Bernard Vonnegut
1914-1997

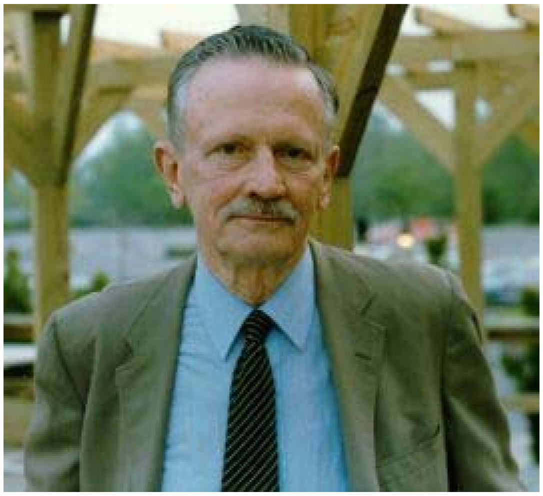

Photo by David Keller, June 1988

Distinguished Professor of Atmospheric Science
State University of New York at Albany

Honorary President, International Commission of the International Union of Geodesy and Geophysics

Fellow of the American Meteorological Society
Fellow of the American Geophysical Union
Fellow of the Royal Meteorological Society

links to awards, publications, patent lists; photos, external web pages

Dr. Vonnegut became fascinated with science when he was young, and his curiosity about the world around him continued for the rest of his life. Although he was initially educated as a chemist, his interests ranged far beyond, into meteorology, cloud physics, atmospheric electricity, aerosols and many other fields. He made significant contributions in many, widely separated fields. For example, as the result of his curiosity about the behavior of liquids, in the early 1950s, he devised a unique method for measuring the low surface tensions of surfactants now used in the secondary recovery of petroleum from nearly depleted oil wells.

Bernard Vonnegut is best known, however, for his discovery on November 14, 1946 at the General Electric Research Laboratory of the effectiveness of silver iodide as ice-forming nuclei that has been widely used to seed clouds in efforts to augment rainfall. While observing copious rainfalls from clouds everywhere warmer than 0o C during a 1949 expedition to Puerto Rico, Dr. Vonnegut recognized that snow was not essential for the formation of rain, and he began to study the formation of precipitation due to cloud droplet collision and coagulation. He studied how colliding droplets, formed above a vertical fountain, often rebound without coalescing because of an intervening, thin boundary of air that is not expelled during the brief encounter. He then discovered, as had Rayleigh in 1879, that the presence of feeble electric forces enhanced coalescence and formation of larger drops, during such collisions. Colliding droplets coalesced instead of rebounding when electrical space charges he created in the air across the room drifted past his fountain. This discovery led him to speculate that also in clouds electrical charges could aid in the coalescence of droplets and thus initiate rainfall. This idea was counter to the prevailing view, that cloud electrification is caused by the fall of charged precipitation, and electrically-induced coalescence between cloud droplets could only be of secondary interest since the electric effects could not take place until appreciable rain was already formed and falling.

Since there was little evidence to support the precipitation idea, Vonnegut began his own speculations as to how clouds become electrified. He proposed an inductive mechanism for the electrification of convective clouds in which ions in the air around the clouds become attached to cloud particles and thereafter are carried by the motions of the cloud. He argued that the Wilson current of negative ions that flows to the positively-charged tops of thunderclouds and the point-discharge positive ions that are carried from the Earth toward an electrified cloud base were not necessarily dissipative of cloud electrification. Some of these ions could be moved in the convective overturn associated with a growing cloud, resulting in point discharge ions being carried by updrafts high in the cloud where they attract more negative ions to the cloud. These in turn become attached to cloud particles near the cloud boundary and are transported downward by the unfolding and downward motions of air in and around a growing cloud. The thundercloud thus acts as an electrostatic influence machine with positive feedback driven by convection in which the Wilson and point discharge currents increase the electrification.

He proposed this idea as a possible alternative or supplement to the widely-held view that lightning is caused by sedimentation of charged precipitation elements in a neutral cloud. While he was never convinced that his ideas about the role of convection were adequate to explain cloud electrification, he was pleased that they suggested experiments that might add to an understanding of cloud processes. He carried out many ingenious experiments, including the widespread releases of ions into the air to test the effect of priming clouds with negative space charges. As he predicted, interesting, anomalous polarity clouds developed over his sources of negative charge that suggested the operation of an influence electrification mechanism. The final assessment of his ideas about the role of convection in cloud electrification has, however, not been made because we still have little information about the fate of the Wilson current and on the trajectories of air parcels in the upper regions of a convective cloud.

After observing the giant clouds and the incredibly frequent lightning associated with the storm that produced a devastating tornado in Worcester, MA on June 9, 1953, Vonnegut suggested that there might be a connection between the vigorous electrification and the intense winds associated with the tornado. He proposed that the kinetic energy concentration in a tornado funnel perhaps was a result of repeated lightning discharges in the same column of air, heating it and causing a strong local updraft as had been observed in the fire whirlwinds that develop over large conflagrations. He also wondered whether the electric wind that arises when high space charge concentration is acted upon by strong electric fields could play a role in concentrating the angular momentum. His observation, that the clouds associated with the Worcester storm penetrated high into the stratosphere, led him analyze the vertical velocities required for such penetration. His result of a 100 m/s updrafts surprised the meteorologists at the time, many of whom had assumed cloud growth was limited at the tropopause. The low temperatures he calculated at the storm cloud top is today measured from satellites and is widely used as an index of storm severity. Vonnegut recognized also that the negative buoyancy and eventual collapse of these cold overshooting turrets was the cause of upper level downdrafts in thunderclouds, that could carry the electric charge deposited on the turret by the Wilson current deep into the cloud.

His summer expeditions to the mountains of New Mexico for the study of thunderclouds with his colleagues and friends at New Mexico Tech in Socorro, were times of productive delight and inspiration. Noting that the intense rain that fell often did not exist in the cloud prior to the electric discharge, they proposed an electrostatic precipitation explanation based on the re-arrangement of charges around the lightning channels. Noting that long, grounded wires carried aloft by balloons into thunderclouds escaped being struck by lightning, they realized that the wires protected themselves by their great emissions of point discharge ions. However, after further experimentation using the van de Graaf generator at the Museum of Science in Boston, they found that sparks could be initiated from a wire by making its tip move rapidly in a strong electric field. This discovery led to the modern successes in initiating lightning by rapidly injecting wires, using rockets, into thunderstorms.

With associates, Vonnegut invented, designed and built instruments for his studies. These include a continuous condensation nuclei counter, a devise for measuring the true speed of moving, compressible fluids, an electrostatic generator of uniform aerosol particles, and instruments for measuring the electric fields and space charges in the free air. He devised a simple detector for providing warnings of strong electric fields by sensing the point discharge currents that flow into the air from exposed, sharp conductors under the strong electric fields. He devised a housing for thermometers used for making air temperature measurements in weather reconnaissance that eliminated the error caused by adiabatic compression of the air ahead of the thermometer. He investigated the behavior of evaporating, charged drops, suspended in an electric field. In 1963, when a volcano erupted under the North Atlantic, forming the island Surtsey, Vonnegut made measurements from a fishing vessel of the electrification produced by the plume ejected from the crater. His findings caused other investigators to follow; the joint results provide the most extensive study of volcanic electrification processes now available.

In 1967, after 15 years of productive scientific activities at Arthur D. Little, Inc. in Cambridge MA, Dr. Vonnegut joined the Atmospheric Sciences Research Center as a research scientist and the Department of Atmospheric Science as a professor at the State University of New York at Albany. At the University, he taught courses in atmospheric chemistry, electricity and instrumentation while continuing his studies into atmospheric processes. With students and colleagues in Albany he studied a variety of phenomena. They devised a solid-solution aerosol of silver iodide and silver bromide that eliminated the -4o C threshold for the initiation of ice nucleation when silver iodide nuclei were used. They devised an instrument that determined how strong the electric fields over water surfaces could be without corona emissions. They developed a method of monitoring global electrification by measuring the potential of the Earth relative to the upper atmosphere. They determined the minimum electric field strength at which positive streamers propagate. They studied the stochastic nature of ice nucleation and pointed out that time of exposure of the nucleus was important in rating its efficacy as an ice-nucleating agent. They investigated behavior of miniature "tornadoes" generated in the laboratory by electrical forces. They devised instruments for laboratory simulation of raindrop size distributions. They built and analyzed an instrument for real time measurements of rain rate. They invented and analyzed a unique oscillatory anemometer, and a miniature cell for real time measurements of the electrical conductivity of rain. At the same time his main concern was the electrification of thunderclouds.

Vonnegut was long interested in lightning discharges and their effects on clouds. He began measuring the intensity of light scattered and emitted from thunderclouds and soon discovered a relatively long-lasting transient increase in the light level after lightning discharge within a cloud. He was able to demonstrate that the transient was caused by the reflection of sunlight from ice crystals oriented by the changing electric fields after a discharge. This effect is now being used with a multi-polarization radar to locate regions of strong and changing electric fields in thunderclouds. The reports of spectacular lightning seen from the Skylab in Earth orbit inspired him to study lightning from above. He and associates photographed lightning from high altitude balloons. He and other associates made electrical measurements and photographs from U-2 airplanes flying over thunderclouds and, with associates at NASA he obtained video recordings of lightning from space. They confirmed eye-witness accounts they had compiled of electrical discharges propagating upward from the tops of thunderclouds. This study has now expanded into research projects dedicated to understanding upward-going SPRITES, Blue Jets and Elves.

In 1984, Dr. Vonnegut was honored by the State University at Albany with the appointment as Distinguished Research Professor. When he formally retired the following year, he became Professor Emeritus and continued teaching and pursuing his research interests for the rest of his life. He published more than 190 refereed papers and reports, many of them by himself and others with students and colleagues with whom he worked and stimulated by his ideas. More than thirty of his papers were published after his nominal retirement in 1985. Two more papers were in press at the time of his death in late April, 1997. He supplied articles to 4 encyclopedias, was co-author of five books and was the recipient of 28 patents. Through the years he served on many advisory boards and panels. His quiet, unassuming manner and his tenacity in pursuing an understanding of the natural phenomena in the world around him led one of his friends to dub him, "The Gentle Iconoclast". He was an inspiration to his colleagues and to his students who remember him fondly. His last paper, which he edited from his bed by incorporating a reviewer's suggestions, was aimed at setting straight the old, discredited but tenaciously held view by some meteorologists that updrafts are the only significant air motions in growing cumuli. His first submission of his convective electrification mechanism had been rejected in 1955 in part on that basis and, despite some improvement in the understanding of convection in the later years, he took final issue with a recent revival of that simplistic view of motions in active clouds.

Bernard Vonnegut's legacy includes his lucid expositions of nature's behavior, his engaging approach to teaching and his inspiring students and colleagues with curiosity and imagination.

Biographical Sketch written by C. B. Moore and Haflidi H. Jonsson 1997

Awards to Bernard Vonnegut
Publication list of Bernard Vonnegut
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Thomas Henderson's page for Bernard Vonnegut
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