Non-linearity in future heatwave changes with global warming

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KEY CONCLUSIONS

- The impact of heatwaves affects millions of people globally, and these impacts are predicted to worsen due to global warming.
- We show that in climate models, changes in key heatwave metrics are linked not only to the increases in temperature, but also the future scenario and pathway used.
- This result means that there are a range of possible changes to heatwaves for singular temperature increases.

QUESTIONS & METHODOLOGY

- We want to determine whether there was any difference in Heatwave characteristics at the same level of global warming if different Shared Socio-economic Pathways (SSPs) and emission levels were followed in the future.
- We used four future scenarios outlined in the CMIP6 ScenarioMIP publications, ranging from SSP 126 (quick reduction of emissions, increasingly sustainable use of world resources) to SSP 585 (more fossil fuel development, emissions continue to rise. Models are outlined in the table below.
- We define a heatwave as 3 or more consecutive days in which the calendar day 90th percentile of T_{max}, based on a 15-day moving window is breached, as defined in Perkins & Alexander, 2013.
- We calculate the average severity, duration and frequency of the heatwaves on a 21-year moving window in the future simulations and for 1995-2015 from the historical simulations.

Model name	No. of gridboxes	Number of future ensembles used	Number of historical ensemble members used
AWI-CM1-1-MR	384 x 192	1	5
MPI-ESM1-2-HR	384 x 192	3	5
CCCma-CanESM5	128 x 64	5	5
CSIRO-ACCESS-CM2	192 x 144	2	2
CSIRO-ACCESS-ESM1-5	192 x 145	3	3
BCC-CSM2-MR	320 x 160	1	3
CAMS-CSM1-0	320 x 160	1	2
CMCC-ESM2	288 x 192	1	1
CNRM-CM6-1	256 x 128	1	5
CNRM-ESM2-1	256 x 128	1	5
GFDL-ESM4	288 x 180	1	3
INM-CM4-8	180 x 120	1	1
INM-CM5-0	180 x 120	1	5
IPSL-CM6A-LR	144 x 144	4	5
MIROC6	256 x 128	3	5
MIROC2-ES2L	128 x 64	1	5
MRI-ESM2-0	320 x 160	1	5
NorESM2-MM	288 x 192	1	1
TaiESM1	288 x 192	1	1
UKESM1-0-LL	192 x 144	3	4

RESULTS

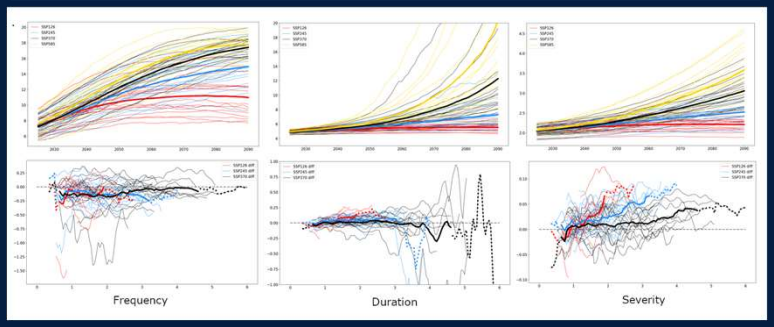

Figure 1: Changes to heatwave characteristics in the future. Top Row) Changes to the frequency, duration and severity through time for each individual model and scenario (thin lines) and multi-model mean for each scenario (thick lines). Bottom Row) Differences between ssp585 and other scenarios, plotted as a function of global land temperature for each individual model and scenario (thin lines) and multi-model mean for each scenario (thick lines). Dashed lines show where a mean is taken from less than 5 models, solid lines indicate that more than 5 models are available for the mean.

- Figure 1 show that globally, all heatwave characteristics initially increase with time for all scenarios, with a slight decrease in characteristics in the SSP 126 scenario towards the end of the century. However, when plotted against the warming, there is a difference in global heatwave severity between the SSP 585 and other scenarios.
- Figure 2 shows that these differences occur in local regions too. Severity is increased in SSP 585 at a given warming, whilst duration is reduced in SSP 585 compared to other scenarios.
- Of the 21 regions we split the world into, only 19 show a difference between SSP 585 and at least 1 other scenario, and over half show differences in at least 2 heatwave characteristics.

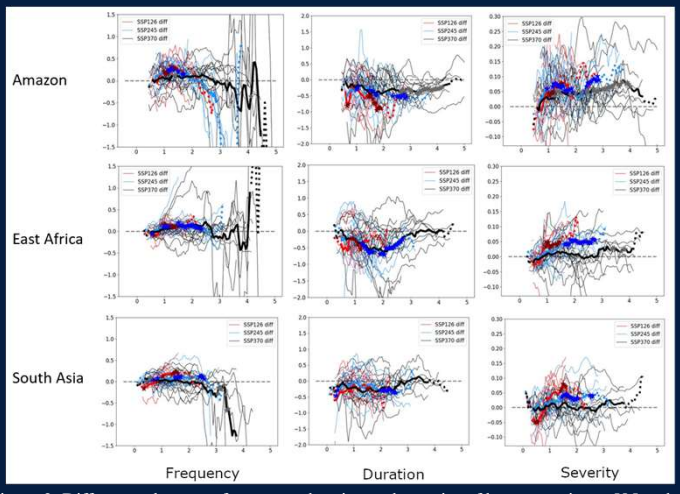

Figure 2: Differences between frequency, duration and severity of heatwaves in ssp585 and other scenarios by local warming, for 3 hand-picked regions. Plot shows each individual model and scenario (thin lines) and multi-model mean for each scenario (thick lines).

CONCLUSION

- These results show that the potential impacts of future heatwaves differs due to the pathway followed, and not just the amount of warming. Therefore, policymakers should consider the impacts of each pathway of emissions, not just a singular warming limit.

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