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Klimatologie und Umweltmeteorologie



## Sensible heat flux measurements using RPAS

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# Outline

- RPAS: M<sup>2</sup>AV
- Campaign: LITFASS 2009
- Results
  - diurnal cycles of  $H$
  - vertical profiles of  $H$
- Summary & Conclusion



# Research RPAS M<sup>2</sup>AV Carolo



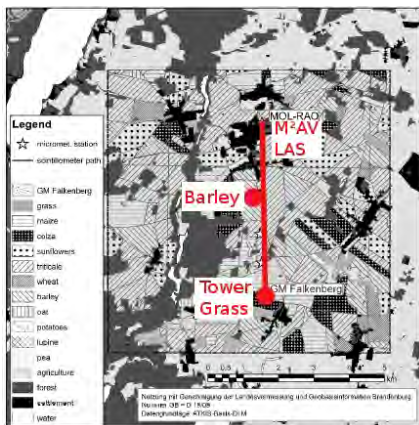
## M<sup>2</sup>AV Carolo

- wingspan: 2 m
- max. take-off weight: 6 kg
- payload: 1.5 kg
- cruising speed: 22 m/s
- endurance:  $\approx$  1 h
- autopilot system: MINC

## Sensor Dome

- 5-hole probe: 30 Hz
- thermocouple: 10 Hz
- slow temperature sensor: 1 Hz
- humidity sensor: 1 Hz
- inertial measurement unit
- (3D) GPS system

## Lindenberg-To-Falkenberg: Aircraft, Scintillometer and large-eddy Simulation



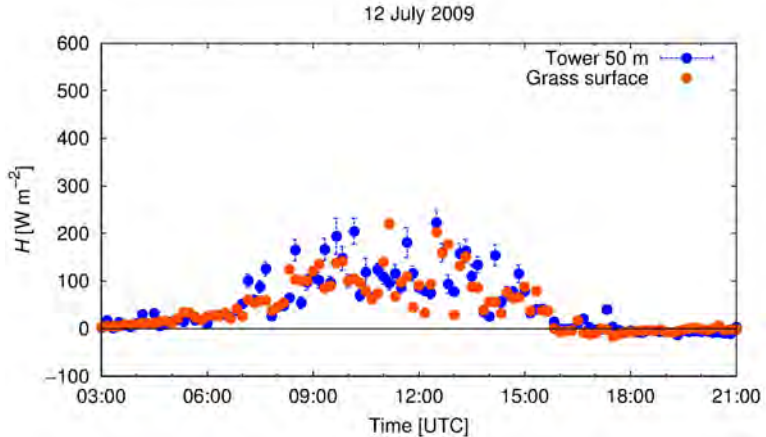
- remote sensing systems
- large-eddy simulations
- **standard observations**
- **micromet. measurements**
- **scintillometer measurements**
- **aircraft measurements (M<sup>2</sup>AV)**

# M<sup>2</sup>AV flights during LITFASS 2009

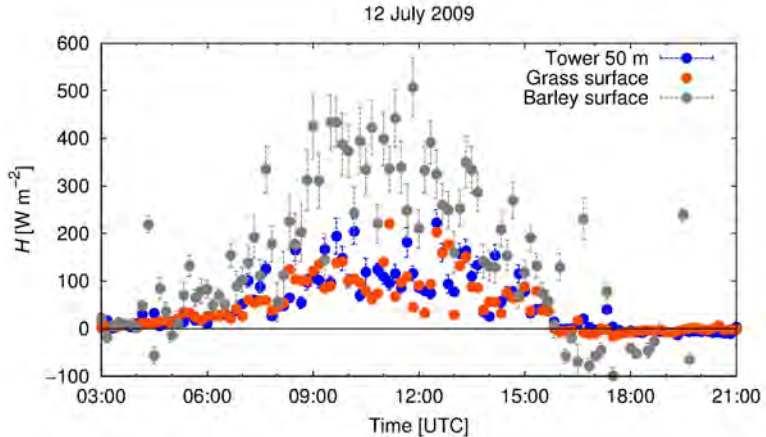
<b>date</b>	<b>takeoff [UTC]</b>	<b>duration [min]</b>	<b>altitudes [m agl]</b>
12 July	09:40	35	70, 100
12 July	11:18	35	50, 70
13 July	10:52	45	55, 80
13 July	12:19	50	55, 80
13 July	14:11	45	55, 80

Length of flight legs  $\approx$  3000 m

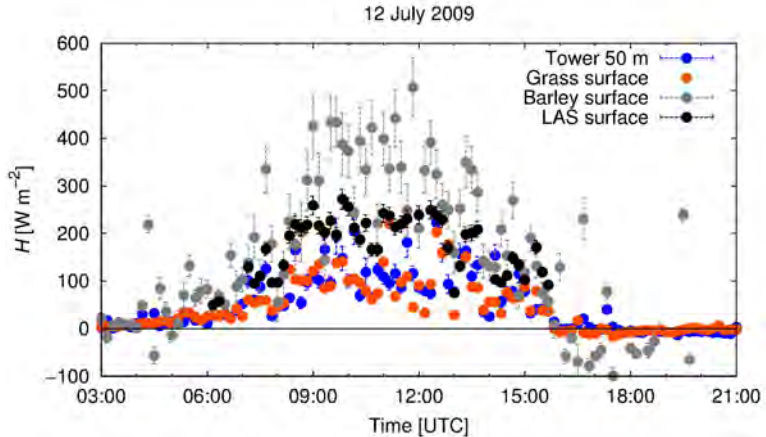
# Vertical sensible heat flux, diurnal cycle, 12/07/09



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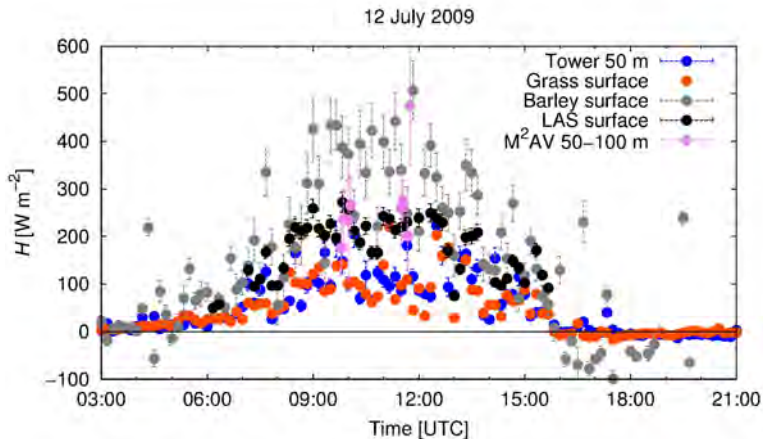


# Vertical sensible heat flux, diurnal cycle, 12/07/09

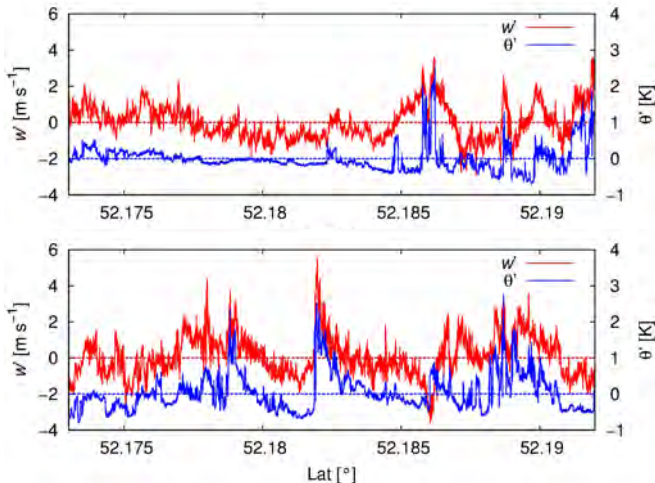




# Vertical sensible heat flux, diurnal cycle, 12/07/09



# 12/07/09 - Capturing strong turbulence

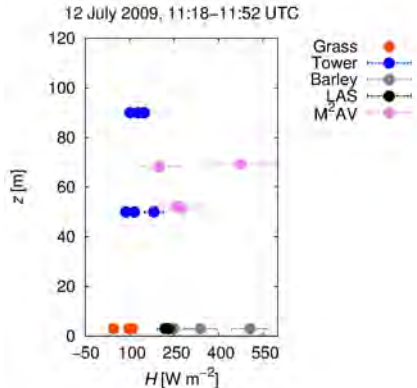
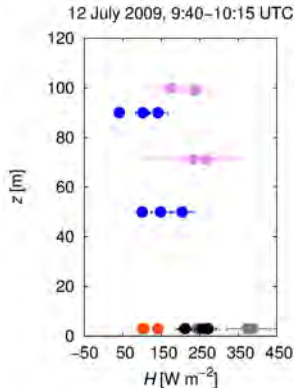


Northward  
 $h = 70$  m agl  
 $\overline{H} = 200$  W m<sup>-2</sup>

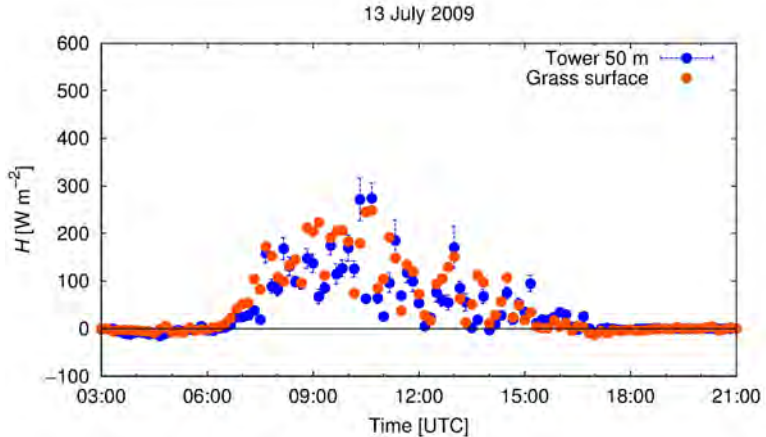
Southward  
 $h = 70$  m agl  
 $\overline{H} = 475$  W m<sup>-2</sup>

Time period:  
 $\approx 2$  min

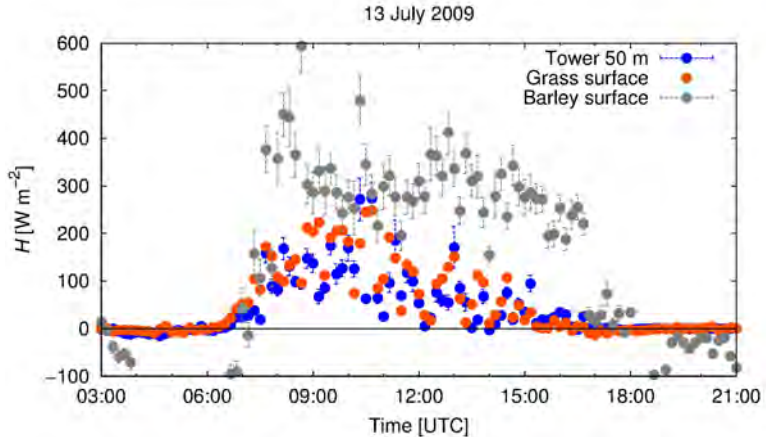
# Vertical sensible heat flux, vertical profile, 12/07/09



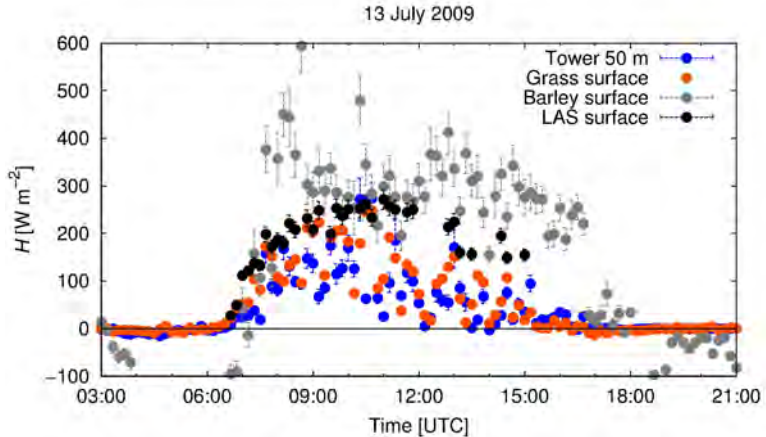
# Vertical sensible heat flux, diurnal cycle, 13/07/09



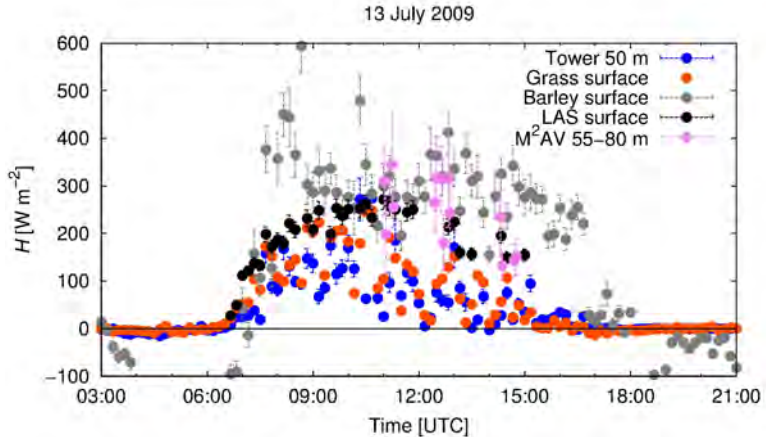
# Vertical sensible heat flux, diurnal cycle, 13/07/09



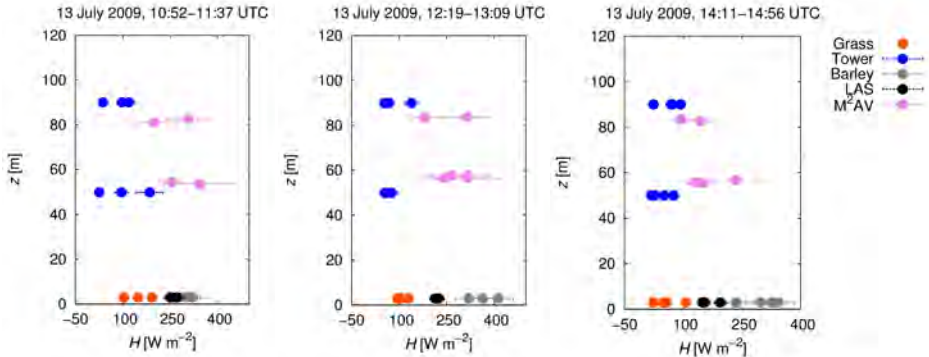
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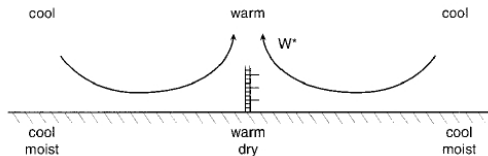
# Vertical sensible heat flux, vertical profile, 13/07/09





# Flux sampling errors

- Ambiguous differentiation between turbulence and other motions
- Omission of transport by stationary or semi-stationary eddies
- Absence of footprint analysis
- Time and space series



(Marth, 1997)

# Summary and conclusion

- Heterogeneous study area due to land use
- Surface flux  $H$  depends on land use (significant differences)
- Tower EC measurements: influenced by land use
- Surface EC measurements: influenced by land use
- LAS: averaging (Gauss distribution)
- $M^2AV$ : averaging (unweighted)
- LAS and  $M^2AV$  results are in agreement (Barley also)
- Statistical variation of  $M^2AV$  data calculated according to Lenschow & Stankow (1986) and Bange (2009) are within the range of 20-25 %

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**Thank you very much for your attention!**