



Resolution-Sensitivity of the Hydrological Cycle in the CAM-MPAS Variable-Resolution Framework



K. Sakaguchi¹, J. Jang², L. R. Leung¹, B. Skamarock², C. Zarzycki³, A. Gettelman², and Z. Feng¹
¹PNNL, ²NCAR, ³Penn. State Univ.

Is the Grell-Freitas convection scheme scale-aware in the resolution range of global climate models?

How does the resolution-sensitivity of convection propagate in the hydrological cycle?

Does the credibility of a VR model improve with resolutions and/or scale-awareness?
By what metric?

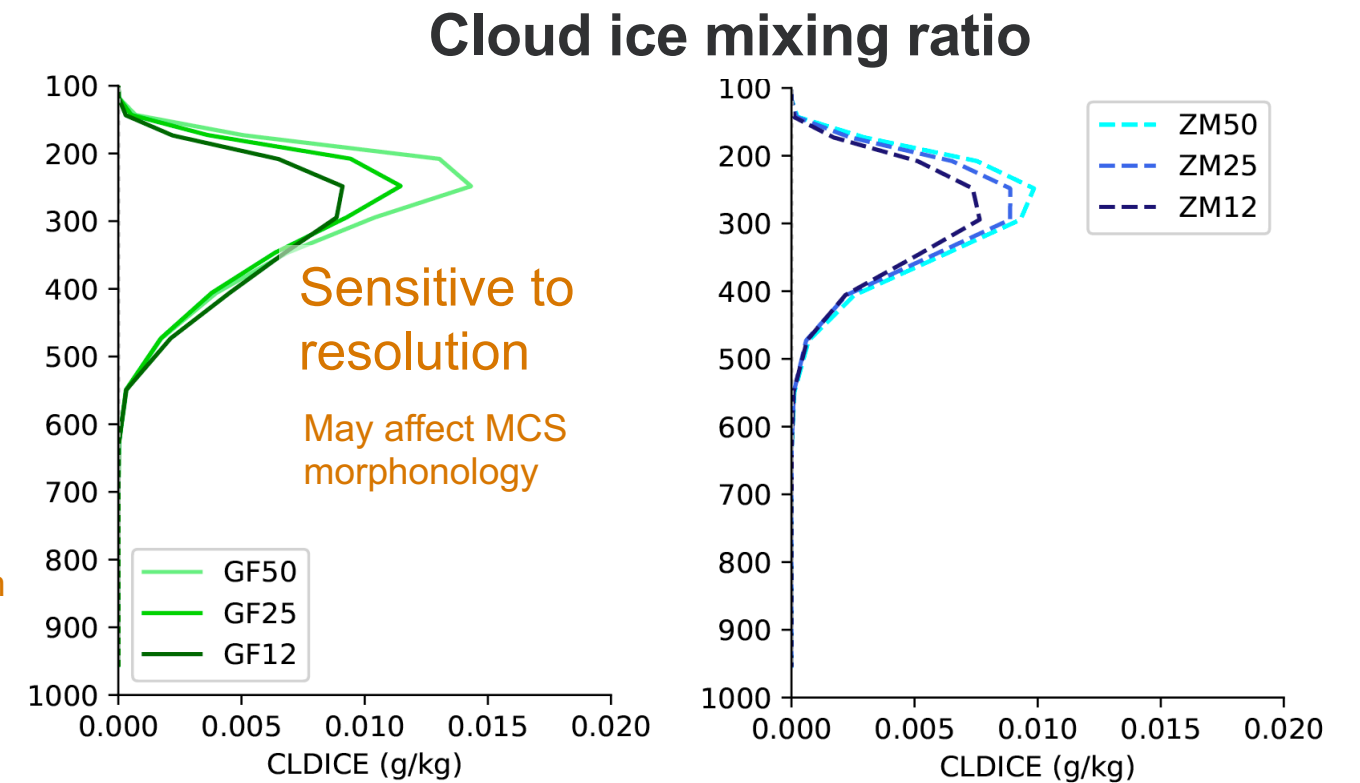
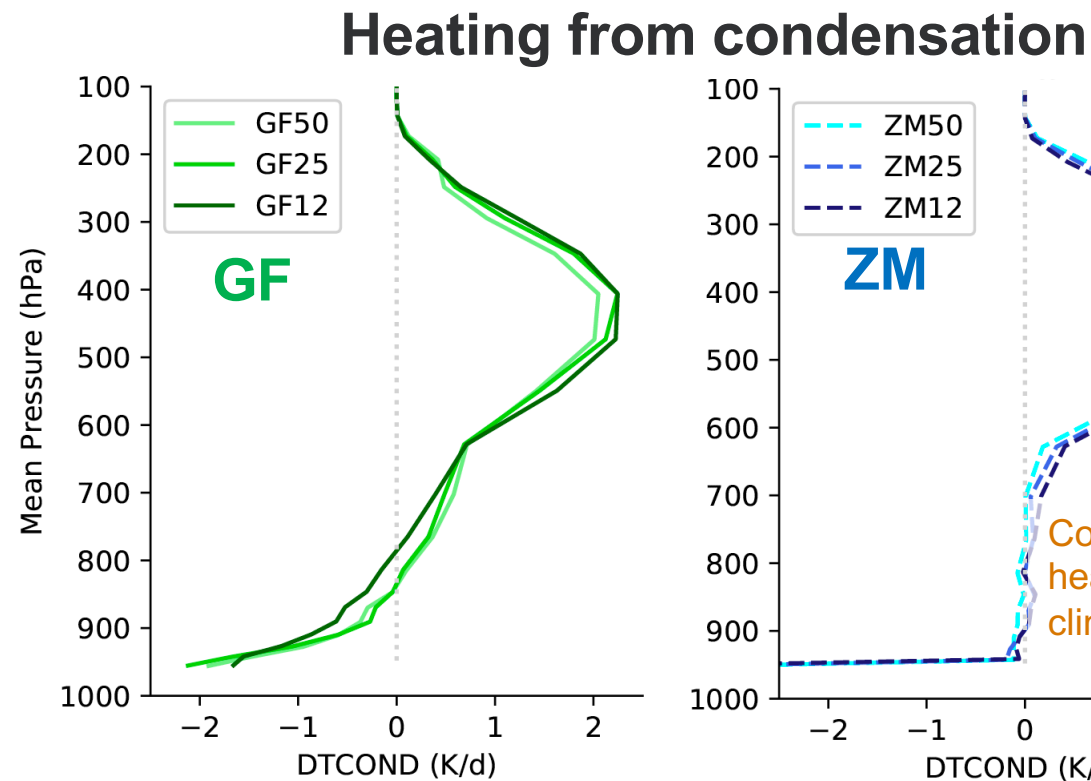
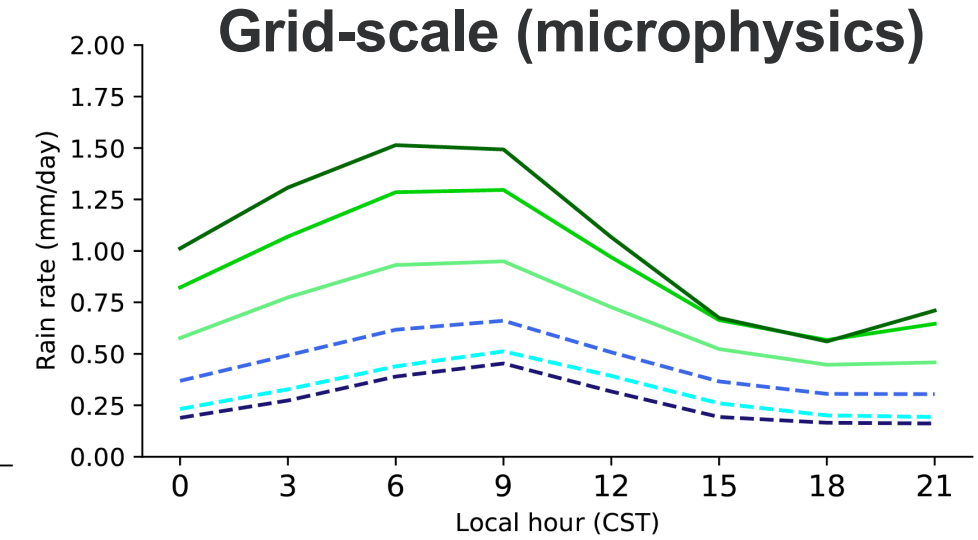
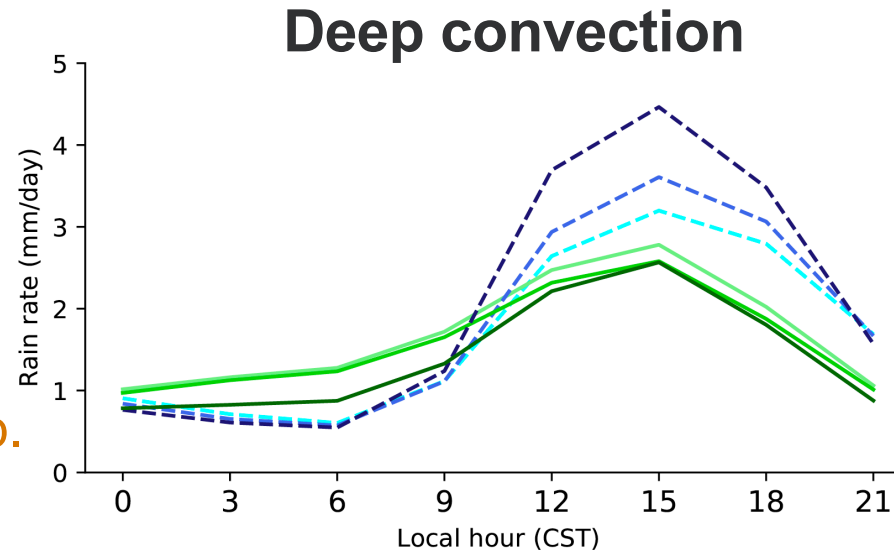
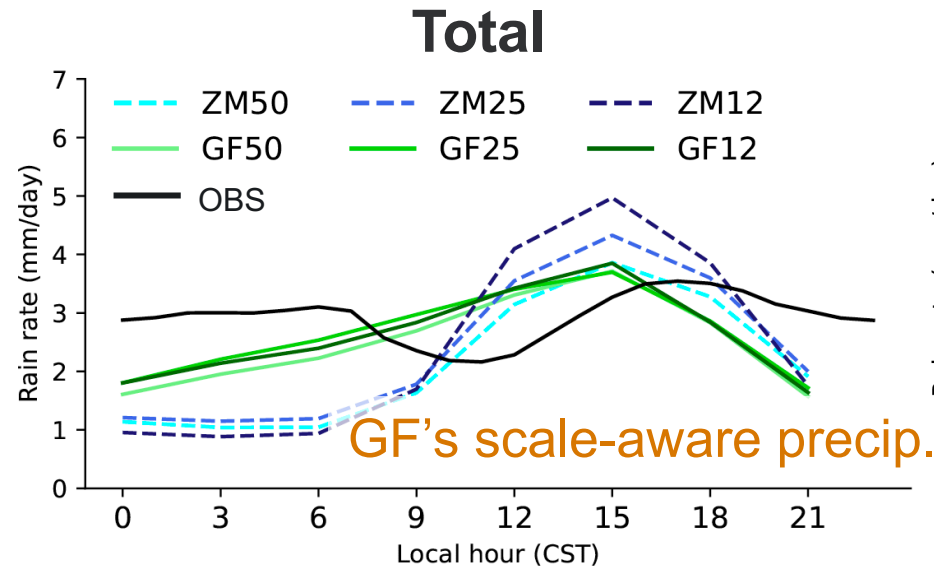


CAM-MPAS VR framework

- CAM5.4 and CLM4
- 5-year AMIP simulation (2000-2004)
- control (Zhang-McFarlane, ZM) vs. experiment (GF)
- focus on JJA

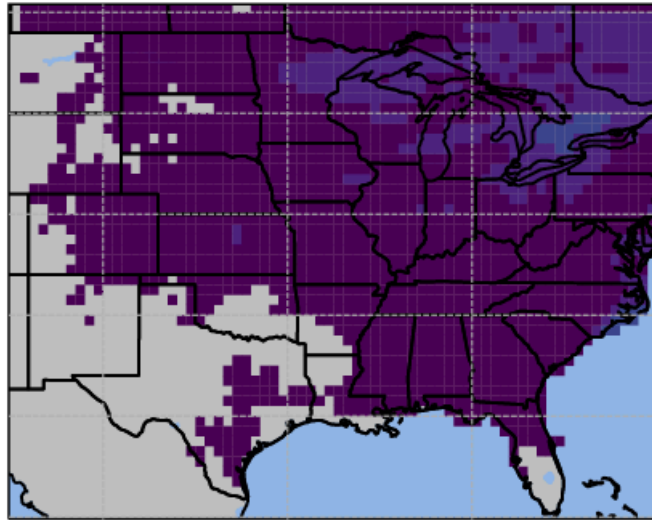
Different resolution-sensitivities in precipitation, condensational heating, and cloud amount

Average over central US and JJA

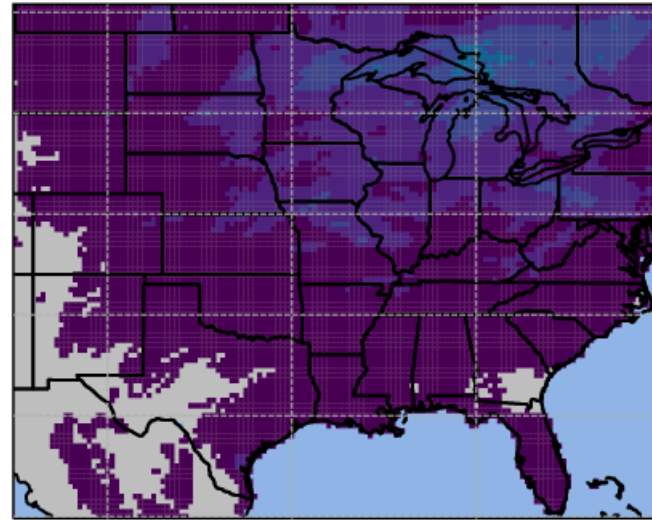


Large sensitivity of MCS to convection schemes; No monotonic improvement in modeled MCSs with resolutions down to the gray-zone

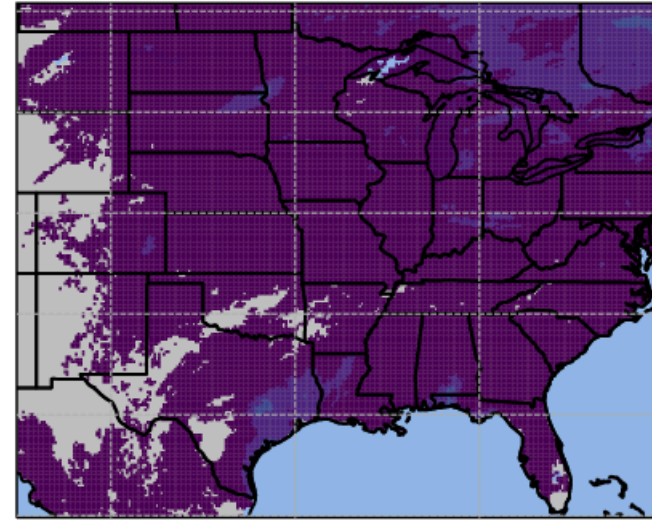
JJA MCS Rain (ZM50)



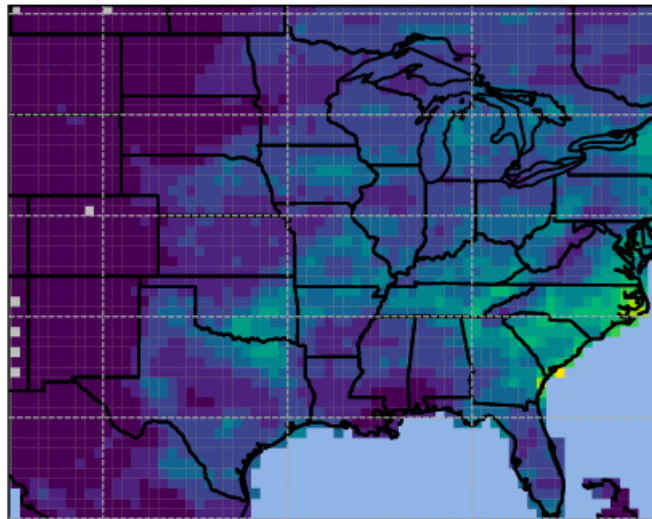
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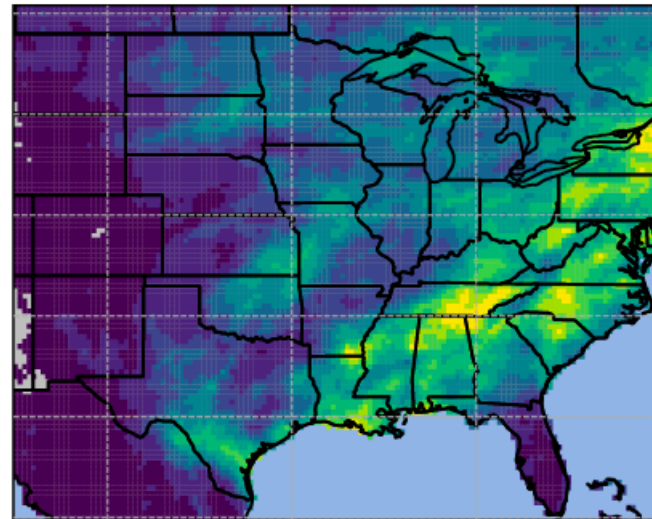
JJA MCS Rain (ZM12)



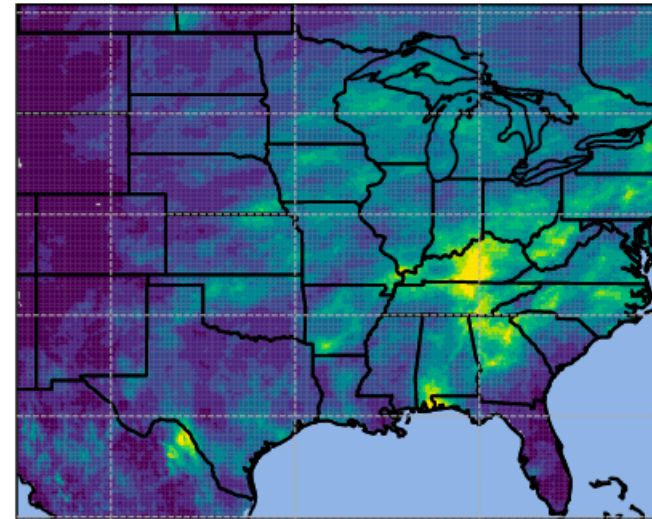
JJA MCS Rain (GF50)



JJA MCS Rain (GF25)



JJA MCS Rain (GF12)

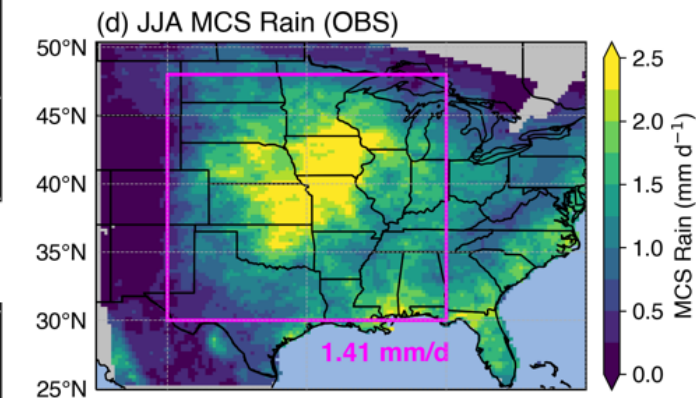


105°W 95°W 85°W

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105°W 95°W 85°W

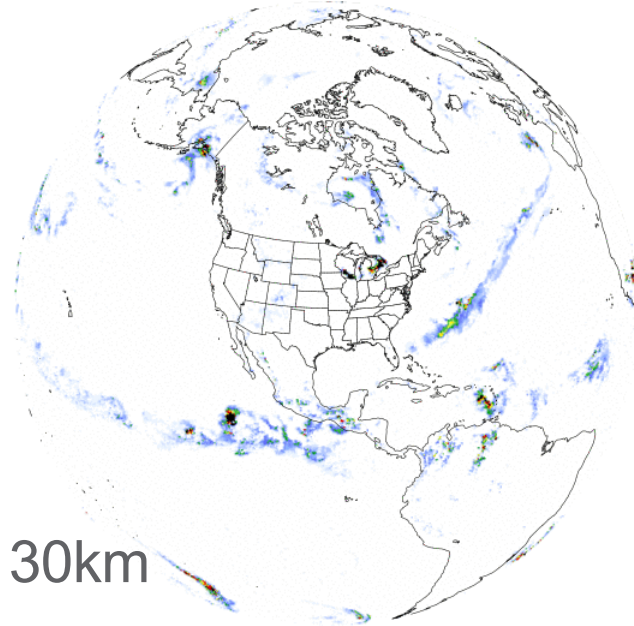
MCS tracked by FLEXTRKR adapted to coarser resolutions (Feng et al., 2020)



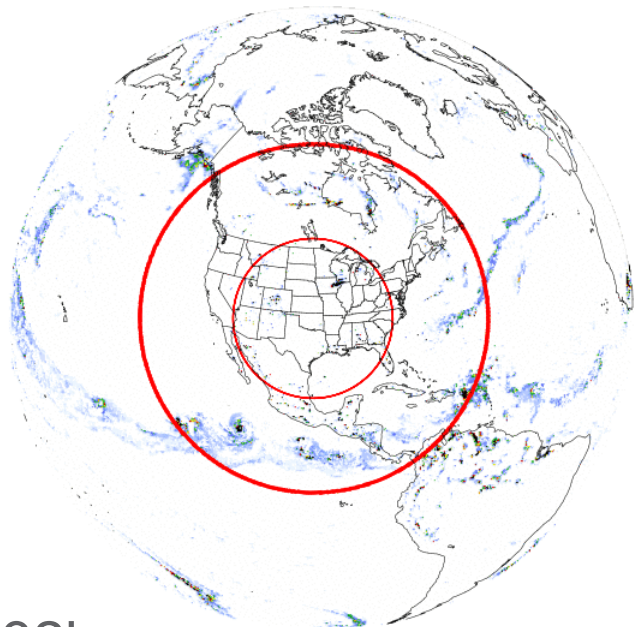
Significant increase of MCS precipitation (less so in total precipitation) from ZM to GF

GF not able to capture the maximum over northern central US

Research needs and opportunities: Next-generation of dynamical downscaling



global 30km



VR 4-32km

Multi-model ensemble of global models with ~ 30km grid spacing (e.g., HighResMIP)



Boundary conditions

Ensemble of convection-permitting regional simulations (Gutowski et al., 2020)

What role does the VR framework play?

Are values of global VR models (upscale effects, model consistency across domains) established for process studies and projections? How is their strength utilized?

Computational costs of downscaling approaches quantified?

Global uniform 120 km ~ 40,000 grid points	Regional CONUS ~30km ~ 30,000 grid points
Global uniform 30 km ~ 700,000 grid points	Regional CONUS ~4km ~ 600,000 grid points
Global VR 30-120km ~ 100,000 grid points	Global VR 4-32km ~ 2,000,000 grid points

Convection scale  Need more data & harder to understand?

“once the horizontal scale of the system reaches below $O(10)$ km..., the flow becomes fully three-dimensional: this is the essence of the convective scale. These flows are far more complex than two-dimensional turbulence, more transient and intermittent (i.e., they lack balance), and they are associated with a much larger degree of freedom.”

(Yano et al., 2018)

“..simulation without understanding imperils scientific progress and, paradoxically, may impede the development of better models.”

(Emanuel 2020)