Assessing the impact of irrigation on water storage dynamics in a Mediterranean catchment using land surface modelling

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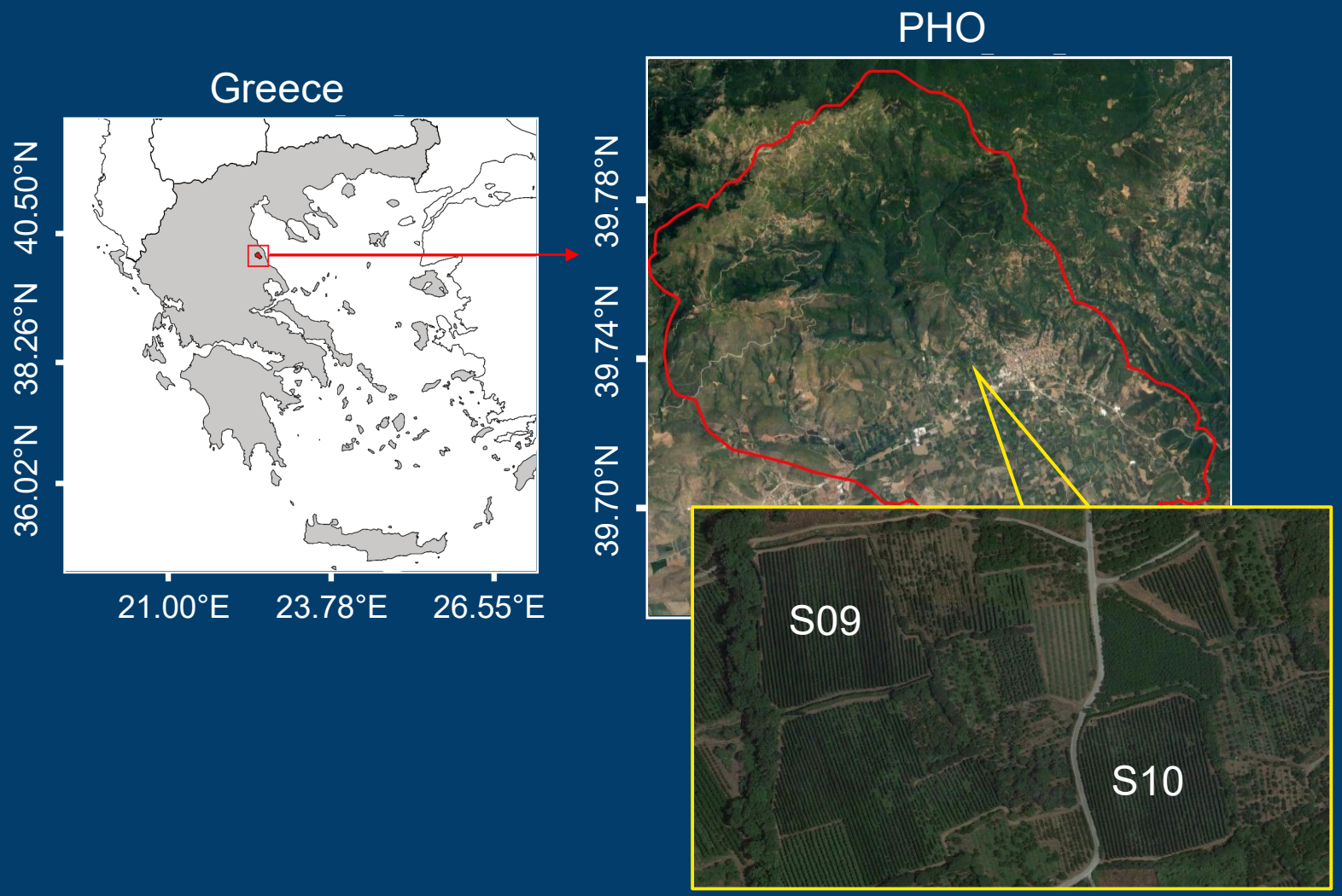
ATLAS
AGRICULTURAL INTEROPERABILITY AND ANALYSIS SYSTEM

JÜLICH
Forschungszentrum

Mitglied der Helmholtz-Gemeinschaft

THE CASE STUDY: Pinios Hydrological Observatory



- Mediterranean climate
- T_{mean} 15 °C
- P 500-1200 mm
- ET_{pot} 1100 mm

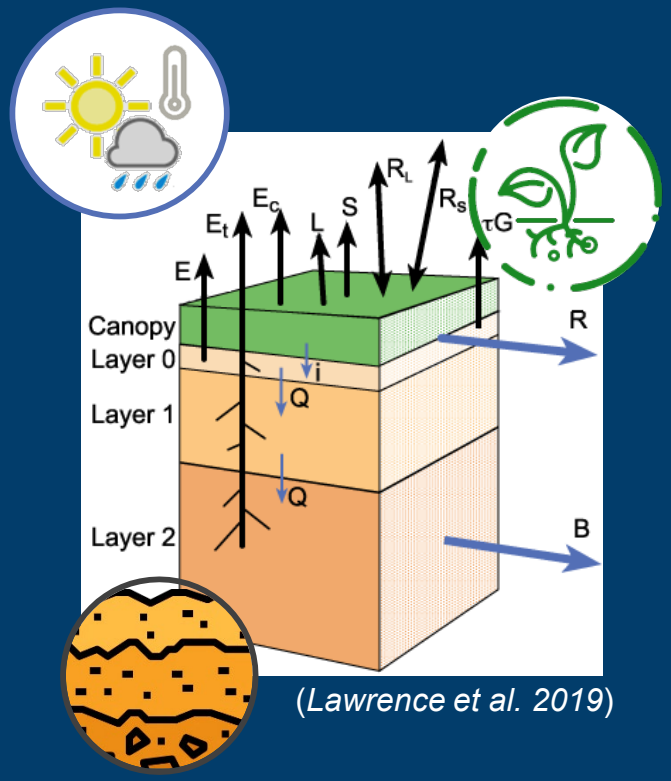
- Highly productive agricultural area
- >85 % of groundwater abstraction for irrigation

Two highly instrumented irrigated apple orchards

THE MODEL: Community Land Model v. 5

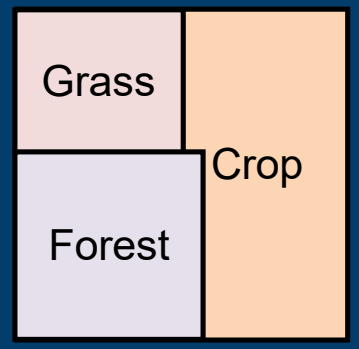
- Land component of Community Earth System Model (CESM)
- Fully distributed physically based model

✓ Surface energy fluxes
✓ Hydrology
✓ Biogeochemical fluxes



(*Lawrence et al. 2019*)

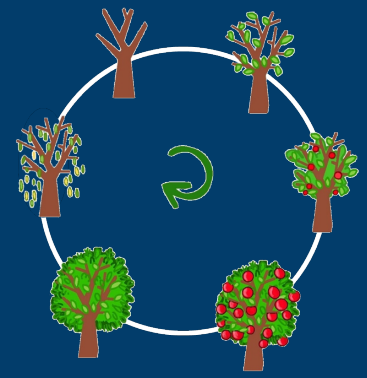
Sub-grid heterogeneity
different plant functional types



1x1 grid cell

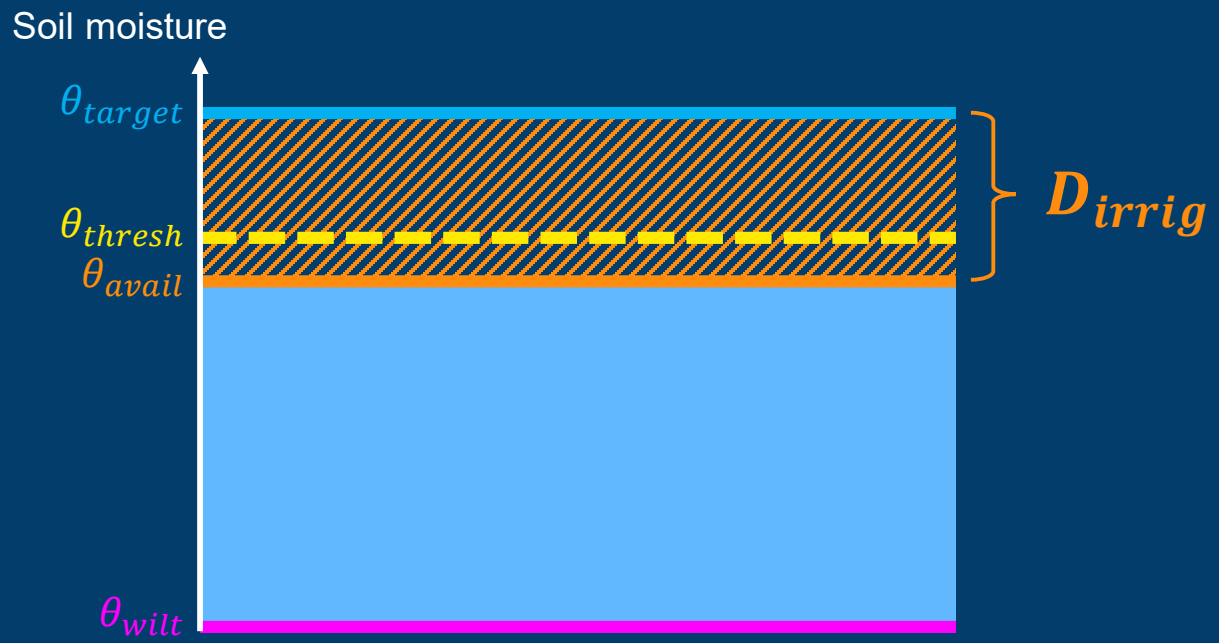
Human management

CLM5-FruitTree sub-model
(*Dombrowski et al. 2021*)



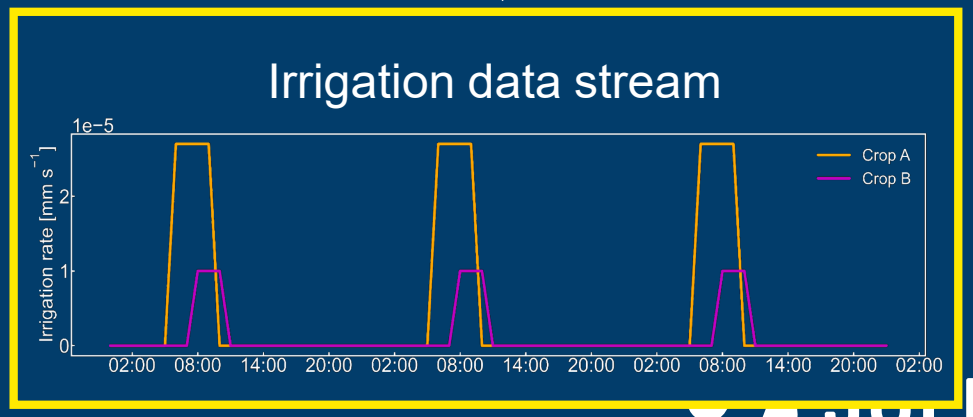
IRRIGATION IN CLM5

- Irrigation responds dynamically to soil moisture (θ)
- Soil moisture threshold to trigger irrigation (θ_{thresh})
- Daily calculation of irrigation deficit ($D_{irrig} = \theta_{target} - \theta_{avail}$)



✓ Delivers “optimal” irrigation scenario

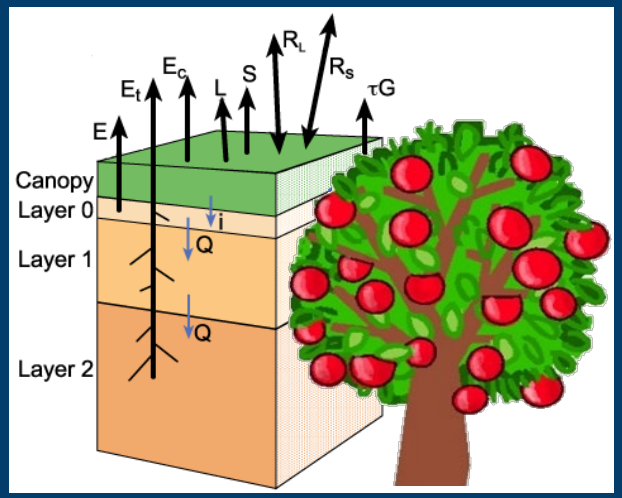
- Cannot reproduce field practices
- Running irrigation scenarios is not straightforward



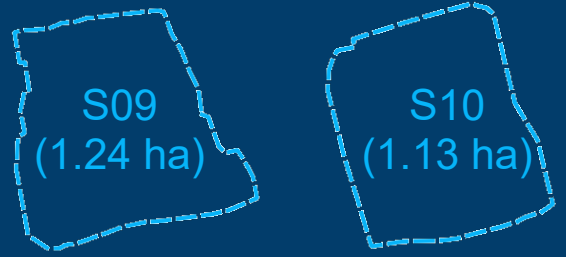
STUDY DESIGN

Types of model simulations performed

CLM5-FruitTree

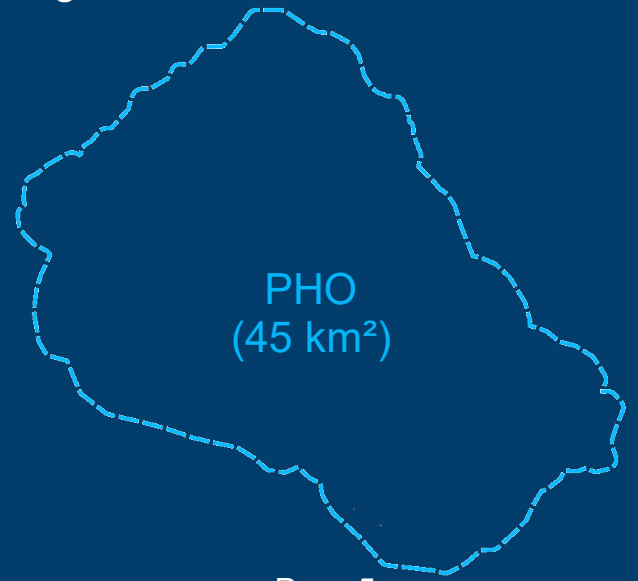


Single point simulations on two pilot fields



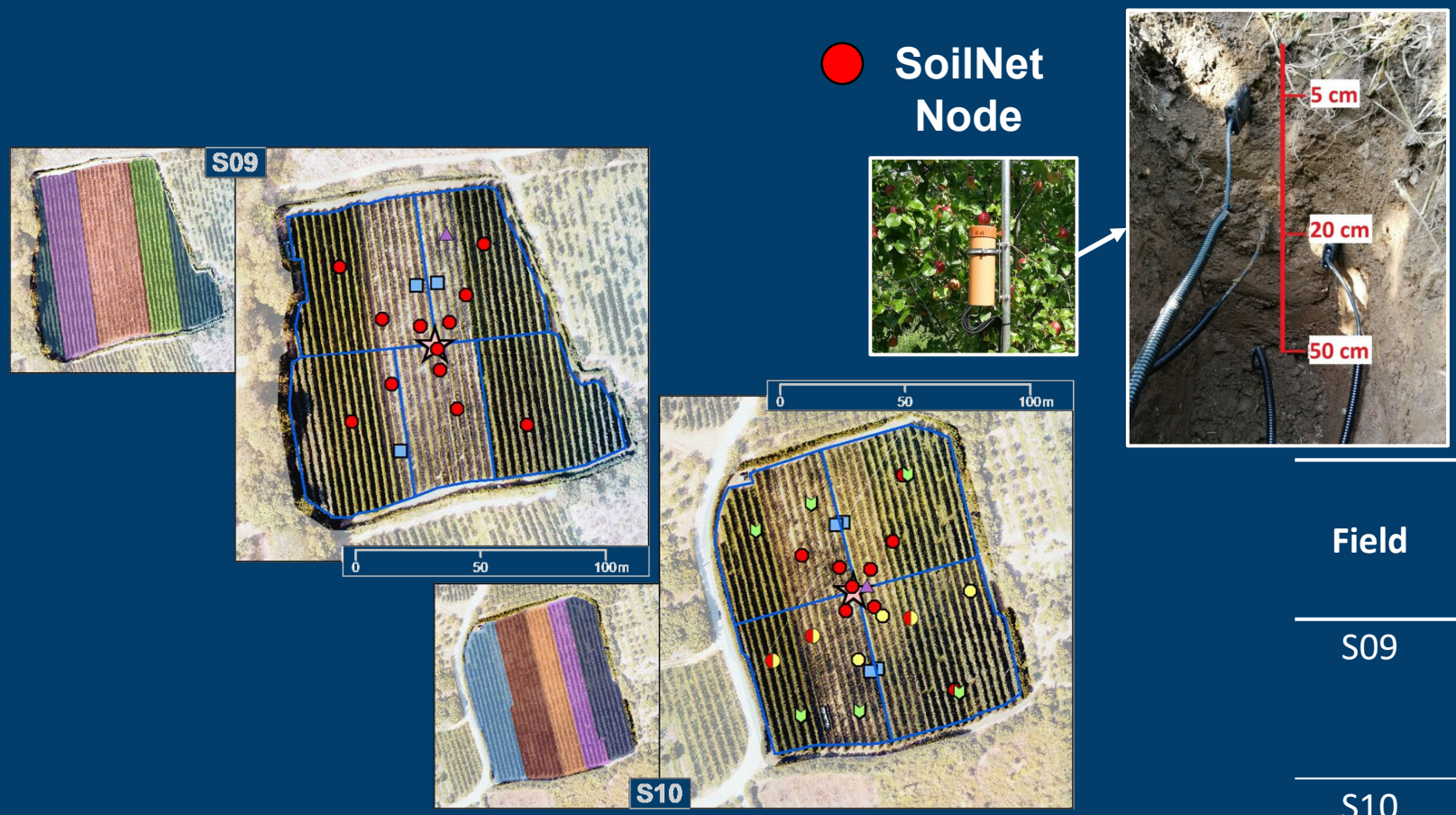
→ Model calibration and validation
→ Field scale irrigation and soil moisture dynamics

Regional simulation of the PHO



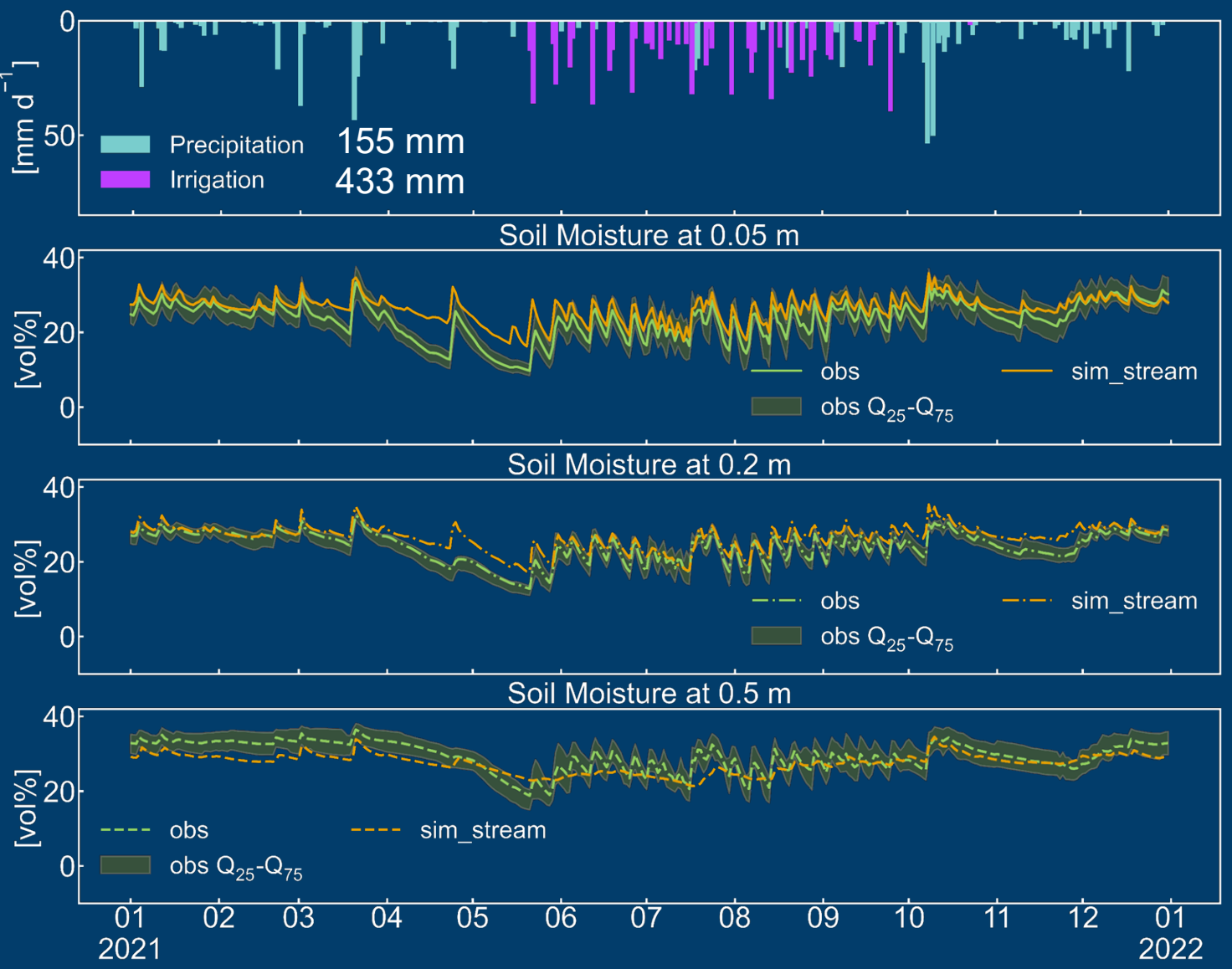
→ Regional irrigation and soil moisture dynamics
→ Irrigation scenarios

PILOT FIELDS AND INSTRUMENTATION



Field	Soil depth (cm)	Sand (%)	Clay (%)	Organic carbon (%)	Gravel content (%)
S09	0-30	64.5	17.8	1.5	23.3
	30-60	63.0	21.9	1.2	20.6
	60-90	59.9	24.6	0.7	13.7
S10	0-30	64.3	12.5	1.44	28.2
	30-60	65.8	12.7	0.86	28.7
	60-90	65.4	13.7	0.66	28.7

SOIL MOISTURE DYNAMICS



Good model performance

r ~0.85

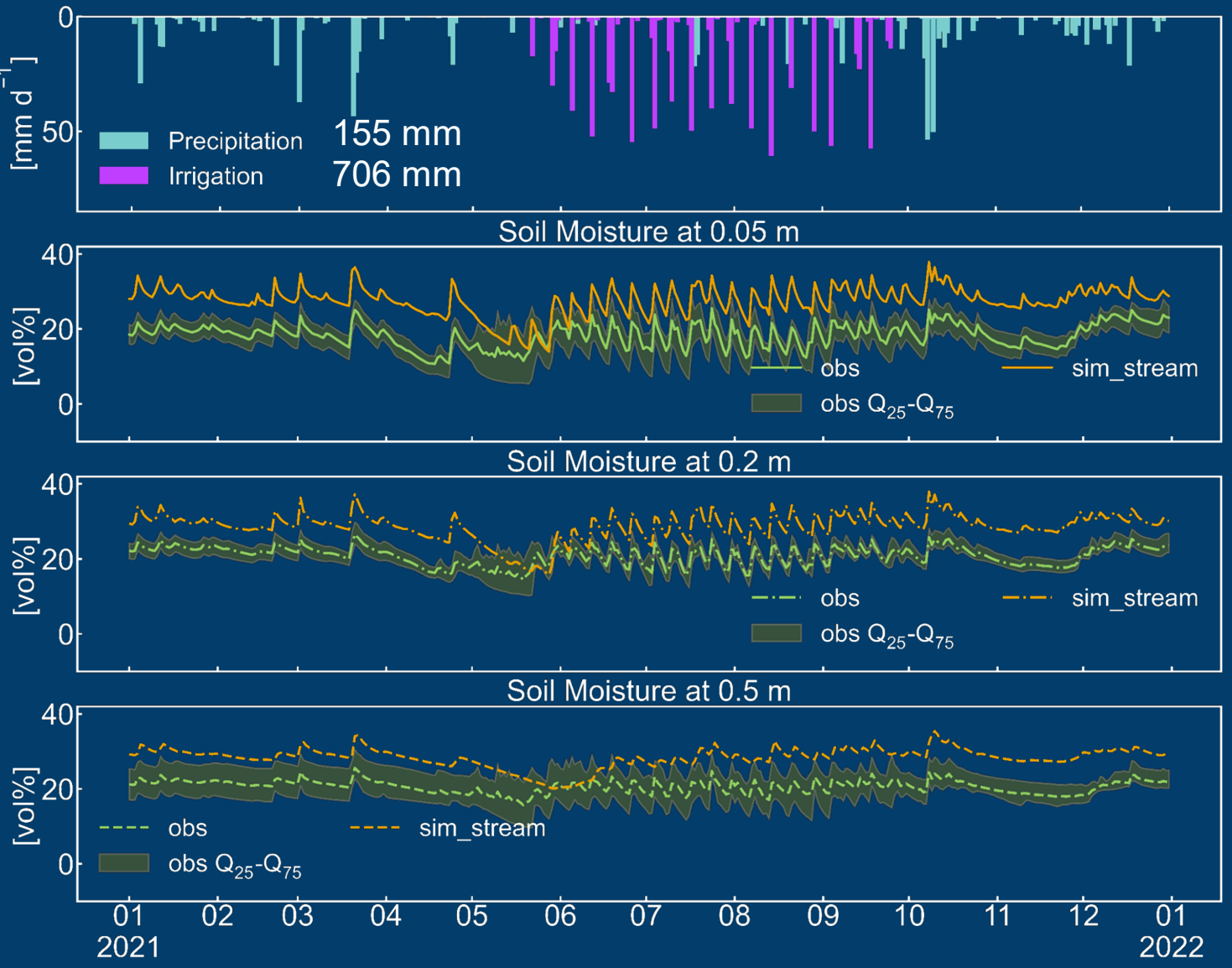
RMSE ~3.4 vol%

Differences in “dry out” spring period

Low simulated dynamics at 0.5 m

SOIL MOISTURE DYNAMICS

S10

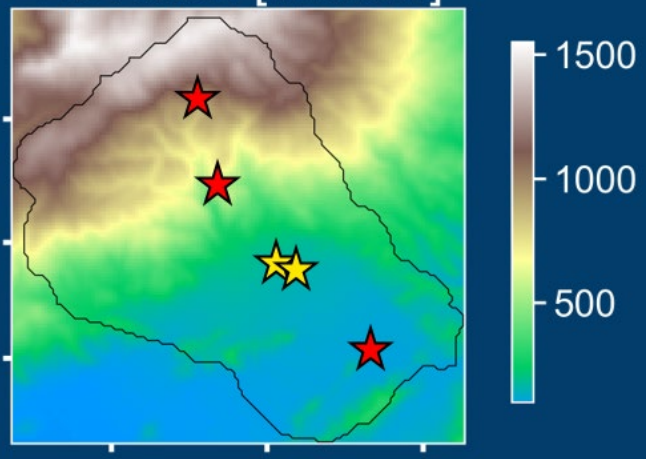


Wet bias in model

8.35 vol% higher than observation

REGIONAL CASE – MODEL INPUT DATA

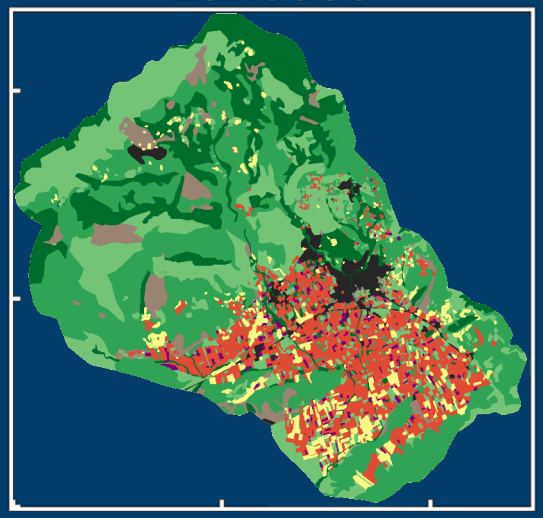
Elevation [m.a.s.l.]



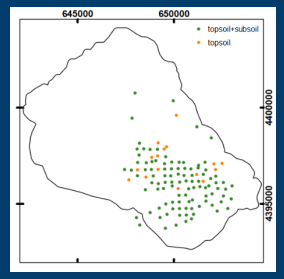
Climate station data

- CS1-3 2016-2022
- S09/S10 2020-2022

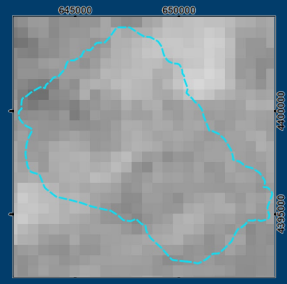
Landuse



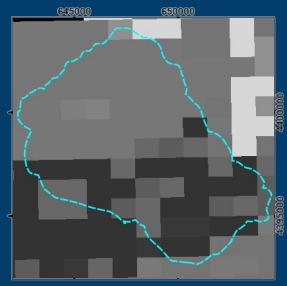
- Irrigated apples
- Irrigated cherries
- Unirrigated crops
- Mixed forest
- Shrubs
- Grassland
- Bare soil
- Urban



PHO soil sampling
116 locations



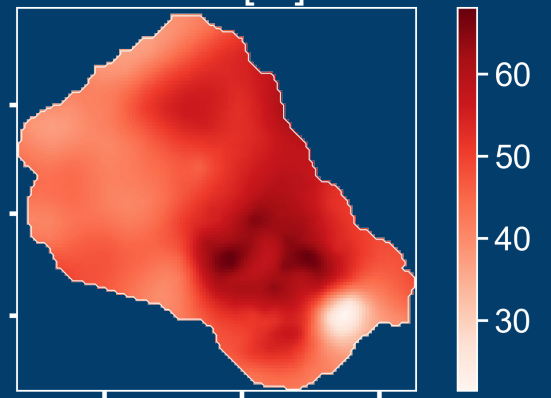
LUCAS topsoil map
500x500 m



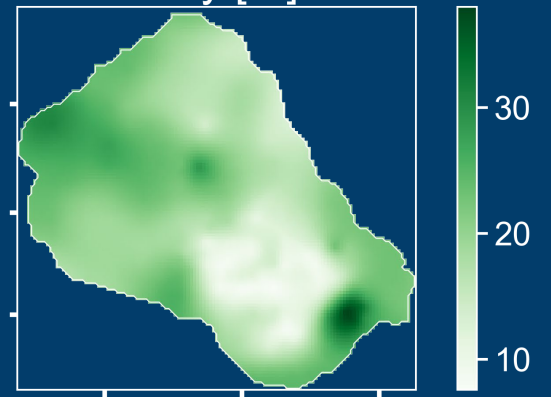
European Soil Database
1000x1000 m

Soil maps

Sand [%]

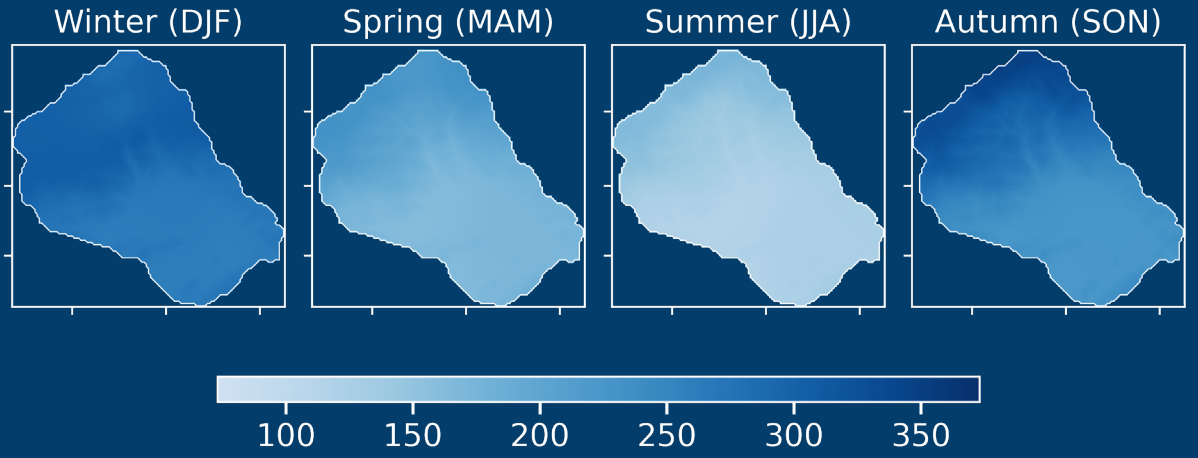


Clay [%]

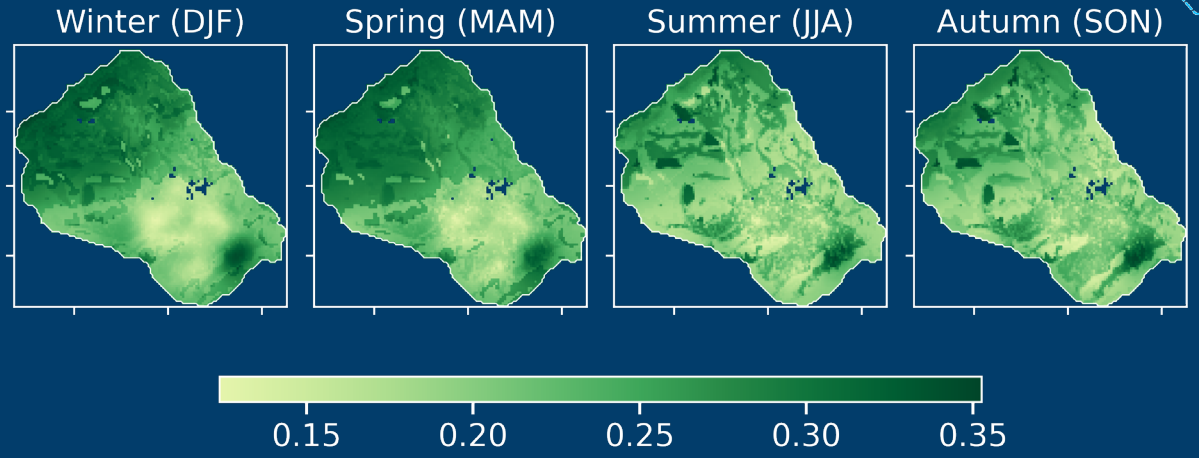


SPATIAL DYNAMICS & IRRIGATION SIGNATURE

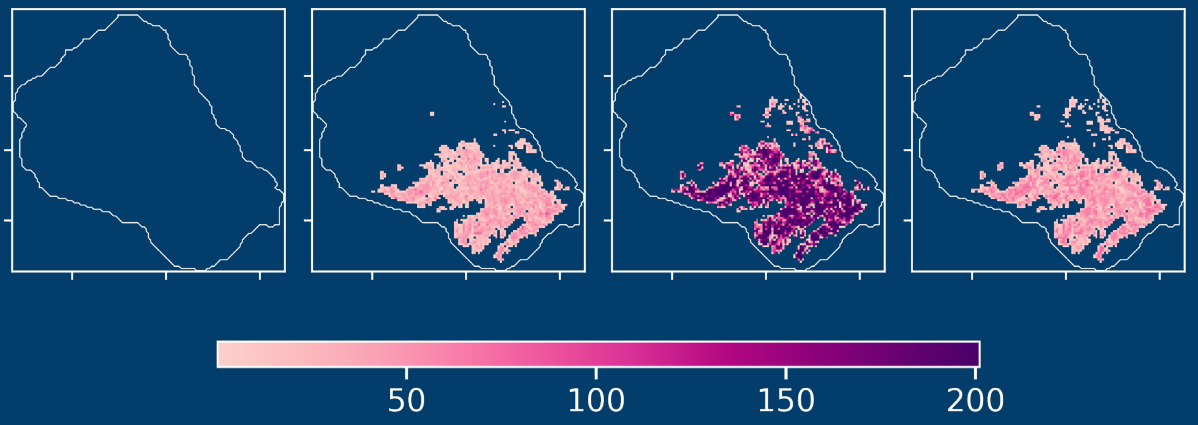
Precipitation sums [mm]



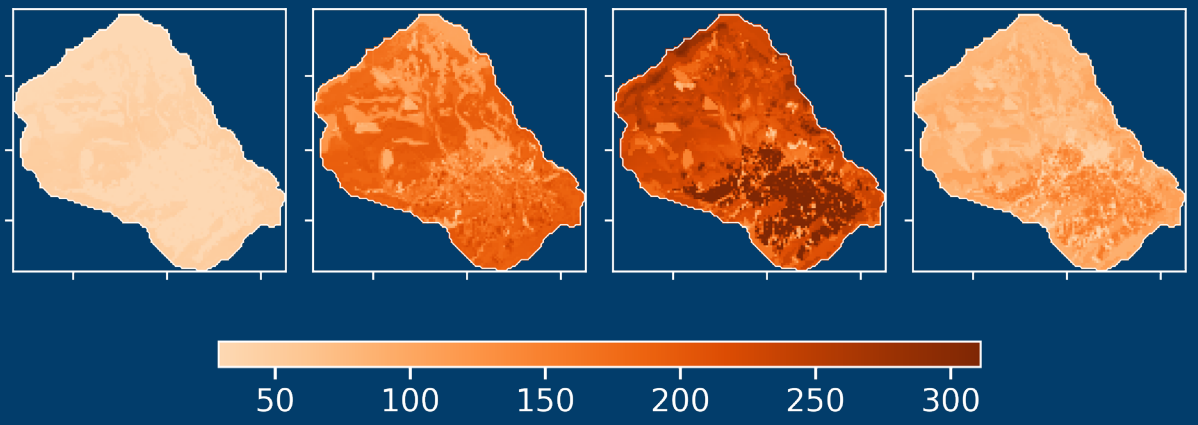
Mean soil moisture [cm³ cm⁻³]



Irrigation sums [mm]

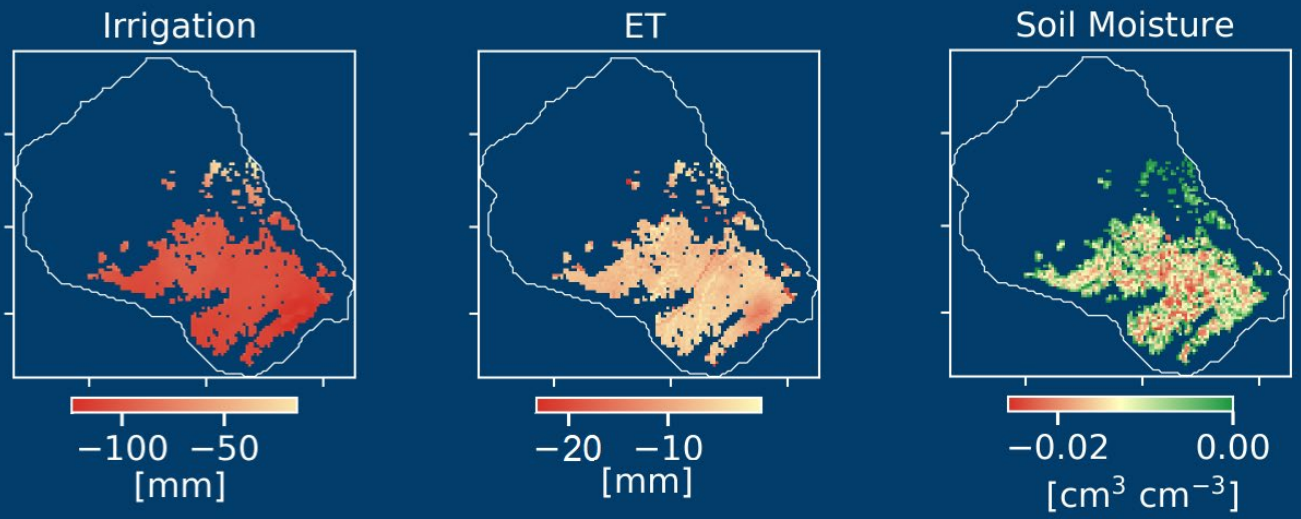


Evapotranspiration sums [mm]



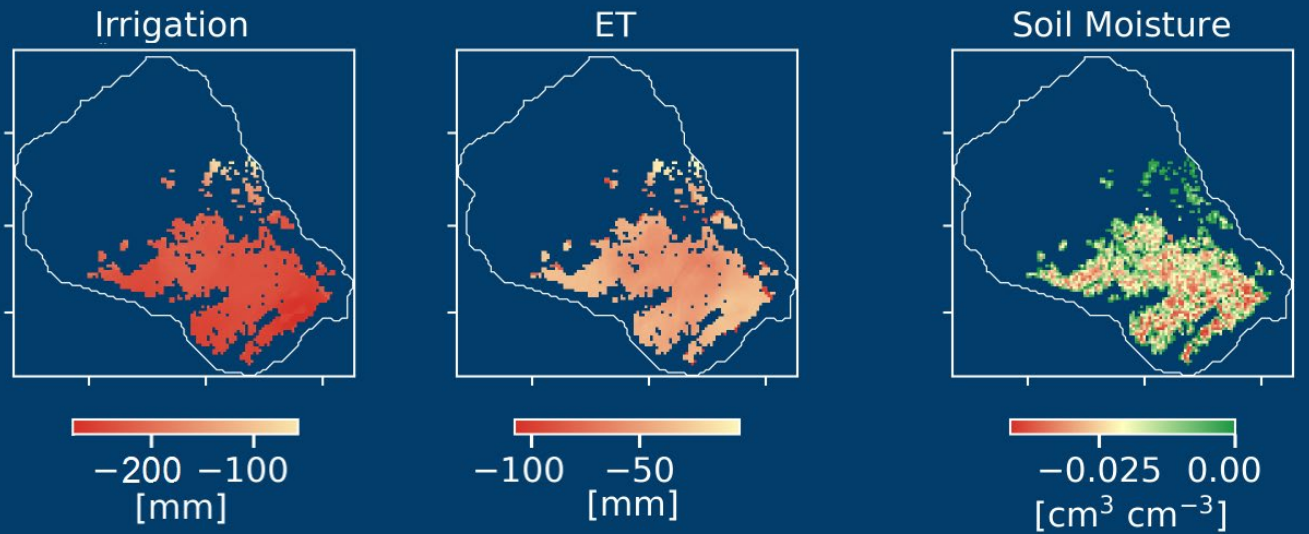
IRRIGATION DEFICIT SCENARIOS (DI)

25 % less irrigation
DI75-FULL



little effect on yield

50 % less irrigation
DI50-FULL



up to 30% yield decline

CONCLUDING REMARKS

- CLM5 could capture observed soil moisture using the implemented irrigation stream
- Some model biases exist in representation of soil hydraulic properties

- Irrigation changes regional soil moisture pattern and evapotranspiration
- Considerable amount of water could be saved using deficit irrigation

Modelling results can...

- Inform interaction between irrigation practices and freshwater resources
- Assess policy impacts and their dependency on future climatic scenarios