Column Absorptance, Transmittance, and Reflectance Measured During ARESE

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Introduction

The Atmospheric Radiation Measurement Enhanced Shortwave Experiment (ARESE) was conducted in 1995 to address fundamental questions about the amount of solar radiation absorption occurring in clear and cloudy skies. We present an analysis of data from instruments flown on stacked aircraft as part of this experiment. Valero et al. (1997b) describe the experiment and instrumentation.

For the column spanning 2 km to 13 km in altitude, i.e., in between the stacked aircraft, flux measurements are combined to yield column absorptance and transmittance. These measurements are made separately in the solar broadband, 0.2 µm to 3.9 µm, and in the near-infrared broadband, 0.7 µm to 3.3 µm. Near-infrared flux is subtracted from the solar to give visible flux, 0.2 µm to 0.7 µm. The solar absorptance in the column is seen to increase strongly with increasing cloud amount, i.e., with decreasing transmittance. This cloud-associated increase in absorptance is seen in the near-infrared and in the visible fluxes (Valero et al. 1997a).

Model calculations are compared with the measured fluxes for several representative days. From these quantities, the ratio of transmission in the near-infrared to transmission in the visible as a function of total (solar) transmission is computed, following Francis et al. (1997). Similarly, the column reflection or albedo in the various bandpasses is examined.

Findings

Due to the presence of cloud-induced enhanced absorption in both the visible and near-infrared parts of the solar spectrum, the ratios of reflectance or transmission in these regions, as in R_{nir}/R_{vis} and T_{nir}/T_{vis}, will not be indicators of the presence or absence of enhanced absorption.

The presence of enhanced absorption becomes evident when the reflectance and transmittance of a cloud are measured simultaneously and then fit with a standard model. The standard water cloud reflects too much energy while at the same time transmitting too much energy.

Flux profiles measured on October 30, 1995, can be compared to model calculations as another illustration of this point. Flux data were retrieved during the Egrett aircraft's ascent and descent. The values were normalized to a 54° solar zenith angle and are shown as solid circles in Figure 1. The square symbols are whole-flight averages of the Egrett and Twin Otter fluxes measured in level flight and also normalized in solar zenith angle. Model flux profiles are shown by the dashed line (for a cloud of optical depth 20) and the solid line (cloud optical depth of 40). With a cloud of optical depth 20 the model allows too much energy to be transmitted through the cloud. Increasing the cloud thickness to 40 results in the transmitted flux being closer to the observations but the energy reflected up from the top of the cloud is much too high.

The model can be made to fit the observed reflectance and transmittance by introducing some absorbers like arctic-haze-type aerosols or water droplets with enhanced absorption. For example, Figure 2 shows the same October 30 data compared to a model that has an enhanced-absorption water cloud of optical depth 40. The enhancement is introduced by increasing the cloud droplets' single-scattering co-albedo beyond the standard Mie value.

References

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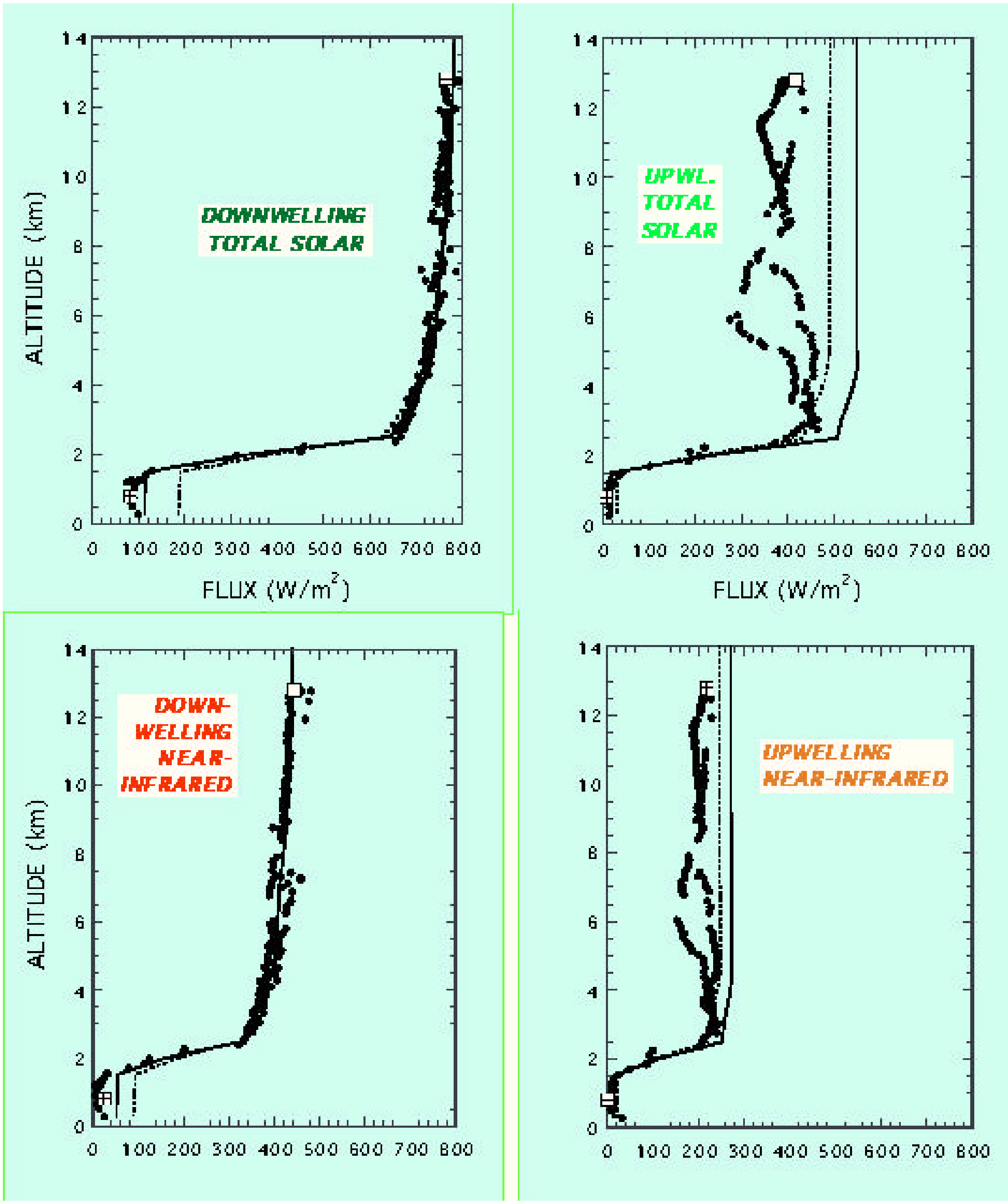

Figure 1. Flux data were retrieved during the Egrett's ascent and descent and normalized to a 54° solar zenith angle to produce these profiles for October 30, 1995. The square symbols are whole-flight averages of Egrett and Twin Otter fluxes measured in level flight and also normalized in solar zenith angle. The dashed line is a model calculation with a cloud of optical depth 20; the solid line represents a model with optical depth 40. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/pope-98.pdf*.)

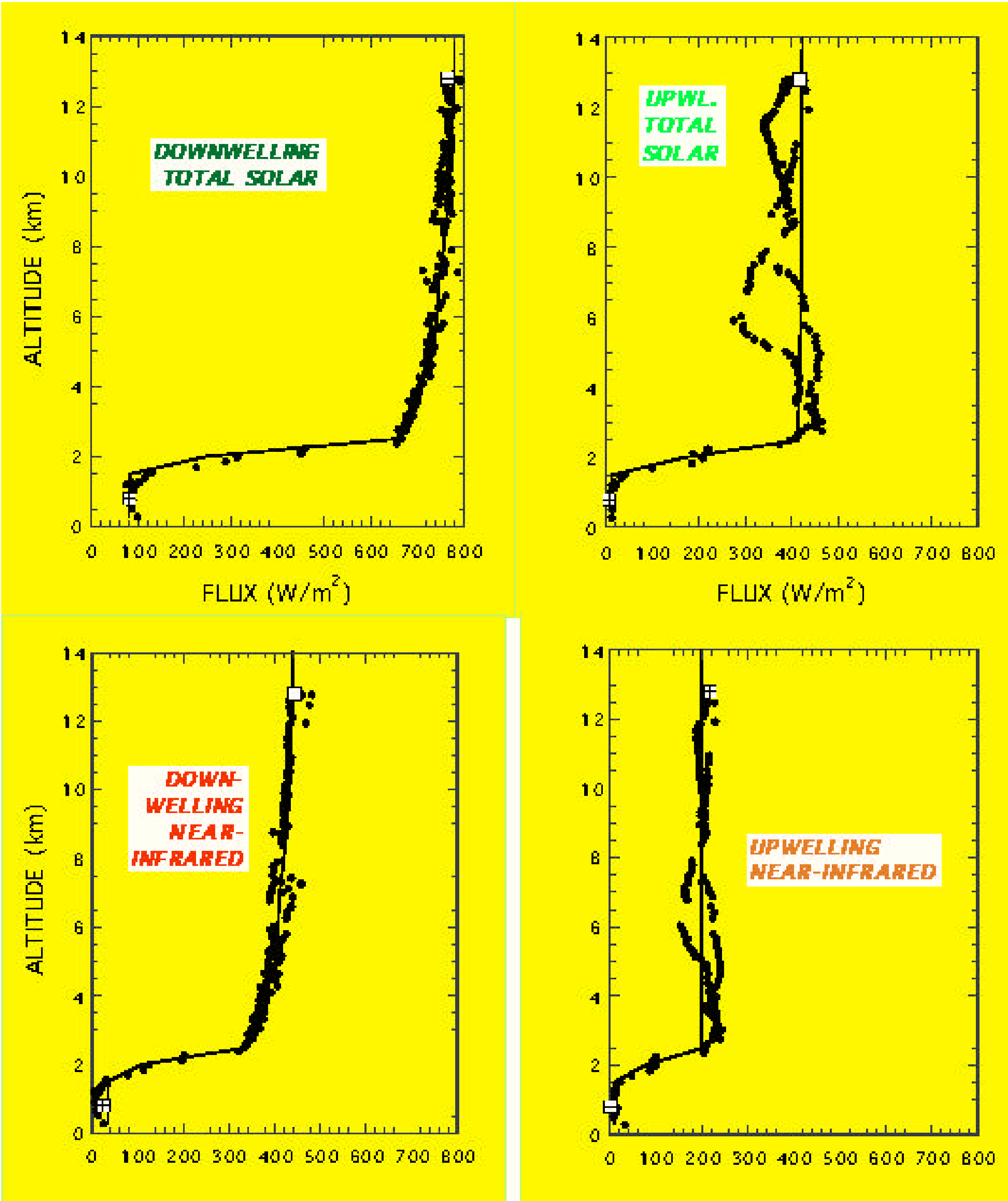

Figure 2. The same data as in Figure 1 are shown compared to a model which has enhanced absorption in the water cloud droplets. The model cloud optical depth is 40, and the absorption is enhanced by increasing the droplets' single-scattering co-albedo over the standard Mie value. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/pope-98.pdf*.)