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Bayesian Analysis of Non-Gaussian Long-Range Dependent Processes

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Recent studies [e.g. the Antarctic study of Franzke, J. Climate, 2010] have strongly suggested that surface temperatures exhibit long-range dependence (LRD). The presence of LRD would hamper the identification of deterministic trends and the quantification of their significance. It is well established that LRD processes exhibit stochastic trends over rather long periods of time. Thus, accurate methods for discriminating between physical processes that possess long memory and those that do not are an important adjunct to climate modeling. As we briefly review, the LRD idea originated at the same time as H-selfsimilarity, so it is often not realised that a model does not have to be H-self similar to show LRD [e.g. Watkins, GRL Frontiers, 2013].

We have used Markov Chain Monte Carlo algorithms to perform a Bayesian analysis of Auto-Regressive Fractionally-Integrated Moving-Average ARFIMA(p,d,q) processes, which are capable of modeling LRD. Our principal aim is to obtain inference about the long memory parameter, d, with secondary interest in the scale and location parameters. We have developed a reversible-jump method enabling us to integrate over different model forms for the short memory component. We initially assume Gaussianity, and have tested the method on both synthetic and physical time series.

Many physical processes, for example the Faraday Antarctic time series, are significantly non-Gaussian. We have therefore extended this work by weakening the Gaussianity assumption, assuming an alpha-stable distribution for the innovations, and performing joint inference on d and alpha. Such a modified FARIMA(p,d,q) process is a flexible, initial model for non-Gaussian processes with long memory. We will present a study of the dependence of the posterior variance of the memory parameter d on the length of the time series considered. This will be compared with equivalent error diagnostics for other measures of d.