# Cooling power of urban river under the background of urbanization

## Abstract

## Introduction

### 1.1. UHI

* 城市化正在进行
* 城市化对环境的影响
* 城市热岛效应
* 热岛效应的危害
* 需要相关手段
* With population explosion and economic development, urbanization has witnessed significant global expansion globally.
* According to the prediction from the United Nations, this trend will continue in the following decades and the urbanization rate is estimated to be up to 68 % by 2050 (United Nations. 2019).
* As has been observed in numerous cities over the world, urbanization has caused adverse effects on local environment, such as water and air pollution, ecosystem degradation and urban heat island (Wang et al., 2020; Ahmad et al., 2021).
* Urban heat island is a phenomenon by which temperature tends to be higher in urban areas compared to the surrounding rural areas.
* Elevated temperature is found to increase energy consumption in summer and pose a threat to public health (Guan et al., 2017; Nieuwenhuijsen et al., 2018).
* Therefore, certain measures are necessary to address the associated negative effects.

## 1.2. 水体降温效应

* 目前，主要的城市降温措施包括改变表面材料、优化土地覆盖、促进通风等。
* 对于土地覆盖与利用，水体的影响关注较多。
* 水体包括河流、湖泊等类型
* 由于水体的热特性，其对周边热气候有显著影响。在白天的大多数时候，水体对周边环境有降温效应。
* 降温范围
* 湖泊和河流是城市水体的主要类型，两者具有不同的形态特征。在城市内，多数湖泊面积较小，并分散于城市内各处，而河流呈狭长型线性布局，多数贯穿整个城市。由于上述不同，河流与湖泊对周边环境的温湿效应存在差异。比如，在我国东北城市长春和吉林市，河流对周边环境的降温效应显著强于湖泊和绿地 (Xue et al., 2019)。
* 相对湖泊，河流相关研究较少
* 在有限的河流热效应研究中存在的不足
* Primary measures to address excessive urban heat include altering surface materials, optimizing spatial layout of land cover, and promoting ventilation (Azhdari et al., 2018; Taleghani，2018; He, 2020).
* In terms of land cover, the impact of water bodies have received much attention.
* Compared to impermeable surfaces, water has a low thermal conductivity and a high specific heat capacity. This causes the water surface to absorb less heat during the day, resulting in lower temperatures.
* The temperature contrasts can contribute to the heat transfer between water surfaces and surrounding urban areas and further cool the waterfront areas.
* According to an observation in summer, a 22-meter river can generate a temperature reduction of up to 1.5 °C in in Sheffield, UK (Hathway et al., 2012).
* In urban areas, rivers and lakes are 2 major types of water bodies and they have different characteristics.
* Most lakes are relatively small in size and scattered throughout the city, while rivers have a narrow and linear layout, mostly traversing the entire urban area.
* Due to these differences, rivers and lakes exhibit contrasts in their thermal effects on the surrounding environment.
* In the northeastern Chinese cities of Changchun and Jilin City, rivers have significantly stronger cooling effects on the surrounding environment compared to lakes and green spaces. (Xue et al., 2019)
* Currently, researches on the cooling effects of urban water bodies primarily focus on lakes, with fewer studies addressing the impacts on rivers.

### 1.3. 城市化对UHI的影响

* 伴随着快速的城市化过程，土地利用正在广泛地改变
* 土地利用变化对气候的影响：城市化引起的城市土地覆盖变化（ULCC）主要是由于植被覆盖的减少引起的。
* 介绍相关研究
* 相应地，土地利用变化对热变量与环境因素的关系也有影响
* 因此，在城市化背景下，水体对周边的热效应会发生显著变化。
* 目前，相关研究对动态的城市化过程对水体热效应的影响的研究不足，需要从这一角度进行研究。
* Along with the rapid urbanization process, the spatial patterns of land cover are undergoing widespread changes in most cities, which are mainly generated by the decline of vegetation cover.
* Correspondingly, changes in land cover of waterfront areas also have significant impacts on the thermal effects of water bodies. Currently, relevant studies of water cooling effect are mostly restricted in a certain year. The annual changes of water cooling under the background of urbanization have not been well investigated. Chongqing is a metropolitan city consisted of more than 10 million people. Like most Chinese cities, Chongqing has experienced a continuous urbanization process for more than 30 years. In this study, we select Chongqing as an example to analyse the changes and its influencing factors of water cooling effect under the rapid urbanization.

### 1.5. 研究目的

重庆是中国西部最大的城市之一，最近30年来经历了快速的城市化过程。在此期间，温度和地表格局发生了显著的变化，温度格局也相应改变。因此，本研究拟以重庆为例分析降温效应：（1）降温的空间格局是什么（2）降温的时间变化（3）时空变化与环境因素的关系

## 2. Data and Methods

本研究的分析方法如下：首先基于遥感数据计算地表温度，设置500米宽的缓冲区，计算缓冲区内的降温指标。该阈值的设置是基于温度指标与环境因素的相关性得到的。通过将降温指标与环境因素进行相关分析，相关性最高的则为500米。在每1000米河岸长度设置一个缓冲区。然后计算各缓冲区对应的环境因素和降温指标，进行相关分析，流程图如下：

### 2.1. Study area

* Chongqing is located in the upper reach of the Yangtze River in southwest China. The Yangtze River runs through the metropolitan area and its main tributary, the Jialing River, converges with the Yangtze River in the city.
* The urban area of Chongqing is located in a subtropical monsoon climate zone.
* Influenced by the surrounding topography and, the average wind speed is less than 3 m/s, and the average humidity is over 70% throughout the year.
* The summer period typically lasts from June to September, during which temperatures often exceed 35°C, especially in July and August. The highest temperatures can reach up to 43°C.
* In the past 20 years, the urban area of Chongqing has undergone rapid expansion, with the built-up area increasing from 200 km²in 2000 to 700 km²in 2021, and the urban population growing from 2 million in 2000 to 9 million in 2020.

### 2.2. Data

* The surface temperature data used in this study were obtained from the Landsat-5 and Landsat-8 datasets, provided by the United States Geological Survey (USGS) (https://earthexplorer.usgs.gov/). For the period from 2000 to 2023, each year from June to September was considered as the summer season, and one cloud-free data product with a spatial resolution of 30 meters was selected for each year.
* Additionally, land cover data were sourced from the CLCD 2021 Landuse dataset of China, with a spatial resolution of 30 meters. This dataset was computed from Landsat data on the Google Earth Engine platform. It covers land cover type distribution in China from 1985 to the present, categorizing land cover types into nine classes, with a spatial resolution of 30 meters and a temporal resolution of one year. Currently, this dataset has been applied in various research areas, including land cover, ecology, urban climate, and more.
* Terrain data were obtained from the SRTM V3 dataset.

### 2.3. Land surface temperature

### 2.4. Indexes of water cooling effect

* 之前的相关研究中，主要考虑了

### 2.5. Calculation of impact factors

* 该研究中所考虑水体降温效应有潜在影响的环境因素主要包括地理位置、地形、空间覆盖等因素。其中，空间格局的因素包括空间组成和配置。组成变量包括对应缓冲区的蓝、绿、灰的面积比例，配置变量包括各土地利用类型的斑块形状指数、patch index等。
* XX指数表示XX。LSI表示XX，当LSI为1表示，LSI为0则表示
* 在地理位置变量方面，我们考虑了各缓冲区中心点的经度、纬度、距市中心的距离，垂直于河岸线的朝向。在地形方面，我们考虑了

### 2.6. Statistical analysis

首先计算河流特征描述符，绘制了散点图以检查它们与 RCI 和 RCD 的关系。对于空间格局变量和位置变量，我们进行了 Pearson 相关分析以检验它们与 RCI 和 RCD 的线性关系。然后建立了两个逐步[多元回归](https://www.sciencedirect.com/topics/social-sciences/multivariate-regression" \o "从 ScienceDirect 的 AI 生成的主题页面了解有关多元回归的更多信息)模型，分别以RCI和RCD为因变量，探讨变量对RCE的相对贡献。

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