

Memorandum

To: International Radiation Commission
From: Robert G. Ellingson
ICRCCM Co-Chair
Subject: 1994-95 Working Group Report
Date: July 11, 1995

A meeting of the ICRCCM Working Group was held from 24 to 26 May 1995 at the University of Maryland at College Park to:

1. discuss the results of comparisons of longwave radiance observations with model calculations, and
2. identify long-and-short-wave problems needing further study.

In all, 28 scientists representing research groups in 7 different countries attended the meeting. A draft summary report, including a list of participants and a detailed agenda is attached.

In general, the ICRCCM participants were very pleased with the level of agreement between the observed and model calculated radiances and fluxes (downward flux at the surface to 4.5 W m^{-2} rms). However, due to the small range of water vapor and temperature observed during the SPECTRE and the lack of observations in the 0 to 500 cm^{-1} portion of the spectrum, the ICRCCM Working Group can not yet place firm estimates on the accuracy of fluxes and cooling rates at all levels of the atmosphere for clear-sky conditions. The problems associated with shortwave radiation remain as they were following our last major workshop in 1988. Therefore, we recommend that ICRCCM continue with its current terms of reference, namely:

1. Maintain the library of reference test cases based on high-precision, line-by-line calculations.
2. Provide updated assessment of the state-of-the-art in the computation of atmospheric radiative transfer for climate modeling and other applications.

3. Determine the requirements for real *in situ* data for validation of high spectral resolution models and other radiative transfer computations.
4. Explore ways of obtaining these data by either a specific dedicated measurement programme or by appropriate enhancement of other experimental activities as may be part of different regional experiments.
5. Provide scientific leadership in this area of activity.

The ICRCCM activity in the area of shortwave radiation has been relatively inactive over the past four years. However, there is renewed interest in this area both for clear and for cloudy sky conditions. Dr. Ramaswamy of GFDL, Princeton University, has volunteered to steward this new activity. The Working Group recommends that the IRC appoint Dr. Ramaswamy as co-chair of ICRCCM for the shortwave activity to replace Prof. Fouquart who has led this effort since the formation of ICRCCM in 1983..

The Working Group also discussed the relationship between the three complementary IRC working groups, ASA, ITRA and ICRCCM. The ICRCCM participants do not believe we should combine with either of the other two at this time because we focus on climate modeling, whereas the others focus more on spectroscopy (ASA) or on remote sensing (ITRA). However, we recommend continued close interaction and joint workshops with the other two.

The ICRCCM Working Group believes that it is making significant progress at understanding the validity of radiation codes used in and used to develop codes for use in climate models. Unfortunately, the number of participants from the climate model community actually participating in ICRCCM is dwindling (only six climate modelers participated). This is partially due to our use of spectral data in this comparison, and most climate models can not easily compute spectral radiance. Nonetheless, we need a mechanism for either having more climate model participants or access to documented codes used in climate models. We welcome suggestions from the IRC on how to obtain more involvement by the climate model community.

The members of the ICRCCM Working Group that met in College Park, Maryland are primarily involved with longwave studies. In order to map out a more comprehensive plan for ICRCCM for both short-and-long wave studies, we suggest that a two-day workshop be held in August 1996 prior to the IRS. One day should be devoted to discussions of the corrected longwave results, initial discussions of the trace gases comparisons, progress on the longwave cloudy-sky study and planning for the next four years. The second day should be devoted to initial results of the proposed shortwave activity and planning of shortwave studies for the next four years.

**The Intercomparison Of Radiation Codes Used In
Climate Models (ICRCCM)**

**Summary of a Workshop
College Park, MD, 24-26 May 1995**

**Robert G. Ellingson
(First Draft)**

Exercise Description

The current exercise consists of comparisons between model calculations with clear-sky observations of the vertically downward, thermally emitted, atmospheric spectral radiance in the 520 to 3000 cm^{-1} interval. The observations were obtained with a self-calibrated FTIR (University of Wisconsin) at about 0.5 cm^{-1} resolutions concurrent with observations of the atmospheric radiative properties during the SPECTRE field campaign held as part of FIRE Cirrus II at Coffeyville, KS, USA in November 1991. Participants were furnished with four sets of sounding data obtained simultaneous to observed spectra that spanned the range of water vapor (0.5 to 2 cm) and temperature (0 - 20°C) conditions of the experiment. The participants were furnished with but one of detailed spectra (the driest) with the soundings prior to submitting calculations.

Each participant performed the calculations at their model resolution and submitted their calculations to Ellingson at the University of Maryland for comparison with the observations. Since the line-by-line modelers were not furnished with the instrument response function, line-by-line calculations were integrated to 10 cm^{-1} resolution for comparison purposes (comparisons at higher resolution are being done as part of ITRA). After all model calculations were received, the comparisons between individual model calculations with observations were returned to each participant, and they were allowed to revise their results. All data exchange was carried out via FTP.

Results

Overall, 22 participants submitted 29 sets of calculations, including 10 line-by-line, 12 narrow-band, and 7 broad-band (climate model) models. For intercomparison purposes, Ellingson integrated the various model calculations and the observations to a common grid when possible (19 different sets before the workshop). A comparison of the average of detailed spectra with the average narrow-band spectra is shown in Fig. 1, whereas Fig. 2 shows a comparison of the distribution of the mean observed minus calculated radiance at the common resolution. In order to estimate the effects of these differences on the downwelling flux at the surface, the differences were integrated over the 520 to 3000 cm^{-1} interval and converted to flux using model-calculated angular corrections. The distributions of the flux differences is shown in Fig. 3. Since some participants were concerned that their calculations contained errors due to a variety of different causes, each participant was given until July 31, 1995 to submit a revised, but final, set of calculations to be used in the summary statistics.

Overall, the model calculations and observations of the downward flux incident at the surface agree to within $\pm 4.5 \text{ W m}^{-2}$ rms. The spread is enhanced by 5 of 19 models differing from the observations by more than 5 W m^{-2} . On a spectrally integrated basis, the rms differences between observations and calculations are of the order of the 1% accuracy of the observations. This agreement is about a factor of 5 better than the agreement expected from the model comparisons shown in the 1991 ICRCCM Special edition of *JGR*. It should be remembered, however, that the observations used in the study cover but a small range of water vapor loading and temperature. Confidence at larger water vapor amounts has not yet been established.

Despite the good spectrally integrated agreement, some models showed large differences from the observations in different portions of the spectrum (see Fig. 2). As such, part of the good agreement for these comparisons can not be extended to other levels or to dissimilar conditions because the cancellation of errors of different signs can not be assured to occur. Note that the largest spectral disagreements between observations and calculations tend to occur in portions of the spectrum there is a transition from opaque to transparent conditions (e.g., 520-600, 700-820, and 1190-1380 cm^{-1}). The causes for these differences have not been identified.

There is a relatively large spread between the models in the 9.6 μm band of O₃. These have not yet been examined in detail, and there is a general feeling that the ozonesonde data are not of sufficient accuracy to help us resolve the causes for differences between the observations and calculations in this region at this time.

In order to understand some of the differences between the models, some members of the working group agreed to perform a few additional sets of calculations. These include calculations for the pure rotational water vapor band for lines only at very narrow intervals, the vertical distribution of spectral cooling rates for a few cases, and line-by-line calculations using the FTIR instrument function.

Recommendations - Longwave

In summary, the workshop participants were quite pleased with the level of agreement between the observations and calculations. However, there is a general agreement that our job is not yet done for clear-sky conditions because of the small range of water vapor and temperature covered by SPECTRE and because of the lack of observations short of 500 cm^{-1} . As regards the clear-sky problem, the working group recommends:

1. Spectral comparisons in the 800-1200 cm^{-1} region be made at higher water vapor amounts in order to solidify our confidence in the parameterization of the water vapor continuum used in line-by-line models;
2. Spectral radiance data concurrent with atmospheric radiative properties be obtained in the 300 to 500 cm^{-1} region in order to adequately test the parameterization of the pure rotation spectrum that controls the cooling of the middle and upper troposphere; and
3. Efforts be made to obtain spectra and/or flux measurements at different altitudes in order to more adequately test the ability of the models to calculate flux divergence.

Ellingson offered to provide a spectra and flux data sets from ARM and ARM-UAV to meet (1) and part of (3). We will attempt to obtain spectra measured by Steve Warren in Antarctica (University of Washington) to gain experience working at low temperatures and water vapor amounts in the 500 to 500 cm^{-1} region. More thorough tests of the models at long wavelengths awaits observations during the SHEBA and ARM experiments in the arctic.

As for cloud-sky conditions, the ICRCM Working Group recommends comparisons of observed and model calculated FTIR spectra using data obtained during FIRE Cirrus II. The spectra will be chosen from time periods for which there are lidar and radar observations of thin cirrus that give ice water content and vertical distributions of ice crystals. Dr. Fu will provide single scattering albedo and extinction coefficients as a function of wavelength for different size distributions.

A number of ICRCM participants are also interested in a longwave sensitivity study of trace gas effects. Kratz, Grossman, Gupta, Pinnock, Anderson and Schwarzkopf volunteered to organize this activity and report to the ICRCM Working Group.

Recommendations - Shortwave Radiation

Ramaswamy and Wiscombe led a discussion of shortwave radiation problems on the second afternoon of the workshop. It was pointed out that the previous ICRCM exercise had identified relatively large differences between model calculations of absorption by atmospheric gases, particularly water vapor, but most of the effort has been spent on longwave problems because of the difficulty in calibration of shortwave sensors. Nevertheless, the differences between different model calculations are warrant a SPECTRE-like experiment to ferret out the cause for disagreement between the models. Thus, the ICRCM recommends to the IRC that:

1. A program of spectral model intercomparisons be undertaken to identify differences between different model calculations, particularly climate models, for a few cases, and
 2. The IRC should explore ways of obtaining spectral shortwave radiance/irradiance data to validate spectrally resolved and climate models.
- Dr. Ramaswamy volunteered to organize the shortwave comparisons.

Future ICRCM Activities

The Working Group discussed the relationship between the three complementary IRC working groups, ASA, ITRA and ICRCM. The ICRCM participants do not believe we should combine with either of the other two at this time because we focus on climate modeling, whereas the others focus more on spectroscopy (ASA) or on remote sensing (ITRA). However, we recommend continued close interaction and joint workshops with the other two.

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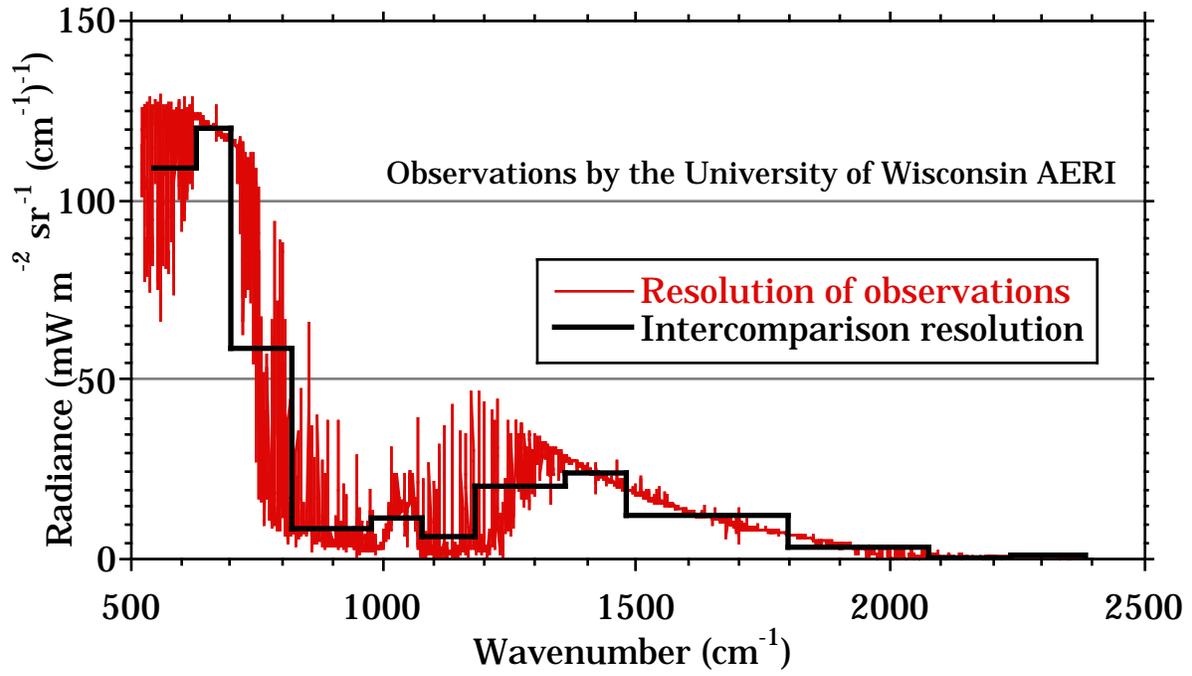


Fig. 1. Average spectrum for 4 ICRCM Test cases.

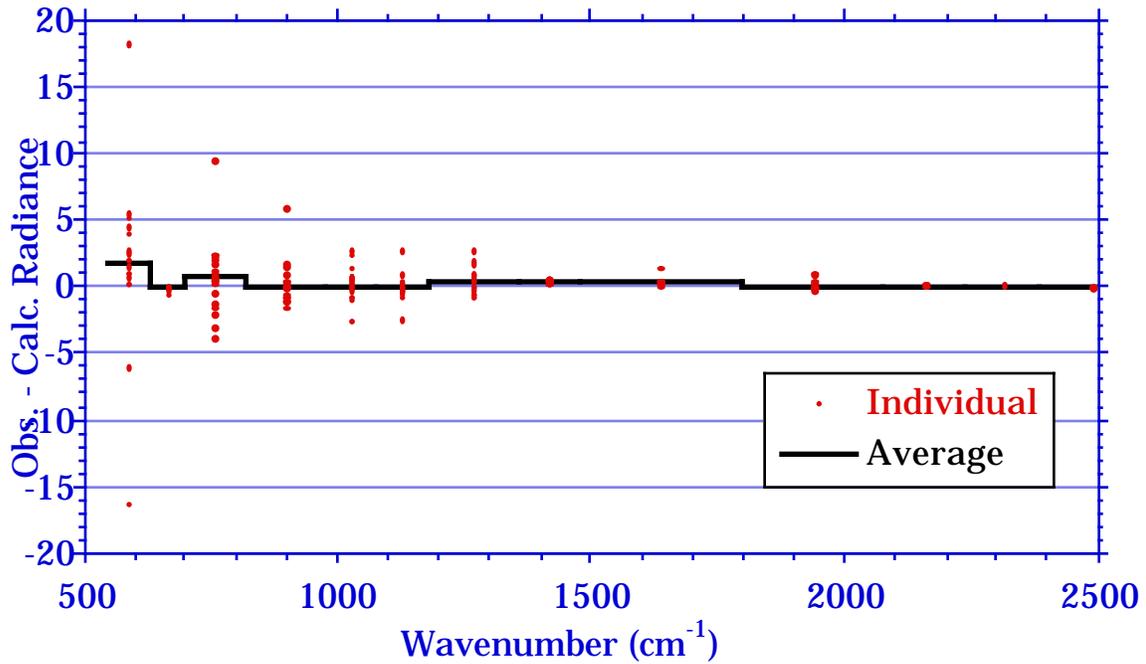


Fig. 3. Distribution of average observed-calculated radiance spectrum.

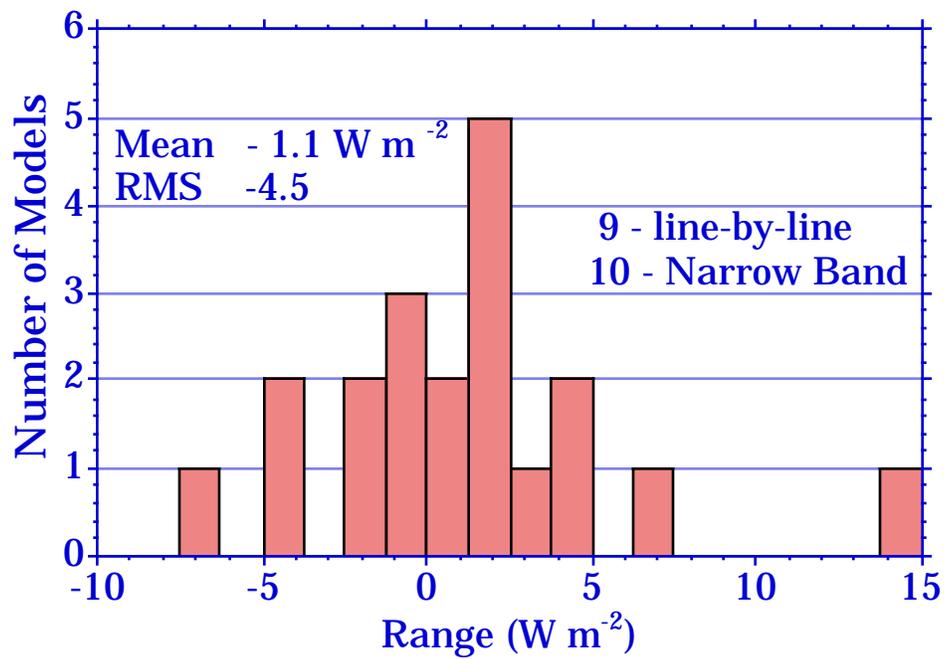


Fig. 3. Distribution of average observed-calculated fluxe.

ICRCCM 1995 Workshop
24 - 26 May 1995
University of Maryland
College Park, MD
Tentative Agenda

Wednesday - Maryland Inn (Hunt Room)

- 0800 - 0830 - Coffee and Danish
- 0830 - 0900 - Welcome and ICRCCM Background - Bob Ellingson
- 0900 - 1000 - The SPECTral Radiation Experiment - Warren Wiscombe
- 1000 - 1030 - Coffee Break
- 1030 - 1130 - Overall Comparison Results - Bob Ellingson
- 1130 - 1200 - Discussion of model-observation comparisons (all)
Petri Raisanen
- 1200 - 1330 - Lunch (Skipjack Room)
- 1330 - 1530 - Discussion of model-observation comparisons (all)
Eli Mlawer, Keith Grant/Alan Grossman, Gunnar Myhre/Stordal,
Istvan Laszlo, Qiang Fu, and Shashi Gupta
- 1530 - 1600 - Break
- 1600 - 1730 - Discussion of model-observation comparisons (all)
Simon Pinnock, Diane Schweizer, Wenyi Zhong, Gail Anderson,
David Kratz, and Ming-Dah Chou

Thursday - University of Maryland, Department of Meteorology

- 0800 - 0830 - Coffee and Danish
- 0830 - 0930 - Discussion of model-observation comparisons (all)
Boris Fomin, Daniel Schwarzkopf, Tony Clough, Bob Ellingson
- 1000 - 1030 - Break
- 1030 - 1200 - Reports on ICRCCM Related Activities
ASA - Larry Rothman -
ITRA - Noelle Scott
ARM - Bob Ellingson
- 1200 - 1330 - Lunch
- 1330 - 1530 - Needs for Shortwave Comparisons
V. Ramaswamy and Warren Wiscombe
- 1530 - 1600 - Coffee
- 1600 - 1730 - Identification of key problems and observational needs - All

Friday - Maryland Inn

- 0800 - 0830 - Coffee and Danish
- 0830 - 1000 - Discussions
Identification of key problems and observational needs - All
- 1000 - 1030 - Break
- 1030 - 1200 - Develop recommendations for future ICRCCM Activities- All
- 1200 - 1330 - Lunch
- 1330 - 1500 - Develop recommendations for future ICRCCM Activities- All
- 1500 Adjourn**