

**FINAL REPORT OF NASA CONTRACT NAS1-18272
ERBE SCIENTIFIC INVESTIGATIONS**

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SUMMARY OF CIMSS PARTICIPATION IN ERBE

The CIMSS has actively participated in the validation and analysis of the ERBE data products.

Examples of some of these activities are summarized below.

- A method of integrating the ERBE scanner observations to simulate the non-scanner measurements at the satellite altitude was developed and used in a cross-validation of the two instruments. The error in simulating a single measurement was 1% for the longwave and 3% for the shortwave (Wu, 1986; Green *et al.*, 1990).
- NOAA-9 ERBE scanner data were compared with aircraft flux observations during FIRE I as an independent check on the ERBE fluxes. Agreement was within the expected errors of the aircraft instruments (Ackerman *et al.*, 1990).
- An assessment was made of the ERBE algorithm which inverts longwave filtered observations to unfiltered broadband observations. ERBE observations were compared with high-spectral resolution infrared measurements from high-altitude aircraft. In the mean, there was excellent agreement between the HIS and ERBE filtered to unfiltered ratios (Ackerman *et al.*, 1988, Ackerman *et al.*, 1993).
- An algorithm was developed for estimating the outgoing longwave radiative fluxes from multi-spectral VAS observations. Results from the VAS algorithm were compared to ERBE broadband flux measurements. The algorithm was developed to test the diurnal coverage of the ERBE satellite system and to study the time variation of various meteorological phenomena. (Smith and Woolf, 1983)
- The reasonableness of the ERBE derived flux observations were investigated in a study of the maximum/minimum fluxes available on the S-9 data products. The time/space averaging model used to derive the maximum/minimum fluxes was found to be in error, and a method to derive an improved product was developed. The utility of analysis of maximums/minimums was demonstrated (Ackerman, 1989).
- The effects of dust on the regional scale shortwave (SW) and longwave (LW) radiative energy budgets over Saudi Arabia and the Arabian Sea were quantified using the ERBE S-8 and S-9 data products and model simulations. The largest impact was observed in the SW over the ocean in the LW over the desert (Ackerman and Chung, 1992).

- A method of incorporating ERBE flux observations to improve cloud diagnostics in a numerical weather prediction model was developed and tested. Largest effects were seen in the forecast of surface temperature (Wu and Smith, 1992).
- ERBE observations were collocated with AVHRR and HIRS/2 observations to describe the broadband and spectral radiative properties of the earth-atmosphere system. The radiative characteristics of clear sky conditions over the eastern Pacific were presented as a function of sea surface temperature and atmospheric water vapor structure. Changes in the top of the atmosphere LW and SW energy budgets were presented as a function of cloud amount and cloud top pressure (Ackerman *et al*, 1992).
- AVHRR pixel observations were collocated within the ERBE footprint to study the coupling between the surface and top of the atmosphere radiative energy budgets. Preliminary analysis showed that over the Sahael as the vegetation was reduced, the albedo and OLR increased. No discernible relationship was observed over the interior desert. (Ackerman *et al*, 1992, Ackerman and Inoue, 1993)
- Three Master degrees and one Ph.D. degree were awarded under this NASA supported work.
- CIMSS representatives have actively participated in all the ERBE Science Team meetings.

Details of the above studies can be found in the references cited and in the minutes of the ERBE Science Team Meetings. Copies of papers published in referred journals are included and give a detailed summary of work carried out by CIMSS under this NASA grant.

PUBLICATIONS in REFEREED JOURNALS

- Ackerman, S. A. and T. Inoue, 1993: Radiation energy budget studies using collocated AVHRR and ERBE observations. Accepted for publication in *Jour. Appl. Met.*
- Ackerman, S. A., W. L. Smith and H. E. Revercomb, 1993: Comparison of broadband and high-spectral resolution infrared observations. Accepted for publication in *Internat. Jour. of Remote Sens.*
- Ackerman, S. A. and H. Chung, 1992: Radiative effects of airborne dust on regional energy budgets at the top of the atmosphere. *J. Appl. Meteor.* **31**, 223-233
- Ackerman, S. A., R. A. Frey and W. L. Smith, 1992: Radiation budget studies using collocated observations from AVHRR, HIRS/2 and ERBE instruments. *J. Geo. Res.* **97** 11513-11525.
- Wu, X., and W. L. Smith, 1992: Assimilation of ERBE data with a nonlinear programming technique to improve cloud-cover diagnosis. *Mon. Wea. Rev.*, **9**, 2009-2024
- Green, R. N., F. B. House, P. W. Stackhouse, X. Wu, S. A. Ackerman and W. L. Smith, 1990: Intercomparison of scanner and nonscanner measurements for the Earth Radiation Budget Experiment (ERBE). *J. Geo. Res.*, **95**, 11,785-11,798.

Conference Proceedings and Presentations

- Ackerman, S. A. and T. Inoue, 1993: Using collocated AVHRR and ERBE observations to investigate climate change processes. IAMAP and IAHS Joint International Meeting, July 11-23 Yokohama, Japan.
- Ackerman, S. A., and T. Inoue, 1993: Radiation energy budget studies using collocated AVHRR and ERBE observations, Sixth topical meeting of the Optical Society of America's conference on Optical Remote Sensing of the Atmosphere, Salt Lake City, UT, March 8-12.
- Ackerman, S. A., R. A. Frey and C. Collimore, 1992: Coupling between surface properties and the energy budget at top of the atmosphere. International Radiation Symposium, Tallin, Estonia, August 3-8.
- Flatau, P. J., S. A. Ackerman and G. L. Stephens, 1992: Simple parameterization of single scattering properties of ice and water clouds. International Radiation Symposium, Tallin, Estonia, August 3-8.
- Ackerman, S. A., S. Limaye, G. S. Wade and P. Fry, 1992: Spectral signatures of dust, smoke, forest fire and volcanic aerosols from satellite observations. Sixth Conference on Satellite Meteorology and Oceanography, January 5-10, Atlanta, Georgia.
- Ackerman, S. A., R. A. Frey and W. L. Smith, 1992: Radiative properties of the earth-atmosphere system from combined AVHRR, HIRS/2 and ERBE observations. Sixth Conference on Satellite Meteorology and Oceanography, January 5-10, Atlanta, Georgia.
- Ackerman, S. A., R. Frey and W. L. Smith; 1991: Cloud Radiative Forcing Determined from Combined Observations of NOAA-9 ERBE, HIRS/2 and AVHRR instruments. Presented at the IAMAP symposium on Aerosol-Cloud-Climate Interactions, Vienna, Aug, 1991.
- Ackerman, S. A., 1991: The Effects of Dust on Tropospheric and Stratospheric Radiative Heating Rates. Presented at the IAMAP symposium on Aerosol-Cloud-Climate Interactions, Vienna, Aug, 1991.
- Ackerman, S. A. and D. P. Wylie, 1990: ERBE and HIRS/2 coincident observations of the radiative properties of cirrus clouds. Seventh Conference on Atmospheric Radiation, San Francisco, CA, July 23-27.
- Herman, L. D., S. A. Ackerman, F. Chen and G. Wade, 1990: Observations of the daily radiative energy budget at the top of the atmosphere from the Earth Radiation Budget Experiment. Seventh Conference on Atmospheric Radiation, San Francisco, CA, July 23-27.
- Ackerman, S. A., 1989: Maximum and minimum in the earth radiation budget. Presented at the IAMAP 89 Symposium on the Earth's Radiation Budget, August 3-5.
- Chung, H. S. and A. A. Ackerman, 1989: The effects of dust on the earth radiation budget. Presented at the IAMAP 89 Symposium on the Effects of Aerosols and Clouds on Climate, August 9-11.
- Ackerman, S. A., 1988: Atmospheric radiative heating and cloud probability statistics. Presented at the International Radiation Symposium, August 18-24, Lille, France.
- Ackerman, S. A., H. Chung, S. K. Cox, L. Herman, W. L. Smith and D. P. Wylie, 1988: Comparison of NOAA-9 ERBE measurements with cirrus IFO satellite and aircraft measurements. Presented at the FIRE science team workshop, July 11-15, Vail, CO.

Degrees Granted Under this Contract

- Wu, Xiangqian, 1986: *A Method for Comparing ERBE Data*. Department of Meteorology, University of Wisconsin-Madison, Master of Science Thesis. 50 pp.
- Chung, Hyo-Sang, 1989: *The Evaluation of Radiative Effects of Airborne Dust on Regional Energy Budgets at the Top of the Atmosphere*. Department of Meteorology, University of Wisconsin-Madison, Master of Science Thesis. 72 pp.
- Wu, Xiangqian, 1990: *Assimilation of ERBE Data with Nonlinear Programming Technique to Improve Cloud Cover Diagnosis*. Department of Meteorology, University of Wisconsin-Madison, Ph. D. Dissertation. 98 pp.

Zaras, Daphne, 1992: Earth radiation budget studies of the sahara and saudi arabian desert regions.
Department of Meteorology, University of Wisconsin-Madison, Master of Science Thesis. 86 pp