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# Modeling the influence of open water surfaces on summertime temperatures and thermal comfort in the city

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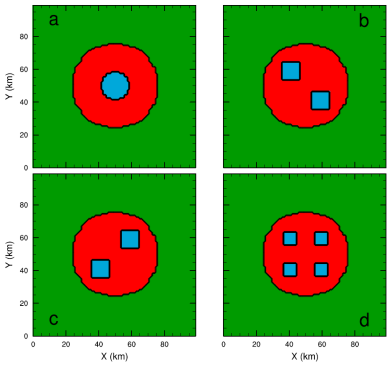
## Background

Urban areas experience a substantially different weather than its rural surroundings. In warm episodes cities are usually warmer than the countryside. This may lead to adverse human thermal comfort and heat stress. Water bodies are often introduced to mitigate these adverse effects (Fig 1). Here we study whether water bodies are indeed cooling the city. Or are they a source of additional heat load?

*Figure 1: Water bodies are widely used to improve the urban climate.*

## Methods

These mesoscale meteorological model WRF has been employed for an academic circular city in Europe. Herein 10% of the area is covered by water. We study the impact of the spatial distribution of the water (Fig. 2), and the sensitivity to water temperature from 10ºC-20ºC.




Model results show that introduction of the lakes cools the city in a confined downwind plume during daytime, for all water temperatures. At night however, an evident warming plume is found for water temperatures of 15ºC and 20ºC, which even propagates beyond the city border.

*Figure 2: Set up of the model configuration for water.*

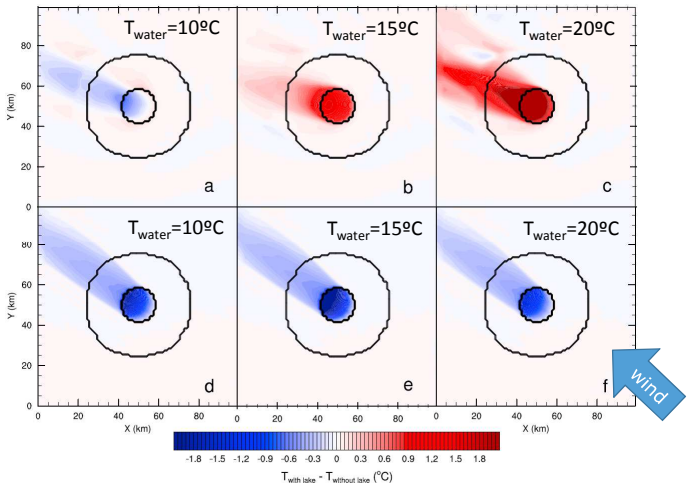



*Figure 3: Spatial distribution of air temperature change due to the introduction of a lake. Top: 6 local time. Bottom : 16 local time.*

## Results

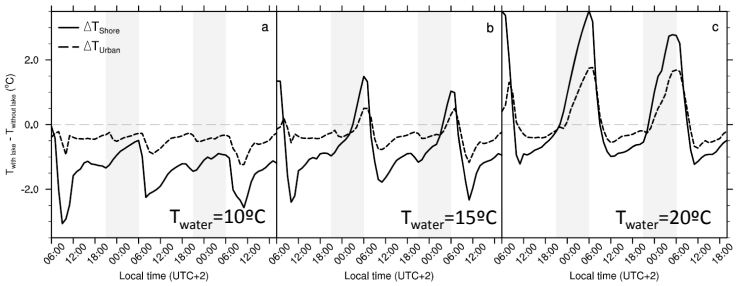



*Figure 4: Air temperature change at the lake shore and downwind due to introduction of an urban lake for different temperatures.*

Figure 4 shows that the thermal effects decay with distance from the lake. The warming effect by lakes is confirmed by data from hobby meteorologists in the Netherlands (Fig 5-left). WRF shows that the daytime cooling effect is largest for the single lake configuration, though the spatial impact is largest with 4 lakes (Fig. 5-right). Finally, a substantial part of the gained daytime thermal comfort by cooling, expressed in the wet bulb globe temperature, is limited by the extra humidity (Fig. 6). This compensation may reach up to 33%.

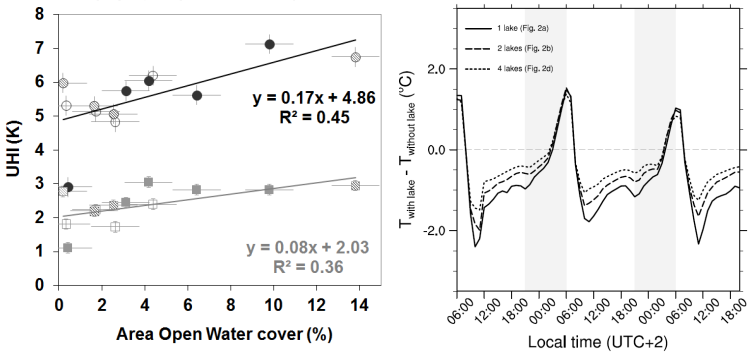



*Figure 5: Left: Observed median (grey) and the 95 percentile (black) of the UHI vs water cover. Vegetation fraction (VF) indicated by the marker fill, full: VF < 15%, dashed 15%< VF <30%, open: VF >30% (Steeneveld et al 2011;2013). Right: Air temperature change at the lake shore as function of the lake spatial distribution.*

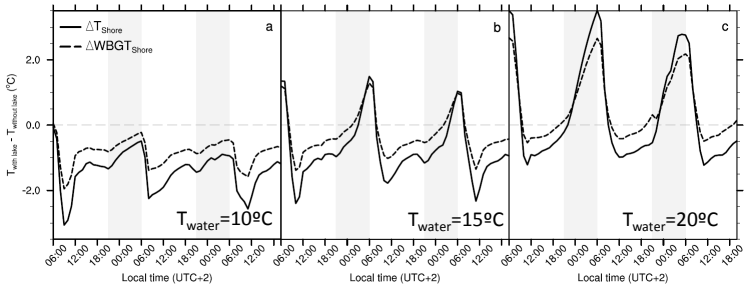



*Figure 6: Air temperature change at the lake shore and downwind due to introduction of an urban lake for different temperatures.*

## Conclusions

- Water bodies cool urban areas during daytime. However, they act as warming elements at night, especially in late summer and early autumn.
- The daytime improvement of thermal comfort due to the cooling effect of water bodies is substantially counteracted by increased humidity.
- Multiple small lakes affect a spatially larger area than a single large lake, but the thermal effect is strongest for a single large lake.

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**References**

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