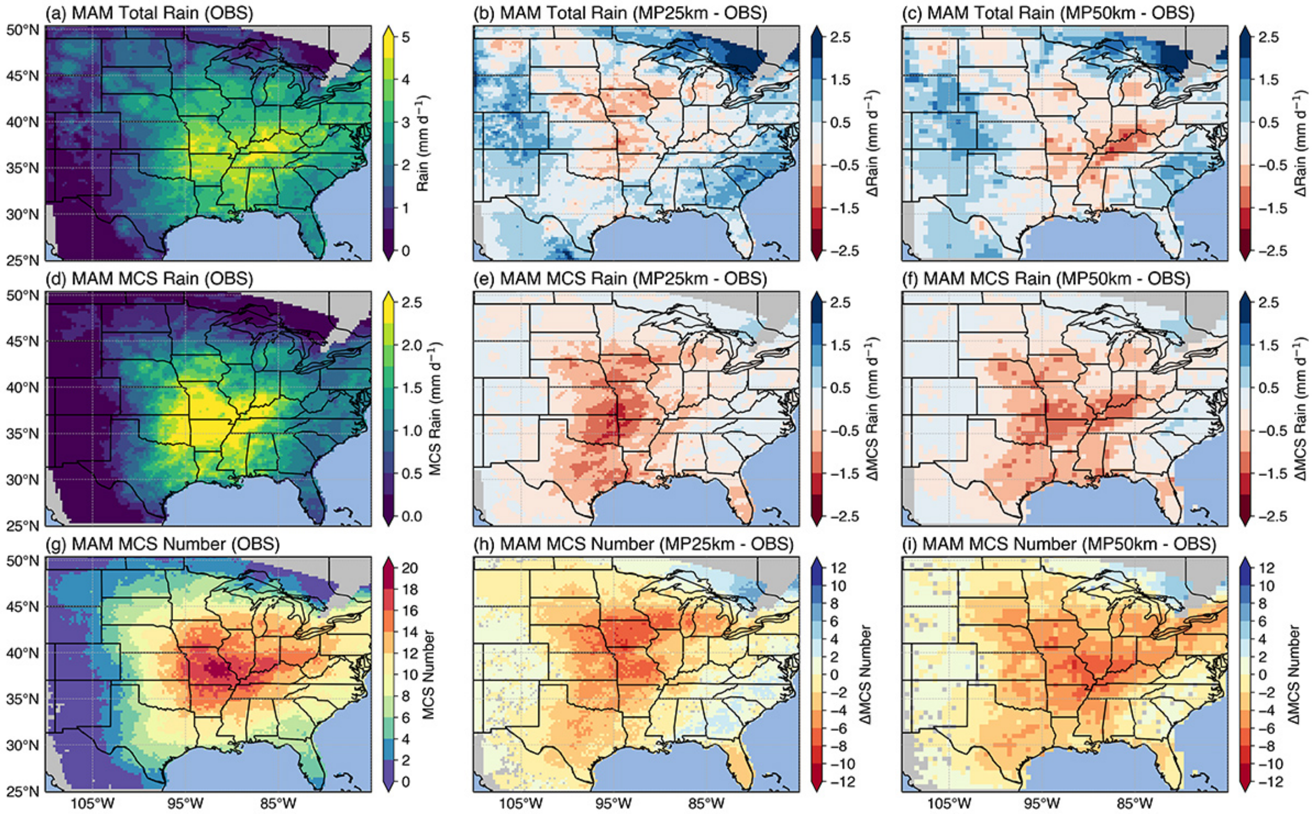
Evaluation of Mesoscale Convective Systems in Climate Simulations: Methodological Development and Results from MPAS-CAM over the U.S.

*Zhe Feng[1], Fengfei Song[1], Koichi Sakaguchi[1], Ruby Leung[1]

1. PNNL

A process-oriented approach is developed to evaluate warm-season mesoscale convective system (MCS) precipitation and their favorable large-scale meteorological patterns (FLSMPs) over the U.S. This approach features a novel observation-driven MCS-tracking algorithm using infrared brightness temperature and precipitation feature at 25 km and 50 km resolution and metrics to evaluate the model large-scale environment favorable for MCS initiation. The tracking algorithm successfully reproduces the observed MCS statistics from a reference 4-km radar MCS database. The process-oriented approach is applied to two climate simulations produced by the Variable-Resolution Model for Prediction Across Scales (VR-MPAS) coupled to the CAM5.4 physics, with refined horizontal grid spacing at 50 km and 25 km over North America. With the tracking algorithm applied to simulations and observations at equivalent resolutions, the simulated number of MCS and associated precipitation amount, frequency and intensity are found to be consistently underestimated in the Central U.S., particularly from May to August. The simulated MCS precipitation shows little diurnal variation and lasts too long, while MCS precipitation area is too large and intensity is too weak. Simulation at 25-km grid spacing does produce more realistic MCS characteristics. The model is able to simulate four types of observed FLSMP associated with frontal systems and low-level jets (LLJ) in spring, but the frequencies are underestimated because of low-level dry bias and weaker LLJ. Precipitation simulated under different FLSMPs peak during daytime, in contrast to the observed nocturnal peak. Implications of these findings for future model development and diagnostics are discussed.

Keywords: Mesoscale convective system, Large-scale environments, Climate simulation, Model evaluation, Storm tracking


(a) MAM Total Rain (OBS)
(b) MAM Total Rain (MP25km - OBS)
(c) MAM Total Rain (MP50km - OBS)
(d) MAM MCS Rain (OBS)
(e) MAM MCS Rain (MP25km - OBS)
(f) MAM MCS Rain (MP50km - OBS)
(g) MAM MCS Number (OBS)
(h) MAM MCS Number (MP25km - OBS)
(i) MAM MCS Number (MP50km - OBS)
Rain (mm d−1)
ΔRain (mm d−1)
MCS Rain (mm d−1)
ΔMCS Rain (mm d−1)
MCS Number
ΔMCS Number
50°N
45°N
40°N
35°N
30°N
25°N
105°W
95°W
85°W