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Spatial analysis of avalanche frequency at the township scale

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For a rigorous computation of snow avalanche return periods, the quantification of avalanche frequency is necessary. Its empirical estimation with reasonable confidence levels is possible on well documented avalanche sites but very hazardous when few or no historical data are available. In France, four thousand avalanche sites are monitored by local foresters, some of them since the beginning of the XX^{th} century. Although data quality is subject to serious caution, this offers a possibility to overcome the lack of local data with a statistical spatial analysis at the township scale. The Cartesian coordinate is thus a surrogate for unobserved or unobservable covariates that explain the data. And the spatial structure allows reducing the local uncertainty by transferring information from one township to the others that are spatially close.

The proposed statistical model was developed mainly in the field of statistical epidemiology. It associates a discrete process at the township scale and a latent autocorrelated Gaussian random field. Spatial heterogeneity of the avalanche phenomenon can thus be quantified and local noise can be distinguished from the spatial structure. Model inference and predictive sampling can be advantageously carried out with bayesian Marcov Chain Monte Carlo simulation methods.

The illustrative example concerns the district of Savoie with 124 townships and 18755 avalanche events recorded over the last 60 years. The number of monitored sites is surprisingly the unique significant topographical covariate and is therefore sufficient for data standardization. It then appears that spatial structure explains about sixty percent of the total variability of avalanche frequency. Besides, predictive values at the township scale range from 0.01 avalanches per year and path to 1.4 avalanches per

year and path.