

Title: Anthropogenic heat forcings and the Urban Heat Island Effect in Rotterdam, The Netherlands

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Recently, it gets broadly acknowledged that the release of heat due to anthropogenic activities (anthropogenic heating) is a major component of the urban energy budget. Anthropogenic heating is therefore one of the major causes of the additional heating of cities as compared to the surrounding rural areas, commonly known as the Urban Heat Island effect. In this study the effect of anthropogenic heating on the climate of the Dutch coastal town Rotterdam. The city of Rotterdam is quite special, as estimates by the Large scale Urban Consumption of energy (LUCY) model have revealed that anthropogenic emissions of the city and particularly the harbor area of Rotterdam are very high as compared to other cities in Europe. Also, the city of Rotterdam is interesting, as its meteorology is rather complex due to multiple processes such as the interaction between the sea and the land, the availability of open water close to the city centre and other large cities and industrial area in its environment. To study the impact of anthropogenic heat sources on the urban meteorology of Rotterdam, detailed simulations of the urban meteorology of Rotterdam have been performed with both the 3D and the 1D version of the Weather Research & Forecasting (WRF) model. This model incorporates a detailed description of the exchange processes between the urban surface and the overlying atmosphere, the so-called SLUCM model. From our simulations it becomes apparent that the effect of anthropogenic emissions on the UHI is (locally) significant. From our study it appears that the anthropogenic emissions contribute to UHI effect with values up to 1.5 K for an anthropogenic emission of 100 W m^{-2} , locally emitted in the core of the industrial and residential heart of Rotterdam and the surrounding large cities.