



## Prof. Veerabhadran Ramanathan

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### **Most important awards, prizes and academies**

*Academies:* American Association for the Advancement of Science; American Geophysical Union; American Meteorological Society; 2002-date Member of U.S. National Academy of Sciences; Foreign Member, Academia Europea, Third World Academy of Sciences. *Awards:* 1995 Buys Ballot Medal, Royal Netherlands Academy of Sciences; 1997 Volvo Environment Prize; 2002 Rossby Medal, American Meteorological Society; 2004 Gutenberg Lecture.

### **Summary of scientific research**

My fundamental interest is in understanding how human activities are influencing the climate and environment of this planet. In particular, I am focusing on how atmospheric gases, clouds and aerosols regulate the planetary greenhouse effect, solar radiative heating and climate. As a post doctoral fellow I identified the greenhouse effect of the vibration-rotation bands of chlorofluorocarbons (CFCs); on a per molecule basis, CFCs were about 10000 times more

effective than CO<sub>2</sub> as a greenhouse gas. This surprising finding opened the door to the discovery of the greenhouse effect of numerous other trace gases and the field of trace gases-climate-chemistry interactions. Clouds, the Gordian knot of the climate problem, were my next focus. I designed a satellite radiation budget experiment along with NASA scientists, and demonstrated that clouds had a net cooling effect on the planet; i.e. the reflection of solar radiation to space by clouds far exceeded their greenhouse effect. This cloud radiative forcing data is still being used to validate climate models. My current interest is to understand the influence of sub-micron size manmade particles in the atmosphere. I designed (along with P.J. Crutzen) the Indian Ocean Experiment, which led to the discovery of the widespread South Asian Brown haze, and its surprisingly large impact in reducing the solar radiation at the surface, as it not only cools the region but could also lead to global drying. This work led to a UN initiated project to study the impact of such brown clouds worldwide. I am now designing an experiment using miniaturized instruments and unmanned aircraft to understand how the planet regulates its albedo.

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### Main publications

Ramanathan's principal publications include over 150 journal papers and articles in books on Atmospheric and Climate Sciences and Planetary Atmospheres. Selected publications are listed here: Ramanathan, V., 1975, Greenhouse Effect Due to Chlorofluorocarbons: Climatic Implications, *Science*, 190: 50-1; Ramanathan, L.B. Callis and R.E. Boughner, 1976, Sensitivity of Atmospheric and Surface Temperature to Perturbations in Stratospheric Concentration of Ozone and Nitrogen Dioxide, *J. Atmos. Sci.*, 33: 1092-112; Fishman, J., V. Ramanathan, P.J. Crutzen and S.C. Liu, 1980, Tropospheric Ozone and Climate, *Nature*, 282: 818-20; Madden, R.A. and V. Ramanathan, 1980: Detecting Climate Change Due to Increasing CO<sub>2</sub>, *Science*, 209, 763-8; Ramanathan, V., R.J. Cicerone, H.B. Singh and J.T. Kiehl, 1985, Trace Gas Trends and Their Potential Role in Climate Change, *J. Geophys. Res.*, 90: 5547-66; Ramanathan, V., L. Callis, R. Cess, J. Hansen, I. Isaksen, W. Kuhn, A. Lacis, F. Luther, J. Mahlman, R. Reck and M. Schlesinger, 1987, Climate-Chemical Interactions and Effects of Changing Atmospheric Trace Gases, WMO Report#1, Volume III on *Atmospheric Ozone*, Chapter 15 on Trace gas Effects on Climate; 821-94; Ramanathan, V., 1981, The Role of Ocean-Atmosphere Interactions in the CO<sub>2</sub>-Climate Problems, *J. Atmos. Sci.*, 38: 918-30; Ramanathan, V., E.J. Pitcher, R.C. Malone and M.L. Blackmon, 1983, The Response of a Spectral General Circulation Model to Refinements in Radiative Processes, *J. Atmos. Sci.*, 40: 605-30; Ramanathan, V., R.D. Cess, E.F. Harrison, P. Minnis, B.R. Barkstrom, E. Ahmad, and D. Hartmann, 1989, Cloud-Radiative Forcing and Climate: Results from the Earth Radiation Budget Experiment, *Science*, 243: 57-63; Raval, A. and V. Ramanathan, 1989, Observational Determination of the Greenhouse Effect, *Nature*, 342: 758-61; Ramanathan, V. and W. Collins, 1991, Thermodynamic Regulation of Ocean Warming by Cirrus Clouds Deduced from Observations of the 1987 El Niño, *Nature*, 351: 27-32; Zhang, G.J., V. Ramanathan and M.J. McPhaden, 1995, Convection-Evaporation Feedback in the Equatorial Pacific, *J. Climate*, 8: 3040-51; Ramanathan, V., B. Subasilar, G. Zhang, W. Conant, R. Cess, J. Kiehl, H. Grassl and L. Shi, 1995, Warm Pool Heat Budget and Shortwave Cloud Forcing: A

Missing Physics?, *Science*, 267: 499-503; Ramanathan, V., and 40 co-authors, 2001, The Indian Ocean Experiment: An Integrated Assessment of the Climate Forcing and Effects of the Great Indo-Asian Haze, *J. Geophys. Res.*, 106, (D 22), 28,371-28,399; Satheesh, S.K. and V. Ramanathan, 2000, Large Differences in Tropical Aerosol Forcing at the Top of the Atmosphere and Earth's surface, *Nature*, 405: 60-3; Ramanathan, V., P.J. Crutzen, J.T. Kiehl and D. Rosenfeld, 2001, Aerosols, Climate and The Hydrological Cycle, *Science*, 294, 2119-24; Ramanathan, V., and P.J. Crutzen, 2003, Atmospheric Brown 'Clouds', *Atmospheric Environment*, 37, 4033-5; V. Ramanathan and M.V. Ramana, Atmospheric Brown Clouds, Long Range Transport and Climate Impacts, *EM*, 28-33, December 2003; Ramanathan, V., and M.V. Ramana, Persistent, widespread and strongly absorbing haze over the Himalayan foothills and the Indo-Gangetic Plains, *Pure and Applied Geophysics*, 162, 8-9 (2005), pp. 1609-26; Jacob, D., R. Avissar, G.C. Bond, S. Gaffin, J. Kiehl, J. Lean, U. Lohmann, M. Mann, R. Pielke, Jr., V. Ramanathan, and L. Russell, 2005, *Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties* (Washington, DC: The National Academies Press, 2005), pp. 224; Ramanathan, V., 2006, Atmospheric Brown Clouds: Health, Climate and Agriculture Impacts, Pontifical Academy of Sciences *Scripta Varia* 106, Interactions Between Global Change and Human Health (Pontificia Academia Scientiarvm 2006), pp. 47-60; Kiehl, J.T. and V. Ramanathan, eds. (2006), *Frontiers of Climate Modeling*, Cambridge University Press, Cambridge; Ramanathan, V. and A. Inamdar, 2006: The Radiative Forcing due to Clouds and Water Vapor, *Frontiers of Climate Modeling*, J.T. Kiehl and V. Ramanathan, eds. (Cambridge University Press 2006), pp. 119-51; Ramanathan, V., *et al.*, (2007), *Evaluating Progress of the U.S. Climate Change Science Program: Methods and Preliminary Results*, National Academies Press, Washington DC; Ramanathan, V., Role of Black Carbon in Global and Regional Climate Change, *Testimonial to the House Committee on Oversight and Government Reform*, October 18, 2007; Ramanathan, V. (2007), Global Dimming by Air Pollution and Global Warming by Greenhouse Gases: Global and Regional Perspectives, in C.D. O'Dowd and P.E. Wagner, eds., *Nucleation and Atmospheric Aerosols: 17th International Conference Galway, Ireland*, pp. 473-83; Ramanathan, V. (2008), Why is the Earth's Albedo 29% and was it always 29%?, *ILEAPS Newsletter*, Issue 5 (April), pp. 18-20.