Climate-to-humans: A study of urbanized coastal environments, their economics and vulnerability to climate change.

T4-2

Rutgers University: E. Curchitser, F. Felder, Y.F. Reinfelder, N. Fefferman, J. Seneca, N. Mantell, M. Lahr, C. Andrews, H. Sigman, M.T. Alvarez-Martinez, H. Zhang, S. Chandramowli, W. Irving, A. Broccoli, D. Kang, J. Wilkin, J. Levin and R. Kopp.

NCAR: J. Bacmeister, P. Lawrence, W. Large, B. Sacks. **NOAA-NMFS/SWFC:** F. Werner.

Background

The fundamental aim of this project is to develop a framework for investigating the interactions between human activity and the climate system, using state-of-the-art multi-scale climate and economic models. We chose to study the highly industrialized and urbanized coastal region of the northeast US with an emphasis on New Jersey. The framework is developed around the NCAR Community Earth System Model (CESM). The CESM model capabilities are augmented with enhanced resolution of the land surface model in our region of interest, a more sophisticated ground water capability, downscaled coastal ocean and a high-resolution global atmosphere capable of generating storms. We are coupling the physical model with human activity models for the utility sector, a 300-equation econometric model with sectorial details of an input-output model for the New Jersey economy, an agent-based model for land use changes and finally a social network model used to study the decision making process affecting climate and its relation to economic activity.

Figure 1 on the right highlights the linkages we are exploring between climate change and economic and social activity. The feedback between the various systems is designed to be dynamically evolving.

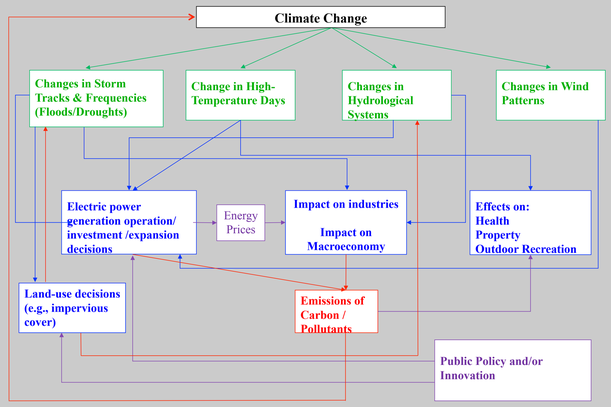

Figure 1: Wiring diagram showing linkages between climate and socio-economic models.

Economic and social models

The following models are being linked to the CESM:

1. Utility industry model (energy production)
2. Regional econometric model—key modeled sectors are: Mining, construction, manufacturing, information, transportation, retail, wholesale, finance, health, education and other sectors totaling 300 industries.
3. Land use (settlement patterns adaptation to climate change, and feedbacks)
4. Social decision models

These models use high-resolution (hourly, 1 km) CESM climate output such as temperature, wind speed, cloud cover, humidity and precipitation and are used to compute energy demand and production by conventional and renewable sources, industrial production, land use changes and other economic variables. Figure 2 is an example of the framework developed for coupling of the electricity and climate models while Figure 3 expands on the details of the electricity market model.

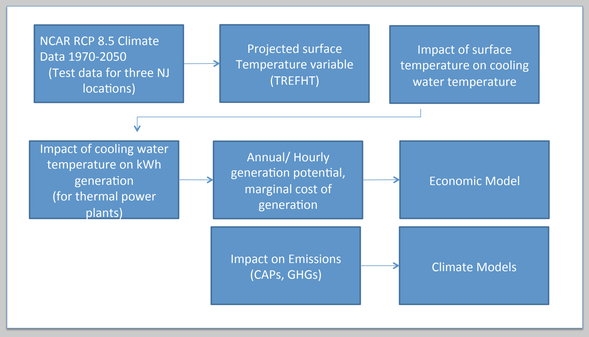

Figure 2: Data flow example for electricity generation starting with model computed surface temperature for a climate scenario.

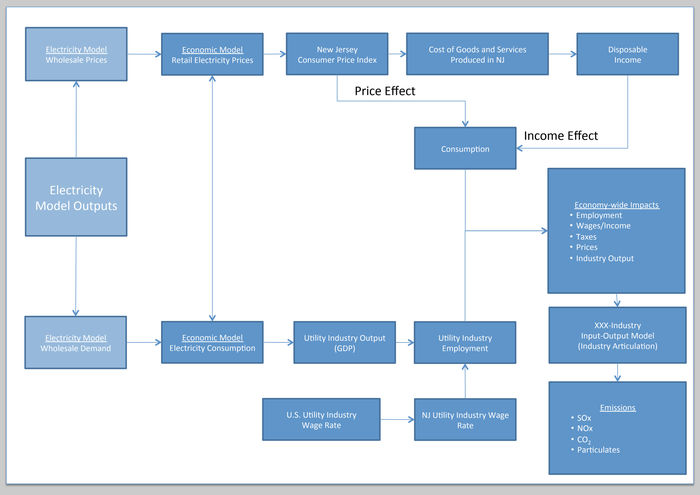

Figure 3: Detailed flow chart of electricity market model.

CESM High-resolution land-climate modeling

We utilize new capabilities in the Community Land Model (CLM) in order to perform high-resolution simulations of historical and projected future climate over the New Jersey region (Fig. 4). These simulations then drive the social and econometric models under various climate drivers. The CLM model represents Urban, Forest and Agricultural landscapes. The high resolution historical simulations show details that are not captured in coarser General Circulation Model (GCM) such as summer and winter urban heat islands (Fig. 5).

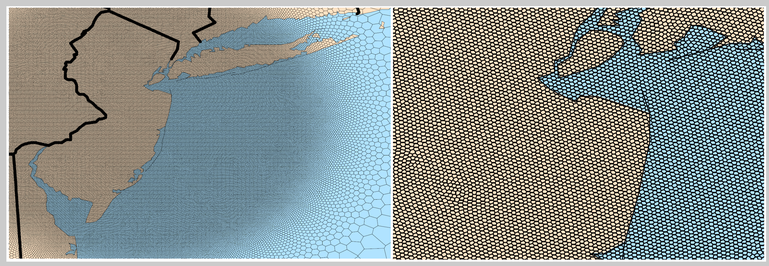

Figure 4: Land model grid (left) and detail (right) telescoping from 70 km globally to 1 km over New Jersey.

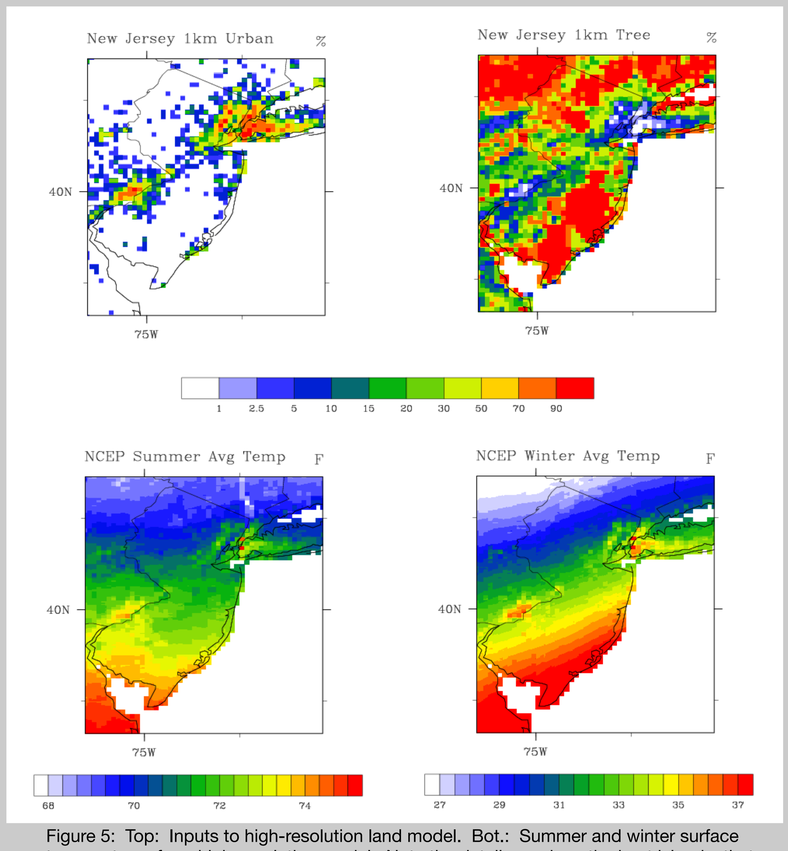

Figure 5: Top: Inputs to high-resolution land model. Bot.: Summer and winter surface temperatures from high-resolution model. Note the details, such as the heat islands, that would be missing from coarse global models.

CESM High-resolution atmosphere and multi-scale ocean

In order to understand how future climate will affect coastal communities we need to project both the mean state and extreme events. For this project we employ a high-resolution (0.25 degree) global atmosphere capable of generating its own tropical cyclones. Figure 6 shows the evolution of a hurricane generated in the model and moving over New Jersey. Changing storm tracks, temperatures, humidity, etc., will have significant effects on regional economic and social issues.

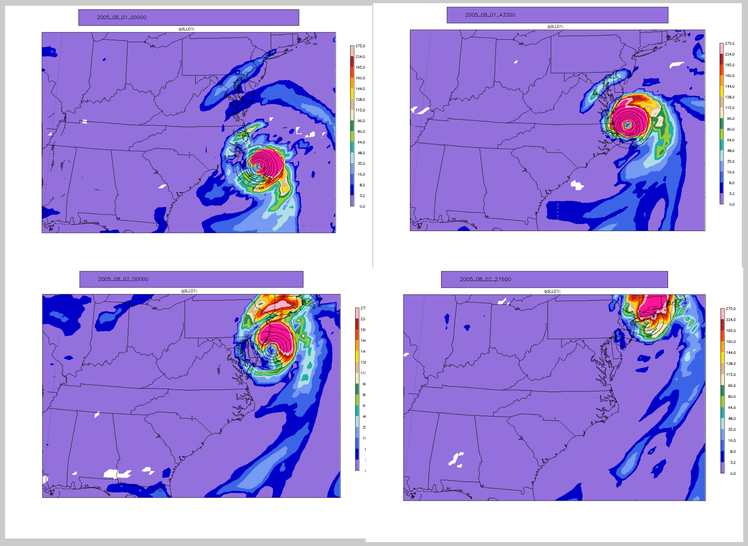

Figure 6: Evolution of a model generated hurricane over New Jersey using a 0.25 degree global atmosphere in CESM.

Biases in ocean western boundary current regions in global models affect the location and intensity of storm and the regional climate. In this project we have developed a multi-scale ocean for the northwest Atlantic within the CESM framework (Fig. 7) that addresses some of the known ocean biases in the region.

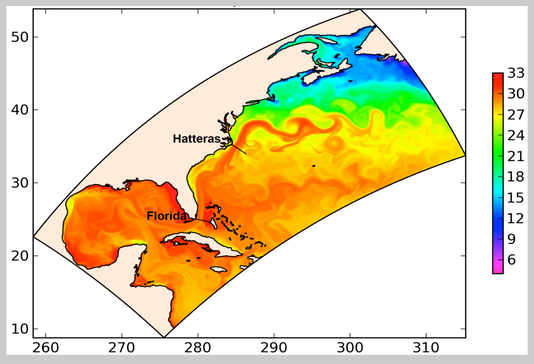

Figure 7: SST from a ROMS-based high-resolution ocean component of CESM in the northwest Atlantic.

Summary: State-of-the-art socio-economic and multi-scale climate models are coupled in order to study the interactions between the climate system and human activity. The climate model is downscaled to resolutions that both enhance the regional representation of the physical system in the land, atmosphere and ocean as well as provide spatial and temporal detail to the social and economic models. The framework developed here will be used to study both current and future climate states in the northeast US. This work is sponsored by the National Science Foundation.