Simulation of Ice Cloud Particle Size, Humidity and Temperature Measurements from the TWICE CubeSat

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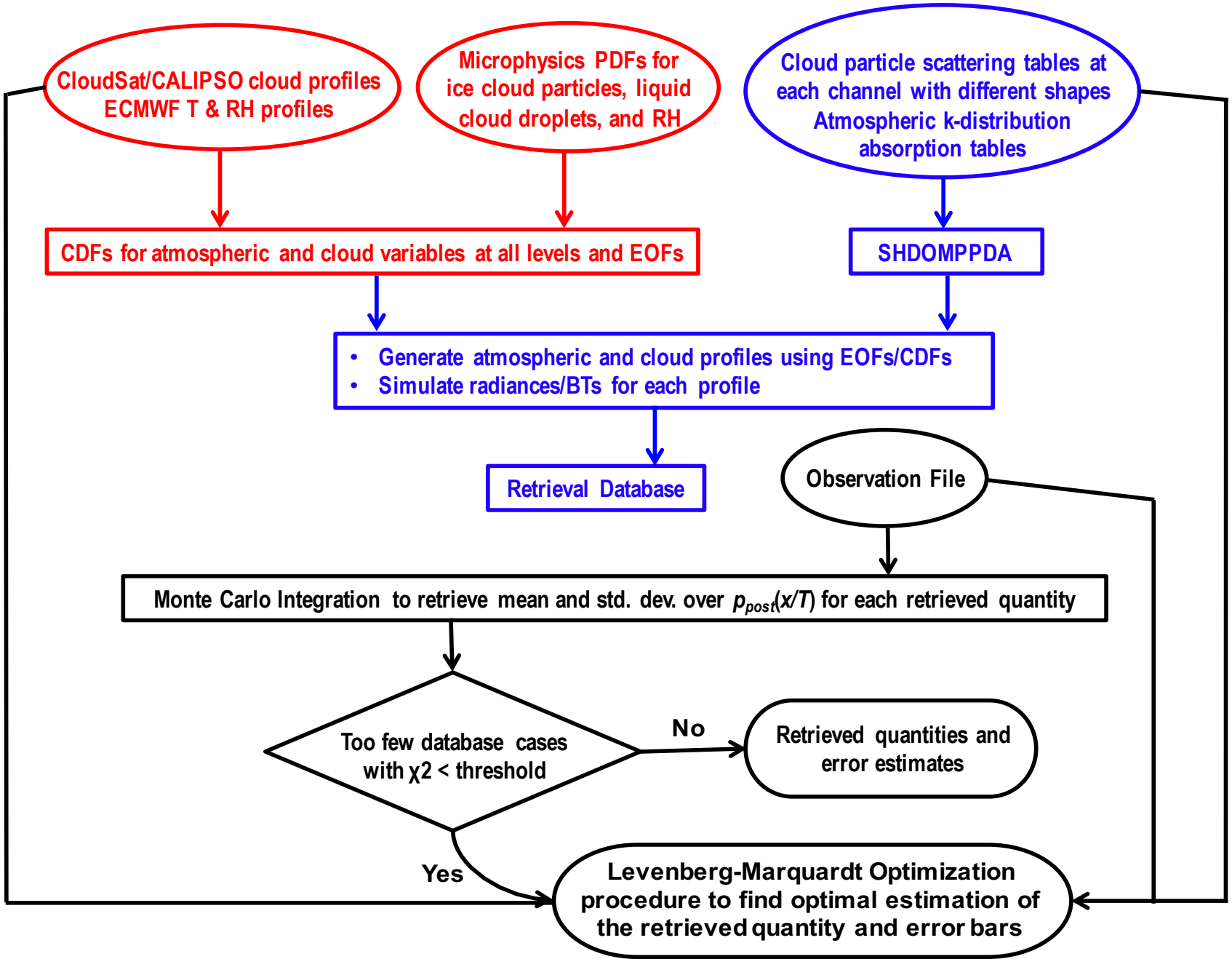
Abstract:

Cloud ice particle size is an intrinsic parameter that determines ice cloud formation and evolution as well as atmospheric humidity, cloud radiative effects and precipitation rate. Ice particle size is also one of the most important parameters that determines climate sensitivity. TWICE will fill the void of remote sensing of ice cloud microphysical properties by providing the first-ever global measurements of seasonally and geographically varying vertical profiles of ice cloud particle size, enabling a breakthrough in accurate quantification of ice cloud effects on radiation and precipitation, thereby improving climate projections.

The FMRS Simulation and Retrieval Algorithm



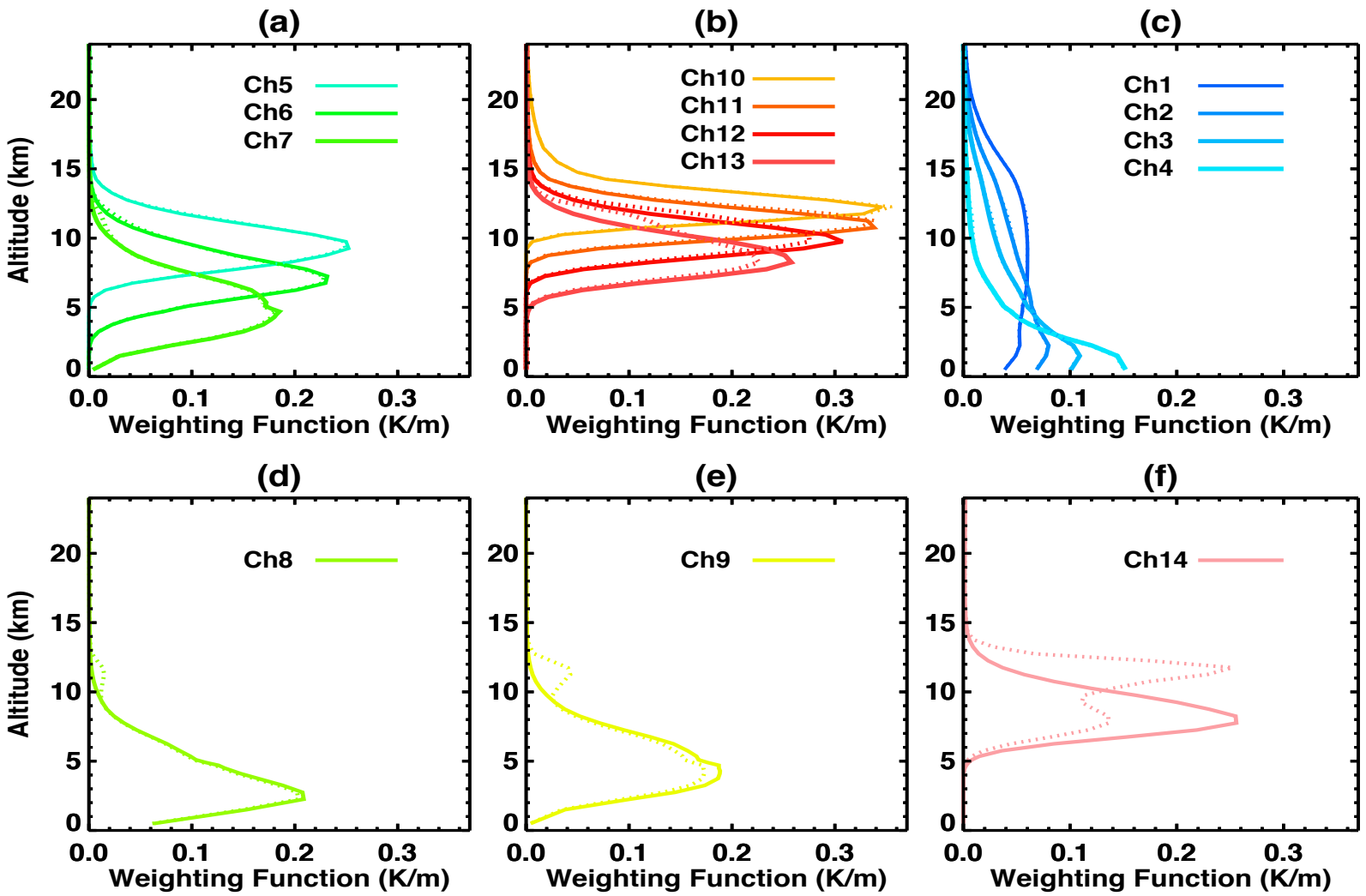


Figure 2: (a) Weighting functions vs. altitude at TWICE channels near the 183.31 GHz water vapor line; (b) Weighting functions vs. altitude at TWICE channels near the 380.20 GHz water vapor line; (c) Weighting functions vs. altitude at TWICE channels near the oxygen line at 118.75 GHz; (d), (e), and (f) Weighting functions vs. altitude at window channels near the 240 GHz, 310 GHz, and 664 GHz ozone lines, respectively. The solid lines are for clear sky, and the dotted lines are for cloudy scenes.

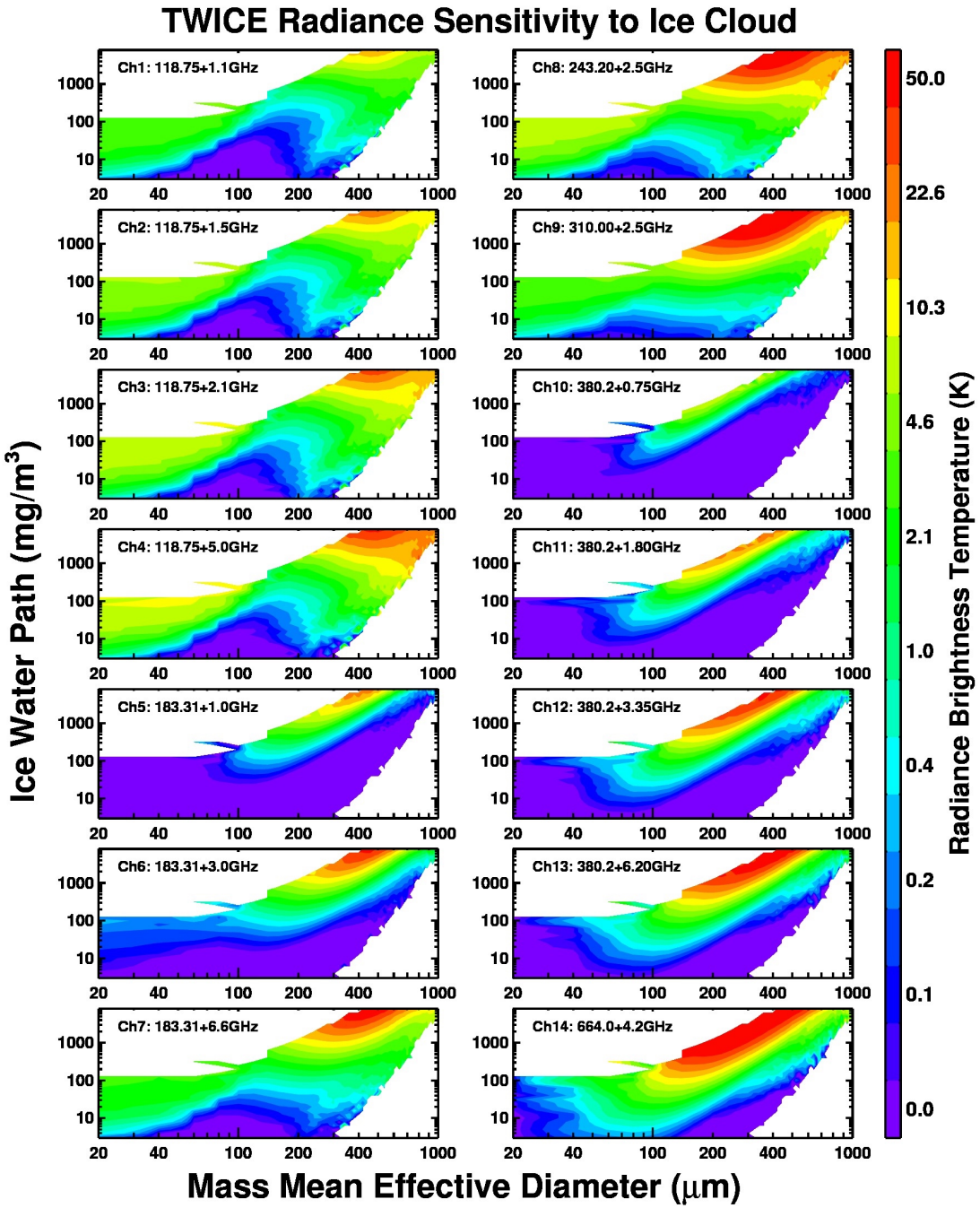


Figure 3: The FMRS simulated radiance brightness temperature differences due to ice particle scattering at 14 TWICE frequency channels as a function of IWP and D_{me}.

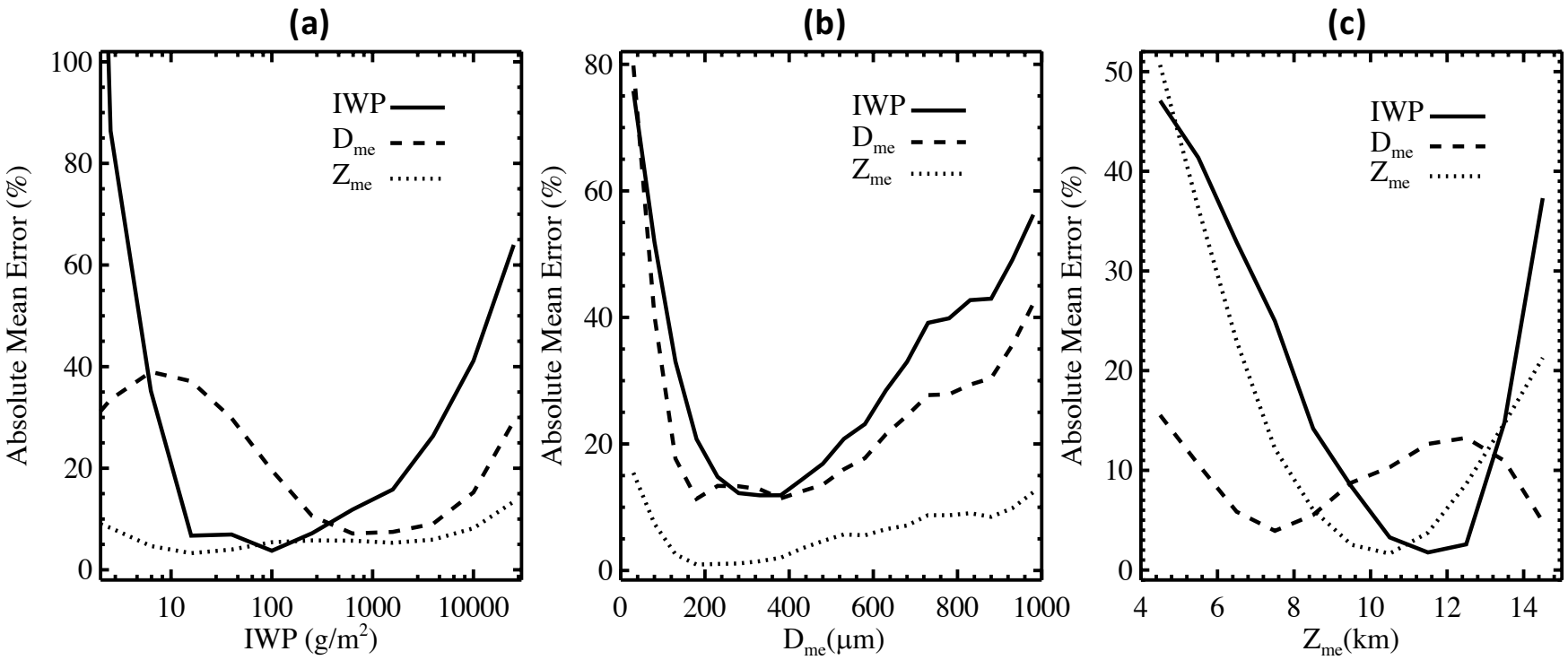


Figure 4: The median absolute fractional error of the retrieved IWP, D_{me}, and Z_{me} as (a) a function of IWP, (b) as a function of D_{me}, and (c) as a function of Z_{me}.

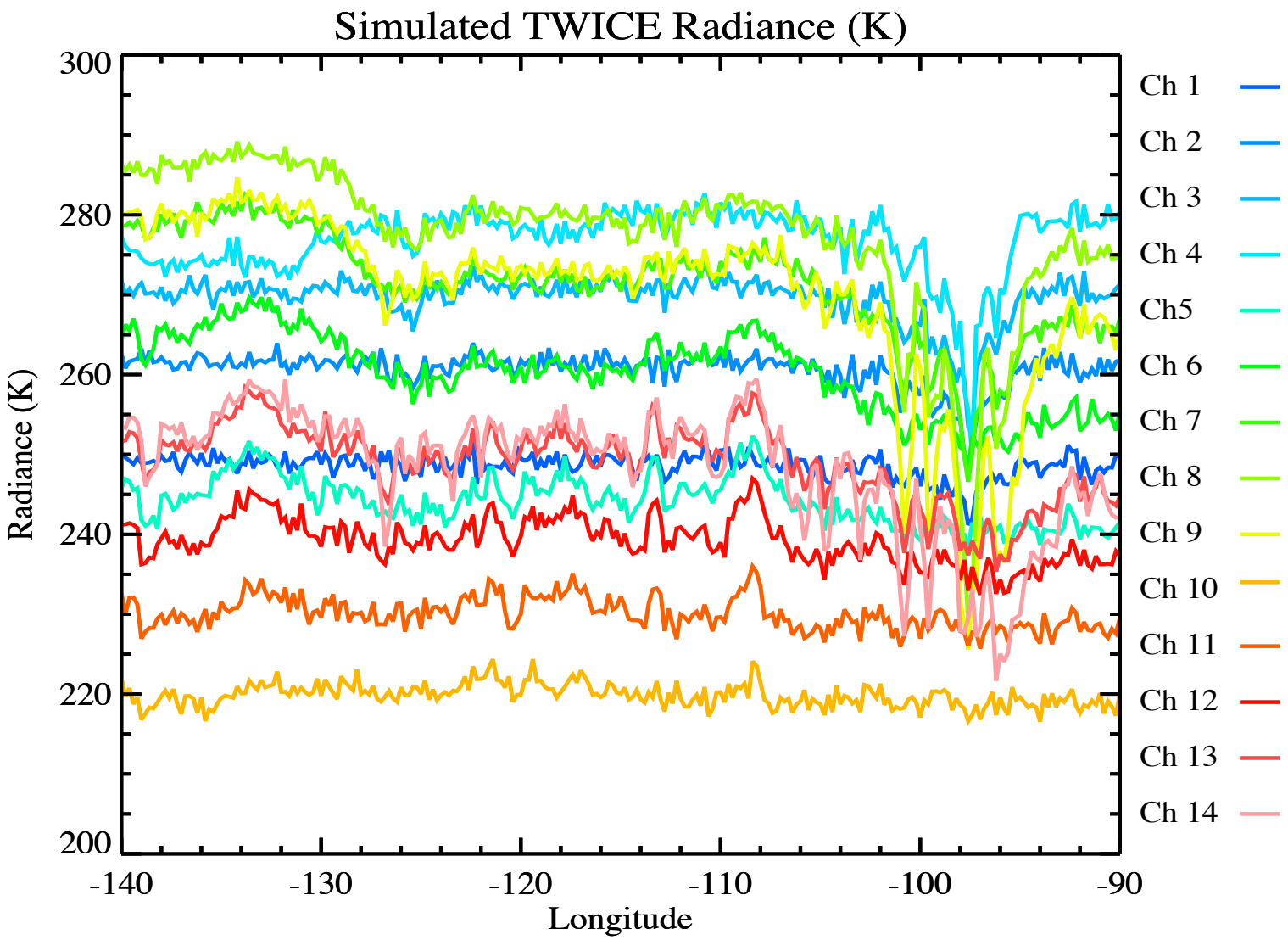


Figure 5: The FMRS simulated radiances as "seen" by the TWICE frequency channels. TWICE channel numbers are defined in Table 1.

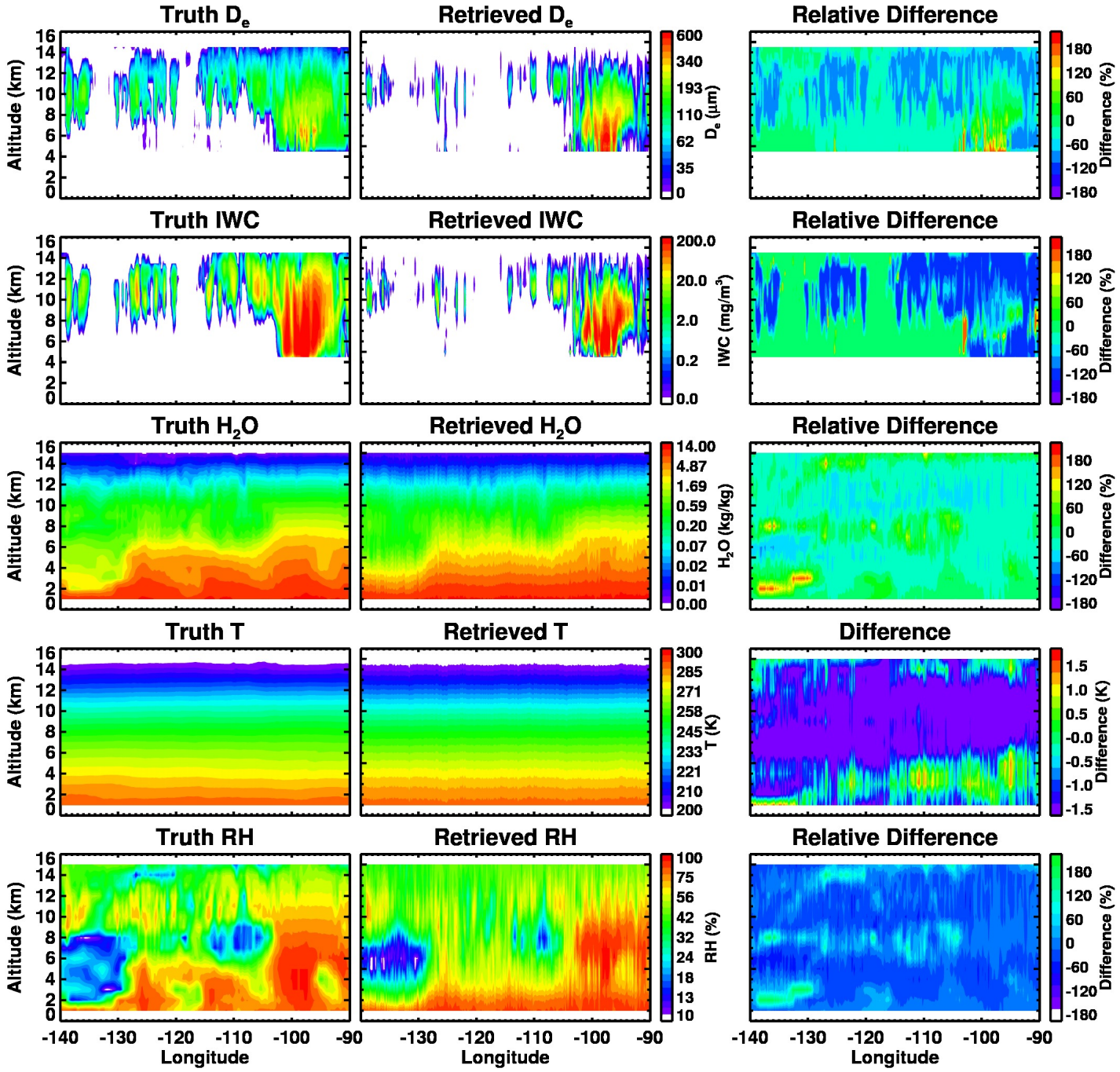


Figure 6: Left column: The vertical profiles of D_e, IWC, H_2O, T, and RH along the latitude of 15°N band between longitudes of 140°W and 90°W from WRF simulations, which are used as "truth". Middle column: The retrieved profiles of the same parameters from the FMRS retrieval algorithm for TWICE. Right column: The relative differences, in percent, computed as the retrieved values minus the truth values and then divided by the truth values. Differences for temperature are shown in K due to the low percentage values .

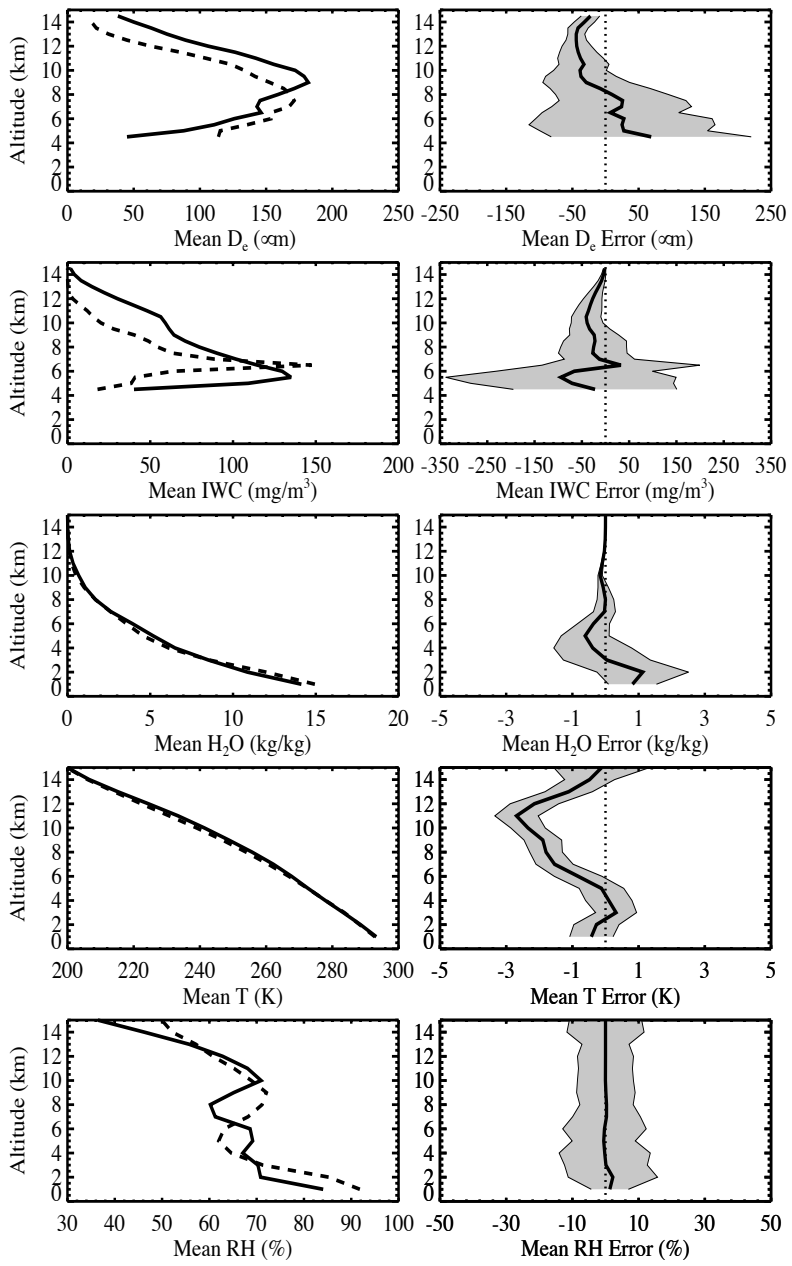


Figure 7: Left-column: The mean truth (solid-line) and mean retrieved (dashed-line) profiles of D_e, IWC, H_2O, T, and RH. Right-column: The mean error and RMS error of the mean profiles.

Summary

We perform simultaneous retrievals of cloud ice particle size, ice water content (IWC), water vapor content (H_2O), and temperature from the simulated TWICE radiances using the FMRS. We show that the TWICE instrument is capable of retrieving ice particle size in the range of ~50-1000 μm in mass mean effective diameter with approximately 50% uncertainty. The uncertainties of other retrievals from TWICE are about 1 K for temperature, 50% for IWC and 20% for H_2O.

Jiang, J.H., Q. Yue, H. Su, S.C. Reising, P.P. Kangaslahti, W.R. Deal, E.T. Schlecht, L. Wu, and K.F. Evans, "[PDF] from wiley.com A Simulation of Ice Cloud Particle Size, Humidity and Temperature Measurements from the TWICE CubeSat," *Earth and Space Science*, 2017.