US Army Corps of Engineers®

Urban Flood Demonstration Program

Post-Fire Debris Flow in Southwestern U.S.: An Increase in Risk Due to Climate Change?

Figure 1. Post-fire debris flow event in 1969, Glendora CA, causing 73 fatalities.

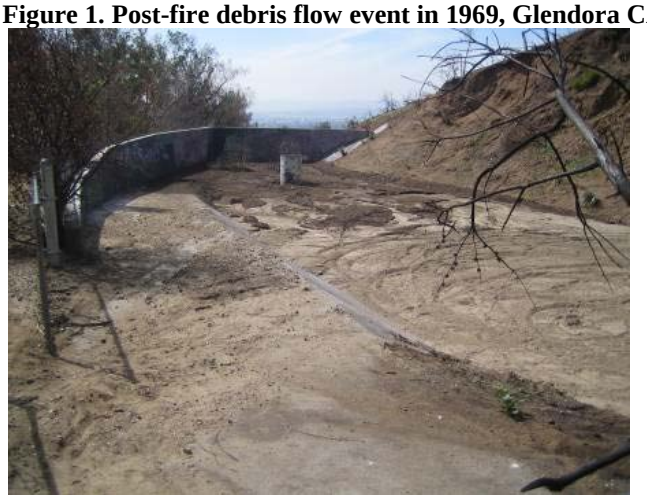

Figure 2. Basin in San Fernando, CA, filled with debris after the 2008 "Sayre" Fire.

Products

This research effort will produce a review of currently available process-based debris flow models in a scientific publication on post-fire debris flow modeling that considers potential climate change impacts.

Benefits

Process-based models are useful for predicting debris flow events because, unlike empirical models, extrapolation is not limited to regression analysis of historical events, which enables projection on future climate change conditions (e.g., precipitation pattern, vegetation, soil conditions) to be performed. One promising processed-based model successfully shown to predict debris flow in Europe is **Ra**pid **M**ass **M**ovement**s** module (RAMMS; Christen et al. 2008). RAMMS combines three-dimensional process modules for debris flow with protection (forest, dams, barriers) and GIS-based visualization modules (GUI) in one user-friendly tool for hazard mitigation studies in mountainous regions affected by gravity driven, rapid mass movements. The objective of this project is to evaluate alternative process-oriented debris flow models (e.g., RAMMS) and their suitability for predicting debris flows under climate change scenarios in southern California.

Issue

In the past 20 years, wildfires in the western United States have increased in frequency, duration, and size. The total forested area burned from 1987 to 2003 is 6.7 times the size of the areas burned from 1970 to 1986 (Westerling et al. 2006). Wildfires threaten life and property not only by direct impact but also through secondary effects like floods and debris flow triggered by storm events after a fire. Debris flow is a flood flow that contains 20-45 percent solid debris, making it particularly devastating if it reaches urban areas (Fig. 1). An increased threat for larger and more dangerous debris flow events (Mote et al. 2005, Knowles 2006) is predicted as a result of more frequent and intense storms and wildfires stemming from climate change impacts, bringing warmer temperatures, longer dry seasons, and more precipitation occurring as rain (Westerling et al. 2006, 2009). Debris basins, (Fig. 2) downstream of fire-prone watersheds, are designed and constructed to prevent debris from entering urban areas. They are sized based on empirical data from previous fire, precipitation, and debris flow events (USACE 1992; Pak and Lee 2008). However, it is unclear whether and to what extent the currently used, empirically-based methods to assess post-fire debris flow (Rowe et al. 1949; LA County Department of Public Works (LACDPW) 1991; USACE 1992; Pak and Lee 2008) can be applied under altered climate conditions.

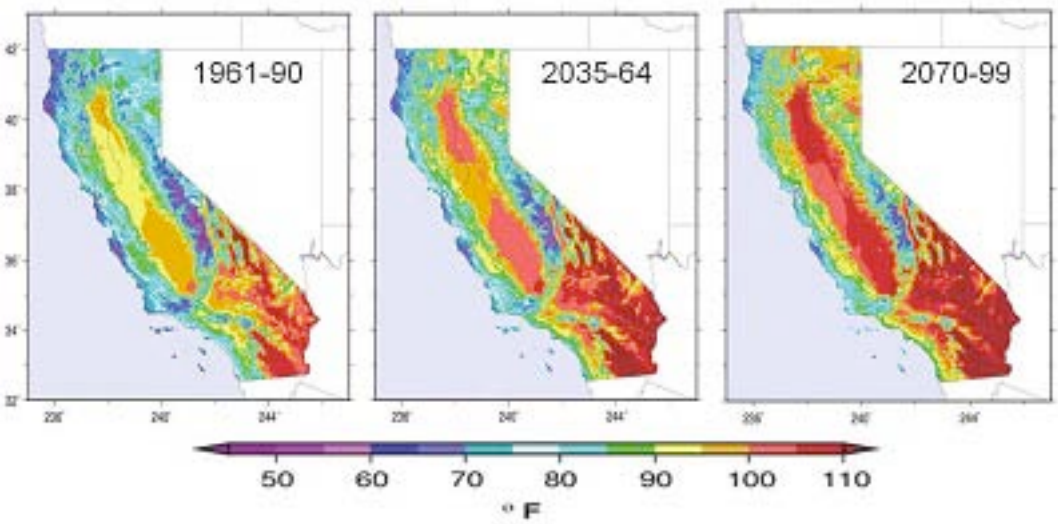

Figure 3. California historical and projected July temperature increase 1961-2099 (Source: Cayan et al. 2009)

Description

To develop the review of process-based debris flow models, the following tasks will be performed:

1. Review process-based post-fire sediment and debris flow methods to extend the base of knowledge on this topic for the USACE.
2. Validate selected model(s) from Task 1 using data from recent post-fire debris flow events within the LA Basin.
3. Develop 3-5 climate change scenarios, based on the regional California climate change model (California Natural Resources Agency 2009), including alterations of precipitation pattern, vegetation, and soil moisture status. Scenarios may include but are not limited to (a) temperature increase of 2-5°F by 2050 and 4-9°F by 2100, (b) precipitation increase of 12-35 percent by 2050 (Cayan et al. 2009). Scenario will be developed in close collaboration with the UFDP FY10 research effort titled “Climate Change and Flood Risks” lead by Rina Schumer.
4. Predict debris flow with selected models taken from Task 2) using scenarios from Task 3) and compare the results to the status quo.
5. Visualize post-fire debris flow events under different scenarios developed in Task 4).

Sponsor Urban Flood Damage Reduction and Channel Restoration Development and Demonstration Program for Arid and Semi-Arid Regions (UFDP)

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References

Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick 2009. *Climate change scenarios and sea level rise estimates for the California 2008 climate change scenarios assessment.* PIER Research Report, CEC-500-2009-014, Sacramento, CA: California Energy Commission.

California Natural Resources Agency. 2009. California Climate Adaptation Strategy. A report to the Governor of the State of California in Response to Executive Order S-13-2008, www.climatechange.ca.gov\adaptation.

Christen, M., P. Bartelt, J. Kowalski, and L. Stoffel. 2008. Calculation of dense snow avalanches in three-dimensional terrain with the numerical simulation program RAMMS International Snow Science Workshop 2008, Whistler, BC, CAN. http://www.creaso.com/english/15_succ/idl_es_ramms/idl_es_ramms.htm

Knowles, N., M. Dettinger, and D. Cayan. 2007. *Trends in snowfall versus rainfall for the Western United States, 1949–2001*. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2007-032

LACDPW. 1991. Sedimentation Manual, Los Angeles County Department of Public Works (LACDPW), Water Resources Division, Los Angeles.

Mote, P.W. et al., 2005, Declining mountain snowpack in Western North America. *Bulletin of the American Meteorological Society* 86: 39-49.

Pak, J.H., and J.J. Lee. 2008. A statistical sediment yield prediction model incorporating the effect of fires and subsequent storm events. *Journal of the American Water Resources Association.* 44:689-699.

Rowe, P.B., Countryman, C.M. and Storey, H.C. 1949. Probable Peak Discharges and Erosion Rates from Southern California Watersheds as Influenced by Fire, US Department of Agriculture, Forest Service, Berkeley.

USACE. 1992. Debris method - Los Angeles district method for prediction of debris yield, U.S. Army Corps of Engineers, Los Angeles District, Los Angeles.

Westerling, A.L., B.P. Bryant, H.K. Preisler, H.G. Hidalgo, T. Das, and S.R. Shrestha,. 2009. *Climate change, growth, and California wildfire*. PIER Research Report, CEC-500-2009-046-D, Sacramento, CA: California Energy Commission.

Westerling, A. L., H. Hidalgo, D. R. Cayan, and T. Swetnam. 2006. Warming and earlier spring increases in Western US forest wildfire activity. *Science* 313: 940-943. As cited in Westerling, A., and B. Bryant (2006). *Climate change and wildfire in and around California: Fire modeling and loss modeling*. PIER Research Report, CEC-500-2005-190-SF, Sacramento, CA: California Energy Commission.