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Spatial heterogeneity of debris-flow watershed

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The intermittent surge is the basic manifestation of viscous debris flow, which emerges universally over the world, especially exemplified by those in Jiangjia Gully (JJG), a valley famous for its high frequency and variety of debris flow surges. It has been found that the surges originate from various sources in the watershed, thus identifying the source areas plays a fundamental role in studying the mechanism and process of surge developing. Advancement of GIS provides an apparent convenience in geospatial analysis of the watershed, which is used as a dominate tool in this paper.

In this study the JJG is divided into 97 tributaries (sub-watershed) and the hypsometric analysis is performed for each, from which derive the height of inflection points and the gravitational potential energy, coupled with the fitted parameters of specific power function. Then the morphology parameters, including slope, roundness, vegetation and soil, are revealed in tributaries. Besides, spatial autocorrelation among tributaries is quantified both globally and locally through Moran's I and Getis-Ord G_i*, so that the HI spatial distributions are quantified and visualized. In particular, hot spots are conspicuously visible and highlight the geologic meaning of the HI when exploratory spatial data analysis is applied to the data distributions through local indices of spatial autocorrelation.

The results show that H-curves approximately present as S-shaped, and the integral values (HI) range from 0.18 to 0.69 and show positive relationship with both gravitational potential energy and the height of the inflection points. By the HI value, the tributaries are identified as in 5 phases of evolution. The younger tributaries (HI>0.49) make up the majority, which are expected to be the main possible sources for debris flows. Additionally, the slope distribution of tributaries all conform to the extreme distribution while the curves for the upstream, where the HI of tributaries generally manifest higher coupled with larger roundness, tends to skew to the right.

Finally the correlation between possible sources are explored through geospatial analysis. The spatial association in JJG provides an explanation of the debris flow source areas. Global spatial autocorrelation manifests significantly clustered (Moran's I shows 0.449, passing the significance test) while tributaries with high HI value concentrate mainly in the Menqian Valley. Moreover, the drainage form of Menqian Valley represents a large possibility of debris flow source area with the respect of that being in Duozhao Valley.

Keywords: debris flow source area; hypsometric analysis; topographical characteristics; spatial

autocorrelation; evolutionary phases