UC Irvine Extends Climate Research With IBM Supercomputer

By Charlie Zender

Scientists around the world study the impact of human influences, such as global warming and pollution, on natural climate cycles such as El Niño, polar-ice movement and chemical cycles. Earlier this year, researchers at the University of California-Irvine received a grant to invest in technology that would allow them to predict the climate, climate changes, and climate extremes that will affect Earth’s inhabitants in future decades. The university chose a powerful new IBM supercomputer, the Earth System Modeling Facility (described below), to simulate the effects of global warming, pollution and other climate stresses for up to three hundred years in the future.

Earth’s weather and climate result from an intricate and complex interplay of physical, chemical, and biological processes of the atmosphere, oceans, and land surface. The global environment that supports life on Earth absolutely depends on the coupling of these Earth system components. This linking across ocean/land/atmosphere places significant constraints on the architecture of computers being able to solve the problem efficiently. It’s important to predict future climate well enough in advance to understand how best to mitigate environmental changes that may have potentially adverse, even disastrous, effects on the planet and its living organisms.

In fact, growing evidence suggests the ocean-atmosphere system that controls the world’s climate can lurch from one state to another in less than a decade—a change that’s radically tilted until suddenly it flips over. Although it’s still unclear exactly how much we are to the threshold, abrupt climate change may occur in the near future, possibly overwhelming many societies with the need to rapidly adapt, and upsetting the geopolitical balance of power.

Climatologists at UC Irvine have been using computer simulations to track the environmental effects of phenomena like increasing fossil-fuel emissions, aerosols, and disappearing sea ice for many years. This complex research was always done through national supercomputing centers such as the San Diego Supercomputing Center. But with the emergence of more innovative technology applications and newer simulation capabilities, we realized that having our own dedicated supercomputer would dramatically increase the quality and scale of research conducted by our department.

Our new computer system, the Earth System Modeling Facility (ESMF), gives us the freedom to attempt more ambitious computing projects with an almost endless number of variables, including well-known factors, man-made pollutants such as car exhaust, and more obscure influences, such as volcanic disturbances and underwater ecosystems.

How It Works

The supercomputer consists of seven IBM eServer p655 AIX-based systems, each with eight POWER4+ microprocessors connected by IBM’s clustering technology—and one IBM eServer p690 system with thirty-two POWER4+ microprocessors. This infrastructure delivers a freeze-frame of the changing world of high-performance technical computing and is designed to provide the sustained compute capability, speed, and storage capacity necessary to understand and predict atmospheric interactions with the Earth. The supercomputer allows us to pursue data-intensive research involving large geophysical data sets from current and next-generation numerical models and satellite observations.

Final Discovery

Our first project involves the emission and long-range transport of mineral aerosols. We used the ESMF to probe the physical causes and biogeochemical and climate consequences of large airborne particles, and found a huge discrepancy between previous simulations, which underestimated the abundance of these particles, and our observations. Remote regions such as the Southern Ocean near the Antarctic may receive inputs of dust-borne nutrients like iron much less regularly, and in much larger-sized particles, than currently thought.

The ESMF makes possible new simulations that will include the complex, time-consuming physical processes we have shown responsible for greater emissions of large desert dust particles. We will soon run new, coupled simulations, which address the previous biases of dust on climate and biogeochemistry. These will have fewer surfaces cooling, more atmospheric heating, and more variable dust fertilization of ocean biogeochemistry than current models.

Our improved dust distributions will strengthen radiative feedbacks in dust source regions and weaken them afar. We believe these results will show that dust is more capable of drying out and regions, and generating more dust than previously thought.

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This article originally appeared in the 7/1/2004 Issue of Syllabus