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

William Morrison (1), Simone Kotthaus (1,2), Sue Grimmond (1), and Atsushi Inagaki (3)

(1) University of Reading, Meteorology, United Kingdom (w.morrison@pgr.reading.ac.uk), (2) Institut Pierre Simon Laplace, Ecole Polytechnique, France, (3) Tokyo Institute of Technology, Japan

Remotely sensed (RS) skin surface temperatures $T_s$ can be used to estimate the sensible heat flux $Q_H$ across a range of spatial scales [1]. However, sampling a complete urban surface temperature $T_s(c)$ [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 $T_s(c)$ from $T_s$ 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 ($T_b$) that includes vertical facets commonly under-sampled by remotely sensed imagery. The $T_b$ 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]. $T_b$ is produced by extrapolating classified observations to their associated surface class in 3D space. The high temporal and spatial resolution of $T_b$ 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 ($T_s$). $T_s$ can then be used to evaluate more conventional $T_s$ products (e.g. from satellite RS platforms).

References