Source attributions of radiative forcing by regions, sectors, and climate forcers

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"Achieving the low forcing levels strongly relies on negative CO_2 emissions under the scenarios we considered. GHGs are projected to contribute most of forcings at the end of this century, under all socioeconomic scenarios, with short-lived climate forcers (except methane) playing relatively minor roles. Our results indicate a crucial role of China for reducing the end-of-the-century forcing from high to low levels."

Introduction

- Understanding the contributions of radiative forcings by different regions, sectors, and climate forcers can help policymakers understand the relative importance of various sources for meeting the Paris Agreement temperature targets.
- We used the latest historical and future emissions data for a full suite of climate forcers, as well as land-use datasets.
- We applied a normalized marginal approach to quantifying the contributions of regions, sectors, and climate forcers under scenarios towards the forcing levels of 1.9 Wm^{-2} and 2.6 Wm^{-2} in 2100, a proxy of the 1.5 °C and 2 °C targets of the Paris Agreement, respectively.

Methodologies

- **SCM4OPT v3.0**

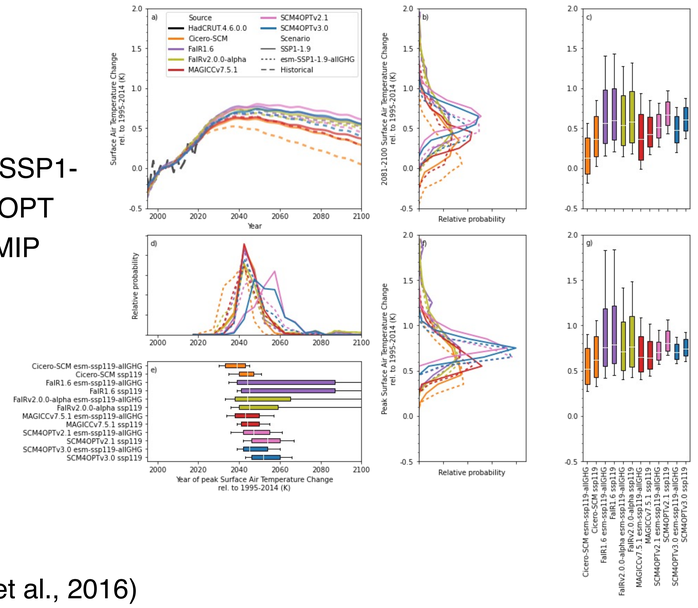


Figure 1: Temperature increases of SSP1-1.9 scenario produced by the SCM4OPT v3.0, compared to the results of RCMIP phase 2 (Nicholls et al., 2021).

- **Normalized marginal method** (Li et al., 2016)

$$F_e = \left(F_{all} - F_{e,\epsilon}\right) \Big/ \sum_{e\prime} \left(F_{all} - F_{e\prime,\epsilon}\right) \cdot F_{all}$$

F_e indicates the marginal effect of the the forcing agent, F_{all} shows the forcing agent with global emissions as input while $F_{e,\epsilon}$ means the forcing agent with the global emissions after subtracting $e \cdot \epsilon$, ϵ=0.001, as input.

Results

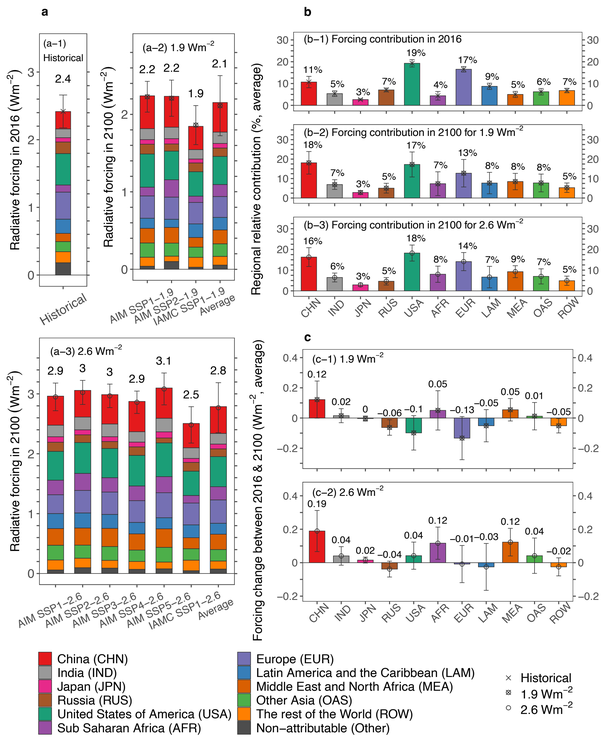
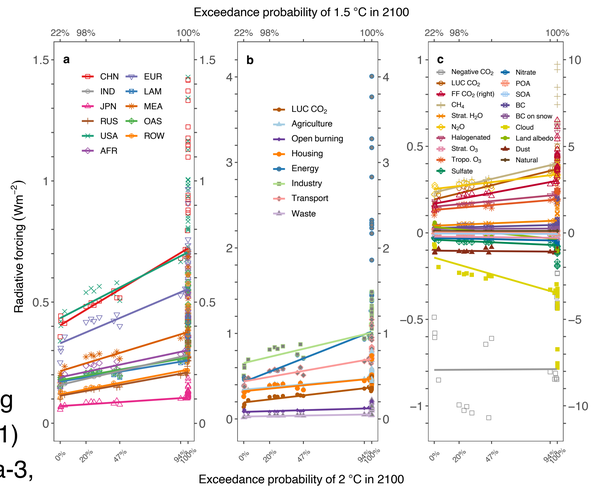


Figure 2: Forcing contributions of regions. Regional forcing contributions in 2016 under the historical scenario (a-1, b-1) and in 2100 under the 1.9 Wm^{-2} (a-2, b-2) and 2.6 Wm^{-2} (a-3, b-3) scenarios. Panel c shows the forcing increases in 2100, compared to the 2016 level under the 1.9 Wm^{-2} (c-1) and 2.6 Wm^{-2} (c-2) scenarios.

Figure 3: Forcing contributions of regions, sectors, and climate forcers under a range of forcing scenarios and their relation to the exceedance probability of the Paris Agreement targets. The figure shows the relationship of the exceedance probability of the 2 °C or 1.5 °C target in 2100 to regional forcing contributions (a), sectoral forcing contributions (b), and forcing contributions from climate forcers (c).



Conclusion

- Our results indicated increases in forcing contribution from developing regions, such as **China, India, the Middle East and North Africa, sub-Saharan Africa and other areas in Asia**, in 2100 under both the 1.9 Wm^{-2} and 2.6 Wm^{-2} scenarios.
- The negative CO_2 forcing is projected to contribute **-0.52±0.32 Wm^{-2} and -0.93±0.56** Wm^{-2} under the 1.9 Wm^{-2} and 2.6 Wm^{-2} scenarios, respectively. This finding illustrates the importance of negative CO_2 emissions in achieving climate targets under the scenarios we considered.
- Our results indicated that, to increase the likelihood of achieving the Paris Agreement temperature targets, **China** would play a larger role in lowering the end-of-the-century forcing than other regions.