ESTO

Earth Science Technology Office

COUPLING HIGH-RESOLUTION EARTH SYSTEM MODELS

Powerful, high-resolution modeling tools, which can increase predictive capabilities by incorporating NASA mission data at the scale of observations, are fast becoming vital to nearly every area of Earth science. It is, therefore, critical to ensure that Earth science models can operate together. In this project, several key models were coupled using the recently developed Earth Science Modeling Framework (ESMF).

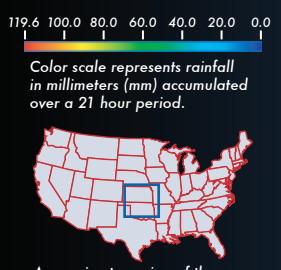
How It Works

ESMF is a nation-wide effort to create a software infrastructure capable of operating disparate climate and weather models together on parallel supercomputers. The team utilized the emerging ESMF code to successfully couple a land model component – the NASA Land Information System (LIS) – with two atmospheric model components: the Weather Research and Forecasting (WRF) model (developed by the National Weather Service and the National Center for Atmospheric Research) and the Goddard Cumulus Ensemble (GCE) model. LIS consists of several land surface models that use observation-based inputs for a variety of surface conditions, including soil moisture, temperature, topography, radiation, surface winds, precipitation, and so on. The WRF and GCE are models used for atmospheric forecasting and cloud resolution, respectively.

Weather Research and Forecasting (WRF) Model

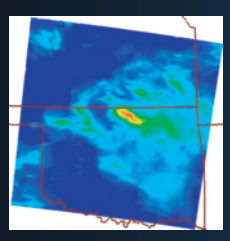
Goddard Cloud Ensemble (GCE) Model

In a demonstration of the coupled models, the team focused on a section of the Southern Great Plains (specifically in Oklahoma and Kansas) which was studied extensively during the 2002 International H20 Project (IHOP) field program. LIS was first executed in an uncoupled manner ("spun up") to provide initial soil moisture and temperature conditions for the case study period. Then the LIS, WRF, and GCE models were executed in a coupled manner using the ESMF framework in a high-performance computing environment. The results show good agreement with observations, particularly with respect to convection currents.

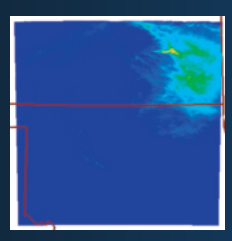


Color scale represents rainfall in millimeters (mm) accumulated over a 21 hour period.

Approximate region of the Southern Great Plains studied during the 2002 IHOP field program.

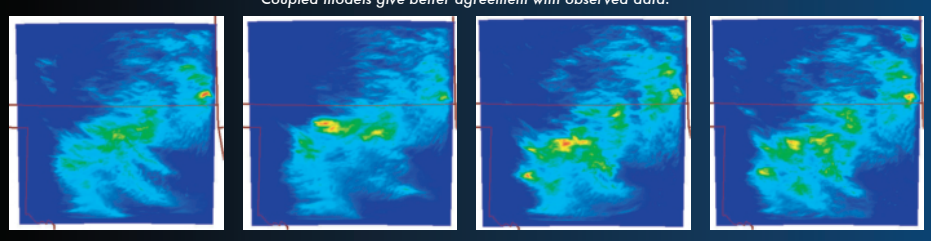


Observed precipitation from Radar and rain gauge data (from the National Centers for Environmental Protection (NCEP) national mosaic)



WRF Standard Initialization (WRFSI) with no spin-up provides poor agreement with observed data.

Coupled models give better agreement with observed data.



GDAS + FAO | GDAS + STATSGO | NLDAS + FAO | NLDAS + STATSGO

GDAS – NCEP Global Data Assimilation System (low resolution forcing, 2.5 degree)
STATSGO – USDA State Soils Geographic Database (high resolution soils, 1:1/4m)
FAO – United Nations food and Agriculture Organization (low resolution soils, 1:5m)
NLDAS – North American Land Data Assimilation System (high resolution forcing, 1/8th degree)

Features and Benefits

- **Demonstrates the feasibility and utility of ESMF to couple high-resolution models**
- **Increases the resolution and time scale length of predictability**
- **Fully resolves the physical processes of land surface and clouds**
- **Advances the understanding of the role of land-surface atmospheric interactions at finer scales**
- **Increases ability to predict severe weather and its consequences**
- **Facilitates the incorporation of up to four new land surface models into the WRF model**
- **Models play a key role in mission design by supporting Observing System Simulation Experiments**

Future Applications

- **LIS / WRF / GCE coupled models could be used in predicting water and energy cycles at resolutions near 1Km – the scale of current space-based observations**
- **Coupling methods can be applied to a range of useful pairings, especially with the LIS**

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