How do we identify and recommend forcings datasets for models
example of simple plume aerosols

Stephanie Fiedler

CMIP Forcings Workshop, ECMWF Reading
29 October 2024

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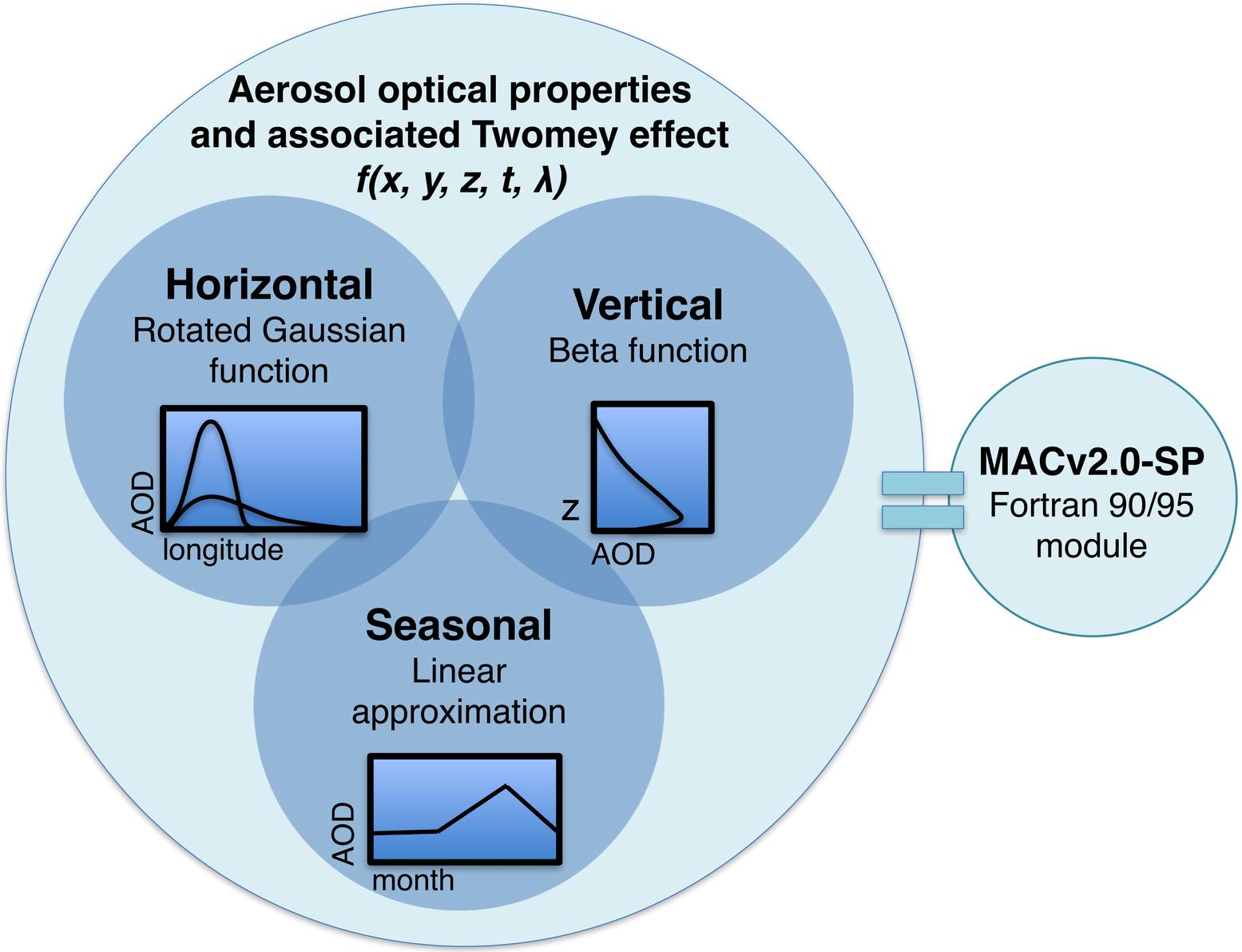
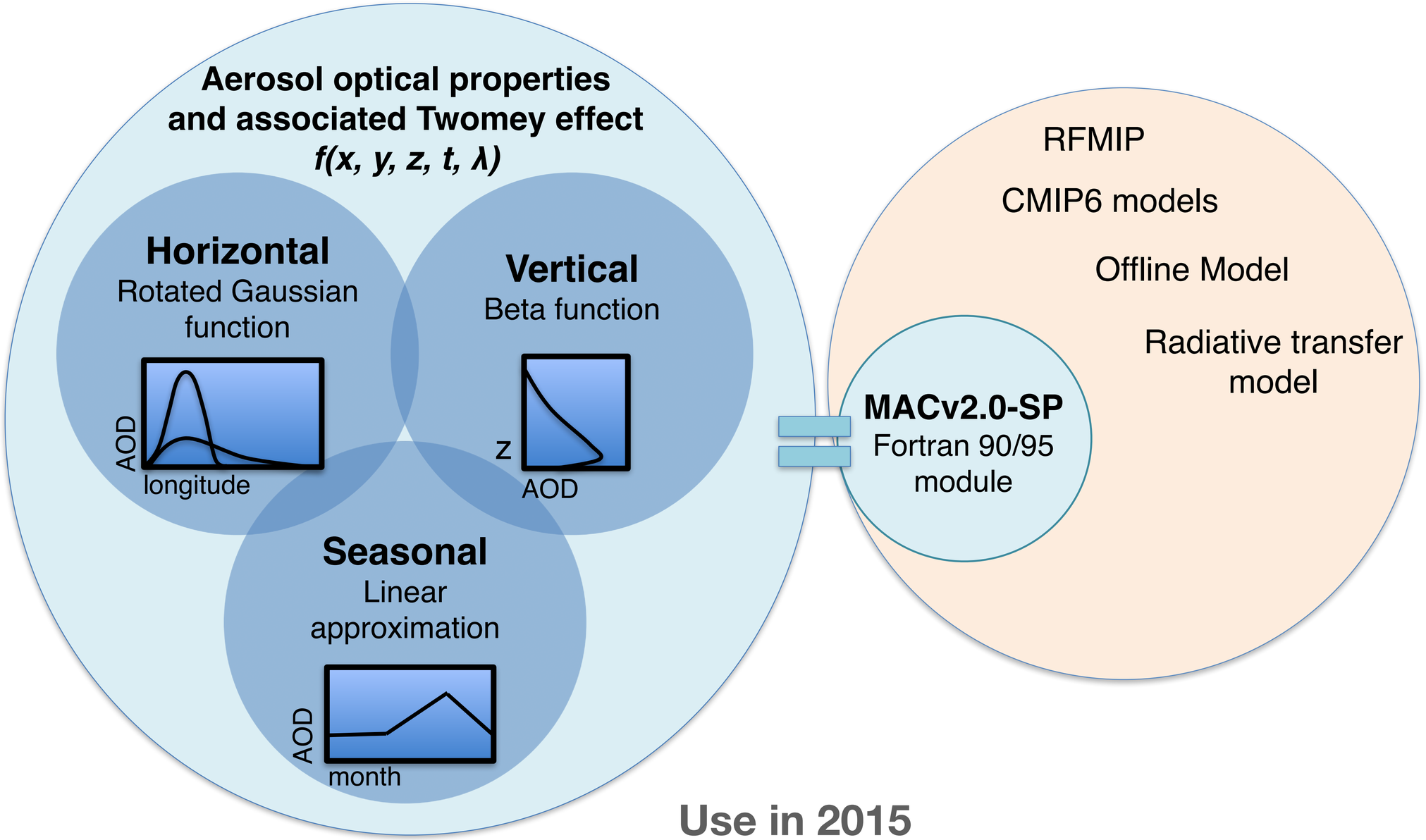
Simple plumes parameterisation



MACv2.0-SP
Fortran 90/95
module

Simple plumes parameterisation

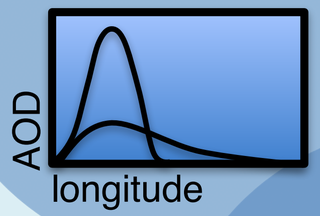


Use in 2015

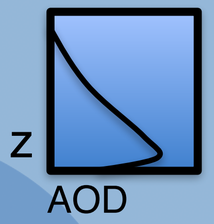
Simple plumes parameterisation

Aerosol optical properties and associated Twomey effect
f(x, y, z, t, λ)

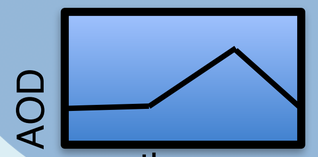
Horizontal
Rotated Gaussian function



Vertical
Beta function



Seasonal
Linear approximation



MACv2.0-SP
Fortran 90/95 module

RFMIP

CMIP6 models

Offline Model

Radiative transfer model

Standard in some global climate model

Regional climate model

Use in 2019

CMIP6 historical data from Stevens et al. (2017)
CMIP6 Scenario data from Fiedler et al. (2019)

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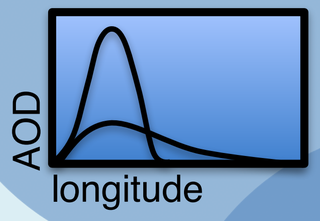

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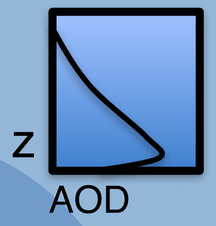

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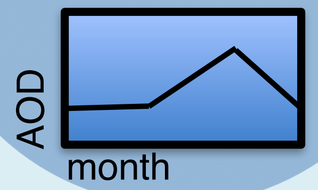

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CovidMIP

RFMIP

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Regional climate model

Satellite retrieval for radiation fluxes

Climate predictions

Request for CMIP7 forcing data

Request for time scales beyond CMIP

. . .

Use in 2024

CovidMIP Scenario data from Fiedler et al. (2021)
CMIP7 data in prep.

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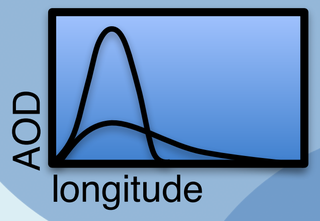

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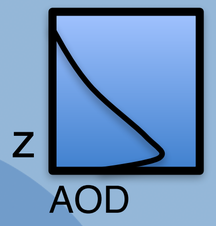

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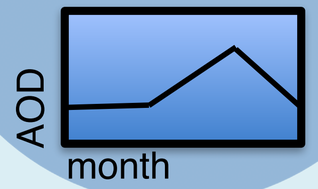

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Desert-dust plumes

Use in 2024

CovidMIP Scenario data from Fiedler et al. (2021)
CMIP7 data in prep.

Simple plumes parameterisation

Why MACv2.0-SP ?

Constrained by observations

- Optical properties from MACv2.0 climatology

Computationally **efficient**

- Mathematical construction of plumes at nine locations

Easy to implement

- Input: grid, orography, time, wavelength
- F90/95 and netCDF

Flexible applications

- Different models, resolutions, and time periods
- Easily changeable setup to facilitate experimentation

Simple plumes parameterisation

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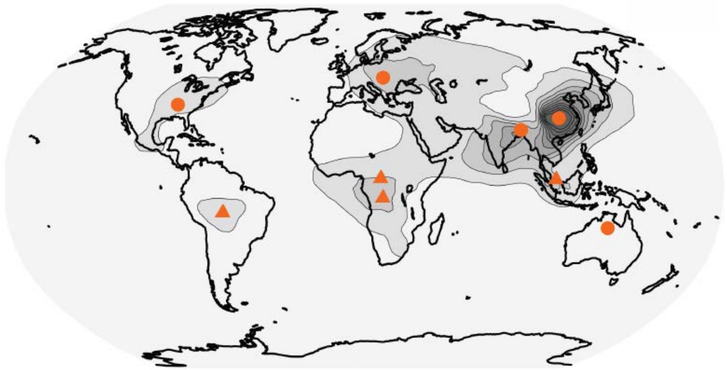
Informed by observational climatology

Spatial pattern for 2005



anthropogenic fine-mode AOD

0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5

Stevens et al. (2017)

Simple plumes parameterisation

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- **Constrained** by observations → Optical properties from MACv2.0 climatology
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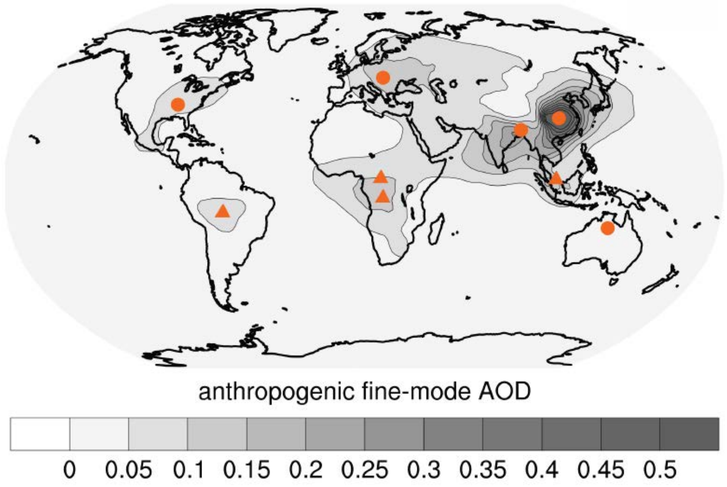
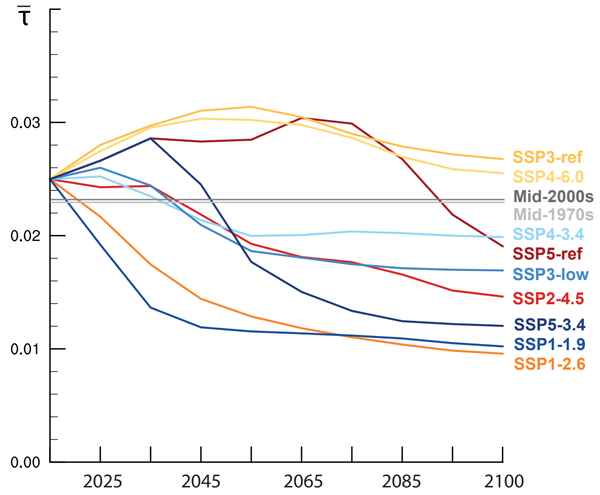


Stevens et al. (2017)

Scaling with emissions of SO_2 and NH_3

MACv2-SP for CMIP6 scenarios



Fiedler et al. (2019)

How was MACv2-SP used to better understand the reasons for the model differences in aerosol ERF?

Unified representation of anthropogenic aerosol properties helps to understand reasons for spread in simulated present-day ERF of anthropogenic aerosols

RFMIP-ERF
Different aerosol representations

IPSL-CM6A-LR -0.59

EC-Earth3-AerChem -1.34

NorESM2-LM p1 -1.21

MPI-ESM-1-2-HAM -1.26

RFMIP-ERF (-1.06 Wm^{-2})

RFMIP-SpAer (-0.57 Wm^{-2})

Different parameterizations for anthropogenic aerosols

Unified parameterization for anthropogenic aerosols

Multi-model mean [Wm^{-2}]

−12 −8 −4 0 4 8 12

RFMIP-SpAer
Same aerosol representation

IPSL-CM6A-LR -0.46

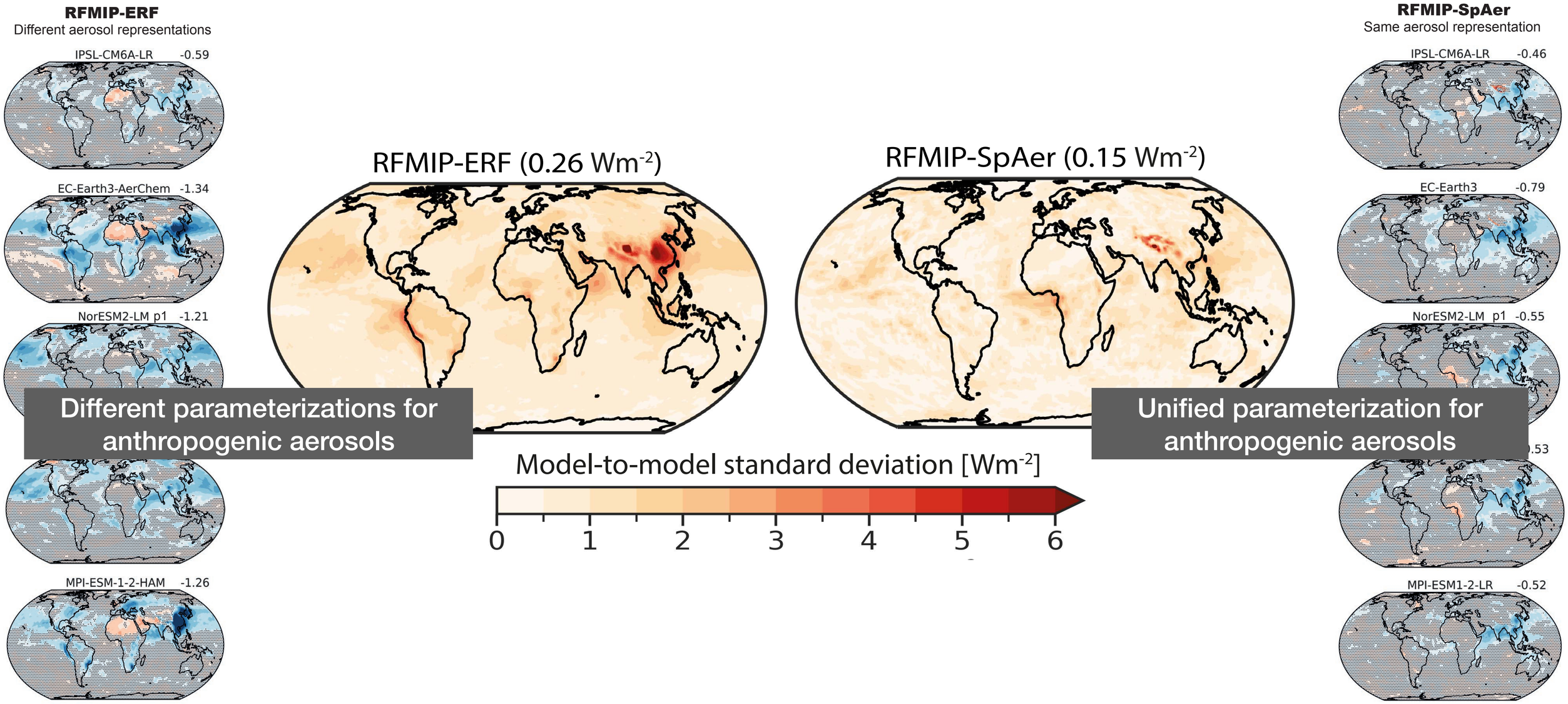
EC-Earth3 -0.79

NorESM2-LM p1 -0.55

.53

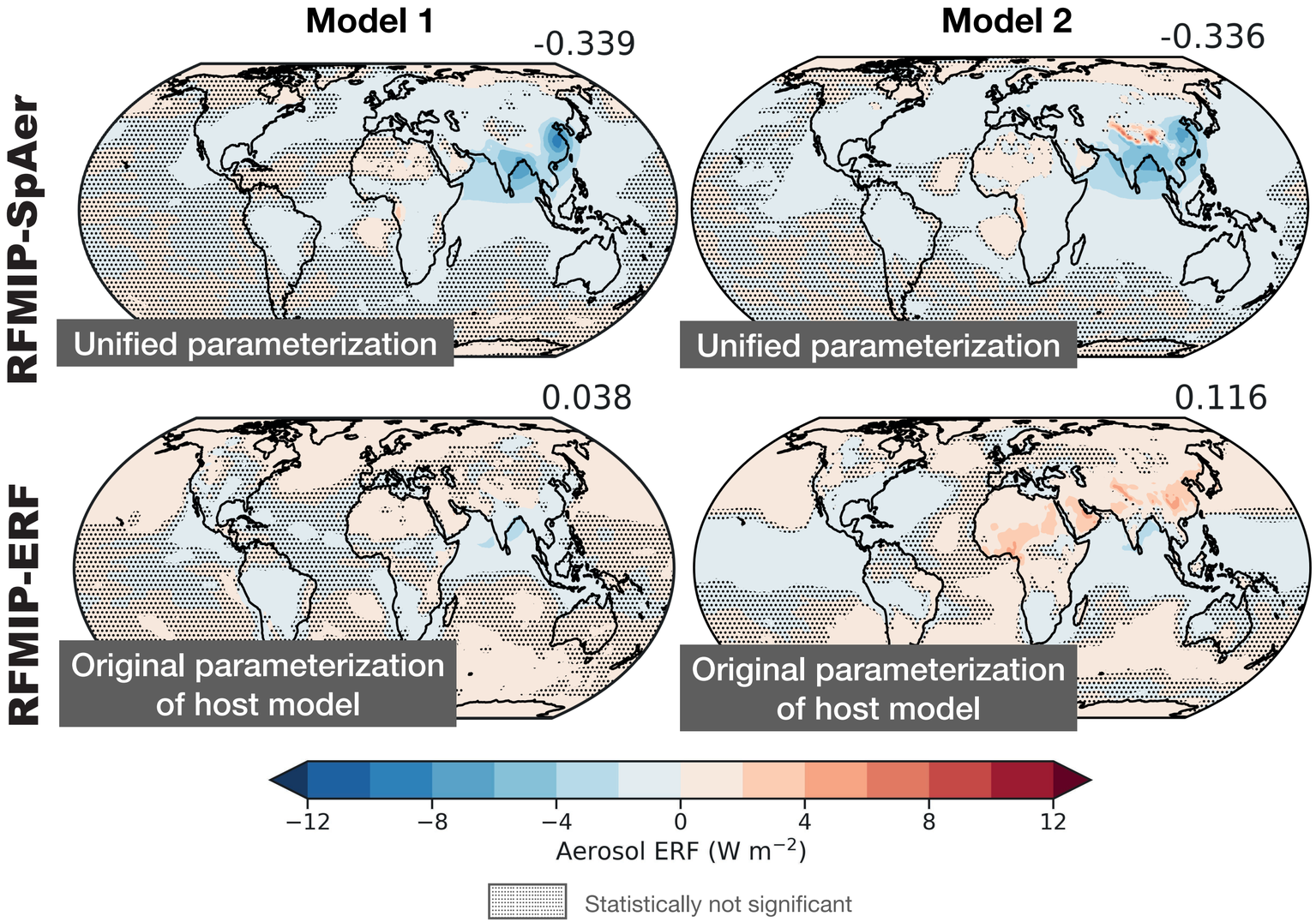
MPI-ESM1-2-LR -0.52

Unified representation of anthropogenic aerosol properties helps to understand reasons for spread in simulated present-day ERF of anthropogenic aerosols



Additional process separation indicate reasons for model differences in anthropogenic aerosol ERF

Direct effects



Fiedler et al. (2023)

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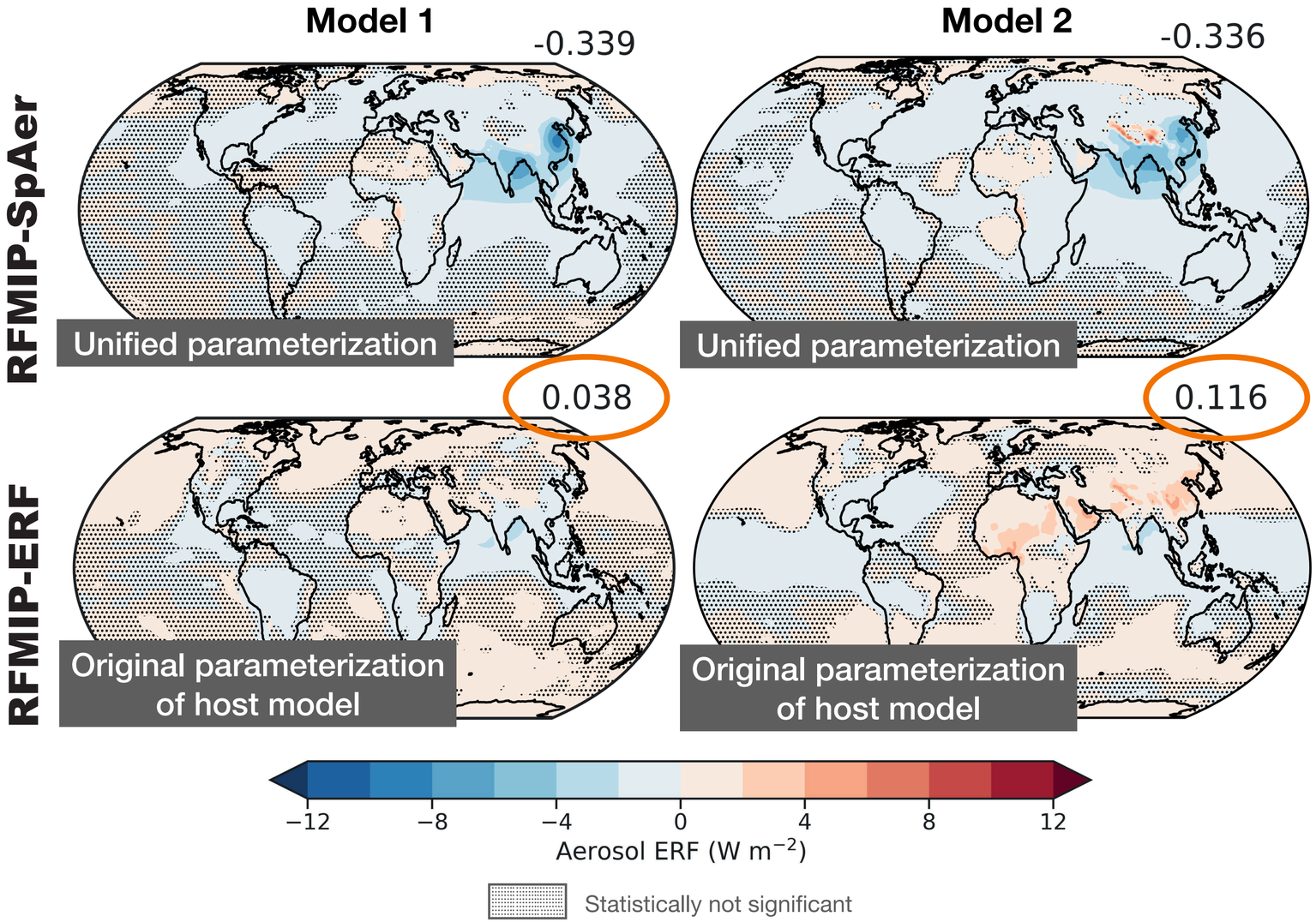
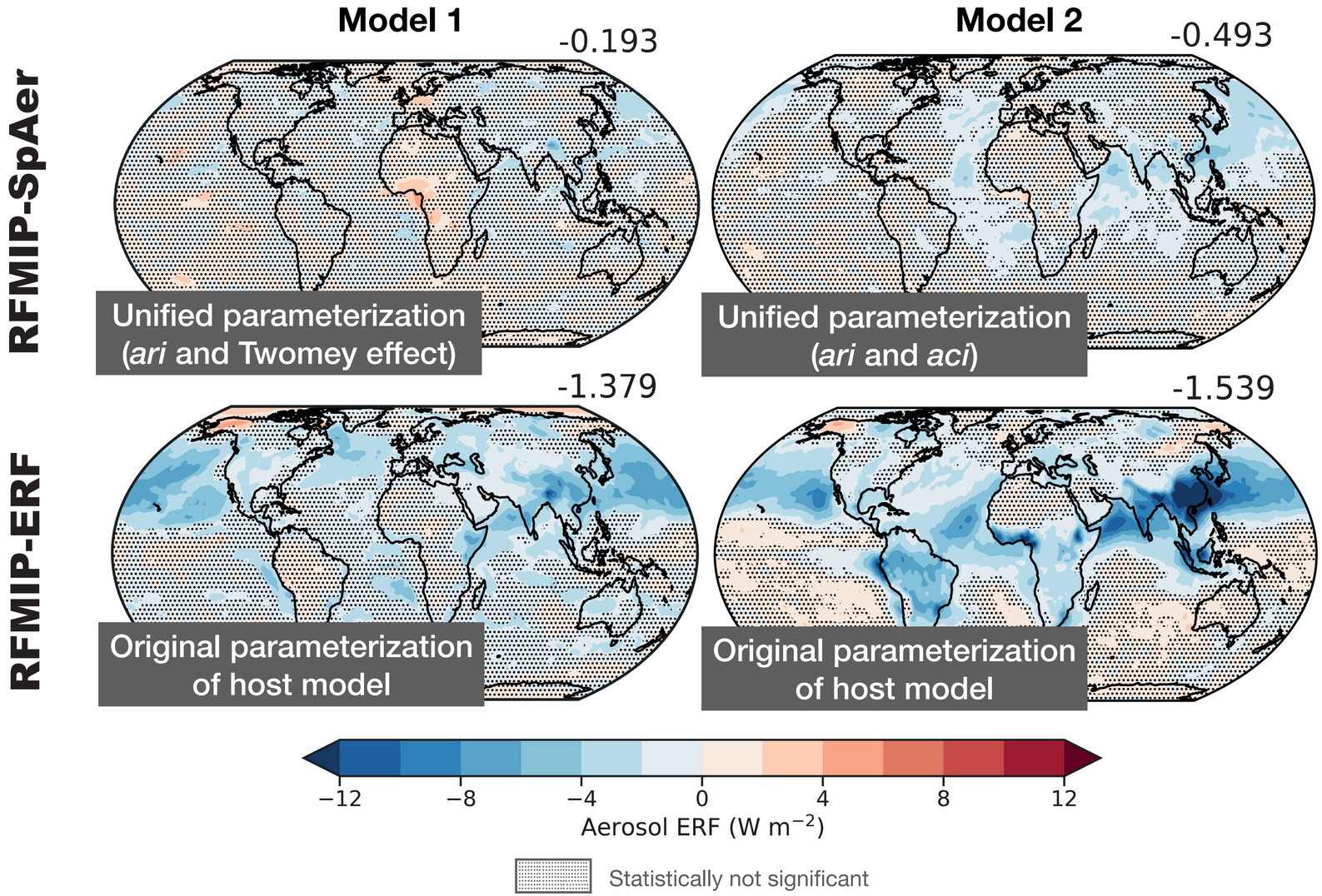


Positive direct aerosol radiative effects in CMIP6 models are associated with strong aerosol absorption

Fiedler et al. (2023)

Additional process separation indicate reasons for model differences in anthropogenic aerosol ERF

Cloud-mediated effects



Fiedler et al. (2023)

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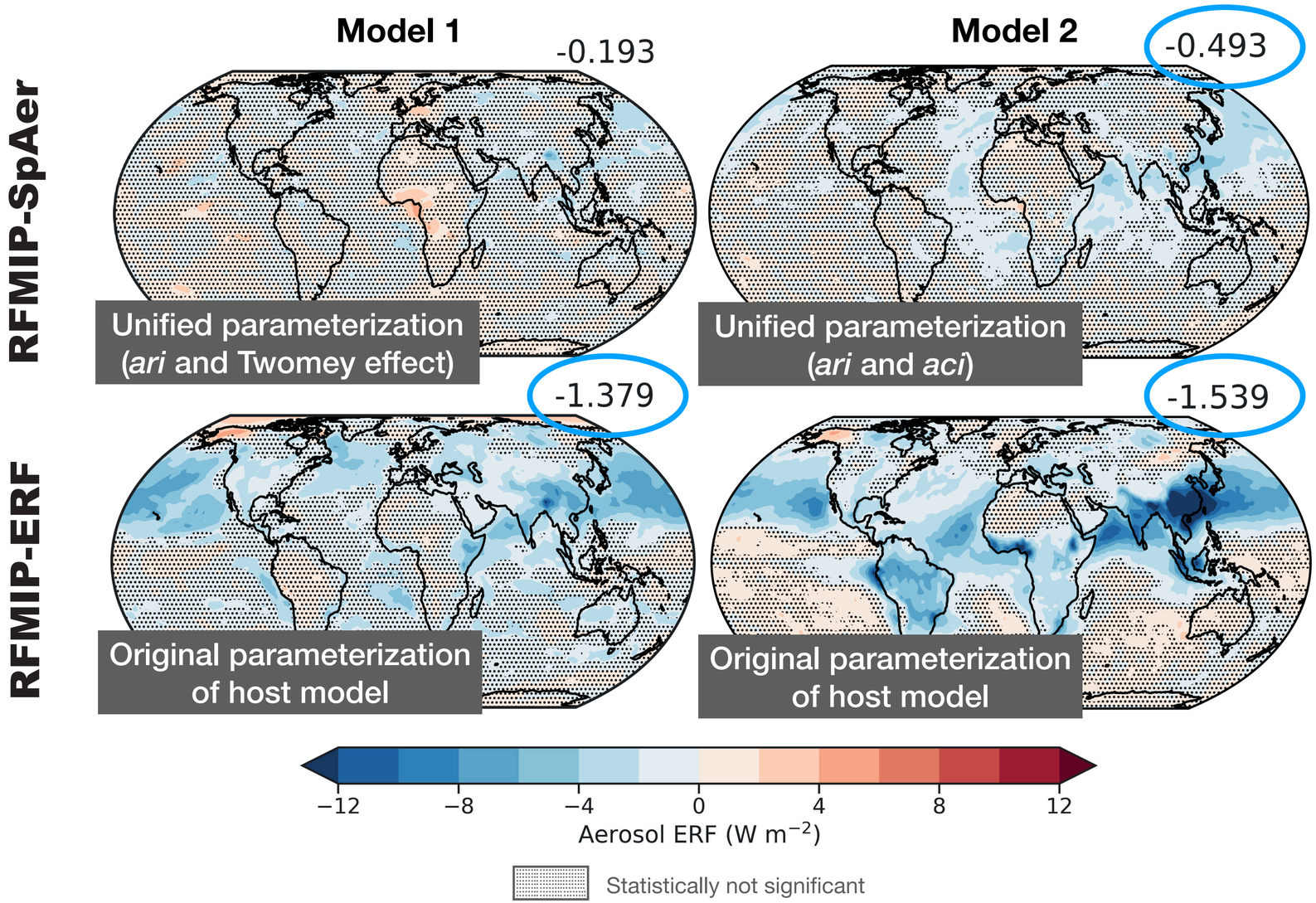
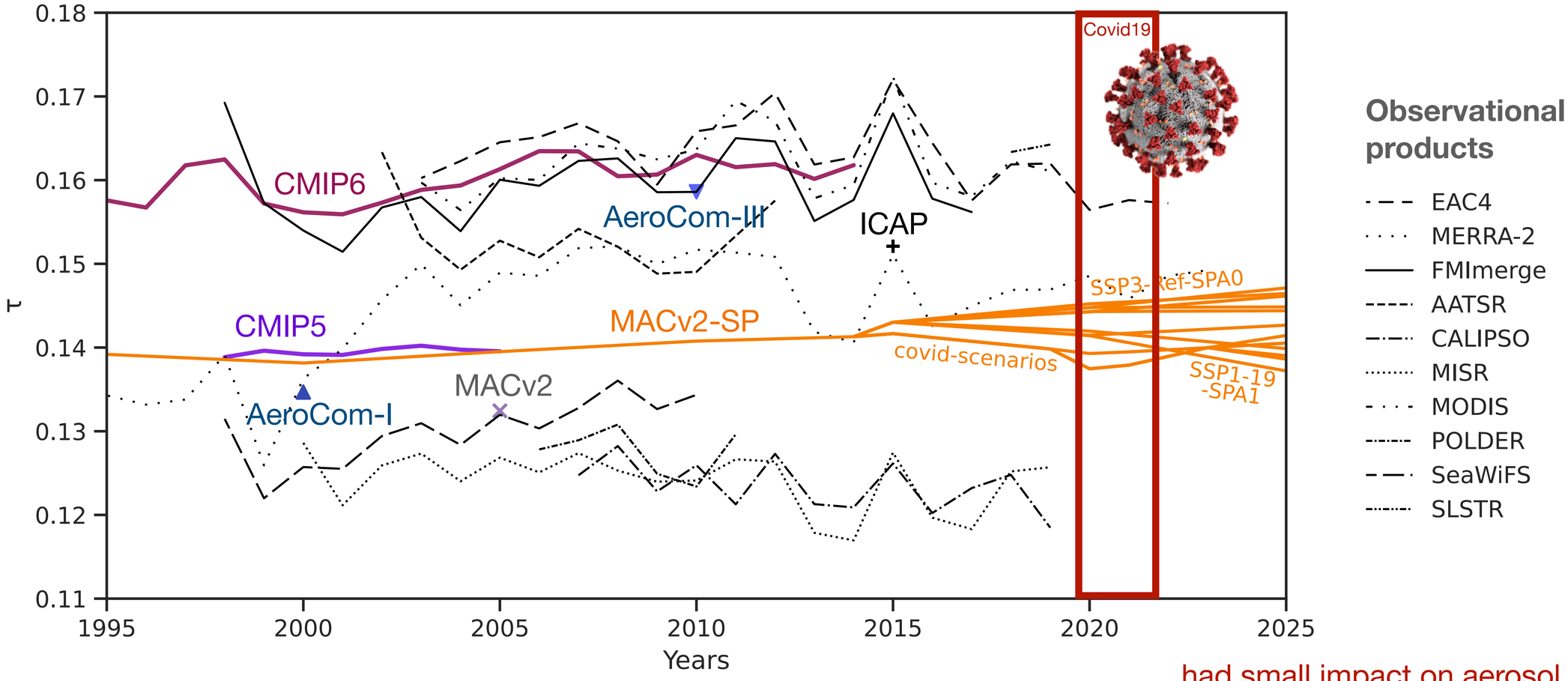


Diverse and often strong cloud-mediated effects primarily determine the magnitude of aerosol ERF in CMIP6

Fiedler et al. (2023)

Data differences for total aerosol optical depth



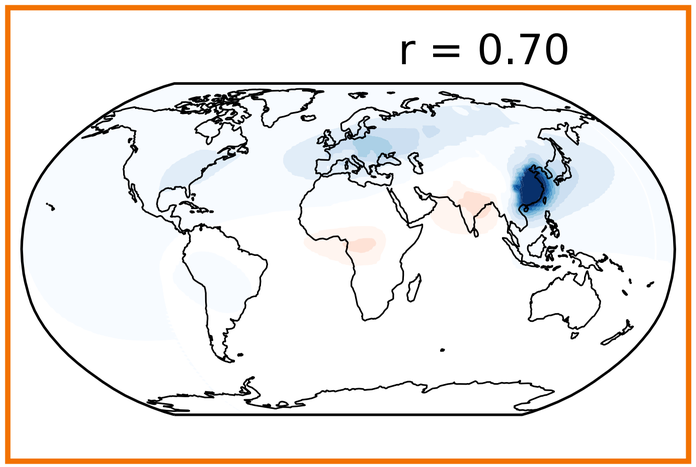
… had small impact on aerosol ERF
Fiedler et al. (2021)

Data collection following Vogel et al. (2022)

Fiedler et al. (in prep.)

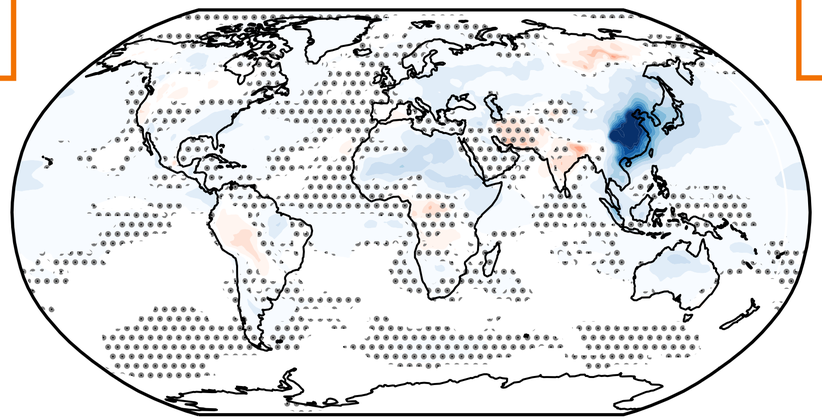
What scenario is closest to the observed pattern of the 2010-2022 trend in aerosol optical depth?

With CovidMIP Scenarios

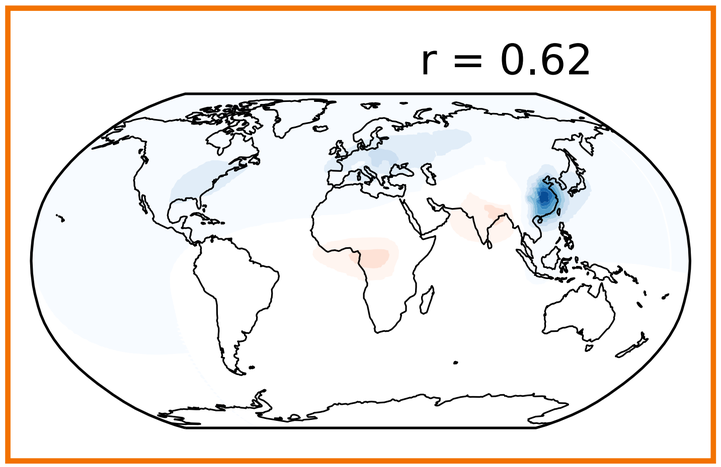


Historical data from Stevens et al. (2017)
Scenarios from Fiedler et al. (2021)

Observations



Best CMIP6 Scenario



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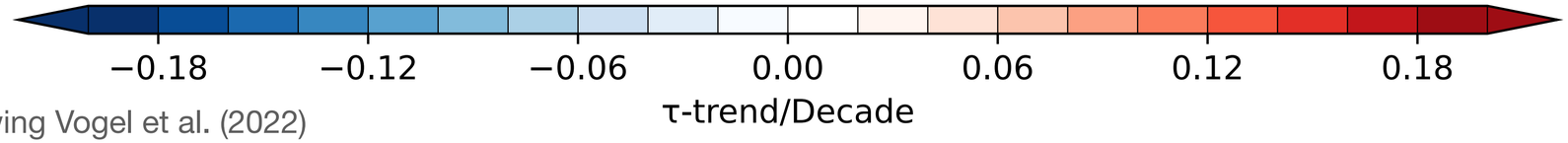

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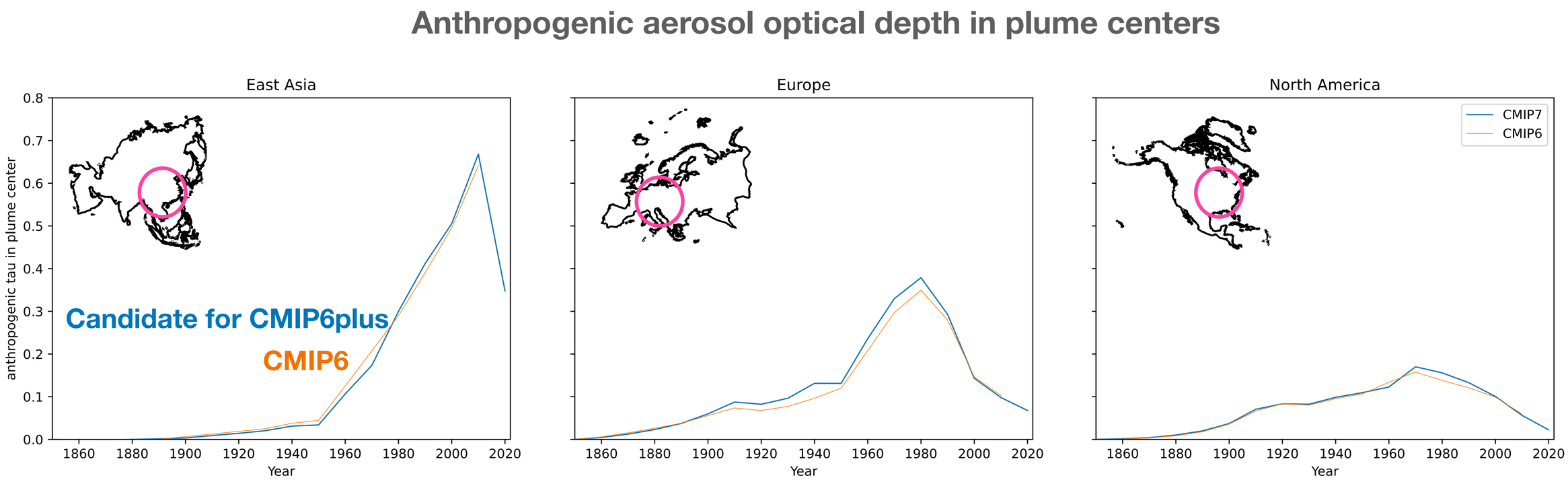
What changes do we expect compared to CMIP6? (Based on preliminary CMIP6plus emission data)



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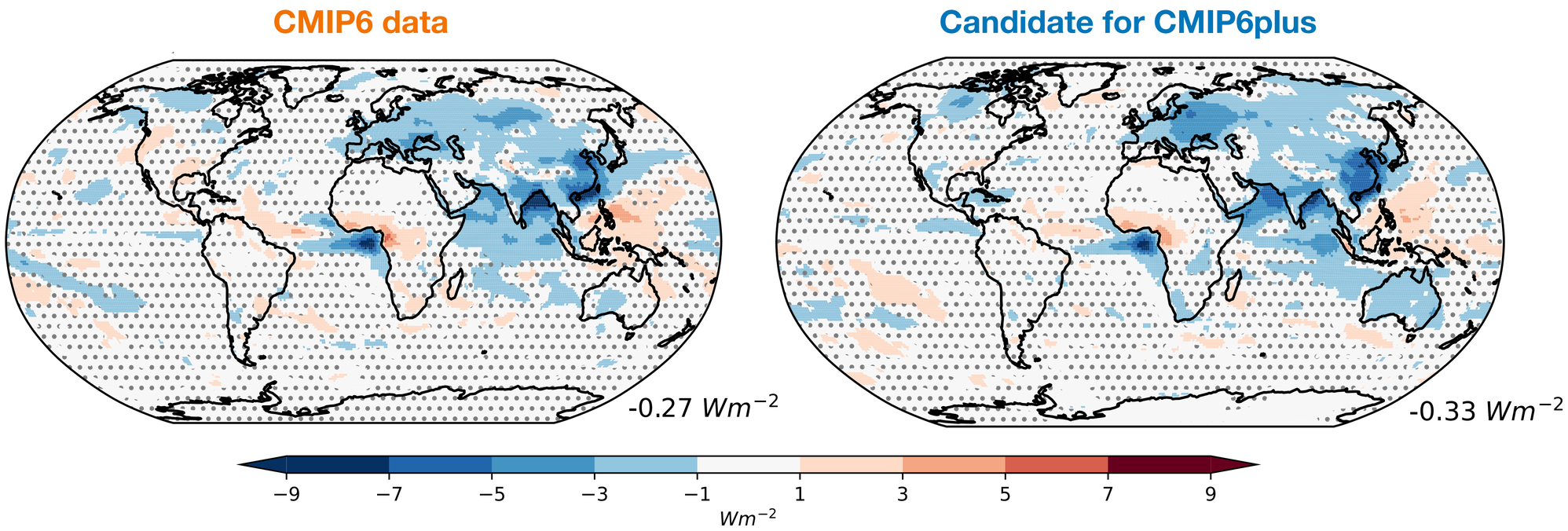
Effective radiative forcing from SP data in ICON



Fiedler et al. (in prep.)

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What is next?

1. CMIP6plus / CMIP7 data for SP
2. New dust plumes parameterisation

Thank you.

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