



Diagnosing above- and below-canopy temperature impacts of forest in the Netherlands during heatwaves

Jingwei Zhou ¹, Adriaan J. Teuling ¹, Michiel van der Molen ²

¹ Hydrology and Quantitative Water Management Group, Wageningen University & Research, Wageningen, Netherlands

² Meteorology and Air Quality Group, Wageningen University & Research, Wageningen, Netherlands

jingwei.zhou@wur.nl

Introduction

Heatwaves have significant effects on ecosystems and human populations. At local scales, forest management could be a potential approach of modifying surface energy budget and in this way alleviating heatwave impacts. In this study, open-site, below-canopy, and above-canopy climatic conditions from 3 different sites during the time period 1997-2020 in the Netherlands were compared to investigate canopy functions of affecting above-canopy macroclimate and as a thermal insulator to regulate understory microclimate and land surface ecology.

Methodology

Dataset

1. Loobos (subhourly)
23.5m, 7.5m, and soil litter layer
eddy covariance flux measurements
2. KNMI Deilt and Deelen (hourly)
1997-2020

Definitions

1. HWD: sequence of at least five days during which the daily maximum temperature exceeds the climatological mean over the reference period 1997-2006 by at least 5 °C.
2. Summer: Jun., Jul., Aug., Sept.
3. Diurnal time: 6-21
4. Night time: 0-5, 22, 23

Results

Figure. 1 | Correlation between open site temperature and open site vs surface temperature difference during summer times.

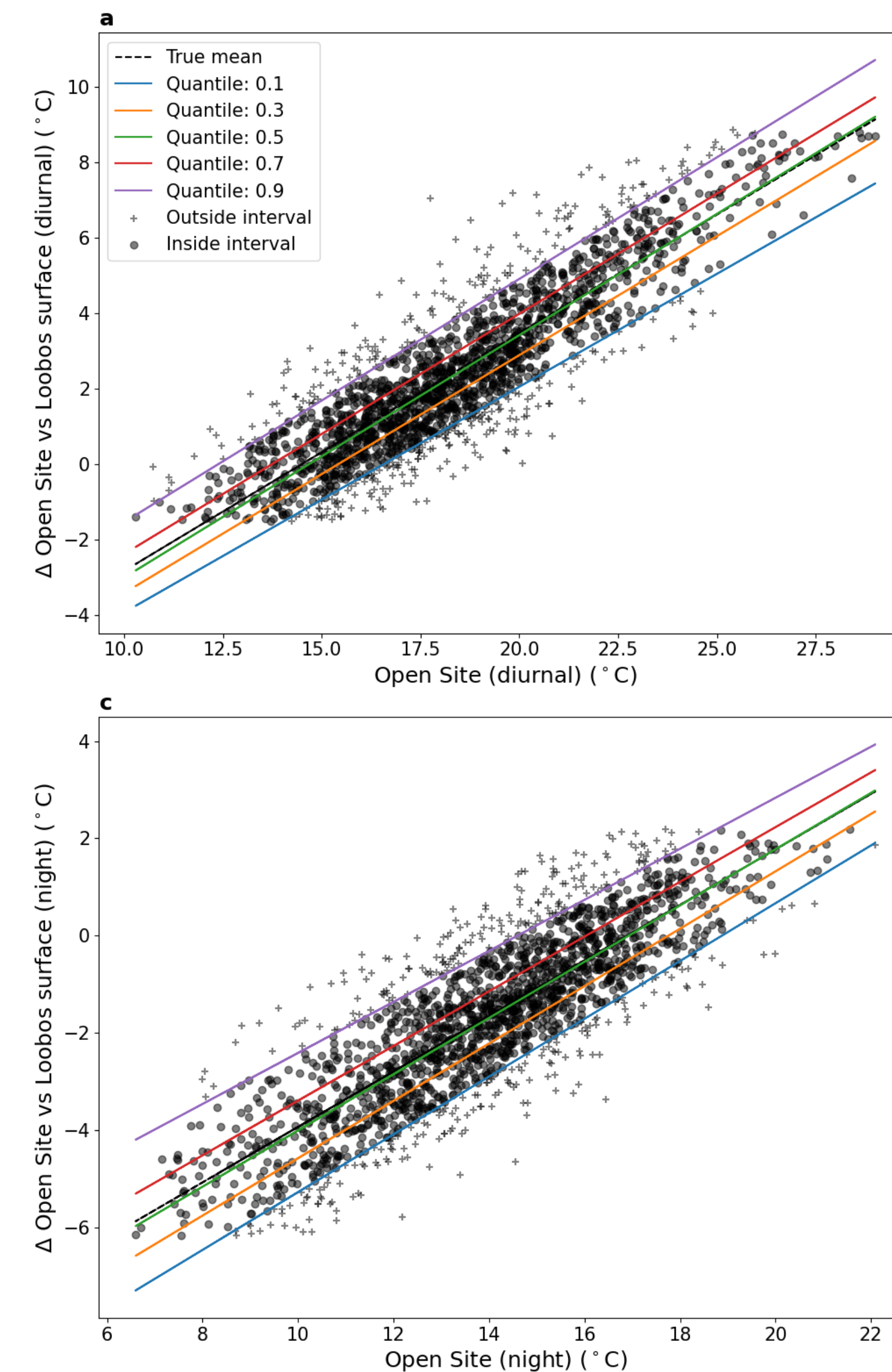
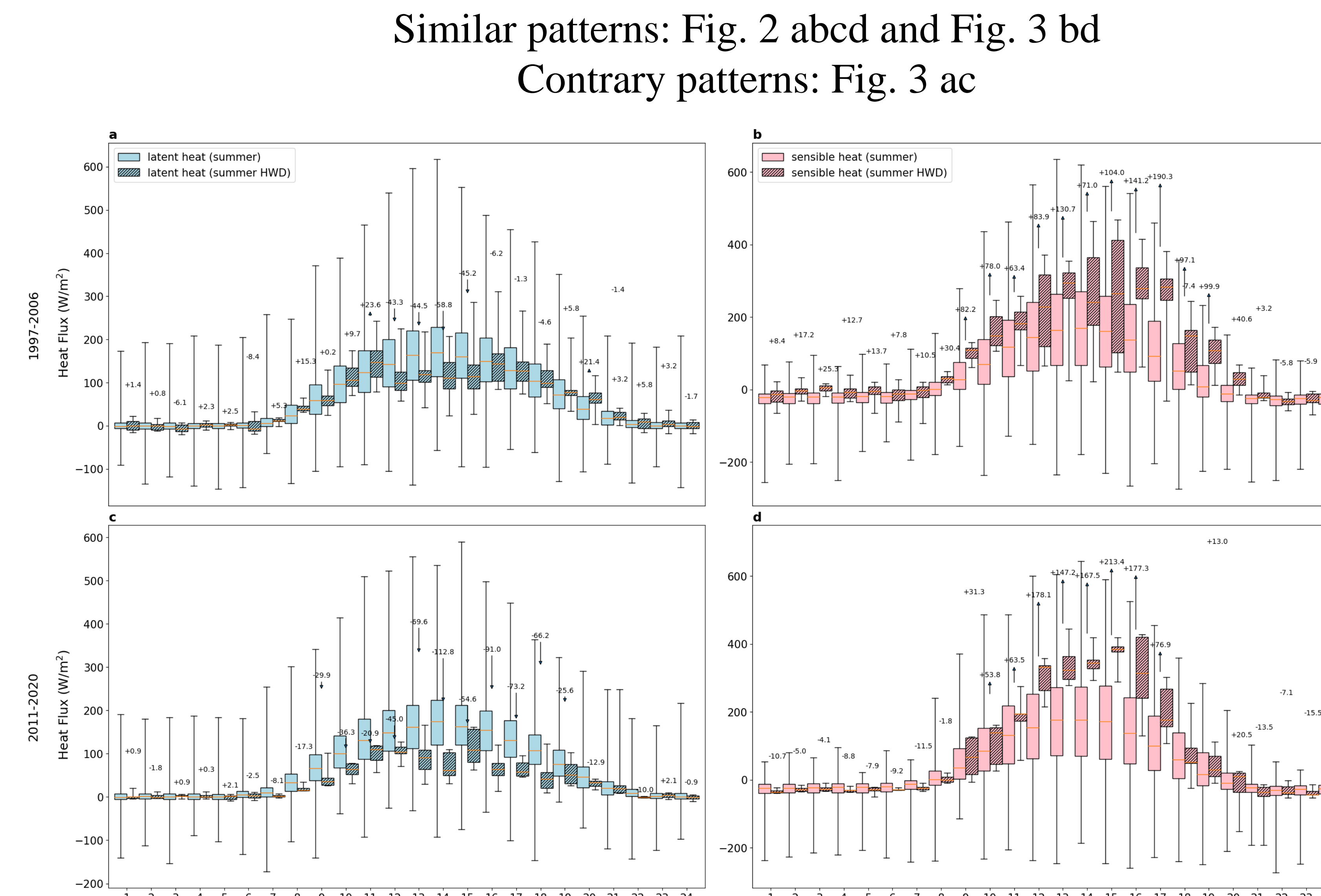


Figure. 2 | Daily changes of heat fluxes at Loobos during summer times.



Cooler means temperature at 23.5m and soil surface is lower than that at the open sites, warmer indicates vice versa.

Figure. 3 | Daily changes of temperature difference at open sites and Loobos during summer times.

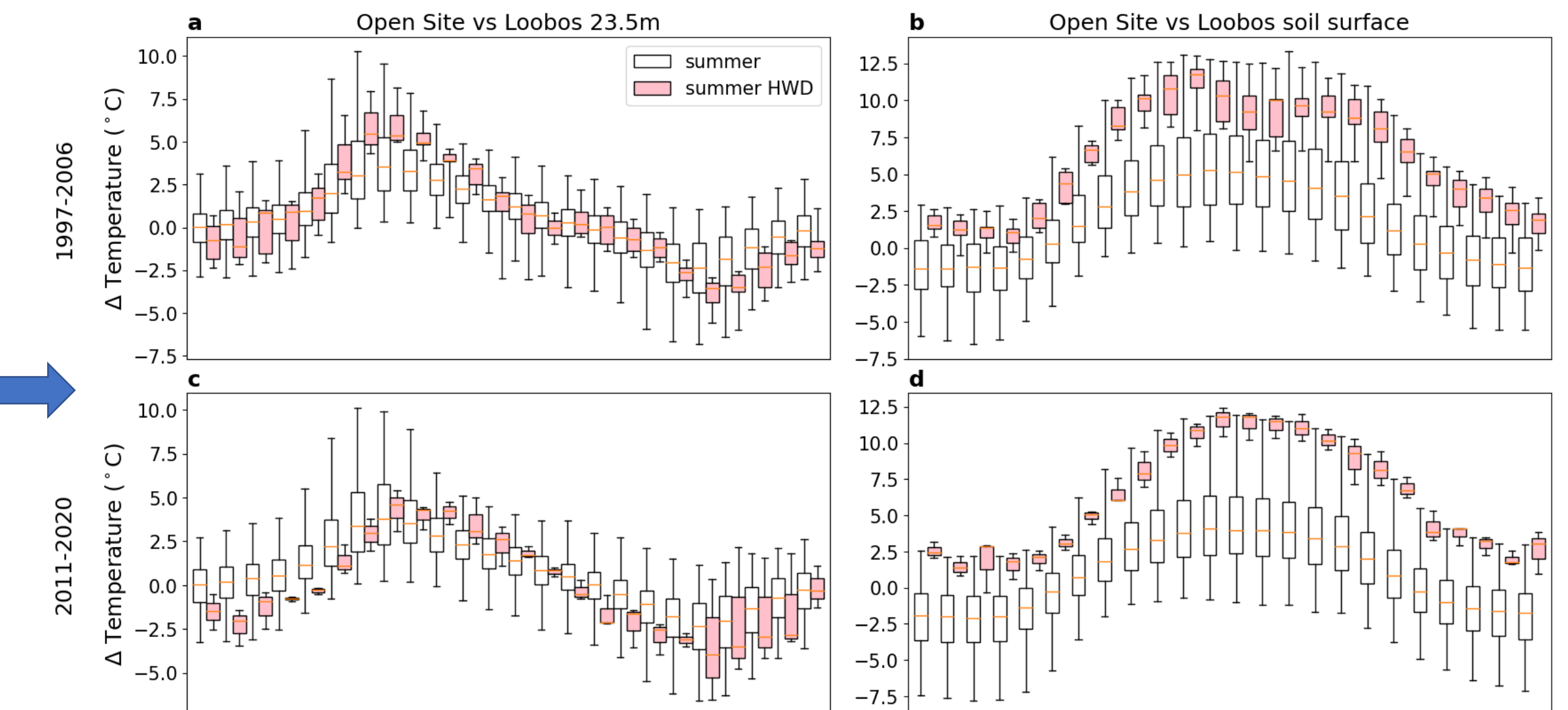
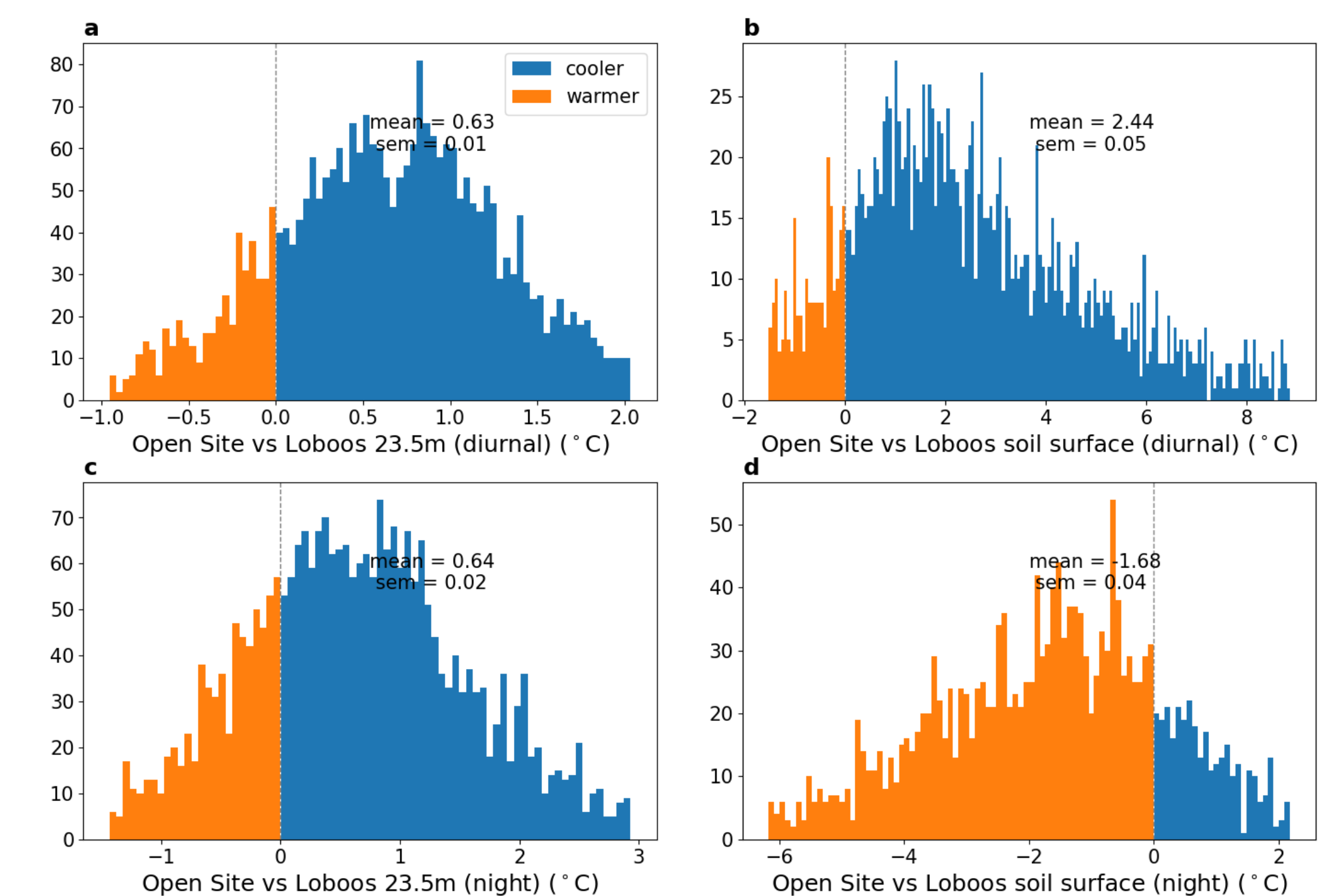


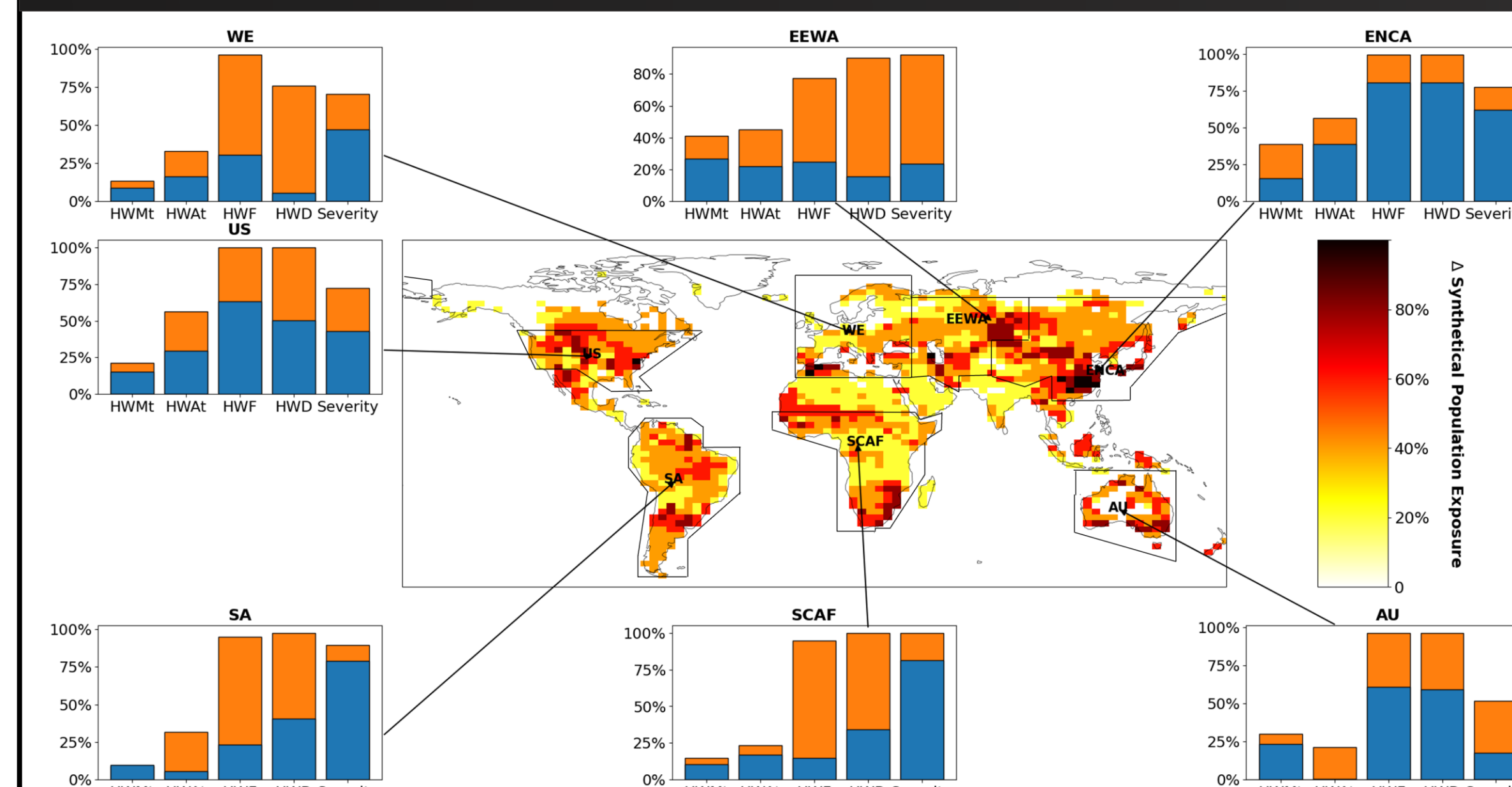
Figure. 4 | Distributions of temperature difference between Loobos and open sites during summer times.



Global Study

A sketch for my other work *Increasing Population Exposure to Future Heatwaves Influenced by Soil Drying*

Figure. 5 | Projected changes of population exposure to heatwaves. Increases of heatwaves' impacts on the human population induced by soil moisture changes and other factors are shown in the form of five different heatwave characteristics, which includes heatwave mean intensity (HWMt), peak intensity (HWAt), frequency (HWF), duration (HWD), and severity. The changes are between 2070–2100 and 1980–2010 and are calculated between the population percentage that is above the threshold (HWMt, 18.5 °C; HWAt, 32 °C; HWF, 3%; HWD, 5 days; Severity, 1) in both present period (1980–2010) and future period (2070–2100). The population data in the present period is of 2010, while that in the future period are of 2070-2100. The map indicates the synthetical increases of the population exposure based on five heatwave characteristics. In the bar plots, the orange part indicates contributions from soil drying; the blue part indicates other factors.



Conclusions

1. Open site temperature shows a strong linear relationship with temperature difference between open site temperature and Loobos surface temperature;
2. Open sites tend to have higher temperature than temperature profile (not only for the surface temperature but also for the above-canopy temperature) at Loobos except for night times;
3. Under most cases, canopy effects are stronger during heatwave days compared with summer times;
4. The daily change patterns of both fluxes align with those of temperature differences between open sites and surface temperature;
5. The energy lag off may cause the condition where the temperature in open sites is higher than above-canopy temperature.