Pacific Northwest
NATIONAL LABORATORY

The Roles of Large-Scale Advection and Land surface Conditions in the Initiation of Convection during HI-SCALE

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U.S. DEPARTMENT OF ENERGY | BATTELLE | ARM | ASR Atmospheric System Research

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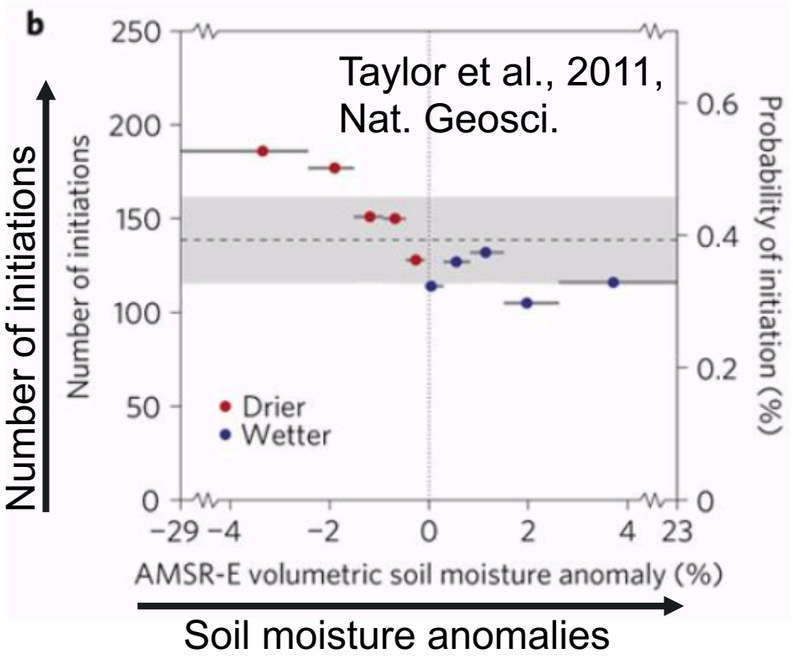
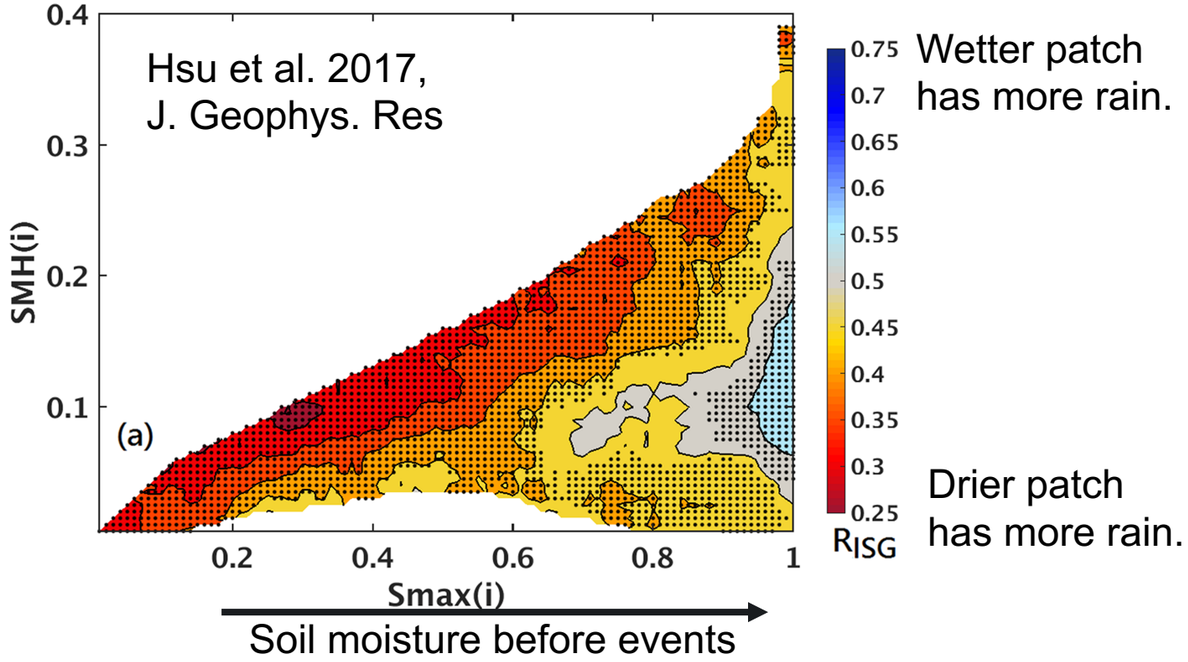
Convection Initiations and Land-Atmosphere Interactions



- Negative soil moisture feedback



- Relatively drier (wetter) patches have more possibilities to receive rain in dry (wet) conditions.

Scientific Question:

- How are the land surface conditions related to the initiation of convection and how does large-scale advection affect this relationship?

Methodology

Case Overview

- **Time and Location:**
  - August 30th, 2016
  - Southern Great Plain
  - HI-SCALE Field Campaign
- A “golden day” with transitions from shallow to deep convection

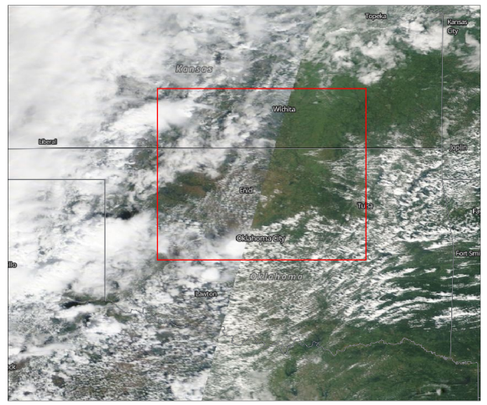
WRF-LES Simulations

1. Control Simulation

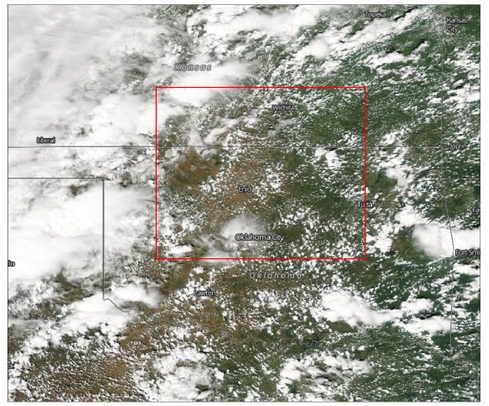
- 08/30/2016 5:29 to 17:29
- Domain Size: 297km×297km
- Spatial Resolution: 300m
- Realistic SMOIS and LU.
  (Fast et al., JAMES, 2019, in revision)

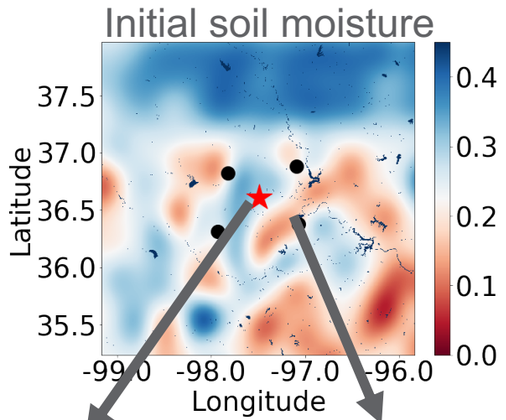
2. “No Advection” Simulation

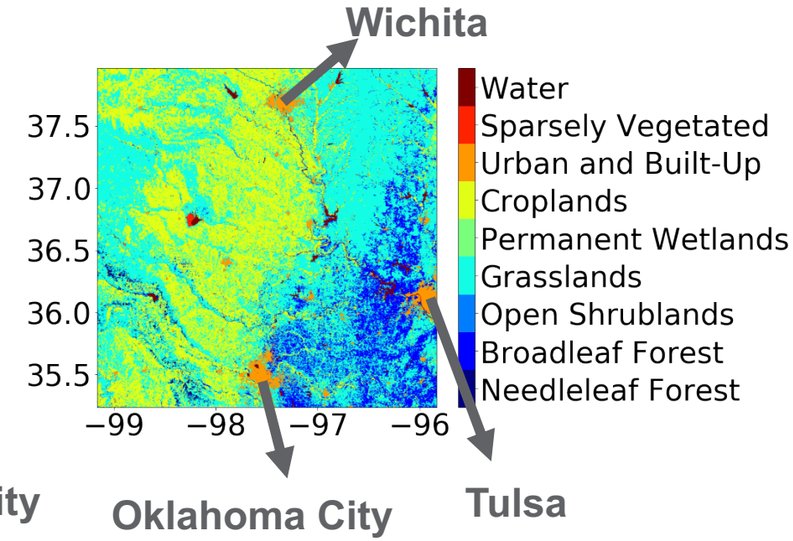
MODIS Terra ~1030 CST



MODIS Aqua ~1350 CST

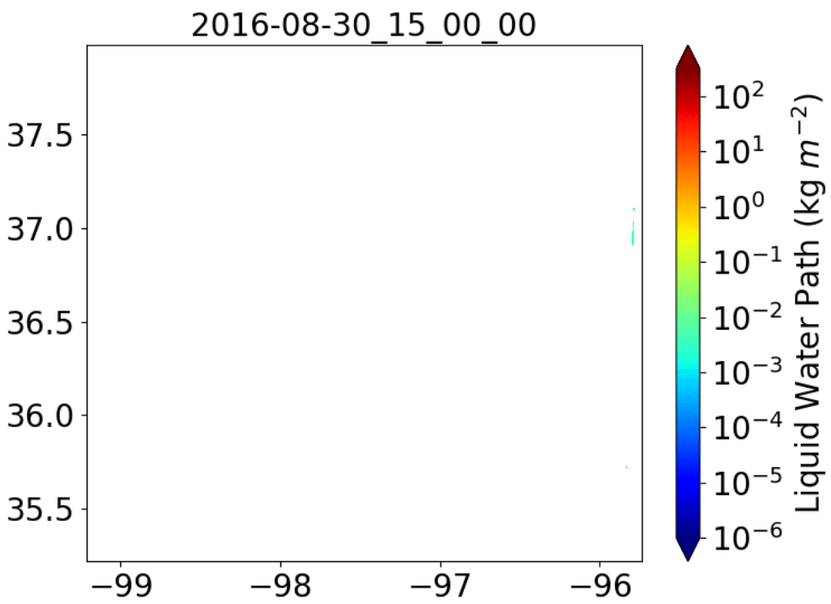




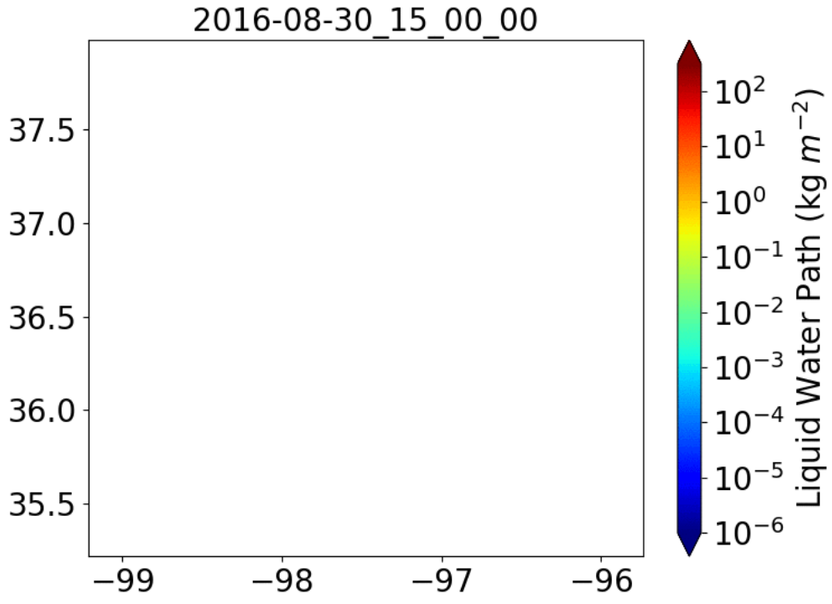


Impacts of Large-Scale Advection on Clouds

Control



“No advection”

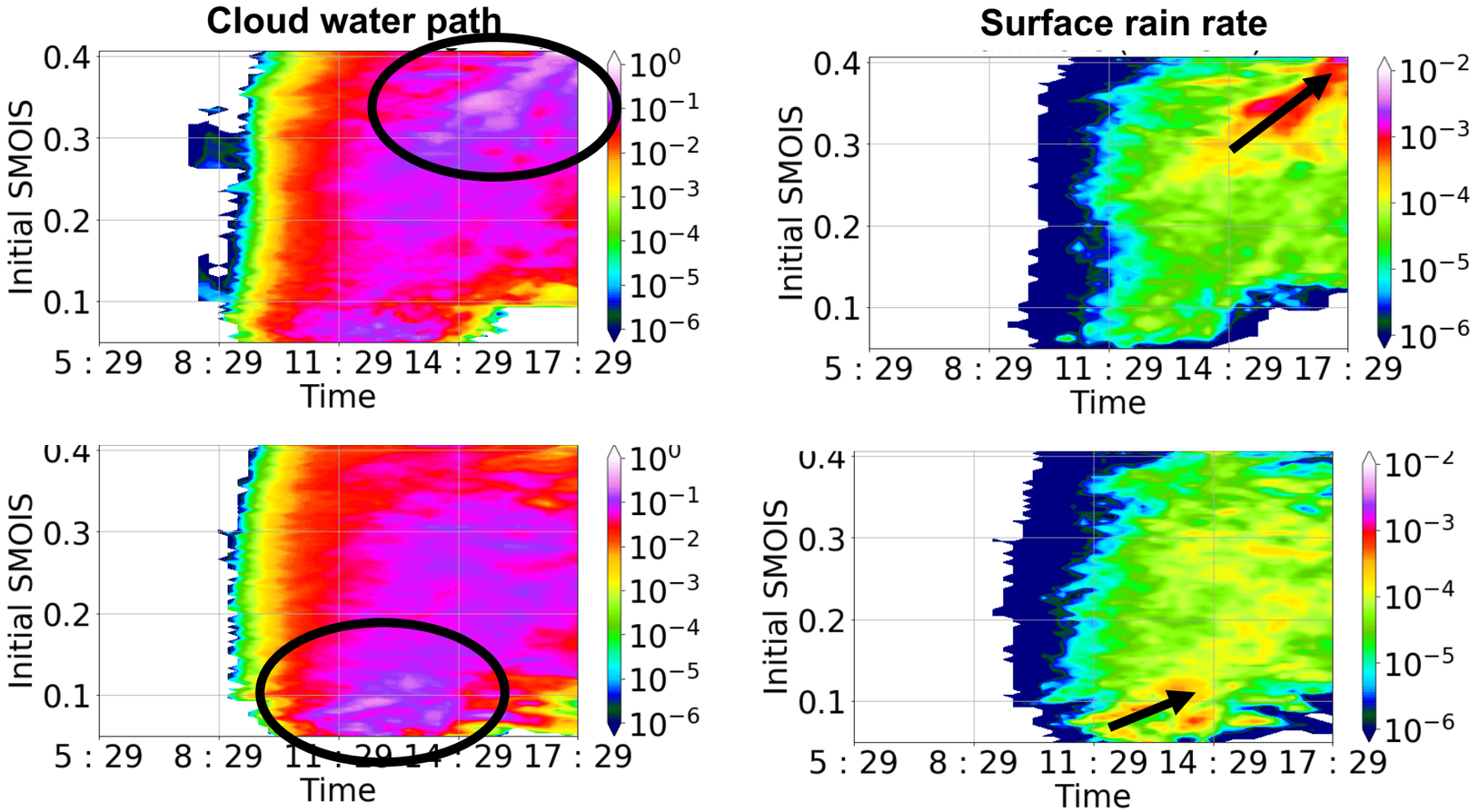


- Large-scale advection causes more organized clouds on the west of the domain.

Impacts of Large-Scale Advection on LAIs

Control

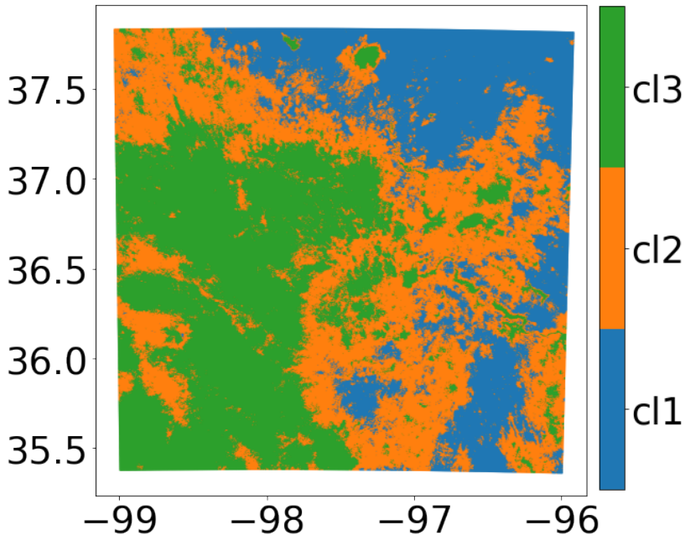
“no advection”

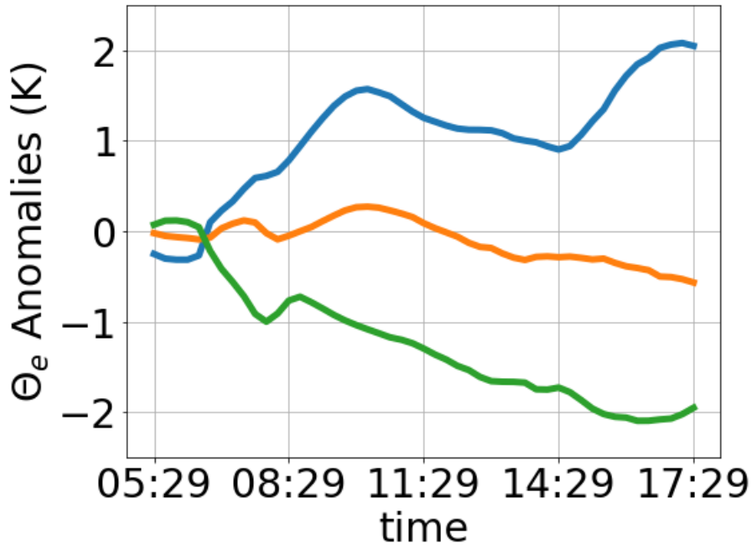


In the absence of advection,

- clouds are more likely over the dry soil;
- rain rates increase earlier than those in the control simulation.

Cluster Analysis of “No Advection” Simulations

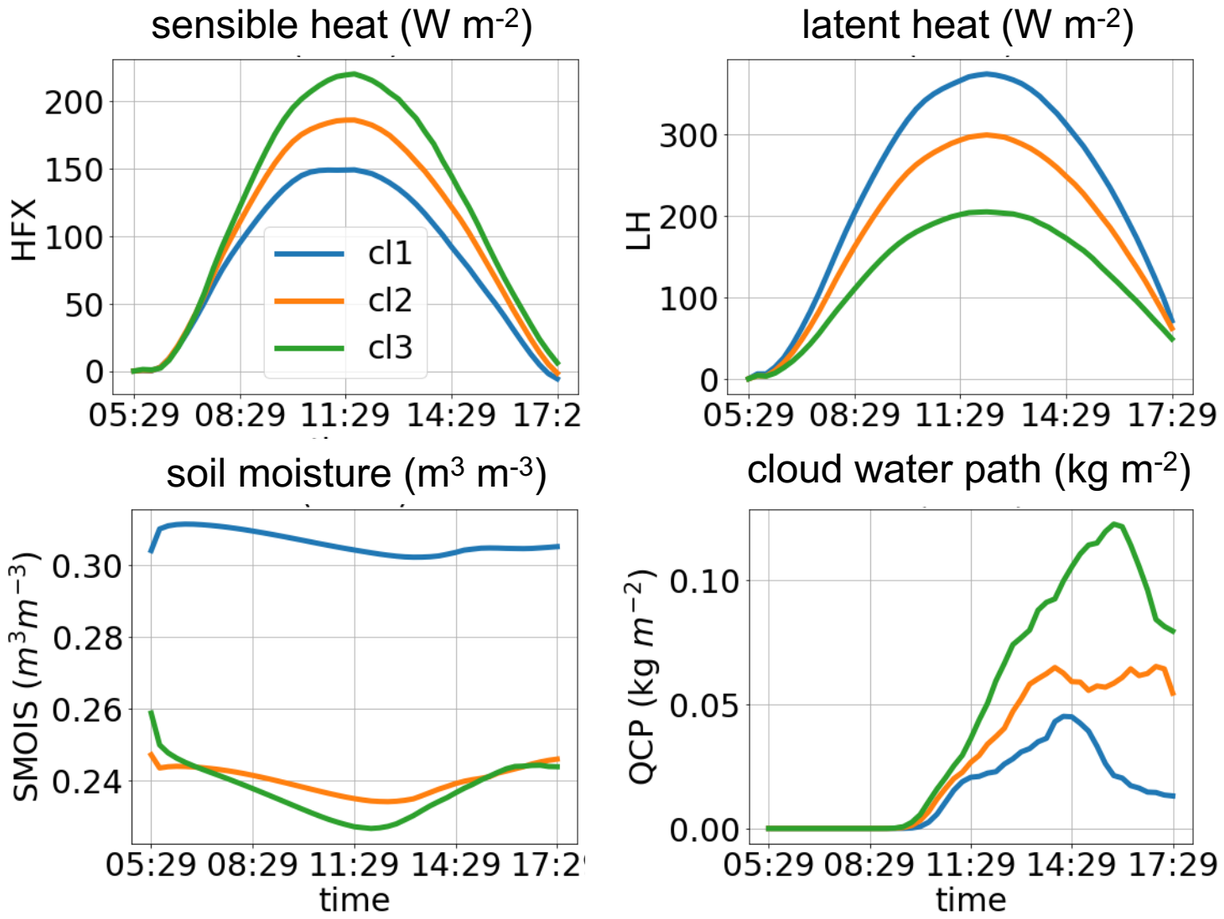




“K-means” unsupervised learning

- Samples: θ_e close to surface (~30m)
- Features: 49 time steps
- Three clusters
- The features of convection close to the surface, represented by θ_e', are dramatically different.

Land and Cloud Properties of Each Cluster



- The cluster with positive $\theta_e{}'$ is associated with low sensible heat, high latent heat, high soil moisture, and low cloud water path, and vice versa.

Summary

1. Large-scale advection weakens the land forcing and delays precipitations.
2. In the absence of advection, most of the clouds are over the dry soil while large-scale advection moves the clouds over the wet soil.
3. In the absence of advection, LAIs are explored by cluster analysis of θ_e.
   - Learning algorithm successfully divides the time series of θ_e into three different clusters, which represent different convection features.
   - Low HFX, high LH, and high SMOIS grids are associated with high θ_e.
   - Clouds forms over high HFX, low LH, and low SMOIS grids, where low θ_e are observed.

My poster is at 3:30-5:00 on Wednesday (B1).