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# Microclimatological effects of rain-out shelters within EVENT II

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# Outline

## 1 Motivation

## 2 Setup and data analysis

- The EVENT II experiment
- Horizontal mobile measurement system (HMMS)
- The HMMS within Event II

## 3 Results

- General results
- Specific situations

## 4 Influence on plant energy exchange: Convection vs. radiation

## 5 Conclusion

# Assessing impact of climate change

## Climate change

It is commonly expected that climate change will increase the probability of extreme weather events. The potential impact of such events on ecosystems can be explored in manipulation experiments in the field.

## Rain-out shelters as a tool for simulating extreme droughts

Rain-out shelter not only exclude precipitation, but change other microclimatological parameter:

- 10% reduction of photosynthetic active radiation by the used film (but unknown reduction in the other parts of the spectrum)
- warming inside the shelter due to “greenhouse” effect

⇒ Micrometeorological measurements to quantify these effects

## The EVENT II experiment



# The horizontal mobile measurement system (HMMS)

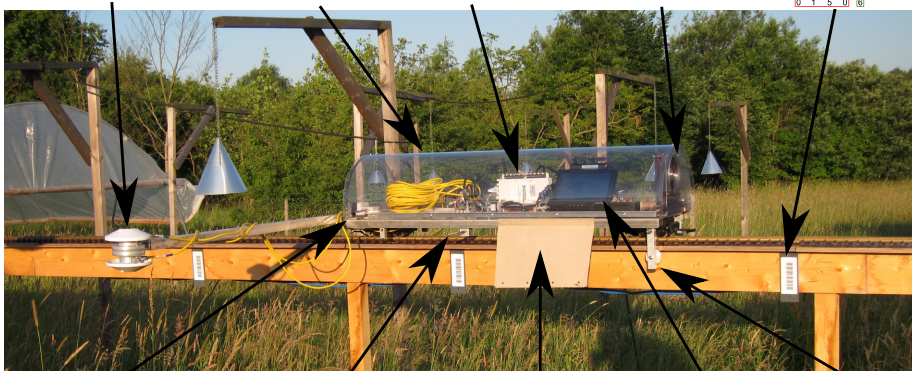
Pyrgometer CGR3  
(long-wave radiation)

Makrolon®  
cover

DAQ device

Housing  
ventilation

Code 39 bar code



Inlet for HMP155 (temp-  
erature and humidity)

Inlet for  
CO<sub>2</sub> sensor

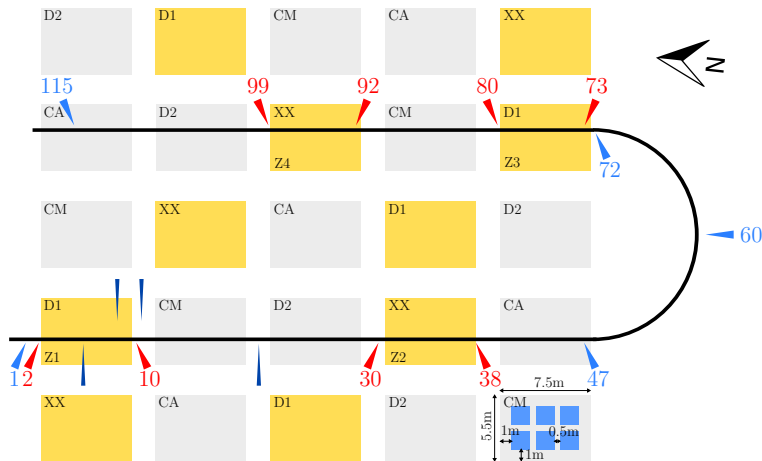
Barcode scanner with  
solar protection

Monitor

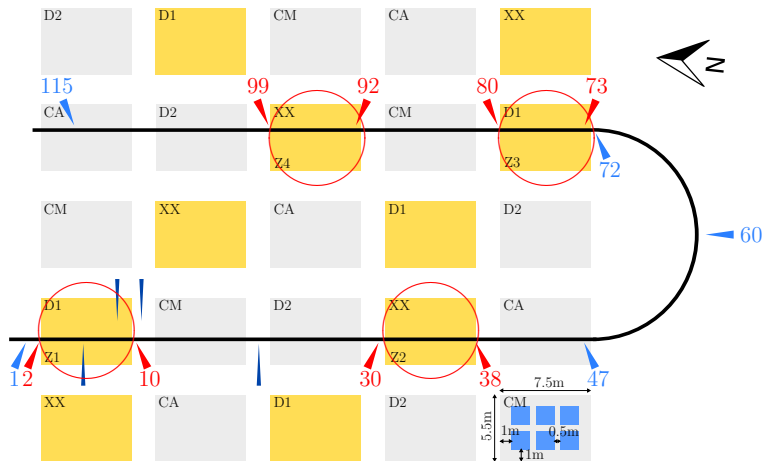
Lateral holders

Setup of the HMMS (Hübner et al., 2014)

## Setup of the HMMS in 2012

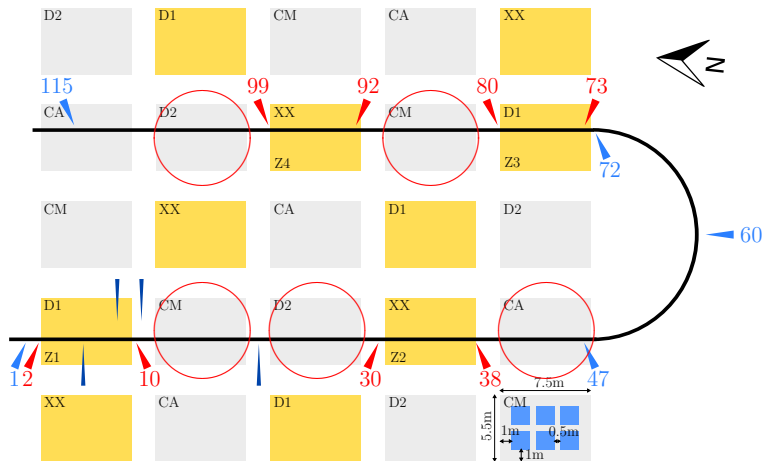


## Setup of the HMMS in 2012



rain-out shelter

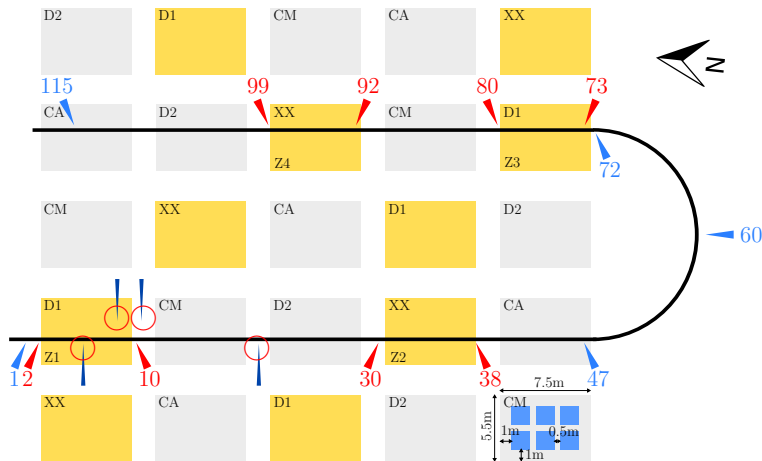
## Setup of the HMMS in 2012



open plots



## Setup of the HMMS in 2012



### Minimum Thermometer

# Analysis

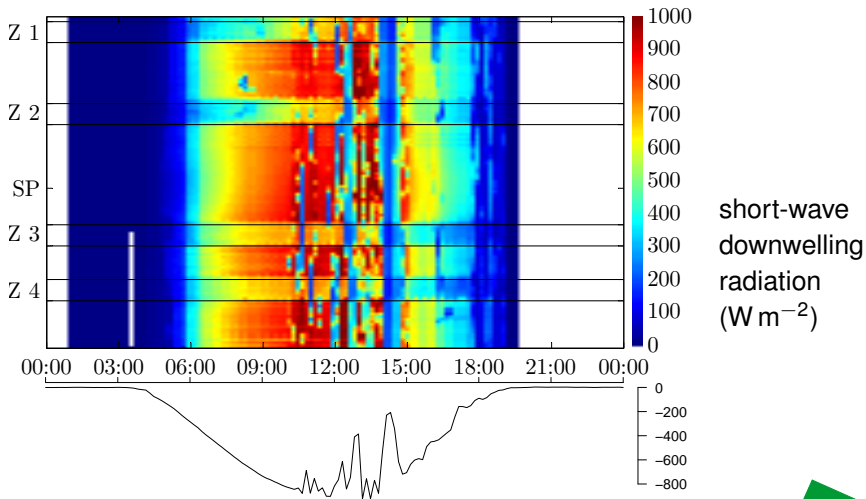
## Variables

- short-wave radiation (incoming and reflected)
- long-wave radiation  $\Rightarrow$  calculation of surface temperature
- air temperature and humidity, vapour pressure deficit

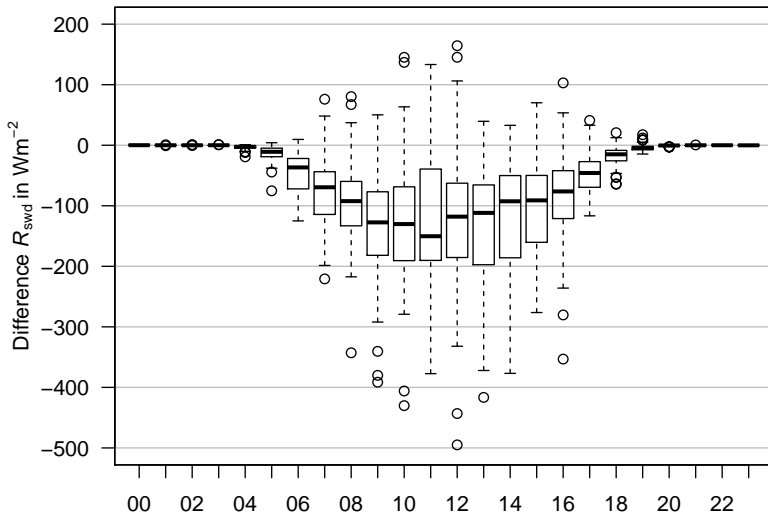
## Situations

- time of the day (morning, noon, evening, nighttime)
- wind velocity and atmospheric stability (EC - measurements)
- cloud cover

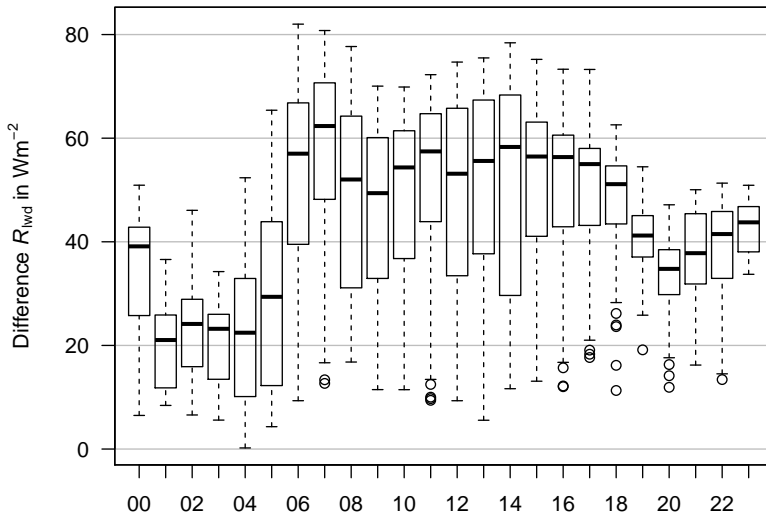
## HMMS raw data



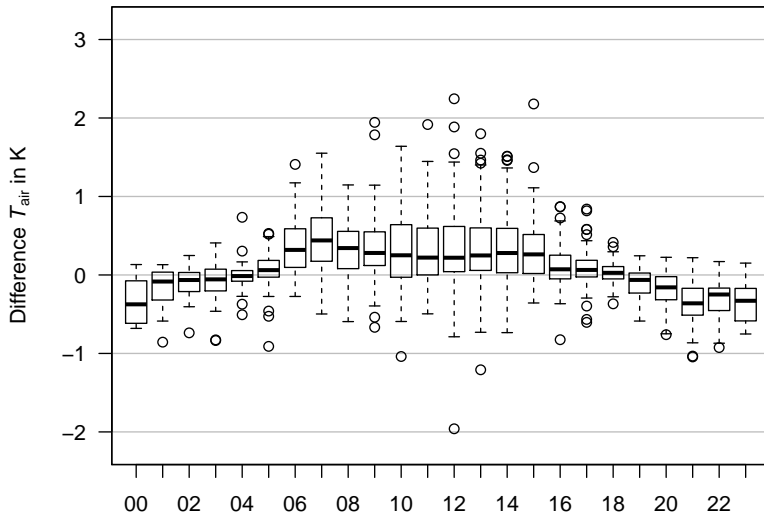
## Shelter - outside conditions: Incoming short-wave R



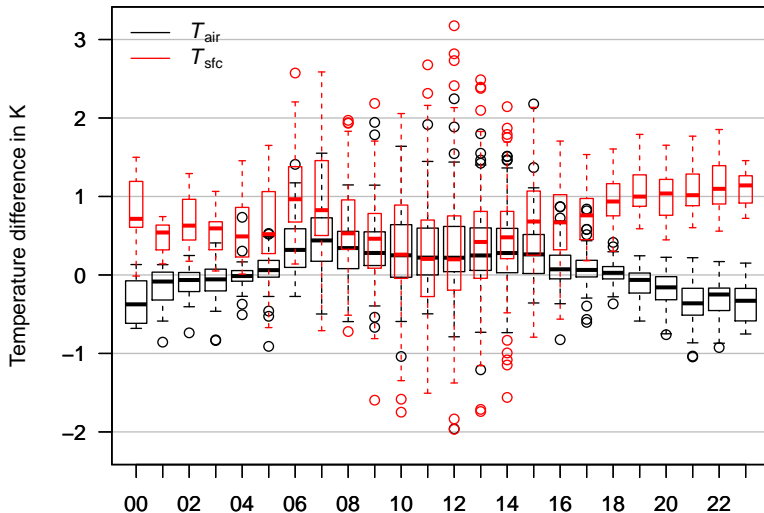
## Downwelling long-wave Radiation



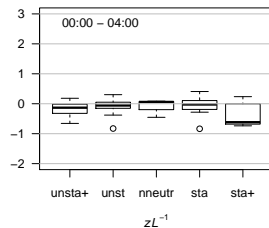
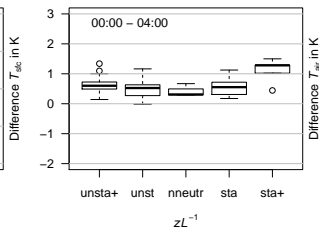
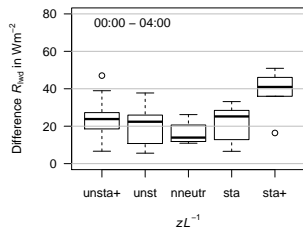
## Air temperature



# Surface temperature

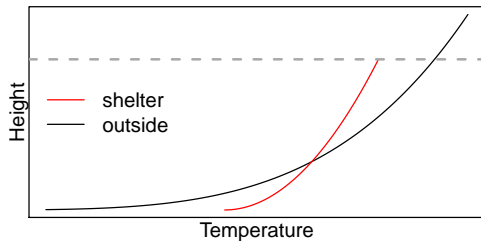
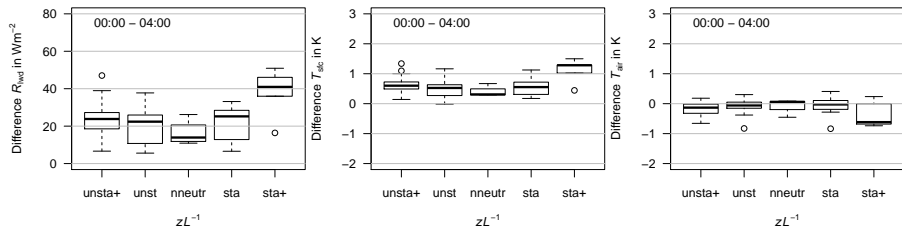


# Nighttime

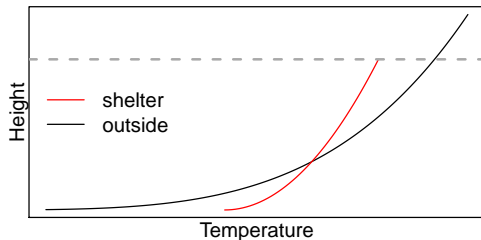
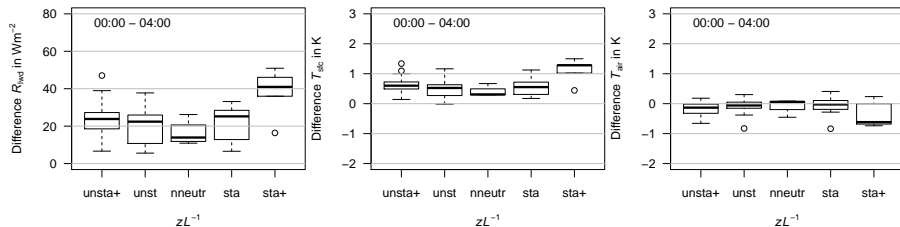




# Nighttime



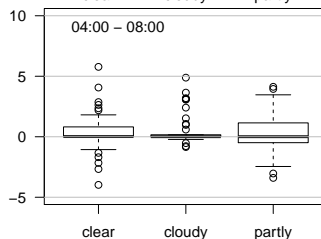
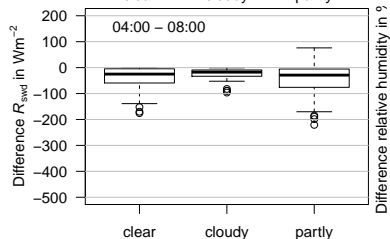
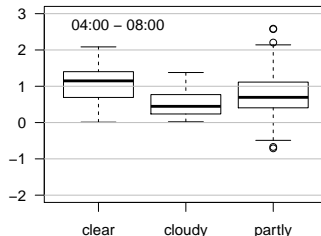
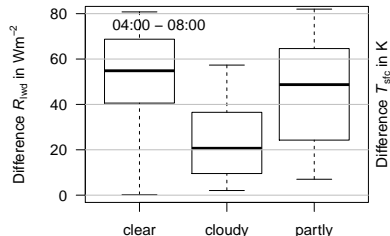
# Nighttime



## Minimum temperatures

Date	outside	shelter	cloud cover
02.06.	1.4°C	5.0°C	clear
03.06.	1.2°C	4.6°C	clear
16.06.	11.2°C	12.8°C	cloudy
17.06.	10.8°C	12.0°C	cloudy
27.06.	1.2°C	4.4°C	clear

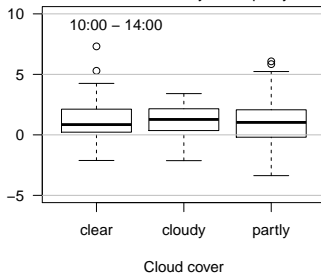
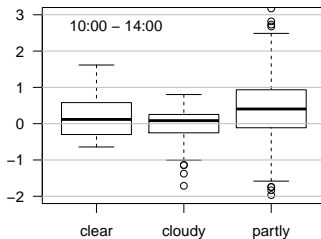
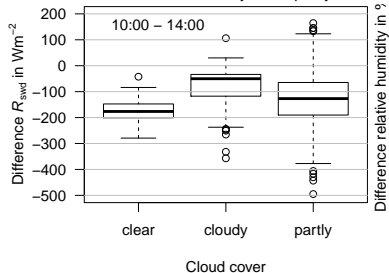
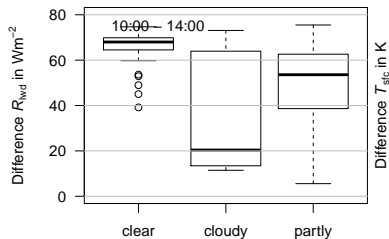
# Morning transition



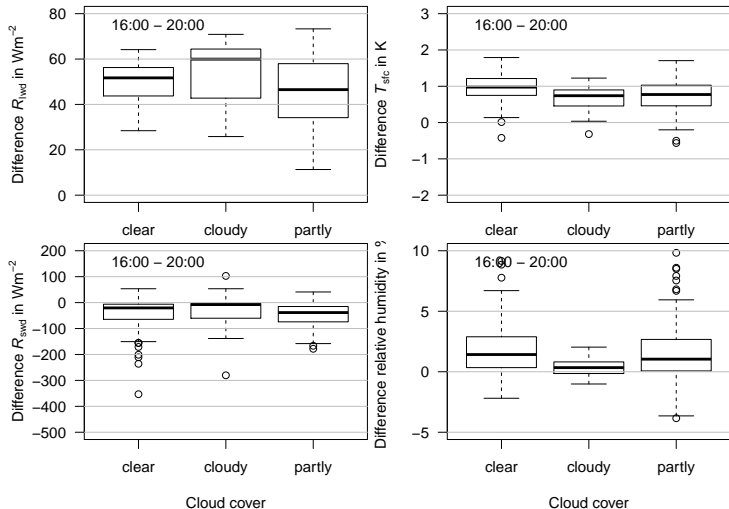
Cloud cover

Cloud cover

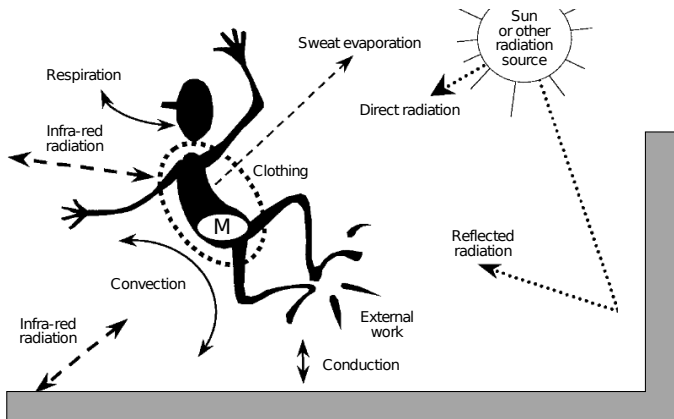
# Noon



# Evening transition

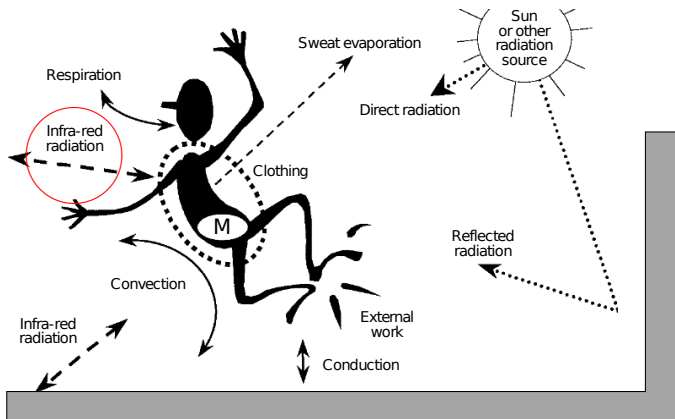


## Energy balance of any organism



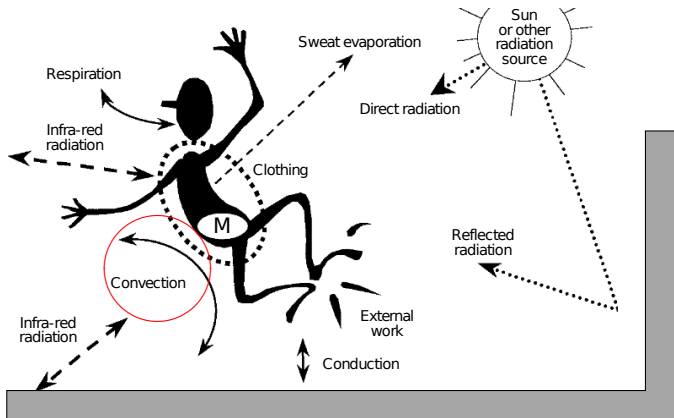
(Havenith, 2003)

## Energy balance of any organism



(Havenith, 2003)

## Energy balance of any organism



(Havenith, 2003)



## Relevance for plant energy balance

### Result

rain-out shelter tremendously change the radiation regime

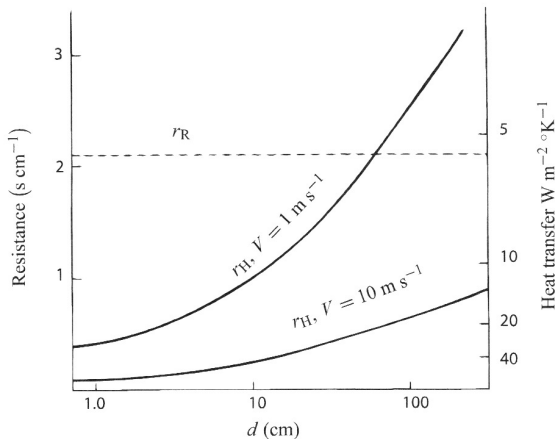
### Heat exchange by convection

- driven by gradient between  $T_{\text{sfc}}$  and  $T_{\text{air}}$
- exchange depends on heat transfer resistance  $r_H$

### Heat exchange by radiation

- driven by gradient between  $T_{\text{sfc}}$  and " $T_{\text{rad}}$ "
- exchange depends on radiative transfer resistance  $r_R$

## Influence of body diameter



$r_H$  depends on

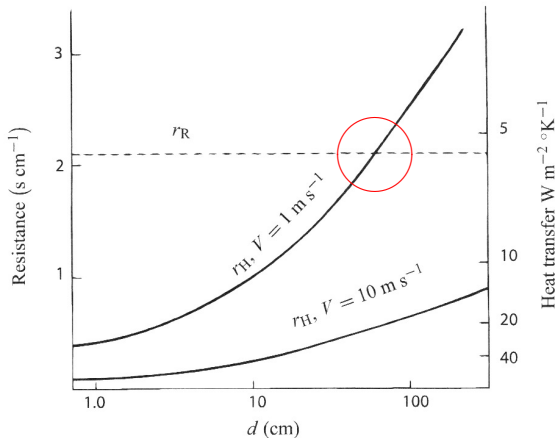
- geometry
- wind speed
- diameter

$r_R$  depends on

- geometry

(Monteith and Unsworth, 2008)

## Influence of body diameter



$r_H$  depends on

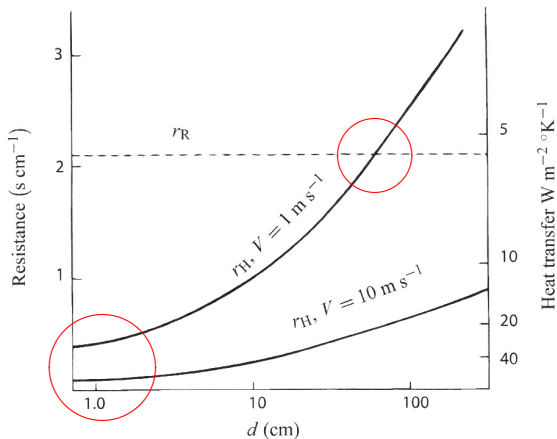
- geometry
- wind speed
- diameter

$r_R$  depends on

- geometry

(Monteith and Unsworth, 2008)

## Influence of body diameter



$r_H$  depends on

- geometry
- wind speed
- diameter

$r_R$  depends on

- geometry

(Monteith and Unsworth, 2008)

## Conclusions

### Rain-out shelter...


- alter short-wave and long-wave radiation balance
- consistently increase plant surface temperature (0.5-1 K) and near-ground air temperature (up to 4 K in clear sky nights)
- enhance humidity in the afternoon

### Influential factors

- time of the day
- atmospheric stability and wind velocity, but well described by cloud cover

### Relevance for manipulation experiments

- despite largest differences found in downwelling short-wave and long-wave radiation, surface temperature seems to be the most relevant measure to characterize the impact on plants
- air temperature often not representative

A photograph of a greenhouse at dusk. In the foreground, there is a field of tall, green grass with some purple flowers. A metal frame of a greenhouse is visible in the background, with a hanging lamp. The sun is low on the horizon, creating a warm glow. A horizontal light streak is visible on the right side of the image.

Thanks for your attention!

## References I

- Havenith, G.: Clothing and Thermoregulation, in: Textiles and the Skin, edited by Elsner, P., Hatch, K., and Wigger-Alberti, W., vol. 31 of *Current Problems in Dermatology*, pp. 35–39, Basel, Karger, doi:10.1159/000072236, 2003.
- Hübner, J., Olesch, J., Falke, H., Meixner, F. X., and Foken, T.: A horizontal mobile measuring system for atmospheric quantities, *Atmos. Meas. Tech.*, 7, 2967–2980, doi:10.5194/amt-7-2967-2014, 2014.
- Monteith, J. and Unsworth, M.: *Principles of environmental physics*, Elsevier academic press, London, 418pp., 3 edn., 2008.