SPRINTARS
(Spectral Radiation-Transport Model for Aerosol Species)

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Difference in the aerosol direct radiative forcing between clear-sky and all-sky conditions with aerosol transport-radiation model

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Outline

- Calculation of the aerosol direct radiative forcing under clear-sky and all-sky conditions with the global aerosol transport-radiation model.
- Test of sensitivities to relative altitudes of aerosol and cloud layers.

Model description

SPRINTARS
(Spectral Radiation-Transport Model for Aerosol Species)

Takemura et al. (JGR, 105, 17853-17873, 2000)
Takemura et al. (J. Climate, 15, 333-352, 2002)
Takemura et al. (JGR, in press, 2004JD005029, 2005)

Coupled with CCSR/NIES/FRCGC AGCM

Tracers: black carbon (BC), organic carbon (OC), sulfate, soil dust, sea salt, SO_2, DMS

Emission

- BC, OC: biomass burning, fossil fuel, biofuel, agricultural activity, terpene
- SO_2: fossil fuel, biomass burning, volcano
- DMS: oceanic phytoplankton, land vegetation
- Soil dust: dependence on 10-m height wind, vegetation, soil moisture, snow amount
- Sea salt: dependence on 10-m height wind

Advection

Flux-Form Semi-Lagrangian (FFSL) method
Arakawa-Schubert cumulus convection

Diffusion

Chemical reaction (sulfur)

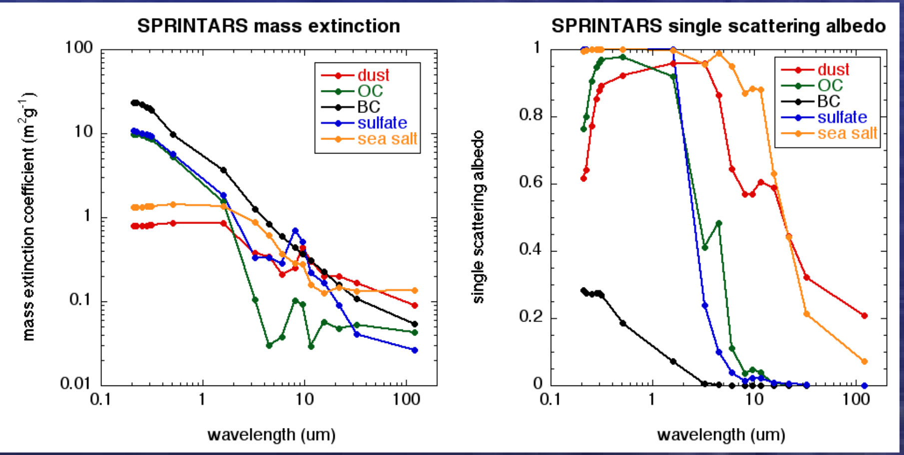
Gas phase: $DMS+OH \rightarrow SO_2$, $SO_2+OH \rightarrow SO_4^{2-}$
Liquid phase: $S(IV)+O_3 \rightarrow SO_4^{2-}$, $S(IV)+H_2O_2 \rightarrow SO_4^{2-}$
»OH, O_3, H_2O_2: CHASER (*Sudo et al. 2002*)

Deposition

Wet deposition (wash out, rain out)
Re-emission by evaporation of rain
Dry deposition
Gravitational settling

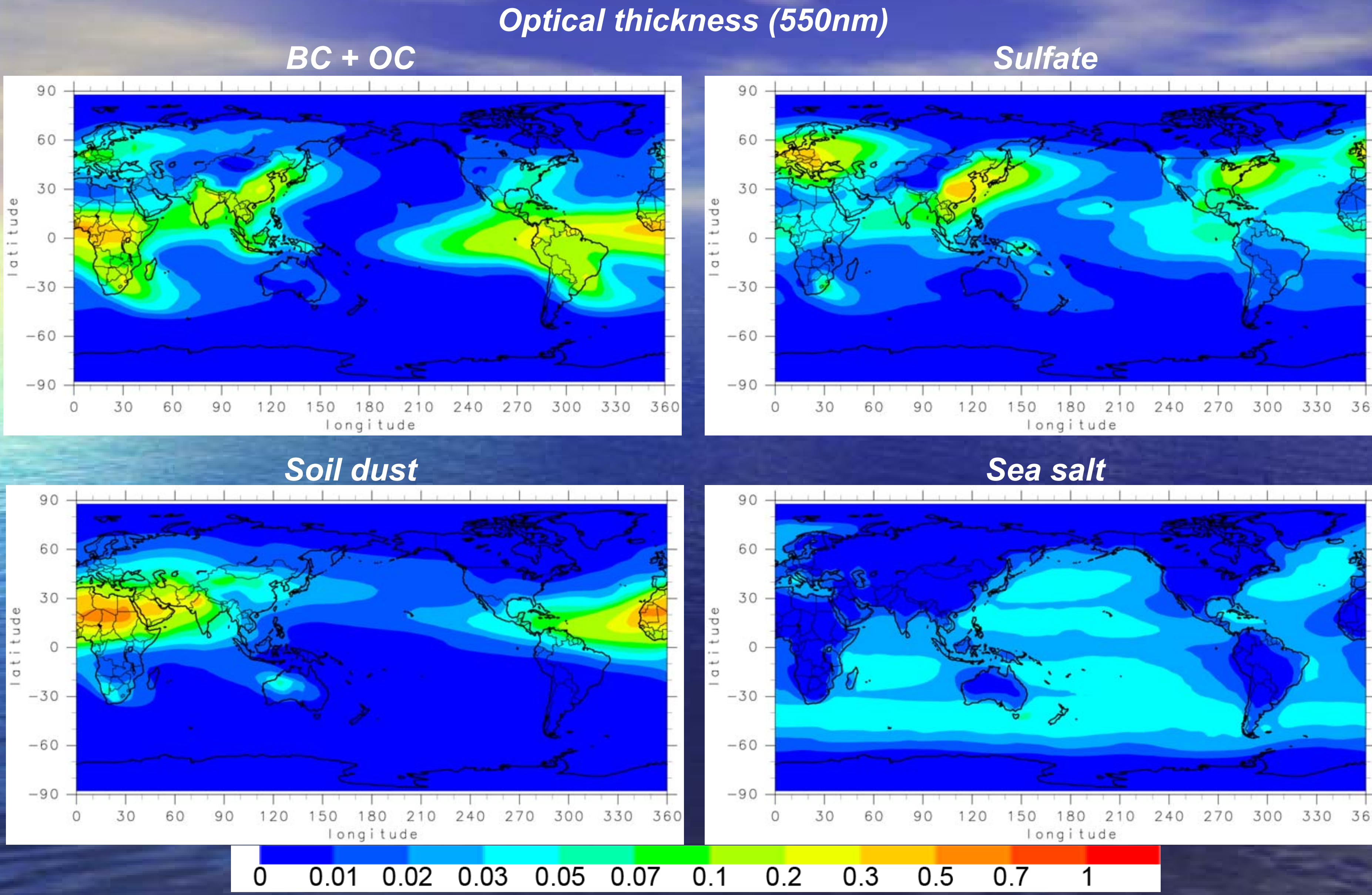
Aerosol direct effect

Distinction of refractive indices, size distributions, and hygroscopic growth among aerosol species.



Wavelength dependences of mass extinction efficiency (left) and single scattering albedo (right) for dry particles of each aerosol species.

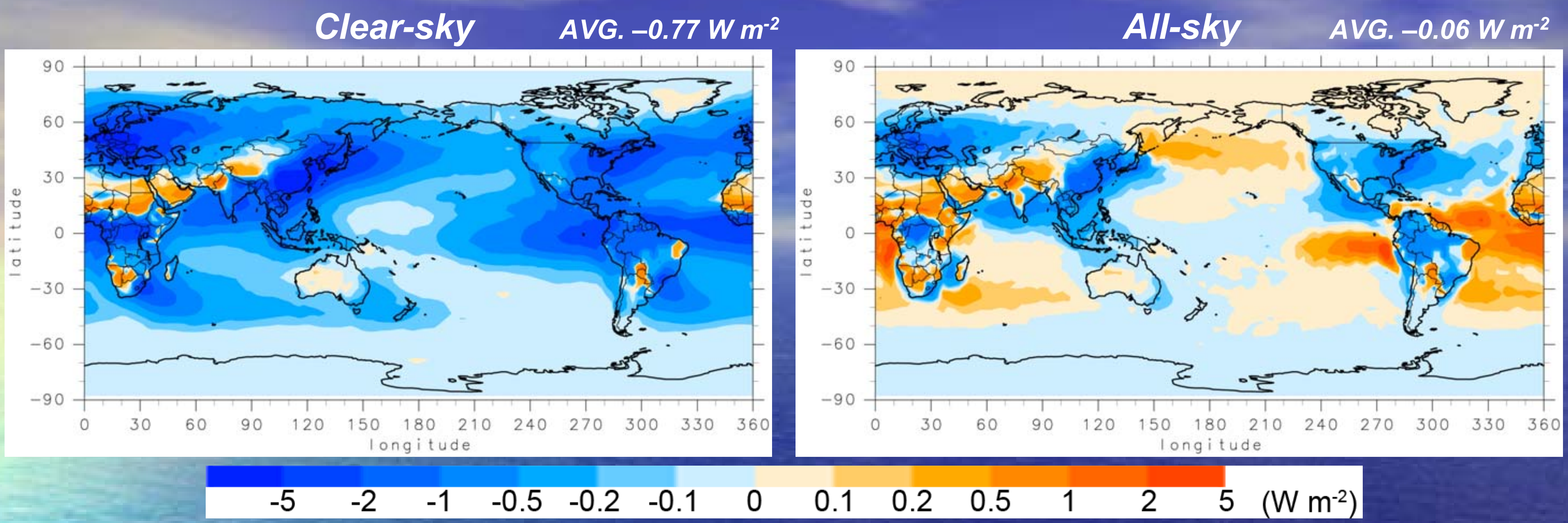
Aerosol optical thickness



Annual mean distributions of the optical thickness at 550 nm for each aerosol component.

Direct radiative forcing

Takemura et al. (JGR, in press, 2004JD005029, 2005)

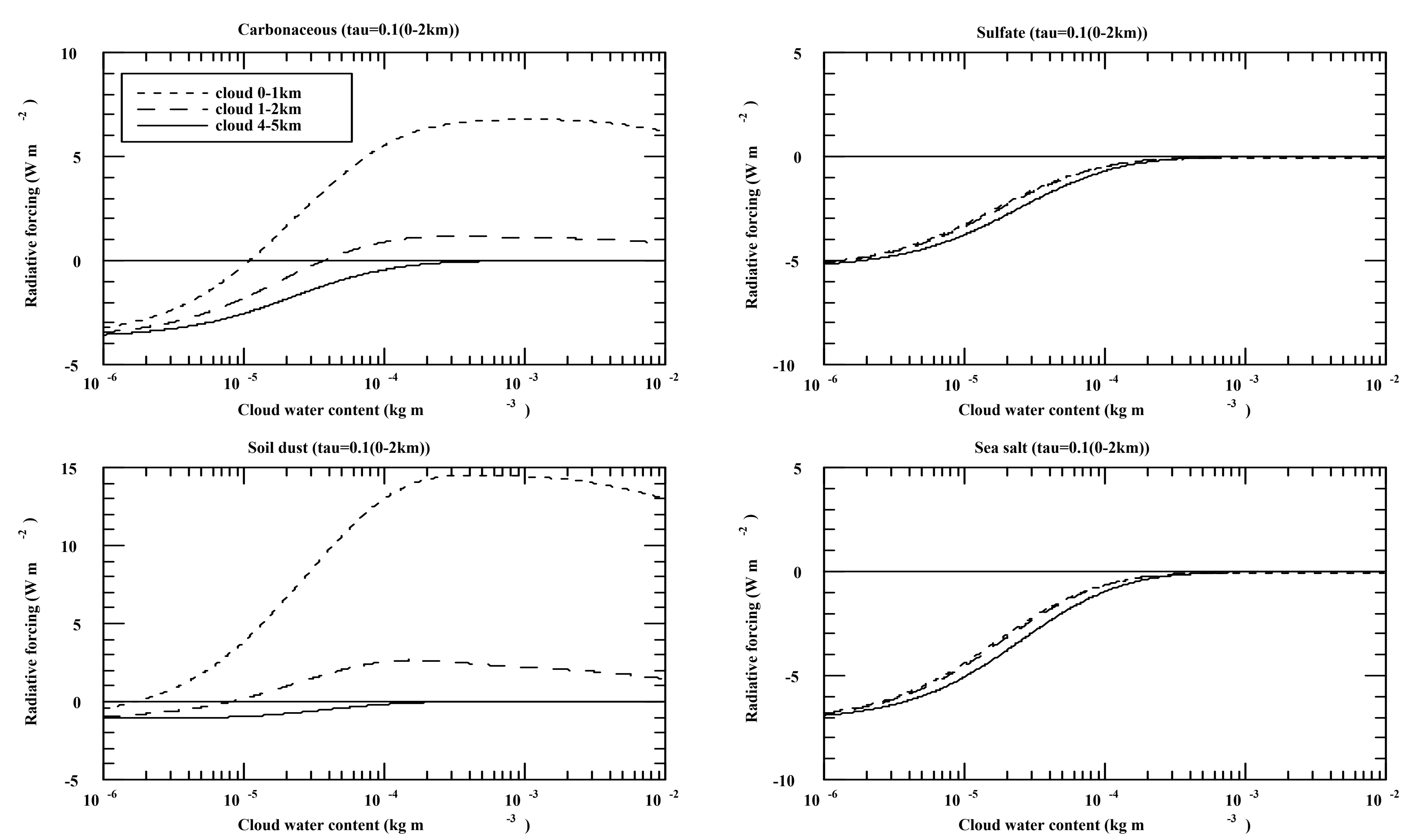


Annual mean distributions of the direct radiative forcing at the tropopause by anthropogenic aerosols under clear- and all-sky conditions.

	Tropopause ($W\ m^{-2}$)		Surface ($W\ m^{-2}$)	
	All-sky	Clear-sky	All-sky	Clear-sky
BC	+0.42	+0.26	–0.76	–0.94
OC	–0.27	–0.51	–0.36	–0.57
Sulfate	–0.21	–0.52	–0.16	–0.41
Total	–0.06	–0.72	–1.28	–1.92

Annual global mean direct radiative forcing from pre-industrial to present days at the tropopause and surface under all- and clear-sky conditions in $W\ m^{-2}$.

Sensitivity of direct radiative forcing to cloud



Direct radiative forcing of each aerosol component as a function of the cloud water content and the cloud layer height assuming homogeneous aerosol optical thickness of 0.1 between 0 and 2 km height. A surface albedo of 0.07 and a cosine of solar zenith angle of 0.5 are assumed (*Takemura et al., J. Climate, 15, 333-352, 2002*).