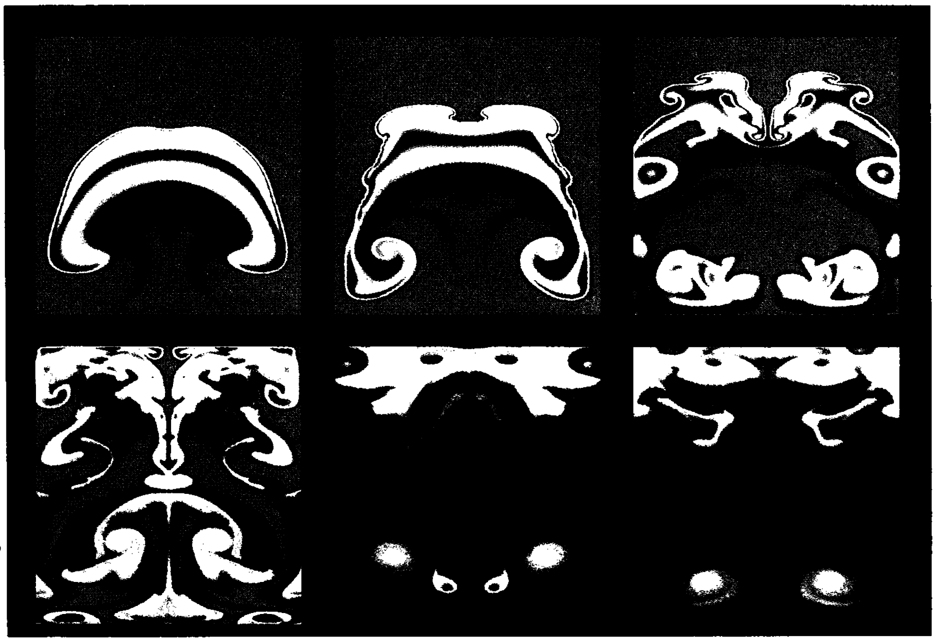

Kelvin Droegemeier

A sharper view of the life of a plume. *These six snapshots of a rising plume of warm air demonstrate how the breakdown and resulting turbulence at the leading edge of the plume can be simulated by the Piecewise Parabolic Method without the spurious oscillations inherent in other techniques.*

artificial viscosity or dissipative techniques, but then the gradients get smeared out and potentially significant small-scale fluid structures are lost.

An obvious way to get more accuracy in a numerical solution is to use a finer grid and take tinier time steps. Doing so, however, quickly overwhelms the capacity of even the largest computers: halving everything in a three-dimensional model increases the amount of computation by a factor of 16; an additional decimal place in each direction ups the ante by a factor of 10,000.

PPM takes a different approach. Instead of keeping track of, say, the temperature at each grid point, PPM keeps track of certain averages of the temperature over each grid *cell*. In effect, PPM represents the temperature variation within each separate cell as a unique parabola—hence the name. Because it uses a different parabola in each cell, PPM allows for small—or large—discontinuities. In a sense, PPM believes there are discontinuities *everywhere* in the fluid.

When applied to this collection of parabolas, the fluid flow equations are cast into characteristic form and make use of something called a Riemann problem, which can be solved exactly—for one time step—to obtain the nonlinear flux of quantities between neighboring zones. The solution, however, no longer looks like a bunch of parabolas, so before taking another time step, it is necessary first to re-average within each cell to smooth the data back into parabolic shape. PPM also uses a "monotonicity switch" to ward off the jitters—the spurious oscillations that plague standard techniques.

The clear separation of the approximation step from the exact solution step appeals to physicists, Woodward says, because it makes it clear how to add other physics to the problem. In meteorology, for instance, modelers can include effects such as cloud nucleus condensation.

But why parabolas? Mathematically it's a natural step. Godunov's original method used constant values within each grid cell. Van Leer advanced to linear approximations, in addition to introducing the monotonicity switch. Quadratic approximations—namely parabolas—are the sensible next step. It's entirely possible that a Piecewise Cubic, Quartic, or Quintic Method is somewhere down the road. For now, though, parabolas—the epitome of what-goes-up-must-come-down physics—seem well suited to the diverse interests of modelers, from the formation of storms on Earth to the course of galactic explosions.

■ BARRY A. CIPRA

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Neptune's Triton Spews a Plume

Voyager scientists who took dark streaks on the icy surface of Neptune's moon Triton as signs of ongoing volcanism now have solid proof that their bold speculations were well founded. After a month examining the 8000 images returned during Voyager 2's encounter with the Neptune system, scientists find that a few clearly show a volcano-like plume of fine dust particles. It rises an impressive 8 kilometers into Triton's thin atmosphere and streams 150 kilometers downwind.

The discovery nonetheless leaves researchers with a daunting conundrum. It takes heat energy to turn ice to gas that can drive dust particles out the throat of a volcano, like bullets shot from a gun, or even to loft volcanic dust on a warm plume of buoyant gas. How could anything so cold as Triton, which has a surface temperature of just 40°C above absolute zero, drive such an energetic, towering plume?

Internal heat of the kind that drives Earth's volcanism largely faded away millions, if not billions, of years ago on Triton. Nor does Neptune warm Triton any longer by gravitationally squeezing it, the way Jupiter warms its moon Io, the solar system's only other known volcanically active moon.

JPL/NASA

A sign of an active Triton. *An 8-kilometer-tall dark plume (between arrowheads on left) drifts downwind to right.*

So that leaves sunlight as everyone's favorite suspect. For example, David Stevenson of the California Institute of Technology suggests that the preferential absorption of solar energy by a surface layer of darkened methane ice may warm underlying nitrogen ice and turn some of it to gas. If so, it would mean that the solar system's three known types of active volcanism are all powered by different types of energy sources.

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