Coalition of
Academic
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C A S C

HIGH PERFORMANCE COMPUTING RESTORES AND PROTECTS WATER QUALITY

High Performance computing is playing a critical role in developing cost-effective strategies for preserving and restoring the quality of our nation's water supplies. Run-off from farm chemicals and fertilization, industrial pollutants, timbering, road gas, motor oil and sewage disposal are just some of the factor that contaminate drinking water, threaten commercial fishing and other food sources and disrupt the ecological balance that supports important forms of life.

Attempts to address these problems through traditional experimentation are time-consuming, costly and often pose the risk of further environmental damage. Interrelationships between groundwater flow patterns and complex geological formations are not yet fully understood, nor is the impact of ground and surface water contaminants on key biological processes.

High Performance computer simulation and visualization is providing the most precise information ever available on these phenomena. Groundwater flow regions can be a mile or more across, yet have features such as wells and pollution sites which are a yard or less in size. Only truly advanced computers can handle this diverse range. Likewise, supercomputer models can provide the analysis required to distinguish an urgent site from a relatively benign one.

Scientists working with university-based supercomputing centers are testing the efficacy of various anti-pollution and clean-up strategies at reasonable cost and low risk. The economic benefits of such priority-setting are enormous, as are the implications for developing sound public policy. Here are some examples:

Toxic Waste Management and Groundwater Cleanup -- Researchers at the National Science Foundation's Center for Research on Parallel Computation (CRPC) are working with the Department of Energy and other research organizations to examine options for removing toxic waste from groundwater basins -- before the soil is ever reached by contaminants. In using massively parallel computers for petroleum research, the CRPC team recognized that their software and 3-D modeling methods could have similar applications for environmental concerns. By providing more detailed visual and analytical information to environmental engineers and scientists, new groundwater modeling methods developed at CRPC are reducing time, cost and risk factors associated with the delicate and complex task of groundwater cleanup.

The San Diego Bay Project-- The San Diego Supercomputer Center is working with the San Diego Interagency Water Quality Panel and more than 39 other data collection agencies in a cooperative investigation of the San Diego Bay and related coastal estuarine environments. The goal is to use high performance computing to simulate and visualize the effects of recreational and commercial uses on the Bay and to provide policy makers with the insights needed to create balanced and effective regulations. So other locales can benefit, findings from the project are being made available on the World Wide Web. Future plans include creating a three-dimensional virtual collaborative environment, that enables scientists and policy makers at remote sites to benefit fully from the technology and from one another's input.

Underground Hydrology in Permafrost Conditions -- For decades underground hydrology has been studied in temperate regions. But only recently have researchers begun to look at how permafrost conditions affect groundwater flow. At the Arctic Region Supercomputing Center and at the University of Alaska, Fairbanks, high performance computing is helping scientists to better understand contamination problems unique to such a climate and to develop strategies for addressing hazardous waste management and other groundwater issues. This research includes modeling subsurface migration of petroleum and other contaminents in Antarctica, studying hydrologic linkages in the Arctic watershed and simulating in situ bioremediation techniques in mineral and organic soils.

Environmental Hydrology and Water Quality Research -- The National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign is collaborating with the Army Corps of Engineers Waterways Experiment Station (CEWES) in Vicksburg, Mississippi to create a three-dimensional Virtual Reality (VR) model of the Chesapeake Bay -- The nation's largest and most productive estuary. The goal is to better understand the impact of population growth, agricultural and industrial development and other factors on water quality. Using the data collected by CEWES and NCSA's virtual reality tools, including the $CAVE_{TM}$ (a room-sized virtual environment) and $ImmersaDesk_{TM}$ (a table-sized 3-D VR unit), computer-generated representations are being created. New collaborative technologies now under development will also enable researchers working at two geographically-distant ImmersaDesks to study and work on the same model at the same time. In effect they will be able to slog around the virtual banks of the Chesapeake Bay together, though one is in a lab in Vicksburg and the other is at the University of Illinois -- or in fact anywhere else in the world.

Reducing Groundwater Contamination -- Researchers at Oak Ridge National Laboratory's Center for Computational Sciences (CCS) are working with several universities and other research facilities to develop high performance computational tools for studying groundwater supplies, including identifying and predicting areas of subsurface contamination and orchestrating solutions to this pervasive problem.

These efforts are already paying off in predicting subsurface contamination and in designing cost effective remediation strategies at many US Department of Energy waste disposal sites, including Oak Ridge, Portsmouth and the Savannah River. Some examples are: cost benefit analysis to determine when natural attenuation or containment walls is a more effective waste management strategy; simulation of acidic uranium waste leaching which can lead to better drainage treatment systems; predication of tritium migration, leading to better assessment of its health risks and improvement of injection-extraction systems used in remediation of the common industrial contaminant trichloroethylene (TCE) at a gaseous diffusion plant.