Climate Science for a Sustainable Energy Future

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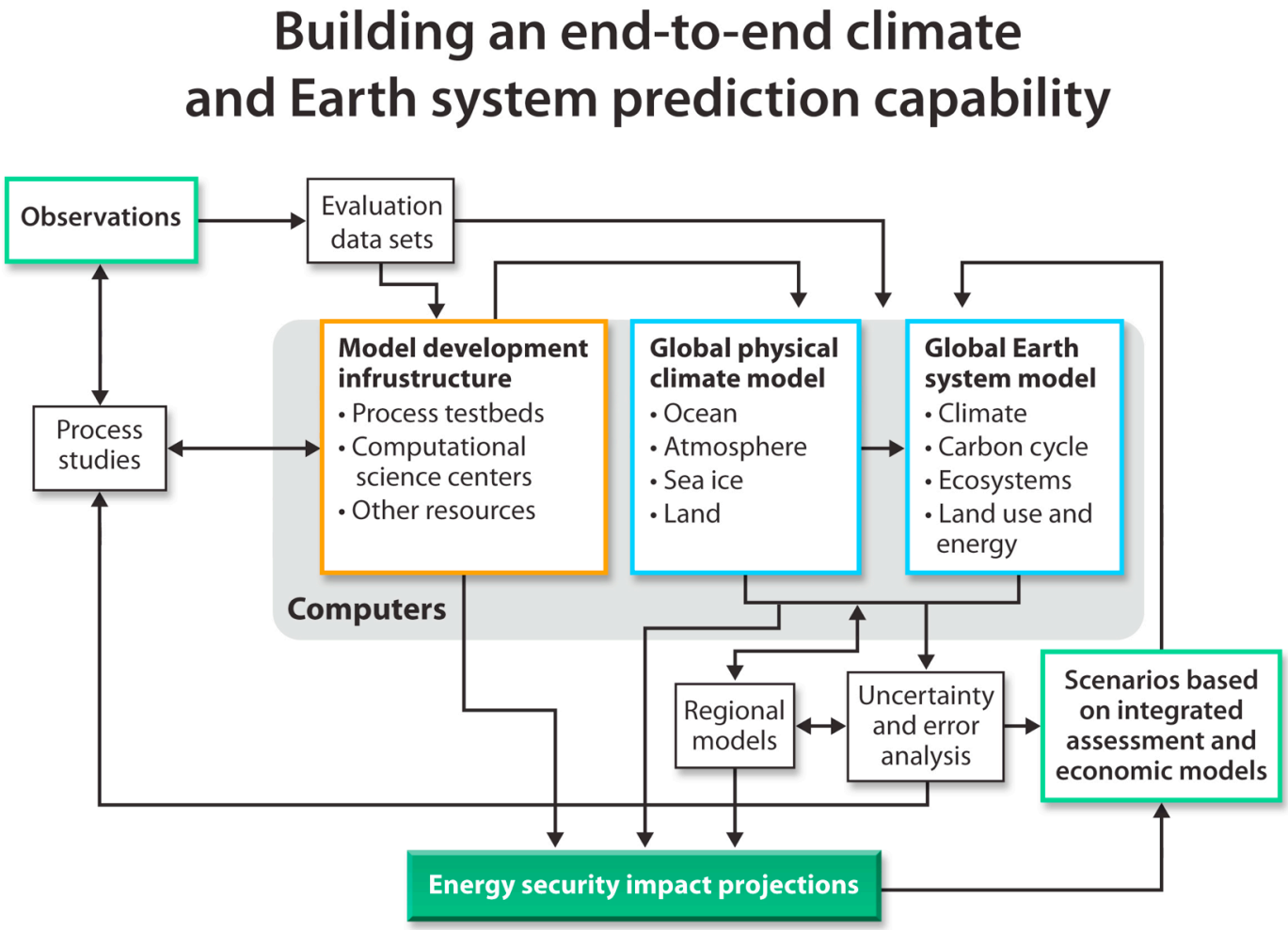


Fig. II.1. Conceptual view of an ongoing climate simulation and prediction enterprise such as the CESM project. New versions of models are developed from increased understanding gained through the integration of observations, process research and earlier model studies.

Tightly Integrated Project Focused on CESM 3 Components (2015-2020)

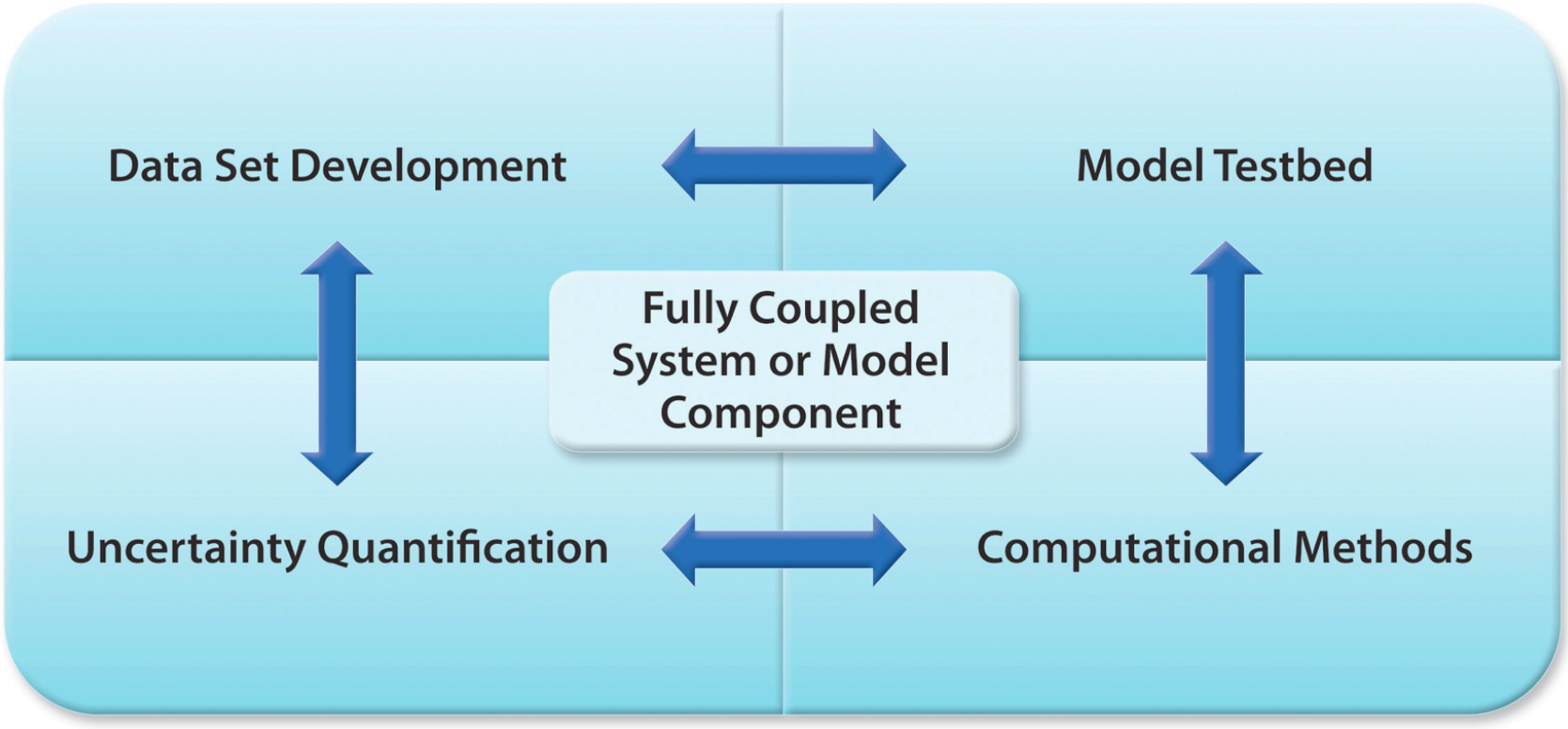


Fig. II.2 Relationships among the four research themes.

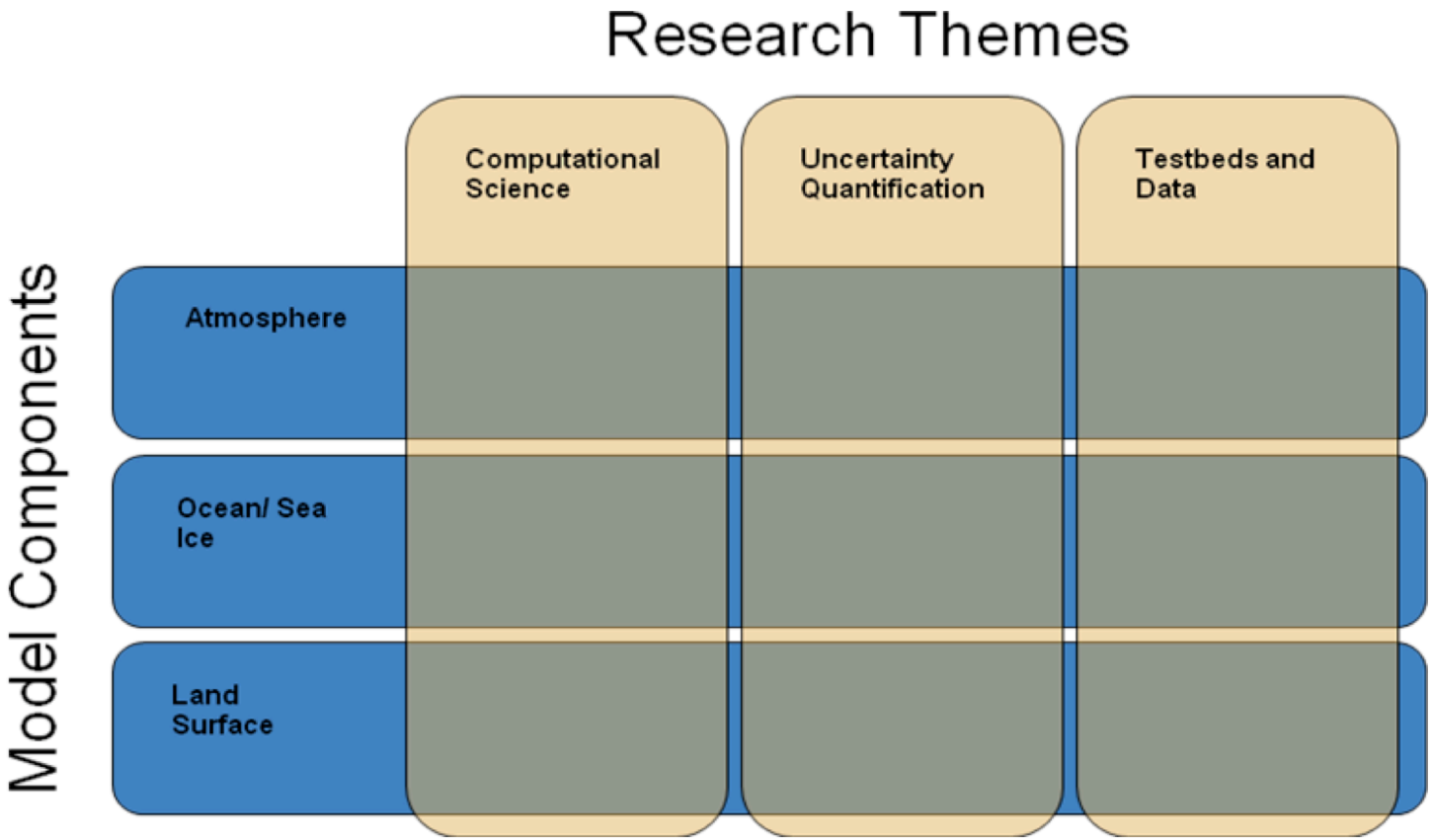
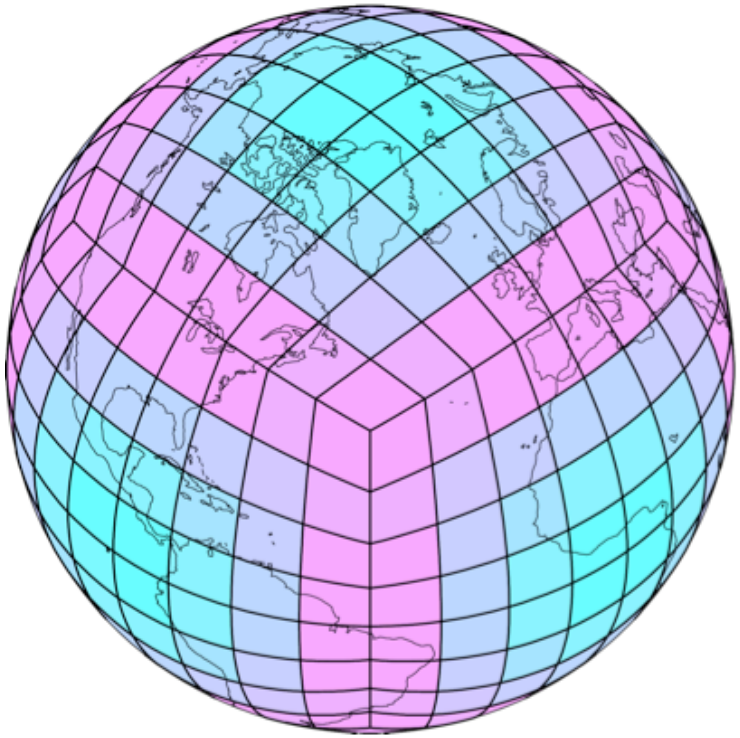
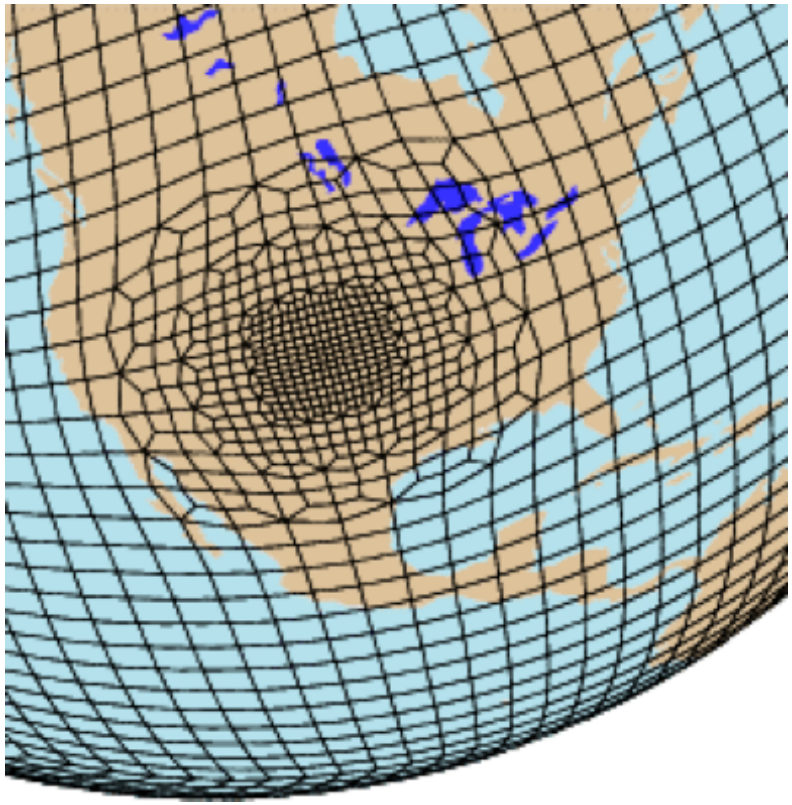
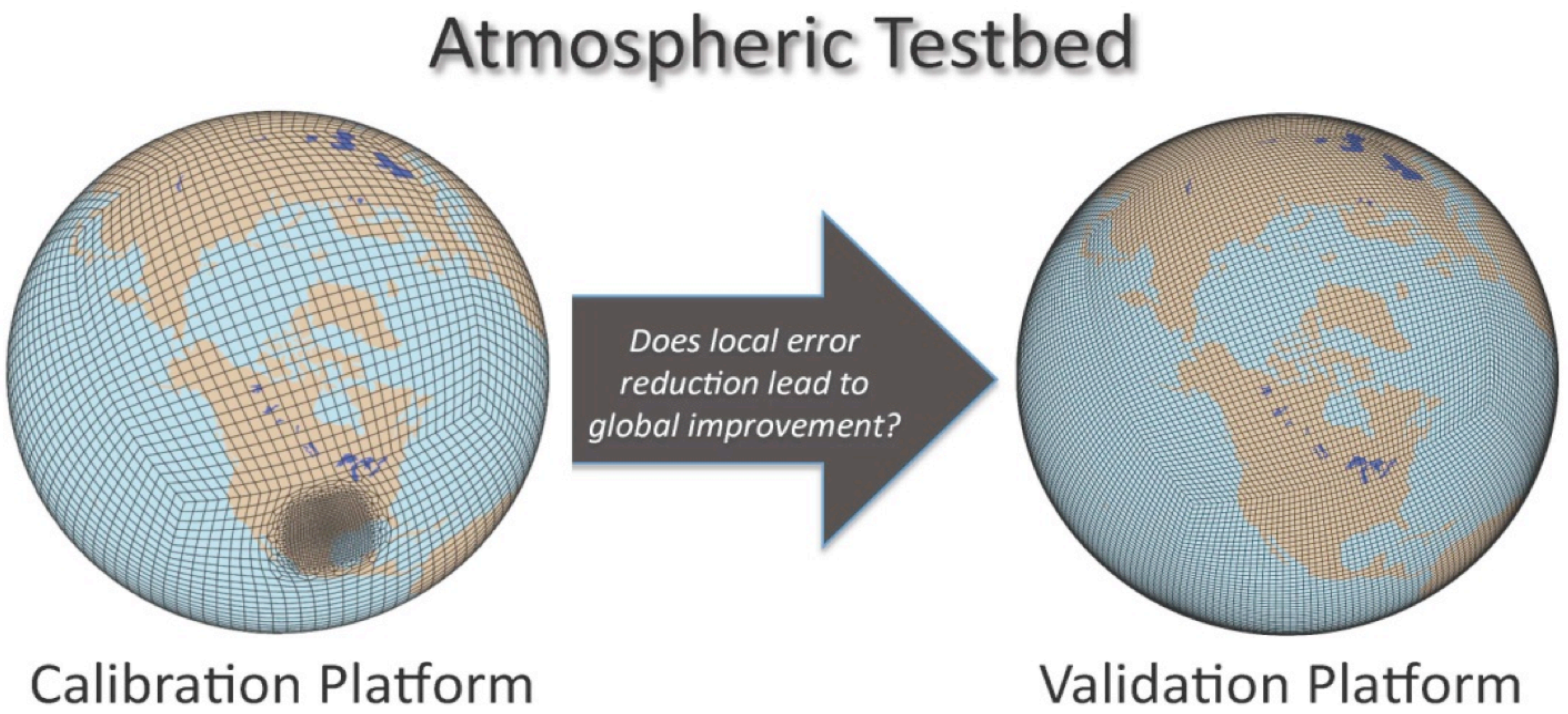


Fig. II.3. CSSEF project structure.





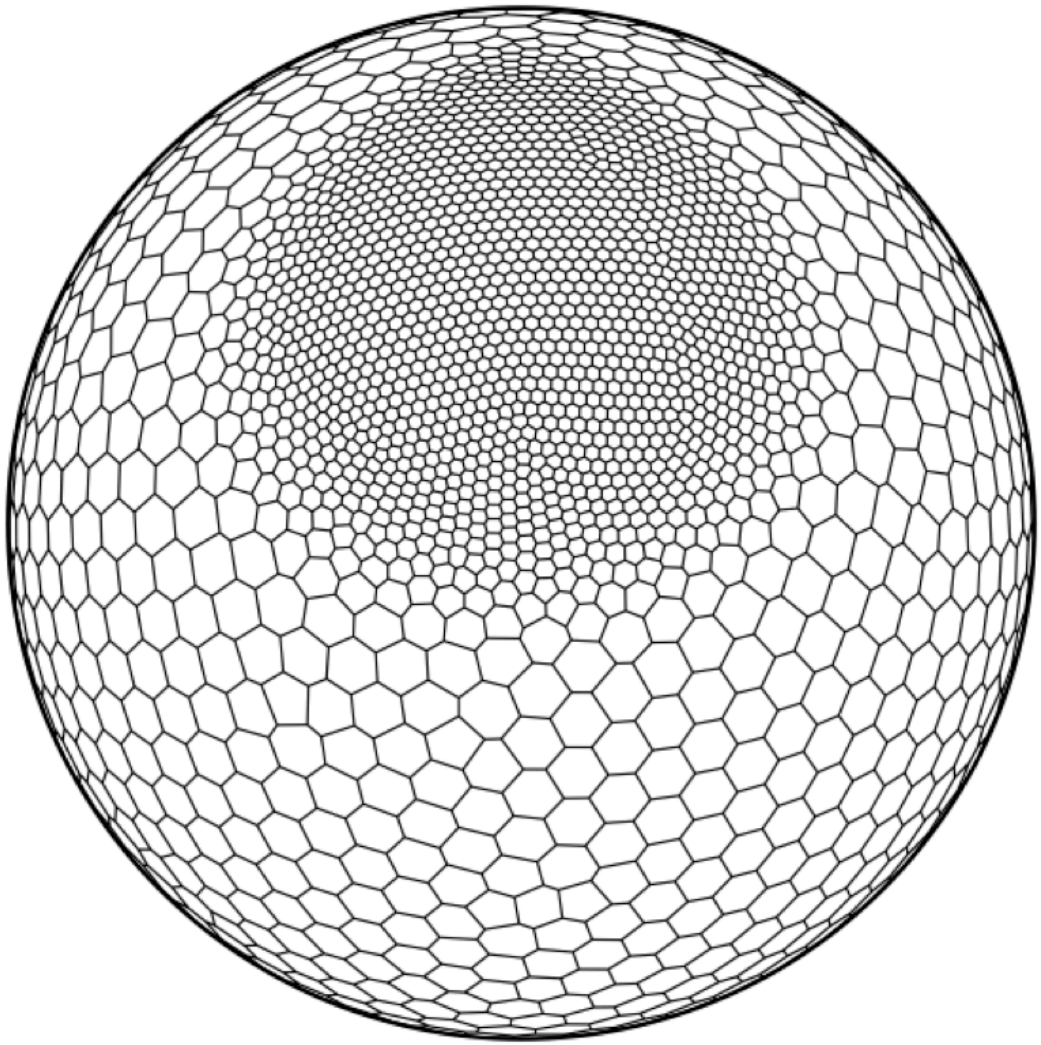
Some of the horizontal grids it is now possible to use in CAM5 when running with the HOMME dynamical core. Left: A low-resolution quasi-uniform resolution cubed-sphere grid. Right: Close-up view of a variable resolution global grid with localized mesh. refinement over the SGP ACRF site.



. Schematic of the Atmospheric Testbed.

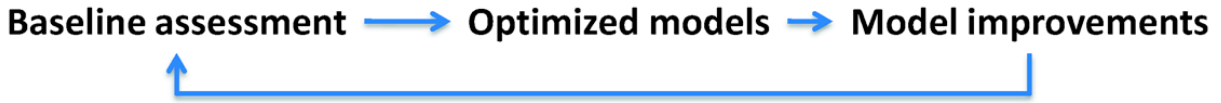
Table IV.1. Characteristics of Calibration and Validation Platforms

	Calibration Platform	Validation Platform
Model Construction	Global model with static mesh refinement above sites of interest	Global model with uniform grid
Forcing	Weather-forecast mode with nudging to analysis data on coarse outer grid	Free-running climate mode with initial condition from analysis data
Initial Resolution	1/8° fine mesh transitioning to 1°	1/8° everywhere
Uncertainty Quantification Methods	Parameter tuning: calibration of uncertain parameters with local data sets	Ensemble of simulations with parameter sets generated by parameter tuning
Data sets	Local water cycle data sets such as ACRF site data	Global data sets such as satellite or re-analysis data



A variable resolution grid based on a Spherical Centroidal Voronoi Tesselation.

	Sensitivities & Uncertainties	Observations & Calibration	Model Development
Land	• About 40 parameters (6-12 main drivers) • Forcing from CAM ensembles	• FluxNet data at sites • Global gridded data • Multi-site calibration (real and 'proxy' sites) • Global calibration	• Ecosystem demography • Soil carbon dynamics • Subgrid scale hydrology
Ocean	• Eddy mixing in Gent-McWilliams scheme • Resolution of static refined meshes	• T, S, ACC transport, CFC ventilation • Calibrate kappa-i as a function of (x,y,z)	Optimal placement of high resolution meshes using calibrated eddy mixing
Atmosphere	• About 20-30 parameters (cloud formation, convection, etc)	• ARM data at individual sites • Calibration at sites using statically refined mesh	New parameterizations of convection and cloud processes



Crosscutting UQ activities applied to the CESM component models. For example, sensitivity analysis and parameter calibration exercises will be applied to each component.

Review Comments

- *The team is made of excellent scientists and engineers, and a consortium of DoE national laboratories seems to be right tool to carry the work in keeping with the strong tradition of climate modeling and modeling generally at DoE.*
- *Although the four research themes stated in the proposal partly overlap with ongoing DOE projects including the development of model development testbeds and CESM component, the "integrated and hierarchical" view taken by the PI is unique and the practice of well-coordinated research in my opinion is critical in order to accomplish the enormously complicated task of climate model development and validation.*

Review Comments (cont.)

- *DoE's past and planned investment in climate research is laudable, its thrust to spearhead the climate modeling frontier is contributing to important research and development, and its laboratories have assembled a wide range of unique expertise to tackle many of the issues laid out in this proposal. Frontier problems in computational science in particular, and the enabling of much improved climate simulations with quantified uncertainties in predicted climate indices will rely heavily on the work coming out of DoE labs. This work provides the nation (and the world) with much needed decision making tools to tackle potentially severe consequences of climate change.*

Review Comments (cont.)

- *It could be said that the current generation of climate models has reached a plateau, and to answer the more challenging questions now being posed of them requires a step change in the development of the models. This proposal puts forward a bold and clearly thought through programme to make that step change.*
- *I was really impressed by the overall level of coordination and organisation in the proposal. Managing a programme such as this that brings together several different scientific disciplines across a number of labs will be quite some challenge. While the approaches taken are not uniform, reflecting the different starting points of the various disciplines, overall the level of coordination achieved in the proposal is a good sign that the team will be able to make it work.*

Review Comments (cont.)

- *This is an important project that will greatly expand the capabilities of one the top models being used to understand climate processes and the potential effects of human and natural activities on the Earth's climate.*
- *The additional focus of the project on uncertainty quantification and the development of testbeds and enhanced databases for comparison with observations is likely to be an extremely important contribution of this project. Such capabilities are badly needed.*
- *DoE projects toward this end have played a key role toward addressing this problem, and have resulted in substantial progress embodied in the Community Climate System Model's (CCSM) developments, its deployment in climate projection calculations in support of IPCC, and its use by the scientific community.*

Status

- Dorothy Koch replaced Wanda Ferrell as Program Manager
- Initial funding of $5M for last quarter of FY 11 (money arriving at labs “imminently”) for activities with potential results in the short term
- Sub-contract to NCAR/CGD
- Future – uncertain, but we will plan for continued funding at different levels

Example Initial Projects

- Early MPAS ocean development
- Variable and high resolution CAM-SE (HOMME)
- Initial SGP testbed and incorporation of ACRF (ARM) data
- Initial Uncertainty Quantification experiments to examine change in parameter sensitivities between model versions