

Understanding Earth's Climate System

Our planet's climate is a complex system, and understanding how that system functions is a challenge of critical importance for our future. We know from Earth's history that our climate has changed dramatically in the past, sometimes over long periods but sometimes with startling speed. With growing evidence that human activity is driving changes in global climate, we need a clearer understanding of how the global climate operates to improve our ability to predict climate change, evaluate its consequences, and determine what steps to take in addressing it. Among our most important tools for gaining this understanding will be integrated Earth system models (ESM) and the high-performance computers that enable them to realize their full potential.

Our global climate system is actually a system of systems, comprising the atmosphere, the biosphere (living organisms), the cryosphere (ice sheets, glaciers, and sea ice), the geosphere (soils, sediments, and rocks), and the oceans. Efforts to model each of these systems and their interactions have been under way for decades, and substantial progress has been made as improved models have been developed and run on increasingly powerful computers and compared with observational data.

Today's ESMs can provide reasonably accurate simulations of past changes in temperature and precipitation, and work being done to reduce uncertainties is making the models steadily more useful for predicting future climate change and assessing mitigation and adaptation strategies. Nevertheless, much remains to be done to develop next-generation ESMs that are far more accurate and comprehensive than our current tools.

In particular, there is a growing need for credible high-resolution climate simulations at a regional scale. This represents a tremendous multidisciplinary challenge that calls for major increases in computational resources and modeling capability, coupled with increased scientific knowledge of climatological phenomena derived from experiments and observation.

Recently, DOE's Office of Science upgraded the Jaguar supercomputer at the Oak Ridge Leadership Computing Facility to a peak computational performance of more than 2.3 quadrillion calculations per second (or, greater than 2.3 petaflop/s), making it the world's fastest computer. The SciDAC program continues to play a key role in developing scalable algorithms that can effectively utilize the Jaguar petascale system and the upcoming exascale systems. New, robust techniques must be developed

Biography in Brief



Dr. Thomas Zacharia

Dr. Thomas Zacharia oversees one of the nation's largest research and development programs, with annual expenditures of \$1.3 billion in materials and physical sciences, energy and engineering sciences, computing and computational sciences, life and environmental sciences, neutron sciences, and national security. Prior to his present position, Deputy Director for Science and Technology, he served as ORNL's associate laboratory director for computing and computational sciences from 2001 to 2009. In this capacity, he organized and built a computing directorate with funding from the DOE, the National Science Foundation (NSF), and the Department of Defense. He is a professor in the Electrical Engineering and Computer Science Department at the University of Tennessee–Knoxville, and he successfully led the proposal to establish the National Institute for Computational Sciences through a \$65 million grant from the NSF.

to enhance the input/output, storage, processing, visualization, and wide-area networking demands of exascale datasets.

Scientists are working to predict climate variability and change on regional scales, which are directly relevant to society and to decision makers, such as business leaders and local and state government. A variety of scientific issues are associated with the ability to resolve regional-scale features in the atmospheric and oceanic circulations and their implications for understanding human-induced changes and natural variability of the climate system. We aim to improve the ability to predict changes in land cover, vegetation types, oceanic biology, and atmospheric and ocean chemistry. We expect to learn how carbon, methane, and nitrogen cycles interact with climate change, and how local and regional water, ice, and clouds change with global warming. ●

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Back Cover CAM4 T341: Water Vapor/Landscan Population Density – Himalayan Watershed Study. The proper simulation of the distribution of water vapor in the climate system is essential to the accurate treatment of the hydrological cycle and the planetary radiation budget. The image on the back cover of this issue shows the simulated distribution of total column water vapor using a high-resolution configuration of the Community Climate System Model (CCSM) Community Atmospheric Model Version 4. The water vapor image is overlaid with the LandScan Dataset, which comprises a worldwide population database compiled on a 30 arc second grid has been developed as part of the Oak Ridge National Laboratory Global Population Project for estimating ambient populations at risk. The color density is proportional to population density.