Working group Acoustics and Remote sensing

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Introduction

The research group Acoustics/Remote sensing is developing and applying innovative measurement systems to remotely monitor spatially resolved sound propagation parameters and meteorological quantities for different spatial scales. The main interest of research is thereby concentrated on acoustic travel-time tomography. The special method of acoustic tomography developed by the group was applied under different environmental conditions, e.g. in rural environment with heterogeneous surface properties to evaluate atmospheric models, as well as for different spatial scales, from outdoor areas down to an indoor wind tunnel. Beside the expertise in acoustical and micrometeorological measurements the research group is dealing with operationally applicable acoustical models describing the meteorological influences on the outdoor sound propagation. The self-developed model SMART (sound propagation model of the atmosphere using ray-tracing) was successfully evaluated with measurements and applied in several studies to operationally forecast the ‘sound weather’ and evaluate the ‘sound climate’ of a region in comparison to an undisturbed sound propagation. Furthermore, the modelling, measurement, and valuation of noise as a long-term risk factor will extend the research profile. Such studies allow to deduce information for decision support for a sustainable management of urban regions.

Schematic view of the tomographic measurement system around the area of investigation. The red lines between the loudspeakers and the microphones indicate the sound paths.

Horizontal 2-D acoustic tomography – example Lindenberg measurements

- Measurement site: 300 x 440 m², heterogeneous surface characteristics (grassland and bare soil)
- 8 sound sources, 12 receivers

3-D acoustic tomography – example Dresden wind tunnel

- Measurement site: 1.3 x 1.0 x 1.2 m³, inhomogeneous flow (partly blocked wind tunnel nozzle)
- 16 sound sources, 16 receivers

Modelling and measurement of outdoor sound propagation

- Outdoor sound propagation depends on the structure of the atmosphere: (especially vertical) gradients of temperature and wind vector (sound refraction), turbulence (sound scattering), temperature and air humidity (sound absorption)
- Calculation (model SMART) of sound rays applying geometrical acoustics
- Modelling the sound level attenuation because of meteorological effects
- Measurements of the sound level to validate the model SMART and engineering models
- Results: ‘sound weather’, ‘sound climatology’, noise exposure

Measurement of sound propagation – examples for evaluation of models

- Simulation of meteorological effects on sound propagation
- Long-range sound propagation, e.g. shooting noise
- Short-range sound propagation, e.g. traffic noise
- Forecast of ‘sound weather’ using measured or modelled vertical profiles of wind and temperature
- Sound-climatological regionalisation of Germany using radiosonde data sets
- Modelling the influence of the height of sound sources (up to 140 m above ground surface, e.g. wind energy converter) on the sound propagation in the atmosphere
- Evaluation of acoustic models by sound propagation measurements
- Investigation of the sound propagation in urban areas considering the special state of the atmosphere

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Further information: http://www.uni-leipzig.de/~ziemann/

Scientists of the working group at present (August 2009): M. Barth, G. Fischer, A. Raabe, M. Wilsdorf, A. Ziemann
- Former members of the working group: R. Arnold, K. Balogh, D. Daniel, S. Horn, A. Kniffka, K. Kroll, A. Schleichardt, R. Vierel

Fig. 1: Schematic view of the tomographic measurement system around the area of investigation. The red lines between the loudspeakers and the microphones indicate the sound paths.

Fig. 2: Acoustic measurement site (dotted line) at the Boundary Layer Field Site Falkenberg (DWD Lindenberg Meteorological Observatory - Richard Adiann Observatory), 52°19'N, 14°03'E, 70 m a.s.l.

Fig. 3: Horizontal slices, i.e. tomograms, through the temperature (colours) and wind field (arrows) at a height of 2 m, on the 6th July, 2002, 05:20 UTC.

Fig. 4: Arrangement of acoustic sound sources and receivers within the wind tunnel of the TU Dresden. Flow field properties are visualized using smoke.

Fig. 5: Horizontal slices through the 3-D tomographically reconstructed flow field. Arrows denote in-plane velocity components, colours the normal (vertical) component in m s⁻¹.

Fig. 6: Sound rays upwind (shadow zone with decreased sound levels) and downwind (enhanced sound levels) from a sound source at the ground surface.

Fig. 7: Vertical profiles of temperature (red), wind speed (blue), and meteorological wind direction (green) of the radiosonde station Bergen on the 16th January, 2001, 12:00 UTC.

Fig. 8: Sound level attenuation [dB] map of the station Bergen (52°48'N, 9°56'E, 70 m a.s.l.) on the 16th January, 2001, 12:00 UTC, calculated by SMART.

Fig. 9: Measured and modelled (SMART) sound attenuation. The atmospheric influence results in an enhanced sound emission of ca. 10 dB for positive vertical gradients of effective sound speed.

Fig. 10: Mean (60 min.) difference between measured and modelled (VDI-2714) sound level close to a noise barrier at a highway. The standardized model underestimate the sound level by maximally 4 dB which is problematic for noise protection.