Comparison of radiative transfer models for limb-viewing scattered sunlight measurements

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Received 12 June 2003; revised 15 December 2003; accepted 22 December 2003; published XX Month 2004.

[1] This study compares the limb scattered radiances calculated by six radiative transfer models for a variety of viewing conditions. Atmospheres that include molecular scattering, aerosol scattering, and ozone absorption are considered. All models treat single scattering accurately in full spherical geometry. Two ''approximate spherical'' models (CDI and LIMBTRAN) rely on the plane-parallel atmosphere approximation to calculate the diffuse radiance field; the remaining four ''spherical'' models (Siro, MCC++, GSLS, and CDIPI) treat multiple scattering in a spherical atmosphere. Only three of the models (Siro, MCC++, and GSLS) have vector treatment with polarization. A brief comparison of vector radiances with the limb scattered radiances measured by the SOLSE and LORE instruments demonstrates agreement usually within 15% and always within 30%. The inclusion of polarization appears to have little effect on the level of agreement among the models (which agree to within 2% for this sample case). A more general comparison among calculated scalar radiances follows, including four solar zenith angles (20°, 60°, 80°, and 90°), three relative azimuth angles (20°, 90°, and 160°), and two surface albedos (0 and 0.95). The single scattered radiances agree to within 1% for almost every case. Comparisons of the total radiance show larger differences, with 2–4% spread among the results of the spherical models. The approximate spherical models show a positive radiance difference relative to the other models that increases with tangent height, reaching as much as 8% at 60 km. The rule used to divide the model atmosphere into discrete layers is shown to affect the calculated radiance, causing a height-dependent difference of up to 1% for 1 km layer thickness. *INDEX TERMS:* 0305 Atmospheric Composition and Structure: Aerosols and particles (0345, 4801); 0360 Atmospheric Composition and Structure: Transmission and scattering of radiation; 0669 Electromagnetics: Scattering and diffraction; 3359 Meteorology and Atmospheric Dynamics: Radiative processes; *KEYWORDS:* radiative transfer, limb scattering, model comparison

Citation: Loughman, R. P., E. Griffioen, L. Oikarinen, O. V. Postylyakov, A. Rozanov, D. E. Flittner, and D. F. Rault (2004), Comparison of radiative transfer models for limb-viewing scattered sunlight measurements, *J. Geophys. Res.*, *109*, XXXXXX, doi:10.1029/2003JD003854.

1. Introduction

[2] The solar ultraviolet (UV), visible and infrared radiation emerging from the Earth's atmosphere carries information about atmospheric composition. Many insights have been gained from measurements of back-scattered radiance in the nadir (or near-nadir) directions, from instruments such as Solar Back-Scattering Ultraviolet (SBUV) [*Bhartia et al.*, 1996], Total Ozone Mapping Spectrometer (TOMS) [*McPeters et al.*, 1998], and Global Ozone Monitoring Experiment (GOME) [*Burrows et al.*, 1999a]. This viewing geometry permits global coverage with high horizontal resolution for a single instrument in a low-Earth orbit, with frequent revisit times (e.g., 1 day for SBUV and TOMS, 3 days for GOME). Nadir viewing is very useful for measuring the column abundance of various species, but the ability to discriminate profile structure is often poor. Another measurement method is solar occultation, in which the solar irradiance transmitted through the limb of the atmosphere is measured. Occultation instruments include Stratospheric

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0148-0227/04/2003JD003854$09.00