3) **Insolation/dating.** George Kukla pointed out that it is insufficient and can even be misleading to correlate paleo-data with the summer insolation at 65°N. Especially for the interpretation of tropical records and leads and lags between the northern and southern hemispheres, a deeper understanding of the driving transient, seasonal, and latitudinal insolation changes, as well as of the role of the individual orbital parameters is inevitable.

Michael Sarnthein's presentation showed that not only are more and larger global data compilations needed to enable data-model intercomparison, but also a common time scale. For modelers, the use of a season definition based on the astronomical position of the Earth (instead of using the present-day length of seasons) is recommended. For the individual archives, the use of a common time scale is often difficult, as discussions on the Greenland Ice Core Project (GRIP) and the Greenland Ice Sheet Project (GISP), on Devil's Hole, or on the orbitally tuned Spectral Mapping Group (SPECMAP) oxygen-isotope record showed. Nevertheless, as the results of Maria Sanchez Goñi and Frank Sirocko impressively demonstrated, a common time scale could easily lead to new insights.

4) **Definition of Last Glacial Inception.** Finally, it should be emphasized that the Last Glacial Inception was discussed as the transition from oxygen isotope stage 5e to 5d, and not from stage 5 to 4.

The workshop participants agreed that keeping the needs of both the paleo-data and the modeling community in mind would be mutually beneficial. The next EMIC workshop will take place in April 2003 along with the EGS-AGU-EUG Joint Assembly in Nice, France.

The EMIC's Workshop on the Last Glacial Inception was held 24–25 October 2002, in Potsdam, Germany.

Reference

Claussen, M., et al., Earth system models of intermediate complexity, Closing the gap in the spectrum of climate system models, *Clim. Dyn.*, *18*, 579–586, 2002.

—Claudia Kubatzki and Martin Claussen, Potsdam Institute for Climate Impact Research, Germany

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GEOPHYSICISTS

Nelson Spencer (1918-2002)

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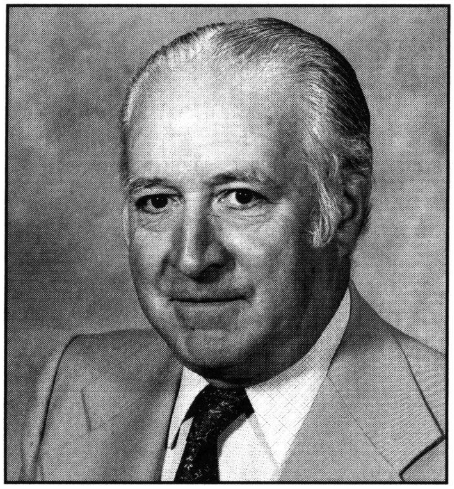

Nelson Spencer, former chief of the Laboratory for Atmospheres at NASA/Goddard Space Flight Center, died on 31 August 2002 in Bethesda, Maryland, at the age of 84 due to complications from Parkinson's disease. He had been an AGU member (SPA) since 1950.

He was born in Buffalo, New York, and graduated from the University of Michigan in 1941 with a degree in electrical engineering. Spencer served as a naval officer during World War II and attended Harvard and the Massachusetts Institute of Technology while in the service. After the war, he returned to the University of Michigan for graduate studies, earning his master's degree in electrical engineering in 1953. He soon became director of that department's Space Physics Research Laboratory (SPRL), and later, a full professor. In 1960, Spencer moved to Washington D.C. to lead Goddard's upper atmosphere research effort, serving for many years as chief of the Laboratory for Atmospheres. He retired in 1986.

Spencer made many valuable scientific contributions to aeronomic science, both at Michigan and Goddard. A series of SPRL rocket flights in the late 1950s led to the rather controversial discovery that the daytime ionosphere is not in thermal equilibrium, as had long been assumed by ionosphere theorists. He found that the daytime electron temperature at middle latitudes was typically twice the neutral gas temperature inferred from satellite drag measurements. Even higher electron temperatures were found in auroral regions where particle precipitation provided additional electron heating. These observations inspired new theoretical work on the electron heating and cooling processes that showed that thermal equilibrium indeed should not have been expected. These early results were later confirmed by simultaneous measurements of both the electron and neutral gas temperatures.

Other flights showed that this condition also persists at night at both middle and high latitudes, a result that was later explained by field-aligned heat conduction from the plasmasphere and magnetosphere. The instruments Spencer developed during the rocket program at Michigan led him to a decades-long satellite exploration of the thermosphere after his move to Goddard. His scientific work there focused on the use of moving baffles in front of neutral gas spectrometers to measure thermospheric temperatures and winds. Used on the Atmosphere Explorers (AE), Dynamics Explorer-2 (DE-2), and San Marco satellites, this method has provided the only global in situ measurements of thermospheric winds and temperature; these data have been used widely in studies of global thermosphere heating and transport.

Spencer's other early contribution to atmospheric research was his ability to promote the idea that aeronomy satellites should be included in NASA's space science program. He was successful in this and became project scientist for several of the missions mentioned above. He was also of enormous help to NASA headquarters in their efforts to establish the Orbiting Geophysical Orbiter program in which he later served as a project scientist. Later, Spencer was successful in gaining approval for the DE satellites, which were to examine the energy coupling between the upper atmosphere and magnetosphere by making simultaneous measurements in both. He also organized the San Marco international satellite program. This was a cooperative effort in which the Italians built the satellites and provided some of the instruments, while U.S. investigators provided other instruments and NASA provided launch services. Spencer was the principal investigator for the wind and temperature experiment on several of these missions.

His atmospheric research interests were not limited to the Earth. In 1970, he joined Richard Goody at Harvard and Don Hunten at the University of Arizona to push for NASA approval to conduct aeronomy missions at the other terrestrial planets, Venus and Mars. The goal was to find out why the atmospheres of these planets evolved so differently from that of Earth. Could their differences in composition and temperature be explained simply by differences in their masses, rotation rates, or solar distances? Their efforts led to the approval of the Pioneer Venus project in 1973 and launches in 1978.

This highly successful mission involved a deep-diving orbiter with many in situ and remote measurements, and a second spacecraft carrying an array of entry probes to measure atmospheric temperature and composition all the way to the surface. Sadly, a comparable aeronomy mission to Mars has not yet been conducted, so the hoped-for comparative planetary atmosphere studies remain incomplete.

Another of Spencer's early innovations was the idea that theorists and experimentalists should work together in planning and executing NASA's scientific missions. He implemented this idea by including leading atmospheric theorists as principal investigators in the AE, DE, and Pioneer Venus science teams. Working in concert with the experimenters, the theorists played a key role in defining the scientific questions to be addressed, the relevant physical parameters, the best instruments, orbits, and data acquisition patterns for the purpose at hand, and then joined in the interpretation and publication of the scientific results.

Yet another innovation, conceived in the early 1960s with Erwin Schmerling at NASA headquarters, was the then-revolutionary idea that each mission should have a dedicated computer. This approach helped to facilitate the near-real time distribution of raw data to the investigators, the sharing of geophysical data within the science team, and the prompt submission of final data to the appropriate data centers. This integrated approach was especially important in the atmospheric sciences, because they require simultaneous measurements by many different instruments. The use of dedicated computers was so successful that it was adopted by other scientific disciplines.

Spencer was a leader of broad vision. By 1975, he had seen that the next generation of atmospheric science would need to focus more closely on anthropogenic effects, so he led Goddard's Laboratory for Atmospheres into the newly emerging field of stratospheric ozone. He understood that the stratosphere was a three-dimensional medium that would require examination through three-dimensional models. An unprecedented effort would be needed to develop these models and to obtain the kinds of satellite data required to test their validity. So Spencer established an atmospheric chemistry branch within his laboratory and searched the nation and the world for the key people who would be required. Then he helped to gain NASA approval for the Upper Atmosphere Research Satellite that later went on to obtain the required measurements.

Spencer's contributions have been widely acknowledged by both NASA and the University of Michigan. He received the Michigan Frontiersman Award in 1960, the Goddard Exceptional Performance Award in 1960, the NASA Exceptional Scientific Achievement Awards in 1970 and 1980, the Michigan College of Engineering Outstanding Alumni Achievement Award in 1981, a nomination for the Presidential Rank of Meritorious Executive in 1983, and the John C. Lindsay Memorial Award in 1984.

Perhaps the greatest recognition of all comes from the many scientists, engineers, and graduate students whose careers he so profoundly advanced. They gratefully remember his pioneering role in conceiving, promoting, directing, and participating in the many pioneering flight projects noted above. He was truly one of the most important figures in the early decades of America's space science program.

—LARRY BRACE, GEORGE CARIGNAN, TOM DONAHUE, AND ANDREW NAGY, University of Michigan, Ann Arbor; AND DONALD HUNTEN, University of Arizona, Tucson

BOOK REVIEWS

Self-Organized Criticality in Earth Systems

STEFAN HERGARTEN

Springer, New York; ISBN 3-540-43452-6; ix + 272 pp.; 2002; $69.95.

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Scale invariance and the associated "fractal" power law distributions may be regarded as a common thread connecting a wide variety of phenomena throughout the various disciplines of the Earth sciences. The empirical Gutenberg-Richter law, which states that the frequency-size relationship of earthquakes scales according to the same power law for all seismogenic regions, regardless of geological history and tectonic setting, is but one prominent example. The initial enthusiasm over the abundance and seemingly universal nature of scale invariance largely focused on the detection of new examples and the ever-more detailed description of the various phenomena. Conversely, concerted attempts to systematically explore the origins of these ubiquitous fractal scaling laws were few and far between.

Given the similarity and universality in the scaling relations of so many diverse phenomena, the question that naturally arises is whether there might be a common fundamental concept capable of explaining this enigma. Self-organized criticality, which explores the behavior of complex systems, could possibly be such a unifying concept. Simply speaking, a system is referred to as complex and self-organized if its response depends, generally non-linearly, on many different parameters, and if the system tends to organize or structure itself in a certain fashion.

The critical point of a self-organized system is also known as the "edge of chaos," which implies that at this point, any external change can push the system toward either deterministic or chaotic behavior. It seems that many complex systems tend to gravitate toward this point, and it is in this region where the most interesting behavior of complex dynamic systems occurs. In the vicinity of the critical point, the parameters of a self-organized system obey scale-invariant or fractal power law distributions with correlation lengths that span the range of the entire system. Clearly, many, if not most, phenomena studied by Earth scientists can be regarded as products of complex systems. Whether these systems are also self-organized and critical remains, however, largely unexplored. *Self-Organized Criticality in Earth Systems*, by Stefan Hergarten, attempts to fill this gap. It discusses the importance of self-organized criticality for a limited and rather diverse selection of systems within the Earth sciences. The book consists of 11 chapters and an appendix.

The first four chapters provide a review of fractals, power law distributions, self-affine sequences, and deterministic chaos. Amongst the many texts available on these topics, the introductory chapters of this book stand out in terms of clarity and focus. The author achieves an excellent balance between methodological rigor and conceptual simplicity, and so these chapters provide a suitable introduction into the overall topic for non-specialists from a variety of backgrounds. The same can be said for chapter five, which introduces the basic concepts of self-organized criticality. Based on simple "reductionist" models, the remainder of the book explores the potential importance of self-organized criticality for the universal scaling laws that characterize earthquakes, forest fires, landslides, and drainage networks.

The author finds that simple models can explain many, albeit not all, of the statistical characteristics of earthquakes. Conversely, such models seem to provide rather incomplete descriptions of the phenomenology of forest fires, landslides, and drainage networks, possibly because the models are indeed too simplistic or because these systems are rarely near their critical points. The implications for the limitations of the corresponding fractal scaling laws are, however, highly interesting in their own right. The last two chapters provide an outlook and a summary, and the appendix outlines the numerical aspects of the solution of ordinary differential equations used in some of the modeling applications.

The book is hard-bound and has a pleasant LATEX-type, camera-ready typesetting. The contents of the reference list and the index are pertinent, but not overloaded. The graphic material is all black and white and consists essentially of computer-generated plots, graphs, and maps. Despite their rather "spartan" nature, I found these figures quite readable, which is certainly helped by the largely self-contained captions. Another benefit of this book is its attention to algorithmic and computational detail, which should readily allow one to reproduce and further use the models discussed.

I enjoyed reading this book and recommend it as an introduction into the overall topic for interested graduate students and research scientists.

—KLAUS HOLLIGER, Swiss Federal Institute of Technology (ETH), Zurich