Case study of an urban heat island in London, UK: Comparison between observations and a high resolution numerical weather prediction model

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Why is this interesting?

Lots of people rely on forecasts of urban weather, but cities can be difficult to represent in forecast models.

Urban schemes must be compared with observations to assess their accuracy and impact.
Met Office 1.5 km model grid

Regent’s Park

Marylebone Road

Hyde Park
Representation of urban surfaces in the UKV

- Separate Roof and canyon tiles
- Accounts for in-canyon radiation exchange
- Roof thickness and canyon dimensions can be altered to suit local morphology

- Single ‘slab’ with defined roughness and heat capacity
- Radiatively coupled with soil (like a vegetation canopy)
- Simpler to implement

MORUSES (new)  
(Porson et al. 2010)  

Best scheme (operational)  
(Best 2005)
Science questions

• Can the UKV (1.5 km version of the Unified Model) accurately represent the structure of the urban boundary layer?
• Can the UKV reproduce the diurnal behaviour of temperature, heat fluxes etc. in London?
• Does the new heat flux scheme of MORUSES produce more physically realistic behaviour?
• What is causing any differences noted between the UKV and observations?
Case study (30/09 – 01/10 2011)

- Chosen because no clouds or fronts affected the area – simple(ish) situation.
- Conditions would be expected to produce a strong UHI, and remained the same for several days.
- The UBL would be strongly influenced by the urban surface energy balance in these conditions.
- Chilbolton (~100 km WSW of London) used as a rural reference site.
Day time BL depth is underestimated in both rural and urban areas

Time (UTC)

Height (m)

Time (UTC)

London, Chilbolton – model = pale lines
Using MORUSES increases sensible heat flux and reduces model time lag.
Rural site shows good daytime match, but model is too negative at night

Chilbolton (1.5 m)
Improvement in $H$ doesn’t translate to an improvement in temperature.

Suppressed diurnal cycle at rooftop site is similar to modelled rural behaviour. Delayed warming and cooling seems to be an urban effect.
Chilbolton

Rural site shows similar suppressed diurnal cycle, but no lag

Observations, operational UKV, UKV + MORUSES
Model captures structure of the wind field well, but tends to underestimate speed slightly.
Long-term comparison between model and observations doesn’t show a clear difference
Long-term comparison between model and observations doesn’t show a clear difference

The case study results may only apply in similar conditions – the longer dataset requires filtering to determine the affects of different meteorological conditions
Conclusions

• Some features of the UBL are reproduced by the model (higher BL top in urban area, wind field structure), but some are not (BL growth rate and maximum depth). This is influenced by the background state of the model.
• The operational UKV underestimates heat flux in London, and produces a phase lag of ~ 1-2 hours in the diurnal cycles of $T$ and $H$. (heat capacity too large?)
• Using MORUSES improves the modelled values and timing of $H$, but only gives a slight improvement in $T$.
• These conclusions cannot be generalised to the whole dataset – filtering by different conditions is required