Day 1 Speakers: May 20, 2024

History of postfire debris-flow science- how did we get here?
Speaker: Paul Santi; Colorado School of Mines

Abstract: Post wildfire debris flows (PFDF) have increased in number, magnitude, and impacts over the last decades. Correspondingly, the amount of research into the subject has also skyrocketed, with an uptick starting in the 1990s and growing geometrically. Over time, the topic has matured, with early research focused on causes and characteristics, and more modern research that incorporates modeling, forecasting, risk, and climate change effects. Nevertheless, there remain significant challenges, a few of which include runout prediction and avulsion modeling, volume and probability models for newer areas that are starting to experience PFDF, development of better and more consistent data sets, more finely tuned triggering thresholds, scaling of lab tests to include coarse particles, and better understanding of sediment movement during events and between events. Advances in mitigation options and designs have been incremental, with most changes coming from better computer and laboratory-scale models.

The Meteorology Behind Post-Fire Debris Flows
Speaker: Dawn Johnson; National Weather Service

Flash Floods and Post-Fire Debris Flows are a significant concern for much of the West, with meteorologists and hydrologists focused on an ever-expanding coverage area as wildfires become more extreme. We know that it can take as little as 0.15" of rainfall in a 10-15 minute window to cause problems. The Slinkard Burn proved this with a debris flow that blocked US-395 near Topaz Lake for several days in May 2018. What do meteorologists look for to cue in on days that may have a high risk? What are the challenges and limitations of the data both before and during an event? We will explore all this and more in a presentation focused on the meteorology behind post-fire debris flows.

Day 1 Poster Session: May 20, 2024

1. **Machine Learning Exploration of Post-Wildfire Debris-Flow Negative Sample Space and Low-Hazard Area Delineation**

Presenter: Adam Wade; Pacific Gas & Electric Geosciences
Co-authors: William Haneberg, Ozgur Kozaci, Teddy Atkinson

Machine learning exploration of the post-wildfire debris flow sample space with an eye towards confident delineation of low-hazard areas exploits a class imbalance typical of many empirical slope stability studies, namely that there are more locations at which events have not occurred than locations in which they have. An alternative strategy of confidently predicting locations not susceptible to post-wildfire debris flows may be useful for supporting hazard management and policy decisions. Reproducing the Staley et al. (2016, USGS OFR 2016-1106) logistic regression model but using non-occurrence as the positive outcome increases the critical success index (threat score) from 0.38 to 0.55. The results can also be expressed as positive and negative predictive values (the positive and negative variants of the model precision), which are 0.42 and 0.90, respectively. Considering the no-flow condition to be the positive outcome, however, reduces recall (also known as sensitivity or the true positive rate) from 0.82 to 0.58. Neither approach is inherently correct or incorrect because there is always a sensitivity-precision tradeoff. Recall and precision can both range from 0 to 1. A recall value of 1 means the model produced no false negatives (i.e., classified a location as non-flow when a flow occurred). A precision value of 1 means that the model did not generate any false positives. Regardless of the definition of the positive outcome, the hazard management question is this: It is more important to minimize false negative or false positive model predictions? Or, attempt to simultaneously optimize both? A focus on non-occurrence adds non-trivial complications, most notably via errors in the selection of non-flow locations for the training and evaluation datasets (i.e., delineation of the negative sample space), but may ultimately lead to improved debris flow model utility.

2. **A vision for the WPC Burn Scar/Rain Rate Dashboard**
   Presenter: Alexandria McCombs; National Weather Service (NWS)/WPC
   Co-author: James Nelson

   Monitoring of burn scars is of utmost importance to WPC, as very low rain rates can trigger debris flows and flash flooding in post-fire burn scars. The objective of this project is to develop a dashboard that provides probabilistic guidance to NWS forecasters on whether a debris flow is probable or not. This project will provide the current vision of the developers for this forecasting tool.

3. **Predictive models for postfire debris-flow occurrence at the watershed scale in the southwest USA**
   Presenter: Ana Fernandez-Sirgo; University of Arizona
   Co-authors: Luke McGuire, Ann Youberg, Tao Liu

   Postfire debris flows pose threats to human life and infrastructure and can negatively affect stream habitat conditions. Models designed to assess the potential for postfire debris flows at the watershed scale in response to design or forecast rainstorms are beneficial for managing and mitigating postfire debris flow hazards. This study used four machine learning algorithms, Logistic Regression, Linear Discriminant Analysis (LDA), Random Forest, and XGBoost, to develop classification models for predicting postfire debris-flow occurrence. These algorithms were trained and tested using a newly compiled dataset of postfire debris flows in the Southwest USA, specifically Arizona and New Mexico. The dataset includes information related to rainfall, terrain characteristics, burn severity, and soil properties. We found that a model that uses two features, one based on a metric that combines peak 15-minute rainfall intensity (I15) and terrain steepness and another that combines I15 and a burn severity metric, performed well. All four algorithms produced models that performed well, with threat scores ranging from approximately 0.36 to 0.40. However, logistic regression was the top performer and provided an option that was relatively easy to interpret and apply. Results improve our ability to assess postfire debris-flow hazards in the southwest USA and provide more general insight into the rainfall, terrain, and burn severity characteristics that influence postfire debris-flow initiation.

4. Developing Dynamic Soil Survey and Ecological Site Interpretations for Postfire Debris Flow Risk

Presenter: Andrew Brown; U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Sonora Soil Survey Office

The USDA-NRCS Soil and Plant Science Division (SPSD) is responsible for maintaining soil surveys and ecological site descriptions for public and private lands across the United States and its territories. Soil surveys provide data on soils, geomorphology, and ecology that can be useful for understanding controls on the sources, types, and quantities of materials mobilized in postfire debris flows. Ecological site descriptions correlated to all soil map unit components provide state-and-transition models (STMs) that are used to model the effects of major disturbances and management practices on the landscape as well as restoration pathways relevant to dynamics of different land conditions. Recent wildfire and debris flow events throughout the Sierra Nevada and broader Southwest Soil Survey Region (SWSSR) underscore a need for more detailed interpretations, and updates of existing map products, to provide better information pertaining to debris flow hazards. SPSD is developing Dynamic Soil Survey products that incorporate traditional soil survey information, STMs, continuous (raster) estimates of soil properties and land cover, and other novel data sources to produce spatially and temporally explicit interpretations. This poster will share information about data elements of the Soil Survey Geographic Database that are currently available as well as progress on development of new interpretations related to debris flow risk. Further, we (SWSSR) are seeking input and cooperation from our partners in the update of soil survey and ecological site information throughout the southwestern United States, especially with respect to dynamics of soil and ecological systems in response to fire.

5. Developing a method for updating postfire debris-flow hazard assessments to reflect changing hazard potential with burned area recovery

Presenter: Andrew Graber; U.S. Geological Survey
Co-authors: Matthew Thomas, Jason Kean, Jonathan King, Jaime Kostelnik

Each year, the U.S. Geological Survey (USGS) performs postfire debris-flow hazard assessments for more than a hundred thousand acres of steep, burned terrain in the U.S. These products provide quantitative rainfall thresholds for runoff-generated postfire debris flows and predict the likelihood of debris-flow occurrence within the burned area, given a range of design rainstorms. The hazard assessments use normalized burn ratio (NBR) data collected immediately after the fire is contained to evaluate burn severity and therefore provide guidance for hazard conditions soon after fire. However, debris-flow hazard potential changes through time as vegetation and soil hydrology recover towards prefire conditions. Spatially variable recovery processes can complicate this hazard evolution, leading to non-uniform changes in hazard potential. As a result, there remains a need to develop updated hazard maps and rainfall thresholds that reflect these changes in hazard potential. We present a method for predicting debris-flow rainfall thresholds on an annual basis for the first three years after a fire using the USGS M1 debris-flow likelihood model. Our approach updates the burn severity input data (e.g., NBR) to the model on an annual basis to evaluate the changes in likelihood and rainfall thresholds as the burned area recovers. We test our projected thresholds against a multi-year inventory of debris-flow monitoring data from 12 fires across the western United States. We find that re-running the debris-flow likelihood model with updated burn severity input data produces thresholds and hazard maps that are in good agreement with our debris-flow inventory. We discuss these predictions in the context of overall recovery trends for our study fires and consider possible criteria for how long hazard assessments for a given fire should be updated.

6. Uncertainty in Precipitation Observations, Hindcasts, and Forecasts over Southern California for Post-Tropical Storm Hilary

Presenter: Ann Sinclair; Northwestern University
Co-authors: Joshua West, Marin K. Clark, Daniel E. Horton

Rainfall intensity-duration thresholds are critical tools for predicting post-fire debris flows. To develop such thresholds, scientists rely on observations and reconstructions of past precipitation events. Rain gauges are widely used for creating intensity-duration thresholds, yet these instruments provide only point-source information. The spatial coverage of gauges is especially limiting in regions with steep precipitation gradients like southern California. Gridded precipitation estimates and forecasts offer more complete spatial coverage; however, they are often inconsistent with one another. In this study, we assess the differences among several quantitative precipitation estimates (QPEs) and forecasts (QPFs) over southern California during Post-Tropical Storm Hilary. The products we evaluate include several gauge networks (e.g. National Weather Service stations and Automated Local Evaluation in Real Time (ALERT) gauges); radar estimates from the Multi-Radar/Multi-Sensor System (MRMS); satellite estimates from the Integrated Multi-satellite Retrievals for GPM (IMERG), Precipitation Estimation from Remotely Sensed Information Using Artificial Neural Networks (PERSIANN), and Global Satellite Mapping of Precipitation (GSMaP); statistical estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM); and forecasts from the High Resolution Rapid Refresh model (HRRR). We find that these QPEs/QPFs disagree substantially in magnitude and rate during the event. The satellite-derived products significantly underpredict the rainfall recorded by gauges, especially along the San Gabriel and San Bernardino Mountains. Estimates from radar-derived products are more consistent with gauge measurements, but they fail to capture the high accumulations recorded at some stations. Forecast models, on the other hand, tended to overpredict the magnitude and rate of precipitation relative to gauge measurements. Our results highlight the uncertainty across QPE/QPF products over southern California. This uncertainty may propagate to uncertainty in intensity-duration thresholds, meaning QPE/QPF choice may have important consequences for our ability to understand, model, and predict post-fire debris flows.

7. Post-Fire Flood Risk Considering Infrastructure Sedimentation Across Riverside County, CA

Presenter: Ariane Jong-Levinger; Chapman University
Co-authors: Douglas Houston, Brett F Sanders

Previous work to model post-fire floods and debris flows has focused on characterizing the complex hydrologic, geomorphic, and meteorological drivers of these hazards, yet the impact of engineered flood infrastructure on the risk to downstream communities remains poorly understood. Jong-Levinger et al. (2022) developed a stochastic modeling framework for estimating the risk of flood infrastructure clogging with sediment and overtopping, given the interactions between wildfires, rainfall, and infrastructure design and maintenance. The model produces watershed-scale, multidecadal estimates of sediment-laden flood risk designed to inform long-term emergency planning efforts and infrastructure design and maintenance and was developed through a collaboration with Riverside County Flood Control and Water Conservation District. Here, we present estimates of post-fire flood hazards facing populations downstream of 29 watersheds across three mountain ranges in Riverside County, California. Post-fire sediment volumes were estimated using an empirical model developed by the Los Angeles District of the U.S. Army Corps of Engineers and adjusted for each mountain range based on site-specific sediment volume observations from UAV photogrammetric surveys and debris basin cleaning records. After parameterizing and calibrating the model for each watershed using largely publicly available data, century-long simulations of flood infrastructure overtopping events were used to identify hotspots of post-fire flood risk and explore how the spatial distribution of risk varies with factors such as infrastructure type and design capacity. Maps of post-fire flood hazards at the regional scale can be used to better understand where the most vulnerable populations are located, as well as how hazard management agencies should allocate resources for infrastructure improvements or increased maintenance activities in advance of the next major post-fire flood or debris flow.

8. **Advancing Wildfire Science and Collaboration: Insights from the California Fire Science Consortium**
   Presenters: Autym Shafer, Katanja Waldner; The California Fire Science Consortium

   This poster presentation sheds light on the mission and impactful initiatives of the California Fire Science Consortium (CFSC). With a mission to expedite the awareness, understanding, and adoption of wildland fire science information, the CFSC employs diverse dissemination tactics to reach federal, tribal, state, local, and private stakeholders in ecologically similar regions. The consortium's efforts extend beyond information dissemination; they actively foster collaboration and build robust networks across research, management, policy, and public spheres. Join us to explore how the CFSC is playing a pivotal role in advancing wildfire science and promoting informed decision-making across diverse landscapes and stakeholder groups.

9. Postfire hazard monitoring, modeling, and risk communication: the role of the NOAA Fire Weather Testbed User Needs Assessment

Presenters: Benjamin Hatchett, Emily Wells; Colorado State University CIRA/National Oceanic and Atmospheric Administration (NOAA) Global System Laboratory Fire Weather Testbed
Co-author: Zach Tolby

NOAA is increasing strategic investments in and planning for increasing wildfire-related hazards, including the establishment of the NOAA Fire Weather Testbed (FWT). The FWT intends to bring together decision-makers, researchers, and operational weather forecasters of multiple agencies and jurisdictions to develop and improve products for decision support. Critically, the FWT focuses on the information needs of those involved with wildland fire before, during, and after the flames to create a fire-ready nation: one that is fire-adapted and fire-resilient.

The FWT will work with other NOAA Testbeds and Proving Grounds to facilitate the evaluation and transition of fire weather-related activities. Housed within NOAA's Global Systems Laboratory in Boulder, Colorado, the FWT consists of physical and virtual facilities for conducting evaluations and experiments. Social and behavioral science will be a critical component of FWT user needs assessments, research, and evaluation activities.

As postfire hydrologic hazard potential increases with more frequent, severe, and larger fires compounded by precipitation intensification, there is a growing need for monitoring and modeling to inform management and communication strategies, tactics, and investments. The FWT is engaging in a user needs assessment focused on, but not limited to, the following postfire topics: short duration, high intensity precipitation observations and modeling of water balance changes spanning forecast (warning) to climate change timescales, postfire recovery and the role of climate conditions, runoff and mass movement-induced hazards and transport of fire-caused environmental pollutants and sediment, observations of streamflow, and implications for flood risk management, and risk communication across timescales (i.e., days-to-years) between decision makers and the public

Here, we intend to engage with postfire scientists to understand current knowledge gaps and areas where tool and product evaluations will support postfire hazard decision-making. We hope to develop transdisciplinary collaborations that improve our shared understanding of the total fire environment.

10. Historical and Forecasted Storm-based Scenarios with Framework for Debris Flow Modeling with a Micro-Hydrologic Network from Lidar Topography to Estimate Asset Risk and Support Emergency Response Planning.

Presenter: Benjamin Lowry; Teren Inc
Co-authors: John Norman, Ozgur Kozaci, Teddy Atkinson

Teren and PG&E partnered in a post fire debris flow hazard pilot study focused on a 361 square mile area within the greater 1505 square mile Dixie fire burn area. PG&E has operational assets within this burn area that may be affected by ongoing debris flow issues. This work improves upon standard USGS forecasting models by the creation of a dynamic analytical framework that allows for scenario-based simulations incorporating forecasted and historical storm events as model inputs. In concert with high resolution digital terrain models from lidar, a micro-hydrologic network attributed with soils, vegetation, land cover, and burn severity creates increased specificity for evaluating debris flow hazard. This integration allows debris flow initiation, flow path and flow termination to be modeled at high spatiotemporal resolutions and identify asset risk at operationally relevant scales. Model environments were optimized for high performance, cloud based computing environments that allow for rapid run times and tactical scenario modeling to support operational decision making. This approach coupled with advancing weather models and instrumentation supports advanced parameterization opportunities with calibration using sensitivity analysis, Monte Carlo simulation, and scale effects for any debris flow prone terrain.

11. Characterization and volume estimation for the 12 September 2022, debris flow event at Birch Creek, Oak Glen, southern California, sourced from the 2020 El Dorado Fire

Presenter: Brian Swanson; California Geological Survey

On September 12, 2022, heavy rainfall generated by Tropical Storm Kay impacted the Yucaipa Ridge area of southern California and generated multiple debris flows within the 2020 El Dorado Fire. The largest of these flows occurred at Birch Creek and inundated downstream floodplain areas at Oak Glen causing millions of dollars of damage to multiple structures and water facilities. A San Bernardino County camera captured images of the flow characteristics upstream of Oak Glen Road illustrating the occurrence of multiple flow pulses that progressively aggraded in the trunk channel until the channel capacity was exceeded. Water-dominated recessional flows then eroded the in-channel deposits back to the approximate original channel grade. CGS staff made field observations of the inundation area on September 13 and 14 including documentation of the spatial extent and depth of the flow deposits at representative stations along the flow path extending about two kilometers downstream of the mountain front where the flows re-entered existing channels and were conveyed to a debris basin. No rain gages were present within the watershed at the time, but multi-radar, multi-sensor (MRMS) precipitation estimates suggest peak accumulations of about 1.5 to 3 inches of rainfall in one hour within the watershed, which corresponds to a 100- to 500-year storm at the one-hour duration (NOAA Atlas 14). High-resolution digital elevation models (DEMs) derived from lidar or structure from motion were unavailable following the event and a hydrograph could not be constructed due to the channel aggradation. Therefore, neither DEM differencing nor a hydrograph could be used to assess the total debris volume. Consequently, the minimum sediment volume has been estimated based on the field measured flow limits and depths. This sediment volume will add to the existing limited database on postfire debris-flow sediment yield volumes used in future modeling and emergency planning efforts.

12. Modeling and Remote Sensing of Postfire Debris-Flow Susceptibility at Regional Scales

Presenter: Chuxuan Li; Northwestern University
Co-authors: Alexander Handwerger, Daniel Horton

Following wildfire occurrence, reduced tree canopy interception and increased soil water repellency can substantially increase surface runoff and lead to destructive debris flows. Given the large spatial scales of debris-flow triggering weather systems and wildfire burn perimeters, regional-scale modeling is critical to advance debris-flow susceptibility predictions. To date, however, the use of physics-based modeling to predict postfire debris flow susceptibility at regional scales remains limited. To close the gaps, we adapt NOAA's National Water Model, WRF-Hydro, to simulate hydrological conditions and assess postfire debris-flow susceptibility over a central California for an event in January 2021. During that event, more than four debris flows were triggered by a landfalling atmospheric river that dropped more than 300 mm of rain within four days onto the Dolan burn scar in Big Sur, California, with a peak precipitation rate of 240 mm/hr. We use radar-informed MRMS precipitation data at 1-km spatial and hourly temporal resolutions as a boundary condition for WRF-Hydro. To replicate the burn scar effects on hydrology, we modify the land cover and soil infiltration parameters in WRF-Hydro. When burn scar conditions are added, our model's ability to reproduce the USGS stream gage observations increases substantially – Nash-Sutcliffe Efficiency scores increase from negative values to 0.84, 0.73, and 0.53 at three gages located downstream of the burn scar. After validating the model, we divide WRF-Hydro's simulated peak overland flow and streamflow discharge by the corresponding catchment area to indicate debris-flow susceptibility. Our results show that WRF-Hydro simulated debris-flow susceptibility estimates agree well with a decrease in vegetation observed from satellite imagery, i.e., catchments with high simulated susceptibilities correspond well with vegetation loss – likely due to the occurrence of debris flows or debris floods. This study suggests WRF-Hydro to be a promising tool for process-based hazard assessments and regional-scale prediction of postfire debris-flow risk.

13. **Observations of Debris Flows in Small Basins Following the 2021 Tamarack Fire, Alpine County, CA**

Presenter: Cory Wallace; Gannett Fleming
Co-authors: Casey Smith, Julie Ryan, Trevor Coolidge

The Tamarack Fire burned roughly 70,000 acres (280 km^2) in Alpine County, California, and western Nevada in July through October 2021. During a convective thunderstorm several weeks after the fire, debris flows inundated a section of the Diamond Valley Ditch, a water conveyance canal roughly two miles east of Woodfords, California, interrupting water delivery and prompting emergency response and rehabilitation efforts. The flows contained mud- through boulder-sized rocky debris and significant woody debris and ash. The area is characterized by relatively small (<1 km^2) basins with relatively low relief (up to ~150 m) and moderate slopes within the semi-arid scrubland typical of the eastern Sierra Nevada. Observed debris flow volumes were on the order of 10^2 to 10^3 m^3, and sediment volumes of roughly the same magnitude were transported and deposited in the canal by sheetwash and rilling. The basin response to rainfall was unexpected due to the relatively gentle topography and low burn severity; however, the predicted debris flow volumes reported by the U.S. Geological Survey as part of the Emergency Assessment of Post-fire Debris Flow Hazards for the Tamarack Fire generally showed good agreement with the observed volumes. Existing chain-link fences along the inboard edge of the canal proved to be effective at retaining coarser sediment while passing the finer particles, especially where transport was dominated by sheetwash. Recurring debris flows have periodically affected the canal in the years following the fire, and the volume of debris mobilized in subsequent events has generally diminished since 2021.

14. Translating wildfire soil thermal alterations to post-fire hydromechanical parameters

Presenter: Dani Or; University of Nevada Reno
Co-authors: Hamed Ebrahimian, Sudeep Chandra, Markus Berli

Harnessing advances in wildfire modeling to define characteristics of heat exposure and transport within soil remains a challenge, moreover, the translation of thermal information to soil physicochemical alterations lacks a coherent framework. The nuances of wildfire induced soil heat exposure (heat flux amplitude and duration) determine the extent and duration of fire impacts on landscapes, particularly on soil structure, hydraulic and mechanical properties. We present a model for using the highly transient and localized wildfire intensity to establish boundary conditions for soil thermal exposure as constrained by the resolution of fuel information, mechanistic modeling (WRF-Fire, WFDS) and remote sensing data. We propose a two-layer soil alteration model for post-fire parameterization of changes in soil hydraulic and mechanical properties using time and depth-resolved soil temperature exposure primarily via effects on soil organic carbon (the binding agent of soil structure), and in some cases, changes in soil minerals. While parameterization is, at present, largely empirical and heuristic, the proposed framework offers a consistent platform to introducing mechanistic models of soil structure and mechanical thermal alterations including the decay and recovery of root reinforcement at hillslope scales. The loss of root reinforcement combined with less permeable and weakened soil mantle promote the onset of debris flows.

15. A dynamic flow multiplier for postfire emergency response in California

Presenter: Donald Lindsay; California Geological Survey / Burned Watershed Geohazards Program
Co-authors: Paul Richardson, Brian Swanson

Wildfire can radically alter watershed processes resulting in increased risk to life, property and infrastructure from flash floods and debris flows, particularly within the first two years following wildfire. However, the magnitude of postfire flows is difficult to predict because necessary data on soil properties, surface roughness, and vegetation cover are often lacking. Consequently, the current state of practice used by emergency response agencies to estimate postfire flood and debris-flow hazards is to adjust pre-fire discharge estimates using a simple bulked-flow multiplier (BFM) to account for increases in post-fire runoff plus sediment and debris entrainment. Current BFMs, defined as the ratio of postfire to pre-fire peak discharge, are a function of several factors including watershed size, burn severity, sediment and woody debris availability, and the storm recurrence interval (RI) of interest. BFMs applied by both federal and state postfire emergency response teams in California typically do not exceed a multiplier value of 10 in the first two years following fire. However, rainfall and runoff data across a range of hydrogeomorphic provinces throughout California show BFMs much higher than 10. Here we introduce a new term, referred to as the Dynamic Flow Multiplier (DFM), to account for complex flow regimes that occur within the dilated flow front of debris-laden flows. We explore defining the DFM as a function of large wood recruitment, channel morphology, and in-channel grainsize. Preliminary results suggest additional work is needed to adequately determine appropriate post-fire flow multipliers to account for observed runoff magnitude and associated hazards.

16. A surrogate-based strategy for analyzing post-fire debris flow inundation hazards

Presenter: Elaine Spiller; Marquette University
Co-author: Luke McGuire, Palak Patel, Abani Patra, Bruce Pitman

Numerical models of post-fire debris flow bulking and runout are computationally intensive. These models depend on poorly constrained and difficult to measure parameters related to fire-altered soil and vegetation, some of which change in time. Further, the development of debris flows also depends on the rainfall intensity of potential storms. To date, modeling-based hazard analysis has largely focused on “if" a debris flow might be triggered on a given fire scared hillside, and not on the extent or footprint of potential debris flow run outs. We employ Gaussian process emulators to high-dimensional debris flow model output to quantify uncertainties and aid in model-based hazard assessments of post-fire debris flow inundation. The end goal is a family of maps or analyses that represent how a hazard threat of inundation evolves under different assumptions or different potential future scenarios. Further, this approach allows us to rapidly update hazard analyses as new data or precursor information arrives.

17. Linking Active Fire Properties to Post-Fire Impacts on Vegetation and Hydrology

Presenter: Eli Orland; NASA Goddard Space Flight Center
Co-authors: Douglas Morton, Melanie Follette Cook, Tempest McCabe, Yang Chen, Shane Coffield, Robert Field, Rachel Loehman, Brian Ebel

Following wildfire, there can be lasting impacts to the landscape within and downstream of the burn scar that promote hydrologic hazards. However, uncertainties remain as to how a fire induces changes to soil hydraulic properties, vegetation, and erosion potential. We use the recently introduced Fire Events Data Suite (FEDS) tracking algorithm to reconstruct the 12hr spread progression and intensity metrics of 1800 wildfires in the United States as detected by the Suomi NPP VIIRS satellite sensor. When compared to thematic burn severity data provided by the Monitoring Trends in Burn Severity (MTBS) program, we find a positive relationship between fire intensity, spread rate, and burn severity. Using this large-scale analysis as a guide, we focus on the Hermit's Peak/Calf Canyon wildfire, the largest in New Mexico's history, to investigate the role of fire behavior on watershed recovery. Within the burned Gallinas Creek Watershed, streamflow properties are observed to return to pre-fire levels within approximately one year of burning, yet the recovery of vegetation is highly variable and closely linked to the initial assessment of burn severity. Given that vegetation regrowth stabilizes hillslopes, intercepts rainfall, and increases both transpiration and available soil pore space, our analysis suggests that despite watershed-scale streamflow properties approaching pre-fire levels, hydrologic processes at the hillslope scale are likely to remain highly variable and influenced by the state of local vegetation recovery. Satellite- derived estimates of active fire spread and intensity reveal that fire behavior can serve as an early indicator of vegetation burn severity, and thus, helps anticipate the spatially heterogeneous patterns of recovery within a burn scar as soon as a few hours after observation. Our work demonstrates an advancement in understanding the processes which affect burn severity, and provides an early indicator of the spatial heterogeneity of post-fire hydrologic hazard potential.

18. A Proof-of-Concept Application of the Wildfire Continuum Flood Frequency Analysis

Presenter: Guo Yu; Desert Research Institute
Co-authors: Tao Liu, Luke A. McGuire, Daniel B. Wright, Benjamin J. Hatchett, Julianne J. Miller, Markus Berli, Jeremy Giovando, Michael Bartles, Ian E. Floyd

Moderate to high (M-H) severity wildfire can abruptly alter watershed properties and enhance extreme hydrologic responses such as debris flows and floods. The compounding effects of wildfire on flood hazard, represented here via flood frequency analysis (FFA; e.g. 100-year flood) are of growing importance. Standard statistical FFA approaches are ill-suited to examining this issue because wildfire-affected flood peak observations are limited in number and violate the assumption of independent and identically distributed events. Here, we developed a process-based FFA framework that integrates a stochastic rainfall generator, wildfire simulation, inverse modeling, and a physics-based hydrological model to directly simulate the impacts of wildfire on FFA. We applied this framework in the upper Arroyo Seco (uAS) watershed in Southern California, which experienced M-H burn during the 2009 Station Fire. An FFA analysis, performed with simulated peak flows from the first year since fire demonstrates the 100-year flood can be three times larger than simulations that only consider peak flows in non-fire-affected years. On the other hand, coupling process-based FFA with stochastically-simulated wildfire events and watershed's time-varying hydrologic recovery yields "fire continuum FFA", a concept introduced here for the first time. Fire continuum FFA accounts for multiple wildfires within very long synthetic time series. Variability in upper tail flood peaks is substantially higher in fire continuum results as compared with pre-wildfire FFA. This result highlights the importance of wildfire inter-arrival time and post-wildfire recovery processes, both of which are expected to change as a result of climatic change and evolving fire management strategies.

19. Micro to Macro Assessment of Post-Wildfire Debris Flow Internal Structure

Presenter: Ingrid Tomac; University of California, San Diego
Co-authors: Wenpei Ma, Haohua Chen, Teagan DePoint-Spang, Caitlin Kim, Mahta Movasat

Postwildfire mudflow and debris flow's internal composition is dynamic and evolving. Raindrops fall on ashy and burned soil surfaces that often turn sufricially hydrophobic, and solid particles erode, forming devastating mudflows. During erosion and raindrop splash, as well as due to naturally occurring soil porosity, air entrapment into mudflows is possible. Therefore, this research hypothesizes that not only the mudflow composition is more complex than anticipated solid and water slurry, but the constituent ratios and micro-forms like air bubbles entrapped in the mixture, the ratio of solids, water and air, and the amount of hydrophobic particles affect flow and transport. This research uses field, laboratory, and analytical techniques to tackle and assess post-wildfire mudflows' complex internal structure and flow behavior. Mechanisms like liquid marble formation are responsible for long-term air entrapment into mudflows. Hydrophobic particles attract air bubbles due to their specific surface properties that are water-repellent like air, which results in particles covering air bubbles in water, known as liquid marbles. Specifically, the microstructure of a flowing mixture of hydrophobic and hydrophilic sand particles, fines, ash, water, and air bubbles is presented. Findings propose predictive relationships for the rheological behavior of complex mudflow mixtures, entrapment of air that leads to density changes, and transition of rheology-driven to collision-driven flow and transport equations.

20. Revisiting tiered rainfall thresholds for postfire debris flows

Presenter: Jason Kean; U.S. Geological Survey

Early warning of debris flows from recent burn areas requires estimates of the triggering rainfall thresholds. At-threshold rainfall typically initiates small, nuisance-level debris flows, whereas higher rainfall rates tend to mobilize larger flows that are more likely to escape channels and cause damage. Ideally, early warning includes an indication of the potential magnitude of a debris-flow event so emergency managers can respond appropriately. In practice, however, warning operations tend to rely on a single low threshold that is representative of the initiation conditions. Although tiered rainfall thresholds based on the number and expected volume of debris flows have been developed for the San Gabriel Mountains (SGM) Los Angeles County, California, they are not necessarily transferable to other regions. One barrier to transferring the tiered SGM thresholds is that debris-flow volume scales with burned drainage area, and regions with different distributions of drainage area may have potential volumes that do not match the SGM criteria. For example, the larger drainage areas of the Santa Ynez Mountains in neighboring Ventura and Santa Barbara Counties, which sourced the fatal 2018 Montecito debris flows, have expected debris-flow volumes that exceed the SGM criteria. To develop more general tiered rainfall thresholds, I revisit a catalog of impactful debris-flow events in southern California and use volume-inundation-area scaling relations to define tiered thresholds that are independent of burned drainage area. This alternative approach places greater emphasis on the propensity of a debris flow to escape a channel than on the absolute magnitude of the flow, and it thus provides tiered warning criteria that is not limited to a specific region.

21. Crisis Migration Through Post-Wildfire Debris Basin Design: A HEC-HMS Case Study in Riverside and San Bernardino Counties

Presenter: Jay Pak; U.S. Army Corps of Engineers, Hydrologic Engineering Center
Co-authors: Moosub Eom, Jacqueline Oehler, Julia Kim

In the aftermath of wildfires, watersheds face increased susceptibility to severe flooding, sedimentation, and hazardous debris flows, particularly following even minor precipitation events. This case study introduces a methodology for post-wildfire hydrology and debris flow numerical modeling, utilizing the recently developed Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS). The approach enables the anticipation of essential details for designing debris basins, such as potential locations and capacities, derived from estimated post-wildfire hydrology runoff debris yields.

The study focuses on the El Dorado fire, which started on September 5th, 2020, in El Dorado Ranch Park, San Bernardino County, consumed 22,744 acres. In response to these wildfires, the U.S. Army Corps of Engineers (USACE) utilized the post-wildfire hydrologic and debris yield model to identify high-risk communities, proposing mitigation measures to minimize potential flood and debris damage.

HEC-HMS models were crafted for a watershed, namely Oak Glen Creek. The initial calibration involved pre-fire conditions using observed events and regional regression equations. Post-fire conditions, accounting for decreased permeability in burned areas, were modeled by adjusting loss parameters based on fire burn severity. These post-fire models not only generated hydrographs but also estimated debris yield at eight return frequencies. These projections played a vital role in shaping the design of the debris basin, considering a 2-year debris yield. They helped identify suitable locations and set capacities, contributing to improved preparedness and risk reduction in susceptible areas.

22. The Wildfire Forecast and Threats Intelligence Integration Center and the National Weather Service

Presenter: Jessica Chiari; National Oceanic and Atmospheric Administration (NOAA)/National Weather Service
Co-author: Jose Cuellar

The primary mission of the Wildfire Forecast and Threat Intelligence Integration Center (WFTIIC) is to gather, evaluate, and analyze fire weather data, atmospheric conditions, and other indicators that could lead to severe wildfires. Our aim is to diminish the occurrence and severity of wildfires, thus safeguarding lives, property, and the environment. To achieve this, we develop and share intelligence products pertinent to fire weather and fire threat conditions, tailored for government decision-makers.

Functioning as California's central hub for wildfire forecasting, weather information, and threat intelligence, the WFTIIC coordinates the collection, analysis, and dissemination of wildfire threat intelligence and data among a diverse range of stakeholders, including federal, state, and local agencies, tribal governments, utilities, academic institutions, and non-governmental organizations.

As a crucial federal partner, the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) assigned a dedicated Meteorologist to work within the WFTIIC. This Meteorologist serves as the liaison between the NWS Western Region's Regional Operations Center in Salt Lake City, UT, and the WFTIIC. This collaborative role is essential to ensure effective interpretation of NWS data and messaging from 10 NWS Weather Forecast Offices, as well as Predictive Service units in Northern and Southern California. By aligning with the WFTIIC, the NWS extends its impact-based decision support services, thereby assisting in critical decision-making processes to protect lives and property.

23. Developing a method for regional-scale prefire hazard assessments in Colorado

Presenter: Jonathan King; U.S. Geological Survey
Co-authors: Jason Kean, Jaime Kostelnik

Postfire debris-flow hazard assessments provide crucial data for assessing postfire risk. However, the limited time between wildfire activity and debris-flow triggering rainstorms often prevents officials from using these assessments for effective emergency response planning. Prefire debris-flow hazard assessments can allow for more complete emergency planning, and there is interest in producing these assessments for fire prone areas of the western US. Here, we discuss efforts to develop prefire assessments for the state of Colorado.

The current USGS postfire debris-flow hazard model requires two inputs pertaining to wildfire severity: differenced Normalized Burn Ratios (dNBRs) and a field-validated map of soil burn severity classes. As such, any prefire effort must simulate these datasets before performing a hazard assessment. Here, we expand on existing work using historical dNBR distributions to estimate wildfire severity for different types of vegetation. We used data from 1813 historical wildfires across the western United States to produce empirical dNBR distributions for each vegetation class in the LANDFIRE Existing Vegetation Type (EVT) database. These distributions allowed us to simulate a wildfire scenario, and thereby implement a debris-flow hazard assessment, for any area exhibiting these vegetation types. We then used a series of leave-one-out experiments to test the skill of our prefire assessment method for 88 historical Colorado wildfires. These experiments allowed us to selectively examine sources of error in our prefire assessment method; here we focus on (1) errors resulting from our wildfire simulation method, and (2) errors from in situ estimation of wildfire severity percentiles. We also examined the effects of constructing historical dNBR distributions from state-wide versus national domains. With this context, we then used our method to produce regional-scale prefire assessments for Colorado, focusing on the Pikes Peak Massif and Sangre de Cristo Range.

24. An assessment of the methodologies to characterize post-fire soil hydraulic properties

Presenter: Jorrin Lenton; Simon Fraser University
Co-authors: Brendan P. Murphy, Tom Millard, Yanik Nill

The impacts and risks from runoff-generated, post-fire debris flows (PFDF) are increasing with rising wildfire activity across western North America. Approaches to predict these hazards by rainfall-runoff process-based modelling are becoming more common, but require the collection of post-fire soil hydraulic properties (SHPs), often collected with a mini disk infiltrometer (MDI). As a relatively nascent field, there is significant variation in the collection protocols. To ensure consistent and reliable interpretation and comparison of data, there is a need for an evaluation and standardization of the methods used to characterize post-fire soil conditions. Here, we present a comprehensive and systematic assessment of the methods commonly used to assess post-fire soil properties using original datasets from recent wildfires in British Columbia, Canada. First, to capture landscape-scale variations, we assessed soil conditions in fires across three ecosystems: coastal temperate rainforests, dry mixed-conifer forests, and boreal forests. Next, to capture variability in soil conditions with burn severity, we assessed six sites (using 15-meter fixed radius plots centered on Landsat cells) that spanned the range of dNBR (including one unburned plot). Finally, to capture plot-scale SHP heterogeneity, we took co-located measurements within five 1-m2 quadrats at each plot. Within each quadrat we measured: infiltration using an MDI at two tensions, soil moisture, the ethanol molarity required for droplet penetration, and collected soil samples (intact and aggregate samples). In total, 360 unique MDI field measurements were collected which will be paired with laboratory-based MDI measurements of intact soil cores, along with analysis of grain size and organic matter. Our ambition with this ongoing work is to provide improved methodological recommendations for assessing post-fire SHPs with the MDI, particularly as it relates to the user-selected tension, measurement duration, sample size, and insights on how these recommendations may vary with soil texture, burn severity, or ecosystem.

25. Regional Risk Assessment of Steep Creek Fans in the Squamish Lillooet Regional District

Presenter: Joseph Gartner; BGC Engineering Inc.
Co-authors: Kris Holm, Carie-Ann Lau, Matthieu Sturzenegger, Caleb Ring, Ethan Faber

The Squamish Lillooet Regional District (SLRD) in southwestern British Columbia, Canada, encompasses mountainous terrain with abundant geohazards that have impacted local communities for over a century and First Nations since time immemorial. With wildfires occurring every year across the SLRD, communities are increasingly concerned about post-wildfire debris-flow and debris-flood risk and would like to be pro-active about understanding and managing these risks in a changing climate.

This study presents a regional geohazard risk assessment of alluvial fans in the SLRD that compares baseline and wildfire-adjusted conditions. We compiled a hazard inventory by mapping alluvial fans with lidar and aerial imagery. Risk was estimated as a function of geohazard likelihood, impact likelihood, intensity and exposure. The wildfire-adjusted risk assessment incorporated estimates of wildfire probability and post-wildfire debris-flow magnitude into the geohazard likelihood and intensity estimates.

Geohazard likelihood estimates were based on historical information, geomorphic evidence and Burn P3 modeling of wildfire probability. Impact likelihood was based on Flow R modeling, and adjusted to account for evidence for past avulsion events or landslide dam outburst flood (LDOF) potential. Geohazard intensity was estimated using empirical models for flow magnitude and rainfall runoff models. Hazard exposure ratings reflect the overall exposure of diverse elements at risk, including historically under-represented populations and building stock on First Nations reserves.

Risk assessment results were provided in an interactive web application. The results assist the SLRD to make regulatory decisions about land use and allocate resources for more detailed risk identification, evaluation and control. The compiled data can also be incorporated into more detailed post-wildfire hazard assessments in the event of a future wildfire.

26. Observations of post-wildfire volumes and velocities in south-central BC

Presenter: Kaushal Gnyawali; University of British Columbia

Co-authors: Kaushal Gnyawali, Dwayne Tannant, Tom Millard, Brendan Miller, Sarah Crookshanks, Gareth Wells, Marten Geertsema

We present a database and analysis of post-wildfire debris deposit volumes and velocities on alluvial fans of small watersheds (<5 km2) in south-central BC. The deposit volumes ranged from 20 – 100,000 m3, and the observed velocities ranged from 2-6 m/s. Short-duration, high-intensity convective rainstorms mostly triggered the post-wildfire flows. The debris deposits mainly came from sediment-laden steam flows or debris flows. Morphometrics like main channel steepness, Melton Ratio, time after fire, and peak rainfall intensity are compared in each event against the volume. The overall observations in south-central BC are compared with the available global dataset. The observations help develop design hydrographs for post-wildfire flows in small watersheds of this region.

27. Burn Area Emergency Response (BAER) Assessment Process

Presenter: Keith Stone; U.S. Department of Agriculture Forest Service

Co-author: Cara Sponaugle

A program to identify imminent post-wildfire threats to human life and safety, property and critical natural or cultural resources on National Forest System lands and take immediate actions to manage unacceptable risks.

28. Estimating postfire runoff characteristics from video: an example from Tropical Storm Hilary

Presenter: Kevin Callahan; California Geological Survey
Co-authors: Brian J. Swanson, Don Lindsay

Oak Glen, CA was impacted by Tropical Storm Hilary on August 20, 2023, which generated a progression of flow conditions in Birch Creek. The Birch Creek watershed is about 3.5 sq km in area and 84% of the area burned at moderate to high soil burn severity on slopes greater than 23 degrees during the 2020 El Dorado Fire. This was the latest in a series of flood, hyperconcentrated and debris flow events that have occurred since the fire. Video imagery captured by a San Bernardino County Flood Control District camera shows great examples of key flow-type indicators as flow conditions evolved. Turbulent, water-dominated flows with extensive bedload and floating woody debris occurred during the early phase of runoff, followed by sediment- and debris-laden hyperconcentrated flows. Water-dominated flow during a later phase of runoff transitioned to a viscous, laminar debris flow comprised of a slurry of more uniformly graded material. The pulsating surge fronts that occur throughout the event contained higher concentrations of woody debris and boulders.

Using the channel geometry and video footage to estimate stream stage vs. time and surface velocity, a runoff hydrograph was constructed for the flow event, with peak discharge quantified for multiple pulsating surge fronts of the various flow types. Correction factors were applied to the observed surface velocities to estimate mean channel velocities and to calibrate Manning's roughness coefficients. The hydrograph was subdivided by flow type and the total flow volume and sediment volume were calculated. Appropriate sediment to water concentrations were assumed based on observed flow conditions and the sediment volume estimates were then compared to modeled results derived from Gartner et al., 2014. Additionally, peak flow estimates for the various flow types were compared to pre-fire clearwater peak flow obtained using regional regression equations to calculate flow multipliers.

29. Field monitoring and climate simulations to advance hazard assessment and long-term planning for postfire debris flows

Presenter: Matthew Thomas, U.S. Geological Survey
Co-authors: Donald N. Lindsay, Nina S. Oakley, Jason W. Kean, Scott W. McCoy

Increased wildfire activity in the western United States has resulted in heightened awareness of postfire debris flows and increased demand for assessment of the hazard. At the same time, the uptick in wildfire activity has also exposed regional gaps in our understanding of postfire debris-flow initiation, such as in northern California, Oregon, and Washington. To address this problem, we conducted hydrologic monitoring and geomorphic mapping to evaluate the applicability and predictive performance of an empirical postfire debris-flow likelihood model for assessing burn areas in central and northern California, where postfire debris flows were previously undocumented. We also used dynamically downscaled, convection-permitting simulations of short-duration rainfall to evaluate how the frequency and magnitude of debris-flow triggering rainfall rates could evolve across California in a changing climate. Like southern California, we observed that the postfire flow type (e.g., low-hazard flooding versus high-hazard debris flow) and sediment yield for our central and northern California study areas is controlled by differences in short-duration rainfall rates and that debris-flow initiation is not sensitive to storm rainfall totals in the first year after fire. The climate projections indicate that the frequency and magnitude of short-duration rainfall capable of triggering postfire debris flows could increase throughout much of California. However, we expect that the effects of rainfall intensification will be more severe in northern California, where, compared to southern California, local communities, emergency managers, and weather forecasters may be less accustomed to contending with postfire debris flows. We conclude that the collection of field-verified inventories of postfire debris flows for regions where the threat of wildfire is new or has worsened, coupled with an understanding of the areas of greatest projected rainfall intensification, may improve our ability to assess and plan for the hazard.

30. Modeling post wildfire hydrology and sediment flow in the Western US

Presenter: Nawa Pradhan; U.S. Army Corps of Engineers - Engineer Research and Development Center (ERDC)
Co-authors: Ian Floyd, Francisca Olmos de Aguilera, Jang Pak, Taylor Cagle, Markus Berli, Rose Shillito, Stephen Turnbull, Jodi Ryder, Stephen Brown, Jeremy Giovando, Jose Paredez, Mitchell Price, Dani Or

Post-wildfire hydrology and sediment flow research and development efforts within the US Army Corps of Engineer (USACE) Engineer Research and Development Center (ERDC) include research on post-wildfire runoff generation mechanisms and sediment transport mechanisms for enhancing the post-fire flood and sediment flow simulation capability of USACE hydrological models. This study developed wildfire-induced soil hydraulic factors to account for the dynamic, hydrophobic intensity as a function of soil moisture content and burn severity, both identified at a 30 m grid scale. This method is implemented in the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model. The coupled model has been applied in several Western US watersheds to develop, test, and verify post-wildfire hydrologic and flood risk assessments. The study watersheds include: (a) Upper Arroyo Seco and Haines Canyon watersheds after the 2009 Station Fire in CA, (b) Tule River watershed after the 2021 Windy Fire in CA, (c) San Ysidro watershed after the 2017 Thomas Fire in CA, (d) Trapper Creek after the 2020 Badger Fire in ID, (e) Weiser watershed after the 2020 Wood Head Fire in ID, and (f) Detroit Lake watershed in OR after several wildfire events in the last two years. This approach improved post-fire hydrologic simulations by increasing simulated flood peaks and volumes as well as the flooding extents, resulting in a closer correlation to observed values in the Upper Arroyo Seco watershed and the San Ysidro Creek watershed in Southern California. The Nash–Sutcliffe Efficiency (NSE) of simulated hydrograph results in the Upper Arroyo Seco watershed was 82% and the coefficient of determination (R2) of the predicted flooding depths in San Ysidro Creek watershed was 0.79. This method was also applied in the modeling of post-fire flooding and sediment flow scenarios for emergency assessments in the Tule River watershed, Trapper Creek watershed, Weiser watershed, and the Detroit Lake watershed.

31. Improved Hydrologic Modeling of Fire-Affected Watersheds: Altered Infiltration

Presenter: Rose Shillito; U.S. Army Corps of Engineers - Engineer Research & Development Center
Co-authors: Markus Berli, Jay Pak

Wildfires pose a threat to life, property and infrastructure. The threat persists once the fire is ended in the form of increased runoff, erosion, flooding, landscape instability, and debris flows. Further, these threats are expected to increase due to changing climatic conditions and growth of the wildland/urban interface (WUI). Our objective is to better understand wildfire effects to improve the modeling of affected watershed hydrology for decisions regarding immediate emergency response as well as longer term water management. Here, we focus on the Green and Ampt infiltration model used in the USACE Hydrologic Modeling System (HEC-HMS). First, we (re-)introduce the soil hydraulic property of sorptivity to account for the well-documented presence of soil water repellency associated with fire-affected soils. Second, we illustrate how the Green and Ampt infiltration model can be altered to include sorptivity. Third, we simulate the effect of fire-altered sorptivity and hydraulic conductivity on infiltration. Results show a quantifiable effect on infiltration and, ultimately, runoff. These efforts form the foundation of a process-based understanding and modeling of the hydrologic response of fire-affected landscapes.

32. Highway 4 Cameron Bluffs Wildfire Geotechnical Response

Presenter: Ryan Gustafson; British Columbia Ministry of Transportation and Infrastructure
Co-author: Katrina Berube

According to the British Columbia (BC) Fire Service, the 2023 wildfires were the largest and most destructive in recorded BC history. 2,245 wildfires occurred with 2.84 million hectares of forest and lands impacted, surpassing the previous record of 1.35 million hectares in 2018.

The Cameron Bluffs wildfire had a significant impact on Highway 4 on Vancouver Island, which is the only public roadway connecting west coast communities such as Port Alberni and Tofino to the remainder of Vancouver Island and the rest of the BC highway network.

This poster highlights the situation that arose, and the actions taken by the BC Ministry of Transportation Geotechnical branch and their consultants during and in response to the Cameron Bluffs wildfire, including:

- Postfire hazards, including debris flow from steep creeks at the flanks of the burn area and rockfall from steep bedrock and colluvial slopes above the highway.
- Use of moveable rockfall barrier and crane supported rockfall mesh to manage postfire rockfall hazards for partial highway reopening.
- Use of rock scaling to manage risk from higher risk rock cutslopes.
- Postfire highway operating procedures in place at this time.
- A summary of postfire rockfall and debris slide events observed to date.

33. A Coarse-Scale Analysis of Fuels, Precipitation, and Soil Moisture Using NASA's SMAP Data Following Successive Wildfires in the Wallow Fire Area, Arizona

Presenter: Sarah Lewis; USDA Forest Service, Rocky Mountain Research Station
Co-authors: Peter Robichaud

Historically, the occurrence of a prior wildfire has been thought to minimize or prevent subsequent wildfire activity, especially within 10 years and in areas that had prior high severity burn scars. The 2011 Wallow Fire in Arizona burned more than 200,000 ha with 25% of the area classified as moderate or high soil burn severity. In the 12 years following the Wallow Fire, 30,000 ha burned via wildfire ignition (n = 11) or prescribed fires (n = 3). We evaluated fuels, precipitation, and subsequent wildfire activity as they related to NASA's Soil Moisture Active Passive (SMAP) data to detect trends in soil moisture that may indicate reburn potential. Annual precipitation was slightly below average (720 mm) over the study period, and in seasons where precipitation was lower than average, soil moisture was also below average as mapped by SMAP. With the exception of one year which had higher than average precipitation, all wildfire initiations began during a season which had significantly lower than seasonal average surface soil moisture (SSM).

In a prior study, three watersheds were instrumented after the Wallow Fire; minimal hydrologic activity occurred five years after the initial burn. However, the 2021 Horton Fire (5000 ha) re-disturbed the soils, and a high intensity storm in 2021 (14-July; 34 mm rain; I10 55 mm hr-1) resulted in weir over-topping events that were at the same magnitude or larger than any event after the Wallow Fire. The study watersheds were in areas burned at high soil burn severity in 2011, and reburned at moderate soil burn severity. This significant hydrologic response was not predicted with traditional post-fire mapping or risk assessment methods.

34. Meteorological and atmospheric conditions associated with post-fire debris flows in California

Presenter: Silvana Castillo Guerra; University of California, Santa Barbara
Co-author: Charles Jones

Enhancing preparedness response for post-fire debris flows can play an important role in reducing severe impacts related to the hazard. One way to contribute to such efforts can be achieved by designing better early warning systems and weather forecasts focused on identifying the atmospheric and meteorological conditions responsible for the rainfall triggering these downslope movements. Therefore, this research aims to investigate the storm conditions associated with post-fire debris flows instances to highlight spatial and temporal differences in California. Reanalysis datasets (e.g., ERA5, MERRA-2) and radiosonde data will be used to extract output variables that help compute moisture flux, convective stability as well as winds at different level pressures in order to describe the synoptic and mesoscale conditions producing the storm rainfall. Radar data will also provide additional information, especially for features like Narrow Cold Frontal Rainbands (NCFRs) and convective cells. We investigate contrasting conditions between post-fire debris flows occurring in the cool and dry seasons and a more prominent effect of orographic precipitation in mountainous terrain. Preliminary results show that 83% of cases in an existing catalog of post-fire debris flow dated until 2021 occurred during Atmospheric River (AR) days (Guan 2022). In addition, using de Orla- Barile et al. (2021) NCFR inventory, we found that 8 events match the mesoscale feature date of occurrences, being three of them in 2014, two in 2017, one in 2018 and two in 2019. The results from our investigation will feed an empirical model comprising environmental, rainfall and storm conditions to determine the importance of these types of variables in the generation of post-fire debris flows.