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

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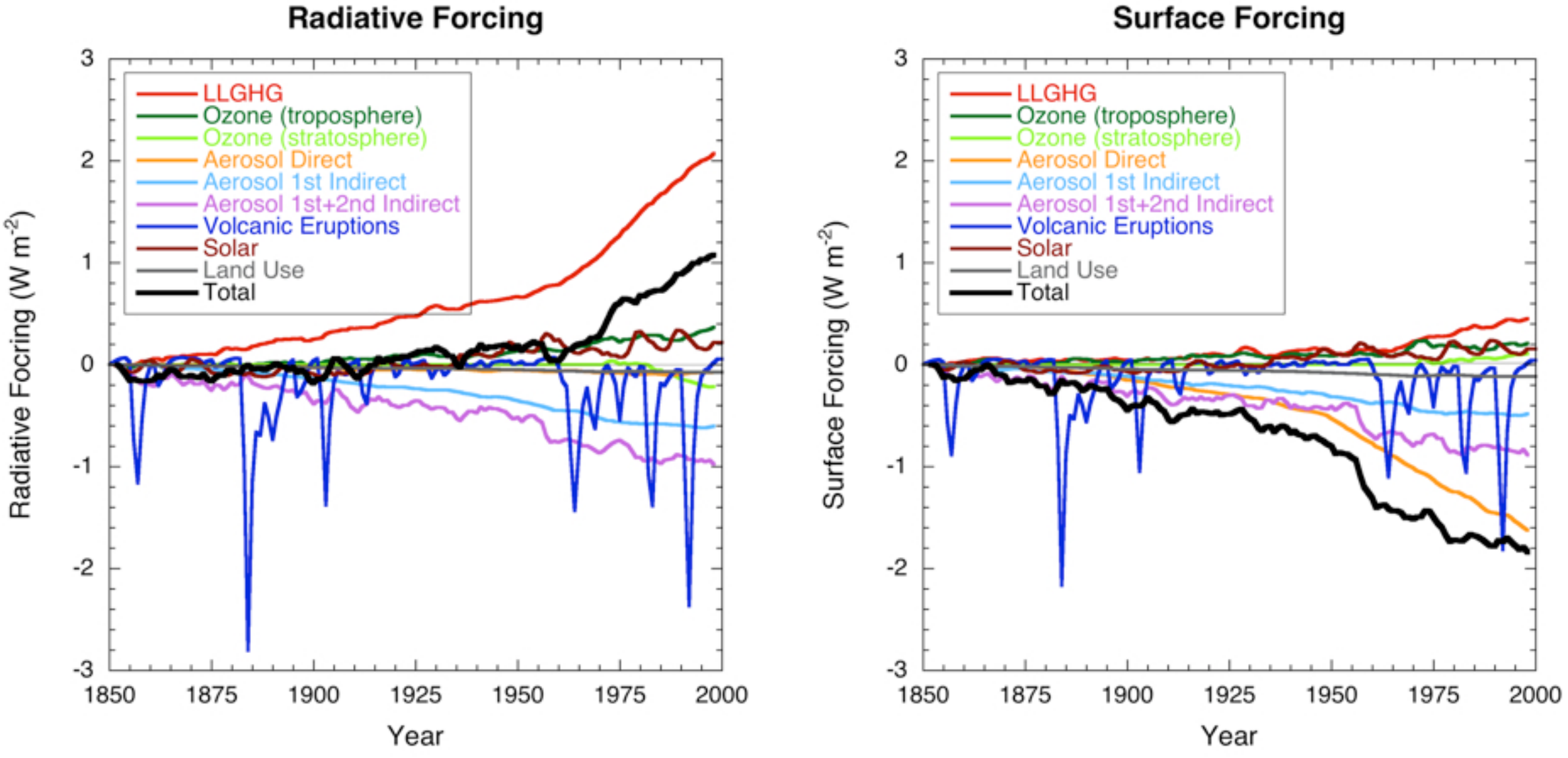
8th AeroCom Meeting (October 5, 2009; Princeton, NJ, USA)

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.

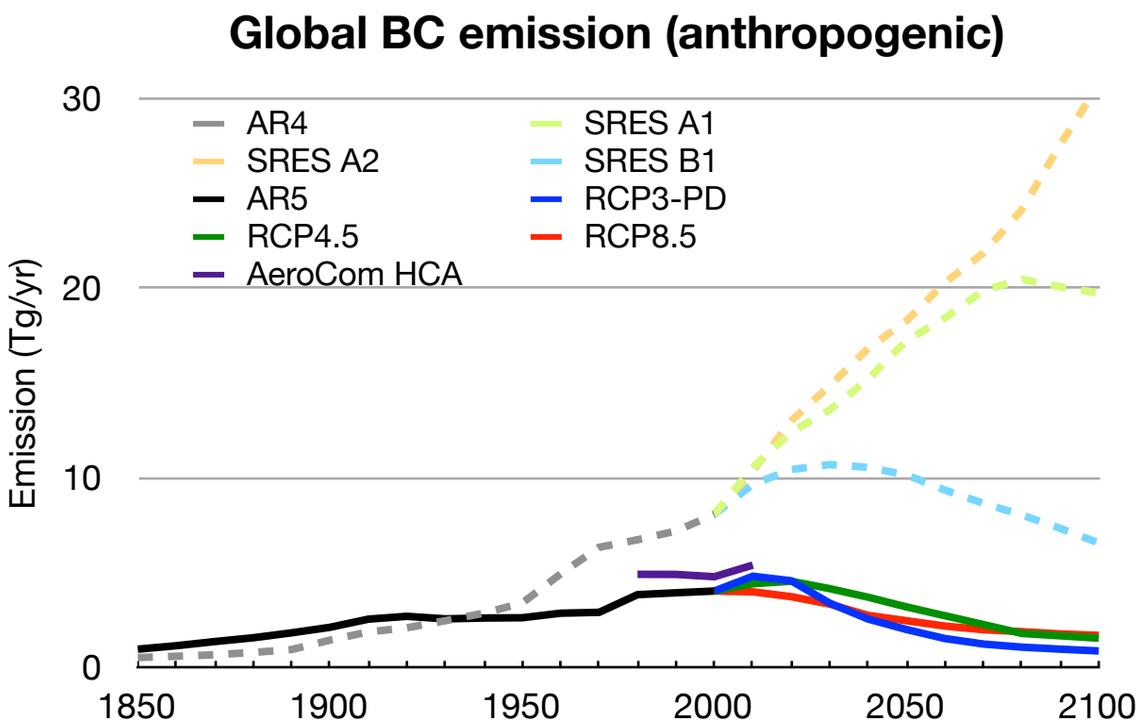
★ Reference Concentration Pathways (RCP) for IPCC AR5

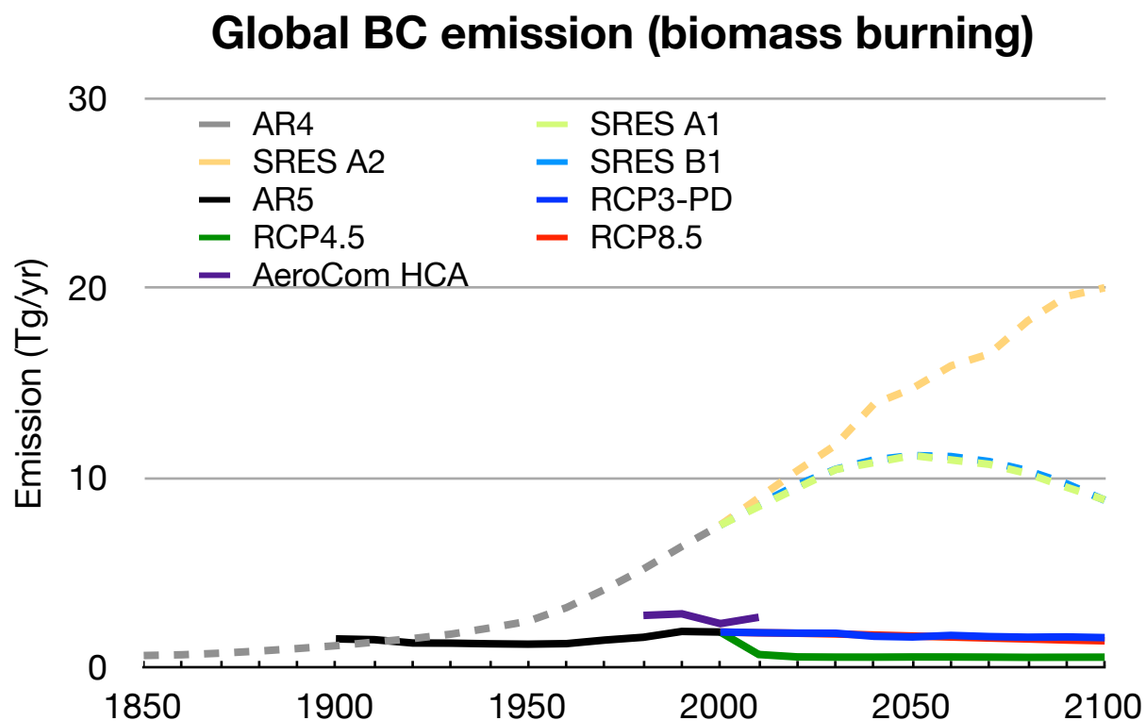
- RCP3-PD: 3.1 W m^{-2} mid-century, returning to 2.6 W m^{-2} by 2100.
- RCP4.5: stabilized before 2100 at radiative forcing of 4.5 W m^{-2}.
- RCP8.5: still increase in radiative forcing at 8.5 W m^{-2} in 2100.

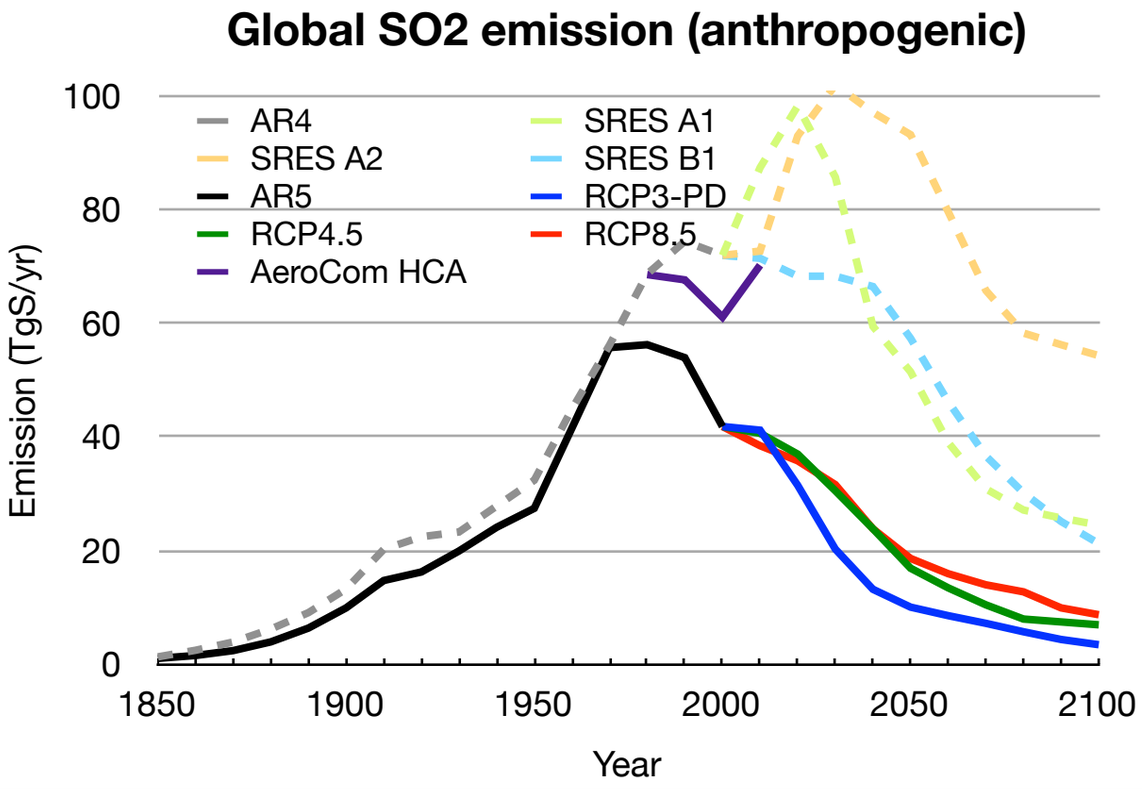
★ Inventories for AeroCom Hindcast simulation

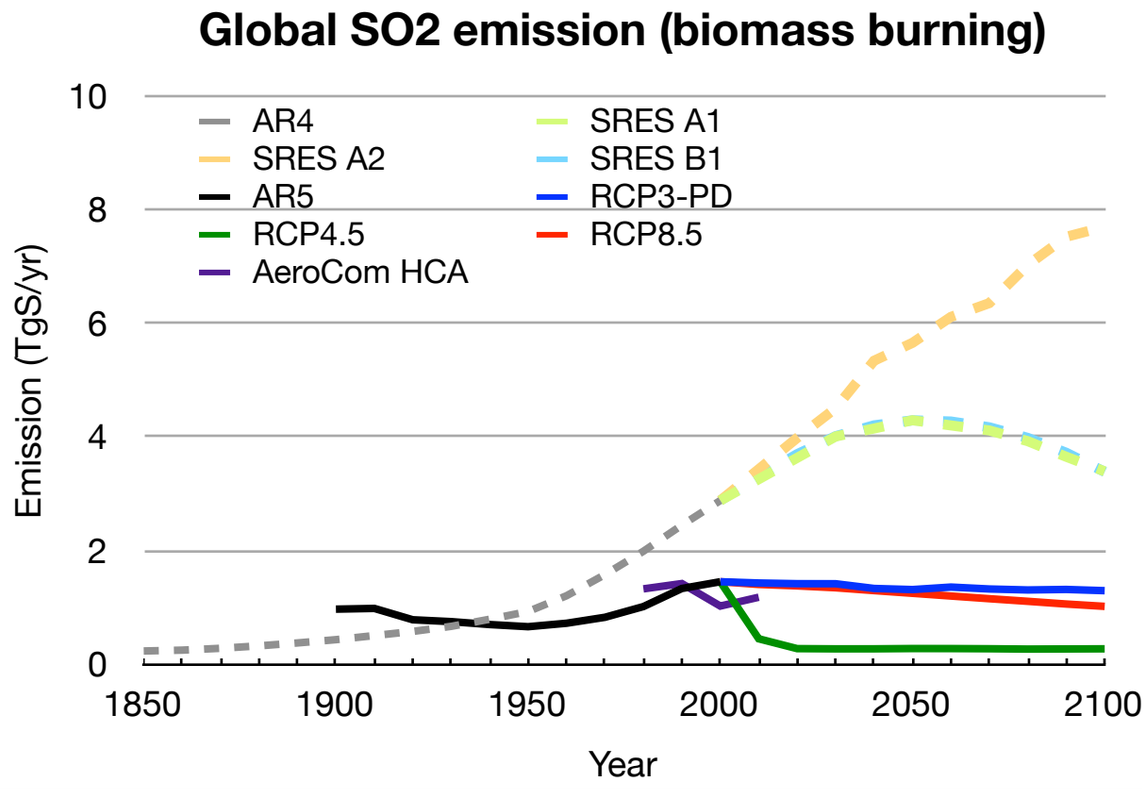
- edited by Thomas Diehl et al.

Aerosol emission inventories

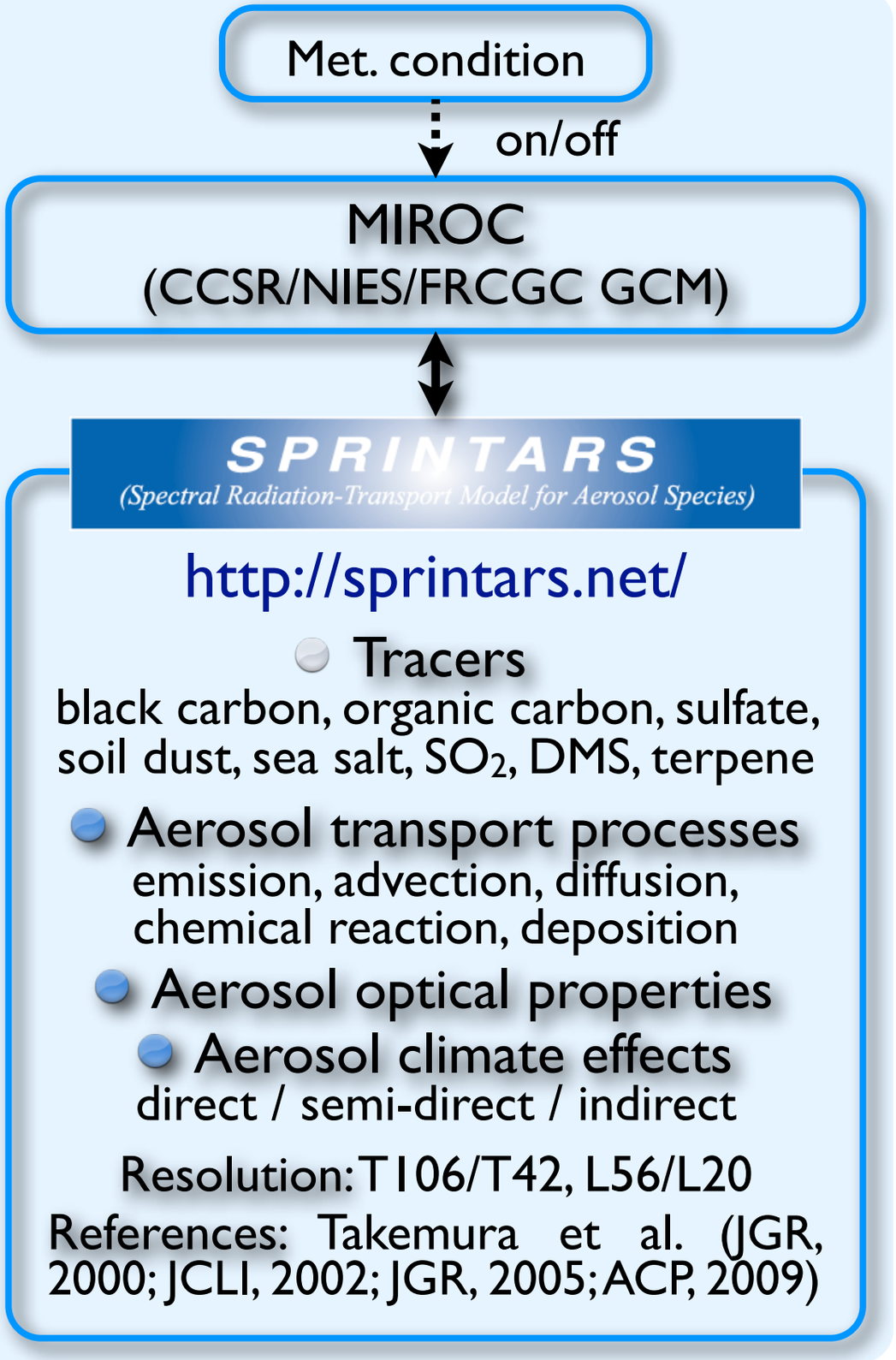








Model description of SPRINTARS



Transport Processes

Emission

- BC, OC: biomass burning, fossil fuel, biofuel, agricultural activities, and terpene origin.
- SO_2: 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

MIROC
(CCSR/NIES/FRCGC GCM)

SPRINTARS
(Spectral Radiation-Transport Model for Aerosol Species)

http://sprintars.net/

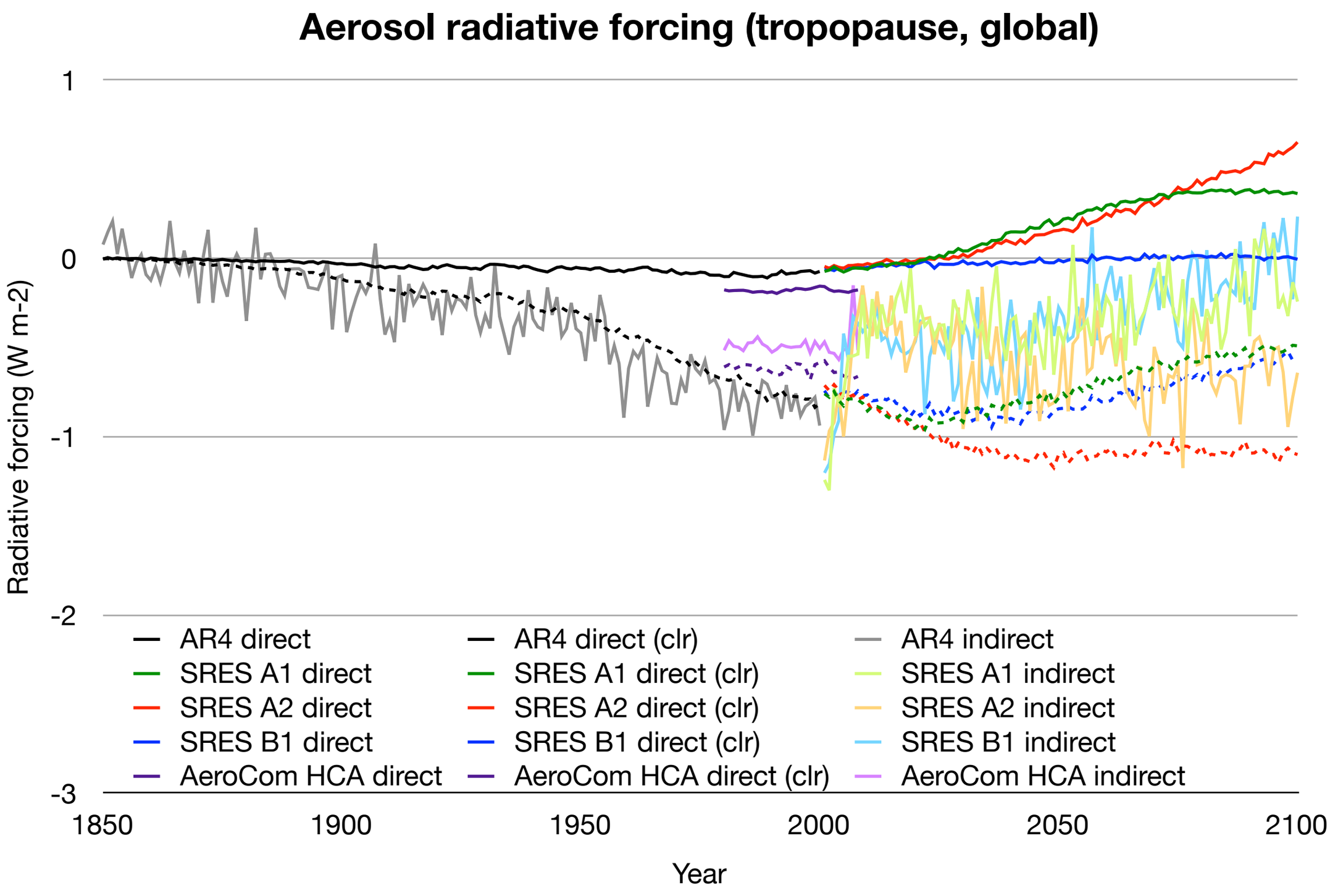
- Tracers
  black carbon, organic carbon, sulfate, soil dust, sea salt, SO_2, DMS, terpene
- Aerosol transport processes
  emission, advection, diffusion, chemical reaction, deposition
- Aerosol optical properties
- Aerosol climate effects
  direct / semi-direct / indirect

Resolution: T106/T42, L56/L20

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

- 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)



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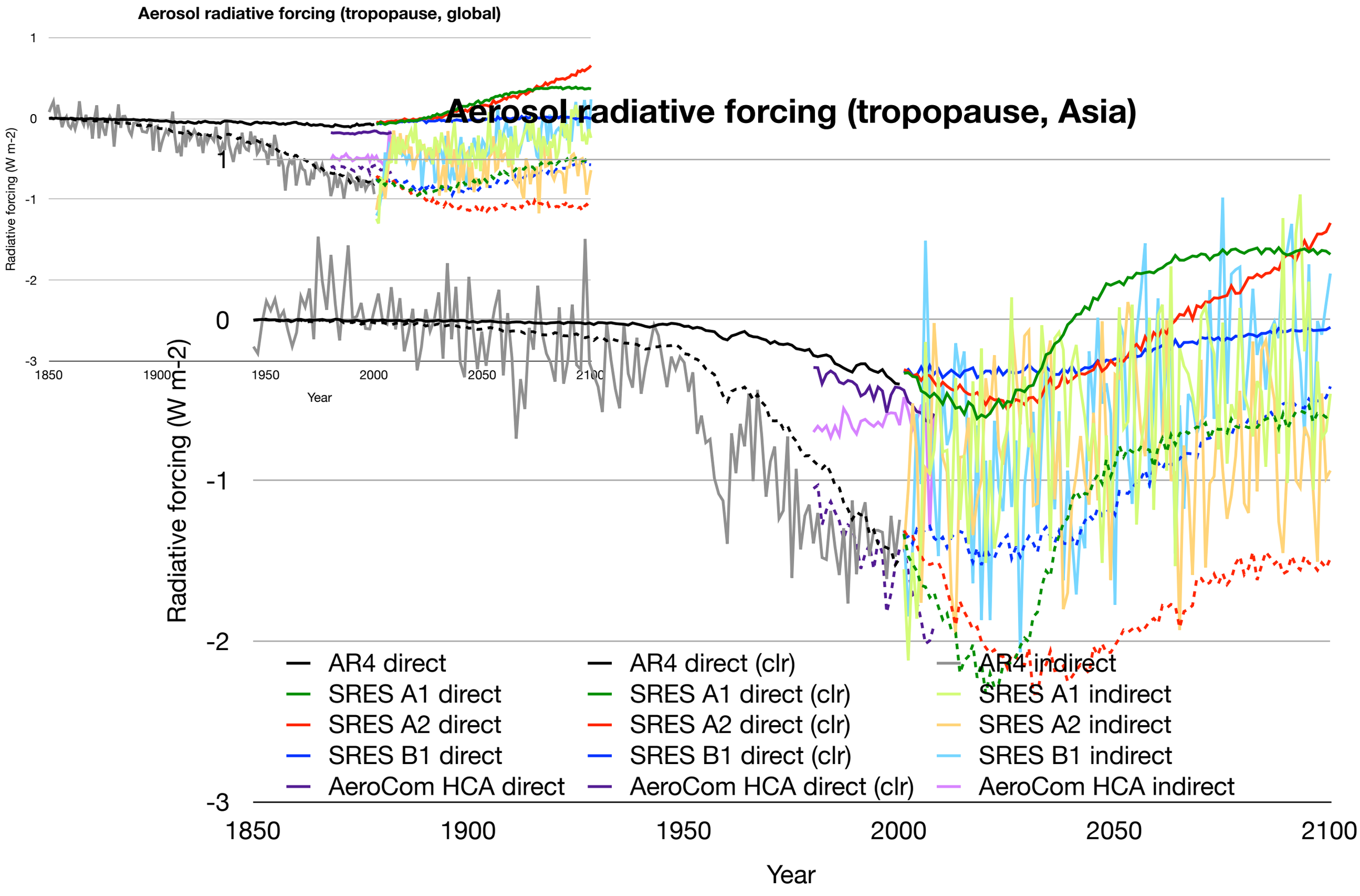
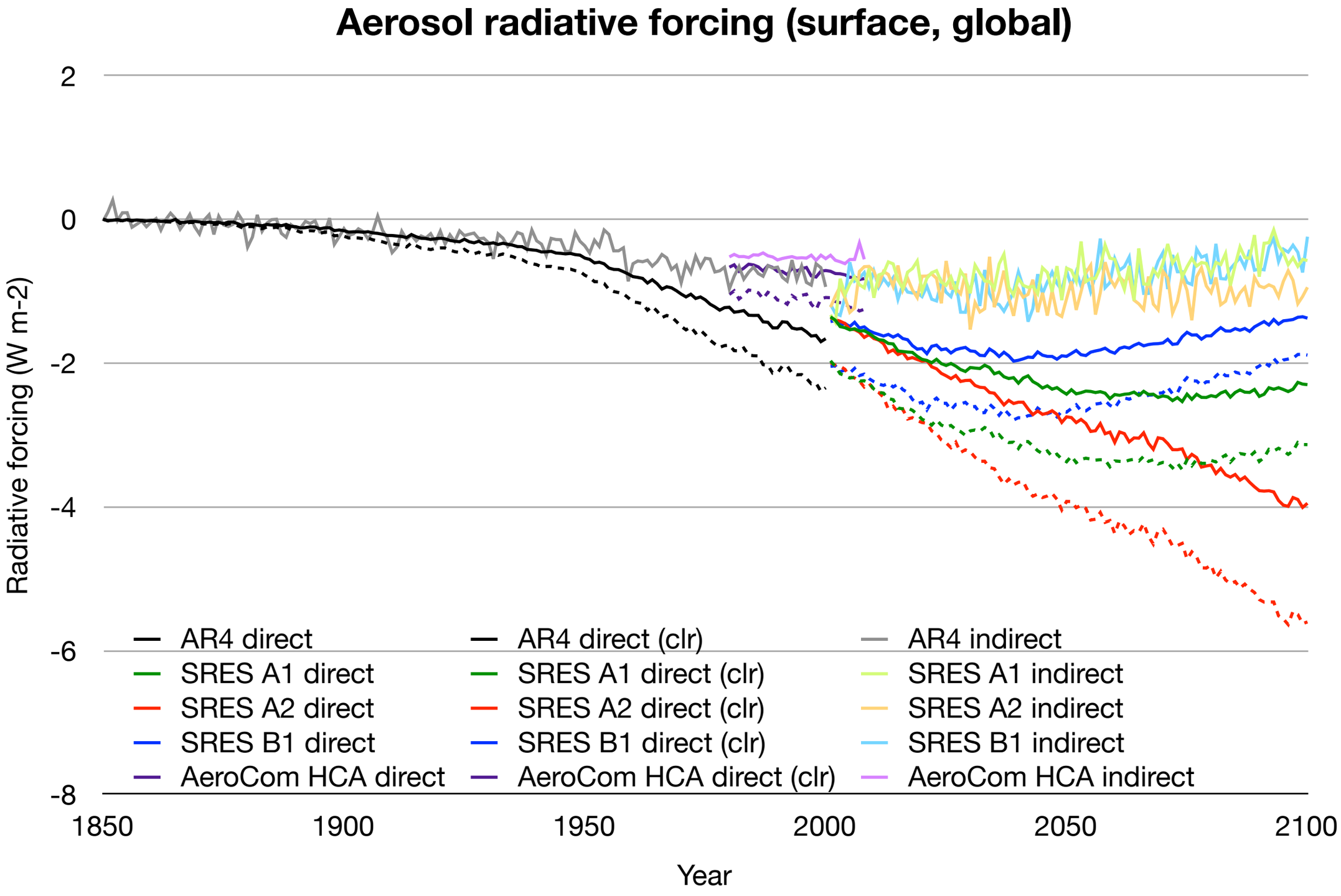


Trend of aerosol radiative forcing (surface)



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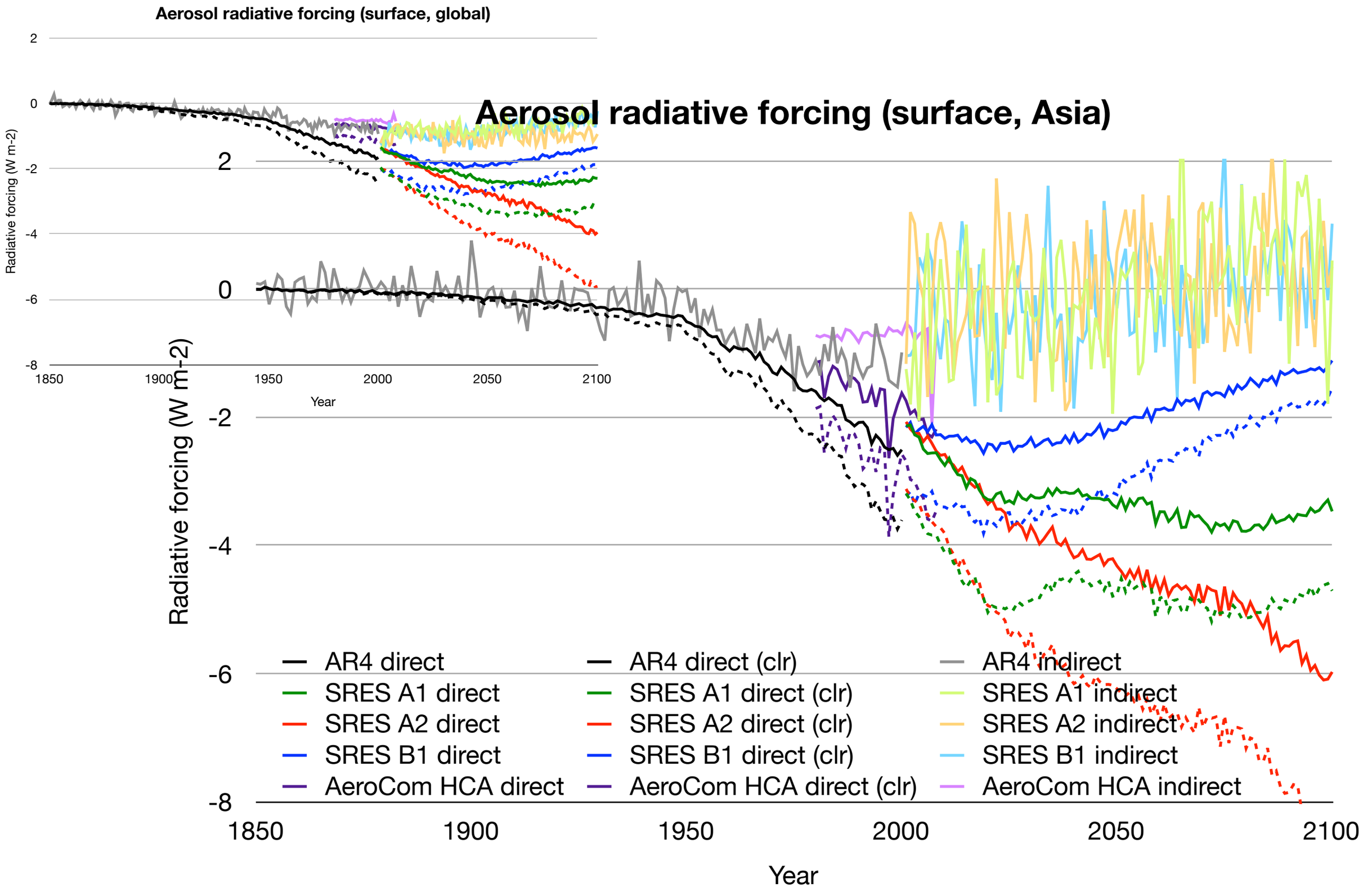
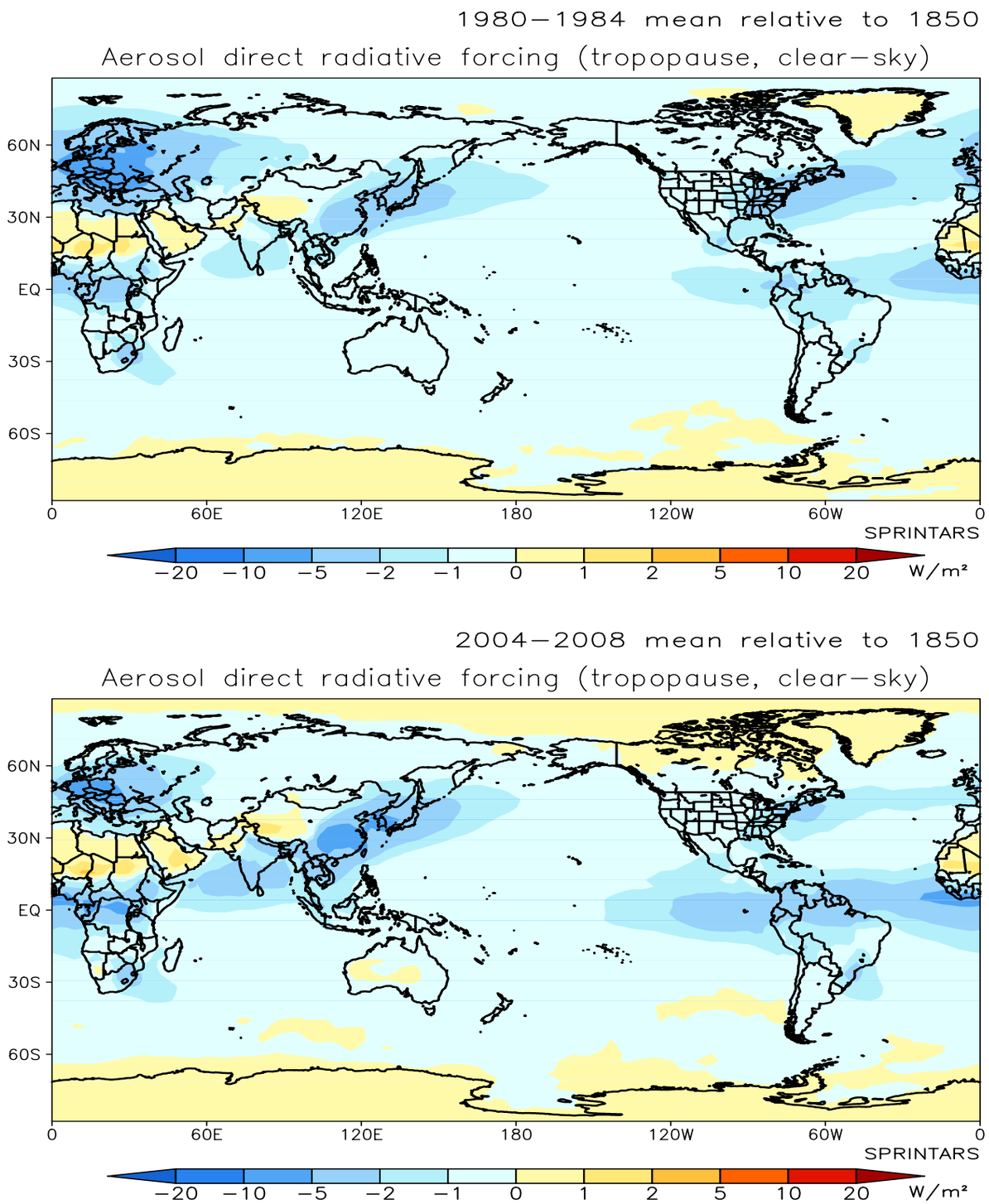
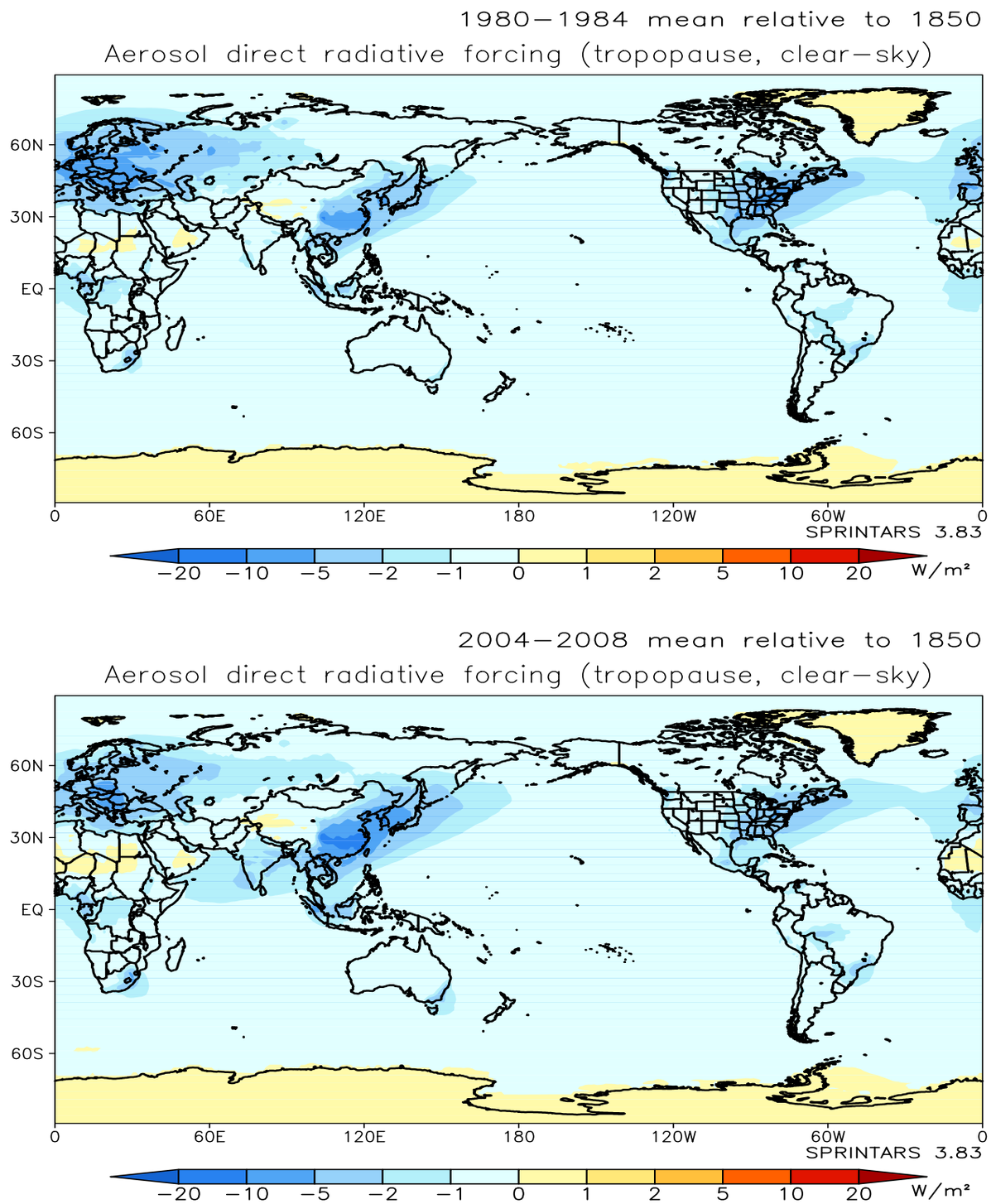


Aerosol forcing in IPCC AR4 and AeroCom HCA

IPCC AR4



AeroCom HCA



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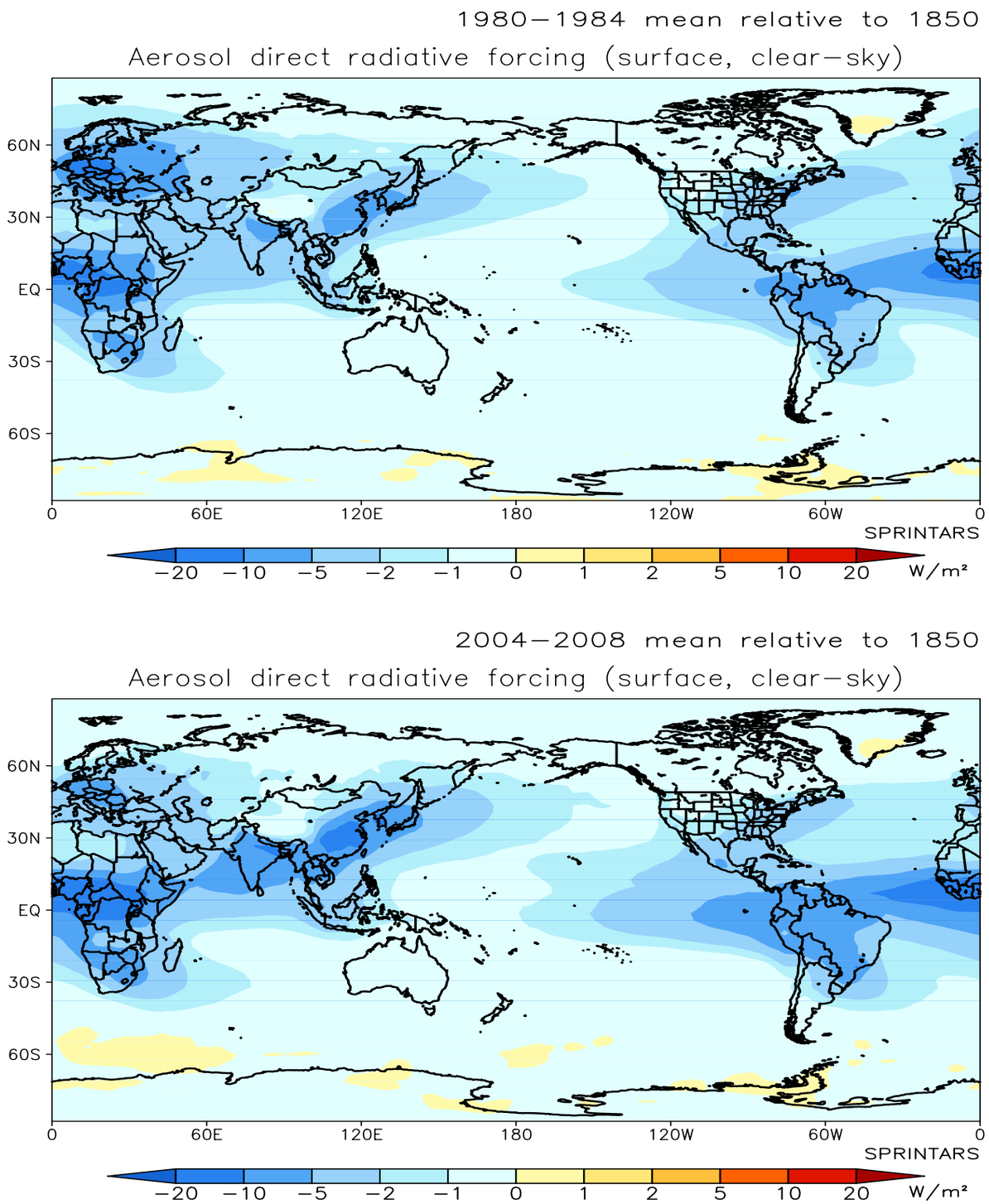
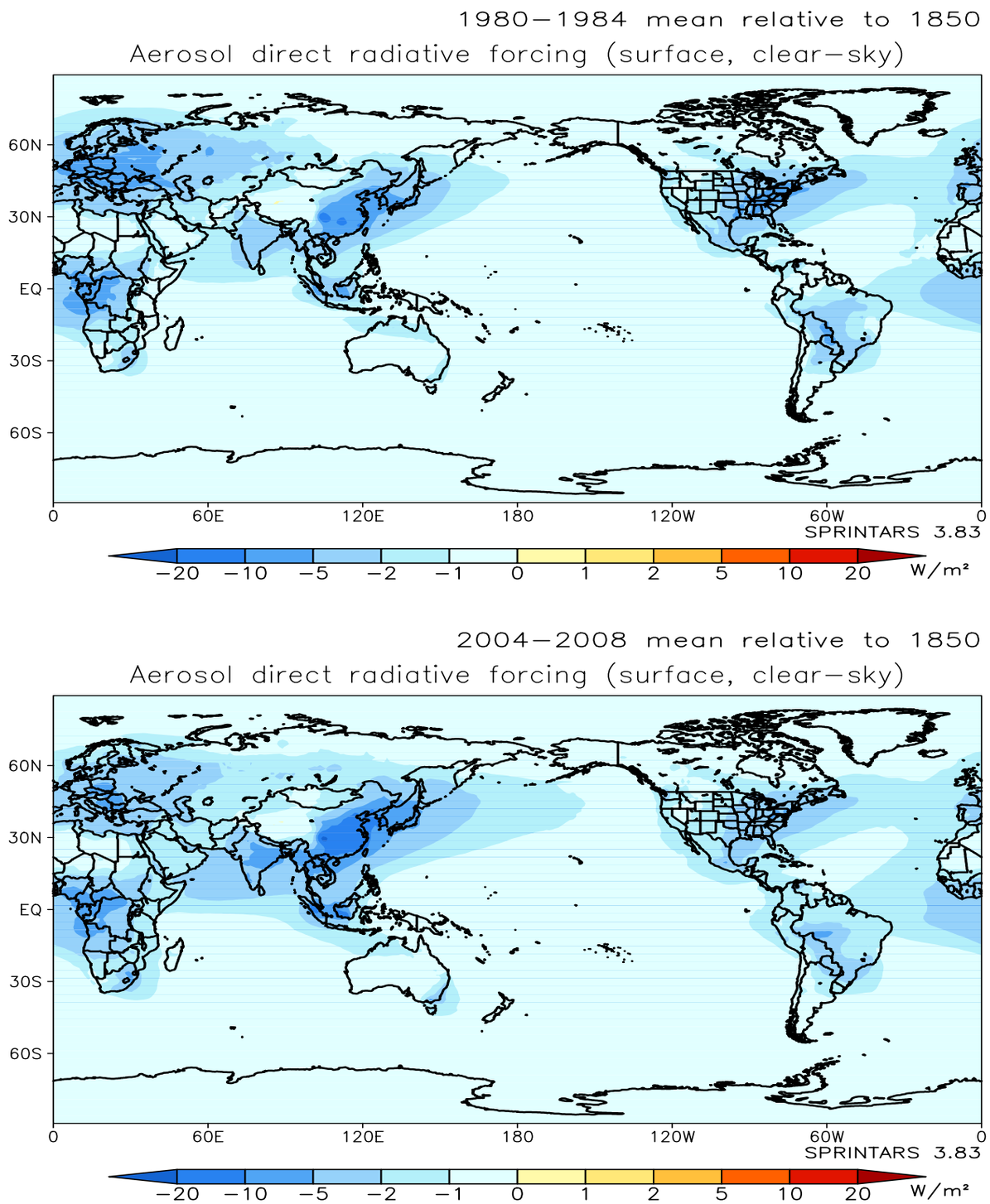


AeroCom HCA



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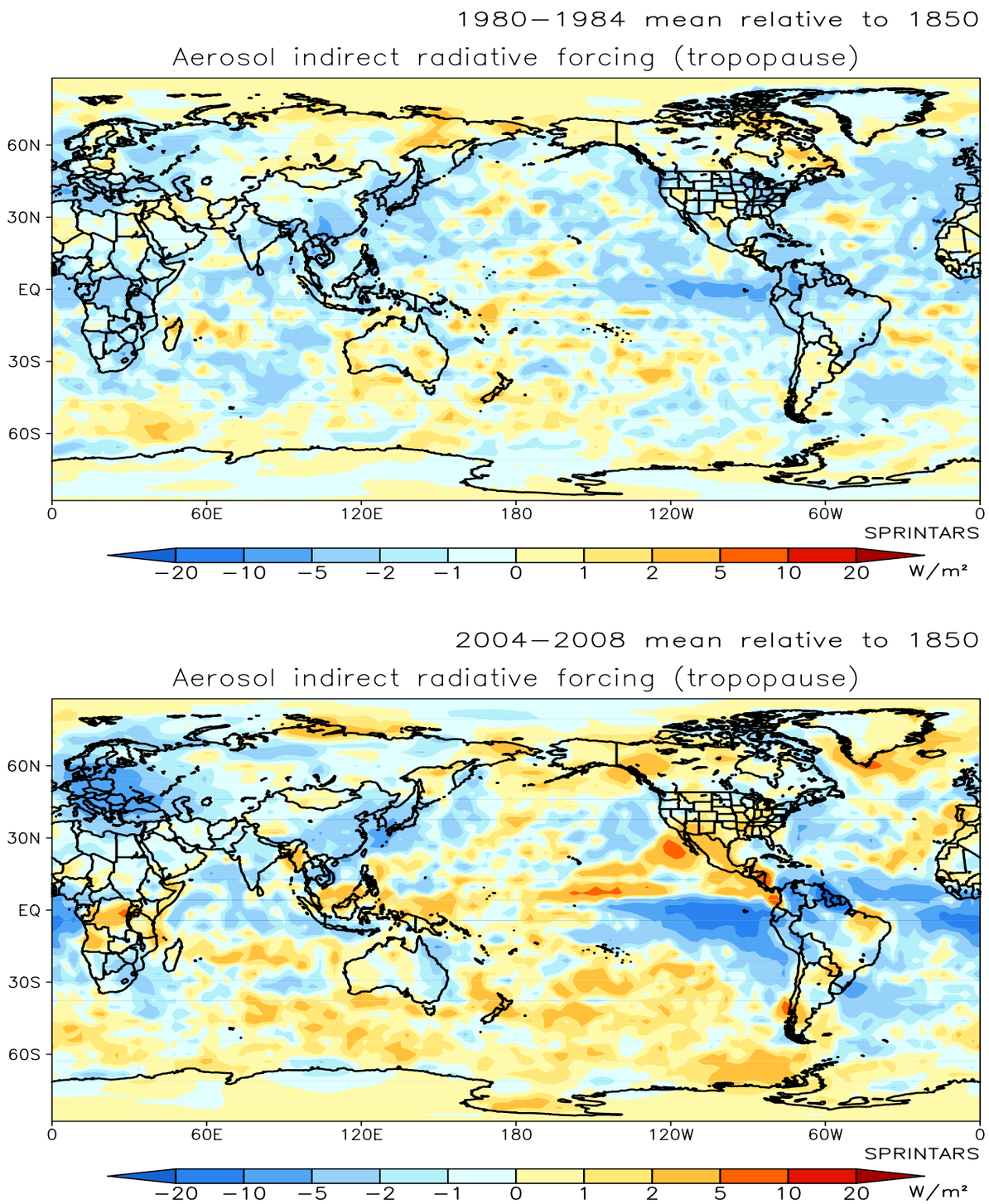
IPCC AR4



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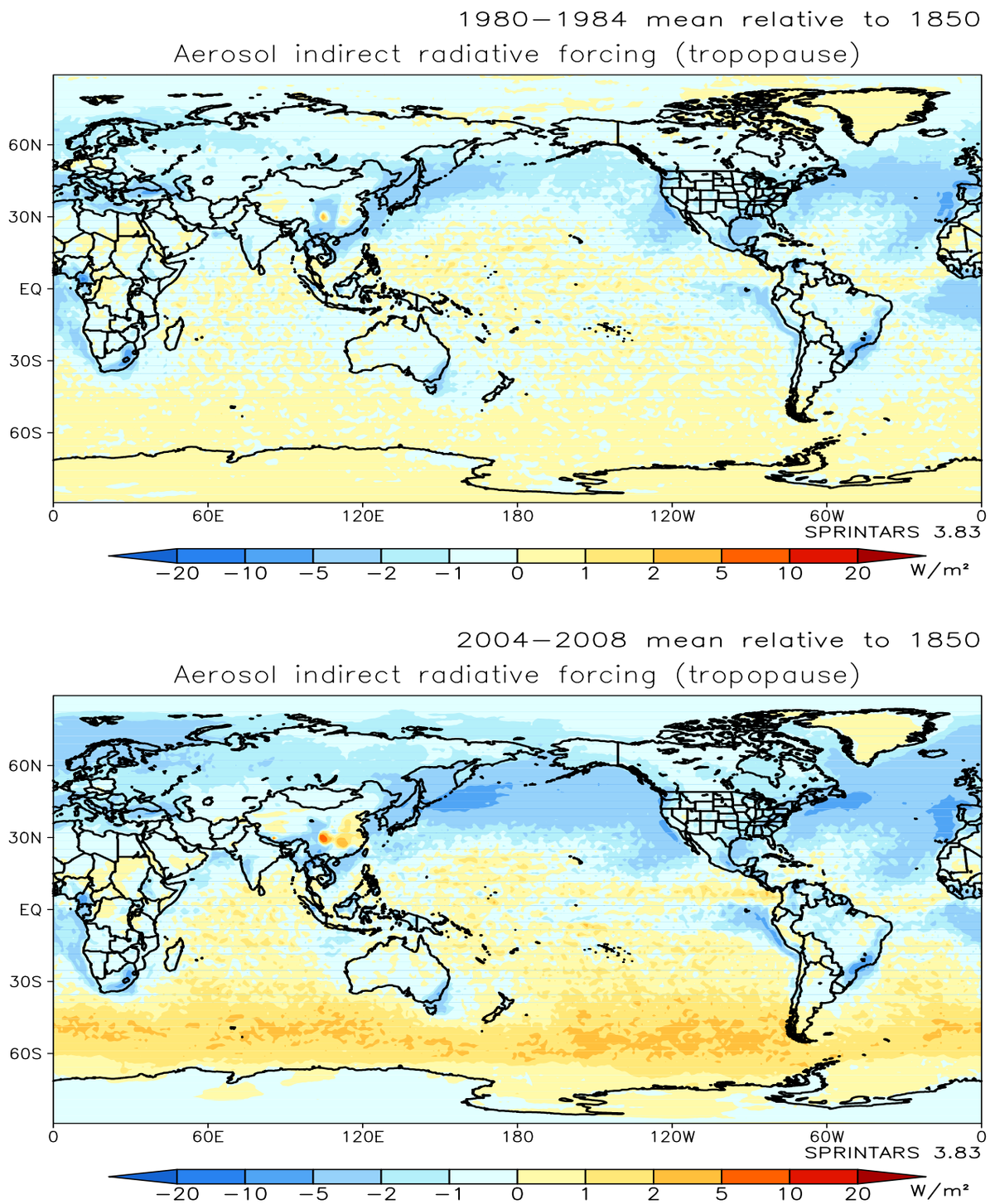

Aerosol data assimilation with SPRINTARS

observation

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MODIS
(AOT, size)

AERONET
(AOT, size)

CALIOP
(vertical extinction)

OMI, MISR,
PARASOL, etc.

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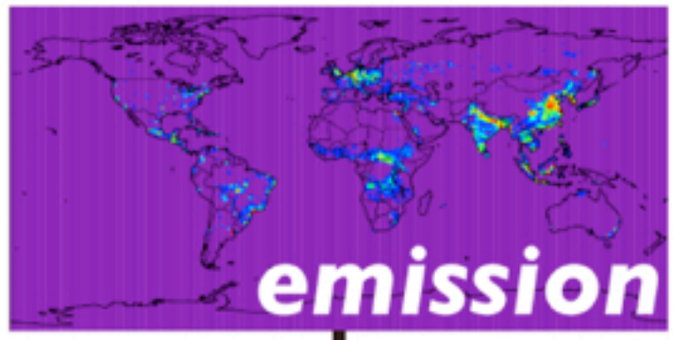
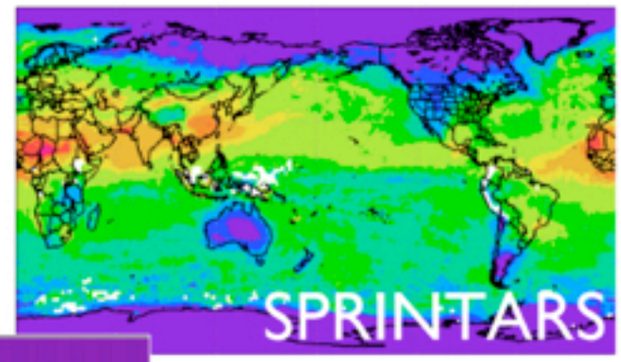
4D-VAR
EnKF

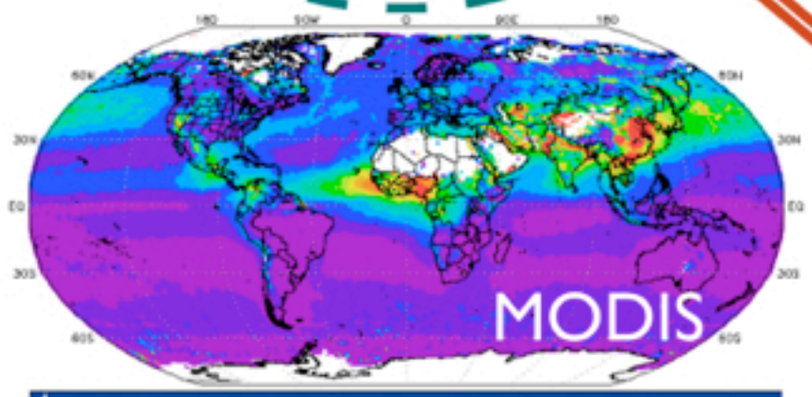
<check>

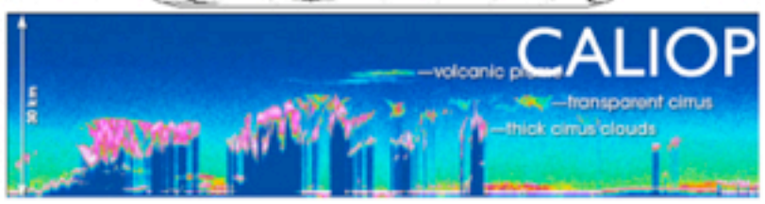
<comparison>

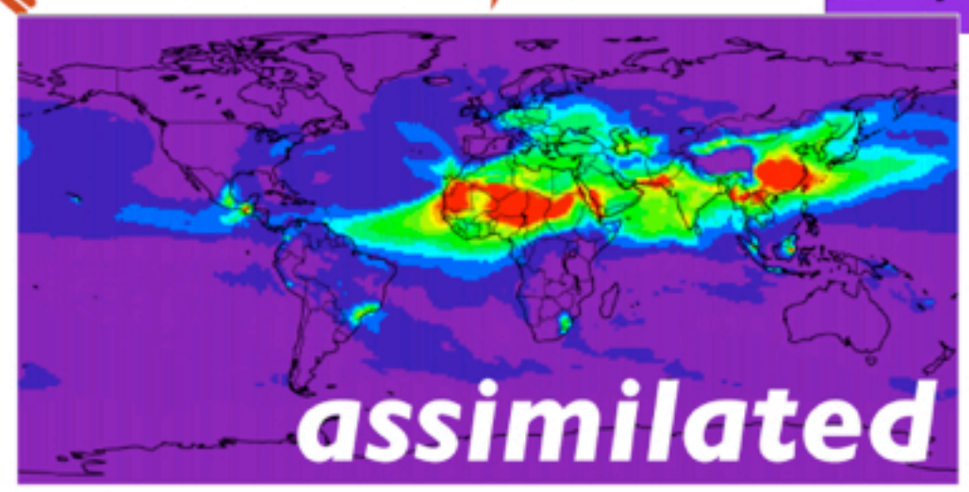


Aerosol climate model
SPRINTARS

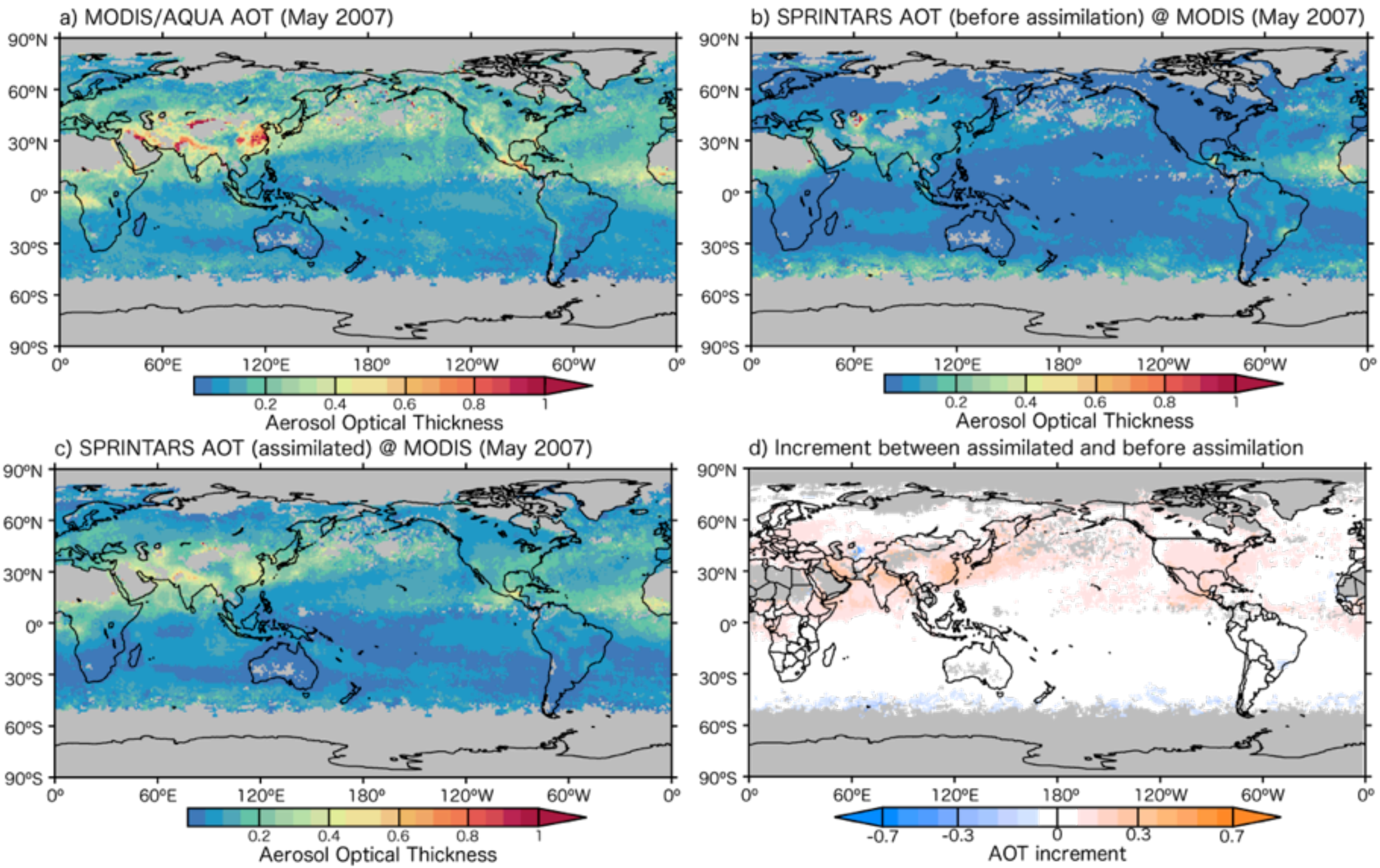








LETKF assimilation in SPRINTARS with MODIS



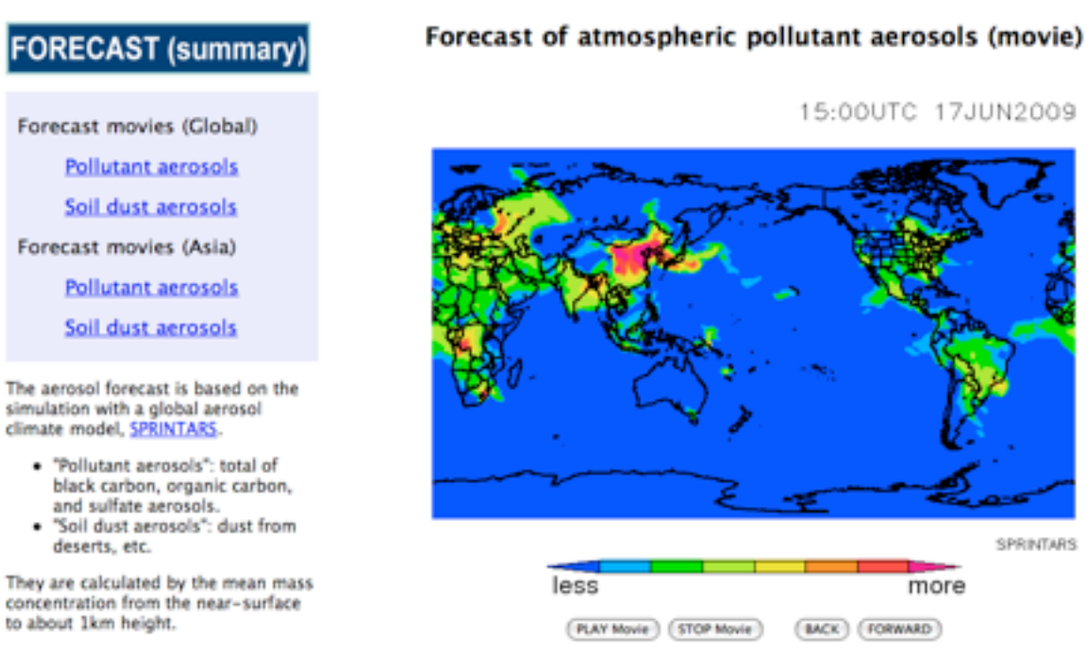
Yumimoto, Eguchi, and Takemura (2009)

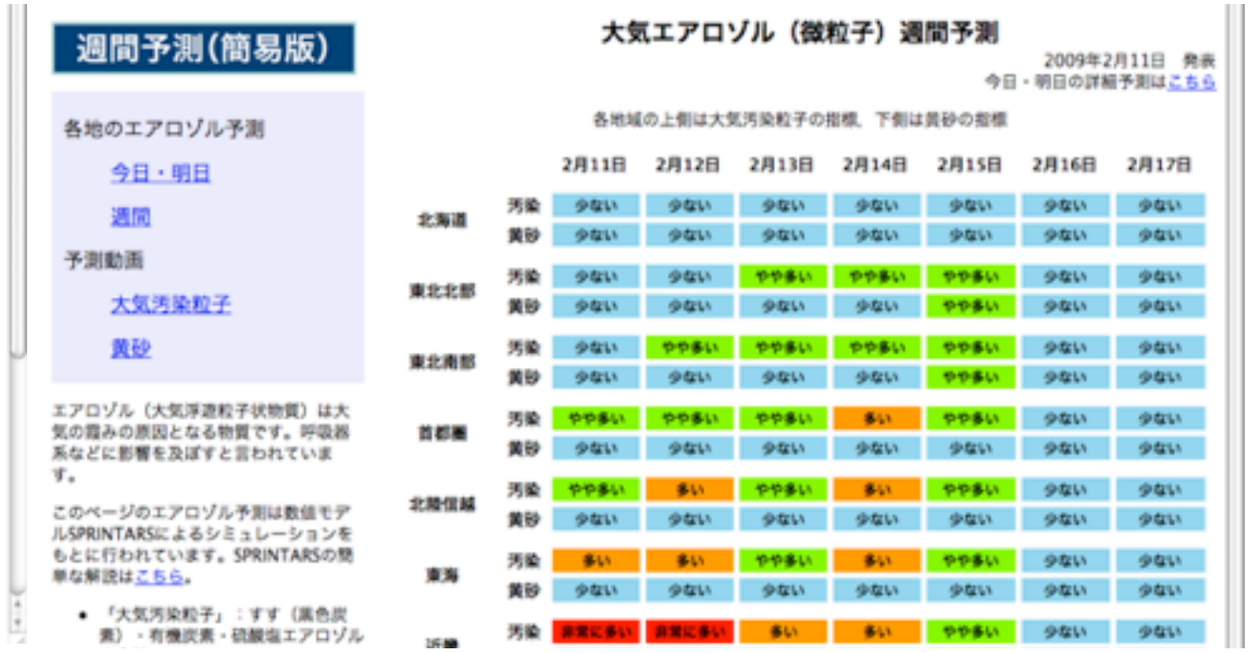
SPRINTARS homepage

SPRINTARS
(Spectral Radiation-Transport Model for Aerosol Species)

http://sprintars.net/

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





Acknowledgments

- CCSR/NIES/FRCGC GCM group
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