A probabilistic view of extreme sea level rise in the Baltic Sea Going from the regional to the local, leveraging spatial dependency and missing values

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The impacts of extreme sea level rise along coastlines are of growing concern, leading to, among other things, the need for improved risk mitigation strategies in coastal planning at different levels of government and time scales. The probabilistic understanding of extreme sea level rise is a crucial part of any coastal planning aiming to account for the risk of such extreme events. However, one common problem is that there are no tidal gauge stations at or near the location of interest. Moreover, the number of observation years varies between tidal gauge stations. Resulting in the problem of the sparsity of observable locations, respectively, and the non-uniformness of observation years between sites. Our assumption, which builds on earlier works, is that there is much to gain by exploiting the spatial dependency of extreme sea level rise in the statistical modeling of such extremes. In addition to levering dependency, we ask what the observed annual sea level maxima at a given location tells us about the corresponding unobserved sea level maxima for locations at varying distances. We utilize methods from Extreme value theory (EVT), Bayesian statistics, and Probabilistic programming to study and drive results for the above discussion. More specifically, we gain probabilistic insights about the extreme sea level rise in the Baltic Sea by applying the Block Maxima approach and the Generalized Extreme Value distribution (GEV) in the EVT, for varying collections of tidal gauge stations, all of which are available at GESLA, together with the Markov Chain Monte Carlo simulations, respectively, the Bayesian hierarchical modeling paradigm, which allows for the smooth modeling of the GEV parameters using Latent Gaussian Process and Hilbert space approximated Gaussian Process, resulting in tight uncertainty bounds for the parameters, the theoretical support of the distribution, respectively, the k-year return levels, and thus decreased uncertainty for estimations at ungauged locations.