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Geostatistics for Forest Fires: from variography to geosimulations

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Forests cover about 30% of the total planet land area and they play an essential role in the dynamic of the life. A major factor perturbing distribution and composition of forest life is fires. This phenomenon can profit forest ecosystems by regulating the functioning of these communities; however, some other non-fire-adapted forest ecosystems, human activities and environment can be negatively affected. Worldwide statistics reveal a growing trend of these fires producing remarkable impacts on ecosystems, regional economies, human health and safety and global climate change. Therefore the identification of vulnerable regions to fire and the understanding of their distribution in space and time are crucial to mitigate fire-related problems, to improve fire occurrence prediction and fire management planning.

From a statistical point of view forest fires can be interpreted as a stochastic point process where events are characterized by the spatial locations (coordinates) of fire-ignition point and other related information such burnt area, ignition-cause, duration, time occurrence, altitude and slope. In order to describe the spatial correlation between these features, a geostatistical tool called variography is applied using a variogram aiming to understand how data are distributed in space as well as understanding interaction effects of forest fires.

Traditional geostatistical analysis uses linear models in order to predict/estimate the value of the function at unsampled points. These models are called kriging models and they are based on structural analysis (variogram). Variograms and geostatistical predictions (family of kriging models) were applied to study spatial dependence of forest fire burnt areas, duration, altitude, slope, and ignition-cause in a 39-years (1969-2008) forest fire database of canton Ticino (Switzerland) and to eventually predict spatial patterns of these events and to characterize corresponding uncertainties.

Results of comprehensive analyses of variograms and cross-variograms between topographic features, burnt area, ignition-causes and duration were performed revealing spatial (co)correlations between these characteristics at both global and local scales.

Finally, in order to characterize spatial variability and uncertainty of the patterns observed the geostatistical conditional stochastic simulations were carried out.

Keywords: forest fires, geostatistics, variography, kriging models, geosimulations.