The theoretical framework of universal forward and backward Monte Carlo radiative transfer modeling in [1] is extended for passive and active polarization observation simulations [2]. It is built upon newly derived forward and backward vector scattering order-dependent integral radiative transfer equations (IRTEs). The unified mathematical formalism not only establishes the design of object-oriented software architecture, but also speeds up software development via the reuse of developed scalar code. The polarization simulations are implemented with the addition of the Stokes vector and the Mueller matrix weight tracing schemes. To improve numerical performance order by order, the extension implementation of hybrid scattering order-dependent variance reduction techniques are given detailedly, with a focus on the formulation of scattering phase matrix truncation on the basis of remodeling vector IRTEs. To enrich polarization simulation features, not only scattering operators but also source vector function and detector response matrix function are formulated in unified mathematical forms for the hierarchies organization of various atmosphere, surface, source and detector classes. The framework was fully implemented in MSCART model. For passive simulation, it not only can handle all 1D and 3D test cases in Phases A and B of the IPRT intercomparison project using forward and backward algorithm, but also simulate polarized radiance in a specified direction at a specified position using backward algorithm. For active simulation, lidar backscatter range-resolved signals can be simulated using forward algorithm. The source package is freely available for research purpose from the corresponding author, with online documentation from https://intersharp.gitlab.io/mscart-docs.

References


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