An Investigation of Microphysics and Sub-grid Scale Variability in Warm Rain Clouds using The A-Train Observations and A Multi-Scale Modeling Framework

*Hanii Takahashi[1,2], Matthew Lebsock[2], Kentaroh Suzuki[3], Graeme Stephens[2,4], Minghuai Wang[5,6]

1. Joint Institute for Regional Earth System Science and Engineering, University of California, Los Angeles, California, 2. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, 3. Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, Japan, 4. Department of Meteorology, University of Reading, UK, 5. Institute for Climate and Global Change Research, and School of Atmospheric Sciences, Nanjing University, Nanjing, Jiangsu Province, China, 6. Collaborative Innovation Center of Climate Change, Nanjing, Jiangsu Province, China

Particle-growth processes (e.g. the cloud-drizzle-rain process) in warm rain clouds play a significant role in controlling the energy budget and hydrological cycle. However, the cloud-to-precipitation process is generally not well represented by models. A common problem in climate models is that they are likely to produce rain at a faster rate than is observed and therefore produce too much light rain (e.g., drizzle). Interestingly, the Pacific Northwest National Laboratory (PNNL) multi-scale modeling framework (MMF) whose warm rain formation process is more realistic than other global models, has the opposite problem: the rain formation process in PNNL-MMF is less efficient than the real world. To better understand the microphysical processes in warm cloud, this study evaluates warm cloud properties, subgrid variability, and microphysics, using A-Train satellite observations to identify sources of model biases in PNNL-MMF. Like other models PNNL-MMF under-predicts the warm cloud fraction with compensating large optical depths. Associated with these compensating errors in cloudiness are compensating errors in the precipitation process. For a given liquid water path, clouds in the PNNL-MMF are less likely to produce rain than are real world clouds. However, when the model does produce rain it is able to produce stronger precipitation than reality. As a result, PNNL-MMF produces about the correct mean rain rate with an incorrect distribution of rates. The sub-grid variability in PNNL-MMF is also tested and results suggest that the possible sources of model biases are likely to be due to errors in its microphysics or dynamics rather than errors in the sub-grid scale variability produced by the embedded cloud resolving model.

Keywords: Warm rain clouds, Microphysical process, Sub-grid scale variability, A-Train observations, Multi-scale modeling framework

