Land and extremes

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Impacts of extremes on humans and ecosystems

- Water
  - Drought
  - Flood
- Ecosystem functioning (carbon)
  - Vegetation mortality due to fire, drought, windthrow
  - Permafrost
- Agriculture
  - Heat extremes at flowering
  - Drought and flood
  - Livestock health
- Urban
  - Heat and mortality
  - Impacts of hurricanes

Impacts-related processes in CTSM

CTSM/CESM increasingly applicable for research into impacts of extremes

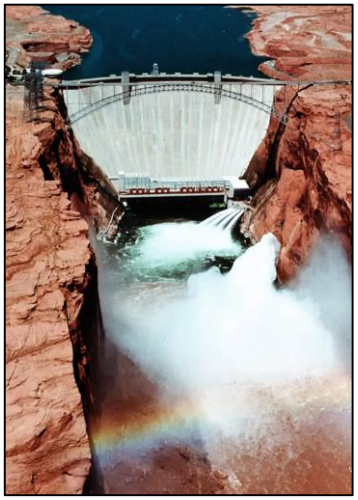
Crops

Urban

Logging

Irrigation

Reservoirs (soon)



Ecosystems (FATES)

Fire

Land and extremes

Extremes impacts

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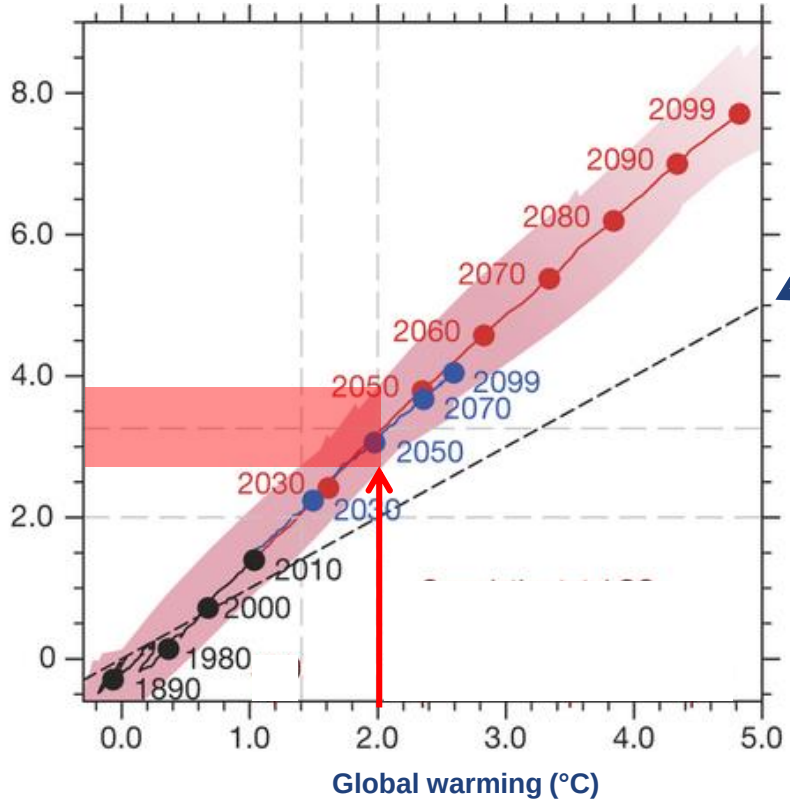
Impact of land processes on extremes

- Soil moisture / vegetation feedback
  - Amplify temperature extremes
  - Amplify drought, flood, storms
- Direct human influence
  - Land-use and land-cover
  - Irrigation
  - Urban properties

Temporal variability

2° warming will not be uniform across the year

Mediterranean warming, warmest day of the year (°C)

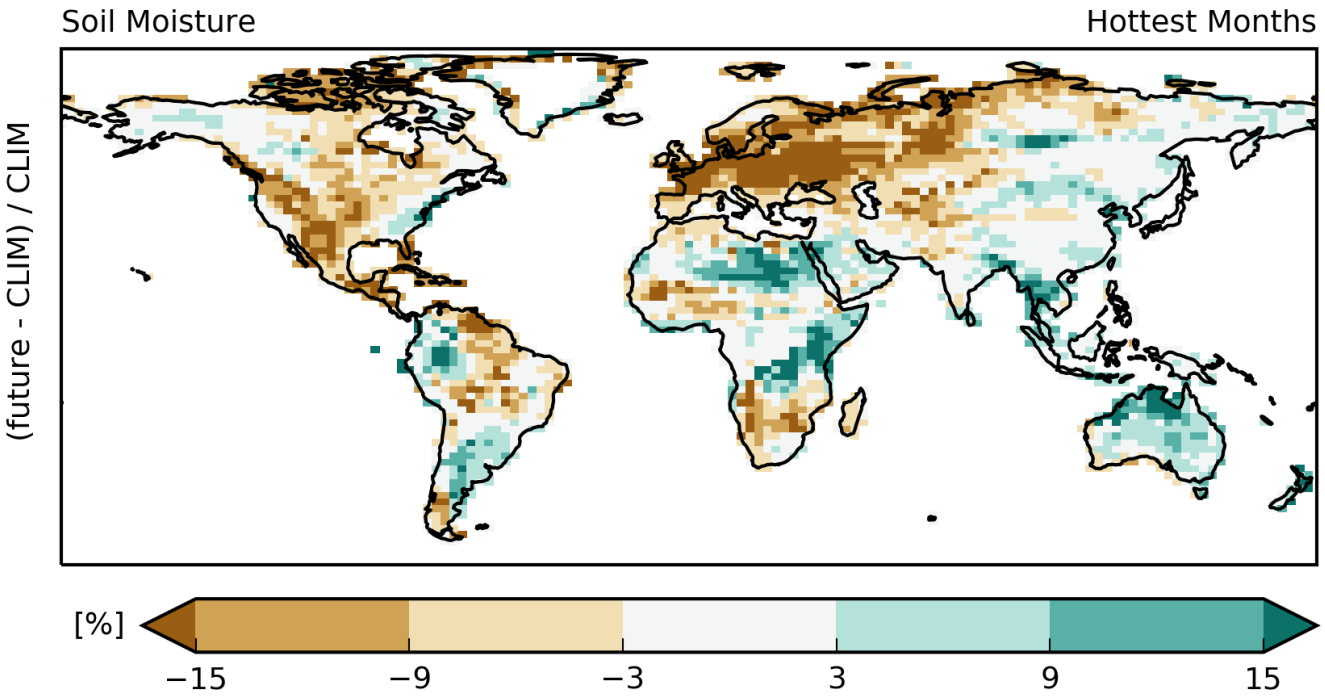


1:1 line

(Seneviratne et al., 2016 Nature)

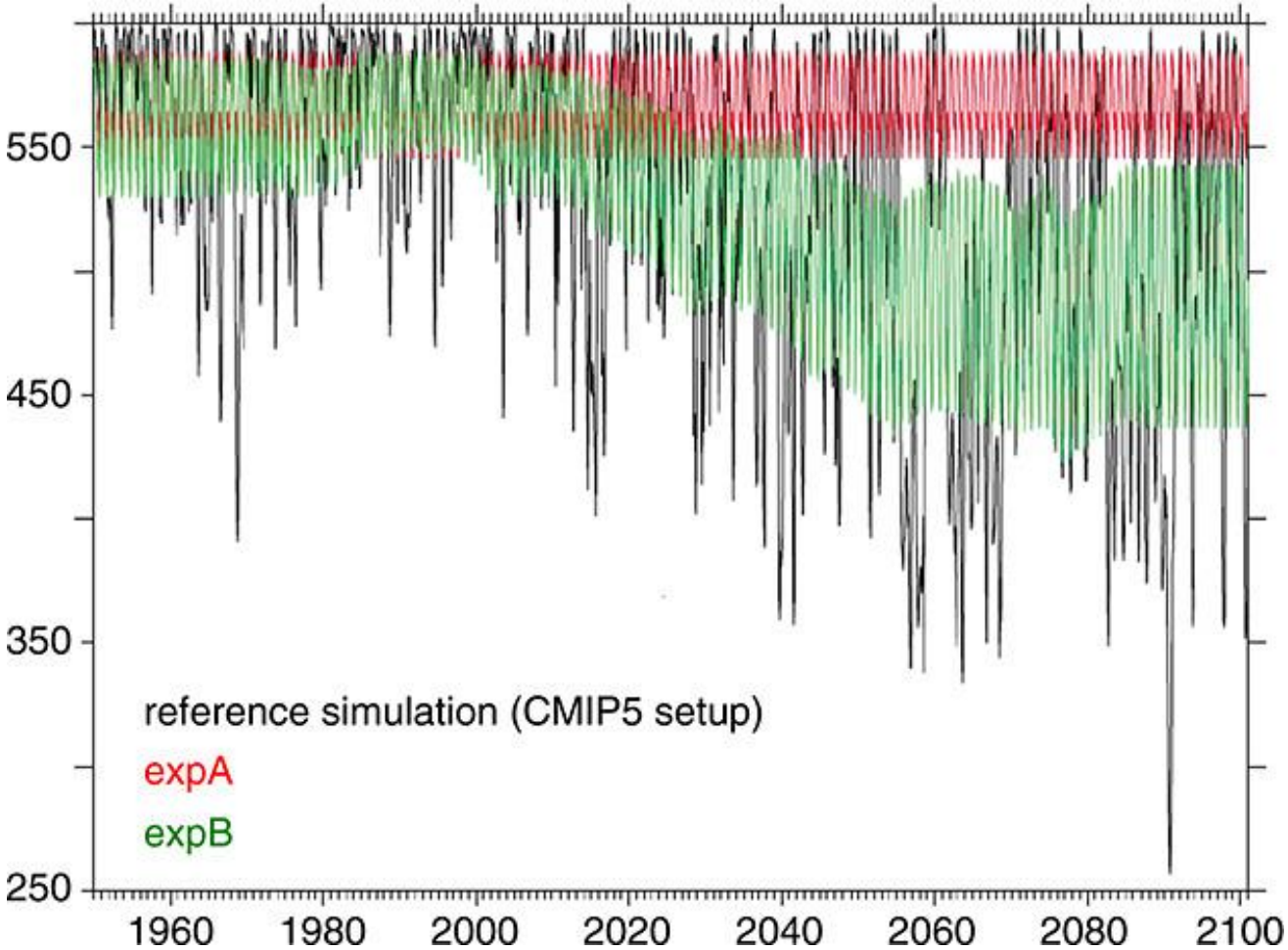
Projected soil moisture change

RCP8.5 | 10cm depth | 2070-2099 vs. 1971-2000



(Hauser, Thiery & Seneviratne, 2019 ESD)

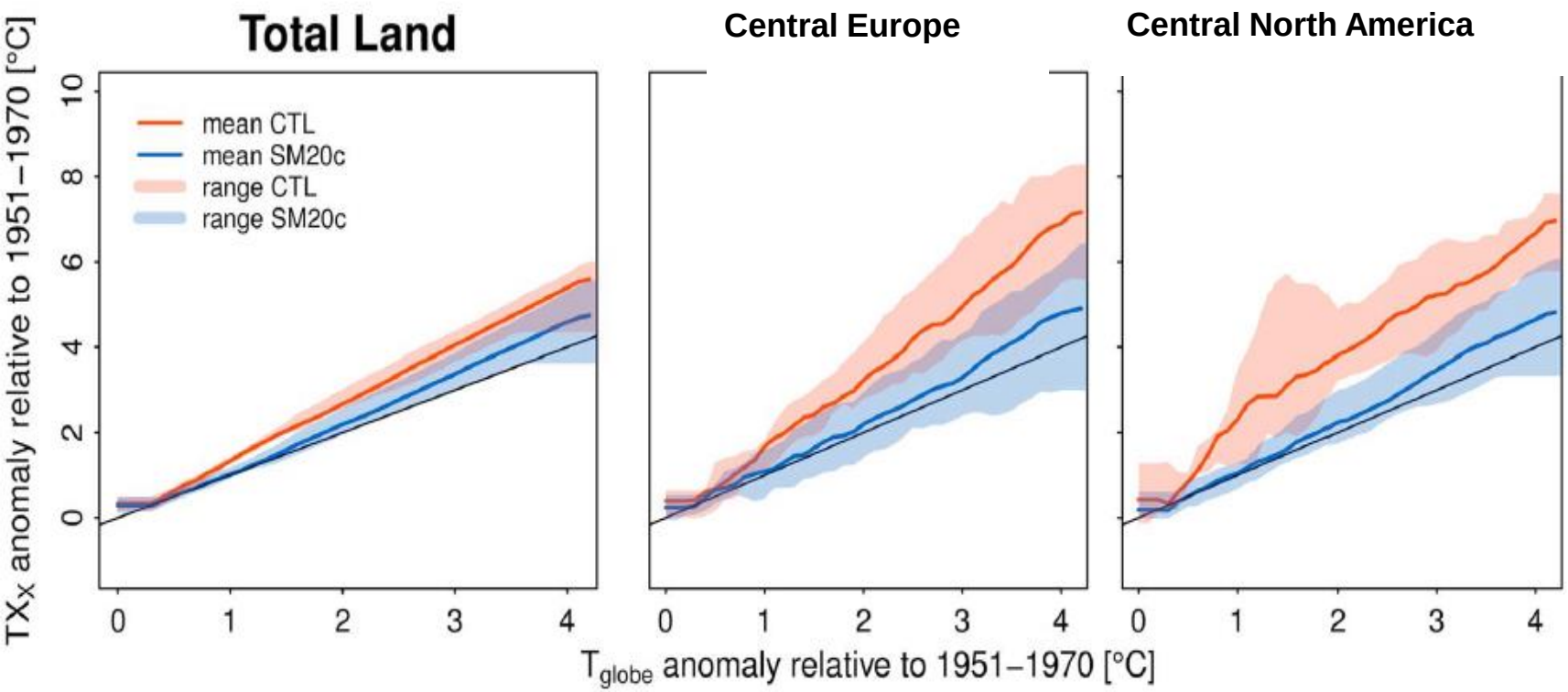
GLACE-CMIP5 MIP



(Seneviratne et al., 2014, GRL)

Soil moisture-temperature feedbacks

strongly affect the occurrence of hot extremes

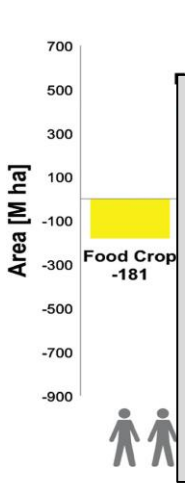


LS3MIP will repeat with more models and with 'bias-corrected' soil moisture from land-only runs

(Vogel et al., 2017 GRL)

Impact of Land-Use and Land-Cover Change on extremes

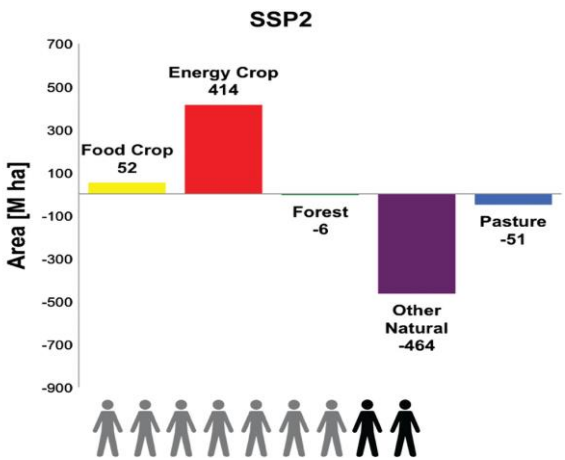
1.5°C target can (potentially) be achieved through several Socioeconomic Pathways each with own LULCC pathway, which exerts differing impacts on extremes

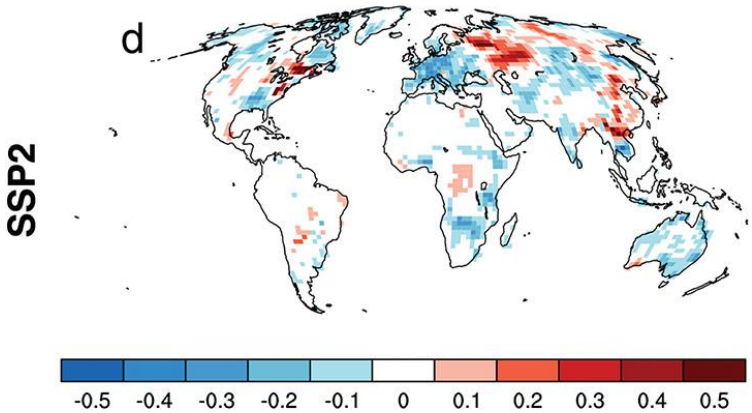


ΔTXx

Emphasis on LULCC impacts on extremes in LUMIP (simulations with alternative land use scenarios)

Joint assessment of quality of simulated LULCC response with alternative land use scenarios



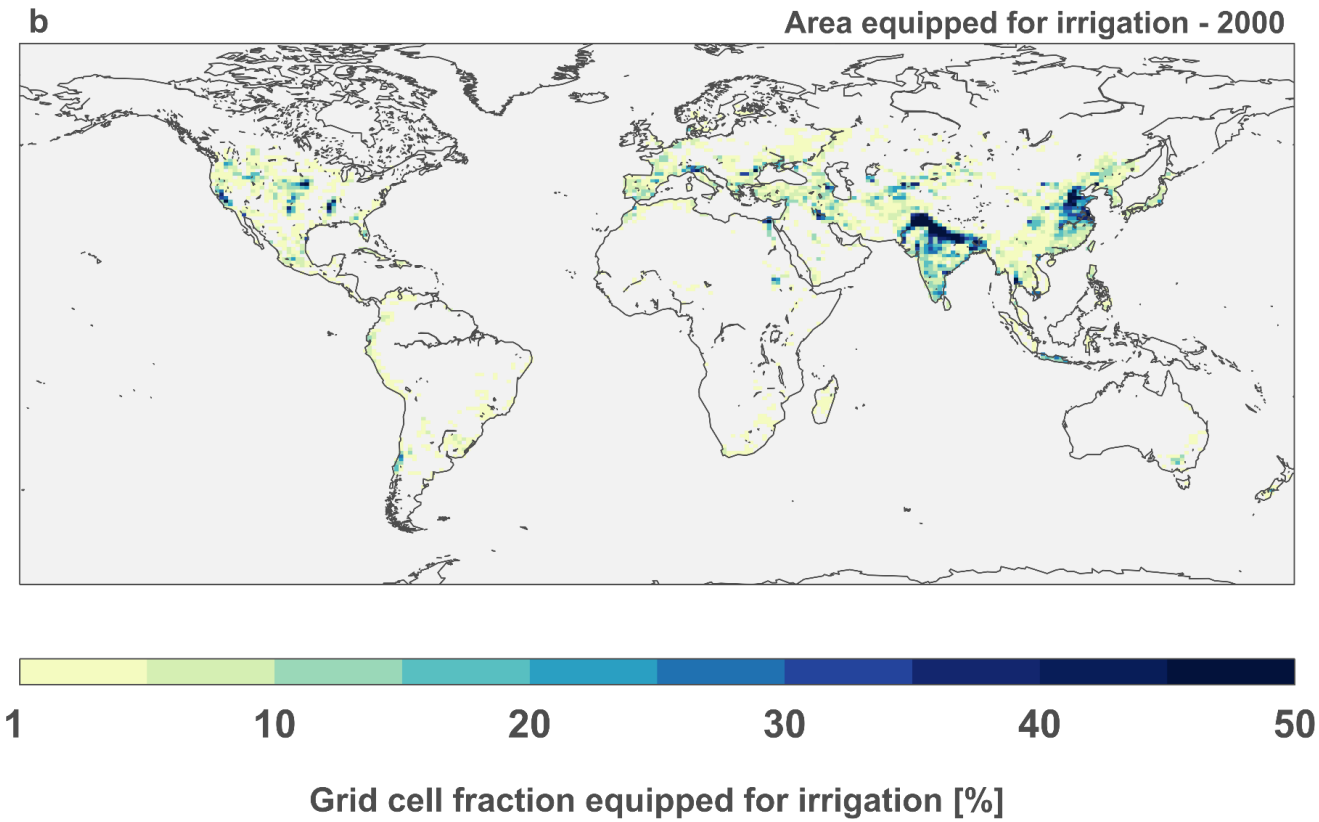


Hirsch et al., 2018

Impacts of irrigation on extremes

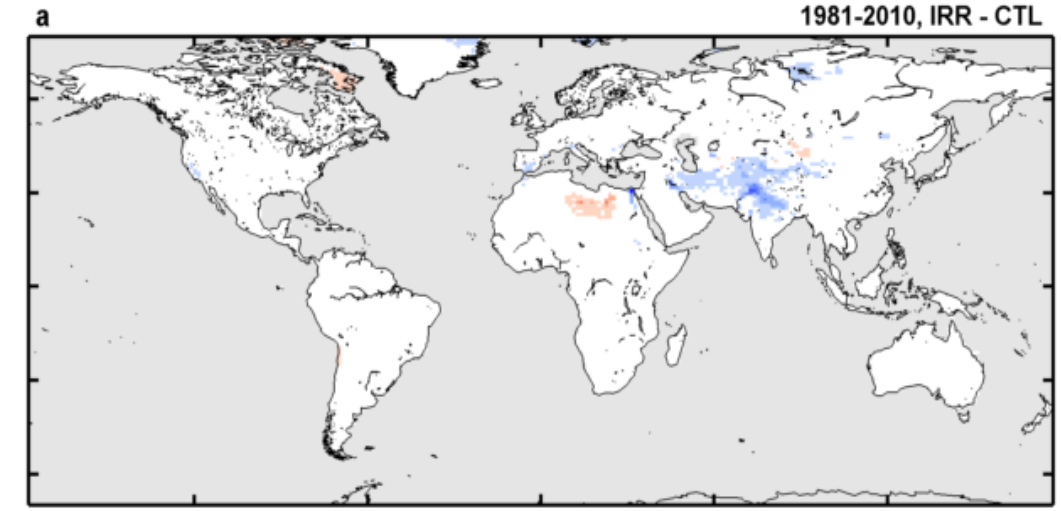
(flickr.com)

Present-day irrigation extent

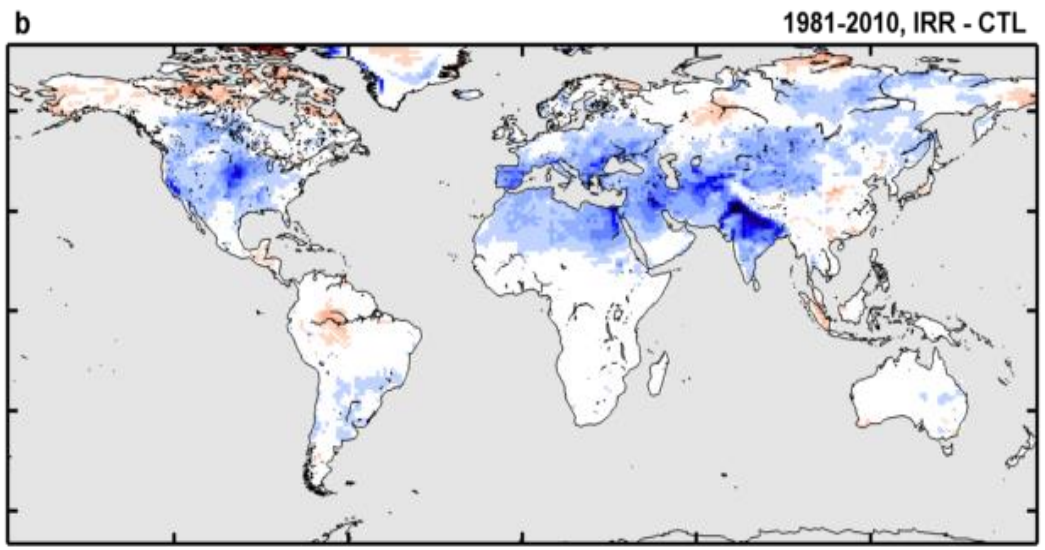


(Adapted from Siebert et al., 2005 HESS)

T_{2m}

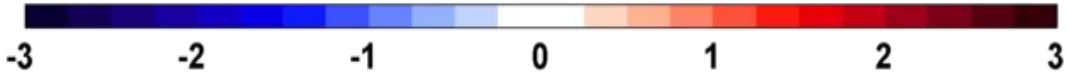


TXx
(hottest day of the year)

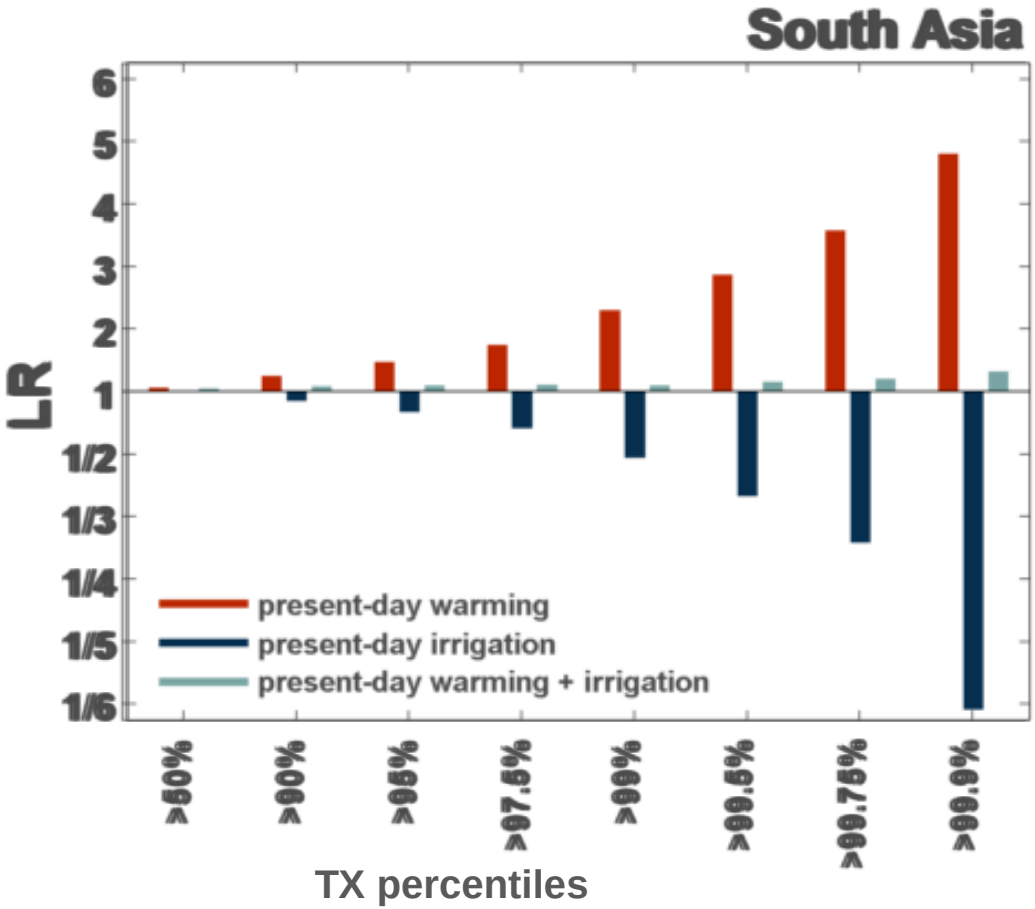


(Thiery et al., 2017 JGR)

[K]



Change in LR



Hot extremes become more likely

Hot extremes become less likely

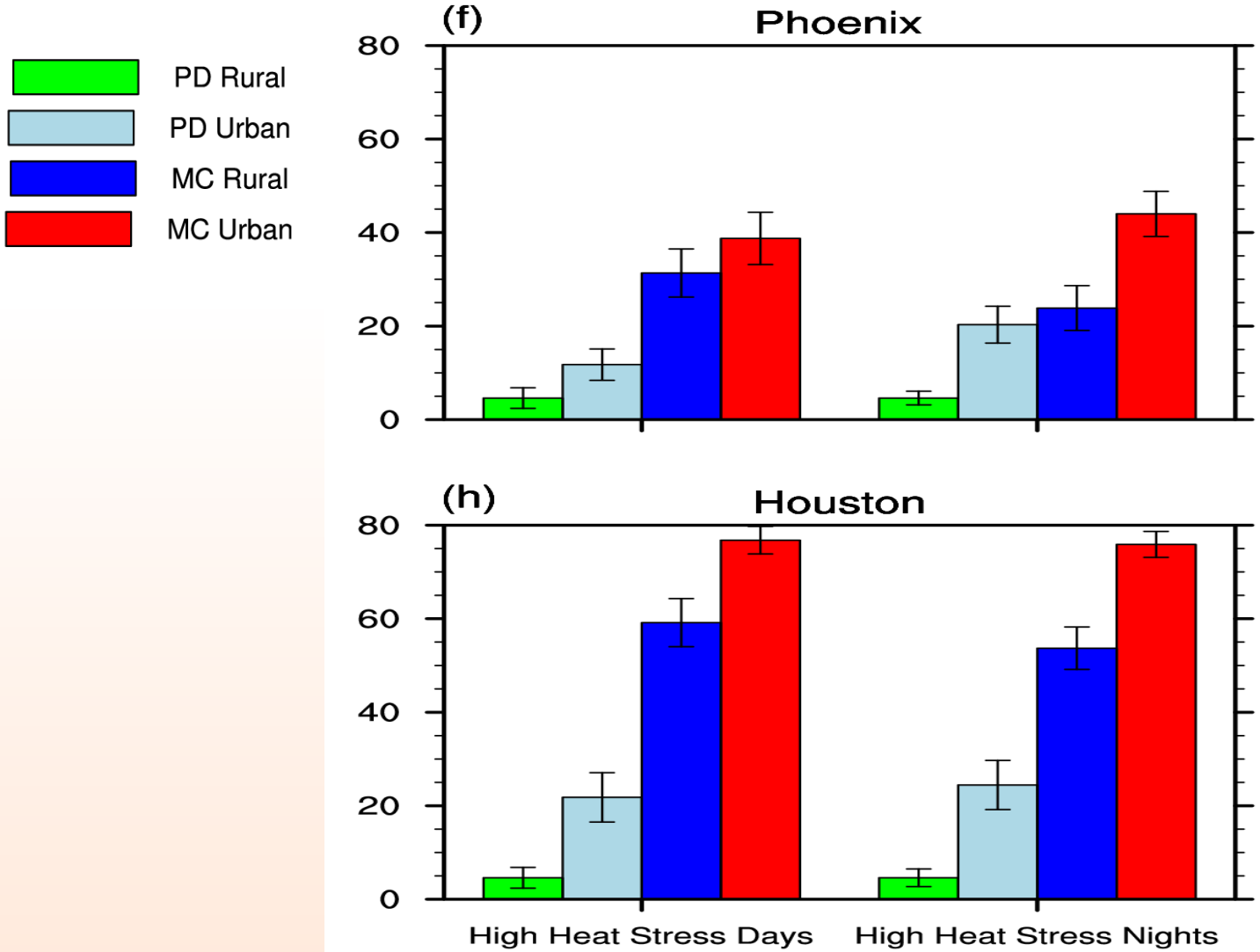
(Thiery et al., in rev.)

$$LR = \frac{P_{new}}{P_{ref}} = \frac{0.5}{0.1} = 5$$

Urban amplification of extremes

Present-day (PD) & Mid-century (MC) High HeatStress Days and Nights

NWS Heat Index (HI)



Oleson et al. 2013, Climatic Change

Influence of urban building properties on extremes

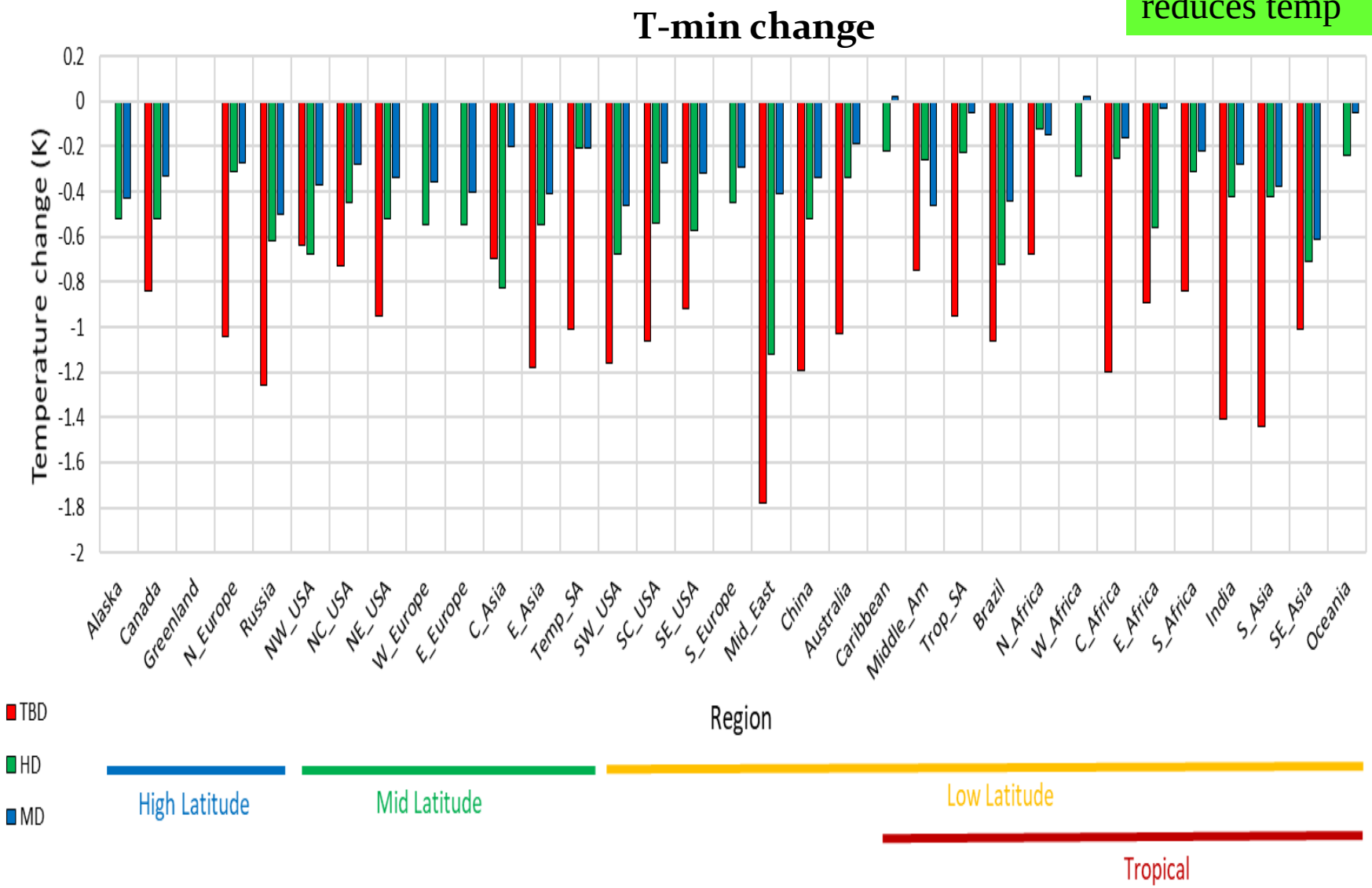
Scenario: Light Weight Insulated Walls and Roofs (LtWt)

- All walls replaced by lightweight (low heat capacity) wall made of wood frames with cement particle board exteriors, extensive layers of insulation and dry wall interior walls.
- All roofs are made of EPDM, roof felt, 6 layers of insulation and two layers of interior drywall.

Feddema et al. 2019, in prep

LtWt: Changes in Min Annual Temperature

Less stored heat released at night reduces temp



Feddema et al. 2019, in prep

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  - Heat index and human health
  - Impacts of hurricanes

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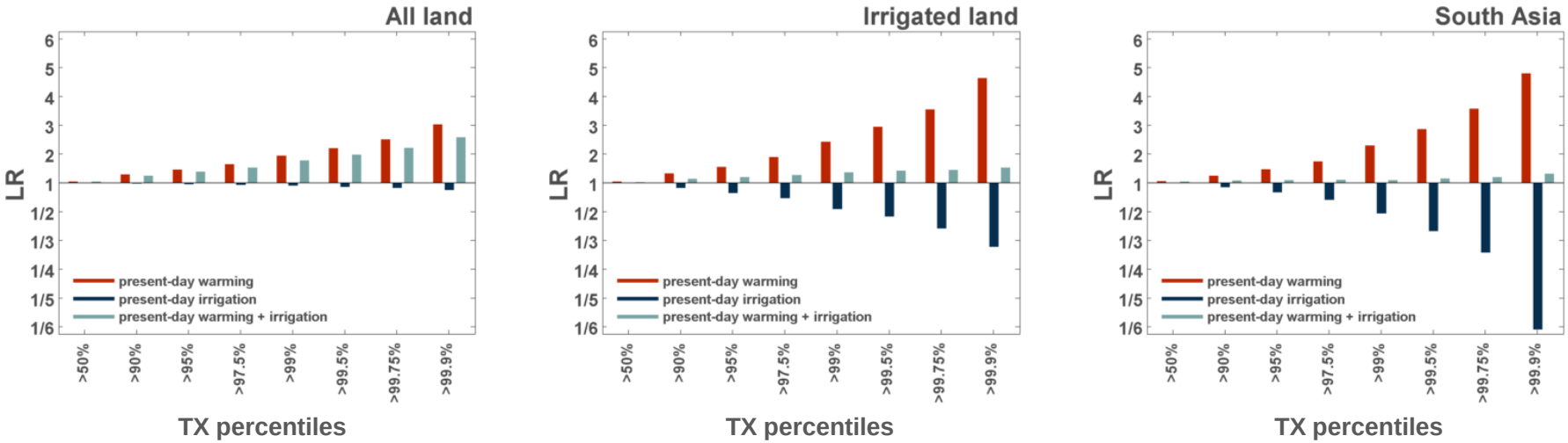
Many potential extremes topics at intersection between land processes influence on extremes and impacts research

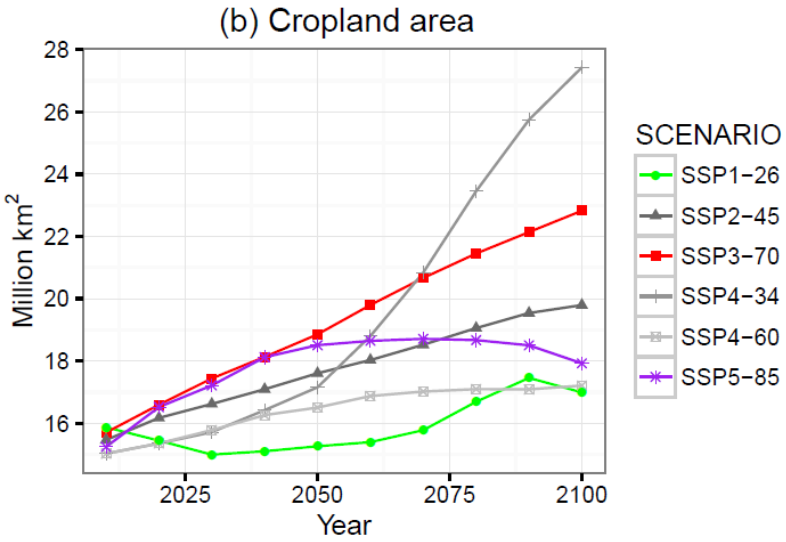


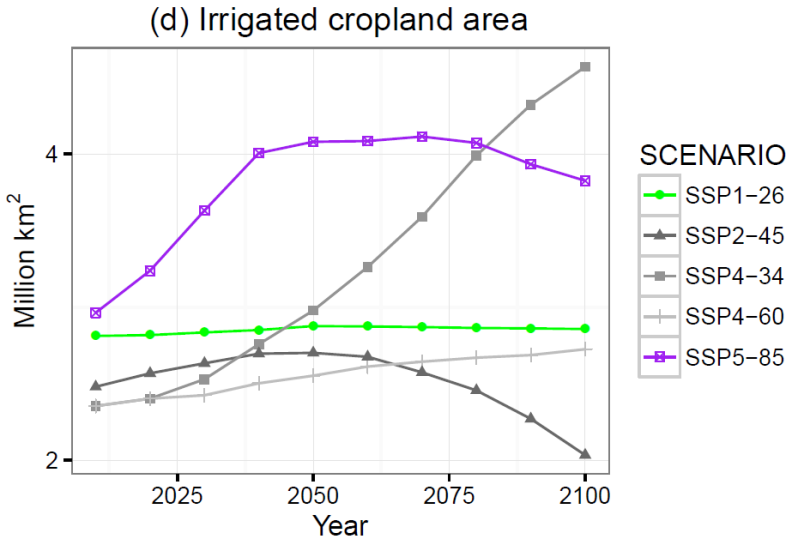
~5 % of all land

~3 % of all land

(Thiery et al., in rev.)

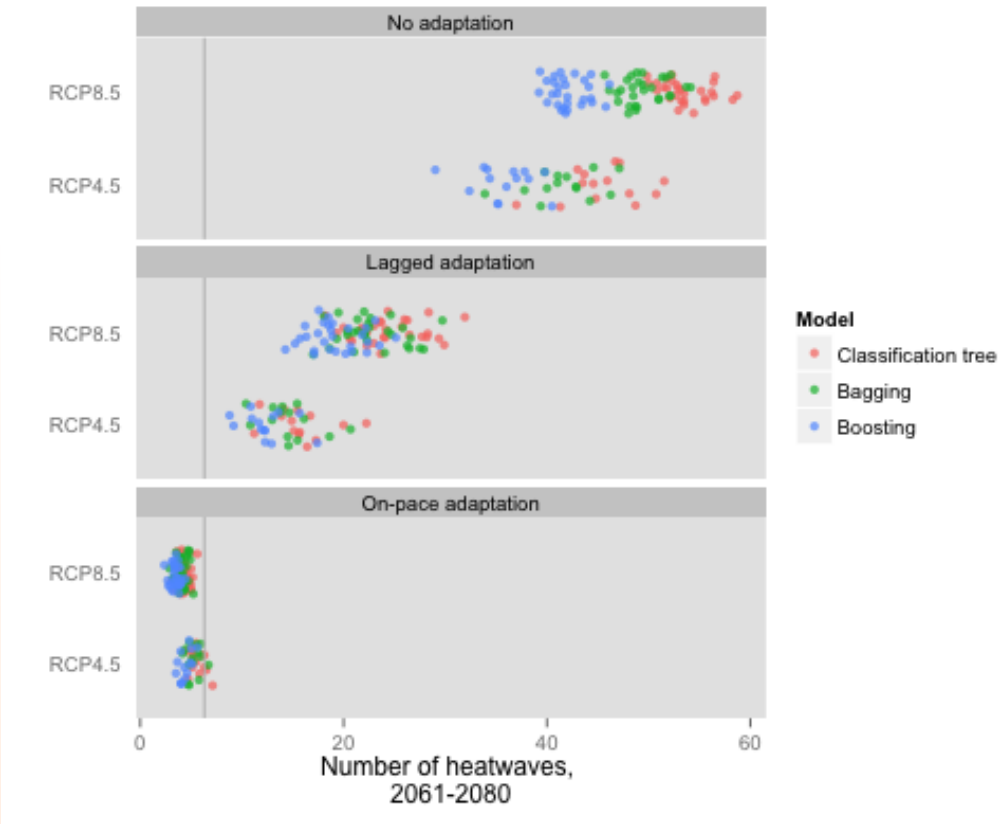
Projections of irrigated area





(Lawrence et al., 2016 GMD)

Frequencies of high-mortality heat waves



Estimated frequencies of high-mortality heat waves under future scenarios summed across 82 study communities for 2061—2080. Each dot represents the projected number of high-mortality heat waves for one ensemble member under a given combination of climate and adaptation scenarios. All projections use the SSP3 population scenario. The gray reference line shows the approximate current frequency of high-mortality heat waves.

Anderson et al. 2015

Early 20th Century

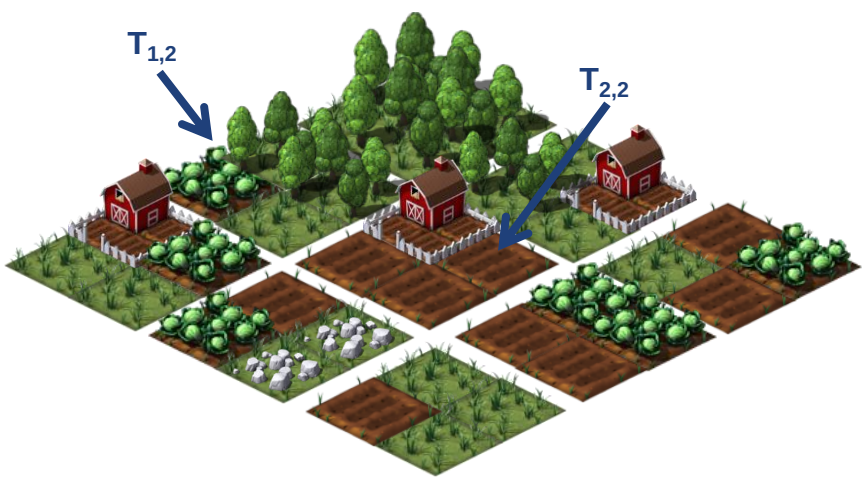
$\overline{T}$

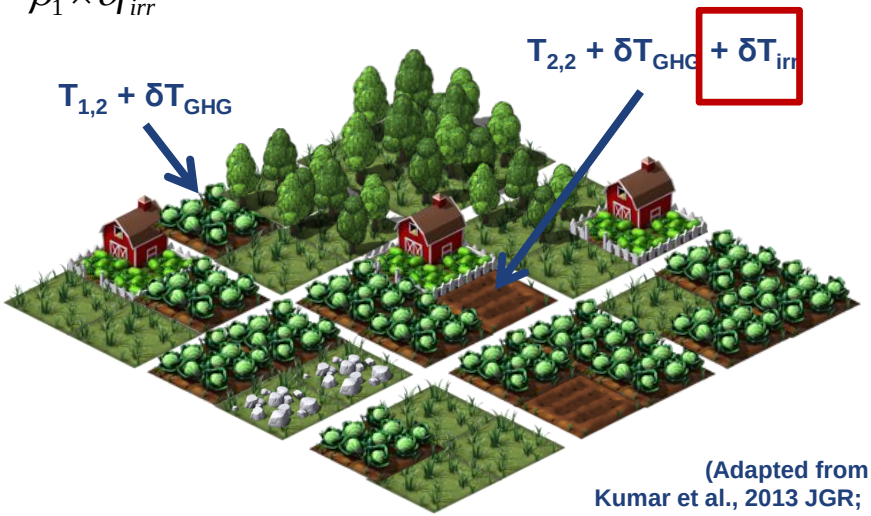
Present-day

$\overline{T} + \overline{\delta T}_{GHG}$

Big Box: $\delta T_{tot} = \beta_0 + \beta_1 \times \delta f_{irr} + \beta_2 \times lat + \beta_3 \times lon + \beta_4 \times elev$

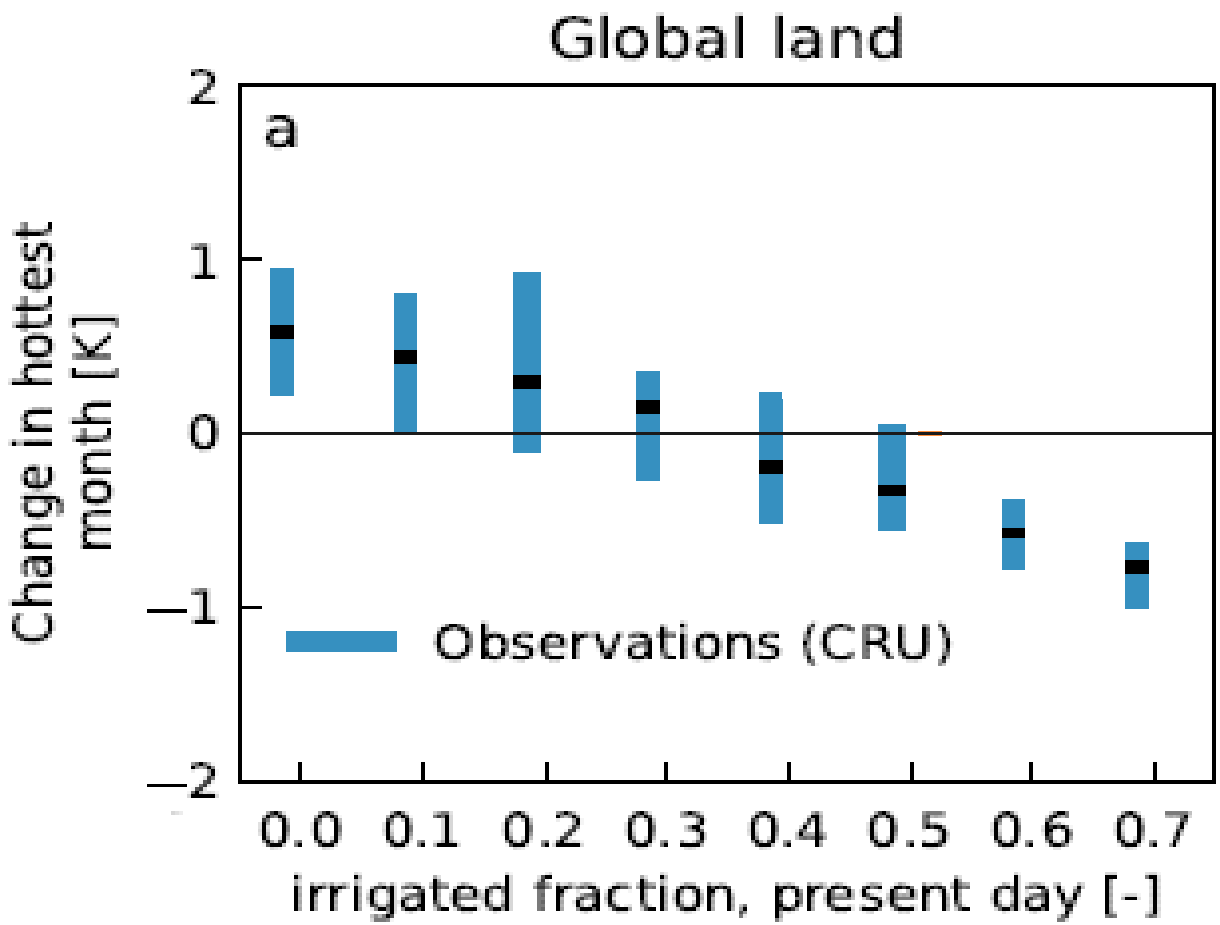
Center pixel: $\delta T_{irr} = \beta_1 \times \delta f_{irr}$





(Adapted from Kumar et al., 2013 JGR; Lejeune et al., 2018 Nature CC)

20thC change in daytime temperature during hottest month (CRU)



(Thiery et al., in rev.)