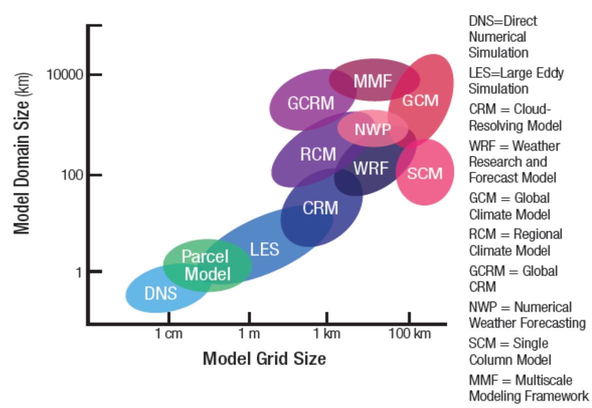
U.S. DEPARTMENT OF ENERGY | Office of Science

FAST-PHYSICS SYSTEM TESTBED AND RESEARCH (FASTER) PROJECT

Earth's climate system involves multiple physical processes over a wide range of space-time scales. Many key processes occur on scales smaller than climate model grid sizes and representation (parameterization) of the so-called fast physics—primarily cloud-related processes—a main source of uncertainty in climate models. Parameterizations pose daunting challenges in a variety of areas, ranging from observations to modeling, from understanding the processes to formulating effective parameterizations, from testing parameterizations to ultimately using them in climate models. The Earth System Modeling (ESM) Program of the U.S. Department of Energy's Office of Science initiated the Fast-Physics System Testbed and Research (FASTER) project in 2009 to meet the challenges by forming a multi-institutional*, interdisciplinary team of complementary areas of expertise to develop an effective, integrated multiscale model evaluation framework that best capitalizes on the detailed, continuous, long-term measurements from the different climate regimes of the Atmospheric Radiation Measurement (ARM) climate research facility sites.

The FASTER Project's goal is to accelerate and enhance the cycle of developing, implementing, testing and evaluating fast-physics parameterizations in climate models. This is accomplished by forming a unique multidisciplinary team, conducting eight interrelated tasks, and developing an innovative integrated



FASTER meets the challenges through development of a common multiscale data framework that synthesizes the measurements from different observational platforms at the ARM sites and various models targeting processes at different levels/scales. The multiscale integration enables FASTER to readily follow progress in both measurements and modeling, and will be extremely valuable to inform development of next-generation high resolution climate models.

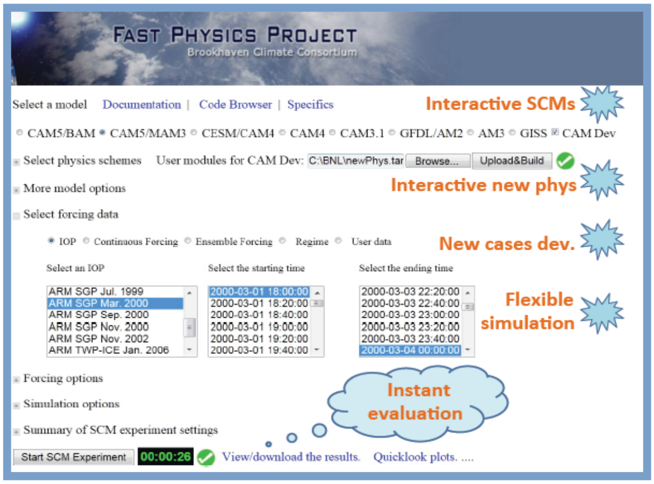
THEMES AND OBJECTIVES

- Focus on the ARM sites with detailed, continuous, long-term measurements in different climatic regimes.
- Construction of a fast physics testbed, a multiscale data assimilation system, and eventually a multiscale visualization and evaluation system (MVES) that permits rapid, efficient evaluation and diagnosis of various fast processes at multiple scales.
- Integrative evaluation by combining models of different types and scales (from cloud to global scales), in addition to multiple models of each type, to better address the multiscale nature of processes and process interactions.
- Interactive utilization of targeted, idealized case studies as well as investigation of continuous, realistic, long-term observations.
- Strong integration of observations and models at multiple scales through use of multiscale data platform.
- Direct participation of main U.S. climate modeling centers to facilitate/accelerate implementation and testing of new/improved fast physics parameterizations in climate models.

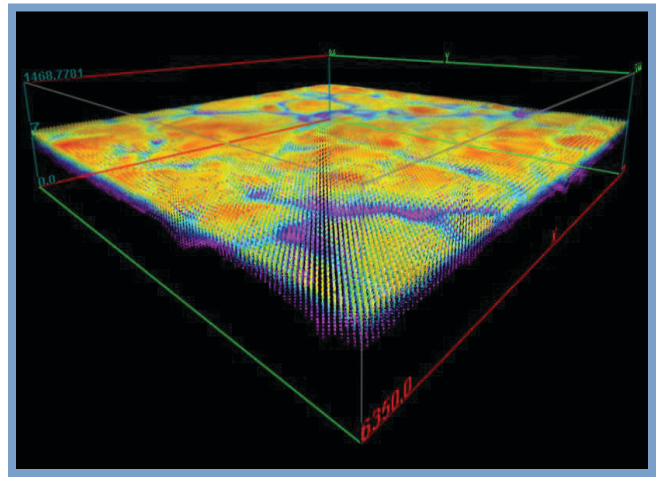
ACCOMPLISHMENTS

- A fast-physics testbed has been constructed and the beta-version released for the registered users. The current testbed consists of two major complementary components that capitalize on the continually evolving cloud measurements at the ARM sites: a single-column model (SCM) testbed and a numerical weather prediction model (NWP) testbed. The SCM-NWP integration allows use of not only rich ARM measurements, but also a vast pool of NWP results.

** BNL, LBNL, Stony Brook University, Columbia University/GISS, GFDL, UCLA/JPL, University of Reading, Royal Netherlands Meteorological Institute, Texas A&M*



The SCM component of the FASTER Fast-Physics Testbed web application enables users to modify and run any hosted SCMs with specified parameterizations and compare against ARM measurements. The testbed currently features SCMs for the CESM (CAM3, CAM4, or CAM5), GFDL and GISS climate models. Users can choose models, parameterizations and measurements for comparison.



Stratocumulus cloud simulated by WRF-FASTER and visualized by FASTER 3D Data Visualization & Analysis Toolkit. Besides the ARM observations, FASTER uses CRM/LES suites to enhance the fast-physics testbed, facilitate parameterization development, and supplement data necessary, but unavailable with current measurements, and inform development of high-resolution climate models.

- The community Weather Research and Forecasting (WRF) model has been reconfigured as a typical Cloud-Resolving Model (CRM) or Large Eddy Simulation (LES) driven by idealized or realistic ARM large-scale forcings (WRF-FASTER). WRF-FASTER has been tested extensively and will soon be released to the general public.
- A multiscale data assimilation system (FASTER-DA) has been developed by combining the JPL-muliscale-3DVAR system with the NCEP-Gridpoint Statistical Interpolation (GSI) system and implementing them in the community WRF model. The FASTER-DA can choose between WRF and WRF-Chem as the base model for different purposes.
- A web-based data visualization and analysis toolkit is being developed to fulfill the need for dynamic interactivity with large volumes of data at a range of scales. Future plans include collocated aircraft trajectories, multi-dimensional data visualization via parallel coordinates and dynamic scatter plots, and integration with the FASTER testbed.

FASTER investigators have also conducted scientific research and published numerous peer-reviewed publications in virtually all the eight project task areas, including examination of ARM data products and case development of boundary clouds for modeling studies; evaluation of SCM/NWP/GCM/CRM/LES models; objective classification of weather and cloud regimes; development of new approaches for estimating cloud albedo, cloud fraction, and entrainment rates; parameterization analysis/development for microphysics, surface flux convection, entrainment-mixing, radiation, and process coupling.

CRITICAL CHALLENGES

- Synthesize observations and models at multiple scales to best address the multiscale nature of fast physics in alignment with one of the Climate and Environmental Science Division (CESD) grand challenges: the scaling challenge.
- Optimize FASTER portfolio to develop an integrative multiscale model evaluation framework.
- Improve/develop parameterizations for microphysics including aerosol-cloud interactions, turbulence, convection, and radiation, with an emphasis on physics and filling in knowledge gaps in entrainment/mixing, subgrid variability/structure, process coupling, and compensating errors.

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