Distributions and radiative forcings of aerosols during the 21st century

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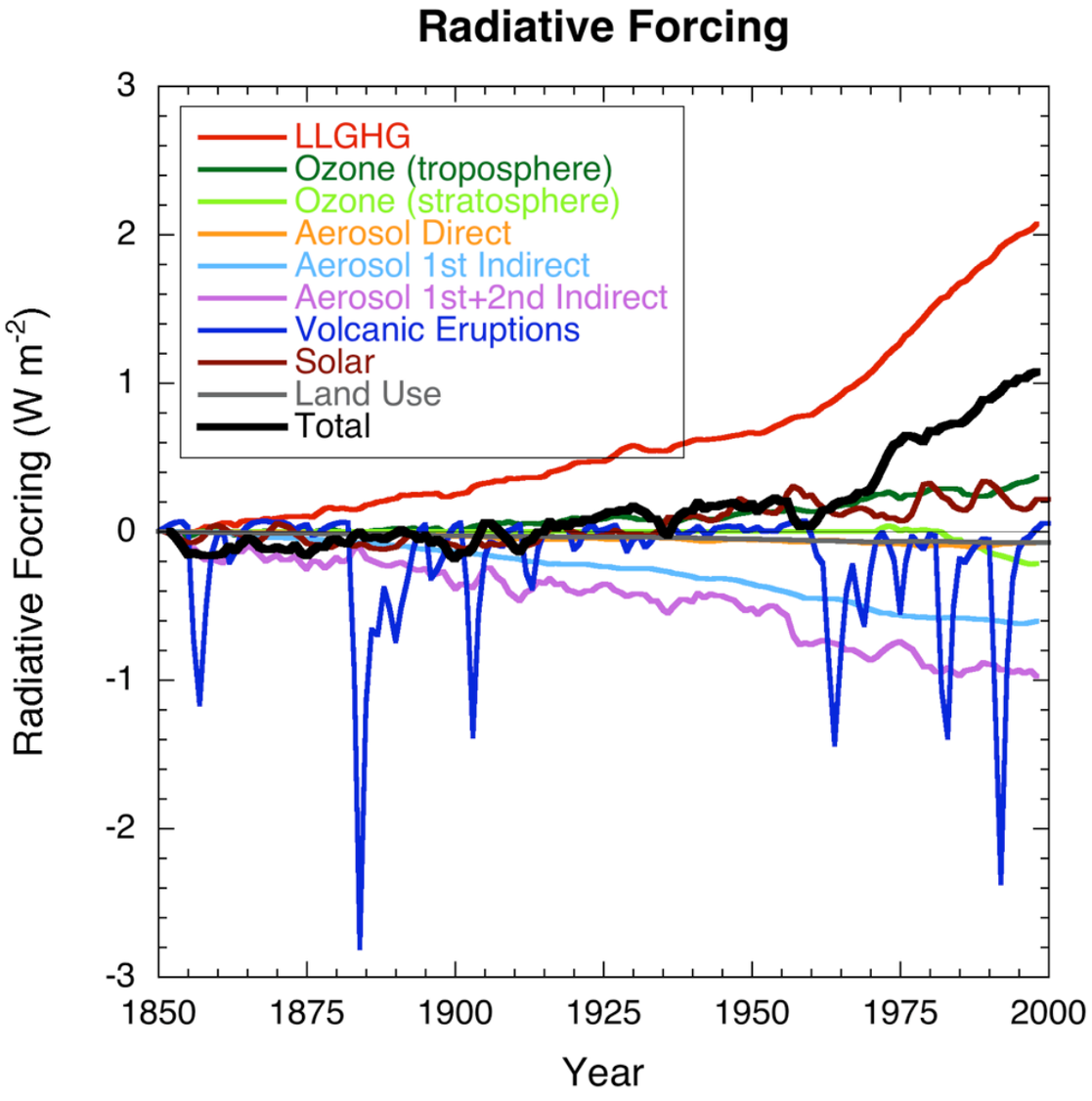
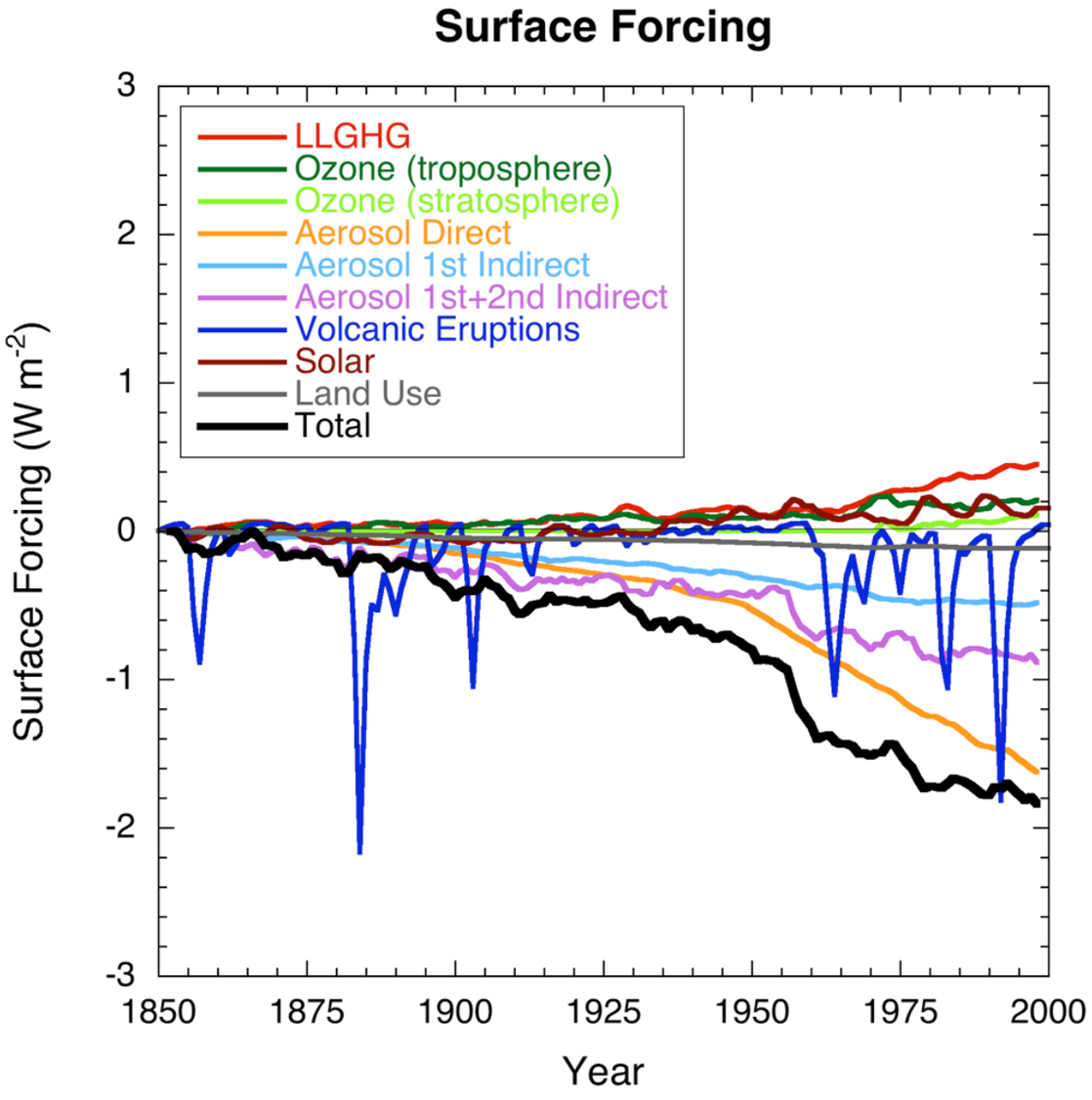
- Objective of this study

  Global distributions and radiative forcing of atmospheric aerosols during the 21st century are predicted by an aerosol climate model, SPRINTARS, with the emission inventories from the present to 2100 based on the Special Report on Emissions Scenarios (SRES) of the Intergovernmental Panel on Climate Change (IPCC).

7th AeroCom Meeting (October 8, 2008; Reykjavik, Iceland)

Time evolution of past radiative forcings





(Takemura et al., GRL, 2006)
→ (IPCC AR4 WGI Chapter 2)

Experiment for global aerosols in the 21st century

★ Adapted IPCC SRES scenarios in this study

- A1B (economic & global): More integrated world (balanced emphasis on all energy sources)
- A2 (economic & regional): More divided world
- B1(environmental & global): More integrated and ecologically friendly

✴ Concentrations of CO_2, N_2O, CH_4, and 16 halocarbons for radiation

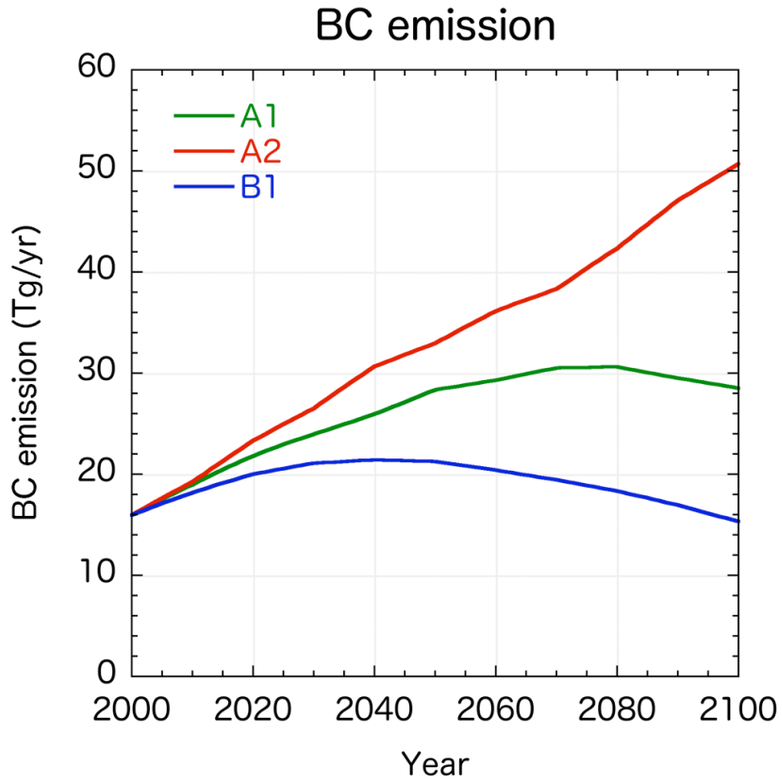
➡ according to SRES.

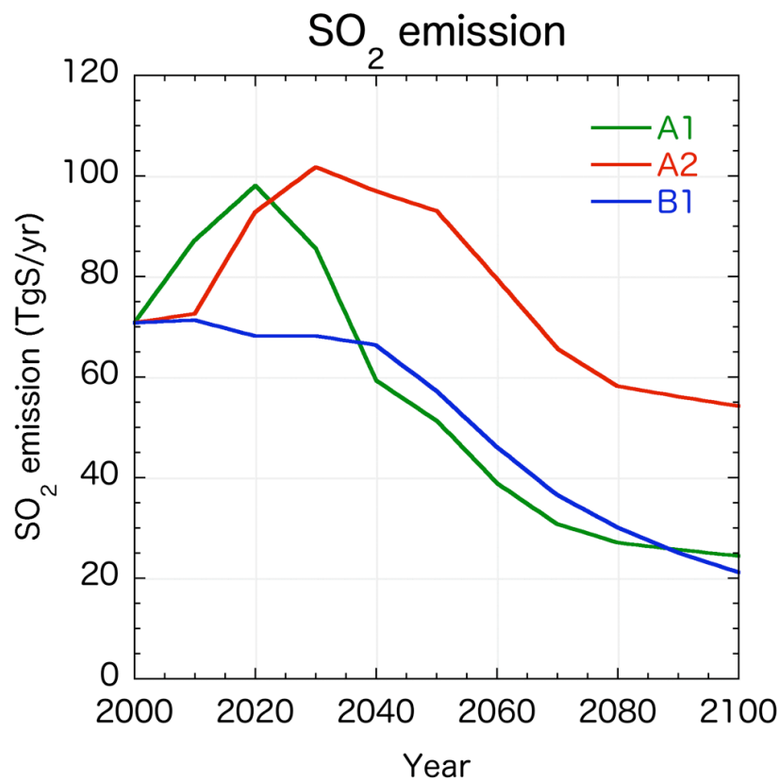
✴ Distributions of O_3 for radiation and OH, H_2O_2, and O_3 for sulfur chemistry

➡ prescribed by CHASER simulation based on SRES (Dr. K. Sudo, Nagoya Univ.).

✴ Distributions of SST and sea ice

➡ prescribed by MIROC simulation based on SRES (CMIP).

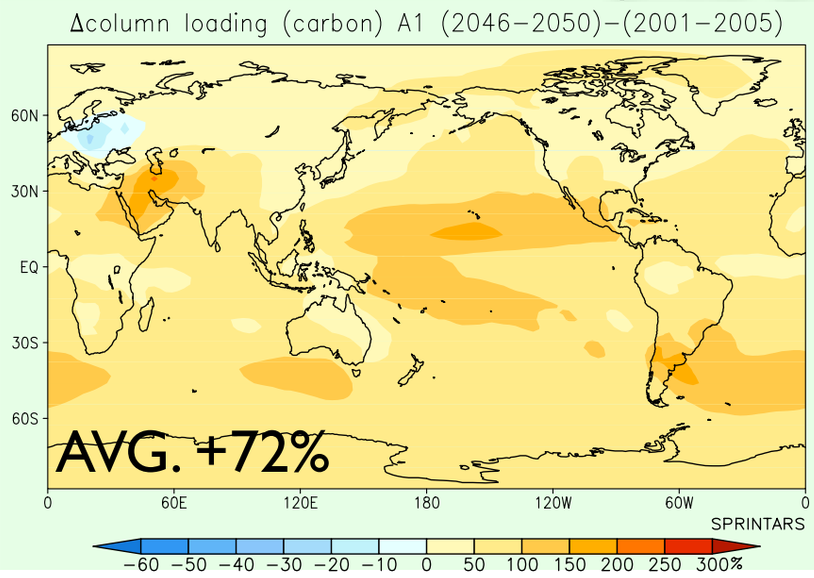


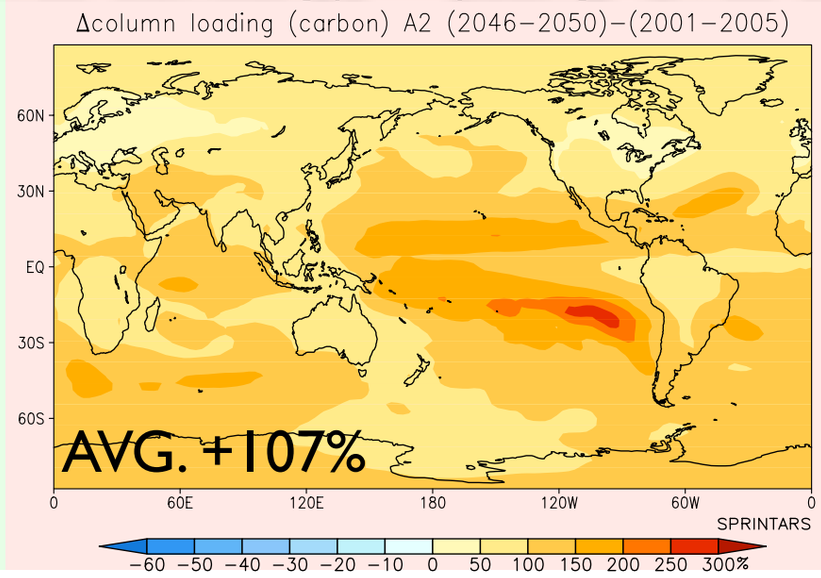


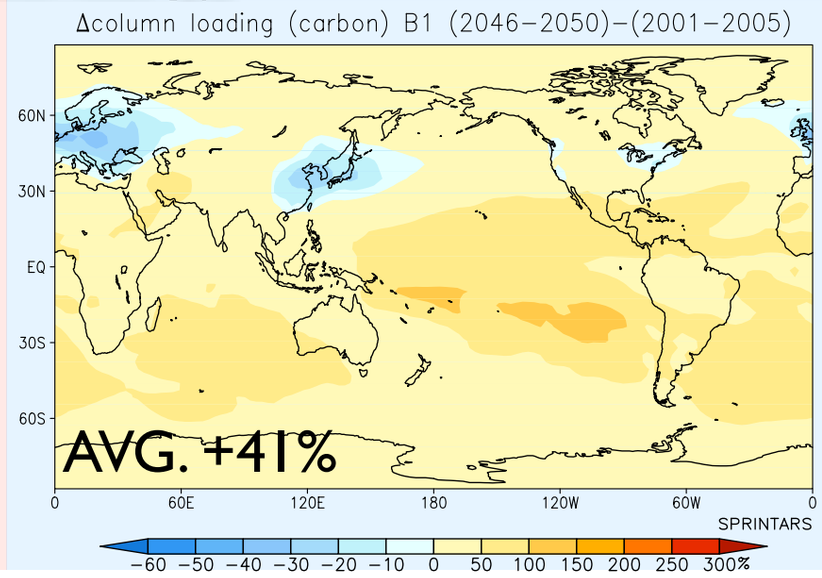
Projection of BC+OC distributions

A1B	A2	B1

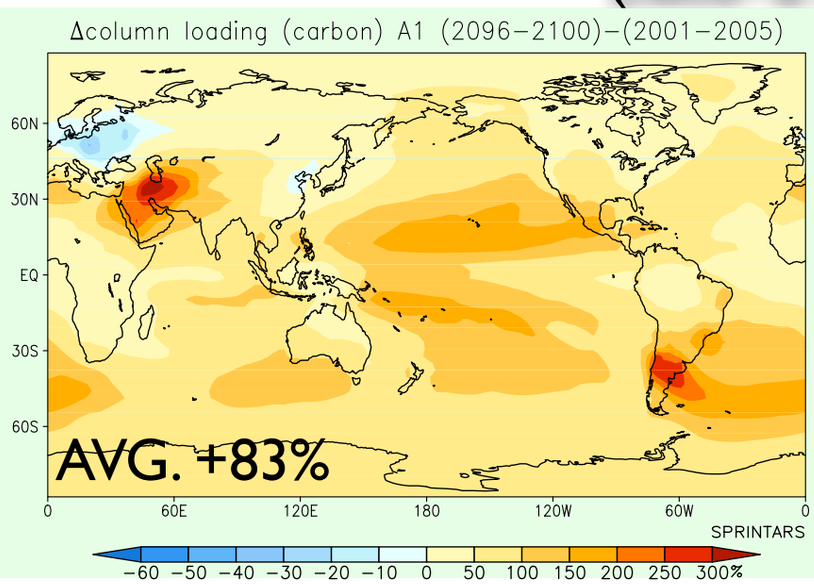
(mid-21st century) – (early-21st century)

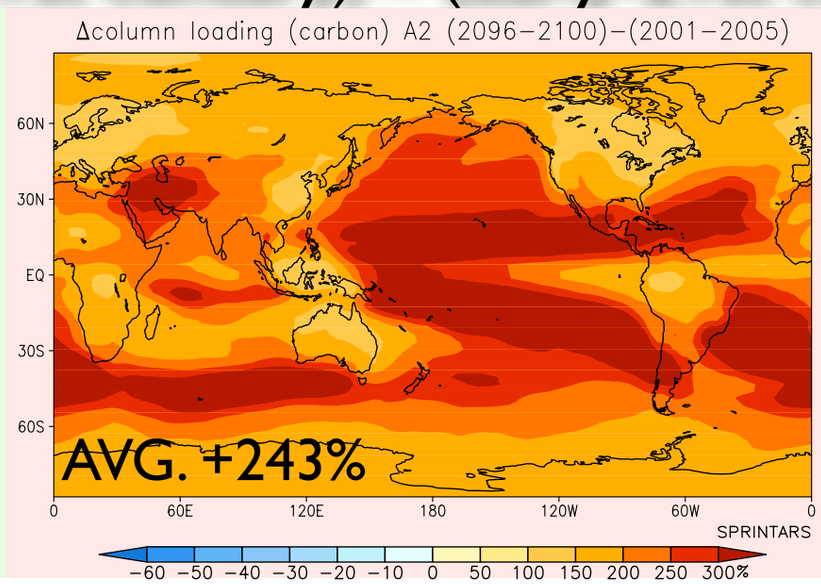


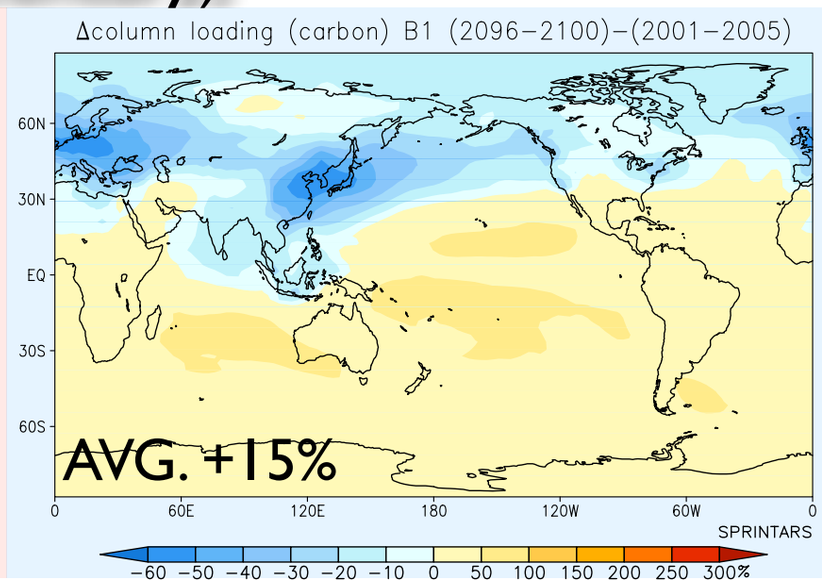




(late-21st century) – (early-21st century)



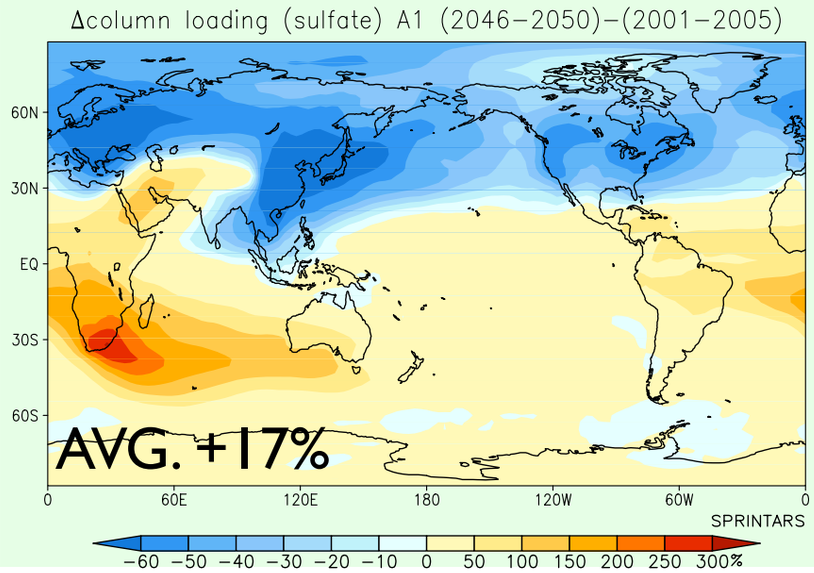


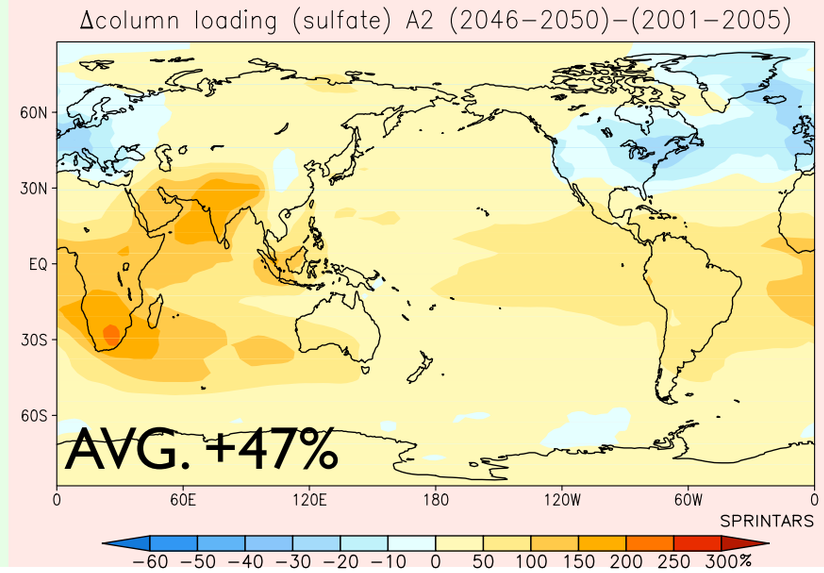


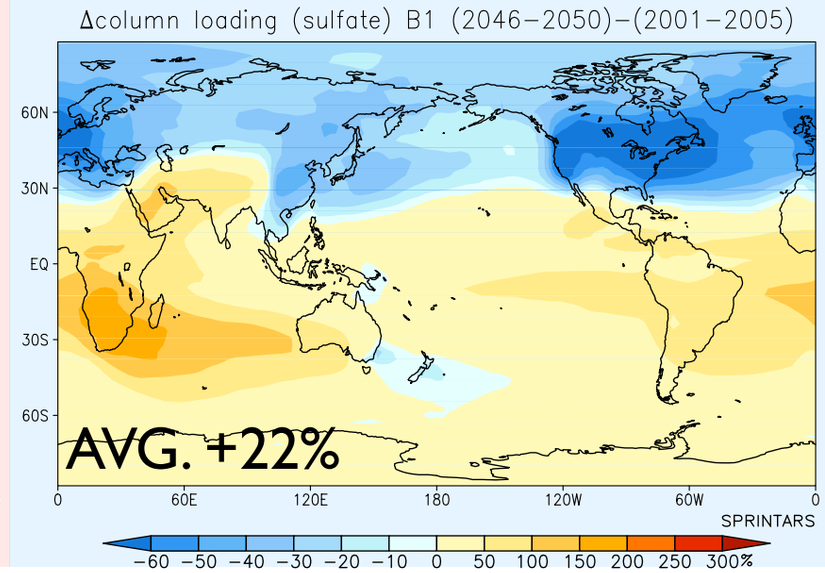
Projection of sulfate distributions

A1B	A2	B1

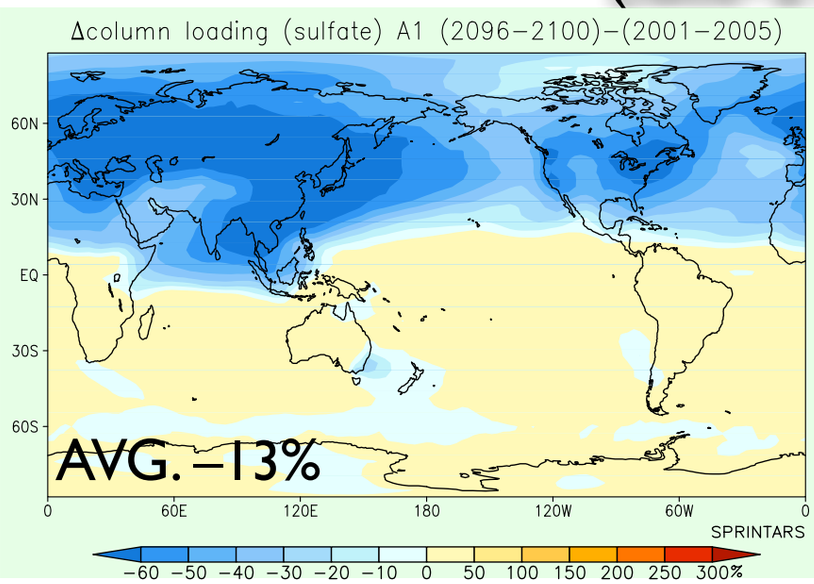
(mid-21st century) – (early-21st century)

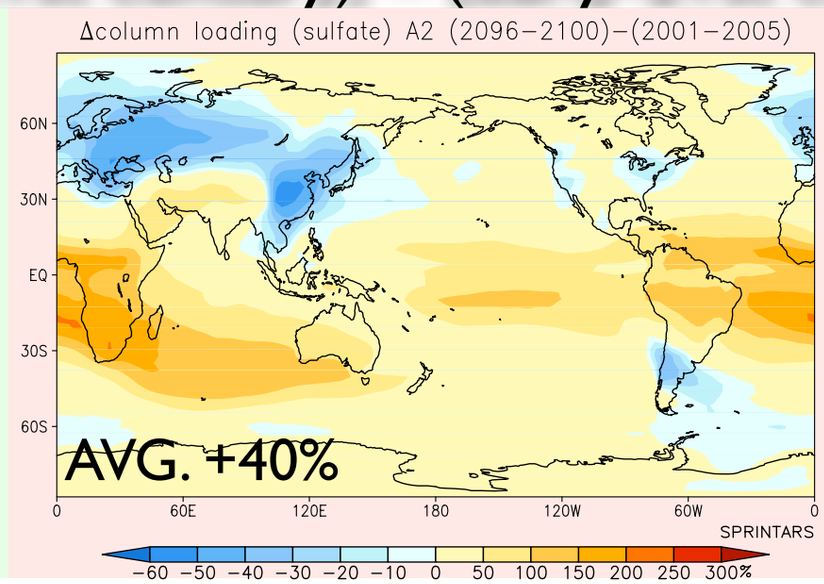


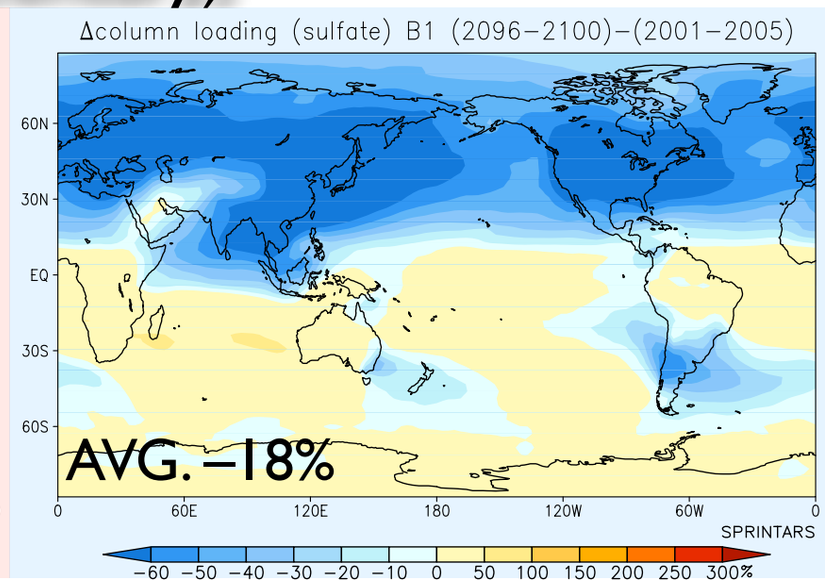




(late-21st century) – (early-21st century)



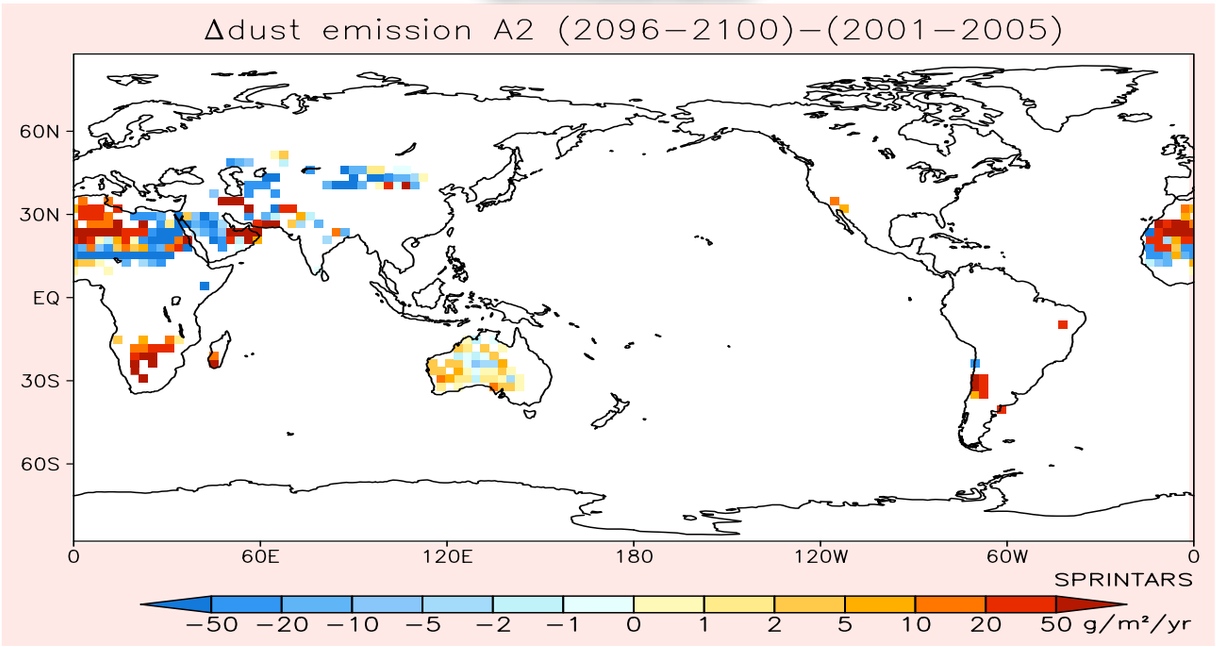




Projection of emission and distribution for dust

A2 (late-21st C.) – (early-21st C.)

emission



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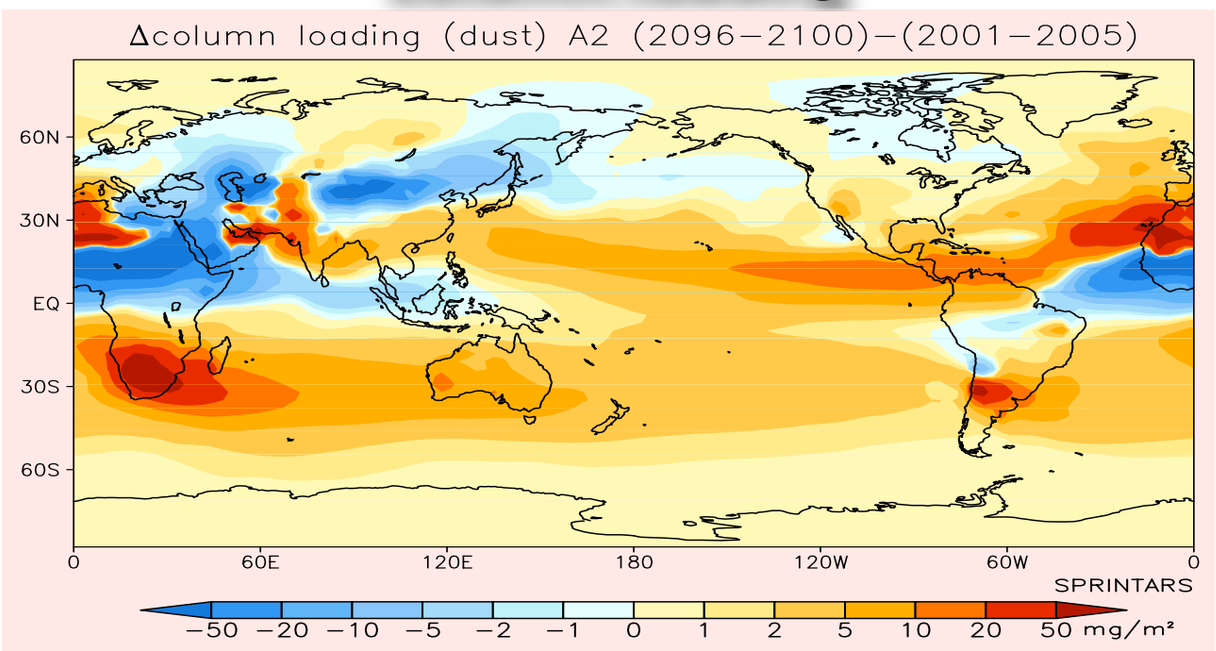


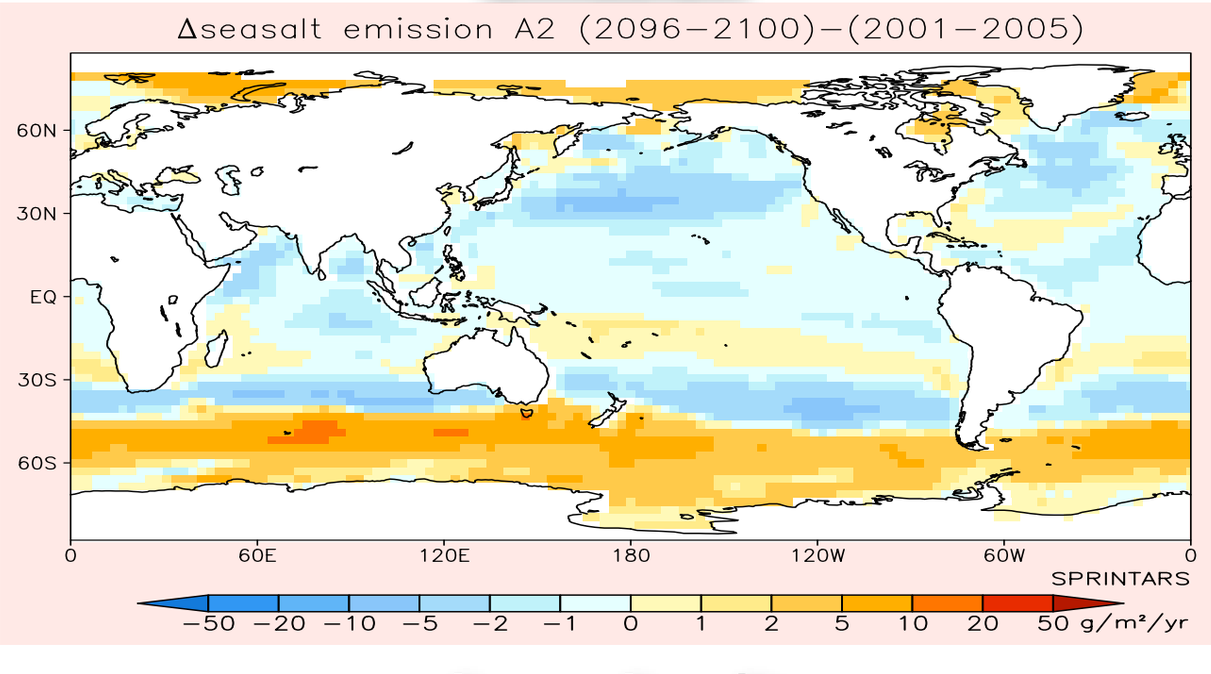
A2 dust emission (relative to early-21st century, Tg/yr)

Region	mid-21st C.	late-21st C.
Sahara	+163 (+8%)	+179 (+9%)
Middle and Near East	+50 (+9%)	+90 (+16%)
Asia and Europe	+10 (+5%)	+9 (+4%)
Australia	+3 (+6%)	+8 (+16%)
North America	+1 (+24%)	+2 (+68%)
South America	+18 (+29%)	+31 (+49%)
Southern Africa	+16 (+40%)	+92 (+237%)
Total	+260 (+9%)	+411 (+13%)

Projection of emission and distribution for sea salt

A2 (late-21st C.) – (early-21st C.)

emission



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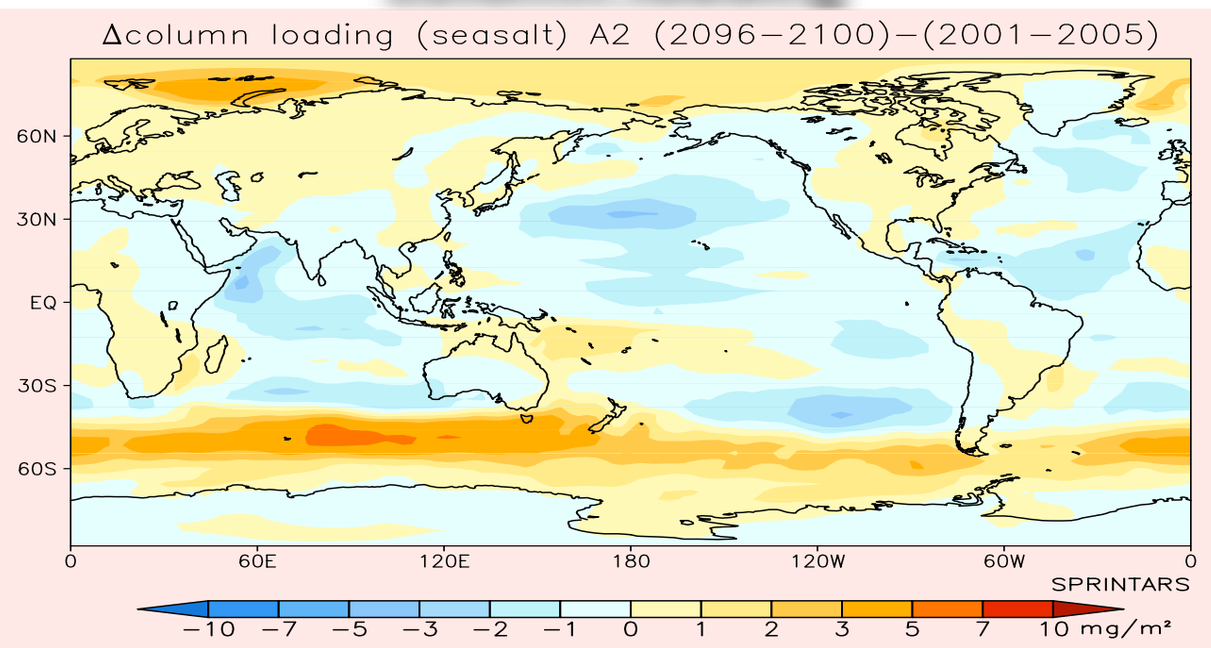
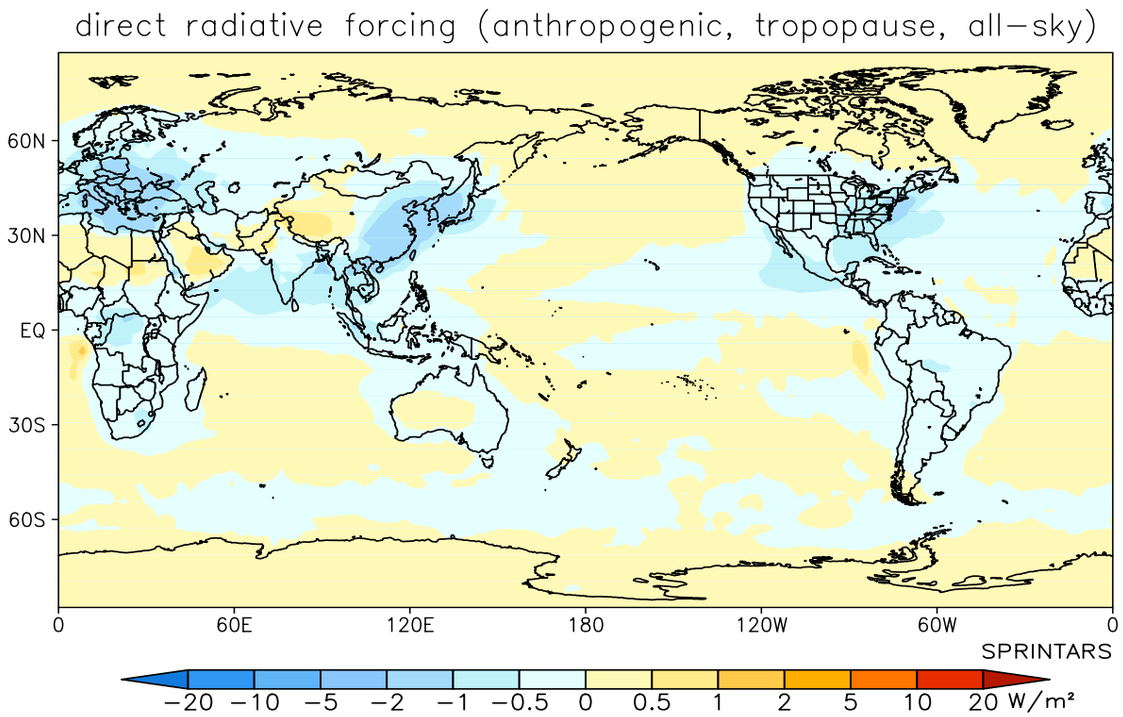


A2 sea salt emission (relative to early-21st century, Tg/yr)

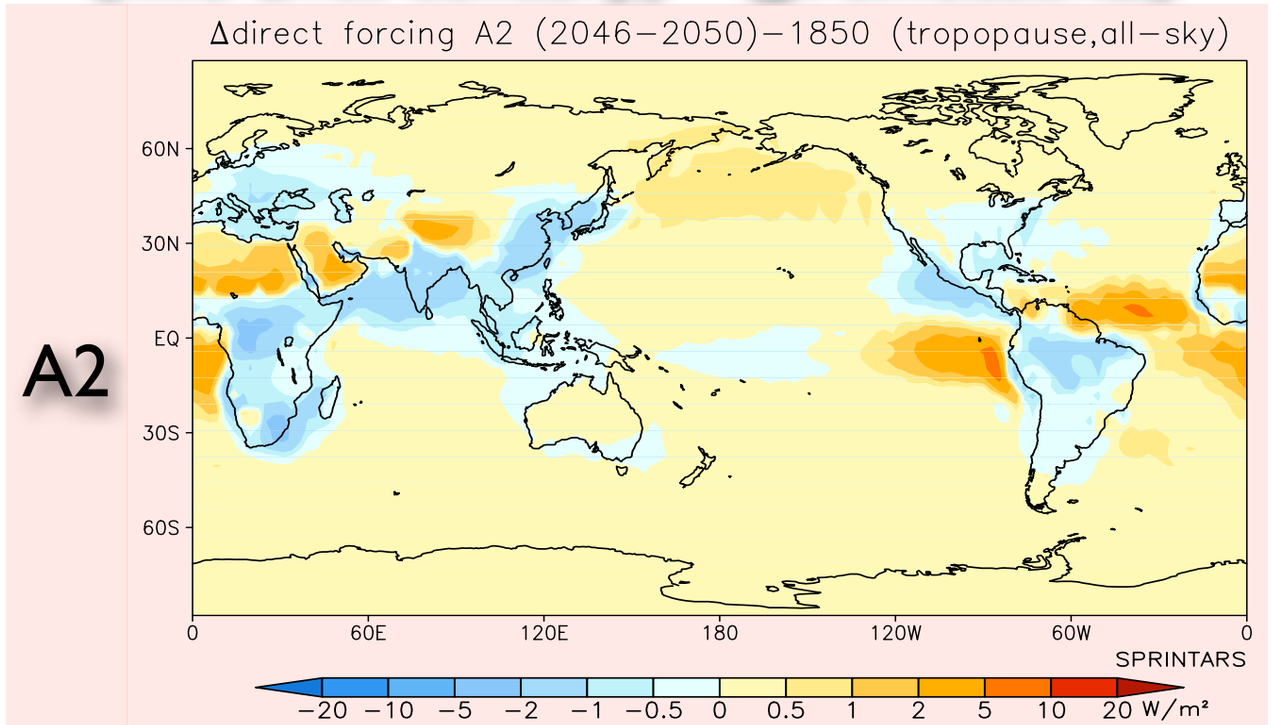
Latitude	mid-21st C.	late-21st C.
90°N – 60°N	+10 (+14%)	+24 (+34%)
60°N – 30°N	+12 (+2%)	+5 (+1%)
30°N – 0°	+7 (+2%)	+2 (+0%)
0° – 30°S	+14 (+3%)	+19 (+4%)
30°S – 60°S	+94 (+5%)	+238 (+12%)
60°S – 90°S	+17 (+9%)	+34 (+18%)
Total	+153 (+4%)	+321 (+8%)

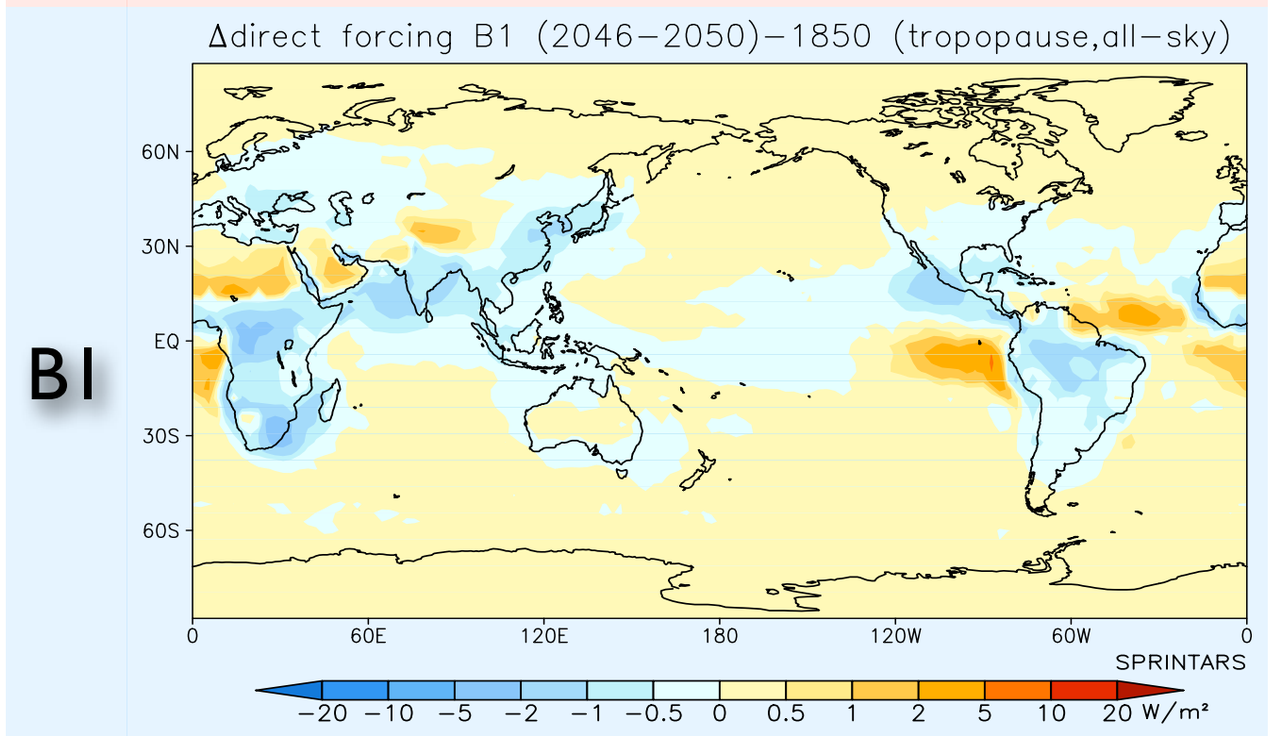
Projection of direct radiative forcing at tropopause

(present) – (preindustrial)



(mid-21st century) – (preindustrial)



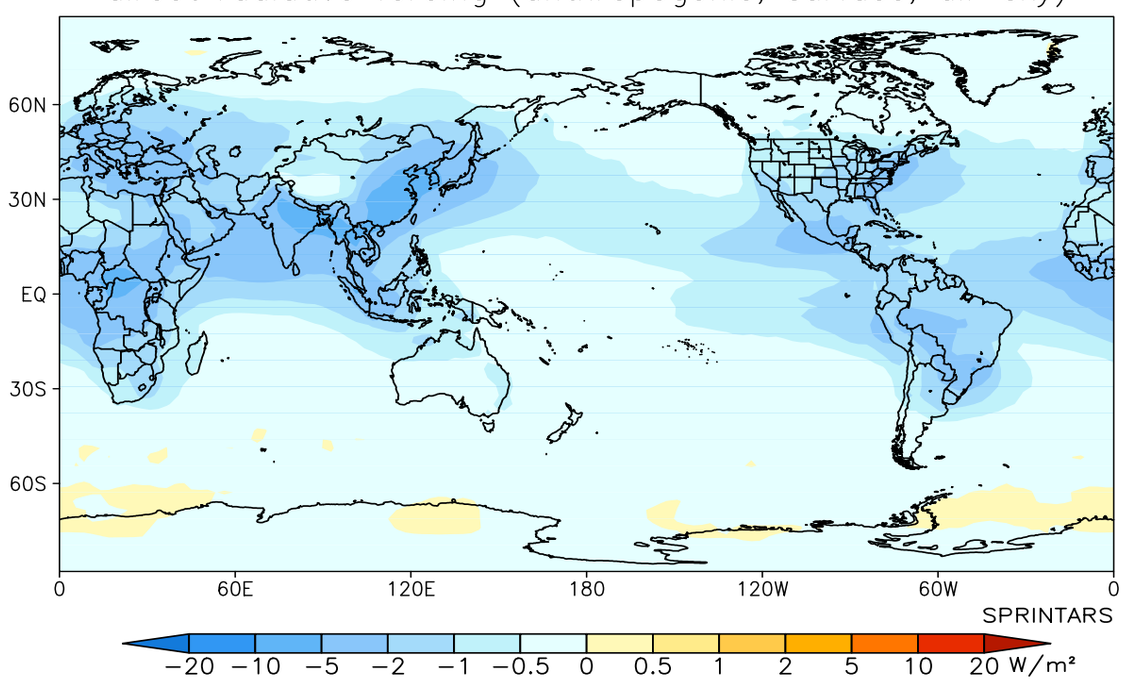


global mean ($W\ m^{-2}$) relative to preindustrial

	A1B	A2	B1
present		–0.1	
mid-21st C.	+0.2	+0.1	–0.0
late-21st C.	+0.4	+0.6	+0.0

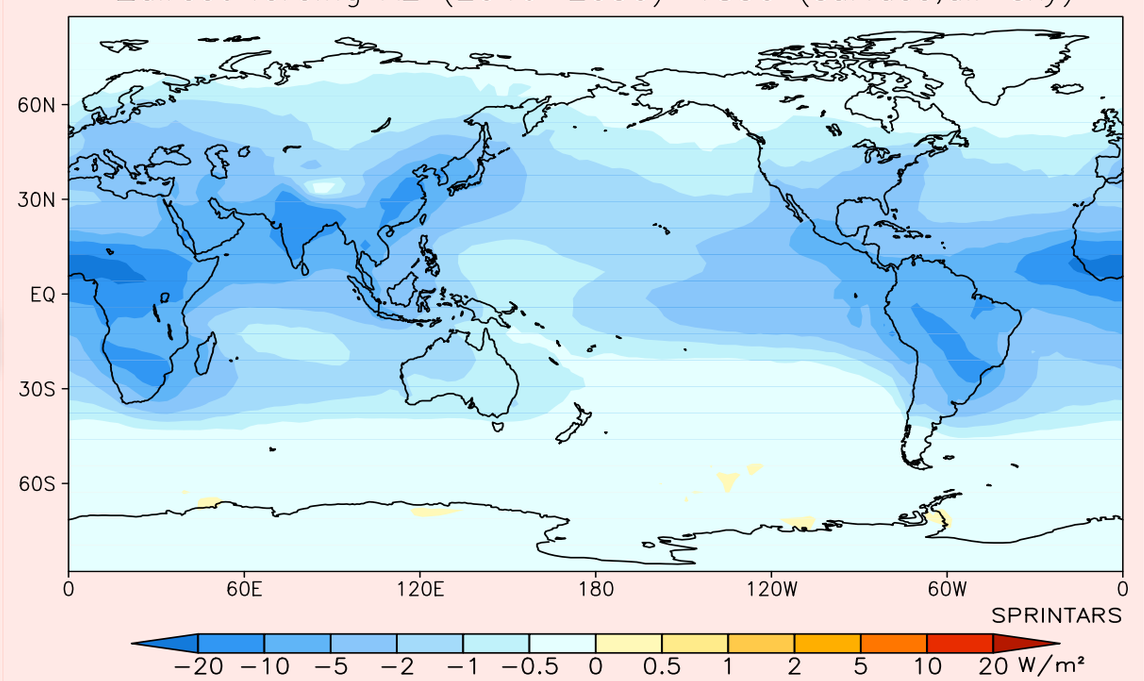
Projection of direct radiative forcing at surface

(present) – (preindustrial)

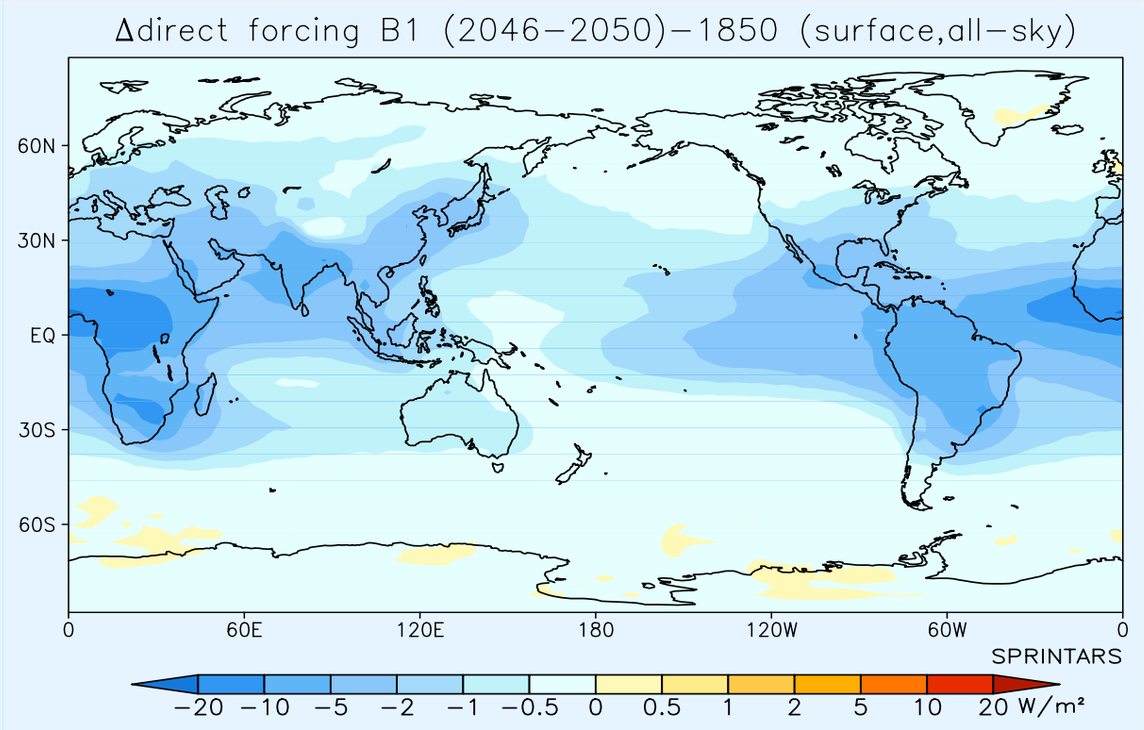


(mid-21st century) – (preindustrial)

A2



B1

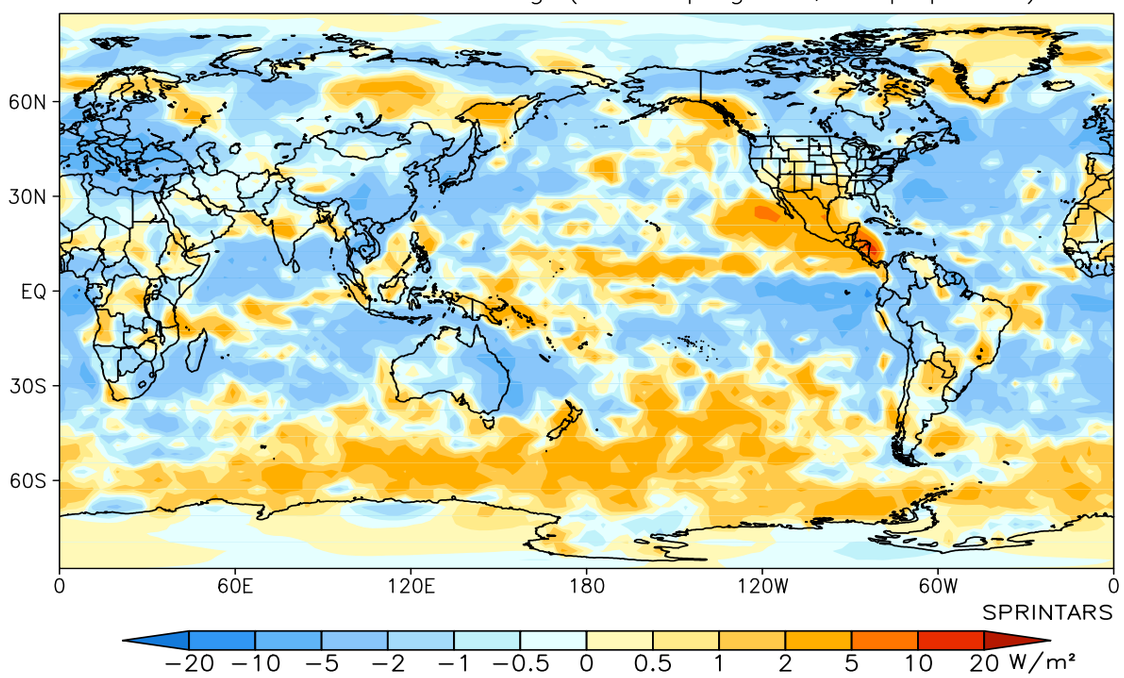


global mean ($W\ m^{-2}$) relative to preindustrial

	A1B	A2	B1
present		–0.9	
mid-21st C.	–2.4	–2.7	–1.9
late-21st C.	–2.3	–3.9	–1.4

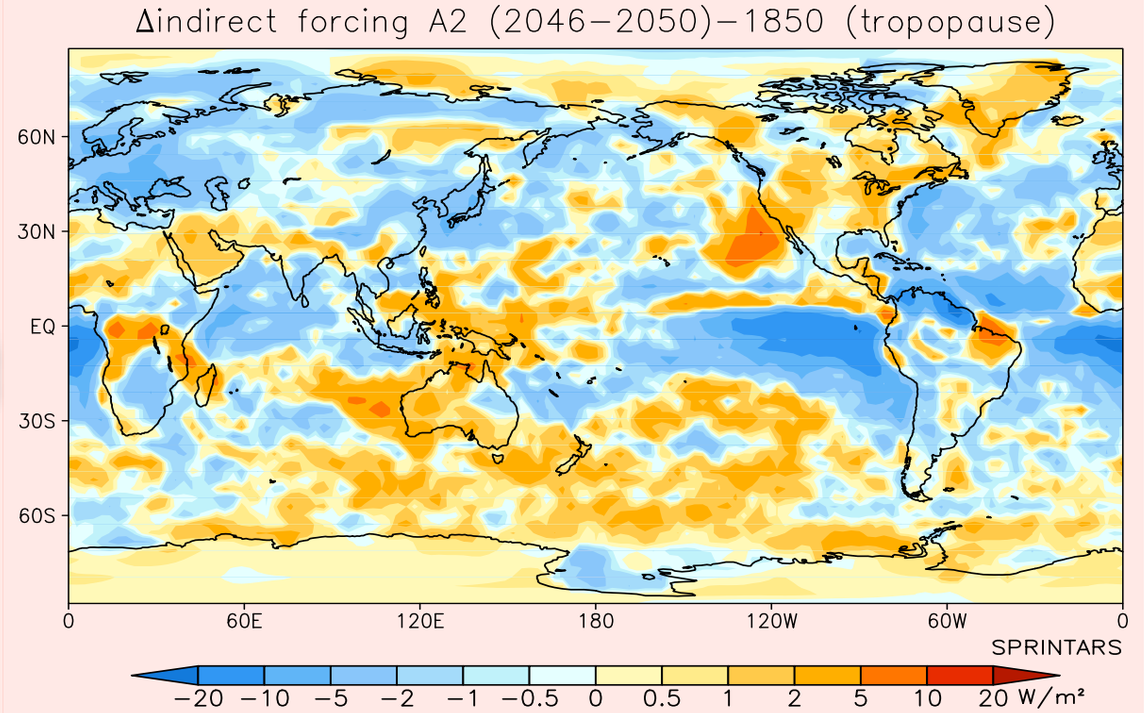
Projection of cloud radiative forcing

(present) – (preindustrial)

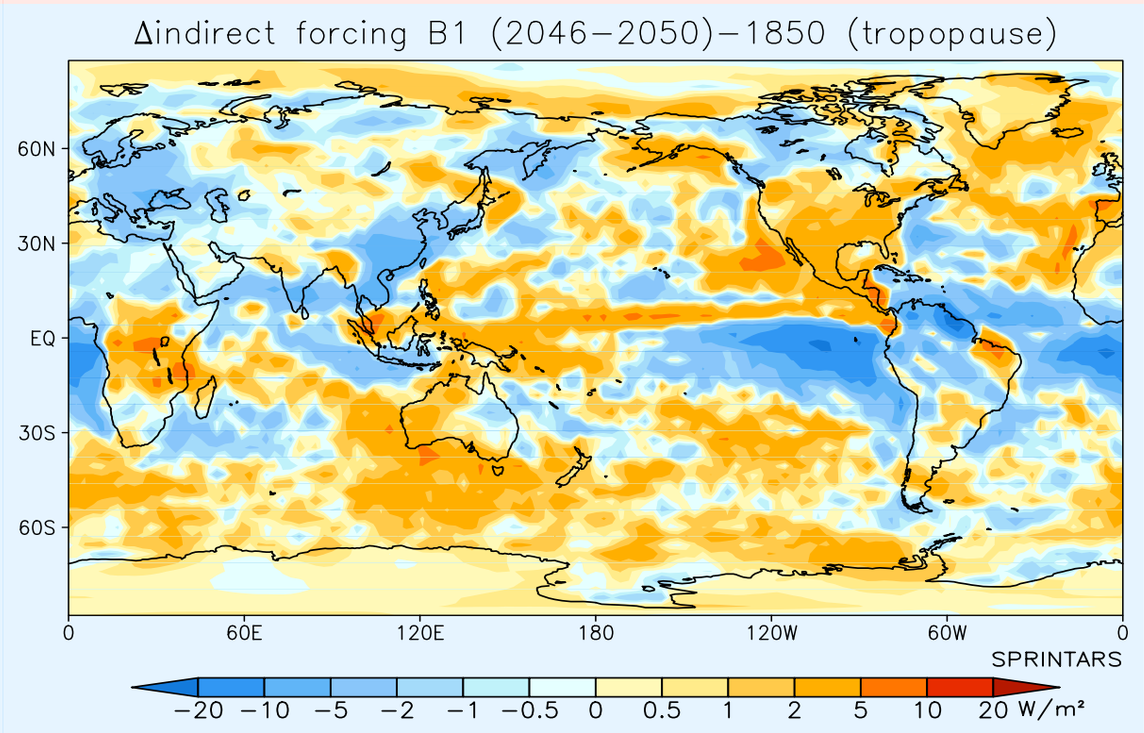


(mid-21st century) – (preindustrial)

A2



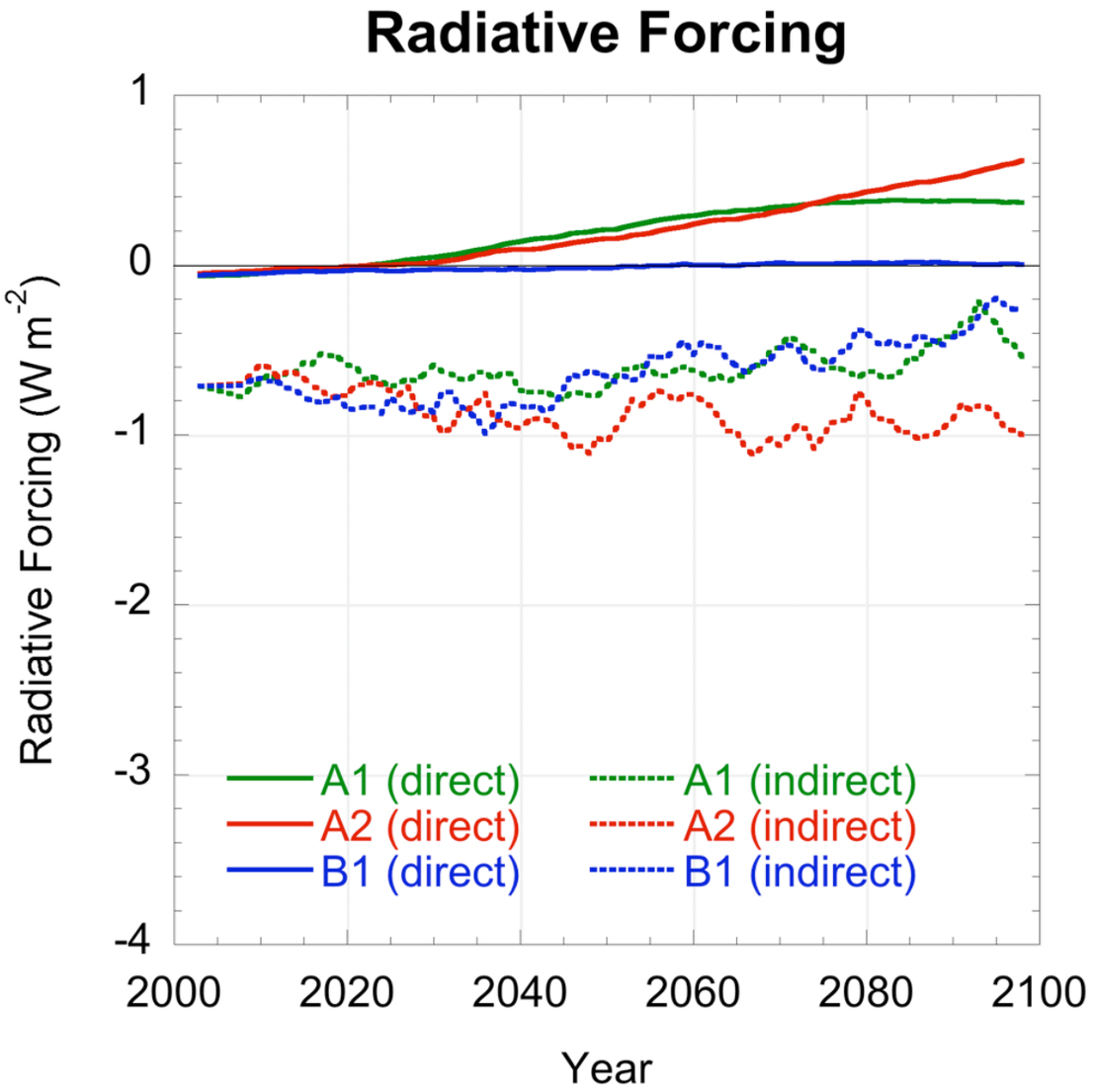
B1

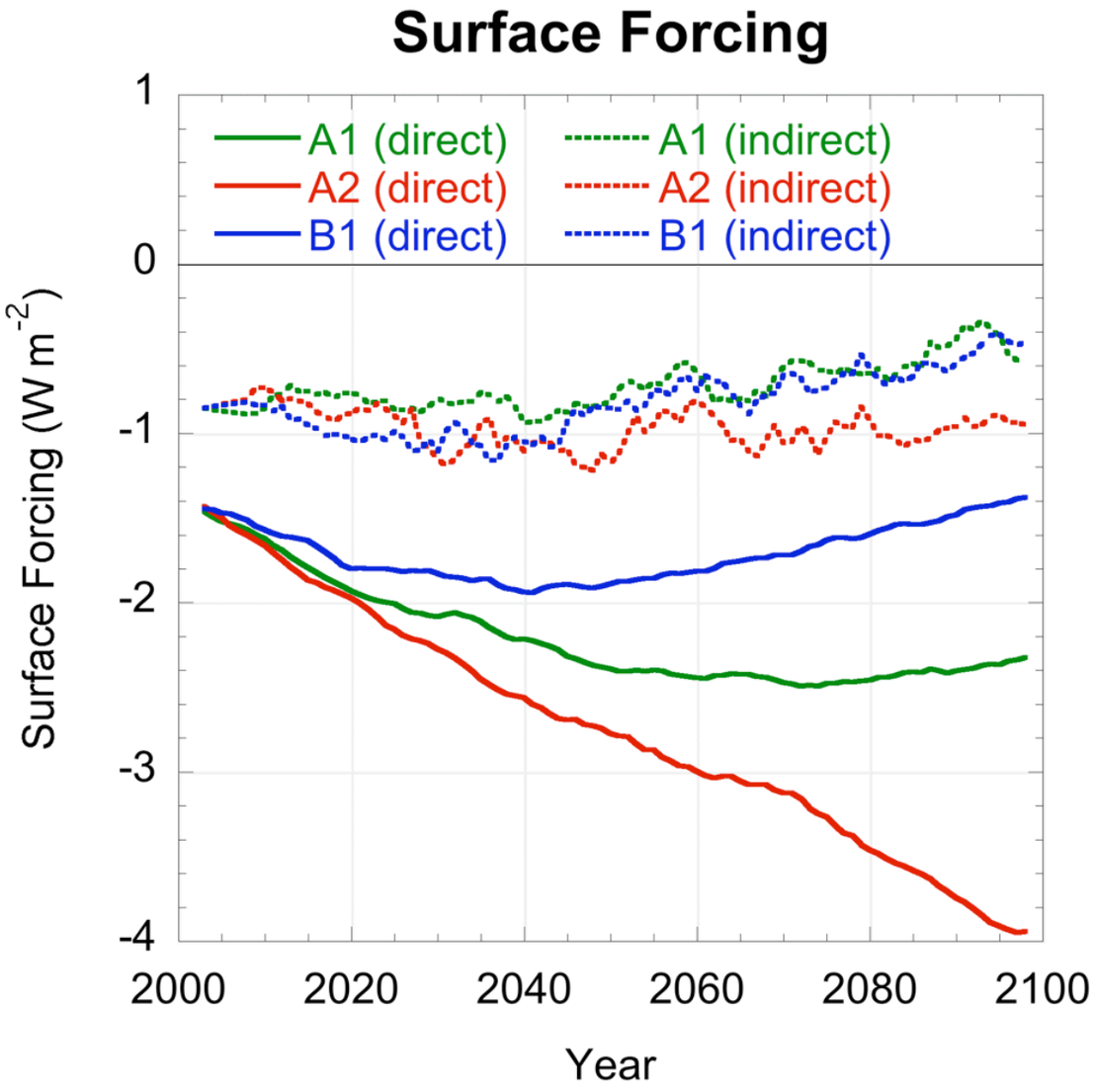


global mean ($W\ m^{-2}$) relative to preindustrial

	A1B	A2	B1
present		–0.7	
mid-21st C.	–0.8	–1.1	–0.6
late-21st C.	–0.5	–1.0	–0.2

Time evolution of future aerosol radiative forcings





Conclusions

Aerosol global distributions and radiative forcing during the 21st century are predicted by an aerosol climate model, SPRINTARS, with the emission inventories from the present to 2100 based on the SRES of IPCC.

- Carbonaceous aerosols will increase in the South Asia, central and southern Africa, and South America for all scenarios. On the other hand, they will decrease over the other populated regions for ecologically friendly scenarios.
- Sulfate aerosols will greatly decrease over the Northern Hemisphere after the mid-21st century for ecologically friendly scenarios.
- Emissions of soil dust and sea salt aerosols will increase due to drier condition in arid regions and due to melting sea ice, respectively.
- Direct radiative forcing at the tropopause of anthropogenic aerosols will shift to positive because of the increase in carbonaceous aerosols and decrease in sulfate aerosols.
- Negative direct radiative forcing at the surface will be strengthened until the mid-21st century for all scenarios.
- Negative indirect radiative forcing will be kept or reduced depending on the scenarios.