Interpolation of rainfall observations during extreme rainfall events in complex mountainous terrain

Trevor Page[1], Keith Beven[1], Barry Hankin[2], and Nick Chappell[1]

[1]Lancaster University
[2]JBA Consulting

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Abstract

The representation of rainfall is important for hydrological modelling, particularly for spatially distributed models. Accurate estimation of rainfall is particularly challenging in mountainous regions where observations are often sparse relative to the spatial variability of rainfall, making interpolation challenging. In these regions, orographic processes lead to complex patterns of rainfall enhancement and rain shadow depletion. This study tests one deterministic method, Natural Neighbour Interpolation (NNI), and two geostatistical methods, ordinary kriging (OK) and ordinary cokriging (CK), to determine if CK improves rainfall interpolation during three extreme rainfall events that occurred in the north west of England. Preliminary analysis using long-term annual average rainfall totals, including additional high elevation rainfall observations, showed that CK with an effective elevation index as a secondary variable performed better than NNI and OK with an overall improvement of around 40%. Using rainfall totals for long-term wind direction and wind speed rainfall classes, CK performance was variable across classes but provided an improvement of approximately 15% for wind direction classes without an easterly wind component. For 15-minute timesteps during extreme rainfall events, there were comparatively small differences between interpolation methods, attributed to having only relatively low elevation rainfall observations for cross-validation, providing weak constraint. Importantly, cross-variogram estimation (that controls the strength of the correlation between rainfall magnitude and the secondary variable) provided differing cross-validation results when estimated for different rainfall total periods: 15-minutes, hourly, daily and long-term. Variograms and cross variograms estimated at a 15-minute timestep frequency were robust for many timesteps, but were difficult to fit automatically for others. Variograms estimated from longer periods were more reliably estimated, but tended to have lower variance and cross-variance and longer correlation ranges producing a smoother interpolated rainfall field. Given the weak cross-validation constraint, care must be taken in identifying the most appropriate method and variogram estimation period.

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