

# **Lysimeter experiments reveal effects of elevated atmospheric carbon dioxide on soil-water fluxes and biomass production of alpine grassland under drought**

S. Birk<sup>1</sup>, M. Vremec<sup>1</sup>, V. Forstner<sup>1</sup>,  
M. Herndl<sup>2</sup>, A. Schaumberger<sup>2</sup>

<sup>1</sup>University of Graz, Institute of Earth Sciences,  
NAWI Graz Geocenter, Austria

<sup>2</sup>Agricultural Research and Education Centre  
(AREC) Raumberg-Gumpenstein, Austria

# Objective: Effect of elevated CO<sub>2</sub> on soil water fluxes and biomass production

Vegetation response to elevated CO<sub>2</sub> (eCO<sub>2</sub>) on evapotranspiration (ET):

- Partial stomatal closure reduces ET at leaf scale – **Water Use Efficiency** (WUE) effect
- Increased foliage cover increases ET at canopy scale – **CO<sub>2</sub> fertilization** effect



*“Increasing atmospheric CO<sub>2</sub> concentrations increase **plant growth** and **water-use efficiency**, but there is low confidence in how these factors drive regional water cycle changes.”*

IPCC (2021)

Aim: Identify the effects of eCO<sub>2</sub>

- on evapotranspiration, soil-water availability, and above ground biomass (AGB)
- of managed alpine grassland
- under drought.

# Approach: Grassland experiment

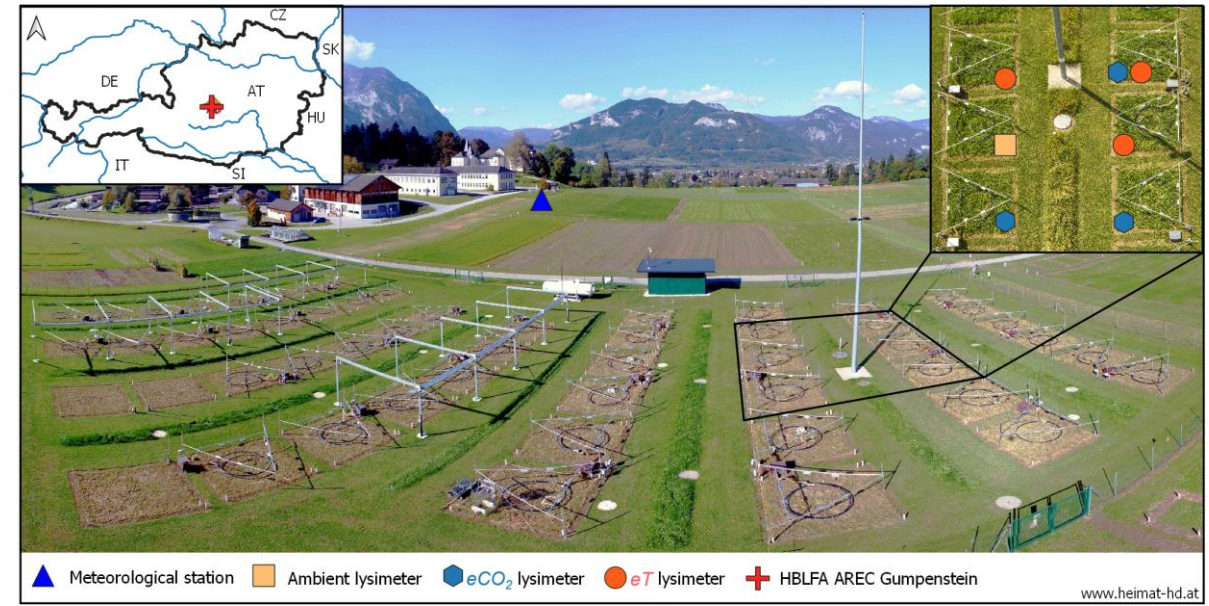
- ClimGrass site, AREC Raumberg-Gumpenstein
- Warming (infrared heaters)
- CO<sub>2</sub> enrichment (fumigation ring)
- High precision weighable lysimeters

Available data:

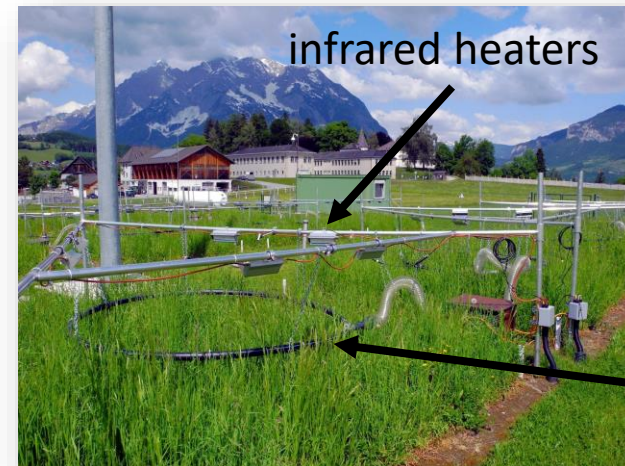
- Meteorological data
- Soil water fluxes (ET, seepage, storage change)
- Crop height, leaf area index and biomass throughout the growing season
- Data availability: 2015-2021

For details see Forstner et al., HESS, 2021

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



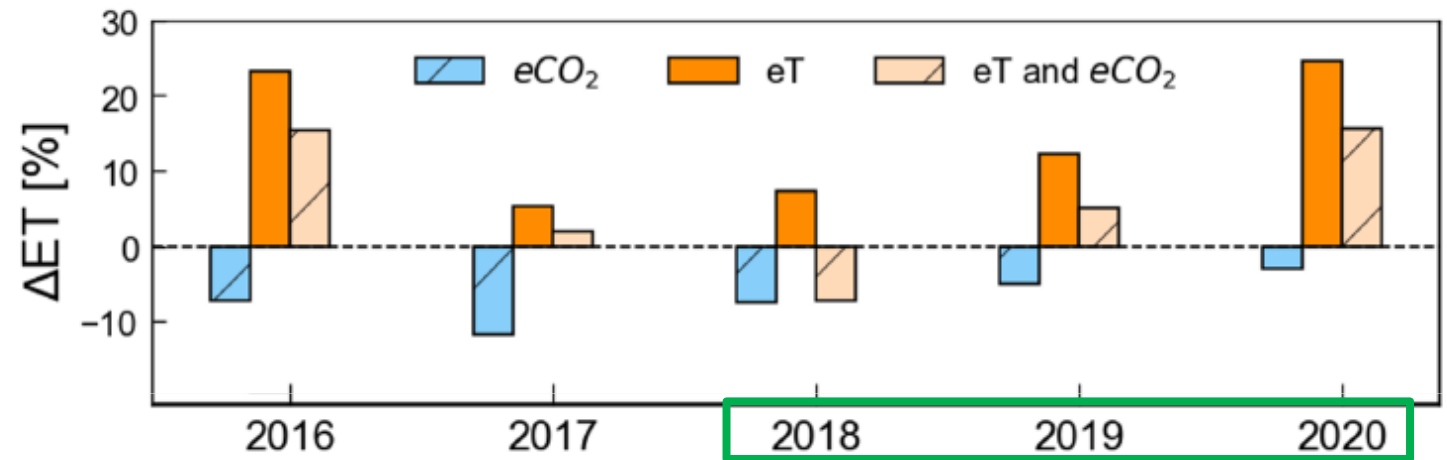
(Vremec et al., under review)



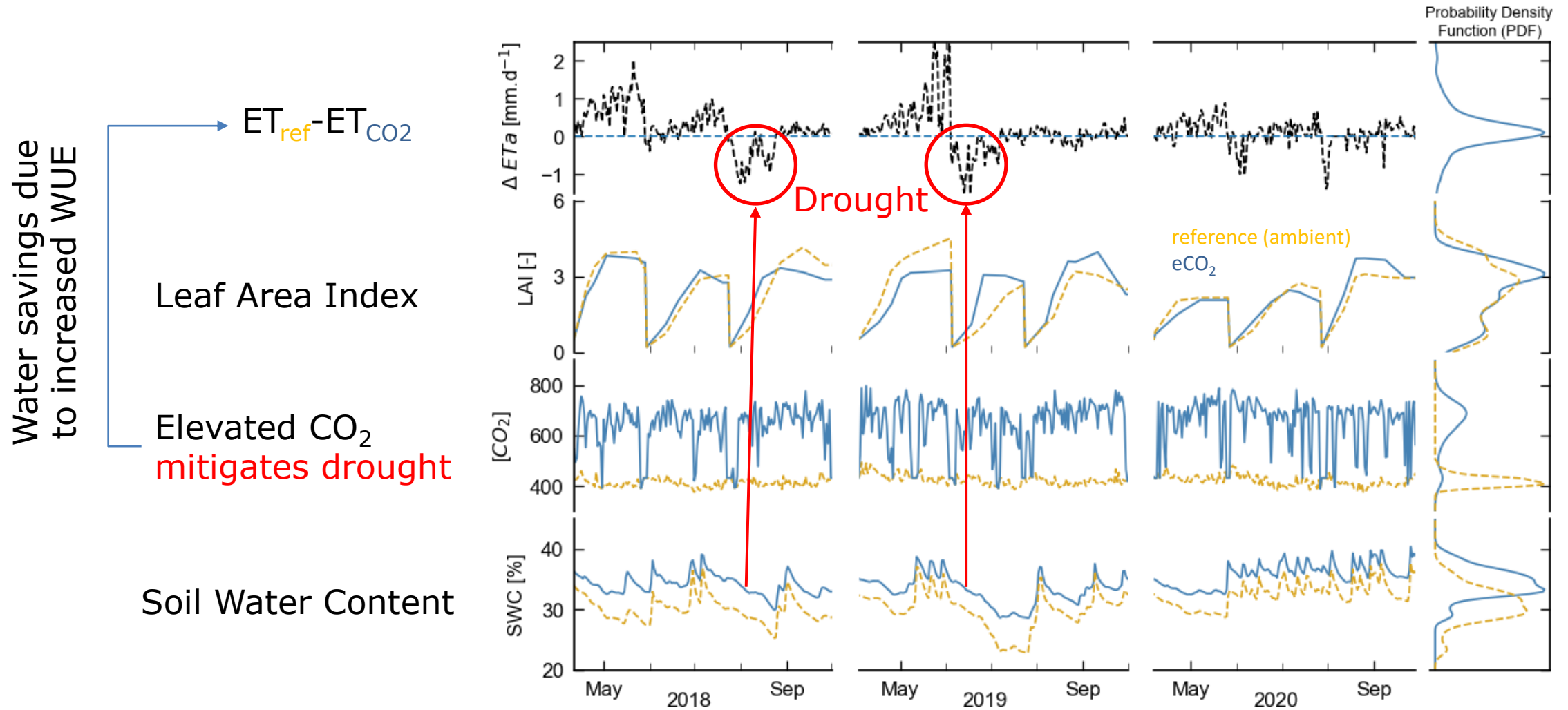
# Effect of eCO<sub>2</sub> on ET

- eCO<sub>2</sub> decreases ET
- Warming increases ET
- Combined treatment
  - tends to increase ET
  - but the effect differs between the years
- Detailed evaluation of data from 2018-2020

Annual evapotranspiration 2016-2020:  
Differences to ambient lysimeter



# Effect of eCO<sub>2</sub> on ET

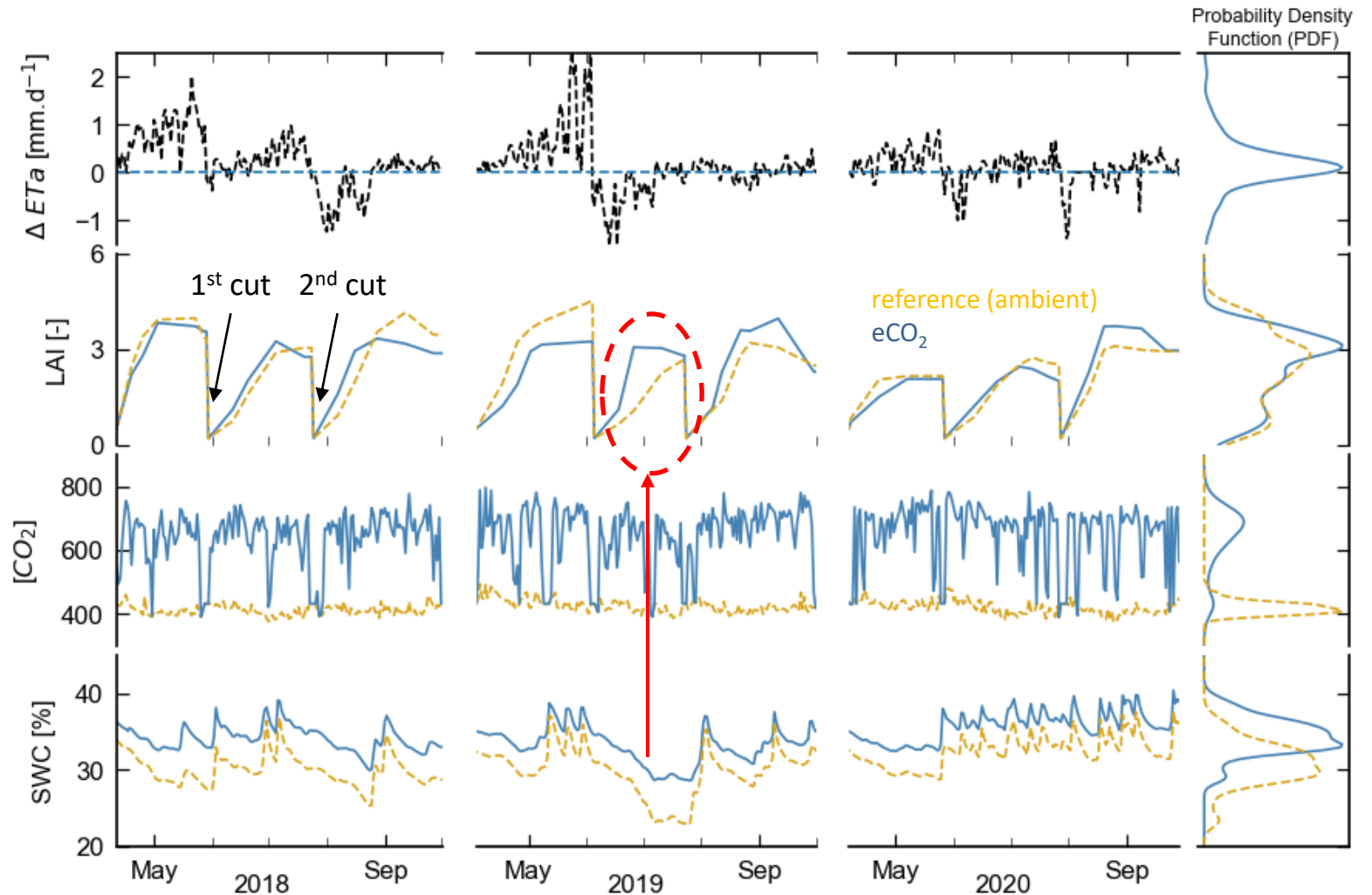


# Fertilization vs. WUE effect

Observed effect of eCO<sub>2</sub> :

- Increased Leaf Area Index (LAI) only in **drought 2019**
  - Likely resulting from water savings due reduced ET
- ⇒ Mainly water use efficiency effect
- ⇒ Fertilization effect not confirmed

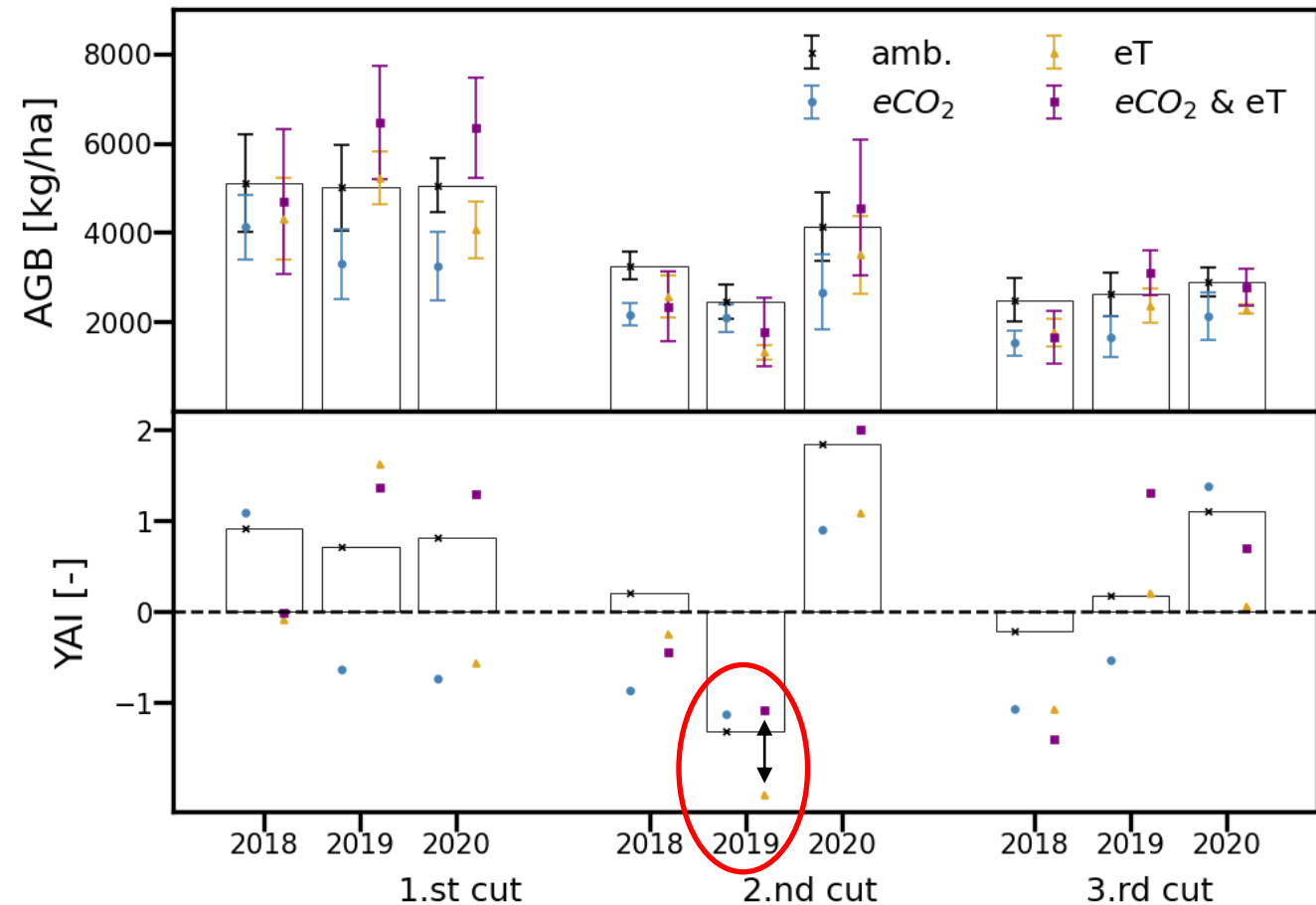
Soil Water Content



# Effect of summer drought 2019 on above ground biomass (AGB)

Yield Anomaly Index (YAI) reveals effect of drought on AGB of **2<sup>nd</sup> cut in 2019**

- Strongest yield anomaly on heated plots (eT)
- Weaker yield anomaly with elevated CO<sub>2</sub> (eCO<sub>2</sub>, eCO<sub>2</sub> & eT)
- Most pronounced effect of eCO<sub>2</sub> under warming



# Conclusions

Partial stomatal closure due to elevated atmospheric carbon dioxide

- increases the water use efficiency of grassland,
- reduces evapotranspiration,
- results in soil water savings,
- mitigates drought effects on biomass production of managed alpine grassland,
- most effectively under warming.

# Acknowledgements



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