

Crop albedo enhancement reduces the intensity of heatwaves under future climate

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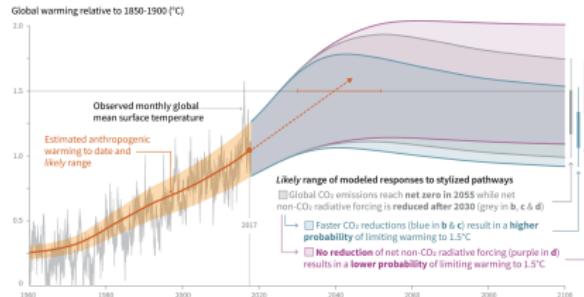
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Martin de Kauwe (UNSW), Andy Pitman (UNSW), Rachel Law (CSIRO)

11th June 2021

1.5°C is on our doorstep

Cumulative emissions of CO₂ and future non-CO₂ radiative forcing determine the probability of limiting warming to 1.5°C

a) Observed global temperature change and modeled responses to stylized anthropogenic emission and forcing pathways



b) Stylized net global CO₂ emission pathways

Billion tonnes CO₂ per year (GtCO₂/yr)

CO₂ emissions decline from 2020 to reach net zero in 2055 or 2040

1980 2000 2020 2040 2060 2080 2100

Faster immediate CO₂ emission reductions limit cumulative CO₂ emissions shown in panel (c).

c) Cumulative net CO₂ emissions

Billion tonnes CO₂ (GtCO₂)

1980 2000 2020 2040 2060 2080 2100

Maximum temperature rise is determined by cumulative net CO₂ emissions and net non-CO₂ radiative forcing due to methane, nitrous oxide, aerosols and other anthropogenic forcing agents.

d) Non-CO₂ radiative forcing pathways

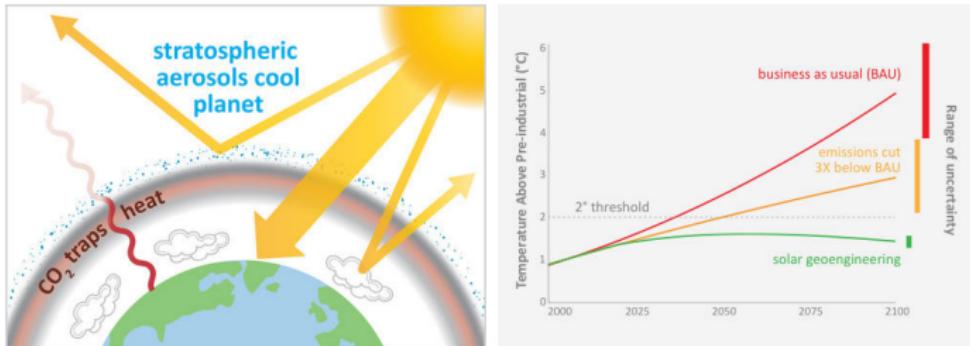
Watts per square metre (W/m²)

1980 2000 2020 2040 2060 2080 2100

Non-CO₂ radiative forcing reduced after 2030 or not reduced after 2030

From: <https://www.ipcc.ch/sr15/graphics/>

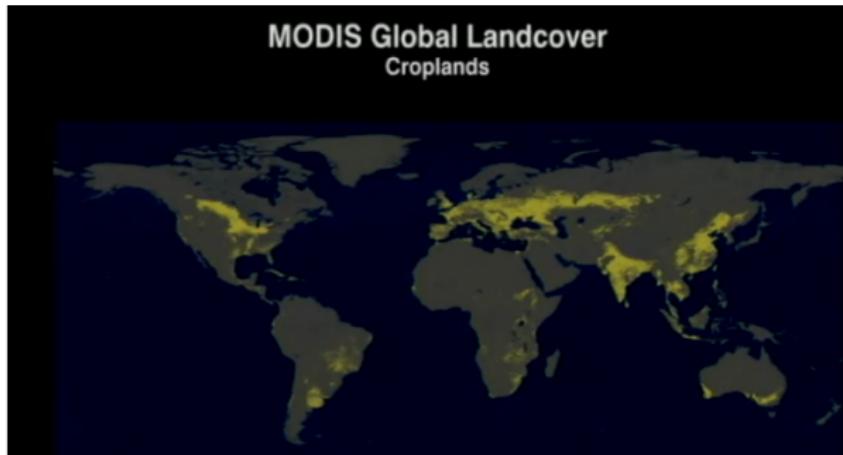
Climate geo-engineering to limit warming?



From: <https://geoengineering.environment.harvard.edu/geoengineering>

- ▶ Costs, governance, un-intended impacts, termination effects, band-aid solution, the list goes on.....

We already manage a lot of agricultural land



From: <https://svs.gsfc.nasa.gov/2264>

- ▶ What about land surface albedo management via crop management?
 - ▶ Much simpler to implement, effects mostly regional rather than global

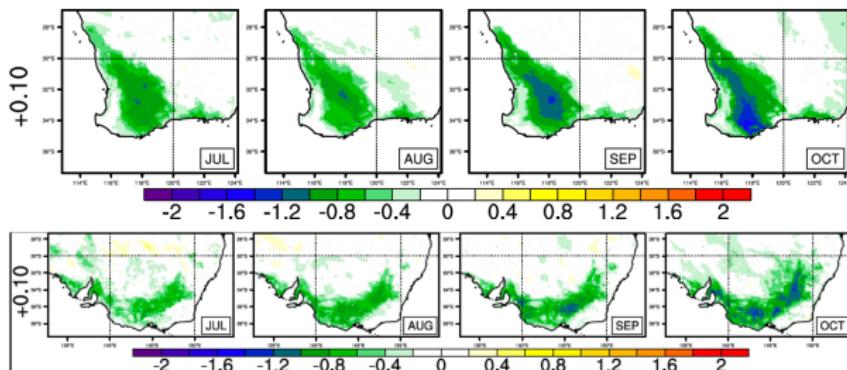
Surface albedo changes by altering crop varieties



Picture from Franco Miglietta, provided by Annette Hirsch

What we already know about making crops more reflective in climate models

- ▶ Increasing Crop albedo by up to 0.1 results in significant regional cooling in summer and yearly mean maximum temperatures



J. Kala, A. L. Hirsch (2020) Could crop albedo modification reduce regional warming over Australia? Weather and Climate Extremes, 30, 100282, doi:10.1016/j.wace.2020.100282

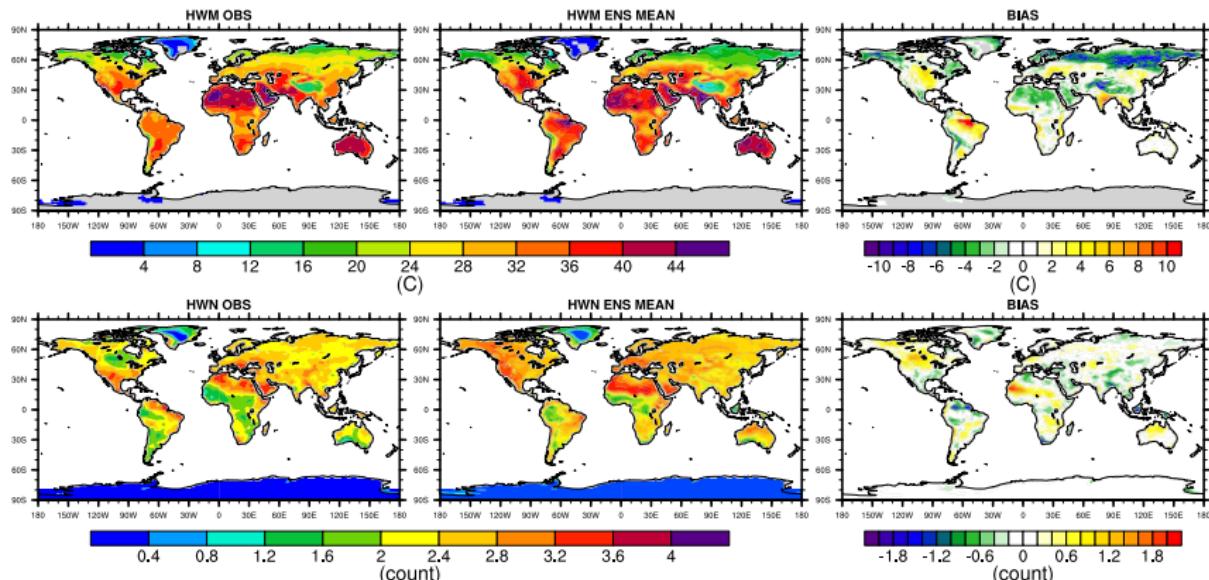
Influence of crop albedo modification on heatwaves?

- ▶ But what is the effect on heatwave events?
 - ▶ 3 or more consecutive days above particular temperature thresholds, e.g., 90% percentile of maximum temperature
- ▶ Could more reflective crops reduce heatwave intensity, duration and frequency?

Simulations

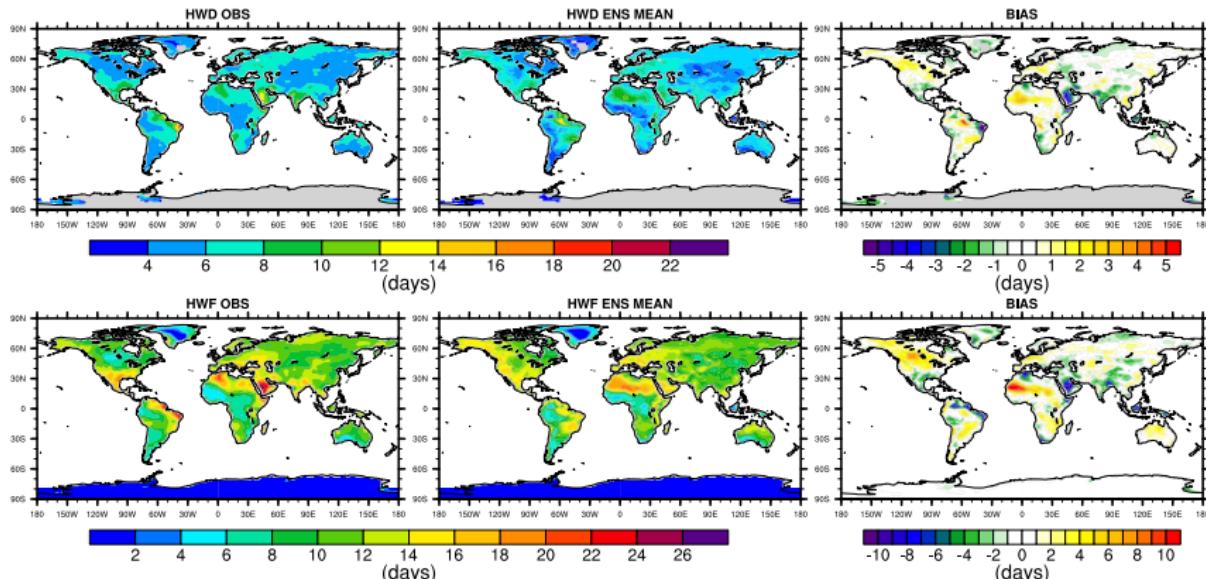
- ▶ Fully coupled simulations using ACCESS ESM1.5 following SSP-245 for future climate
 - ▶ Control: 10 Ensembles 1850-2100
 - ▶ Experiment: same 10 Ensembles but with higher crop albedo by approximately +0.1 applied from 2021 to 2100

How well does ACCESS ESM1.5 simulate heatwaves under current climate?



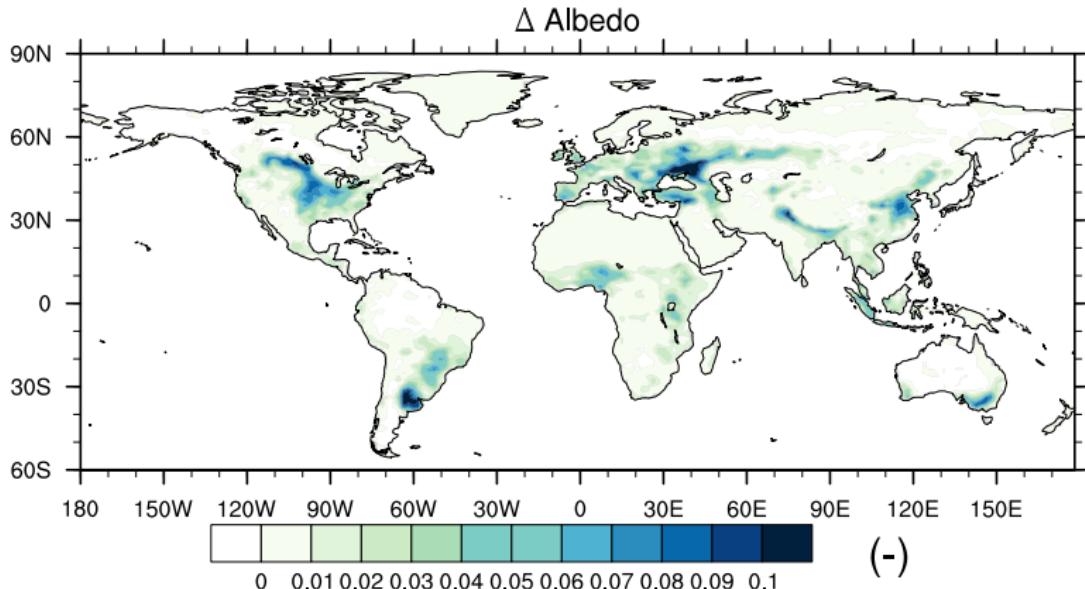
- ▶ HWM = Heatwave Magnitude
- ▶ HWN = Heatwave Number

How well does ACCESS ESM1.5 simulate heatwaves under current climate?

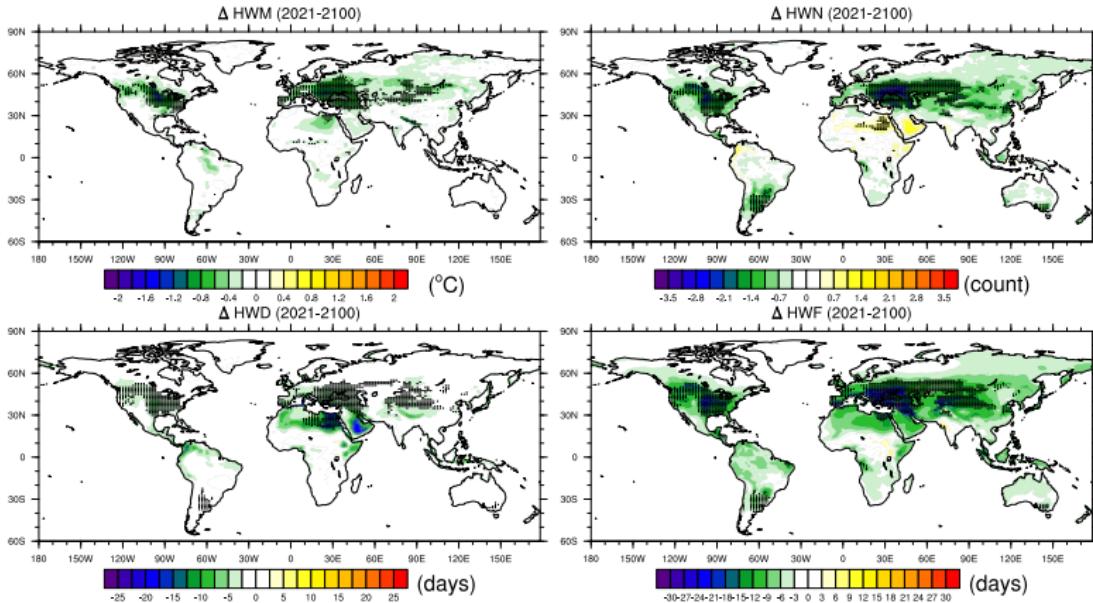


- ▶ HWD = Heatwave Duration
- ▶ HWF = Heatwave Frequency

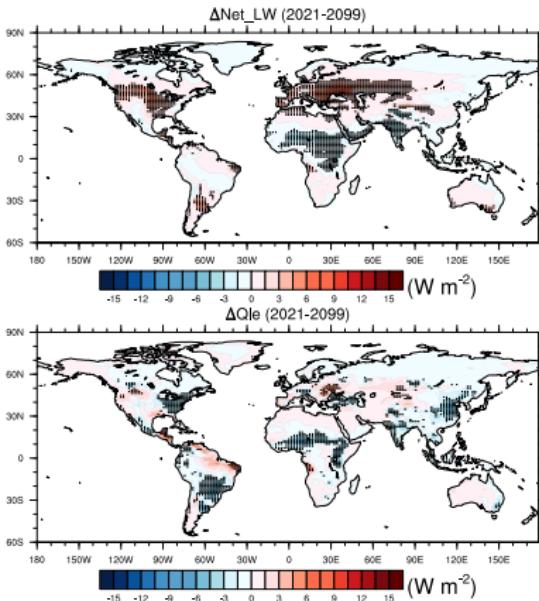
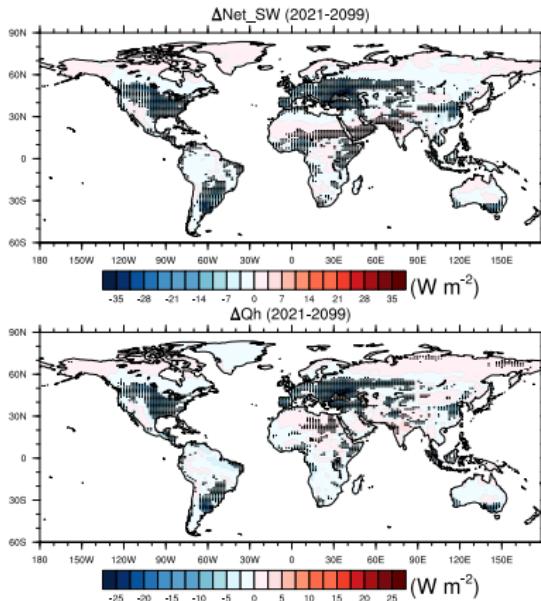
Imposed Albedo Perturbation from 2021 onwards



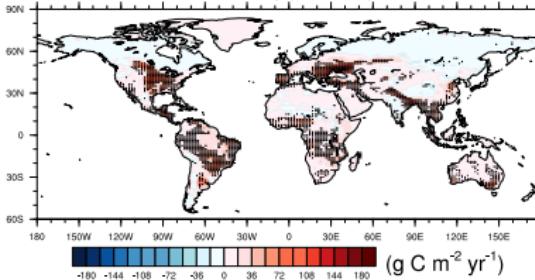
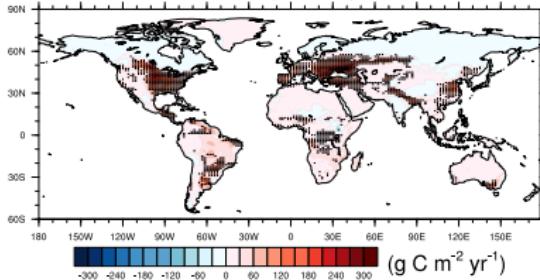
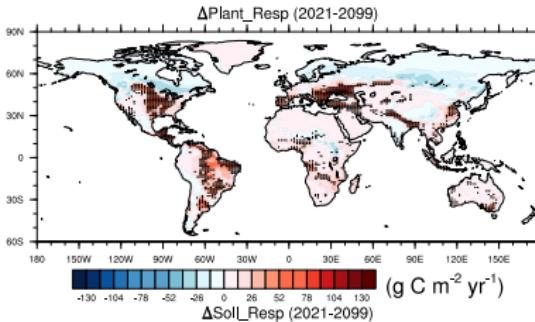
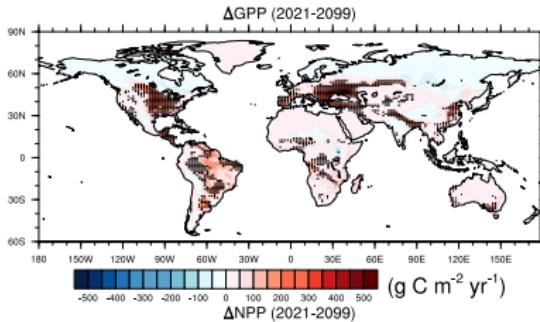
Effect of higher crop albedo on heatwave metrics



Change in the surface energy balance



Change in the Carbon budget



Concluding remarks

- ▶ Increasing crop albedo by 0.1 is the “top of the envelope”
- ▶ There is one generic C3-Cropland category (as is the case in most ESMs)
- ▶ Our changes in the C-cycle are larger as compared to other studies using CESM to investigate crop albedo enhancement
 - ▶ But the overall effect is still an increase in the land sink of Carbon, it's not a bad thing