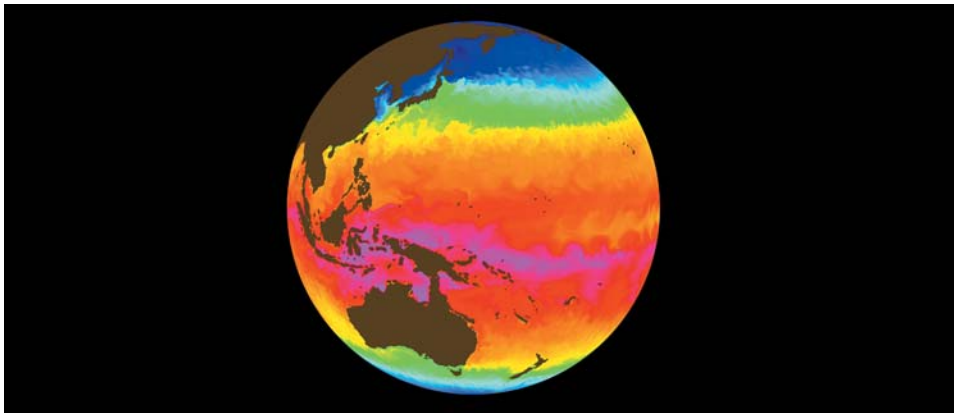
Success Story

Global-scale Research



This is an ECCO simulation of ocean conditions in early 1993. Ocean surface temperatures range from -1.9 degrees Centigrade (in dark blue) to 37 degrees Centigrade (in pink/white).

# Charting the Oceanic Future at NASA

"We want to know how the Earth system is changing, and how those changes affect life on Earth."

*– Dr. Walt Brooks, NASA Ames Advanced Supercomputing Division Chief*

With every form of life on Earth dependent on water, it's difficult to imagine research more essential than deciphering the future of the planet's oceans. But global-scale research requires global-scale observations and models, criteria that rapidly thin the field of potential leaders in ocean studies.

One such leader enjoys a particular edge. "Using the vantage point of space, NASA gains an understanding of our home planet that we could never achieve were we bound to the Earth's surface," notes Dr. Ghassem R. Asrar, associate administrator of NASA's Earth Science Enterprise. NASA's remarkable 45-year history and vast scientific and engineering resources have helped the agency launch numerous research missions to understand and protect planet Earth.

One such mission is underway at NASA Ames Research Center in Mountain View, Calif. Ames deploys some of the world's most powerful computing systems to achieve things that, quite literally, have never been done before. Recently, Earth sciences researchers from Ames and NASA's Jet Propulsion Laboratory (JPL) did it again.

Just weeks after attaining record levels of sustained performance and scalability on a 256-processor global shared-memory SGI® Altix™ 3000 system, the team at NASA Ames doubled the size of its Altix™ system-achieving 512 processors in a single image, by far the largest supercomputer ever to run on the Linux® operating system. (NASA announced its technical feat at the SC2003 supercomputing conference.) NASA's effort is part an intra-agency collaborative research program between NASA Ames, JPL and NASA's Goddard Space Flight Center to accelerate the science return for large-scale earth modeling problems.

The group's current focus is to apply its 512-processor Altix system toward scaling the performance of ECCO (Estimating the Circulation and Climate of the Ocean). An application collabora-

tively developed by the Massachusetts Institute of Technology, JPL, and the Scripps Institution of Oceanography, ECCO is designed to improve the understanding of large-scale ocean dynamics by assimilating real-time ocean conditions as measured by satellites and onsite observation. With the more powerful Altix system, NASA researchers can progress to higher resolution models that better match withsatellite observation.

With its 256-processor Altix system, NASA achieved the fastest ECCO results ever recorded, with an ECCO ocean circulation model executing a one-quarter-degree global problem at a rate of 1.4 simulated years per wall clock day. Researchers now are aiming for a near-linear advance in performance on the larger single system image. While such a goal can be daunting, if not impossible, for traditional computer systems, NASA is able to take full advantage of its Altix system's 512 Intel® Itanium® 2 processors by leveraging the latest Intel® compilers, a robust and proven 64-bit Linux operating environment, and the high-bandwidth SGI® NUMAflex™ global shared-memory architecture.

"Large-scale problems require an extremely low-latency interface," notes Bob Ciotti, lead for the Terascale Application group at NASA Ames. "That determines how well you'll scale on these tightly coupled problems. And by having a single system image, we benefit from a more efficient and simpler programming development environment and a more robust I/O architecture that's a good match for applications where we're pushing lots of data."

"Lots of data" might be something of an understatement. All told, NASA Ames' Earth sciences and aerospace research has generated more than a petabyte (or 1,024 terabytes) of data. With the acquisition of the Altix system-first 128 processors, then another 128, and finally another 256-NASA also invested in a total of 28 terabytes of SGI® InfiniteStorage capacity. The Fibre Channel storage installation keeps simulation and observational data accessible to ECCO ocean circulation models-an advantage that will prove even more important as ECCO models increase in resolution and produce even larger data sets.

With applications designed to run on hundreds more processors than they do today, NASA researchers have made specific efforts to optimize the return on their Altix investment. Running their codes on the record 512-processor single system image has allowed NASA researchers to see immediate scalability benefits with little or no porting or tuning. The first Linux OS-based supercomputers to enable global shared-memory, SGI Altix systems are powered by the third-generation NUMAflex supercomputing architecture. With NUMAflex, high-performance computing (HPC) innovators like NASA can analyze data sets as whole entities, without breaking them up into smaller segments to be handled by individual processors.

"Technically, this effort will pave the way for us to make full use of satellite observations by bringing satellite data directly into the model," says Dr. Ichiro Fukumori, ECCO Project Scientist from JPL. "We'll move toward a much more data-driven model. Our models will include real-world data that will constantly refine and constrain our results."

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Today for instance, ECCO models achieve one-quarter-degree resolution, which is roughly equivalent to 25 kilometers. But eventually, NASA wants to drive the level of detail to one-tenth of a degree. "This will make our results much more accurate," adds Fukumori. "And that just wasn't possible before."

With code capable of scaling beyond 512 processors, NASA will continue to push the limits of computing as it seeks answers to some of the most important questions facing humankind today. In the end, SGI and Altix are helping NASA uncover insights that may well touch the lives of every living thing on the planet.

"The Earth is complex and fragile, and the only known harbor of life in the solar system," notes Dr. Walt Brooks, NASA Ames Advanced Supercomputing Division chief. "We want to know how the Earth system is changing, and how those changes affect life on Earth. That's the work we do here."



Corporate Office
1500 Crittenden Lane
Mountain View, CA 94043
(650) 960-1980
www.sgi.com

North America +1 800.800.7441
Latin America +55 11.5509.1455
Europe +44 118.925.7500
Japan +81 3.5488.1811
Asia Pacific +1 650.933.3000



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