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Mark Cane

2014 Fellow of The Oceanography Society

Contributed by Richard Seager

Mark Cane, who was honored in 2014 as a Fellow of The Oceanography Society, is the G. Unger Vetlesen Professor of Earth and Environmental Sciences at Columbia University, based at Columbia's Lamont-Doherty Earth Observatory in Palisades, New York. He received a bachelor's degree from Harvard in 1965 and his PhD from MIT in 1975. He moved to Lamont in 1985 and has made his research home there ever since. His unusual career has ranged from theoretical equatorial ocean dynamics to studying links between climate variability and social conflict. In all cases, he has applied his piercing intellect, deep intuition, and methodological rigor to make major advances in understanding of the ocean, the climate system, and how climate variability and change impact human society. In particular, Mark Cane is a founding father of seasonal-to-interannual climate prediction, a revolutionary field in ocean and climate science.

Mark's earliest contributions were among his most fundamental when, working with Ed Sarachik, he developed the theory of equatorial ocean wave dynamics in a series of papers of tremendous mathematical ingenuity and elegance. This was a major advance in geophysical fluid dynamics that, perhaps unbeknownst to Mark at the time, also paved the way for development of seasonal-to-interannual prediction. By the early 1980s, the El Niño-Southern Oscillation (ENSO) had grabbed people's attention, but, despite Bjerknes' pioneering work on positive tropical atmosphere-ocean feedbacks, there was no understanding of how the system oscillated between El Niños and La Niñas.

Mark and his graduate student, Steve Zebiak, set about building a numerical model of the tropical Pacific atmosphere-ocean system using an ocean model based on Mark's earlier equatorial wave theory. The Zebiak-Cane model simulated ENSO with a quite remarkable degree of realism, partly because of the clever and wise choice to construct the model as a linearization about the observed climatological mean basic state. State-of-the-art coupled models retain notorious tropical biases, and Mark's decision to bypass that whole matter probably advanced prediction by a couple of decades. This decision reflects his great dexterity and flexibility in approaching scientific investigation: he produced both a series of mathematically elegant and highly formal papers on wave dynamics and a model that drew on that work but, by necessity, introduced simplifications and fixes that could only be justified with intuition and after-the-fact proof that the model worked. The field of seasonal-to-interannual (S/I) prediction can thank Mark for his unique ability to combine brilliant theories with utter pragmatism.

Before fully understanding the physical basis for the growth and decay of El Niño events, Mark and Steve applied the model to hindcasting past El Niños, initializing them with sea surface temperature anomalies seasons in advance of the event. Because this proved successful, they then, in a bold (and some said rash) move, in summer 1986 published and disseminated a prediction of the 1986/87 El Niño event. In Henry IV Part I, Glendower says, "I can call spirits from the vasty deep," to which Hotspur retorts, "Why, so can I, or so can any man; But will they come when you do call for them?" The answer to that question is that, in the winter of 1986/87 when Mark summoned forth an El Niño from the tropical Pacific Ocean, it did indeed come. And it was not a flash in the pan but the birth of S/I prediction, Mark's baby, a startling success that revolutionized climate science.

Mark realized the potential of what he had unleashed, and putting his deep sense of social justice into practice, joined with Ed Sarachik to spearhead the creation by the US National Oceanic and Atmospheric Administration of the International Research Institute for Climate Prediction (now IRI for Climate and Society). IRI was and remains unique in that its work involves not just S/I prediction but also application of the predictions to problems in such areas as agriculture, water resources, hazards, and public health across the world, with a special focus on the developing world. From its pilot project days in the early 1990s to the large and dynamic organization it is now, IRI proves the value of seamless prediction and adaptation where climate, agricultural, and health scientists, along with others, work side by side and where oceanographic and atmospheric research inform and are informed by on-the-ground decision making in, say, tropical Africa. In 1979 when Mark was writing "Forced Baroclinic Ocean Motions III: The Linear Equatorial Bounded Case"

Mark Cane enjoying time with his grandchildren, Melech Mahalel and Charlotte Cane.

with Ed Sarachik (*Journal of Marine Research*, 37(2):355–398), he could not know that one day this knowledge would be the basis for critical guidance to African farmers.

From that point on, Mark's career followed multiple, but simultaneous, tracks. He advanced the science of applying climate forecasting to real-world problems, publishing, for example, a paper on the strong connections between ENSO and maize yields in Zimbabwe. This work began a long series of studies on the social impacts of climate change that was highlighted recently in a paper that showed armed conflict to be more common in El Niño years than La Niña years. However, Mark also continued his oceanographic and climate research. Working with various students, Mark placed the tropics at the center of the debates on glacial-to-interglacial transitions, abrupt climate change, millennial variability, and Holocene climate change. More than a decade ago, Mark published papers that used his ENSO forecast model to hypothesize that orbital variations caused weaker ENSO activity in the mid-Holocene. At the same time, he also hypothesized that rising greenhouse gases would strengthen the east-west sea surface temperature gradient across the tropical Pacific Ocean. In both of these cases, Mark's predictions excited a considerable amount of research and have so far been substantiated by the data.

It is rare to encounter a scientific career that has spanned such a range of studies and made fundamental contributions in each, from geophysical fluid dynamics, climate prediction, and paleoclimatology to climate and agriculture and social impacts of climate variations. Indeed, Mark reminds us of one of his heroes, L.F. Richardson, who, in *Weather Prediction by Numerical Process* (1922, Cambridge, The University Press), presented a visionary idea of computational fluid dynamics and computer weather prediction long before computers existed, and who also wrote *Statistics of Deadly Quarrels* (1960, Boxwood Press), which introduced the quantitative study of the causes of conflict. Richardson's career is an excellent point of comparison to Mark's, and Mark's has been equally as distinguished, innovative, wide-ranging, and impressive.

Mark just turned 70, but his scientific career is almost as busy as ever. He is still working on the same vast range of topics, all of which he will now pursue as an Oceanography Society Fellow. It is an honor Mark deserves as one of the most important oceanographers and climate scientists of the last half-century, one who also ensures that the advances in science he makes are used to improve the lives of ordinary people.

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