Improved return level estimation via a weighted likelihood latent spatial extremes model

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Uncertainty in return level estimates for rare events, like the intensity of large rainfall events, makes it difficult to develop strategies to mitigate related hazards, like flooding. Latent spatial extremes models reduce uncertainty by exploiting spatial dependence in statistical characteristics of extreme events to borrow strength across locations. However, these estimates can have poor properties due to model misspecification: latent spatial extremes models do not account for tail dependence, which is spatial dependence in the extreme events themselves. We improve estimates from latent spatial extremes models by proposing a weighted likelihood that uses the extremal coefficient to incorporate information about tail dependence during estimation. While max-stable process models directly incorporate tail dependence, latent spatial extremes models are still popular because max-stable process models are intractable for many real datasets. We adopt a hierarchical Bayesian framework to conduct inference, use simulation to evaluate the weighted model, and apply our model to improve return level estimates for Colorado rainfall events with 1% annual exceedance probability.