The march toward increased computing power has opened new vistas and opportunities for computer simulations of nonlinear, complex physical phenomena that involve the interaction of many different effects. In August 2002, the Los Alamos National Laboratory Center for Nonlinear Studies examined the state of the art of this capability in a conference entitled “Frontiers of Simulation.” CiSE’s editors subsequently invited a number of conference speakers to write articles that illustrate the power and variety of current computer simulations.

These articles illustrate our present ability to model the effects of many different phenomena with realistic geometries and physical data. The simulations increase our scientific understanding of these phenomena by helping identify important underlying effects and helping predict the behavior of complex real-world phenomena in a way that is useful for both scientific and public policy.

The articles describe models of swimming organisms, the impacts of asteroids on Earth, space weather, pollutant flow, turbulent shocked-fluid flow, and watersheds. Each article describes a problem, basic physical and computational models, nu-

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merical solution techniques, and verification and validation methods, along with illustrative results. Two of these simulations are featured in this issue; the remainder will appear in a later issue.

The first article, “Solution-Adaptive Magnetohydrodynamics for Space Plasmas: Sun-to-Earth Simulations” by Tamás I. Gombosi, Kenneth G. Powell, Darren L. De Zeeuw, C. Robert Clauer, Kenneth C. Hansen, Ward B. Manchester, Aaron J. Ridley, Ilia I. Roussev, Igor V. Sokolov, Quentin F. Stout, and Gábor Tóth, describes a model for the flow of solar plasmas from the Sun to Earth. The calculation involves the very challenging solution of a highly nonlinear set of three-dimensional equations for the self-consistent interaction of the solar plasma with the magnetic fields of both the Sun and Earth. The simulation brings together techniques developed in many different disciplines (including aerodynamics, applied mathematics, and controlled fusion research) to meet the challenge of modeling such a compressible magnetized plasma on an astronomical scale. The modern solution techniques employed include high-resolution upwind difference schemes, adaptive mesh refinement, and domain decomposition. The applications include space weather, the Earth’s magnetosphere, the solar corona, solar flare eruptions, and plasma flow from the Sun to Earth.

The second article, “From Canonical to Complex Flows: Recent Progress on Monotonically Integrated LES” by Fernando F. Grinstein and Christer Fureby, describes a good example of how an approximate, practical model can be developed for phenomena that cannot be modeled straightforwardly (such as fluid turbulence). The challenge is to develop a method for calculating the effects of turbulent fluid flow using present-day computers. The simulation uses subgrid-scale models to capture the major effects of turbulence; the authors then used the model to calculate the flow of water around submarines and the dispersion of air-borne pollutants in an urban environment.

We hope you find these two articles useful in your own work. Please stay tuned for the second part of this special issue, which will appear soon.

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