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Constraints on the width of GCM total water PDF from observations and high resolution models

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The simulation of the hydrological cycle and of the cloud and radiative forcing in a GCM depends to varying degrees on the amount of grid scale condensation produced with a given atmospheric state. This is determined by the characterization of the sub-grid scale variability of water, either in terms of a critical relative humidity (RH) for condensation or by the width of the sub-grid scale probability density function of a water variable. Observational information from AIRS as well as calculations of sub-grid scale variability from high resolution model results are used here to estimate the profile of critical relative humidity for use in a GCM grid scale condensation scheme. Results of GCM simulations with different profiles are presented to demonstrate the sensitivity and improvements in simulated RH profiles using the AIRS and high resolution model derived profiles. Monthly mean AIRS cloud cover and relative humidity are used to compute the relative humidity at which cloud fractions are between 0 and 10%. This relative humidity is shown to correspond to the relative humidity at which condensation begins. Profiles of critical relative humidity from AIRS generally are largest near the surface, decrease rapidly near 800 mb, increase slightly again near jet level, and decrease above. The surface values over land surfaces are generally almost 15% of RH smaller than over ocean surfaces. The range and shape of the critical RH profiles change little with season, and show some small dependance on geographic regime. Very high resolution model simulation (7.5 km globally) results are used to compute sub-grid scale variability of total water for a range of coarser model resolutions. Regional averages of sub-grid scale variance, which relates directly to the critical RH at which condensation occurs, show general behavior that is similar to the profiles produced by the AIRS calculations. Results demonstrate a clear dependance on the resolution of the coarse grid used to compute the average. The general vertical profile of subgrid scale total water variance is unahchanged as the grid resolution changes, and shifting to lower variance values with smaller grid size.