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Bernard Vonnegut (1914-1997)

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not release names of specific ships, specific times of data collection, or any other information that might reveal sensitive information about the subs and their military missions.

"The Arctic in general, and the Arctic Ocean in particular, remain the last real frontier[s] on Earth," says Newton. "The research community of the world knows more about the topography of the planet Venus than it does about the bathymetry of the Arctic Ocean." He says the submarine data represent an order of magnitude addition to the understanding of the Arctic Ocean, which once was viewed as a big blank spot on the map and now is considered by scientists to be the weather engine for the northern hemisphere.

Garrett Brass, executive director of USARC, a government agency established in 1984, says the Navy provided all the information that the group requested. "As far as we know, we've scooped them out of all useful data from 1957 to 1982," he says, adding that the subs apparently did not carry magnetometers. He says the commission and other scientists may push for additional data recorded since 1982.

The science community, in general, is clamoring for access to data concerning Earth and space science, and for the collecting of additional data to better understand the natural environment. The American Geophysical Union adopted a resolution last May concerning the importance of making geophysical data available for research and education purposes.

Brass says the bathymetry data about the Arctic Ocean, which is among the coldest of former Cold War battle grounds, will help scientists fill in their understanding of "a place of intense and peculiar interaction between Sun, atmosphere and ocean."

The bathymetric data could contain clues about global warming, and why both the ocean water temperature, and circulation appear to be changing rapidly. In addition, the data will help to improve the understanding of the Arctic's plate tectonics and the accuracy of hydrographic charts. This includes the locations of ridges, notches and other topographic features within the four major basins of the Arctic Ocean that help to define water flow. The data also will refine understanding of the transport of contaminants. More than 2.5 million Curies of radioactive waste from major industrial rivers in the former Soviet Union have spread throughout the ocean, according to the National Oceanic and Atmospheric Administration. Radioactive waste and other pollutants also enter the ocean from Great Britain, France, and elsewhere. The contaminants also serve as markers that allow scientists to determine water flow. And the information could indicate potential gas and oil deposits and locations of polymetallic sulfides, a class of metals sometimes found adjacent to spreading sea floor ridges.

Norman Cherkis, a research oceanographer with the Naval Research Laboratory, says the bathymetry data will complement information released on a CD-ROM last January as a result of binational discussions between Vice-President Al Gore and Russian Prime Minister Viktor Chernomyrdin. The CD-ROM, which is the first of four anticipated volumes of a "Russia-American Atlas of the Arctic Ocean," contains more than one million observations of the Arctic Ocean collected between 1948 and 1993 by Russian and U.S. sources. It includes hydrometeorological data concerning the water column, such as temperature, salinity, and dissolved oxygen. Three additional CD-ROM atlases are scheduled for release by the end of 1998 that address summer conditions in the Arctic Ocean, the sea-ice cover that forms the Arctic cap, and Arctic meteorology.

"Each of these data sets by itself [the CD-ROMs and bathymetry data] is a significant gold mine of information," says Cherkis, who is involved with sanitizing and digitizing the bathymetry data. "These are areas denied to the scientific community for such a long time because of the Cold War. They are interrelated. Without knowing what the bottom looks like, you can't create accurate models of circulation patterns, which will tell us about the weather.

"Each one by themselves would be a good data set. But it's like having a pair of shoes and missing one," he says. "If you've got one or another, you'll get around, but you'll walk with a limp." Funding for cleaning up the bathymetry data is being provided through the Strategic Environmental Research and Development Program, which is jointly chartered by the Departments of Defense and Energy and the Environmental Protection Agency.

Brass says that the bathymetry and CD-ROM data "represent a couple of flash floods as opposed to a trickle" of information that previously had been available about the Arctic. "Systematic observation [of the Arctic] really is a child of the '90s," he says, concerning the dearth of data for such a large area of the globe.

Rear Admiral Joe Krol of the office of the Chief of Naval Operations says the military branch only recently grew aware of the value of the data the subs have collected. "It dawned on us that we represent a large repository of significant data that we really, to be truthful, didn't realize we had on our hands."

With some research money tighter following the end of the Cold War, the release of this bathymetric data is one benefit of the military and science communities working to establish a level of trust between their sometimes disparate cultures in order to creatively stretch their budgets and advance scientific interests.

For more information, contact the U.S. Arctic Research Commission, 4350 North Fairfax Drive, Suite 630, Arlington, VA 22203; tel. 1-703-525-0111.—*Randy Showstack*

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Bernard Vonnegut, a Fellow of AGU, the American Meteorological Society, and the Royal Meteorological Society, died of cancer in Albany, N.Y. on April 25, 1997. At 82, he was still an active and innovative scientist serving as both Distinguished Professor of Atmospheric Sciences at the State University of New York, at Albany and Honorary President of the International Commission of the International Union of Geodesy and Geophysics.

Vonnegut became fascinated with science when he was young, and his curiosity continued throughout 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 in which he made significant contributions. In 1941, he devised a novel method for measuring surface tension that is now employed to characterize surfactants used in petroleum recovery.

He is best known for discovering the effectiveness of silver iodide as ice-forming nuclei while at General Electric Research Laboratory in 1946. This approach has been widely used to seed clouds in efforts to augment rainfall. However, after observing copious rainfalls from clouds everywhere warmer than 0°C during a 1949 expedition to Puerto Rico, he recognized that snow was not essential for the formation of rain, and he lost enthusiasm for the use of silver iodide crystals in attempts to augment rainfall. Thereafter, he considered cloud seeding as demonstrating that the Wegener-Bergeron mechanism was one process, a low-rate one, by which some rain was formed, and he turned his attention to learning how more intense rains are produced. In 1950, he began to study what happens when water droplets collide in a cloud. He found that 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 results of such collisions are different in the presence of feeble electric forces, which cause colliding droplets to coalesce and form larger drops. This discovery led him to begin studies of thunderstorms and atmospheric electricity, which were to last throughout his career.

In 1953, Vonnegut 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 then are carried by the motions of the cloud. He thought a thundercloud might act as an electrostatic influence machine with positive feedback driven by convection in which the Wilson and point-discharge currents increase the electrification. Vonnegut proposed the hypothesis as a possible alternative or supplement to the widely held view that lightning is caused by the sedimentation of charged precipitation elements in a neutral cloud. Later, he carried out many ingenious experiments, including widespread releases of ions into the air to test the effect of priming clouds with negative space charges. As he predicted, anomalous polarity clouds developed on several occasions over his sources of negative charge, which suggested that the electrification was caused by an influence mechanism.

Although Vonnegut's cloud electrification process has not been widely accepted, in part because the actual motions within a convective cloud are more complex than initially treated in his model, his ideas provide explanations for many features of the still poorly understood thundercloud electrification phenomena.

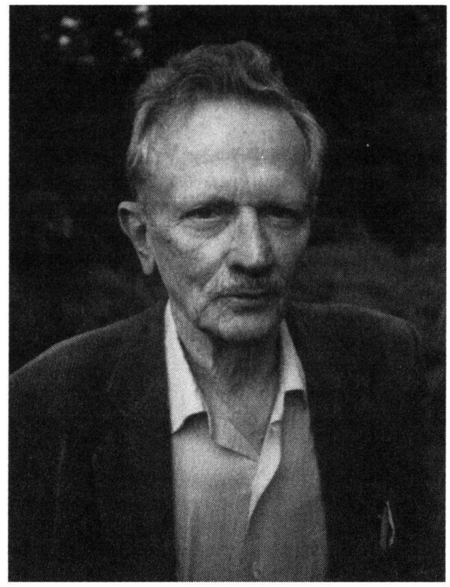
After observing the frequent lightning associated with the storm that produced a devastating tornado in Worcester, Mass., in 1953, Vonnegut suggested that there might be a connection between the vigorous electrification and the intense winds associated with the tornado. He proposed that the kinetic energy concentration in a tornado funnel could be a result of repeated lightning discharges in the same column of air, heating it and causing a strong updraft as had been observed in the fire whirlwinds that develop over large conflagrations. His observation that the clouds associated with the Worcester storm rose high into the stratosphere led him to study the updrafts required for the penetration. His calculation of the adiabatic cooling was a surprise to meteorologists of the time, many of whom had assumed that cloud growth was limited at the tropopause. The low temperatures he calculated at the tops of high cloud turrets are now measured from satellites and are widely used as an index of storm severity.

Vonnegut's summer expeditions to the mountains of New Mexico to study thunderclouds with his colleagues and friends at New Mexico Tech in Socorro were times of productive delight and inspiration. After finding that the gushes of rain that fell after lightning often did not exist in the cloud prior to the discharge, they proposed an electrostatic precipitation explanation based on the rearrangement of charges around the lightning channels. Noting that long, grounded wires carried aloft by balloons into thunderclouds were not struck by lightning, they realized that the wires protected themselves by emitting point-discharge ions. However, after experiments with the van de Graaff 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 into thunderclouds.

With his associates, Vonnegut built many new instruments. These included counters of condensation nuclei, 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 hazardous electric fields by sensing the point-discharge currents that flow into the air from exposed, sharp conductors. He invented a thermometer 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 in the North Atlantic Ocean, forming Surtsey, Vonnegut measured from a fishing vessel the electrification produced by the plume from the crater. His findings, with those of the other investigators, provide the most extensive study of volcanic electrification processes ever.

In 1967, after 15 years of productive science at Arthur D. Little, Inc. in Cambridge, Mass., Vonnegut joined the Atmospheric Sciences Research Center and the Department of Atmospheric Science at the State University of New York at Albany, where he taught courses in atmospheric chemistry and electricity, while continuing his studies into atmospheric processes. With students and colleagues, he devised a solid-solution aerosol of silver iodide and silver bromide that eliminated the -4°C threshold for the initiation of ice nucleation when silver iodide nuclei were used. With others, he 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 and determined the minimum electric field strength at which positive streamers of lightning propagate. Vonnegut and colleagues also studied the stochastic nature of ice nucleation and pointed out that time of exposure of the nucleus is important in rating its efficacy as an ice-nucleating agent.

Vonnegut discovered that ice crystals in thunderclouds become oriented by the electric fields, a phenomenon that is now used with radar to locate regions of strong electric



fields in thunderclouds. The reports of spectacular lightning seen from the Skylab in Earth orbit inspired him to study lightning from above, a study that has expanded into research on sprites and blue jets.

Vonnegut was frequently involved in scientific public service; he analyzed the electrical behavior of an airplane in a thunderstorm for the Federal Aviation Agency and pointed out that the lightening strikes are often initiated by the airplane itself. He served as a member of the U.S. Air Force Scientific Advisory Board from 1971 to 1977, provided strong support for the scientific work at the Air Force Phillips Laboratory, and helped establish the National Center for Atmospheric Research.

In 1984, Vonnegut was named Distinguished Research Professor by the State University of New York at Albany. He continued to teach and pursue his research interests. After his retirement in 1985, Vonnegut published more than 30 papers. Throughout his career, Vonnegut published more than 190 refereed papers, many of them with students and colleagues, and received 28 patents. His last paper, which he edited from his bed, was aimed at setting straight the old, discredited but tenaciously held view that updrafts are the only significant air motions in growing cumuli.

Vonnegut's quiet, unassuming manner and his pursuit of an understanding about the natural phenomena in the world around him led one of his friends to dub him "The Gentle Iconoclast." Bernard Vonnegut's legacy includes his lucid expositions of nature's behavior, his engaging approach to teaching, and his ability to inspire students and colleagues with curiosity and imagination.—*C. B. Moore, New Mexico Tech, Socorro, N. Mex.; Haflidi Jonsson, Naval Postgraduate School, Monterey, Calif.; Sally Marsh, State University of New York at Albany*