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Vector Geometry based method for the extraction of the second-order terrain factor by using DEMs

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The first-order terrain factor is derived from the preliminary mining of terrain surface information. With the deepening of research, the second-order terrain factor is proposed as a tool for further mining terrain information. Scientific and accurate calculation of second-order terrain factor is not only the basic task of geomorphometry, but also an important part of many branches such as physical geography and environmental science. The surface curvature dominates the existing second-order terrain factor, and its core is to directly perform two derivation operations on the elevation value matrix. However, the second-order terrain factor calculation method based on the first-order terrain factor is ignored. This method is traditionally based on mathematical scalar methods. However, the first-order terrain factor matrix, as the source data for calculating the second-order terrain factor, has the characteristic of directionality. Thus, misunderstandings and errors would be produced if the second-order terrain factor was calculated by scalar method because its source data has the directional property. On a basis of the mathematical Gaussian surface and 5m-resolution DEM data of different landform sample areas, the mathematical vector method is proposed to calculate the second-order terrain factor with a full consideration of directional property of the first-order terrain factor matrix. In this method, the original first-order terrain factor matrix has been transformed into the polar coordinate system, and the vector geometric representation of angel value matrix could be achieved. Then the second-order terrain factor is calculated on a basis of this vector transformed first-order terrain factor data. In this paper, two first-order terrain factors, slope and aspect are taken as examples. The traditional method and the method we proposed are used to calculate the two second-order terrain factors: slope of slope (SOS) and slope of aspect (SOA). And then, a comparative analysis is conducted among our proposed method and precious methods. The results show that the two second-order terrain factors, SOS and SOA, calculated by vector geometry method could effectively avoid the error calculated by traditional method. Meanwhile, a more reasonable second-order terrain factor result can be achieved in the other main areas, and a more stable result can be obtained by using our method in different resolution DEMs. The vector geometry method proposed in this paper could help to provide a reference for accurate digital terrain analysis, and it is also an important practice to solve problem in DTA by mathematical vector geometry.