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Fast polarized radiative transfer calculations for the Orbiting Carbon Observatory mission

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The Orbiting Carbon Observatory (OCO) mission was proposed to quantify the sources and sinks of CO_2 by making highly precise measurements of its column abundance. The OCO spectrometers measure absorption of reflected sunlight at the top of the atmosphere (TOA) in three narrowband near infrared (NIR) spectral regions. The high precision requirements in conjunction with the polarization sensitivity of the instrument make it essential to account for polarization in the retrieval algorithm. We use a fast polarization correction algorithm based on the assumption that only two scattering events (two orders of scattering, 2OS) contribute to polarization. The 2OS model was used in conjunction with a scalar RT model (Radiant) to simulate OCO backscatter measurements. Computations were performed for different sites and seasons, spanning a variety of surface and aerosol types. The nadir (high spatial resolution), glint (high signal to noise ratio over ocean) and target (validation using coincident uplooking measurements) modes of operation were simulated. The aerosol extinction was also varied. The radiance errors using the Radiant/2OS (R-2OS) RT model are an order of magnitude (or more) smaller than errors arising from the use of the scalar model alone. Further, a linear error analysis study show that the errors in the retrieved column-averaged dry air mole fraction of CO_2 (X_{CO_2}) using the R-2OS model are much lower than the "measurement" noise and smoothing errors appearing in the inverse model. On the other hand, use of the scalar model alone induces X_{CO_2} errors that could dominate the retrieval error budget. The 2OS computation is also an order of magnitude faster than a full multiple scattering scalar calculation.