Skill of a debris flow model at different temporal resolutions in the Matilija Creek watershed

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Background:

Figure 1: Reference image for California with the location of the study site indicated by a red star.

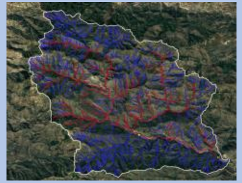

Figure 2: Reference image of Matilija Creek Watershed. Red segments of stream are areas where debris flows occurred.

Debris flows are a common issue in Southern California. Studies have shown that there is an increase in debris flow after wildfires. High intensity rain after a fire often leads to excessive runoff and hillslope erosion, resulting in mass movements (Cannon & Gartner, 2005). When modeling debris flows in these areas, low temporal sampling of precipitation data used to calculate streamflow is often insufficient to forecast peak flows accurately. Here, we evaluate the effect of precipitation data resolution on discharge using 30-minute IMERG-early data averaged over different time intervals to model streamflow using data from the Matilija Creek Watershed. The Matilija Creek watershed had a fire in late 2017 to early 2018 followed by an extreme precipitation event which led to a debris flow (Culler, 2020).

Method Overview:

30-minute IMERG-early data → Distributed Hydrology Soil Vegetation Model (DHSVM) → Dimensionless discharge threshold model → Debris Flow location predictions

The dimensionless discharge model uses stream flow flux and produces a proportional value that can then be compared to a threshold (Tang et al., 2019). 30-minute IMERG-early data was averaged over varying time intervals to test how resolution effected debris flow prediction.

Dimensionless Discharge Equation:

$$q_* = \frac{q}{\sqrt{\frac{\rho_s-\rho}{\rho} g D_{50}^3}}$$ (Tang et al., 2019)

Assumptions:

$D_{50} = 0.015\ m$

$\rho_s = 1330\ kg/m^3$

Conclusion:

- Low resolution data is unable to capture all debris flow locations
- Averaging over 2 hours of data really seems to degrades the results

Data Resolution (hr.)	0.5	1	2	6	24
Segments Predicted over Threshold (%)	76.81%	68.84%	63.77%	47.83%	9.42%

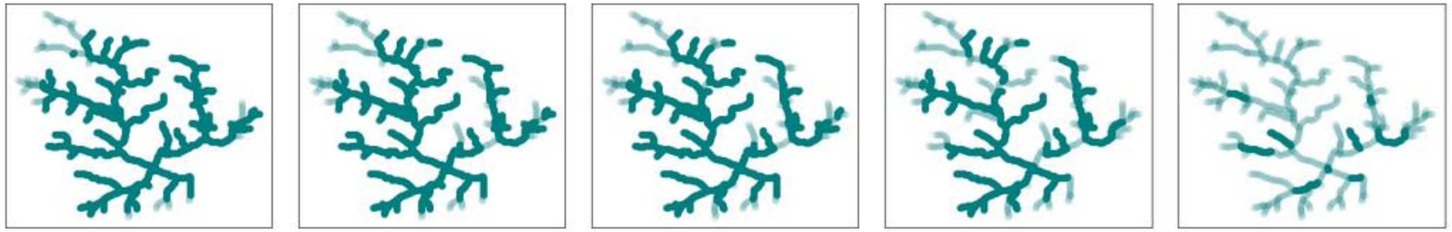

Figure 3: These plots show the predicted debris flow locations calculated in the dimensionless discharge model on top of all the stream segments tested. In general, higher temporal resolution leads to more debris flows being identified.

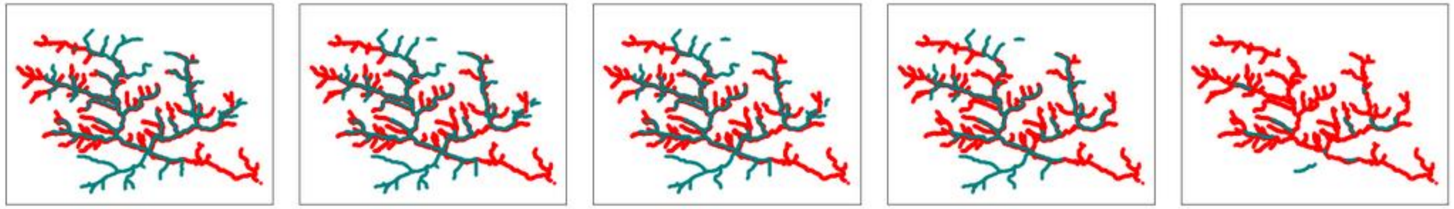

Figure 4: In these plots, predicted debris flow locations (teal) are plotted on top of true debris flow locations (red). Lower temporal resolution is unable to really capture all areas of debris flow.

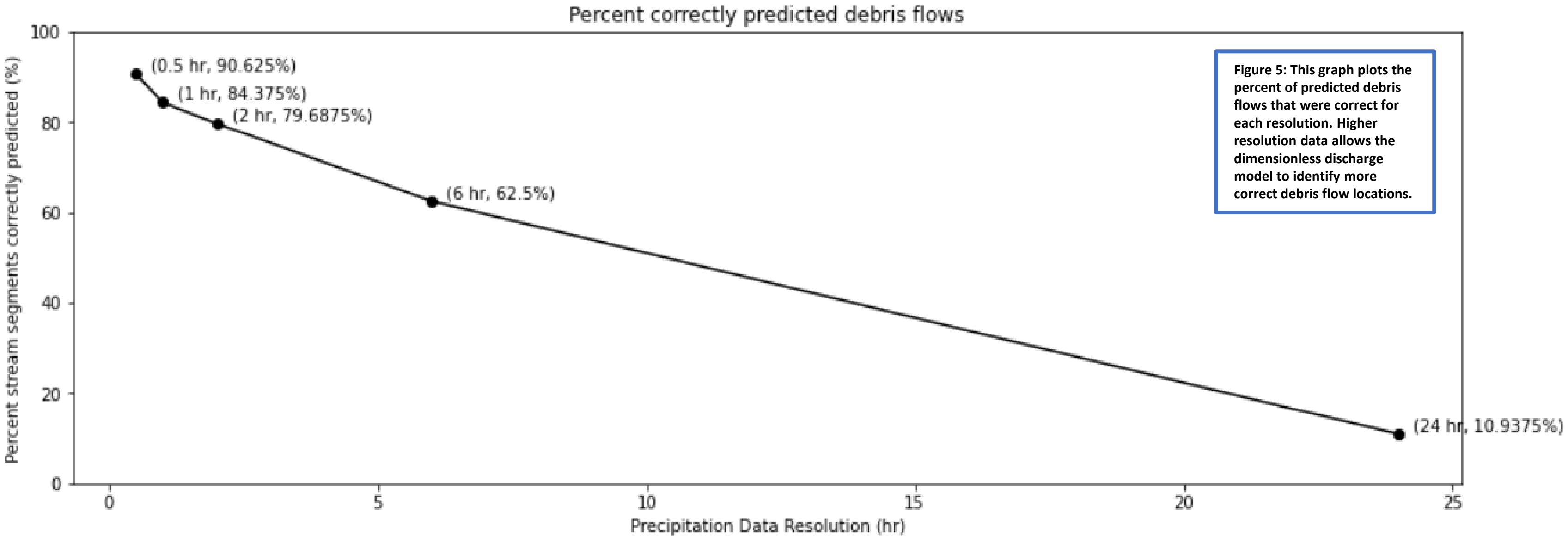

Figure 5: This graph plots the percent of predicted debris flows that were correct for each resolution. Higher resolution data allows the dimensionless discharge model to identify more correct debris flow locations.

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Citations:

Cannon, S. H., & Gartner, J. E. (2005). Wildfire-related debris flow from a hazards perspective. In M. Jakob & O. Hungr (Eds.), Debris-flow Hazards and Related Phenomena (pp. 363–385). Springer. https://doi.org/10.1007/3-540-27129-5_15

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Tang, H., McGuire, L. A., Rengers, F. K., Kean, J. W., Staley, D. M., & Smith, J. B. (2019). Developing and Testing Physically Based Triggering Thresholds for Runoff-Generated Debris Flows. *Geophysical Research Letters*, *46*(15), 8830–8839. https://doi.org/10.1029/2019GL083623