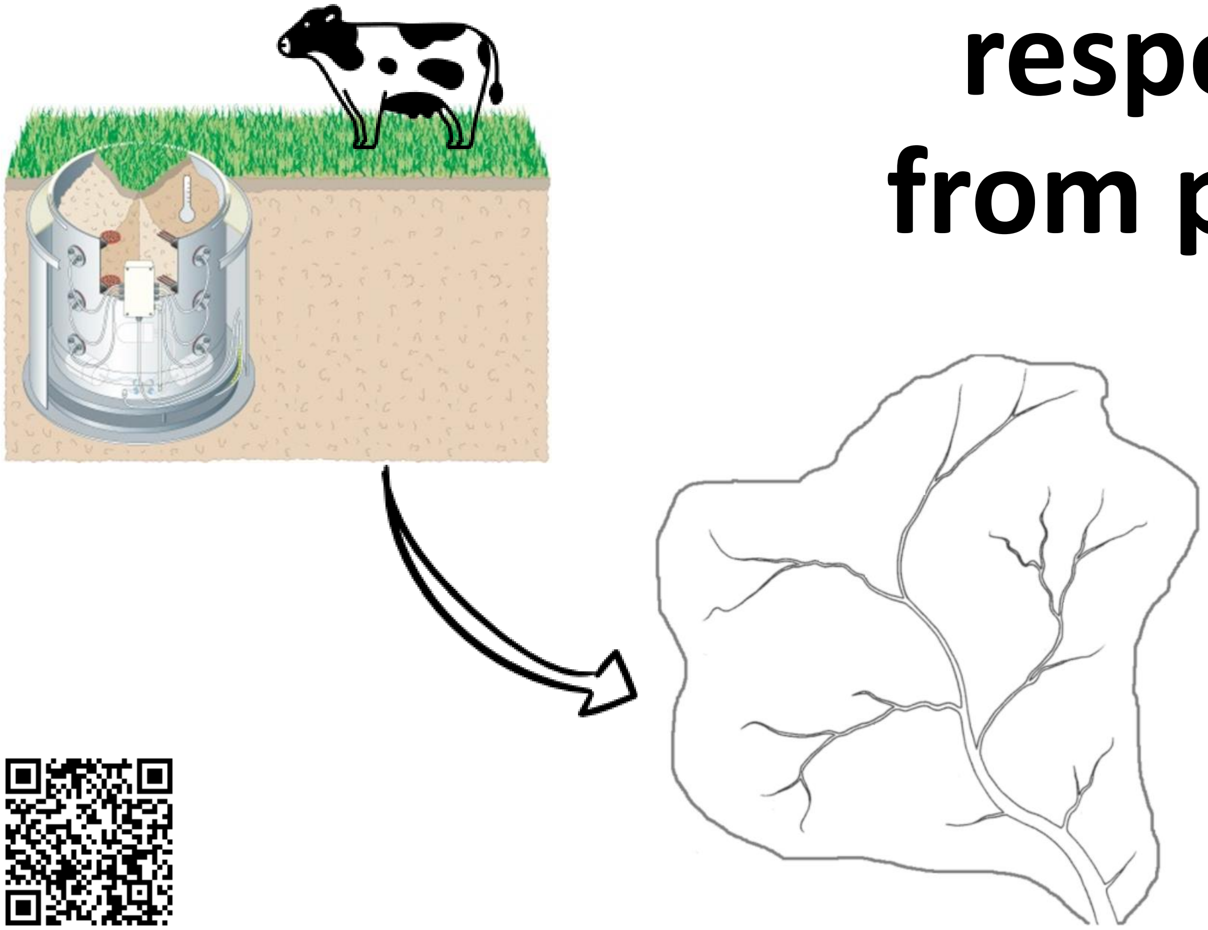
NAWI Graz GEOCENTER

Alpine grassland hydrologic response to climate change from plot to catchment scale



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Objective: Alpine grassland hydrologic reponse to warming and elevated CO_2

Warming (*eT*) ⟶ Higher evaporative demand (high confidence) - IPCC (2021)

Elevated CO_2 (eCO_2) ⟶ Increased water-use efficiency of plants (high confidence) - IPCC (2021)

Aim: identify individual and combined effects of *eT* and eCO_2

⟶ on evapotranspiration, groundwater recharge and runoff

⟶ of managed alpine grassland

„In summary, there is high confidence that a warming climate drives an increase in atmospheric evaporative demand, decreasing available soil moisture. There is high confidence that higher atmospheric CO_2 increases plant water-use efficiency, but low confidence that this physiological effect can counterbalance water losses." IPCC (2021)

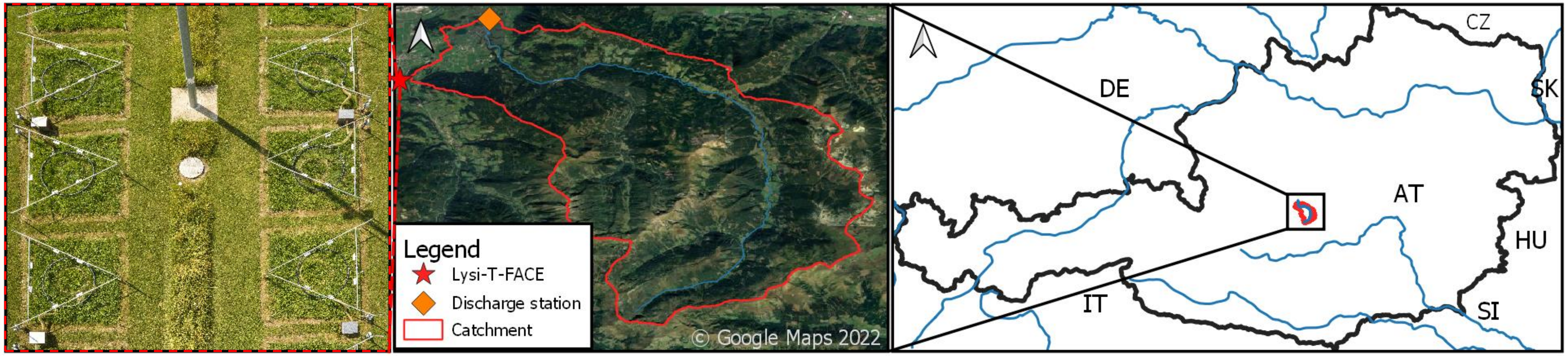
Approach: from plot to catchment level

→ Generalize findings at plot level and upscale them to the catchment.

- → lysimeter measurements (plot level)
- → hydrological modelling (catchment level)

→ From evapotranspiration, to groundwater recharge, to river runoff.

Plot level → Catchment level



Approach: Lysi-T-FACE grassland experiment (plot level)

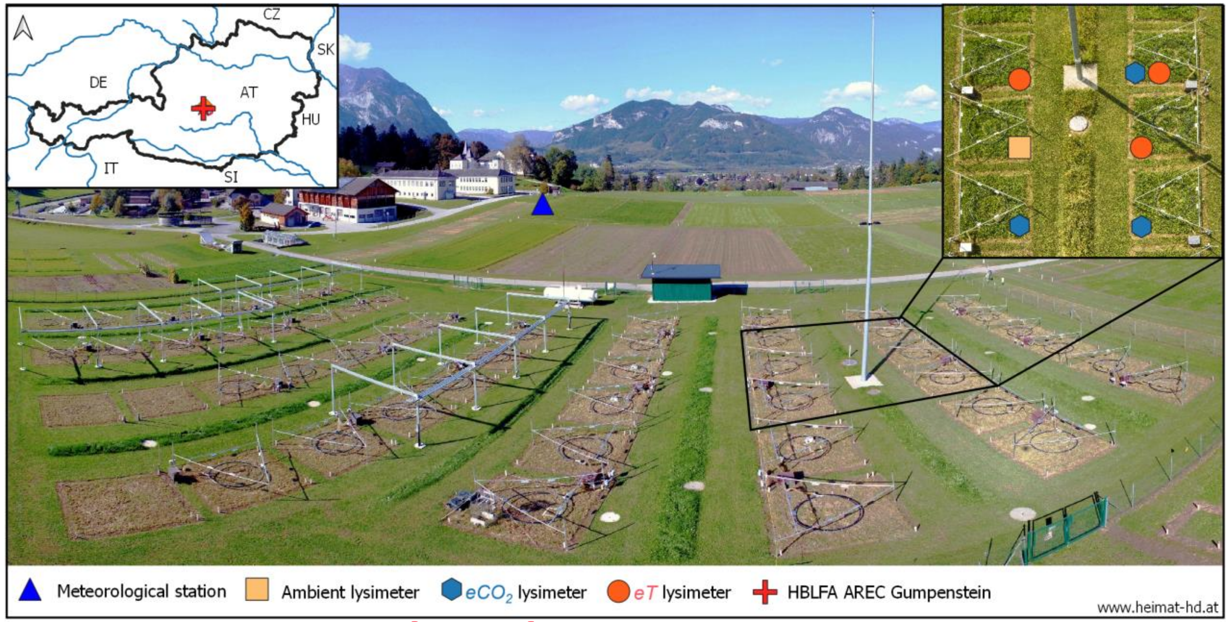
- **Lysi-T-FACE** experimental setup at HBLFA Raumberg-Gumpenstein
- Warming (infrared heaters)
- Elevated atmospheric CO_2 (fumigation rings)
- High precision weighable lysimeter

Available data:

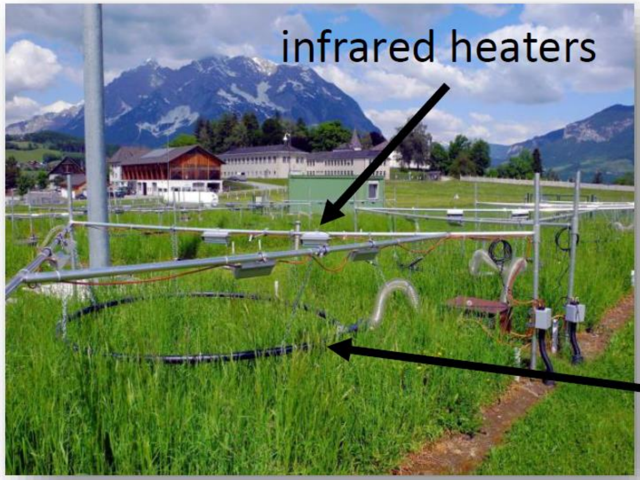
- 1990-2016:
  - Spartacus, ZAMG (Precip, T, RH, Rad, Wind)
  - Discharge data (Gulling catchment)
- 2015-2020:
  - Lysimeter soil water fluxes (AET, Precip, Groundwater recharge)

For details see Forstner et al., HESS, 2021

https://doi.org/10.5194/hess-25-6087-2021



***eT* (+3 K)**



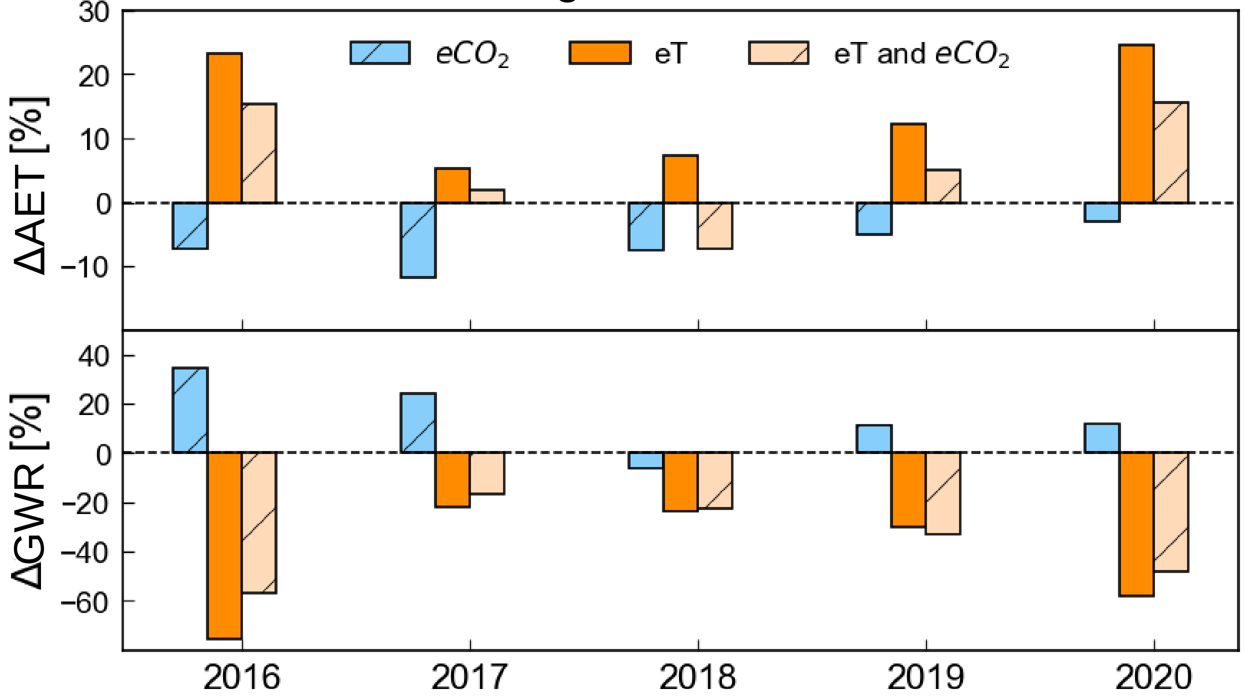
Vremec et al. (under review)

***e*CO_2 (+300 ppm CO_2)**

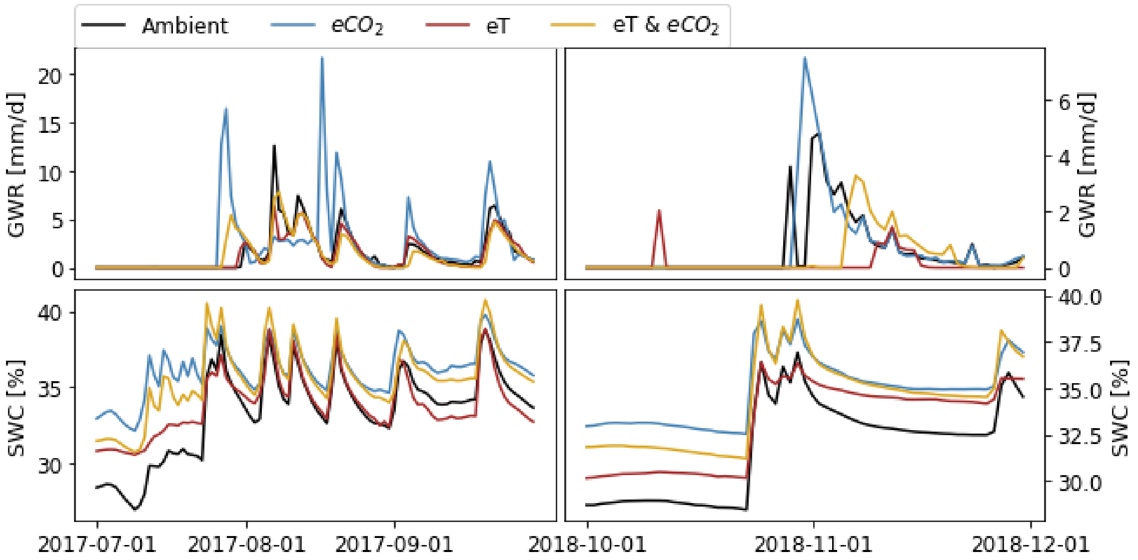
Effects of eT and eCO_2 from lysimeter data

- *eCO_2* decreases AET and increases groundwater recharge (GWR).
- *eT* increases actual evapotranspiration (AET) and decreases groundwater recharge.
- *eT* & *eCO_2* tend to increase AET and decrease groundwater recharge.

Relative change to ambient conditions:



Effect of antecedent soil moisture conditions:

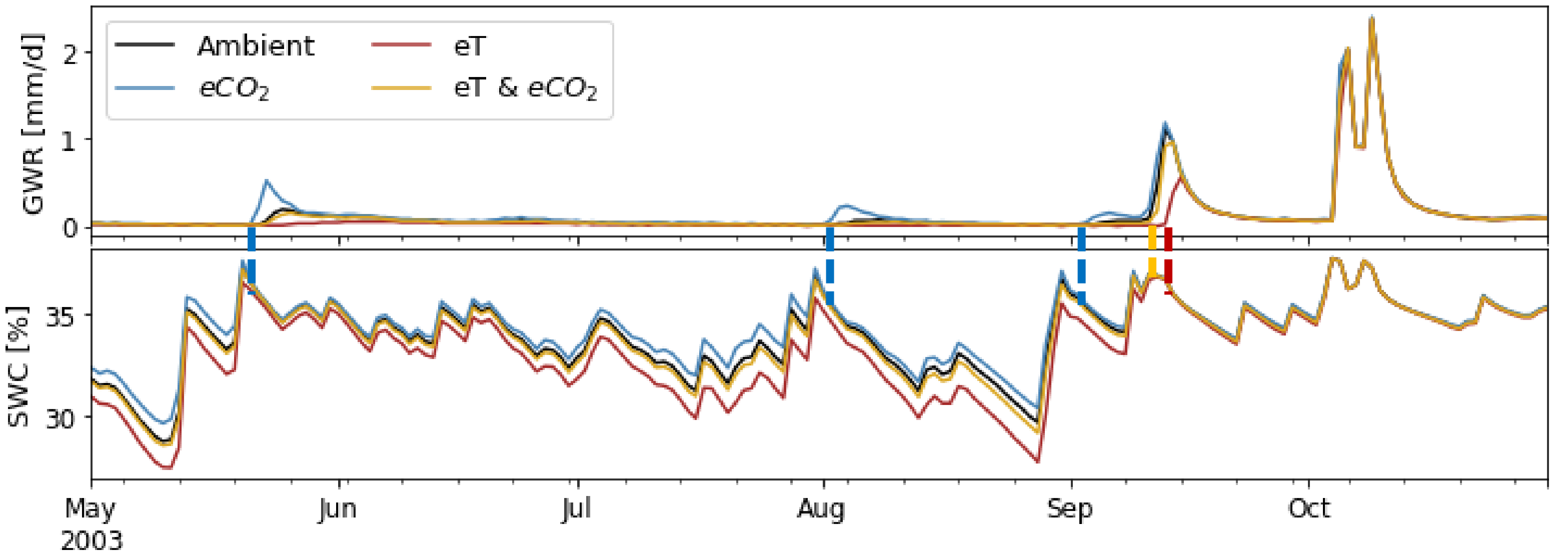


Effects of eT and eCO_2 from soil and catchment-scale hydrological models

	eCO_2	eT	eT & eCO_2
AET (lysimeter)	Decrease	Increase	Increase
Groundwater recharge (lysimeter)	Increase	Decrease	Decrease
Groundwater recharge (HYDRUS-1D)	Increase	Decrease	Decrease
Runoff (GR4J)	Increase	Decrease	Decrease
Runoff (CWatM)	Increase	Decrease	Decrease

Δ% > 10%
10 % > Δ% > 0%
0 % > Δ% > -10%
Δ% < -10%

Effect of antecedent soil moisture conditions (HYDRUS-1D):



Take Home Messages and outlook

- runoff and groundwater recharge show similar behavior under warming (*eT*) and elevated CO_2 concentrations (eCO_2).
- the effects of *eT* and eCO_2 appear to be buffered at the catchment scale.

- antecedent soil moisture conditions play an important role in how changes in evapotranspiration under *eT* and eCO_2 translate into groundwater recharge at the plot level. What about runoff at the catchment?
- how does model complexity affect the propagation of the *eT* and eCO_2 effect from evapotranspiration to groundwater recharge to runoff?

ÖAW ÖSTERREICHISCHE AKADEMIE DER WISSENSCHAFTEN

Thank you!

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