Department of Meteorology

Probing the urban boundary layer: the ACTUAL project

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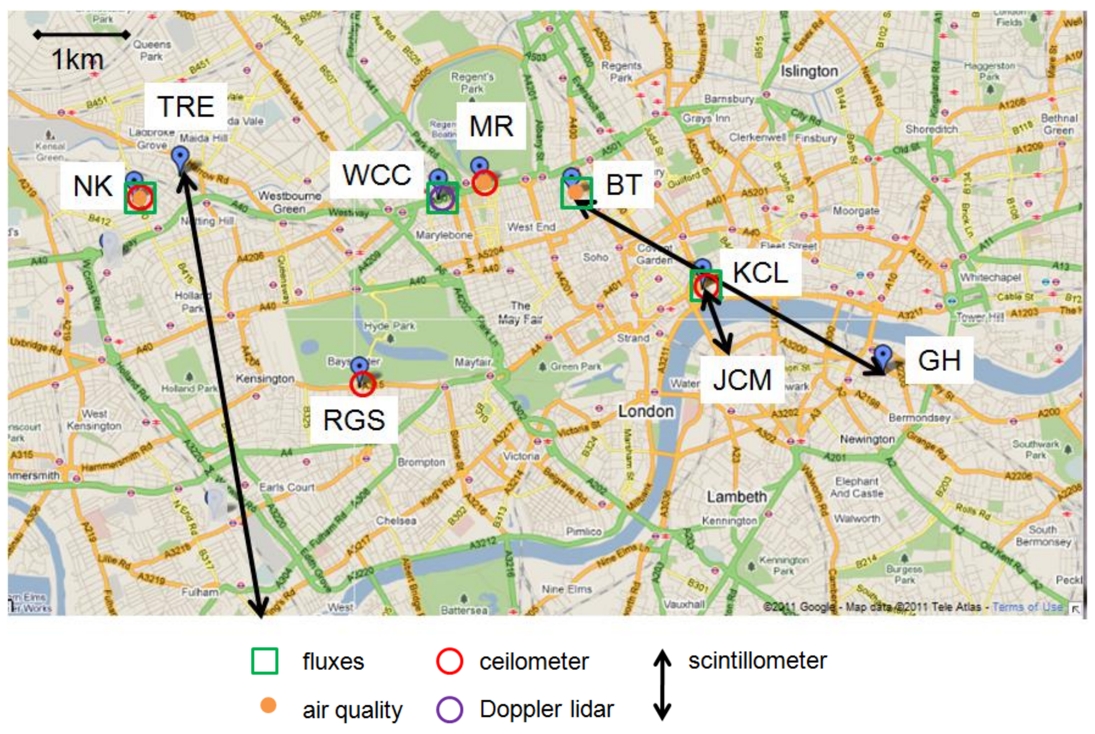
ACTUAL: Advanced Climate Technology Urban Atmospheric Laboratory

The urban boundary-layer can evolve a complex structure in response to the complex urban surface. Observations of winds and turbulence in cities are rare due to the challenges in establishing observations high enough to be representative. For this reason, ground-based remote sensing is increasingly used as a research tool. Initial results are presented here from a comparison of wind-speeds derived from Doppler LiDAR, scintillometry and a point measurement on the BT Tower in central London. This is a collaboration between the University of Reading and King's College London as part of the ACTUAL project (www.actual.ac.uk).



- **ACTUAL**:
BT - BT Tower
WCC – Westminster City Council
- **King's College London:**
KCL – KCL Strand campus building
GH – Guy's Hospital
JCM – James Clerk Maxwell building
RGS – Royal Geographical Society
- **ClearfLo:**
NK – North Kensington LAQN site
MR – Marylebone Road LAQN site
TRE – Trellick Tower

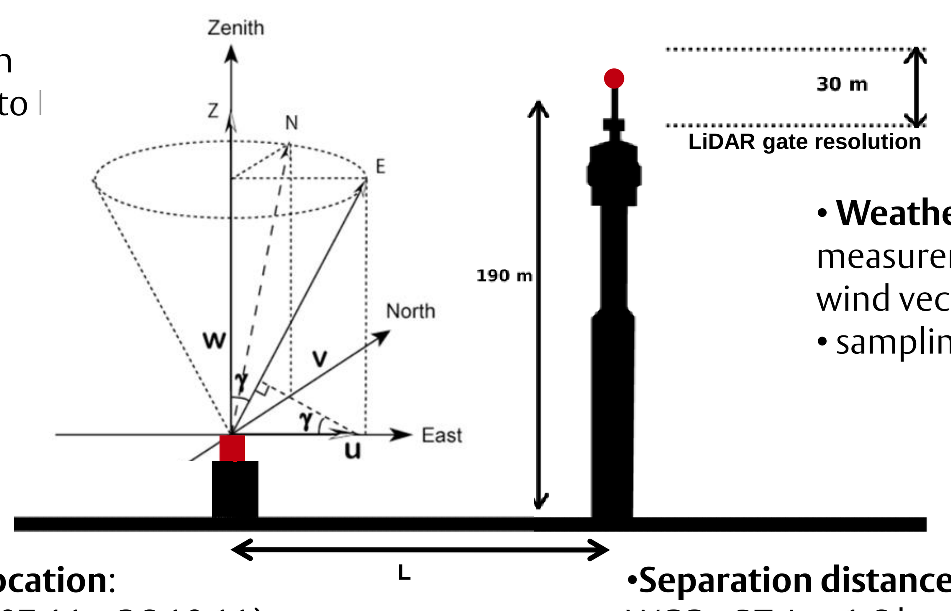
Figure 1: Central London measurements across ClearfLo, KCL and ACTUAL instrumentation platforms.

Site	Instrumentation	Measurement	Height (AGL)
BT	Vaisala WXT520 weather station	T, RH, p, U, dir	190 m
WCC and KCL	Halo Photonic Doppler LiDAR	U(z), dir(z), backscatter Radial velocity V_r	105 m up to c. 2km (local roof height 15 m)
KCL-JCM	Scintec Boundary Layer Scintillometer BLS 900 (BLS)	C_n^2, cross-wind	~20-34 m, path 808 m

Table 1: Instrumentation details for data shown here. For full instrument list see www.actual.ac.uk , www.clearflo.ac.uk and geography.kcl.ac.uk/micromet.

Doppler LiDAR evaluation

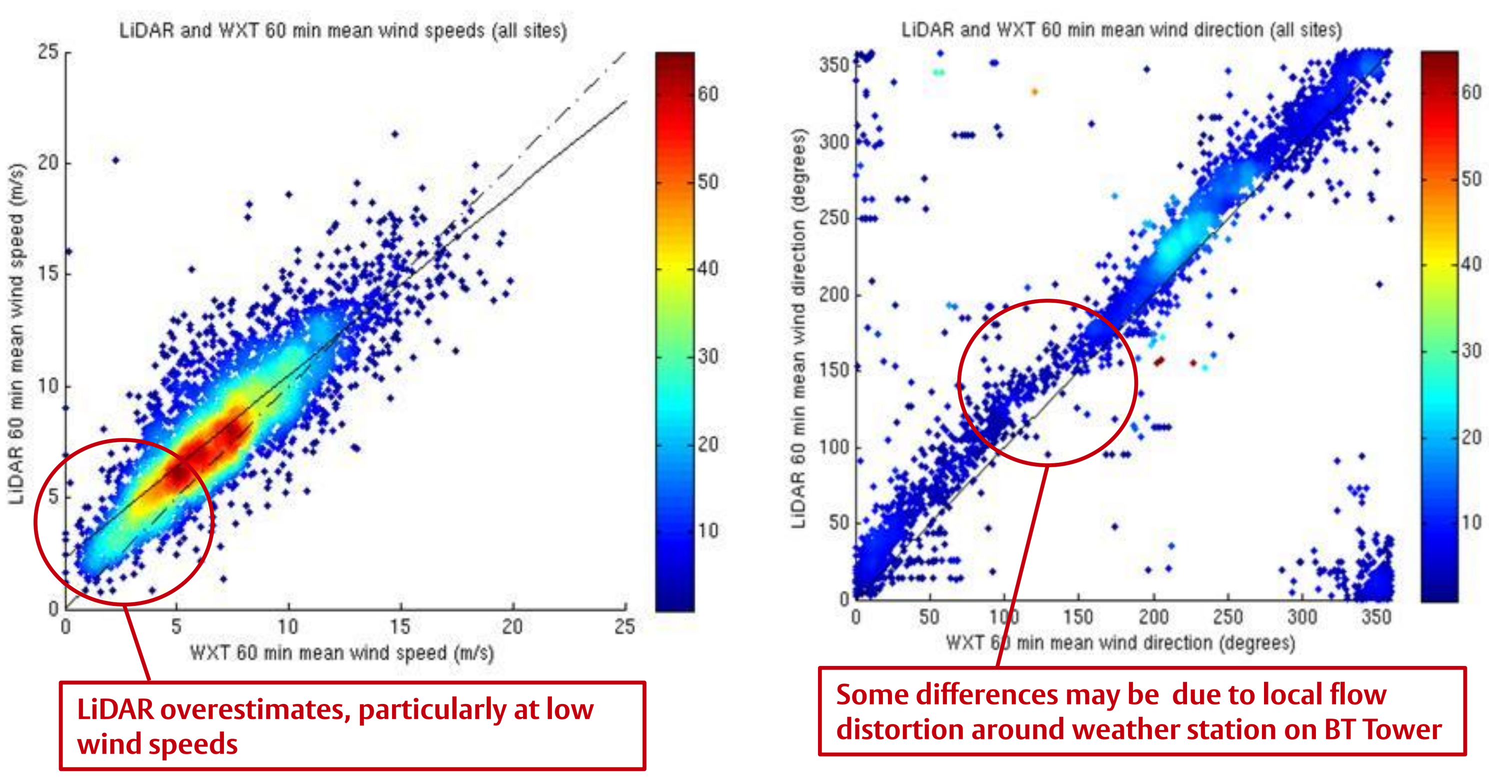
- **D**oppler **B**eam **S**winging (DBS) used to derive wind vector (u, v ,w) at different gate heights
- angle to zenith γ = 15°
- gate resolution = 30 m
- min. sampling height = 105 m
- mid-point of gate compared to BT Tower =180 m
- DBS scan every 5 minutes, duration ~ 60 s



- **Weather station**: sonic measurement of horizontal wind vector (u,v)
- sampling frequency = 1Hz

- **LiDAR location**:
WCC (01.07.11 – 26.10.11)
KCL (26.10.11 – 18.05.11)

- **Separation distances:**
WCC – BT: L ~ 1.6 km
KCL – BT: L ~ 2 km



Flow over the river Thames

Method: deriving winds from multiple LiDAR scans

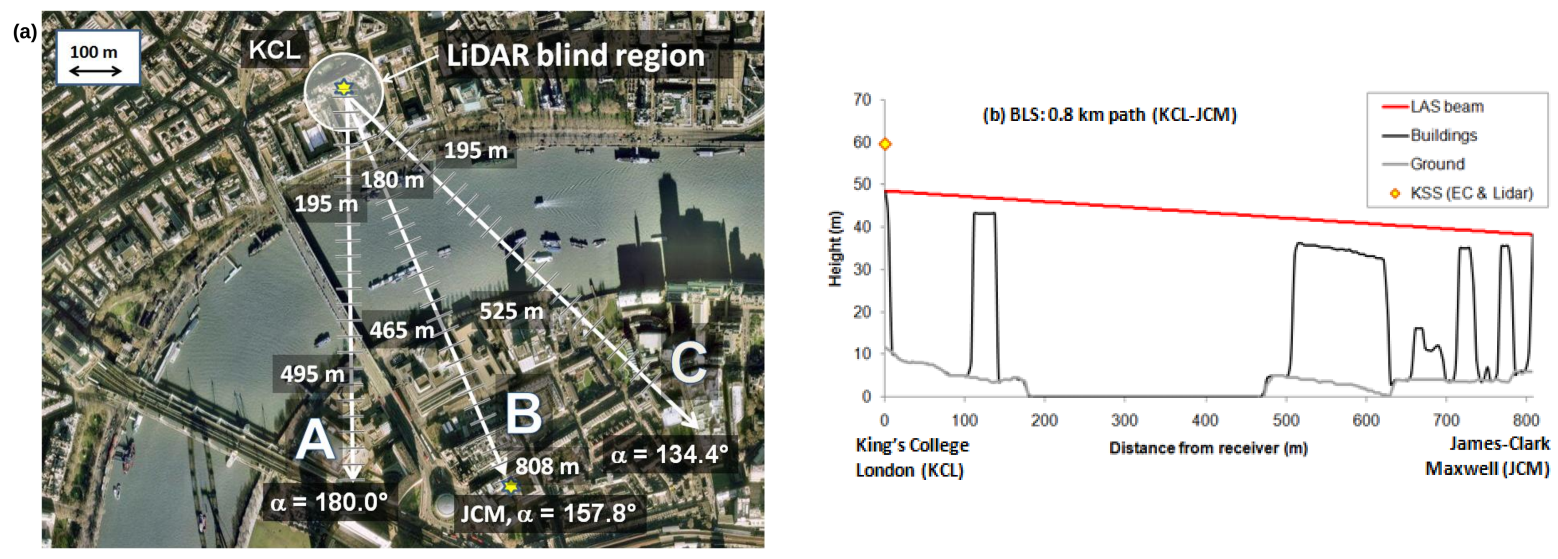
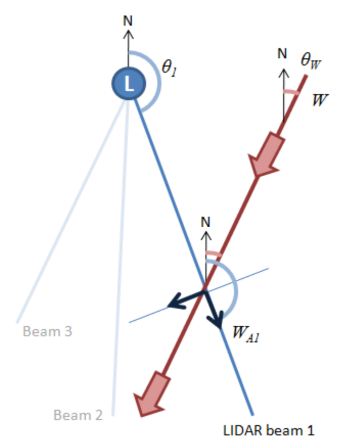


Figure 2: River measurements a) LiDAR scan configuration b) height of BLS path, along B.



- When beam is in the first position a measurement of W_{A1} is made, which is related to the actual wind speed and direction by:

$$W_{A1} = W\cos(\theta_W + 180 - \theta_1) \quad (1)$$

- When the beam moves to the second position, assuming that measurements are made at the same points in space and time for the centre point of each gate, the LIDAR measurement gives W_{A2}:

$$W_{A2} = W\cos(\theta_W + 180 - \theta_2) \quad (2)$$

Solving for W and θ_W gives the wind-speed and direction.

Case studies: compare LiDAR and BLS cross-wind components

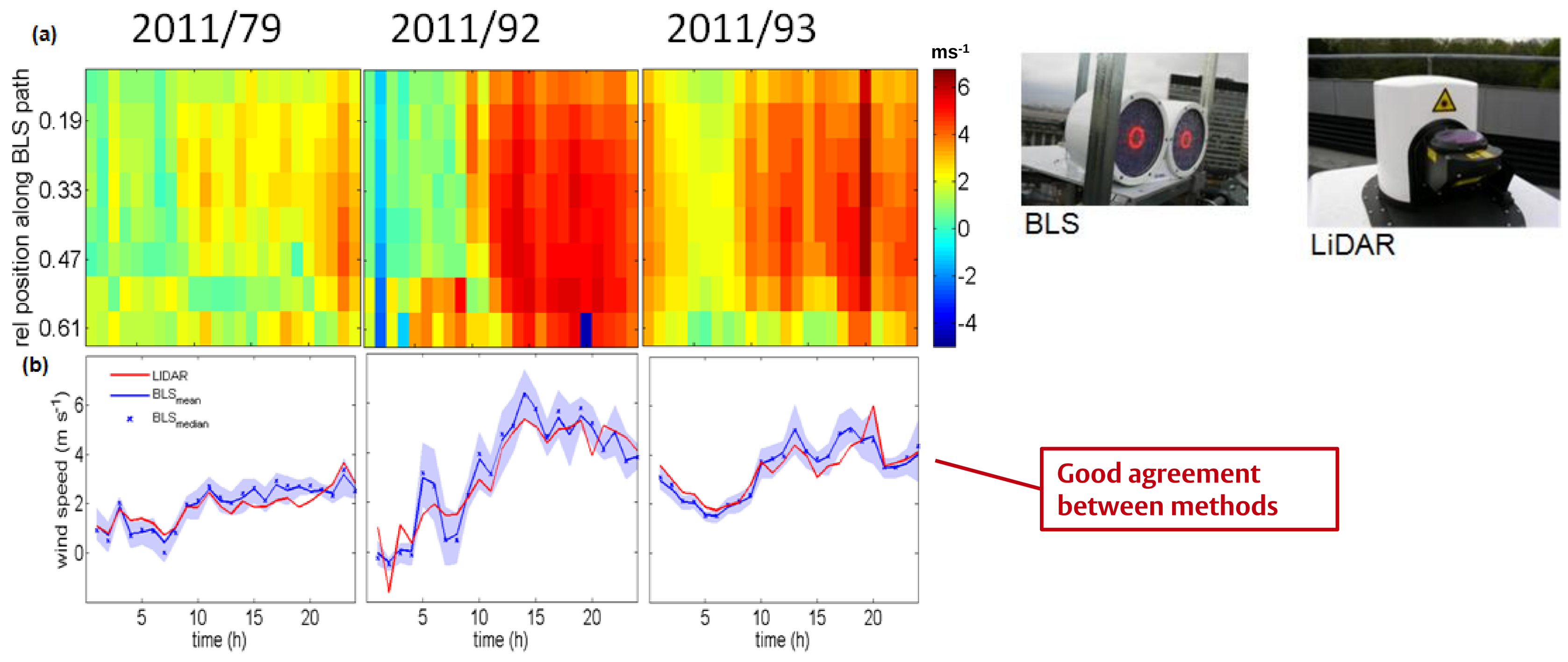


Figure 3: Three case study days showing 30 min averaged cross-winds a) LiDAR wind component over river for each gate b) comparison between LiDAR data weighted using BLS weighting function and BLS cross-wind from lagged-cross covariance between beams.

Three month-average: diurnal and spatial variation

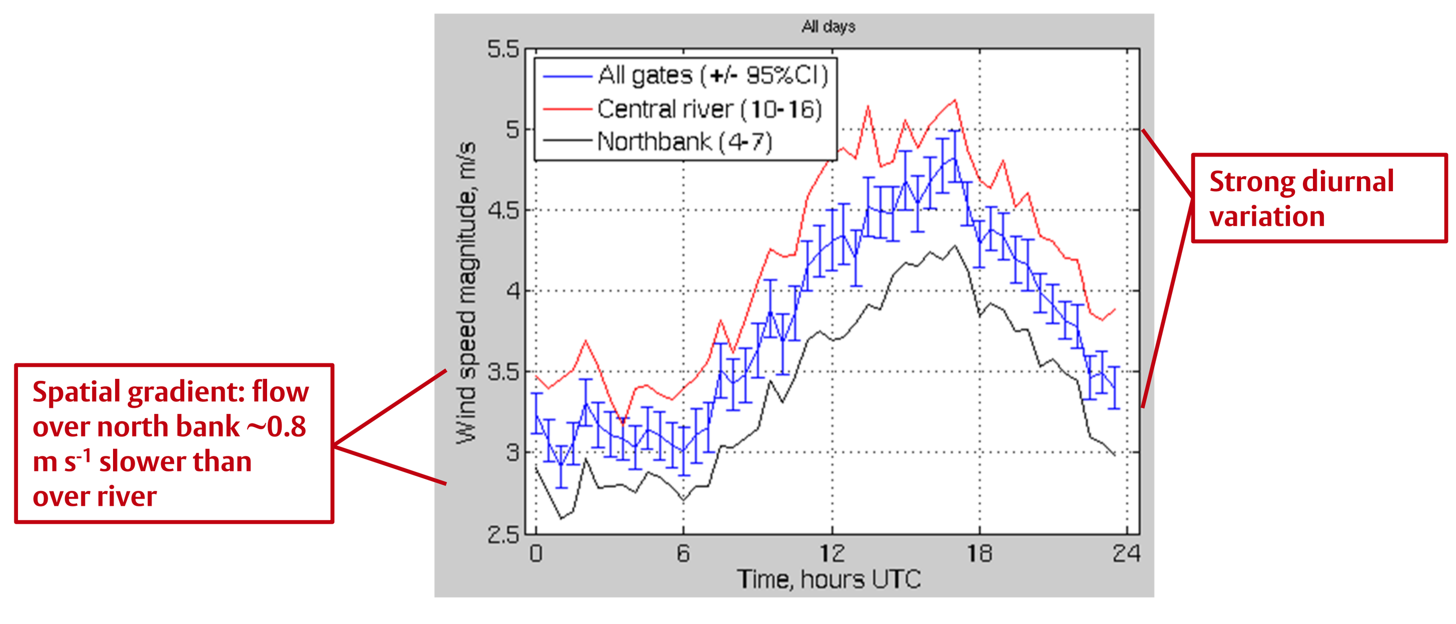


Figure 4: LiDAR wind-speeds averaged over period of observations (18.02.11-30.04.11, 04-17.05.11) for all gates; north bank (gates 4-7); central river (gates 10-16).

Conclusions

The Doppler LiDAR measured wind-speeds appear to agree well with both point and scintillometer derived values – further work is necessary to quantify agreement. Next steps are to analyse vertical wind and turbulence profiles as a function of stability and wind direction; evaluate UKMO Unified Model profiles against ACTUAL data; and analyse river flows in light of sea breeze and tidal variation.

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