# IMPACTS OF FORCED AND INTERNAL CLIMATE VARIABILITY ON CONVECTIVE ENVIRONMENTS OVER THE EASTERN UNITED STATES

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CESM CLIMATE VARIABILITY AND CHANGE WORKING GROUP MEETING 2024

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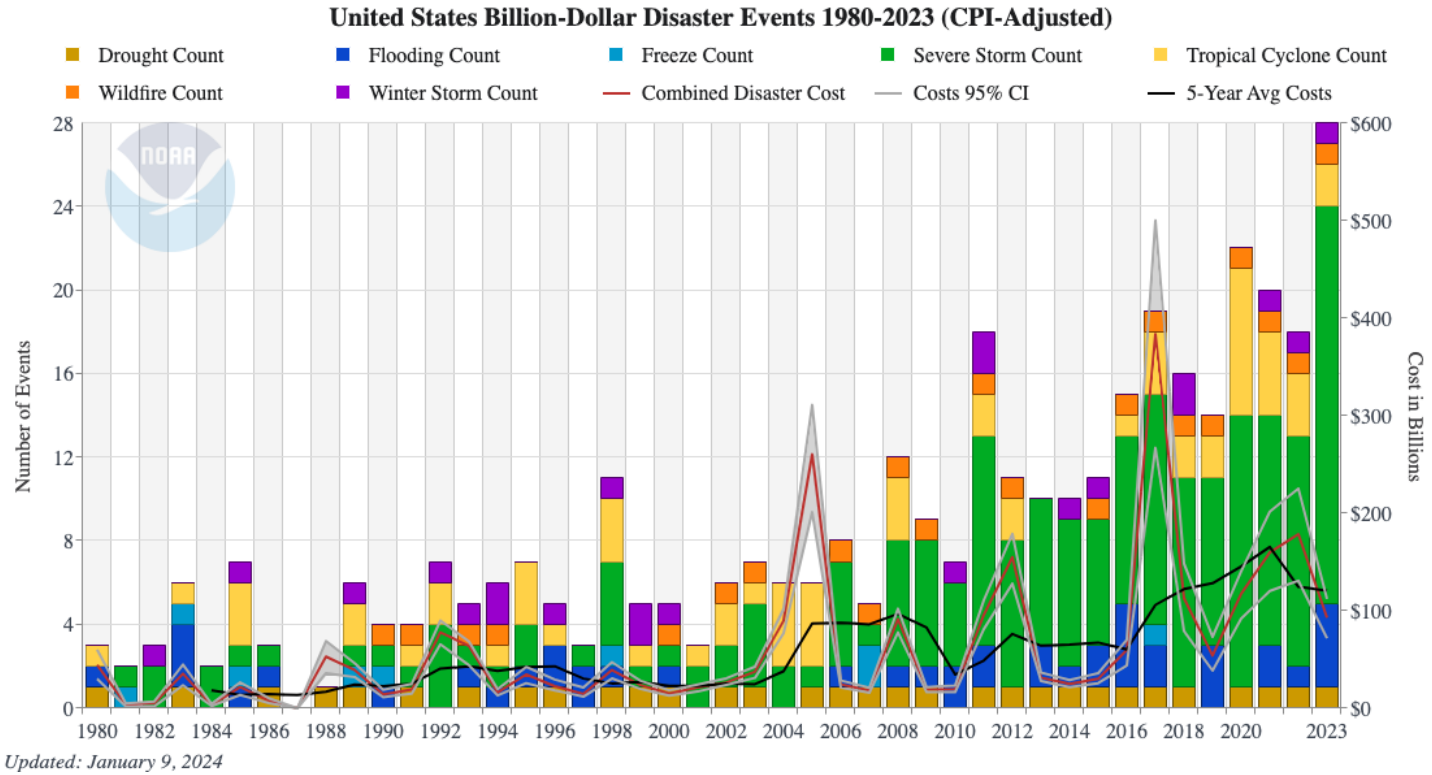
# NUMBER OF COSTLY SEVERE WEATHER EVENTS IN THE U.S. CONTINUES TO RISE

- **19 SEVERE STORMS** COSTING OVER $1 BILLION IN DAMAGES IN THE U.S. DURING 2023
- SUBSTANTIAL THREAT TO
  - GROWING POPULATION/HUMAN LIFE
  - INFRASTRUCTURE
  - AGRICULTURE
- EXPECTED TO CONTINUE TO RISE WITH INCREASES IN GLOBAL TEMPERATURE (VIA CLAUSIUS CLAPEYRON SCALING)




NCEI (2024)

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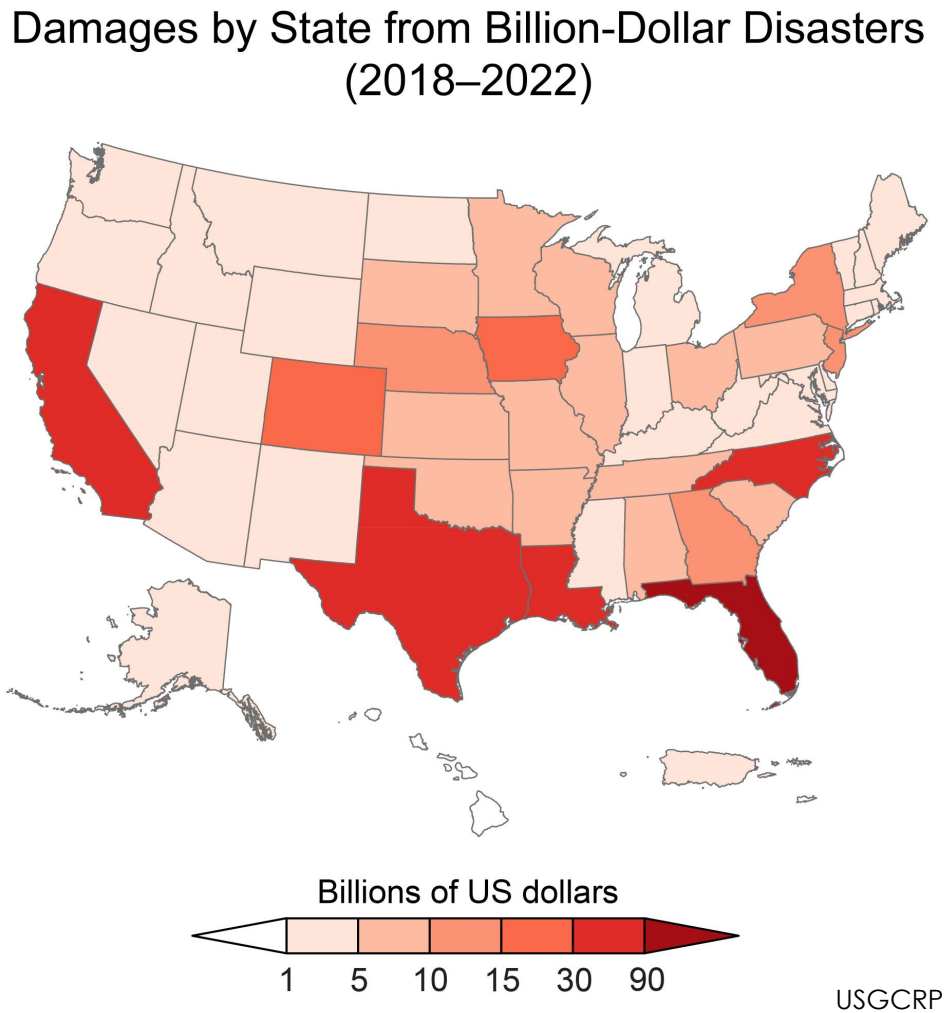
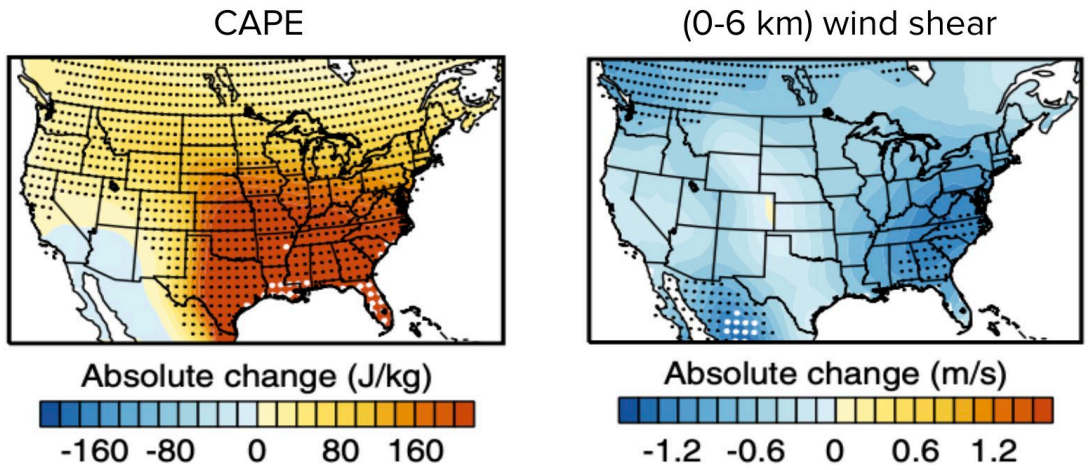
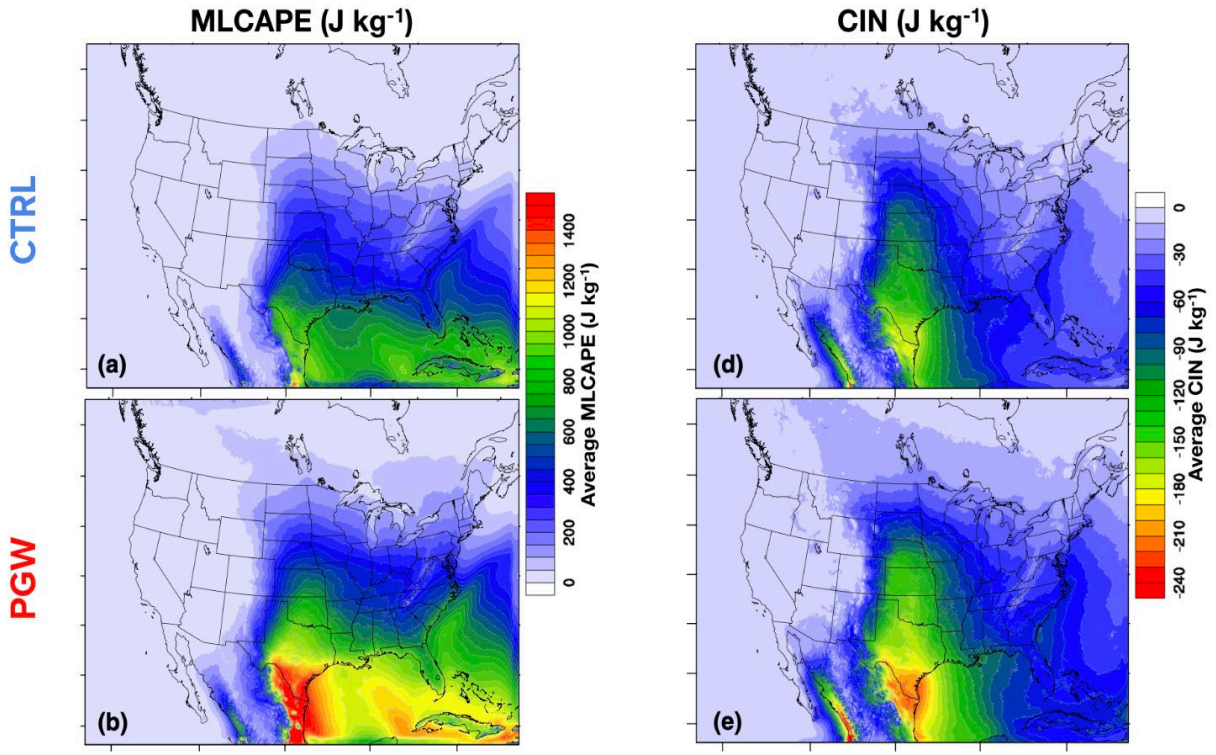



USGCRP (2023)

# PRIOR RESEARCH HAS PRIMARILY FOCUSED ON CHANGES IN FUTURE CONVECTION RESULTING FROM THE FORCED RESPONSE




Diffenbaugh et al. (2013)



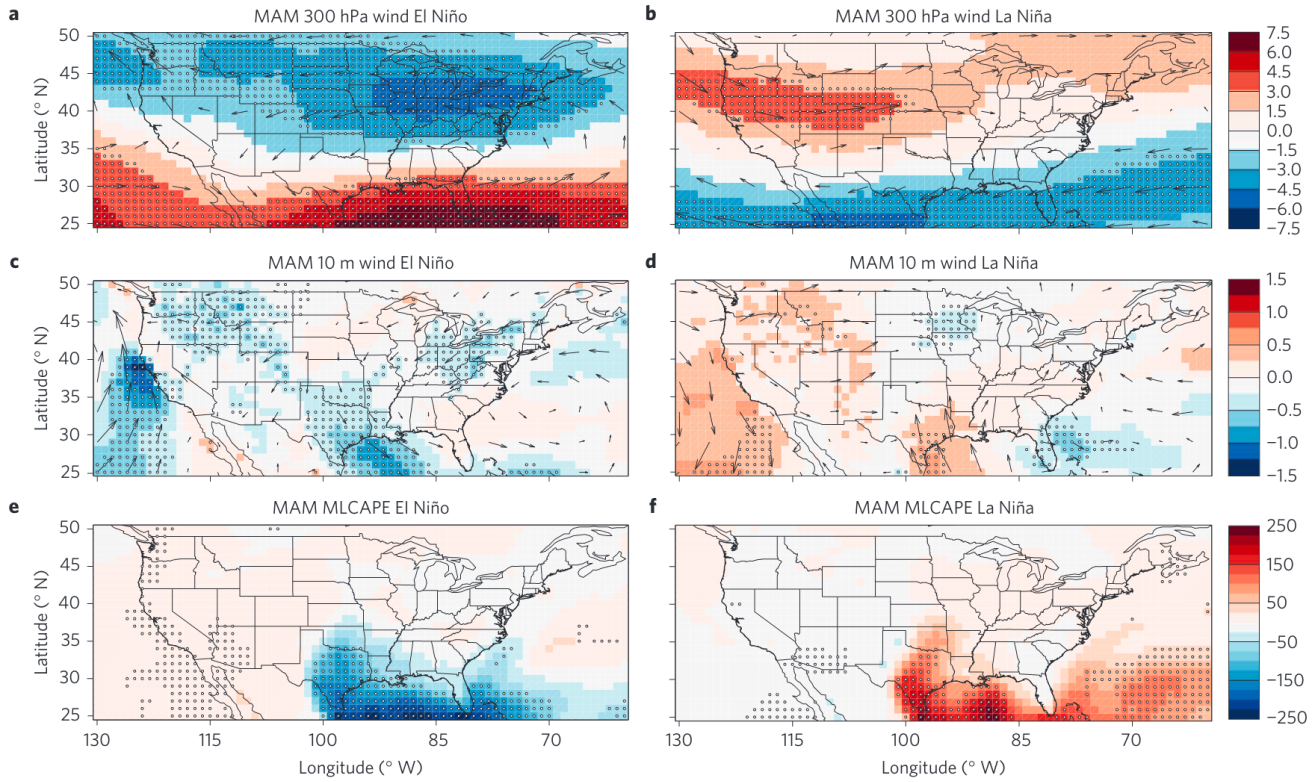

Rasmussen et al. (2017)

## CHANGES BY 2100…

- DECREASES IN BULK VERTICAL WIND SHEAR
- HIGHER CAPE AND CIN MAGNITUDES ARE INDICATIVE OF ENVIRONMENTS LESS SUPPORTIVE OF WEAK-MODERATE CONVECTION, RELATIVE TO THE HISTORICAL PERIOD

# LESS ATTENTION HAS BEEN GIVEN TO THE ROLE OF INTERNAL CLIMATE VARIABILITY ON CONVECTIVE ENVIRONMENTS

- STUDIES HAVE PRIMARILY FOCUSED ON CHANGES IN THE FORCED RESPONSE
  - SMALL SET OF ENSEMBLES FROM A SINGLE MODEL
  - ANALYZE LIMITED TIME PERIODS SUCH AS END-OF-CENTURY CHANGES
  - MULTI-MODEL ENSEMBLE MEANS WITH VARIOUS FORCING SCENARIOS
- CONSIDERATION OF THE IMPACT OF INTERNAL VARIABILITY FREQUENTLY FOCUSES ON PARTICULAR MODES
  - LITTLE ATTENTION ON HOW THE FULL SPECTRUM OF INTERNAL CLIMATE VARIABILITY IS LIKELY TO IMPACT THESE ENVIRONMENTS
- A LARGE ENSEMBLE (>40) APPROACH PROVIDES AN OPPORTUNITY TO GAIN FURTHER INSIGHT INTO BOTH FORCED AND INTERNAL VARIATIONS
  - HOW UNFORCED CLIMATE VARIABILITY MODULATE THE LARGE-SCALE ENVIRONMENT CRITICAL FOR SEVERE WEATHER IS STILL UNKNOWN.




Allen et al. (2015)

# OBJECTIVE

**LEVERAGE THE CESM2 LARGE ENSEMBLE TO ANALYZE THE HISTORICAL AND PROJECTED FUTURE EVOLUTION OF BOTH FORCED AND INTERNAL CLIMATE VARIABILITY ON CONVECTIVE ENVIRONMENTS OVER THE U.S.**

- HOW DO PROJECTED CHANGES IN CLIMATE IMPACT THE ENVIRONMENTAL CONDITIONS MOST CRITICAL FOR CONVECTION?
- TO WHAT EXTENT DOES INTERNAL CLIMATE VARIABILITY MODULATE THE FORCED RESPONSE OF CONVECTIVE ENVIRONMENTS OVER THE COMING DECADES?

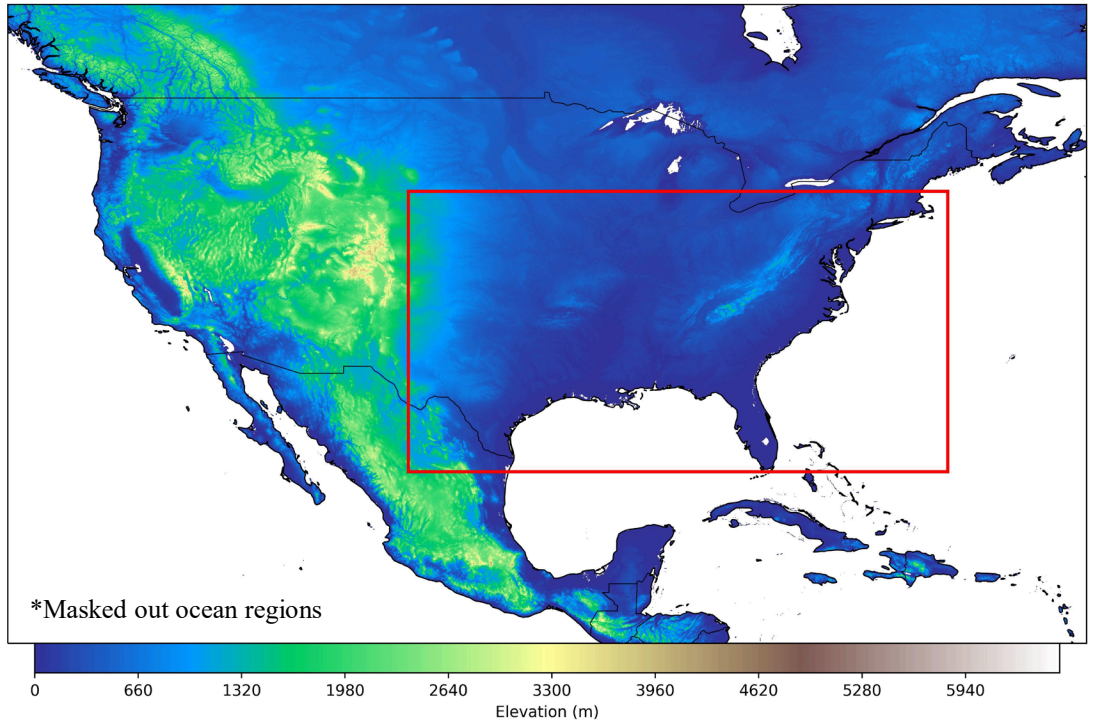
# THE DETAILS

## Model and Data Information:

- 50 members of monthly mean data from the CESM2-LE
- 1870-2100
- March - June (MAMJ) season
- Anomalies calculated relative to 1971-2000 climatology

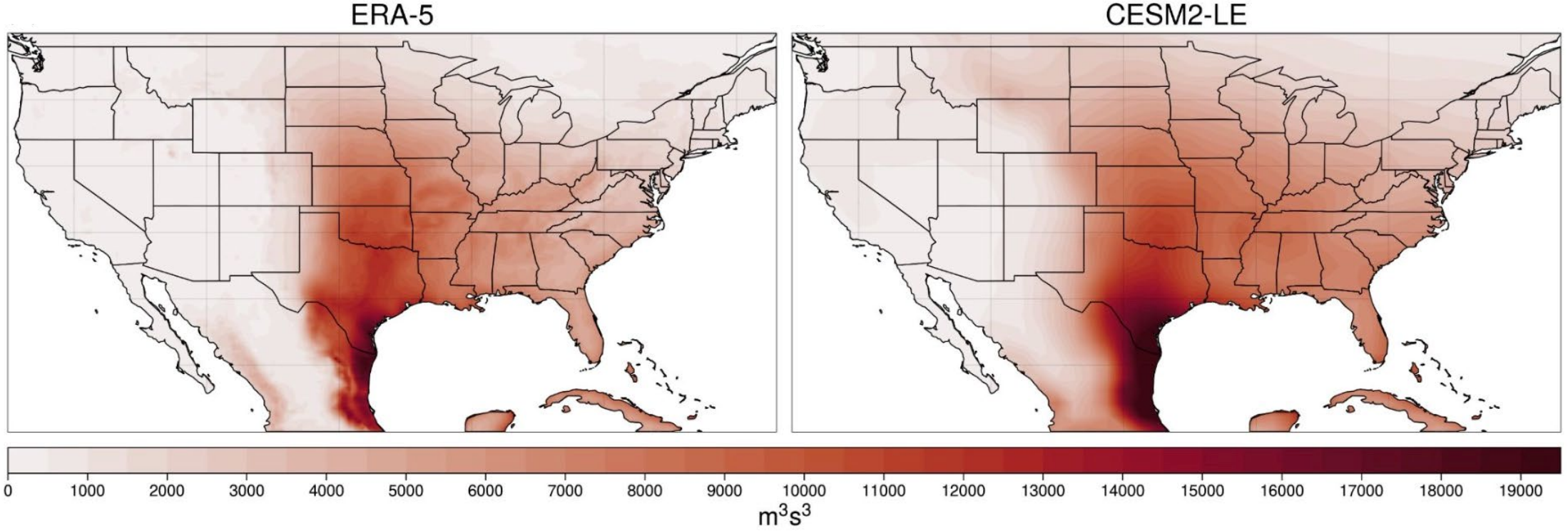
## Convective Variables

- Convective available potential energy (CAPE)
- Convective inhibition (CIN)
- 0-6km bulk vertical wind shear (S06)
- CAPES06



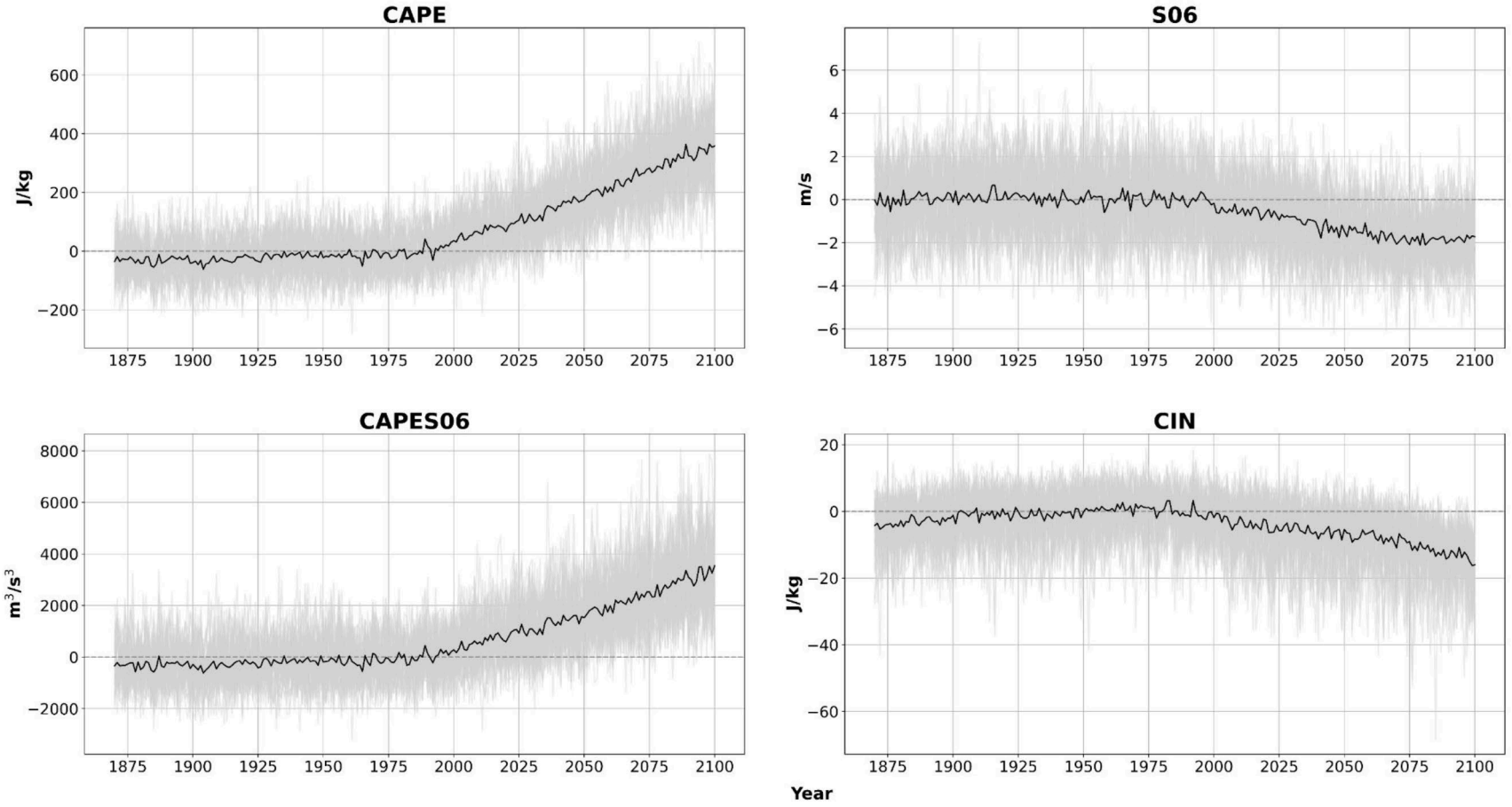
# HOW WELL DOES CESM2 SIMULATE CONVECTIVE ENVIRONMENTS?

MAMJ CAPES06 CLIMATOLOGY
1980-2019

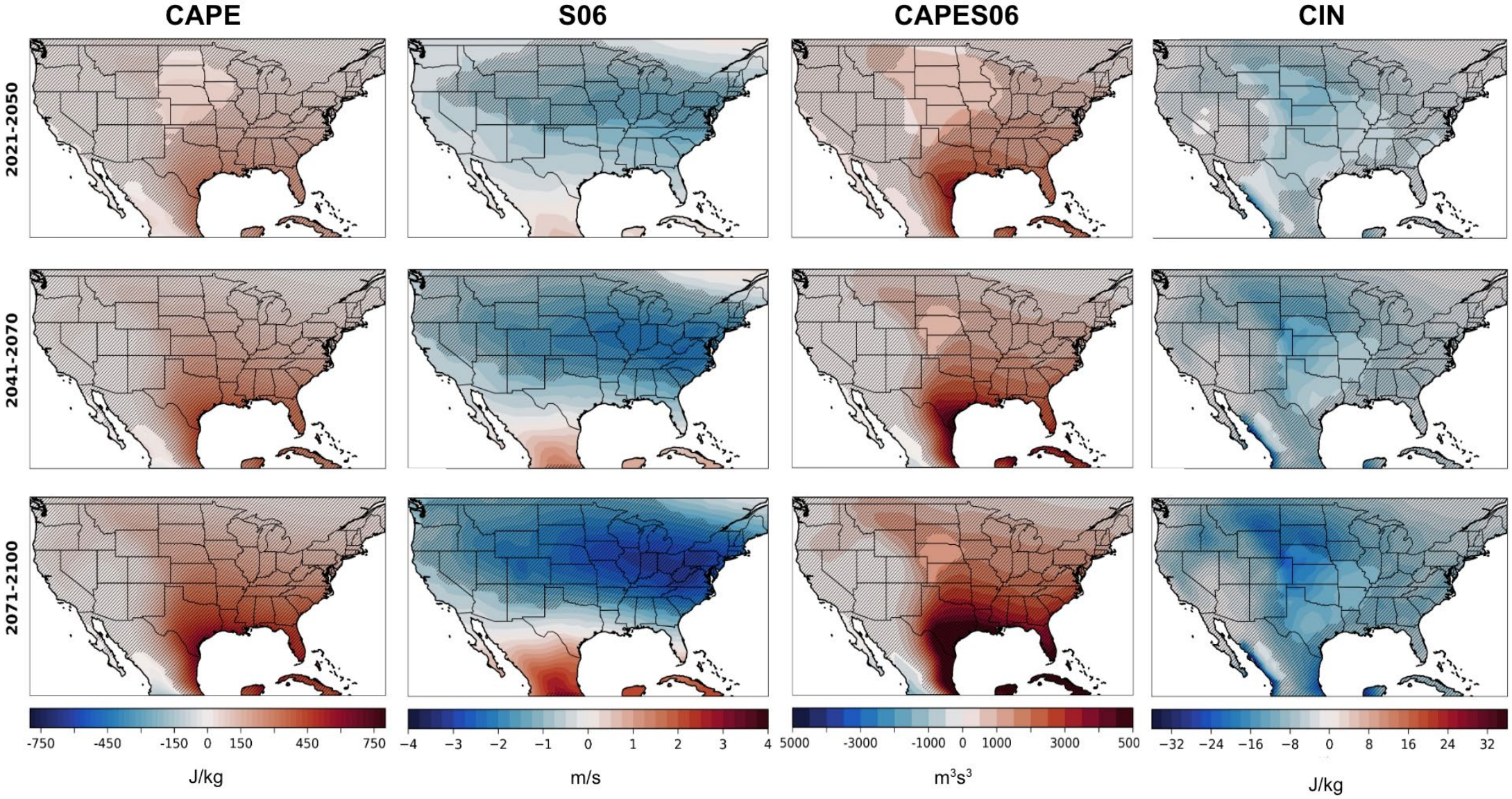


# EVOLUTION OF MAMJ CONVECTIVE ENVIRONMENTS OVER THE EASTERN U.S.

- ANOMALIES FROM THE 1971-2000 REFERENCE CLIMATOLOLGY
- MINIMAL DEVIATIONS FROM THE REFERENCE CLIMATOLOGY OVER THE HISTORICAL RECORD
- FORCED RESPONSE DUE TO CLIMATE CHANGE EMERGES JUST PRIOR TO THE YEAR 2000



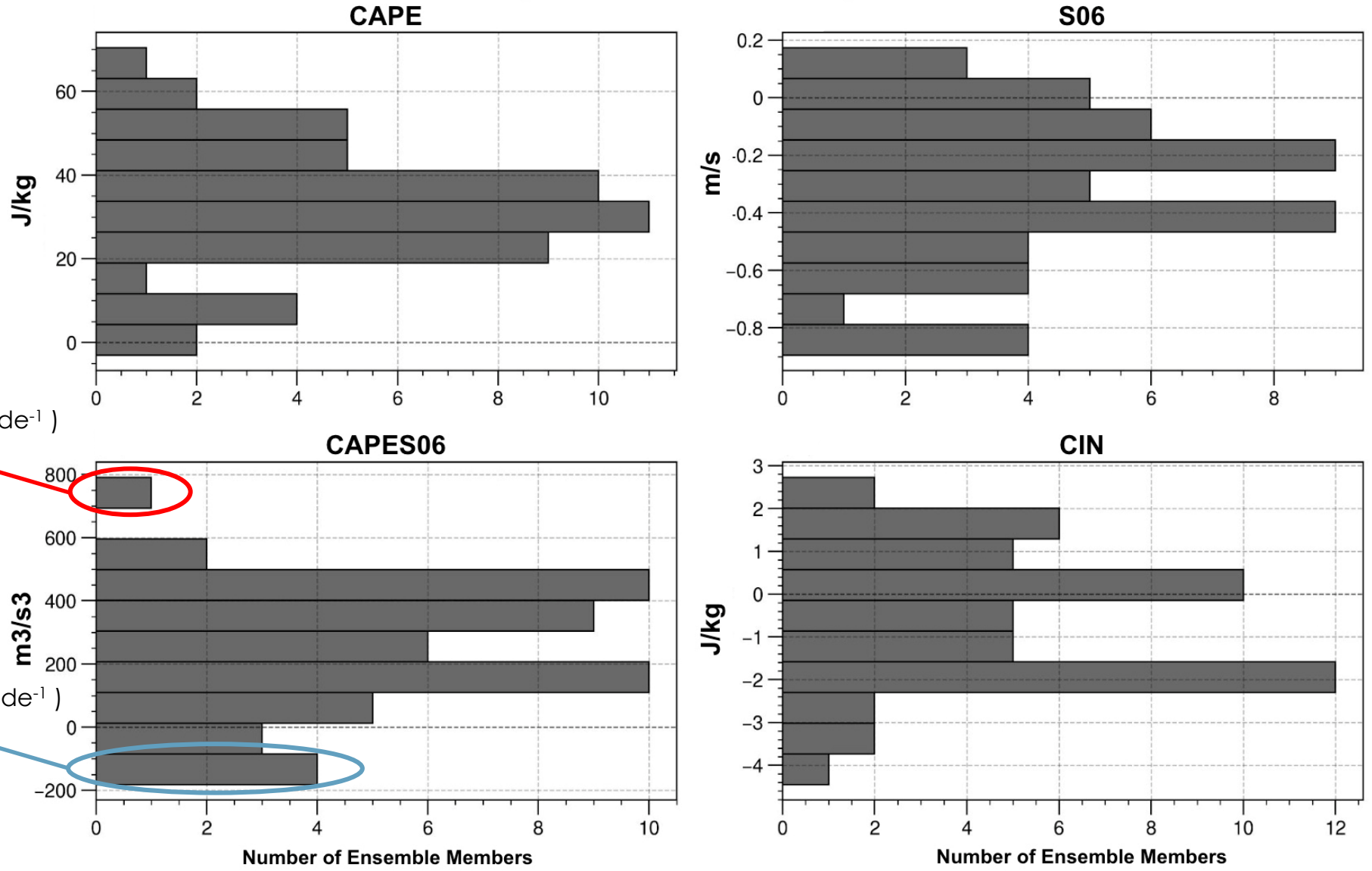
# EVOLUTION OF MAMJ CONVECTIVE INDICES RELATIVE TO 1971-2000



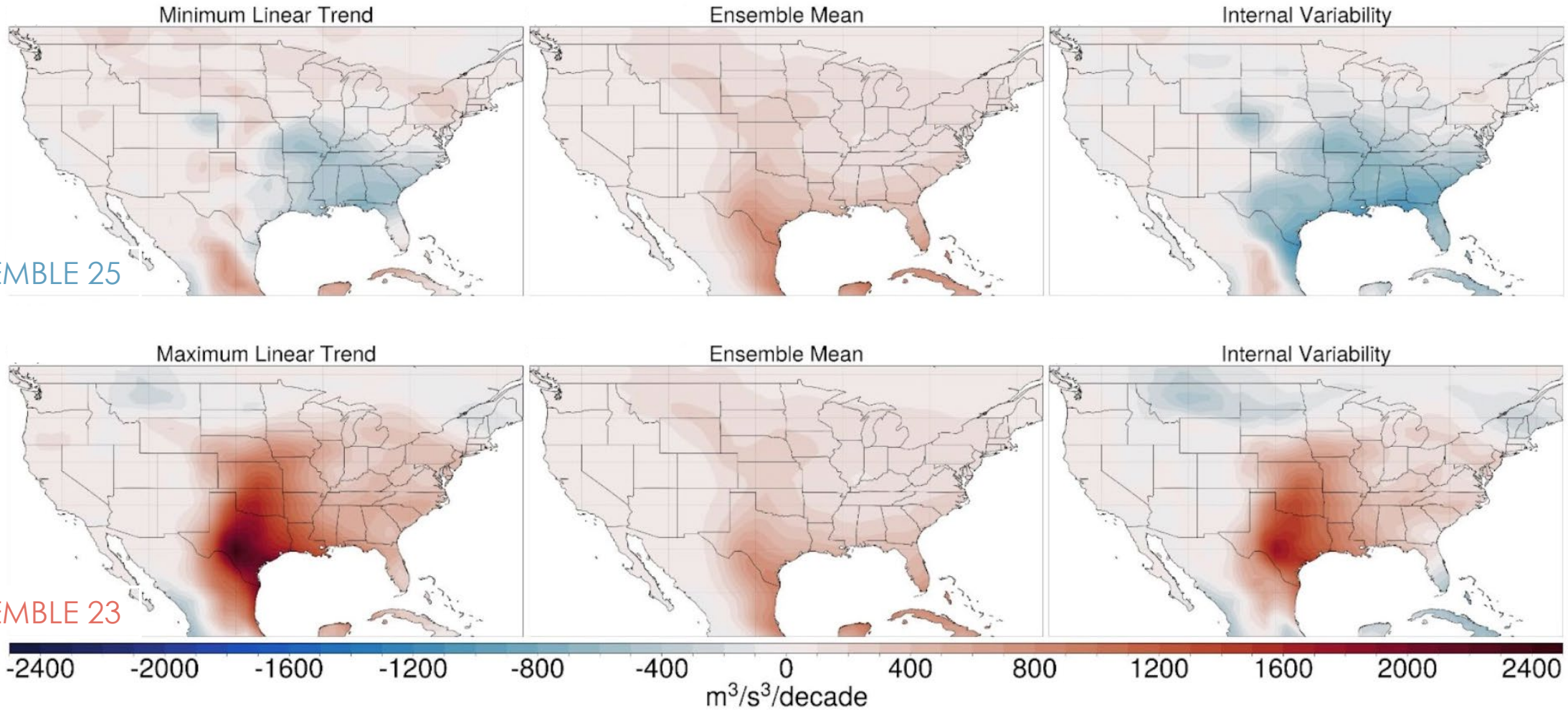
# RANGE OF LINEAR DECADAL TRENDS (2021-2050)

ENSEMBLE 23
(m = 791 J kg$^{-1}$ decade$^{-1}$ )

ENSEMBLE 25
(m = -182 J kg$^{-1}$ decade$^{-1}$ )



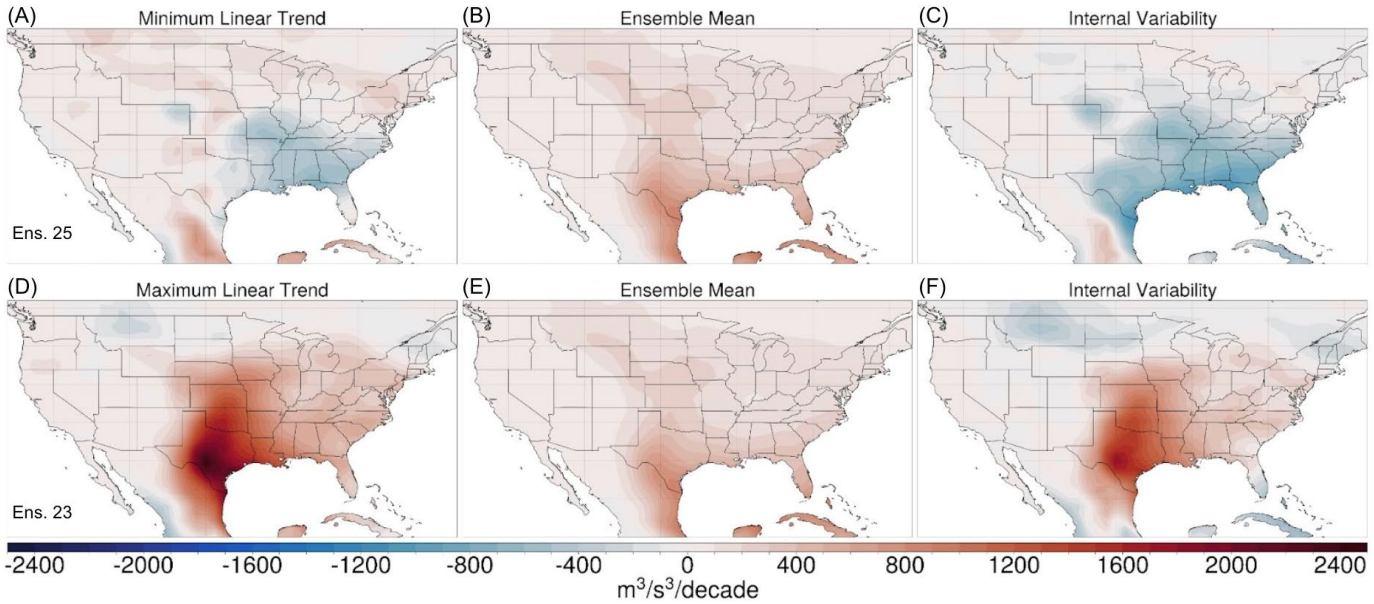
# MODULATIONS OF DECADAL TRENDS OF CAPES06 (2021-2050)



# SUMMARY AND CONCLUSION

KEY FINDINGS:

1. THE SIGNAL OF CLIMATE CHANGE IN LARGE-SCALE CONVECTIVE ENVIRONMENTS OVER THE U.S. EMERGES FROM THE INTERNAL VARIABILITY IN THE LATE 1990'S.
2. FUTURE CONVECTIVE ENVIRONMENTS OVER THE EASTERN U.S. MAY BE SUPPORTIVE OF LESS FREQUENT AND SHORTER LIVED, BUT MORE INTENSE STORMS.
3. LARGE-SCALE INTERNAL CLIMATE VARIABILITY COULD SIGNIFICANTLY ENHANCE OR SUPPRESS FUTURE ANTHROPOGENICALLY-DRIVEN CHANGES IN CLIMATE.



# THANK YOU!

FURTHER QUESTIONS OR COMMENTS:

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# REFERENCES


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