ACOUSTIC TRAVEL TIME TOMOGRAPHY IN COMPARISON WITH CONVENTIONALLY MEASUREMENTS OVER INHOMOGENEOUS SURFACES

K. Arnold (1), A. Raabe (1), G. Spindler (2) and A. Ziemann (1)

(1) Institute of Meteorology, University of Leipzig; (2) Institute for Tropospheric Research Leipzig

arnold@rz.uni-leipzig.de

Experimental set-up

Within the framework of the VERTIKO network Project (BmBF – AFO2000) the field experiments STINHO (**ST**ructure of the turbulent transfer above **INHO**mogeneous surfaces) were carried out. The aims of the these measurement campaigns are:

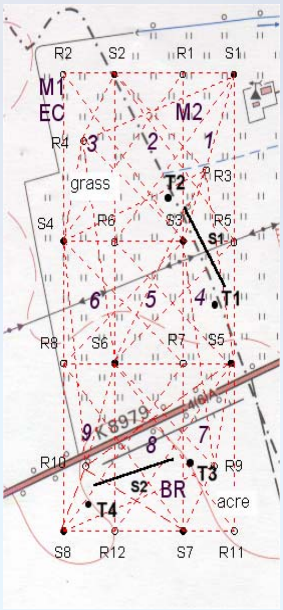
- To determine the horizontal divergence of the sensible heat flux over microscale heterogeneous surfaces.
- To verify the representativeness of point measurements for the surrounding area.

These investigations should lead to an better understanding of the turbulent exchange of the energy above microscale heterogeneous surfaces.

The experiment STINHO-1 was conducted at the research station of the Institute for Tropospheric Research (IfT) in Melpitz (45 km north east from Leipzig, Germany) in autumn 2001. The investigation area with an extension of 300 m × 700 m was arranged over a region with different surface properties: one part was grassland and the other was a recently tilled acre. Thus due to the different vegetation properties and depending on the radiation conditions, horizontal air temperature gradients were expected.

Measuring systems during this field experiment:

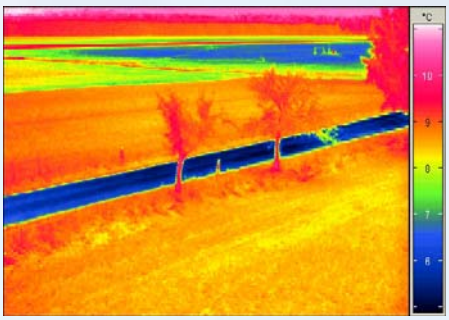
- remote sensing systems:
  - acoustic tomography,
  - infrared camera,
  - SODAR,
  - scintillometer,
  - airborne measurements (Do 128)
- conventional point measurements
  - eddy-correlation systems,
  - modified bowen-ratio systems,
  - wind and temperature profile masts,
  - fast response temperature/humidity sensors



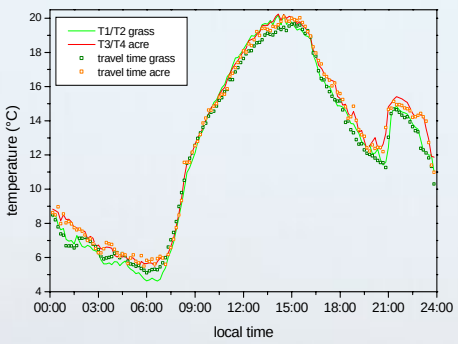
Layout of the area under investigation (300 m × 700 m) at the research station Melpitz. The northern part was grassland and the southerly of the road acre. The dotted lines represent the source receiver connections of the tomographic array.

For the acoustic tomography 12 sound sources and 8 receivers were positioned at the borders or inside the array. The positions of the transmitters and receivers were set in such a way that the covering of the investigation area with sound paths is optimal.
All acoustical devices and the turbulence sensors were mounted at a height of 2 m, respectively. Due to the appropriated configuration of the transmitter and receiver the separation of the wind field (be use of reciprocal sound transmission) could be done for nine parts of the total array (cells 1 to 9).

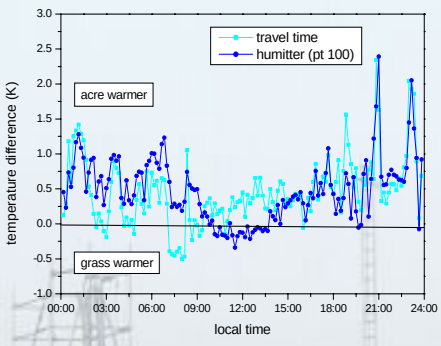
R1… R12	sonic receiver
S1 … S8	sonic sources
T1 … T4	humitter sensors
M1, M2	12m profile masts
EC	eddy correlation
BR	bowen-ratio



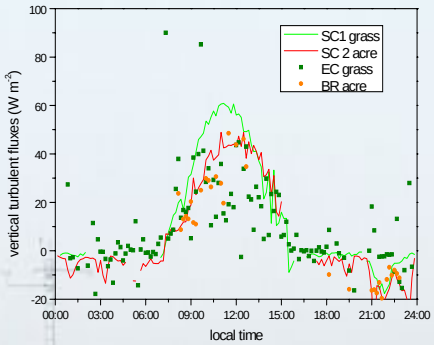
View of the investigation area with the infrared camera: the different surface temperatures, due to the varying land use types, are visible.



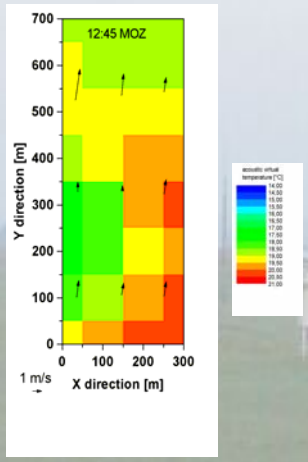
Daily course of the air temperature registered by acoustic tomography (travel time) and humitter (T1…T4) above variable land use types (grass and acre).



Temperature difference between the variable land use types (acre – grass) registered by the different systems: mean values of travel time data and humitter sensors.



Daily course of the vertical sensible heat fluxes measured with the scintillometer S1 and S2 and the flux measurements EC and BR.



Tomogram of the acoustic virtual temperature (32 cells) and wind speed (arrows in 9 cells) on the 6 October 2001 at 12:45 local time.

Results:

- The point measurements and the remote sensing systems record nearly the same temperature values, small differences appear during the day (influence of the direct solar radiation).
- The observations point out, that spatial air temperature differences between the acre and grass of about 1 K occur over longer periods.
- The major temperature differences were measured during the warming period in the late evening; during the day, due to higher wind speeds, the horizontal temperature gradients between acre and grass decrease.
- The influence of the surface heterogeneity is also visible in the vertical sensible heat fluxes (estimated with two scintillometer and the flux measurements EC and BR across grassland and acre): the amount of the sensible heat fluxes varies above the different land use types.

Conclusions:

- Depending on the respective land use type, different micro-mete-orological fields results.
- At the selected day higher air temperatures were observed across the acre zone (due to the difference in the surface albedo).
- Also within each land use type local heterogeneities exist, which can be proved with the tomographic measurements.
- Due to the different measuring methods – remote sensing systems and in situ measurements – as well as due to the different spatial dimensioning – area- or line averaged measure-ments and point measurements – different results were observed.
- The horizontal temperature gradients, combined with other results, can be used to estimate the amount of the horizontal divergences of the sensible heat fluxes. This divergences should quantify the influence of the surface heterogeneity on energy balance measurements at one point.

Acknowledgements

We would like to thank F. Weiße, M. Engelhorn and Dr. S. Schienbein for their support in the development and manufacturing of the acoustic measuring system and the humitter sensors. Special thanks are going to C. Liebethal and M. Göckede (University Bayreuth) for providing the turbulence data. Furthermore, we acknowledge the staff of the test site Melpitz (Institute for Tropospheric Research) for the assisting during the field experiment.