Regional and sectoral contributions to climate change

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Introduction

- Countries' or **regional contributions** to climate change are important in the formulation of climate change policy.
- Developed countries emit CO_2 or non-CO_2 emissions which may date back to pre-industrial and the **historical emissions are large**; while developing countries contribute relative fewer emissions in historical period but **increase significantly in recent years or visible future**.
- The objective of this study is to quantify the **contributions to climate change for each region or country in the world, as well as the relative contribution from each anthropogenic emission, including CO_2 and non-CO_2 emissions or sectoral contribution**. A **regional contribution table** considering historical timescale will be obtained for making climate change policy.

Method

- **Normalized marginal method** (Li et al., 2016)
- For each GHG emission, we performed three simulations:
  - ✓one 'normal' with all emissions included in the simulation ('all');
  - ✓one with country emissions reduced by a fraction ε ('$-\varepsilon_{Country}$'), here ε=0.1%;
  - ✓and one with all except the country emissions reduced by the same fraction ('$-\varepsilon_{RoG}$', for rest of the globe).
- Relative contribution α following the normalized marginal method: $\alpha = [Tem(all) - Tem(-\varepsilon_{Country})]/[2 \times Tem(all) - Tem(-\varepsilon_{Contry}) - Tem(-\varepsilon_{RoG})]$.
- The **S**imple **C**limate **M**odel for **OPT**imization (**SCM4OPT**) is used for climate change simulation.
- **Climate-related uncertainties:**

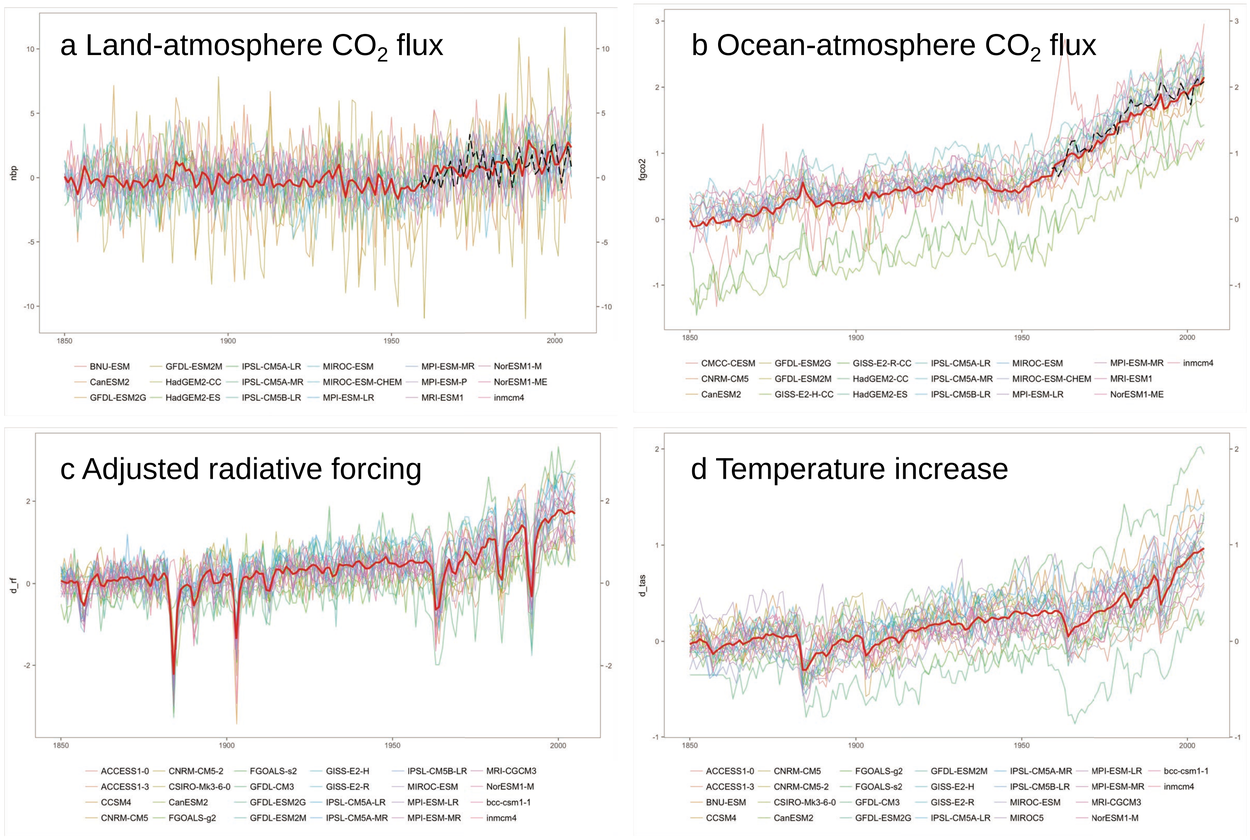

Figure 1: **CMIP5 historical simulation used in the model calibration.** a Land-atmosphere CO_2 flux (unit: GtC yr^{-1}), solid red line indicates mean values and black solid line shows results from Global Carbon Project 2017. b Ocean-atmosphere CO_2 flux (unit GtC yr^{-1}), solid red line indicates mean values and black solid line shows results from Global Carbon Project 2017. c Adjusted radiative forcing (unit: W m^{-2}), estimated based on Forster et al. (2013). Solid red line indicates mean values. d Temperature increase above preindustrial level (unit: K). Solid red line indicates mean values.

Results

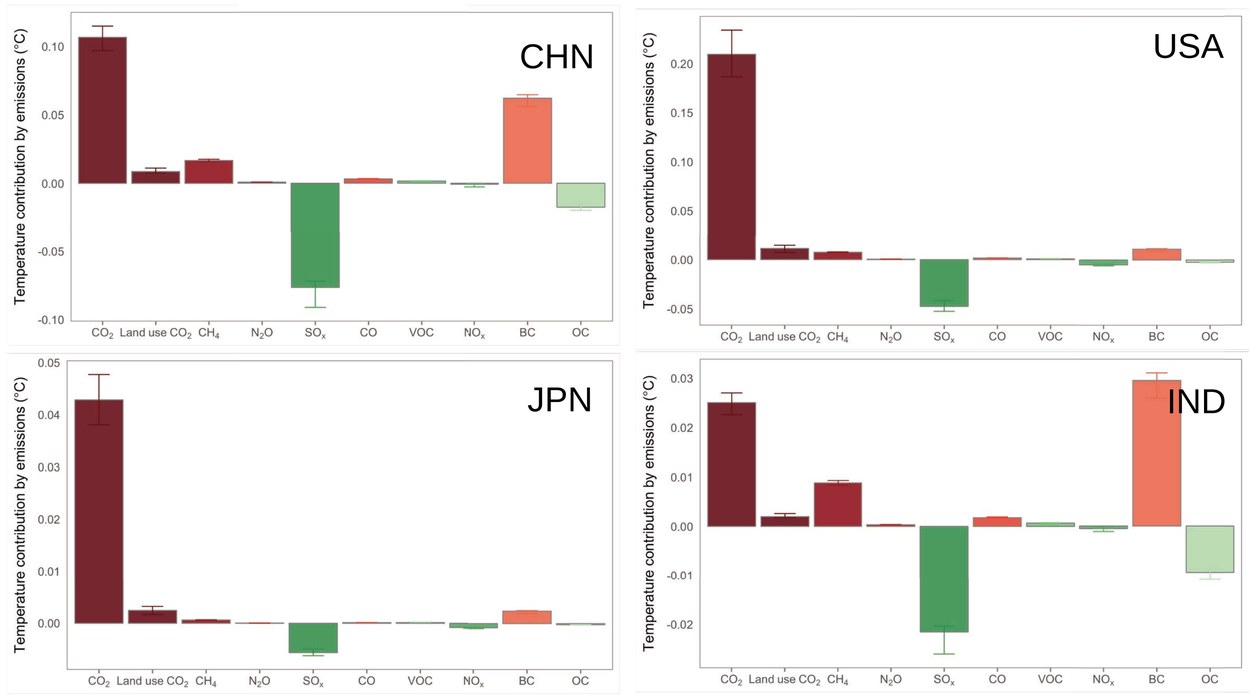

Figure 2: **Regional contributions to climate change of temperature increase.** The ranges in a indicate the 25th and 75th percentiles; and the bar indicates the 50th percentile.

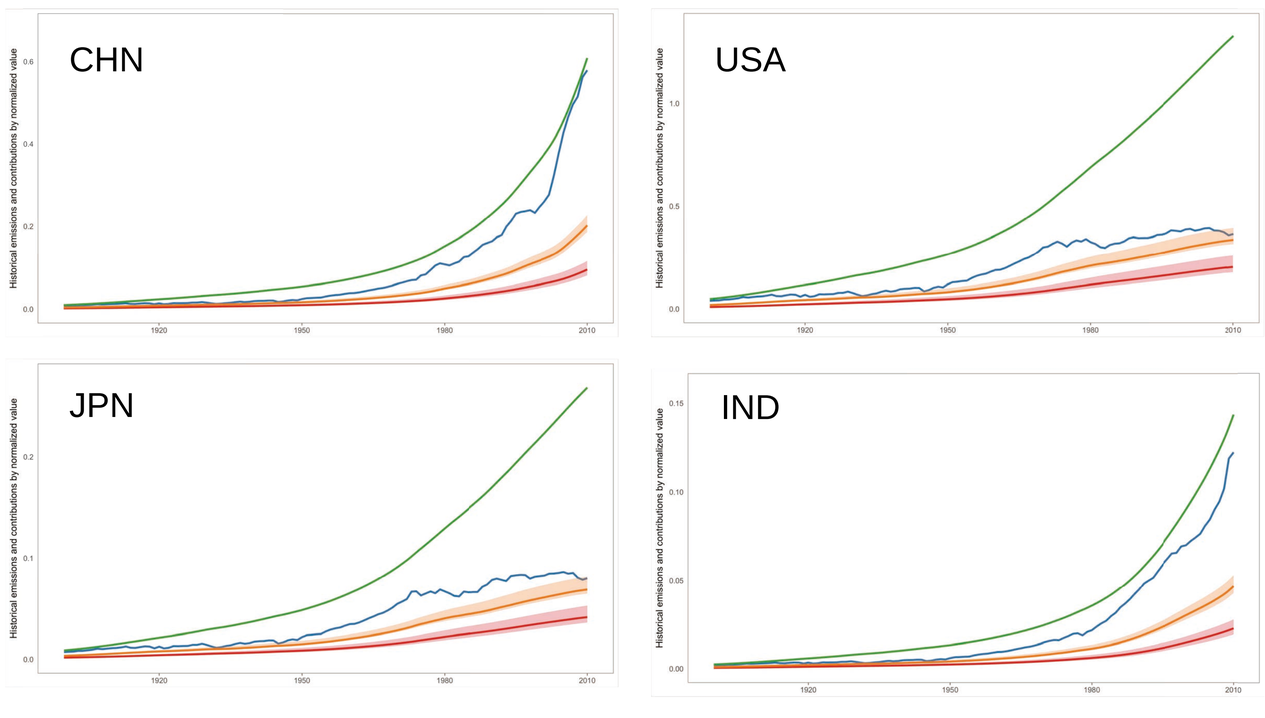

Figure 3: **Regional emissions and contribution trends**; Green lines are cumulative CO_2 emissions, blue lines show historical industrial CO_2 emissions, orange lines are radiative forcing and red lines are temperature increase contributed by selected countries. The ranges in a indicate the 25th and 75th percentiles; and middle solid line indicates the 50th percentile.

Table 1: **Climate contributions of industrial CO_2 by 2012**

Country	Cumulative CO_2 share	Forcing contribution	Temperature contribution
CHN	**14.9%**	**13.7%**	**11.4%**
USA	**22.1%**	**23.3%**	**24.7%**
IND	**3.4%**	**3.2%**	**2.7%**
RUS	**7.6%**	**7.6%**	**8.0%**
JPN	**4.7%**	**4.8%**	**5.0%**
DEU	**4.1%**	**4.6%**	**5.1%**
KOR	**1.3%**	**1.2%**	**1.0%**
IRN	**1.1%**	**1.1%**	**0.9%**
CAN	**2.0%**	**2.1%**	**2.1%**
MEX	**1.3%**	**1.2%**	**1.1%**
BRA	**1.1%**	**1.1%**	**1.0%**
GBR	**2.4%**	**2.8%**	**3.1%**
SAU	**0.9%**	**0.8%**	**0.7%**
IDN	**0.9%**	**0.8%**	**0.6%**
AUS	**1.2%**	**1.2%**	**1.2%**

Conclusions

- This study tries to quantify the **contributions to climate change for each region or country in the world, as well as the contribution from each anthropogenic emission.**
- The output shows that, **developed countries emitted more GHGs in historical period and the contributions to current climate change are large**; while the contributions from developing countries are relative small, however, **such contributions will become lager in near future since their emissions increase rapidly nowadays**.

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