Bootstrap estimation of the scale of geophysical process models

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Models of geophysical or environmental processes inherently involve a concept of scale, either temporal or spatial or both. Although the concept of scale is pervasive, there have been few attempts to give it an explicit definition or to quantify it. Scientists in different specific disciplines may also have quite different notions of what the term means. For purely empirical stochastic models, scale is often related to the resolution at which data are available. For deterministic models, scale may be related to the extent of time or space needed for output of a process model to cover the entire range of behaviors allowed by the dynamics of the model. The following "scale" problem is motivated by a need to compare regional climate models (RCMs), which aim to enhance the local resolution of climate forecasts through modifications to more well-understood global climate models. Various modifications provide an array of possible RCMs, but these can disagree in climate predictions. To develop comparisons of RCMs which are informative to meteorologists formulating RCMs and interpreting their climate predictions, we consider a resampling device for assessing the scale of "structured processes."

A mild probabilistic definition of a "structured process" is first introduced, based on a concept of a stationary scale at which a process may vary. A diagnostic quantity, based on the block bootstrap, is then proposed as a tool for quantifying the scale of such process models. In particular, the block bootstrap is applied to reconstruct empirical distributions from an observed process, though our use and intentions with the bootstrap are non-standard here. Often, the block bootstrap is known to be asymptotically valid over a range of block values. However, for scale-structured processes, this is not the case. This aspect turns out to be potentially useful. In fact, the block bootstrap re-creations exhibit a maximal level of variability only when the block length used matches the scale of the underling process. Hence, the bootstrap has certain asymptotic behaviors that make it useful for determining when resampling blocks have become large enough to preserve the dynamic structure of the process model, which quantifies our concept of scale. Use of the diagnostic is illustrated and further motivated though simulation, and is then used to compare the scales of several regional climate models (where some discernable behavior emerges).

Keywords: Block bootstrap; Block choice; Piecewise Stationary; Regional Climate Model.