

American Association for the Advancement of Science
Science serves its readers as a forum for the presentation and discussion of important issues related to the advancement of science, including the presentation of minority or conflicting points of view, rather than by publishing only material on which a consensus has been reached. Accordingly, all articles published in *Science*—including editorials, news and comment, and book reviews—are signed and reflect the individual views of the authors and not official points of view adopted by the AAAS or the institutions with which the authors are affiliated.

Publisher: William D. Carey

Editor: Daniel E. Koshland, Jr.

Deputy Editors: Philip H. Abelson (*Engineering and Applied Sciences*); John I. Brauman (*Physical Sciences*); Gardner Lindzey (*Social Sciences*)

EDITORIAL STAFF

Managing Editor: Patricia A. Morgan

Assistant Managing Editors: Nancy J. Hartnagel, John E. Ringle

Senior Editors: Eleanor Butz, Lawrence I. Grossman, Ruth Kulstad

Associate Editors: Martha Collins, Sylvia Eberhart, William Greaves, Barbara Jasny, Katrina L. Kehler, Edith Meyers

Letters Editor: Christine Gilbert

Book Reviews: Katherine Livingston, *editor*; Linda Heiser-

man

This Week in Science: Ruth Levy Guyer

Chief Production Editor: Ellen E. Murphy

Editing Department: Lois Schmitt, *head*; Caitilin Gordon,

Stephen Kepple, Lisa McCullough

Copy Desk: Isabella Bouldin, *chief*; Mary McDaniel, Sharon

Ryan, Beverly Shields

Production Manager: Karen Schools

Graphics and Production: John Baker, *assistant manager*;

Holly Bishop, Kathleen Cosimano, Eleanor Warner

Covers Editor: Grayce Finger

Manuscript Systems Analyst: William Carter

NEWS STAFF

News Editor: Barbara J. Culliton

News and Comment: Colin Norman, *deputy editor*; Mark H. Crawford, Constance Holden, Eliot Marshall, R. Jeffrey Smith, Marjorie Sun, John Walsh

Research News: Roger Lewin, *deputy editor*; Deborah M. Barnes, Richard A. Kerr, Gina Kolata, Jean L. Marx, Arthur L. Robinson, M. Mitchell Waldrop

European Correspondent: David Dickson

BUSINESS STAFF

Chief Business Officer: William M. Miller, III

Business Staff Supervisor: Deborah Rivera-Weinhold

Associate Business Supervisor: Leo Lewis

Membership Recruitment: Gwendolyn Huddle

Member and Subscription Records: Ann Ragland

Guide to Biotechnology Products and Instruments Editor: Richard G. Sommer

ADVERTISING REPRESENTATIVES

Director: Earl J. Scherago

Production Manager: Donna Rivera

Advertising Sales Manager: Richard L. Charles

Marketing Manager: Herbert L. Burklund

Sales: New York, NY 10036: J. Kevin Henebry, 1515 Broadway (212-730-1050); Scotch Plains, NJ 07076: C. Richard Callis, 12 Unami Lane (201-889-4873); Chicago, IL 60611: Jack Ryan, Room 2107, 919 N. Michigan Ave. (312-337-4973); Beverly Hills, CA 90211: Winn Nance, 111 N. La Cienega Blv. (213-657-2772); San Jose, CA 95112: Bob Brindley, 310 S. 16 St. (408-998-4690); Dorset, VT 05251: Fred W. Diefenbach, Kent Hill Rd. (802-867-5581).

Instructions for contributors appears on page xi of the 20 December 1985 issue. Editorial correspondence, including requests for permission to reprint and reprint orders, should be sent to 1333 H Street, NW, Washington, DC 20005. Telephone: 202-326-6500.

Advertising correspondence should be sent to Tenth Floor, 1515 Broadway, NY 10036. Telephone 212-730-1050.

Greenhouse Role of Trace Gases

Atmospheric scientists are emphasizing the role of trace gases as important factors in a future substantial global increase in temperature.* They estimate that, in 1980, trace gases contributed more than half as much to a greenhouse effect as did increased carbon dioxide.

From 1880 to 1980, CO₂ increased from about 275 parts per million (ppm) to 339 ppm. The principal relevant trace gases in 1980 were CH₄, 1.6 ppm; N₂O, 0.3 ppm; CCl₂F₂, 0.00028 ppm; CCl₃F, 0.00018 ppm; and O₃, which increased in the troposphere substantially over earlier values.

The key to effectiveness of the trace gases lies in their infrared absorption characteristics. They are transparent to most of the incoming solar radiation, but effective in absorbing outgoing earth radiation in the wavelength range 8 to 12 micrometers. That is the window through which a substantial fraction of the earth's heat ordinarily escapes. The earth's blackbody radiation is at a maximum in that wavelength region, and water is less effective as an absorber in that part of the spectrum.

Methane (CH₄) is at present the most effective greenhouse trace gas. Its concentration has been increasing about 1 percent per year since 1950. The total content in the atmosphere is about 5000 million tons. Methane is destroyed slowly, mainly in the troposphere, by the reactive OH. Residence time for CH₄ is 5 to 10 years. This implies an annual addition of at least 500 million tons to hold the level constant. Growth of 1 percent per year requires an extra addition on the order of 50 million tons. Principal sources of CH₄ appear to be ruminant animals, organic-rich sediments, and rice paddies. A complicating factor in estimating trends in CH₄ distribution is the competition of CO for OH. Emissions of CO have been increasing, and they destroy OH that otherwise might react with CH₄.

For a long time, nitrous oxide (N₂O) has been present in the atmosphere in substantially its current concentration. It has a residence time greater than 100 years. It is increasing at about 0.2 percent per year, with microbial interactions with fertilizers in soils and combustion of nitrogen-rich fuel likely sources. Destruction by stratospheric photolysis is the only known removal process. The contribution of N₂O to the greenhouse effect is about one-sixth that of CH₄.

The chlorofluorocarbons CCl₂F₂ and CCl₃F (freons) came into major use in the 1960's. Global emissions of them actually declined from the mid-1970's through 1982, but their long residence time, 120 years and 70 years, respectively, leads to a continuing buildup. In 1980, their contributions to a greenhouse effect were, respectively, one-third and one-fifth that of CH₄. Another halocarbon that could become important is C₂H₃Cl₃, which is used as a solvent. It has a residence time of about 10 years, and its concentration has been increasing at the rate of 8 percent per year. Much of the CCl₄ that has been produced is now in the atmosphere—mixing ratio 0.00013 ppm (about 3.6 million tons). Residence time of the chemical is 25 to 50 years. However, it does not absorb in the important region of the spectrum. Two other commercially significant halocarbons, C₂HCl₃ and C₂Cl₄, have short residence times and have thus no consequential greenhouse effects.

Climate modelers have great computational power at their disposal, but the atmospheric system is complex. Thus, estimates of a warming corresponding to the equivalent of a doubling of CO₂ have a range of 1.5° to 4.5°C. In addition, there is uncertainty about the timing of a warming. No one can be sure of the natural lag time in the response of the earth's physical and biological systems. Heat transfer from the oceanic surface waters to deeper waters could determine the rate at which the earth's climate equilibrates to a new energy budget. The other unpredictable is the behavior of humans. Experience tells us that extrapolation from the present is not a good guide to the long-term future. However, humans are increasing the concentrations of greenhouse gases, and ultimately major effects are likely to be manifest.—PHILIP H. ABELSON

*This editorial is based on testimony by Ralph J. Cicerone, director of the Atmospheric Chemistry Division, National Center for Atmospheric Research, Boulder, CO, before the Senate subcommittee on toxic substances and environmental oversight on 10 December 1985.