Atmos. Meas. Tech. Discuss., 8, C158–C165, 2015
www.atmos-meas-tech-discuss.net/8/C158/2015/

Atmospheric Measurement Techniques
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Discussions

Interactive comment on "The effect of radiometer placement and view on inferred directional and hemispheric radiometric temperatures of a urban canopy" *by* C. Adderley et al.

Anonymous Referee #1

Received and published: 20 February 2015

General comments The presented study is highly relevant for improving the understanding of thermal properties of urban areas. It addresses one of the main challenges in observing long-wave radiation or surface temperatures of cities from different platforms: the implications of viewing geometry. An innovative approach was taken to generate a dataset from a real urban setting using a combination of creative measurements and data analysis. This unique dataset allows for critical issues such as thermal anisotropy and sensor viewing geometry to be analysed. Important conclusions are drawn that are relevant for observations of similar urban surface types. In general, the work is very well presented including well designed figures, however, some minor as-

pects (especially regarding the role of material properties) should be discussed more consistently.

Specific comments Page 1898, line 21: Although Kup is the shortwave radiation reflected at the surface, it is better not to call it 'shortwave reflectance' as this terms usually refers to the ability of the surface to reflect radiation, i.e. the ratio of Kup/Kdn

Page 1898, line 19: Comment on the spectral discrepancy between the FLIR and the CNR1.

Page 1900, line 6: Comment on the uncertainty from manual material identification for emissivity detection. Was there any ambiguity? Specifically comment on material class 'paint'. Given the large fraction of walls being this material class, it is quite critical to understand potential emissivity variations. How did you define the emissivity of the paint? Given emissivity of paint can vary immensely, detection 'by eye' may introduce errors. Are all walls painted with the same paint? Also, there are many types of 'rock' and stucco can have various compositions, how did you determine the emissivity value? The emissivity of aluminium can change with finishing and can also be effected by age and weathering, please comment on the state of the materials. It would be good to see a short sensitivity test on the impact of emissivity values assigned on the complete surface temperature.

Page 1901, line 5: Please comment on the accuracy of matching the USM pixels and to those of the PTST. Are you assuming a perfect overlap, i.e. no errors in the USM or the spherical tilt and azimuth angles assigned to the PTST pixels? Page 1901, line 16: Why is atmospheric correction highest for the road? Should it not make most impact over lawn where evaporation is higher?

Page 1901, line 16: Comment on uncertainly of atmospheric correction.

Page 1901, line 19: reference for equation 1

Page 1902, line 4: Is it correct that you approximate the canyon radiance based on the complete surface temperature? Would that not over-/underestimate the radiance incoming onto a wall or ground pixel given these actually do not 'see' the roof facets? Also, if the complete surface temperature is taken as a basis for canyon radiance, this does not take into account the distance of the facets to each other. For example, the walls will have most incoming radiance from the adjacent lawn rather than the road in the middle of the canyon and probably only little radiation is emitted between east and west facing walls given the large width of the canyon. Similarly, the lawns probably do not receive any radiation from the adjacent road. Please comment on the uncertainty associated with the assumption that relative location and distance of the facets is neglected.

Page 1902, line 12: Given the buildings are located in close distance to each other, how well does the PTST actually sample the south and north facing walls?

Page 1902, line 24: This is to say that the difference in SVF needs to be below the threshold? Say this explicitly.

Page 1903, line 7: What are the implications of this cap-filling procedure? Comment on the variability of surface temperature within one pixel class, i.e. at a given time how do temperatures differ between pixels with the same facet type, material type, orientation, and SVF? Probably ground pixels also require gap filling, e.g. for areas obstructed by buildings? How do you address the fact that ground surface to the east or west of a building exhibits different shading patterns during the day? Is this incorporated? How do you deal with the case if multiple replacement pixels are available but with a differing temperature? Do you use the average?

Page 1905, line 12: Why is the number of pixels per diameter fixed? Should this not vary with sensor height?

Page 1906, line 16: reference other studies discussing variations in roof temperature.

Page 1907, line 12: Please comment on the differences in night-time wall tempera-

tures: given the surface morphology of the study area, south and north facing walls have a much lower SVF than the east and west facing walls. In theory, the latter should cool easier – why could the south facing walls have the lowest temperatures? Is this due to small scale variations in wall structure, i.e. porches etc.? Or the vegetated ground surface in the vicinity? Could the small deviation be explained by sampling bias?

Page 1908, line 7-8: reword 'at this point a sensor with a narrow IFOV in the nadir sees mostly horizontal surfaces' – this is always the case. I think you rather want to point out that at this point, horizontal facets tend to be warmer than vertical ones, the latter being hardly sampled by the nadir sensor?

Page 1908, line 13: How do you explain the relative behaviour shown in Figure 5 and Figure 7? In Figure 5, the facet temperatures seem all very similar at about 9 am, one could assume that viewing geometry is least relevant at this time of day. However, best agreement between complete surface temperature and nadir view is found at 10.30 am instead as seen in Figure 7. True, at this point in time average wall temperature is close to the complete surface temperature (Figure 5) but this is the case for a much longer morning period.

Page 1909, line 4-5: check: 'overestimates' and 'underestimates' are misplaced

Page 1911, line 1: Radiation observed over west lawns higher when walls are within FOV, but are the west lawns themselves also warmer? Could the higher long-wave radiation also partly be explained by warmer grass temperatures as west lawns receive more incoming shortwave radiation because they are a) not shaded and b) also receive radiation reflected by the east-facing walls?

Page 1911, line 8: Point out where the 'lane' is. Not clear. According to Table 1, ground surfaces are either composed of concrete or grass, now higher radiation from roads is explained by areas being composed of asphalt – inconsistent.

Page 1911, line 19: True, Figure 5 shows roof facets to be warmer than the ground, however, Figure 10 now reveals that this is mainly attributed to the high surface fraction of grass. Only two roof positions show higher outgoing long-wave radiation compared to the road and lane surfaces observed with the hemispherical sensor just above the surface. While Lh just above road and lane ranges between 515-530 W m-2, only the west roof at y=0 and the east roof at y=30 show similar or higher values. The remaining four curves start at/below 515 W m-2. This raises the question on how much of the temperature differences is caused by geometry and shading and how much is related to material properties and other processes such as evaporative cooling. Discuss this also with respect to the applicability of your findings to other urban surface types, i.e. do you expect the same relation between roof and ground temperatures (Figure 5) in dense urban settings where less vegetation is present? Or is this behaviour representative for suburban land use only? (You mention this in the discussion on radiometer placement in Section 3.4, page 1904 – but would be good to make this more explicit during the analysis at this point already.)

Page 1911, line 22: Comment on the impact of roof orientation. Given the roofs are not flat and according to Figure 3 orientations vary between buildings, one could expect the buildings at x=30, y=-15 and x=30, y=15 to show higher temperatures at their east-facing roof parts in the morning?

Page 1911, line 22: How do you explain the rather high peak of west lawn, y=30 temperature at about 1.5 zb? Here, the lawn temperature exceeds the roof temperature west roof, y=30. If the contribution of road surface to the lawn positions is similar across the y-locations, how can this particular lawn position show such high radiation? Also, the radiation measurement over east lawn at y=30 does not seem to respond too the adjacent warm roof (east roof at y=30). Instead, the curve is very similar to the east lawn at y=-30 where the radiation from the roof is lower by about 20 W m-2.

Page 1911, line 24: Again, please re-visit your argument on the impact of material properties on the results presented. In Section 2.4 (page 1903) it is stated that the

analysis of L derived from corrected surface temperatures is not affected by emissivity or atmospheric effects, i.e. allowing isolated analysis of viewing geometry implications. Now variations in Lh are explained by differences in material composition and related emissivity (e.g. aluminium vs. asphalt for roof surfaces).

Page 1912, line 5: The across canyon variations are much more pronounced than the east-west comparison. Can you explain the differences of lawn observations at different y-locations? They do not necessarily seem to be related to variations in roof temperature which are similar at y=-30 and y=0 but vary clearly at y=30 between east and west roof, whereas radiation observed above east and west lawn is most similar at y=30. Can this be explained by variations in wall temperature?

Page 1912, line 11: What do you mean by ‘horizontal slices’? There is definitely varying behaviour across y-locations, e.g. radiation observed at 0.5zb over the east lawn at y=-30 appears significantly lower that that observed over east lawn at y=0.

Page 1912, line 12: How do you explain the increase of radiation observed over roads up to 1zb? According to Figure 5 and Figure 10, road surfaces are the warmest during night-time. Increased measurement height presumably increases the fraction of grass and walls contributing to the measurement of long-wave radiation. If these are relatively cooler than the road and lane surface, should L not decrease throughout the whole profile?

Page 1912, line 17: How do you explain the behaviour of the profiles over roof locations during the day relative to the night-time profiles? Judging from the analysis of Figure 10a, the west roof at y=0 is made of asphalt and the west roof at y=-30 is made of metal, the one at y=30 is somewhere in the middle. Whereas during night time, roof west at y=-30 and y=0 show very similar behaviour while the west roof at y=30 emits about 25 W m-2 more radiation. Can this be explained by material properties?

Page 1912, line 20: How do you define the convergence of the profiles? For the daytime case, you state convergence is reached at about 5zb and at about 6zb for the night-time. Judging from Figure 10a, the spread of profiles is about 10 W m-2 at 5zb a threshold which would be reached probably below 5zb in Figure 10b. A lower nighttime value for convergence would also be more consistent with the discussion in Section 3.4.

Page 1914, line 14: How could this be explained? Could it be that the extra conversions performed for the hemispherical sensor introduce further uncertainty? i.e. L is calculated per pixel, then corrected for cosine response and averaged to one integrated value which is then converted back to a hemispherical temperature, while T0,d is averaged only? At 8zb how much do vertical facets contribute to the IFOV of the hemispherical sensor? Or, could there be a bias introduced by the choice of location for the hemispherical radiometers? Even though they show clear convergence at 8zb minor differences remain that could be linked to the RMSE difference of 0.4 K. Would the curves look slightly different, if Lh was determined at e.g. y=-15 and y=15? Also it may not so surprising that the nadir temperature provides a good representation of the complete surface temperature in the current study, given the T0,C appears to be an average between T0, roof and T0,ground with the wall temperatures being very similar to T0,C (Figure 5). In such a case sampling the walls does not make a big impact given they are very similar to the average between roof and ground. In such a case it may be more important to sample every pixel of ground and roof surfaces in detail as is done by the nadir sensor?

Technical corrections

Page 1897, line 22: delete ‘to a’

Page 1901, line 2: ‘camera location’

Page 1904, line 4: ‘correct model of the 3D model’ – does this refer to the USM?

Page 1907, line 7: reference to Figure 5

Page 1909, line 18: Should this reference rather be ‘Fig. 8a’?

Page 1909, line 24: Should this TBP be T0,d?

Table 1: include reference for emissivity values in caption

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 1891, 2015.