Land use change impacts on hot extremes

Edouard Davin, Jonas Schwaab, Ronny Meier,
Christine Bürgi, Quentin Lejeune, Annette Hirsch,
Benoit Guillod, Wim Thiery, Sonia Seneviratne

1. Does land use change affect extremes more than the mean climate? → underlying processes

2. Land cover change-induced impacts on extremes in historical and future scenarios

3. Implications for adaptation: Fostering resilience to heat extremes through land management

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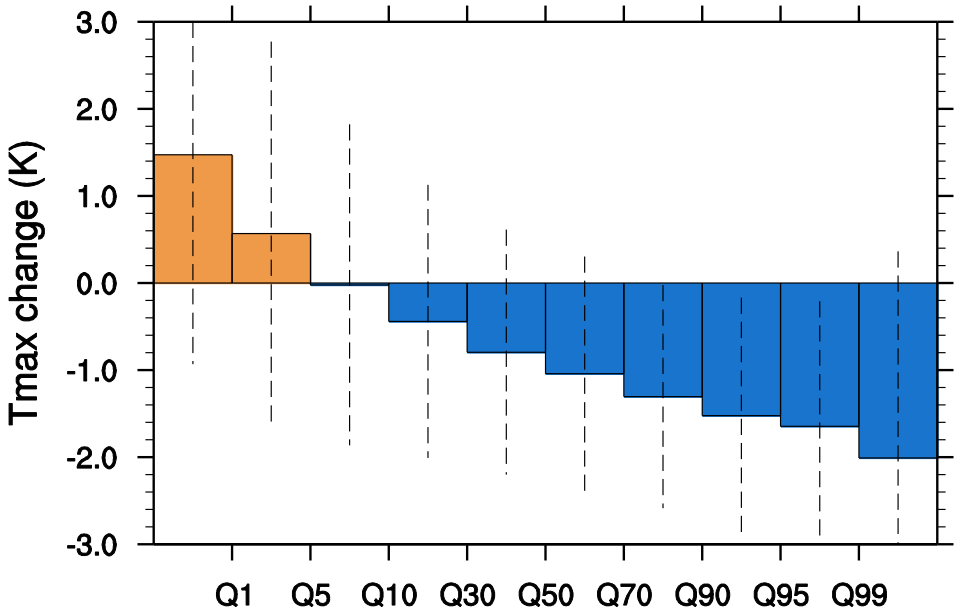
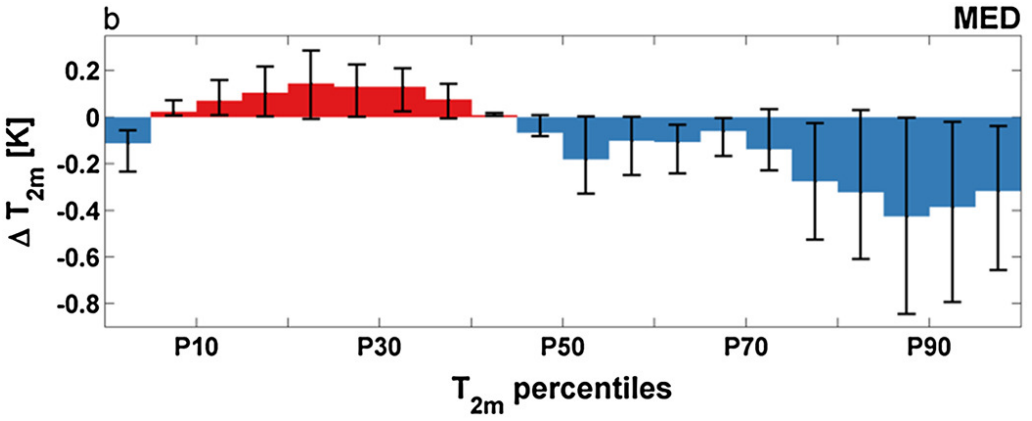
Photograph by Jim Richardson

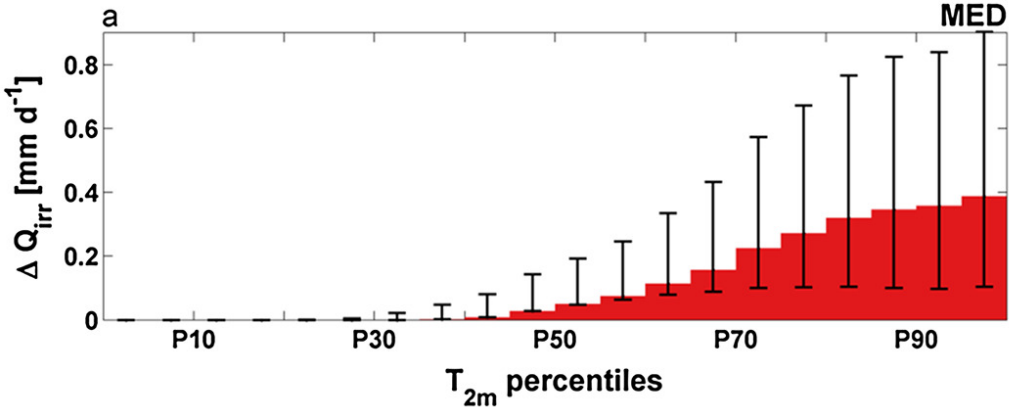
Albedo change through no-till farming



Davin et al., PNAS, 2014

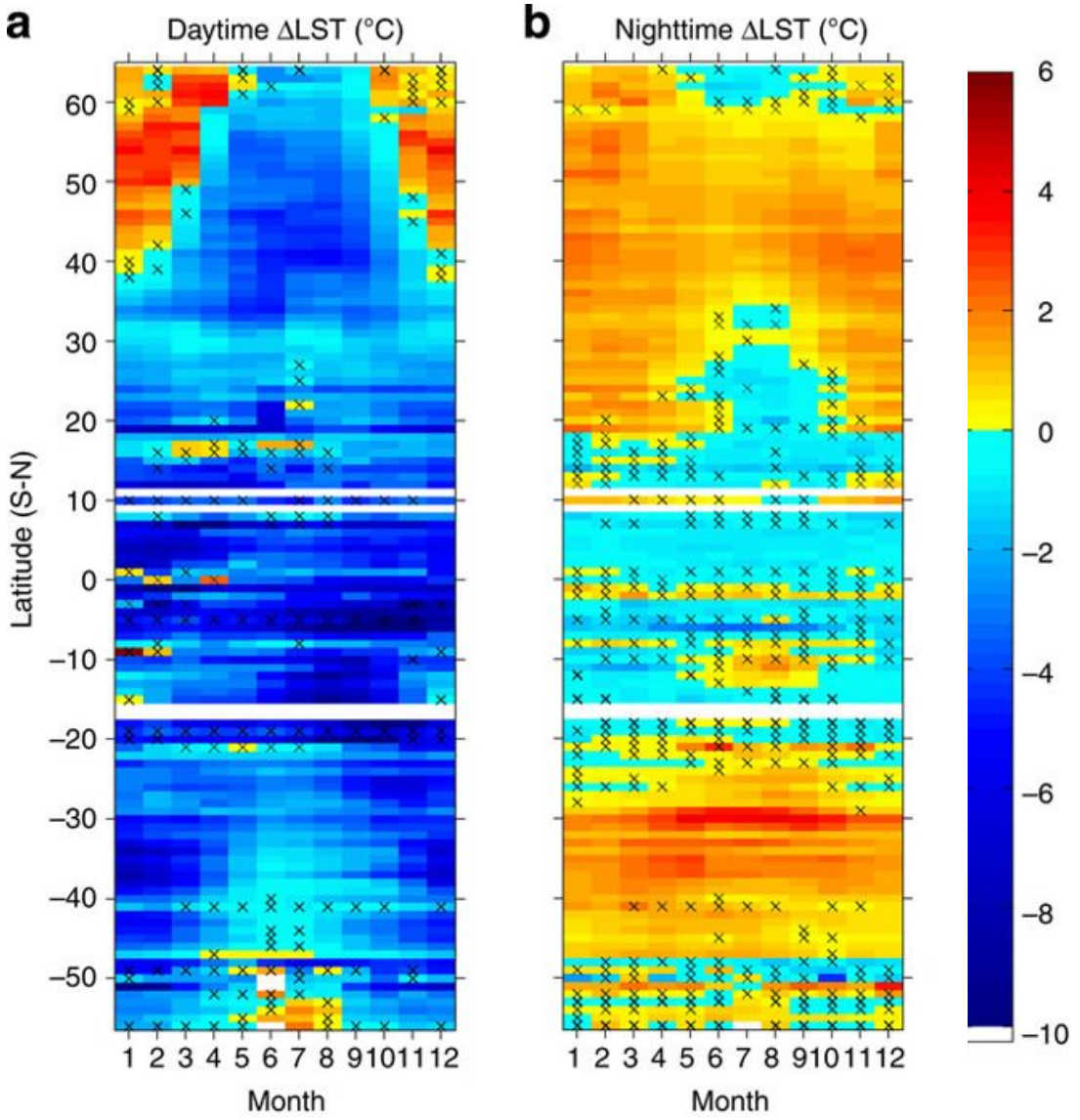
Moisture change through irrigation





Thiery et al., JGR, 2017

Contrasted diurnal and seasonal pattern of forest change effect on temperature



Li et al., NatComm, 2015

Key messages

Possible reasons for larger impacts of land use change on extreme temperatures:

- ✓ Albedo change generates higher radiative forcing during clear-sky conditions (e.g. heat waves)
- ✓ Moisture-temperature coupling stronger in dryer conditions
- ✓ Some management practices are applied preferentially in extreme situations (e.g. irrigation)
- ✓ Time averaging often mask contrasted diurnal/seasonal effects

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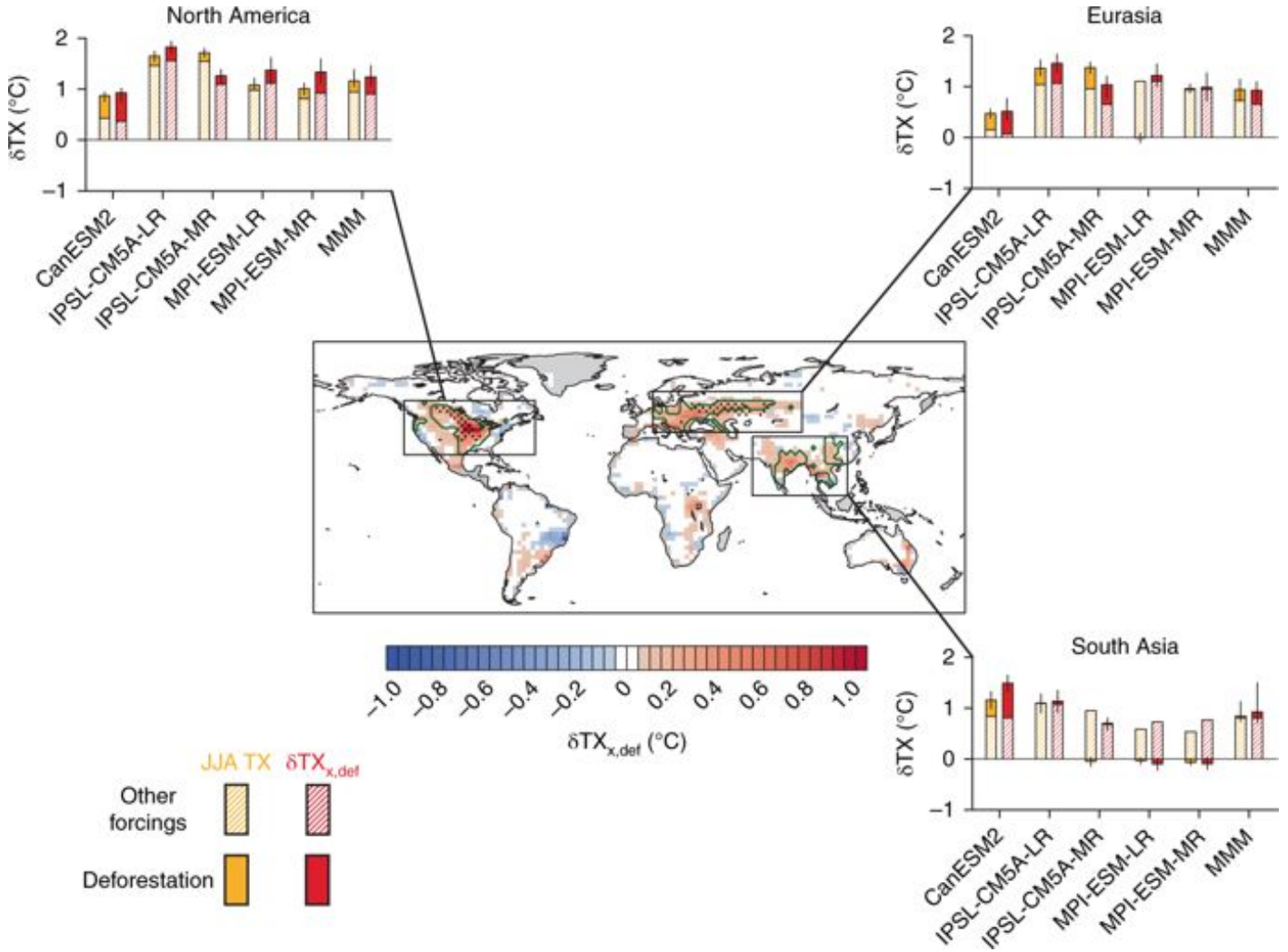
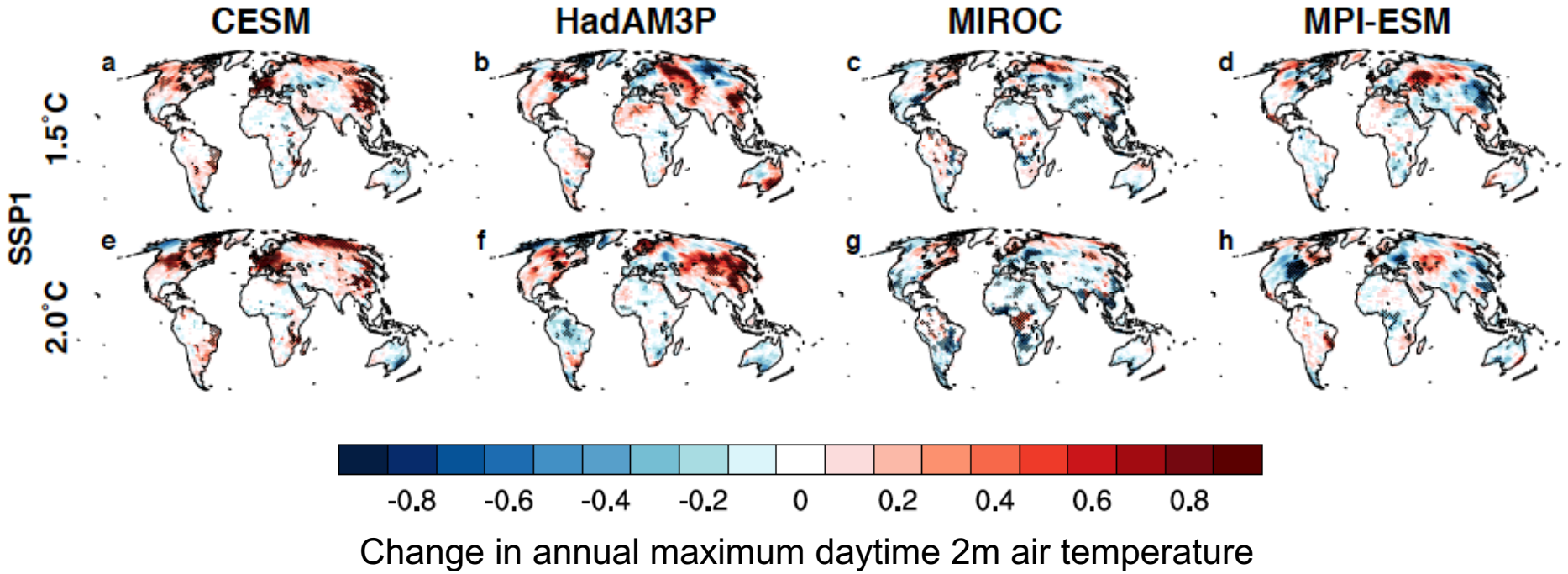
Effect of historical deforestation on extreme temperatures



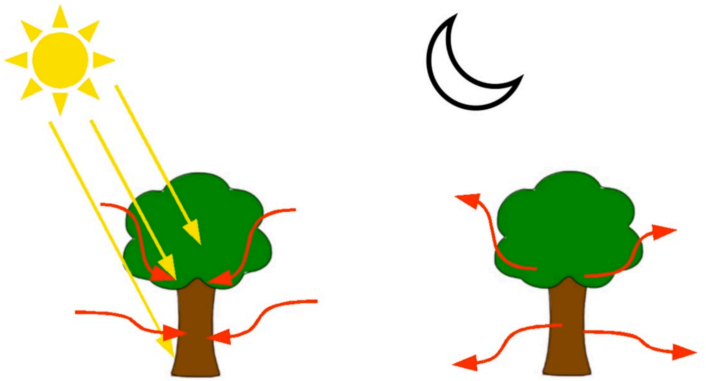
Lejeune et al., NCC, 2018

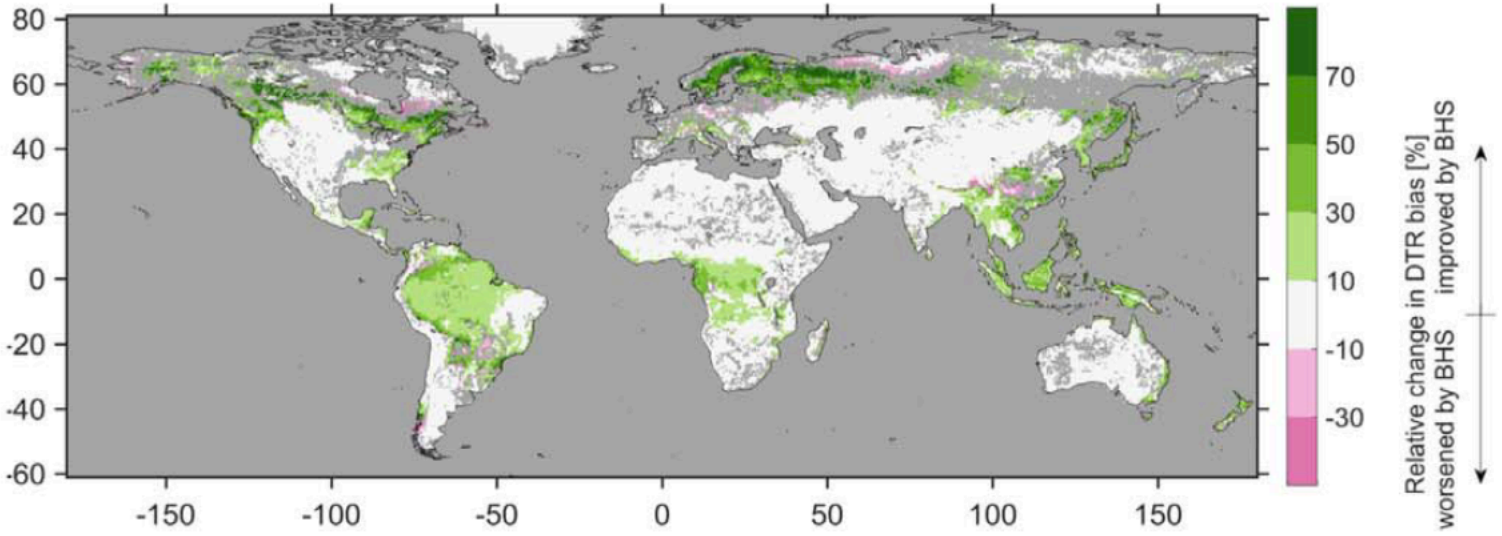
Land use change effect in low emission scenarios: HAPPI-Land experiment



Hirsch et al., EF, 2018

Missing processes: Biomass heat storage





Meier et al., ERL, 2019

Key messages

- Historical deforestation had a small annual mean cooling effect (*medium confidence*; IPCC SRCCL), but it has likely increased the magnitude of heat extremes.

- Future land use changes will continue to impact extremes. In low emissions scenarios, these impacts could be locally as large as CO_2-induced changes, but models strongly disagree on the magnitude and sign of changes.

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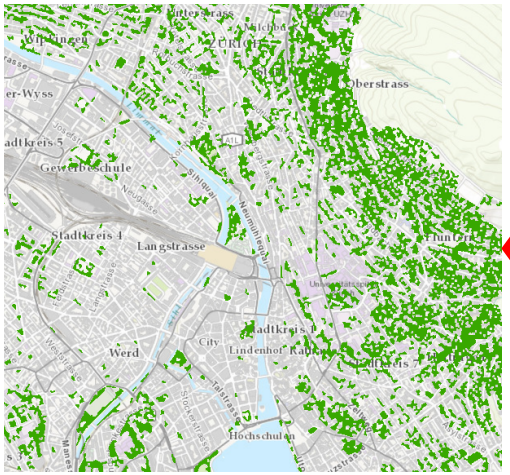
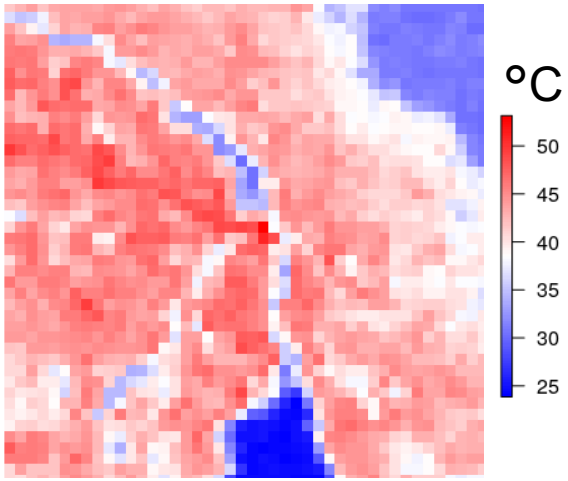
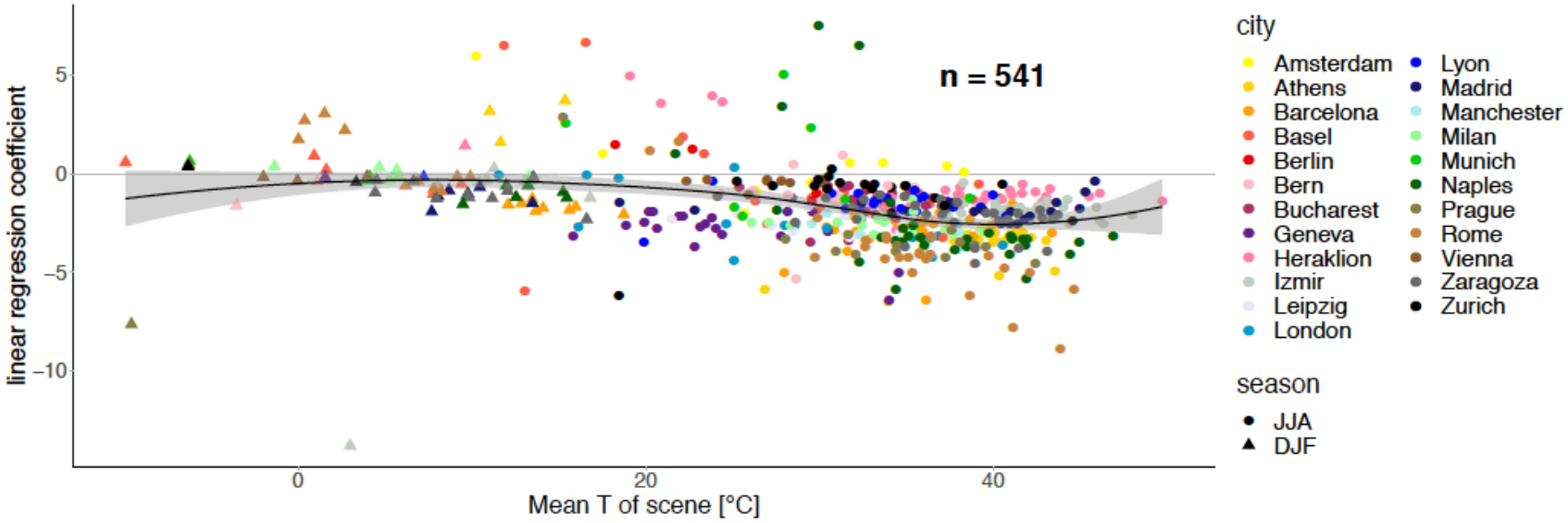
Tree coverage



LST

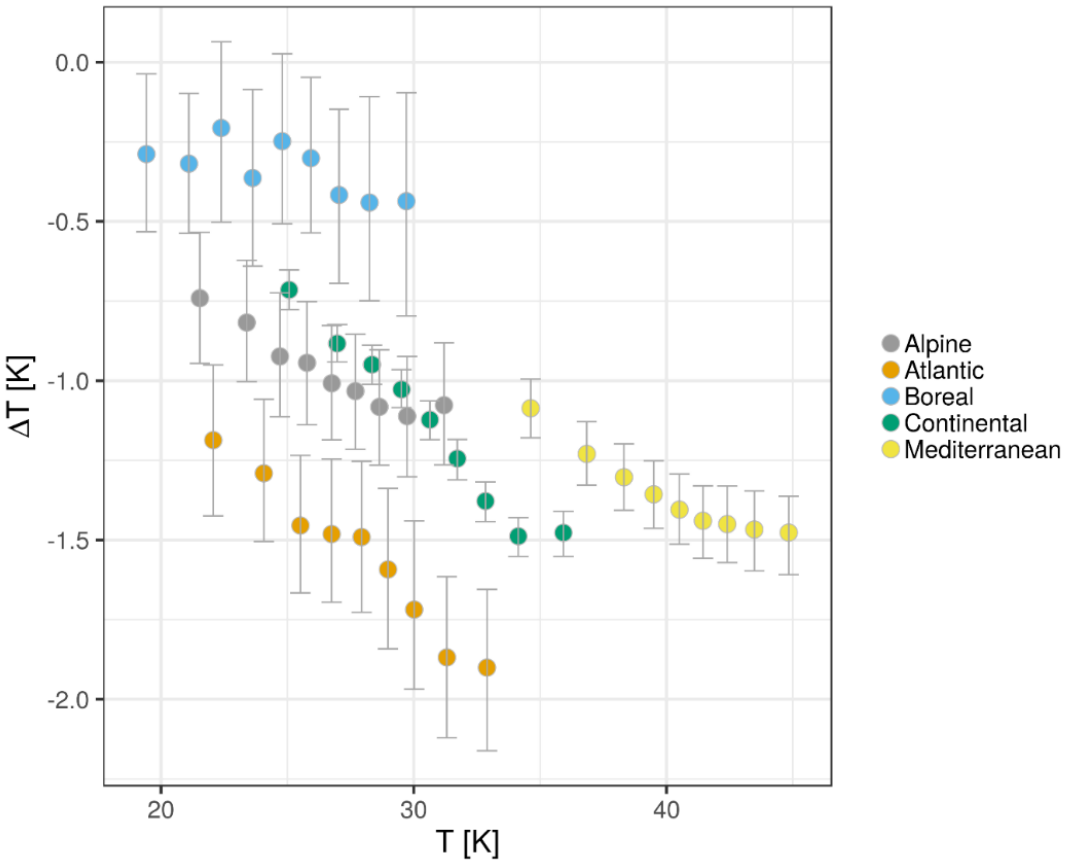


Cooling effect of trees in European cities



Schwaab, Bürgi, et al., in prep.

Forest management change: needleleaf to broadleaf



Schwaab et al., to be submitted

Further albedo-enhancing strategies

NATURE GEOSCIENCE PERSPECTIVE

Table 1 | Approaches relevant to LRMreg in agricultural and urban areas

	No-till farming (albedo changes from retaining crop residues)	Crop phenology and timing of practices (for example, double cropping	Biogeoengineering (cropping with natural, selected, or genetically modified reflective varieties)	Greenhouses	Urban albedo (white roofs, higher reflectivity of paving)
Impact on land albedo	Approx. +0.05 to +0.20 in the case of crops with high reflectivity residues (for example, wheat)[15,20,21]; less efficient for other crops.	Not quantified, probably similar to no-till farming in regions with tillage; depends on crop albedo, and background bare soil albedo, may also vary during crop growth[24].	Approx. +0.02 to + 0.15 (including crop dependent variations in glaucousness, trichomes, canopy morphology)[17,18,42,66].	Approx. +0.05 (winter) to +0.15 (summer)[26].	Approx. +0.1 to +0.15 as average increase over the urban areas[16,18,19] (locally: approx. +0.15 over roofs and +0.25 over pavement[19]).

Seneviratne et al., NatGeo, 2018

Key messages

- Biogeophysical effects from Land Use Change have often more impacts on extreme conditions than on the mean climate

- Extreme events disproportionally affect humans and ecosystems

➢ Land-based adaption considering impacts beyond mean conditions can foster resilience to heat extremes