Pacific Northwest NATIONAL LABORATORY

Different rainfall characteristics in MCS and non-MCS events lead to different hydroclimate impacts and roles in land-atmosphere interactions

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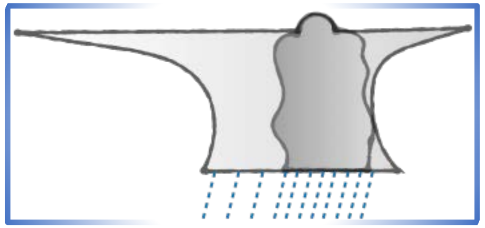
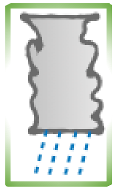
Motivation:

- Mesoscale Convection Systems (MCSs) account for 30-70% of warm-season rainfall in the central US
- Rainfall associated with MCS and that not associated with MCS (non-MCS) events are characterized with distinct rainfall intensity and frequency





Different MCS and non-MCS rainfall characteristics

MCS rainfall is ~7 times more intense than non-MCS rainfall	Non-MCS rainfall occurs more frequently in time and space

Hu et al. (2020) GRL

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Different hydrologic impacts and ecosystem responses

Partitioning into runoff, evapotranspiration and different terrestrial water storages

Hu et al. (2020) JHM

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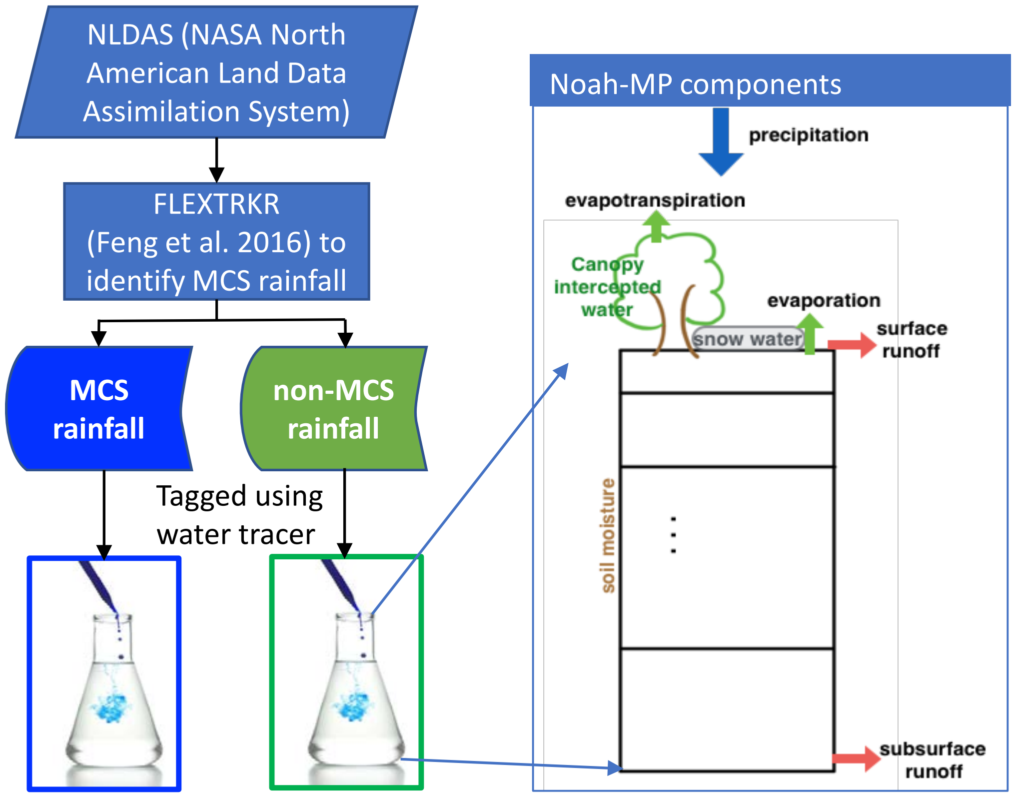
Different roles in land-atmosphere interactions

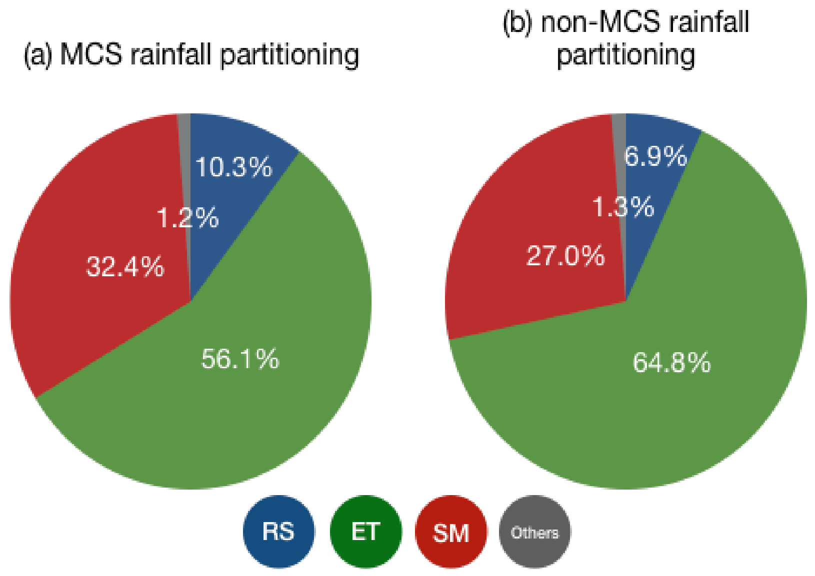
Moisture availability	Soil moisture gradient induced mesoscale circulation

Different Hydroclimatic impacts of MCS and non-MCS rainfall

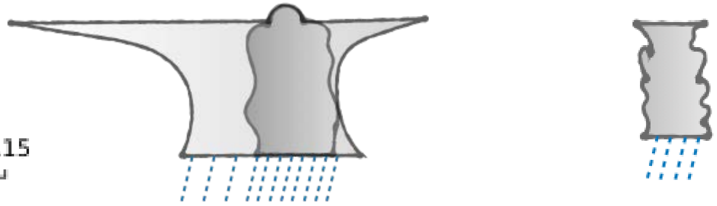
Approach:

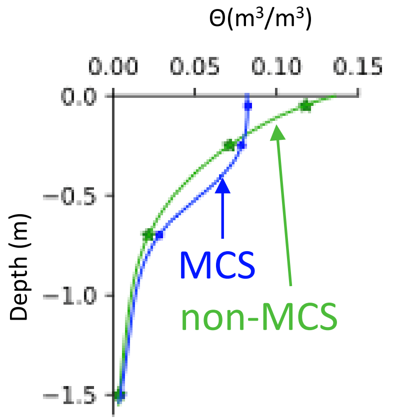
- Use a water tracer tool to numerically tag rainfall sourced from **MCS** and **non-MCS** events, and track their flow and transit in the terrestrial system in a land surface model
- Quantify their contributions to major components in the surface water balance (surface runoff, evapotranspiration and soil moisture) throughout the warm season and attribute to their characteristics





RS: surface runoff
ET: evapotranspiration
SM: soil moisture





- **MCS** rainfall is the primary source of surface runoff
- Penetrates to deeper soil layers

- **Non-MCS** rainfall has greater contribution to evapotranspiration
- Stays shallower in the soil

Hu et al. (2020) JHM

Dominant role of earlier-season MCS rainfall on July rainfall

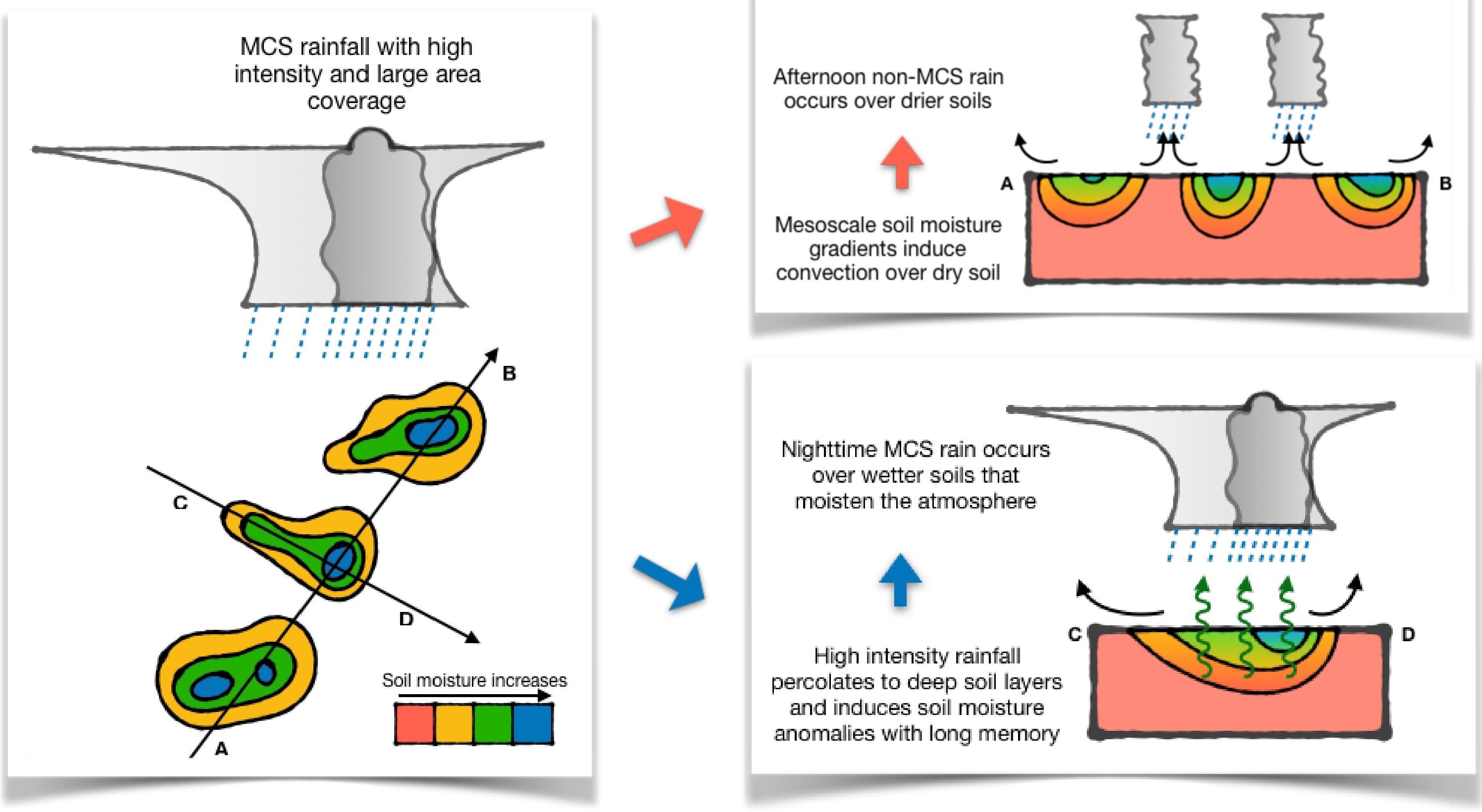
Approach:

- Analyze the sub-daily preferential states of soil moisture favorable for July rainfall and attribute the preferential soil states to earlier-season MCS or non-MCS rainfall
- Examine coupling strengths between antecedent soil moisture (from MCS and non-MCS) and subsequent rainfall (MCS and non-MCS) and how the strengths change with lead time

Results:

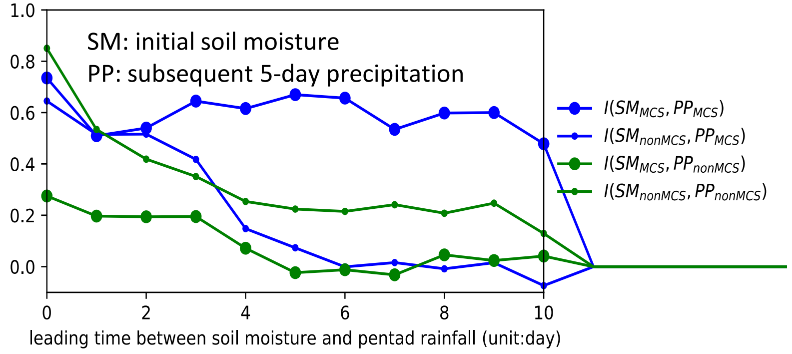
Earlier season (April - June) rainfall

July rainfall

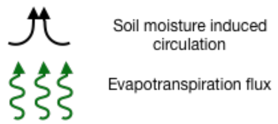


Coupling strength (Dirmeyer 2011):

$$\mathrm{I}(SM, PP) = \sigma(\mathrm{SM}) \cdot \frac{dPP}{dSM}$$

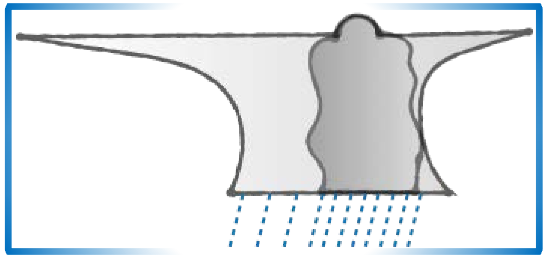


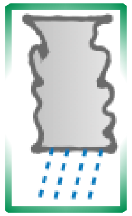
- The coupling strength between soil moisture from antecedent **non-MCS** rainfall and July rainfall drops quickly with lead time
- Soil moisture from **MCS** rainfall, however, are strongly coupled with subsequent MCS rainfall with longer lead time, due to its deeper percolation



Hu et al. (2020) To be submitted.

Summary and Future Research





Rainfall characteristics

MCS rainfall is ~7 time more intense than non-MCS rainfall	**non-MCS rainfall occurs more frequently in time and space**

Key terrestrial water storages and fluxes

MCS rainfall is a major contributor to surface runoff	**non-MCS rainfall is more important to evapotranspiration**

Soil moisture-precipitation feedbacks

Earlier-season MCS rainfall plays predominant role in soil moisture-precipitation feedbacks in July	**Earlier-season non-MCS rainfall is an important moisture sources for July rainfall but with shorter leading time**

Short-term goals:

- Use tracer-enabled coupled WRF simulations to better understand role of antecedent soil moisture (sourced from MCS and non-MCS rainfall) in MCS processes
- Estimate the role of surface and subsurface lateral flow to the transit time of MCS and non-MCS rainfall sourced water and soil moisture heterogeneity in the land surface

Long-term goals:

- Use a combination of numerical models and machine learning techniques to better quantify the movement of water in the coupled land-atmosphere system to advance understanding and modeling of soil moisture-precipitation feedback and the contributions of land processes to predictability of regional precipitation.

References:

Hu, H., L. R. Leung, and Z. Feng, 2020a: Observed Warm-Season Characteristics of MCS and Non-MCS Rainfall and Their Recent Changes in the Central United States. *Geophysical Research Letters*, **47**, 46–11, https://doi.org/10.1029/2019gl086783.

Hu, H., L. R. Leung, and Z. Feng, 2020: Understanding the distinct impacts of MCS and non-MCS rainfall on the surface water balance in the central US using a numerical water-tagging technique. J Hydrometeorol, 21, 1–38, https://doi.org/10.1175/jhm-d-20-0081.1.

Hu, H., L. R. Leung, and Z. Feng, 2020c: Earlier-Season Mesoscale Convective System Rainfall Dominates Soil Moisture-Precipitation Feedback for Summer Rainfall in Central US. To be submitted.