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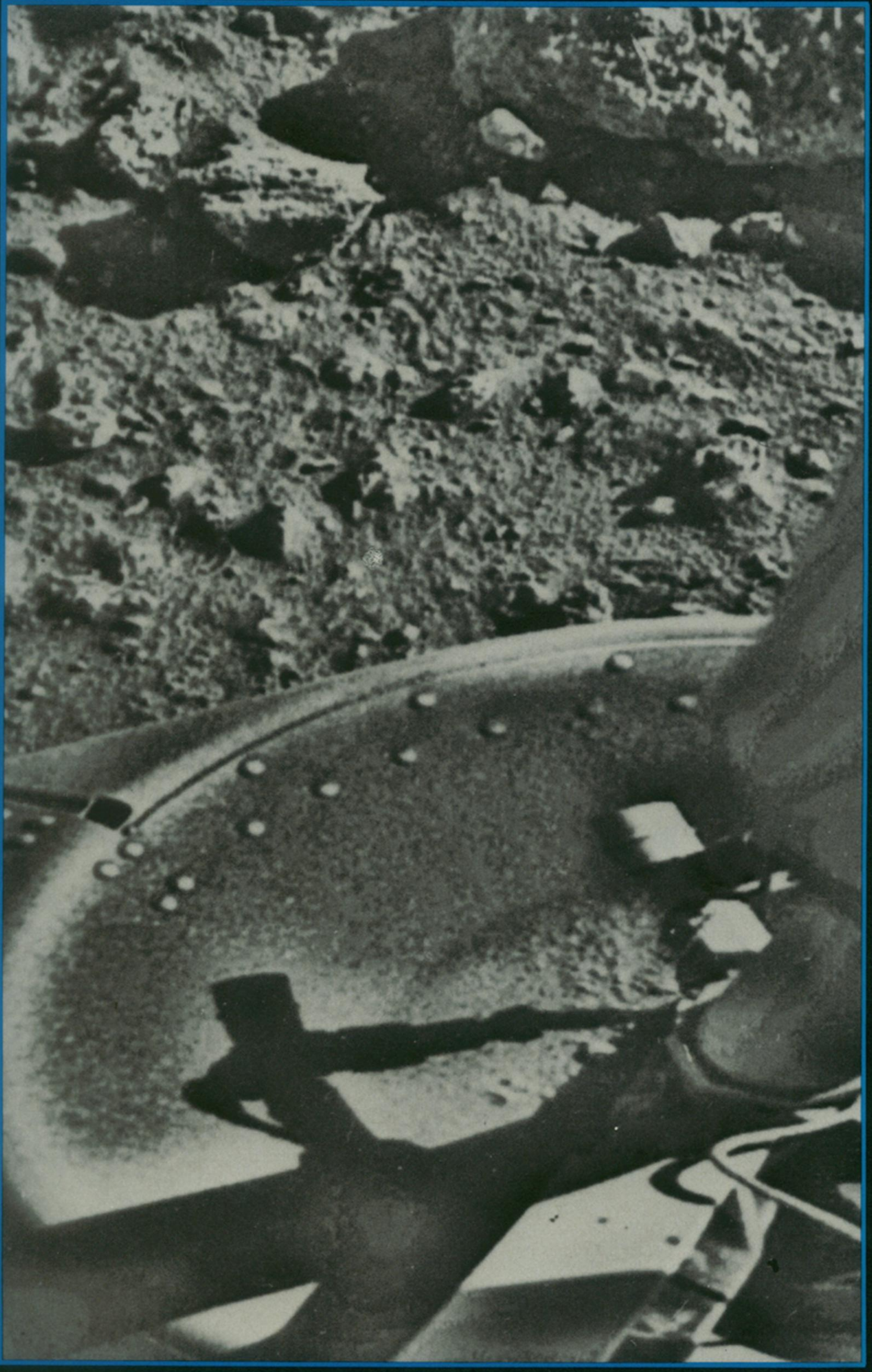
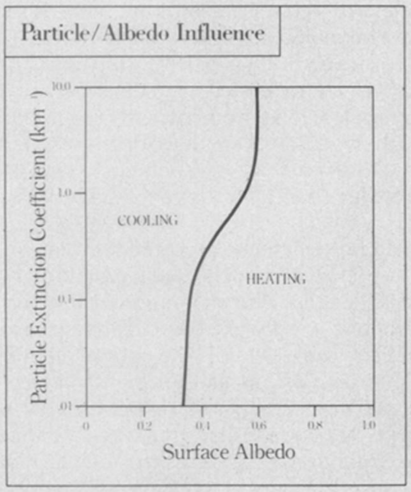
WHAT NEXT



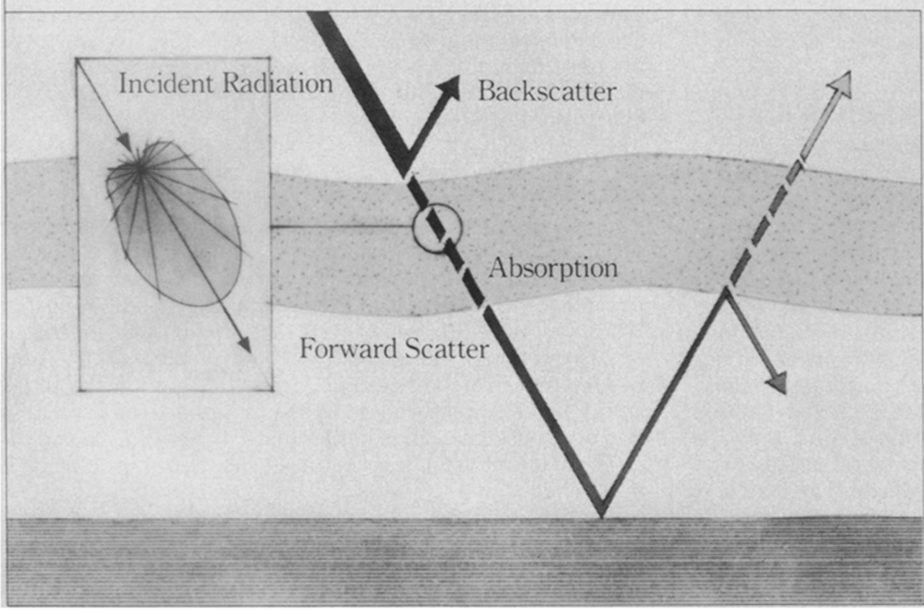
The Albedo Effect

Mathematical models of the atmosphere are the chief scientific tools for predicting long-term climate and identifying possible climatic changes that may result from man's activities. Recent advances at the General Motors Research Laboratories have revealed new information about the contribution of airborne particles to the delicate thermal balance of the earth's atmosphere.



Regions of heating and cooling determined by particle characteristics and surface albedo.

Radiation scattering exhibited by a layer of particles. The inset shows the distribution of scattering by a single particle of mean size.



DEVOID of its atmosphere, the bare earth would reach an average temperature of only −1°C. Atmospheric interaction with solar and terrestrial radiation raises the average surface temperature to fifteen degrees Celsius, making life as we know it possible. Small fluctuations in overall temperature can have large-scale effects. It is believed that a drop of a few degrees Celsius lasting for a period as short as four years could trigger an ice age. Fundamental studies conducted at the General Motors Research Laboratories explore the effect of various atmospheric factors, natural and man-made, on the earth's thermal balance.

New knowledge of the influence of airborne particles on the earth's thermal balance has been revealed by investigations carried out by Dr. Ruth Reck. Dr. Reck's work at General Motors integrated for the first time the complex factor of particles into radiative-convective atmospheric models. Her findings help determine under what conditions particles have a cooling influence, and under what conditions they have a heating influence.

Airborne particles have many sources: volcanic issue, wind-raised dust and sea salt, ash, soot, direct and indirect products of combustion and industrial processing, the products of the decay of plant and animal life, the liquid droplets and ice crystals that make up clouds. Particles alter the radiation flow in the atmosphere by the processes of scattering and absorption. Particles differ by size and composition, factors which determine optical properties.

Prior to Dr. Reck's work, models for calculating the vertical temperature profile included layers of clouds and the significant gases—O_2, O_3, H_2O and CO_2—but neglected the particle factor. To establish the thermal effect of particles, later models assumed a uniform vertical temperature change.

Dr. Reck's contribution was to add the particle factor to a one-dimensional model developed at the Geophysical Fluid Dynamics Laboratory at Princeton University. This model divides the atmosphere into nine layers. An initial temperature distribution is assumed, and the model is used to compute the net radiative energy flow into or out of each layer. A particle population is input for each layer. Calculated radiation imbalances result in a temperature change for each layer within the model, subject to the condition that change in temperature with altitude not exceed the adiabatic lapse rate. The new temperatures are used to compute a new radiation balance. This process is repeated until there are no further changes in temperature.

The particles of interest, known as Mie-scattering aerosols, are comparable in size to the wavelength of the incident radiation. Dr. Reck models the interaction of these particles with the radiation field in terms of two parameters: the single scattering albedo of the particle, which describes backscatter, and an anisotropic scattering factor, which measures the degree of forward scatter. From these two quantities and the size distribution and abundance of the particles, the transmission, absorption and backscatter of each layer in the model can be calculated.

DR. RECK discovered that whether particles have a heating or cooling influence depends upon the surface albedo, or reflective power, of the earth directly beneath them. Snow (0.6) is more reflective than sand (0.3); water is less reflective than either (0.07). Her results indicate that when surface albedo is small, the net effect of particles is to "shield" the earth from incoming solar radiation, producing a cooling influence. When surface albedo is large, a trapping effect prevails, in which the portion of solar radiation that reaches the earth's surface is "trapped" between the surface and the particles, producing a net heating influence. The competition between these two effects, shielding and trapping, determines the overall thermal influence of particles.

Dr. Reck calculated that for the latitudes between the equator and 35°N, where average surface albedo is low, the current background level of atmospheric particles decreases solar radiation reaching the earth by $\sim 1\%$, thus producing a net cooling effect. Her findings indicate that heating takes place at latitudes north of 55°N, where average surface albedo is high. Calculations with the model indicate a correlation between the increase in particle abundance due to volcanic activity in 1970 and a subsequent ice build-up in 1971.

"Previous models did not adequately take into account the role played by particles in the earth's thermal balance," says Dr. Reck. "The geosystem is continually changing. It is important for us to understand the elements that affect this evolution, so that we may know how man's activities influence the atmosphere."

THE WOMAN BEHIND THE WORK

Dr. Ruth Reck is a Staff Research Scientist in the Physics Department at the General Motors Research Laboratories.

Dr. Reck received her Ph.D in physical chemistry from the University of Minnesota. Her thesis, on the statistical mechanics of heterogeneous systems, concerned the theory of diffusion-controlled chemical reactions. Prior to joining General Motors in 1965, she was a Research Associate in the Applied Mathematics Department of Brown University.

In addition to global climate studies, Dr. Reck has done research at General Motors in solid state physics and magnetic materials. Over the last seven years, she has participated in several international exchange programs on climate-related subjects.