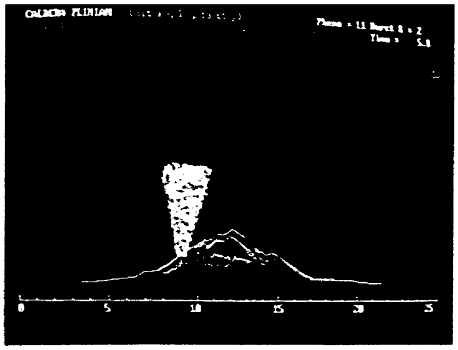
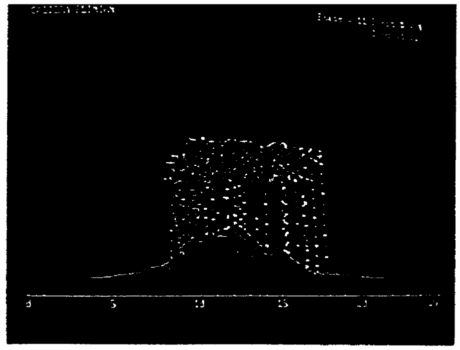


SIMON TONG



SIMON TONG

Two stages of a plinian plume that erupted on the flank of a composite volcano are displayed by the simulation program ERUPT.

ANIMATED COMPUTER MODELS OF VOLCANIC ERUPTIONS

Computer simulation of volcanic eruptions are useful to help educate the public, assist in scientific interpretation of volcanic phenomena, and to assess risk. Personal-computer models can be tested in the field and videotapes of computer simulations can be demonstrated in classrooms, on television, and in other public forums. Graphic models of volcanic eruptions range from static 3-D scenes to sophisticated simulations of multiphase flow.

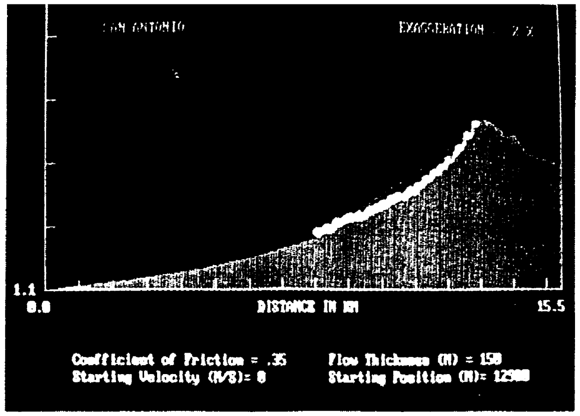
Personal computers have the color capabilities and speed to allow visualization of animated scenes that represent various types of volcanic phenomena. One program that is well suited for educating the general public is ERUPT. This program has also proven useful for researchers and college students. It was used in January to help public safety officials in Mexico understand various aspects of the potentially active Colima Volcano.

The ERUPT program builds a 2-D representation of a volcanic complex in a series of stages by simulating five types of volcanic processes: lava flow, dome growth, strombolian scoria cone, pyroclastic flow and surge, and plinian fall. The algorithms used to animate these phenomena are qualitatively correct, but not scientifically rigorous. They were constructed to present a realistic qualitative model of different types of volcanic activity.

The operator using ERUPT can switch between automatic and manual mode at any time. The size or duration of each eruption can be specified as can the velocity of the wind, which modifies the dispersal of airborne tephra. ERUPT also includes simulation of caldera formation, faulting, and erosion. Using this program, the operator can build realistic cross sections of nearly every type of volcano.

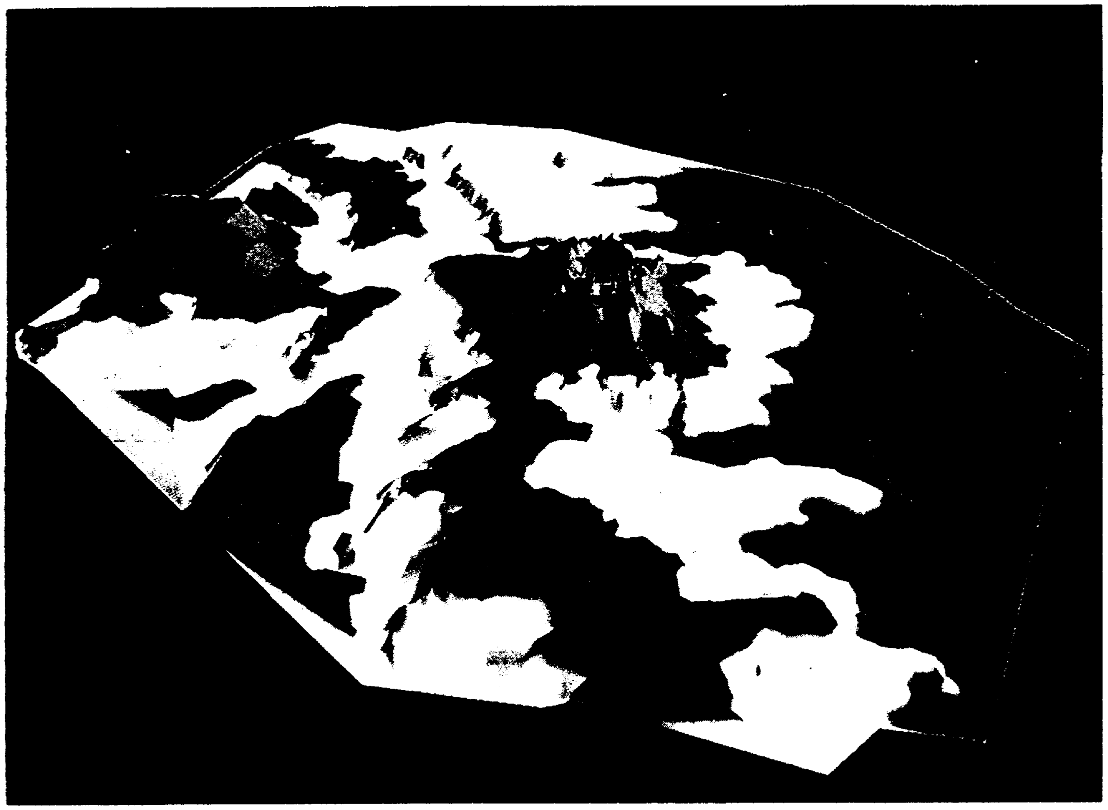
Sequential stages of a plinian plume erupted on the flank of a composite volcano can be displayed by ERUPT. Domes, lavas, scoria cones, and tephra layers within the volcano are represented by the various colors in the image. In the example, the model shows a moderate-size eruption plume with the wind directed to the right. Fallout from this plume will make a thin layer of distinctive blue on the surface.

Another example of a sequence of images generated by ERUPT shows a simulated pyroclastic flow or surge erupted from the summit area of another model of a composite volcano.



SIMON TONG

A sequence of scenes from FLOW were used to predict avalanches and pyroclastic flows during events of 1991 at Colima Volcano.



TROND SKYSETH

Topography of El Chichon Volcano, Mexico, is represented here with its dome intact before the great 1982 eruption. This figure forms the basis for generating 3-D flow models of pyroclastic flows and surges generated in 1982. The movement of flows over the surface can be back fitted to determine model parameters useful for generating volcanic risk maps for this and similar volcanoes.

Another example of a sequence of images generated by ERUPT shows a simulated pyroclastic flow or surge erupted from the summit area of another model of a composite volcano. This volcano has a core of lavas with layers of scoria and tephra on the flanks, and a small summit dome. This collage of pictures simulates the probable climactic eruption expected at Colima Volcano, Mexico.

Models that are more quantitative can actually simulate the movement of gravity-driven pyroclastic material. Such models can provide data on the estimated velocity and position of the flows with time. The program FLOW is a 2-D kinematic model that runs on a personal computer.

FLOW uses an actual topographic profile of the volcano measured along the supposed course of pyroclastic materials as the basis of the computation. The basic principle of the model is the energy-line concept. The gravitational drive is easily computed from the slope of the terrain in each computation interval. Computation of the stress resisting motion, τ_r, follows the example set by researchers who studied the mechanics at the rockslide avalanche of May 18, 1980, on Mount St. Helens. It depends on a combination of Coulomb (a_0), viscous (a_1) and turbulent (a_2) parameters according to the equation $\tau_r = a_0 + a_1v + a_2v^2$; where v is the velocity. These parameters can be chosen to fit various types of flows to be modeled.

The flow is started from a chosen location, either from rest or with a specified initial velocity and moves along the screen with a realistic velocity. It can overtop barriers and swash back and forth in valleys, depending on its energy content. After the flow comes to rest, an energy line can be drawn and the data on velocity vs. distance can be printed. The use of this model can be extended to probabilistic calculations of volcanic risk, provided that there is sufficient field data to constrain the flow parameters.

Another sequence of scenes from the FLOW program were used to predict various types of avalanches and pyroclastic flows during and after the crisis of 1991 at Colima Volcano. The topographic surface representing the flow path to be tested is shown in green and the flow is represented by a yellow trace. Vertical exaggeration can be adjusted as desired.

Thomas Kover, SUNY, Buffalo, has used FLOW's algorithms on 3-D topographic models represented by triangular irregular networks (TIN). This type of representation requires rapid rendering of large numbers of Gouraud shaded polygons, hence the model runs best on graphics workstations such as Silicon Graphics. There are several advantages of TIN polygons over grid-based representations: 1) TIN models better represent the real elevations; 2) details of actual morphology, such as stream valleys, terraces, and ridges are better depicted; 3) adjacent triangles are contiguous so that flow models do not have artificial barriers; and 4) the driving stress and the frictional stress for each polygon can be saved as a look-up table.

The topography of El Chichon Volcano, Mexico, can be represented and shown with its dome intact before the great 1982 eruption. This figure forms the basis for generating flow models of pyroclastic flows and surges generated in 1982. The movement of flows over the surface can be back fitted to determine model parameters useful for generating volcanic risk maps on this and similar volcanoes.

Using these simulations, we hope to develop volcanic risk models and determine the probability of risk from these volcanoes so officials can be prepared to take appropriate action. They can understand what they see on the screen with a very simple explanation and understand the value of using this animation to explain to villagers what could happen during an eruption and what they would need to do to save themselves. The simplicity of the simulation overcomes the difficulty of communicating public safety programs to people in small towns and villages, many of whom may not be able to read.

Michael F. Sheridan
Department of Geology, State University of New York, Buffalo, 14260

Kenneth H. Wohletz
Earth and Environmental Sciences, Los Alamos National Laboratory, Los Alamos, N.M. 87845