

PROFILE: VEERABHADRAN RAMANATHAN

From Burning Dung To Global Warming And Back Again

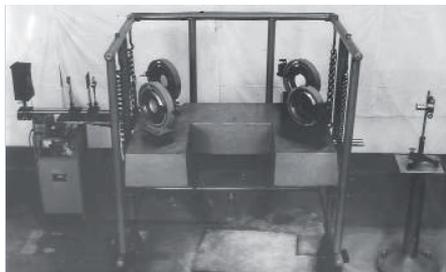
His childhood in rural India inspired the latest twist in climate scientist V. Ramanathan's long career studying—and now fighting—climate change

SAN DIEGO, CALIFORNIA—From his corner office on the terraced seaside campus of the Scripps Institution of Oceanography, Veerabhadran Ramanathan can look out 25 kilometers across the blue Pacific Ocean on a clear day. When San Diego's pollutant "brown cloud" blows in, the dim view reminds him of his current scientific bread and butter: the pernicious boost that such hazes give to global warming.

More personally, the brown smudge on the horizon takes him back to his childhood summers in rural southern India half a century ago, where his grandmother would cough endlessly over her smoky indoor cooking fire of sticks and dung. Fires like hers still stoke the mother of all brown clouds, the one over South Asia.

That connection helps explain Ramanathan's latest zigzag in a career full of unpredictable redirections. After discovering the unrecognized warming threat of trace greenhouse gases, provoking a reexamination of tropical meteorology, and revealing the insidious climate effects of brown clouds, the 64-year-old climate scientist is now going back to rural India. There he hopes to show how today's rural Indian women can cook more cleanly than his grandmother did while staving off disastrous global warming.

Whether discovering a new global warming threat or testing a new cooking stove, Ramanathan "really is bold," says Ralph



Ticket to ride. Building an interferometer took Ramanathan to the United States.

Cicerone, president of the National Academy of Sciences and a 35-year colleague of Ramanathan's. "Though he's very mild-mannered, there's an internal drive that's pretty fierce."

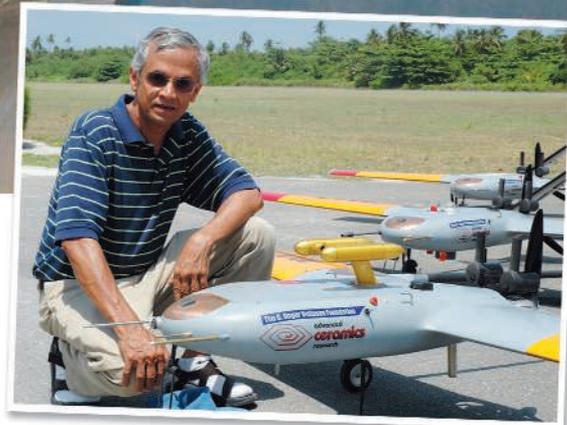
An aimless beginning

That drive came late. From his years working on his bachelor's degree in engineering at the Annamalai University in Chidambaram, south India, Ramanathan says, "all I can remember is honing my skills in tennis and table tennis. I had this vision of being a tennis star." Academically, "I had no goals for myself," he recalls. He did bring a certain independence of mind to his studies. When Ramanathan—Ram for short—was 11, his father, a traveling salesman for Goodyear Tire and Rubber Company, moved the family from Madurai to Bangalore. School there was taught in English, not Ramanathan's native Tamil. While picking up English, "I lost the habit of listening to teachers" he couldn't understand, Ramanathan says. "I had to figure out everything on my own. It helped me enormously in research."

After graduating from the university in 1965, he took a job at a refrigerator manufacturing plant. "Two years into it, I hated it. My job was preventing the [refrigerant] chlorofluorocarbons from escaping; I was not successful." He quit manufacturing and went back to school for a master's degree in engineering. There he got his first taste of research: building India's first Mach-Zehnder interferometer, an optical instrument for studying turbulent fluids. "I hadn't felt capable of anything like that," he recalls. "That gave me confidence."

Off to the planets

Research was not popular in India, however, and Ramanathan was reluctant to go back to manufacturing. "My dream was to come to America and drive American cars and enjoy



the good life," he says. So he wrote to fellow engineer Robert Cess of the State University of New York at Stony Brook (now Stony Brook University) asking about graduate work with the university's brand-new Mach-Zehnder interferometer. Cess took him on but "got bored with what I was doing" just as Ramanathan arrived, says Cess. He switched from studying combustion to studying the planets, taking Ramanathan with him. They applied an engineer's understanding of radiative transfer—the way heat is emitted, absorbed, and scattered—to the nature of the atmospheres of Venus and Mars and the way carbon dioxide traps radiation to produce a greenhouse. That was when "I realized I'd found my calling," says Ramanathan, "working on the natural environment."

No climate jobs came up, but Ramanathan's radiative-transfer expertise won him a postdoctoral position in a NASA laboratory that applied radiative transfer to the problem of how spacecraft can blaze safely home through the atmosphere. Then his new boss, like Cess, switched fields, putting him to work on how ozone in the stratosphere influences surface climate.

This latest random twist in the road carried Ramanathan into climate for good. At an ozone workshop, he learned of a recent landmark paper that tied chlorofluorocarbons (CFCs) to the chemical destruction of stratospheric ozone. Ramanathan recalled from his refrigerator days that CFCs would trap heat escaping from Earth and add to greenhouse warming. But were CFCs powerful enough greenhouse

CREDITS (TOP TO BOTTOM): H. V. NGUYEN, CA/510JCS/D; COURTESY OF VEERABHADRAN RAMANATHAN

Downloaded from www.sciencemag.org on October 15, 2009

◀ **Something in the air.** This brown cloud—fueled by burning fuels in India—led Ramanathan to fly instrumented drones through polluted clouds.

gases to compensate for their parts-per-trillion abundance in the atmosphere?

Working nights, “I did the calculation six times,” he says, and every time the radiative transfer calculation showed that each CFC molecule was 10,000 times more effective as a greenhouse gas than was carbon dioxide. The result became the crux of his first single-author paper, a blockbuster in *Science* in 1975 that launched an entire subfield of climate research. Eventually, Ramanathan and others found that rising trace gases such as CFCs account for 45% of the drive behind greenhouse warming from gases.

Against the tide

Provocation comes naturally to Ramanathan, says his wife of 36 years, Giri Ramanathan. “What Ram is good at is being original,” she says. “He loves going against the tide, he loves to get people on his bandwagon.” After a stint at the National Center for Atmospheric Research in Boulder, Colorado, where he helped build NCAR’s first world-class global climate model, Ramanathan moved on to the University of Chicago in Illinois. There he and his postdoc proposed a provocative hypothesis: Increasing clouds intervene to limit the greenhouse warming due to water vapor. In 1993, Ramanathan co-led his first major field study, the \$20 million Central Equatorial Pacific Experiment (CEPEX), drawing on ship, plane, satellite, and balloon observations to test this “thermostat hypothesis.”

Tropical meteorologists objected vociferously. “I didn’t handle the controversy right,” says Ramanathan. At a meeting, “I pounded the table; I said something that made the community angry. I let personality come in the way.”

Most researchers have since concluded Ramanathan—who has withdrawn from that field—was largely mistaken though perhaps ultimately constructive. “I think his [thermostat] paper is one of the most important in the meteorology of the tropics,” says tropical meteorologist Peter Webster of the Georgia Institute of Technology in Atlanta. “Not because it’s right—I think it’s a little wrong—but because it acted as a catalyst to get people thinking. It shows what a strong, ambitious scientist can bring about.”

To the brown cloud’s heart

CEPEX may not have won the day for Ramanathan, but it did point him to the remainder of his life’s work. CEPEX observations suggested to him that climate models

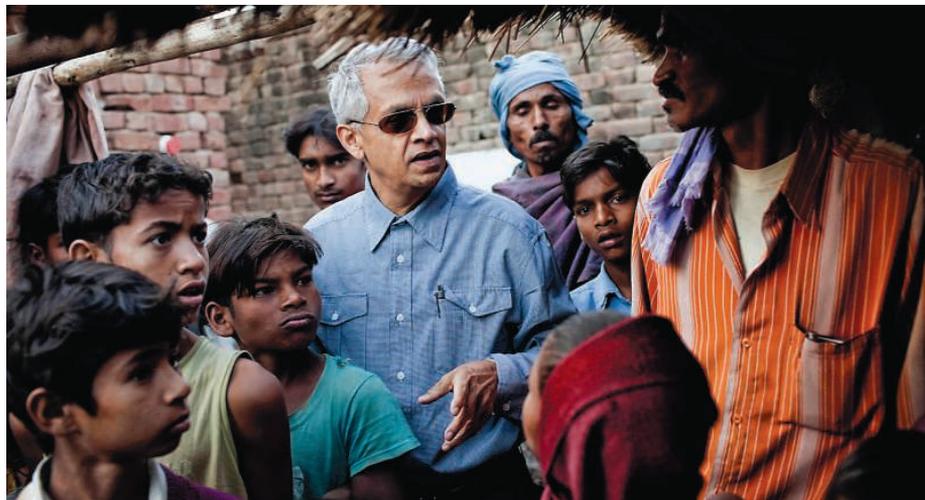
were doing a lousy job of simulating the effect of aerosols, the microscopic particles of dust, sea salt, and pollutant crud that form a sun-dimming visible haze. To find out, Ramanathan co-led with Nobelist Paul Crutzen the \$20 million Indian Ocean Experiment (INDOEX) in 1995 involving six aircraft and 200 international scientists.

INDOEX was wildly successful, unfortunately. Researchers flew into an awe-inspiring brown cloud 3 kilometers thick spread over an area the size of the continental United States. It was so dense that it reduced sunlight reaching the surface by as much as 10% to 15%, an effect missing in the models. The problem was soot. The brown cloud’s particles incorporated black carbon spewed by combustion—burning coal, diesel engines, and dung fires like the one Ramanathan’s grandmother used to cook on. Black carbon-laden aerosols absorb sunlight and warm the air, boosting global warming. They may even be suppressing monsoon

good.” At about the same time, he was shaken by the new science about the brown cloud over Asia. He learned that “most of the black carbon is from biofuel burning,” he says. “That was it. It took me back to what I had seen in my childhood” watching his grandmother coughing over her cooking fire.

Then, 3 years ago, he got yet another push. At the United Nations, “I gave a passionate speech” about global warming to an international group of high school students. “A shy African girl asked, ‘What are you personally doing about this problem?’ I had nothing to say.”

On a personal level, he started taking the bus from home to Scripps and installed solar-electric panels on his house. More globally, he has launched Project Surya—Sanskrit for “sun.” Surya “was a gift from God ... that I have a chance to go back and fix an age-old problem.” Surya is an experiment aimed at someday clearing a major part of South Asia’s



Looking for a fix. Ramanathan is looking to clear the air with cleaner cook stoves in northern India.

rainfall, depressing Indian agricultural production, and melting Himalayan glaciers, as Ramanathan has argued.

Getting personal

INDOEX was a turning point. On the last INDOEX flight, into the Bay of Bengal off southern India, “I saw a vast cloud,” Ramanathan recalls. “I grew up in southern India. I thought, ‘I can’t leave these millions of people to deal with this on their own.’ I knew this is where I was going to spend the rest of my scientific career.”

That commitment evolved when Ramanathan turned 60 in 2004. Crossing that threshold “makes you look back,” he says. “I’d been working on [climate change] 35 years. All I had done was produce one bad-news paper after another. I had to do something

of brown clouds through cleaner ways of cooking. Ramanathan plans to put cleaner-burning cook stoves and solar stoves into the hands of those living in two rural areas of about 50,000 people each in the north of India and monitor the effects. Ramanathan expects to see dramatic declines in airborne black carbon both in their homes and in and near the villages.

Fundraising has been slow so far. Ramanathan has put in \$15,000 of his own money (he recently shared the \$200,000 Tyler Prize for Environmental Achievement) and raised more from colleagues and foundations, although a large grant still eludes him. But there’s no stopping, he says. “If you accept it’s a problem, then you have to do something about it.” If the 4 billion people using biofuels “go the fossil fuels route, there is no hope.”

—RICHARD A. KERR