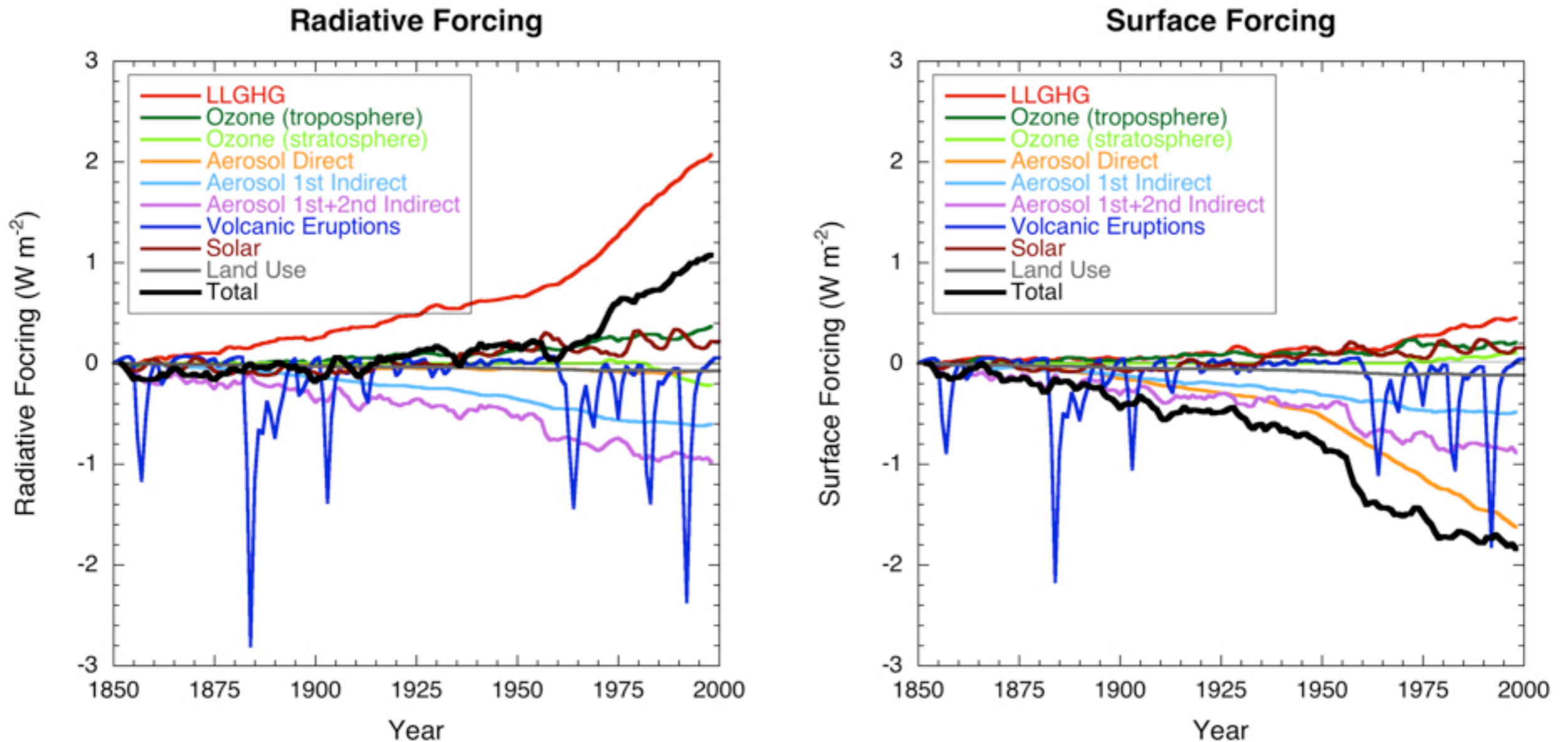


Long-term trend of aerosol radiative forcing estimated with different emission inventories

Toshihiko Takemura

(Research Institute for Applied Mechanics, Kyushu University)

Trend of past radiative forcings in IPCC AR4



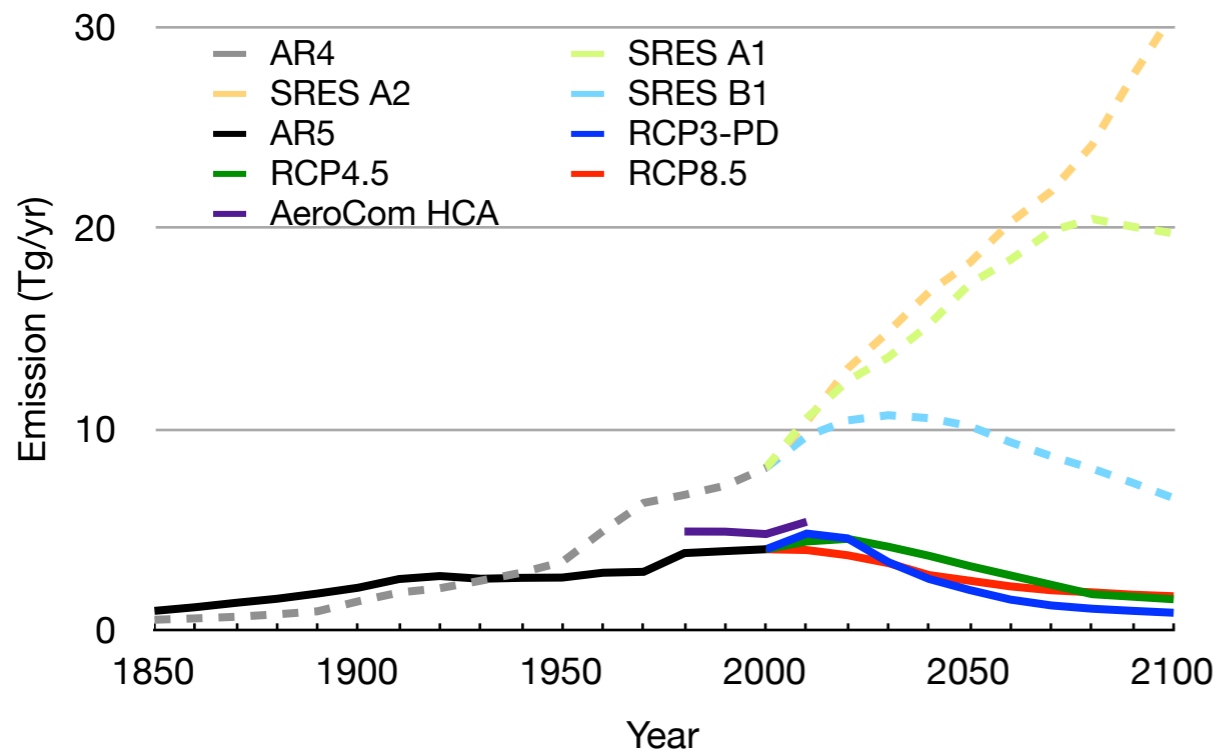
Global mean instantaneous radiative forcings from 1850 to 2000 under all-sky condition due to various climate forcing agents at the tropopause (left) and surface (right) on a global scale (Takemura et al., GRL, 2006 → Fig. 2.23 of IPCC WGI AR4).

Aerosol emission inventories

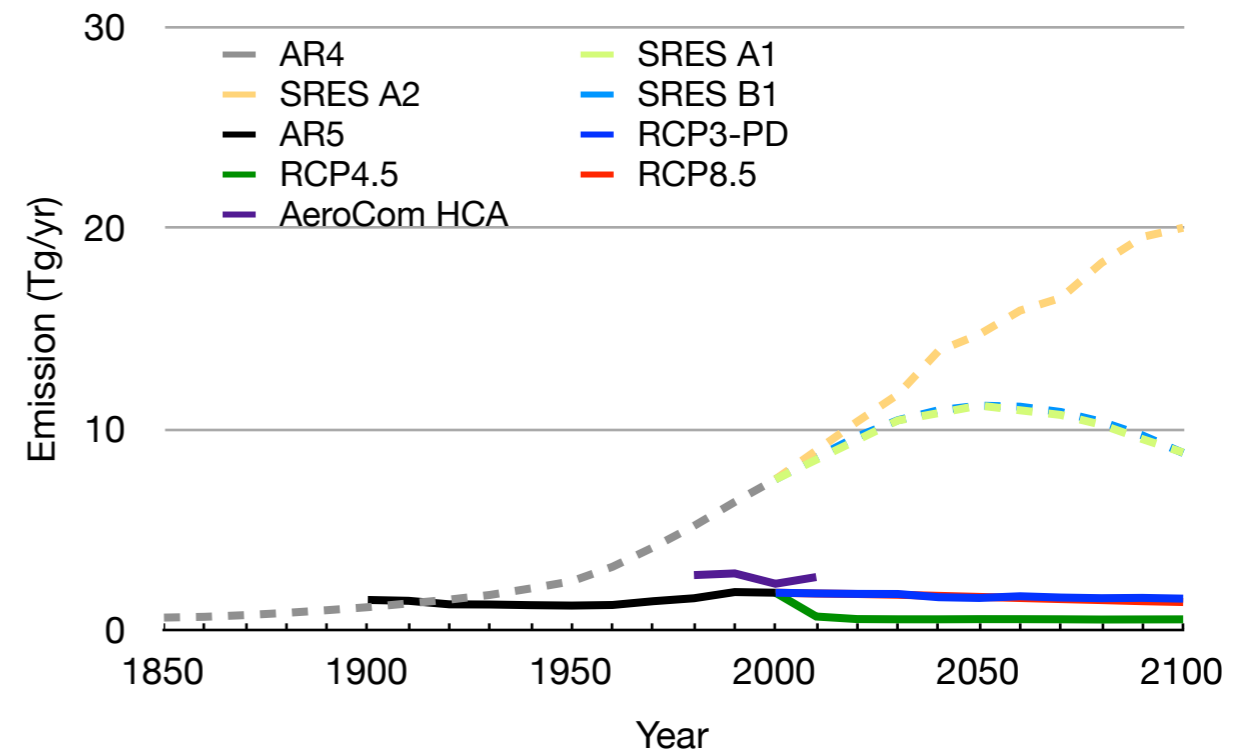
- ★ Special Report on Emissions Scenarios (SRES) for IPCC AR4
 - ▶ A1B: more integrated world (balanced emphasis on all energy sources) → economic & global
 - ▶ A2: more divided world → economic & regional
 - ▶ B1: more integrated and ecologically friendly → environmental & global
 - ▶ edited by National Institute for Environmental Studies, Japan in this study.
- ★ Reference Concentration Pathways (RCP) for IPCC AR5
 - ▶ RCP3-PD: 3.1 W m^{-2} mid-century, returning to 2.6 W m^{-2} by 2100.
 - ▶ RCP4.5: stabilized before 2100 at radiative forcing of 4.5 W m^{-2} .
 - ▶ RCP8.5: still increase in radiative forcing at 8.5 W m^{-2} in 2100.
- ★ Inventories for AeroCom Hindcast simulation
 - ▶ edited by Thomas Diehl et al.

Aerosol emission inventories

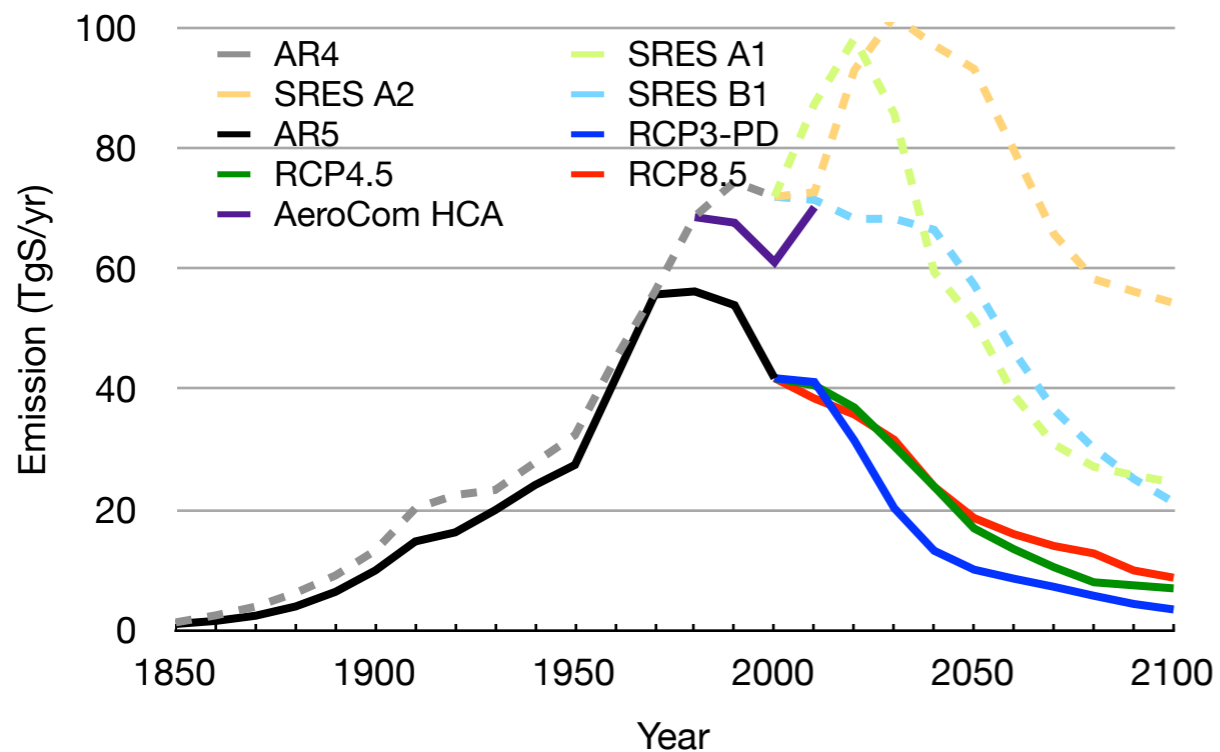
Global BC emission (anthropogenic)



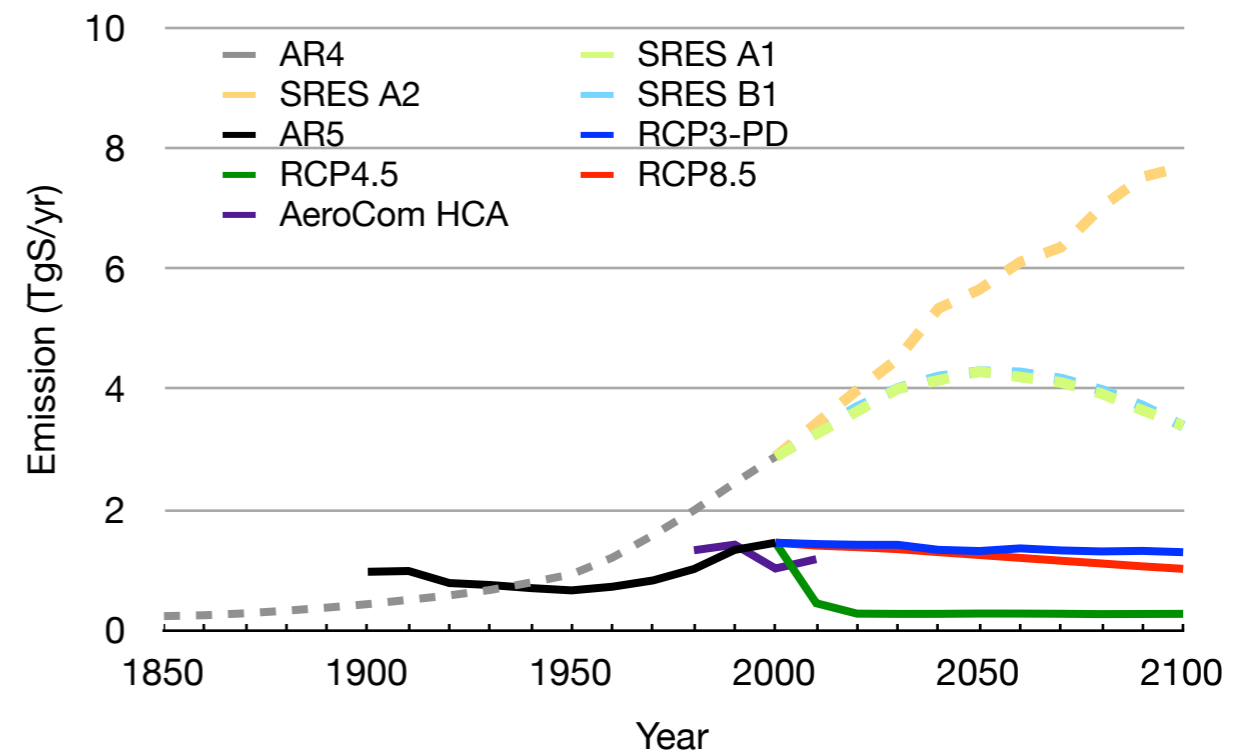
Global BC emission (biomass burning)



Global SO2 emission (anthropogenic)



Global SO2 emission (biomass burning)



Model description of SPRINTARS

Met. condition

on/off

MIROC
(CCSR/NIES/FRCGC GCM)



SPRINTARS

(Spectral Radiation-Transport Model for Aerosol Species)

<http://sprintars.net/>

Tracers

black carbon, organic carbon, sulfate, soil dust, sea salt, SO₂, DMS, terpene

- Aerosol transport processes
emission, advection, diffusion,
chemical reaction, deposition
- Aerosol optical properties
- Aerosol climate effects
direct / semi-direct / indirect

Resolution: T106/T42, L56/L20

References: Takemura et al. (JGR, 2000; JCLI, 2002; JGR, 2005; ACP, 2009)

Transport Processes

Emission

- BC, OC: biomass burning, fossil fuel, biofuel, agricultural activities, and terpene origin.
- SO₂: fossil fuel, biomass burning, and volcanoes.
- DMS: oceanic phytoplankton, land vegetation.
- soil dust: depending on surface wind speed, vegetation, soil moisture, snow amount, LAI.
- sea salt: depending on surface wind speed.

Advection

- Flux-Form Semi-Lagrangian.
- Arakawa-Schubert cumulus convection.

Diffusion

Sulfur chemistry

- sulfur oxidation (gas/liquid phases).
- simplified SOA chemical scheme (option).
- nitrate thermal equilibrium model (option).

Deposition

- wet deposition (wash out, rain out).
- dry deposition.
- gravitational settling.

Model description of SPRINTARS

Met. condition

on/off

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Resolution: T106/T42, L56/L20

References: Takemura et al. (JGR, 2000; JCLI, 2002; JGR, 2005; ACP, 2009)

• Aerosol optical properties

- optical thickness.
- Ångström exponent.
- single scattering albedo.

• Aerosol climate effects

▶ Direct effect

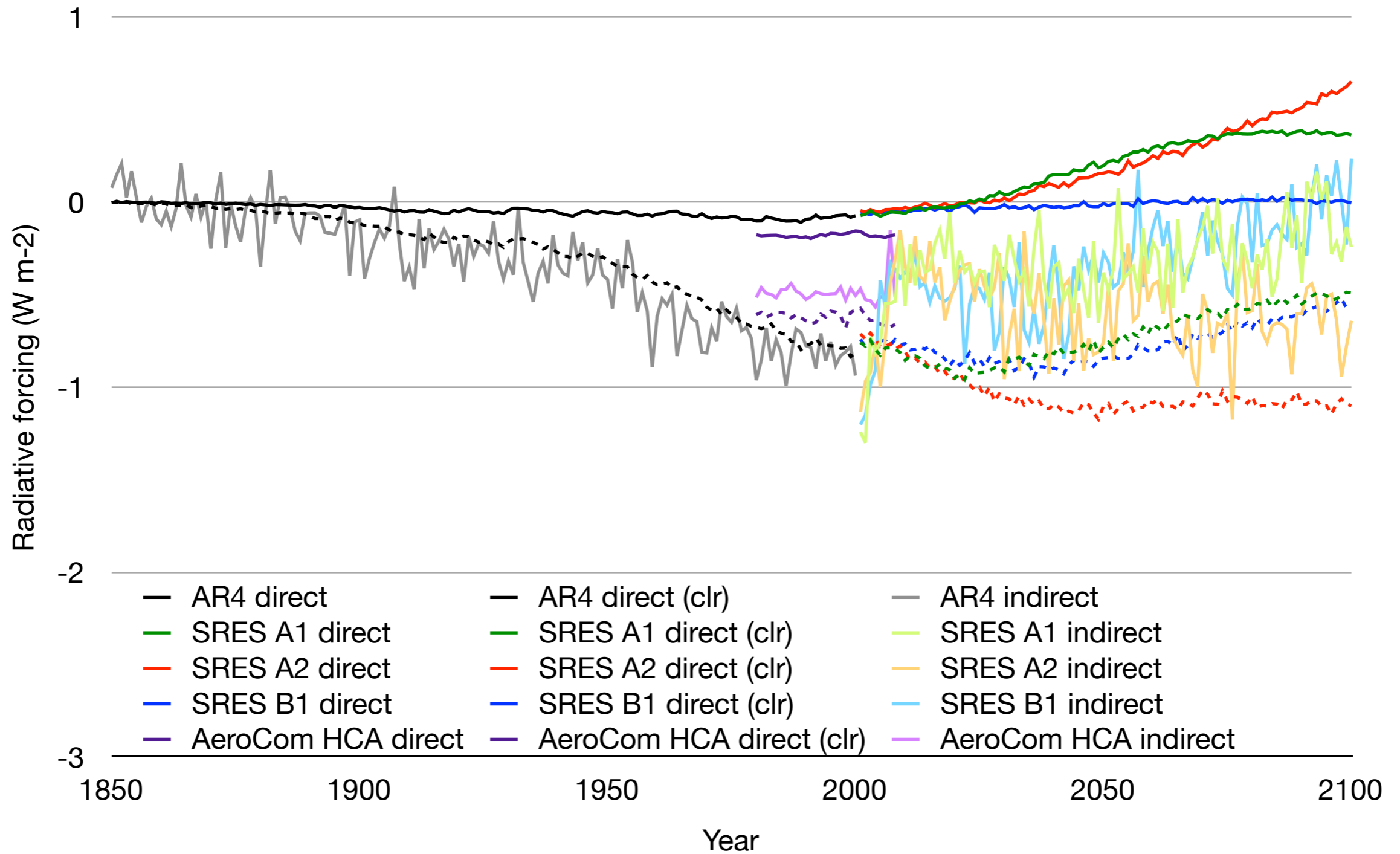
- coupled with radiation process in GCM.
- considering refractive index of each aerosol depending on wavelengths, size distributions, and hygroscopic growth.
- semi-direct effect if SPRINTARS is fully coupled with GCM.

▶ Indirect effect

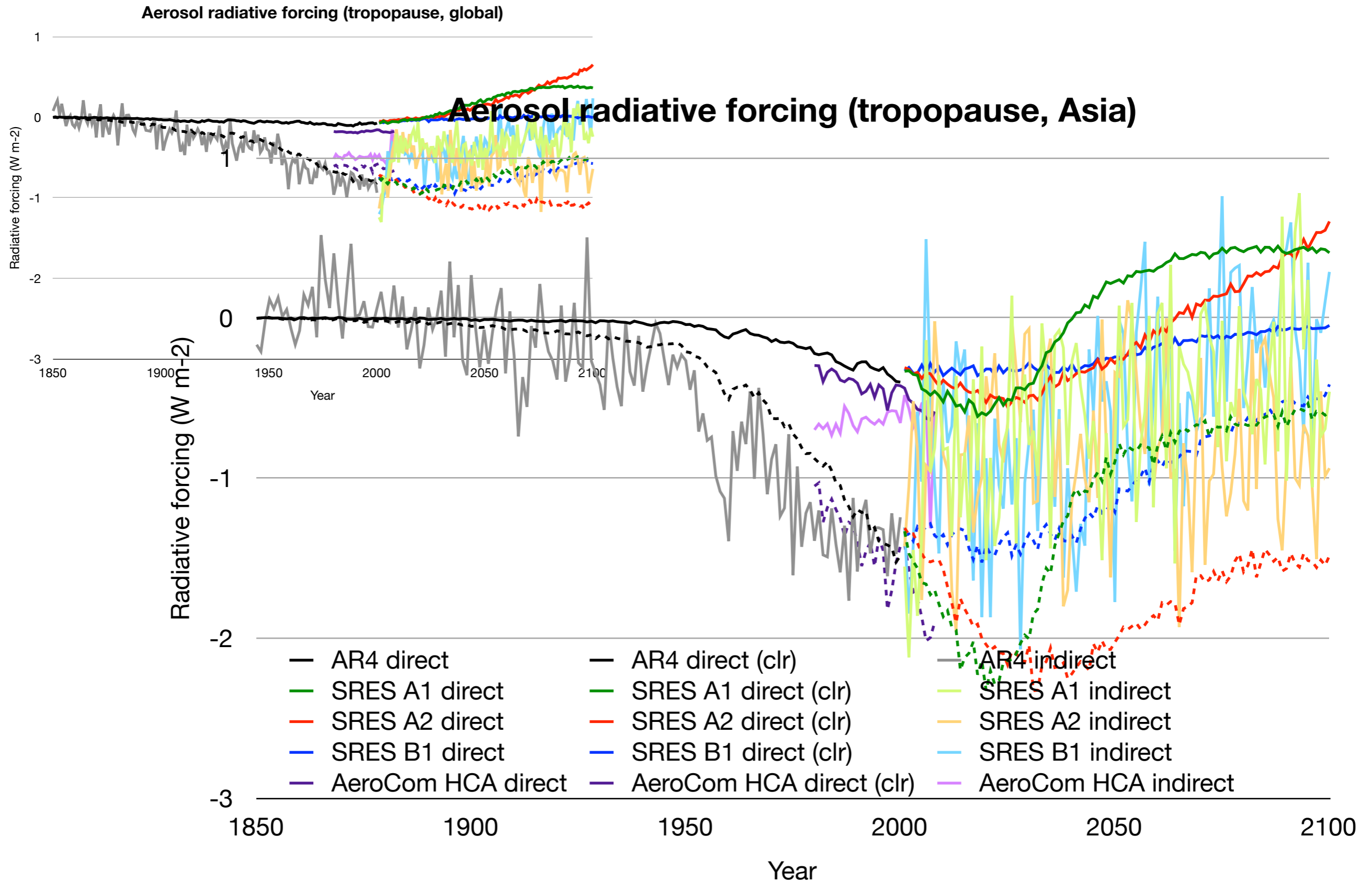
- coupled with radiation and cloud/precipitation processes in GCM.
- prognostic cloud droplet and ice crystal number concentrations N_l, N_i .
- cloud droplet and ice crystal effective radii depending on N_l, N_i » 1st indirect effect.
- precipitation rates depending on N_l, N_i » 2nd indirect effect.

Trend of aerosol radiative forcing (tropopause)

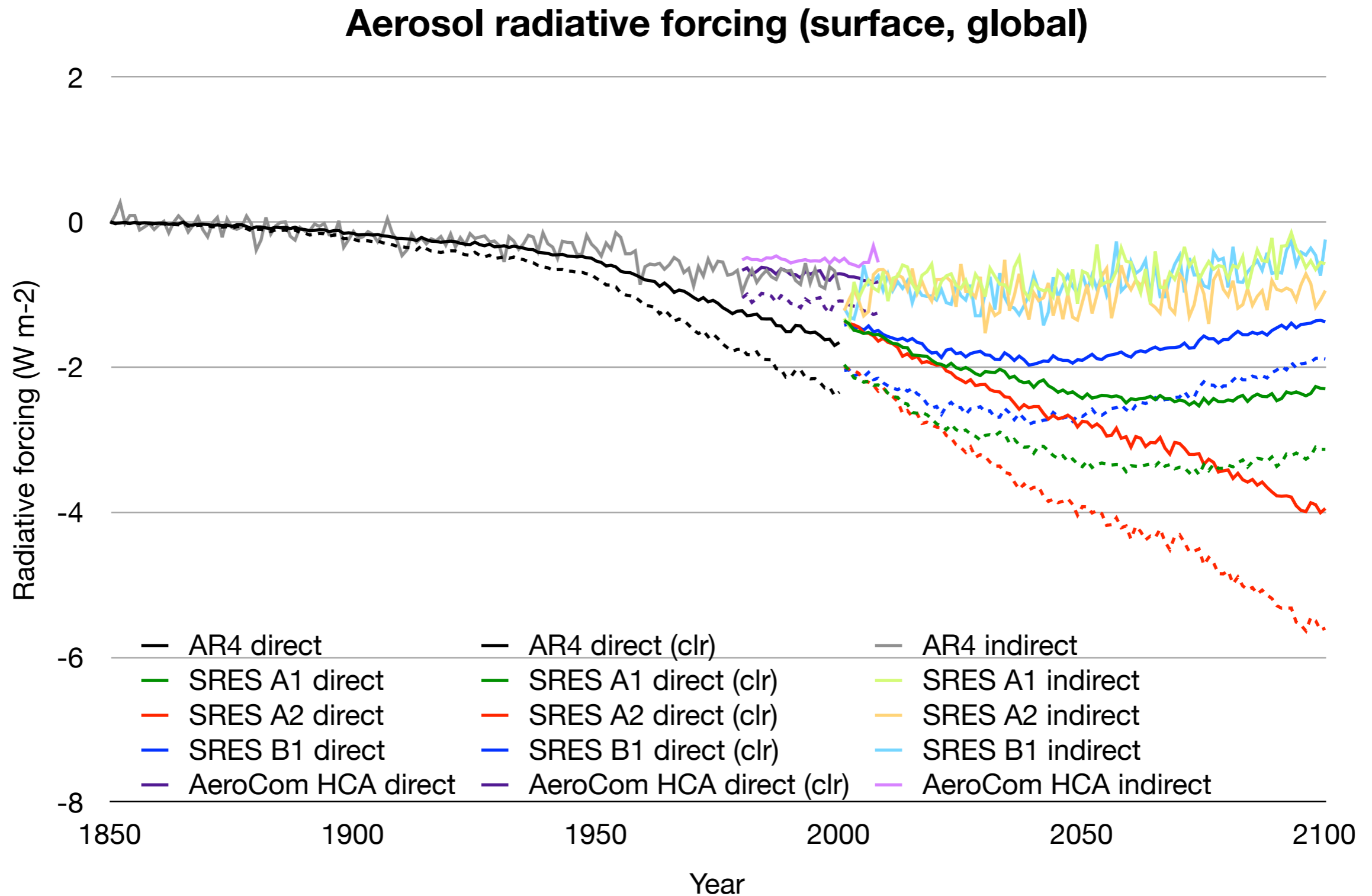
Aerosol radiative forcing (tropopause, global)



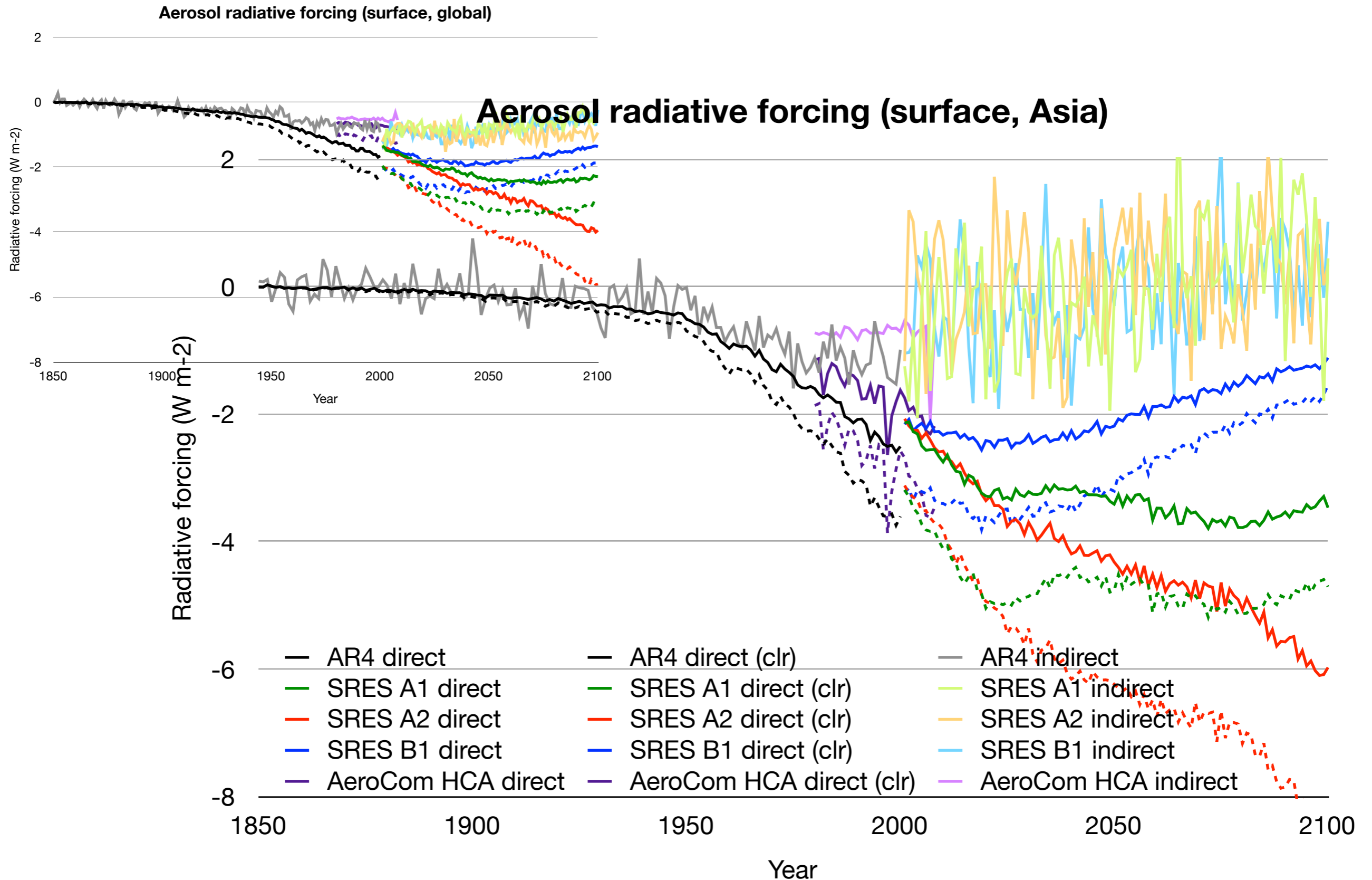
Trend of aerosol radiative forcing (tropopause)



Trend of aerosol radiative forcing (surface)



Trend of aerosol radiative forcing (surface)

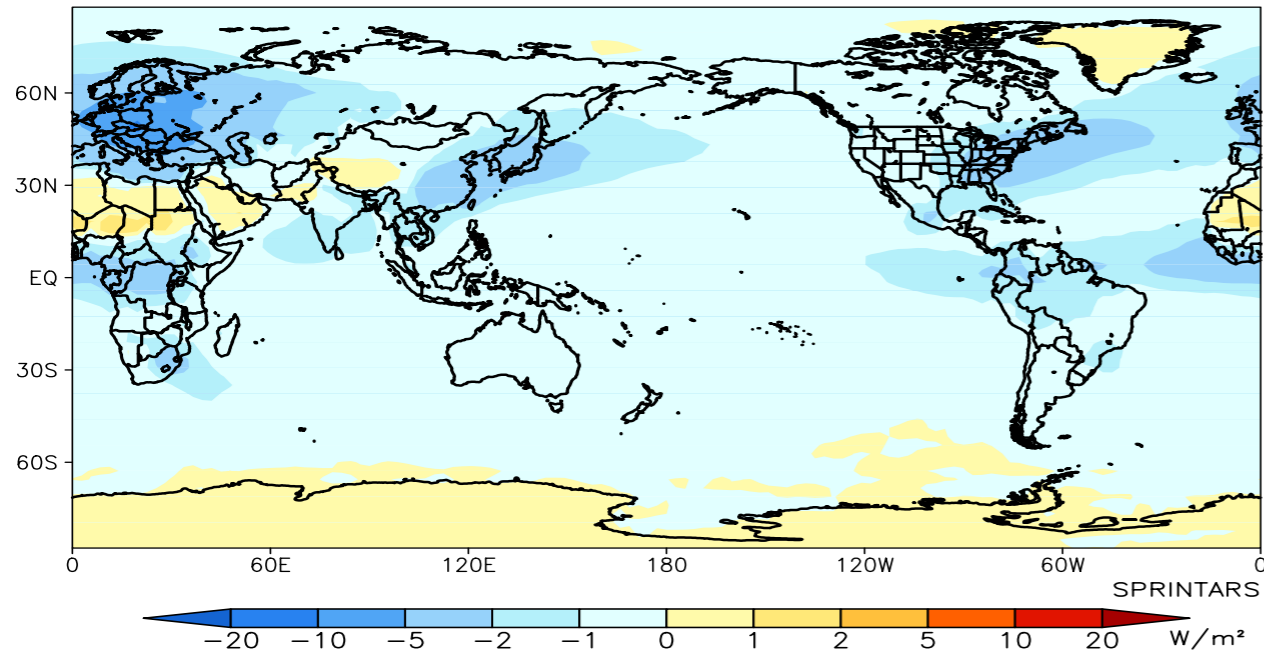


Aerosol forcing in IPCC AR4 and AeroCom HCA

IPCC AR4

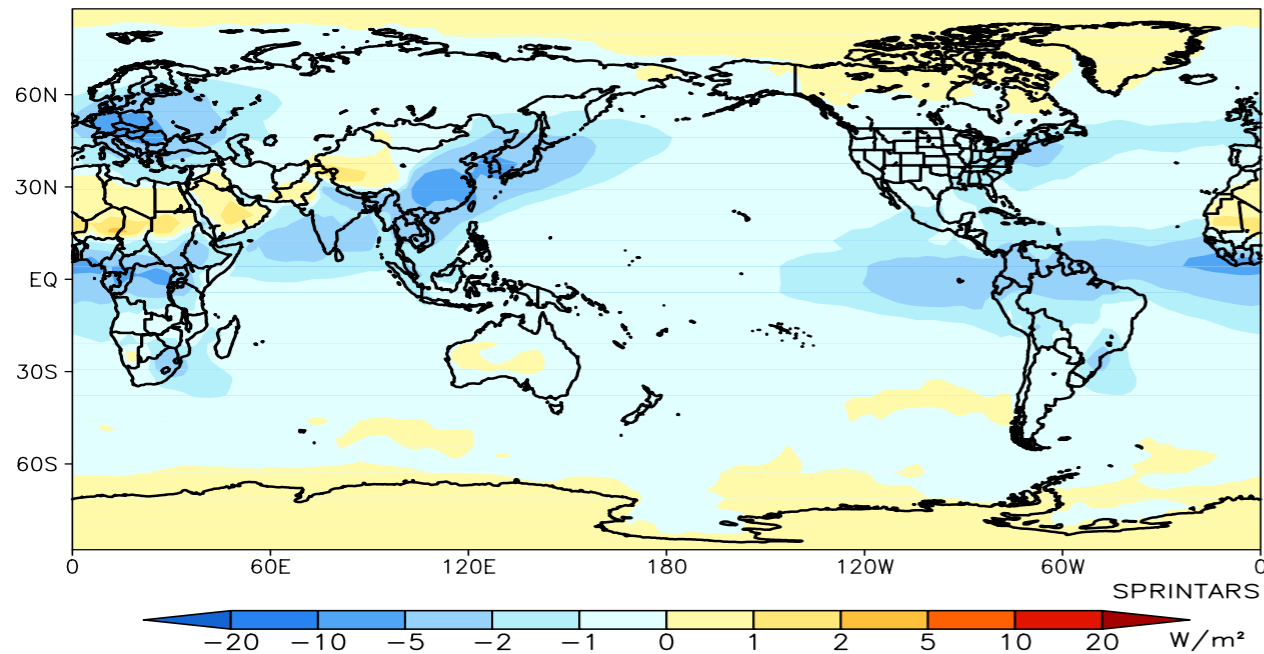
1980–1984 mean relative to 1850

Aerosol direct radiative forcing (tropopause, clear-sky)



2004–2008 mean relative to 1850

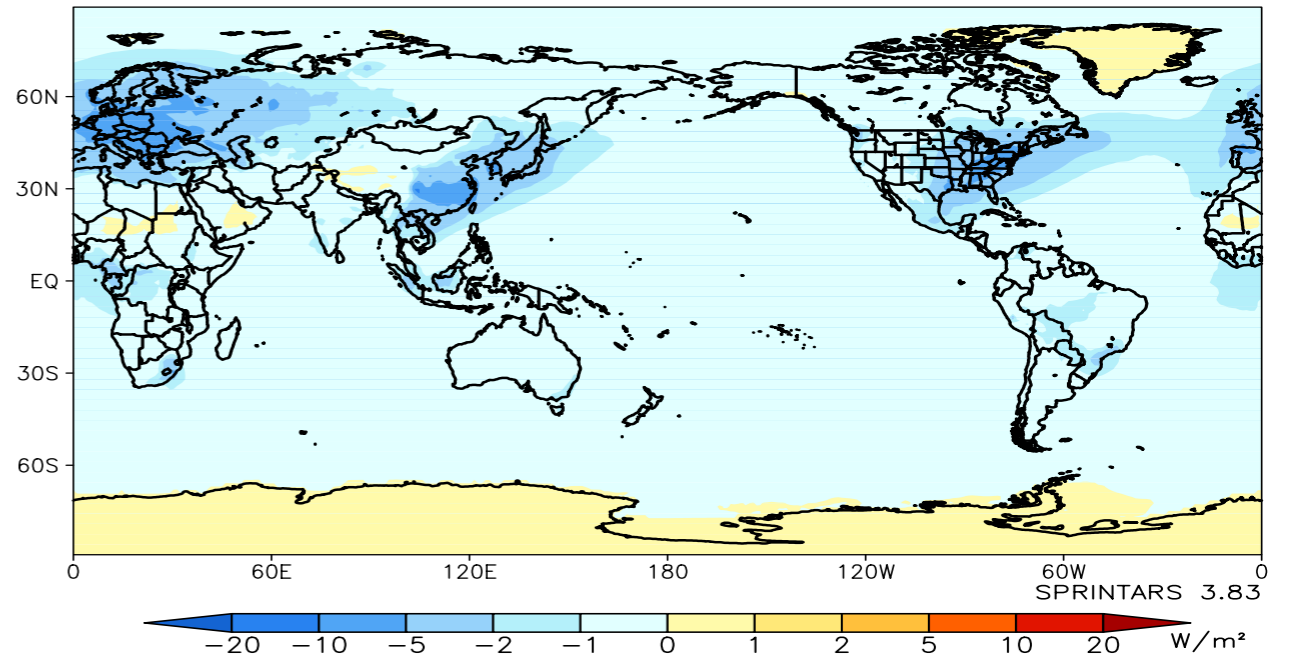
Aerosol direct radiative forcing (tropopause, clear-sky)



AeroCom HCA

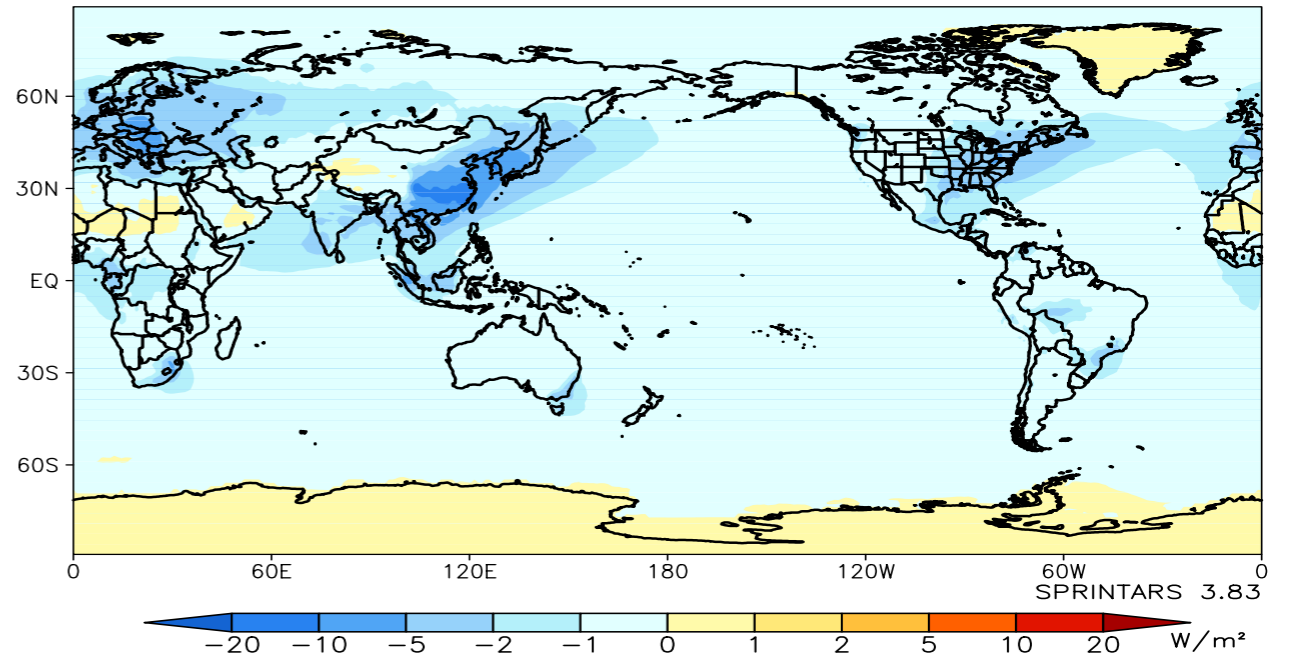
1980–1984 mean relative to 1850

Aerosol direct radiative forcing (tropopause, clear-sky)



2004–2008 mean relative to 1850

Aerosol direct radiative forcing (tropopause, clear-sky)

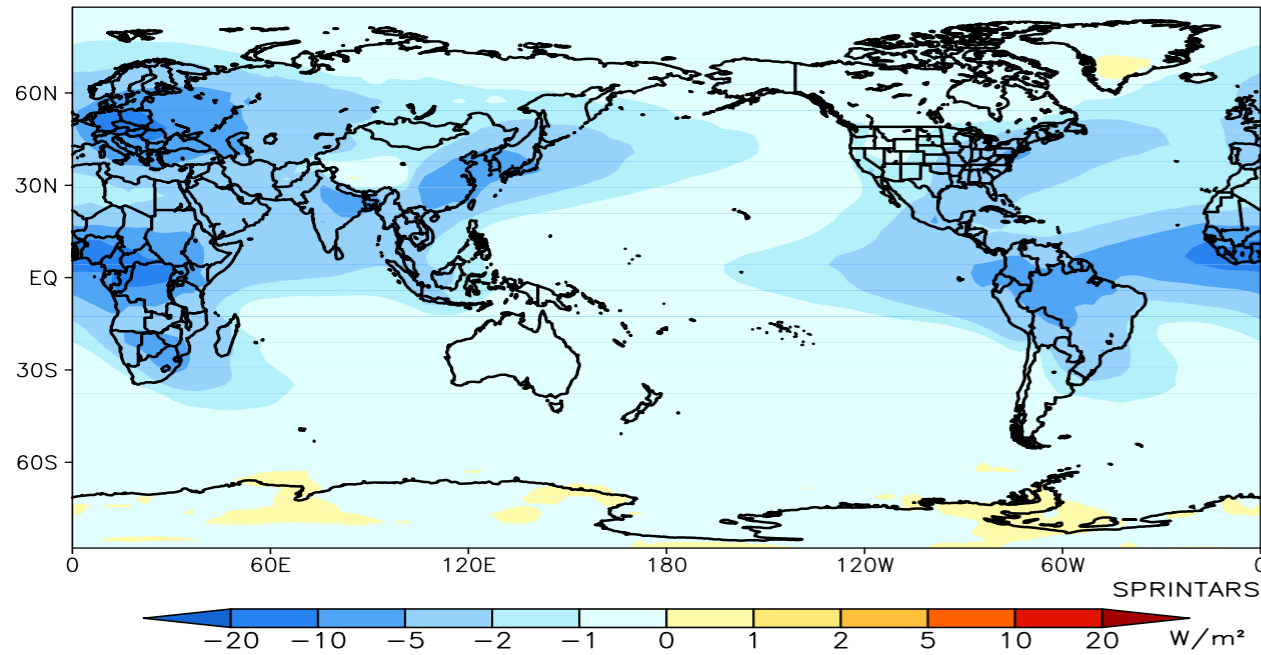


Aerosol forcing in IPCC AR4 and AeroCom HCA

IPCC AR4

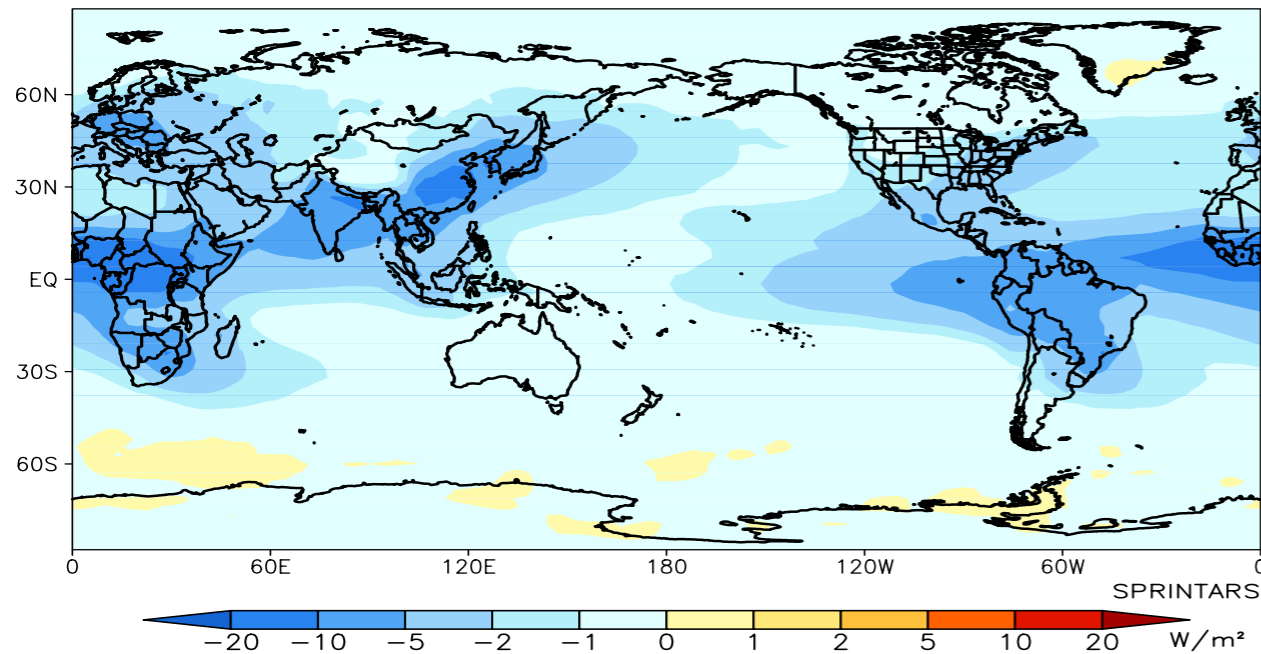
1980–1984 mean relative to 1850

Aerosol direct radiative forcing (surface, clear-sky)



2004–2008 mean relative to 1850

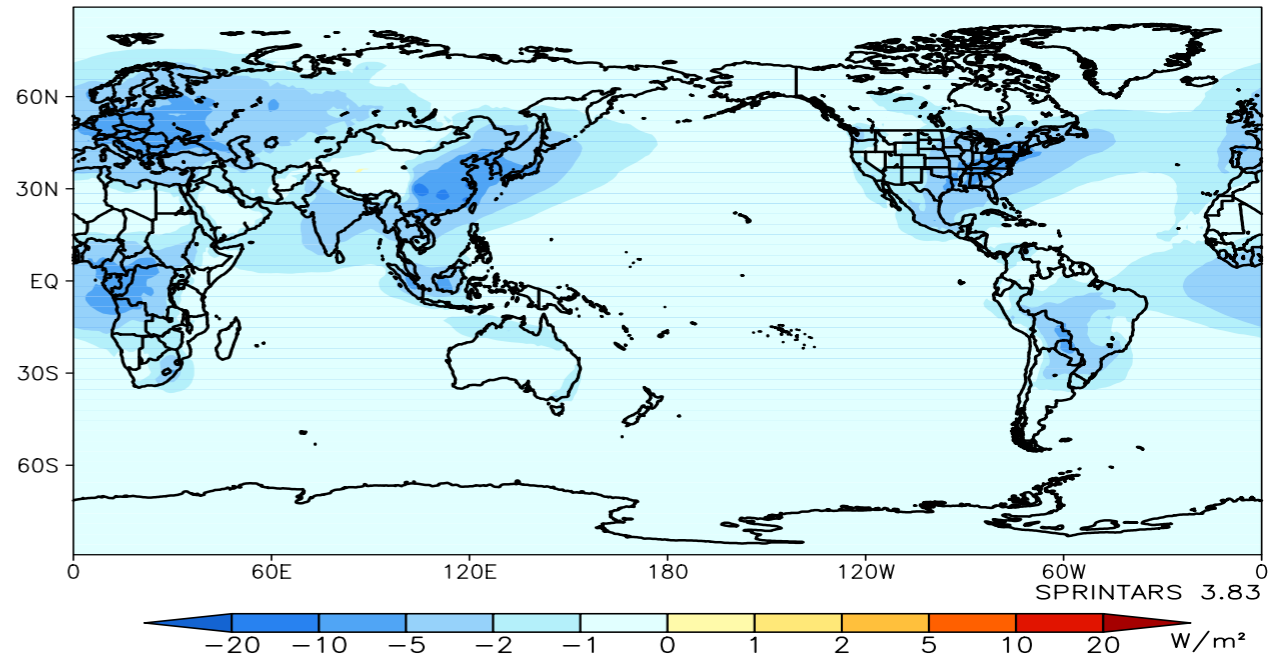
Aerosol direct radiative forcing (surface, clear-sky)



AeroCom HCA

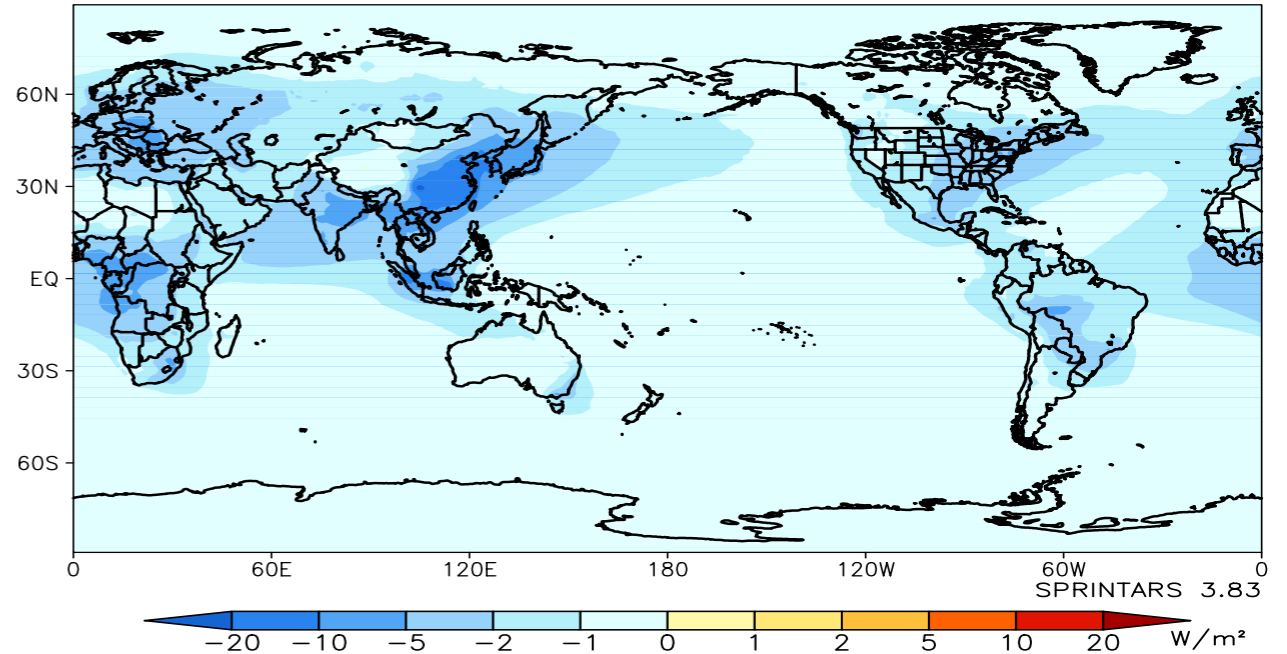
1980–1984 mean relative to 1850

Aerosol direct radiative forcing (surface, clear-sky)



2004–2008 mean relative to 1850

Aerosol direct radiative forcing (surface, clear-sky)

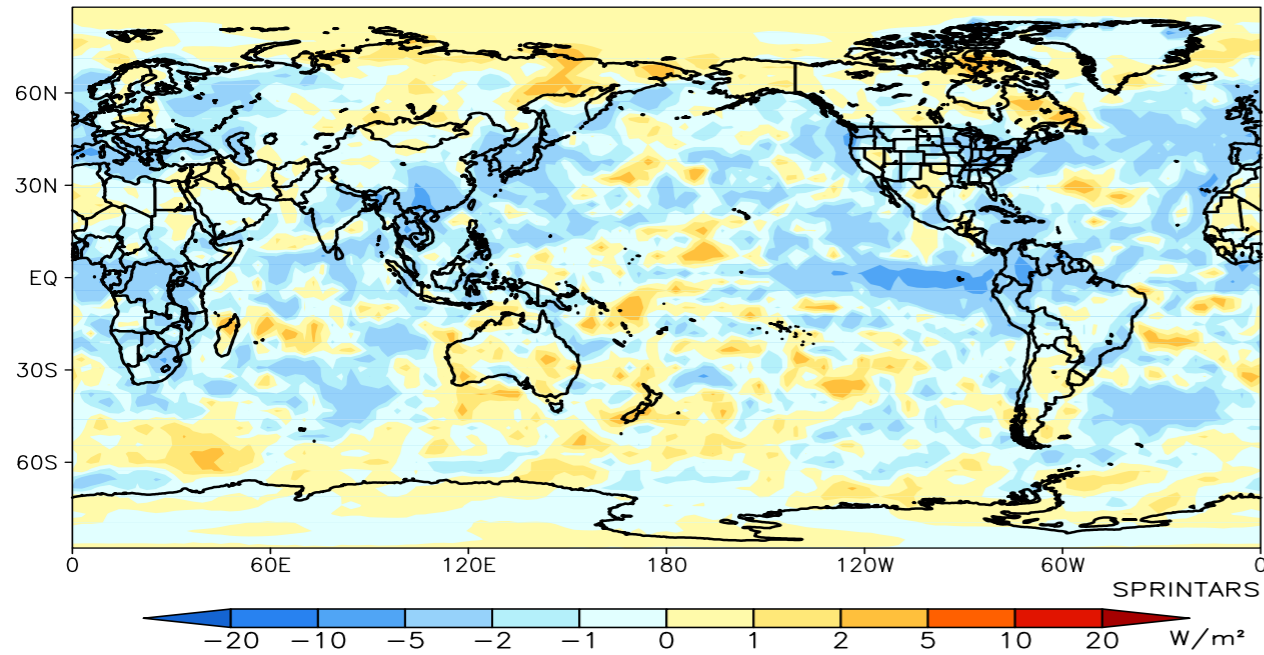


Aerosol forcing in IPCC AR4 and AeroCom HCA

IPCC AR4

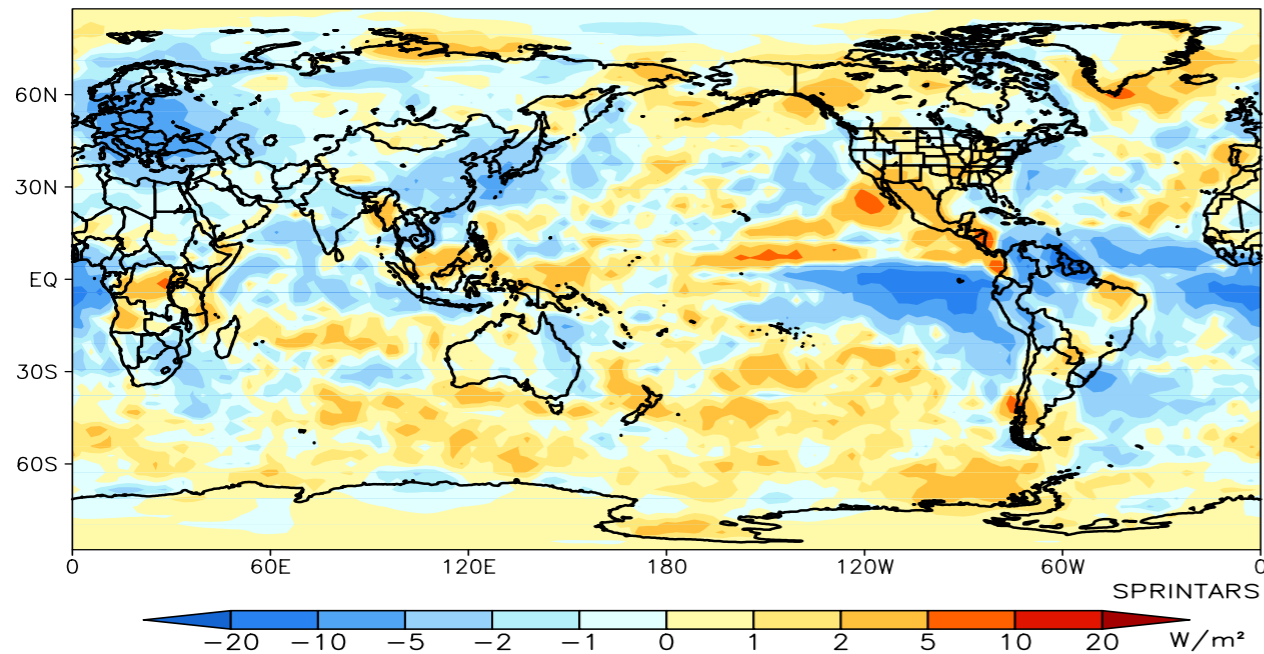
1980–1984 mean relative to 1850

Aerosol indirect radiative forcing (tropopause)



2004–2008 mean relative to 1850

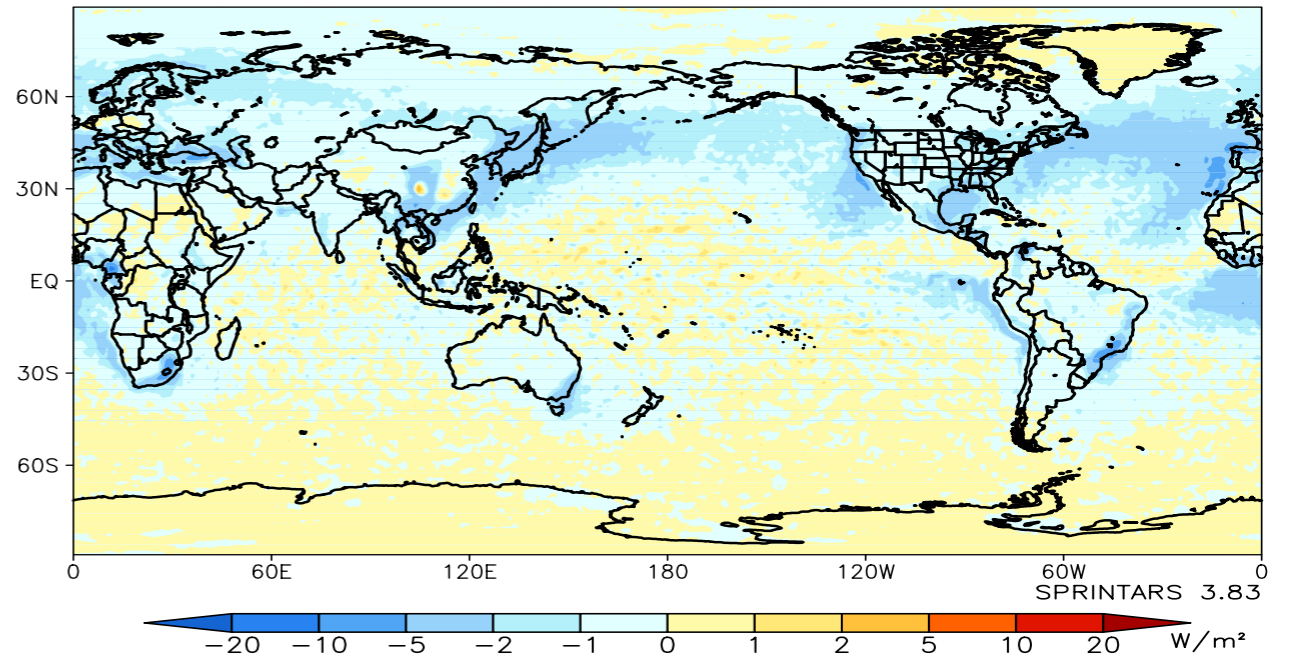
Aerosol indirect radiative forcing (tropopause)



AeroCom HCA

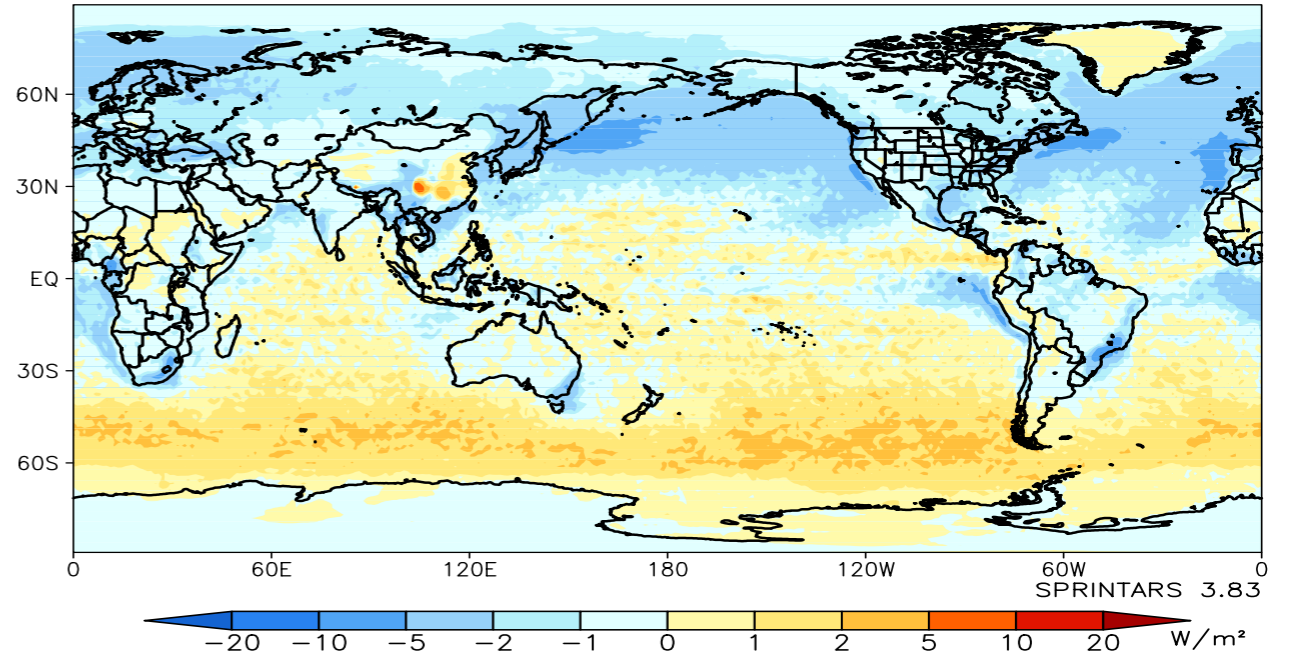
1980–1984 mean relative to 1850

Aerosol indirect radiative forcing (tropopause)

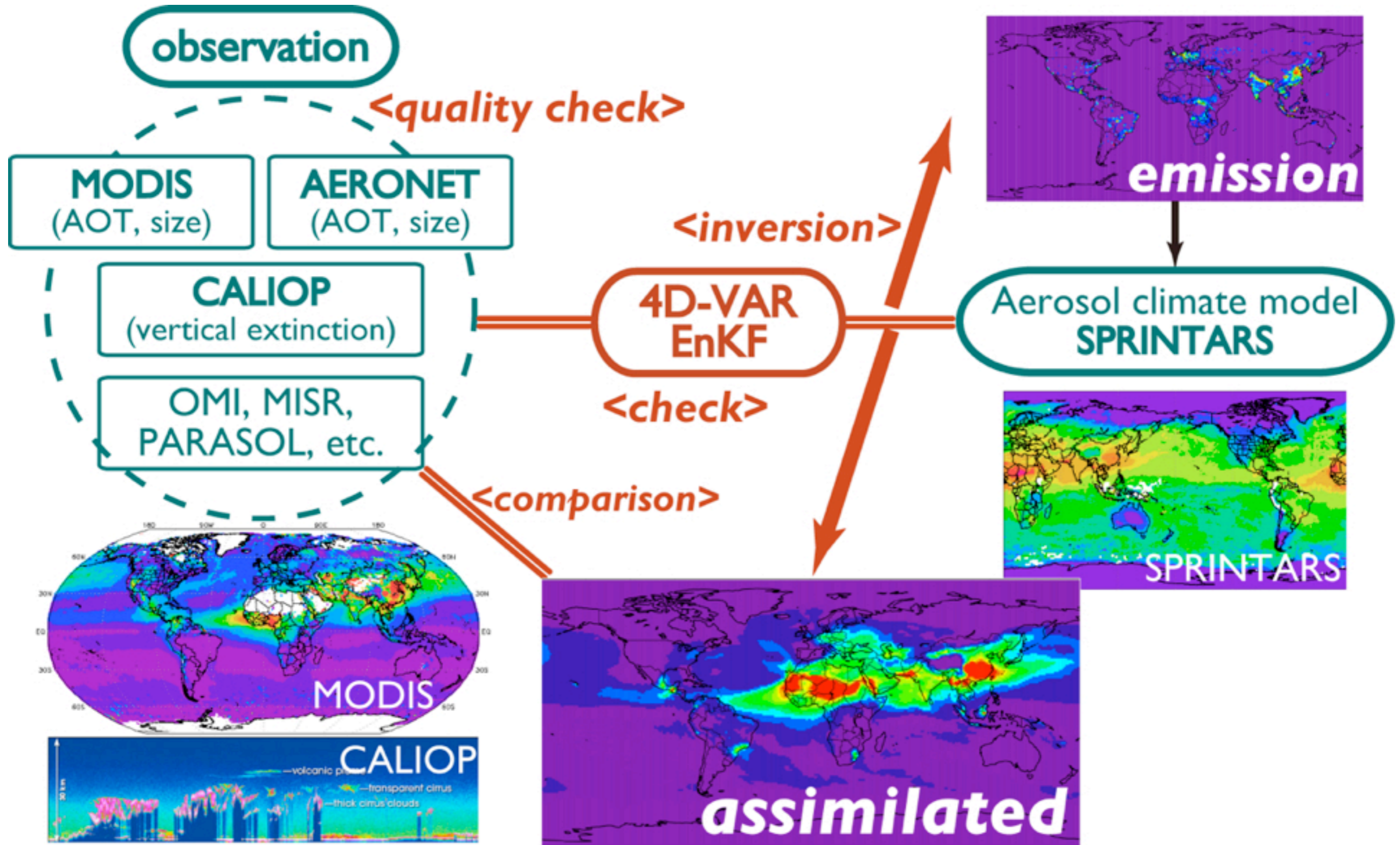


2004–2008 mean relative to 1850

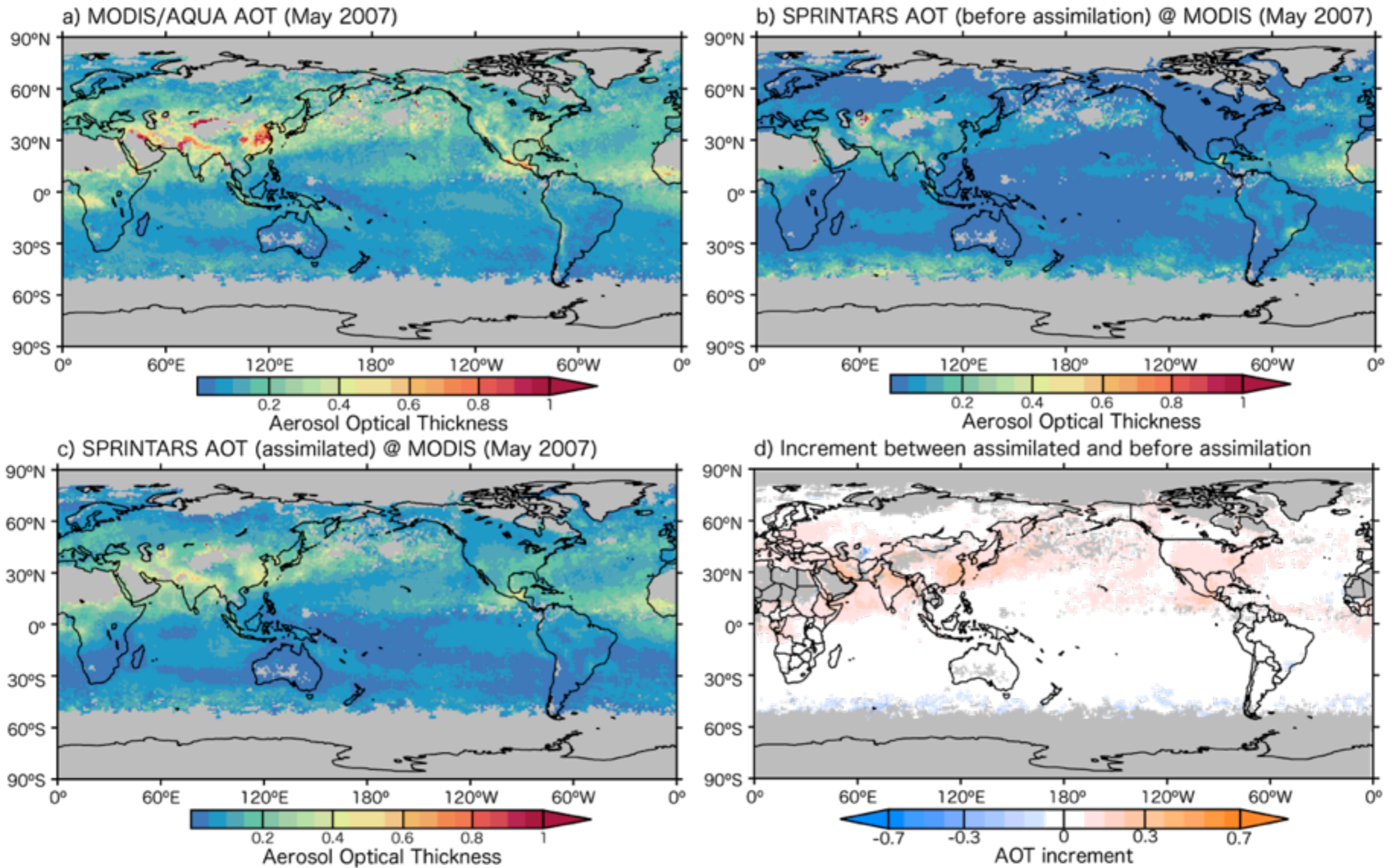
Aerosol indirect radiative forcing (tropopause)



Aerosol data assimilation with SPRINTARS



LETKF assimilation in SPRINTARS with MODIS



Yumimoto, Eguchi, and Takemura (2009)

<http://sprintars.net/>

- weekly global aerosol forecast for public and researchers.
- archive of hindcast simulation from 1980.

FORECAST (summary)

Forecast movies (Global)

[Pollutant aerosols](#)

[Soil dust aerosols](#)

Forecast movies (Asia)

[Pollutant aerosols](#)

[Soil dust aerosols](#)

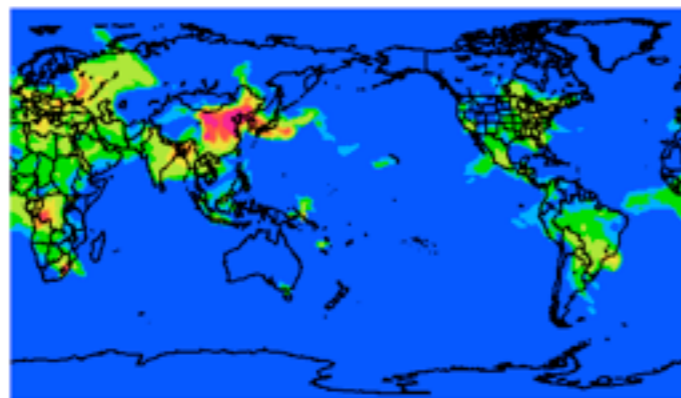
The aerosol forecast is based on the simulation with a global aerosol climate model, [SPRINTARS](#).

- "Pollutant aerosols": total of black carbon, organic carbon, and sulfate aerosols.
- "Soil dust aerosols": dust from deserts, etc.

They are calculated by the mean mass concentration from the near-surface to about 1km height.

Forecast of atmospheric pollutant aerosols (movie)

15:00UTC 17JUN2009



SPRINTARS

less more

PLAY Movie STOP Movie BACK FORWARD

週間予測(簡易版)

各地のアerosol予測

[今日・明日](#)

[週間](#)

予測動画

[大気汚染粒子](#)

[黄砂](#)

エアロゾル(大気浮遊粒子状物質)は大気の霞みの原因となる物質です。呼吸器系などに影響を及ぼすと言われています。

このページのアerosol予測は数値モデルSPRINTARSによるシミュレーションをもとに行われています。SPRINTARSの簡単な解説は[こちら](#)。

- 「大気汚染粒子」:すす(黒色炭素)・有機炭素・硫酸塩エアロゾル

大気エアロゾル(微粒子)週間予測

2009年2月11日 発表
今日・明日の詳細予測は[こちら](#)

各地域の上側は大気汚染粒子の指標、下側は黄砂の指標

		2月11日	2月12日	2月13日	2月14日	2月15日	2月16日	2月17日
北海道	汚染	少ない	少ない	少ない	少ない	少ない	少ない	少ない
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
東北北部	汚染	少ない	少ない	やや多い	やや多い	やや多い	少ない	少ない
	黄砂	少ない	少ない	少ない	少ない	やや多い	少ない	少ない
東北南部	汚染	少ない	やや多い	やや多い	やや多い	やや多い	少ない	少ない
	黄砂	少ない	少ない	少ない	少ない	やや多い	少ない	少ない
首都圏	汚染	やや多い	やや多い	やや多い	多い	やや多い	少ない	少ない
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
北陸信越	汚染	やや多い	多い	やや多い	多い	やや多い	少ない	少ない
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
東海	汚染	多い	多い	やや多い	多い	やや多い	少ない	少ない
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
近畿	汚染	非常に多い	非常に多い	多い	多い	やや多い	少ない	少ない
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない

Acknowledgments

- CCSR/NIES/FRCGC GCM group
- NIES supercomputer system (NEC SX-8R)
- NASA/GSFC MODIS group
- Global Environment Research Fund (RF-091) by the Ministry of the Environment, Japan
- Mitsui & Co., Ltd. Environment Fund (R08-D035)
- Grant-in-Aid for Young Scientists (21681001) of the Ministry of Education, Culture, Sports, Science, and Technology of Japan