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A combinatorial method for improving hourly precipitation interpolation based on singular value decomposition

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Reliable estimation of grid precipitation dataset from gauge observations is crucial for hydrological modelling and water balance studies. Datasets developed by common precipitation interpolation methods are mainly derived from the spatial relationship of gauges while neglecting the trend contained in the antecedent precipitation. Precipitation data can be viewed as an intrinsically related matrix, with columns representing temporal relationships and rows representing spatial relationships. A method, called combinatorial point spatiotemporal interpolation based on singular value decomposition (CPST-SVD) that combines traditional interpolators and matrix factorization and considers the spatiotemporal correlation of precipitation, is proposed to improve estimation. Two widely used approaches including the inverse distance weighting (IDW) and universal kriging (UK) were combined to the new method respectively to interpolate precipitation data. Hourly precipitation data from several flood events were selected to verify the performance of the new method in the time period between 2012 and 2018 under different meteorological conditions in Hanjiang Basin, China. The Funk SVD algorithm and the stochastic gradient descent (SGD) algorithm were introduced for matrix factorization and optimization. The performances of all methods in the leave-one-out cross-validation were assessed and compared by five statistical indicators. The results show that CPST-SVD combined with IDW has the highest accuracy, followed by CPST-SVD combined with UK, IDW and UK in descending order. Through combination, estimation errors in precipitation interpolation can be greatly reduced, especially for the situation that the distribution of surrounding gauges is not so uniform or the precipitation in the target gauge is non-zero. In addition, the larger the amount of precipitation event, the greater the improvement of error. Therefore, this study provides a more accurate method for interpolating precipitation based on the assessment of both temporal and spatial information.