“HARMONIE 37h1 radiation sensitivity tests” Supplement 2: Tests of the IFS delta-Eddington radiative transfer scheme

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For clouds, the shortwave (SW) fluxes can be modelled either directly from given cloud physical properties or in two steps, where first the cloud inherent optical properties are modelled and then the bulk radiative transfer properties, *i.e.* the transmittance, reflectance and absorptance, are calculated. In the HARMONIE model we have tested two SW radiation schemes: hlradia and the IFS radiation scheme. In hlradia SW fluxes are calculated directly from the cloud physical properties. In the IFS radiation scheme the calculation is done in two steps. In a separate supplement (Supplement 1) a comparison of calculated optical properties of liquid clouds based on Mie theory with those calculated with various parametrizations of the IFS scheme is presented. Here we will test the second step by comparing the radiative transfer calculations done in DISORT with 30 streams and with the IFS delta-Eddington radiative transfer scheme that is implemented in HARMONIE. Both schemes are given the same inherent optical properties.

In Figs. 1–8 the results from the comparison are shown for two cosine solar zenith angles $\mu_0 = 1.0$ and $\mu_0 = 0.60$ and for four asymmetry factors $g = 0.0$, $g = 0.4$, $g = 0.8$ and $g = 0.95$. In the upper parts of the figures the results are given as a function of both optical thickess and single scattering albedo. In the lower parts of the figures the results are given for a single scattering albedo of 0.99, which is a typical single scattering albedo for clouds.

The results show that the IFS delta-Eddington scheme has large negative relative errors for the largest scaled optical thicknesses. In these cases, however, the transmittances approach zero so that the absolute errors are small. When the overall transmittance is around 0.5, the IFS delta-Eddington scheme has a general tendency for a positive bias. This bias is highest for tests with cosine solar zenith angle $\mu_0 = 0.60$. For $\mu_0 = 0.60$ and $g = 0.95$ (Fig. 8) relative errors of up to +10% can be seen.

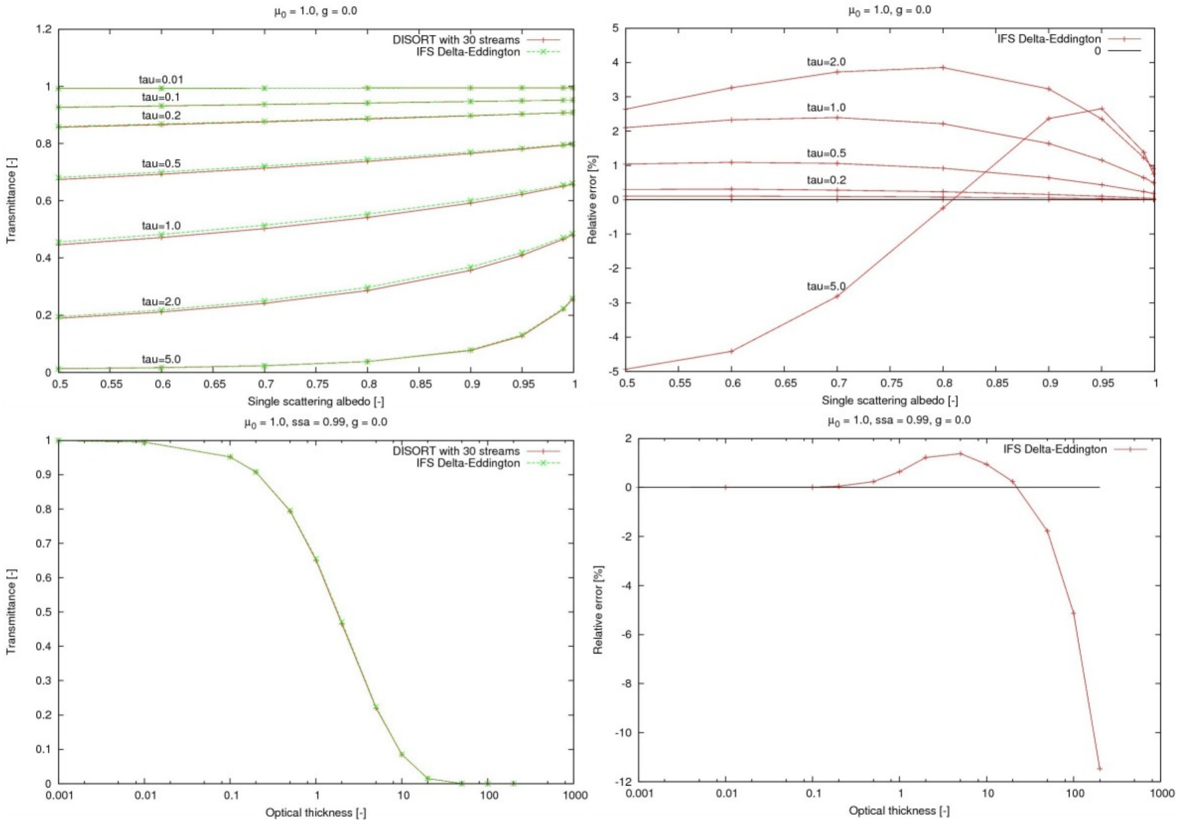

Figure 1: All results in this figure are calculated for an asymmetry factor $g = 0.0$ and a cosine solar zenith angle $\mu_0 = 1.0$. **Upper left:** Comparison of transmittances as a function of single scattering albedo and optical thickness τ. **Upper right:** Relative differences of the IFS delta-Eddington scheme compared with DISORT. **Lower left:** Comparison of transmittances for a single scattering albedo of 0.99 as a function of optical thickness τ. **Lower right:** Relative differences of the IFS delta-Eddington scheme compared with DISORT for a single scattering albedo of 0.99

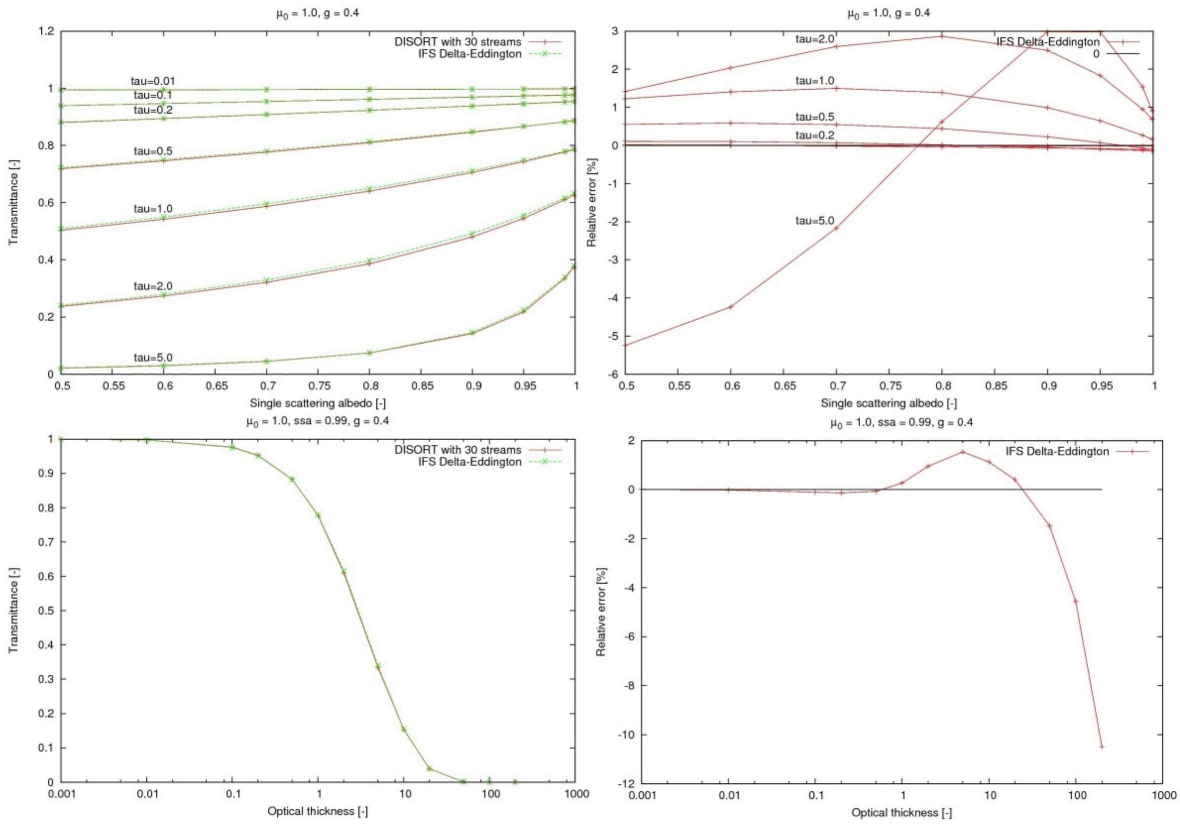

Figure 2: As Fig. 1 but for an asymmetry factor $g = 0.4$.

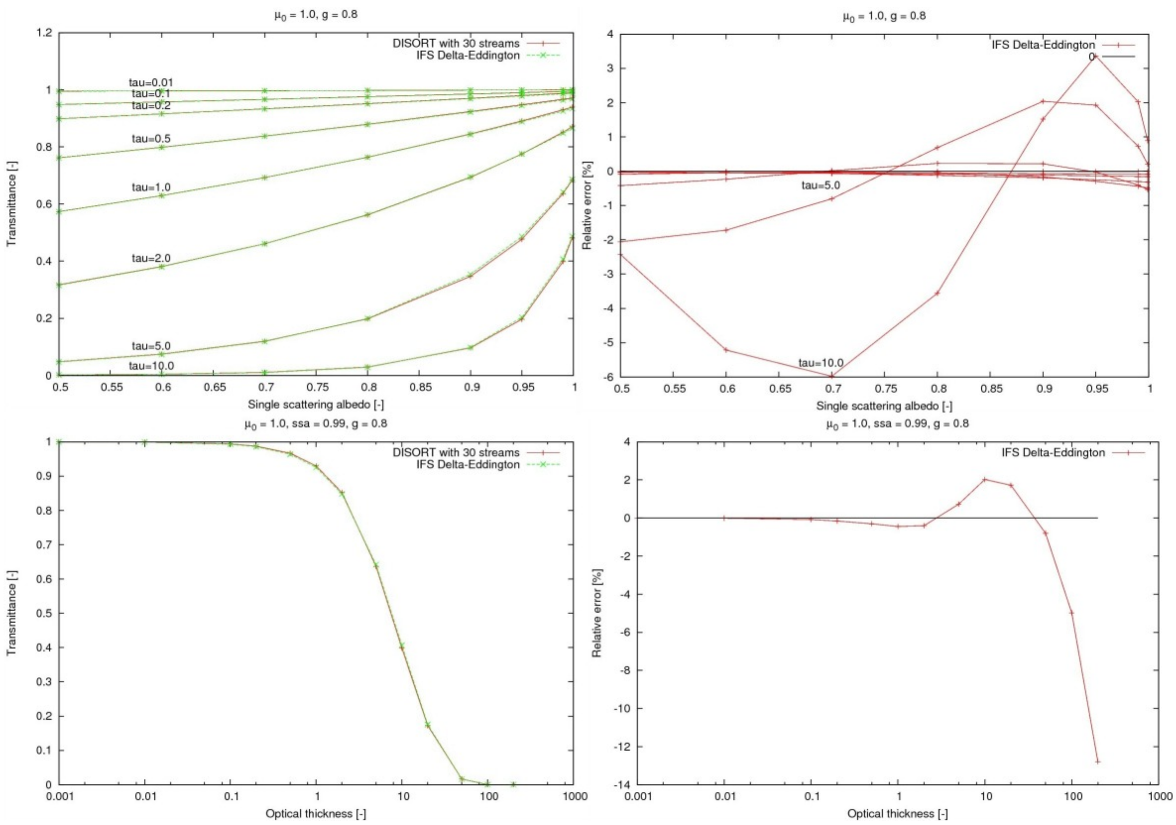

Figure 3: As Fig. 1 but for an asymmetry factor $g = 0.8$.

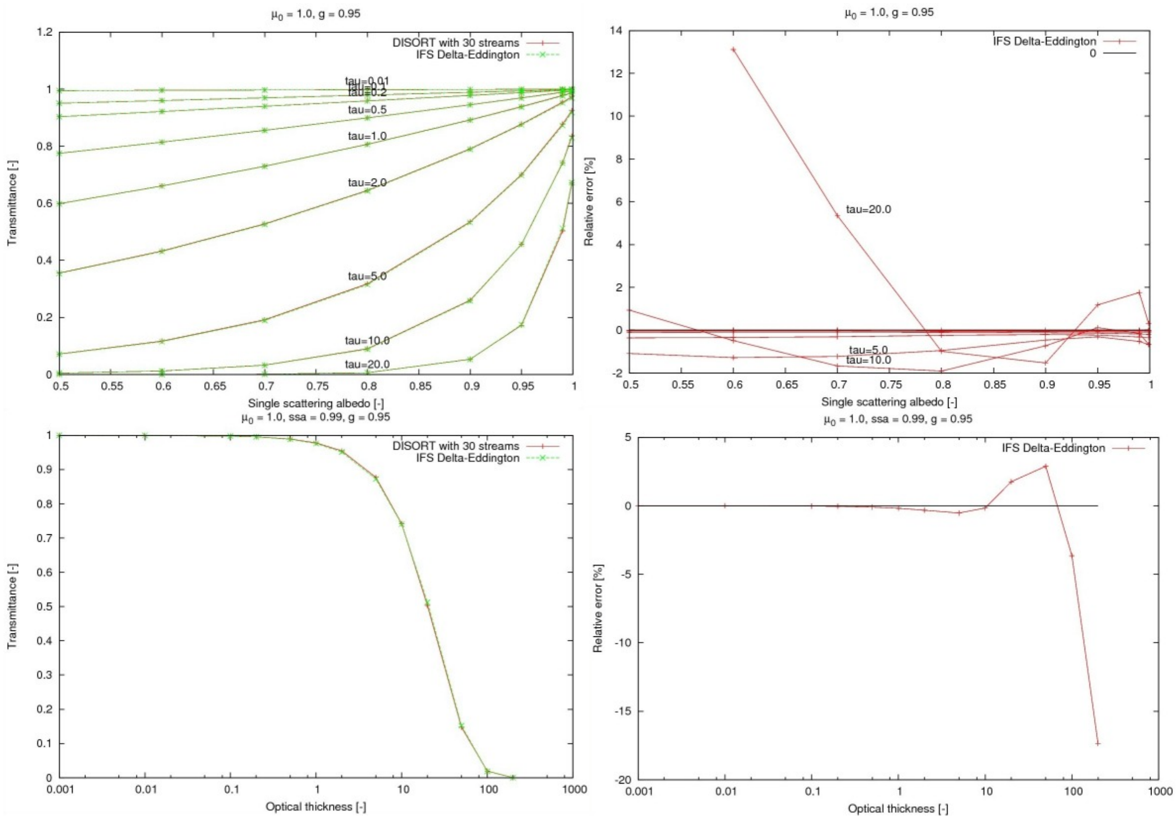

Figure 4: As Fig. 1 but for an asymmetry factor $g = 0.95$.

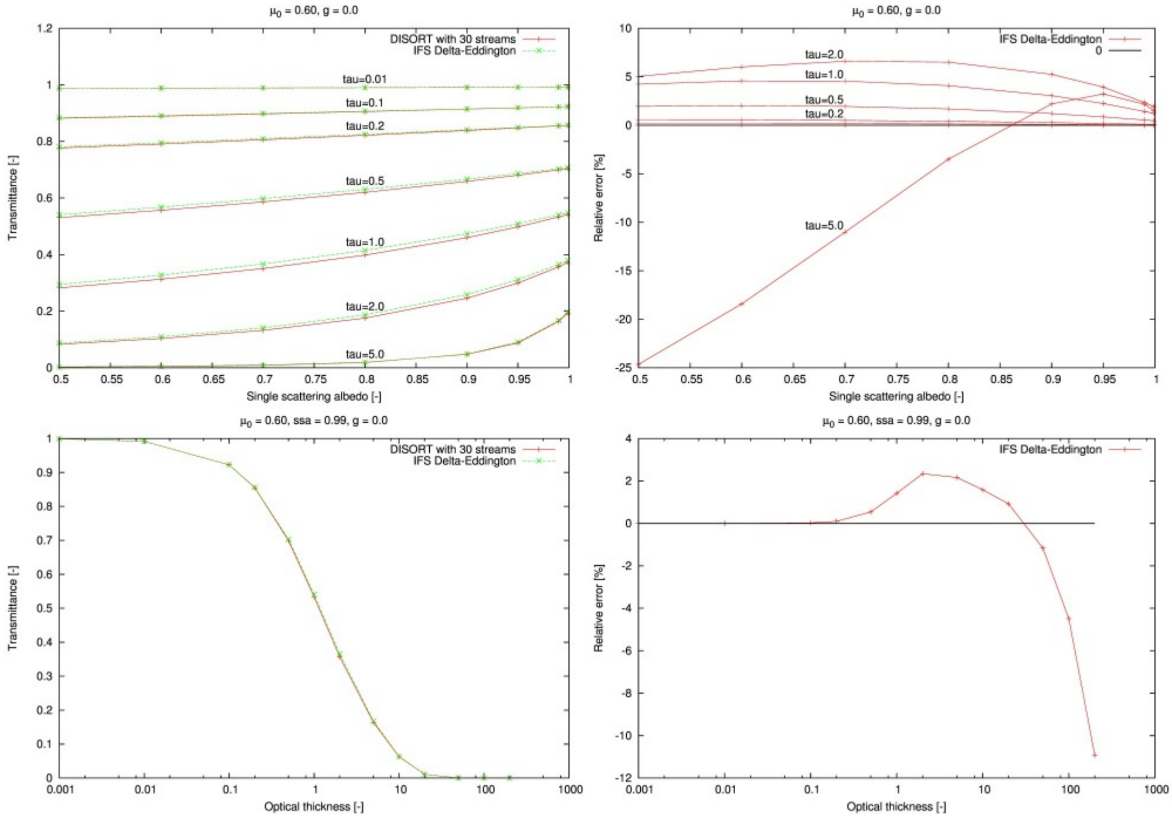

Figure 5: As Fig. 1 but for a cosine solar zenith angle of 0.60.

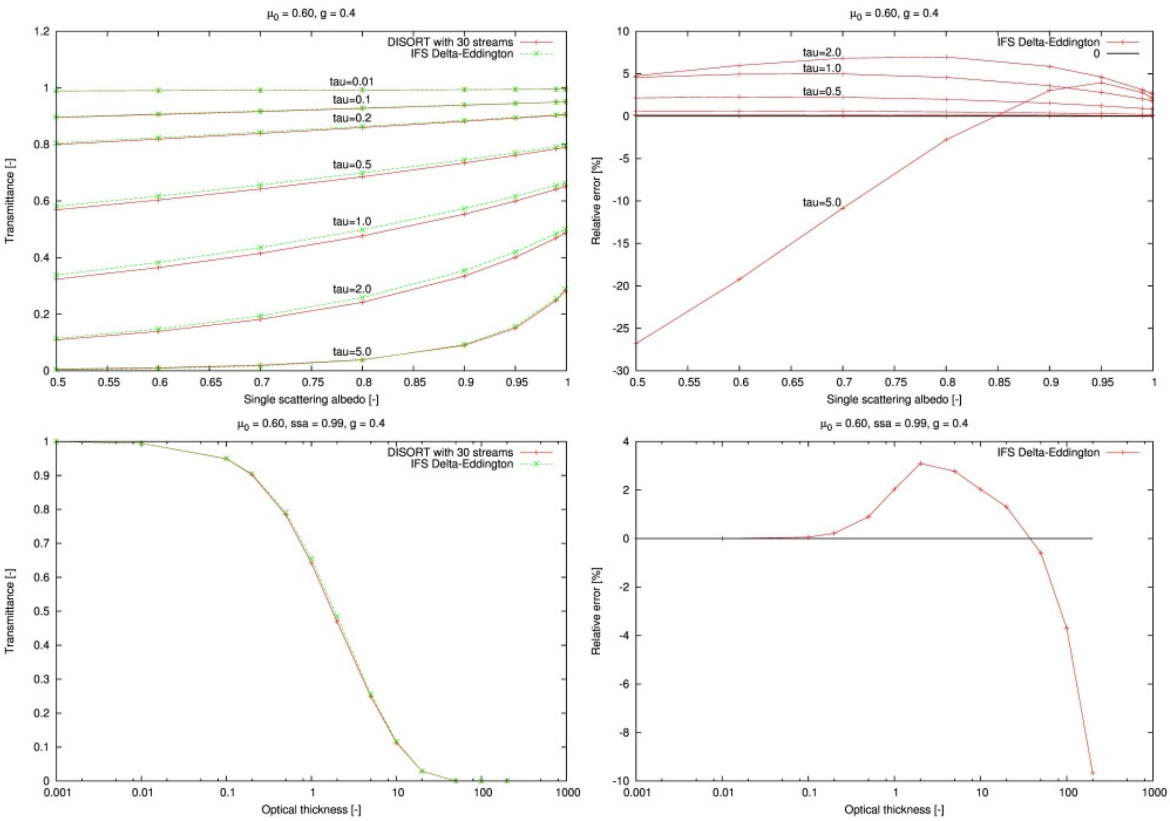

Figure 6: As Fig. 1 but for a cosine solar zenith angle $\mu_0 = 0.60$ and an asymmetry factor $g = 0.4$.

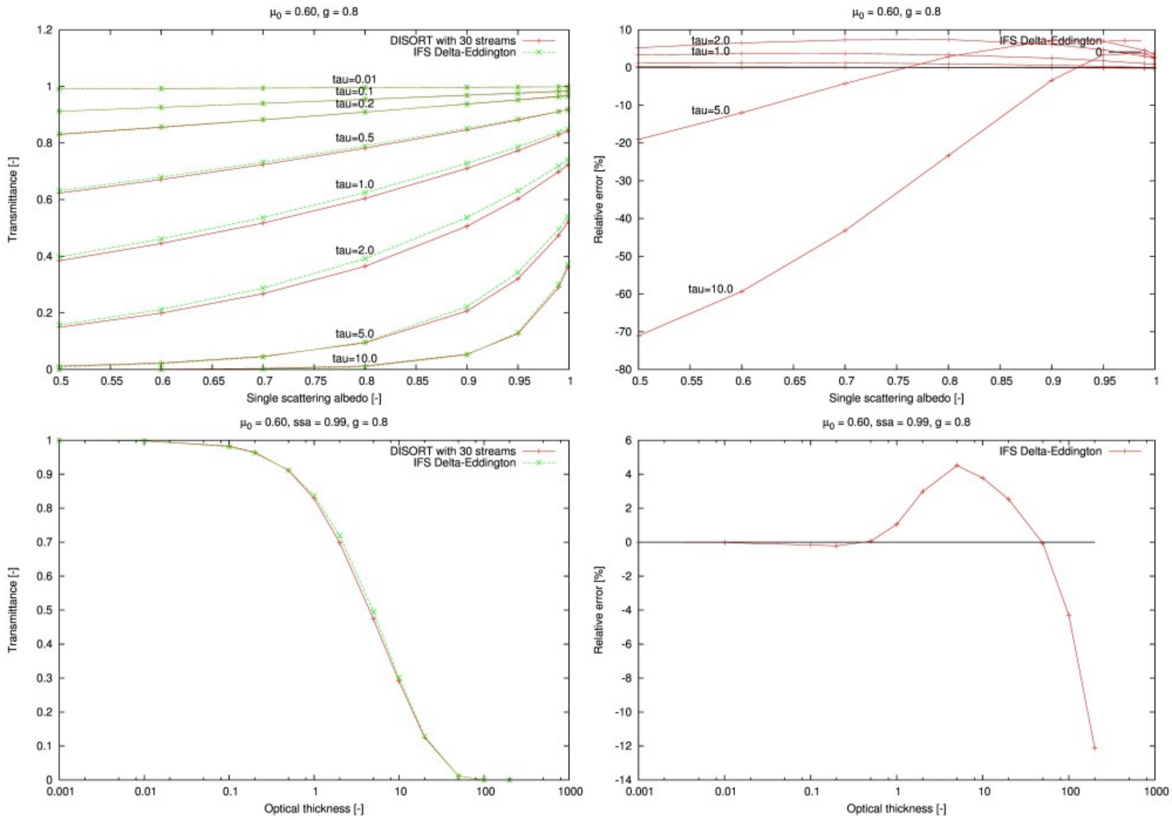

Figure 7: As Fig. 1 but for a cosine solar zenith angle $\mu_0 = 0.60$ and an asymmetry factor $g = 0.8$.

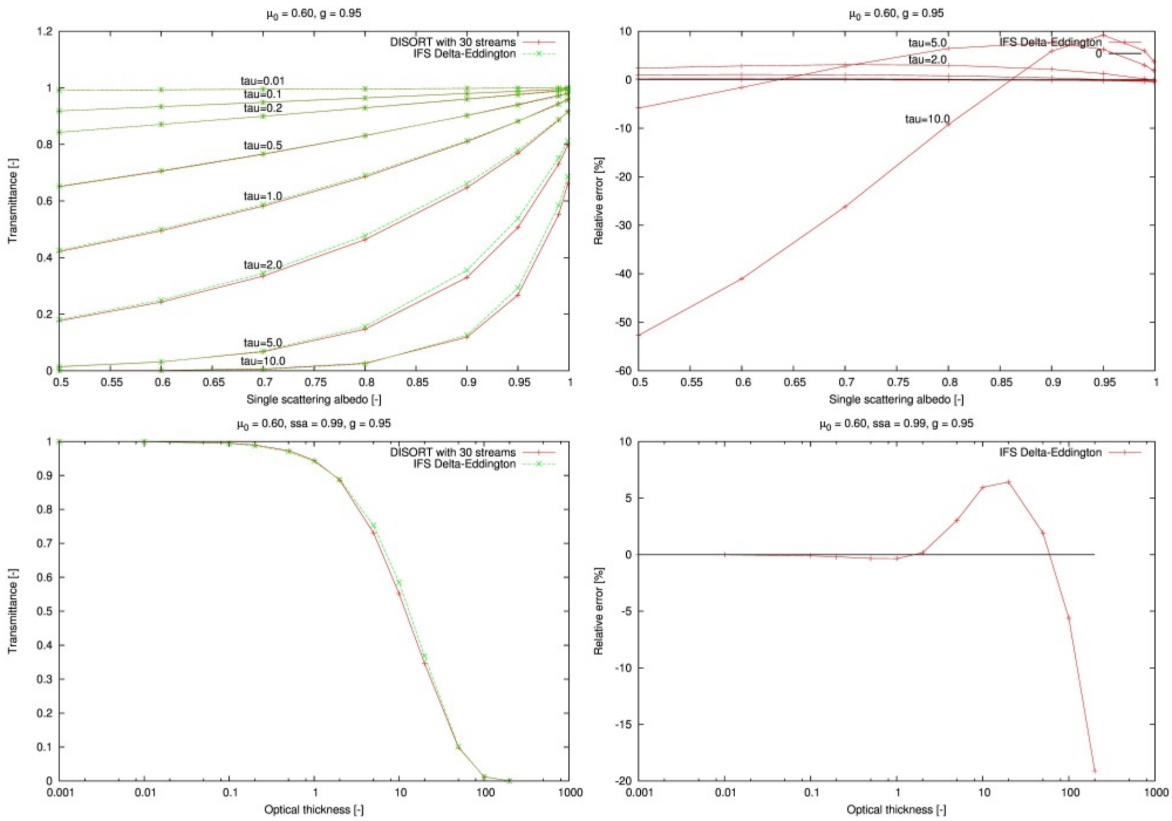

Figure 8: As Fig. 1 but for a cosine solar zenith angle $\mu_0 = 0.60$ and an asymmetry factor $g = 0.95$.