

Wallace Smith Broecker

(1931–2019)

Geochemist who transformed understanding of the climate system.

It was Wallace Smith Broecker who pointed out in the 1980s that massive changes in global climate can arise from modest changes in ocean circulation. After all, the oceans contain roughly 50 times more carbon than does the atmosphere, and are responsible for nearly half of global heat transport towards the poles.

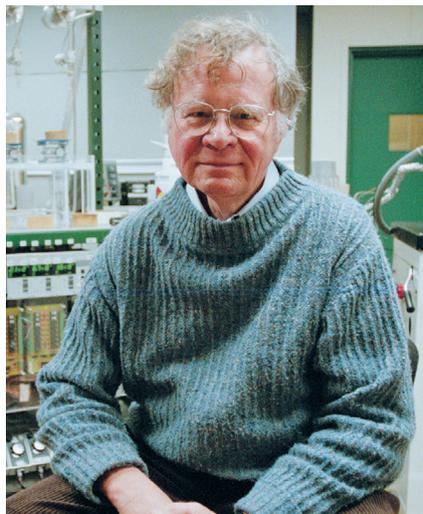
With monumental intellect and unbridled curiosity, Broecker defined much of today's understanding of the climate system. His neat, elegant solutions to complex Earth-science problems — expressed in more than 500 publications and 17 books — reshaped entire disciplines.

His path-breaking career spanned nearly seven decades, during which he defined the ocean's role in global climate change and carbon cycling, and used palaeoclimatic records to understand how climate changed in the past and its implications for our collective future. A wellspring of transformative ideas, Broecker inspired generations of researchers to think expansively about Earth.

Raised in a conservative Christian family in Oak Park, Illinois, Broecker left his undergraduate studies at Wheaton College (where he pledged to eschew smoking, drinking, dancing and films) in his home state for an internship at Columbia University's then-Lamont Geological Observatory (now the Lamont–Doherty Earth Observatory) in Palisades, New York, in 1952. He stayed for the rest of his 67-year career, calling it his 'Garden of Eden'. During his undergraduate studies, he met Grace Carder; they were married for 55 years, until her death in 2007. In 2009, Broecker married long-time close friend and technician Elizabeth Clark, who shared his love for science, puzzles and adventure.

With his warm, direct US Midwestern sensibility, wry smile and penetrating gaze, he was famously supportive of early-career scientists who shared his appetite for hard problems. He was equally famous for his impatience and explosive temper when it came to sloppy science. And he was an epic prankster. When his good friend and colleague George Kukla hosted a distinguished panel of Chinese scientists to bolster the countries' relations, Kukla and his visitors settled into his car to go to dinner, only to discover that Broecker had jacked it up onto cinder blocks.

His doctoral dissertation pioneered environmental applications of radiocarbon measurements. In the 1950s, physical oceanographers were formulating a theory of global



ocean circulation in which surface waters cool and sink at high latitudes, forming cold, deep waters that ventilate the abyss. However, the timescale of this process was unknown. Broecker demonstrated that Atlantic deep waters were only one to two centuries old, providing crucial constraints on rates of ocean flows and chemical cycling. This discovery linked theory and observations, and showed that the oceans were much more dynamic than previously thought, a finding crucial for understanding climate change — past and future.

These initial ocean radiocarbon profiles inspired Broecker to co-lead the first global ocean-sampling programme, the Geochemical Ocean Sections Study (GEOSECS), in the 1970s. For decades, these data were used to answer fundamental questions about the 3D flow and chemical processes in the oceans. Generations of marine geochemists were trained using Broecker's GEOSECS-inspired book, *Tracers in the Sea* (1982), complete with "superproblems" designed to stump even the cleverest students.

The prospect of abrupt climate change was one of Broecker's most transformative ideas. In 1970, Broecker and Columbia graduate student Jan van Donk published a study of ocean sediment cores that revealed for the first time the tempo of glacial–interglacial cycles: large ice sheets take tens of thousands of years to grow, but melt rapidly. The discovery launched decades of research into the cause of this nonlinear behaviour. Current work shows that the climate changes associated with these transitions were indeed large (15 °C of warming near the poles), fast (taking just a few decades) and intimately

coupled with changes in ocean circulation, at the surface and deep down. The climate system, Broecker noted in 1998, is like "an angry beast and we are poking it with sticks" as we pour greenhouse gases into the atmosphere.

On 8 August 1975, Broecker published a paper in *Science* entitled 'Climate change: Are we on the brink of a pronounced global warming?' (W. S. Broecker *Science* **189**, 460–463; 1975). It was the first scientific use of 'global warming', something he did not want to be remembered for. He later offered a reward to anyone who could find an earlier usage. The paper was remarkably well timed, however: global temperatures have risen consistently above baseline values since 1976.

Despite a shower of awards and positions recognizing his leadership, Broecker led a simple life: jeans and jumpers, a dented car and a small, spartan apartment near Columbia University. He had dyslexia and avoided computers, instead pencilling his manuscripts on yellow pads of paper in neat, flowing cursive script, often graphing by hand. "I understand the data better this way," he would say. Later in his career, he became an oracle whom other scientists consulted about their most exciting discoveries and ideas.

In April 2002, US billionaire Gary Comer contacted Broecker to ask why he had been able to sail his yacht, *Turmoil*, through Canada's usually ice-blocked Northwest Passage. They quickly developed a close friendship. After enjoying a campfire picnic with scientists and students — a Lamont tradition — Comer turned to Broecker and said, "How can I help?" Comer went on to invest more than US\$25 million in accelerating climate research, training scores of early-career scientists and building a new geochemistry laboratory at Lamont.

Wally, as he was always known, changed how we think about the climate system. His work invited deep, cross-disciplinary interrogation of nature's workings. Understanding the stakes early in his career, Wally held himself and the Earth-science community to high standards. His legacy challenges us to accelerate our understanding of how our planet is changing, and what it means for humanity. ■

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