NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

C3WE

NCAR Water System Program

Modeling future changes in Mesoscale Convective Systems

Why end-of-century floods might be more severe than expected

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8TH GEWEX OPEN SCIENCE CONFERENCE: EXTREMES AND WATER ON THE EDGE
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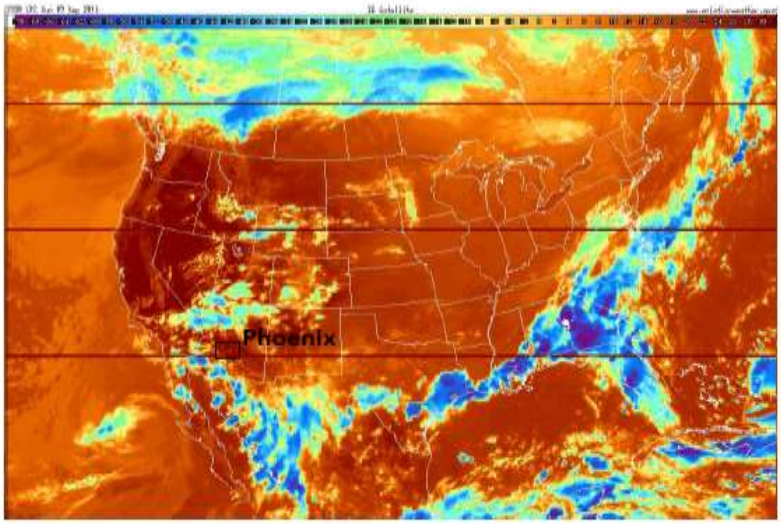
Why are MCSs important?

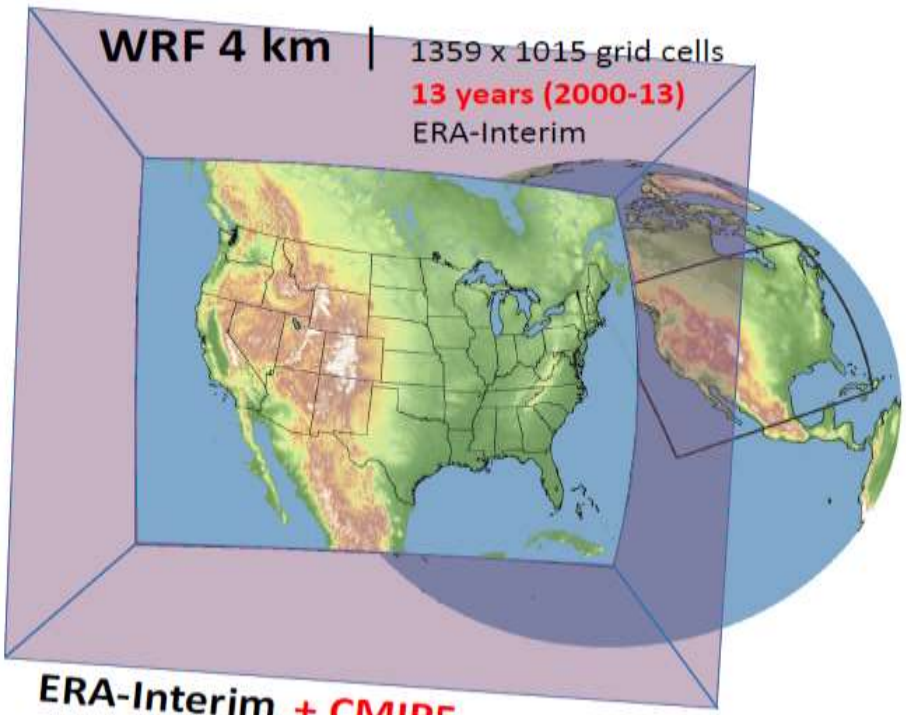
Most major flooding events during the warm season are caused by MCSs

- West Virginia 2016
- Louisiana 2016
- Phoenix AZ 2014



Climate Change and MCS precipitation

Simulation Domain and Setup



ERA-Interim + **CMIP5**
6-hourly
Monthly RCP8.5
19 model average

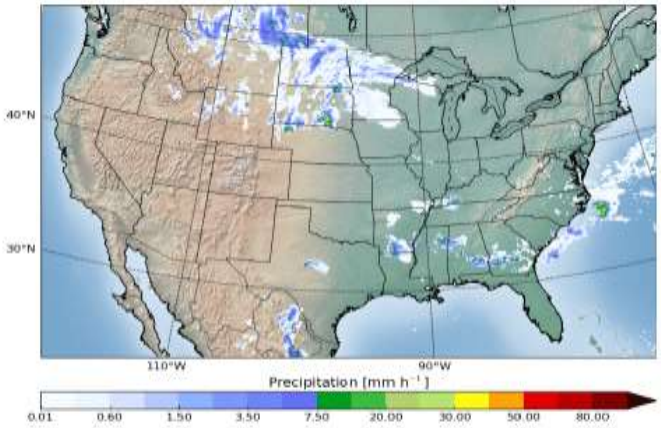
Liu et al. 2016, Clim. Dyn.

Pseudo Global Warming (PGW) [Rasmussen et al. 2011: JOC]

- Monthly averaged climate change perturbations from **19 CMIP5 GCMs**
- Delta 2071 to 2100 – 1976 to 2005 → RCP8.5
- Thermodynamic response of climate change
- No changes in weather patterns / moisture convergence
- No issues with internal variability

Observation vs. Simulation

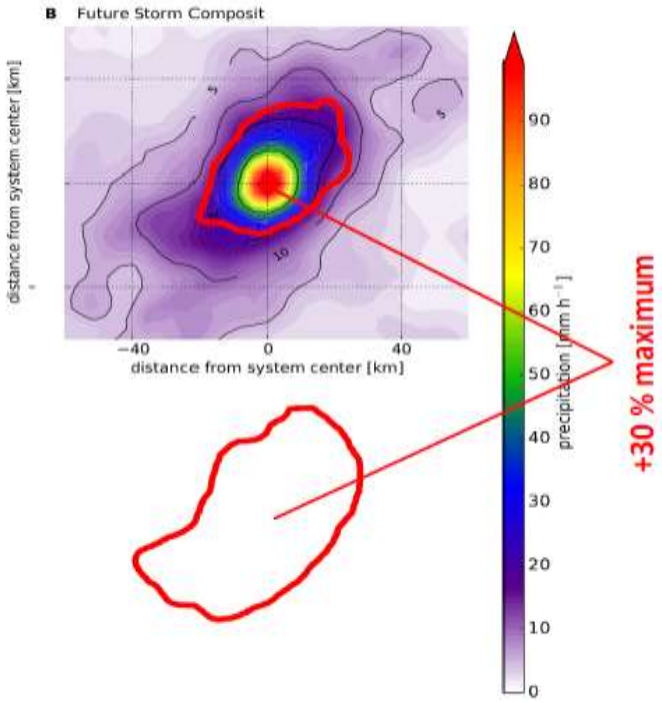
WRF 4 km



Observation

4 km convection-permitting climate simulation is able to realistically reproduce MCS precipitation
[Prein et al. 2017, Clim. Dyn.]

MCS total precipitation – Mid Atlantic



Maximum rain rate

- **+30 %**
  approximately
  Clausius–Clapeyron relation

Size of > 10 mm/h Area

- **+88 %**

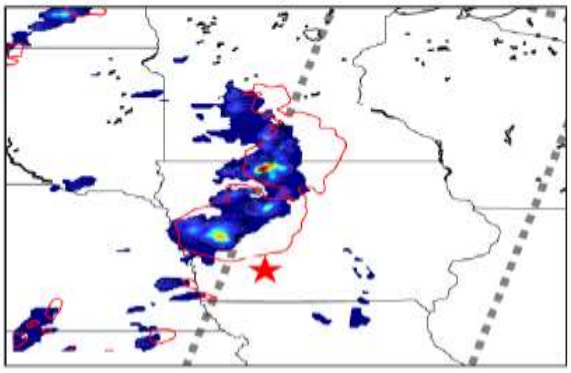
Volume within > 10 mm/h Area

- **+105 %**

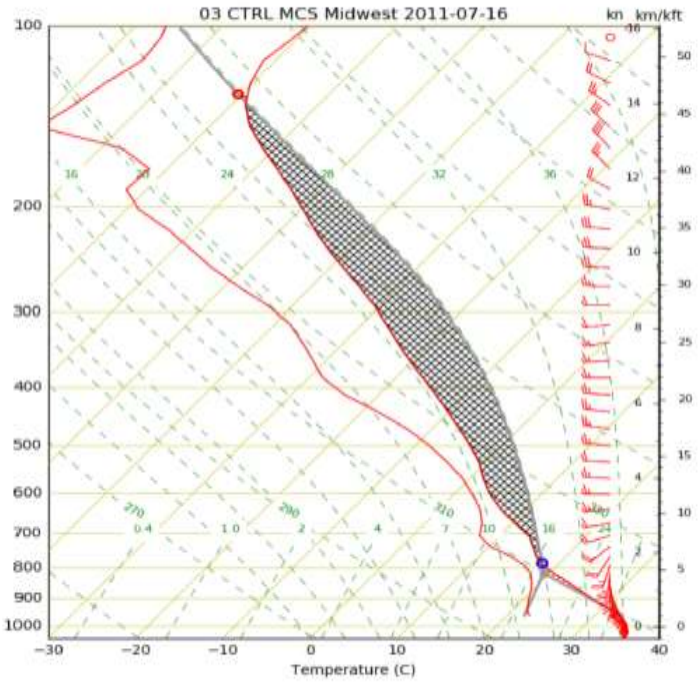
[Prein et al. 2017, Nat. Clim. Change]

MCS precipitation and its sensitivity to grid spacing

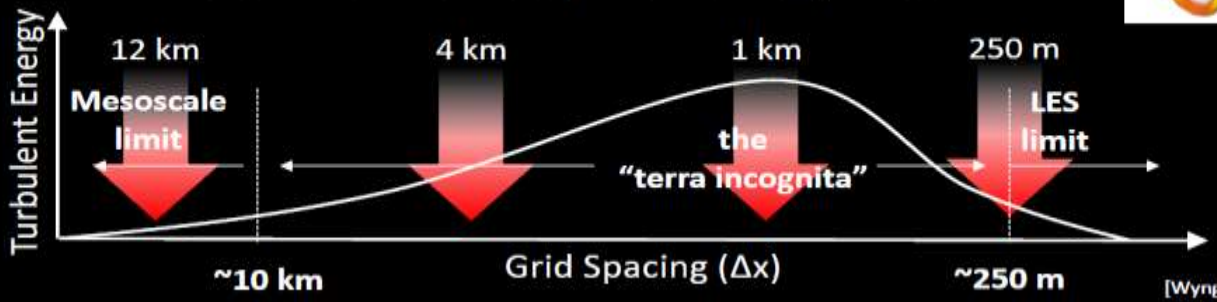
Idealized WRF simulations



WRF model with 500x500 km domain, 94 vertical levels, open boundaries, no radiation, no surface fluxes, 6 hour long integration

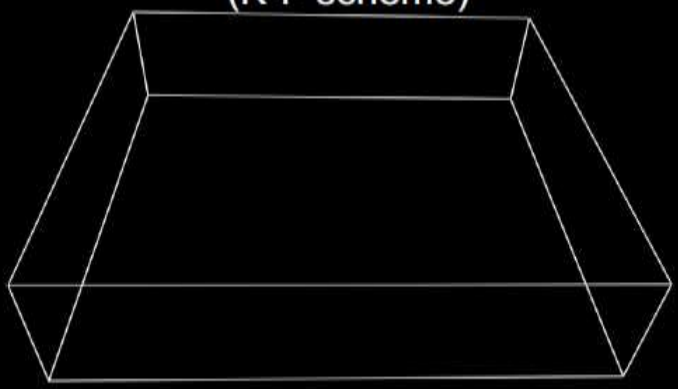


MCS in 3 atmospheric regimes

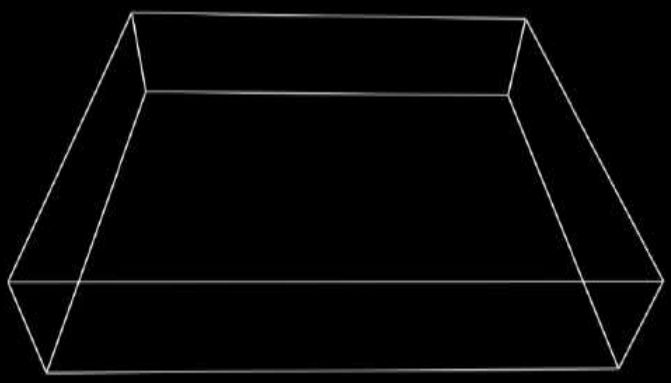


[Wyngaard 2004, JAS]

Δx = 12 km (K-F scheme)



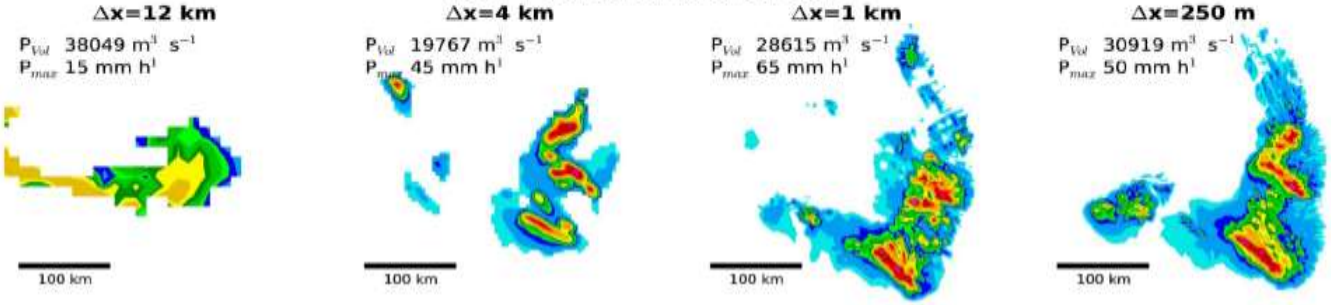
Δx = 4 km



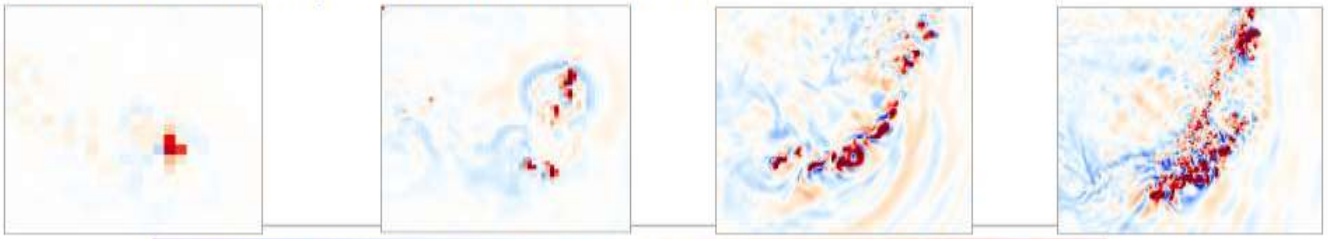
Precipitation Patterns

Hourly precipitation accumulation

hour 4-5 after simulation start



Vertical Wind Speed at 6 km –and 4:30 h



Conclusion and Outlook

- MCS precipitation volume is likely to increase much faster than peak rainfall intensity
- Caused by changes in thermodynamics and microphysics
- Additional idealized MCS simulations will allow to assess the effect of model resolution