# Microphysical Controls of High-Frequency Microwave Scattering: Implications for Radiance Simulations and O–B Biases

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**Abstract**

Microwave radiative transfer at high frequencies is strongly influenced by scattering processes associated with frozen hydrometeors. Despite this sensitivity, most forward modeling and data assimilation frameworks continue to rely on hydrometeor water content as the primary descriptor of scattering signals, often neglecting the role of underlying cloud microphysics.

This talk examines how key microphysical properties—particularly particle density and habit—govern high-frequency microwave scattering and the resulting brightness temperature responses. Using controlled sensitivity experiments and radiative transfer simulations, we demonstrate that even under identical hydrometeor water content, substantial variability in brightness temperatures can arise. These differences are primarily driven by variations in particle structure that modulate scattering efficiency, single-scattering albedo, and phase function characteristics.

We further investigate how such microphysical sensitivities translate into systematic discrepancies in radiance simulations. In particular, inconsistencies between the microphysical assumptions embedded in numerical weather prediction models and those adopted in radiative transfer models are shown to introduce persistent observation-minus-background (O–B) biases. These biases are especially pronounced in high-frequency channels where scattering dominates the radiative signal.

The results highlight the limitations of water-content-based representations and emphasize the need for microphysics-aware radiative transfer modeling. Incorporating physically consistent descriptions of particle density and habit offers a pathway to improving forward simulations, reducing systematic O–B biases, and enhancing the performance of microwave-based retrieval and all-sky data assimilation systems.