Population Dynamics Thrust of the Integrated Multi-Sector, Multi-Scale Modeling (IM^3) Scientific Focus Area

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Motivation

Demographic dynamics—that is, changes in total population, its age structure, urbanization, and spatial distribution—are key determinants of energy use, water demand, land use, and climate impacts. National population size drives the scale of the U.S. economy and its energy and agricultural systems, while broad scale patterns of population distribution, for example the increasing shares of the population in the South and West, are key factors in shifting demands on regional energy and water systems. Finer-scale patterns of spatial distribution, including preferences for living near coastlines, or sprawling versus more concentrated development of urban and suburban areas, strongly influence exposure to climate-related risks and affect demands on transportation systems and their energy requirements.

To facilitate integrated research and planning related to these topics, a demographic modeling framework is required that can consistently project U.S. population at multiple scales, from national to state to local levels, in a manner that allows these dynamics to be linked to energy-economic and impact models, and also allows for feedback from socioeconomic models and ESMs to affect demographic processes. The capacity to model demographic dynamics over multiple timescales is also important, for example to allow for the evaluation of potential short-term responses to extreme events as well as long-term trends driven by regional, national, and international conditions. Currently, there are few multi-scale demographic models or projections over large areas and long (i.e., multi-decadal) time horizons. At the global level, population projections resolved at the national and grid-cell level have been developed for use by the climate change research community, initially as part of greenhouse gas emissions scenarios developed by the Intergovernmental Panel on Climate Change (Gaffin et al. 2004; Grübler et al. 2007), and more recently as part of the Shared Socioeconomic Pathways (SSPs) (Jones and O'Neill submitted; KC and Lutz 2014). At the national level, existing spatial projections for the United States have focused on housing density and built-up land (Bierwagen et al. 2010) or on snapshots of single future years (McKee et al. 2015). However, none is currently well suited to the type of integrated, multi-scale projections and applications required for this SFA or more generally for modeling frameworks that resolve cross-sectoral interactions on multiple space and time scales.

Approach

We propose to build on existing work (Jiang and O'Neill, 2015; Jones and O'Neill, 2013) to develop a community model of U.S. demographic dynamics at the national, state, and grid-cell levels that is designed to allow alternative scenarios of fertility, mortality, migration, and spatial development to be easily specified. A new national and state-level projection model will be developed, integrated with an existing approach to spatial downscaling (Jones and O'Neill, 2013), and linked with GCAM, while also remaining available for more general use. The model will be designed to enable bi-directional links with GCAM and other models for analysis of energy, water, and land-related issues. We will also address several key science questions, such as: What are plausible ranges of uncertainty in future U.S. demographic outcomes, especially regarding the spatial distribution of population? How might future climate change influence migration and spatial distribution within the United States? The population scenarios produced under this research thrust area will be used in other thrust areas to address questions about how population distribution may influence national and regional changes in land use, natural gas infrastructure, and the energy-water nexus. Figure 7 provides a high-level summary of these tasks.

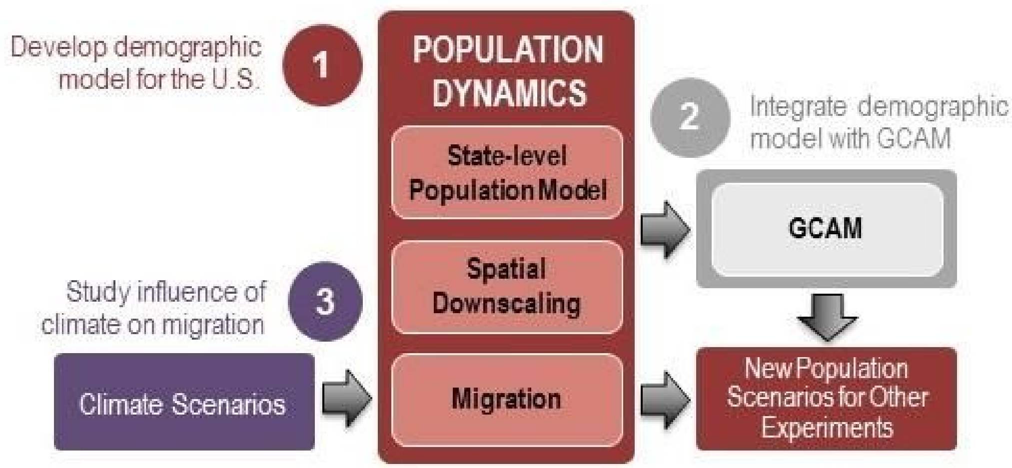

Figure 7. Overview of tasks in the population dynamics research thrust area. Colors correspond to sectors as depicted in Figure 2, and numbers correspond to the tasks numbered below.

Model development and applications during this three-year proposal period will lay the groundwork for possible future extensions of this work, which could address additional questions, including: 1) How might additional socioeconomic or Earth system factors influence demographic dynamics (e.g., labor markets, sea level rise and coastal storms, etc.)? 2) How might short-term population distribution change in response to extreme events? 3) Would modeling the demographics of other large countries (e.g., China, India, Russia, etc.) benefit from a similar multi-scale approach? 4) How are changes in spatial distribution of population related to changes in urban land cover or other types of land use change?