Cloud Modeling

Jon Reisner sits in a bare, modest office inside a small, weather-beaten, prefab building, but he's connected to one of the most-sophisticated supercomputing architectures on the planet. As he explains the complexities of cloud modeling, he keeps an eye on line after line of code from a lightning simulation scrolling down one of his oversized computer screens.

Reisner, of Los Alamos' Earth and Environmental Sciences Division, has made recent breakthroughs in accurately modeling aerosol-cloud processes. His success lies in his willingness to use an approach assumed unsuitable by most of the atmospheric modeling community. It's called the Lagrangian method. As Reisner worked through the physics and math, he found that the common objections to the method were unfounded.

Modeling aerosols and clouds is chiefly about simulating particle behavior, something Los Alamos has been perfecting since its founding. From the protons and neutrons of nuclear reactions to the toxic chemical and biological plumes of potential terrorist attacks, if it involves particles, Los Alamos has probably modeled it. Of the two common computational approaches to particle modeling, the Lagrangian and the Eulerian, the latter has been favored by atmospheric modelers, and that fact has led to some problems in simulating aerosol-cloud interactions.

The mathematical differences between the Lagrangian and Eulerian methods are not easily translated into words, but to get a simplified idea, think of a two-dimensional grid, like a checkerboard, with checkers representing aerosol particles. Modelers break large problems into grids to make complex calculations of the whole problem easier. In a Eulerian simulation, if a checker moves out of its grid square to cross the corner where four squares meet, it is no longer considered a single checker but a fraction of a checker in each of the four grid squares it partially covers. The checker—aerosol particle—gets diffused, which results in problems within computer simulations, especially at a cloud's edge, which is a border between droplets and no droplets. This Eulerian edge problem can cause clouds to instantly vanish from a simulation when, in reality, they would have survived a day or two.

In contrast, the Lagrangian approach solves the edge problem by tracking the checker/particle across grid lines, always representing it as a single undiffused checker. This results in more-accurate tracking and location of particles and also enables better calculations of particle collisions, which are important because colliding cloud droplets merge to form large, falling raindrops—a process that is not yet well understood.

Reisner's method was so accurate that Dubey turned to him to model aircraft observations of the effects of soot pollution on clouds. After 20 other models had failed to simulate the data, Reisner's method successfully re-created the observed response of clouds to soot.