Short term impacts and legacy effects of heat waves and drought in alpine grassland

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Who am I?

- global change ecologist, focus = climate extremes
- experimentalist – natural and artificial systems
- interested in improving methodology

Where do I come from?

Motivation for the study:

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- Knowledge on climate extremes from temperate, lowland systems (artificial or semi-natural) → are the impacts comparable in alpine systems?


Location

AlpFor research station, Furka pass, 2440 m, 46°N, 8°E

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Methods

- Temperature and rainfall control on the cheap: monolith translocation & shelters

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Methods

- Climate extremes: multiple levels of heat waves in combination with drought or as single factor
- Duration: 17 days (15/07-01/08/2013)
- Air temperature, RH, VPD:

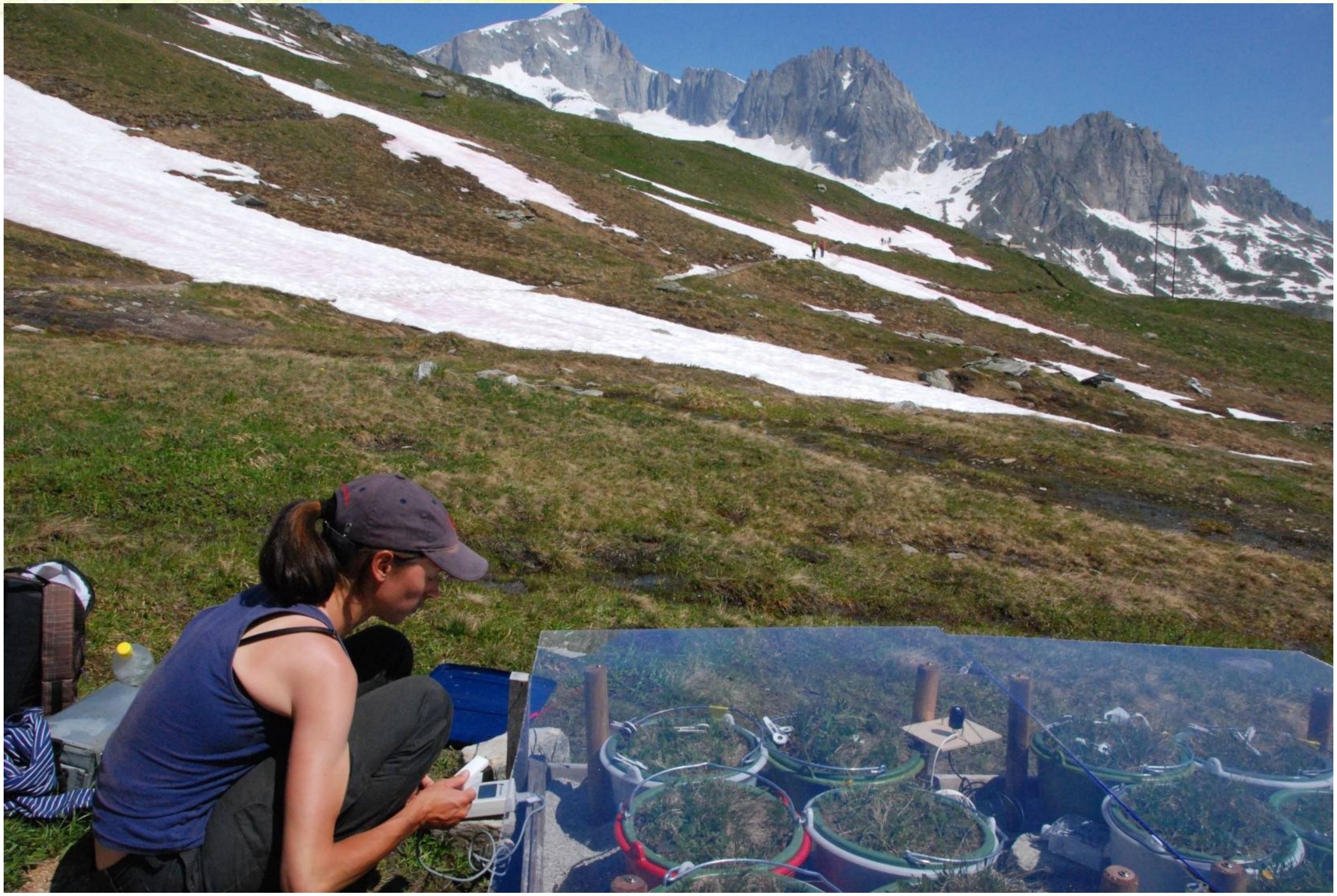
  Furka 2440 m: 11.8 °C, 77.5%, 0.40 kPa

  Oberwald 1390 m: 16.7 °C, 72.3%, 0.76 kPa

  Bister 1040 m: 21.3 °C, 66.0%, 1.16 kPa

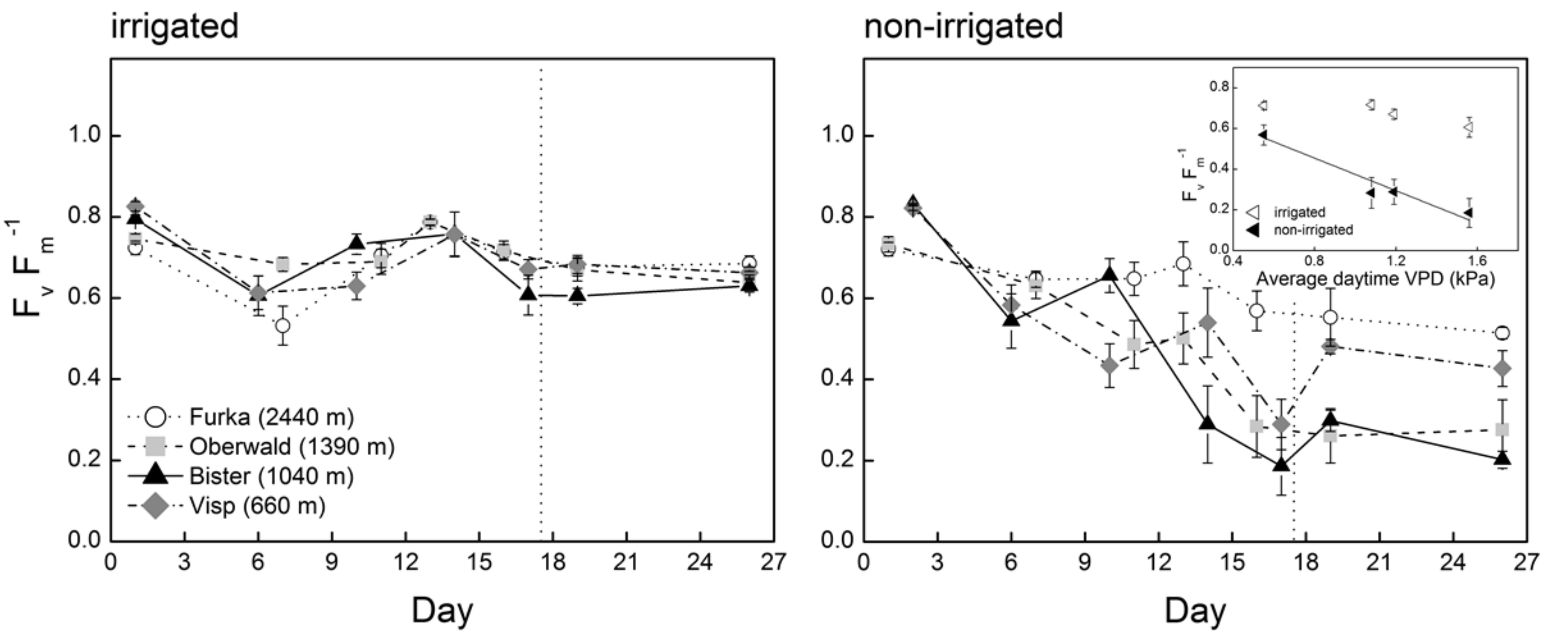
  Visp 660 m: 20.9 °C, 74.3%, 0.87 kPa

Measurements



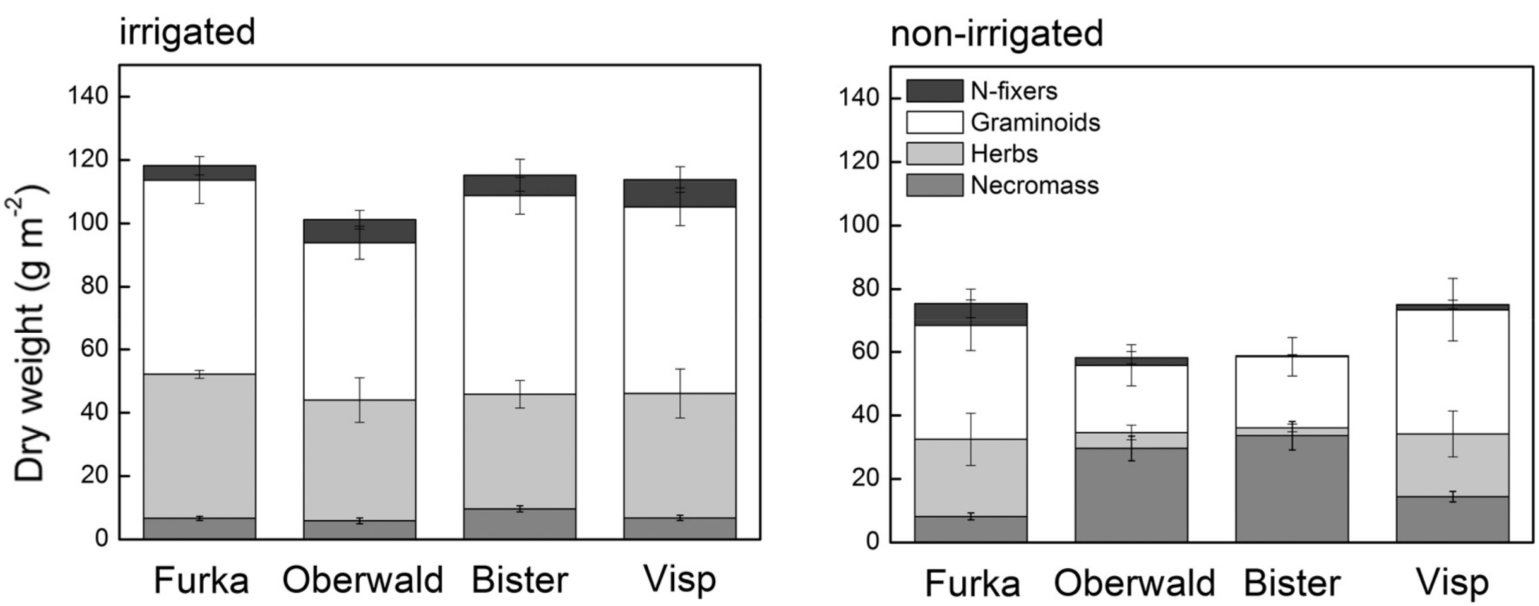
Results

- Fluorescence (F_v/F_m) = a stress indicator:



Results

- Phytomass = an integrator:



Results

- Warming exacerbates drought effects, but its single factor impact is limited → why?

	Day	Treatment	Site			
			Furka	Oberwald	Bister	Visp
T_{canopy} (°C)	10 or 11	irrigated	33.8	38.3	38.3	40.7
T_{canopy} (°C)	10 or 11	non-irrigated	38.2	47.5	45.8	48.8
T_{air} (°C)	10 or 11	both	21.5	30.5	33.6	34.0
PPFD (µmol m^{-2} s^{-1})	10 or 11	both	1869	1445	2151	2139
VPD (kPa)	10 or 11	both	1.08	2.74	3.29	3.03
T_{canopy} (°C)	16 or 17	irrigated	**32.3**	**32.5**	42.7	38.3
T_{canopy} (°C)	16 or 17	non-irrigated	41.4	43.0	52.0	48.2
T_{air} (°C)	16 or 17	both	**18.2**	**25.3**	34.1	31.5
PPFD (µmol m^{-2} s^{-1})	16 or 17	both	1650	1924	1877	1806
VPD (kPa)	16 or 17	both	0.82	1.93	3.24	2.43

Tair vs. Tcanopy: see also De Boeck et al. 2016 BGS

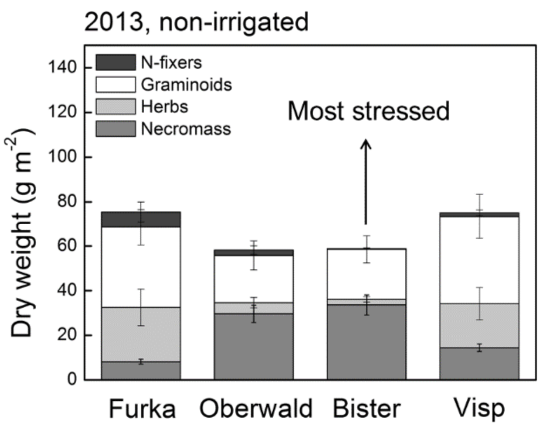
Wrap-up of short-term effects

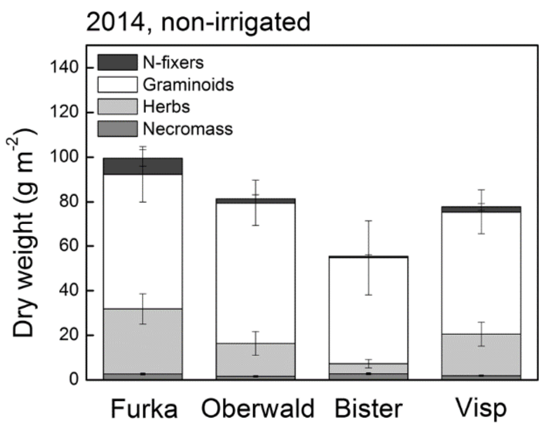
- Observed responses correspond to those found in temperate grasslands:
  - direct heat stress effects limited
  - drought much more important
  - interplay between heat & drought
- Does the rate of recovery in alpine grasslands differ from temperate systems?

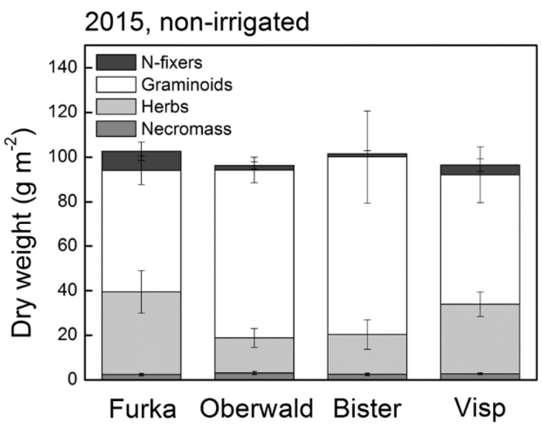
De Boeck et al. New Phytologist (2016)

After the extreme

- Phytomass: differences no longer significant after 2 years, but: changes in functional group ratio



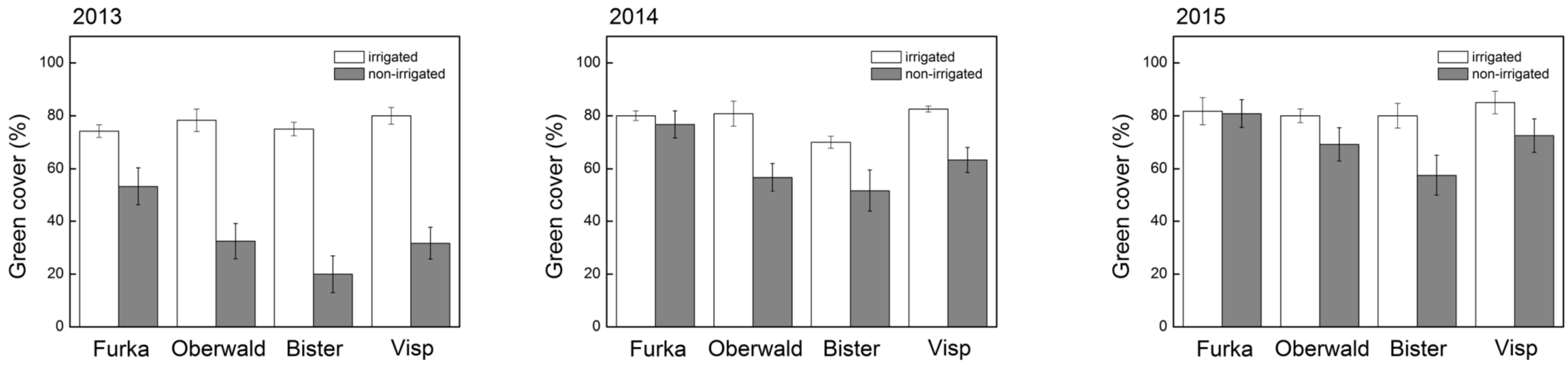




De Boeck et al. Frontiers (2018)

After the extreme

- Green cover: differences persist for harshest extreme



De Boeck et al. Frontiers (2018)

After the extreme

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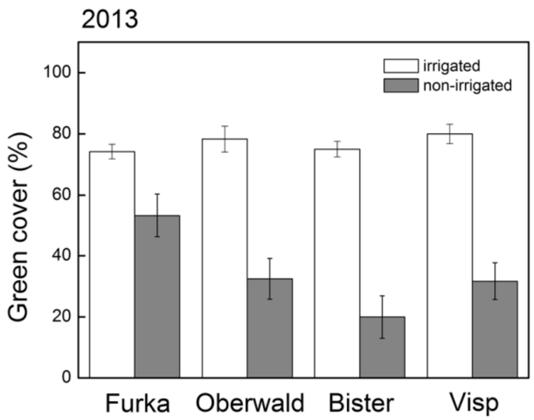
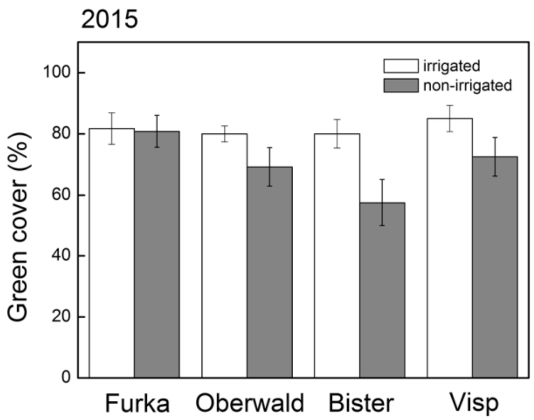
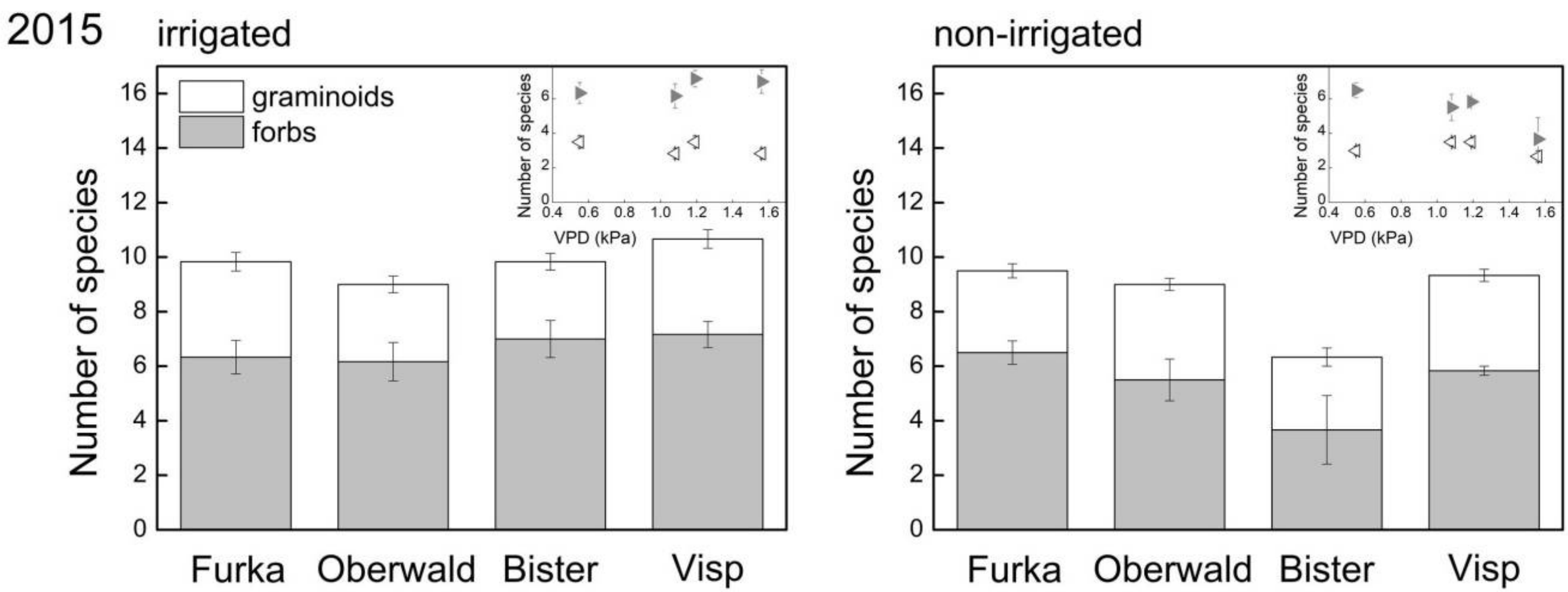




After the extreme

- Biodiversity: dicots lose out, graminoids persist



De Boeck et al. Frontiers (2018)

Wrap-up regarding longer-term (legacy) effects

- Recovery after heat and drought is slow:
  - Productivity took 2 years to get back to control levels
  - Cover did not bounce back completely after harshest extremes (→ consequences for erosion?)
- Composition and diversity changed:
  - Graminoids held on to the (relative) advantage they got during the extremes (SLA as a predictor?)
  - Altered response to new extremes ('pre-adaptation')?
- Resistance crucial in these slow-growing systems

Some thoughts on warming methods

- Book chapter: “Climate Warming Experiments: Selecting the Appropriate Technique”

(in: Terrestrial Ecosystem Research Infrastructures - Challenges and Opportunities)

Method	Technological demands	Cost	Intrusiveness	Plot size	potential ΔT	Control	Main artefact
passive types							
open top chambers	low	low	low	small	small	low	reduced wind
thermal screens	medium	medium	low	large	small	low	asymmetric warming
translocation	low	medium	high	small	high	medium	soil disturbance
geothermal hot spots	low	low	low	unlimited	high	medium	asymmetric warming
active types							
soil heating cables	medium	medium	high	large	medium	high	asymmetric warming
climate-controlled chambers	high	high	medium	medium	high	high	reduced light
infrared heating	medium/high	medium	low	medium/large	high	high	increased ET

Some thoughts on warming methods

Specifically for translocation:

- Other variables also change (e.g. RH, cloudiness, precipitation, snow cover, etc.) → can be an improvement, but careful site selection is important
- Change in partial pressure of CO_2 with elevation (but order of magnitude lower than CC expected under elevated CO_2)
- Unwanted changes: litter inputs, animal interactions
- Monoliths: disturbance and edge effects (incl. soil warming)
- Difficulties for simultaneous measurements

General conclusions and take-home messages

- Temperate and alpine grasslands are similar regarding immediate responses to heat and drought
- Major differences exist regarding recovery
- Microclimate is especially important in the mountains
- A future climate with more frequent and intense heat waves and droughts can significantly alter alpine grasslands – functioning, appearance, and the related ecosystem services
- No warming method is perfect, but be mindful of drawbacks

Thank you!

Michaela Zeiter, Erika Hiltbrunner, Seraina Bassin, Christian Körner, Maya Verlinden

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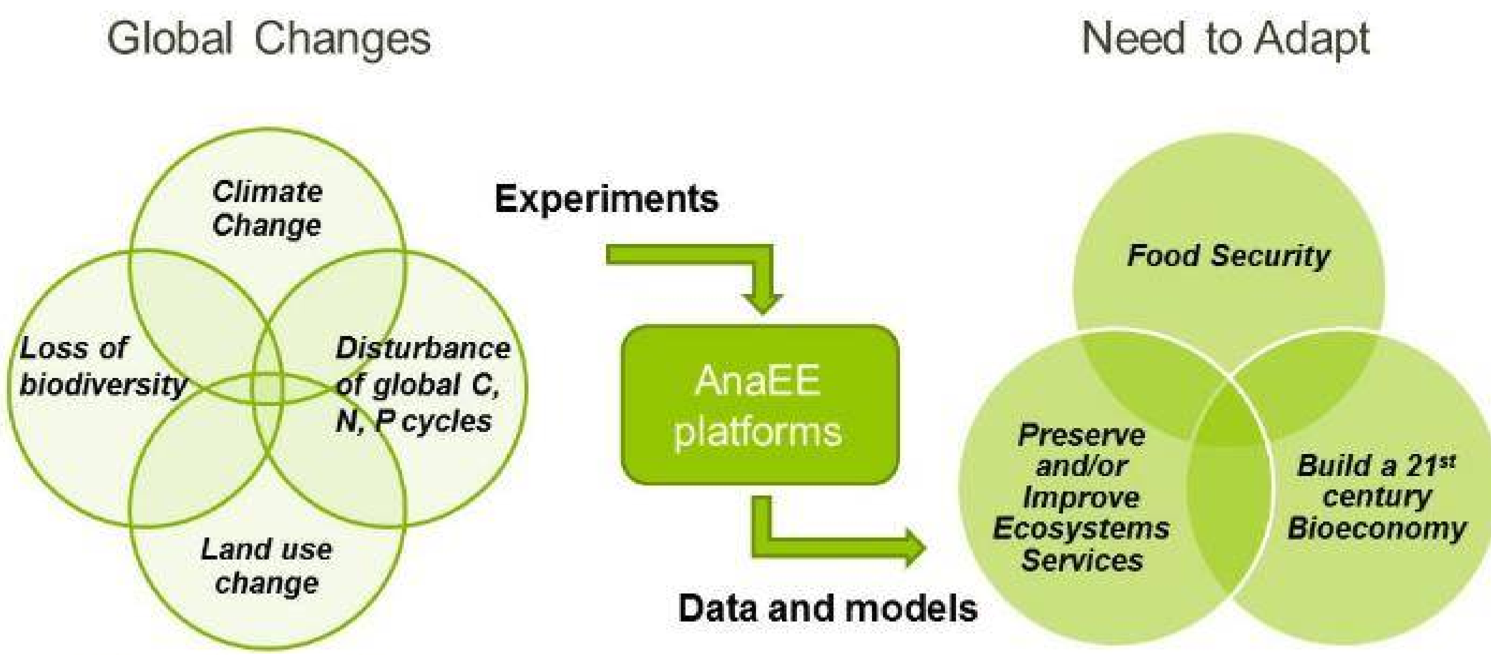
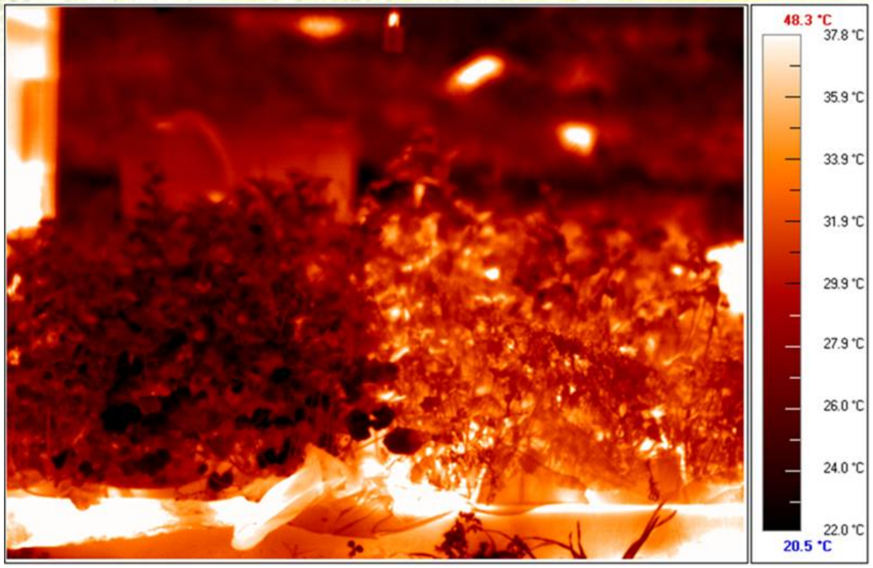
The AnaEE-Europe Concept

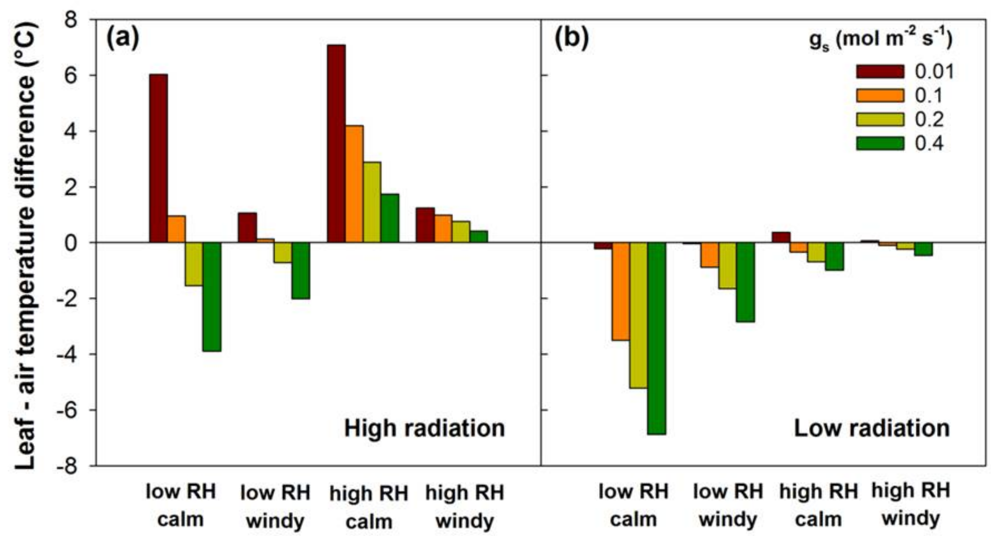
Distributed research infrastructure for the experimental manipulation of managed and unmanaged ecosystems (terrestrial and aquatic)

Provides **data and models** to address the **challenges for ecosystem services**: bio-economy (e.g. food production), clean water, stable soils, carbon storage, flood protection, etc.




R3
R5
R6





De Boeck et al. (2016) Biogeosciences