Irrigation mitigates against local and regional heat extremes

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Irrigation matters! (1)

(Cook et al., 2014 CD)
Irrigation matters! (2)

(Irrigation matters! (2)

(Guimberteau et al., 2012 CD)

(de Vrese et al., 2016 GRL)
Challenges

- Model instead of prescribe irrigation amounts (but still get realistic numbers)
- Avoid ‘contamination’ of natural SM
- Account for natural variability
- Model evaluation

- Focus on extremes
- Quantify contributions from different perturbations of the SEB
- Contrast local effects to grid-cell averages
Hydrology and irrigation in CLM

**CLM4.0**
- Gridcell
- Landuse
  - Glacier
  - Wetland
  - Vegetated
  - Lake
  - Urban
- Columns
- PFTs
  - C3 crop

**CLM4.5**
- Gridcell
- Landuse
  - Vegetated
  - Lake
  - Urban
  - Glacier
- Crop
  - Unirrig
  - Irrig
- PFT
  - PFT1
  - PFT2
  - PFT3
  - PFT4...

- Corn
- Temperate cereal
- Winter Cereals
- Soybean
Hydrology and irrigation in CLM4.0

Hydrology

\( q_{\text{run}} - q_{\text{irr}} \)

\( q_{\text{irr}} \)

\( q_{\text{inf}} \)

\( q_{\text{over}} \)

\( q_{\text{drain}} \)

\( q_{\text{recharge}} \)

\( q_{\text{melt}} \)

\( q_{\text{subl}} \)

\( q_{\text{liq},0} \)

\( q_{\text{run}} \)

\( q_{\text{irr}} \)

\( q_{\text{inf}} \)

\( q_{\text{over}} \)

\( q_{\text{drain}} \)

\( q_{\text{recharge}} \)

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\( q_{\text{inf}} \)

\( q_{\text{over}} \)

\( q_{\text{drain}} \)

\( q_{\text{recharge}} \)
Simulation set-up

- 2 x 5 member ensemble (CTL & IRR)
- CESM1.2.0 - CLM4.0 (SP)
- HadIO SST & Sea ice fraction
- 1976-2010
- 0.9° x 1.25°
- Parameterized irrigation

(from Siebert et al., 2005)
How well does our model perform?
Water added through irrigation
Added value matrix: changes in spatiotemporal RMSE

77 out of 100 cells show enhanced skill
Impact on means and extremes
Impact on T2m and precipitation
Asymmetric response: MED
Asymmetric response: SAS

- (a) \( \Delta Q_{irr} \) [mm d\(^{-1}\)]
- (b) \( \Delta T_{2m} \) [K]
- (c) \( \Delta LHF \) [W m\(^{-2}\)]
- (d) \( \Delta SHF \) [W m\(^{-2}\)]
Impact on extremes
SEB decomposition
SEB decomposition

(a) all land

(b) irrigated land

(c) irrigated land - subgrid effect

ΔTₜ forcing [K]
Effect of scale and ensemble size
Importance of scale

Grid-scale

Subgrid-scale
Importance of ensemble size

In the graphs, the change in 2m temperature ($\Delta T_{2m}$) is plotted against the number of ensemble members. The graphs show the behavior for irrigated land and all land.

For irrigated land:
- The x-axis represents the number of ensemble members (1 to 5).
- The y-axis shows the change in 2m temperature ranging from -0.3 to -0.1.
- The data points for 25, 100, 100, 25, and 1 ensemble members are indicated.

For all land:
- The x-axis represents the number of ensemble members (1 to 5).
- The y-axis shows the change in 2m temperature ranging from -0.14 to 0.02.
- The data points for 25, 100, 100, 25, and 1 ensemble members are indicated.

The graphs suggest a trend in the change of temperature with the increase in ensemble size.
Conclusions

- Running ensembles is necessary for this type of research
- Including irrigation improves the skill of CESM
- Mean influence confirms literature but highlights role of natural variability!
- Asymmetric response, with strong impacts on extremes!
- Bowen ratio decrease is main contributor to T decrease
- Local impacts are larger than grid-scale average
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Thiery, W. et al., Present-day irrigation mitigates heat extremes, JGR, in review.