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Scale issues in runoff and sediment delivery: a global review and statistical analysis

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Scale issues in runoff and sediment delivery (SIRSD) is a hot and frontier topic in the fields pertinent to hydrology and soil erosion. This study combined bibliometric analysis and data mining to provide a systematic and holistic review of global SIRSD studies. The bibliometric results indicate that SIRSD is a comprehensive and multidisciplinary issue that has been extensively investigated with a wide variety of methods by scientists from 85 countries since the 1950s. The rapid growth of publications over the last three decades reveals that the discussions on SIRSD are attracting booming attention due to its great potentials for research and practice on various contemporary issues of environment and natural resources. Especially topics about hydrological and sediment connectivity, storm flood, nonpoint pollution, landslide and debris flow are drawing increasing concerns under the context of climate change. Thematic structure analysis indicates that SIRSD field centres the spatial scaling issues in the delivery of suspended sediment, including sediment budget analysis and sediment delivery ratio (SDR) estimation. Compared to studies dealing with erosion and sediment that mainly focus on the spatial scale, studies related to hydrological runoff and climate tend to discuss more temporal scale issues. Regarding the study distribution, most studies cluster on the time scale from an event to 10 years and the spatial scale from plot to meso-watershed (10 m^2-1000 km^2) and tend to appear in regions that feature free-flowing rivers with rapid agricultural development. Based on the mined 1039 pairs of data on the relationship between SDR and the watershed area, we built a global view of the spatial effect on SDR. The spatial scale effect on SDR is most prominent in Europe, followed by the USA, then the Global average, while most gentle in China due to its high topographic variability. On the contrary, the average SDR is highest in China (0.51), followed by the Global case (0.37), then the USA (0.34), while lowest in Europe (0.28) due to its low mean topographic slope. From this review, we identified several research gaps: 1) lack of multi-scale studies with nested across-scale design and studies on the spatial scale effect on runoff delivery; 2) considerable gaps among the results obtained from different regions, methods, and scales; 3) debatable and unclear questions on the spatio-temporal scale of underground water and soil loss in the karst region. Moreover, we emphasize three areas for future research: 1) scale issues of flood processes regarding extreme rainstorms under climate change; 2) scale transformation methodology and multi-scale modelling of hydrology, erosion, and sediment transport and their integrations with the climate models; 3) comparative study in different regions to bridge the regional gaps.