Aerosol Radiative Effects in the Tropical Western Pacific

A. M. Vogelmann
Center for Atmospheric Sciences
Scripps Institution of Oceanography
University of California
San Diego, California

Introduction

Atmospheric Radiation Measurement (ARM) Program observations are used to quantify the aerosol radiative effects in the climatically important Tropical Western Pacific (TWP). This quantification addresses two primary ARM objectives by (1) ascertaining the existing variability of the radiative forcing and its relationship to atmospheric composition, and (2) providing strong constraints for testing aerosol models that may be used in climate models. Since general circulation models (GCMs) often do not treat aerosols, it is important to assess the potential effects of their absence in this climatically important region.

The TWP sites are downwind from Southeast Asia, where much biomass burning occurs and can advect over the tropical warm pool. Previous ARM results (Vogelmann 2001) found that during August to October 1997, such aerosols had a large impact on the surface radiative energy budget at the Manus TWP site, with values that are much larger than would be expected from a typical maritime aerosol. The objective here is to place these results in a broader climatological context by evaluating the aerosol radiative effects at the TWP sites over the course of the year and for multiple years. This will be achieved using aerosol radiative forcing and associated radiative properties derived from the ground-based sensors.

Results

Measurements from 1997 to 2001 are used to characterize the aerosol properties within the yearly cycle, and for multiple biomass-burning seasons. The analysis is based on aerosol optical depths and Angstrom coefficients obtained from the multi-filter rotating shadowband radiometer (MFRSR) measurements at the Manus Site. The Angstrom exponent provides a measure of the spectral slope of the aerosol optical depths. Fine aerosols, characteristic of continental sources, typically have values greater than about 0.75. Clouds have little to no spectral optical depth variation, and have values that are close to zero.

A stringent cloud screen is applied to the data, which follows the procedure in Conant (2000). An algorithm examines the global and diffuse fluxes in a piecewise linear (windowing) fashion. Clouds appear as sudden changes in these radiative quantities, and those points are excluded. Further, the Angstrom exponent is also used for the cloud screen by being examined for continuity of non-zero values. The daily averaged optical depth and Angstrom exponent are computed for days with a representative number of observations. Values for pristine maritime aerosols in this region are generally ≤ 0.1 and ≤ 0.5, respectively, for the optical depth and Angstrom coefficient.

The yearly cycle of these parameters shows the presence of continental-sized particles during much of the year, but with the greatest presence during the August to October biomass-burning season. The August to October periods are analyzed from 1997 to 2001. All periods show aerosol optical depths and Angstrom coefficients that are larger than those expected for a tropical marine environment. The observations from the El Niño year in 1997 exceed those from any other period. Conversely, 2001 had record amounts of rainfall within the region, leading to the smallest optical depths of the periods.

Future Research

The results reported are the beginning of a project designed to evaluate aerosol effects in the tropical warm pool. In collaboration with Dr. R. Michael Reynolds and Dr. Mark Miller, the geographical extent and magnitude of the aerosol forcing within the tropical warm pool will be determined using ARM data from the Shipboard Oceanographic and Atmospheric Radiation (SOAR) Program.

Acknowledgments

Thanks to Jim Barnard for providing the calibrations for MFRSR Head #3057, and for his assistance with other technical issues. Data were obtained from the ARM Program sponsored by the U.S. Department of Energy (DOE), Office of Science, Office of Biological and Environmental Research, Environmental Sciences Division. This research is supported by the ARM Program through BER, DOE, Grant No. DE-FG03-02ER63341.

Corresponding Author

Andrew Vogelmann, avogelmann@ucsd.edu, (858) 534-6472

References

Conant, W. C., 2000: An observational approach for determining aerosol surface radiative forcing: Results for the first field phase of INDOEX. *J. Geophys. Res.,* **105**, 15,347-15,356.

Vogelmann, A. M., 2001: Observed aerosol radiative forcings: Comparison for natural and anthropogenic sources. In *Proceedings of the Eleventh Atmospheric Radiation Measurement (ARM) Science Team Meeting.* Available URL: http://www.arm.gov/docs/documents/technical/conf_0103/vogelmann-am.pdf