What Economists Need to Know About Climate Science

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The Problem Distilled

• Weather (climate is aggregate weather) is a driver of economic choices and an input to econometric analysis.

• Climate change means the weather record is non-stationary, that is the weather distribution is changing.
  – The past may no longer be predictive of the future. In some places, the future is now.

• Climate models do not forecast future risk.

• Consequently, future yield estimates are likely to be less accurate than in the past.
  – policies built upon them will have a higher risk of not achieving their goals (solution: policies with contingencies)
Climate Change Experiments Are Not Risk Forecasts

• A forecast of future risk must contain future knowledge of climate drivers. Many climate drivers are unknowable.
  – Solar cycles, Volcanic Eruptions, Land Use Change

• Climate change experiments specify climate drivers.
  – Scenarios rather than Risk Forecasts

• Consequently, climate model projections are best used for system vulnerability analysis and in conjunction with scenarios of other societal drivers.
  – Population migration scenarios, Market scenarios
Uncertainty in Climate Projections Arises from Three Main Components

• Climate driver scenarios may diverge.
  – Greenhouse Gas Emissions, Deforestation

• Climate system is highly nonlinear.
  – Different time series given different initial state with identical drivers (boundary conditions).

• Many design choices are made during climate model development.
  – Grid structure varies; time integration varies; some processes implicitly simulated differently

• Other sources of less quantifiable uncertainty
  – Low frequency ocean states are sometimes absent in CMIP 3 simulations; “parameter” settings of implicitly simulated processes may be invalid in future climate
How to Handle Climate Projection Uncertainty in Econometric Analysis

• *Climate Change Signal*: For a given scenario, average over sources of quantifiable uncertainty.
  – Compute long-period average (at least 30 years) to remove low-frequency ocean states.
  – Average results from initial states (ensemble average) and different models (multi-model average).

• Useful in econometric studies either linked to average climate conditions or, perhaps, intercomparison of econometric models that need a common input.
How to Handle Climate Projection Uncertainty in Econometric Analysis

• *Climate Change Cloud*: Use time series from many or all climate projections as input to econometric models.

• Useful in vulnerability and probabilistic scenario analyses.
  – Vulnerability: Exposing limits of system response
  – Probabilistic scenario: Given a scenario, quantifying the risk.
Consideration of Econometric and Climate Projection Scales

- Econometric analysis focuses on model specification, appropriate explanatory variables/covariates, and definition of population.
  - nonlinear v. linear, annual temperature or seasonal temperature or growing degree day, panel v cross-section

- Station weather data are the primary source for climate explanatory variable and covariate information.

- Climate model data is spatially aggregate data and is representative of weather conditions on spatial scales much larger than station data.
  - Reduces spatial variability and this translates into narrower weather distributions that are mismatches with station data
Downscaling: Climate Projections
Replicating Smaller Spatial Aggregate Data

• Empirical Methods (Statistical Downscaling)
  – GCM data are explanatory variables for station data using empirical models (regression, constructed analogues, percentile matching)

• Process Simulation Methods (Dynamical Downscaling)
  – GCM data are initial and boundary conditions for a regional climate process model
Interpolate global model results to initialize the regional model grid.

Continually update the regional model around its lateral boundaries using results from the global model.

Global model Greenhouse Gas Scenario provides results on roughly 2-degree lat/lon grid.
Virtues of Dynamical Downscaling: Projecting Soil Moisture Feedback

Virtues of Dynamical Downscaling: Projecting Rainfall Corridors

This single GCM simulation is given to Red Box NARCCAP Models

Red Box NARCCAP data

CCSM 3.0

WRFG-ccsm

MM5I-ccsm

CRCM-ccsm
Virtues of Empirical Downscaling: Larger Number of Climate Scenarios

2040-2069 minus 1970-1999
June-July-August

- SRES A1B
- SRES A2
- SRES B1
- SRES A2 NARCCAP
Hybrid Downscaling?

We are experimenting with using rainfall intensity distributions from dynamical downscaling as the change factors for station data. That is, a change is applied to the histogram of station data rather than annual or seasonal average values.

Also, dynamical downscaling output can go into regression equations for station data, and the available output variables may be more extensive than global models.
On going Downscaling Projects: AgMIIP

AgMIP Two-Track Science Approach

A statistical downscaling experiment that will use output from currently available climate projections as new ones as they become available.

The climate data will be used as input to multiple agricultural models to understand relative sources of uncertainty in yield projections in all agriculturally active regions of the globe.
Ongoing Downscaling Projects: CORDEX

A dynamical downscaling experiment that will use output from the next round of global climate projections.

More than 20 regional models will make simulations in each of the regional domains at right.

The simulations will include a 150-year simulation beginning in 1951.

Initial focus is on Africa.
Parting Thoughts

- Climate projections provide (partially quantified) probabilistic risk relative to a climate driver scenario rather than a risk forecast
  - Use of a single projection (one global model; one scenario) is unjustifiable and likely misleading
  - Must consider spatial aggregation

- What future opportunity for economic learning is emerging?
  - Substantially more regional climate change information is being developed over the next 5 years.
  - Dialogue with regional climate scientists can improve the types of climate variables available to economists in regional projections.

- Flexible choices must be a key component of policy/economic analysis under climate adaptation planning due to the inherent uncertainty of climate projections.
  - Downside risks can be identified, but surprises will occur.