JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 96, NO. D5, PAGES 8921–8923, MAY 20, 1991

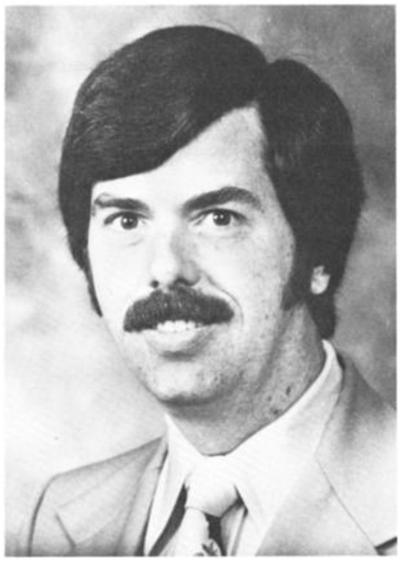
Preface

This special section consists of a series of papers devoted to the scientific aspects of state-of-the-art methods in radiative transfer computations relevant for investigations of the Earth's atmosphere. The results discussed in the papers constitute a portion of the Intercomparison of Radiation Codes in Climate Models (ICRCCM) project, which was developed under the auspices of the World Meteorological Organization (WMO) and the International Council of Scientific Unions and was supported by the Carbon Dioxide Research Division (now called Atmospheric and Climatic Research Division) of the U.S. Department of Energy (DOE). A description of the initial phase of the ICRCCM project can be found in the work by Luther et al. (*Bulletin of the American Meteorological Society*, *69*, 40–48, 1988). The principal objectives of ICRCCM were to develop an understanding of the various radiative transfer algorithms, to investigate the causes and the nature of the differences in the results among the various codes (including their accuracy with respect to benchmark computations), and to ascertain the sensitivity of the algorithms to a number of factors (including spectral parameters, constituent amounts, and meteorological conditions).

The ICRCCM project represented a significant milestone in atmospheric sciences research, inasmuch as it was the first critical quantitative evaluation of several different radiative transfer methods in use at various institutions. The rigorous intercomparison exercises have yielded new physical insights, identified deficiencies in existing algorithms, and led to the development of more accurate radiative parameterizations, some of which are manifest in the accompanying papers. These successful outcomes were brought about by the exceptional scientific roles of two unusually talented scientists, Fred Luther and Steve Fels, both of whom sadly succumbed to cancer while in the midst of the project. Both scientists projected their intellectual stature on the project through their convictions that a fundamental understanding of the modeling of atmospheric physical processes necessitates a careful assessment of the treatment of radiative processes and that accurate determinations of radiative fluxes and heating rates are essential prerequisites for reliable weather prediction and climate model simulations.

Frederick M. Luther (1943–1986)

Fred Luther, associate director of the Geophysical Sciences Division at the Lawrence Livermore National Laboratory (DOE), was one of the first scientists to propose the idea of a radiation intercomparison study. His motivation began in the late 1970s when he noticed the broad range in sensitivity of different climate models to perturbations in the carbon dioxide content of the atmosphere and wondered how much could be attributed to differences in their respective radiation parameterizations. His proposal took root in 1982 when DOE initiated a comparison study of longwave radiative transfer models. Subsequently, with the concept of such investigations being accorded a high priority by WMO and the International Radiation Commission, the intercomparison study grew into a research plan with international participation. ICRCCM was formally organized in 1983, with Fred Luther and Yves Fouquart being designated as joint leaders.



Frederick M. Luther

The following years saw Fred providing important leadership in seeking and enabling the active participation of radiation scientists at many different institutions, including those associated with general circulation models (GCMs) of the atmosphere. His sincere desire for advancing scientific knowledge was a key to sustaining the momentum of the project. He was able to steer adroitly the ICRCCM effort involving more than 60 scientists of several nationalities. Fred always emphasized the benefits of the effort and charted a course that kept in perspective the project's significance for the atmospheric sciences. One of his major achievements was in encouraging the participants to submit their radiation codes and calculations to a critical scrutiny. In spite of the professional risks this may have posed to the participants involved, Fred was able to convince the scientists that the intercomparisons would lead to a better understanding of the uncertainties in atmospheric radiative transfer and enable the development of more accurate parameterizations of radiative processes. He was particularly keen that the exercise should arrive at conclusive statements regarding the state-of-the-art knowledge in radiative transfer and thus contribute to an advancement in the atmospheric sciences. Fred's openness and self-effacing style, together with his scientific perspective, laid the basis for an intellectually stimulating rapport among the participants and ensured the success of the cooperative project. His organizational skills culminated in the first comprehensive radiation intercompari-

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Paper number 91JD00875.
0148-0227/91/91JD-00875$02.00

son meeting in Frascati (Italy) in August 1984, followed by another one at the University of Maryland in March 1986.

Fred's scientific interests spanned several areas of atmospheric radiation, chemistry, and climate, including such significant problems as the potential perturbations due to supersonic aircraft, effects from emissions of trace gases such as carbon dioxide, nitrous oxides, and chlorofluorocarbons, and effects due to injections of volcanic aerosols as well as that due to smoke from fires following a nuclear war. Besides leading to important publications, these interests also enabled Fred to play a distinguished advisory role on a number of major national and international scientific assessments related to climate, such as the studies of the state-of-the-art projection and detection of CO_2-induced climate change.

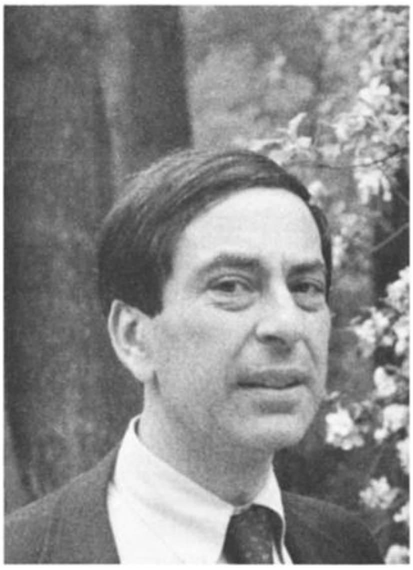
Fred's role in the ICRCCM project represents a meritorious scientific achievement. Fred would have been delighted to learn that many of the aims set forth originally for the ICRCCM project have now been achieved. Indeed, the analysis and interpretation of the longwave intercomparison results have confirmed Fred's long-held beliefs regarding uncertainties in the representation of radiative processes in climate models. The findings from the ICRCCM project have now spawned comprehensive field measurement programs. Fred would have undoubtedly enjoyed this phase, too, because he believed in bringing together theory and observations to resolve scientific problems. His dedication to scientific pursuits, his leadership in the ICRCCM project, and his buildup of an international collegiality will be fondly cherished by all who had the privilege of knowing and working with him.

STEPHEN B. FELS (1940–1989)

Steve Fels was senior research scientist with the National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory and a lecturer with the rank of professor in the Atmospheric and Oceanic Sciences Program at Princeton University. Steve was responsible for fostering the idea of a special ICRCCM section in mid-1987 as a fitting tribute to the contributions made by Fred Luther. Steve also attached considerable importance to the scientific importance of the project itself, as evidenced in excerpts from his July 29, 1987, letter to W. L. Chameides, then Editor of the *Journal of Geophysical Research–Atmospheres*:

> To my mind, the project has been of immense importance to the radiation community, allowing for the first time a fair evaluation of the performance of most of the operational codes against accurate benchmark calculations. . . . Many of the participants would like to see these results presented in a coherent form in the refereed literature. . . . It seems likely that such a collection of papers would become an invaluable reference, and would be heavily cited for many years. . . . Among the topics to be discussed would be descriptions of benchmark calculations, comparison with laboratory data and field observations, comparisons of operational and benchmark models, design considerations for efficient operational models, the accuracy required for various applications (Numerical Weather Prediction and climate modeling), etc.

Steve was appointed the guest editor of this special section, and in that capacity he solicited papers on the scientific results arising directly and indirectly from the ICRCCM exercise, including those that extended the initial project findings. The papers in this section span many of the areas that Steve had originally envisaged.



Stephen B. Fels

Steve's own scientific contributions to the ICRCCM project were unique and of a pioneering nature. His ardent passion for probing into the fundamentals of problems and his penchant for scientific rigor led him to pursue accurate methods for determining the radiative transfer in vertically inhomogeneous atmospheres, including use of the numerically precise and computationally intensive line-by-line (LBL) technique. He viewed the LBL solutions as a strong basis for characterizing the role of the radiative processes in the atmosphere. Beginning in the mid-1970s, the LBL results have yielded invaluable insights and have now become internationally recognized radiative transfer benchmarks, providing the atmospheric sciences community with an accurate means to calibrate various radiative transfer algorithms. Steve's achievements have been particularly instrumental in the development and/or validation of accurate radiative transfer treatments in numerous GCMs, including those employed for operational weather prediction and climate sensitivity research at several institutions in the United States and abroad. Steve also recognized that inaccuracies in the representation of radiative processes would yield systematic biases in GCMs and led an intensive effort to evaluate the performance of the algorithms used for climate sensitivity studies (Fels et al., this issue).

Steve's outstanding research in the atmospheric sciences began in the early 1970s and followed his successful career in high-energy physics. He was deeply interested in investigating the radiative and dynamical processes in the atmosphere. He employed the knowledge derived from his LBL studies to examine the problem of radiative damping in the stratosphere and mesosphere and authored important original papers on radiative-dynamical interactions in the stratosphere, including the evaluation of the climatic perturbations due to changes in the concentrations of carbon dioxide and ozone. He also had an avid scientific interest in investigating the physical processes in other planetary atmospheres, including superrotation on Venus. His enthusiasm for academic pursuits made him an invigorating and a popular teacher.

Steve's incisive reasoning provided authoritative scientific inputs on many issues of global significance, the most recent being the WMO Stratospheric Ozone Assessment of 1988, where he contributed to a major objective interpretation of recent ozone and temperature trends. Steve's stimulating and frank discussions were inspirations to a wide variety of scientists, while his candid questions and delightful wit always provided a refreshing perspective into any problem. Atmospheric science has lost in him a highly esteemed scientist who was a pillar of intellectual strength to all his colleagues.

It is tragic that these truly remarkable scientists, both with a rare capacity for inspiring innovative science and the ability to engage in challenging pursuits, died at the prime of their scientific potential. The collection of 15 papers in this section provide an apt memorial, saluting their distinguished scientific careers. An overview of the ICRCCM project is given by Ellingson and Fouquart, followed by papers that describe the longwave (Ellingson et al.) and the shortwave intercomparison studies (Fouquart et al.). Ridgway et al. and Feigelson et al. analyze results from LBL methods for computing the longwave radiative transfer. These papers, together with others (Chou and Kouvaris, Kiehl and Briegleb, Kratz et al., Lacis and Oinas, Rosenfield, and Schwarzkopf and Fels), also describe and assess the accuracies of various longwave parameterization techniques. A GCM parameterization of the radiative effects due to trace gases is presented by Wang et al., while Fels et al. investigate the accuracy of the longwave radiative transfer treatments in GCMs used for climate sensitivity studies. Morcrette analyzes the effects of the radiative processes in the European Centre for Medium-Range Weather Forecasting operational model. Finally, LBL computations for the shortwave radiative transfer problem are discussed by Ramaswamy and Freidenreich.

Owing to the unfortunate nature of the circumstances surrounding the course of the project, considerable delay has been incurred in preparing this special section. We have attempted to fulfil Steve's last request of bringing out this section by completing the publication process initiated by him. We appreciate the immense patience shown by the authors (all of whom declined the option of having their papers published separately and expeditiously if they so desired), the numerous reviewers, and the editorial offices of AGU. We thank the numerous colleagues and friends of Fred Luther and Steve Fels for sharing with us their perceptions on the memorial.

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