

**The urban surface energy budget and
the mixing height: selected results of
recent activities in Europe stimulated
by the COST-Action 715**

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Important issues COST-715, WG 2

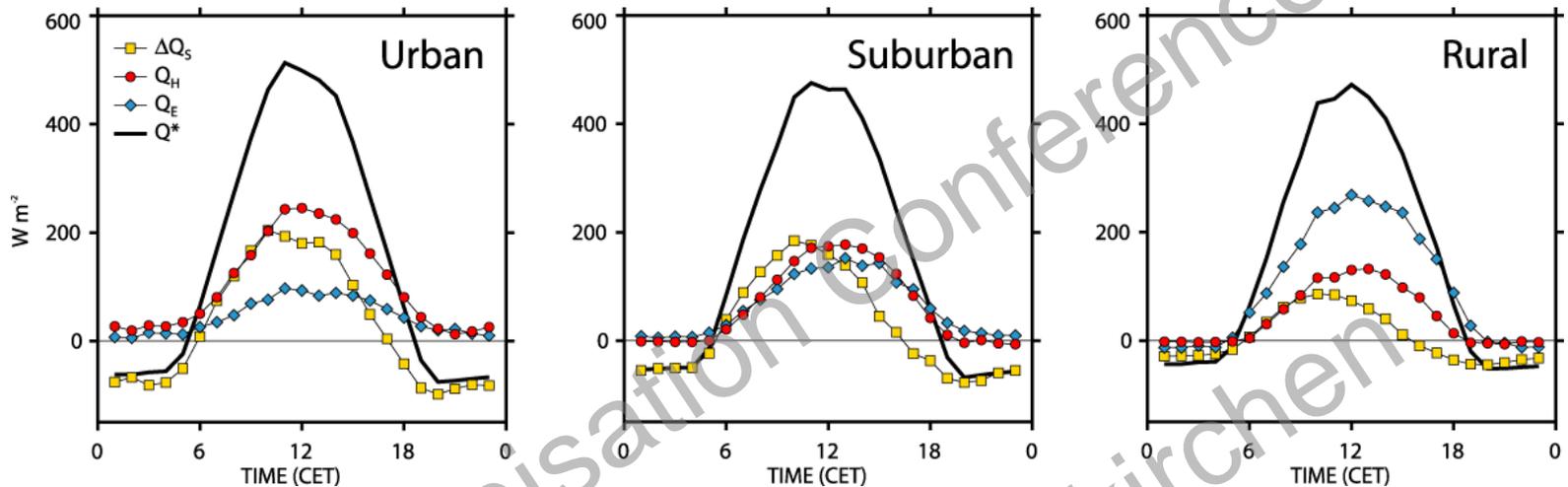
- To review and assess pre-processors, schemes and models to determine the SEB and the MH in urban areas
- To stimulate and carry out experimental campaigns and appropriate modeling
- To identify and review suitable data sets, to carry out inter-comparisons of different schemes against each other and against data
- To present findings, provide recommendations and show future needs

Urban surface energy budget SEB

- SEB determines hydrostatic stability conditions in the lower atmosphere, which regulate the mixing of pollutants
- Radiative properties of buildings and ground-covering materials differ from natural grounds and vegetation
- Vertical and/or slanted orientations of buildings alter radiative transfers and energy budget
- Heat flux to or from the ground changes with surface material
- Anthropogenic energy use influences the local stability of the atmosphere

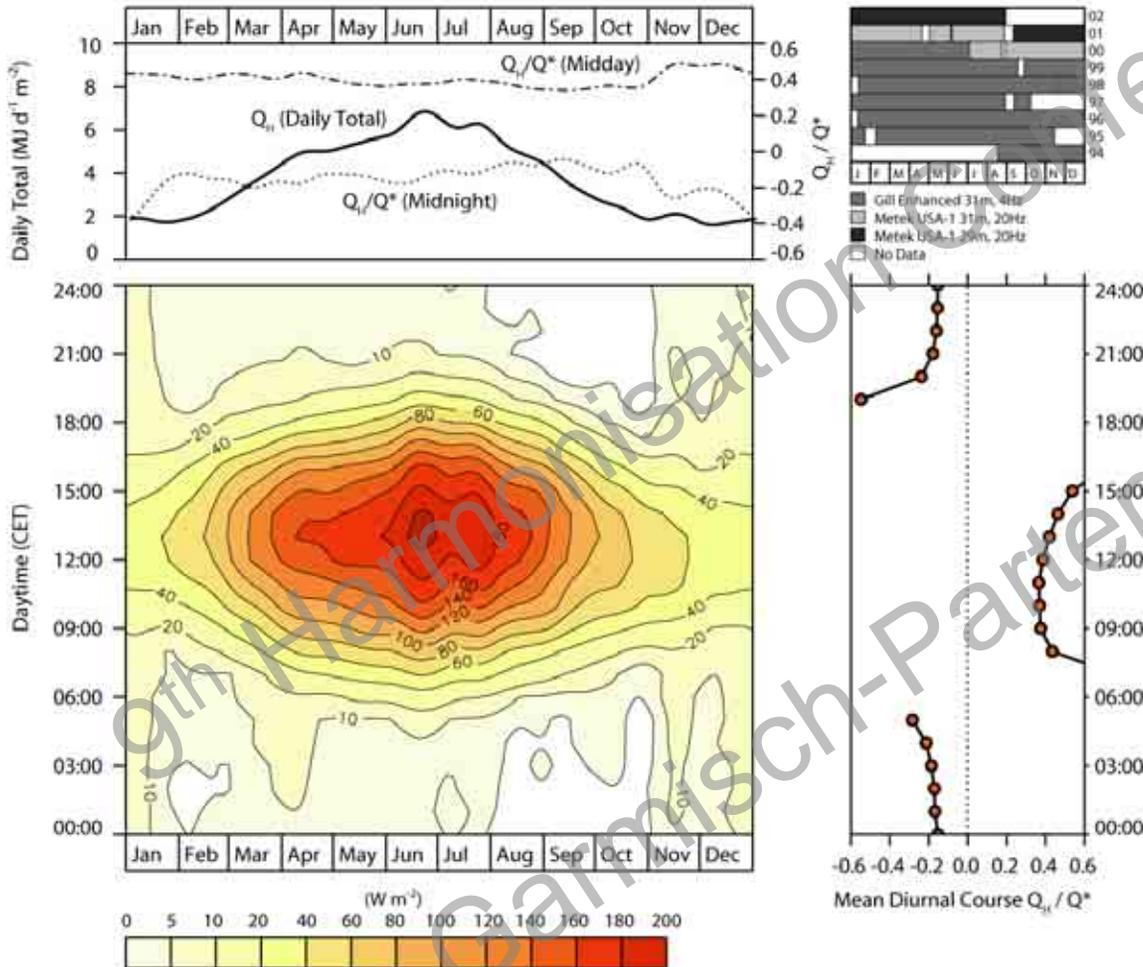
Mixing height MH in urban areas

- MH determines the volume available for pollutant dispersion
- MH depends on basic meteorological parameters, surface turbulent fluxes and physiographic parameters
- MH usually follows a diurnal cycle
- Diagnostic and prognostic methods to determine MH can be verified against measurements (radiosondes and remote sensing devices)
- Both SEB and MH usually not directly measured at meteorological stations

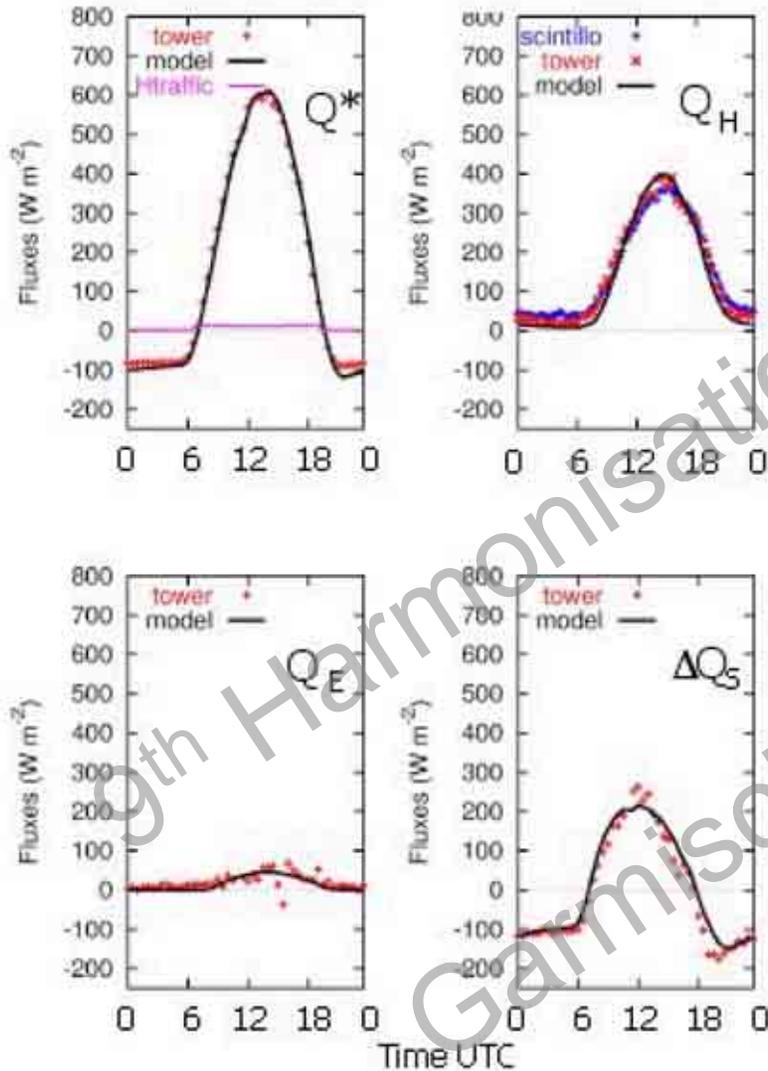


Ensemble diurnal courses of the energy balance at three sites during BUBBLE: average days for the IOP from June 10 to July 10, 2002 (including all sky conditions) of an urban site (Basel-Sperrstrasse), a suburban site (Allschwil), and a rural site (Village-Neuf) (modified after Christen et al., 2003)

Sensible Heat Flux at Basel-Spalenring (Eddy Covariance, 1994-2002)

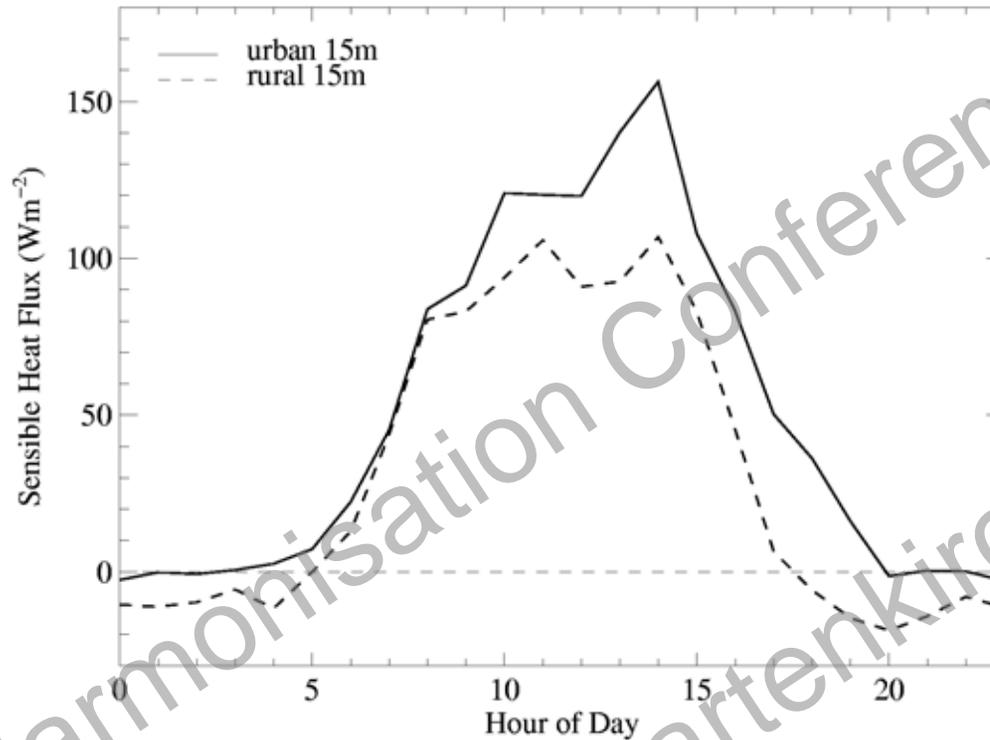


Measured sensible heat flux Q_H between 1994 and 2002. Main plot: climatologically averaged values of the sensible heat flux (W m^{-2}) as a function of the hour and the day of the year. Right plot: mean diurnal course of the fraction Q_H/Q^* as a function of hour of the day for the period 1994–2002. Upper left plot: Yearly course of the daily total values (full line) and fraction Q_H/Q^* at Midday and Midnight. Upper right: Documentation of the different eddy covariance systems that contributed to the climatologically averaged values



Marseille experiment

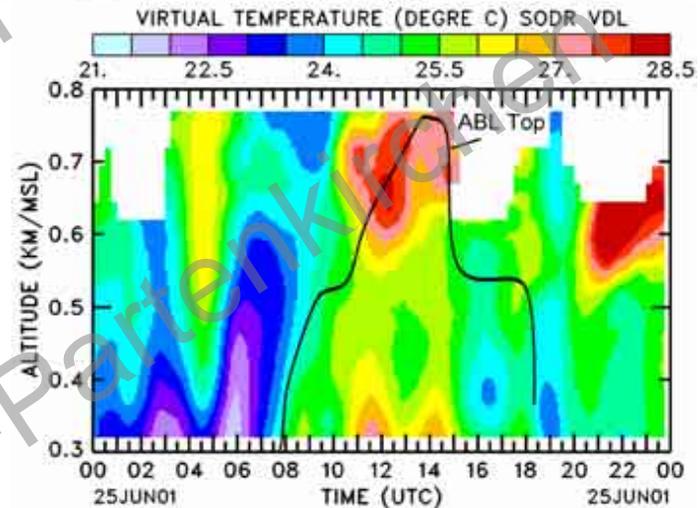
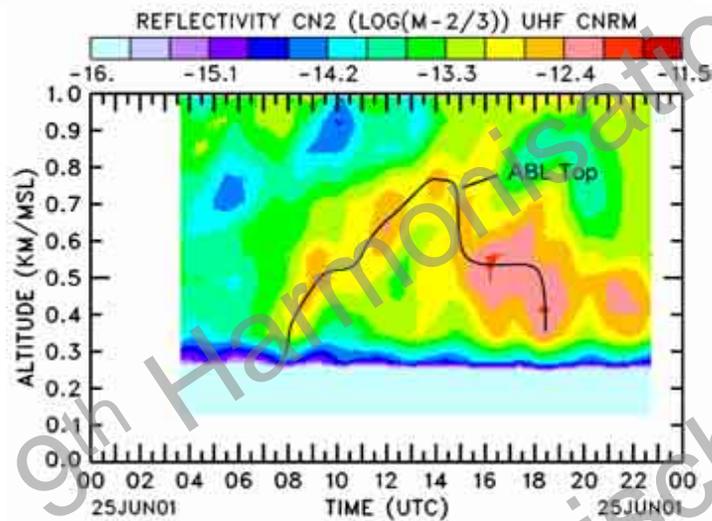
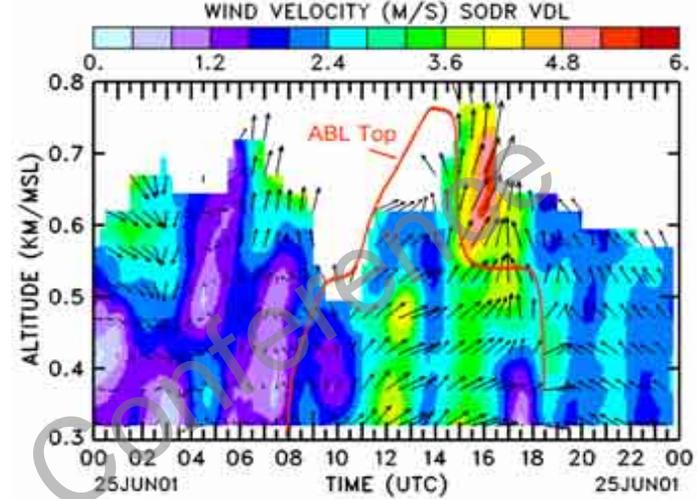
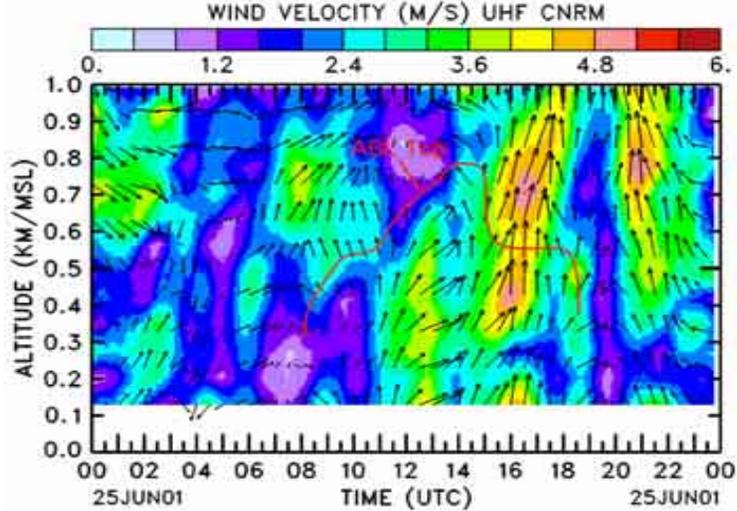
Comparison between observed and simulated surface energy balance fluxes in the city centre, averaged over 21 days. Red crosses - observed eddy covariance fluxes; continuous line - simulated fluxes using TEB (averages of the fluxes from roads, walls, roofs and natural surface cover). Blue stars in the turbulent sensible heat flux graph are calculated from the scintillometer data.



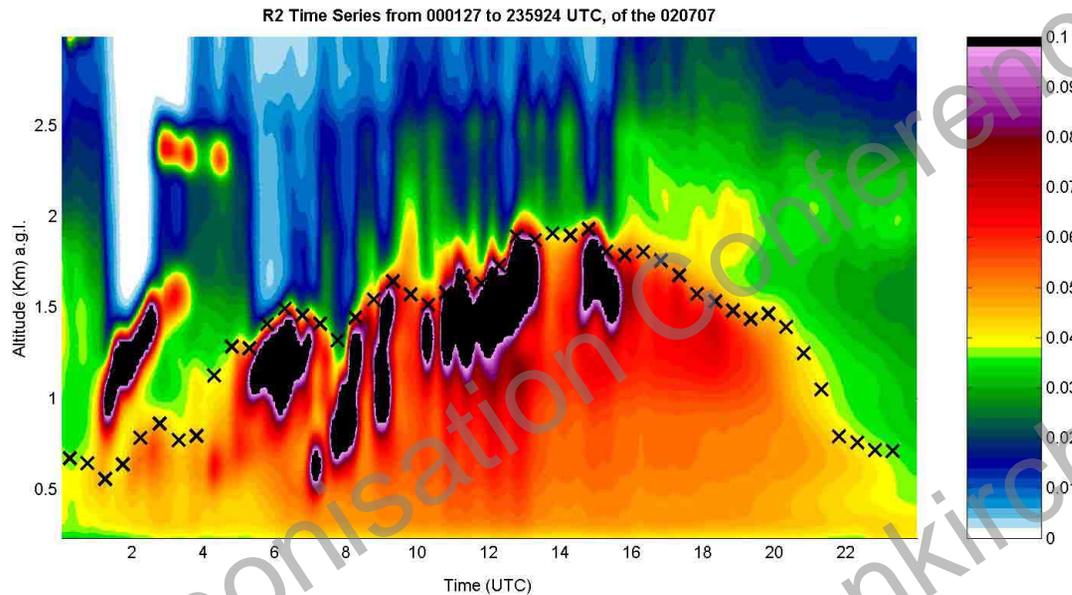
Comparison of sensible heat flux measured using sonic anemometers on 15 m masts at Coleshill synoptic station and at Dunlop Tyres Ltd factory site in Birmingham.
Period from 7 to 28 July 2000

Surface Energy Balance – Findings and Recommendations

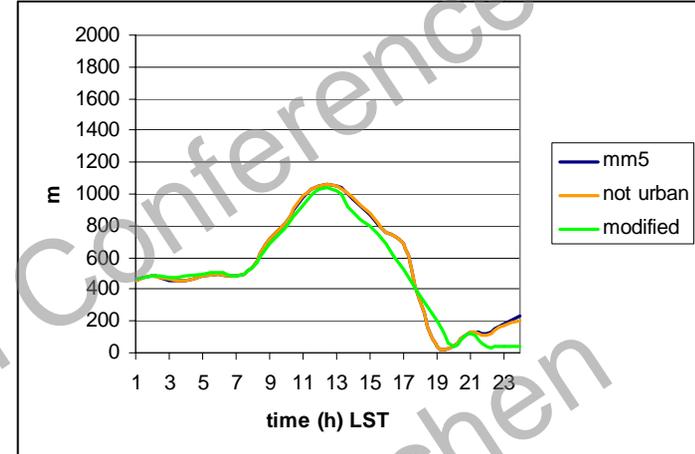
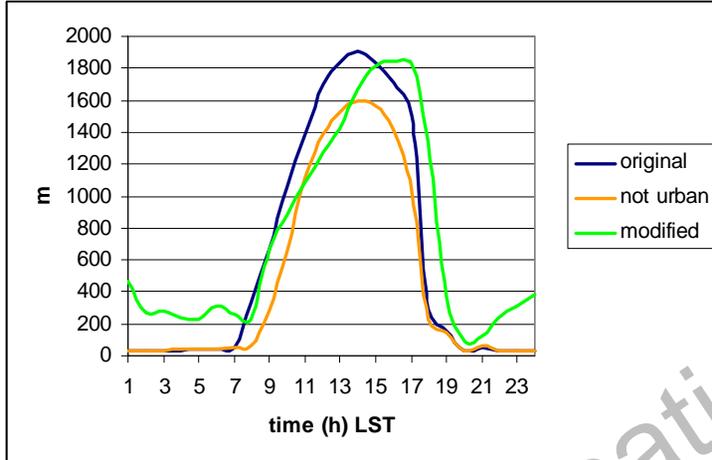
- Measurement of urban surface fluxes have only been realised in research programs of limited duration
- Available observations demonstrate significant perturbation of the surface energy balance partitioning compared to the rural surroundings
- Turbulent flux profiles in the roughness sub-layer require more study (field/models)
- Meso-scale models with sub-models of fluxes for urban areas available (not operational yet)
- No detailed SEP affordable: Met. pre-processors modified for urban surfaces available



Time-height sections of UHF profiler at the Observatoire (left) and sodar-RASS at Vallon Dol (right): (upper) Horizontal wind velocity (lower) C_n^2 reflectivity, virtual temperature



Lidar scans of the backscatter from the atmosphere on 7 July 2002 at a site in central Basel. The colour coding is proportional to the aerosol concentration (black=clouds). Crosses indicate the diagnosed Aerosol Mixed Layer height from the derivative of the logarithm of the range-corrected signal.



The diurnal variation of the mixing height (m) at the NOA station in the city centre of Athens (left) and the rural station of Spata (right), produced by the original MM5/MRF model (dark blue line), the urban area replaced by a dry cropland and pasture area (orange line) and the modified “urbanised” MM5/MRF model (green line) on 14.9.1994.

Mixing heights:

Findings and recommendations

- Daytime MH: standard rural methods more acceptable than for the nocturnal MH, provided they allow for the urban heat storage as well as changed surface characteristics
- Convective UBL: the simple *slab models* (e.g., Gryning and Batchvarova, 2002) were found to perform quite well
- Nocturnal UBL occurs in a counteraction with the negative ‘non-urban’ surface heat fluxes and positive anthropogenic/urban heat fluxes; standard methods less promising
- In urban and meso-scales, MH is an important parameter for air pollution applications
- NWP models: not clear whether MH is sufficiently accurate to be useful
- No evaluation of MH necessary regarding traffic-originated pollution

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