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Sensor view and three-dimensional radiative transfer modelling for urban surface temperature estimation using ground based long wave infrared observations

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Remotely sensed (RS) skin surface temperatures Ts(rs) can be used to estimate the sensible heat flux QH across a range of spatial scales [1]. However, sampling a complete urban surface temperature Ts(c) [2] is extremely challenging due to the 3-dimensional nature of the urban surface. Surface temperatures exhibit a directional variability (or effective thermal anisotropy) caused by complex shadow patterns and radiation trapping. As RS observations are often restricted to certain view directions, this leads to the under-sampling of Ts(c) from Ts(rs) measurements [3]. The diversity of surface material thermal and radiative properties adds another source of variance.

A ground based network of Optris PI 160 infra-red (IR) cameras (Berlin, Germany, 7.5 – 13 μm, 160 x 120 pixel, 1 minute sample rate, 42° - 80° field of view) is installed at the comprehensive urban scale model (COSMO) site [4] (36o 01'36 N, 139o 42'16 E), Nippon Institute of Technology, Saitama prefecture, Japan to produce a high spatial and temporal resolution three-dimensional (3D) canopy brightness temperature (Tb3D) that includes vertical facets commonly under-sampled by remotely sensed imagery. The Tb3D product originates as a 3D surface class map with classes assigned an orientation (NESW, Roof, Ground) and insolation status (sunlit, shaded) for a given timestep. This product is created using a vector digital surface model (DSM) with orientation and insolation classes assigned using Blender 3D rendering software [5] and the Discrete Anisotropic Radiative model DART [6] respectively. IR camera observations for the timestep are then classified based on the surface type within each pixel instantaneous field of view using DART sensor perspective projection capabilities [7]. Tb3D is produced by extrapolating classified observations to their associated surface class in 3D space. The high temporal and spatial resolution of Tb3D is being used to explore the nature of long wave scattering and effective emissivity in urban areas for estimation of emissivity corrected skin surface temperature product (Ts3D). Ts3D can then be used to evaluate more conventional Ts(rs) products (e.g. from satellite RS platforms).

References

1. Xu, W., Wooster, M. J., & Grimmond, C. S. B. (2008). Modelling of urban sensible heat flux at multiple spatial scales: A demonstration using airborne hyperspectral imagery of Shanghai and a temperature–emissivity separation approach. Remote Sensing of Environment, 112(9), 3493–3510.
2. Voogt, J. a. & Oke, T.R., 1997. Complete Urban Surface Temperatures. Journal of Applied Meteorology, 36(9), pp.1117–1132.
3. Voogt, J. A., & Oke, T. R. (2003). Thermal remote sensing of urban climates, 86, 370–384.
4. Kanda, M. et al., 2007. Roughness lengths for momentum and heat derived from outdoor urban scale models. Journal of Applied Meteorology and Climatology, 46(7), pp.1067–1079.
5. Blender Foundation. (2015). Blender 2.76. <http://www.blender.org> [Viewed 01 December 2015].
6. Gastellu-Etchegorry, J. P., et al. (2015). Discrete Anisotropic Radiative Transfer (DART 5) for modeling airborne and satellite spectroradiometer and LIDAR acquisitions of natural and urban landscapes. Remote Sensing, 7(2), 1667-1701.
7. Yin, T., Lauret, N., & Gastellu-Etchegorry, J.-P. (2015). Simulating images of passive sensors with finite field of view by coupling 3-D radiative transfer model and sensor perspective projection. Remote Sensing of Environment, 162, 169–185.