Heat fluxes estimated from SUMO profiles during the BLLAST campaign

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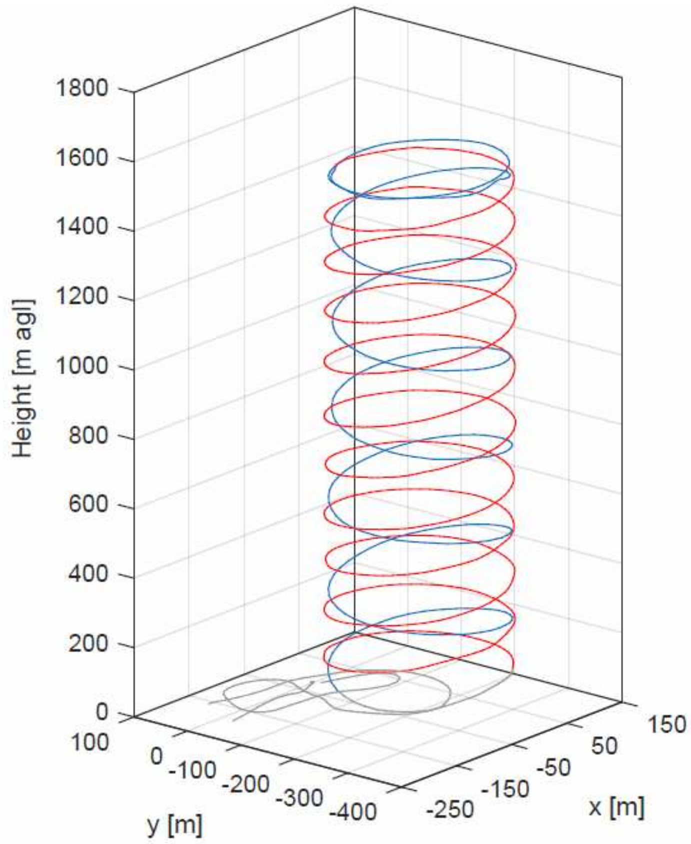
Aim & Motivation

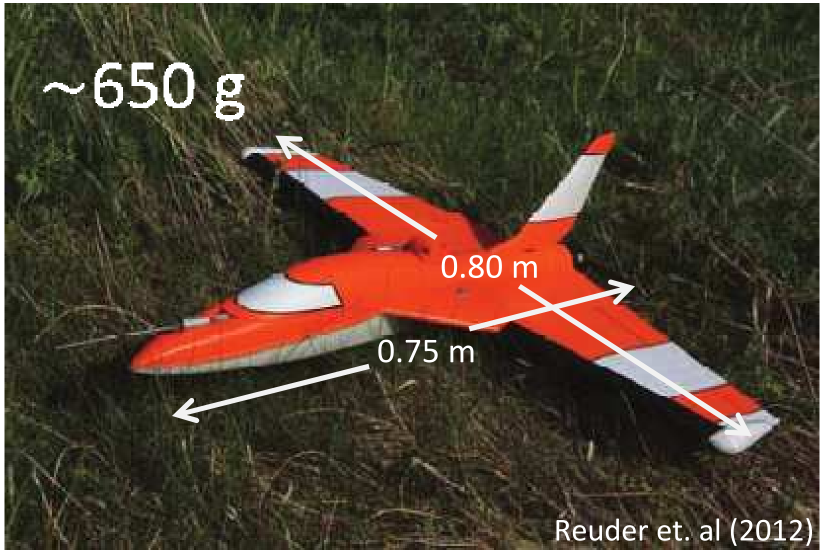
- Evolution of ABL
  - Sensible and latent heat fluxes

- SUMO BLLAST
  - 168 profile flights up to 1500 m agl
  - Routine by Bonin et al. (2013)

- Flux comparison to EC surface stations



SUMO – Small Unmanned Meteorological Observer



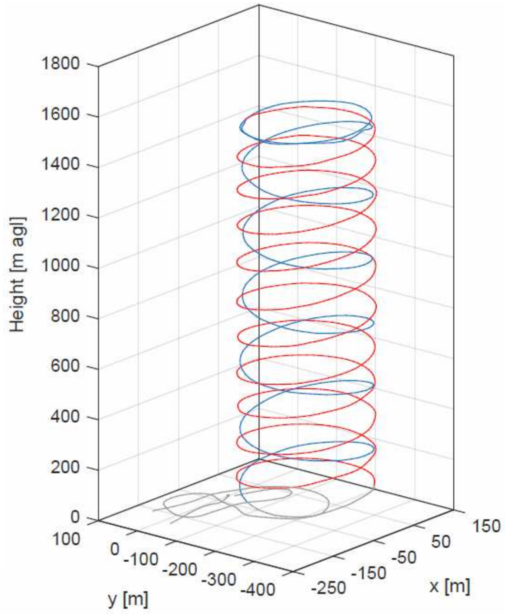
Parameter	Sensor	Range	Accuracy	Acquisition frequency
Temperature	Sensirion SHT75	−40 to 124 °C	±0.3 °C	2 Hz
Humidity	Sensirion SHT75	0 to 100 %	±2 %	2 Hz
Temperature	PT1000 Heraeus M222	−32 to 96 °C	±0.2 °C	8.5 Hz
Pressure	MS 5611	300 to 1200 hPa		4 Hz
Surface temperature	MLX90614			8.5 Hz
3D flow vector	5 hole probe (5HP), Aeroprobe	11 to 35 ms^{-1}	±0.1 ms^{-1}	100 Hz

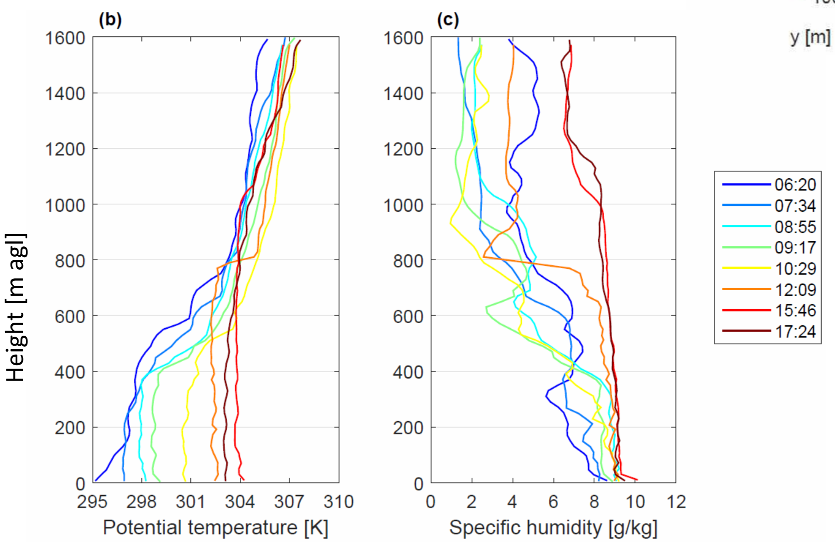
Table 1. Specifications of the meteorological sensors.

Profiles of θ and q

Date	IOP	Profiles	Site	Height [m agl]
17.06		7	1	1500
18.06		5	1	1400
19.06	2	12	1	1500
20.06	3	11	1	1500
21.06		8	1	1500
23.06		2	1	1500
24.06	4	10	1	1500
25.06	5	11	2	1500
26.06	6	11	2	1500
27.06	7	12	2	1500
30.06	8	12	1	1500
01.07	9	6	1	1500
02.07	10	14	1	1500
03.07		6	1	1500
04.07		9	1	1500
05.07	11	13	1	1500
06.07		7	1	1500
07.07		8	1	1500
08.07		4	1	1500

- SUMO descent profiles (red)
- Temperature
- Humidity





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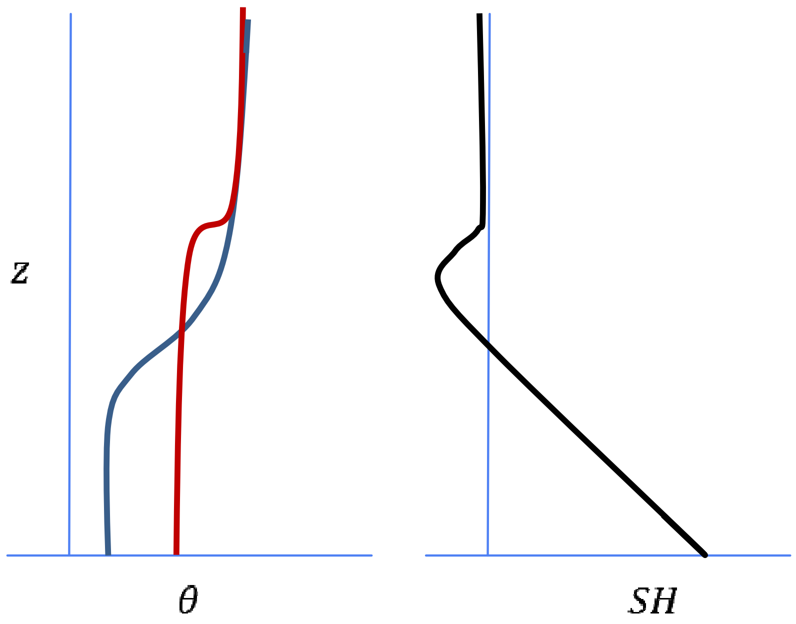
Estimation of heat fluxes

- Algorithm developed for the SMARTSonde by Bonin et al. (2013)
- Based on technique by Deardorff et al. (1980)



- Vertically-integrated horizontally averaged thermodynamic equation

$$\overline{w'\theta'}(z) = \int_z^{h_{F0}} \left(\frac{\partial \theta}{\partial t} + w \frac{\partial \theta}{\partial z} \right) \mathrm{dz}$$

- Assume $w = 0$ → $\overline{w'\theta'}(z) = \int_z^{h_{F0}} \frac{\partial \theta}{\partial t} \mathrm{dz}$

- Finite differencing →

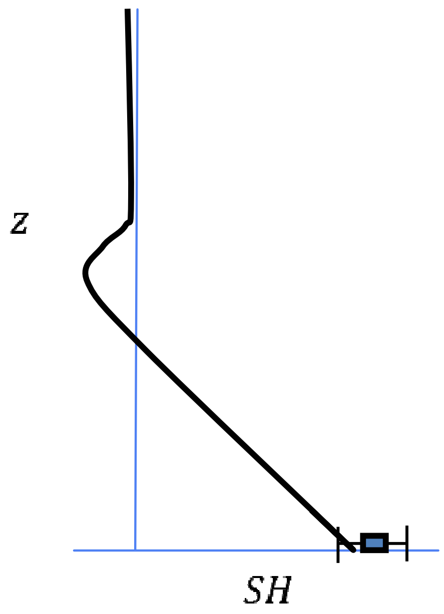
$$SH = c_p \rho \overline{w'\theta'}(z) = \sum_{z/\Delta h}^{h_{F0}/\Delta h} c_p \rho \frac{\Delta \theta}{\Delta t} \Delta h \quad [\mathrm{Wm^{-2}}]$$

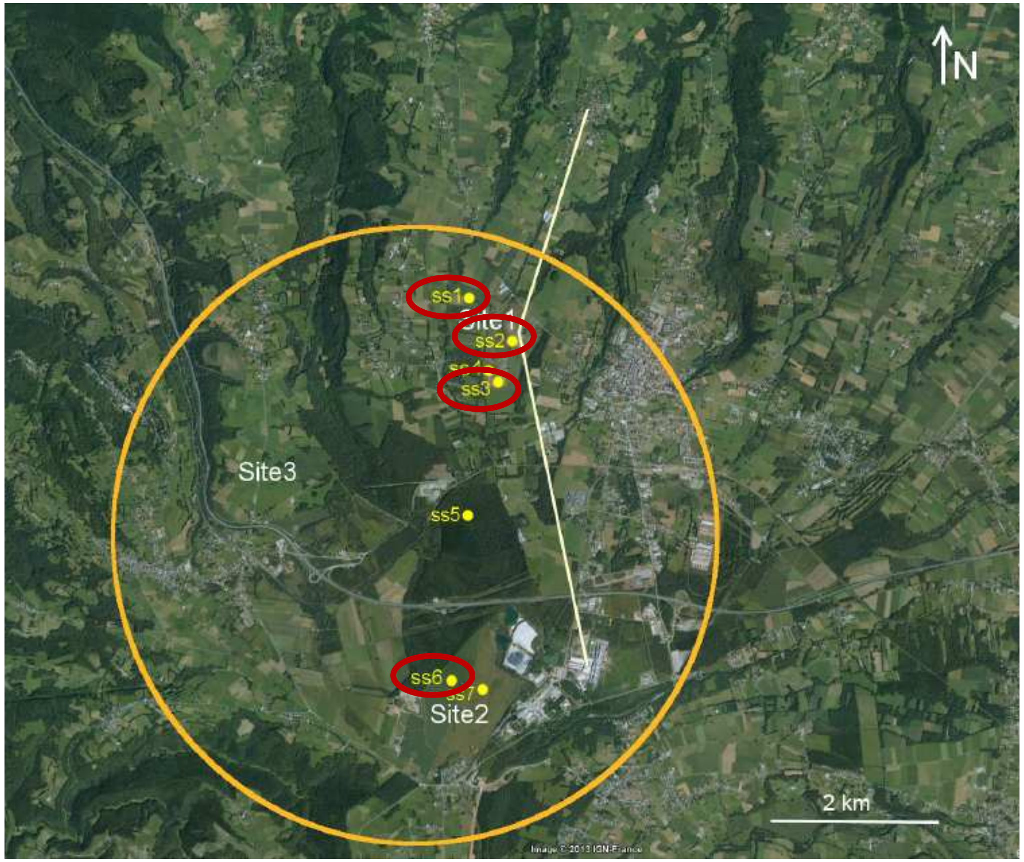
$$LH = L \rho \overline{w'q'}(z) = \sum_{z/\Delta h}^{h_{F0}/\Delta h} L \rho \frac{\Delta q}{\Delta t} \Delta h \quad [\mathrm{Wm^{-2}}]$$

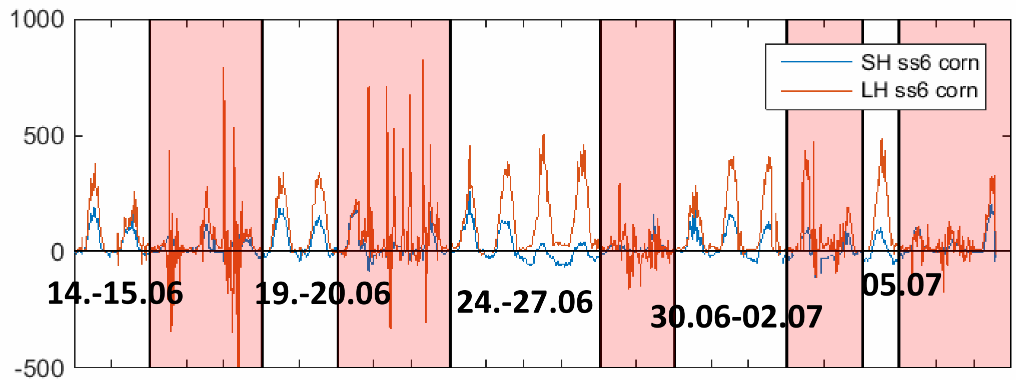
$\Delta h = 1$ m (vertical grid spacing)
$c_p = 1004$ JK^{-1}kg^{-1} (spesific heat)
$L = 2.5 \times 10^6$ Jkg^{-1} (latent heat of vaporization)
ρ = density calculated from T and p

Comparison to surface stations

- 30 min average fluxes from EC surface stations
- ss1 grass, ss1 wheat, ss3 micro site, ss6 corn

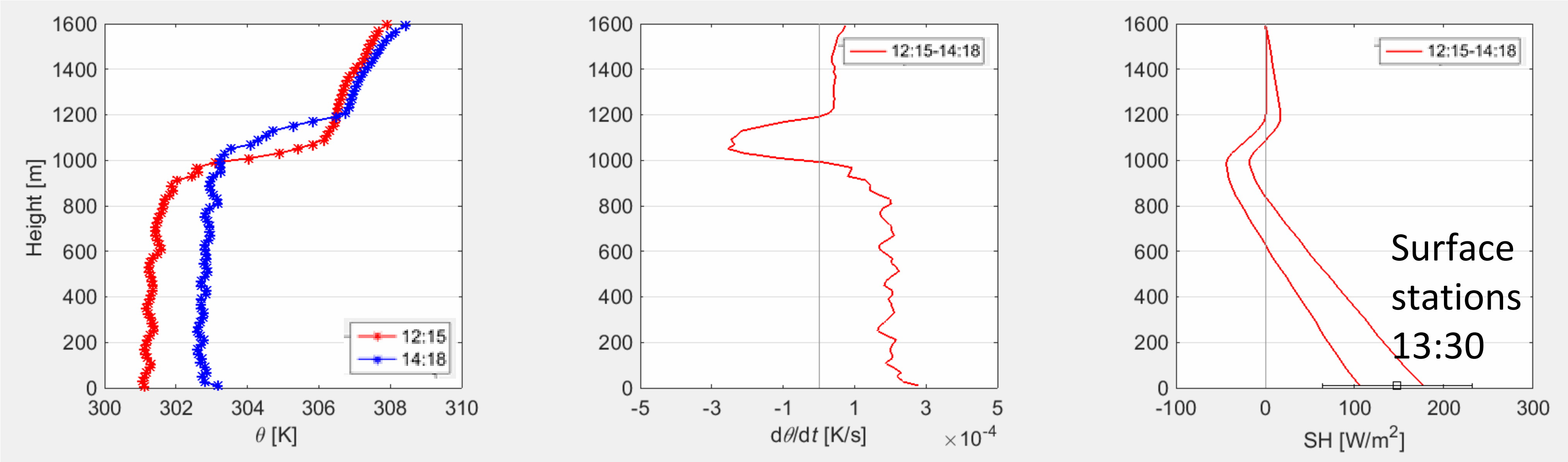






Preliminary results SH

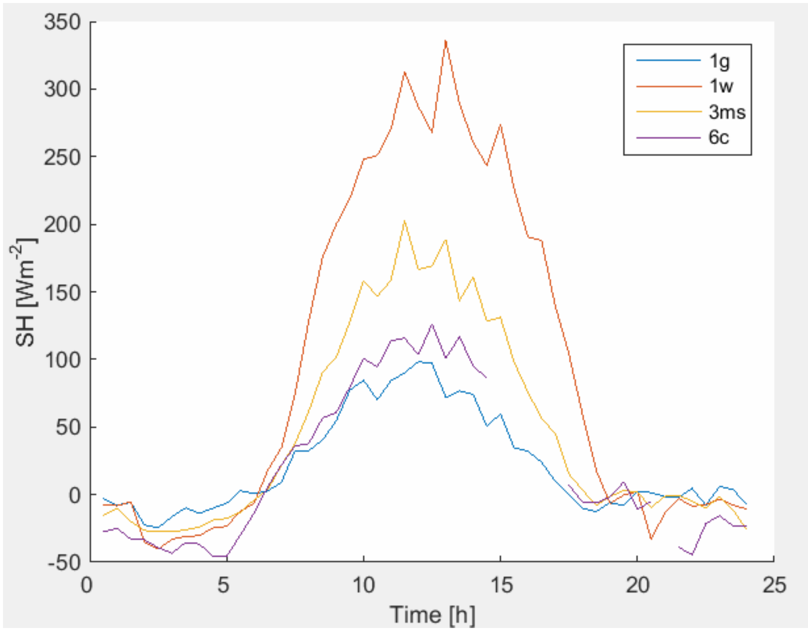
01 July



› Treatment of advection importent

› SH ss1 wheat >> SH other stations

SUMO closer to



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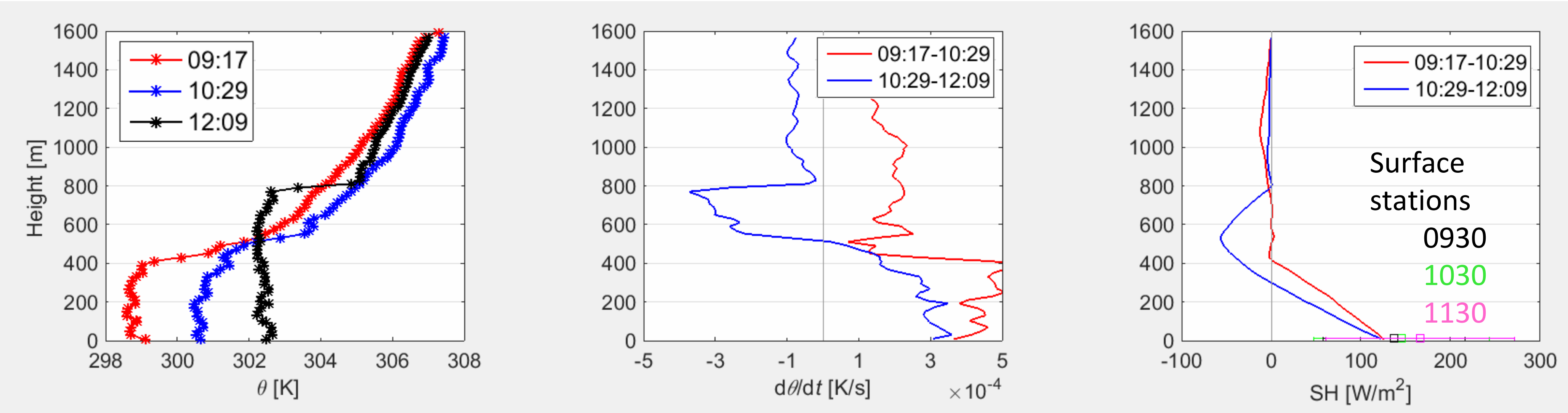
Preliminary results SH

05 July



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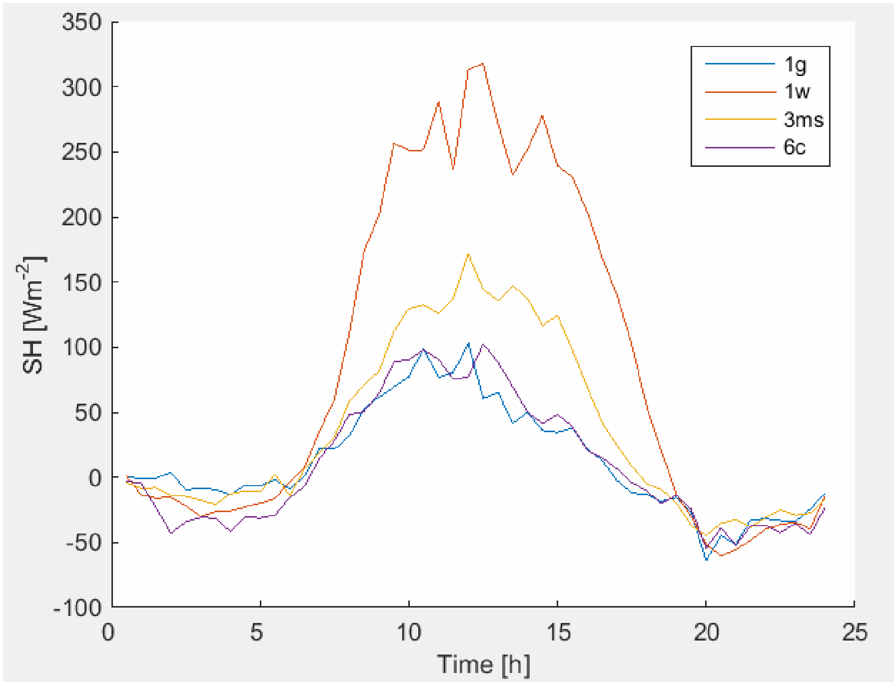
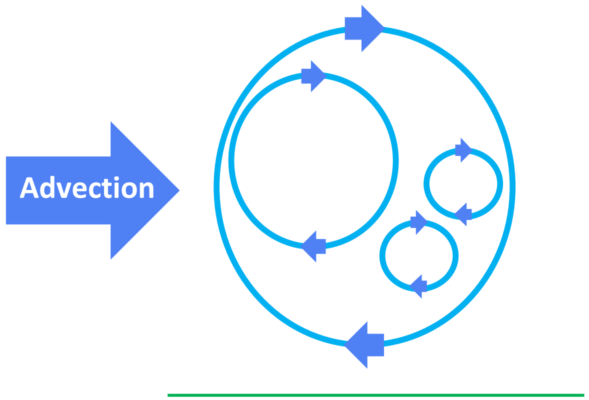


Advection

› Important

› Advection from AROME model data?



Outlook

› Look more into LH

› Pick out BLH automatically

› Implementation of advection from model

› Statistics: SUMO vs. surface stations

› Compare descent profiles to profiles corrected for sensor lag

References

Reuder, J., Båserud, L., Jonassen, M. O., Kral, S. and Müller, M. (2016) Exploring the potential of the RPA system SUMO for multi-purpose boundary layer missions during the BLLAST campaign, *Atmos. Meas. Tech. Discuss*., doi:10.5194/amt-2015-397, in review.

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