

# Heatwaves in Southeast Asia and Their Changes in a Warmer World

Zizhen Dong<sup>1</sup>, Lin Wang<sup>2</sup>, Ying Sun<sup>3</sup>, Ting Hu<sup>3</sup>, Atsamon Limsakul<sup>4</sup>, Patama Singhruck<sup>5</sup>, and Sittichai Pimonsree<sup>6</sup>

<sup>1</sup>Yunnan University

<sup>2</sup>Institute of Atmospheric Physics, Chinese Academy of Sciences

<sup>3</sup>National Climate Center, China

<sup>4</sup>Environmental Research and Training Center

<sup>5</sup>Chulalongkorn University

<sup>6</sup>University of Phayao

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## Abstract

Based on the observational dataset SA-OBS and model outputs from the Community Earth System Model Large Ensemble project, this study investigates heatwaves in Southeast Asia in the current and future warmer climate. A heatwave is detected when the daily maximum temperature exceeds the 90th percentile threshold at each grid for at least three consecutive days. Three characteristics describing the frequency, duration, and amplitude of heatwaves are examined, including the sum of heatwave days per year (HWF) satisfying the heatwave definition, the length of the longest yearly heatwave event (HWD), and the hottest amplitude of the hottest yearly heatwave event (HWA). Results indicate that increased global warming is associated with substantial changes in heatwave characteristics over Southeast Asia, with more frequent heatwaves, longer heatwave duration, and higher extreme temperatures. The increase in HWA has a linear growth against global warming levels with distinct regional differences between the Maritime Continent and the Indochina Peninsula due to their different heat content of lower atmospheric boundaries. In contrast, those in HWF and HWD have nonlinear growth characteristics. The projected warmer future tends to be associated with a higher risk ratio value with the occurrence of rarer extreme heatwaves relative to the current climate. These results reiterate the potential risks of extreme regional heatwaves if global warming is unrestricted.





## Motivation

- A heatwave usually has adverse effects on human health and the ecosystem. However, there is little knowledge of heatwaves in tropical developing countries such as those in Southeast Asia.
- This study investigates three characteristics of the heatwaves in the current climate and their changes in the future warmer climate in Southeast Asia based on observational datasets and outputs from a state-of-the-art model, the Community Earth System Model (CESM) under historical and RCP8.5 scenes.

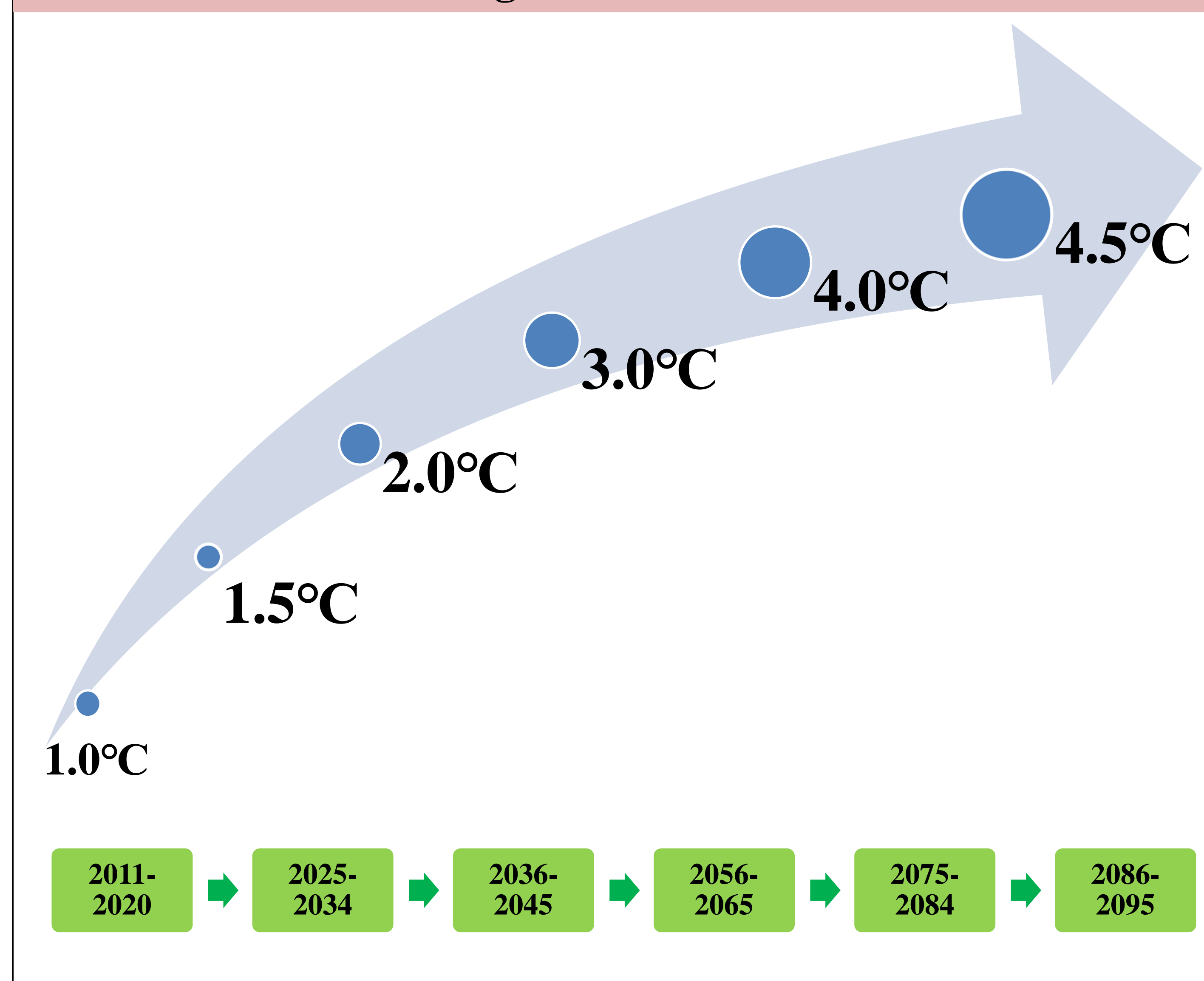
## Methods

- A heatwave is detected when the daily maximum temperature is above the 90<sup>th</sup> percentile threshold at each grid for at least three consecutive days
- **HWF** (frequency): the sum of heatwave days per year (HWF) satisfying the heatwave definition
- **HWD** (duration): the length of the longest yearly heatwave event
- **HWA** (amplitude): the hottest amplitude of the hottest yearly heatwave event
- **Baseline periods**: the pre-industrial climate (1850-1900) and the current climate (1.0°C warmer than the pre-industry)
- **Bias Correction for CESM Model Data**

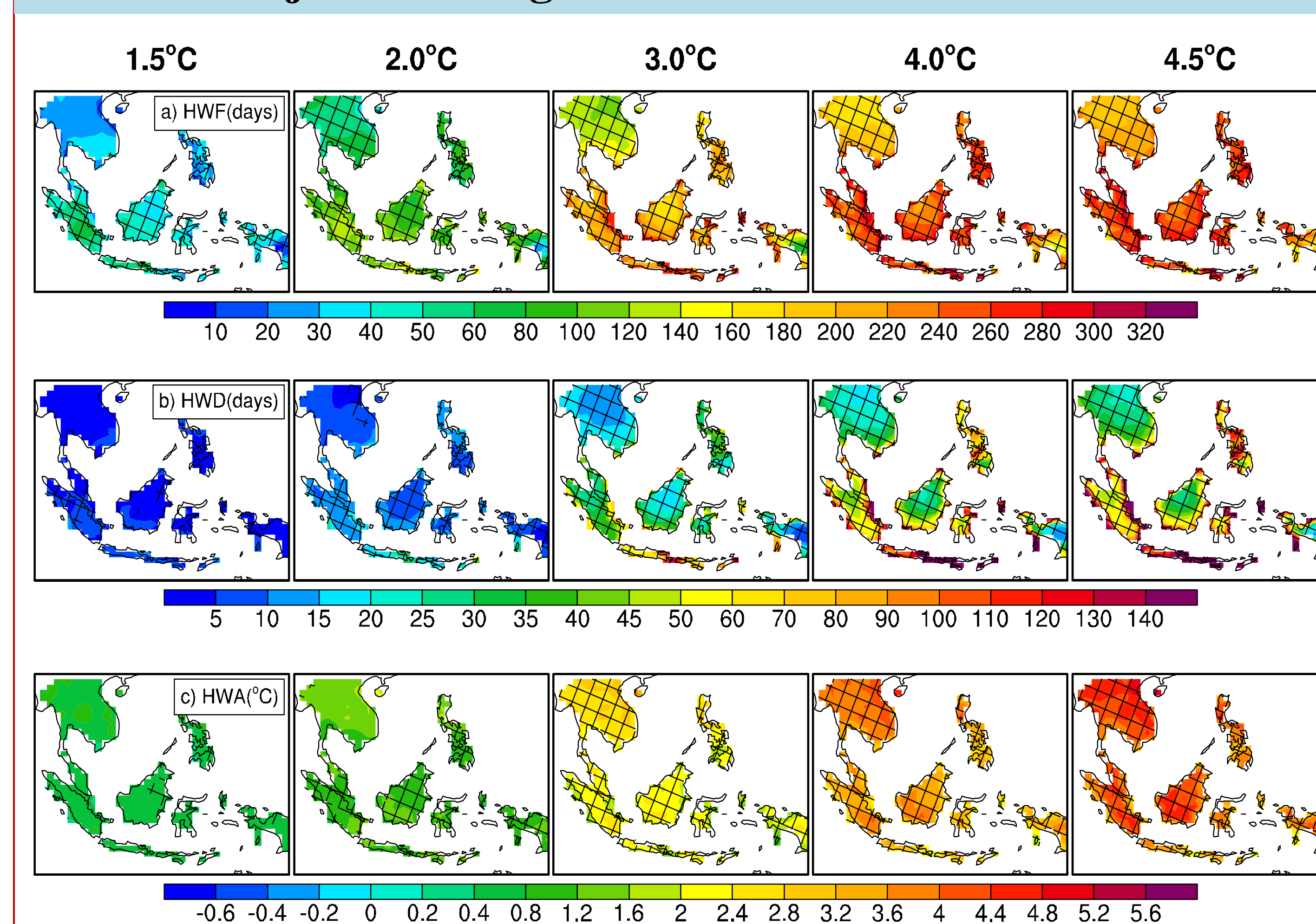
## Main Points

- Global warming is associated with substantial increases in heatwave's frequency, duration, and amplitude over Southeast Asia
- Increase of heatwave amplitude with global mean temperature is quasi-linear, and that of heatwave frequency and duration are nonlinear

## Global Warming Levels in CESM simulation

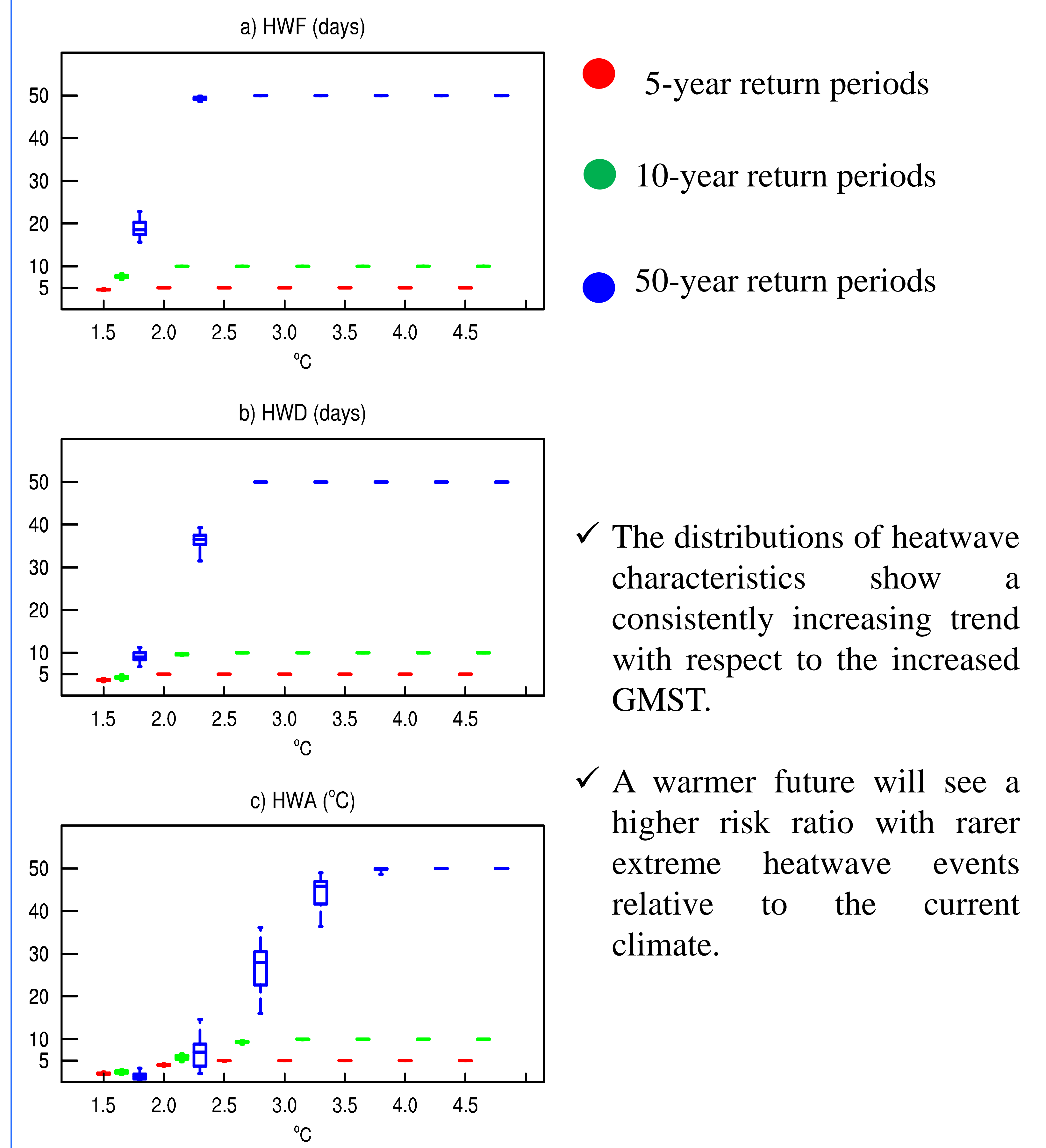
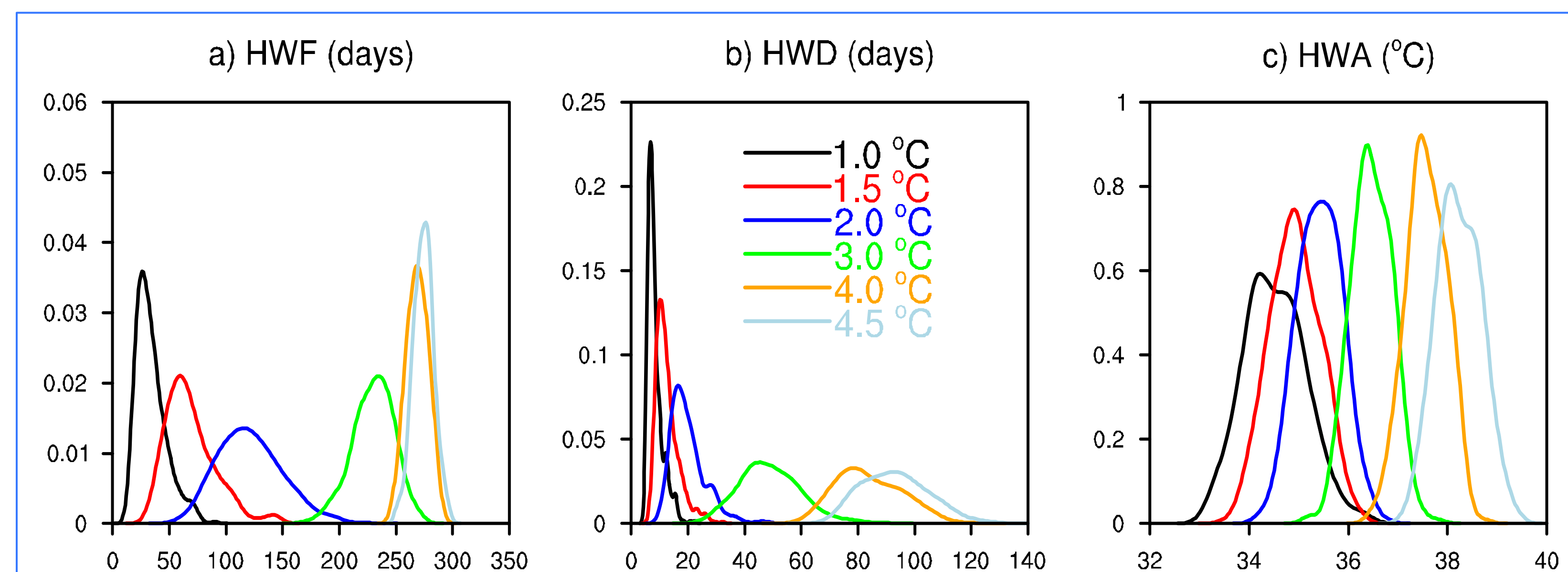


## Projected changes of heatwaves in the future



- ✓ In a warmer future, heatwaves tend to occur most of the time in a year relative to the current climate.
- ✓ Different response of heatwave characteristics to GMST might be rooted in the different lower atmospheric boundaries.

## Substantial increases in PDF estimate (top) and risk ratio (bottom) for SEA heatwaves



✓ The distributions of heatwave characteristics show a consistently increasing trend with respect to the increased GMST.

✓ A warmer future will see a higher risk ratio with rarer extreme heatwave events relative to the current climate.