Extracting a common signal in Northern Quebec black spruce tree-rings with a Bayesian hierarchical model

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Dendrochronology, the scientific dating method based on the analysis of tree-ring growth patterns, has been frequently applied in climatology. The basic premise of dendroclimatology is that tree rings can be viewed as climate proxies, i.e. rings are assumed to contain some hidden information about past climate. From a statistical perspective, this extraction problem can be understood as the research of an hidden variable which represents the common signal within a collection of tree-ring width series. Classical average-based techniques used in dendrochronology have been, with different degrees of success (depending on tree species, regional factors and statistical methods), applied to estimate the mean behaviour of this latent variable. Still, a precise quantification of uncertainties associated to the hidden variable distribution has been lacking. To model the error propagation throughout the extraction procedure, we propose and study a Bayesian hierarchical model. Our method is applied to black spruce (Picea mariana) tree-rings recorded in Northern Quebec and compared to a popular average-based techniques used by dendrochronologists. The main gain of our approach resides in the additional information provided in terms of posterior distributions, instead of the traditional point estimate of the latent variable.