More frequent intense and long-lived MCSs dominate the springtime trend in central US rainfall

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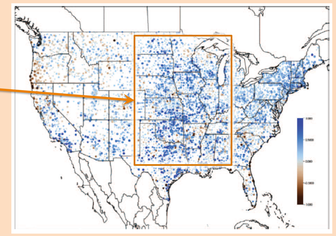
1. Introduction

- Observed extreme rainfall in central U.S. has been increasing in the past several decades, but the cause of this change is unknown
- Current climate models fail to simulate mesoscale convective systems (MCSs), but they produce 30-70% of warm season rainfall in this region, and over half of the extreme daily rainfall

Observed extreme daily precipitation increased significantly in central U.S. (1948-2010)



Hypothesis: changes in MCSs are responsible for the increase in extreme precipitation

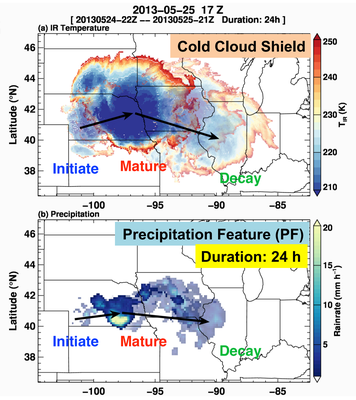
2. Goal

Explore processes that explain the increase in extreme precipitation in central U.S.

3. Approach

Development of long-term MCS database

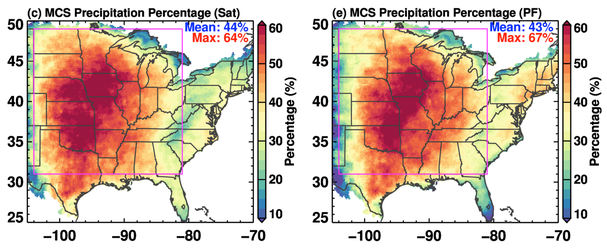
- Track clouds and identify MCS using satellite data (Sat algorithm)
- Develop and train a Precipitation Feature (PF) algorithm to identify the same MCSs using NLDAS precipitation data alone
- Verify PF algorithm against Sat algorithm for MCSs precipitation statistics (2000-2014)
- Develop a 35-year MCS database from NLDAS



An MCS viewed from satellite cloud shield and NLDAS surface precipitation (12km, 1hourly resolution)

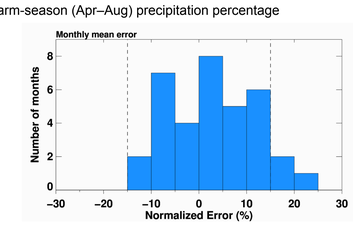
Validation with satellite algorithm

PF algorithm provides consistent MCS rainfall statistics with satellite algorithm

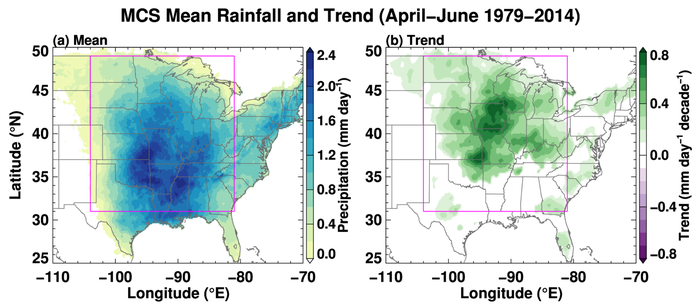


15-year mean MCS warm-season (Apr–Aug) precipitation percentage

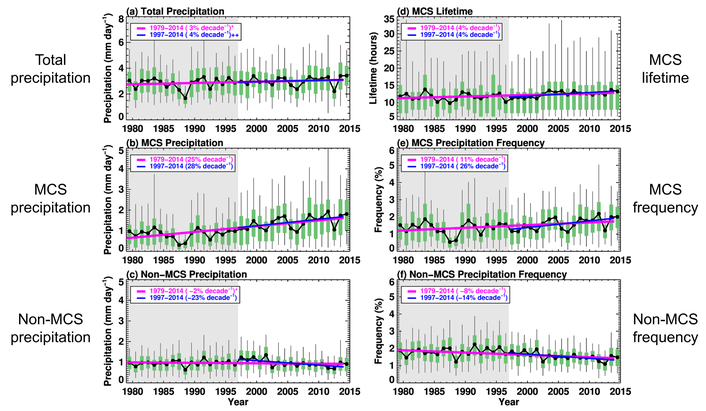
- Monthly averaged error (Sat–PF) are mostly within 15%, no statistically identifyable bias or skewness



4. Trends in MCS Seasonal Precipitation

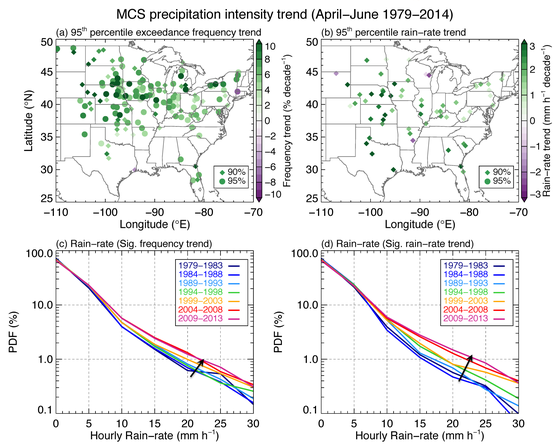


- MCS mean rainfall increases in central and northern plains
- Midwest experiences 0.4-0.8 mm d^{-1} (20-40%) increase



- Central U.S. total precipitation increases by 3% dec^{-1}, mainly due to MCS increase (25% dec^{-1})
- Rainfall more likely come from MCS (+11% dec^{-1}), less likely from non-MCS (-8% dec^{-1})
- Main reason: MCS lifetime increases by 4% dec^{-1}, long-lasting MCS (95th percentile) increases by 7% dec^{-1}

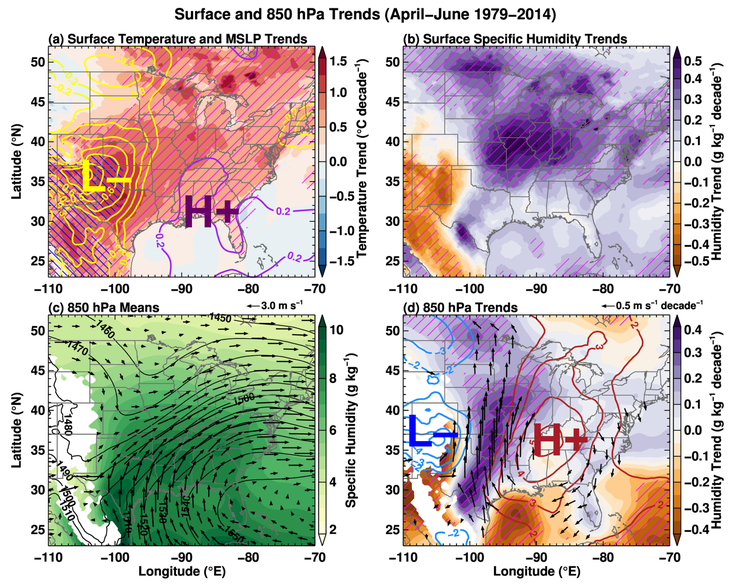
5. Trends in MCS Intensity



MCS extreme precipitation intensity trends

- 95th percentile hourly rain-rate increases in central and northern plains
- Moderate to heavy rainfall intensity (5-30 mm h^{-1}) become more frequent

6. Role of Large-scale Environment Changes

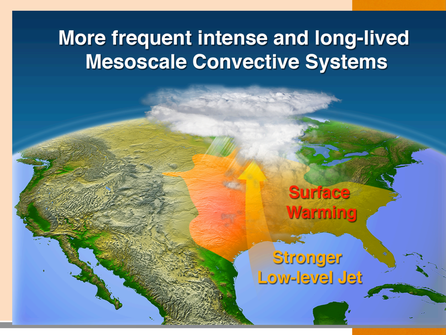


Large-scale environment climatology and trends during occurrence of MCSs

- Large-scale environments during MCSs are composited
- Surface warming in southern Great Plains (GP) and lack of warming in surrounding oceans increase pressure gradient across central US, enhances GP Low-level Jet (LLJ)
- Low-level moistening in central/northern plains are associated with enhanced GPLLJ moisture transport, facilitating more intense precipitation from MCSs in that region

Summary

- A new algorithm to detect MCSs based on precipitation features alone is developed and validated against traditional satellite-based method
- A 35-year MCS database is developed for the central US
- We find changes in long-lasting MCS frequency and intensity dominate the observed increase in springtime total and extreme rainfall in the central US
- Surface warming enhances Great Plains Low Level Jet moisture transport to support long-lasting MCSs
- This work provides a benchmark for climate models to project future changes in extreme precipitation



U.S. DEPARTMENT OF ENERGY

Acknowledgement

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Reference

Feng et al., 2016: More frequent intense and long-lived storms dominate the springtime trend in central U.S. rainfall, *Nat. Commun.*, 13429.

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