# Agreement Between Modeled and Observed 400 nm to 700 nm Surface Irradiance During INDOEX

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## Introduction

Two Biospherical Instruments GUV-511 photodiode flux radiometers were deployed at the Kaashidhoo Climate Observatory (KCO) during the 1998 and 1999 field phases of the Indian Ocean Experiment (INDOEX; Ramanathan et al. 1996). The radiometers measure global and diffuse (scattered) surface solar irradiance in five channels (305 nm, 340 nm, 380 nm, 400 nm to 700 nm, and 540 nm to 700 nm). The visible channels (400 nm to 700 nm and 540 nm to 700 nm) were used to accurately quantify surface aerosol forcing in this spectral region where 60% of the forcing occurs, and where water vapor absorption is negligible.

The angular, spectral, and absolute response characteristics of the radiometers were precisely determined by the author at the Space Science and Remote Sensing laboratory at Los Alamos National Laboratory before and after each experimental field phase. These laboratory-determined instrument characteristics are used to calibrate the data with an accuracy of 2.4% for the global irradiance, and 1.8% for the diffuse irradiance (Conant 2000).

The calibrated clear-sky global and diffuse irradiance data agree to within 5 W $m^{-2}$ of results calculated by a Monte Carlo radiative transfer model (Podgorny et al. 2000) that assumes an aerosol consistent with the aerosol properties simultaneously measured at KCO. Thus, there is no need to include any anomalous gas absorber into the model to obtain agreement with the global or diffuse 400 nm to 700 nm clear-sky irradiance (Figure 1). However, the diffuse flux does show consistency with the relatively low (0.9) aerosol single-scatter-albedo that was simultaneously observed at KCO by a nephelometer and particle soot absorption photometer (Satheesh et al. 1999).

Aerosol forcing efficiency is determined from the change in net 400 nm to 700 nm surface flux with a change in aerosol optical depth at 500 nm ($\tau_{500}$) (Figure 2). For both 1998 and 1999, the forcing efficiency is found to be -4.0 W $m^{-2}$ per 0.1 increase in $\tau_{500}$. By relating aerosol forcing to changes in the observed flux, the method is not sensitive to small bias errors inherent to the measurement. The monthly mean 400 nm to 700 nm forcing for the region is -7.6±1.5 W $m^{-2}$ during 1998 and -16.0±1.5 W $m^{-2}$ during 1999. The forcing obtained from these precise and well-characterized photodiode radiometers serve as the ground truth for the broad scope of broadband and spectral surface aerosol forcing studies conducted during INDOEX from land, ship, and aircraft platforms.

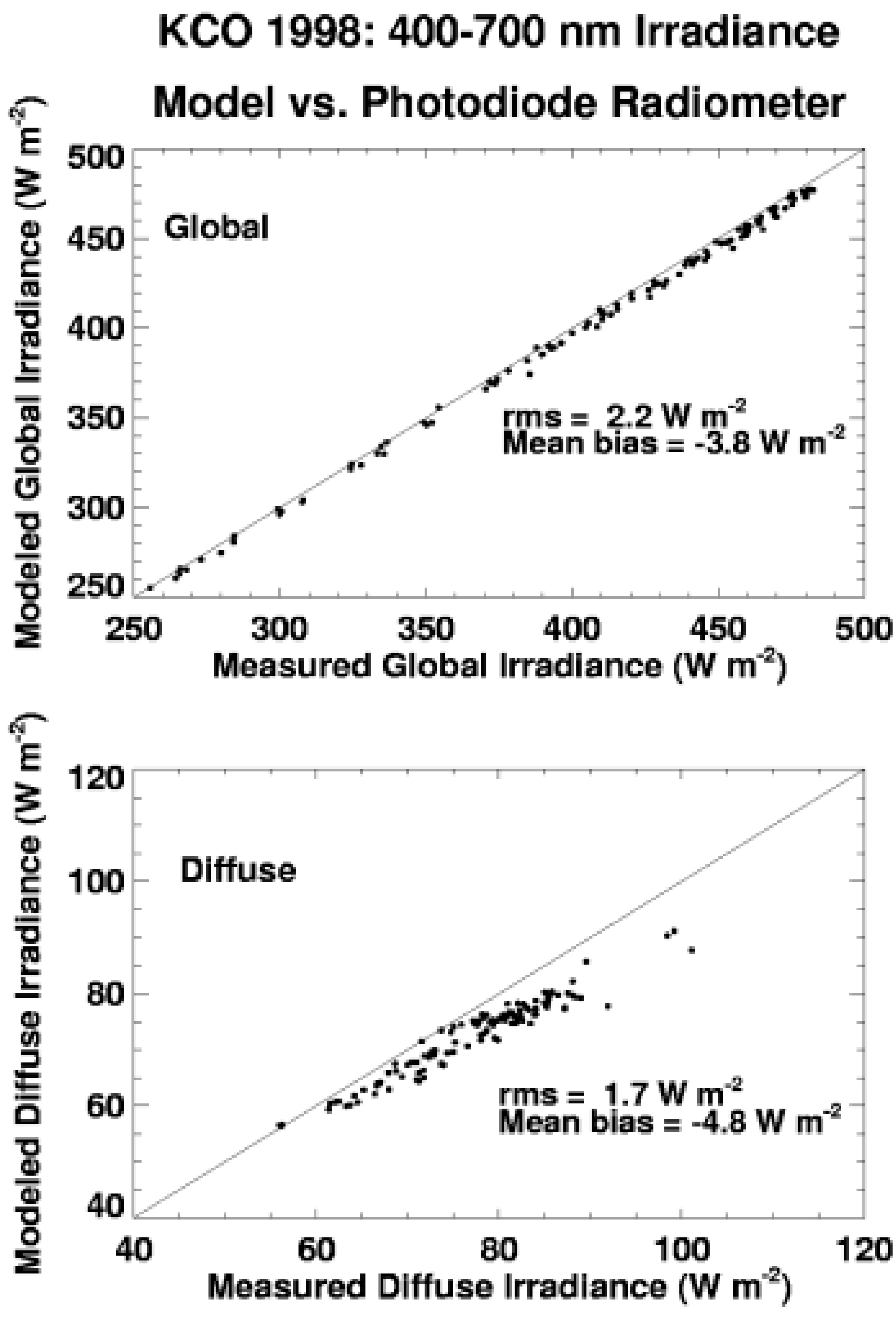


**Figure 1**. Comparison of 400 nm to 700 nm clear-sky surface irradiance predicted by the Monte Carlo model to that measured by the GUV-511. A) Global irradiance; B) Diffuse irradiance. Data are taken from the 1998 experiment. From Conant (2000).

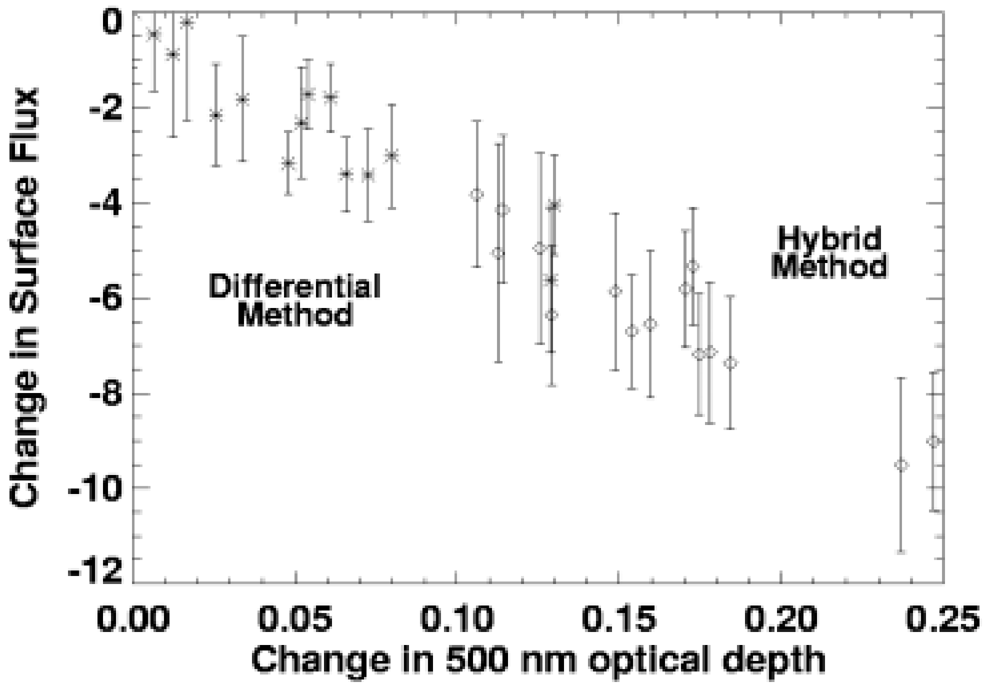


**Figure 2**. Change in daily average 400 nm to 700 nm surface flux (W $m^{-2}$) measured at KCO by the Biospherical Instruments GUV-511 flux radiometer plotted versus change in daily average 500 nm aerosol optical depth measured by the CIMEL Sun photometer. The hybrid method, shown by diamonds, computes the changes relative to an aerosol-free model calculation. The differential method, shown by asterisks, computes the changes relative to the measurement on the day of lowest aerosol optical depth. Error bars encompass experimental uncertainties in the flux changes. Data are taken from the 1998 First Field Phase of INDOEX. From Conant (2000).

The Monte-Carlo radiative transfer model is used to estimate the broadband (200 nm to 4000 nm) forcing from the 400 nm to 700 nm observations. The broadband clear-sky surface forcing is -13 W $m^{-2}$ for 1998 and -29 W $m^{-2}$ for 1999. Most of the surface cooling is caused by an average 0.5 K/day heating of the lower troposphere. Three years (1996 to 1998) of ship aerosol optical depth measurements find a surface forcing gradient of -16 W $m^{-2}$ between the Arabian Sea and the South Indian Ocean. This gradient was even larger (< -25 W $m^{-2}$) during 1999 because of the elevated aerosol burden observed over the North Indian Ocean during this La Niña year.

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## References

Conant, W. C., 2000: An observational approach for determining aerosol surface radiative forcing: Results from the first field phase of INDOEX. *J. Geophys. Res.*, **105**, 15,347-15,360.

Podgorny, I. A., W. C. Conant, V. Ramanathan, and S. K Satheesh, 2000: Aerosol modulation of atmospheric and surface solar heating over the tropical Indian Ocean. *Tellus*, **52**B, 947-958.

Ramanathan, V., P. J. Crutzen, J. A. Coakley, A. Clarke, W. D. Collins, R. Dickerson, D. Fahey, B. Gandrud, A. Heymsfield, J. T. Kiehl, J. Kuettner, T. Krishnamurti, D. Lubin, H. Maring, J. Ogren, J. Prospero, P. J. Rasch, D. Savoie, G. Shaw, A. Tuck, F. P. J. Valero, E. L. Woodbridge, and G. Zhang, 1996: *Indian Ocean Experiment (INDOEX)*, Scripps Institution of Oceanography, University of California, San Diego, available at http://www-c4.ucsd.edu/.

Satheesh, S. K., V. Ramanathan, X. Li-Jones, J. M. Lobert, I. A. Podgorny, J. M. Prospero, B. N. Holben, and N. G. Loeb, 1999: A model for the natural and anthropogenic aerosols over the tropical Indian Ocean. *J. Geophys. Res.*, **104,** 27,421-27,440.