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Impact of cool roofs on thermal comfort and air quality at street level during a heat wave episode in Madrid

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Cool roofs have higher solar reflectance and thermal emissivity than conventional roofs, decreasing the temperature of buildings during sunlight hours. This benefits the buildings (reducing the cooling loads) and the environment (improving the outdoor thermal comfort) during summer. However, cool roofs' impact on outdoor air quality is not well known.

Computational Fluid Dynamic (CFD) models allow the evaluation of environmental improvement measures at very high spatial resolution. Nevertheless, microscale studies combining outdoor thermal comfort and air quality at district or city scales have been scarce in the literature due to the computational cost involved.

The objective of this work is to estimate the impact of cool roofs on outdoor thermal comfort and air quality at the district scale. For this purpose, a CFD model is used considering:

- atmospheric flows through a URANS (Unsteady Reynolds-Averaged Navier-Stokes) approach
- traffic-related NO_X dispersion as a passive scalar
- thermal loads using a complete radiation model (solar radiation, radiation from the environment, transmission through non-opaque surfaces, and emission from non-transparent surfaces)
- thermal and optical properties of the building envelope
- energy storage in walls, floors and roofs (in glazing is negligible) through a non-steady state conjugate heat transfer model between the outdoor and indoor

Firstly, some scenarios of the COSMO experiment (Kawai et al., 2007) are simulated to evaluate the model performance. Finally, the cool roof impact is estimated during 24 hours of a heat wave episode in a district of Madrid (Spain), characterized by a regular morphology (aligned blocks of H=15 m and H/W=1).

Results show that cool roofs modify the urban meteorology (mean radiant temperature, air temperature, wind speed and turbulent kinetic energy), decreasing the Universal Thermal Climate Index, UTCI, at pedestrian height, especially upstream and during hours of higher irradiance.

However, depending on the wind speed, cool roofs can generate thermal inversions at building height affecting the pollutant dispersion within the streets. This fact increases the pollutant concentration at pedestrian height.