POLICY RESPONSES TO CLIMATE CHANGE

Research Challenge

Leading integrated assessment models assume that climate damages are related to the mean surface temperature of the planet. But climate science shows that when the climate cools or warms, high-latitude regions tend to exaggerate the changes seen at lower latitudes due to spatial heat and moisture transport called polar amplification (PA). The low- (high-) latitude regions would be hotter (colder) if poleward heat transport were absent. PA will accelerate the loss of Arctic sea ice, a potential meltdown of the Greenland and West Antarctica ice sheets, which could cause serious global sea level rise. Furthermore, PA will also affect the likelihood of tipping points, such as the “nearest” three potential tipping points located in the high latitudes of the Northern Hemisphere (Arctic summer sea ice loss, Greenland ice sheet melt, and boreal forest loss).

Methods & Codes

The DIRESCU model was developed to include spatial heat and moisture transport from low latitudes to high latitudes, sea level rise, permafrost thaw, and tipping points. To model spatial heat and moisture transport, the team disaggregates the globe into two regions. To address the tipping points and solve the dynamic stochastic programming problem, they adapt the computational method in DSICE showing high parallel efficiency, with an almost linear speed-up from 30 nodes to 5,000 nodes.

Results & Impact

A nonlinear certainty equivalent approximation (NLCEQ) method was published to solve efficiently and high-dimensional dynamic stochastic problems with exogenous trends, and it was applied to analyze the effect of climate and technological uncertainty in crop yields on the optimal path of global land use. The work on the DIRESCU model, which studies optimal climate policies under cooperation and various degrees of competition among regions, finds that excluding some of the elements of climate science leads to significant bias in important policy variables such as the social cost of carbon and adaptation.

Why Blue Waters

The parallel computational package requires low-latency communications, and this large problem corresponds to solving a Hamilton–Jacobi–Bellman equation with 10 or 11 state variables. Moreover, the team solved the model with many specification cases for analysis. The largest problem solved for DSICE used 3,459 computer nodes and took 7.5 wall-clock hours on Blue Waters.