Department of Statistics

DISSERTATION PRESENTATION AND DEFENSE

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Statistical Methods for Climatic Processes with Temporal Non-Stationarity

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ABSTRACT

The societal impacts of future climate change depend on changes in temperature variability in addition to changes in mean temperatures. While general circulation models (GCMs) predict changes in both means and variability, GCMs cannot fully reproduce present-day temperature distributions. We address an ensuing need for simulations of future temperatures that combine the observational record and GCM projections of changes in means and variability. Our perspective is that such simulations should be based on transforming observations to account for GCM projected changes, in contrast to methods that attempt to correct GCM output for discrepancies with observations. Our methodology is designed for simulating transient (nonstationary) climates, which are evolving in response to changes in CO2 concentrations (as is the Earth at present). Since the proposed simulation requires GCM projected changes in covariance, we describe a statistical model for the evolution of temporal covariances in a GCM, and apply this model to an ensemble of runs from one GCM, CCSM3. We find that, in CCSM3, changes in covariance can be explained as a function of the regional mean change in temperature and the rate of change of warming. This feature means that our statistical model can be used to emulate the evolving covariances in the GCM under scenarios for which the GCM has not been run. When combined with an emulator for mean temperature, our methodology can simulate temperatures under such scenarios. The emulator for variability changes is also of interest on its own as a summary of GCM projections of variability changes.

Time permitting, I will also summarize the second component of the dissertation, which concerns modeling a bivariate meteorological process -- temperature and dew point -- measured at high temporal frequencies and given covariate information. Dew point is bounded above by temperature, and both are highly nonstationary over the course of a day, so nonstandard methods are needed to characterize their bivariate distribution. We propose a parametric model for how the spectral matrix of a high-frequency component of the process varies with covariates over time. The model captures many of the observed features of the data, is interpretable, and is constrained to maintain the physical bound in the underlying process.

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