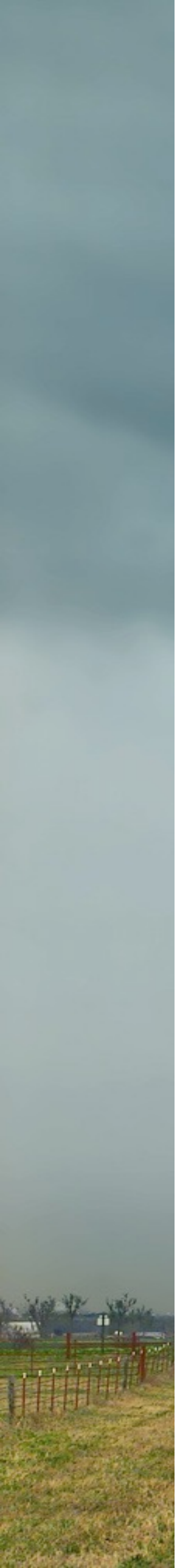

ASR
Atmospheric System Research

Pacific Northwest NATIONAL LABORATORY

An overview of irrigation impact on land-atmosphere-cloud interactions

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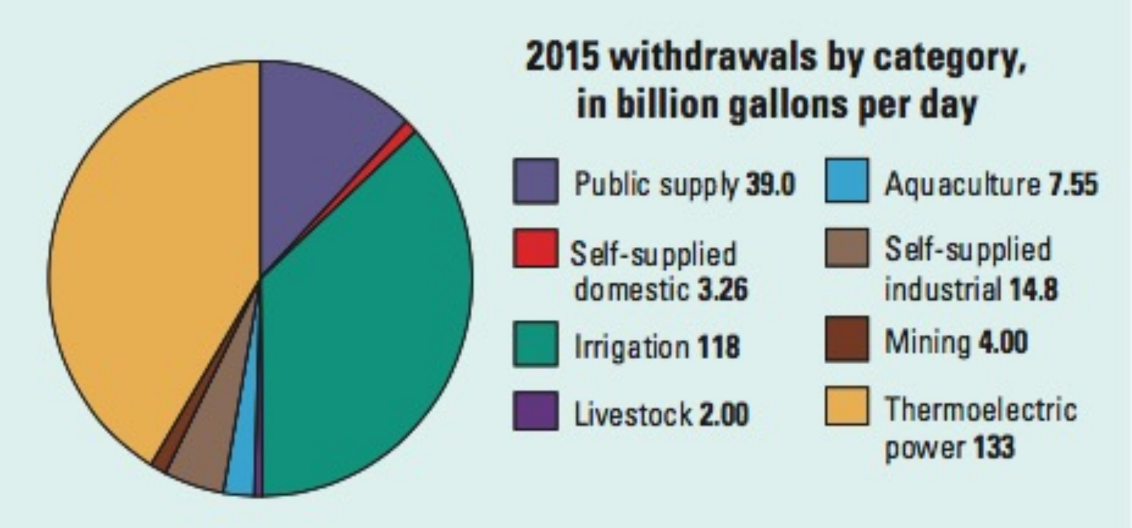
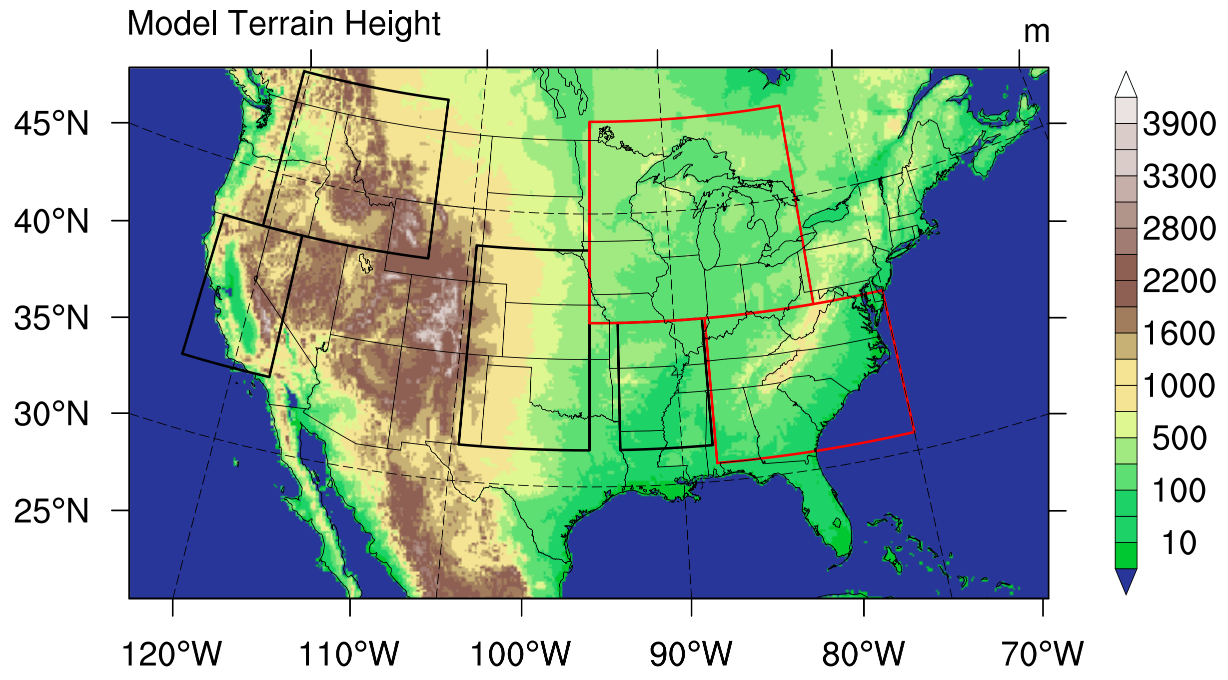
Background



- Irrigation is critical to agriculture in the United States: in 2012, irrigated farms accounted for ~50% of the total value of crop sales on 28 percent of U.S. harvested cropland;
- In 2015, total irrigation withdrawals accounted for 42 percent of total freshwater withdrawals in the US, and over 80 percent of water consumptive use is for irrigation purposes;
- Irrigation perturbs the surface water and energy budgets, and could modulate local to regional atmospheric processes via a mix of biogeophyscial and biogeochemical feedbacks;
- LULCC effects, including those induced by irrigation, account for 40% ± 16% of the human-caused global radiative forcing from 1850 to present day (**high confidence, CSSR, 4th NCA**)

Model configuration and experiment design



- ✓ Incorporated an irrigation scheme into the Noah land surface model as part of WRF.
- ✓ Integrated the FAO potential irrigation area data into the model. http://www.fao.org/aquastat/en/geospatial-information/global-maps-irrigated-areas

Irrigation is triggered when root-zone soil moisture availability (MA) is below a specific threshold over croplands or pastures.

✓ $$MA = \frac{SM - SM_{WP}}{SM_{FC} - SM_{WP}}$$

where SM is current root-zone soil moisture, SM_{WP} and SM_{FC} are soil wilting point and field capacity, respectively.

Version: WRF 3.8.1

Horizontal Resolution: 4 km

Reanalysis data: NCEP FNL (Final) Operational Global Analysis data

Simulation periods:

March 15 – Oct 31, 2011

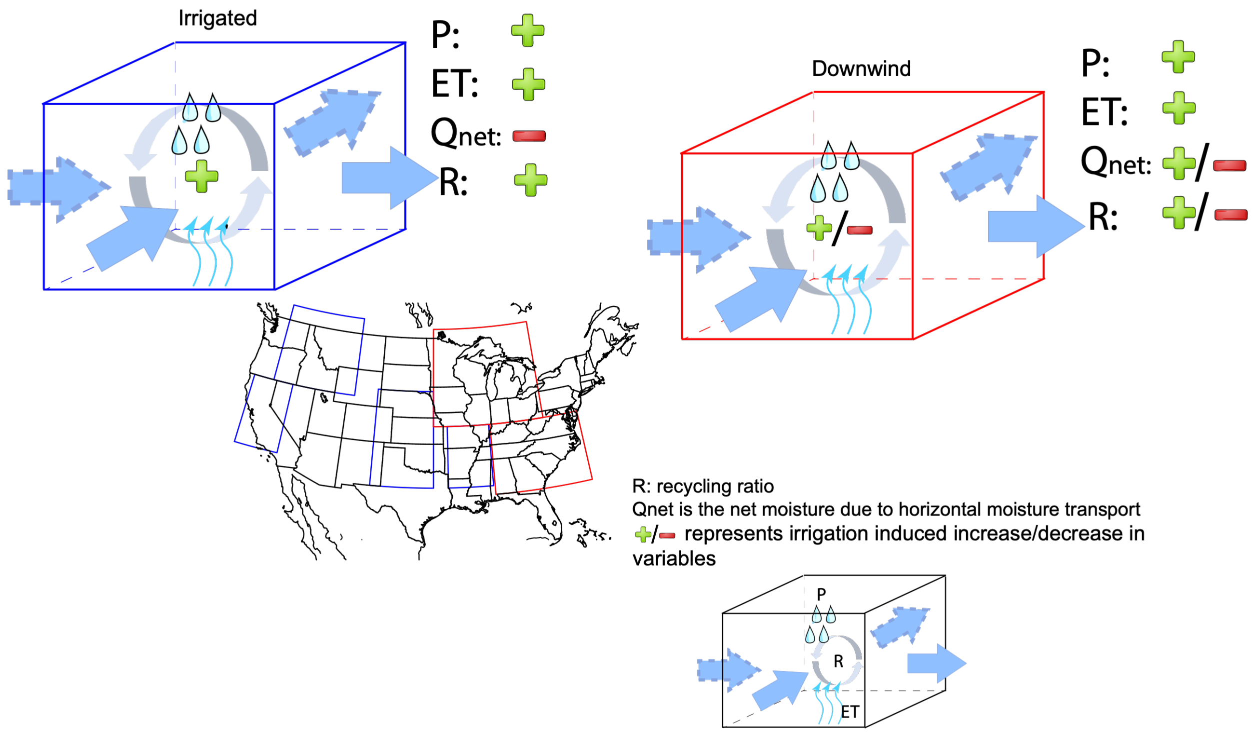
March 15 – Oct 31, 2012

Noah Land surface model: with (IRRG) and without (CNTL) irrigation scheme

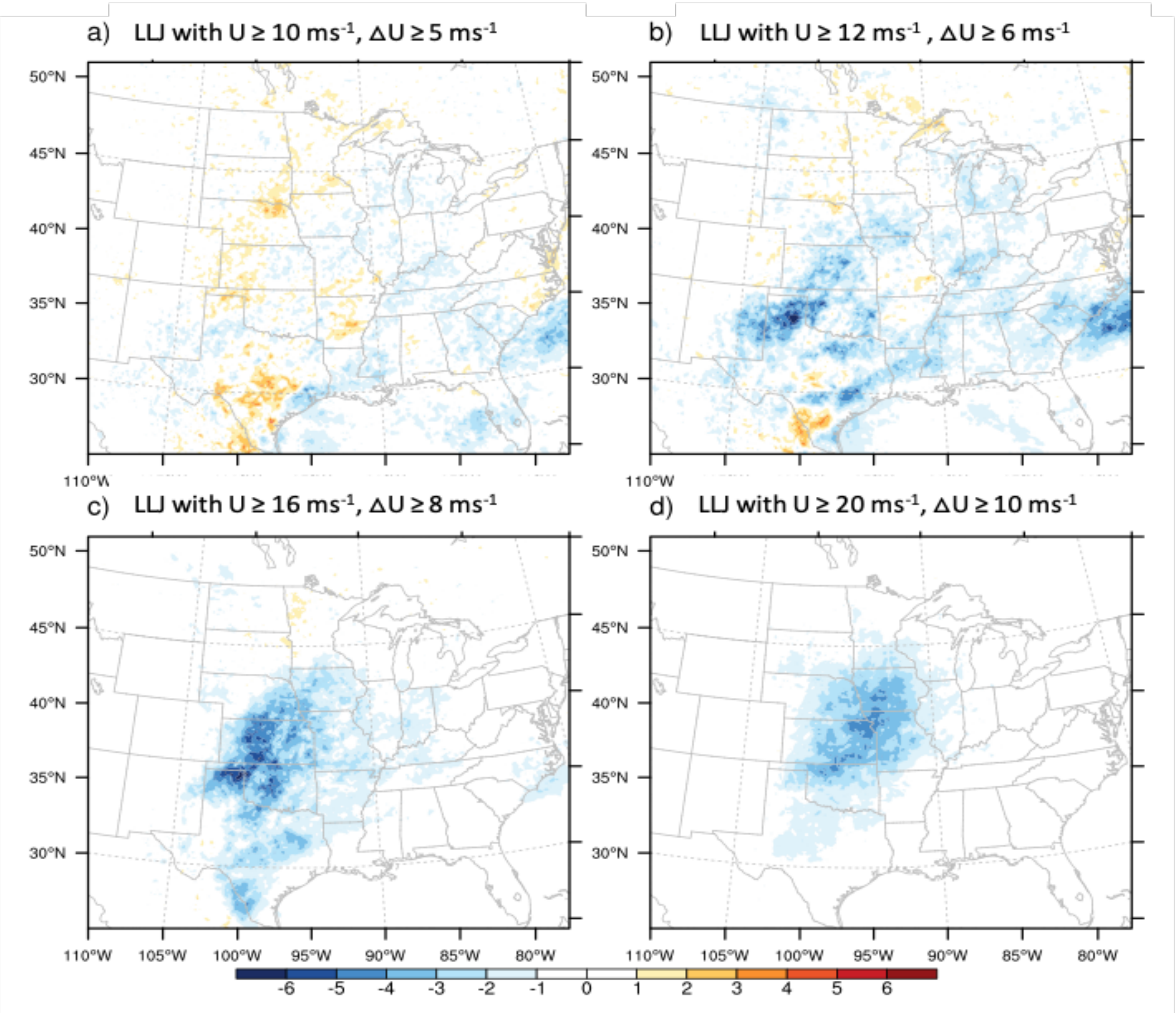
Physical Parameterizations:

Microphysics	Thompson
Radiation	RRTMG
Planetary boundary layer	MYNN

Irrigation alters water recycling and weakens Great Plains low-level jets

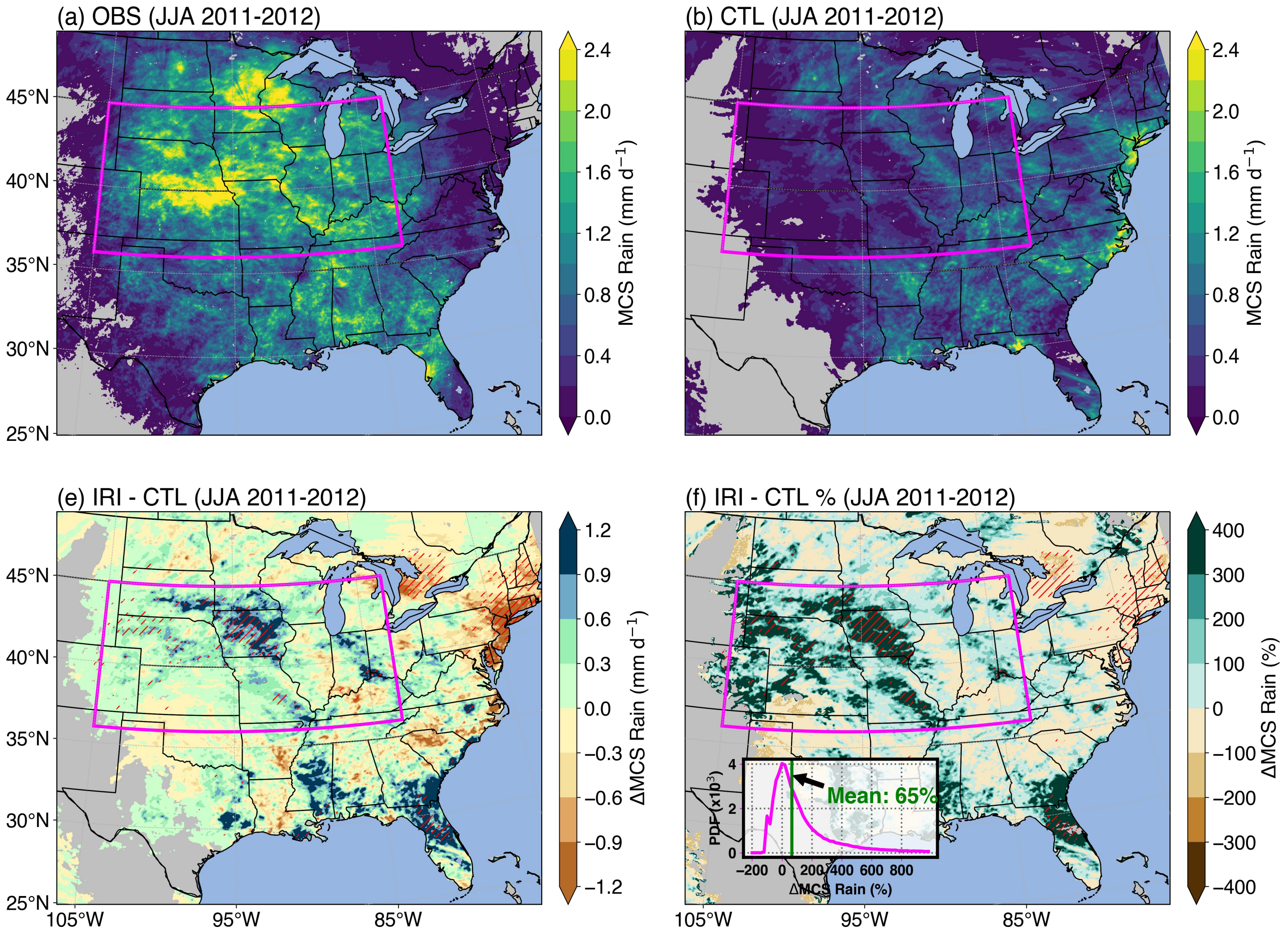


Irrigation leads to an intensified hydrologic cycle over the irrigated regions (Yang et al., 2019)

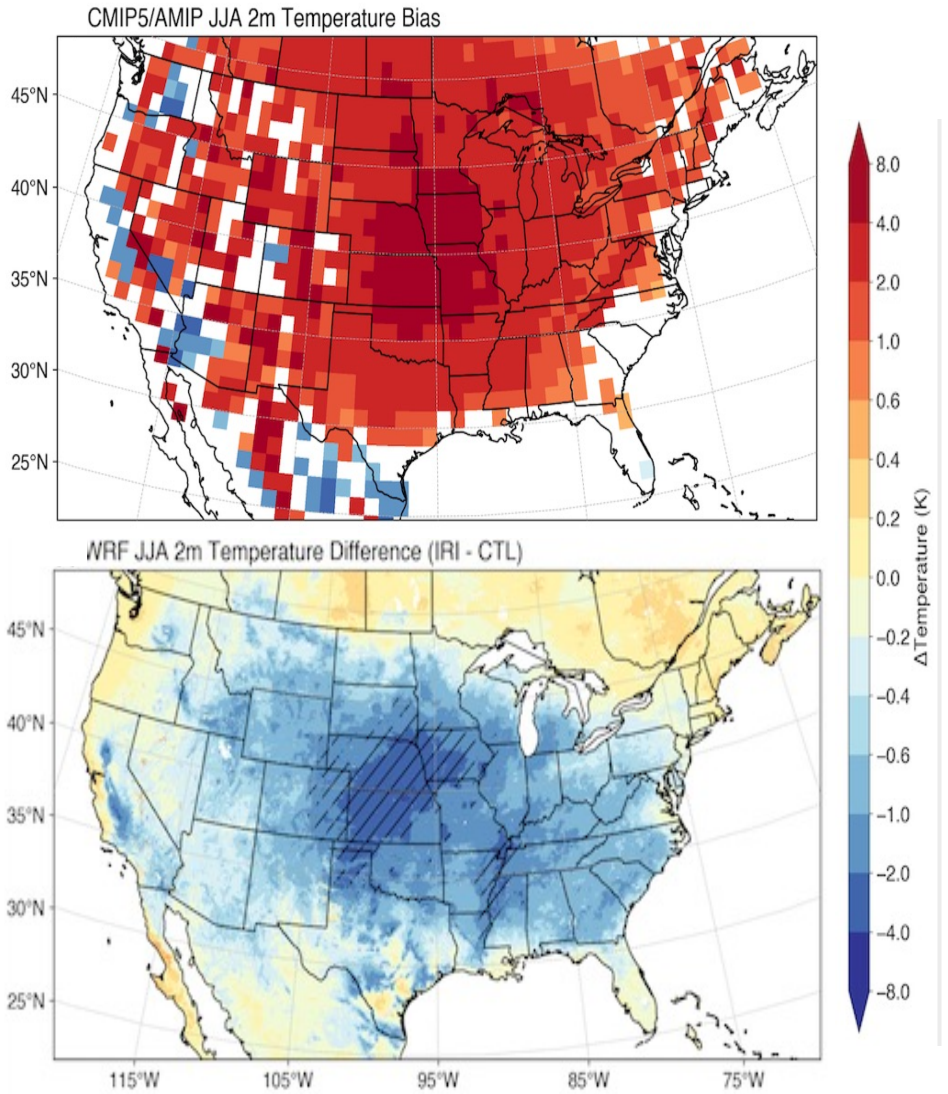


Irrigation-induced changes in frequency (%) for each LLJ category (Yang et al., 2020)

Irrigation alleviates modeled warm-and-dry bias over the central United States



Irrigation increases precipitation mainly through Mesoscale Convective Systems (MCS). MCS precipitation increases by 65% over the chosen region (magenta box). (Qian et al., 2020)



(Top) Warm bias of surface air temperature in climate models. (Bottom) Simulated irrigation-induced cooling (Qian et al., 2020)

Summary

1. **Irrigation intensifies the hydrological cycle and land-atmosphere interactions over the irrigated regions, reflected by the increased precipitation, evapotranspiration, recycling ratio, and moisture export.**
2. **Irrigation reduces the frequency of intense LLJs over the Great Plains because irrigation-induced surface cooling and a mid-level trough decrease favorable conditions for forming LLJs.**
3. **Including irrigation improves the modeled frequency of low-level jets, and spatial patterns, diurnal cycles, and propagation of MCSs.**
4. **Irrigation increases simulated precipitation over the Central United States by increasing the frequency of MCSs, reducing the persistent warm biases in surface air temperature that plague climate models.**

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- Yang, Z., Y. Qian, Y. Liu, L. K. Berg, H. Hu, F. Dominguez, B. Yang, Z. Feng, W. I. Gustafson Jr., M. Huang, Q. Tang. "Irrigation impact on water and energy cycle during dry years over the United States using convection-permitting WRF and a dynamical recycling model." *Journal of Geophysical Research: Atmospheres* 124 (2019). https://doi.org/10.1029/2019JD030524.
- Yang, Z., Y. Qian, Y. Liu, L. Berg, G. I. Gustafson, Z. Feng, S. Koichi, F. Jerome, S.-L. Tai, B. Yang, M. Huang, H. Xiao, "Understanding irrigation impacts on low-level jets over the Great Plains," Clim Dyn, 55(3), 925–943, (2020). DOI:10.1007/s00382-020-05301-7.