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Geomorphological Controls and Land-use Effects on Rainfall Triggered Debris Flows in Brazil

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Debris flows are major processes controlling landscape evolution, especially in tropical environments, where thick talus and colluvial deposits are observed filling bedrock topographic hollows and larger valleys. Besides their geomorphological meaning, they also represent an enormous danger to man when soil-mantled steep hillslopes are densely occupied in urban areas. In Brazil, especially in southern and southeastern portions, due to the steep hilly topography, the high precipitation values and the expansion of the urbanization towards the hillslopes, debris flows are becoming more frequent. This has been the case of the catastrophic debris flows observed in Rio de Janeiro (e.g., 1967, 1988, 1996, 2002) and São Paulo (e.g., 1967, 1975). In these states, due to the dense occupation, debris flows tend to frequently achieve catastrophic proportions. However, more recently, even in areas with sparse occupation and with no previous records of catastrophic landslides, like the ones in the southern states of Paraná and Santa Catarina, debris flows are taking place. This is the case of the recent rainfall triggered catastrophic debris flows that occurred last November in the area Morro do Baú, Santa Catarina state, by far, the most important event that took place in this region. In this location, besides the striking pluviometric records and the geological/geomorphological aspects, land-use changes (huge banana plantations and Pines forested areas) seems to have played a major role in amplifying the magnitude of the processes. However, the scientific community in Brazil seems to be still more concerned with small shallow landslides. Although a lot of effort has already been made towards a better understanding of the conditioning factors controlling landslide initiation at a specific site (hillslope scale), it is urgent to improve our ability in predicting landslide instability in larger areas (drainage basin scale), where positive and negative feedbacks between the hillslope and the channel segments play a major role. Modeling hillslope stability, of course, is not an easy task, especially when dealing with large drainage basin. Consequently, different approaches should be combined in order to attain success in prediction landslide hazards. In this study, based on detailed field mapping and modeling, we compare the role played by the geomorphological and geological factors in defining the location of major debris flows in Brazil. Besides, we discuss the effects of land-use changes, especially the introduction of huge banana plantations on steep slopes, on soil hydrology and landsliding. At last, we show some modeling results obtained in combining the models SHALSTAB and FLO-2D to simulate the catastrophic debris flows that took place in Rio de Janeiro city in 1996. Although our ability to predict where landslides might occur in a certain landscape has greatly improved in the last decades, we still have a long way towards being able to define when they will take place.