

Clean Air For London: How do sea breezes affect pollution in London?



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A consortium of

University of Reading University of York Univ. of Leicester Univ. of Manchester

University of Leeds King's College London UEA

CEH Edinburgh Univ. of Birmingham University of Hertfordshire University of Salford

Coordinated by

National Centre for Atmospheric Science

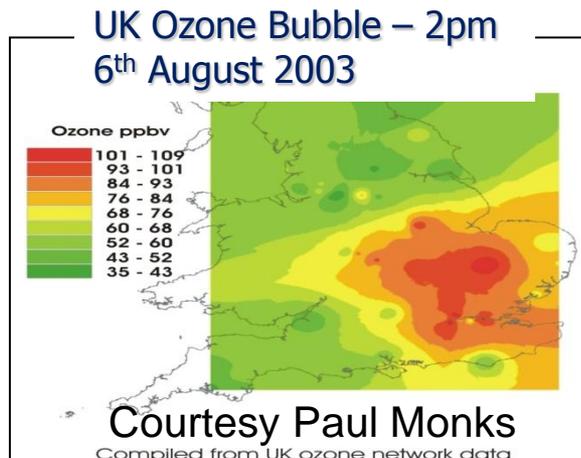
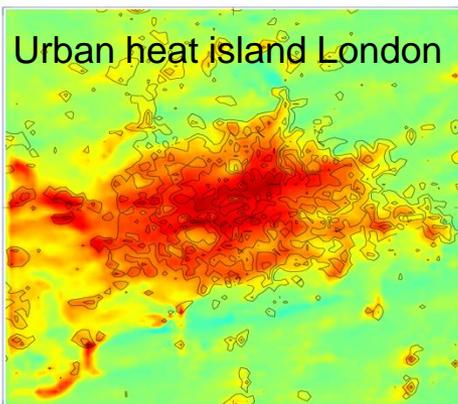


Health factors

Heat

Gas phase chemistry

Particulate Matter



- PM size, composition and processing
- Growth & shrinking

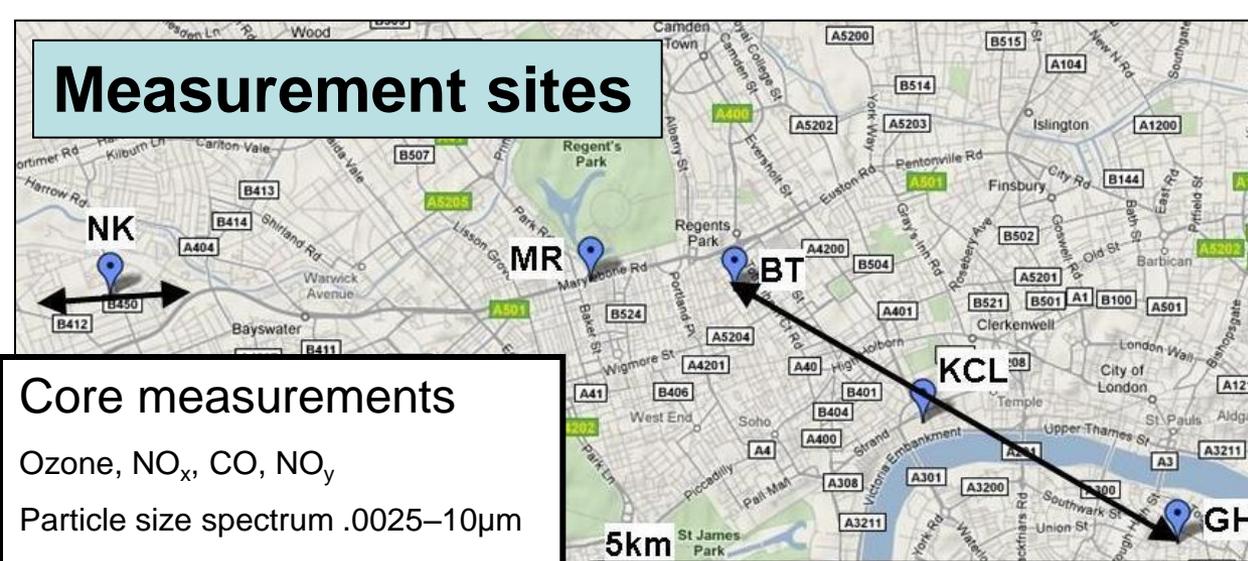
Temperature - mortality

Courtesy Paul Wilkinson, LHSTM

temperature

Integrated measurement of gas phase chemistry, PM and Meteorology

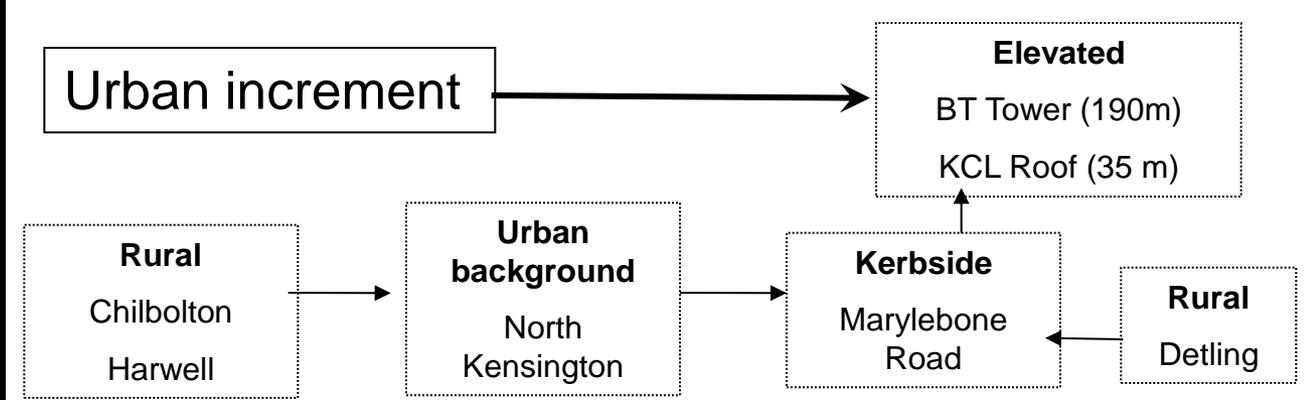
Measurement sites



Core measurements

- Ozone, NO_x, CO, NO_y
- Particle size spectrum .0025–10µm
- Particle mass, PM10, PM2.5
- Particle composition samples
- Boundary-layer structure and energy fluxes

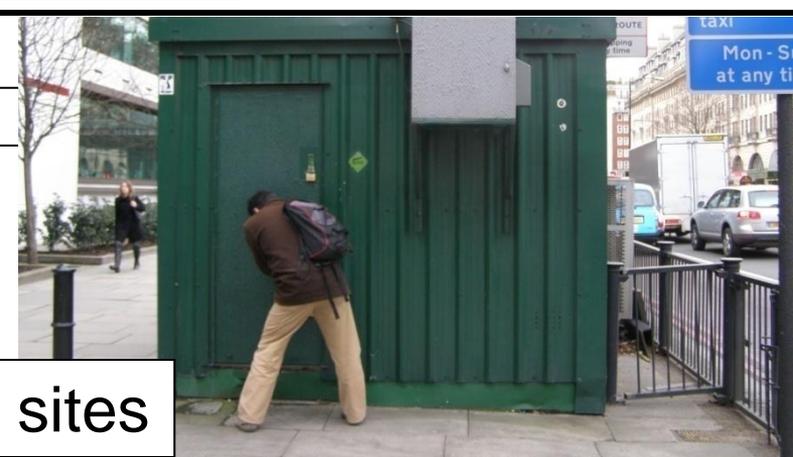
Urban increment



Rural background Detling



Add value to existing sites



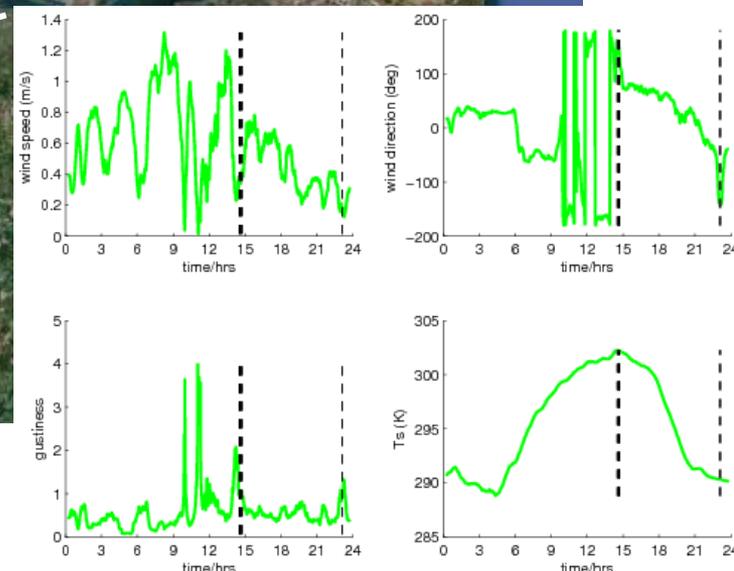
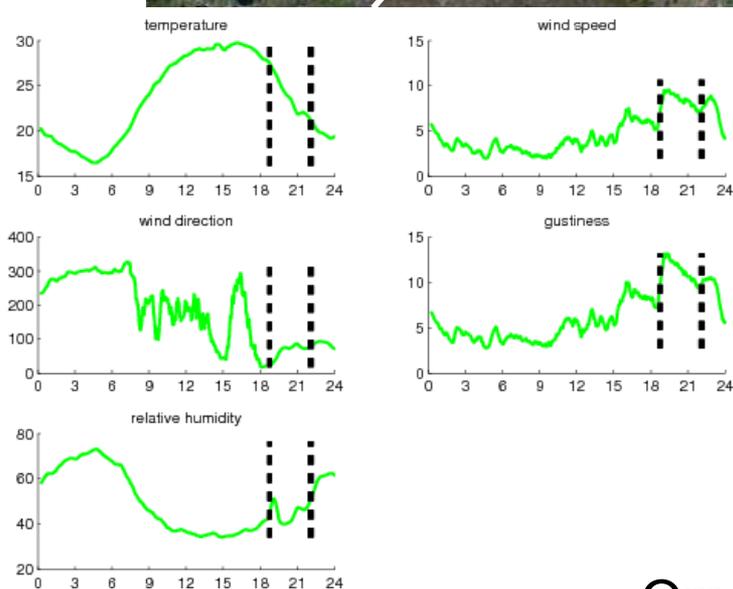
Algorithm to detect sea breezes

Plant and Keith 2007:BLM

- 20 min moving average
- Wind direction change $> 30^{\circ}$ within 15 min
- Wind speed increase $> 1\text{ms}^{-1}$ over 35 min
- Decrease in Temperature over 15 min
- Gustiness value > 1

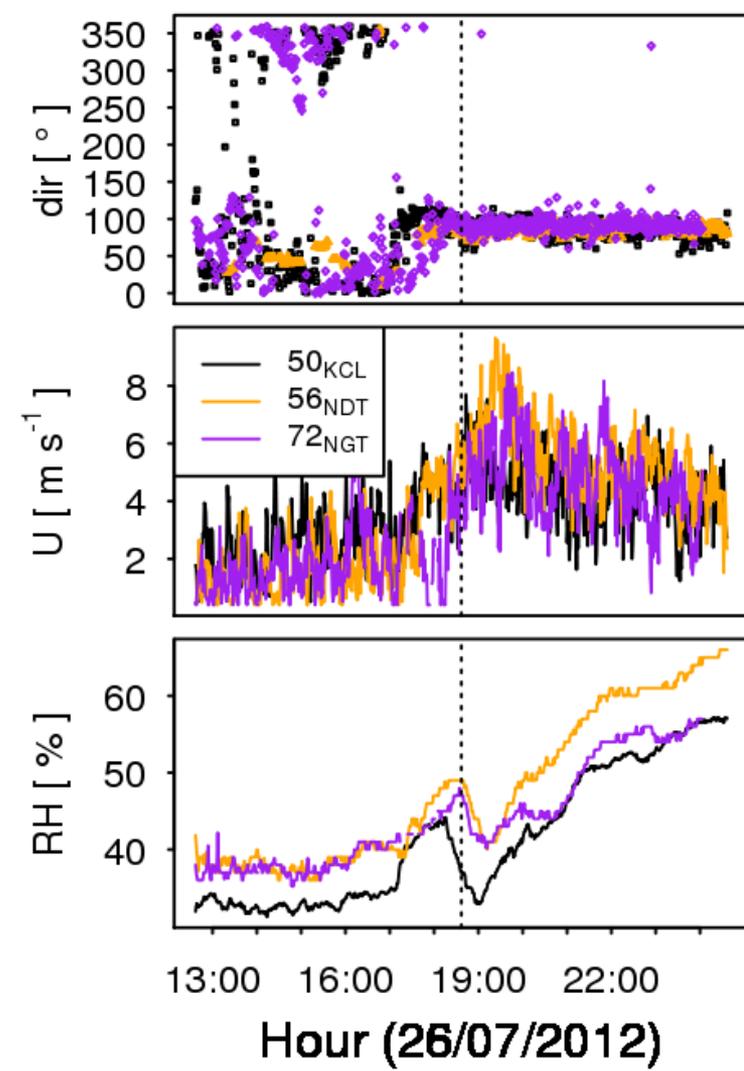
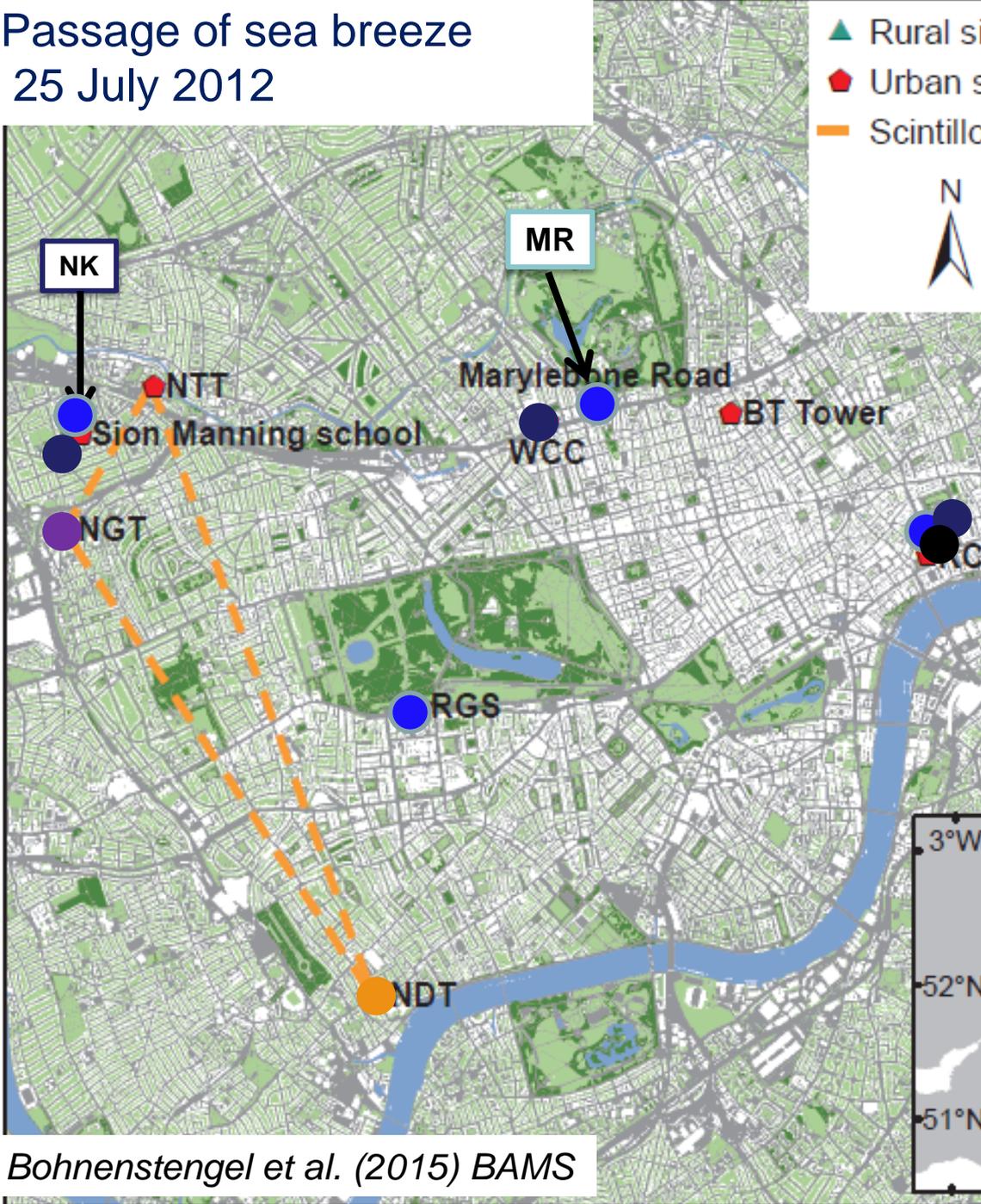
$$G = \sqrt{\frac{u'^2}{U}}$$

Meteorological datasets

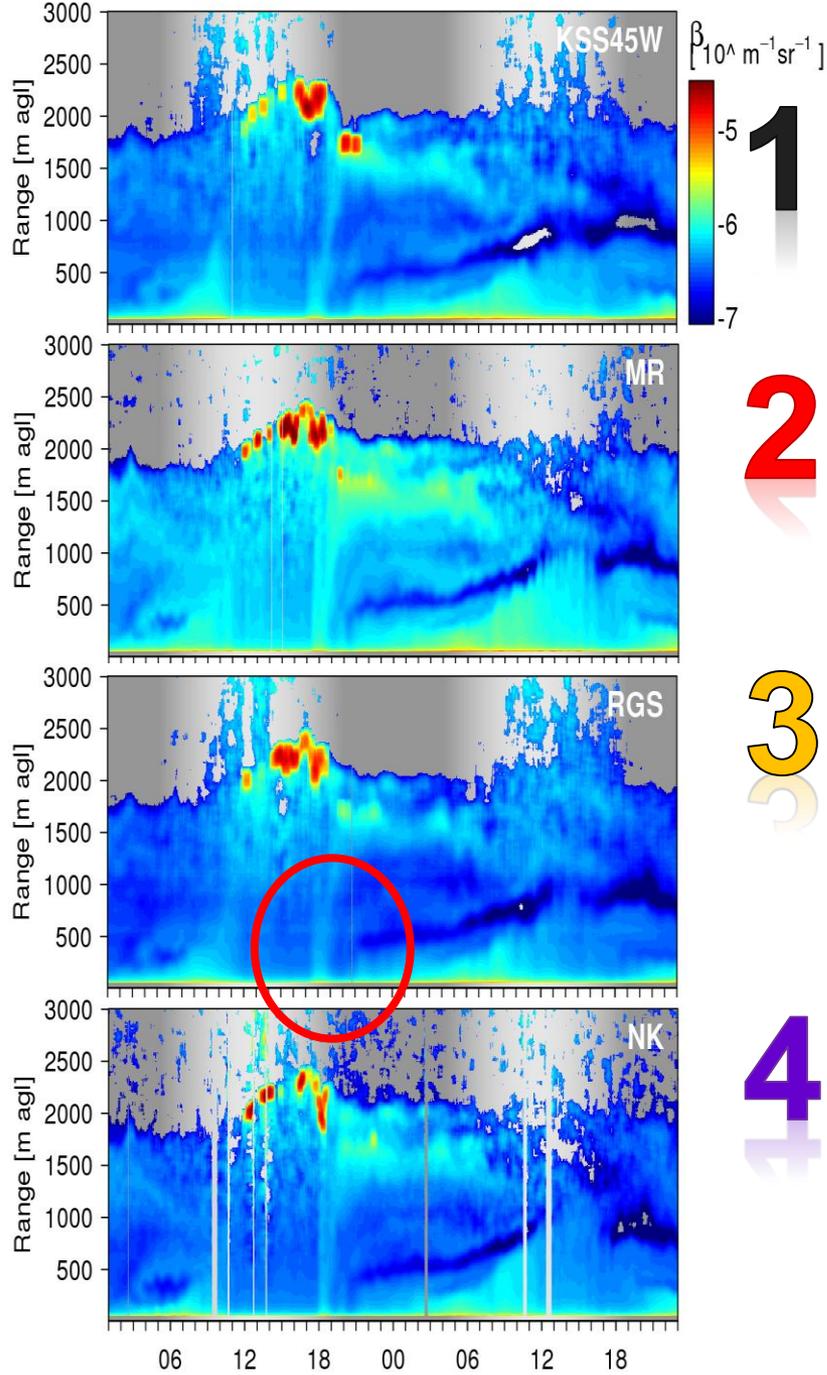


Omduth Coceal

Passage of sea breeze 25 July 2012



Bohnenstengel et al. (2015) BAMS

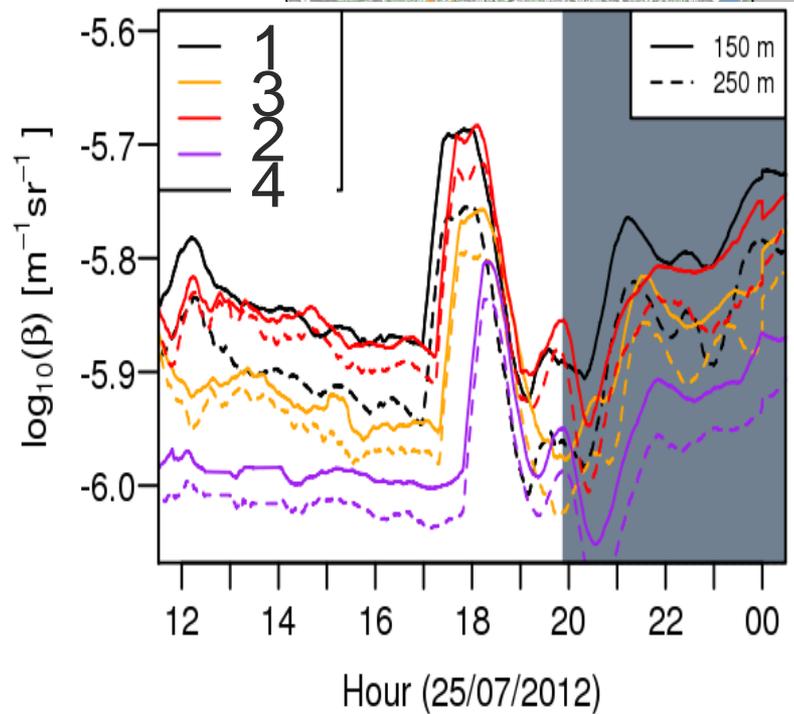
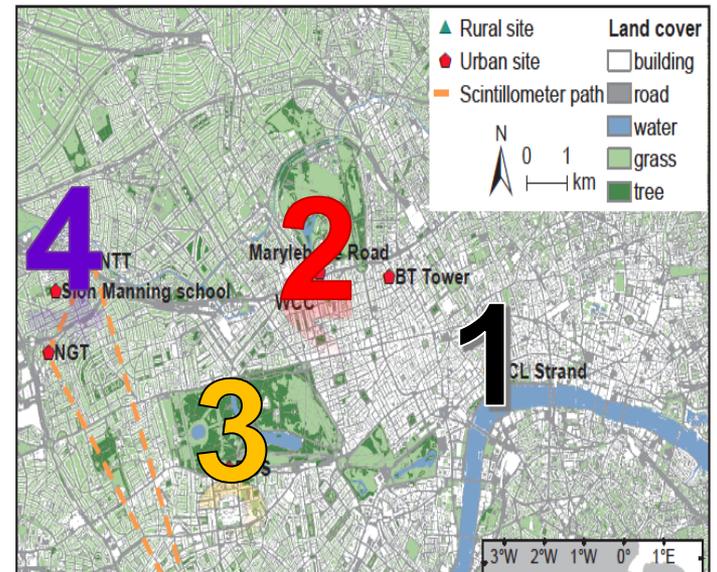


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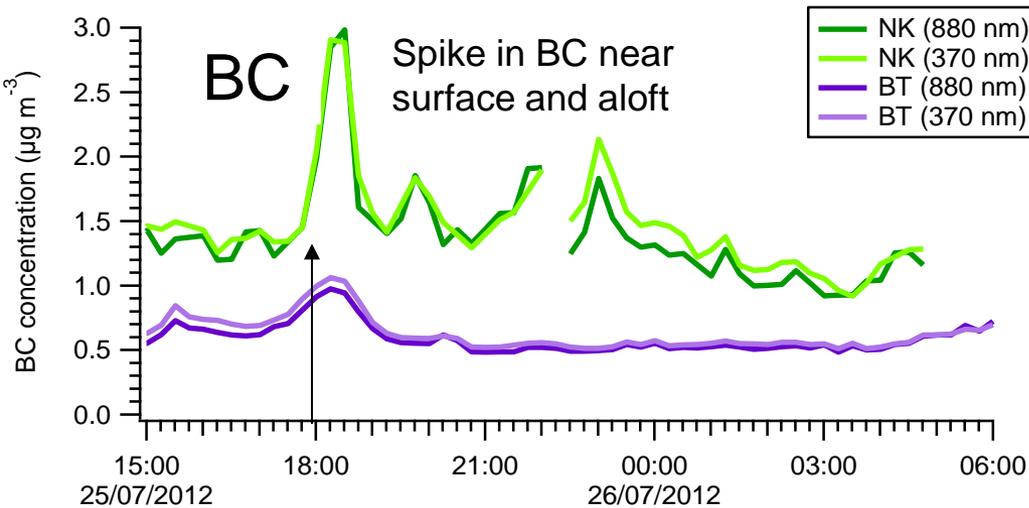
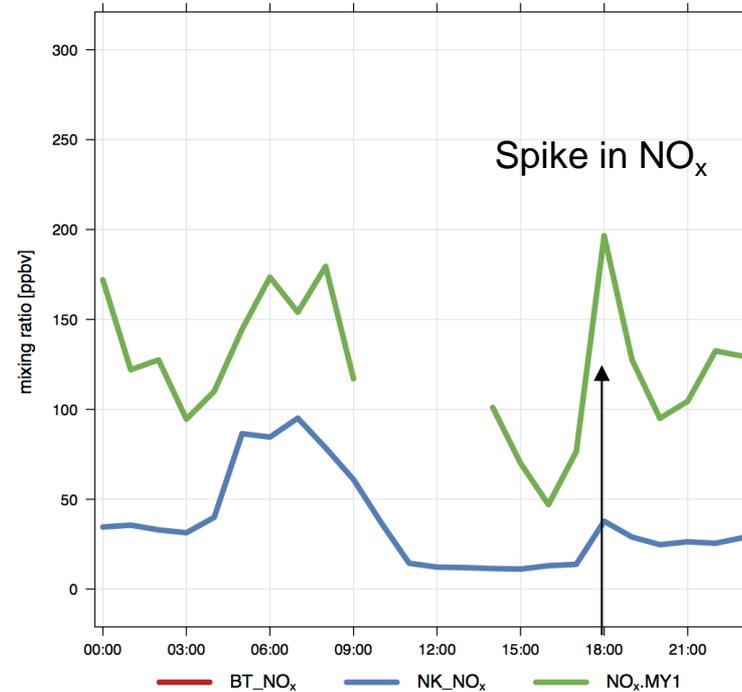
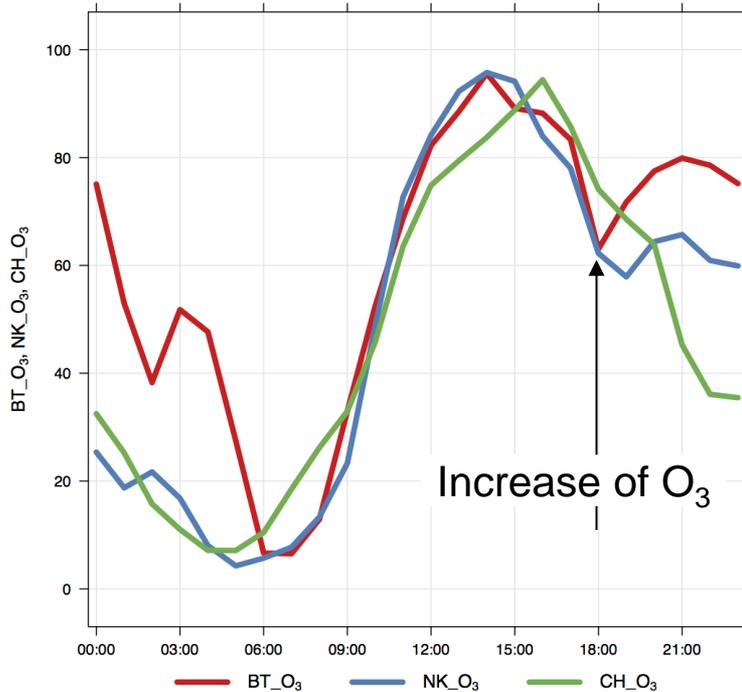
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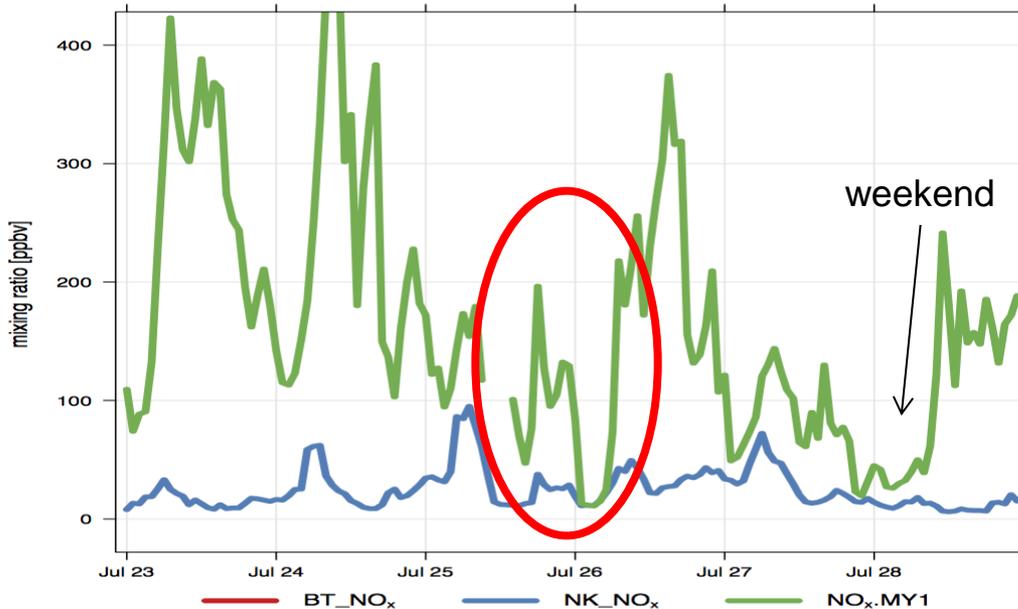
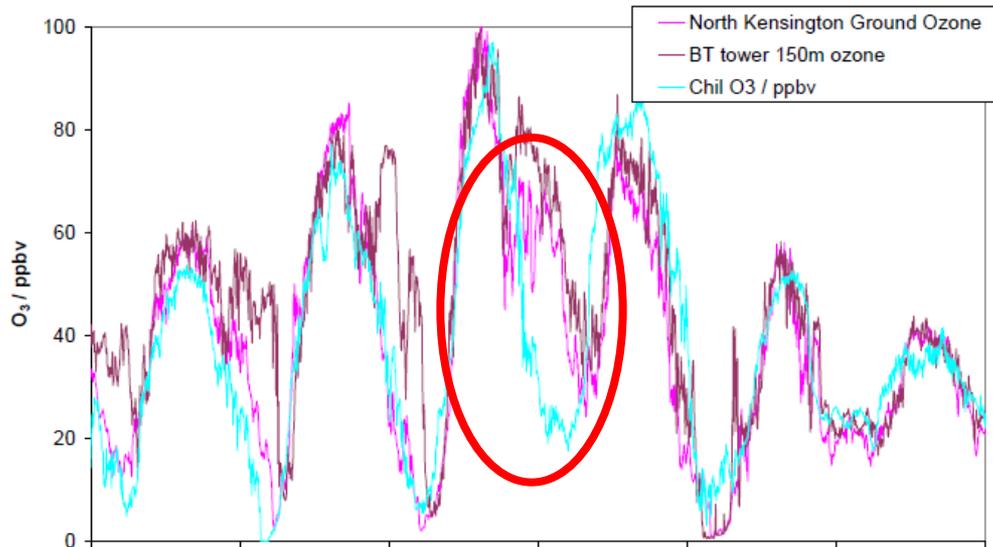


Air quality (O₃, NO_x, BC) 25 July London



- Night time increase in O₃ at surface
- Low NO_x
- Black carbon concentration peaks

Worst ozone episode since summer 2006



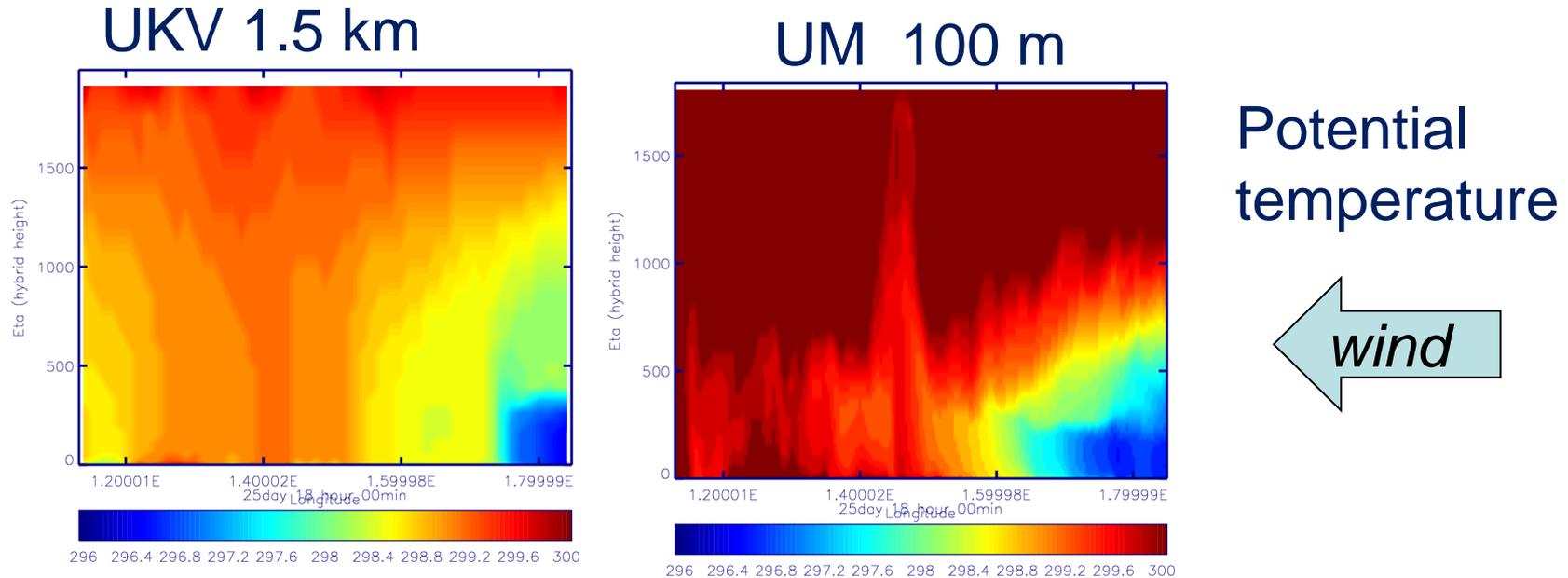
Unusually high surface O₃ after sea breeze event

Unusually low NO_x near Marylebone roadside (equivalent to urban background)

Is rural O₃ advected into London?

UKV & UM-100m: sea breeze on 25 July

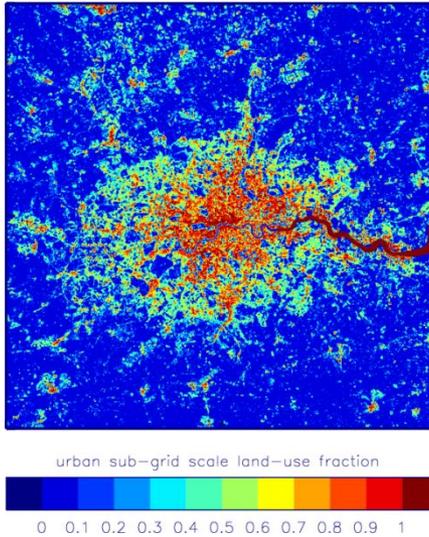
Bohnenstengel & Lean, Met Office



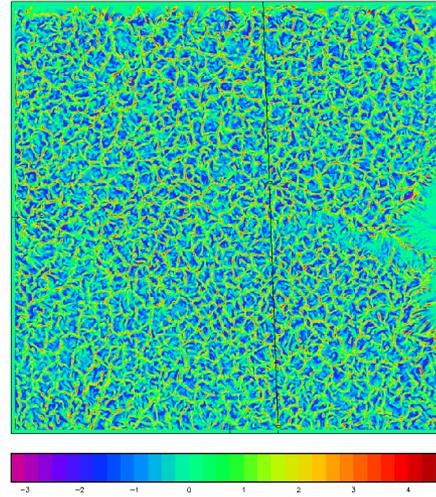
- Sea breeze leads to stably stratified boundary layer in London
- UKV and UM-100m - similar structure
 - Slight offset due to different run start times

UM-100m 25th July 2012

Urban land-use fraction



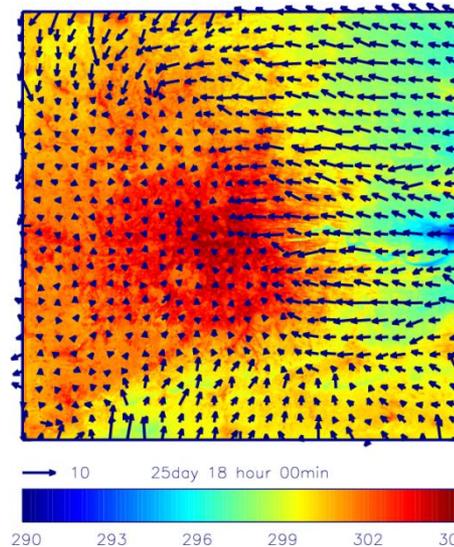
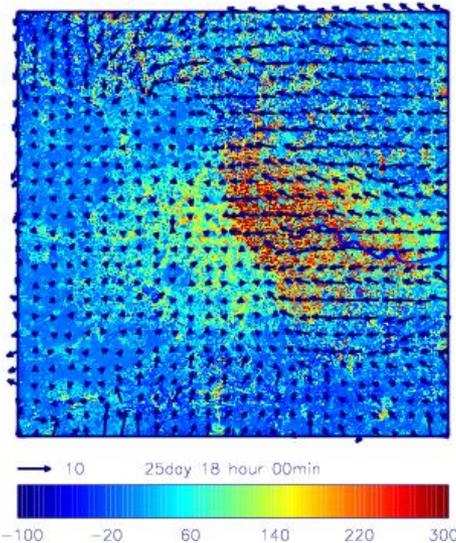
XBDUE Above w contour of wind after timestep of 292.3 metres
At 142 on 25/7/2012, from 132 on 25/7/2012



Vertical velocity:
@ 293 m

Surface sensible heat flux

horizontal wind

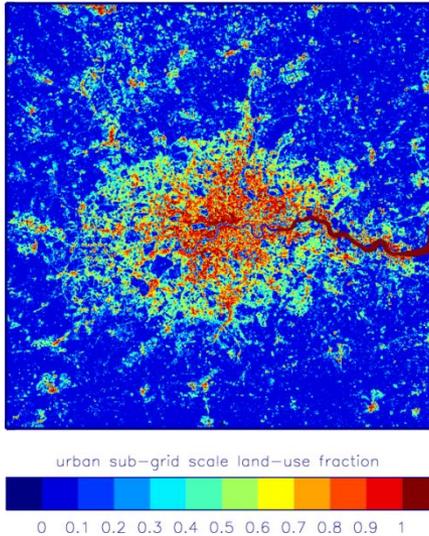


Screen level temperature

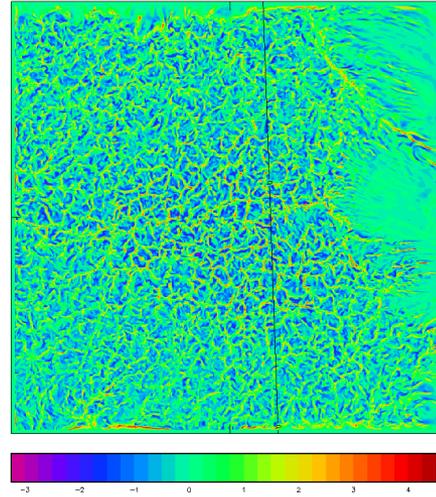
Bohnenstengel &
Lean, Met Office

UM-100m 25th July 2012

Urban land-use fraction



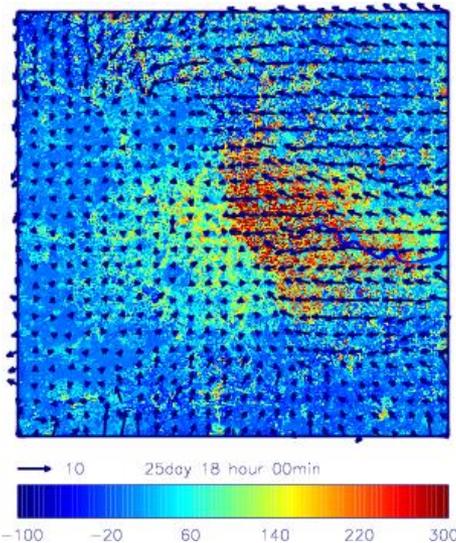
XBDUE Above w contour of wind after timestep of 292.3 metres
At 162 on 25/7/2012, from 152 on 25/7/2012



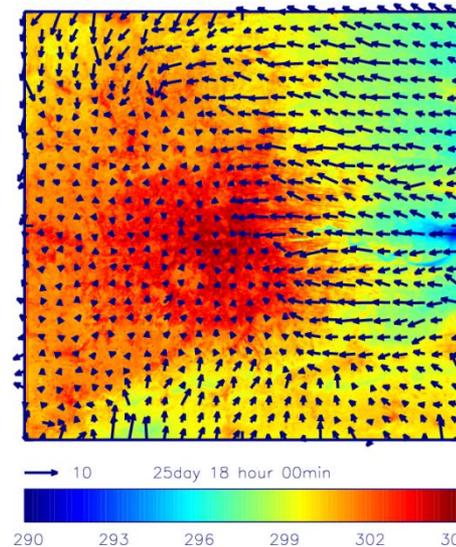
Vertical velocity:
@ 293 m

Surface sensible heat flux

horizontal wind



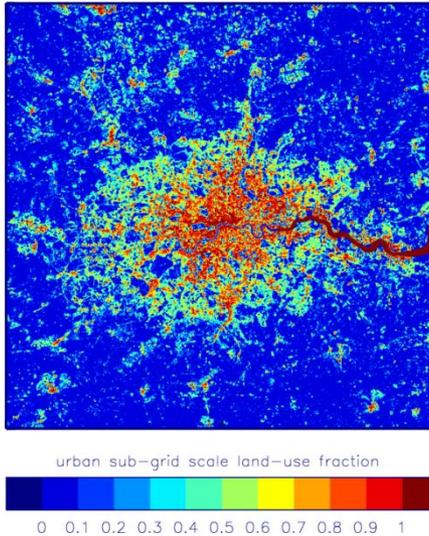
Screen level temperature



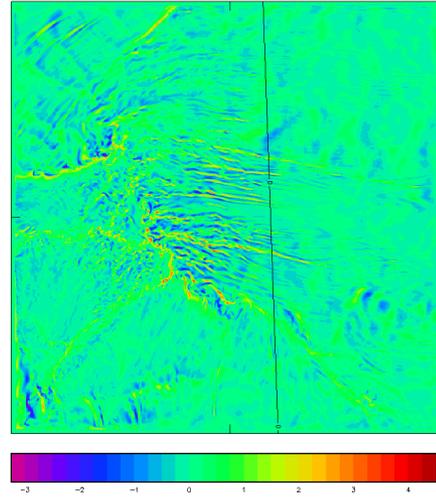
Bohnenstengel &
Lean, Met Office

UM-100m 25th July 2012

Urban land-use fraction



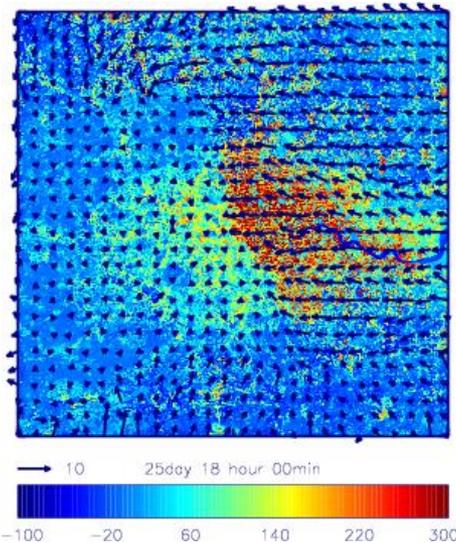
XBDUE Above w contour of wind after timestep of 292.3 metres
At 102 on 25/7/2012, from 102 on 25/7/2012



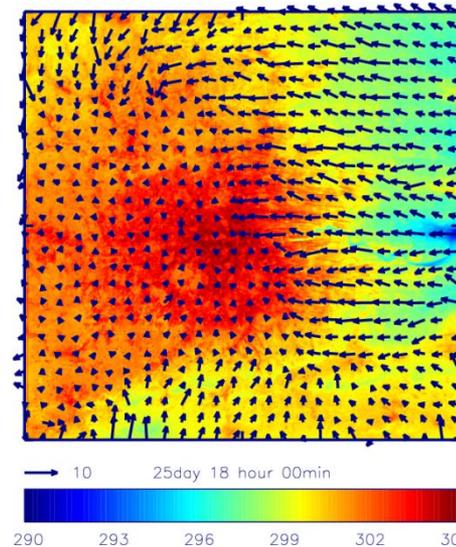
Vertical velocity:
@ 293 m

Surface sensible heat flux

horizontal wind

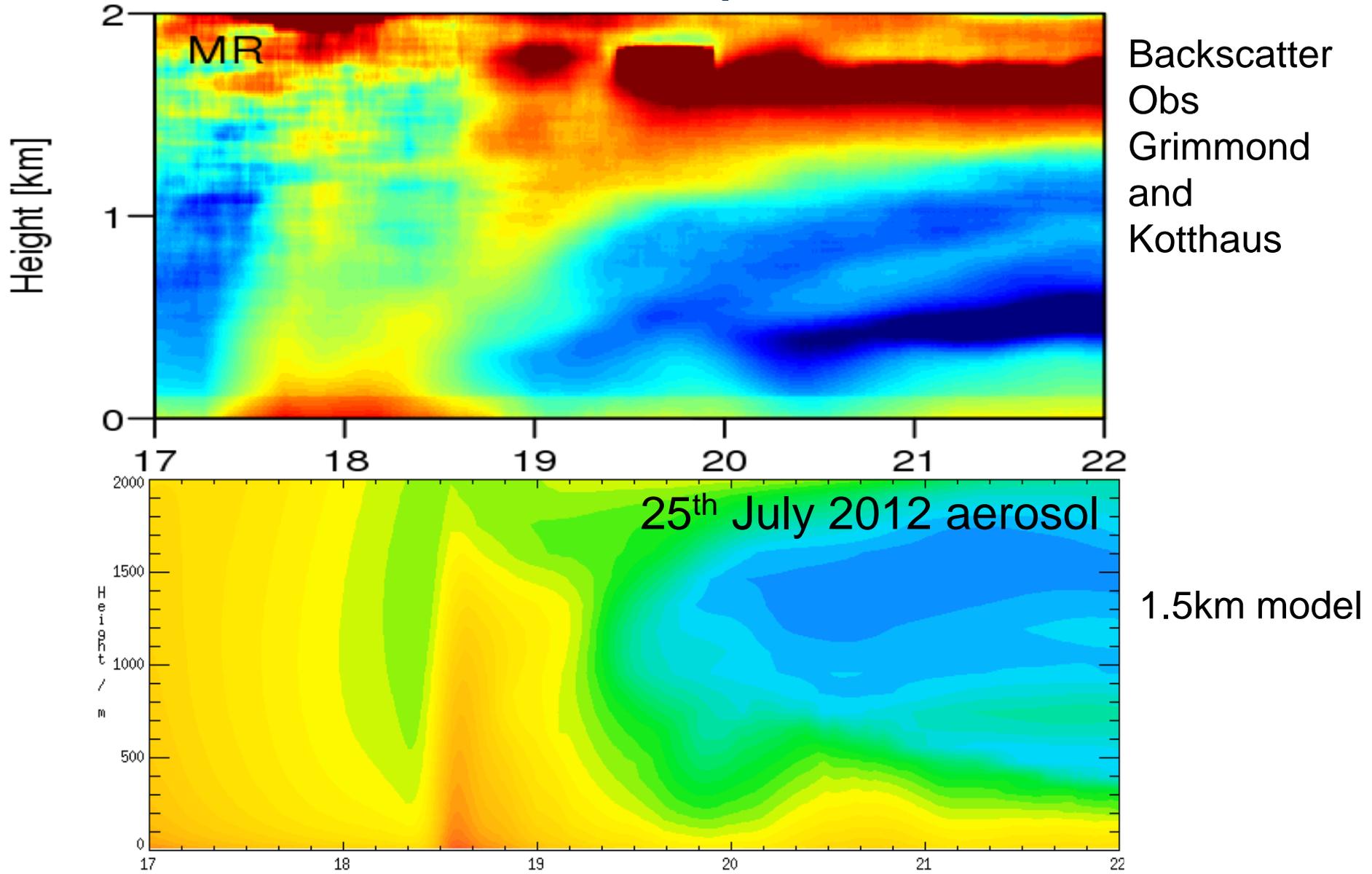


Screen level temperature



Bohnenstengel &
Lean, Met Office

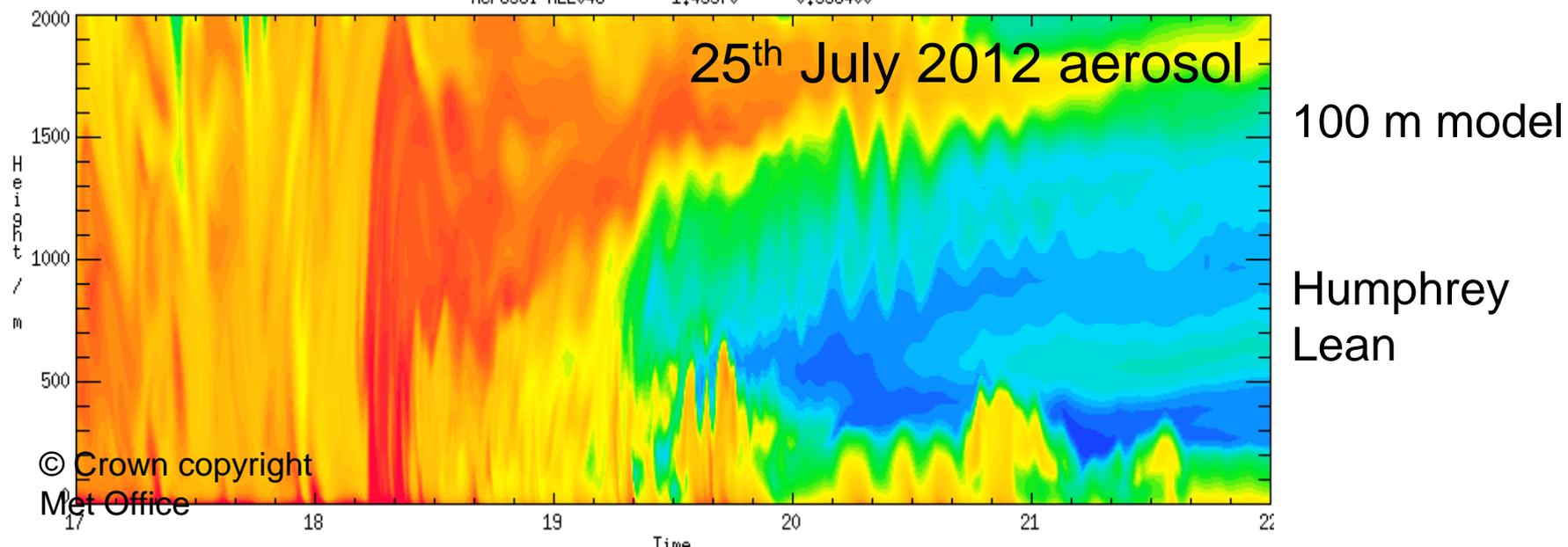
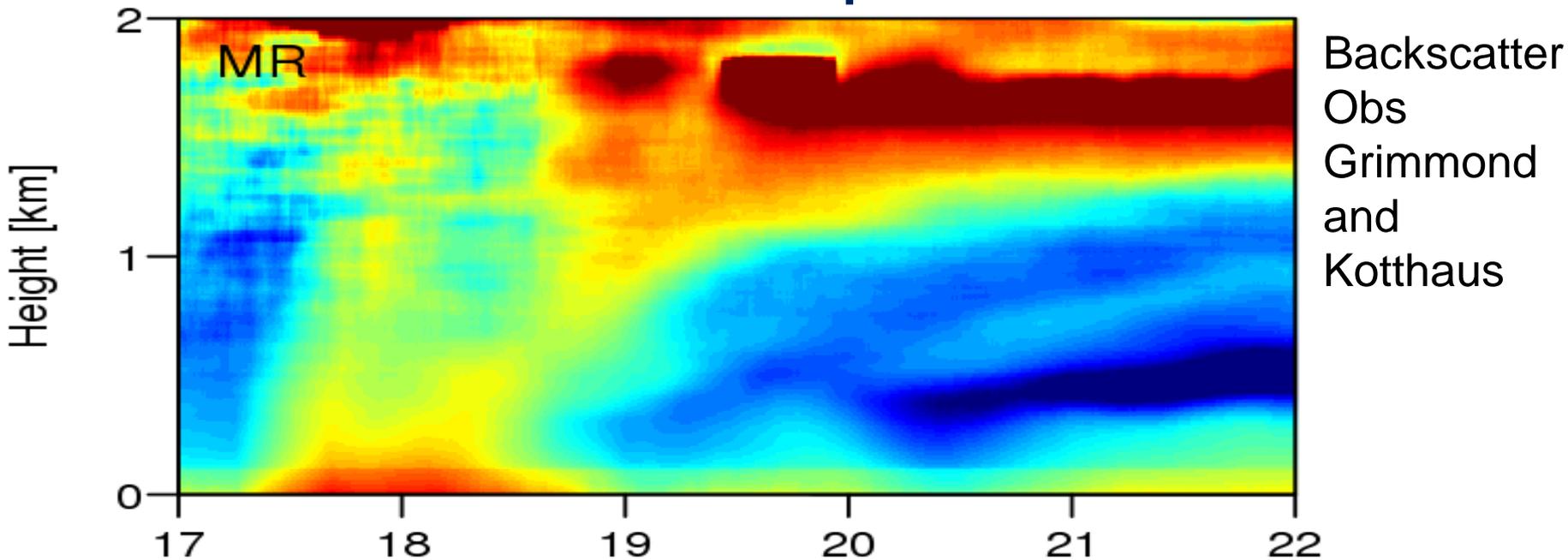
How well does UM capture seabreezes?

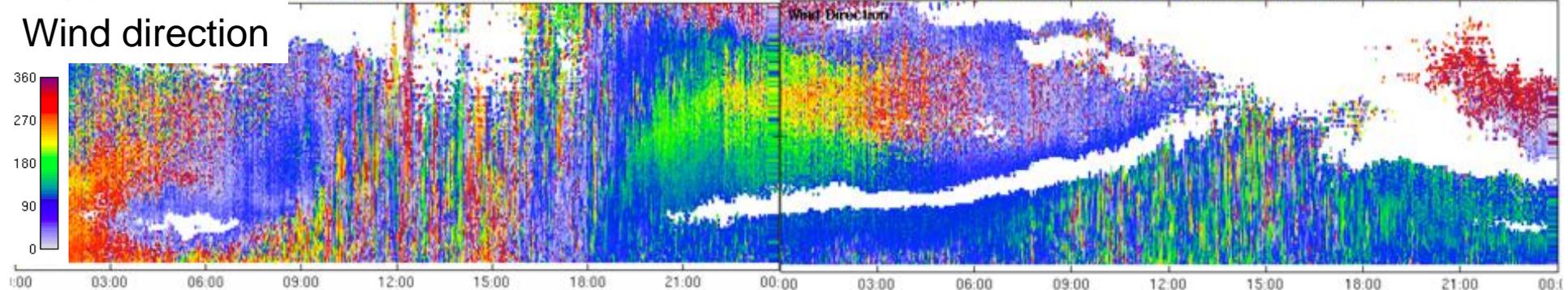
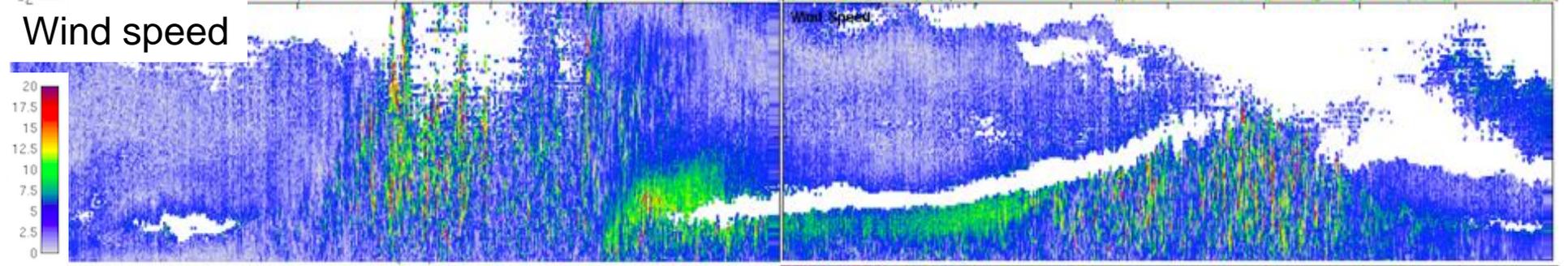
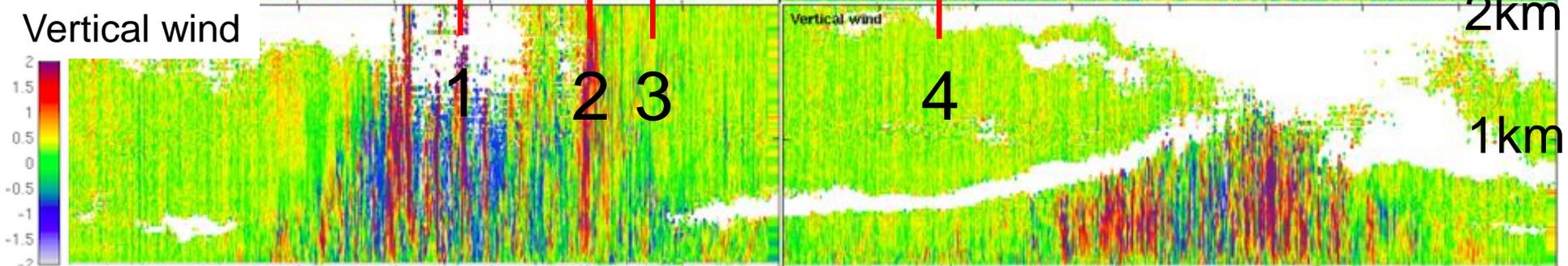
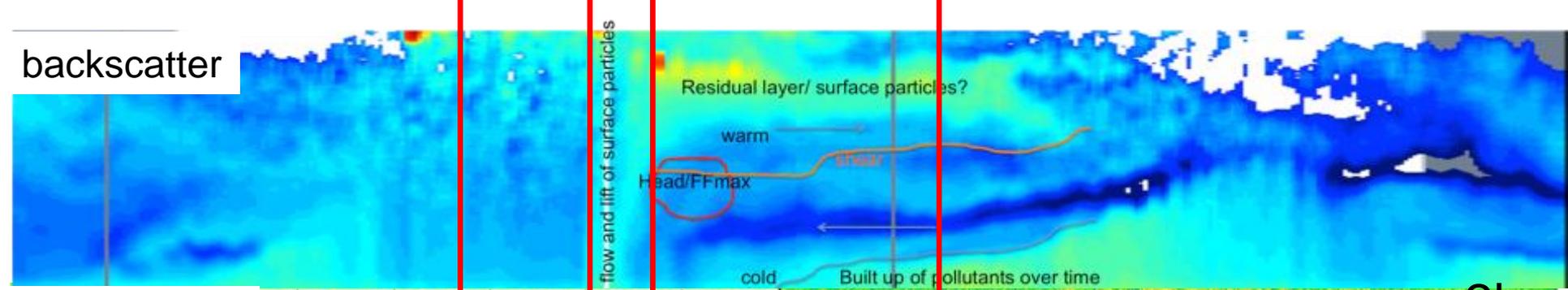


Backscatter
Obs
Grimmond
and
Kotthaus

1.5km model

How well does UM capture seabreezes?





00:00 03:00 06:00 09:00 12:00 15:00 18:00 21:00 00:00 03:00 06:00 09:00 12:00 15:00 18:00 21:00 00:00

Summary

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- Sea breeze signal found in meteorological observations
- Sea breeze signal in various air quality measurements
- O(1km) and O(100m) Met Office Unified Model models simulate observed BL structure

BAMS current issue

S. I. Bohnenstengel, S. E. Belcher, A. Aiken, J. D. Allan, G. Allen, A. Bacak, T. J. Bannan, J. F. Barlow, D. C. S. Beddows, W. J. Bloss, A. M. Booth, C. Chemel, O. Coceal, C. F. Di Marco, M. K. Dubey, K. H. Faloon, Z. L. Fleming, M. Furger, J. K. Gietl, R. R. Graves, D. C. Green, C. S. B. Grimmond, C. H. Halios, J. F. Hamilton, R. M. Harrison, M. R. Heal, D. E. Heard, C. Helfter, S. C. Herndon, R. E. Holmes, J. R. Hopkins, A. M. Jones, F. J. Kelly, S. Kotthaus, B. Langford, J. D. Lee, R. J. Leigh, A. C. Lewis, R. T. Lidster, F. D. Lopez-Hilfiker, J. B. McQuaid, C. Mohr, P. S. Monks, E. Nemitz, N. L. Ng, C. J. Percival, A. S. H. Prévôt, H. M. A. Ricketts, R. Sokhi, D. Stone, J. A. Thornton, A. H. Tremper, A. C. Valach, S. Visser, L. K. Whalley, L. R. Williams, L. Xu, D. E. Young, P. Zotter, (2015) *Meteorology, Air Quality, and Health in London: The ClearfLo Project*, **BAMS**, 96(5), 779-804