Innovations in Predicting Resilient Adaptations: Cascading Coupled Extremes of Wildfire, STORMs, Debris Flows, and Floods

Thad Wasklewicz, PhD (thad.wasklewicz@stantec.com) (Stantec, Fort Collins, CO, USA)
Mark Bartlett, PhD (Stantec, New York, NY, USA)
Richard Guthrie, PhD (Stantec, Calgary, AB, CA)

Background/Objectives. Climate change has led to increased likelihood of extreme wildfires and rainfall. The combination of both hazards, in turn, drives an increased likelihood of debris flows, debris floods, and flooding. These slope and river hazards are key components of risk and represent significant processes for transferring sediment, chemicals and nutrients, and large woody debris from hillslopes. This mass displacement can impact communities, infrastructure, as well as water quality and quantity along the cascading sediment and flow pathways. Innovative solutions are required to proactively assess multiple cascading hazards and capture, in real-time, evidence-based information to decision-makers and protect people, property, infrastructure, and our water supply

Approach/Activities. Our team has developed a series of numerical methods, tools, and near real-time information systems that capture, characterize, and predict, hydrological and slope hazards and help inform risk. Our predictive STORM software uses a modern GRIB reader to collect and aggregate high resolution hourly data to provide remote monitoring tools for stakeholders and inform them when critical thresholds for slope movement and high-water flows are exceeded. The program automatically emails stakeholders when thresholds are exceeded and permits stakeholders to view at-a-glance data for their location(s) of interest. Flood Predictor uses machine learning to provide accurate and data-driven results on where and when flooding is likely to happen in near real-time. A vendor-, device-, and system-neutral platform, Flood Predictor can analyze flood hazards, project future climate scenarios, incorporate local adaptation, and validate against government records. DebrisFlow Predictor (DFP) is an agent-based model capable of probabilistically assessing debris flow pathways, runout, and inundation. DFP has been used to establish debris flow impacts to property, infrastructure, and the environment in the United States, Canada, Europe, and South America. Debris flow impact analyses permit us to accurately represent hazard and risk at regional and local scales and facilitate data driven mitigation designs.

Results/Lessons Learned. DFP has been applied throughout North America in post-wildfire debris flow hazard assessments and risk analyses. We identified credible model scenarios based on an understanding of the number of debris flows initiating per unit area within burned watersheds. Randomly established debris flow initiation points using susceptible areas provides an effective approach to capture runout and inundation, which correspond well to known impacts to properties and communities. An updated version of STORM has been released with a rainfall runoff modeling calibrated to local gauged stations, a predictive component, and improved user interface providing a more robust means of identifying landslide triggering rainfall, scour at pipeline watercourse crossings, and bridge/culvert capacity exceedance across North America. Flood Predictor is being applied regionally to assess priority areas for communities for hazard planning measures. Analyses at a regional scale are possible in a timely manner because the Flood Predictor can produce results faster than traditional approaches. A suite of innovative tools is being deployed individually and in conjunction with one another to proactively examine a range of hydrologic risks that are becoming more extreme with climate change.