5.6 Heat Stress

Definition

Urban areas are generally warmer than surrounding rural areas. This temperature difference is greatest during the night and can level up to 10°C. This so-called "Urban Heat Island"(heat stress) is usually caused by heat absorption in paved materials which enlarge heat accumulation during the day and radiate infrared heat during the night (Leven met Water, 2008:2).

General assumption

The heat stress is measured by a barometer of UNESCO-IHE developed by Wiliam Veerbeek (Veerbeek, 2010). The heat stress depends on the distribution of heat in relation to the type of land use. Different types of land use are responsible for the warming or cooling effect compared to the ambient temperature. The sensitivity to heat stress is determined by the average temperature increase for the area (total area or neighbourhood) under the influence of a change in land use (Veerbeek, 2010).

The heat stress barometer determines both the relative sensitivity and absolute sensitivity. The relative sensitivity is calculated by the new sensitivity to heat stress that is compared with the current / former situation. The absolute sensitivity is the average temperature increase per degree rise in temperature (Veerbeek, 2010). The heat stress occurs in the interval from 25 to 35 degrees. The numerical increase or decrease of the heat stress is calculated based on the average between four discrete temperatures. The table for heat stress related to different types of land use is shown below (Source information table (Veerbeek, 2010))

Landuse	DT	Landuse	DT
Builded area	5	Mixed forest	-9
Large buildings	6	Poplar lane	-7
Warehouses	7	Arable land	-1
High way	7	Pastures	-6
Paved road (2 loans)	4	Orchard	-8
Dirt road	3	Sand	-1
Pedestrian area	8	Soil (additional)	6
Street	3	Cemetery	-3
Cycling lane	5	Fruit Finyard	-6
Parking	8	Dock	0
Forest (Deciduous)	-10	House	4
Forest (Pine trees)	-9	Coast	-10
Surface water	-10		

Table 5.3 Heat stress land use

Model in the Climategame

The heat stress indicator is based on the heat barometer developed by UNESCO IHE. This indicator counts for the increase in temperature due to the use of paved surface. This heat stress is countered by replacing paved surface by green or water surface. These covers will decrease the heat stress of the area.

The goal is to keep the amount of heat stress as low as possible. The heat stress indicator score is determined by the weighted sum of heat scores for each neighbourhood.

$$hE_i = \sum_{t=1}^{n} w_d \cdot calcDTDX\,(i)$$

Where n_h is the number of tiles in neighbourhood h and hE_i is the smoothed heat value of tile i. Each tile has a smoothed heat value, which is calculated by applying a smoothing filter on the heat effect values of the tile and its neighbours within the proximity of 40 meters.

$$calcDTDX\,(i) = \frac{TE\,(35,i) - TE\,(30,i)}{5} + \frac{TE\,(30,i) - TE\,(25,i)}{5} + \frac{TE\,(25,i) - TE\,(20,i)}{5} \qquad (1.15)$$

The function *calcDTDX* calculates the heat value for tile i. This formula is explained below.

$$TE\,(T,i) = CF * (DT_i + 0.1 * DT_i * (T - 20))$$

Where CF is a constant with value 0.6, and DT_i is the heat effect value of tile i.

Importance

The goal is to keep the amount of heat stress as low as possible. The heat stress indicator is especially important for the municipality. In combination with increasing livability measures, both heat stress and livability can be improved.

5.6.1 Game measures

Below an overview is given to show which measures can be taken to have a positive effect on the Heat Stress.

- Realize open water
- Realize green roofs, garden roofs
- Realize Permeable Parking
- Realize parks, forests, fountains
- Realize parking with green roofs
- Realize water squares
- Realize waterways

6.4 Heat Stress

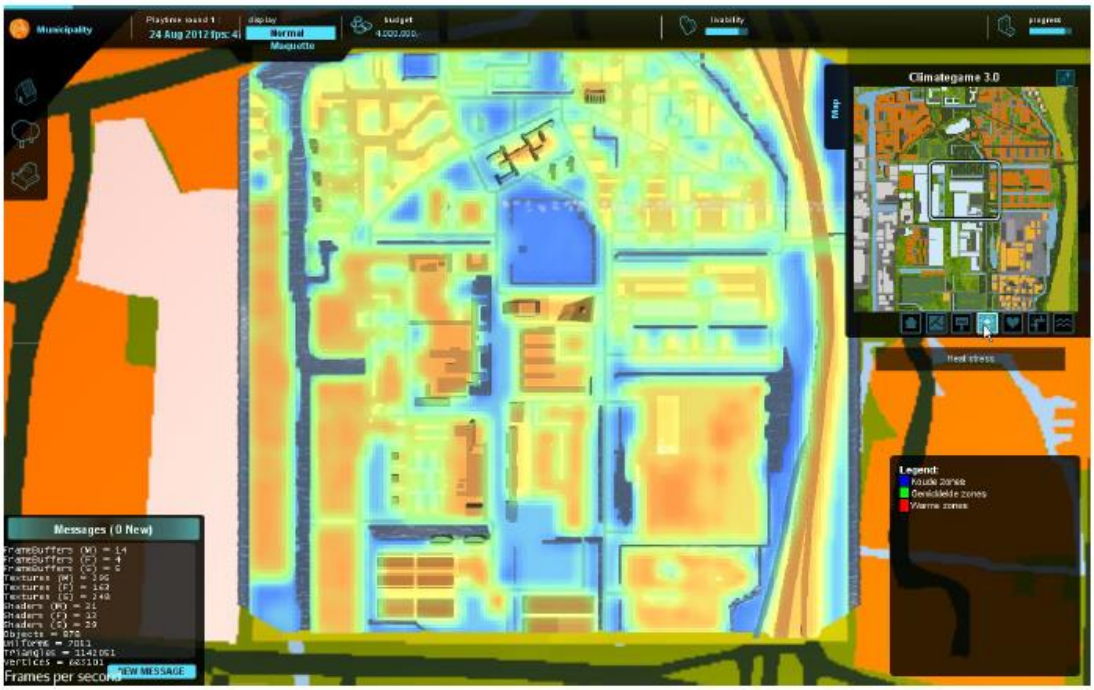

Figure 6.9 Heat stress overlay

The heat stress overlay displays the average temperature on a certain location. This overlay is used for investigating areas with the most heat-stress. The overlay displays three different main colours: blue (cool temperature), green (average temperature), and red (higher temperature).

Blue (Cool temperature)

The blue areas are cool areas. They are mostly open water and areas with a lot of green.

Green (Average temperature)

The green areas are average areas. These areas are mostly situated close to buildings and roads, and are often transitional areas.

Red (High temperature)

The red areas are areas with a higher temperature. Those areas radiate a lot of heat. Dark roofs on office buildings or industrial areas often characterize those areas.

For more detailed information about the heat-stress (and the indicator) see **Error! Reference source not found.**.