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Predict extreme influenza epidemics

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Influenza viruses are responsible for annual epidemics, causing more than 500,000 deaths per year worldwide. A crucial question for resource planning in public health is to predict the morbidity burden of extreme epidemics. We say that an epidemic is extreme whenever the influenza incidence rate exceeds a high threshold for at least one week. Our objective is to predict whether an extreme epidemic will occur in the near future, say the next couple of weeks.

The weekly numbers of influenza-like illness (ILI) incidence rates in France are available from the Sentinel network for the period 1991-2017. ILI incidence rates exhibit two different regimes, an epidemic regime during winter and a non-epidemic regime during the rest of the year. To identify epidemic periods, we use a two-state autoregressive hidden Markov model.

A main goal of Extreme Value Theory is to assess, from a series of observations, the probability of events that are more extreme than those previously recorded. Because of the autoregressive structure of the data, we choose to fit one of the mul- tivariate generalized Pareto distribution models proposed in Rootzén et al. (2016a) [Multivariate peaks over threshold models. arXiv:1603.06619v2]; see also Rootzén et al. (2016b) [Peaks over thresholds modeling with multivariate generalized Pareto distributions. arXiv:1612.01773v1]. For these models, explicit densities are given, and formulas for conditional probabilities can then be deduced, from which we can predict if an epidemic will be extreme, given the first weeks of observation.

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