Summary

The air temperature in cities is generally higher than in the nearby rural areas, a phenomenon which is referred to as the urban heat island effect. While, on average, this temperature difference amounts to a few °C, under certain circumstances it can increase to 7-8 °C and more. It has been demonstrated that, during heat waves, the additional heat stress may give rise to excess mortality in the urban population. Apart from these health effects, the urban heat island has an impact on enhanced energy use (air conditioning devices), and on transportation infrastructure (among other things, damage to railway tracks). With the projected rising temperature associated with global warming, the impact and relevance of the urban heat island is expected to further increase in the future.

The present report describes the development and application of new indicators of the urban heat island in the Flemish Region in Northern Belgium.

In a first step, an indicator was established, based on **in-situ** measurements. Following an analysis of existing observational data sets, an indicator was developed for Antwerp, using measurements acquired at VITO's climate stations in and near the city. The resulting *Heat Wave Degree Days* indicator was defined as the cumulative exceedance of the daily minimum and maximum temperature, beyond limit values prescribed by the Federal Public Service for Public Health. Thus defined, the indicator is a measure for both the duration as the intensity of a heat wave. By plotting together the urban and rural values of this indicator, the urban heat island effect emerges prominently. Using observations for the period 2012-2014, it was found that the value of the indicator is considerably higher in the city than in the nearby rural areas. It should be noted that this in-situ indicator currently is fraught with certain limitations, mainly because (1) the time period with available data is rather short, and (2) the required data are currently being measured in one city only (i.e., Antwerp). Regarding this latter restriction, recommendations were made for an extension of the measurement activities towards other urban areas.

Subsequently, an urban heat island indicator was developed based on **thermal infrared satellite imagery**, which has the advantage of providing full spatial coverage, and to be available for relatively long time periods. After an initial analysis, including an assessment of the spatial versus the temporal resolution of available data, we selected imagery from sun-synchronous satellite platforms with a pixel size of approximately 1 km as a source to establish the indicator with. Two indicators were derived from these data: the *Hot Island Area* (*Population*) yields the percentage of the surface area (population) in the Flemish Region experiencing land surface temperatures in excess of pre-defined threshold values. This indicator was calculated for the period 2002-2013, in which the hot Summers of 2003 and 2006 could be clearly identified. Moreover, the satellite-based indicator was employed to compare the urban heat island of different cities in the study domain.

In a final step, a **model-based** indicator for the urban heat island was developed. The advantage of modelling, in addition to its full spatial coverage, is the capability to perform calculations of future projections and scenarios. Use was made of the CCLM regional climate model, configured with a high spatial resolution of 2.8 km, and containing a recently developed urban surface exchange module. The indicator developed is calculated in the same manner as the above-mentioned in-situ indicator, i.e., the *Heat Wave Degree Days*. Yet, rather than producing one value each year, the model-based approach generates maps containing the spatial distribution of indicator values. Model simulations were conducted for the present situation, as well as for the future (2060-2070), considering several climate scenarios for the latter. Moreover, the model was employed to assess the relative impact (compared to that of climate change) of urbanisation on the urban heat island effect. The main conclusion here is that urban heat stress is expected to increase drastically in the future.