Climate change and impacts due to aerosol effects in Asian region based on modeling studies

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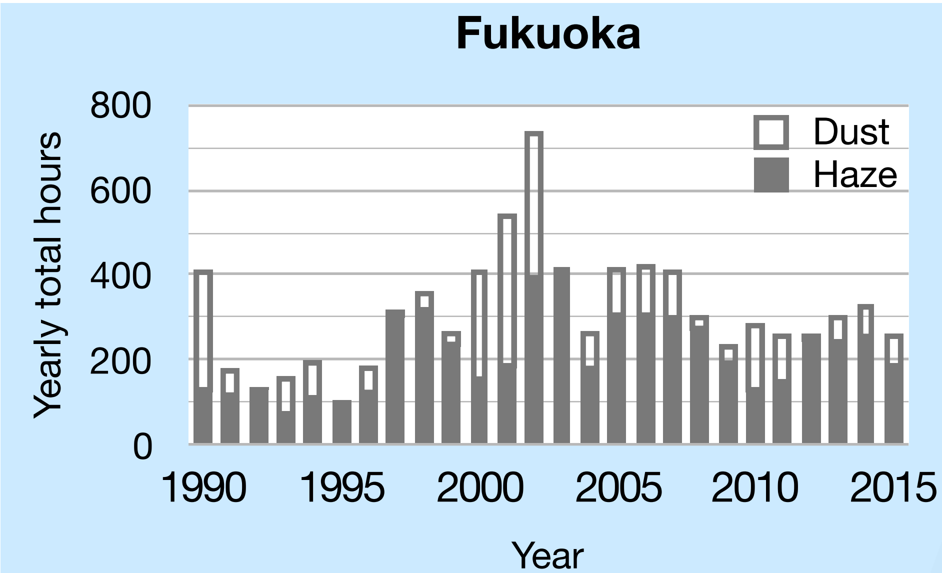
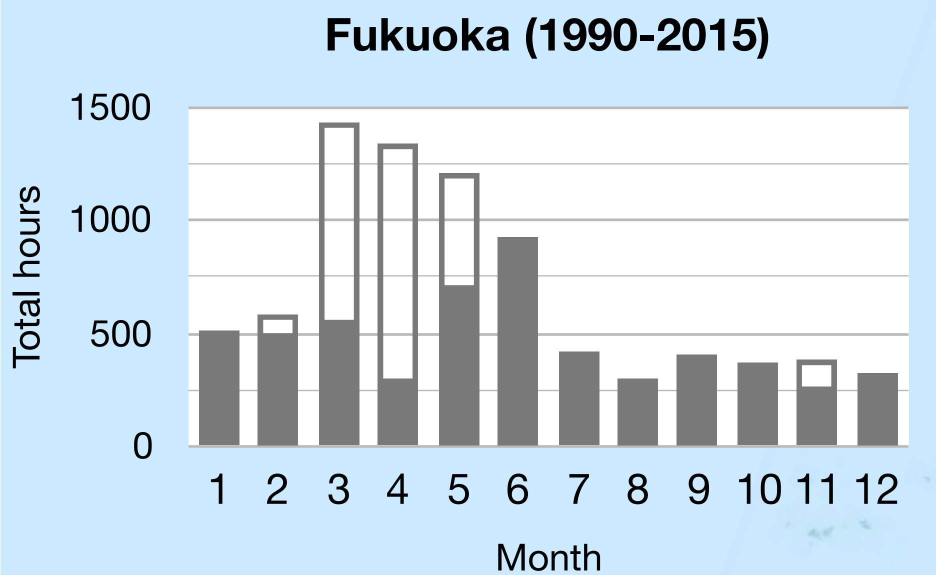
Contents

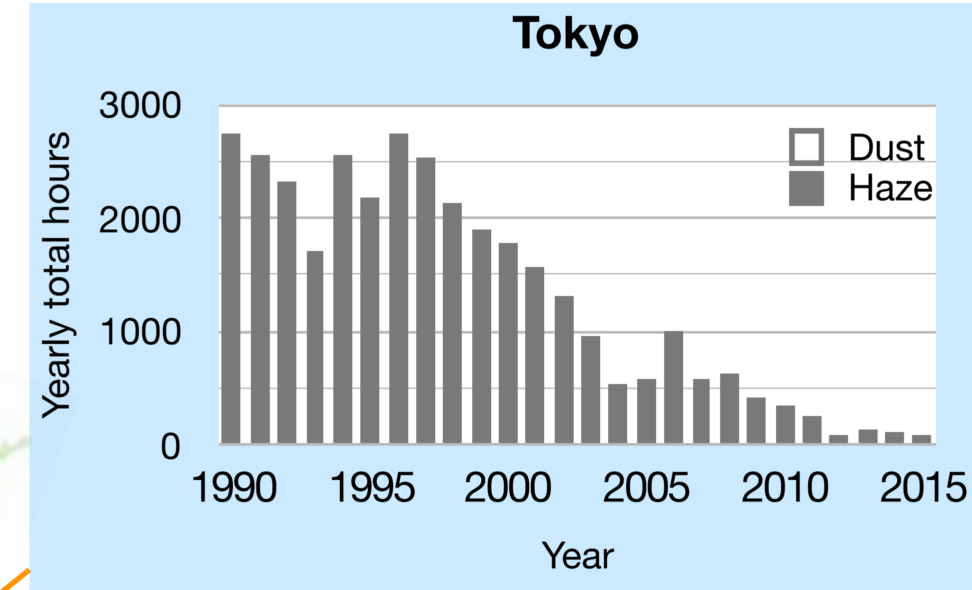
- Recent Japanese haze conditions and aerosol forecasting system.
- Sensitivity assessment of climate change by aerosols to changing aerosol-related emissions with a coupled-ocean global aerosol climate model.

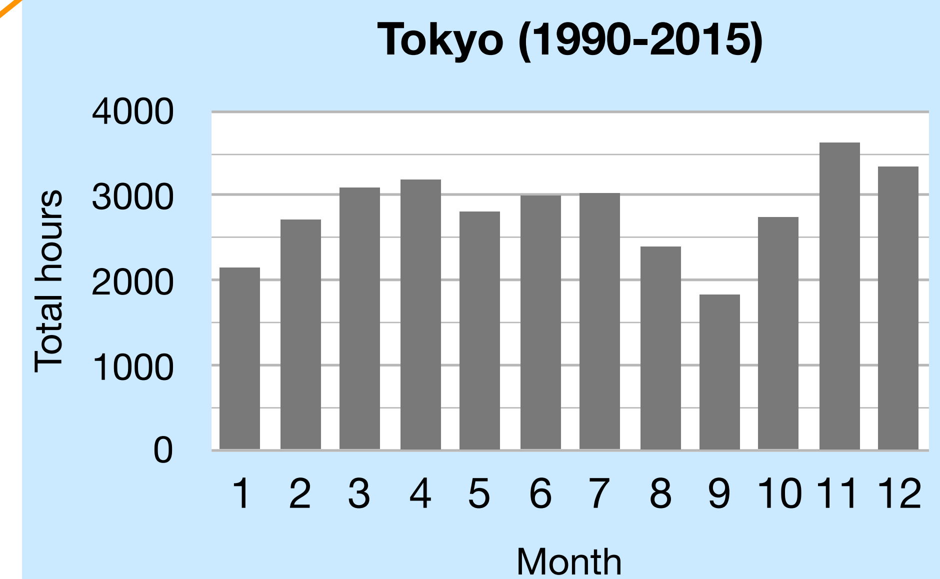
Recent haze and Asian dust in Japan

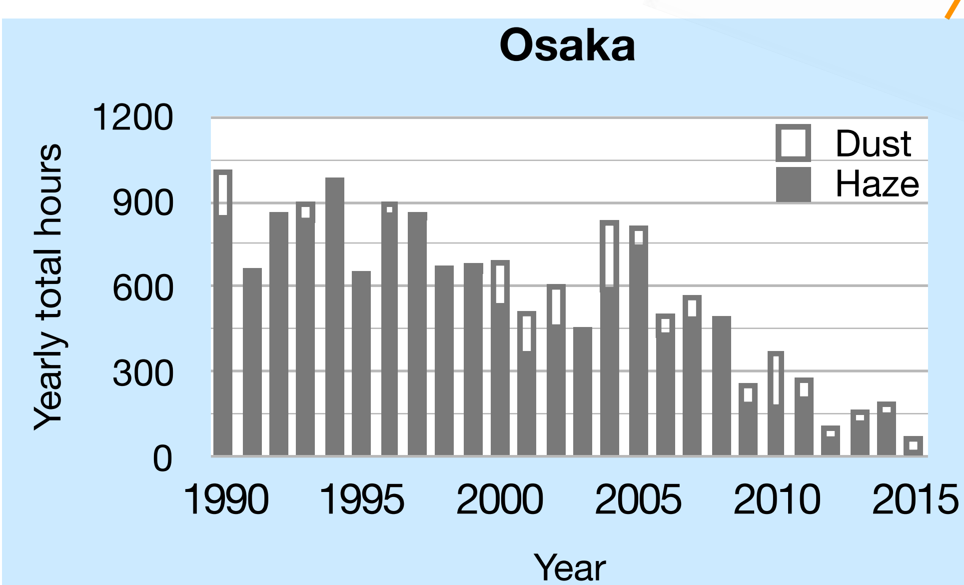
Haze
Visibility less than 10km under the relative humidity less than 75%

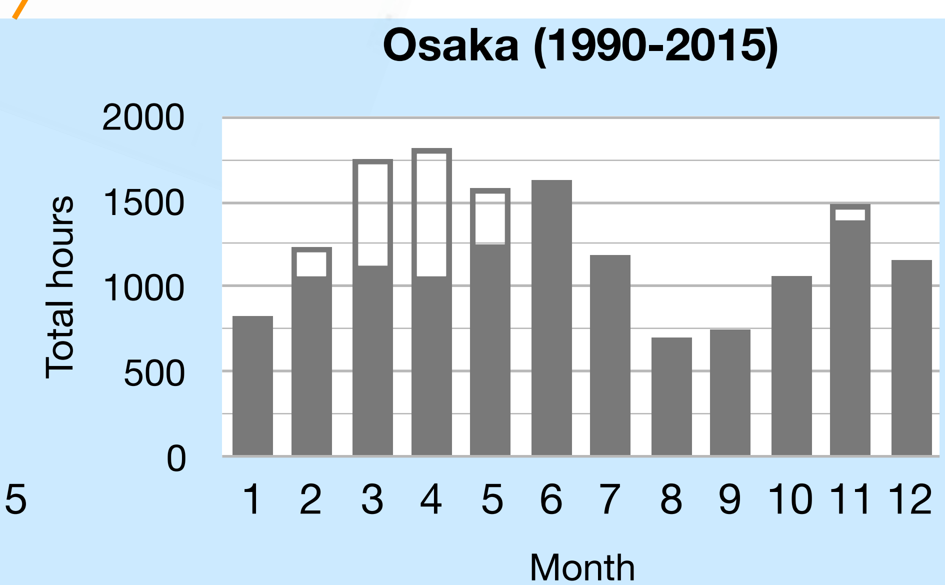












Observed by Japan Meteorological Agency
As of December 31, 2015
(Based on Yamaguchi and Takemura, 2011)

Forecast system for PM2.5 and dust with SPRINTARS

SPRINTARS

Spectral Radiation-Transport Model for Aerosol Species

ホーム　週間予測（一般）　週間予測（専門）　アーカイブ　研究室ホーム

English

毎日午前5時頃更新予定

各地の予測
- 今日・明日
- 週間

予測動画

PM2.5
- 東アジア
- アジア広域

黄砂
- 東アジア
- アジア広域

アジア予測(在留邦人向け)
- 今日・明日
- 週間

このページのPM2.5予測・黄砂予測は数値モデル SPRINTARS を使用したシミュレーションにより行われています。

PM2.5は地表付近の濃度，黄砂は地表付近から高度約200mまでの平均質量濃度を表示しています。シミュレーションは水平方向約35km格子で行われているため，それ以下のエアロゾル濃度の変動は予測されていません。各地方全般の高濃度や他の地方・国からの越境汚染が予測されています。

携帯電話用URLをメール送信する

PM2.5予測・黄砂予測

2016年2月27日　発表

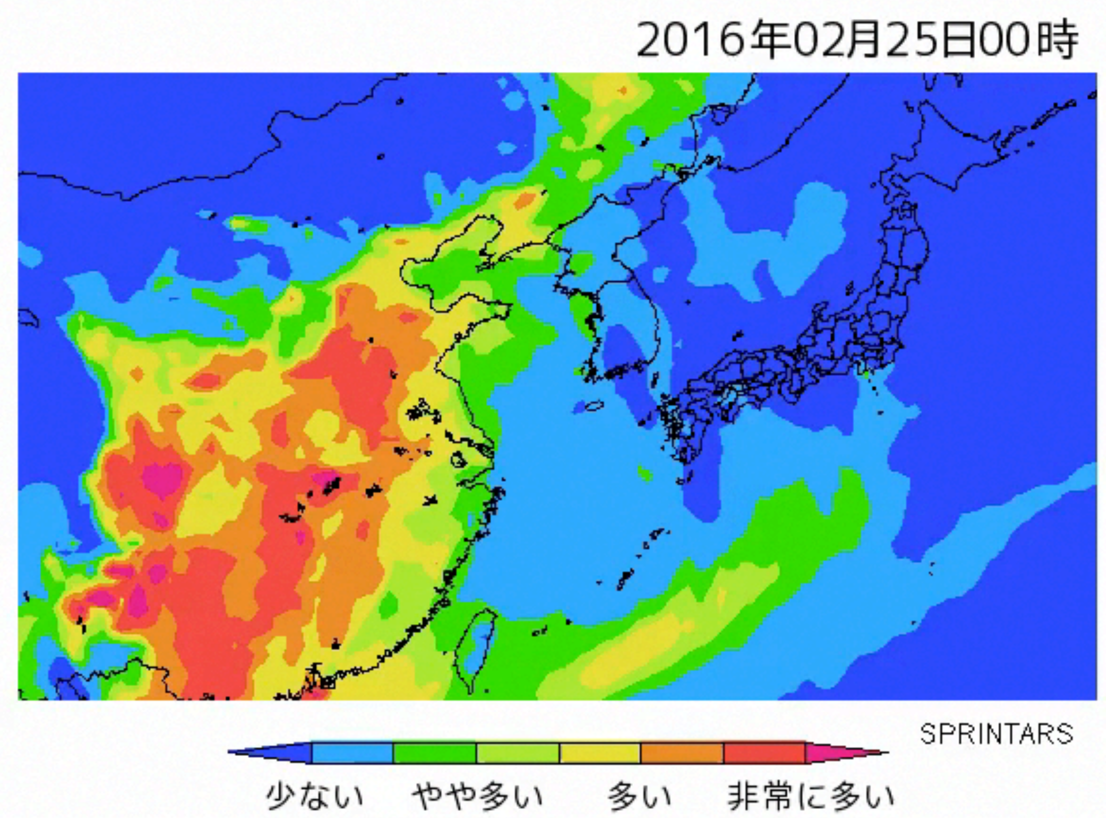
週間予測はこちら

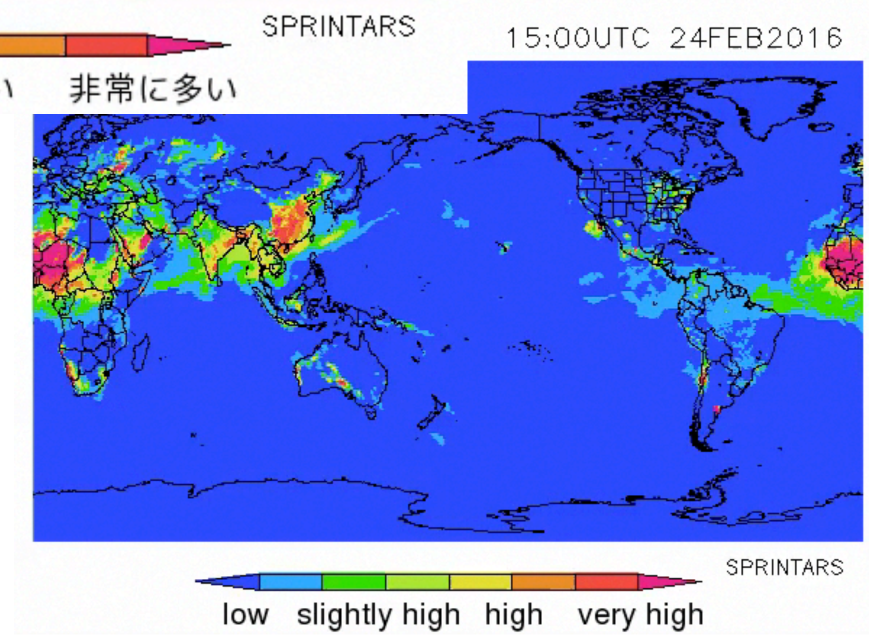
		今日（2月27日）			明日（2月28日）			
	時間帯（時）	6-12	12-18	18-24	0-6	6-12	12-18	18-24
北海道	PM2.5	少ない	少ない	少ない	少ない	少ない	少ない	少ない
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
東北北部	PM2.5	少ない	少ない	少ない	少ない	少ない	少ない	少ない
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
東北南部	PM2.5	少ない	やや多い	やや多い	やや多い	少ない	少ない	やや多い
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
首都圏	PM2.5	やや多い	多い	多い	多い	やや多い	やや多い	多い
	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	PM2.5	多い	多い	多い	多い	やや多い	やや多い	多い
	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	PM2.5	多い	多い	多い	多い	多い	多い	やや多い
	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	PM2.5	多い	多い	多い	多い	多い	多い	やや多い
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
中国	PM2.5	多い	多い	多い	非常に多い	非常に多い	多い	やや多い
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
四国	PM2.5	多い	多い	多い	多い	多い	多い	やや多い
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
九州北部	PM2.5	多い	多い	多い	やや多い	多い	やや多い	多い
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
九州南部	PM2.5	やや多い	やや多い	やや多い	多い	多い	やや多い	やや多い
	黄砂	少ない	少ない	少ない	少ない	少ない	少ない	少ない
沖縄	PM2.5	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
	時間帯（時）	6-12	12-18	18-24	0-6	6-12	12-18	18-24
		今日（2月27日）			明日（2月28日）			

PM2.5予測・黄砂予測トップページへ

非常に多い	注意喚起レベル	多い	日本の環境基準値程度
やや多い	大気が少し霞む程度	少ない	清浄

http://sprintars.net/forecastj.html





Volunteer-based unfunded operation everyday like AeroCom!

- 7-day forecast for levels of PM2.5 and dust in each Japanese prefecture.
- Movies of various aerosol parameters for East Asia, whole Asia, and global.

Reproduced by TV/radio programs, newspapers, local governments, web sites, and apps.

S-12 Project under Ministry of Environment, Japan

S-12 Project (FY2014–2018)

"Active evaluation of SLCP impacts and seeking the optimal pathway"

Theme 1

Theme 2

Theme 3
"Assessment of climate and environmental impacts by SLCPs with numerical models"

Theme 4, 5

Objective of S-12-3

Quantitative assessment of effects of SLCPs on climate, hydrological cycle, health, and agriculture with climate-air quality coupled models.
➡ Contribution to scientific bases for suitable reductions of SLCPs/WMGHGs.

Emission inventories and scenarios [Themes 1 & 2]

Suitable reduction path [Theme 4, 5]

Theme 3

Assessment of SLCPs effects on climate with climate-aerosol-chemistry models (SPRINTARS/CHASER)
[Sub-themes 1 & 2]

Assessment of changes in hydrological cycles by SLCPs with climate models
[Sub-themes 5 & 6]

Assessment of impacts on health and agriculture by SLCPs
[sub-themes 3 & 4]

Model description of SPRINTARS

Met. condition

on/off

MIROC

Atmosphere-Ocean GCM

SPRINTARS

(Spectral Radiation-Transport Model for Aerosol Species)

http://sprintars.net/

Tracers

black carbon, organic matter, sulfate, soil dust, sea salt, SO_2, DMS

Aerosol transport processes

emission, advection, diffusion, sulfur chemistry, deposition

Aerosol optical properties

Aerosol climate effects

aerosol–radiation interaction
aerosol–cloud interaction

Resolution

T319/T213/T106/T85/T42; L56c/L40h/L20c

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

Transport Processes

Emission

- BC, OM: biomass burning, fossil fuel, biofuel, agricultural activities, oceanic OM, terpene/isoprene 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

Chemistry

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

Deposition

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

Model description of SPRINTARS

Met. condition

↓ on/off

MIROC

Atmosphere-Ocean GCM

↕

SPRINTARS

(Spectral Radiation-Transport Model for Aerosol Species)

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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

▸ Aerosol–radiation interaction (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.

▸ Aerosol–cloud interaction (indirect effect)

- coupled with radiation and cloud/precipitation processes in GCM.
- prognostic number concentrations of cloud droplet N_l and ice crystal 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.**

PDRMIP experiments

Precipitation Driver and Response Model Intercomparison Project

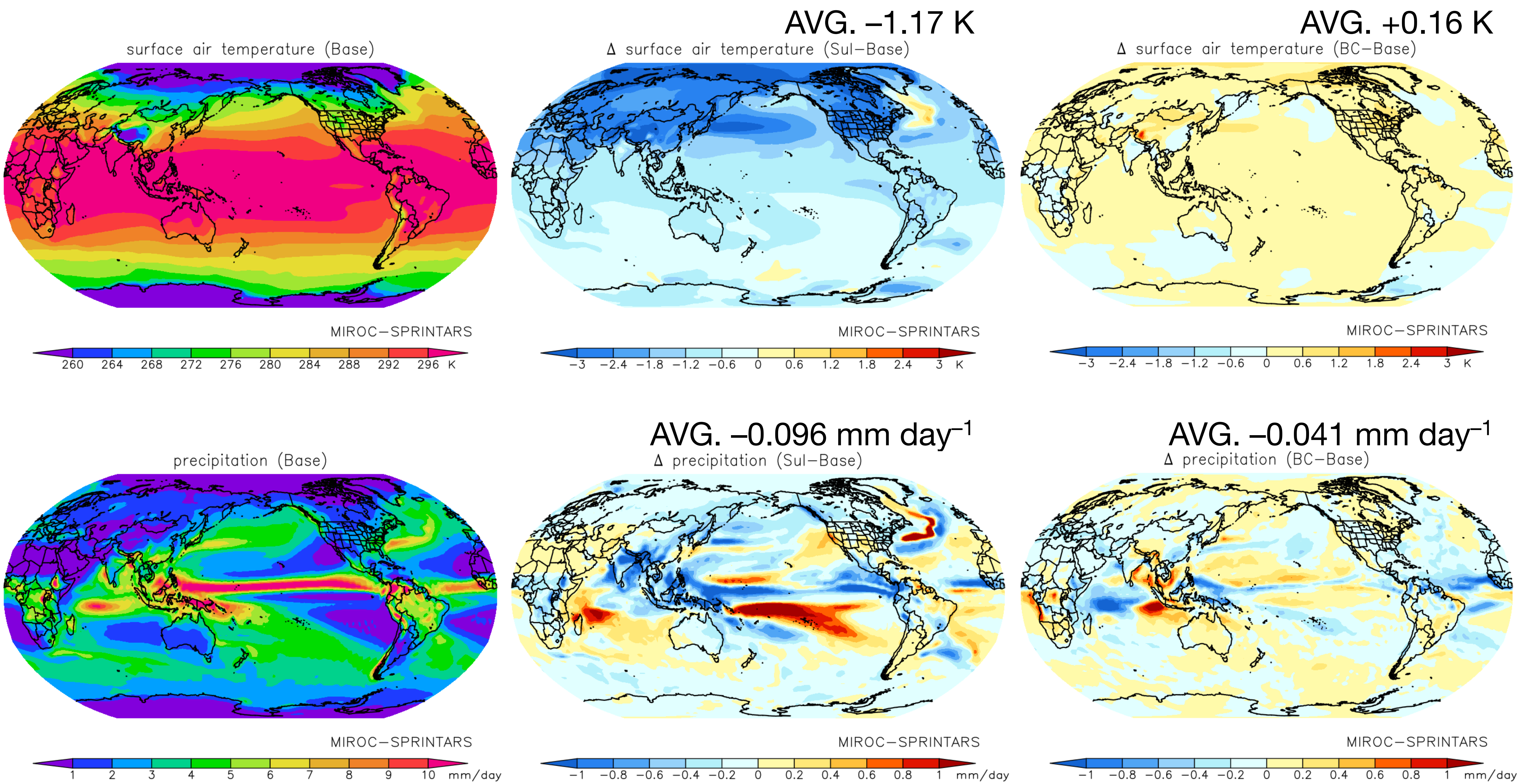
http://cicero.uio.no/en/pdrmip/

PDRMIP compares the precipitation response to various climate drivers across models. Planned analyses include a better understanding of the drivers' importance for inter-model differences in precipitation changes, energy budget analysis and extremes related to precipitation.

Core experiments	fixed SST: 15yr slab/full ocean: 100yr
Base	Specified present day CO_2, CH_4, solar constant, aerosol concentration
CO_2x2	CO_2 concentration from PDC to 2xPDC * PDC: present-day
CH_4x3	CH_4 concentration from PDC to 3xPDC
Solar	Solar constant increased by 2%
Sul	Sulphate concentration/emission from PDC to 5xPDC
BC	BC concentration/emission from PDC to 10xPDC

Additional experiments	fixed SST: 15yr slab/full ocean: 100yr
Sulred	Sulfate concentration from PDC to PIC * PIC: pre-industrial
Suleur	Sul multiplied by 10, Europe only
Sulasia	Sul multiplied by 10, Asia only
BCasia	As BC, but Asia only
Sulasired	As Sulred, but Asia only
O_3asia	Add O_3, Asia only, comparable forcing to Sulasia

Δ Temperature and precipitation by MIROC in PDRMIP



Annual mean surface air temperature (top) and precipitation (bottom) in the PDRMIP Base experiment (left) and its equilibrium change under 5xSO_2 (middle) and 10xBC (right) emissions by a coupled-ocean general circulation model MIROC.

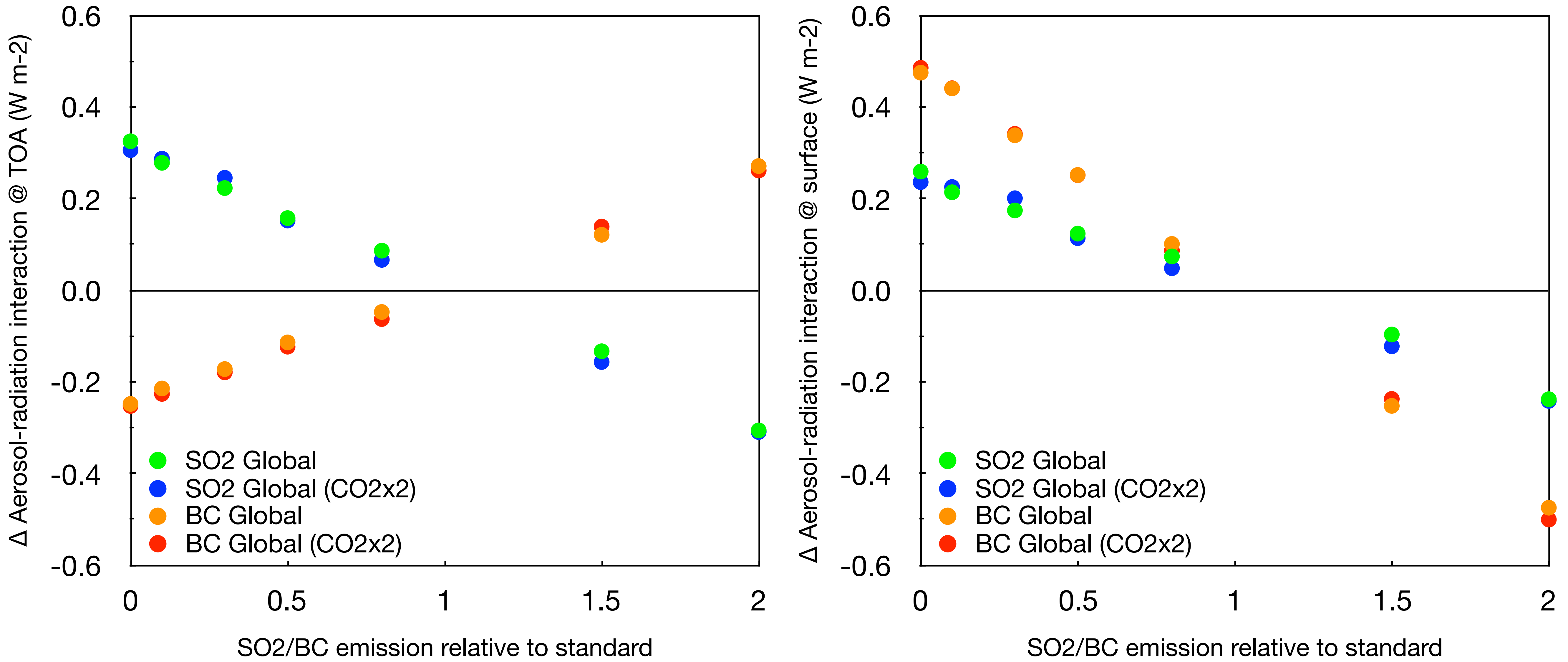
Extended PDRMIP-type experiments in S-12

PDRMIP Core experiments (shown only aerosol-related)	fixed SST: 15yr	slab/full ocean: 100yr * PDC: present-day
Sul	Sulphate concentration (or related emissions) from PDC to 5 x PDC	
BC	BC concentration (or emission) from PDC to 10 x PDC	

Extended experiments	fixed SST: 15yr	slab/full ocean: 100yr
Sulx, BCx****	SO_2 or BC emissions from PDC to 0, 0.1, 0.3, 0.5, 0.8, 1.5, 2, 5, 10 x PDC under 1 x CO_2 and 2 x CO_2	

Contribution to scientific bases for suitable reductions path on aerosols with minimum climate change

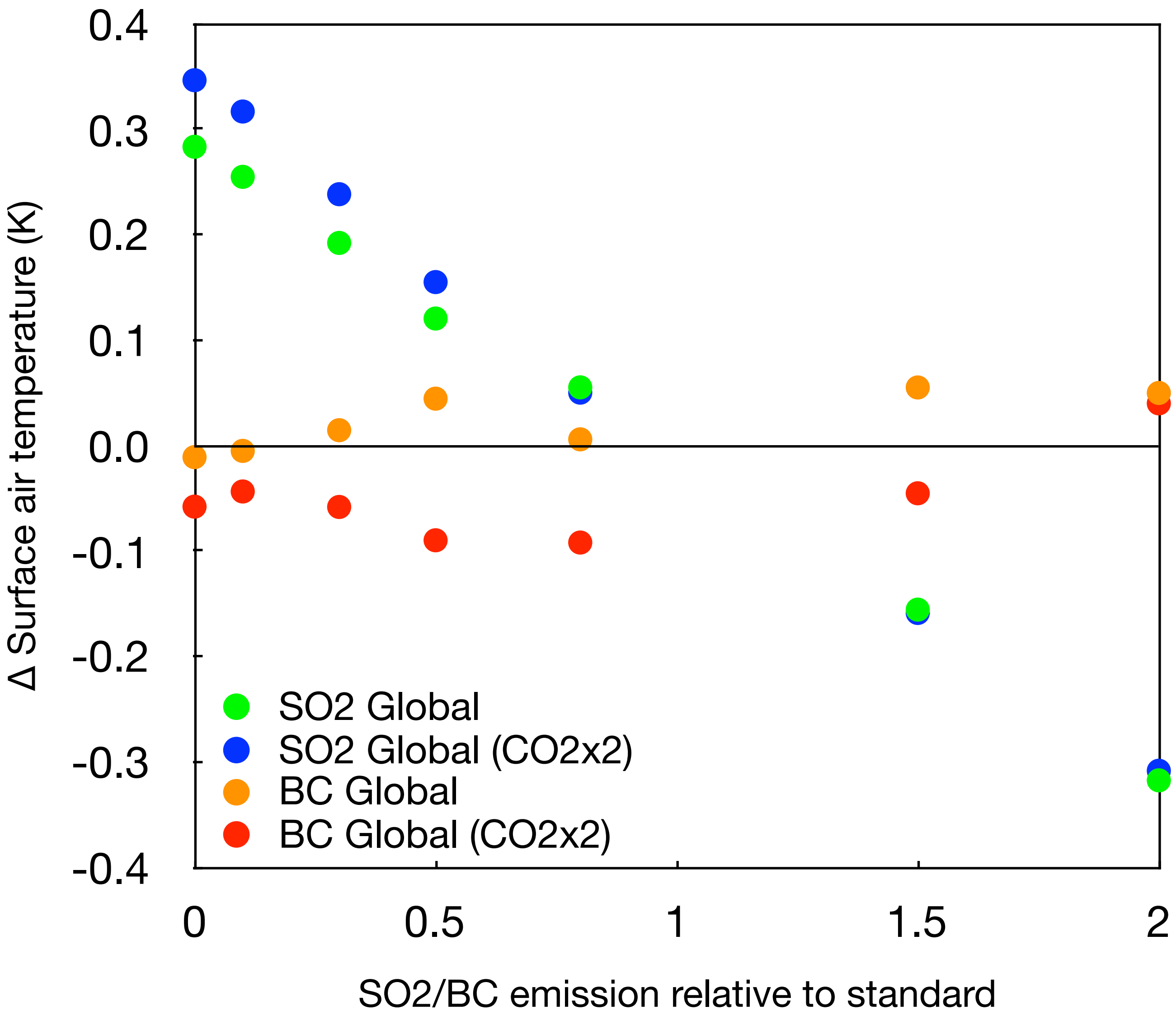
Sensitivities to changing aerosol emissions

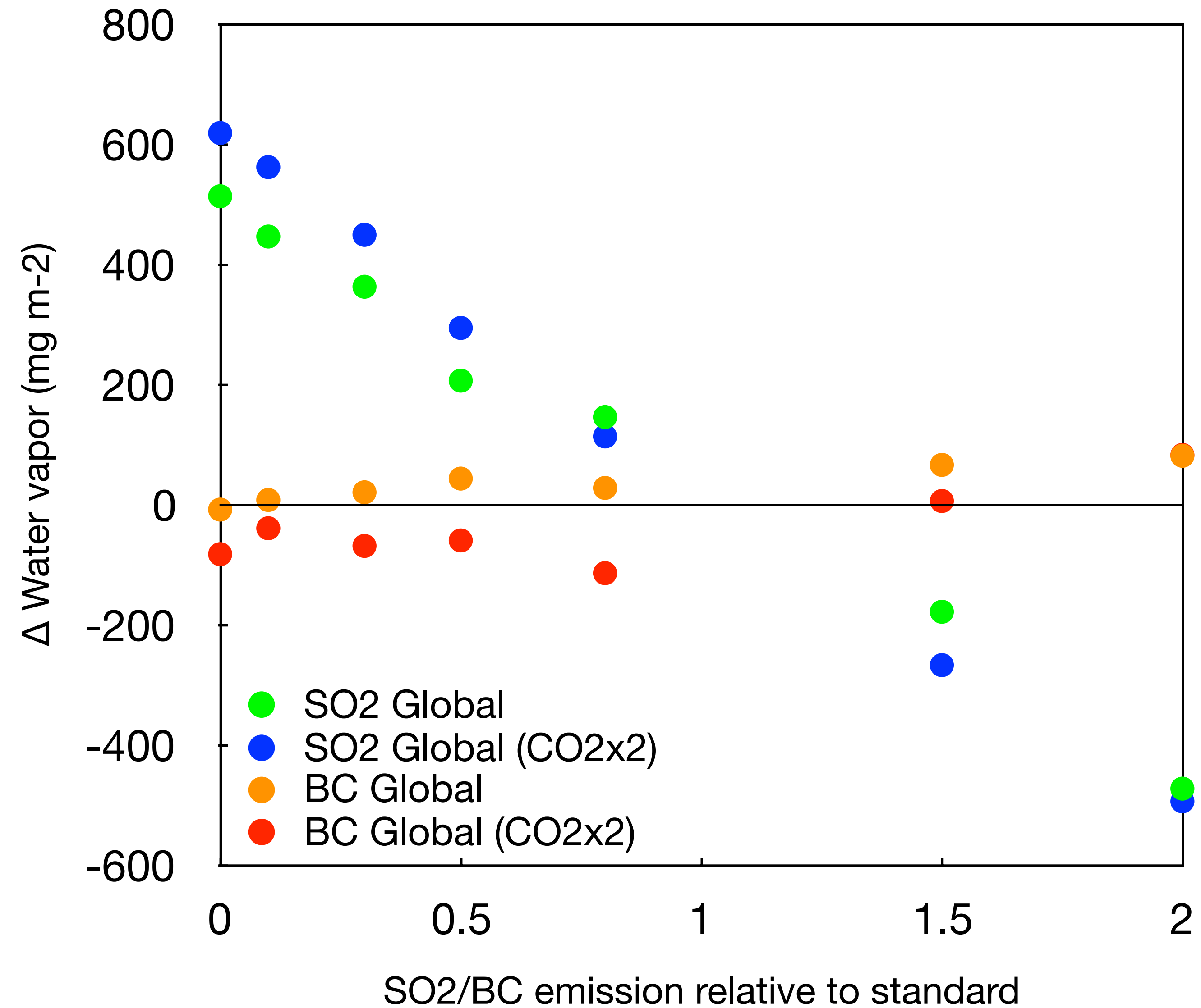


Changes in global mean radiative forcing by the aerosol-radiation interaction due to changes in SO_2 and BC emissions at the (left) TOA and (right) surface.

- Radiative forcing by the aerosol-radiation interaction linearly changes depending on amounts of emissions.

Sensitivities to changing aerosol emissions

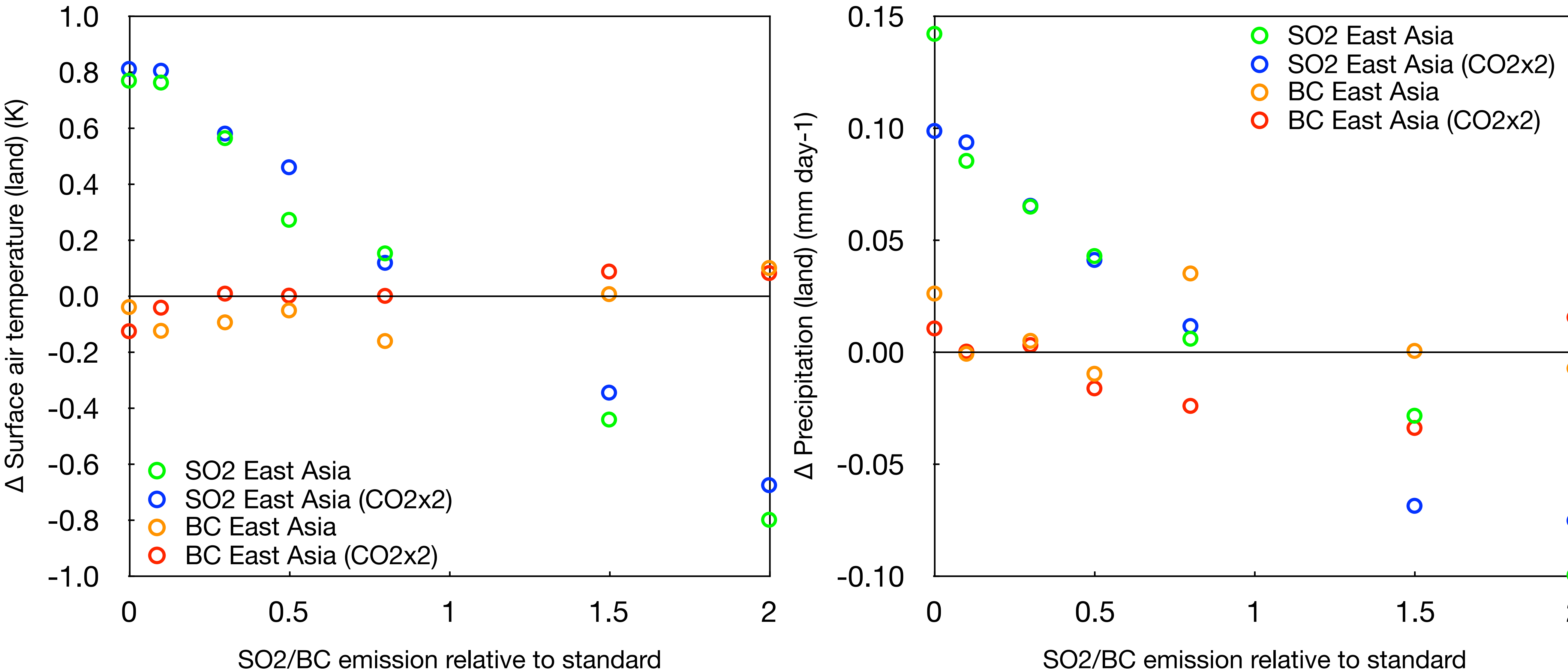




Changes in global mean (left) surface air temperature and (right) column water vapor due to changes in SO_2 and BC emissions.

- Changes in the surface air temperature and precipitation (not shown) have linear trends against SO_2 emissions, while there are not clear trends for changing BC emissions although the radiative forcing by the aerosol-radiation interaction has the linear trend.
- Their trends may strongly depend on a change in water vapor.

Sensitivities to changing aerosol emissions in Asia



Changes in (left) surface air temperature and (right) precipitation in East Asia due to changes in SO_2 and BC emissions.

- Trends of changes in the surface air temperature and precipitation in East Asia are the same as global means, which have linear trends against SO_2 emissions and no clear trends for changing BC emissions.

Summary

- Trends of changes in the surface air temperature and precipitation as well as the radiative forcing of the aerosol-radiation interaction are basically linear to changing SO_2 emissions.
- On the other hand, there are not clear trends of the surface air temperature and precipitation to changing BC emissions, which may depend on the changing in water vapor.

➡ It is an important suggestion for discussion on emission reductions of SLCPs against global warming.

Acknowledgments

- MIROC (AORI/NIES/JAMSTEC GCM) developing group
- NIES supercomputer system (NEC SX-ACE)
- PDRMIP
- Environment Research and Technology Development Fund (S-12-3) of the Ministry of the Environment, Japan
- JSPS KAKENHI (Grant Number: 15H01728 and 15K12190)