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Towards variational retrieval of warm rain from passive microwave observations

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A variational retrieval of oceanic warm rain is presented for the Global Precipitation Measurement (GPM) Microwave Imager (GMI). It is an extension of the Colorado State University 1D variational algorithm (CSU 1DVAR), providing a suite of retrieved variables over ocean for non-raining or predominantly warm raining conditions. The warm rain retrieval is underpinned by hydrometeor covariances and drizzle onset data from CloudSat. Radiative transfer modeling and analysis of drop size distributions (DSDs) from disdrometer observations permit state-dependent observation error covariances that scale with columnar rainwater during iteration.
Comparisons with space-borne and ground radar estimates are provided as a proof of concept, demonstrating that a passive-only variational retrieval of precipitation is feasible. Significant deviations from the forward model cause non-convergence. However, for cases with liquid-only precipitation, this retrieval outperforms the operational GPM retrieval. Quantitative analysis against GPM's Dual-frequency Precipitation Radar (DPR) shows significant discrepancies in precipitation frequency, with the CSU 1DVAR observing more frequent light rain. This approach can be complementary to other precipitation retrievals, and its synergy with the operational GPM retrieval, the Goddard Profiling algorithm, is explored. The 1DVAR's greater sensitivity to light rain rates helps to move GMI-derived zonal means for precipitation closer to those from CloudSat. Additionally, there are implications for data assimilation, as all 13 GMI channels can be simulated over ocean with fidelity from clear-sky through warm raining conditions.