Studying Statistical Methodology in Climate Research

Stats+Climate Workshop; Oslo, Norway, 11–13 November 2013

PAGE 129

Climate can be viewed as having two facets: the statistics of weather and the physics describing the underlying processes. Hence, climate science inherently relies heavily on statistical methodology.

Statistical tools are, for example, used to combine multiple data sources in paleoclimatology, to perform statistical downscaling, and to produce probabilistic climate projections through ensembles of climate models. Extreme value theory provides the necessary foundation for the analysis of extreme events, and model evaluation methods rely on decision theory; both techniques rely on fundamental statistics.

Despite the proliferation in the use of statistics, the number of statisticians working in climate research remains limited. This is evident, for instance, in the small number of statisticians involved in the work of the Intergovernmental Panel on Climate Change.

The Stats+Climate workshop, held in November 2013 in Oslo, Norway, allowed 70 statisticians and climatologists to present their work and discuss better integration of the two disciplines. The discussions covered a broad range of fields, including spatial statistics, hydrology, climate engineering, and paleoclimatology.

A key objective was to identify common threads in the use of statistical techniques in the diverse areas of study involved with climate analysis. For example, the appropriate propagation of uncertainty through complex hierarchical models is an issue that arose in presentations on risk analysis, hydrological modeling, and high-resolution regional climate studies. Discussions noted that Bayesian inference methods allow for smooth uncertainty propagation through the layers of such models. Similarly, many types of statistical analyses require the comparison of climate models to observational data, which may perpetuate uncertainties in complex ways.

Statistical experimental design has thus far not been widely used in climate model development and intercomparison projects. Much discussion was devoted to this issue, with a focus on the selection of parameterization schemes and physical parameters in regional climate models, in particular in the Weather Research and Forecasting model. While this is, strictly speaking, not a statistical issue, statistical experimental design can be a useful tool when selecting parameterization schemes and parameter values from among multiple possibilities while taking into account the complex interactions that can occur between different climate model components.

Extremes were a recurring theme during the workshop. The presentations covered such topics as the definition of extreme weather events—in particular, storms—and evaluating model performance with respect to diverse climate extremes. Another topic falling under the same theme was the analysis of distributional changes, a statistical definition of climate change that relies heavily on statistical theory. While such analyses have mainly been performed for single weather variables, extensions to multivariate quantities are possible and needed.

The topics discussed at the workshop offer abundant open research questions (to be addressed in a follow-up discussion paper) that require interdisciplinary collaborations in which climatologists identify key scientific questions and statisticians provide sophisticated methodology for the interpretation of data and model results. Thus, the workshop was a step forward in the growing dialogue between statisticians and climatologists. It allowed the participants to expand their multidisciplinary network and establish new collaborations that will move the two fields closer together.

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