ENGLISH

Topic/Title

Post-wildfire debris flows and debris floods: evaluating transient hazard change due to wildfire-induced environmental stress

Proposer (Tutor)

Prof. Domenico CALCATERRA

Research proposal

In recent decades, the increasing number and severity of wildfires have become a major concern in many regions of the world. Beside direct consequences on forest, crops and settlements, wildfires can have significant effects on catchments hydrology, altering their response to rainfall and promoting enhanced runoff and erosion. Indeed, wildfires cause significant changes in soil properties, due to i) modification of the mineral soil layer at varying depths, ii) enhancement of water- repellent layers and iii) deposition of a hydrophilic surface layer of ash. Increased runoff in burned areas can be caused by a combination of infiltration- and saturation-excess overland flow and is often attributed to i) soil water repellency,
ii) increase in amount of bare ground and iii) lack of any surface water storage. Having said that, enhanced soil water repellency is not always necessary for enhancing runoff. Increased runoff can often result in catastrophic damage and loss of life by destructive debris flows/floods. This is also related to post-wildfire catchment response, which can be disproportionately large in comparison with the extent of the burned area. In this context, predicting post-wildfire hydrograph is of great importance for debris flows/floods hazard assessment, but it is a very challenging task due to the frequent lack of data depicting cause-effect relationship between rainfall and runoff in burned catchments, which are frequently ungaged. In addition, the prediction of timing

for debris flows/floods due to runoff generation over burned areas is even much difficult. This because of i) the frequent simplified consideration of temporally and spatially uniform rainfall and ii) the frequent lack of data about the "fire-effect modifier" for runoff estimation. On this basis, although many studies have contributed to the topic, further contribution would be required for a better understanding of the transient and/or episodic response of burned catchments due to change in soil properties, also as a consequence of a series of rainfall of differing magnitude, and extent the knowledge of wildfire-related debris flows/floods over the Apennine mountains of Italy, where such processes are becoming increasingly frequent. The proposed PhD research project will be aimed at contributing to a better understanding of i) predisposing environmental change induced by wildfires to enhanced runoff and erosion responsible for debris flows/floods, both in carbonate and pyroclastic rocks dominated environments and ii) modulating action of burn severity and rainfall characteristics on timing for potential debris flows/floods initiation. In addition, specific methods will be tested and/or developed for episodic and transient hazard estimation and prospective scenario generation. In such perspective, the project will use data from literature analysis, field surveys, remote sensing analysis, laboratory testing and numerical modeling. Potential study areas will be identified along the Apennine ranges of both southern and northern Italy and, for comparison purpose, both the Rocky Mountains and Cascade Range of central and western United States.

Research Plan

I° year

- literature analysis
- sites identification and wildfire-debris flows cause-effect relations analysis

II° year

- widlfire hazard assessment acccounting for site features and climate change
- geotechnical characterization of slope deposits involed by landslides

III° year

- Development of methods for post-wildfire landslide hazard assessment and development of prospective scenarios

- Preparation of the doctoral thesis

Additional notes:

The candidate expenses for field and other activities related to the PhD project will be covered by the Engineering Geology and Geotechnics Group Departmental funds. The candidate is expected to have solid background in physics and a general knowledge of informatics. The candidate is expected to complete a training/research period at a foreign institution.