ASR
Atmospheric System Research
Science Focus Area (SFA)

Convection transition and convection organization over land: Case studies using regionally refined-SCREAM and ARM observations

Tying in High Resolution E3SM with ARM Data (THREAD)

Lawrence Livermore National Laboratory

Hsi-Yen Ma

and

Yunyan Zhang, Tianning Su, Cheng Tao, Peter Bogenschutz, Jishi Zhang

Lawrence Livermore National Laboratory

Jingjing Tian, Zhe Feng

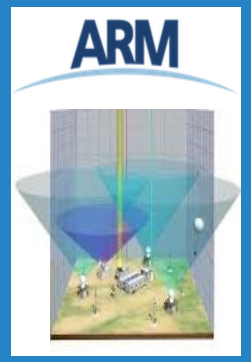
Pacific Northwest National Laboratory

Andreas Prein

ETH Zürich

Dié Wang

Brookhaven National Laboratory



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2025 CESM Workshop, June 11, 2025

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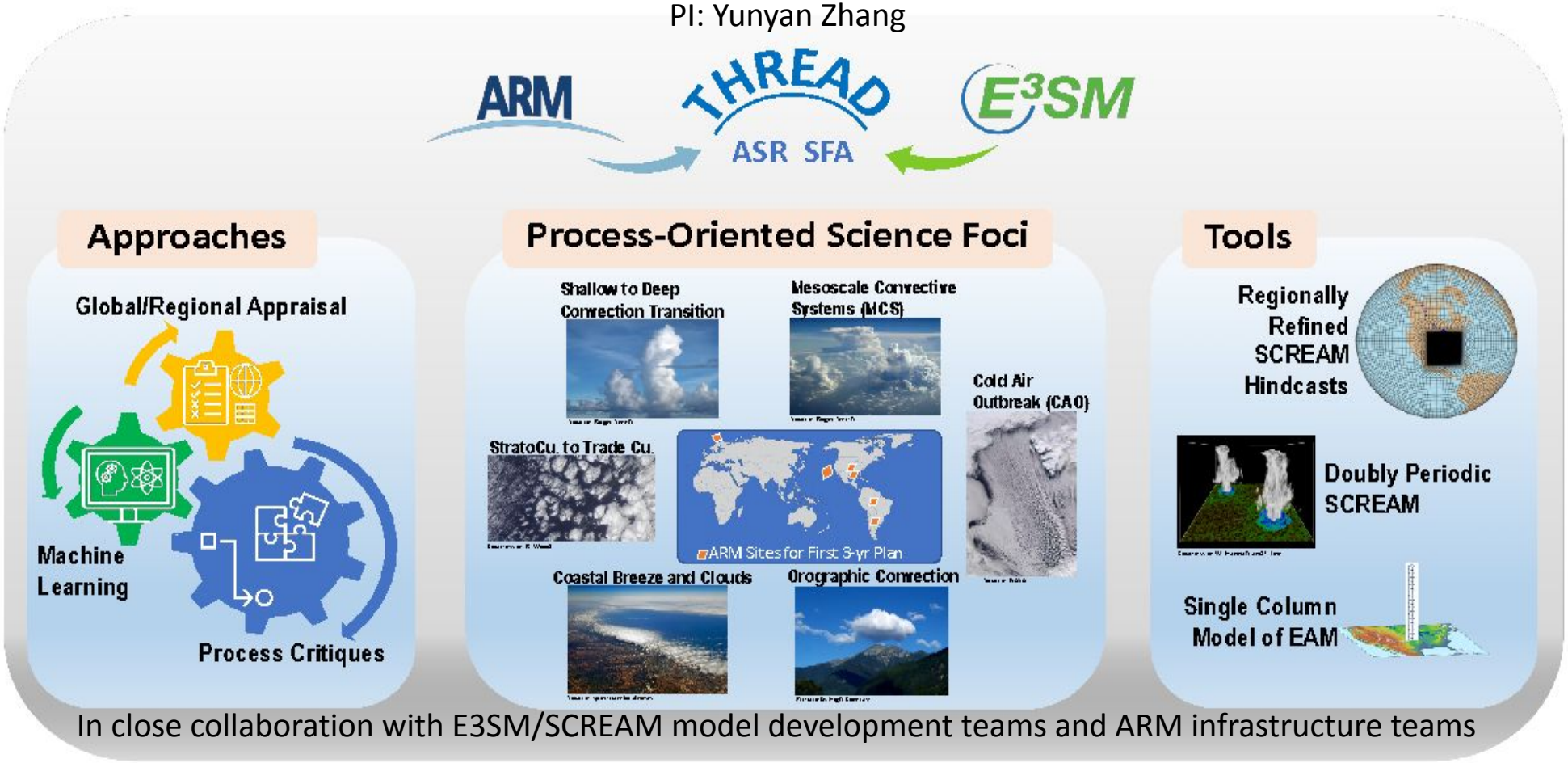
Tying in High Resolution E3SM with ARM Data (THREAD)

PI: Yunyan Zhang



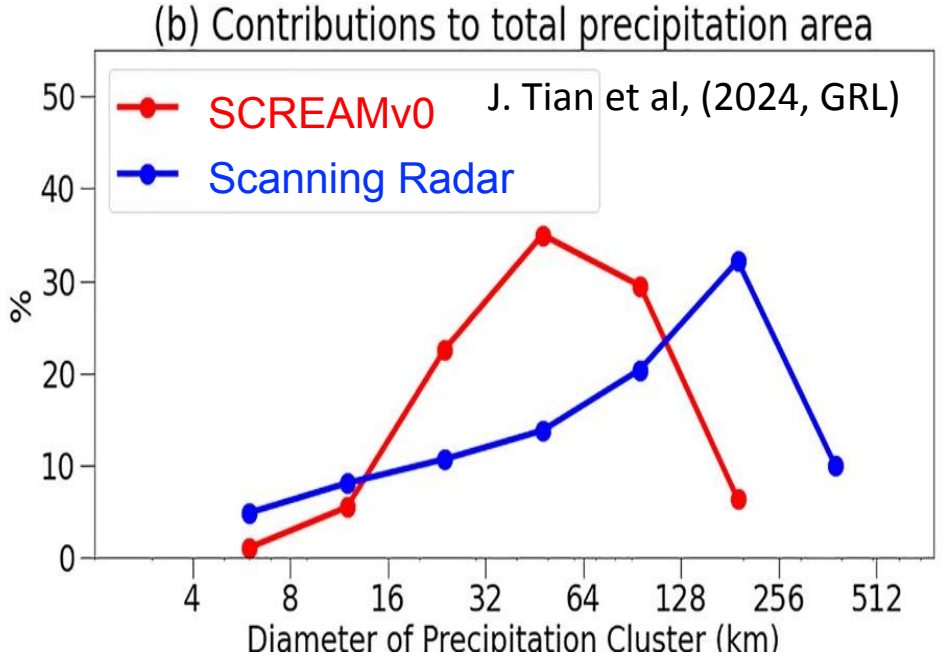
In close collaboration with E3SM/SCREAM model development teams and ARM infrastructure teams

- THREAD uses DOE ARM (and other observations) for diagnosis and improvement of E3SM's kilometer scale model configuration known as the Simplified Cloud-Resolving E3SM Atmospheric Model (SCREAM).

Convective systems do not grow large enough in SCREAM

Challenges

Even with global kilometer-scale models, mesoscale variability of convective clouds and precipitation are at the “gray zone” to be resolved and represented partially through parameterizations.



Underestimated precipitation cluster size
The so-called “popcorn” convection in SCREAM

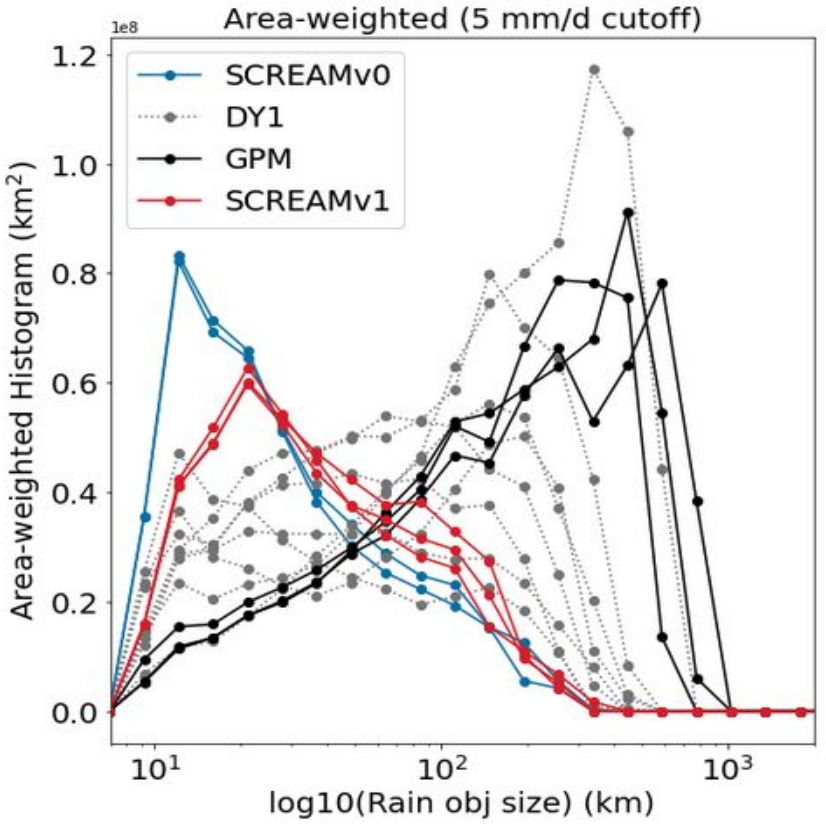


Figure curtesy of C. Terai and P. Caldwell

THREAD's RRM-SCREAM configurations

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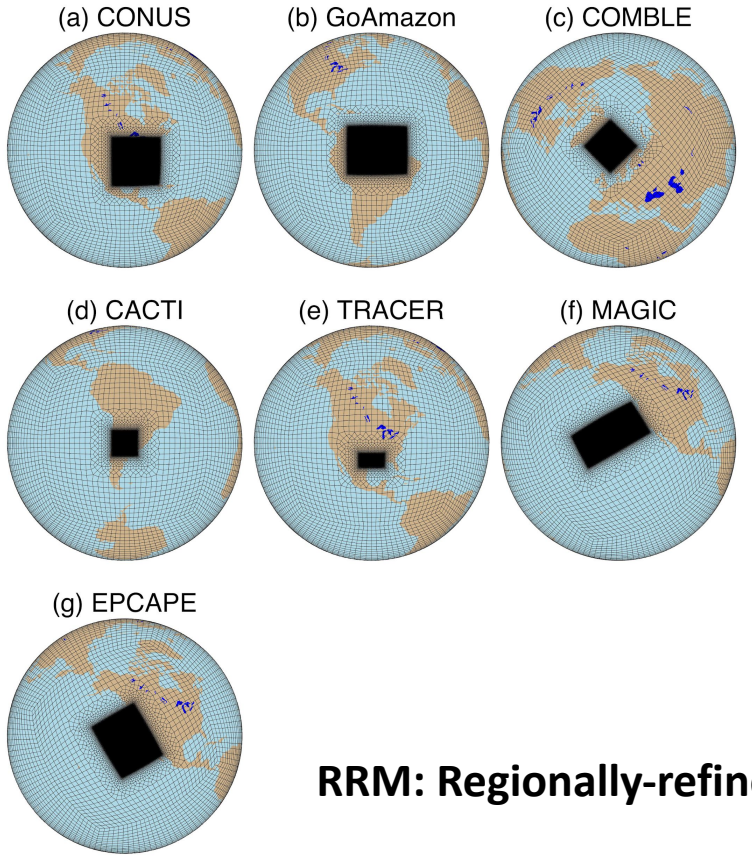
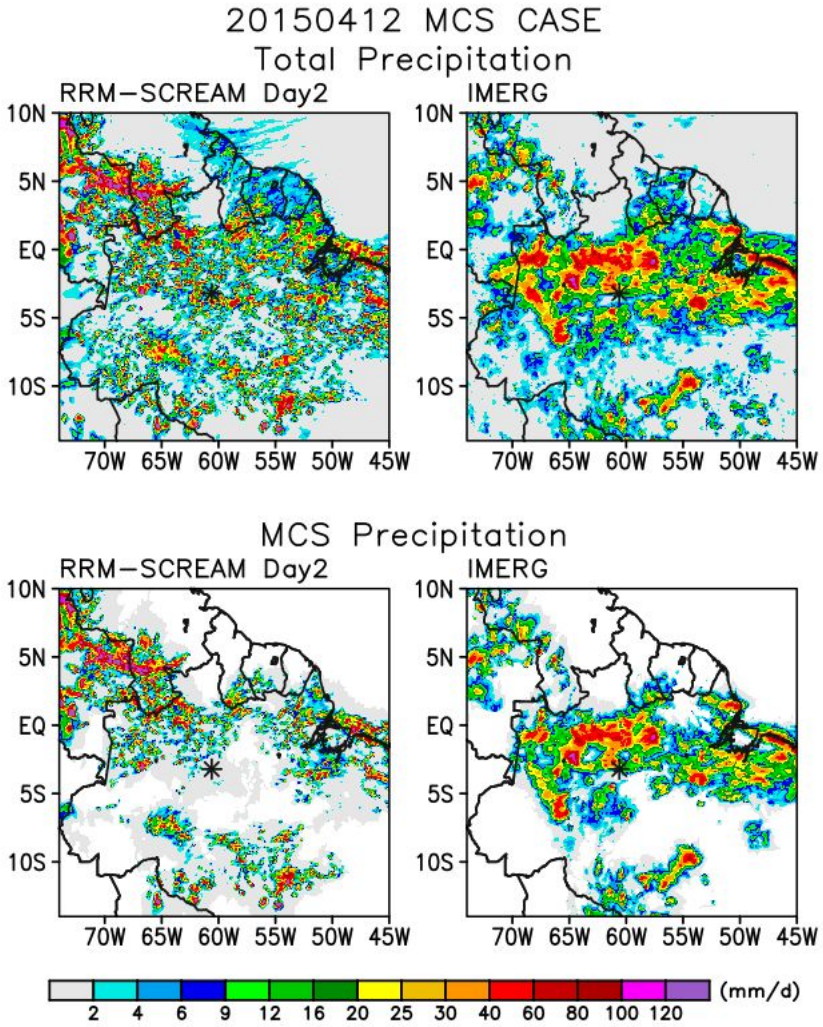
- RRM: An effective and efficient tool for high-resolution model development and diagnosis
- Seven RRM-SCREAM configurations are created to study convection over land, marine low clouds and land-atmosphere interactions in THREAD
- ~3.25 km in the refined region and ~100 km elsewhere around the globe

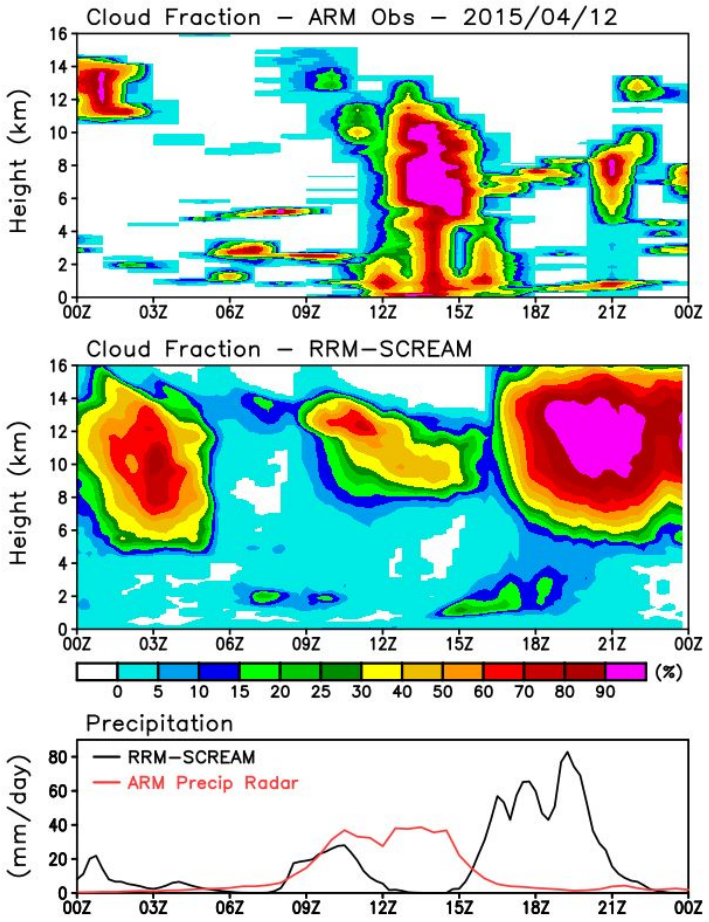
RRM-SCREAM configurations

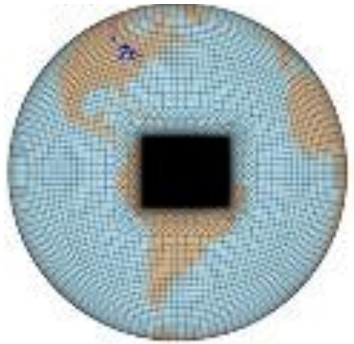


RRM: Regionally-refined Model

GoAmazon MCS case study (11 cases of 2-day hindcasts)

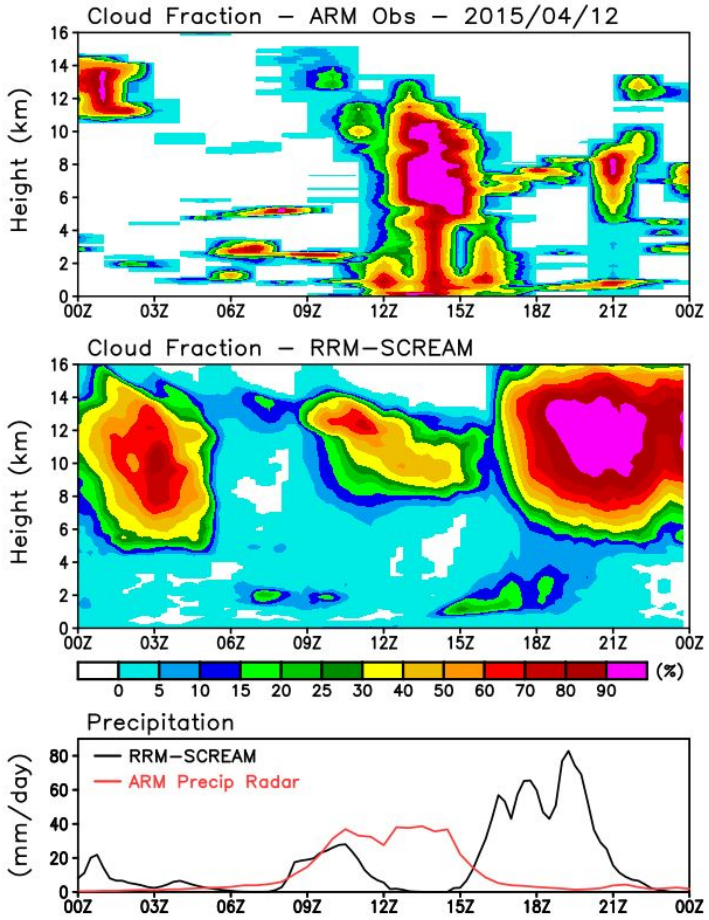


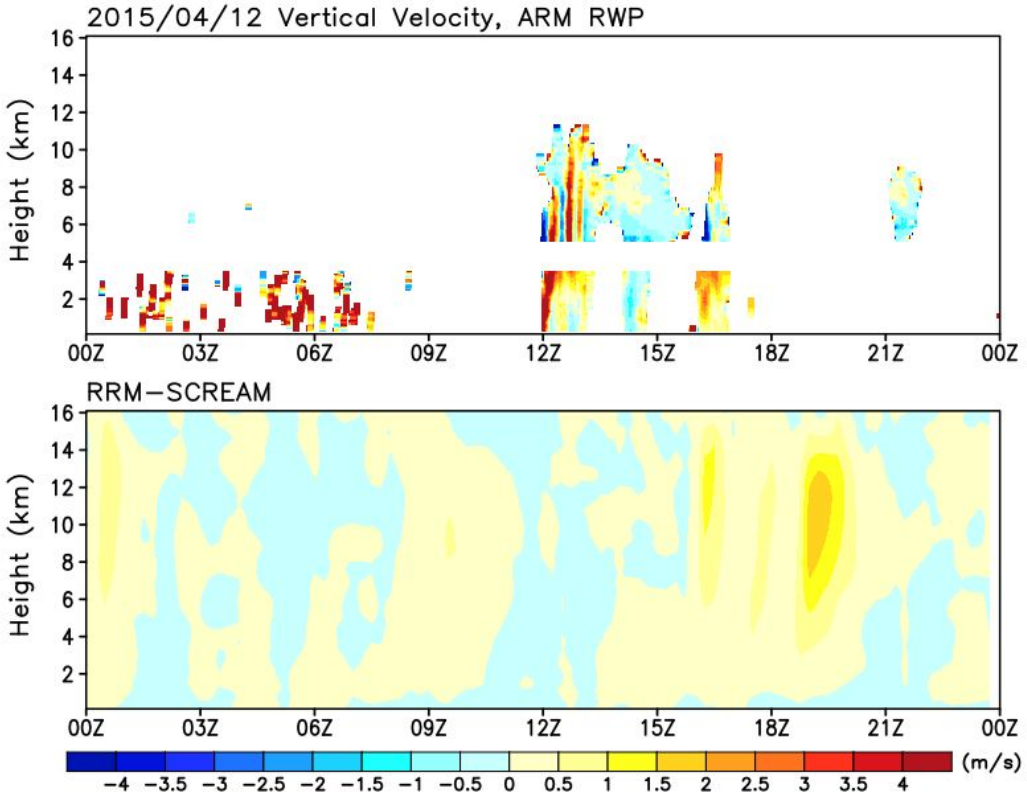




- Precipitation associated with MCSs are generally weaker by SCREAM, and convection is less organized
- Low- and middle-level cloud fraction is generally smaller in SCREAM
- Precipitation peak timing are generally off

GoAmazon MCS case study



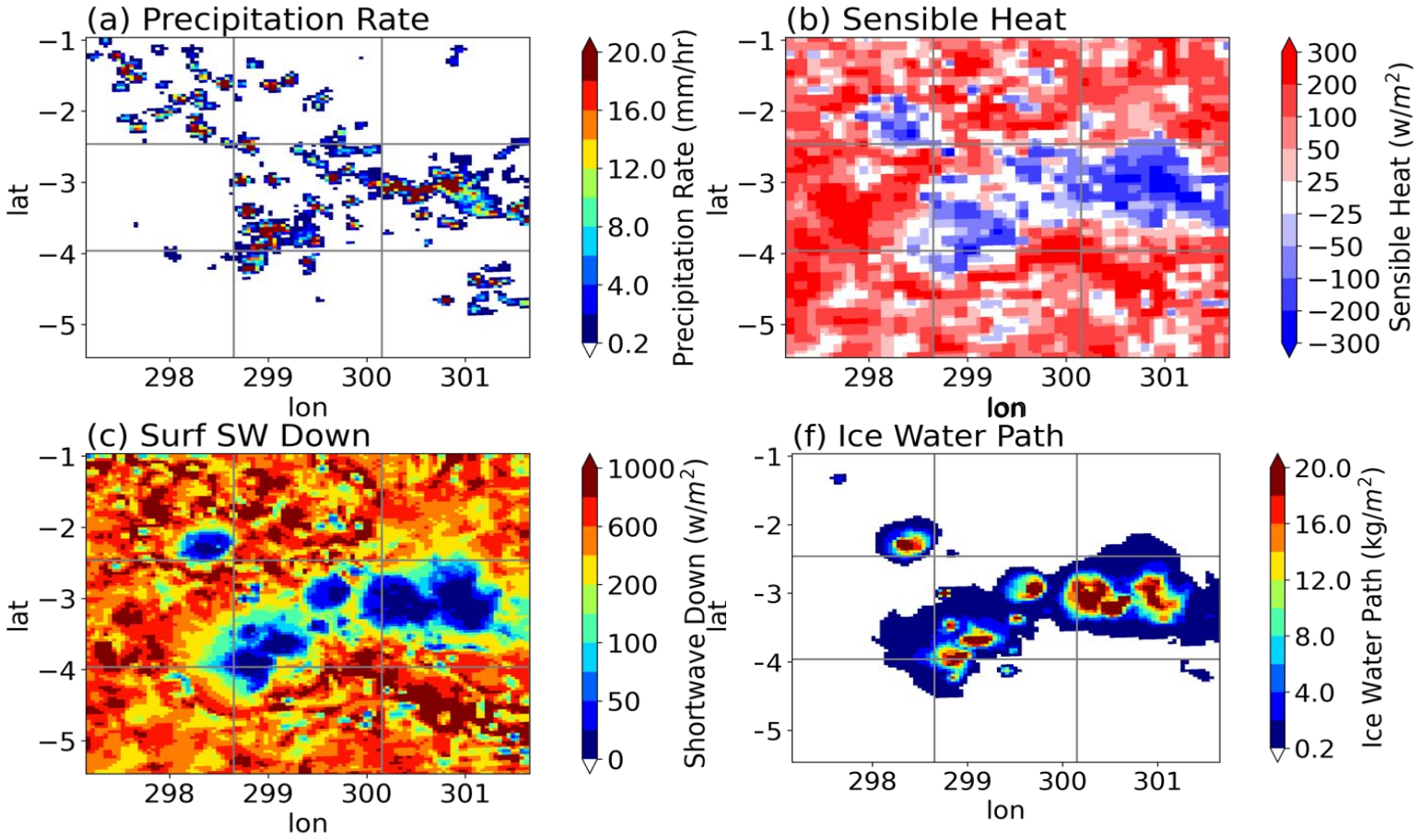


- SCREAM (bottom) simulates much weaker vertical velocity compared to ARM RWP (top)

What are the possible causes?

- Land-atmosphere couple for convection over land?
- Model horizontal resolution?
- Missing physics?

“Popcorn” Convection and Surface Coupling



J. Tian et al, (2024, GRL)

- Large areas of negative sensible heat fluxes cut off convection
- A complex interplay of land surface, radiation and microphysics

Higher model resolution can improve organization

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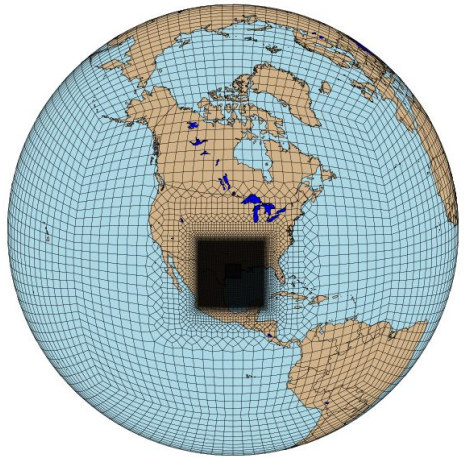
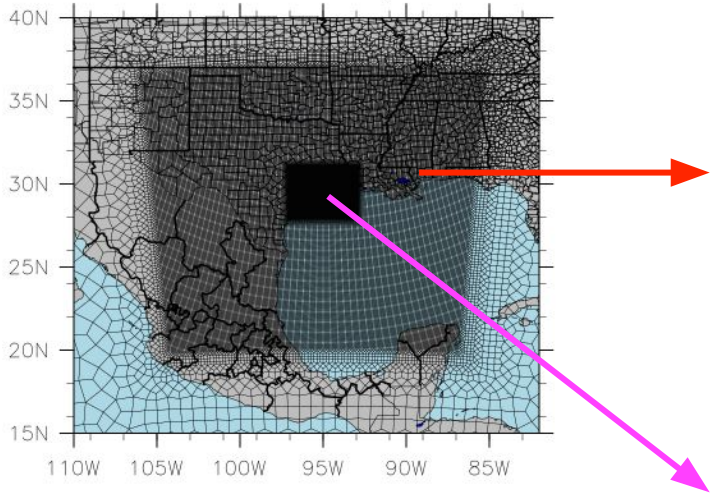
Two regionally refined meshes zooming into Huston, TRACER field campaign



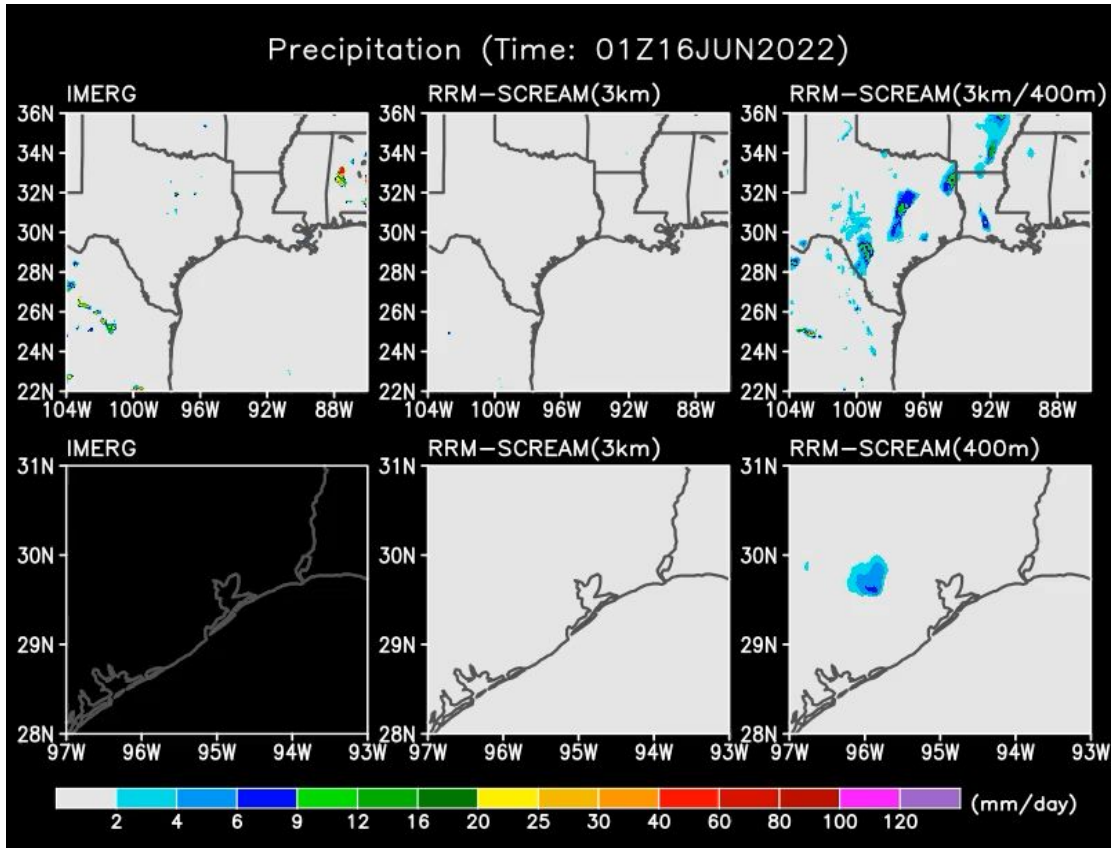


Default mesh design (100km -> 3km)

Multi-nesting mesh design (100km -> 3km -> 400m)

2022/06/17 Seabreeze Convective Precipitation

Satellite | default 3-km mesh | Multi-nesting 400-m



400-meter regionally refined SCREAM is more sensitive in reproducing the Seabreeze front driven convective precipitation when compared with the default 3-km mesh design

Summary

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- SCREAM can simulate the convection transition and MCS events but the precipitation peaks were weaker and convection is less organized. Vertical velocity over convective cores are also weaker
- Land-atmosphere coupling could be an issue in causing the convection organization over land
- Higher horizontal resolution can improve convection organization
- RRM is an effective and efficient tool for km-scale model development and diagnosis