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The MIT IGSM-CAM framework: global and regional climate change research under uncertainty in emissions and climate parameters

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The MIT Integrated Global System Model (IGSM) version 2.3 is a fully coupled earth system model of intermediate complexity that consists of a zonally-averaged statistical dynamical atmospheric model, a dynamical ocean component with a thermodynamic sea-ice model and a biogeochemical module, and a Global Land Systems (GLS) framework to represent the terrestrial water, energy, and ecosystem processes of the global environment. The MIT IGSM2.3 includes an urban air chemistry model and a global scale chemistry model including 33 chemical species. The MIT IGSM2.3 also incorporates a human systems component, the MIT Emissions Predictions and Policy Analysis (EPPA) model, which is a computable general equilibrium model that projects the future economy as well as emissions of greenhouse gases and urban and regional pollutants. A fundamental feature of the IGSM2.3 is the ability to modify its climate parameters: climate sensitivity (through cloud adjustment), net aerosol forcing and ocean heat uptake rate (via the diapycnal diffusion coefficient). Thus, the IGSM2.3 is an effective tool for investigating climate change under uncertainty in emissions and climate parameters. For application to regional climate studies, the IGSM2.3 is linked to the NCAR Community Atmosphere Model (CAM) version 3.1, which is a component of the Community Climate System Model (CCSM) and includes the Community Land Model (CLM) version 3.0. For consistency within the MIT IGSM-CAM framework, we have developed and implemented new modules in CAM to modify the model's climate sensitivity and net aerosol forcing. We modify the climate sensitivity in CAM using a cloud radiative adjustment scheme where the cloud fraction is adjusted in the longwave and shortwave radiation calculations. Loading of sulfate aerosols and carbon aerosols is modified with scaling coefficients to match those in the IGSM2.3. Thus modified, the IGSM-CAM provides an efficient and innovative framework for regional climate studies where climate parameters (climate sensitivity, net aerosol forcing and ocean heat uptake rate) can be adjusted to span the range of climatic uncertainty, and where various emissions scenarios can be tested. We present preliminary results based on three sets of climate parameters (corresponding to a low, median and high transient climate response) and two emissions scenarios ("business as usual" and stabilization at 660 ppm CO_2-equivalent by 2100).