Motivation

To produce relatively low cost projections of climate outcomes for arbitrary forcing scenarios (especially those that have not already been simulated) for use in impact or integrated assessment models.

• making it much easier to carry out coupled human-earth system modeling studies
• and to account for climate change uncertainty.
Current Understanding and Practices

**Pattern Scaling, Climate Model Emulators and their Application to the New Scenario Process**

April 23-25, 2014  NCAR Boulder Colorado

**Goals:**

- Assess the current state of climate model emulator science
- Assess to what extent current approaches can meet the needs of integrated assessment and impact modelers for climate change information
- Identify and prioritize research directions so that these statistical methods can better meet the needs of applied research in the future.
Current Understanding and Practices

Findings:

- It is widely used, but has not been systematically tested.
- Need for addressing regionally and time varying forcing (land use and aerosols)
- Need for joint variable emulation
- Need for less traditional variables, extremes
- No “off-the-shelf” product is available to satisfy users’ needs
- Most-effective is the development of tailored emulation
- Sophisticated statistical approaches and use of simple or intermediate complexity models have been proved effective and methods can be harnessed and further developed.
Emulating GCM output that is impact relevant or of general value for driving impact model as a function of global quantities (e.g., Global Average Temp. change) for use with Hector.

Emulators of CMIP5 ESMs to explore new scenarios (low climate target/geo-engineering).

Emulators for systematic model tuning with application to CLM parameter estimation.

Emulators within Bayesian Hierarchical Modeling to characterize PDFs of quantities of interest in a multi-model paradigm.

Building emulators for individual processes interacting to produce an outcome of interest (e.g. risk from Sea Level Rise)
Some methodological issues were raised: How to emulate jointly correlated variables? How to deal with a multi-model framework and the possibility that different models would have different types or strengths of these correlation? Should we be wary of emulating a multi-model ensemble that is likely misrepresenting uncertainty, underestimating it? Or can emulators be used exactly to extrapolate/explore tails?

Do we need emulators at all? Can we rely on coarser/older/less computationally costly climate models? Can we gauge what we lose by using these emulators or coarser/simpler models?

Different applications may have different tolerance for climate input approximation errors. Tolerances should be tested (i.e. the sensitivity of impact models to the precision of climate information needs to be better explored/understood).

Should we emulate climate model output or directly impact models?
Despite all this, it’s clear that emulators have lots of value: some impact/integrated assessment modeling does not need complex climate information. Emulators could span ranges of scenarios beyond those available as CMIP output.

Climate targets/Mitigation pathways/Timing of mitigation could be thoroughly explored through emulators/simple models.

The availability of the Large and Medium Ensembles and additional complementary experiments with CESM may offer some low hanging fruit for characterizing variability and transferring it across scenarios, in order to avoid running large IC ensembles for other scenarios, if possible.

Other themes of interest (and activities out there) involve emulators for model tuning and emulators for estimating sub-grid scale parameterization using off-line models (e.g., CRMs).
Interest in the room for pursuing some of these themes (Low climate targets/Sensitivity of impact models to climate information/IC ensemble emulation).

Not clear we have bandwidth and resources for a coordinated activity but

We will start a mailing list to keep ourselves informed of progress;
We will continue to have periodic meetings on the subjects featuring work in progress
We will ask IMAGe for help in the coordination of a possible Theme of the Year activity (involving visitors/workshop/etc.)
Despite several methodological issues fleshed out during discussion, it’s clear that emulators have great value:

- Emulators could span ranges of scenarios beyond those available as CMIP output.
- Climate targets/Mitigation pathways/Timing of mitigation could be thoroughly explored through emulators/simple models.
- Emulators can be used for systematic model tuning, and for estimating sub-grid scale parameterization using off-line experiment with expensive models (e.g., CRMs).

The availability of the Large and Medium Ensembles and additional complementary experiments with CESM may offer some low hanging fruit for characterizing variability and transferring it across scenarios, in order to avoid running large IC ensembles for other scenarios.

Interest in the room for pursuing some themes (Low climate targets/Sensitivity of impact models to errors in climate information/IC ensemble emulation). No bandwidth and resources for a coordinated activity but

- We will start a mailing list to keep ourselves informed of progress;
- We will continue to have periodic meetings on the subjects featuring work in progress;
- We may involve IMAGe for help in the coordination of Theme of the Year activity on emulators (involving visitors/workshop/etc.)