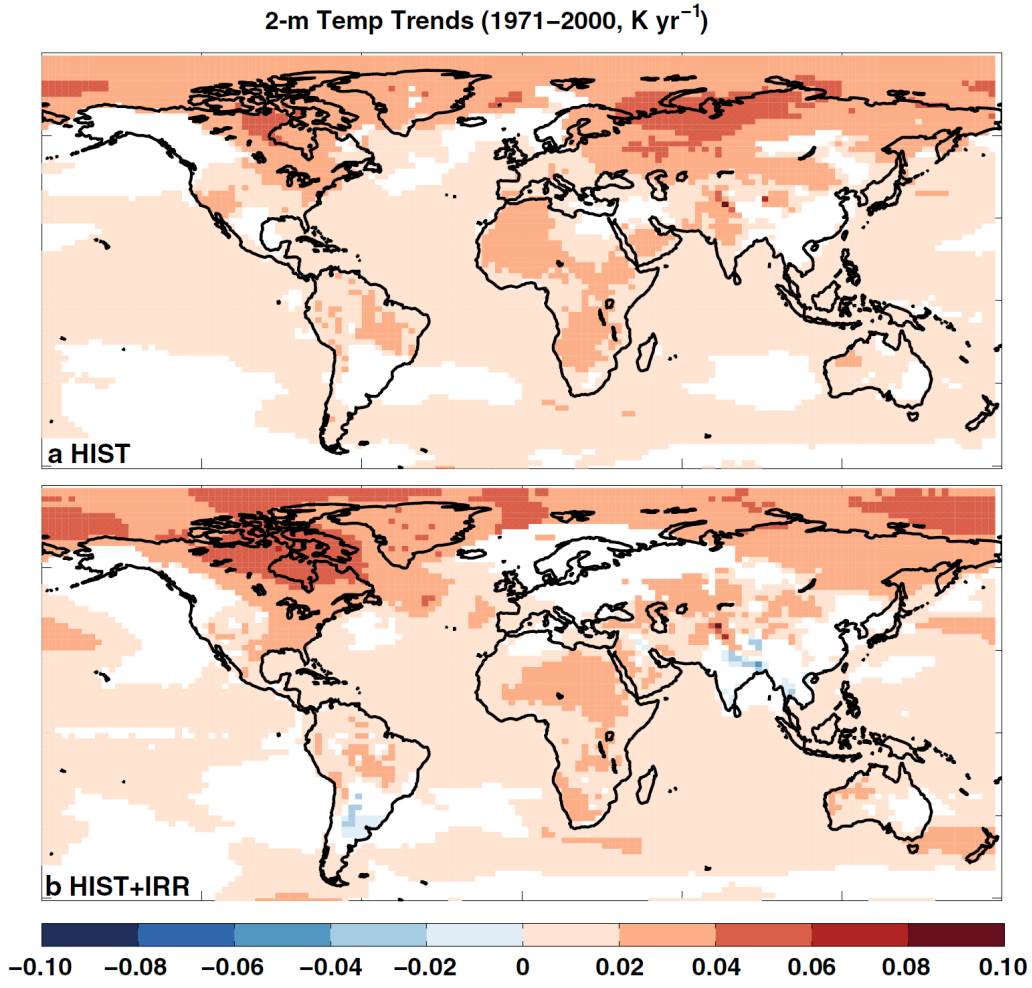
Irrigation mitigates against local and regional heat extremes

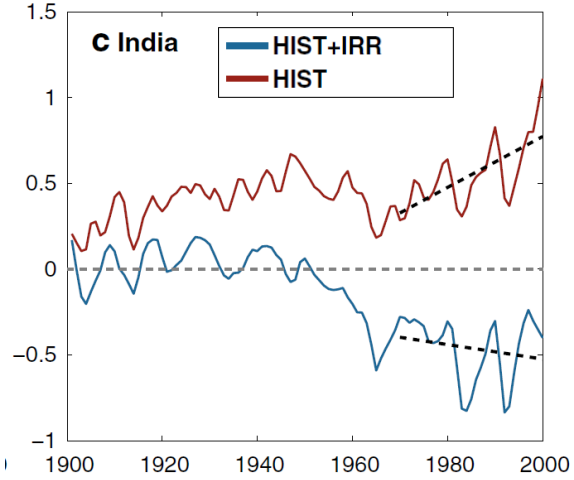
Wim Thiery[1], Edouard Davin[1], David Lawrence[2], Annette Hirsch[1], Mathias Hauser[1], Sonia Seneviratne[1]

[1]: ETH Zurich

[2]: NCAR

Irrigation matters! (1)

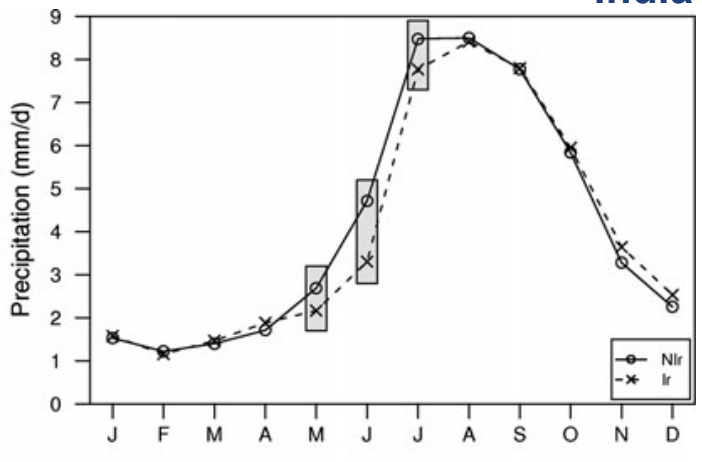




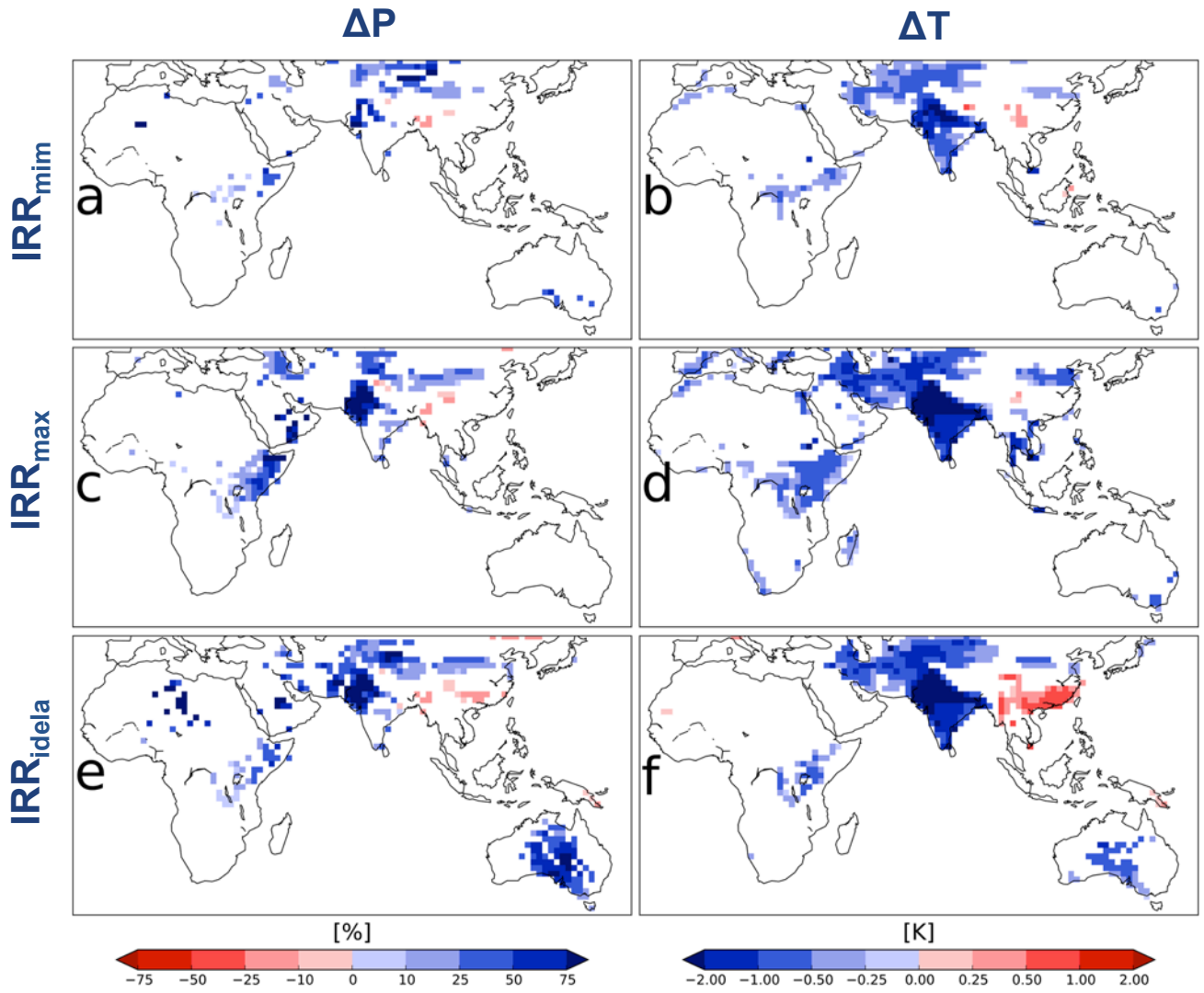
(Cook et al., 2014 CD)

Irrigation matters! (2)

India



(Guimberteau et al., 2012 CD)



(de Vrese et al., 2016 GRL)

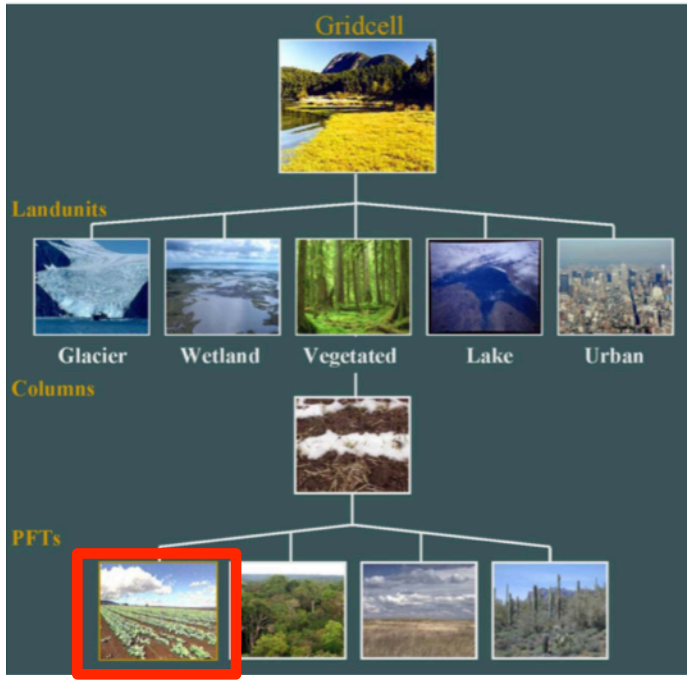
Challenges

- 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

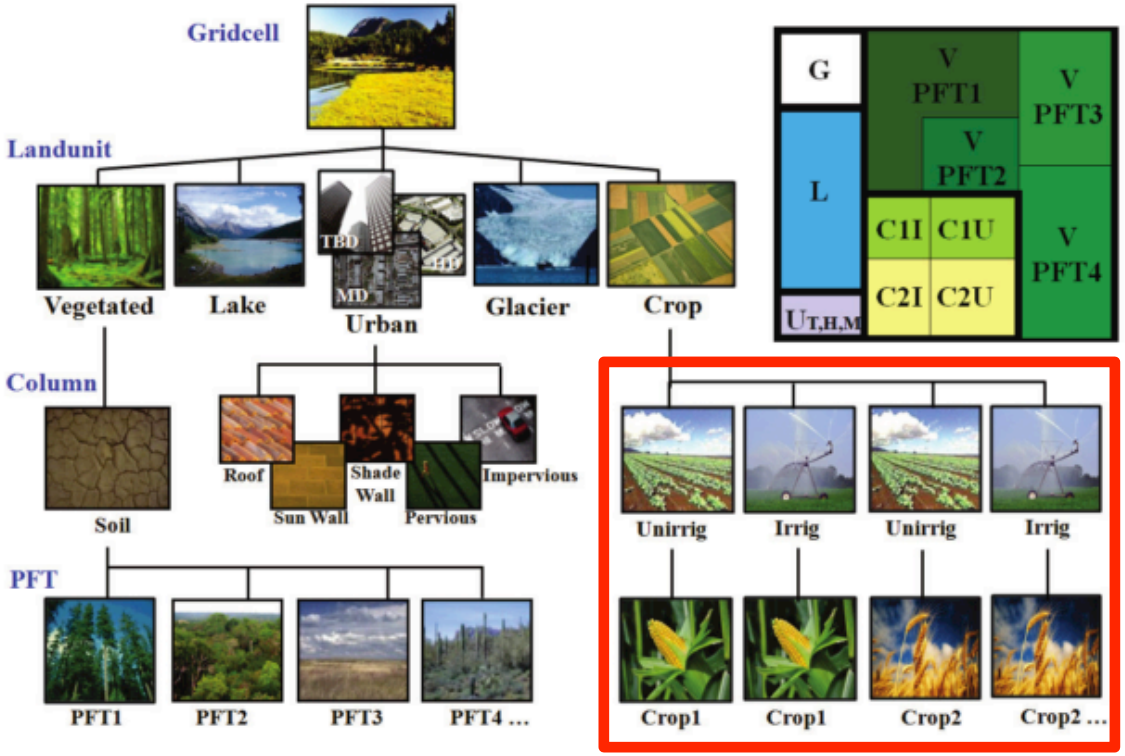
Hydrology and irrigation in CLM

CLM4.0



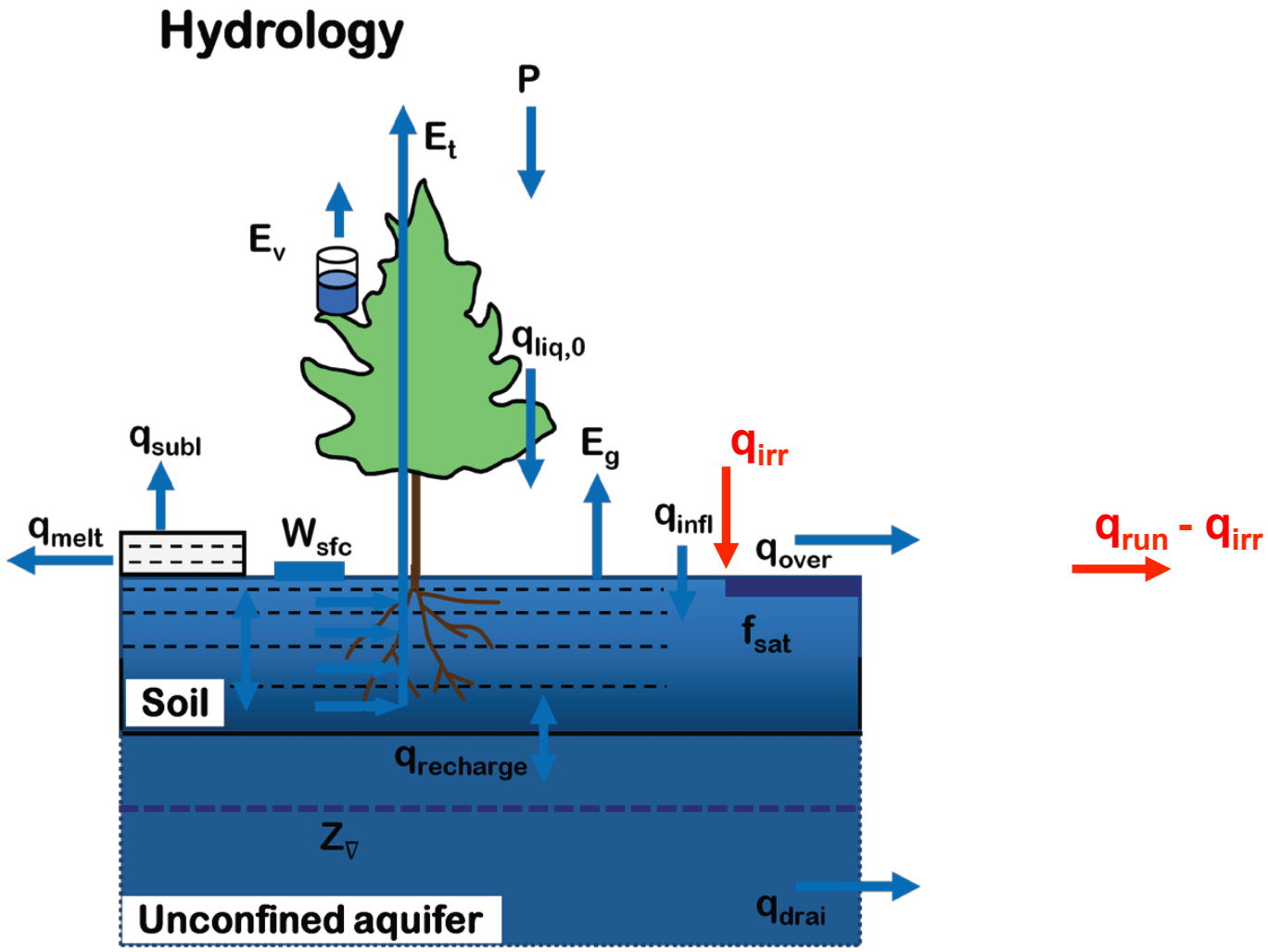
C3 crop

CLM4.5



Corn,
Temperate cereal,
Winter Cereals,
Soybean

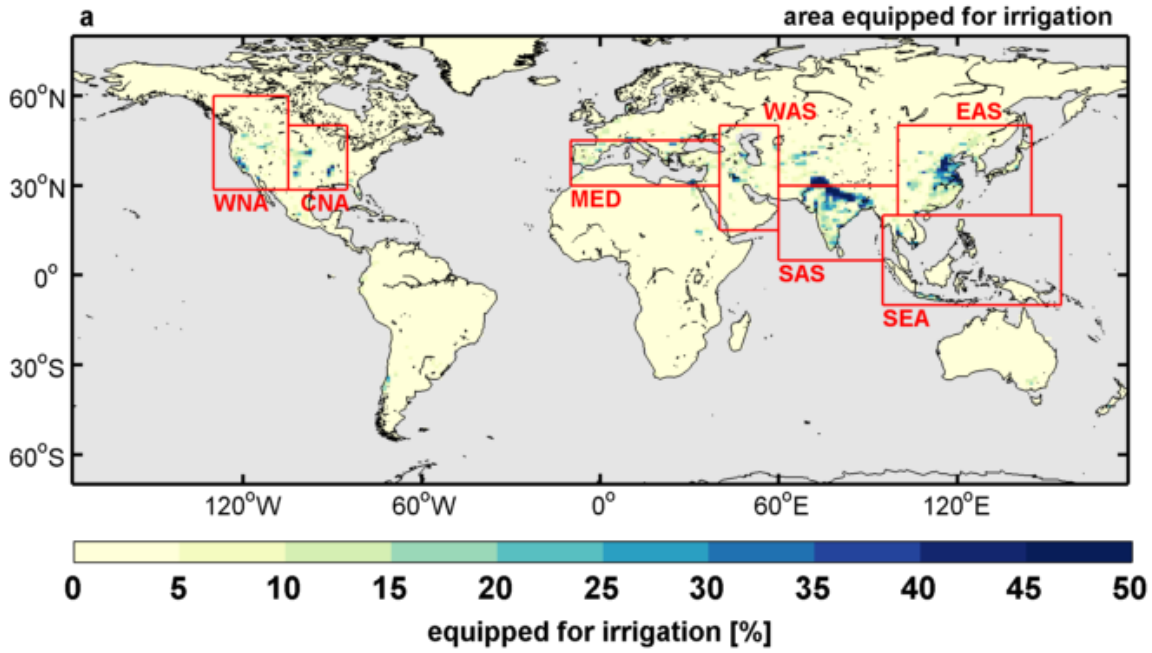
Hydrology and irrigation in CLM4.0



$q_{run} - q_{irr}$

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



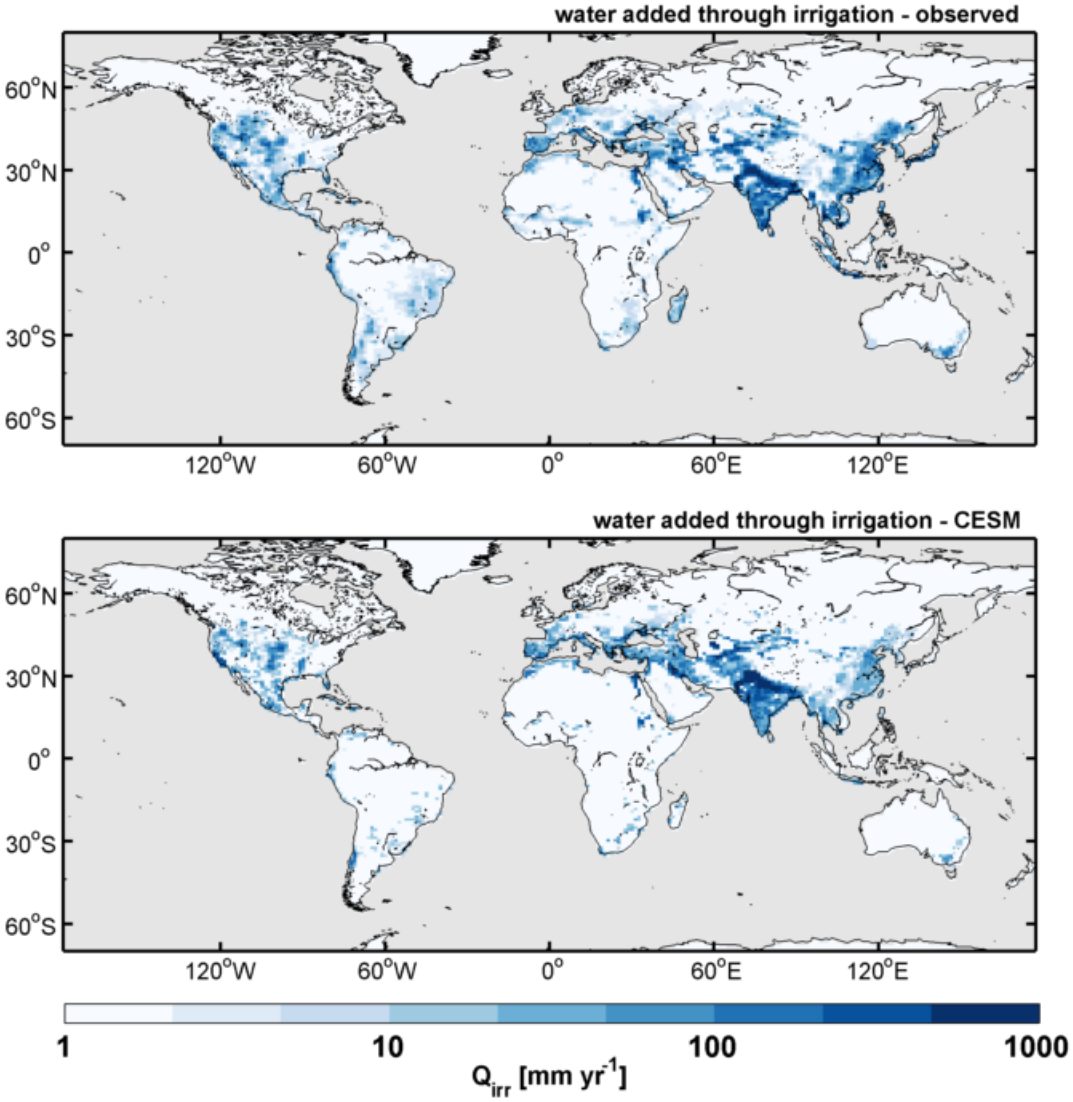
(from Siebert et al., 2005)

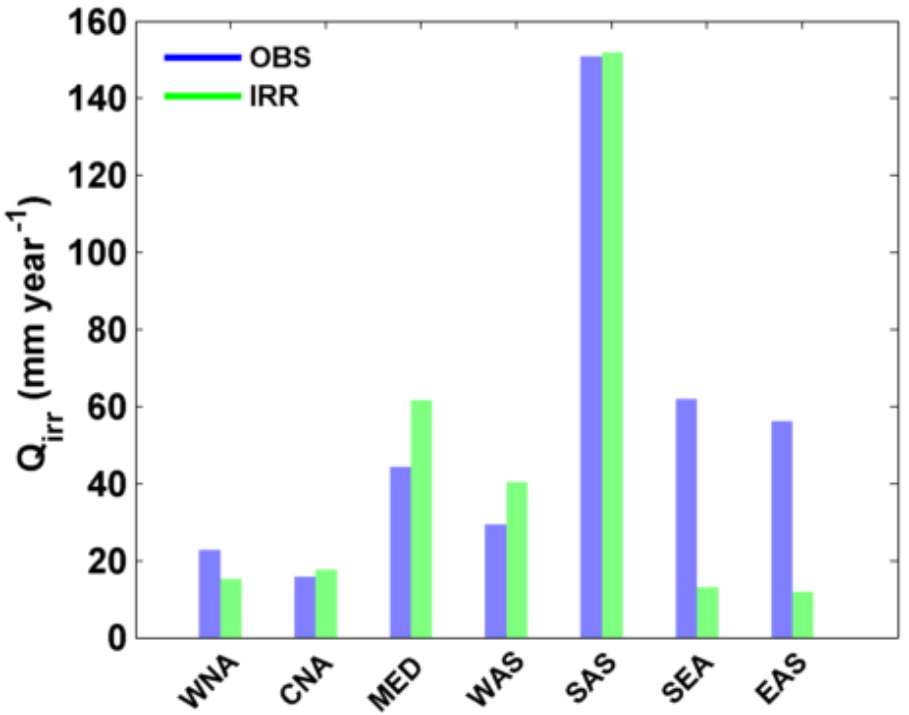

How well does our model perform?

Water added through irrigation

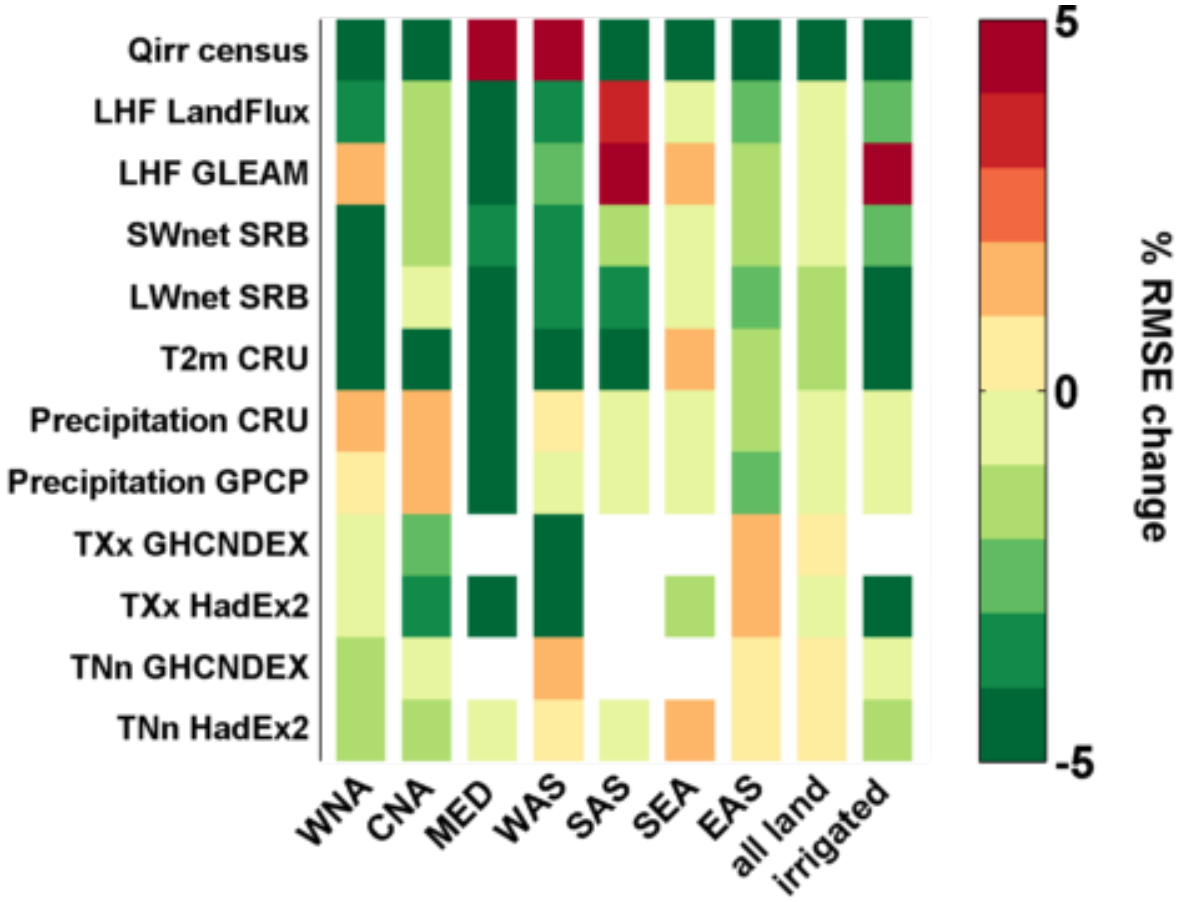
OBS

IRR





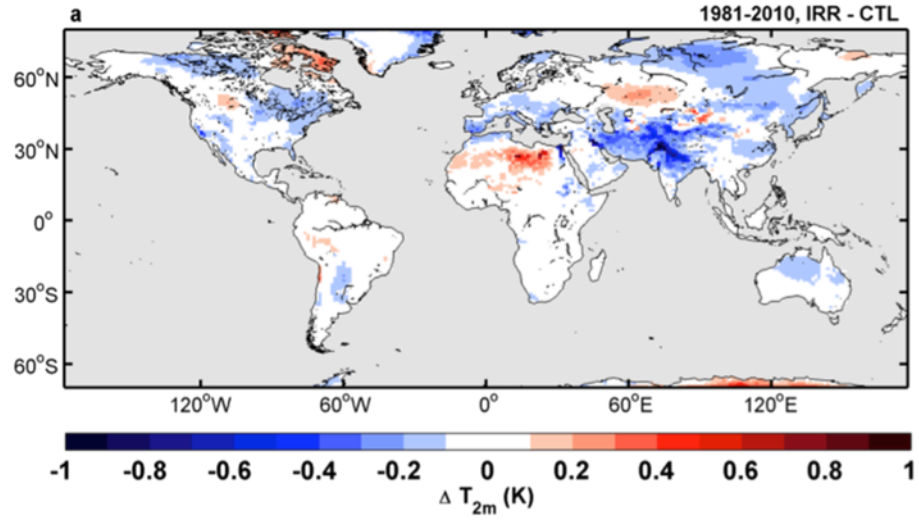
Added value matrix: changes in spatiotemporal RMSE

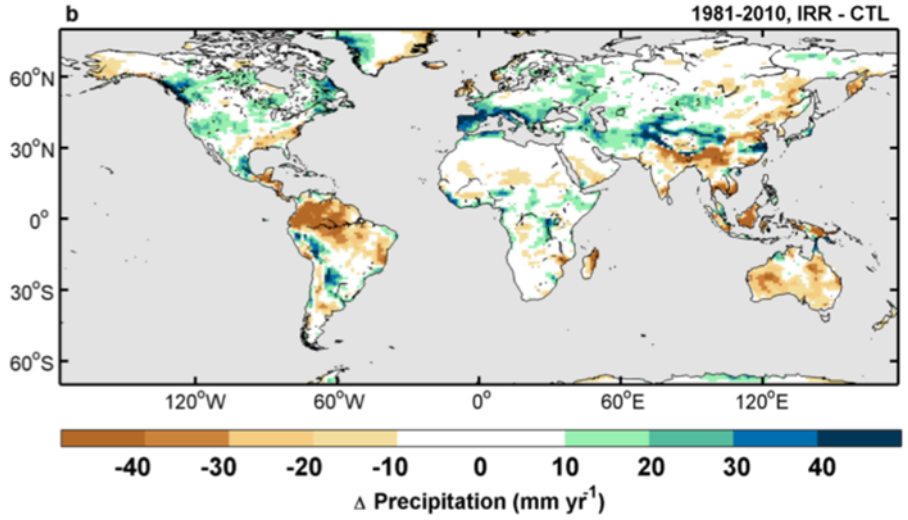


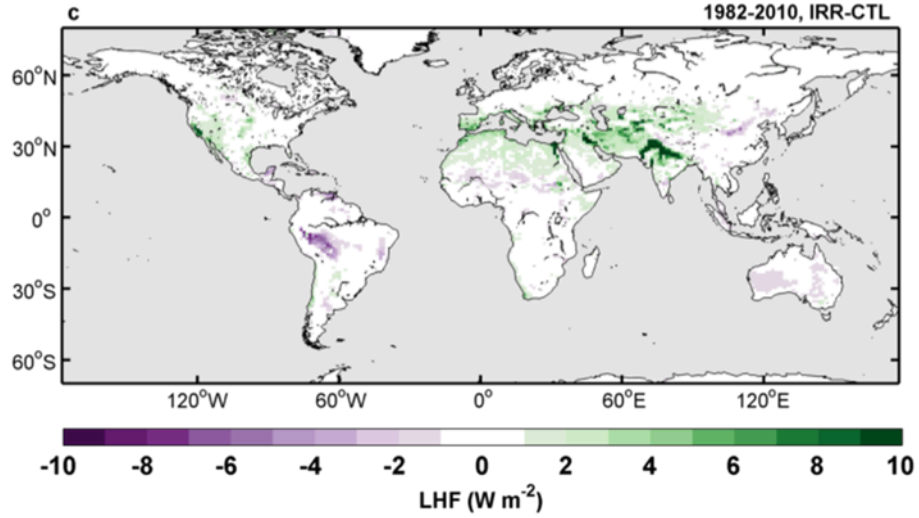
77 out of 100 cells show enhanced skill

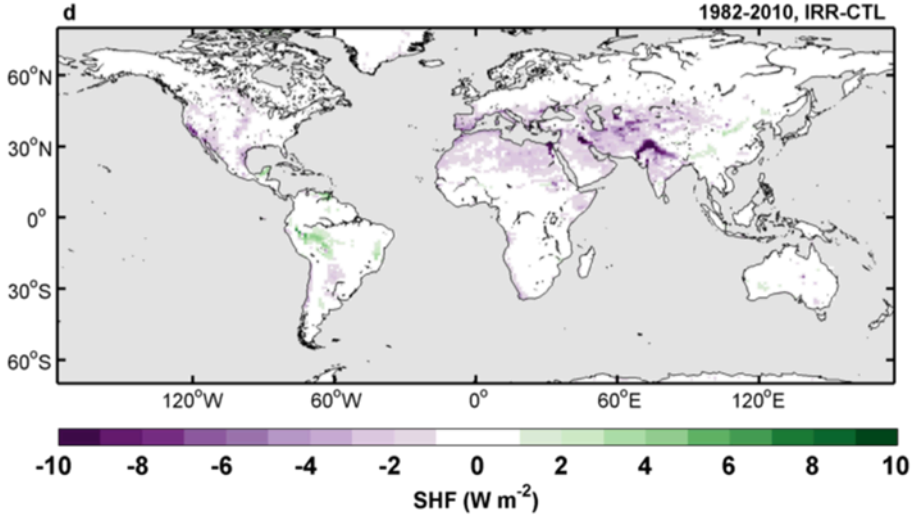

Impact on means and extremes

Impact on T2m and precipitation

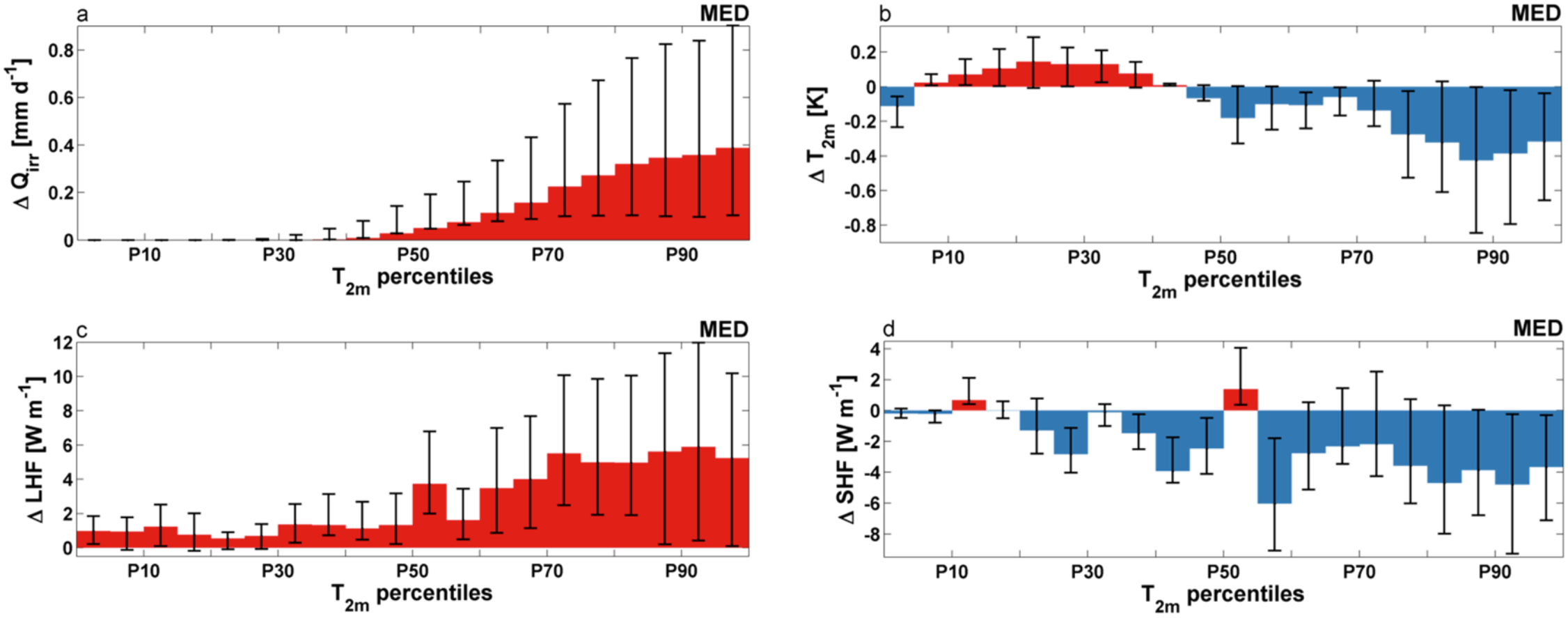




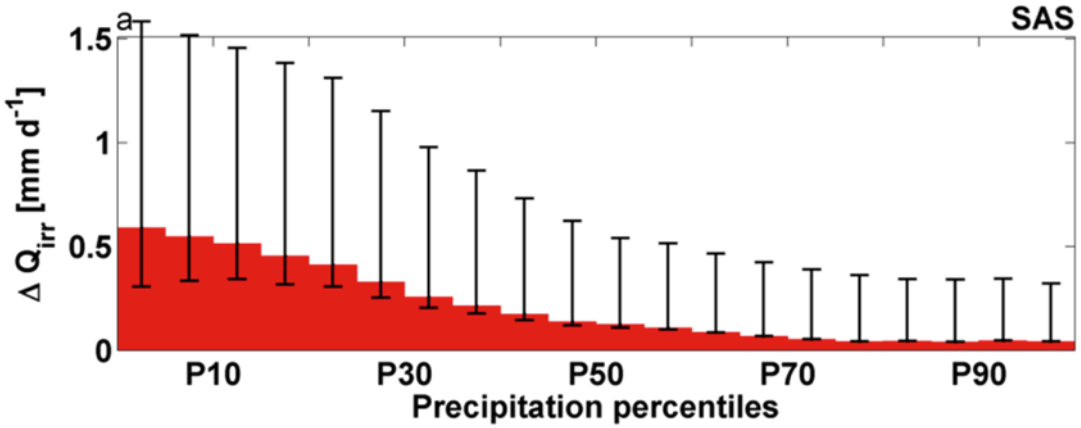


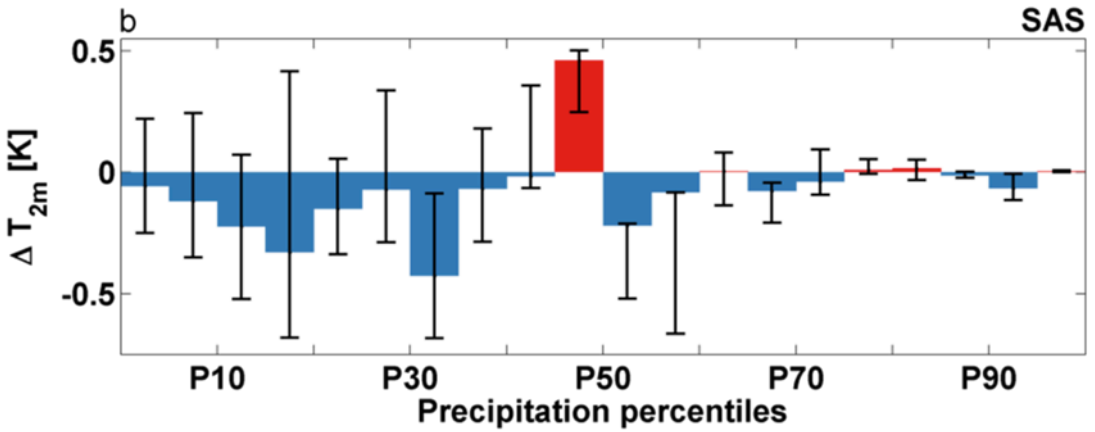


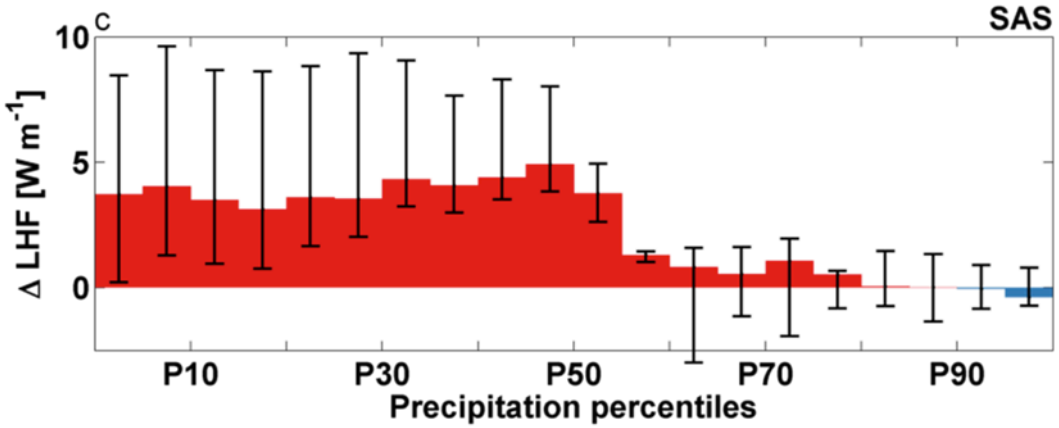
Asymmetric response: MED

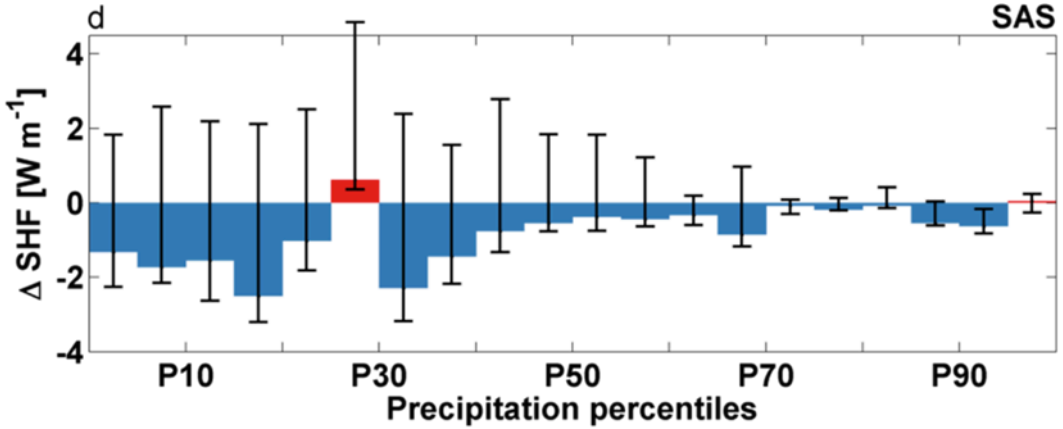


Asymmetric response: SAS

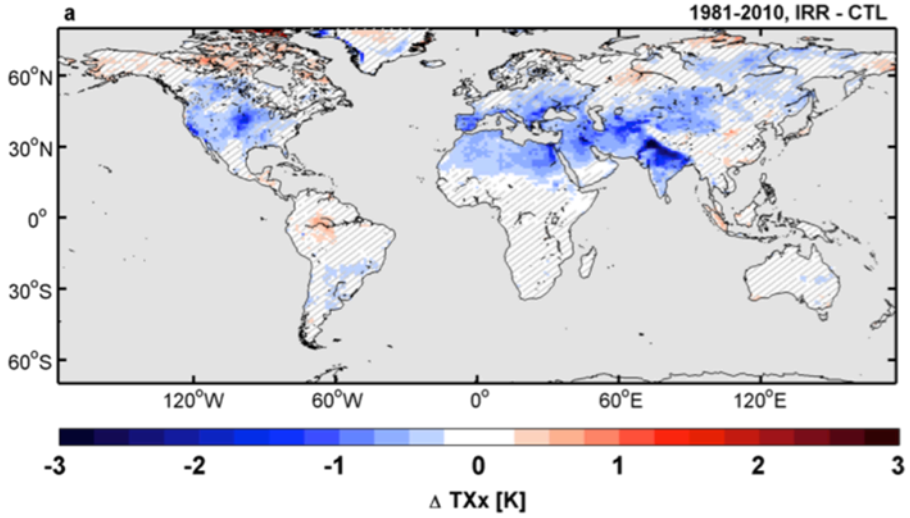


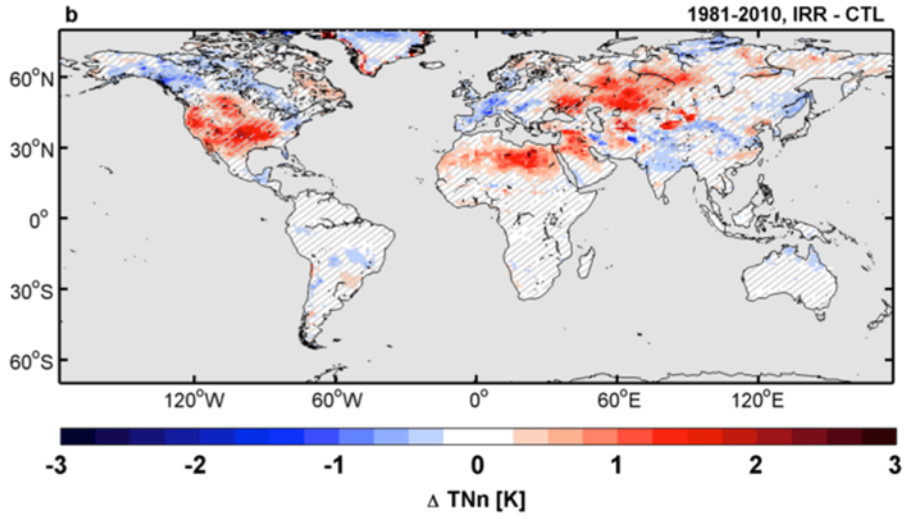


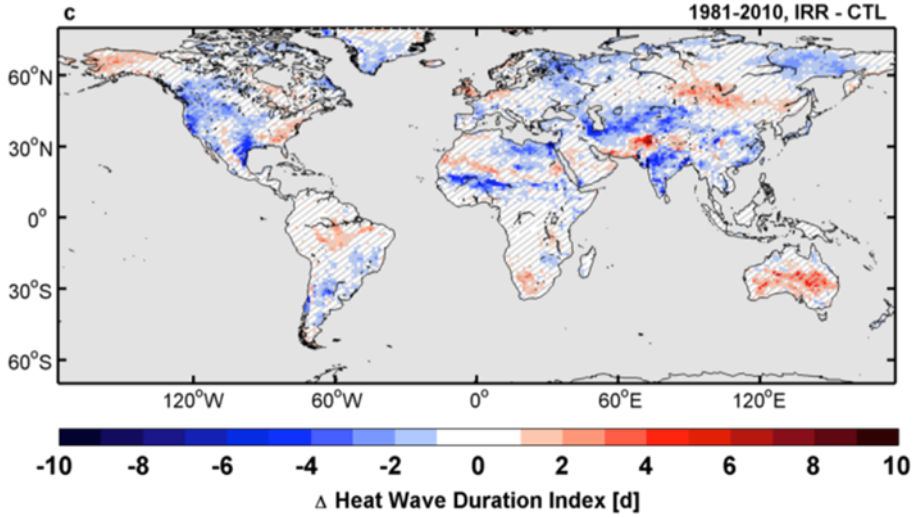


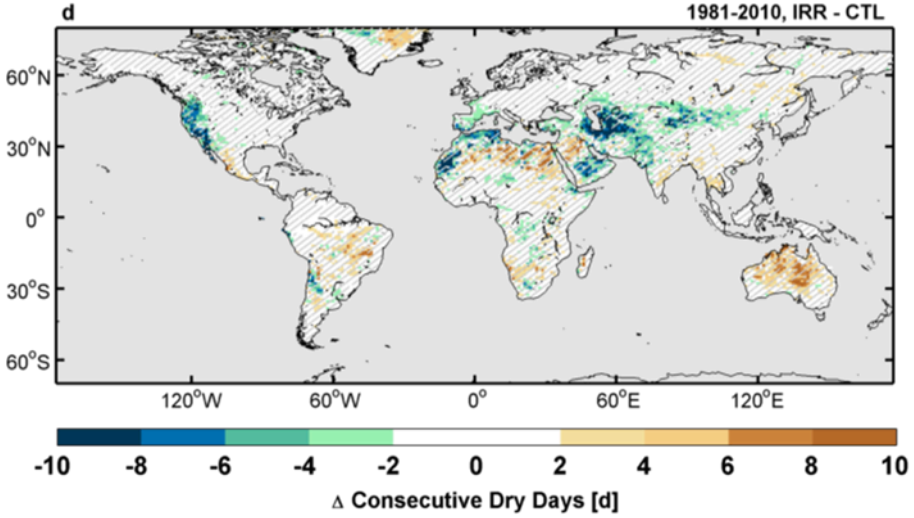


Impact on extremes










SEB decomposition

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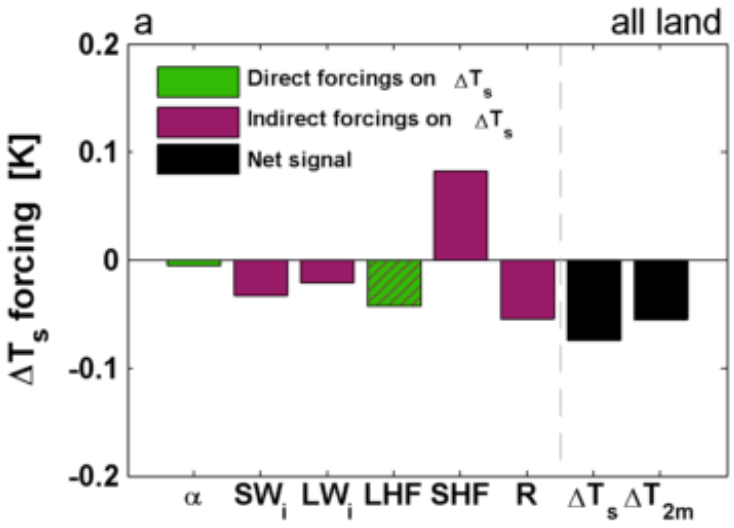
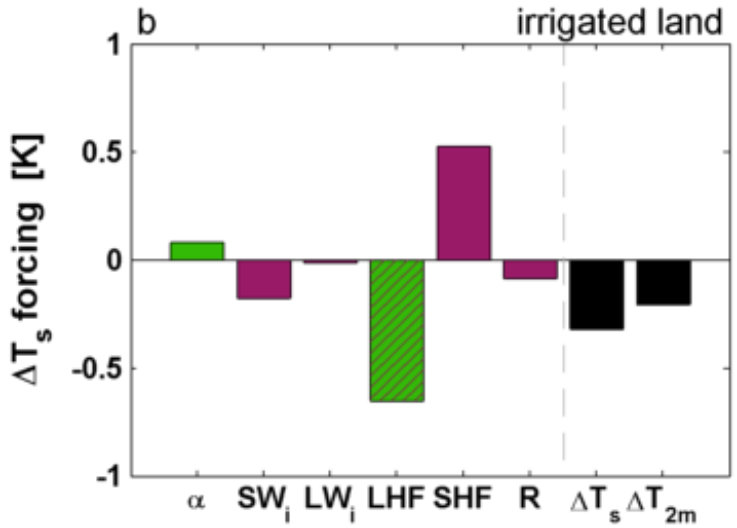
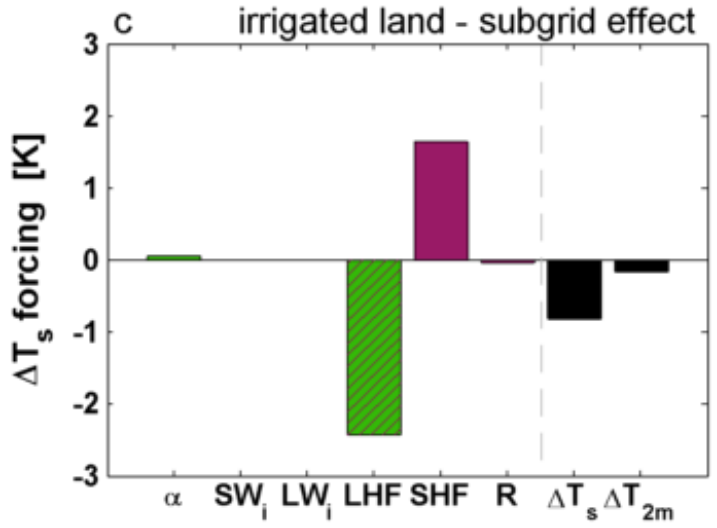
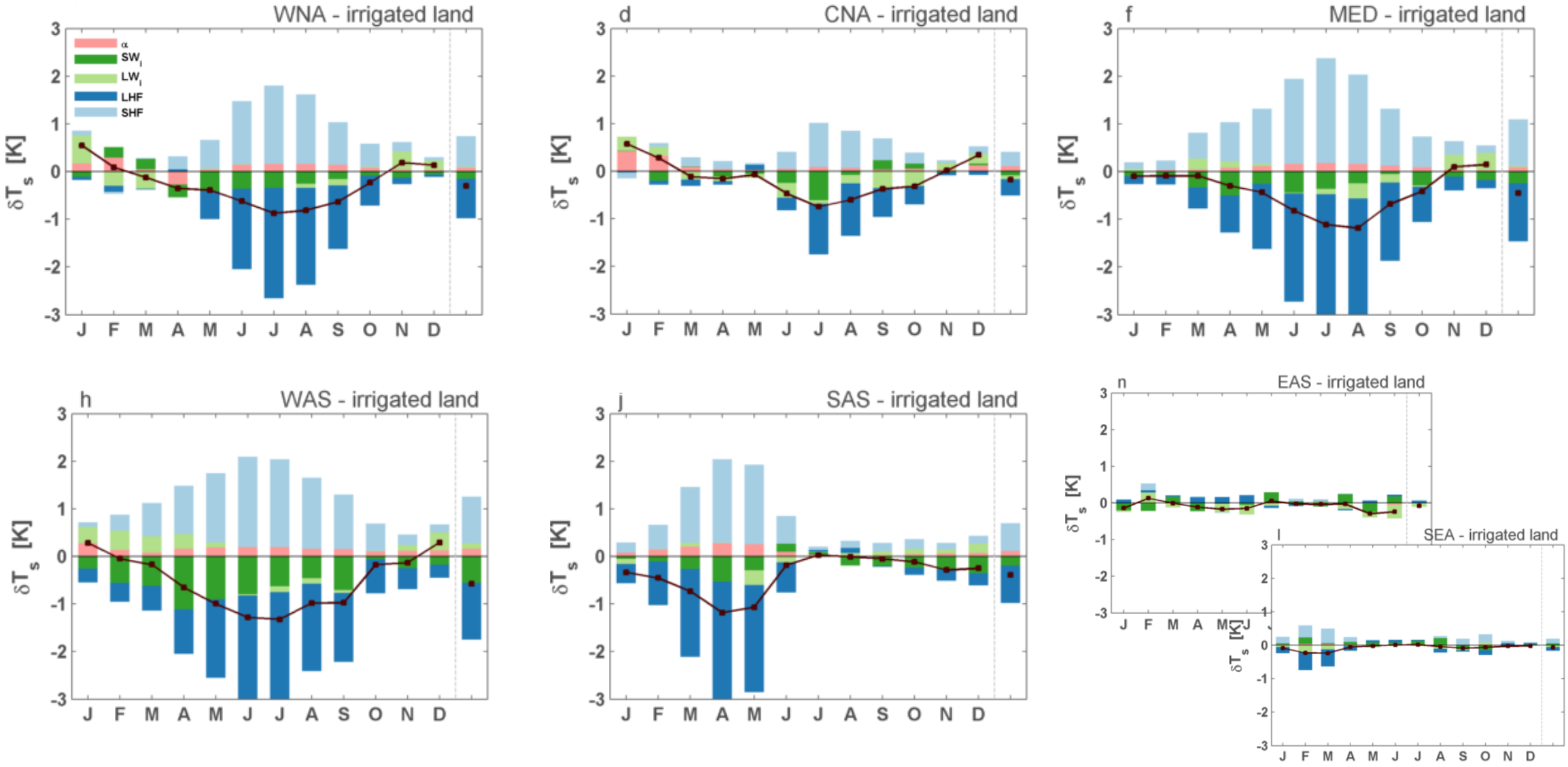




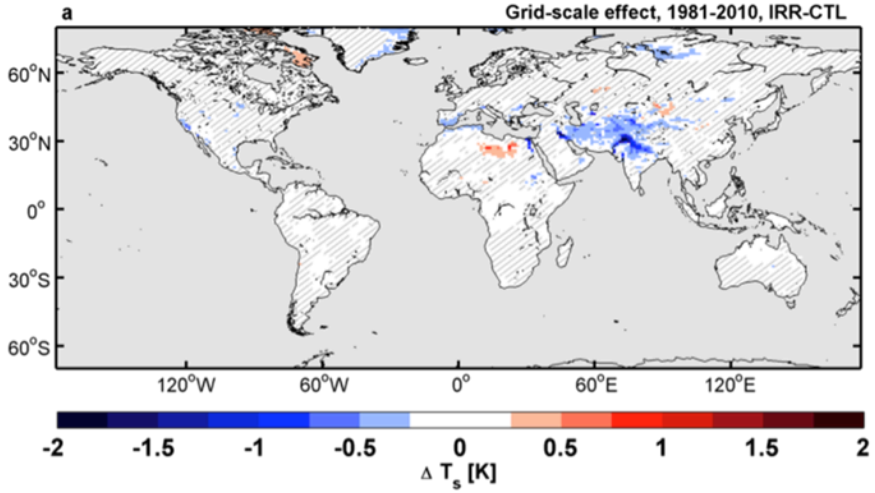


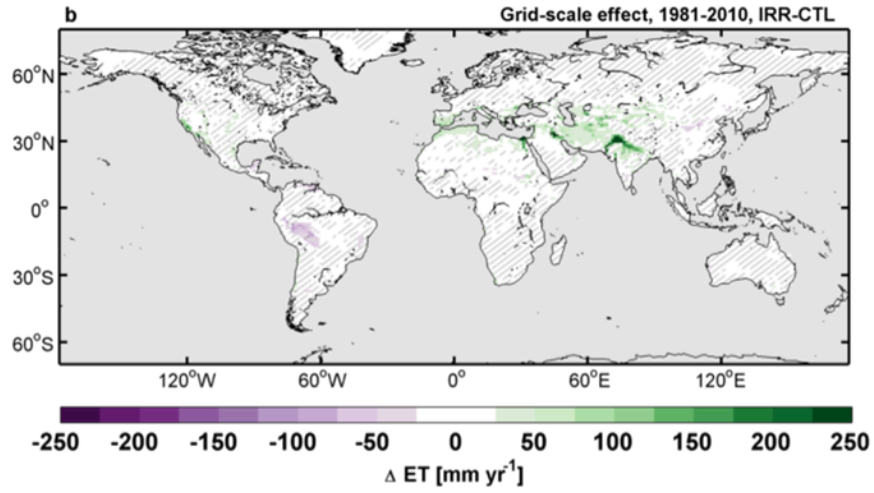

WNA - irrigated land
d
CNA - irrigated land
f
MED - irrigated land
h
WAS - irrigated land
j
SAS - irrigated land
n
EAS - irrigated land
l
SEA - irrigated land
α
SW↓
LW↓
LHF
SHF
δT_s [K]
J F M A M J J A S O N D


Effect of scale and ensemble size

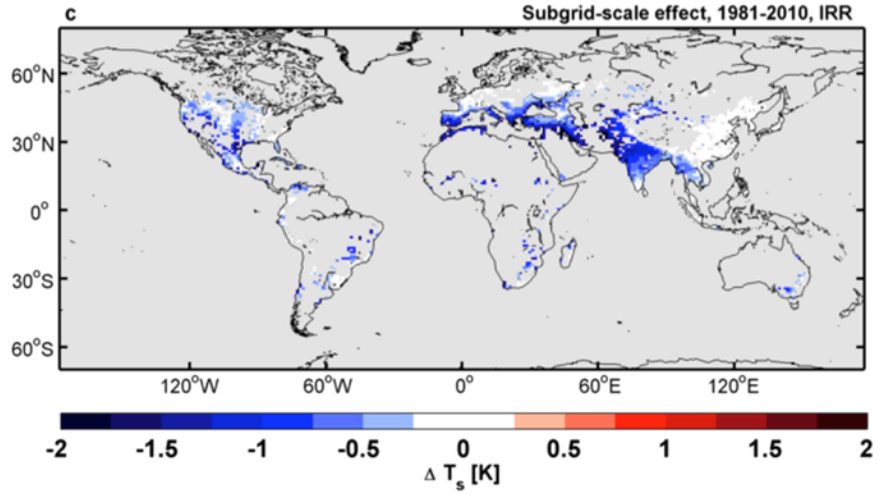
Importance of scale

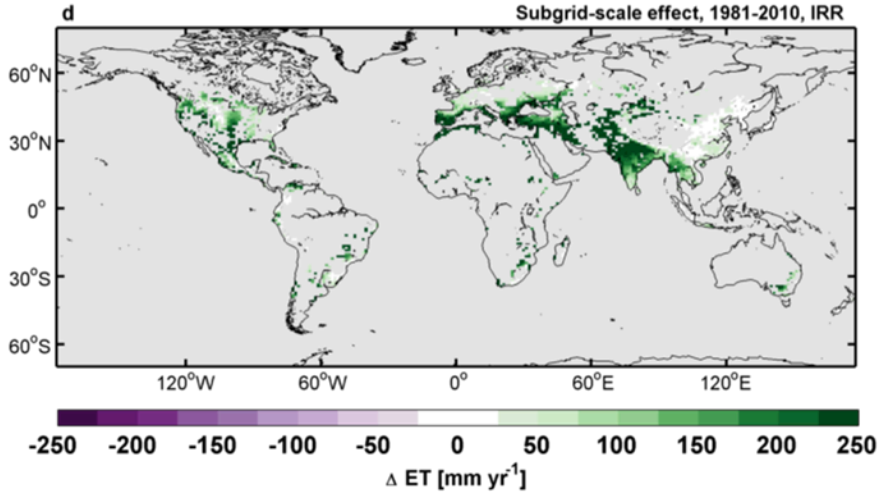
Grid-scale





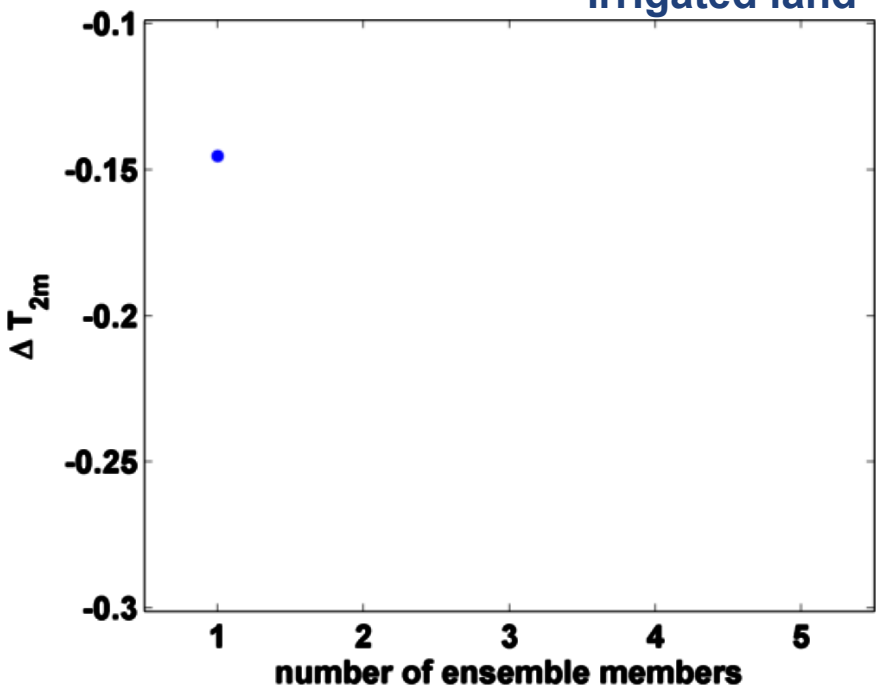
Subgrid-scale





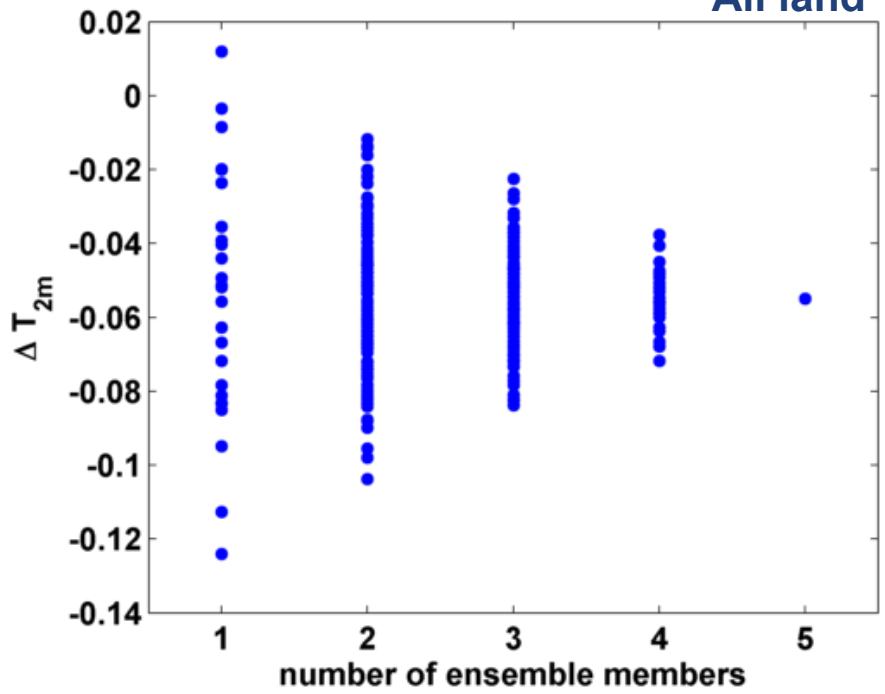
Importance of ensemble size

Irrigated land



(25) (100) (100) (25) (1)

All land



(25) (100) (100) (25) (1)

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

Acknowledgments:
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Thiery, W. et al., Present-day irrigation mitigates heat extremes, JGR, in review.