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Evaluation of the thermal structure in an urban street canyon: field measurements and model simulation

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The results of a research project, aiming at providing tools and criteria to evaluate the temperature field inside an urban street canyon, are presented. Temperature measurements have been carried out, both in summertime and in wintertime, inside a North-South oriented urban canyon in the city of Trento (Italy) in the Alps, with sensors placed at various heights on the front of buildings flanking the street and on top of traffic lights in the middle of the canyon.

The results have been analyzed in comparison with data from an automated weather station placed close to the street canyon, at 33 m above ground level and taken as a reference for the above roof-top level.

During sunny days a well defined cycle was identified in the daily evolution of air temperature measured by the sensors inside the urban canyon, which was primarily influenced by direct solar radiation. As expected, during the morning the East-facing sensors warmed up faster than the other ones, while in the afternoon the West-facing instruments were the warmest.

In most cases the air temperature inside the canyon was higher than above roof level, with differences depending on weather conditions and hour of the day.

The dataset allowed to characterize the microclimate of the urban canopy layer and provided a basis for testing the ability of a simple numerical model to simulate the thermal structure inside the urban canyon. The model displays the following characteristics: assignment of distinct surface types (road, walls and roofs), in order to better simulate their physical properties; computation of radiative exchanges inside the canyon based on view factors between the different surfaces and explicitly treating both the solar reflections and the shadows; storage heat flux simulated by means of the heat conduction equation. The model requires as input the geometry parameters of the street and the values of meteorological variables measured above roof level. The main outputs are the heat fluxes determined by the surface energy balance (road, building fronts), the surface temperatures and the average air temperature inside the urban canyon.

The comparison between the results of the model and the measurements made during the field experiments displays a good agreement, with an average error of 0.3-0.4 °C on the evaluation of the mean air temperature inside the street canyon. This result is remarkable, especially considering the low level of complexity of the numerical code and the simplifying assumptions made.