Effect of aerosol optical scattering and absorbing properties on the Urban heat island intensity during summertime in Rome, Italy

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In 2023, the Italian project "uRban hEat and pollution iSlands inTerAction in Rome and possible miTigation strategies" (RESTART) has been funded by the Italian Ministry for University and Research for 2 years. RESTART aims to explore the interaction between the Urban Heat Island (UHI) and the Urban Pollution Island (UPI) in Rome (Italy), providing a series of mitigation strategies, including tailored Nature-Based Solutions, and ready-to-use guidelines for the improvement of well-being and liveability in urban environments.

The city of Rome (Lat. 41.90 °N, Lon. 12.54 °E) is the most populous and extended Italian city and the third most densely populated metropolis in Europe. Rome is located in the central region of the Italian Peninsula, about 27 km inland from the Tyrrhenian coast. Due to its position in the middle of the Mediterranean Basin and the complex orography of its surroundings, the city is frequently subjected to the advection of Saharan dust in the case of persistent southerly winds, and to the sea breeze regime from the southwest, the latter particularly evident during summertime under anticyclonic conditions. In recent years, the city has experienced significant atmospheric warming and a substantial intensification of extreme weather events, such as heat waves (HW), tropical nights, and droughts.

Within the objectives of this project, an exploratory study was performed on the possible connections between the columnar aerosol optical properties Aerosol Optical Depth (AOD), Single Scattering Albedo (SSA) and Angstrom exponent (Ang), obtained by the SKYNET network, and the Urban Heat Island intensities (UHII) in Rome in the Summer 2022.

The wavelength dependence of this impact within the region 340-1020 nm, during daytime and nighttime (only AOD and ANG in this part of the day), and during HW events was analysed. A relationship between the clear sky (no clouds) aerosol columnar optical properties and the UHII in Rome was found, particularly: i) AOD in the entire summer period was found to be generally anti-correlated with UHII, with the anti-correlation increasing during HW events; during nighttime the correlation was positive; ii) Ang, calculated at the two wavelengths 340-500, was also anticorrelated; iii) SSA and UHII were found to be always correlated, with a weaker correlation during HW events.

The obtained results look physically reasonable. Aerosols, by scattering and absorption, reduce the direct Sun irradiance reaching the surface and possibly contribute to a reduction of the air temperature at the ground. A mechanism which possibly explains the anticorrelation during daytime is that the greatest is the AOD, the larger is the contribution to the temperature reduction and the smaller is the UHII. Concerning ANG, the smaller the particles in the atmosphere (larger ANG values) and the more isotropic is the diffused radiation field which means a reduction of total sunlight reaching the surface and smaller values of UHII, which is consistent with the anti-correlation. Finally, large values of SSA mean less absorbing aerosol in the atmosphere and more radiation reaching the ground level, which is consistent with a correlation between UHII and SSA. But how strong is this radiative impact with respect to the meteorological effects that can both favour or inhibit the development of the UHI, and changing the aerosol properties?

To tackle this question, broad band radiative transfer models (Rstar [1] and Mstrn [2]) will be run to retrieve the radiative forcing of the aerosol having the optical properties measured and retrieved by the SKYNET network in the site of Rome. Other ancillary measurements, necessary as input to the models (e.g., water vapour and aerosol vertical profiles and total ozone amount) will be obtained by real measurements (if available) or climatological studies. The results from this study will be presented in this work.

References

[1] Nakajima, T., and M. Tanaka, 1986: Matrix formulations for the transfer of solar radiation in a plane-parallel scattering atmosphere. J. Quant. Spectrosc. Radiat. Transfer, 35, 13–21, https://doi.org/10.1016/0022-4073(86)90088-9.

[2] Sekiguchi, M., and T. Nakajima, 2008: A k-distribution- based radiation code and its computational optimization for an atmospheric general circulation model, J. Quant. Spectrosc. Radiat. Transfer, 109, 2779 –2793

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