An increasing intensity of extreme temperature due to deforestation over the maritime continent

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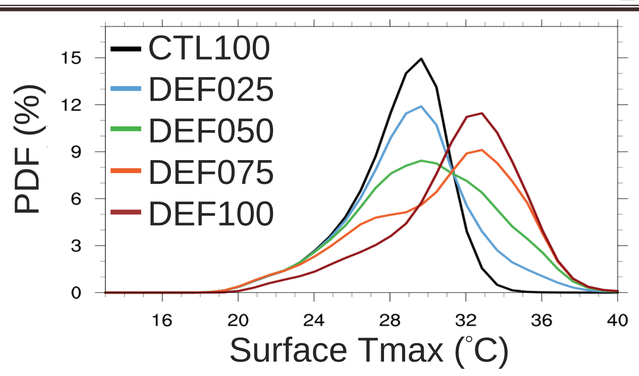
Abstract

In recent decades, the Maritime Continent (MC) has undergone rapid deforestation due to agricultural expansion. This alteration in surface characteristics disrupts the energy balance, leading to an increase in surface temperatures. Utilizing the Community Earth System Model (CESM), this study examines the impact of deforestation on extreme heat days in the MC region. We implemented idealized scenarios ranging from localized coastal to comprehensive deforestation across the entire MC. Our findings indicate a rise in daily mean surface temperature and 2-meter air temperature (T2m). However, we observed a decrease in maximum T2m in the total deforestation simulation compared to the control simulation, despite an increase in maximum surface temperature. This is attributed to a decrease in solar radiation caused by increased cloud cover in the total deforestation scenario. Although the maximum T2m decreased after deforestation, high temperatures persisted longer, and nighttime temperatures were significantly higher in the total deforestation simulation. This indicates an increased risk of human heat stress due to deforestation.

Introduction

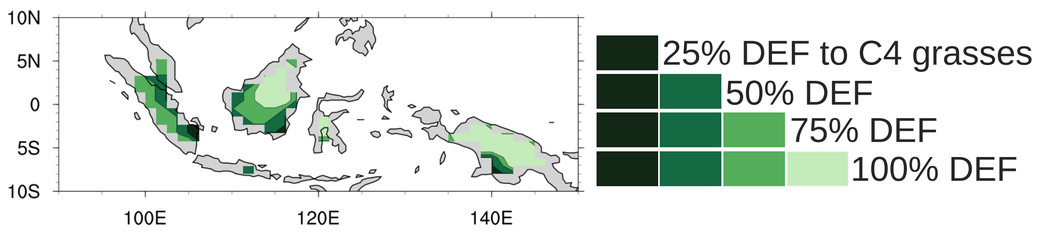


- The probability density function of the daily maximum surface temperature shifted to the right, leading to an increased occurrence of extreme heat.
- As the deforested area increase, more extreme heat was observed.

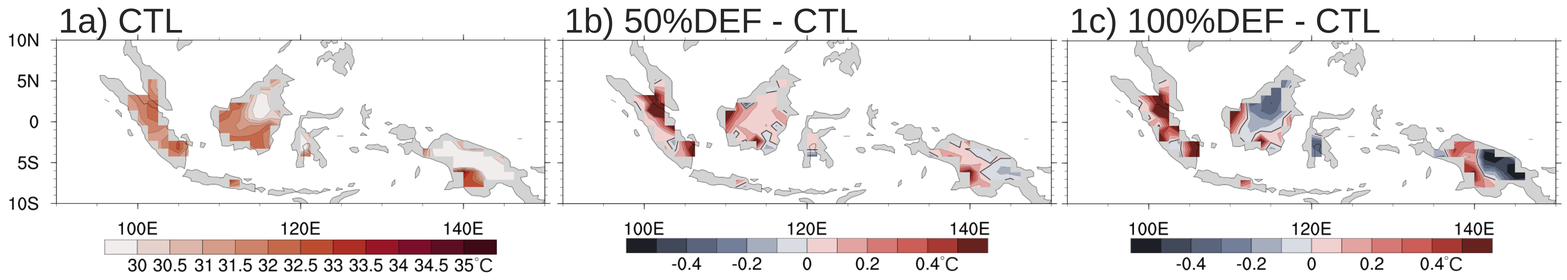
Model, Experiments, and Method

- NCAR Community Earth System Model (CESM) v1.0.3
- CAM5 + CLM4 with prescribed climatological sea surface temperature
- Resolution: 0.9˚x 1.25˚
- Simulation time: 60 years of daily data (5 years spin-up) & 10 years of hourly data

CTL:
100% broadleaf
evergreen tropical trees

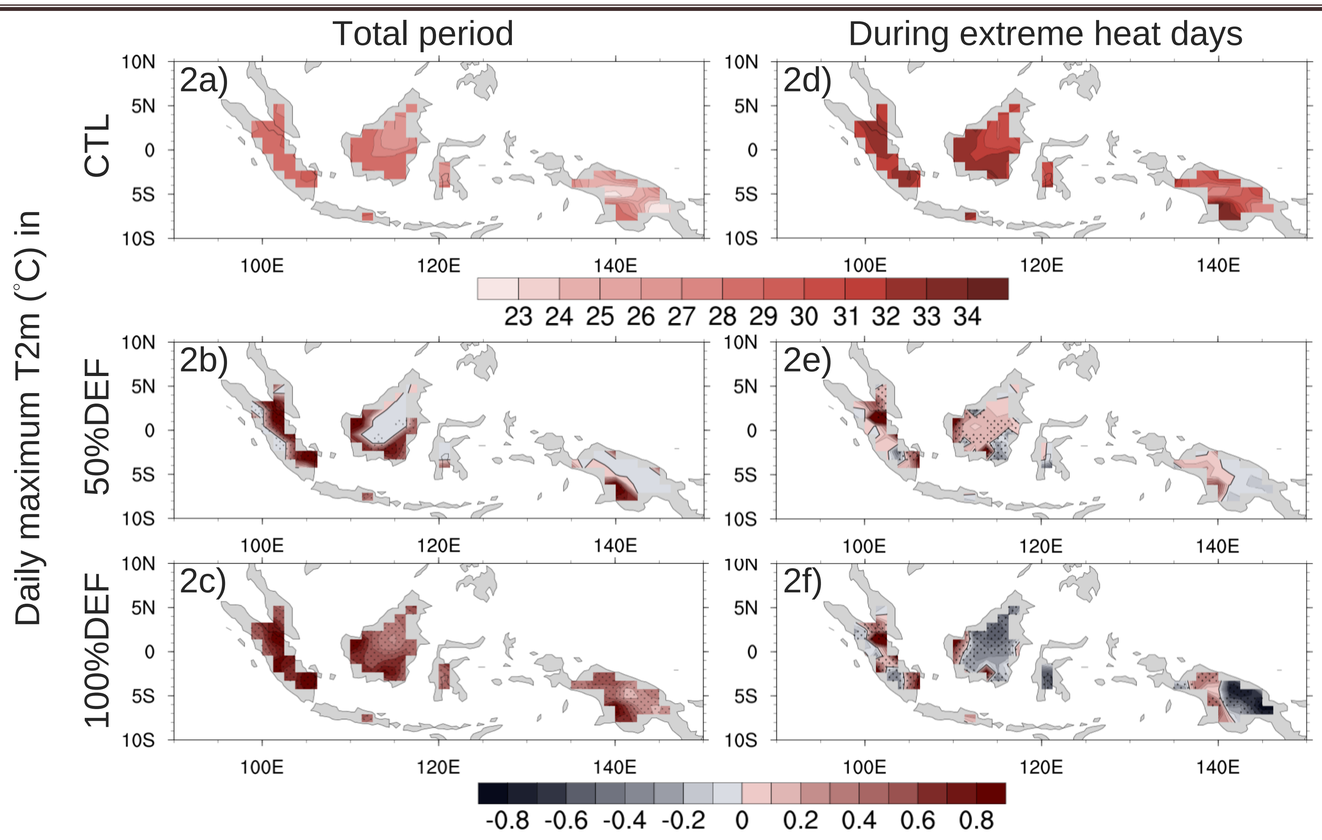


- Extreme high temperature days: The top 1% of maximum T2m for each grid in each simulation.



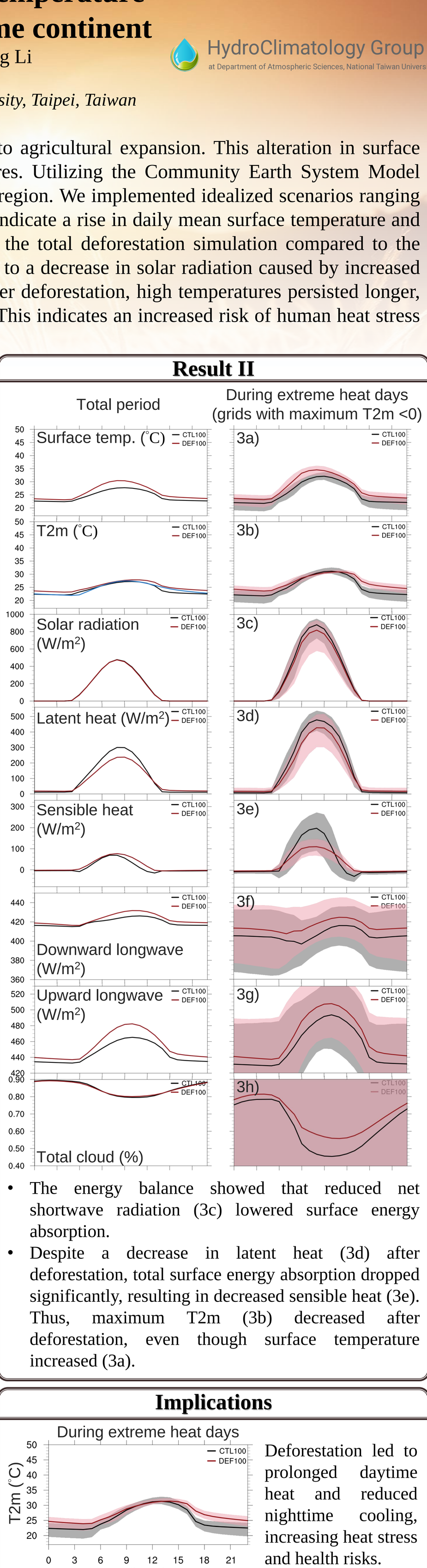
- In CTL (1a), the threshold for extreme heat days decreased as altitude increases.
- In 50%DEF (1b), the threshold increased in most parts of MC even in non-deforested areas.
- In 100%DEF (1c); however, the threshold decreased in some parts of MC.

Result I



- In CTL, max. T2m increased by 4˚C during extreme heat days (2d) compared to climatology (2a).
- In 50%DEF (2b) and 100%DEF (2c), max. T2m increased significantly in the deforested areas.
- During extreme heat days, most parts of MC showed amplified maximum T2m due to intermediate deforestation (2e).
- However, in the total deforestation scenario, the amplitude of maximum T2m decreased (2f).

Result II



- The energy balance showed that reduced net shortwave radiation (3c) lowered surface energy absorption.
- Despite a decrease in latent heat (3d) after deforestation, total surface energy absorption dropped significantly, resulting in decreased sensible heat (3e). Thus, maximum T2m (3b) decreased after deforestation, even though surface temperature increased (3a).

Implications

Deforestation led to prolonged daytime heat and reduced nighttime cooling, increasing heat stress and health risks.

In summary, deforestation results in persistently higher nighttime temperatures, raising the risk of human heat stress. This occurs despite a decrease in maximum T2m, which is primarily due to reduced solar radiation caused by increased cloud cover.