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Current and future adaptation potential of heat-tolerant maize in Cameroon: a combined attribution and adaptation study

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WHY MAIZE, WHY CAMEROON, WHY HEAT-TOLERANCE?

*Fig. 1: Unstressed maize (**left**) and heat-stressed maize with reduced grain set and diminished yield (**right**). Adapted from Waqas et al.[3]*

Maize cropping systems in Sub-Saharan Africa are **climate-vulnerable**[1,2]

- Maize is **heat-sensitive**[3]
- Growing season temperatures **already approach critical temperature thresholds** in the tropics[1]

Conditions causing heat stress in maize are expected to become much **more likely under climate change[2]!**

METHODS & MODELLING APPROACH

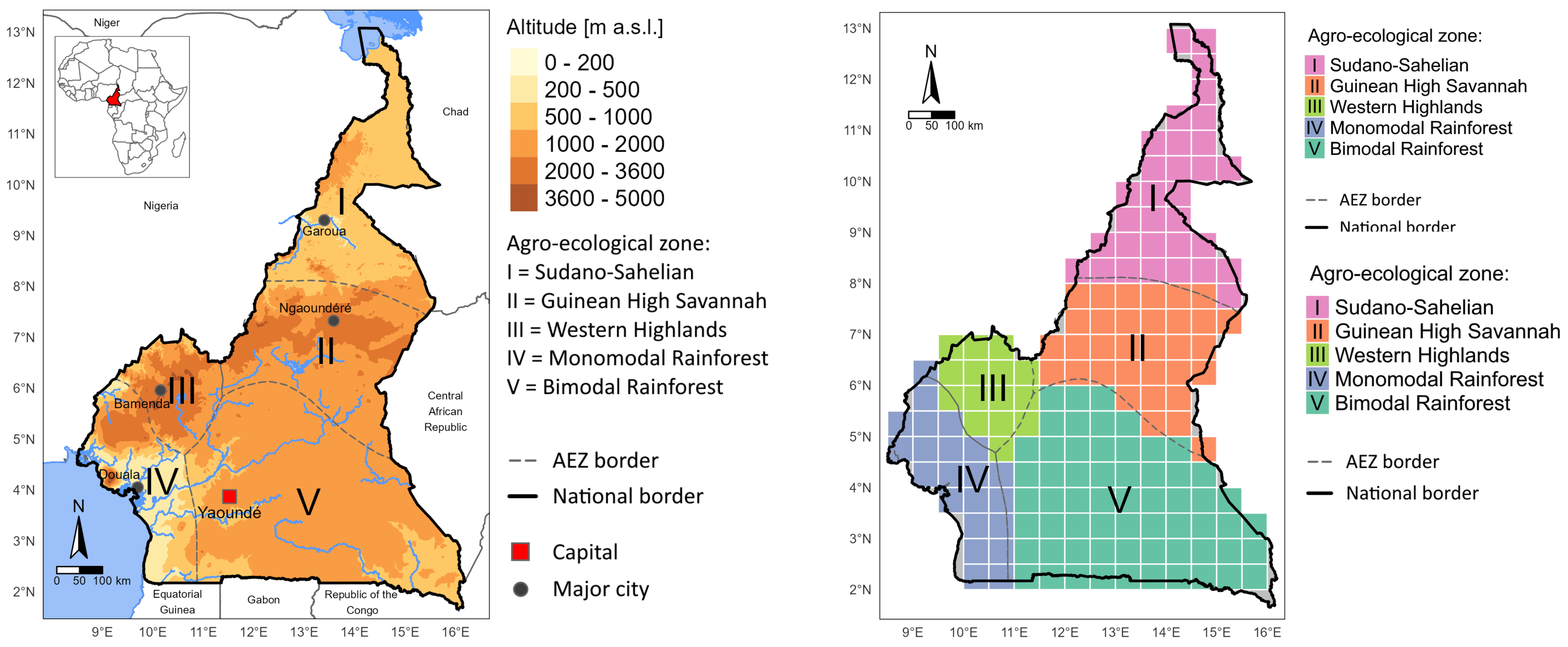


*Fig. 2: Map of Cameroon and agro-ecological zones (AEZs, **left**) and spatially disaggregated grid underlying the crop model (**right**).*

Key data

- Chosen CSM: **APSIM**[4]
- Weather data:
  - *Historical (1986-2014): **W5E5 (ISIMIP 3a)***
  - *Counterfactual (1986-2014): **6 GCMs (ISIMIP 3b)***
  - *Projected (2020-2100): **10 GCMs (ISIMIP 3b)***
- Climate change scenarios:
  - ***SSP1-2.6** and **SSP3-7.0***
- Soil data:
  - *Time-invariant: **ISRIC soil profiles***

Model setup

- **Grid-based** modelling approach
- Management:
  - ***Sowing window** varies with **AEZ***
  - *Rainfed and no fertilisation*
- **Baseline cultivar**: *Hybred 511*
- **Heat-tolerant**: *Hybred 511* with grain set temperature stress thresholds increased by +1 [+0.5, +1.5] °C

Workflow

Calibration

Using **gridded** weather & soil **data** (ISRIC, W5E5)

Using **literature** (soil inorganic N, management)

Using **APSIM** (5-year spin-up for soil moisture)

Perf. eval

Yield simulations based on **W5E5** reanalysis data (1986-2014)

Comparison with gridded yield data (GDHY)

Calculation of model performance indices for spatial and temporal variability (R², Wilmott's d)

Simulation

Yield simulations for **baseline** using GCM-histnat data (1995-2015)

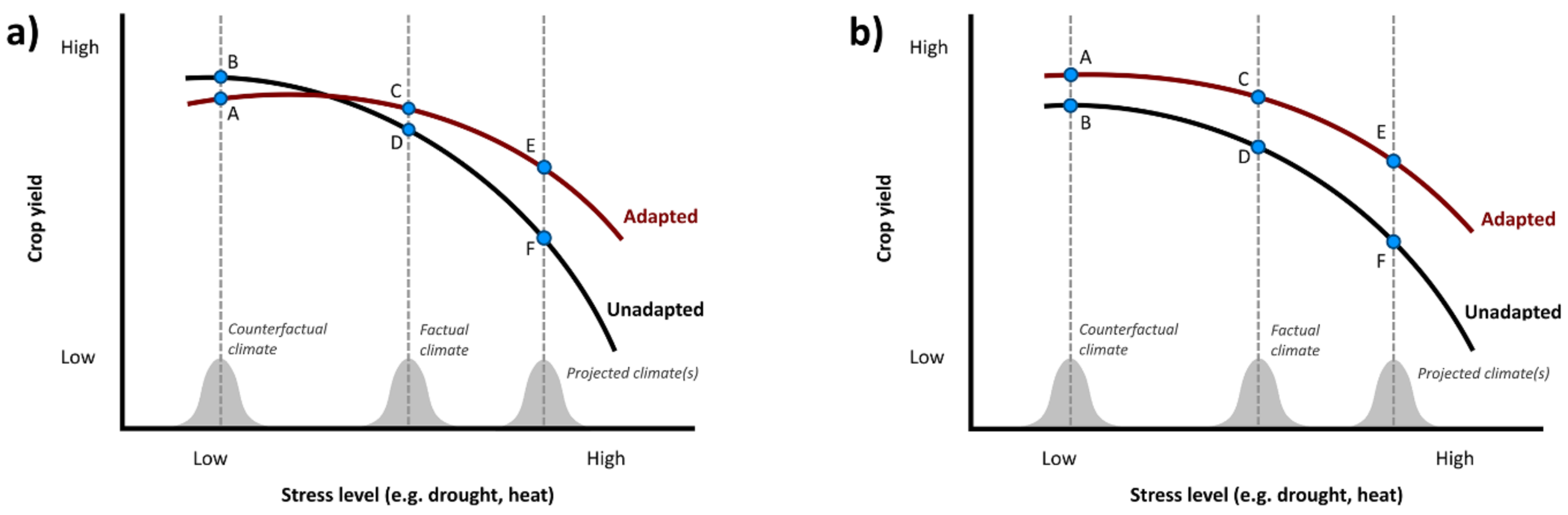
Yield simulations for **2 SSP scenarios and hist** based on 10 GCMs used as input for **ISIMIP3b**

All yield simulations carried out for all **cultivars**

Yearly output

Impact of adaptation on yields under counterfactual climate = A - B
Impact of adaptation on yields under factual climate = C - D
Impact of adaptation on yields under projected climate = E - F

Current adaptation potential = (C - D) - (A - B)
Future adaptation potential = (E - F) - (A - B)



RESULTS

Climate change impacts on the baseline cultivar

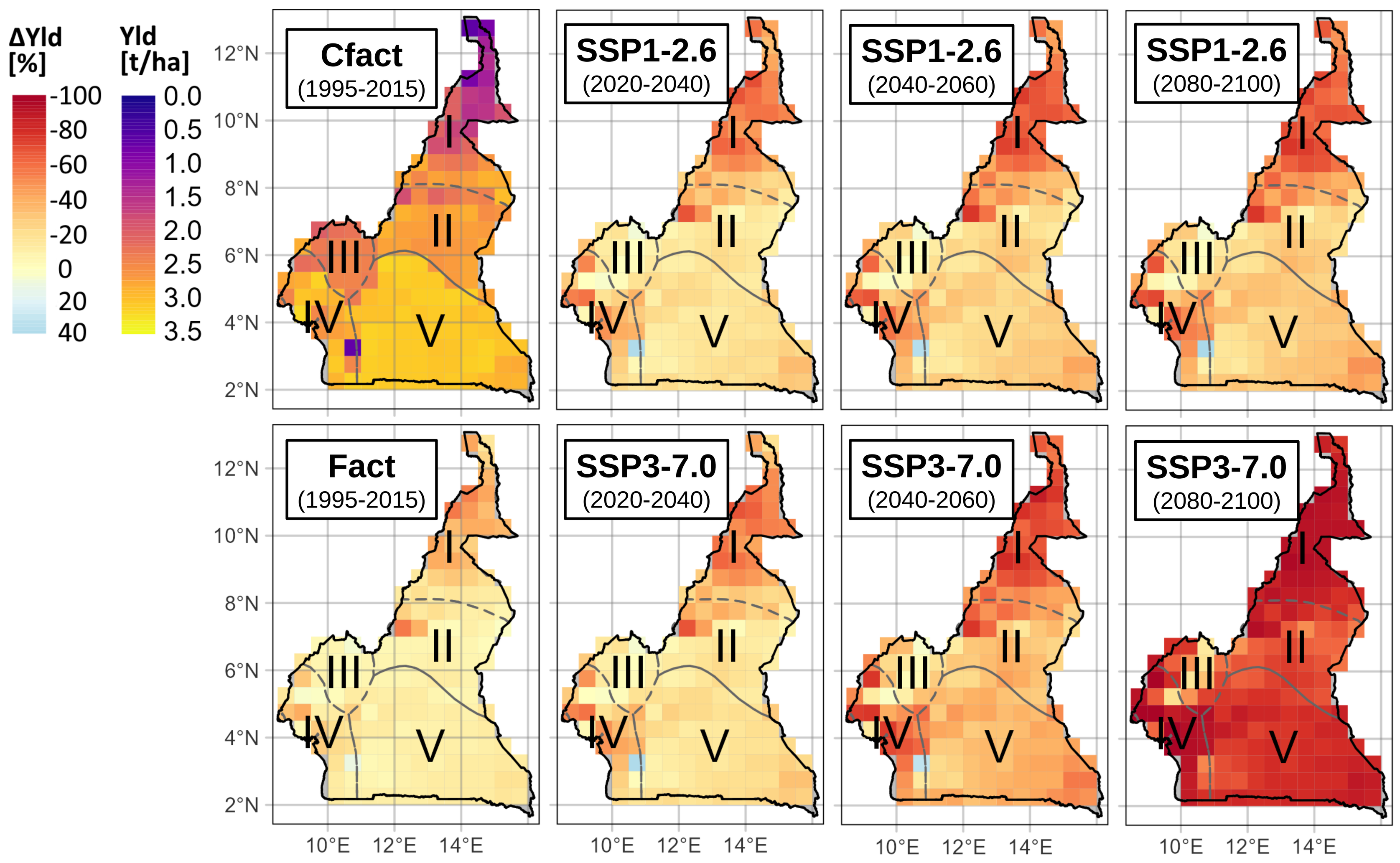


Fig. 3: Counterfactual (Cfact, top left) maize yield (Yld) of the baseline cultivar and relative changes compared to this baseline (ΔYld, all other maps).

- **Compared to the counterfactual scenario, yields are already 25% lower**, with losses almost doubling by 2030 under both climate change scenarios
- **Yield losses** simulated under the high-emissions scenario SSP3-7.0 are **substantially more pessimistic** than in earlier impact modelling studies
  - **Heat stress** identified as **major driver** of yield loss

Impacts and potential of heat-tolerance adaptation

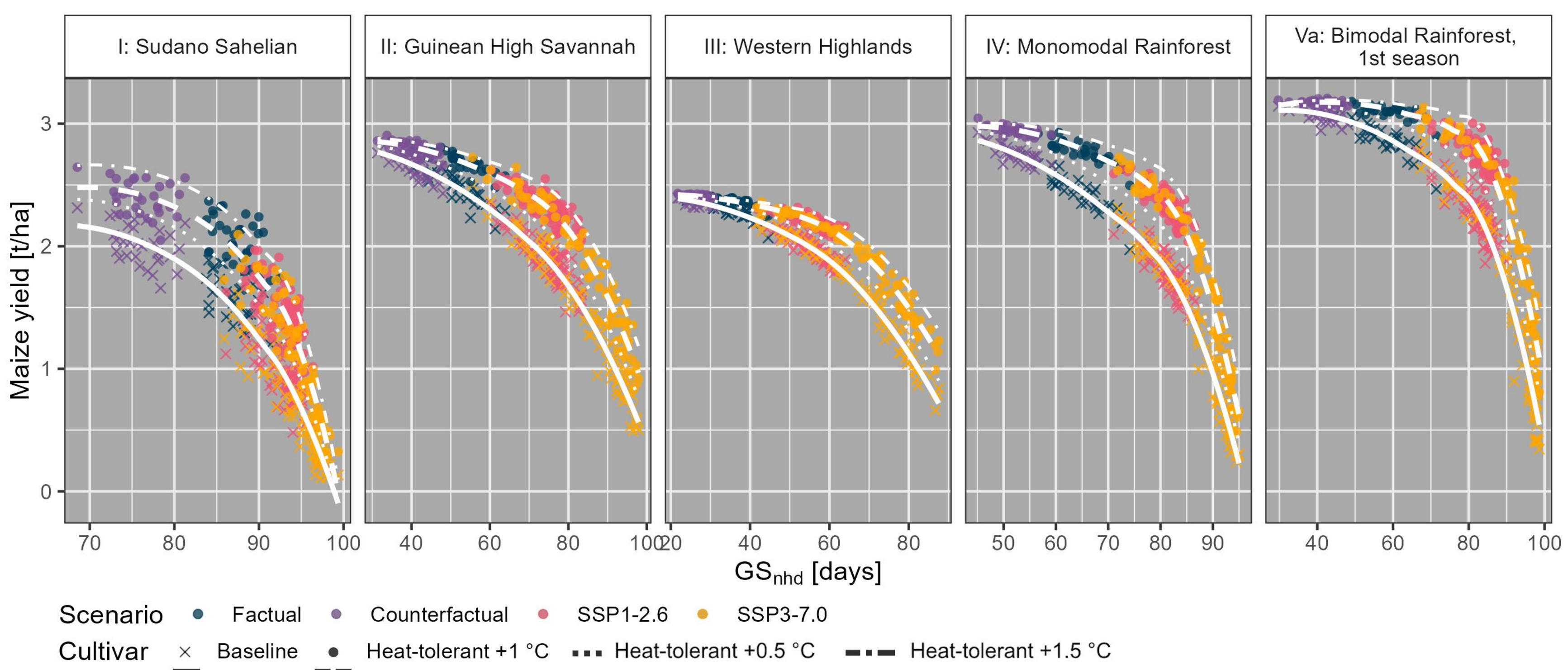
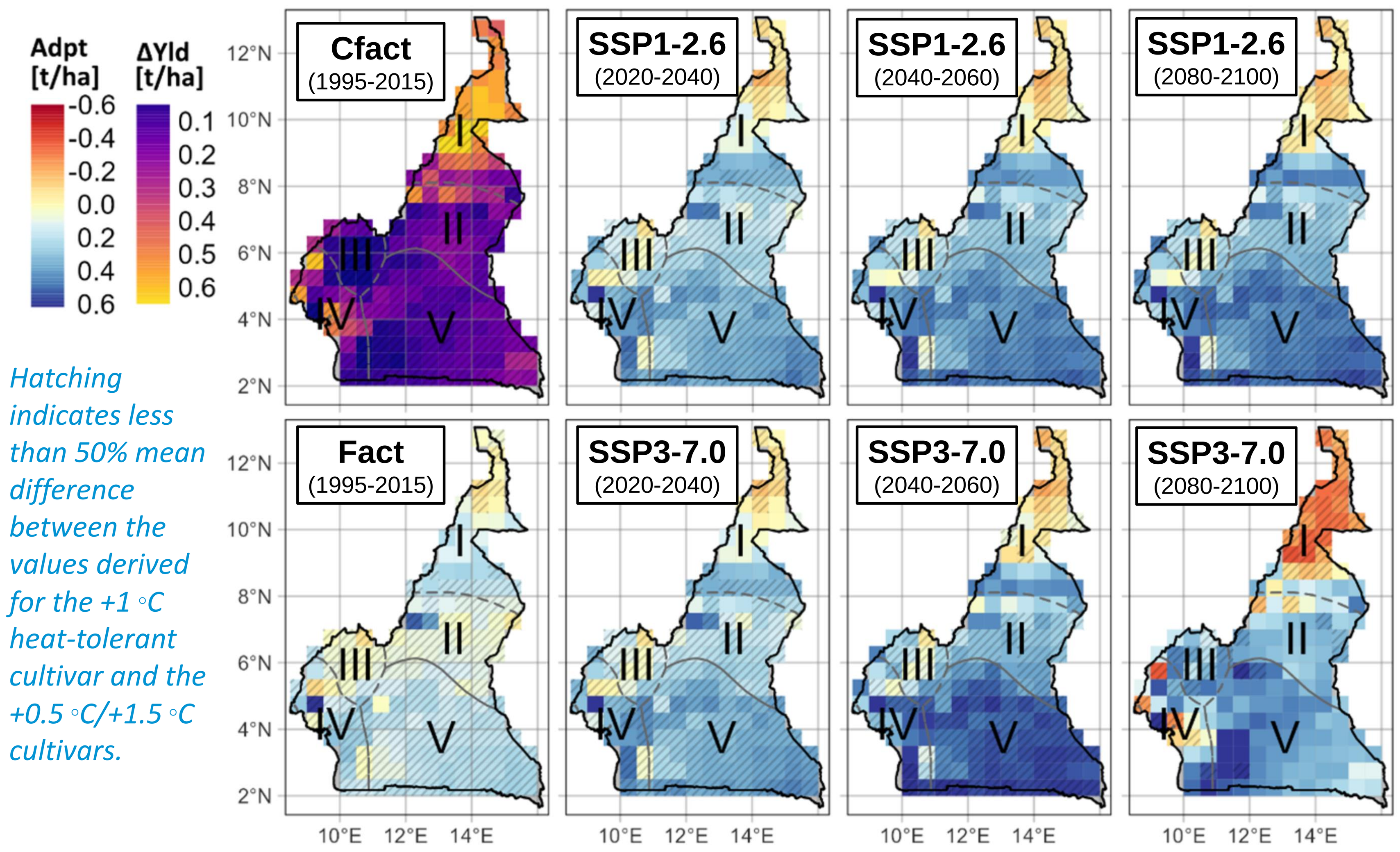


Fig. 4: Maize yields averaged over each AEZ as a function of AEZ-mean growing season number of hot days (GS_{nhd}) by cultivar adaptation. Data points are individual years. Fitted lines are LOESS fits of all cultivars (for visualisation only).



Hatching indicates less than 50% mean difference between the values derived for the +1 °C heat-tolerant cultivar and the +0.5 °C/+1.5 °C cultivars.

Fig. 5: Baseline yield impact (ΔYld) of heat tolerance (+ 1 °C cultivar) under the counterfactual climate (Cfact, top left map) and Adaptation potential (Adpt) of heat tolerance.

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References

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