The Earth System Modeling Framework: Interoperability Infrastructure for High Performance Climate and Weather Models

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Abstract

Weather forecasting and climate modeling are grand challenge problems because of the complexity and diversity of the processes that must be simulated. The Earth system modeling community is driven to finer resolution grids and faster execution times by the need to provide accurate weather and seasonal forecasts, long term climate projections, and information about societal impacts such as droughts and floods. The models used in these simulations are generally written by teams of specialists, with each team focusing on a specific physical domain, such as the atmosphere, ocean, or sea ice. These specialized components are connected where their surfaces meet to form composite models that are largely self-consistent and allow for important cross-domain feedbacks. Since the components are often developed independently, there is a need for standard component interfaces and "coupling" software that transforms and transfers data so that outputs match expected inputs in the composite modeling system.

The Earth System Modeling Framework (ESMF) project began in 2002 as a multi-agency effort to define a standard component interface and architecture, and to pool resources to develop shareable utilities for common functions such as grid remapping, time management and I/O. The ESMF development team was charged with making the infrastructure sufficiently general to accommodate many different numerical approaches and legacy modeling systems, as well as making it reliable, portable, well-documented, accurate, and high performance. To satisfy this charge, the development team needed to develop innovative numerical and computational methods, a formal and rigorous approach to interoperability, and distributed development and testing processes that promote software quality.

ESMF has evolved to become the leading U.S. framework in the climate and weather communities, with users including the Navy, NASA, the National Weather Service, and community models supported by the National Science Foundation. In this talk, we will present ESMF's evolution, approach, and future plans.

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Short Bio

CECELIA DeLUCA is the head of the NOAA Environmental Software Infrastructure and Interoperability group and the lead on national and international software infrastructure projects in the Earth system sciences. Her interests lie in the development of large, high-performance software systems and governance models that promote community and multi-agency ownership. She is an advocate for open source software and the development of shareable infrastructure for modeling and data services. Her education combines liberal arts (A.L.B. Harvard 1992), engineering (M.S. Boston University 1994), and atmospheric science (M.S. Massachusetts Institute of Technology 1996). Projects she has led include the premier U.S. weather and climate framework, the Earth System Modeling Framework (ESMF); the National Unified Operational Prediction Capability (NUOPC) Layer, a set of templates and conventions that increase the interoperability of ESMF-based modeling applications; and Earth System CoG, a collaboration environment and user interface for the Earth System Grid Federation (ESGF), an international network of data nodes that serves the model data on which the Intergovernmental Panel on Climate Change (IPCC) and other national and international climate assessments are based. She is also a co-lead on the international Earth System Documentation (ES-DOC) project, which originates and governs a metadata schema that comprehensively describing Earth system models and creates associated tools for collecting, displaying, and comparing that metadata.