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Anisotropy of thermal infrared remote sensing over urban areas : assessment from airborne data and modeling approach

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Due to the morphological complexity of the urban canopy and to the variability in thermal properties of the building materials, the heterogeneity of the surface temperatures generates a strong directional anisotropy of thermal infrared remote sensing signal. Thermal infrared (TIR) data obtained with an airborne FLIR camera over Toulouse (France) city centre during the CAPITOUL experiment (feb. 2004 – feb. 2005) show brightness temperature anisotropies ranging from 3 °C by night to more than 10 °C by sunny days.

These data have been analyzed in view of developing a simple approach to correct TIR satellite remote sensing from the canopy-generated anisotropy, and to further evaluate the sensible heat fluxes. The methodology is based on the identification of 6 different classes of surfaces: roofs, walls and grounds, sunlit or shaded, respectively.

The thermo-radiative model SOLENE is used to simulate, with a 1 m resolution computational grid, the surface temperatures of an 18000 m^2 urban district, in the same meteorological conditions as during the observation. A pixel-by-pixel comparison with both hand-held temperature measurements and airborne camera images allows to assess the actual values of the radiative and thermal parameters of the scene elements. SOLENE is then used to simulate a generic street-canyon geometry, whose sizes average the morphological parameters of the actual streets in the district, for 18 different geographical orientations. The simulated temperatures are then integrated for different viewing positions, taking into account shadowing and masking, and directional temperatures are determined for the 6 surface classes.

The class ratios in each viewing direction are derived from images of the district generated by using the POVRAY software, and used to weigh the temperatures of each class and to compute the resulting directional brightness temperature at the district scale for a given sun direction (time in the day). Simulated and measured anisotropies are finally compared for several flights over Toulouse in summer and winter.

An inverse method is further proposed to obtain the surface temperatures from the directional brightness temperatures, which may be extended to deduce the sensible heat fluxes separately from the buildings and from the ground.