Chapter VII - Example Applications of Climate Model Results

Dryland Crop Yields

The effects of weather and climate on crops are complicated and not fully understood. Numerous models that simulate crop growth have been developed. These models parameterize many physiological processes. The present generation of state-of-the-art crop models typically steps through the growth process at a daily resolution and utilizes as input a number of meteorological variables that usually include maximum and minimum temperature, precipitation, solar radiation, and potential evapotranspiration. A key characteristic of these models is that they have been developed for application to a point location and have been validated based on point data, including meteorological inputs. Thus, the use of these models for assessment of climate change impacts on crop yields confronts a mismatch between the spatially-averaged climate model grid box data and the point data expected by the crop models. Also, biases in climate model data can have unknown effects on crop model results because the dependence of crop yields on meteorological variables is highly non-linear. The typical applications study circumvents these difficulties by avoiding the direct use of climate model output using some form of statistical downscaling. One approach developed during the early days of climate change assessments is still used today. In this approach, sometimes dubbed the “delta” method, the climate model output is used to determine the future change in climate with respect to the present-day climate, typically a difference for temperature and a percentage change for precipitation. Then, these change functions are applied to historical daily climate data for input to the crop model. In a second approach, the climate model data is used to adjust statistical characteristics of the observed data. Then, daily weather data for future periods are artificially produced using weather generators. In a recent study, Zhang (2005) used this approach to estimate Oklahoma wheat yields for a future simulation from HadCM3. These methods do not transmit certain climate model-simulated changes that do not affect basic statistical characteristics but might affect yields (a change to longer wet and dry spells without a change in total precipitation). Thus, additional uncertainty is introduced by such downscaling.

Small watershed flooding

This application faces many of the same issues as for dryland crop yields. For example, the models used for simulating runoff in small watersheds have been validated using point station data. In addition, runoff is a highly non-linear function of precipitation and the occurrence of flooding is particularly sensitive to the exact frequency and amount of precipitation for the most extreme events. As noted in Section V.H, climate models often under-estimate the magnitude of extremes. The ubiquitous "delta" method is also often used in such applications. Recently, Cameron (2006) determined percentage changes in precipitation from climate model simulations and applied these to a stochastic rainfall model to produce precipitation time series for input to a hydrologic model.

Urban heat waves

This estimation of changes in heat wave frequency and intensity can be accomplished using only near-surface temperature, a state variable. In addition, heat waves are large-scale phenomena and near-surface temperature is rather highly correlated over the scale of grid box size. Biases remain an issue, but that can be circumvented by using percentile-based definitions of heat waves. Meehl and Tebaldi (2004) used output from the National Center for Atmospheric Research/U.S. Department of Energy Parallel Climate Model (PCM) for 2080-2099 to calculate percentile-based measures of extreme heat; they found that heat waves will increase in intensity, frequency, and duration. If mortality estimates are desired, then biases are an issue because existing models (Kalkstein and Green 1997) used location-specific absolute magnitudes of temperature to estimate mortality. However, in this case, there are other factors that should be considered, such as adaptation (e.g. Davis et al. 2002).

***Water Resources in the Western U.S*.**

The possibility that climate change may adversely affect the limited water resources of the mostly arid and semi-arid western U.S. poses a threat to the prosperity of that region. A group of university and government scientists, under the auspices of the Accelerated Climate Prediction Initiative (ACPI), conducted a coordinated set of studies that represented an end-to-end assessment of this issue (Barnett et al. 2004). A suite of carefully selected climate simulations were performed by the Parallel Climate Model (Dai et al. 2004; Pierce et al. 2004). These were then used to drive a regional climate model to provide higher resolution data (Leung et al. 2004), both for direct assessment of effects on water resources and for use in impacts models. Finally, time series of model data at a daily resolution were used in a set of studies to assess water resources impacts (Steward et al. 2004; Payne et al. 2004; VanRheenen et al. 2004; Dettinger et al. 2004; Knowles and Cayan 2004; Christensen et al. 2004) and other environmental impacts (Brown et al. 2004; Pierce 2004). This project is noteworthy because of the close coordination between the production of the model simulations and the needs of the impacts modeling. Those performing the impacts studies had the opportunity of influence the model simulations and the type of model output that was made available. It is also a good example of the use of very detailed, high temporal resolution model data, rather than simple change functions between the present and the future. Overall, this assessment indicated that future climate change will likely create major challenges for water resource management, even under the rather modest changes produced by the low climate sensitivity PCM.