# Forestation Trumps Emissions in Mitigating European Summer Heat Extremes under SSP1

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Infocrue

LUCAS

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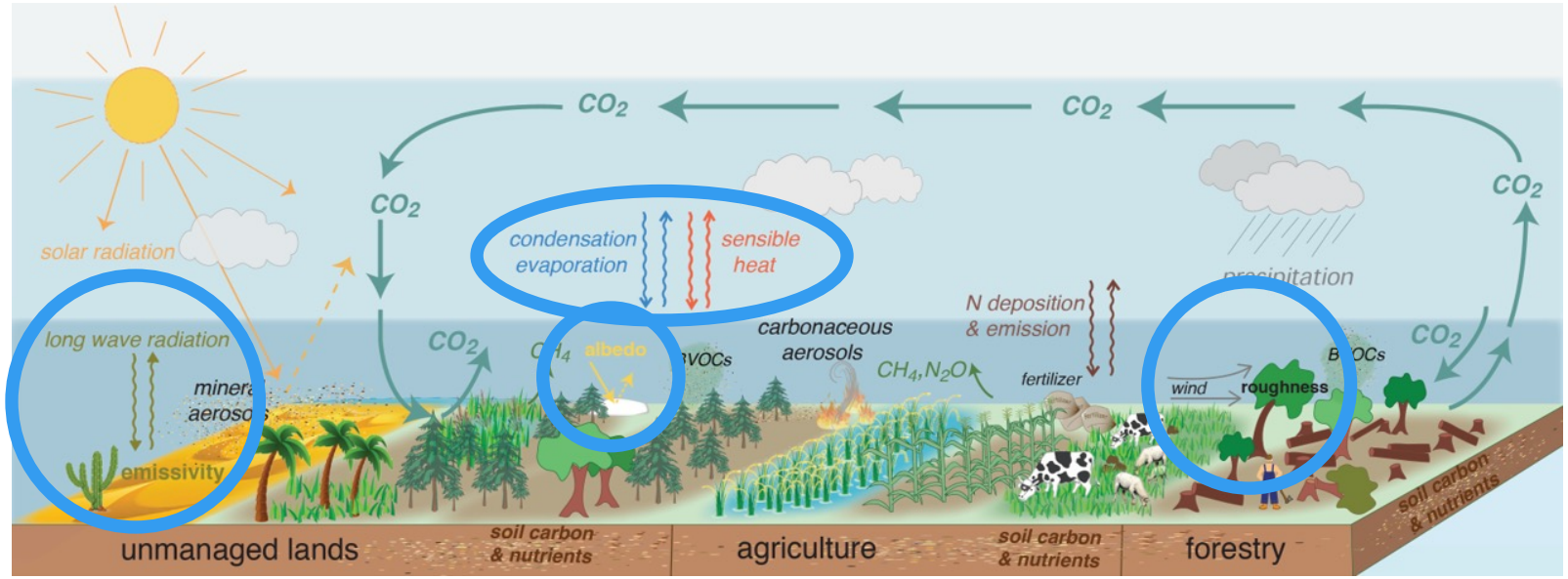
# Biophysical Effects of Land-Use Change (LUC)




**Biophysical effects**
*modifications of energy and water transfers between the surface and the atmosphere*

*scientific question*

**What are the relative contributions of LUC and GHG to present and future climate?**

*method*

**Ensemble of RCM simulations with various combinations of LUC and GHG**

Special Report on Climate Change and Land, IPCC (2019)



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# Simulation Ensemble

| Land covers / GHG | present | SSP1-2.6 | SSP3-7.0 |
|---|---|---|---|
| present | $G_p^1 L_p$ | $G_1^1 L_p$ | $G_3^1 L_p$ |
| SSP1-2.6 | | $G_1^1 L_1$ | |
| SSP3-7.0 | | | $G_3^1 L_3$ |

Earth System Model-Driven Runs, members X=1 to 4.

| Land covers / GHG | present |
|---|---|
| present | $G_p^R L_p$ |
| SSP1-2.6 | $G_p^R L_1$ |
| SSP3-7.0 | $G_p^R L_3$ |

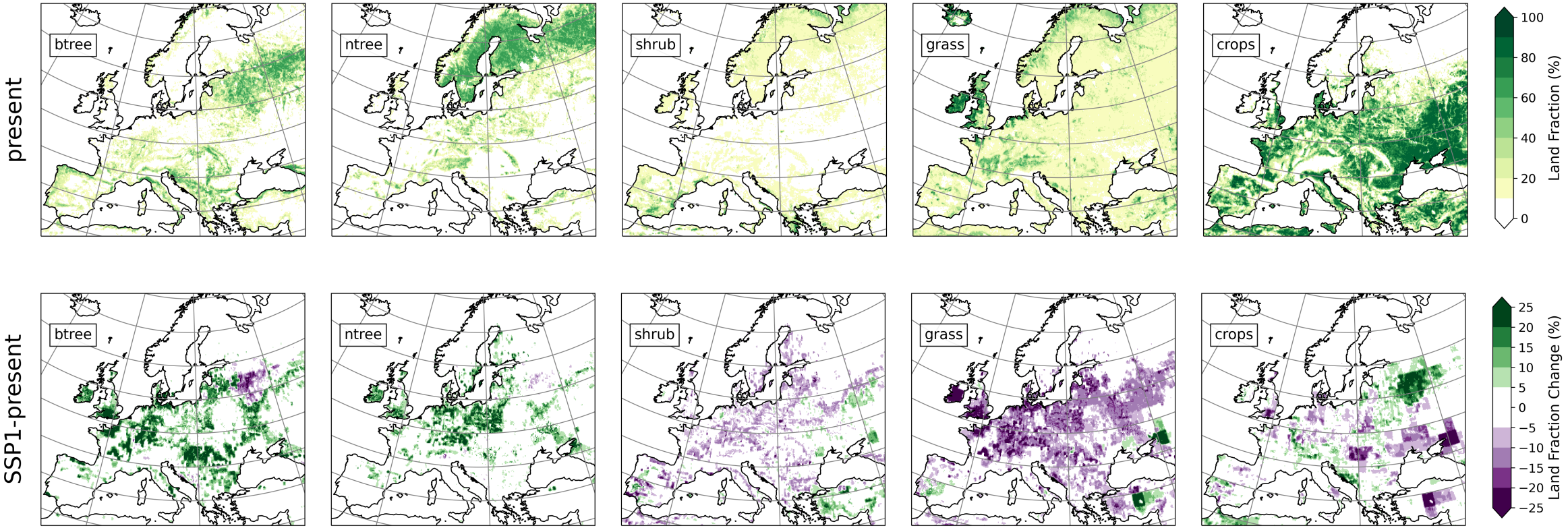
Reanalysis-Driven Runs

# Setup: Complementarity with LUCAS Phase II

| | This Experiment | LUCAS Phase II |
|---|---|---|
| *Global Climate Model* | MPI-ESM-LR | MPI-ESM-HR |
| *Members* | 4 | 1 |
| *Scenarios* | SSP1-2.6 & SSP3-7.0 | SSP1-2.6* |
| *Regional Climate Model* | CRCM5 | Multiple RCMs |
| *Land Surface Model* | CLASS v3.5c | Multiple LSMs |
| *Resolution* | 0.11 | 0.11 |
| *Domains* | Europe & North America | Europe |
| *Land Cover Maps* | LANDMATE | LANDMATE |
| *Land-Use Change* | Static | Transient |

*advantages

# Land Cover Maps: LANDMATE & LUCAS LUC




LUC under SSP1-2.6: forestation of grasslands, a realistic version of FOREST-GRASS.

Reinhart et al. (2022), Hoffmann et al. (2023)



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# Results:
# Summer in Europe under SSP1-2.6

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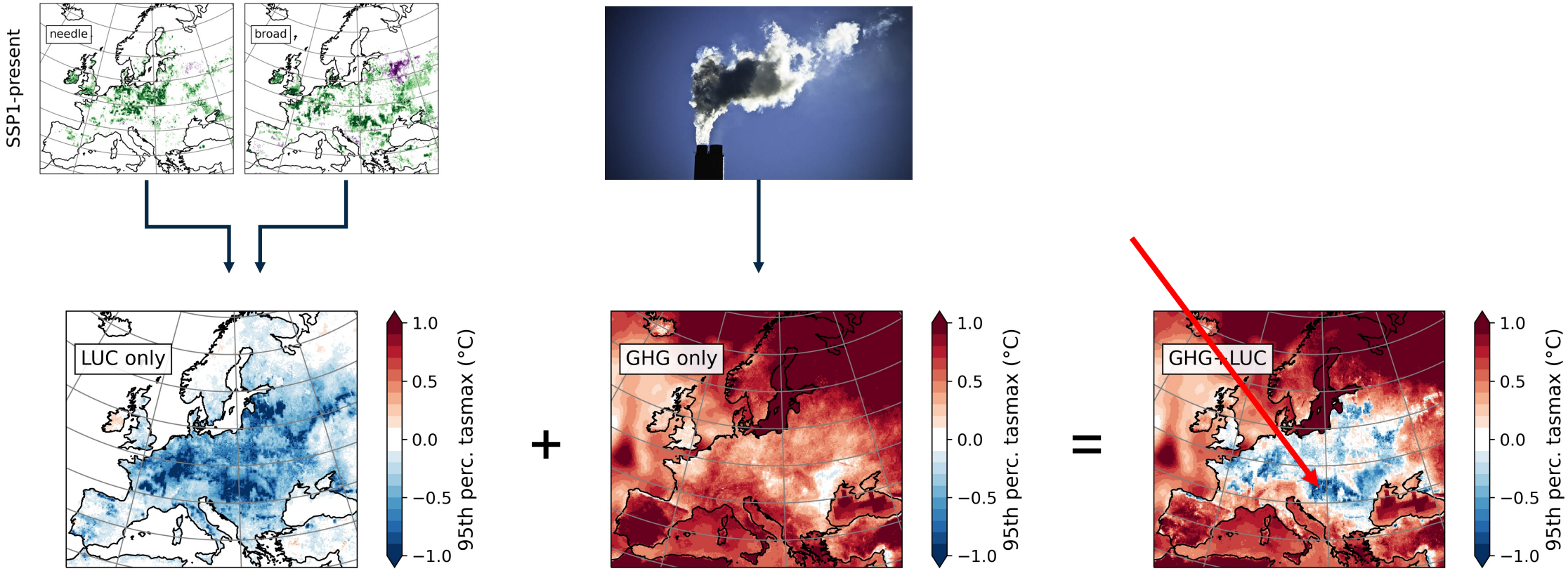
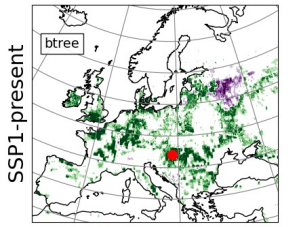
# FORESTATION MITIGATES SUMMERTIME HEAT EXTREMES




End-of-century heat extremes *reduced* under SSP1-2.6!

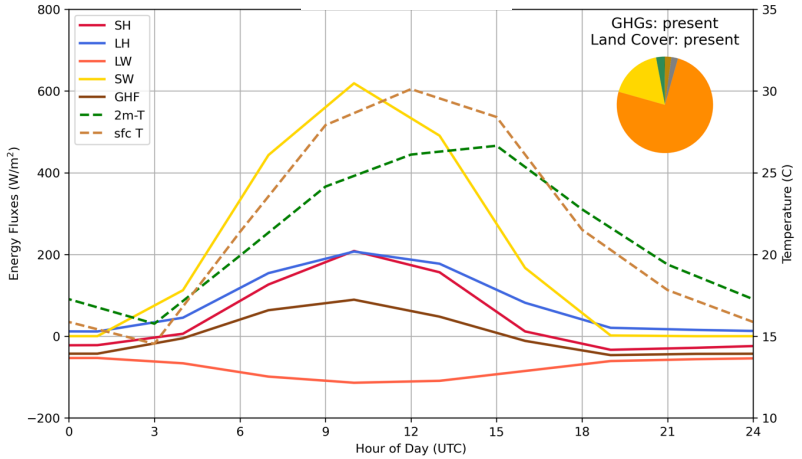
# DIURNAL CYCLE AT A BROADLEAF FORESTATION SPOT

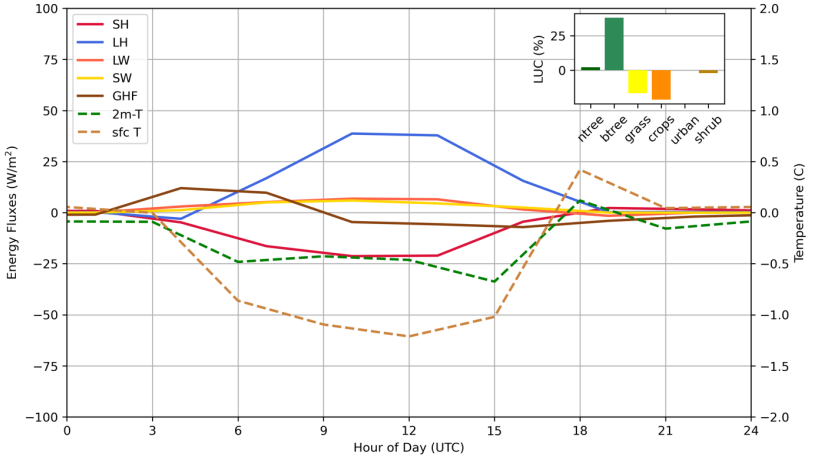



present land cover

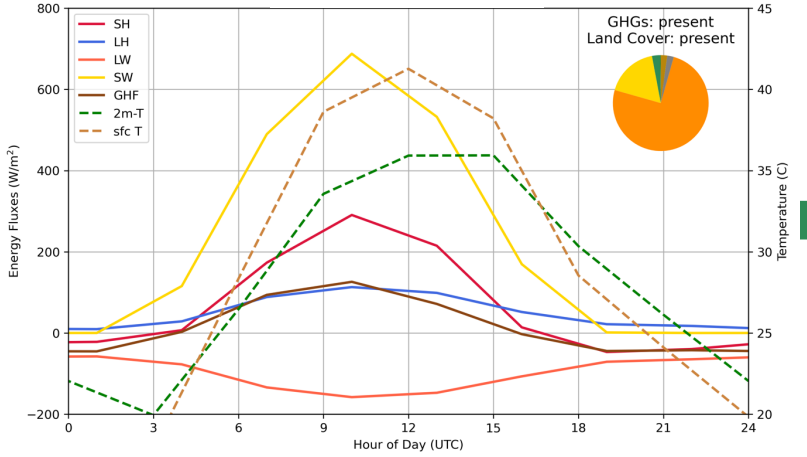
LUC effect

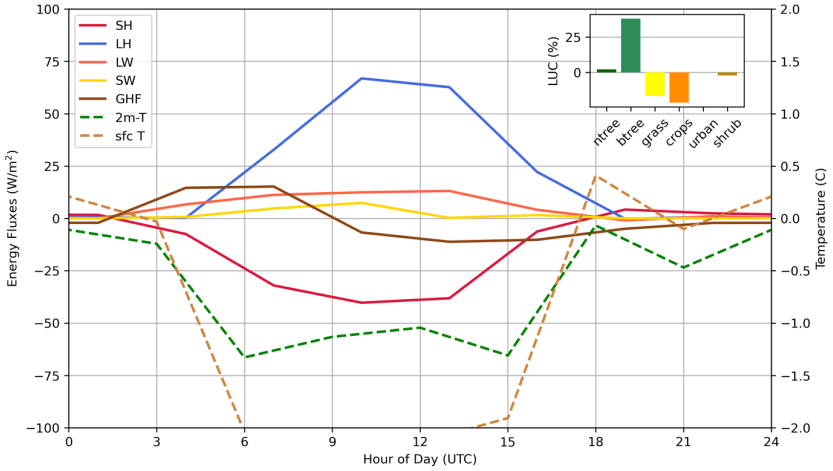
ALL DAYS




HOT DAYS




Forestation favors latent heat at the expense of sensible heat fluxes, damping the daily temperature maximum.

Effects exacerbated during hot days.

Consistent with remote sensing observations (Schwaab et al. 2020)

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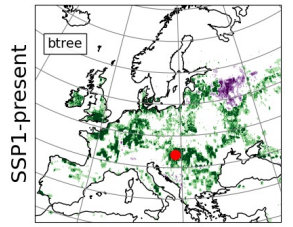
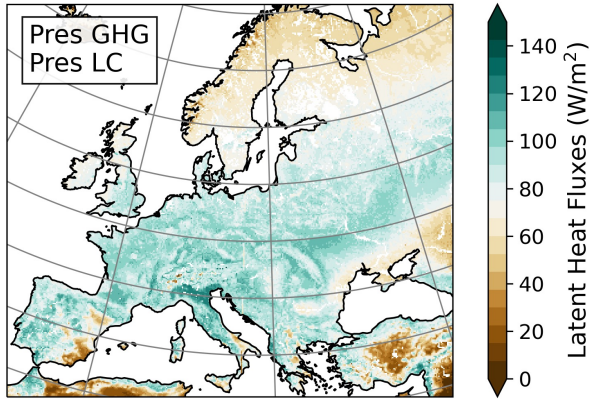
# LUC EFFECT ON LATENT HEAT FLUXES

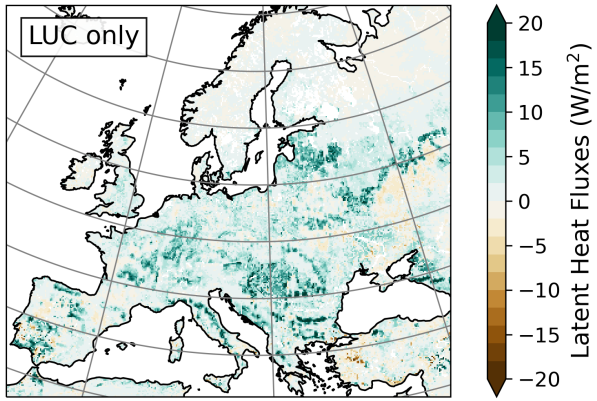



present land cover

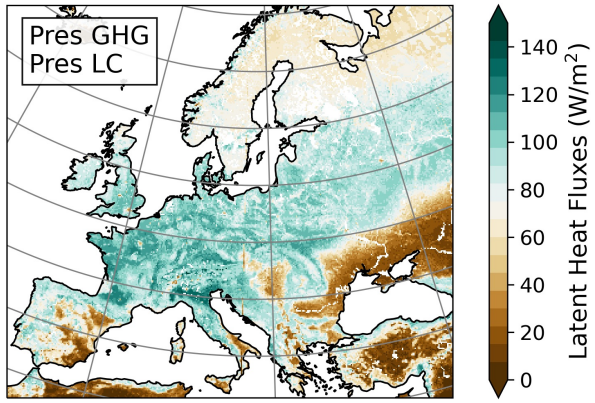
LUC effect

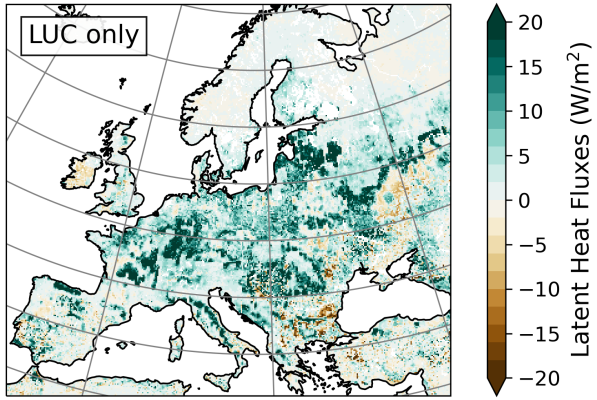
ALL DAYS




HOT DAYS

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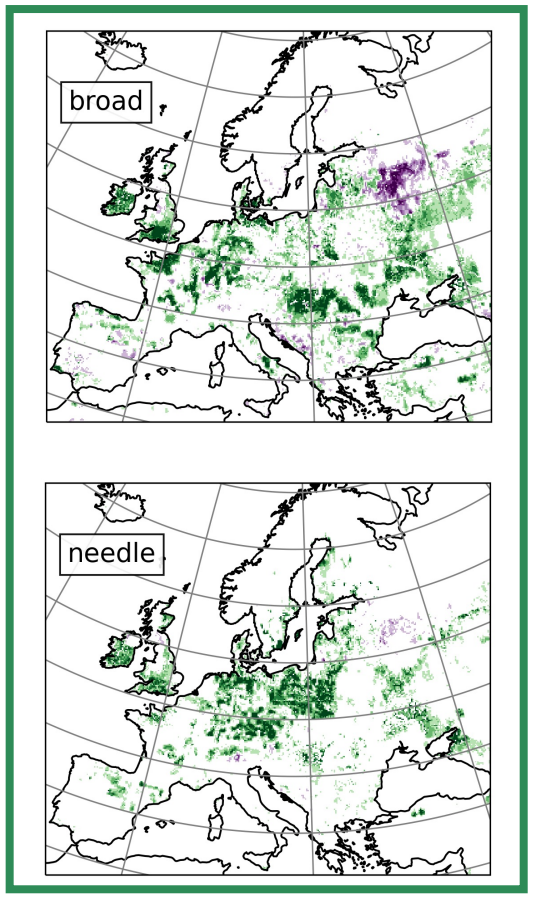
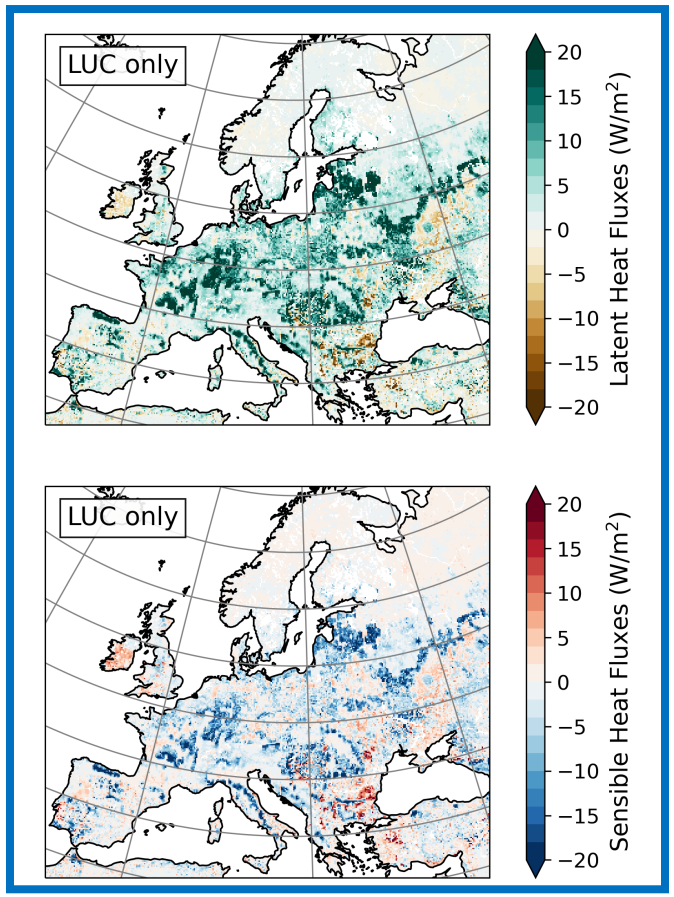
# COOLING PROVIDED BY ENHANCED EVAPOTRANSPIRATION

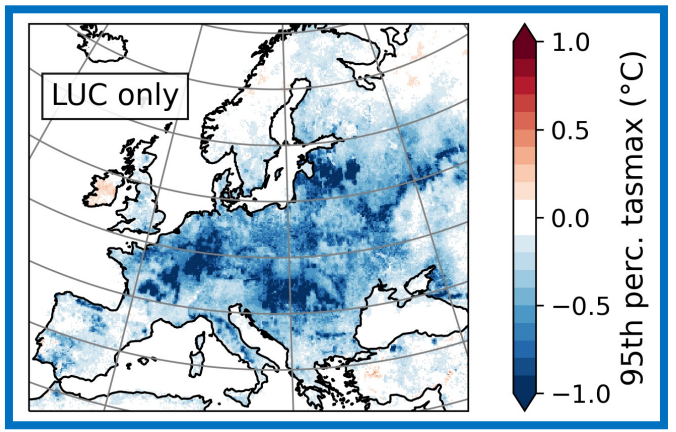
## SSP1 LUC: Forestation




## Shift in turbulent flux partition




## Mitigates Heat Extremes




Where does the water come from?



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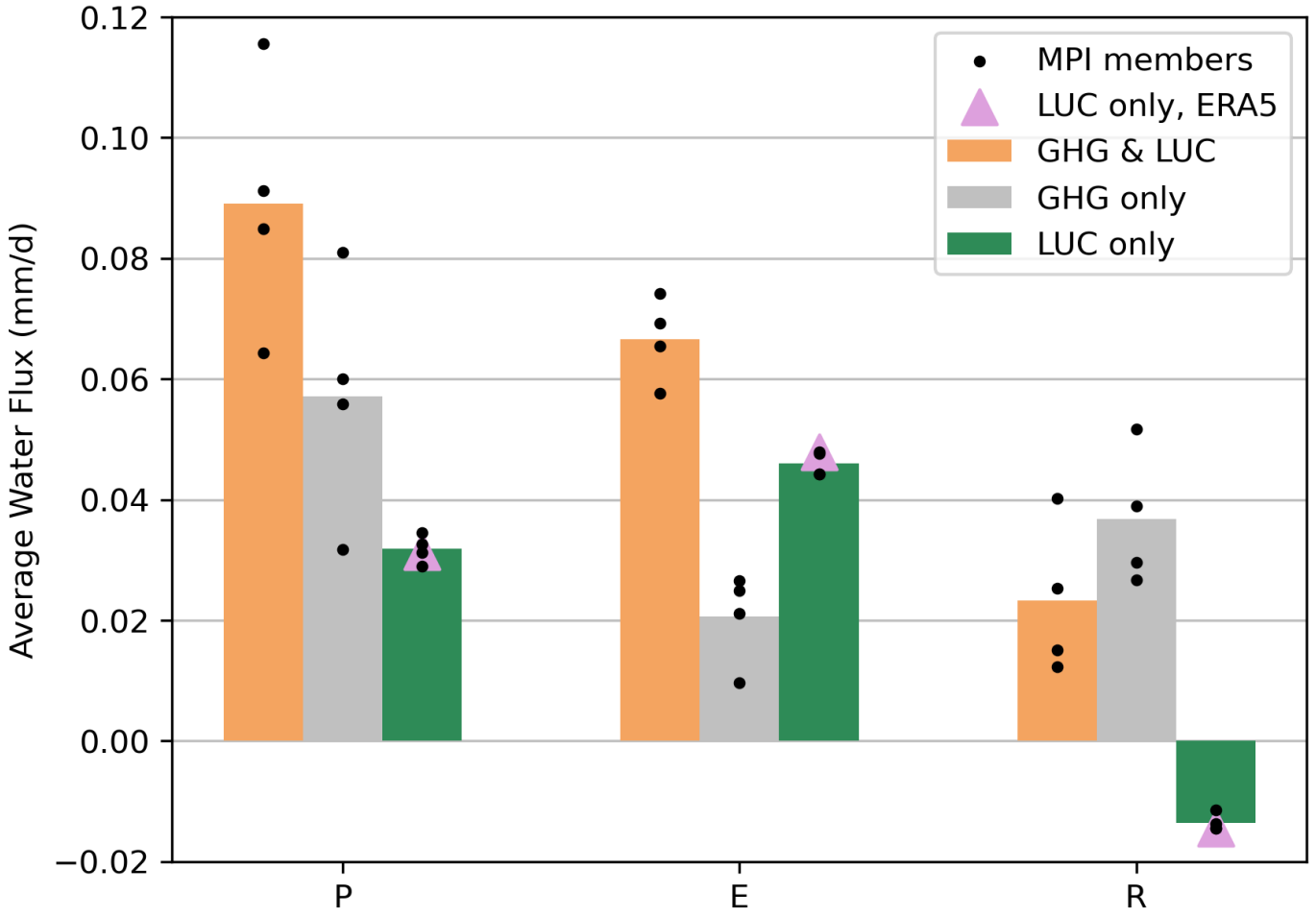
# ANNUAL WATER BUDGET




LUC effects:
+ Precipitation (0.03 mm/d)
+ Evapotranspiration (0.045 mm/d)
- Run-off (0.015 mm/d)



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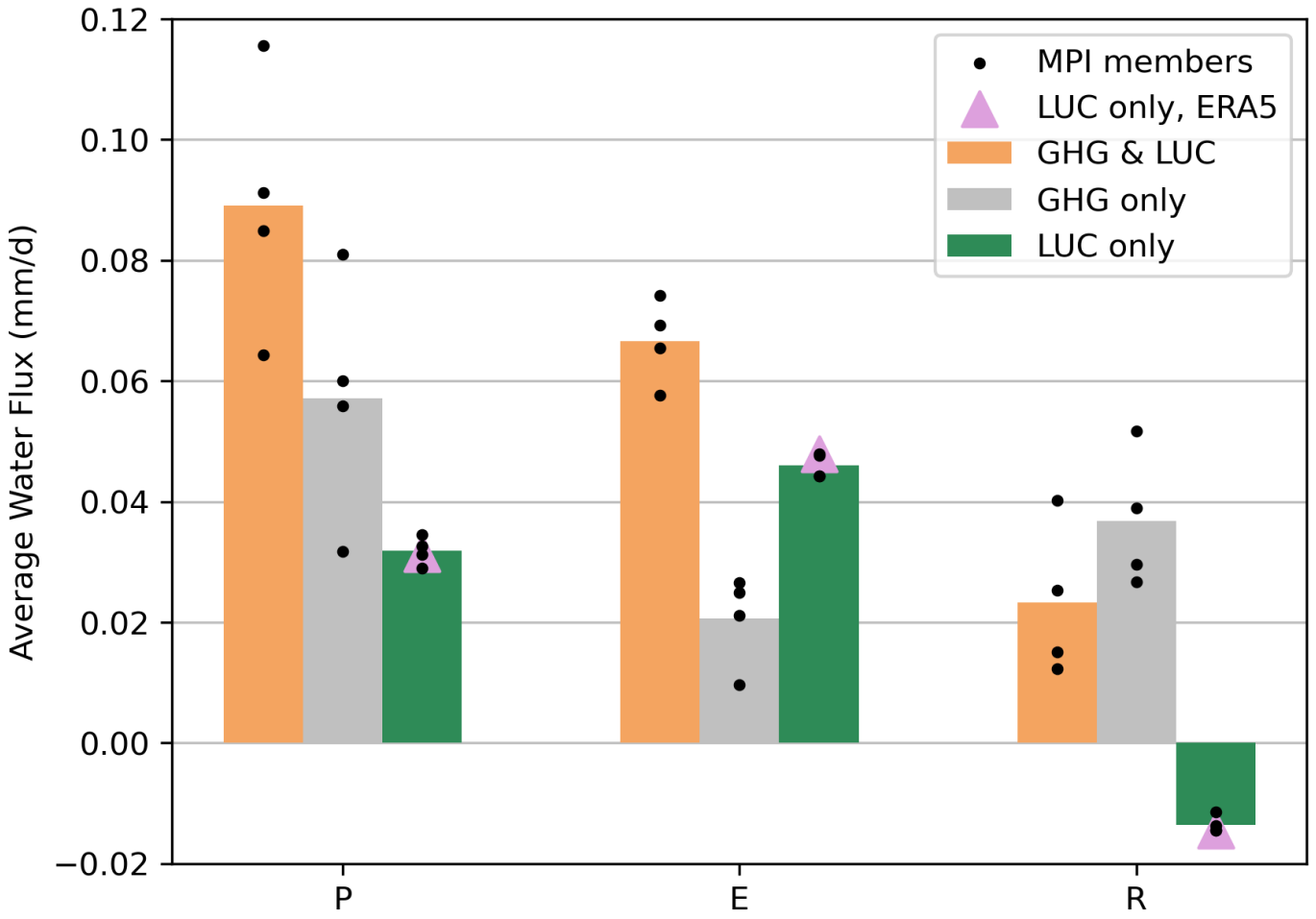
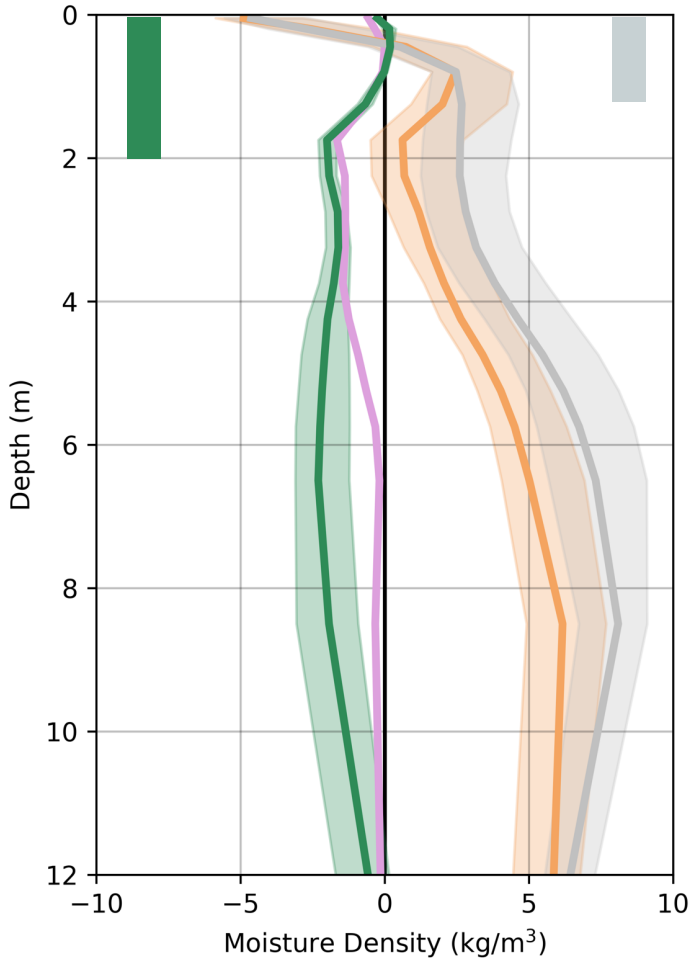
# ANNUAL WATER BUDGET




broadleaf root depth: 2 m

crops/grass root depth: 1.2 m




Trees pump extra water 1-2 m deep. The column below dries up, reducing deep run-off.

# Conclusions

- Forestation damps summertime heat extremes by enhancing evapotranspiration (and reducing sensible heat fluxes)
- Under SSP1-2.6, LUC beats GHG: heat extremes are reduced in 2100
- Increased evapotranspiration facilitated by forestation-induced precipitation, but also ends up drying the soil below 1 meter and reduce run-off.
- Forestation implies trading blue (run-off) for green water (evapotranspiration), with cooling benefits but water availability challenges.

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# Thank you!

For any comment:
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