Effects of Irrigation on Great Plains and Midwest Precipitation Processes

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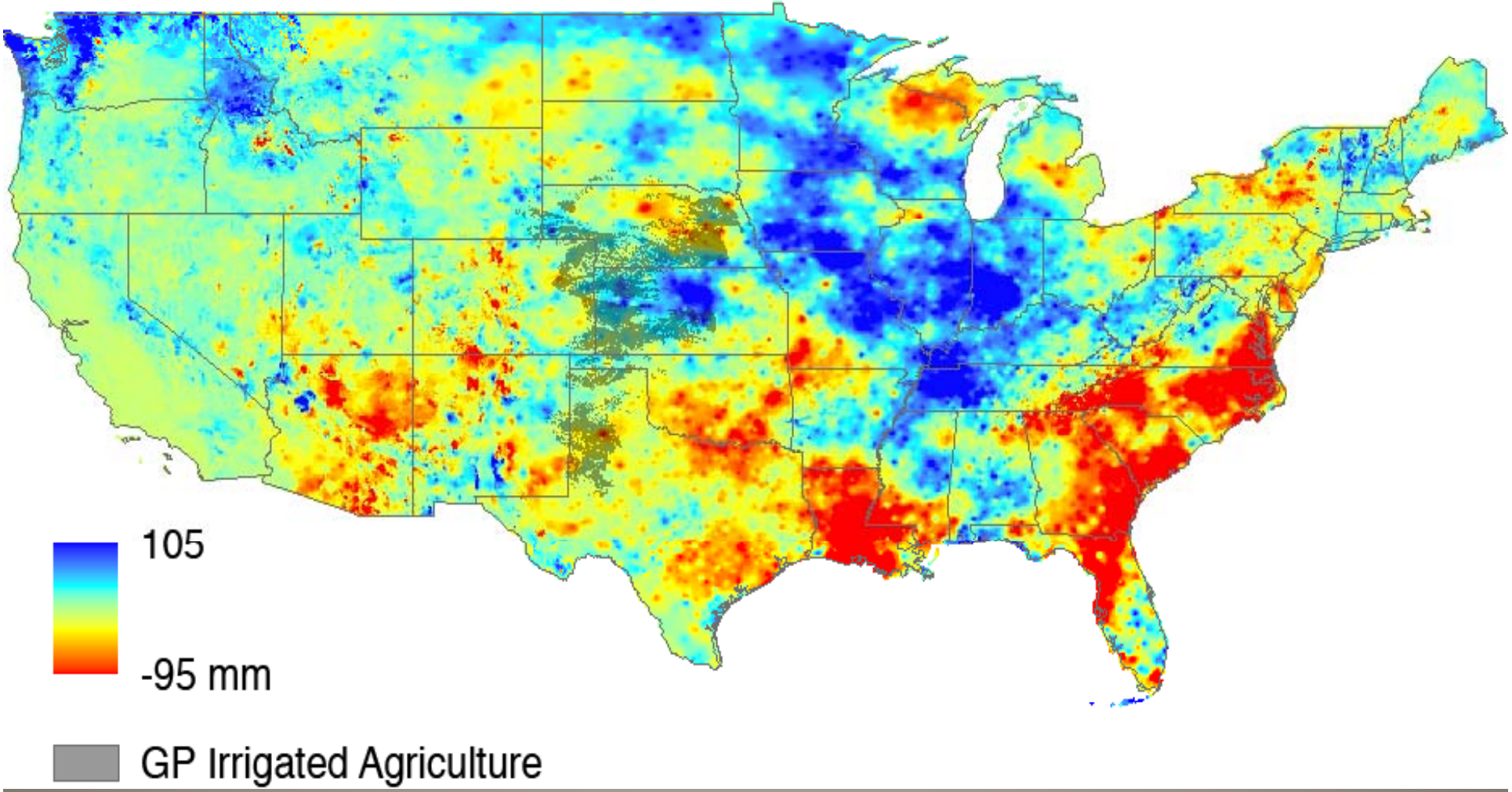
Outline

- Historical and Conceptual Review
- Description of Modeling Approach
- Results
- Conclusion

Historical Changes in Precipitation

Climatological Precipitation Differences (1971 – 2000 minus 1901 – 1930)



Source: PRISM Climate Group

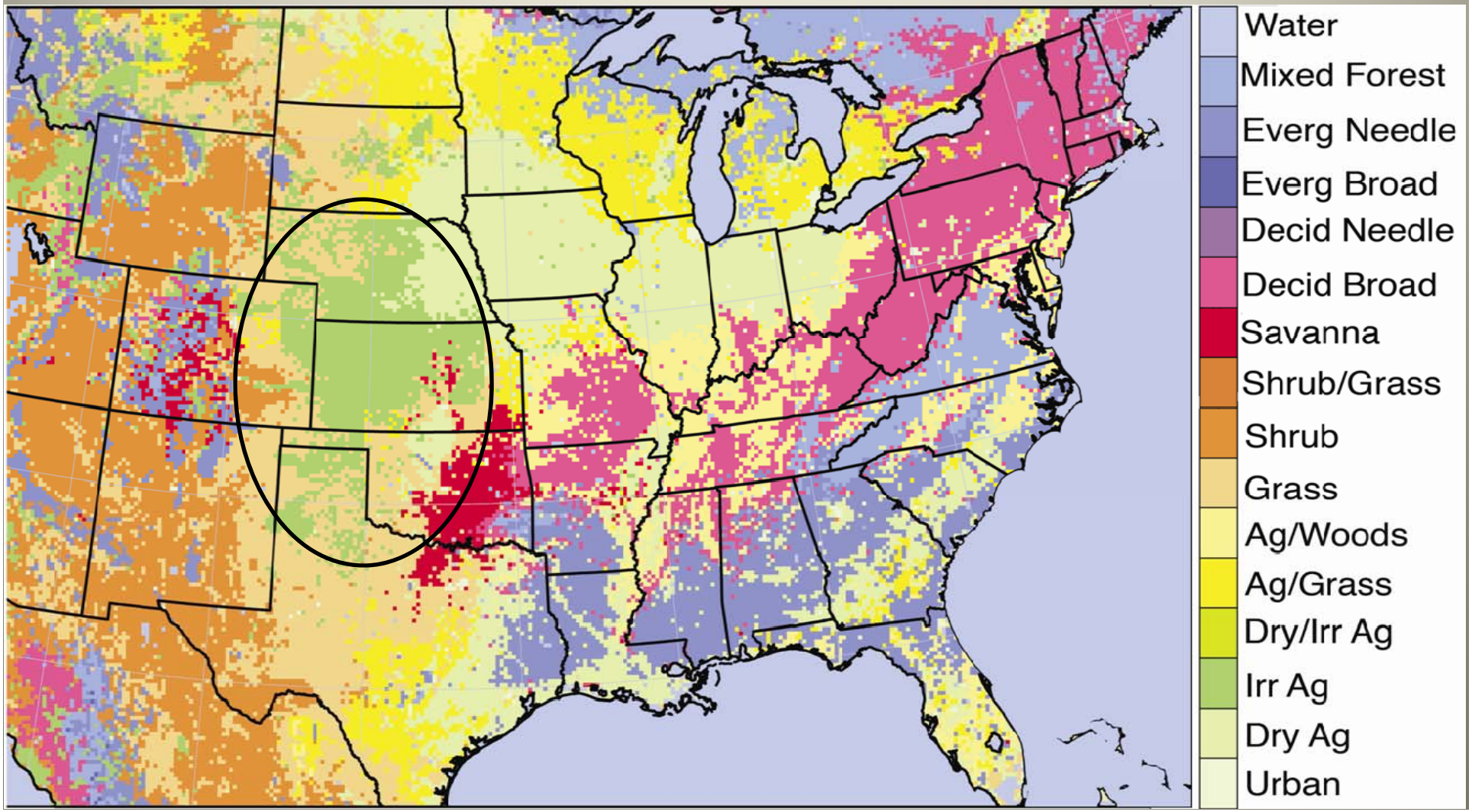
Irrigation-Atmosphere Interaction

- Irrigation introduces additional water to the soil
- The water evaporates or transpires causing
  - Sensible heat is reduced while latent heat increases
  - The surface and lower atmosphere cool
  - The moisture in the lower atmosphere increases
  - The evapotranspirated water is advected northward by the low level jet
  - Humid air is lifted over higher sensible heat areas by deep convective updrafts
  - Precipitation events become more intense
  - Moisture increases in higher sensible heat areas, reducing sensible heat for latent heat
  - Downwelling longwave radiation increases
  - Net radiation increases, increasing evapotranspiration rates
  - Number of cloudy days increases, decreasing net radiation and evapotranspiration
  - Decrease in surface albedo, increase net radiation and evapotranspiration
  - Increase in surface emissivity, decrease net radiation and evapotranspiration

Model Setup

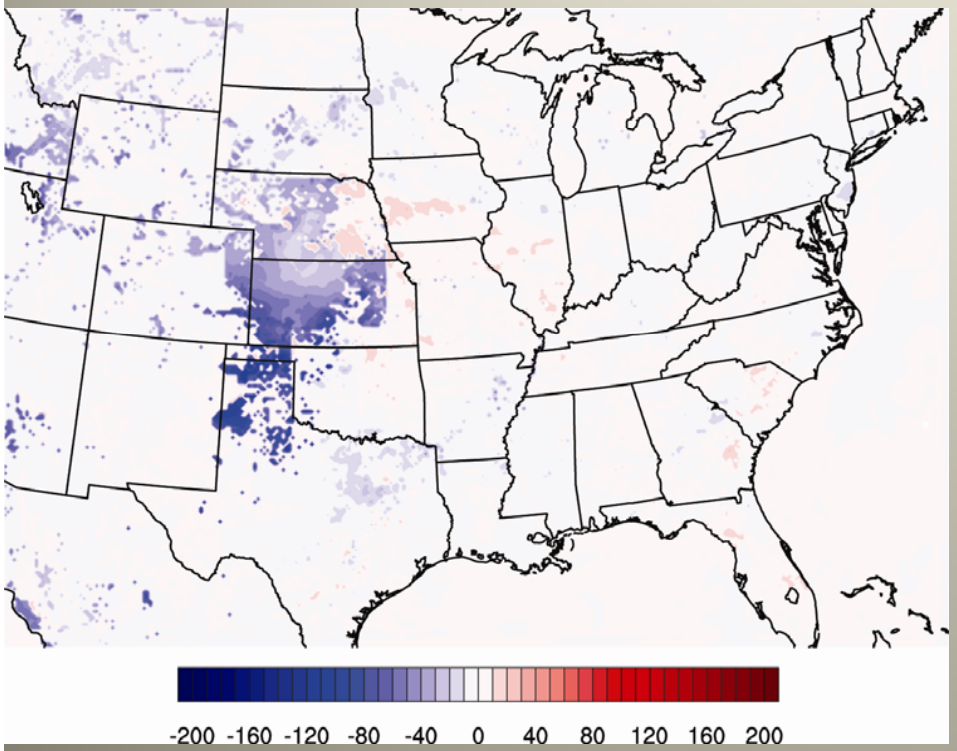
- Sensitivity Study Using WRF V3.1.1
- Modified USGS 24 Category Land Cover Scheme
- Two Experiments (Control and Irrigated)
  - Both experiments over 1 May – 31 July 2001
  - Irrigated sets soil moisture to FC at 0000z starting 1 June on irrigated land cover types
  - Control soil moisture only replenished by rainfall
- Differences Analyzed (July Only)
  - Precipitation, radiation, and flow regimes

Model Domain

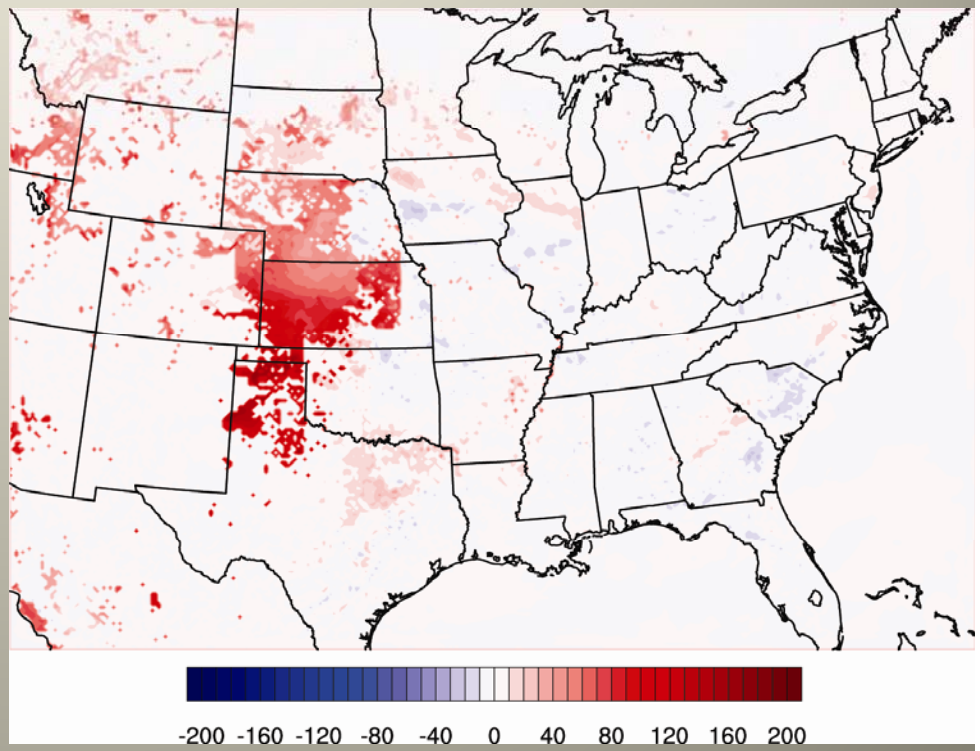


Radiation Differences

Change in Sensible Heat Flux (Wm^{-2})

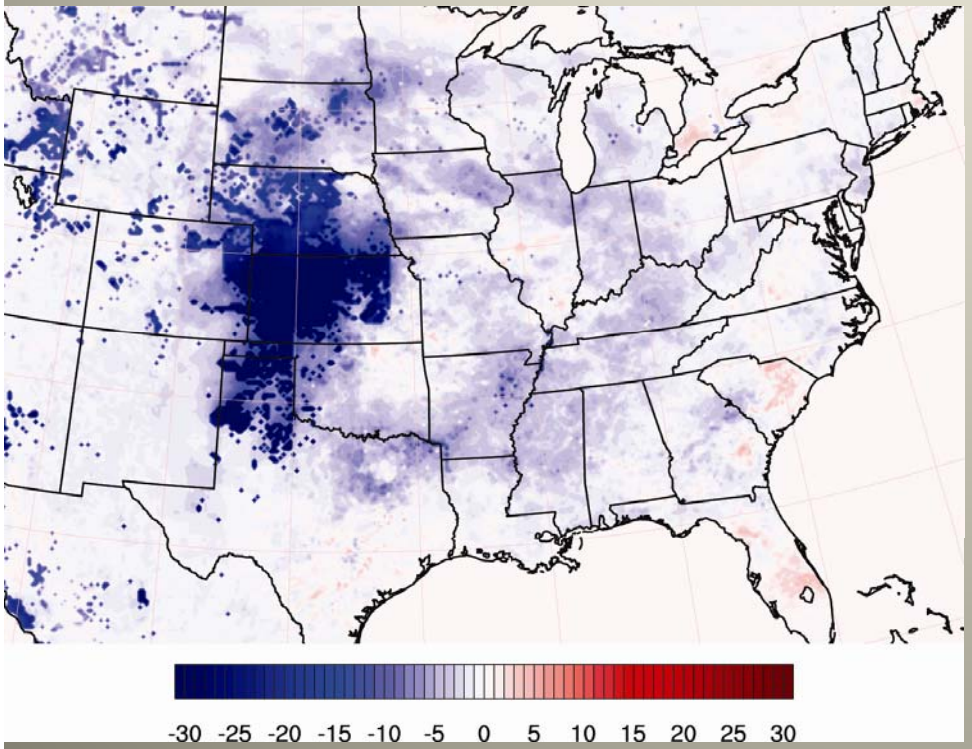


Change in Latent Heat Flux (Wm^{-2})

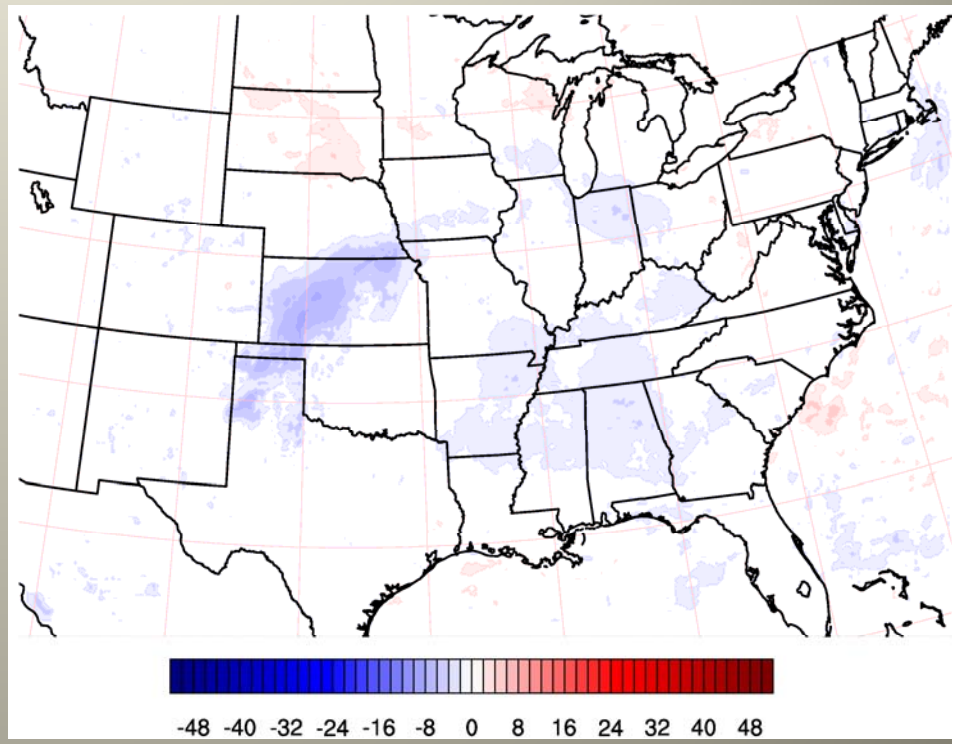


Radiation Differences

Upwelling Longwave (Wm^{-2})

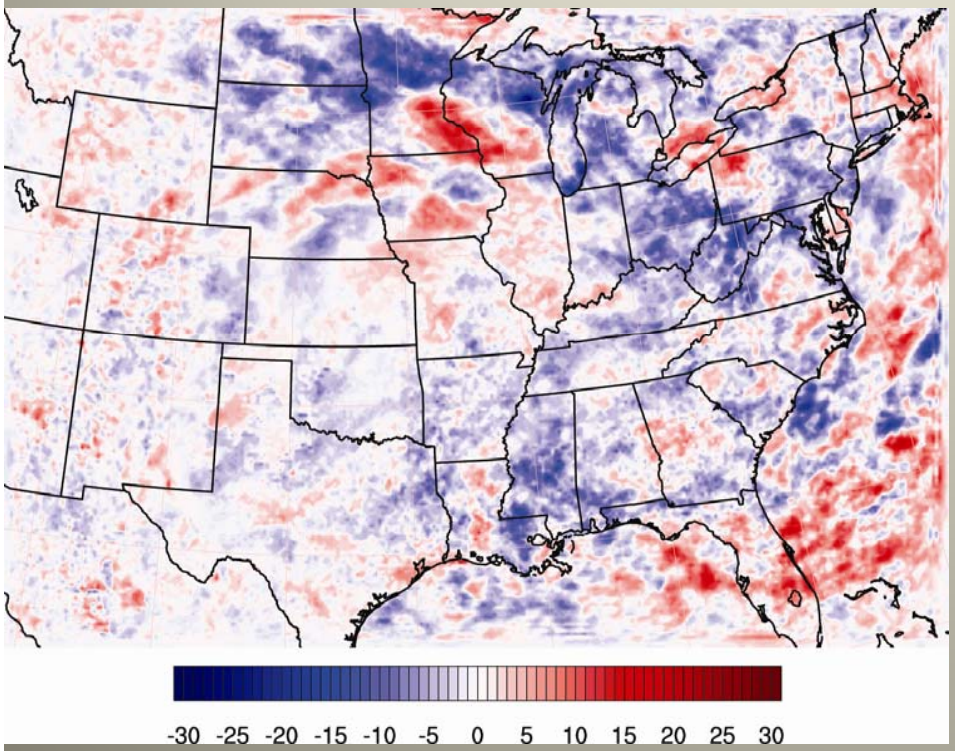


Downwelling Longwave (Wm^{-2})

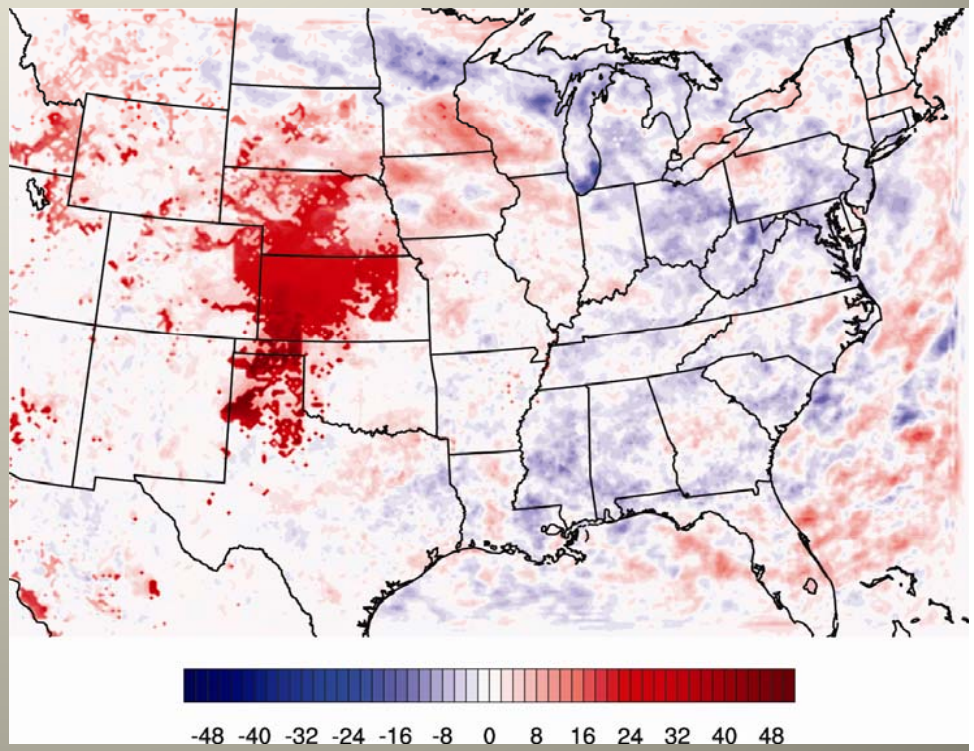


Radiation Differences

Shortwave Radiation (Wm^{-2})

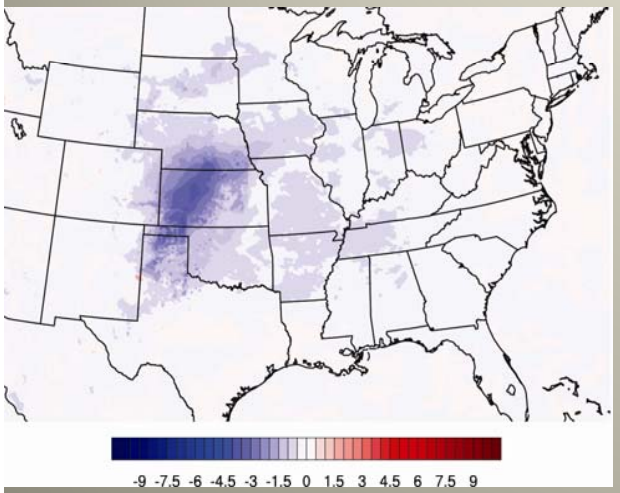


Net Radiation (Wm^{-2})

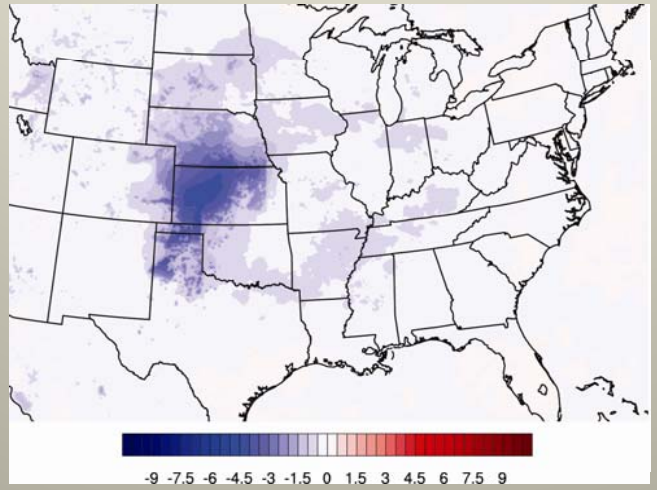


Radiation Differences

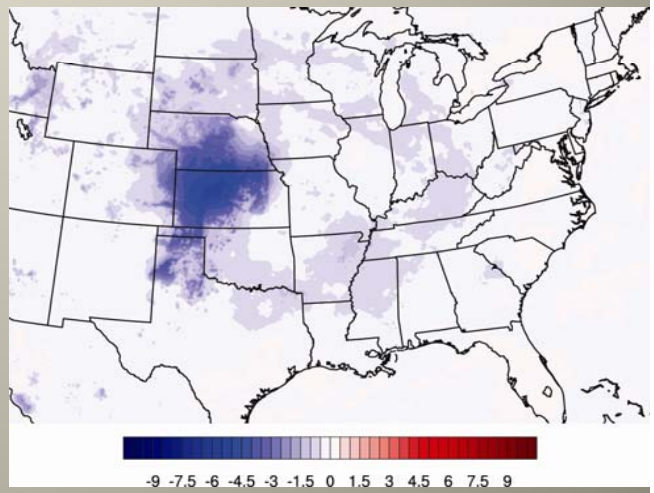
Even with higher R_n values, temperature drops due to lower H and higher LE



Minimum Temperature (K)

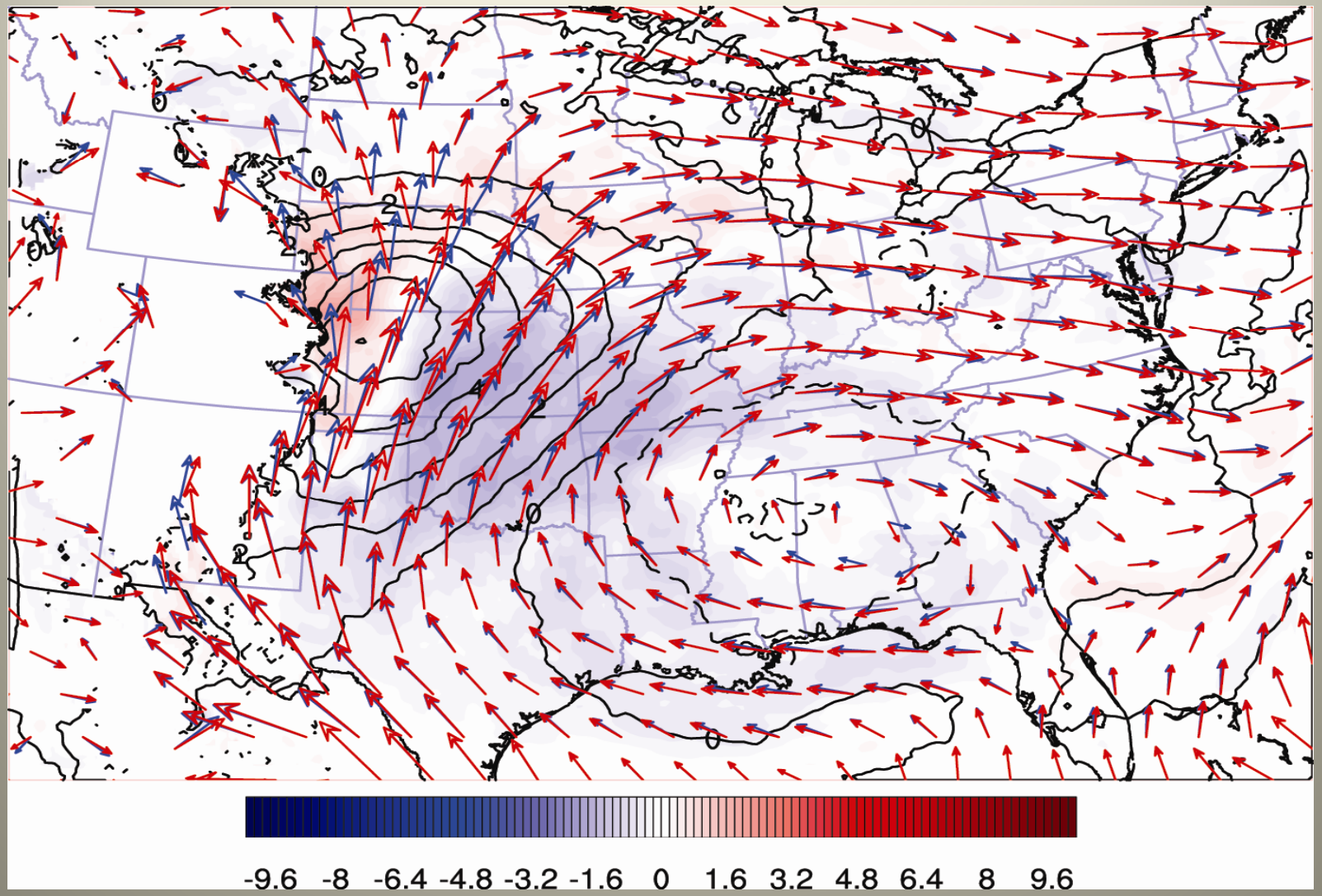


Average Temperature (K)



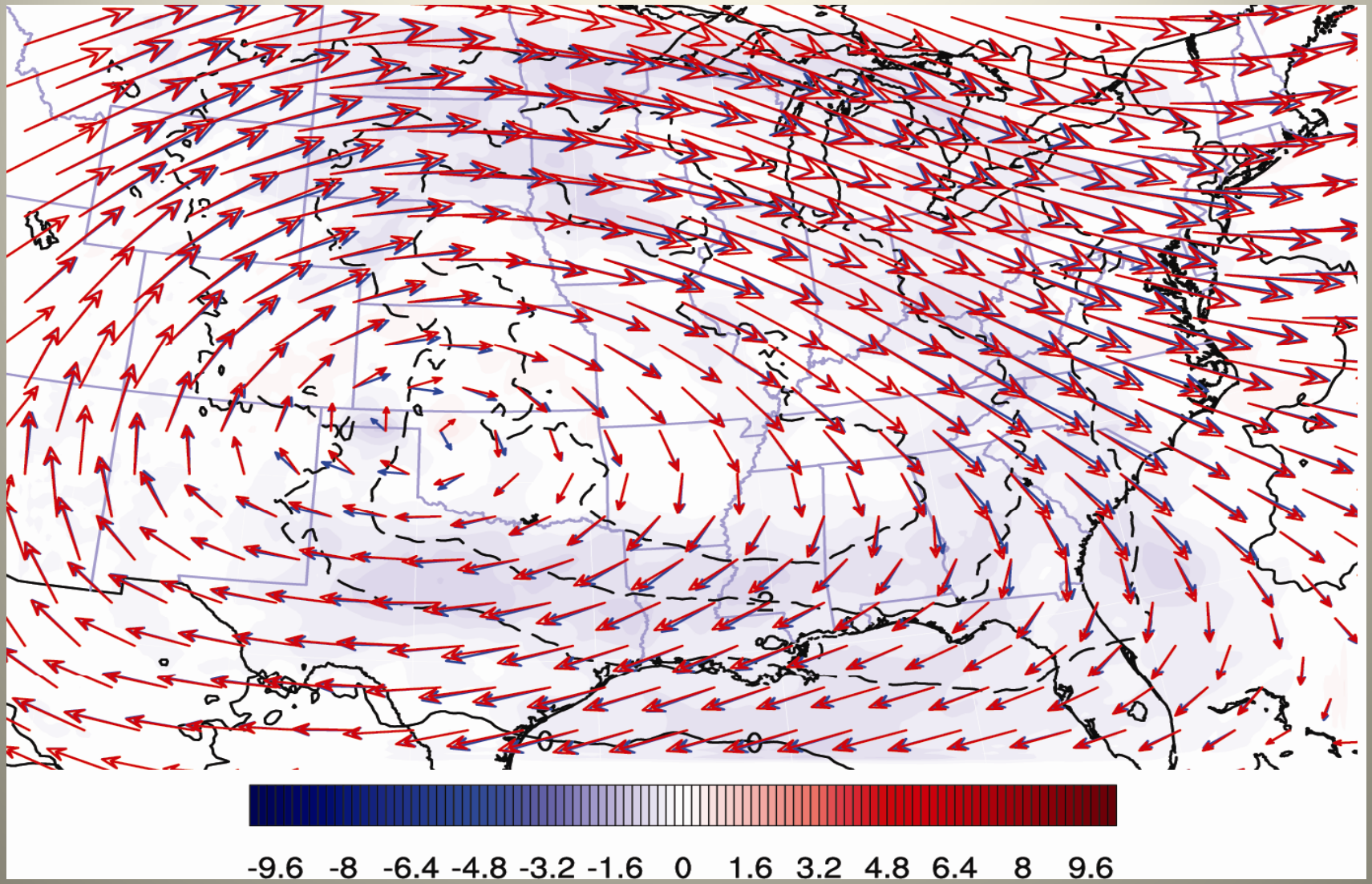
Max Temperature (K)

Flow Regimes



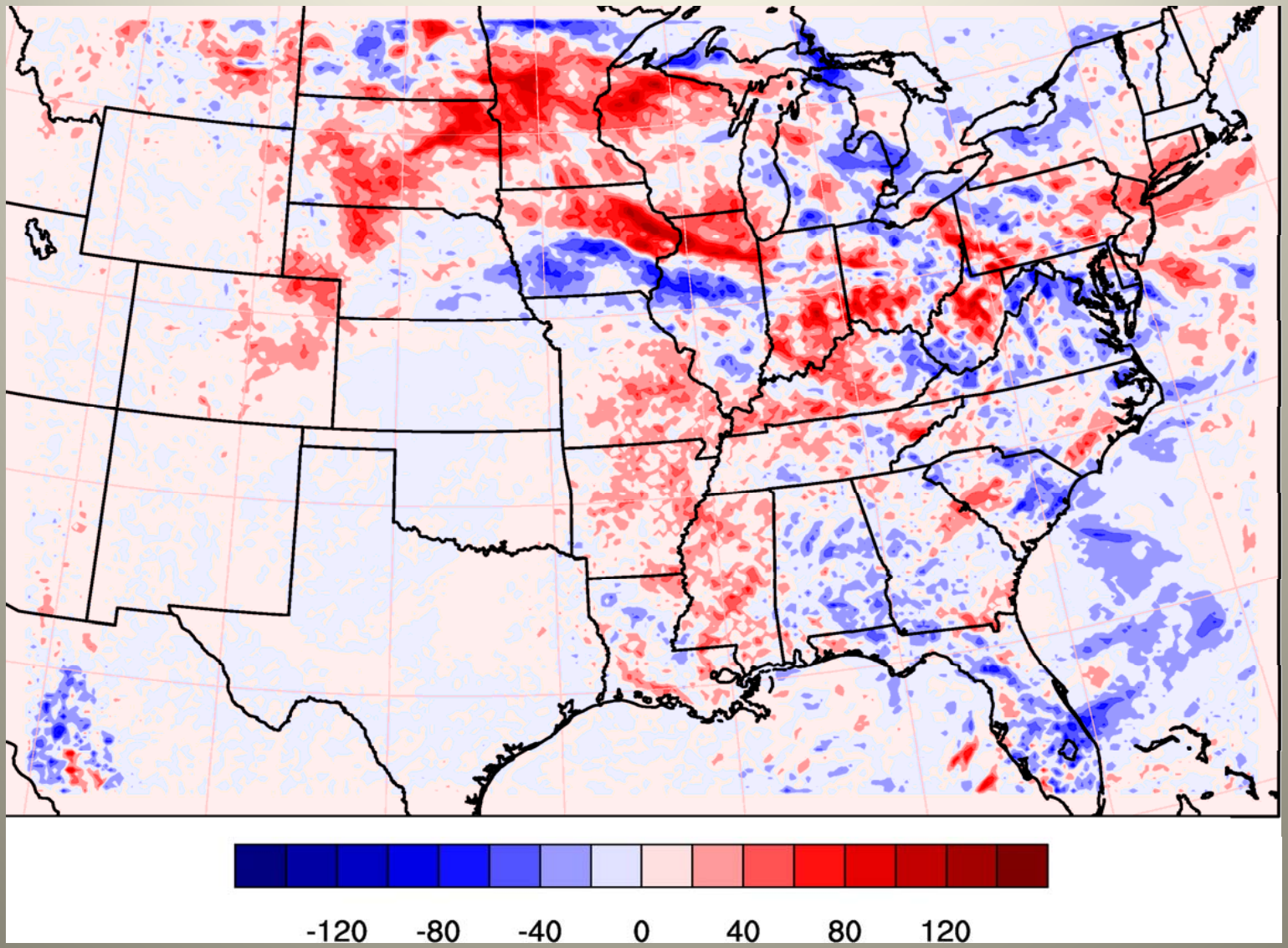
850mb Wind Vectors (arrows, m s^{-1}), Wind Speed Differences (shaded contours, m s^{-1}), and Geopotential Height Differences (black contours, m)

Flow Regimes



500mb Wind Vectors (arrows, m s^{-1}), Wind Speed Differences (shaded contours, m s^{-1}), and Geopotential Height Differences (black contours, m)

Precipitation Differences



Conclusions

- Irrigation Alters the Radiation Balance and Water Budget
- Enhanced Evaporation Cools the Surface and the Lower Troposphere while Increasing Precipitation Downstream
- Temperature Changes Alter the Flow of the Low Level Jet