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A comparison of the scalar and vector forms of a linearized Matrix Operator Method with a focus on the speed and accuracy of calculation of both the TOA reflectances and their Jacobians with respect to atmospheric aerosol and surface parameters.

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Fast and accurate radiative transfer modeling of an observed atmospheric scenario is very important for the remote sensing of various atmospheric species.
We present a vectorized and linearized version of a radiative transfer model (GHMOM) based on the matrix operator method. The model
provides reflectances at top-of-atmosphere and simultaneously its Jacobian matrix, consisting of the derivatives of these reflectances with respect to different parameters governing the state of the atmosphere. This includes derivatives with respect to the optical thickness of each aerosol type present in a given scenario, the aerosol microphysical paramters including the complex refractive index and the size distribution parameters (generally the mean and variance of a
lognormal profile), and the surface properties, which may or may not be polarizing. These derivatives are critical to inverting the parameters given a set of measured reflectances. The quality of the inversion depends strongly on the accuracy of the model and its Jacobian matrix. It is found that neglecting polarization correction due to aerosol can introduce forward model errors that can severely undermine the applicability of an optimization method to a given inversion problem.
This is especially true at higher aerosol optical thicknesses. On the other hand, vector calculations are more time consuming than scalar calculations, which may be preferable in cases where a simple Rayleigh correction can suffice. By comparing scalar and vector versions of the same Matrix Operator Method radiative transfer model for different aerosol and surface types, we provide a quantitative analysis of the relative advantages of each.