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Use of Remote Sensing and In-Situ Observations to Develop and Evaluate Improved Representations of Convection and Clouds for the ACME Model

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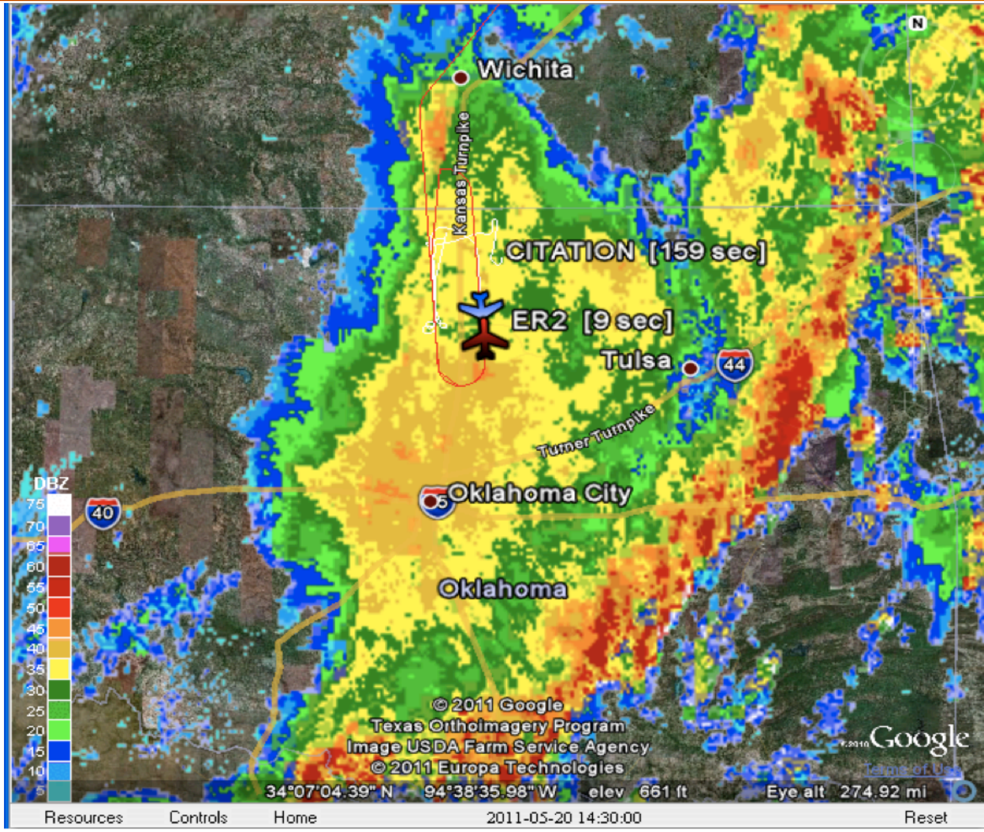
Motivation

- Mesoscale convective systems (MCSs) play important roles in the energy and water cycles.
- GCMs do not capture key MCS features.
- The Great Plains of the U.S. provide an excellent venue for studying continental propagating MCSs.



Hypotheses

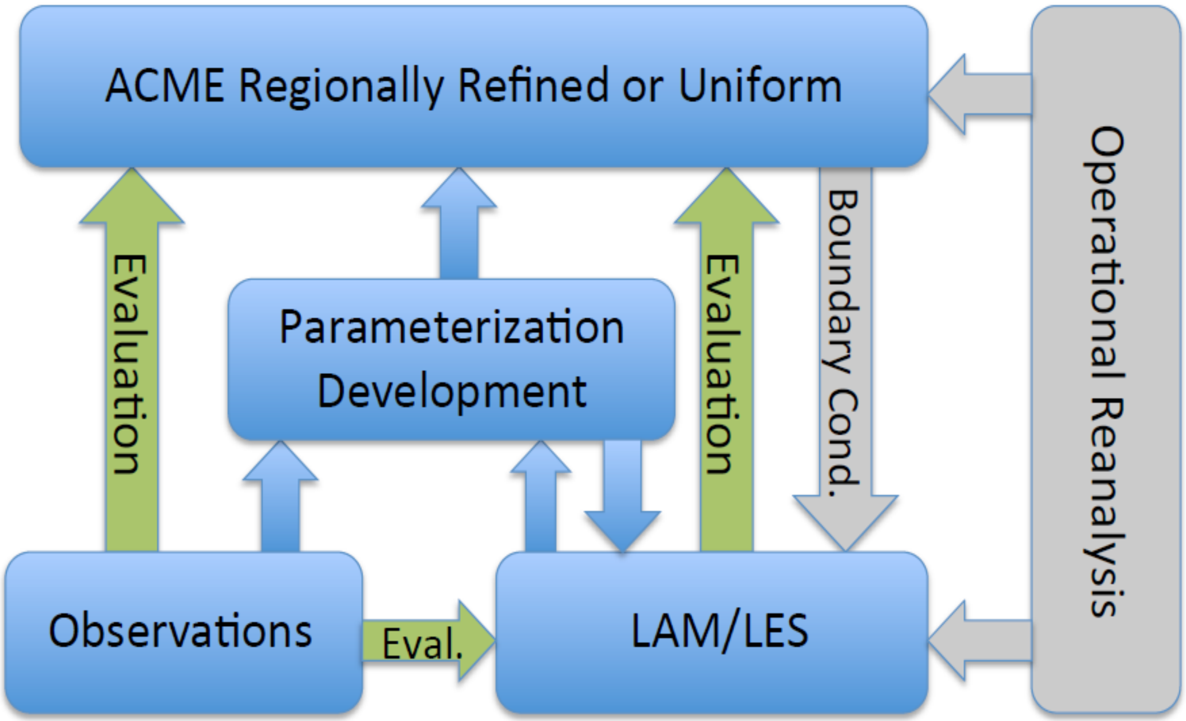
- GCM simulations including horizontal advection of key sub-grid properties of convective cloud systems will simulate MCS propagation better
- MCS features, precipitation PDF and extremes, cloud phase, cloud radiative forcing, and aerosol-cloud interactions will be simulated much better with an improved treatment of ice nucleation and variable width of hydrometeor size distribution
- Parameterizations tested over the central U.S. and Amazon will simulate clouds better elsewhere

Objectives and deliverables

- **Goal:** Improve understanding and simulations of MCS features in large-scale models

- **Deliverables:** Convection and cloud microphysics parameterizations for GCMs that yield better simulations of mesoscale phenomena

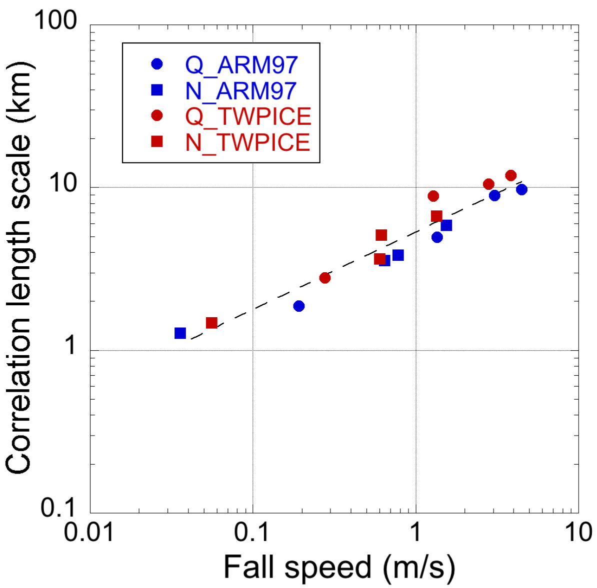
Strategy

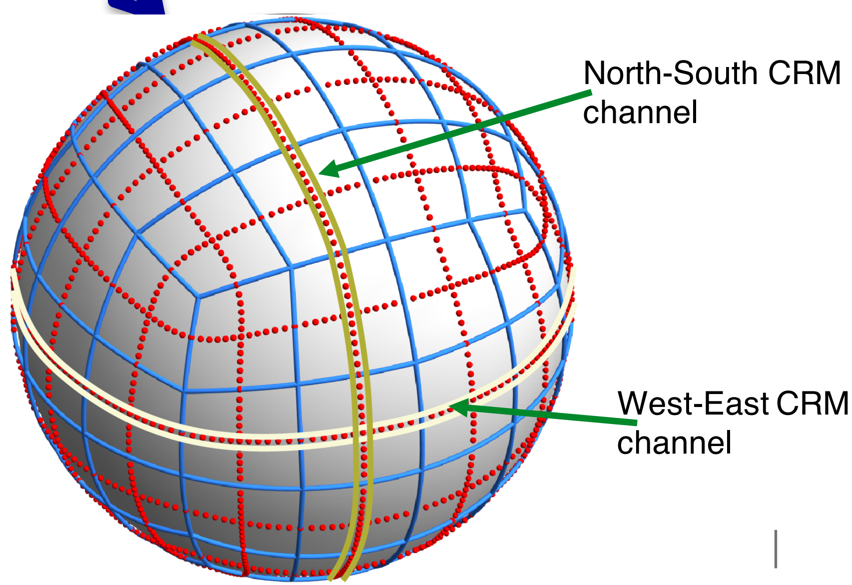


- Use observations and cloud-resolving and large eddy simulations to develop and evaluate cloud parameterizations.
- Evaluate parameterizations using ACME with a regionally-refined grid centered over the ARM SGP site.
- Use additional global observational data to evaluate ACME uniform-grid simulations.

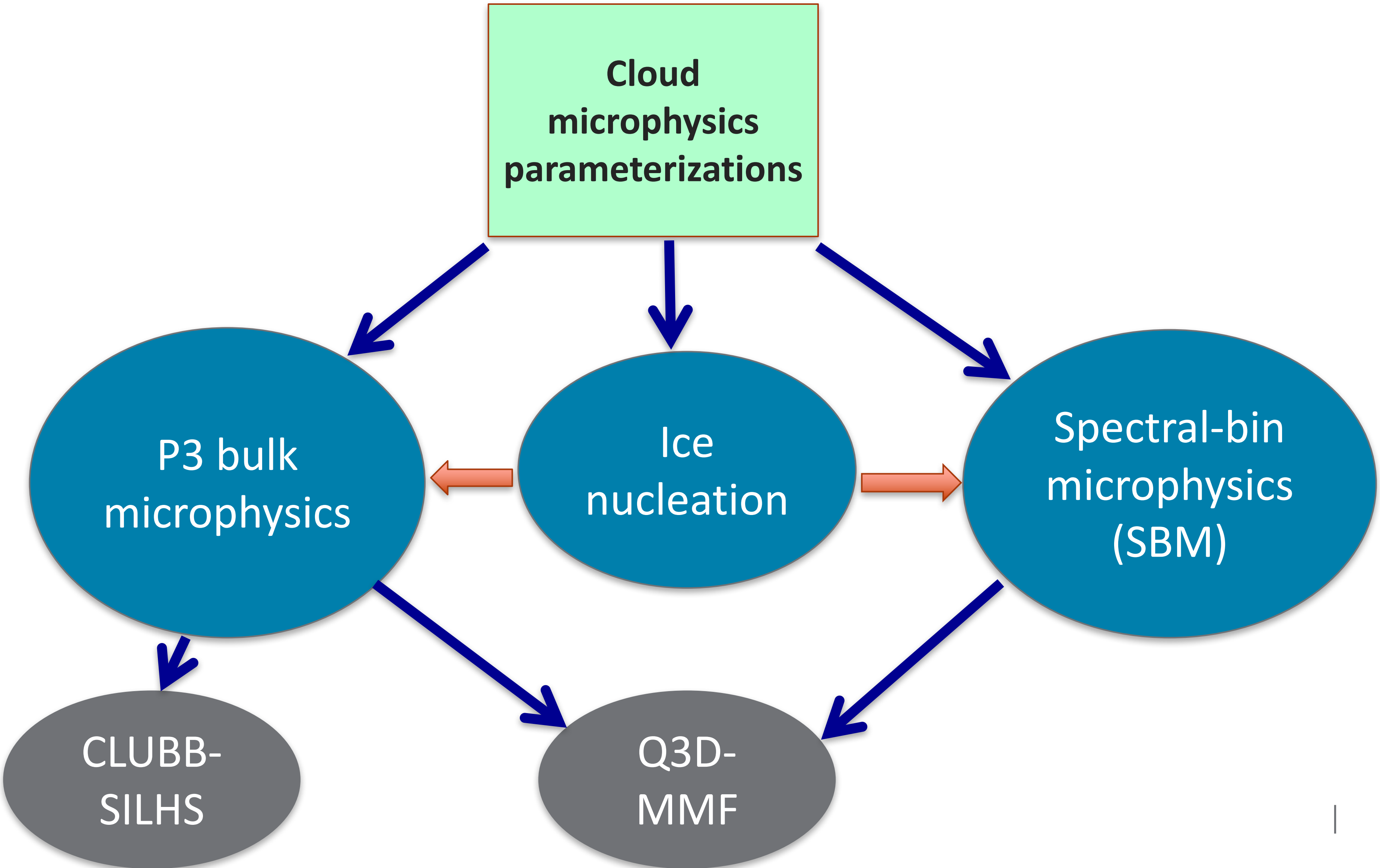
Development of convection parameterizations

Convection parameterizations

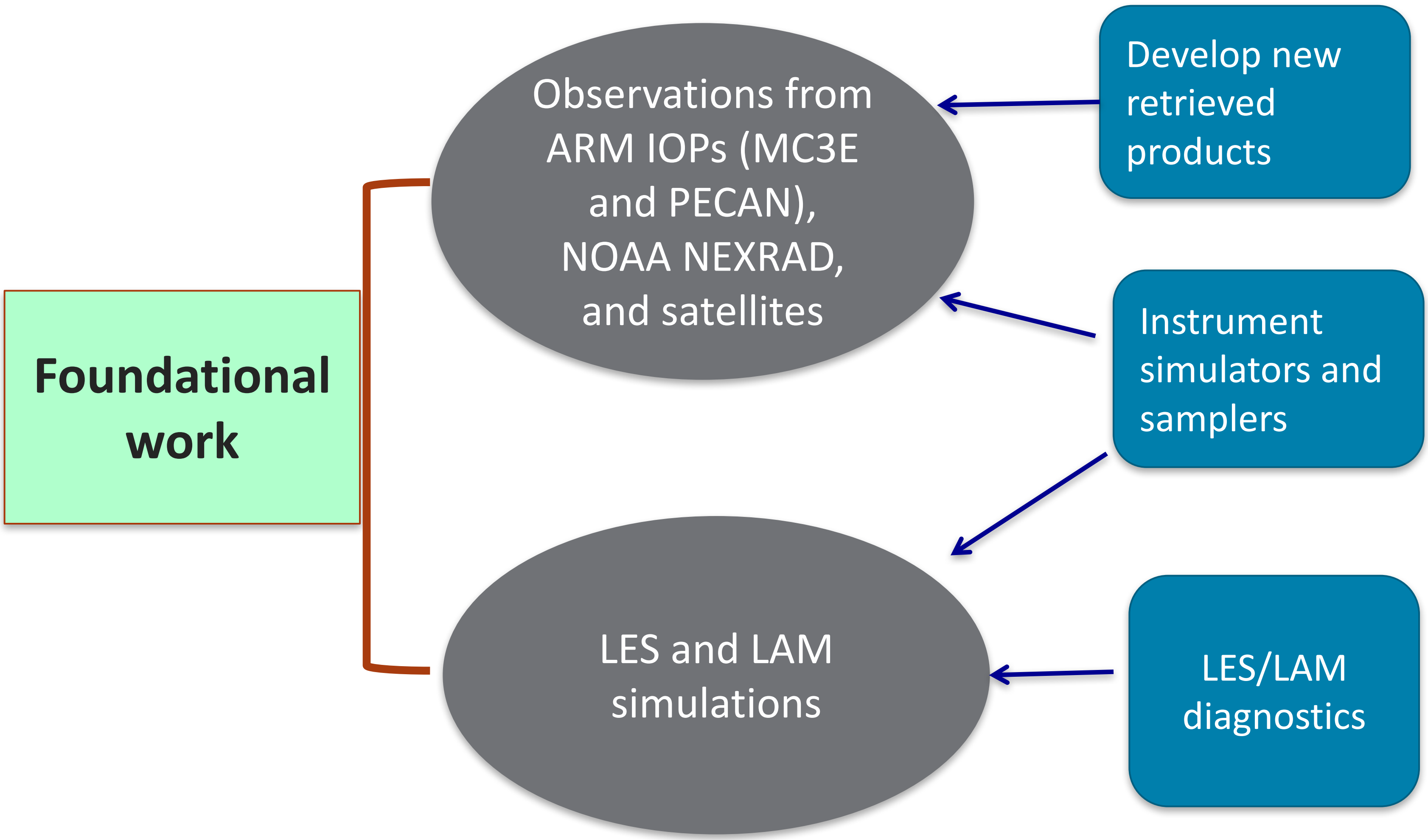




Development of cloud microphysics parameterizations

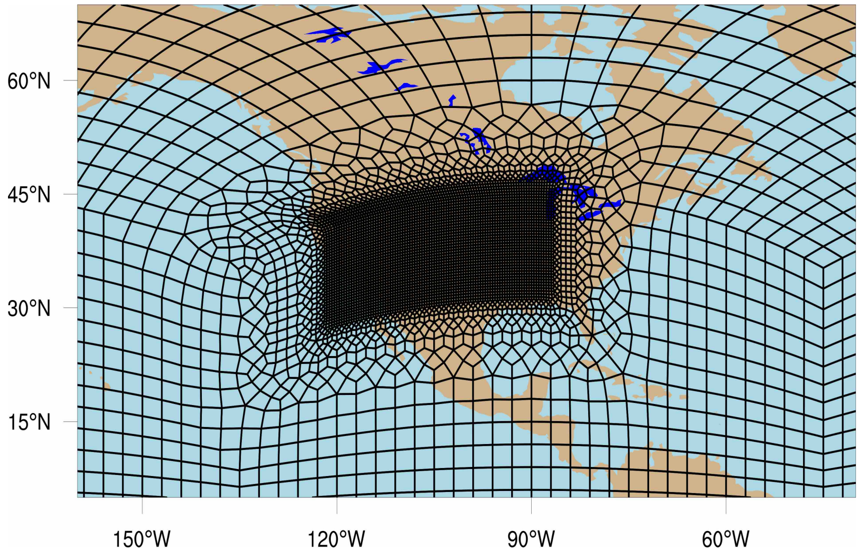


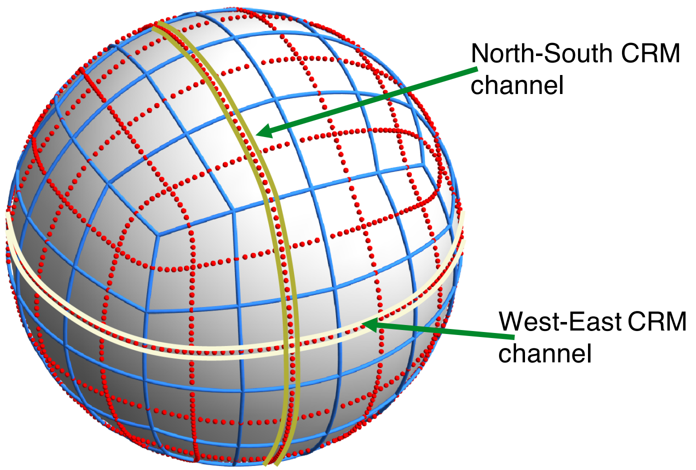
Foundational work for evaluation



Evaluation: configuration

- ACME regionally-refined (RR) simulations
  - From 1 degree down to 1/4, 1/8, and 1/16 degrees
- ACME uniform-resolution (UR) simulations at 1 and 0.25 degrees
- Q3D MMF simulations
  - 1-mom cloud microphysics
  - 2-mom cloud microphysics
  - Spectral cloud microphysics





Evaluation: simulations

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Cloud parameterization	Grid Configuration	Duration	Mode
CLUBB-MG2	UR 1°	Overlapping 3 day sims for month long periods	Hindcast
CLUBB-MG2	UR 0.25°	Overlapping 3 day sims for month long periods	Hindcast
CLUBB-MG2	RR 0.25° to 10 km	Overlapping 3 day sims for month long periods	Hindcast
MMF-1MOM	UR 1° + 4 km	Overlapping 3 day sims for month long periods	Hindcast
Q3D-MMF-1MOM	UR 1° + 4 km	Overlapping 3 day sims for month long periods	Hindcast
CLUBB-MG2	UR 1°	5 years	Free running
CLUBB-MG2	UR 0.25°	5 years	Free running
CLUBB-MG2	RR 0.25° to 10 km	5 years	Free running
MMF-1MOM	UR 1°+ 4 km	5 years	Free running
Q3D-MMF-1MOM	UR 1°+ 4 km	5 years	Free running
Q3D-MMF-ECPP-MG2	UR 1°+ 4 km	5 years	Free running
Q3D-MMF-ECPP-SBM	UR 1°+ 4 km	1 year	Free running
Q3D-MMF-ECEP-MG2	UR 1°+ 4 km	1year	Free running

- Focus on the evaluation of CLUBB, Q3D MMF, new MG2, and SBM.

Evaluation: focused properties

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- Low-level jet and cold pools
- Diurnal variation of convection over the U.S. Great Plains
- Propagation of convection
- Cloud microphysics
- MCS structure analysis
- Surface radiative fluxes, precipitation, temperature and boundary layer processes

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Evaluation: observational data

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ARM field campaign data

- **MC3E, PECAN, GoAmazon, and SPARTICUS**
- **Meteorological properties**: sounding, radiosonde, variational analysis, Raman lidar, surface met.
- **Convection and cloud properties**
  - Retrievals from radars and lidars including KAZR, MMCR, CSPAR, RWP
  - Aircraft in-situ
  - Disdrometers

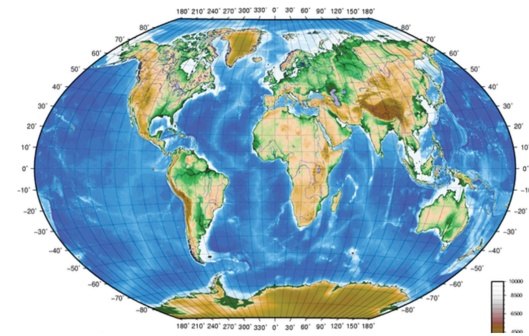
ARM long-term data at the SGP site

- Surface met.
- Cloud, convection, precipitation: RWP, disdrometers, ARSCL
- Radiation and precipitation: surface radiometer, rain gauge

Other sources

- NOAA NEXRAD
- NASA GOES, CERES, GPCP, TRMM, GPM
- NLDAS, Oklahoma Mesonet

Evaluation: global assessment



free running UR simulations at 1 and 0.25 degrees

- Standard ACME diagnostics
- Satellite datasets (NASA CERES cloud and radiation products, and TRMM, GPCP and GPM precipitation products) for other climate regimes such as tropical oceanic and continental convection
- Statistics of satellite data to evaluate MCS structures and other global features (e.g., MJO, ITCZ)

Impact

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- Demonstrate a climate model evaluation framework that uses comprehensive observational datasets **at different scales** to understand mesoscale convective processes and evaluate representations of those processes in state-of-art climate models.
- Significantly improve ACME simulations

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