

Solar Energy Resource in Urban Heat Islands

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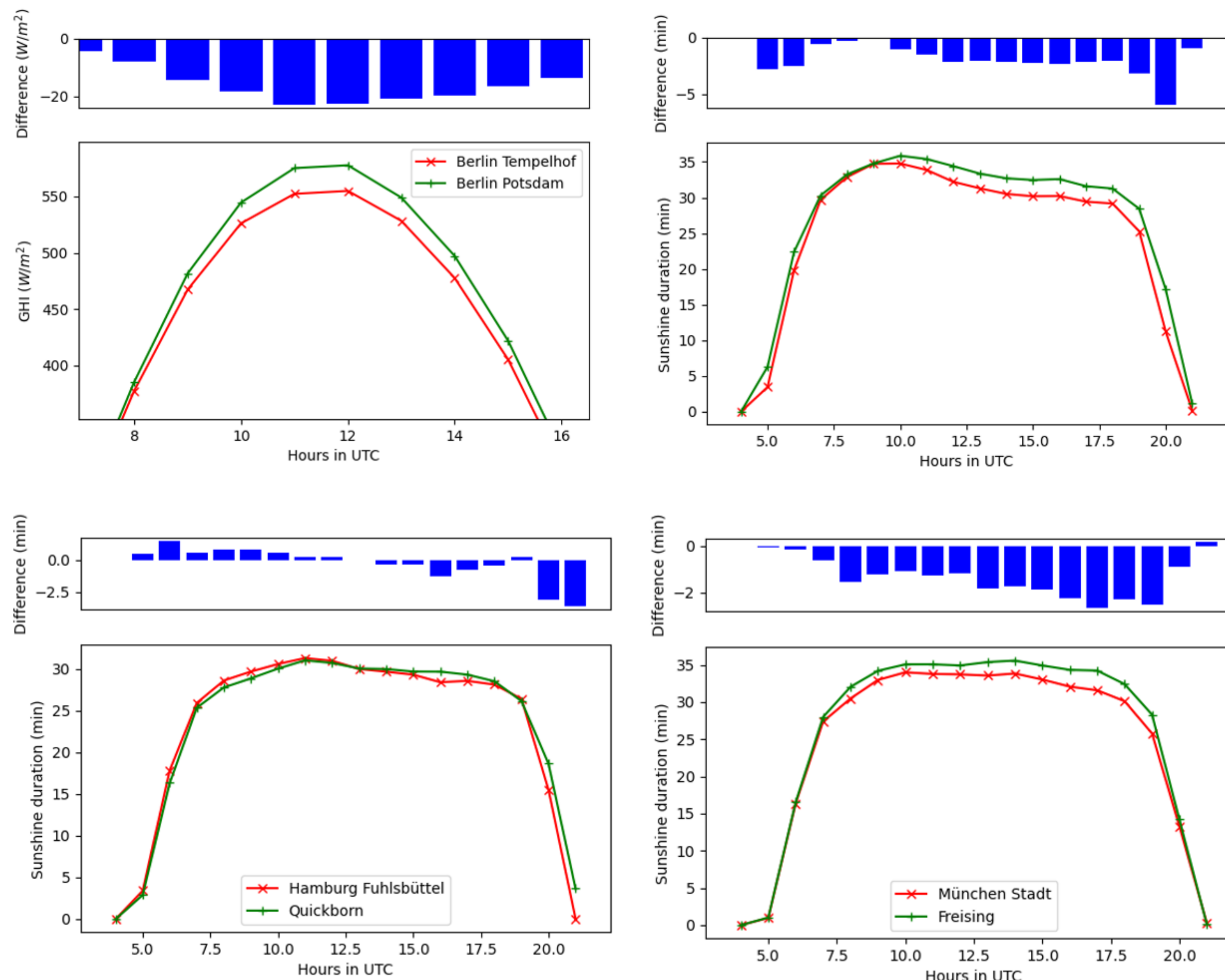


Figure 1: Diurnal variation in GHI (at the Berlin site pairs) and the sunshine duration (at the Berlin, Hamburg and Munich site pairs)

Table 1: List of study sites

Site pairs	Station inside the city	Station outside the city	Separation
Berlin	Tempelhof	Potsdam	25 km
Hamburg	Fuhlsbüttel	Quickborn	19 km
Munich	Heideckstraße	Freising	29 km

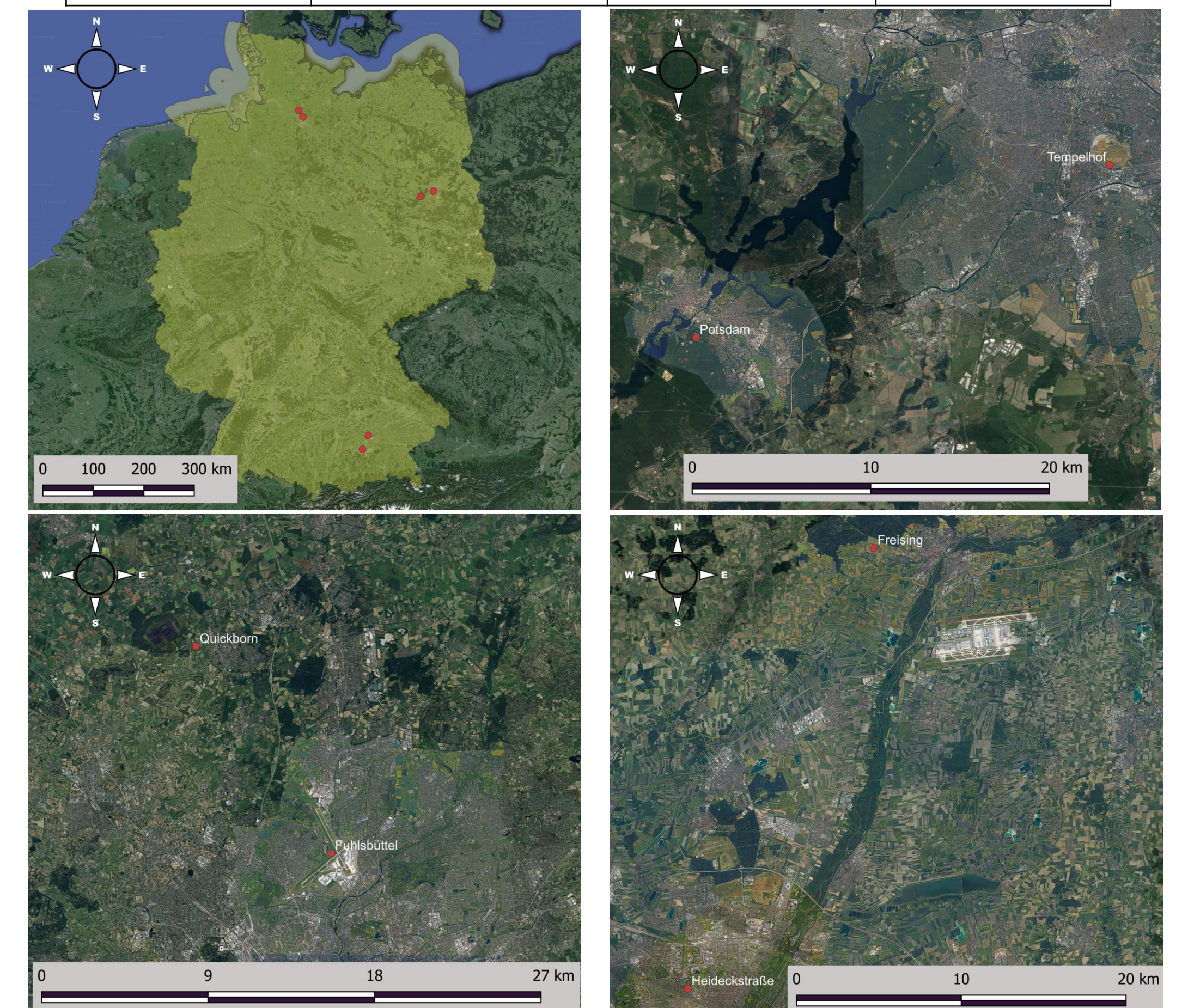


Figure 4: Locations of the site pairs

Introduction

- **Urban Heat Island (UHI) Effect: Large cities are significantly warmer than the surrounding rural areas** due to the urbanization of the land surface.

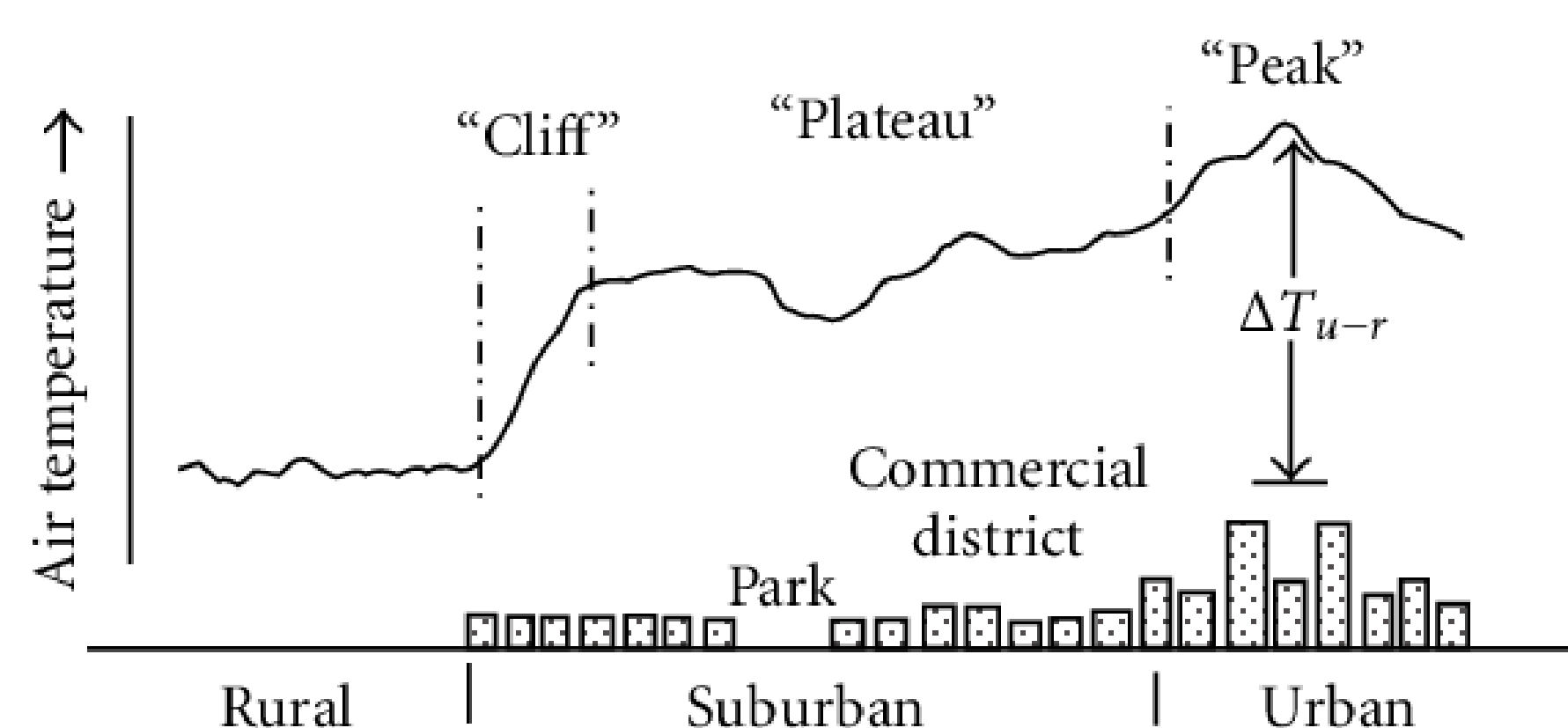


Figure 2: Generalized cross-section of UHI^[1]

- **Temperature difference** between cities and their surroundings rises through the afternoon and **peaks during the nighttime.**

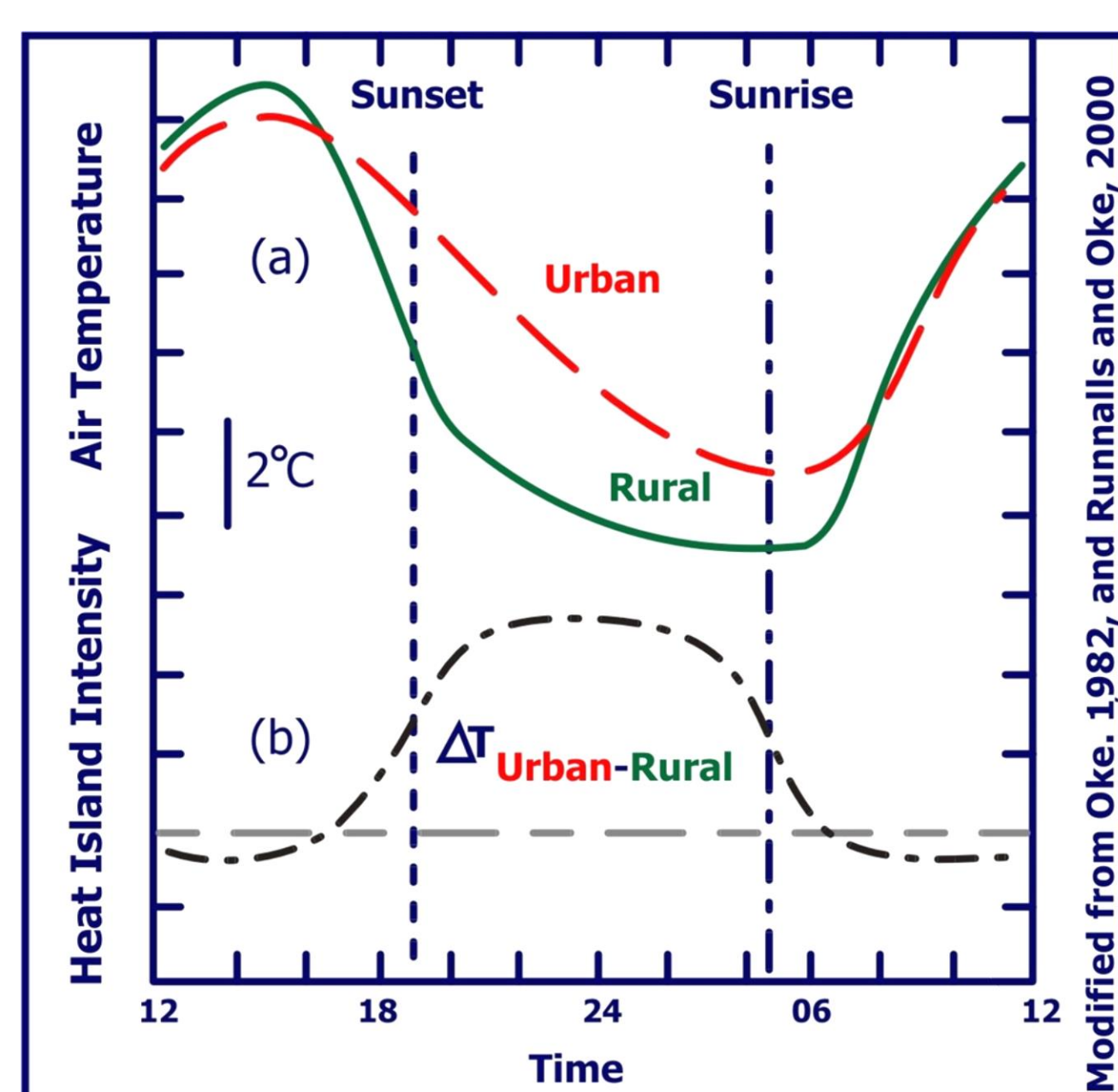


Figure 3: Diurnal variation of temperature and UHI intensity^[2]

- Recent studies^[3] show that low clouds persist longer over megacities from afternoon onwards and reaches its peak in the evening due to the UHI effect.

- The **difference** in cloud fraction between the **urban area and its surrounding** can be of the order of **4-5 %** ^[3].
- **Clouds** have the **largest impact** on the global horizontal solar irradiance (**GHI**) reaching the **Earth's surface.**
- GHI is the source of fuel for **solar photovoltaic (PV)** modules, increasingly being installed on **rooftops and balconies** or **integrated into building** in cities^[4].
- What is the **impact of the increased cloudiness** due to UHI on the **ground measured GHI or sunshine duration** ?

Materials and Method

- **GHI** (where available) and **sunshine duration** datasets from the **meteorological measurement stations** of the **German Weather Service (DWD)**^[4] for the period **2010-2019.**
- Ground measurements from rural and urban (i) **Berlin**, (ii) **Hamburg** and (iii) **Munich**
- Datasets are filtered and **only daytime** datapoints from the **summer months of May, June, July and August** are included.
- The **average diurnal value** of **GHI** and **sunshine duration** is obtained for the **six locations** at **10 minutes** and **60 minutes** resolution respectively.

Results and Discussion

- The average hourly sunshine duration does not exceed 40 minutes at any of the stations.
- The largest difference in average hourly sunshine duration is observed in the afternoon at all the stations.
- Munich city shows consistently higher cloudiness (lower sunshine duration) throughout the day compared to Freising (farthest stations pairs).
- Noon time onwards, higher cloudiness is observed inside Berlin city compared to Potsdam.
- Hamburg Fuhlsbüttel, which is almost at the edge of the city limit, has higher cloudiness than Quickborn for only a short period in the afternoon (closest station pairs).

Conclusion

At two out of three station pairs, a noticeably higher cloudiness is observed in the afternoon consistently. The degree of difference in cloudiness between a station pair is related to their relative positions with respect to the center of the city and the distance between them. The reduction in solar PV production due to the higher cloudiness, higher temperature and lower wind speed (wind stilling) in large cities, could lead to reduced financial benefits for the owners. Higher cloud induced variability in power supply may be a cause of concern for the city electricity distribution system operator. These impacts will be analyzed in future studies.

References:

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5. Deutscher Wetterdienst Climate Data Center (CDC) portal https://opendata.dwd.de/climate_environment/CDC/observations_germany/climate/