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Interconnections of the urban heat island with the spatial and temporal micrometeorological variability in Rome

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The interconnections between the spatial-temporal anomalies of temperature, wind speed, relative humidity are investigated together with turbulent and radiative fluxes at the urban site of Rome and its rural surroundings. The annual and diurnal behavior of the anomalies (Urban-Rural) is important to predict the possible impacts of the future land-use development on air pollution and climate change in urban areas. A three-year dataset from 4 automated micrometeorological stations located in and around the city of Rome is used. The stations are part of the regional network for weather and air quality monitoring run by the Regional Agency for Environment Protection (ARPA) of Lazio. Positive temperature anomalies, ranging from 1°C to 2°C, are observed all year round from 0000 ST to 0700 ST and from 1100 ST to 2400 ST. The highest values occur in July and August. Only for a few hours (from 0700 ST to 1100 ST), the city is, at most, 1°C cooler than the surrounding areas. Due to the impermeability of the surfaces and the scarce vegetation, the sensible heat in the city, reaches the peak value 3 hours later than in the rural areas in all seasons with a peak varying between 250 Wm-2 (summer) and 70 Wm-2 (winter). In the afternoon, the sensible heat flux in the city decreases more gradually than in rural areas and, even at night, remains positive. A positive anomaly of the sensible heat flux (maximum value 120 Wm-2 during the summer) is observed from 1400 ST to 2400 ST. Only in the early morning, the urban structure releases the heat stored during the day and the anomaly becomes negative. The turbulent kinetic energy shows a similar behavior. Furthermore, due to its thermal capacity and roughness the city evidences a residual turbulence during the night that attenuates or cancels the atmospheric stability. This turbulent nocturnal boundary layer contribute to reduce the local effect of polluting emissions by distributing them throughout the urban area but, at the same time, possibly favoring the chemical reactions that give rise to the formation of secondary particles.
The roughness elements reduce the local wind over the city. In addition, as the hot air in the city center locally lowers the pressure, a toroidal circulation develops reducing the sea breeze. The wind speed over the city (maximum values 3 ms-1 in summer at 1600-1700 ST) is always lower than in the surrounding areas (4.5-5 ms-1 in summer at 1600 -1700 ST). The wind speed anomalies strongly decrease after 1900 ST up to the 1000 ST of the day after.