



Decadal convection-permitting irrigation impact across the European Continent

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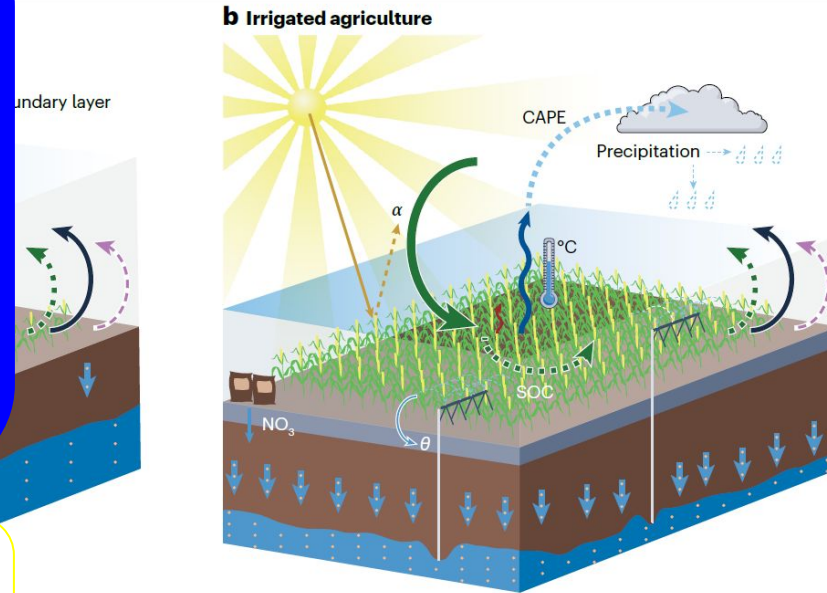
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March, 2026

- Irrigation affects Earth system processes.
- Some impacts are well documented.
- Other impacts remain poorly understood.

[Valmassoi and Keller, 2022; McDermid et al., 2023.]

Motivation



Impact ■ Carbon ■ CH₄ ~ Sensible heat
Impact ■ N₂O ■ NO₃ ~ Latent heat

There is the need for more research to understand its full effects.

[McDermid et al., 2023. Irrigation–Earth system interactions]

Aim

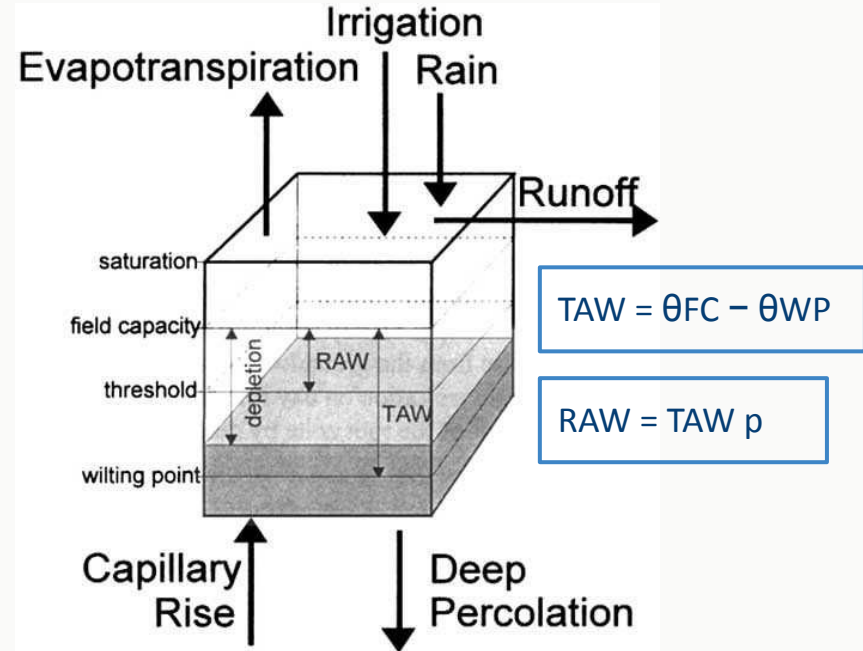
Quantifying the long-term impacts of irrigation on surface and atmospheric variables over the EURO-CORDEX domain using convection-permitting ICON simulations from 2011 to 2022.

Parameterization

- CHANNEL parameterization (Valmassoi et al. 2020)
- Interface ICON-TERRA

- Soil type:

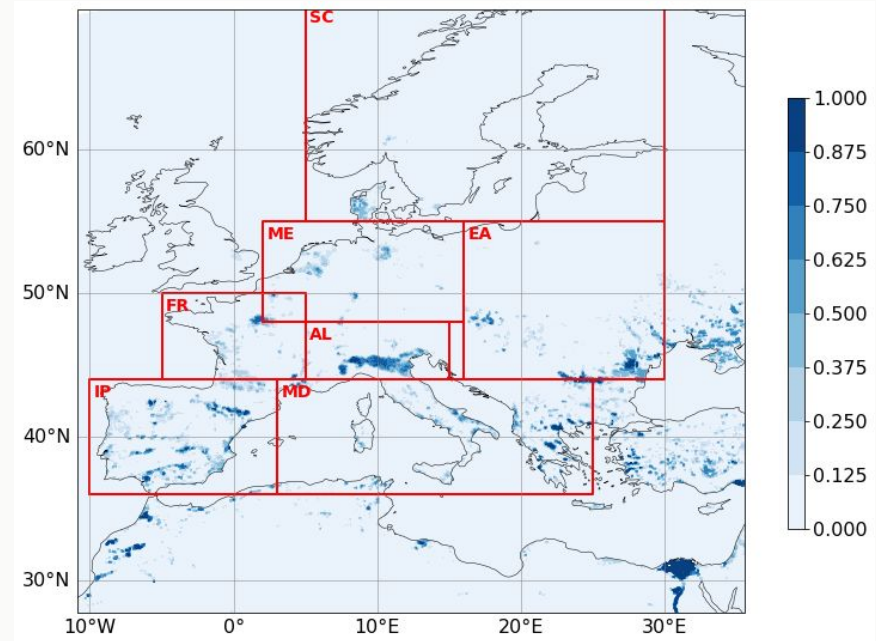
```
irr_amount = (s_fc - s_pwp) * d_frac  
* root_d_irr
```



<https://www.fao.org/4/x0490e/x0490e0b.htm#calculating%20etc> (FIGURE 43.
Water balance of the root zone)

Set-up for the experiments

- EURO-CORDEX domain
- 3 km horizontal resolution
- 75 vertical levels
- ICON-DREAM reanalysis boundary and initial conditions
- Simulation period: Jan-Dic/2010-2022
- Irrigation settings: start_date = 01.05;
start_hour = 5 UTC; irri_length = 5 h;
irri_freq = 12 days

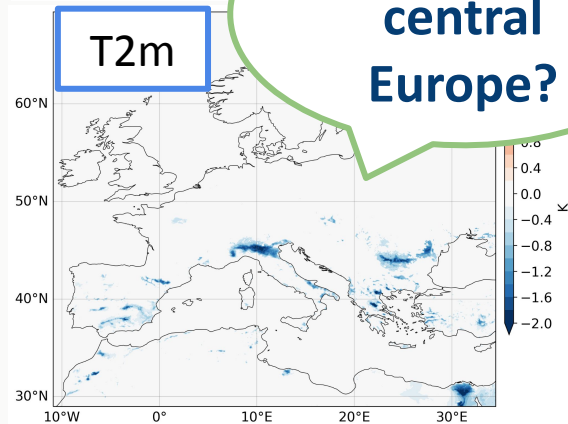
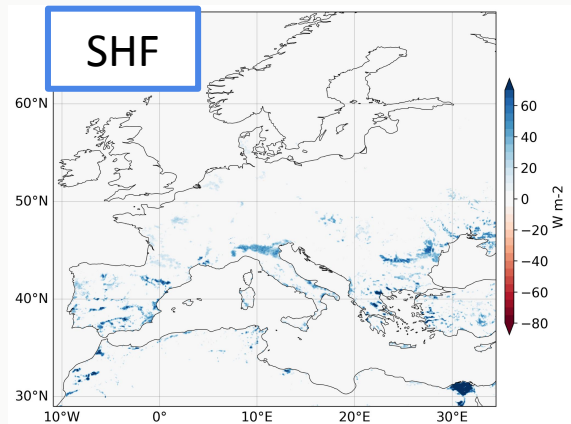
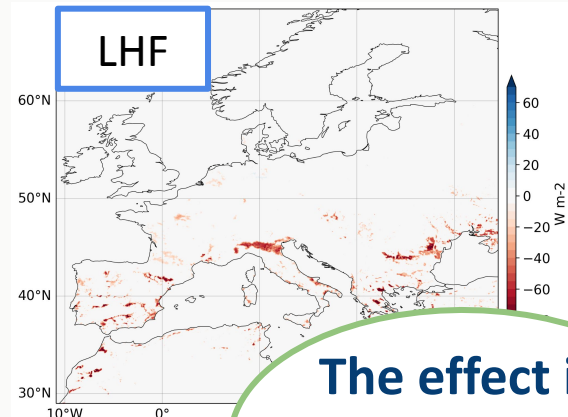
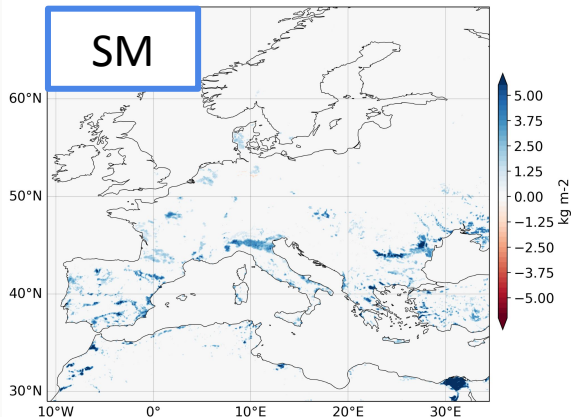


[Siebert et al., 2013]



Results

Mean differences for JJA 2011-2022



**The effect in
central
Europe?**

In irrigated areas:

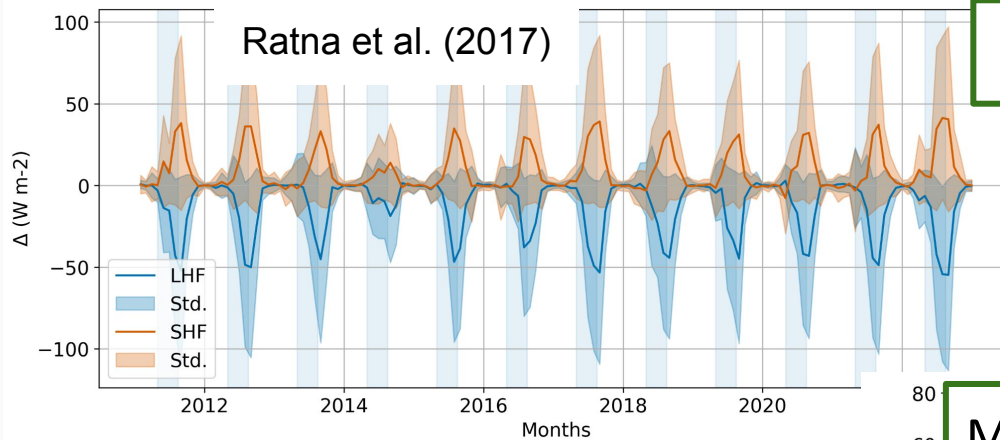
↑ SM 2.45 kg m⁻²

↑ LHF 34.81 W m⁻²

↓ SHF 28.40 W m⁻²

↓ T2m 0.78 K

Time series of monthly mean differences - Energy Flux.



Alps

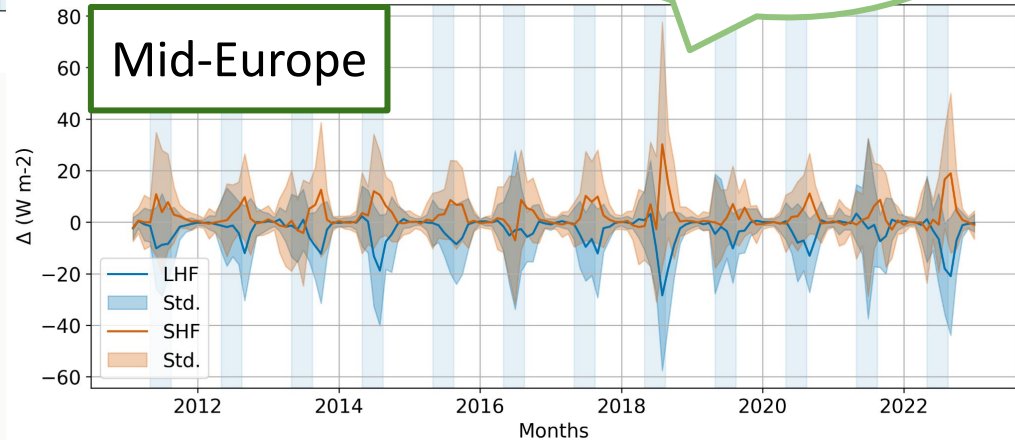
↓ 20.77 (± 13.18) W m⁻²

↑ 27.99 (± 13.18) W m⁻²

What is the event in 2018?

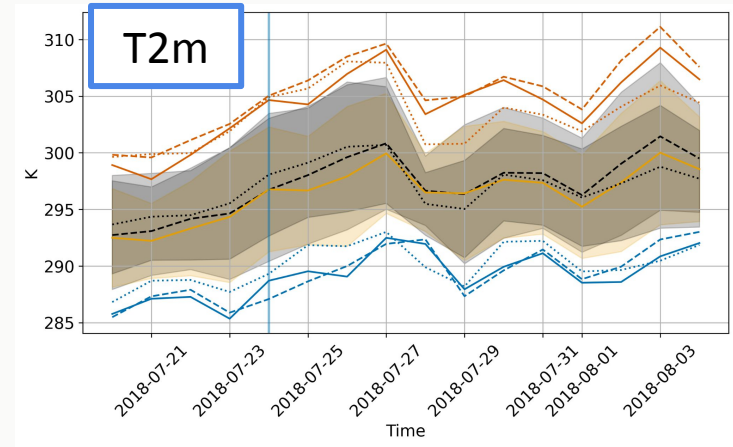
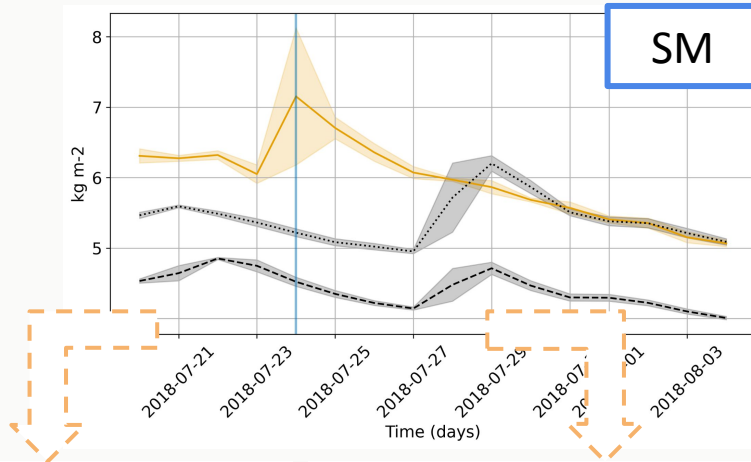
↓ 5.59 (± 6.36) W m⁻²

↑ 7.15 (± 6.10) W m⁻²

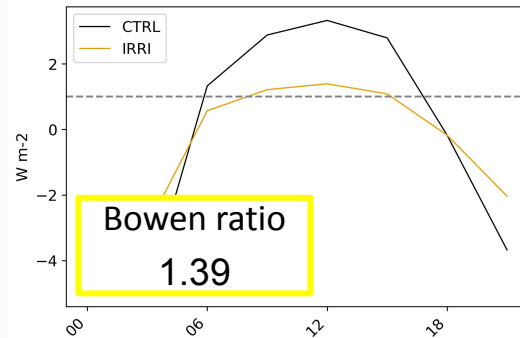
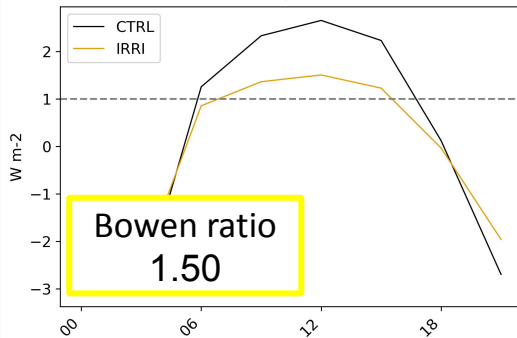




2018 Heat wave in Central Europe



--- CTRL_TMEAN --- IRRI_TMAX DREAM_TMAX
 --- CTRL_TMAX --- IRRI_TMIN DREAM_TMIN
 --- CTRL_TMIN DREAM_TMEAN --- Irri_event
 --- IRRI_TMEAN



- ❑ The 2018 HW intensifies the soil moisture-temperature coupling.
- ❑ Irrigation effect visible.

Relative difference of the Bias for T2m $[(\text{abs(IRRI)} - \text{abs(CTRL)})/\text{abs(CTRL)}]$

Alps



Mediterranean



Conclusions and outlook

- ❑ The magnitude of the irrigation impact is limited by the irrigated region and the year of study.
 - ❑ Clear influence of soil moisture regimes in the irrigation impact per region.
 - ❑ The average monthly T2m bias decreases in the irrigation experiment.
- ➔ Comparison of soil moisture with ESA CCI 3km.
 - ➔ Submit the manuscript

Soil matters: Evaluating soil texture and irrigation impacts in Earth system simulations

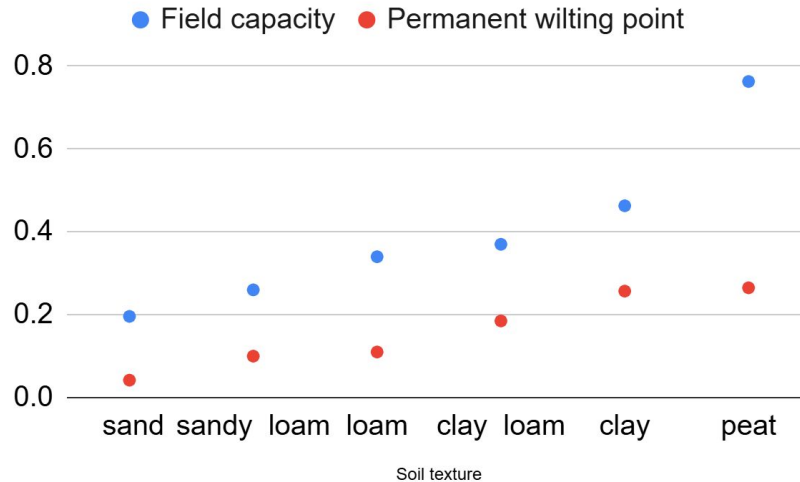
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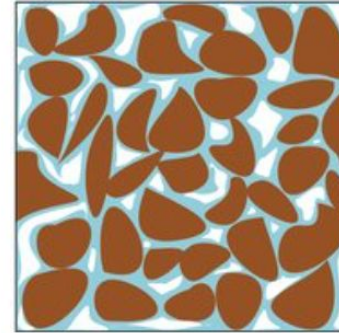
March, 2026

Motivation

Irrigation parameterizations are usually based on soil moisture thresholds.



Permanent
wilting point



Research question

What is the impact of two uniform soil texture classes (loam and sandy) on the surface energy and water budget components, both in isolation and in combination with irrigation?

Parameterization and Experiments

- CHANNEL parameterization (Valmassoi et al. 2020).
- Interface ICON-TERRA.
- Field capacity (FC):
Soil moisture forced to field capacity (0 - 81 cm depth).

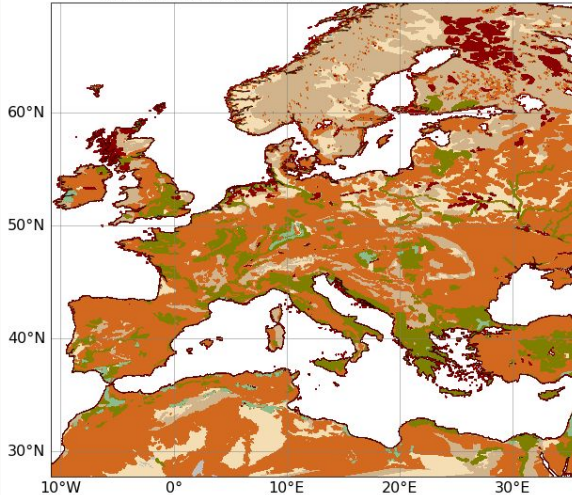
Experiment	Name	Soil map	Irrigation
0	CTRL	Default *	No
1	UNI_LOAM	Uniform loam	No
2	UNI_SAND	Uniform sand	No
3	UNI_LOAM_i	Uniform loam	Yes
4	UNI_SAND_i	Uniform sand	Yes

*default soil map in TERRA land surface scheme.

Soil Maps

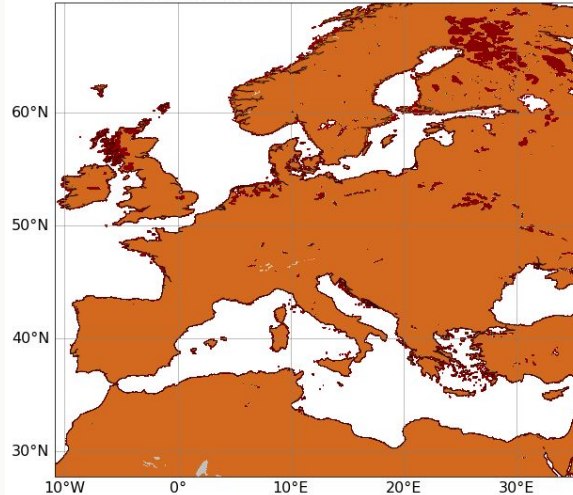
Default

soil type derived from FAO Digital Soil Map of the World



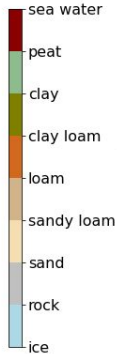
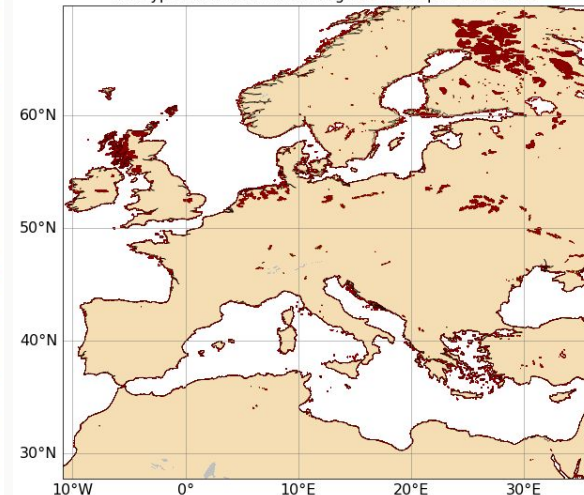
Loam

soil type derived from FAO Digital Soil Map of the World



Sand

soil type derived from FAO Digital Soil Map of the World



* Locations with peat, ice or rock stayed the same as the default map

Surface Energy Balance Decomposition (SEB)

From Thiery et al., 2017 (Eq. 1):

$$\epsilon \sigma T_s^4 = (1 - \alpha) SW_{in} + LW_{in} - LHF - SHF - R$$

Exp - Ctrl

The change in surface temperature ΔT_s is decomposed by calculating the total derivative of equation (1) and solving for ΔT_s (assuming constant $\epsilon = 1$):

$$\Delta T_s = \frac{1}{4\sigma T_s^3} \left(-SW_{in} \Delta \alpha + (1 - \alpha) \Delta SW_{in} + \Delta LW_{in} - \Delta LHF - \Delta SHF - \Delta R \right)$$



SEB in Mid Europe - soil experiments (JJA)

Uni_Loam - CTRL

Uni_Sand - CTRL

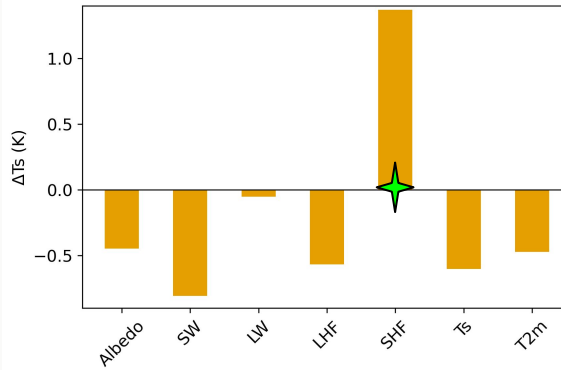
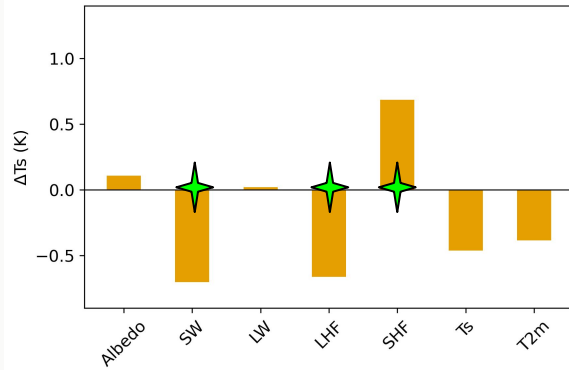
2017

3 factors mainly contribute to the T_s change in Uni_Loam, while only SHF controls in Uni_Sand exp.

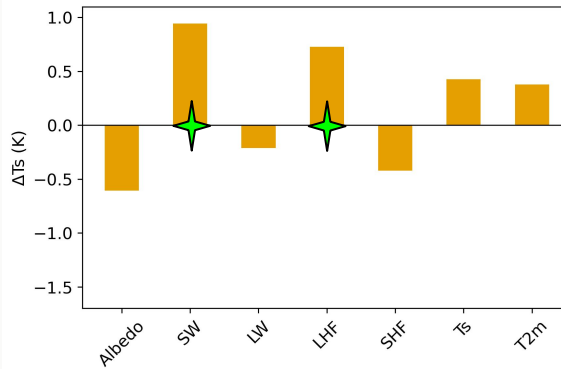
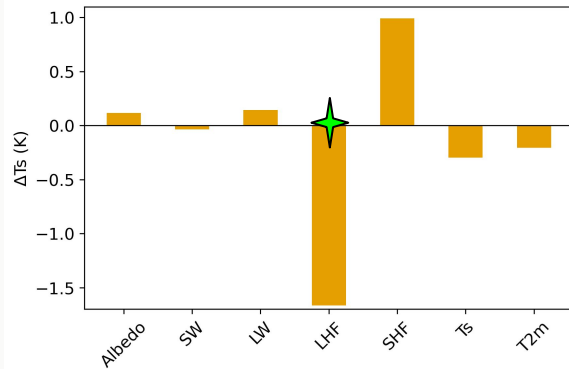
2018

Uni_Sand intensifies the heat wave conditions due to an increase in SW and a decrease of LHF.

2017



2018



SEB in Mid Europe - irrigation experiments (JJA)

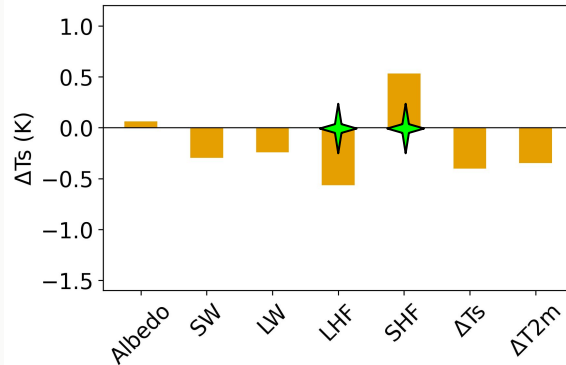
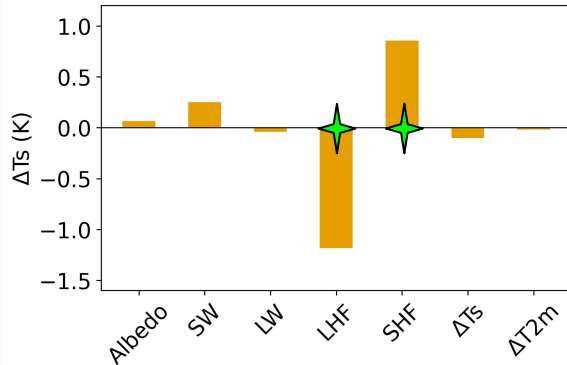
Loam_irri - Uni_Loam

Sand_irri - Uni_Sand

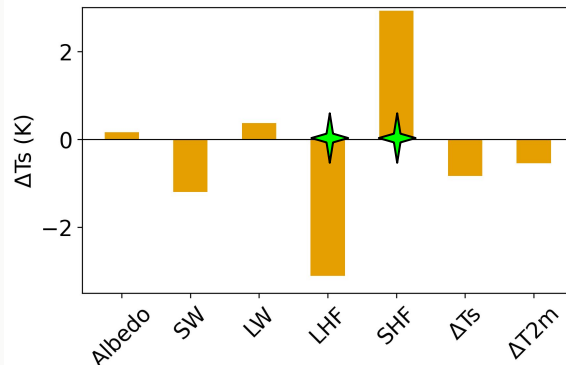
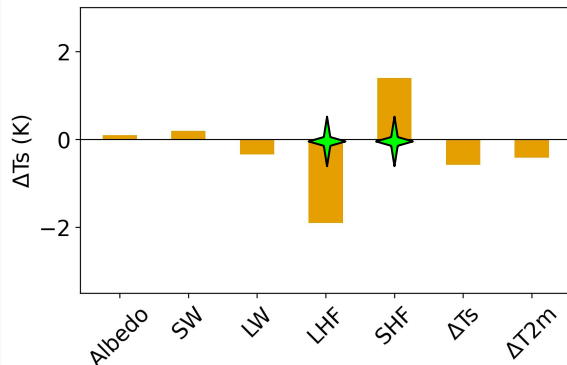
2017

LHF and SHF control the Ts cooling in Loam_irri and Sand_irri. SW and LW also contribute the Ts change in Sand_irri Ts.

2017



2018



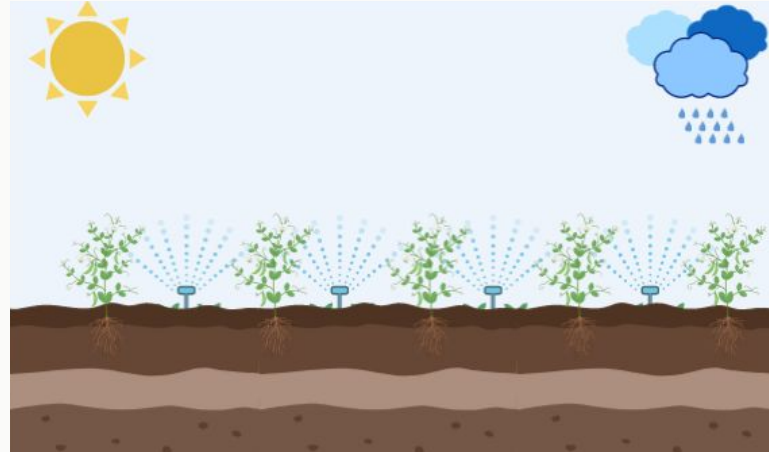
2018

The cooling effect is higher in Sand_irri due to higher LHF and SHF contributions.

Conclusions and outlook

- ❏ Uniform sandy soil intensifies the heat wave in 2018.
 - ❏ During an extreme warm year the irrigation impact is stronger over Sand_irri exps. in AL, EA and ME.
 - ❏ In moisture-limited regions the irrigation impact is stronger over Loam_irri exps.
 - ❏ SEB confirms the variables that contribute the most in the Ts change in each region.
- ➔ Evaluate sm (working with SMI)
 - ➔ Evaluate water budget variables
 - ➔ Check local soil information
 - ➔ 3rd paper and thesis

Irrigation influences the Earth System



References

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- ❑ Valmassoi, A., J. Dudhia, S. D. Sabatino, and F. Pilla (2020, 7). Evaluation of three new surface irrigation parameterizations in the wrf-arw v3.8.1 model: The Po Valley (Italy) case study. *Geoscientific Model Development* 13, 3179–3201.
- ❑ Valmassoi, A. and J. D. Keller (2022). A review on irrigation parameterizations in earth system models. *Frontiers in Water*

Irrigation parameterization in ICON-nwp

Based on:

- ❑ CHANNEL parameterization (Valmassoi et al. 2020)
- ❑ Interface ICON-TERRA
- ❑ Grid-scale precipitation

ICON
INTERF.
TERRA

