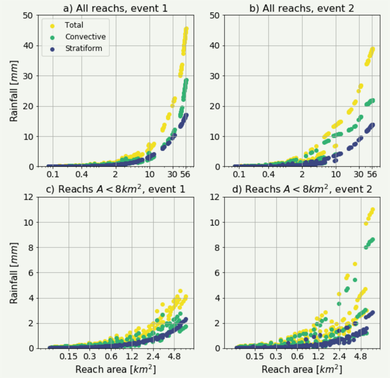

Figure 7. *Rainfall accumulation by reach*

Convective and stratiform behavior differ during both events. Convective accumulation is more heterogeneous than stratiform.

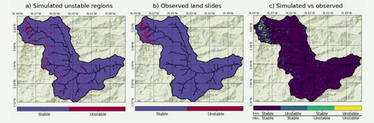

Figure 8. *Simulated landslides.*

The model simulates the regions of landslides occurrence.

However, it fails to obtain the exact localization.

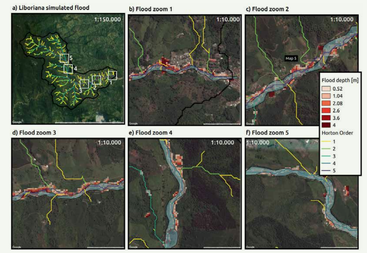

Figure 8. *Simulated flood spots*

The flash flood model reproduces well the flooded spots, in some regions with very high accuracy (c, e, and f). However, there are errors related to model conceptualization and DEM problems.

Conclusions

We use a model with field campaign data in order to reproduce a flash flood event in a poorly gauged basin. The methodology presented here reproduces hydrological and risk conditions associated with the flash flood. Results highlight the influence of convective systems and its interaction with soil conditions. Taking into account the available data, the performance of the model reproducing the Salgar flash flood event is very good.

Bibliography

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E. Aristizabal. SHIA_Landslide. Landslides, 13(3):497–517, 2016. doi: 10.1007/s10346-015-0580-7.

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