Soil Moisture and Land-Atmosphere Coupling with Higher Resolution Soil Moisture
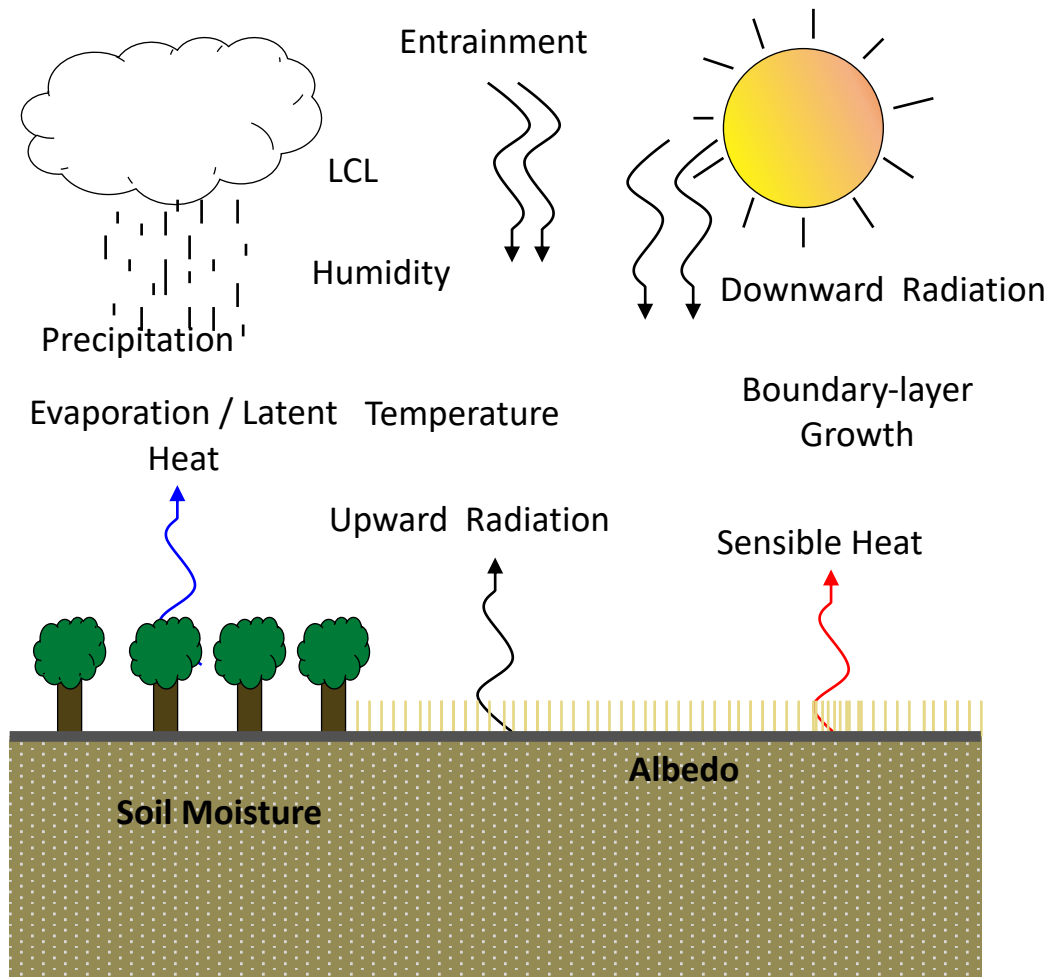
Joshua K. Roundy

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University of Kansas

Wednesday October 11, 2023

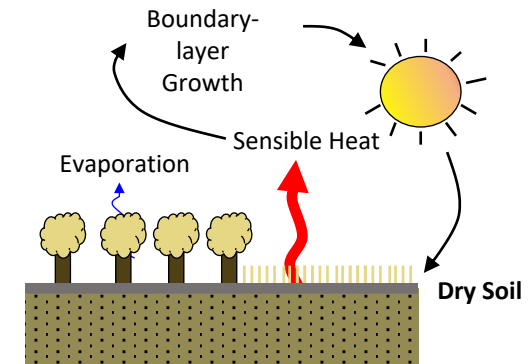JPL CCS workshop: Science of 10-km L-band Radiometry
Pasadena, CA

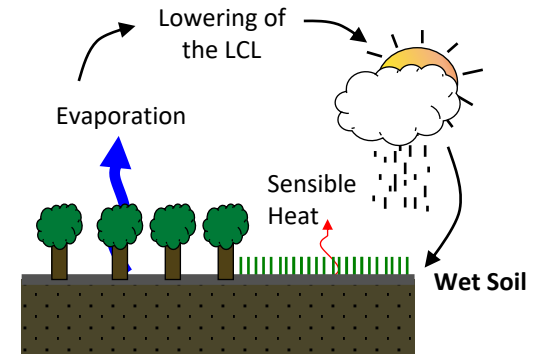# Land Atmosphere Interactions Impact on Extreme Events

While land-atmosphere coupling plays a role in these events, consistent large-scale forcing is also necessary
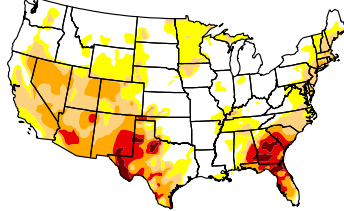
Current Remote Sensing capabilities Provide Insights for Large Scale Droughts
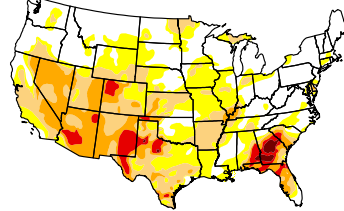
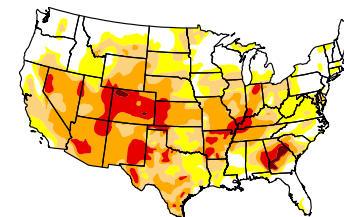

US Drought Monitor

Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

May 8, 2012
Jun 5, 2012
Jul 3, 2012
Jul 31, 2012
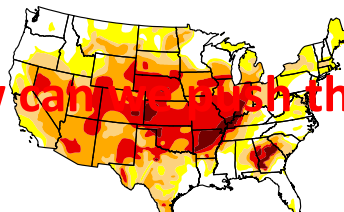
Class Change
Recovery   Intensification

- 1 Class Improvement
- 2 Class Improvement
- 3 Class Improvement
- 4 Class Improvement
- 5 Class Improvement
- No Change
- 5 Class Degradation
- 4 Class Degradation
- 3 Class Degradation
- 2 Class Degradation
- 1 Class Degradation
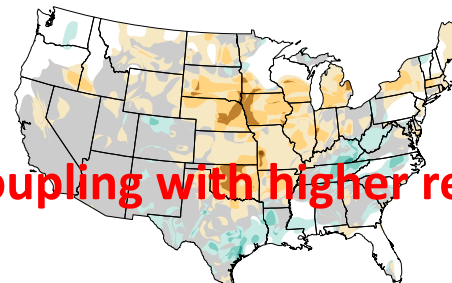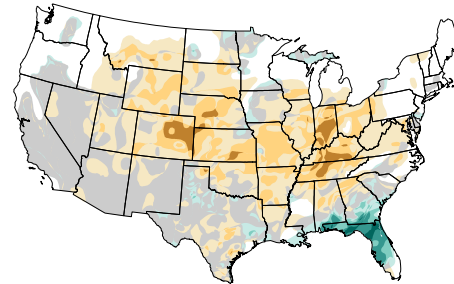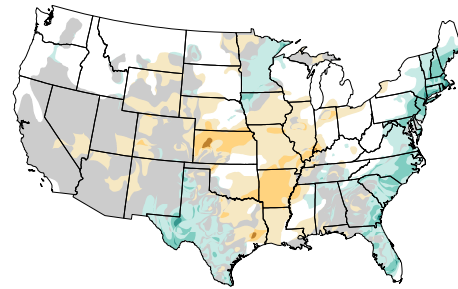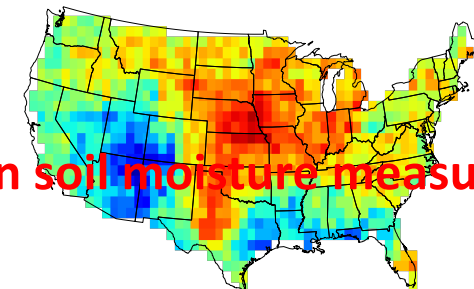
Remote Sensing Coupling Anomalies
Recovery   Intensification

−0.8 −0.6 −0.4 −0.2 0.0 0.2 0.4 0.6 0.8
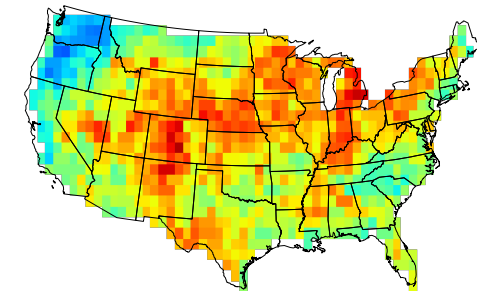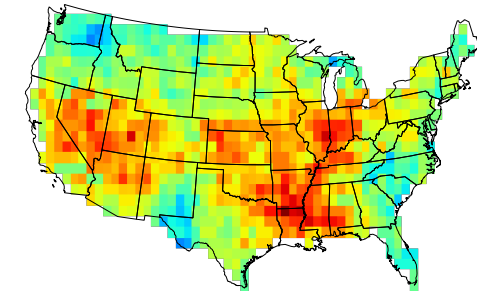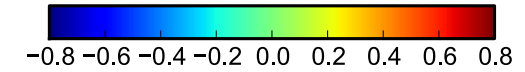
How can we push the science of L-A coupling with higher resolution soil moisture measurements?

Spatial Heterogeneity of Soil Moisture During the Evolution of droughts

2018 Drought Kansas-Missouri-Nebraska, Iowa

Zhang et al. (in preparation)
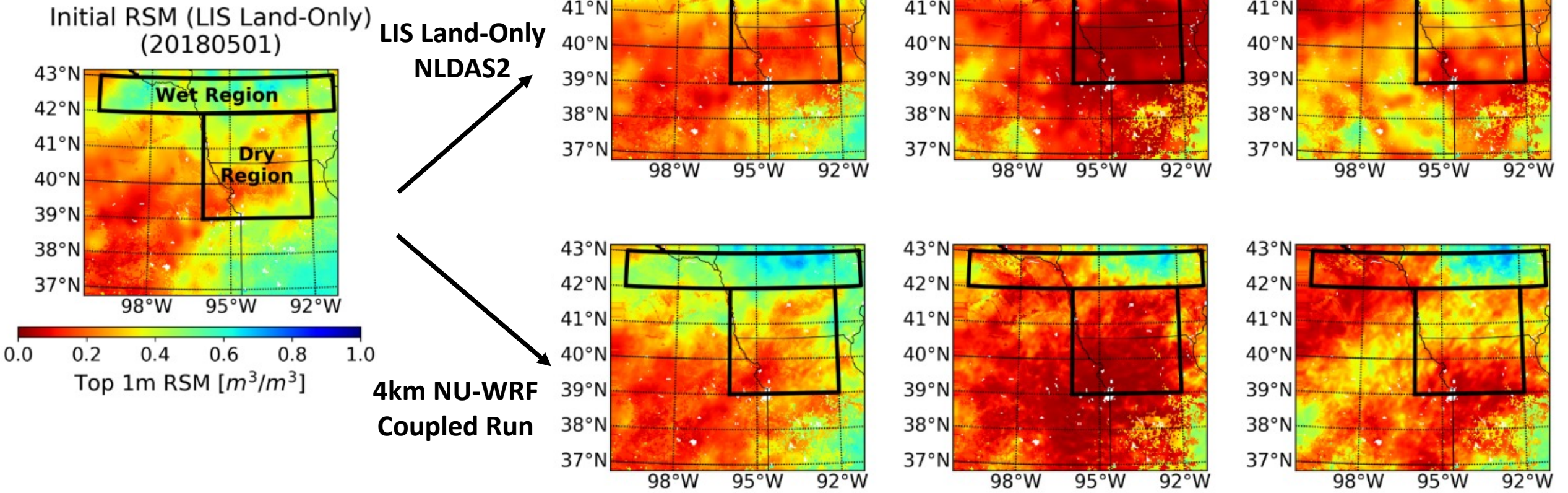
Spatial Heterogeneity of Soil Moisture is Connected with Mesoscale Circulation
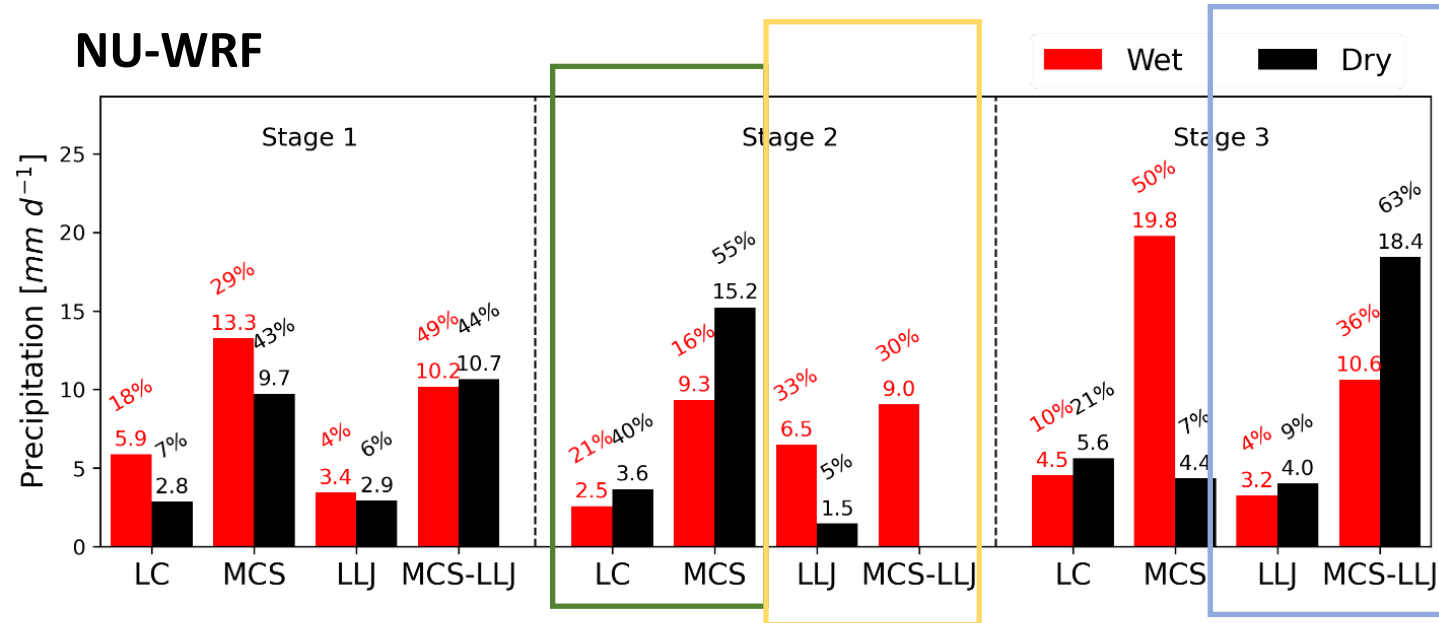
LC – Local Feedbacks

MCS – Mesoscale Convective System
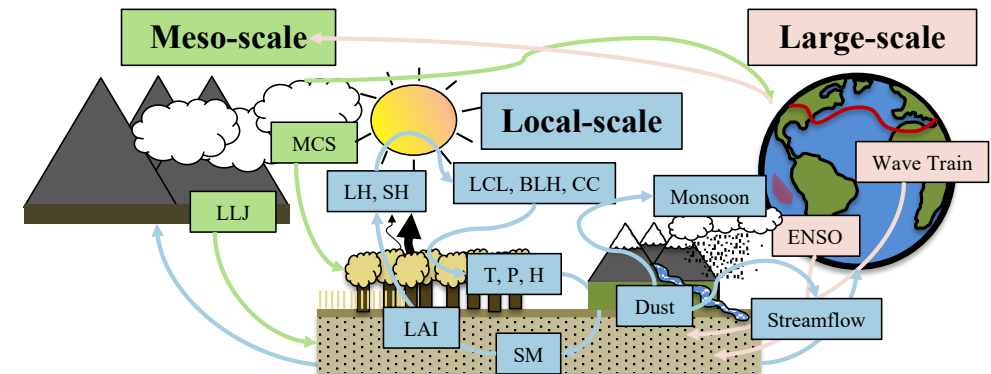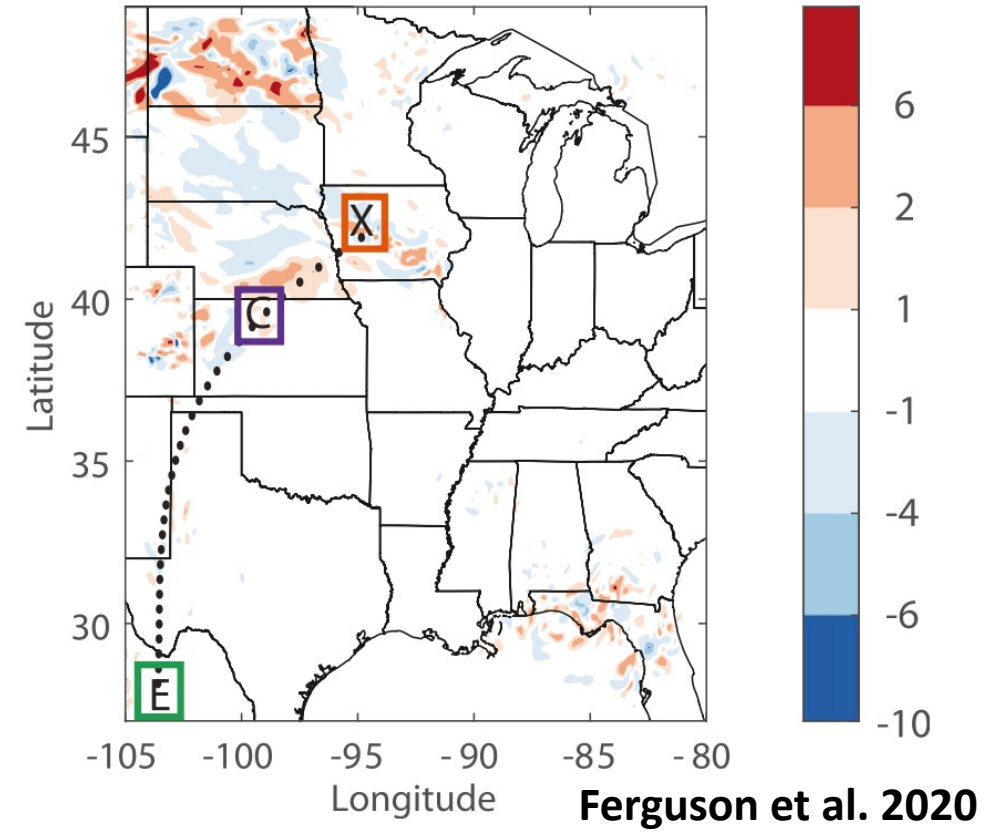
LLJ – Low Level Jet

MCS-LLJ – Both MCS and LLJ

NU-WRF

Zhang et al. (in preparation)
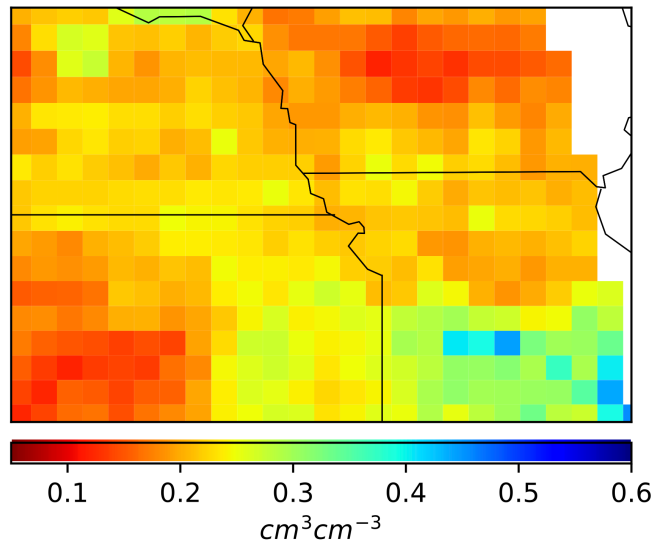
Ferguson et al. 2020

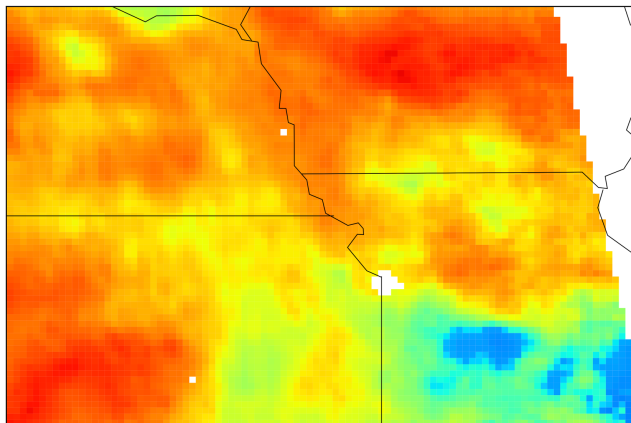# Hires Soil Moisture Measurements is Needed for Understanding Extreme Events

- Heterogeneity of Soil moisture is important for understanding the evolution of extreme events
- Heterogeneity is important to untangling the feedbacks between the local and mesoscale
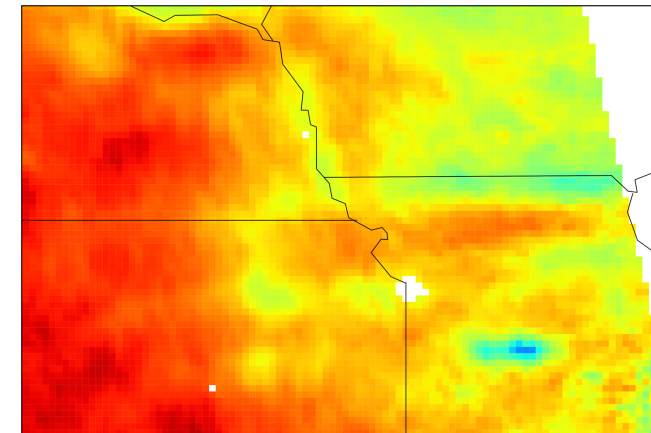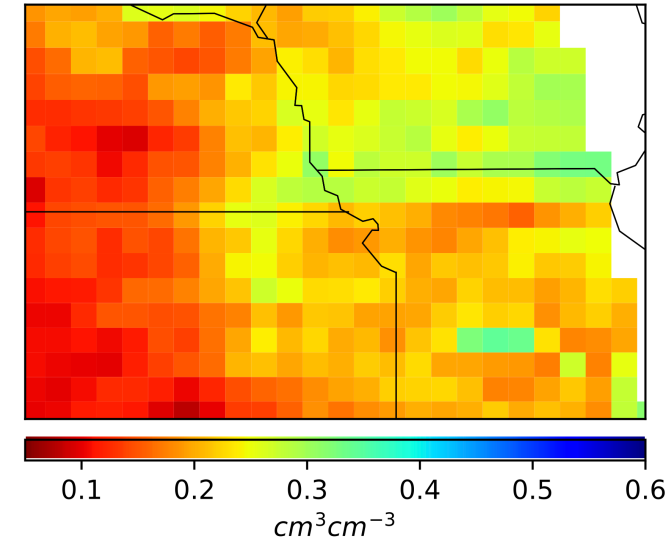
SMAP Soil Moisture May 1, 2018

SMAP Soil Moisture Sep 30, 2018

36 km

9 km

cm^3cm^{-3}

Hires Soil Moisture Measurements is Needed for Understanding Human Impacts

**Lawston-Parker et al. 2023, HESS**

- Even a small percentage of irrigation can cause large changes in soil moisture, fluxes, and PBLH
- Different irrigation maps create a different spatial signature of irrigation and downstream impacts
- The spread in evaporative fraction (EF) is different across irrigated runs even though the spatial averages are similar
- Some 'tiles' reach critical moisture and PBL thresholds that allow for PBL feedbacks that are not well represented by the 'gridcell' average value
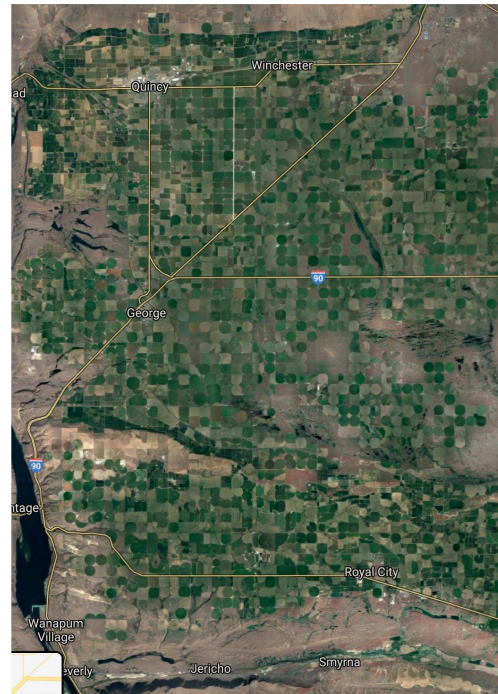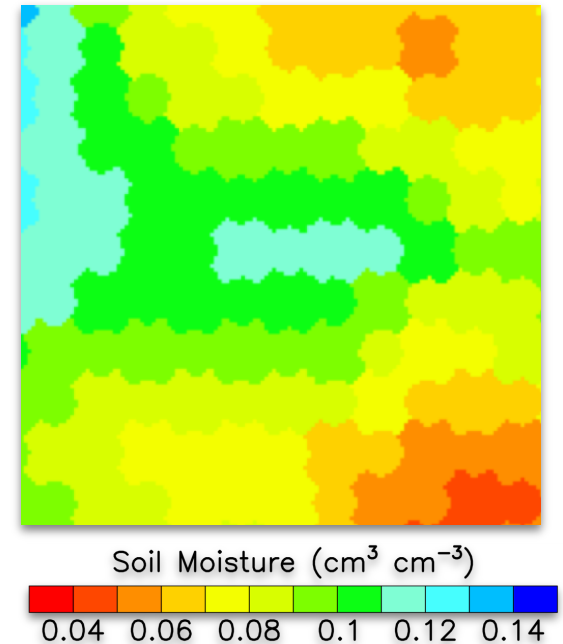
Example for Central Washington

ECOSTRESS LST
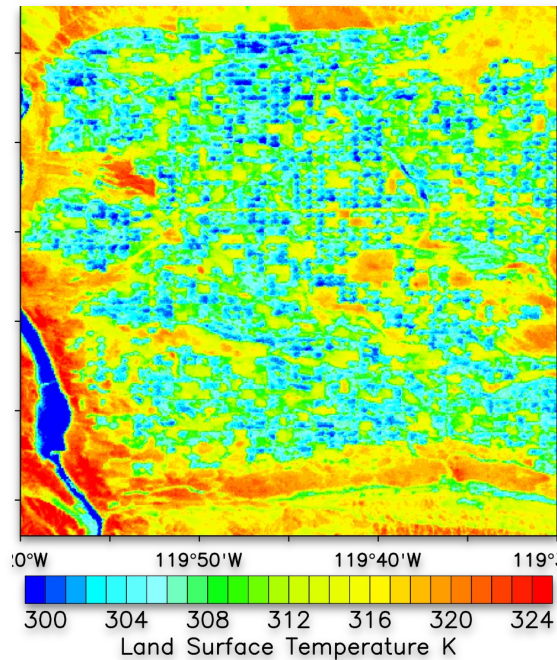
MODIS LST
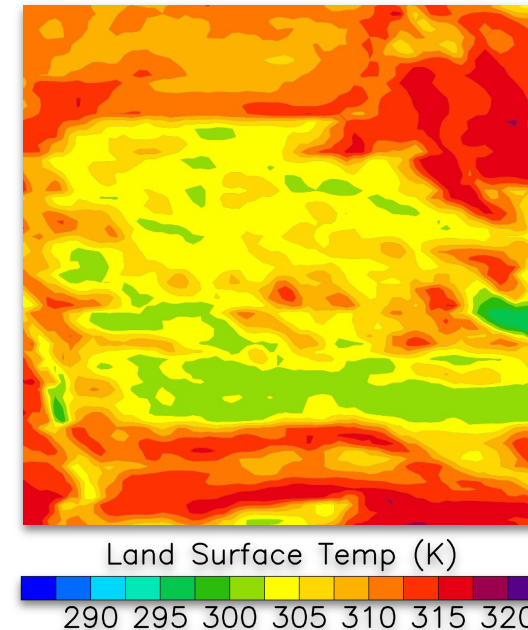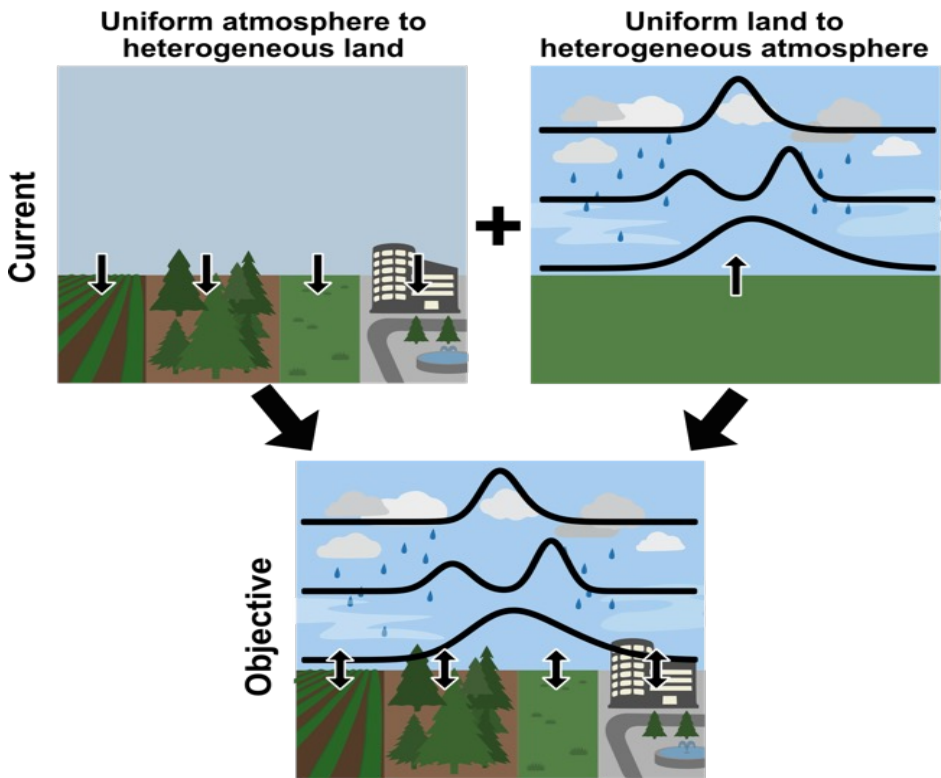
SMAP SM

~ 50 km

~ 40 km

70 m

1 km

9 km

Hires Soil Moisture Measurements is Needed for Forecast Models

Physical Models

Getting these feedbacks correct in physical models is important for future forecasts
- We need hires observations of soil moisture to scrutinize physically based models
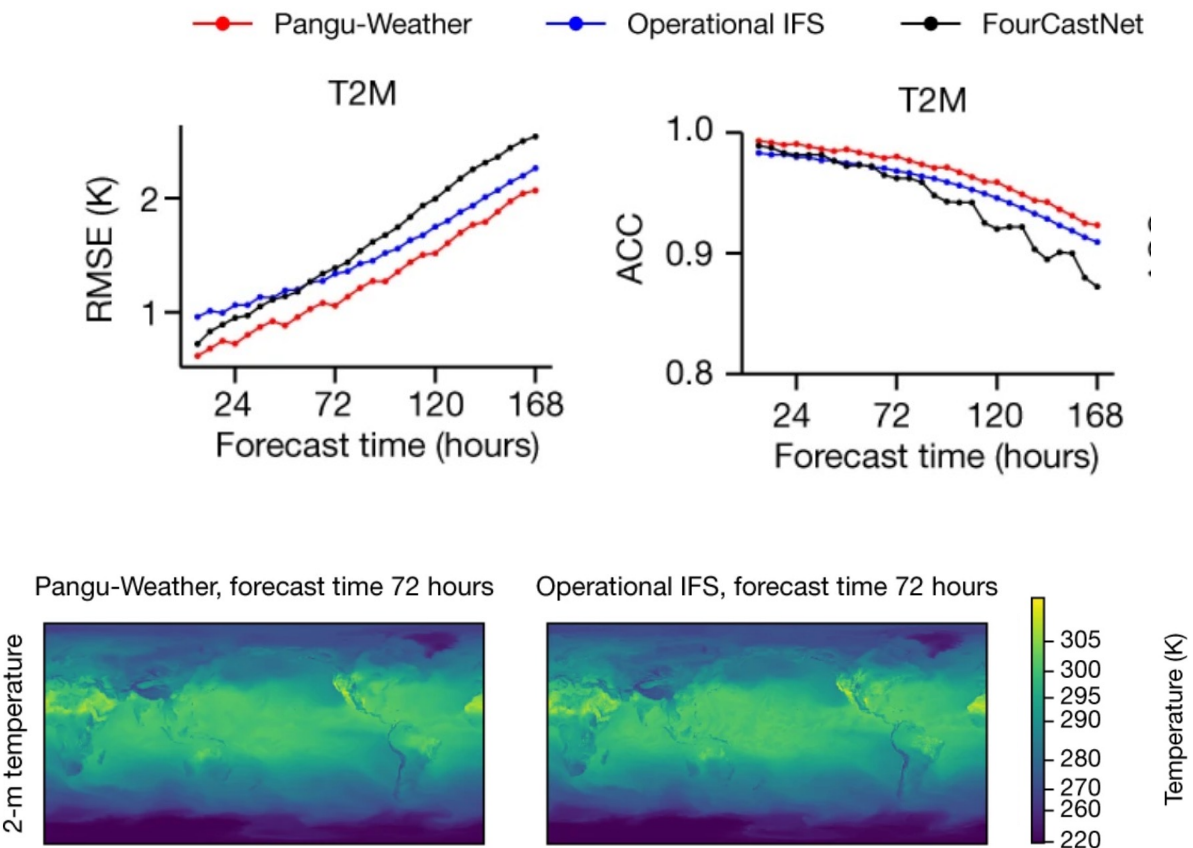

NOAA CPT: Coupling of Land and Atmosphere Subgrid Parameterizations (CLASP), Lead PI: Nate Chaney

ML/AI Models

The future of extreme event forecasting lies in ML/AI
- We need hires observations of soil moisture to train and run ML/AI models.

Bi et al. 2023, Nature

Summary and Conclusions

Higher resolution soil moisture measurements will push the science of L-A coupling for:

- **Extreme Event Evolution**
- **Human Impacts**
- **Forecast Models**

This is due to the heterogeneity of soil moisture and land-atmosphere feedbacks that occur at different scales (local, meso)

36 km

$cm^3 cm^{-3}$

9 km

$cm^3 cm^{-3}$