BREAK-OUT SESSION 6

TRENDS

SAYER (MODERTAOR) / **TSIKERIDEKIS** (RAPPORTEUR)

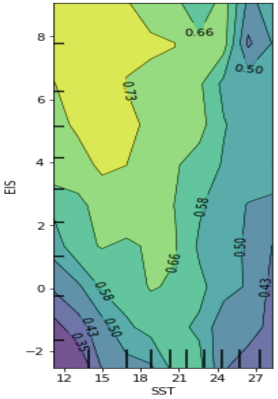
Douglas, Alyson	**Machine Learning: Changes in warm clouds**
Tsikerdekis, Athanasios	**Emission estimation using future satellite obs**
Wandji, William	**sunshine-duration AOD vs ECHAM over Europe**
Xie, Bing	**Contributions of short-lived climate pollutants …**
Yang, Yang	**Domestic emissions and regional transport on …**
Garrigues, Sebastien	**AOD monitoring with the CAMS assimilation**
Kramer, Ryan	**Observed forcing trends over the A-Train era**
Myhre, Gunnar	**Update on AeroCom Historical experiment**
Schutgens, Nick	**Evaluation of modeled AAOD and SSA**
Su, Wenying	**comparison trends from HIST and satellites**

Predicting pre-industrial warm cloudiness using ML

Compare a multivariate linear regression (MVLR) with stochastic gradient boosting (SGB) and random forest (RF) ML models in order to predict a pristine cloud fraction as pre-industrial proxy and a comparison against the actual, observed cloud fraction

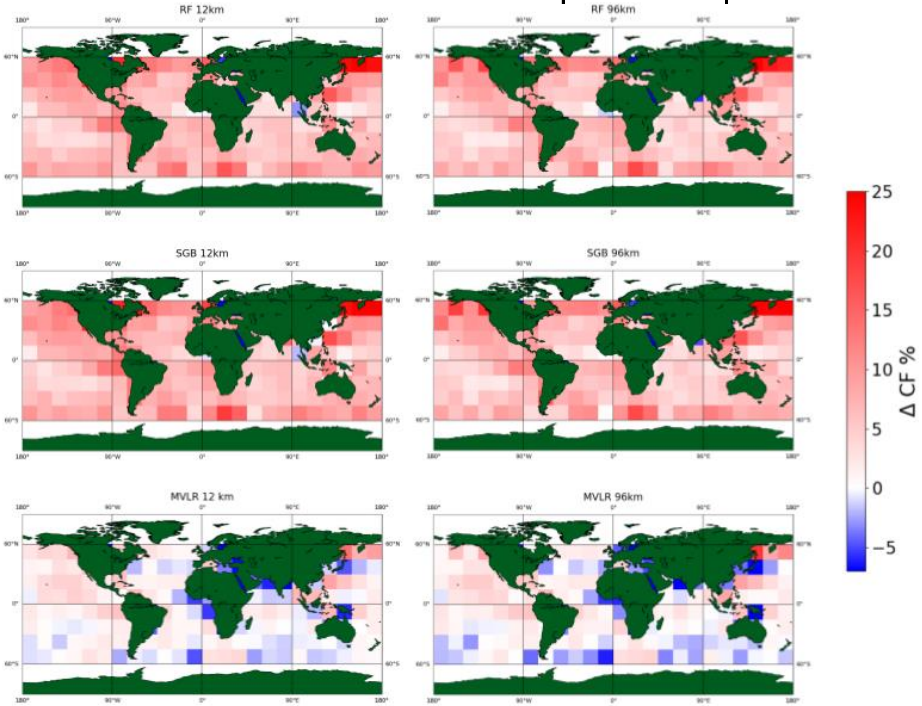
Aerosol-cloud interactions may have increased global cloudiness by 1.15% leading to a cooling effect of -.31 Wm^2

The RF and SGB have less than 1% error in predicting pristine cloudiness, while the MVLR has >7% error

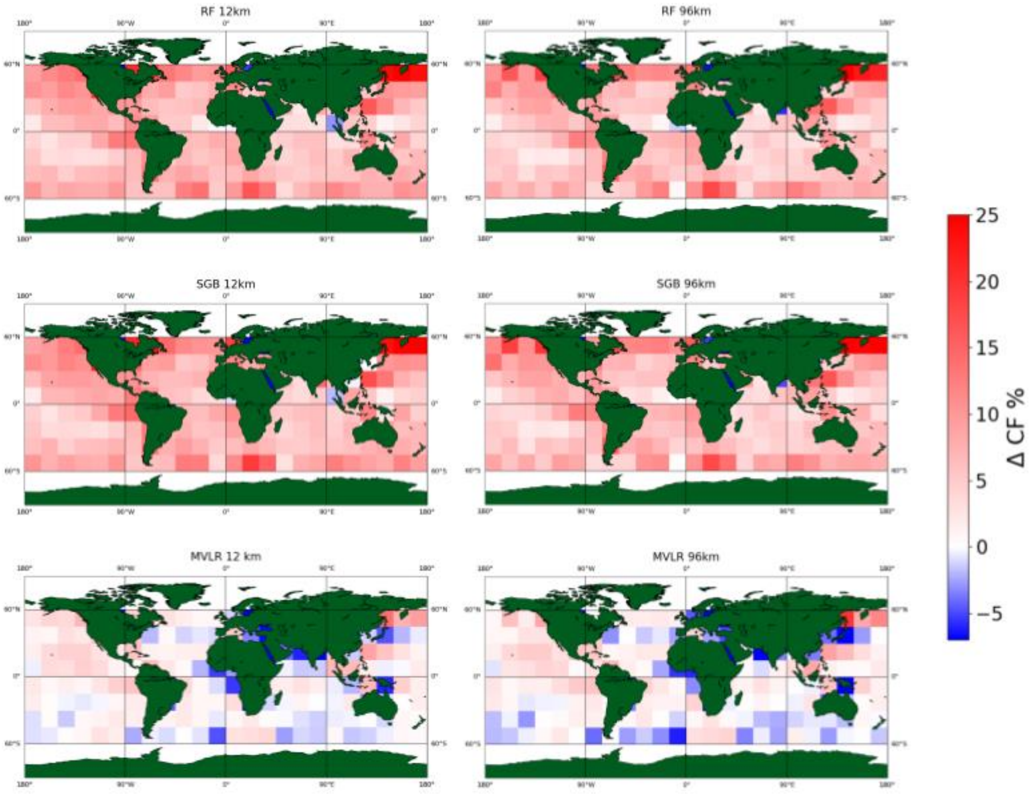


The learnings of the ML models can be used to understand ACI and the errors in current parameterizations of ACI in GCMs

$$\Delta \textbf{ CF} = \textbf{CF}_{\text{actual}} - \textbf{CF}_{\text{predicted pristine}}$$



RF, SGB suggest the north Pacific storm track region in particular has shown large increases in



Studies based off sensitivities alone may miss this signal as it may not be strictly linear

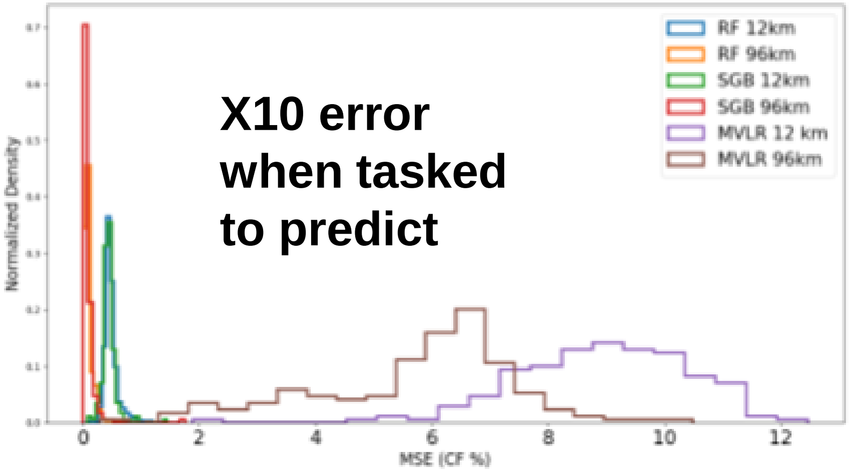
Environment-cloud interactions may overrule aerosol-cloud interactions, which obscures the signals when only finding a sensitivity

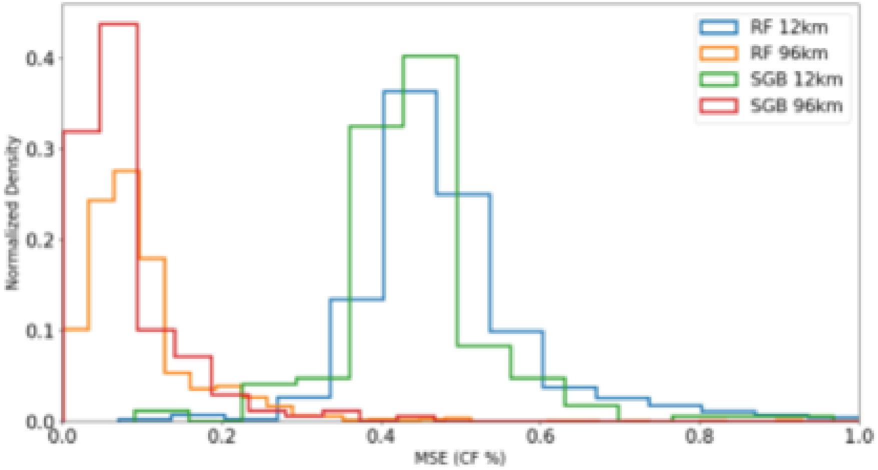
MVLR does not show coherent regional patterns or the same magnitude of changes as the SGB and RF

MVLR more prone to error, suggests may not be suitable for understanding more complex interactions in the Earth system

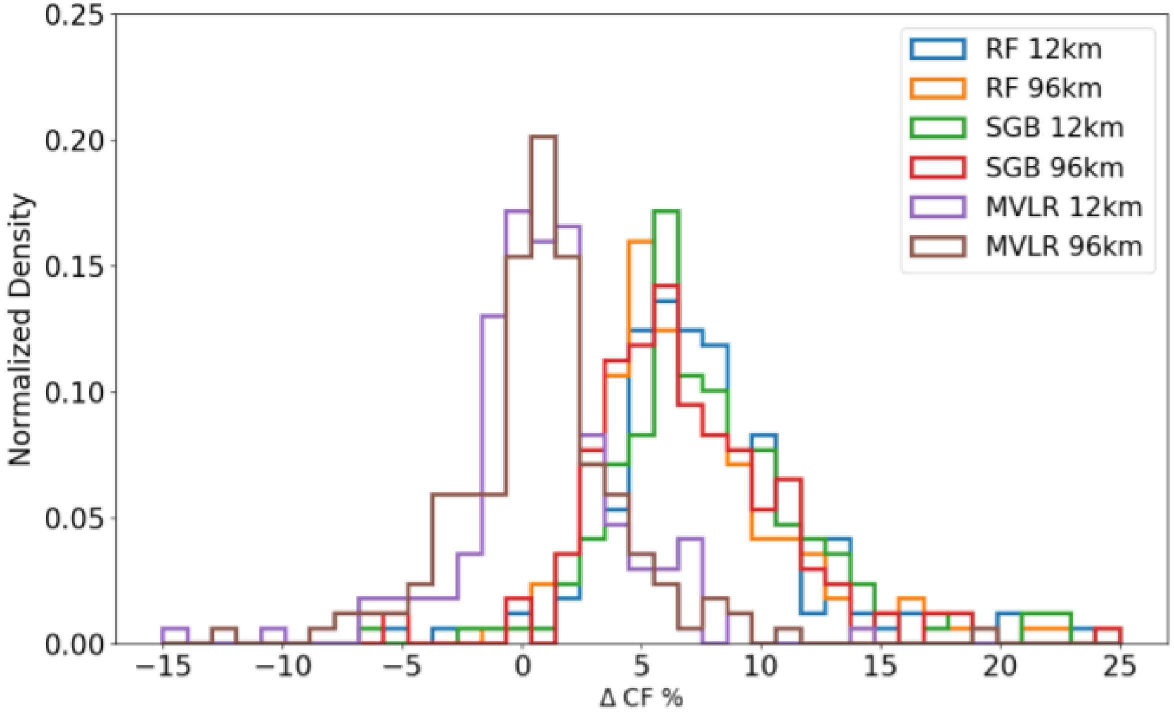
SGB, RF error is less than 1% cloud fraction

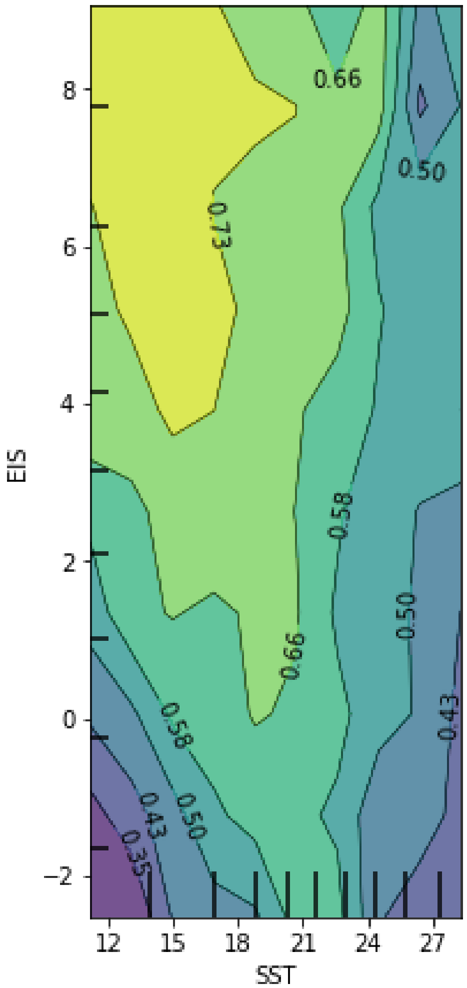
Frameworks can represent non-linear interactions





An MVLR based estimate would show almost no change in cloudiness from pre-industrial times most clouds, contradicting prior knowledge on warm clouds





The learnings of the models can be used to inform our understanding of the processes involved in cloudiness and other cloud processes

These can be used as comparison against GCM parameterizations to help inform what regimes have inaccurate representations

The latent space representations in more complex types of ML such as neural networks could be used to similarly distill the complex relationships into explainable figures

AEROCOM 2020

Aerosol emission estimation using "perfect" satellite observation capabilities and Observing System Simulation Experiments (OSSEs)

Athanasios Tsikerdekis[1,2], Nick A.J Schutgens[2], Otto P. Hasekamp[1], Guangliang Fu[1]

1. Netherlands Institute of Space Research (SRON)
2. Free University of Amsterdam (VU)

A.Tsikerdekis@sron.nl

SRON

Netherlands Institute for Space Research

Netherlands Organisation for Scientific Research (NWO)

OSSE and the case of a "Perfect" Satellite…

In an OSSE we use a simulation as Nature (a.k.a Nature Run)
This Nature has altered emissions (e.g. Sea Salt Emissions x 0.5)

Data assimilation estimates these emissions using
- Aerosol Optical Depth (AOD)
- Angstrom Exponent (AE)
- Single Scattering Albedo (SSA)

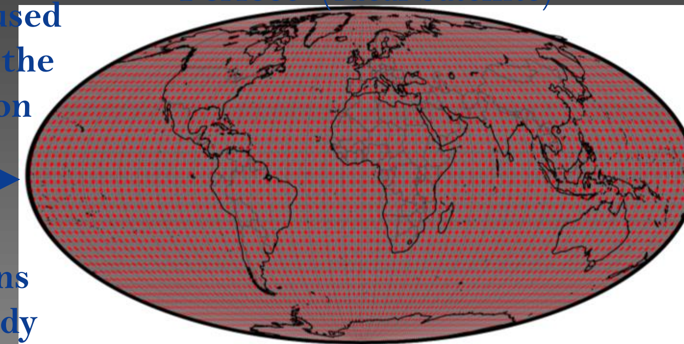
Benefits

1. Ground Truth is known ⇉ Complete Evaluation
2. Can replicate any satellite observation capabilities.

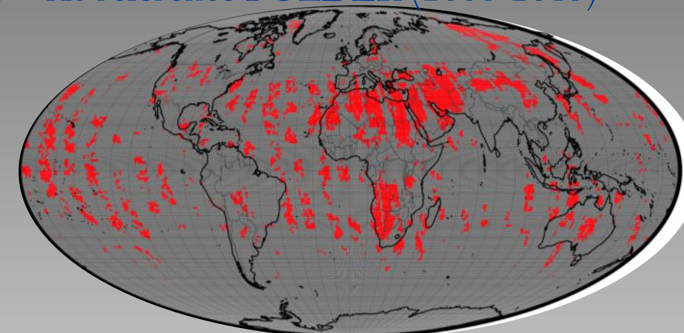
Satellite Coverage in two days
"Perfect" (Ideal Satellite)

This one is used throughout the presentation

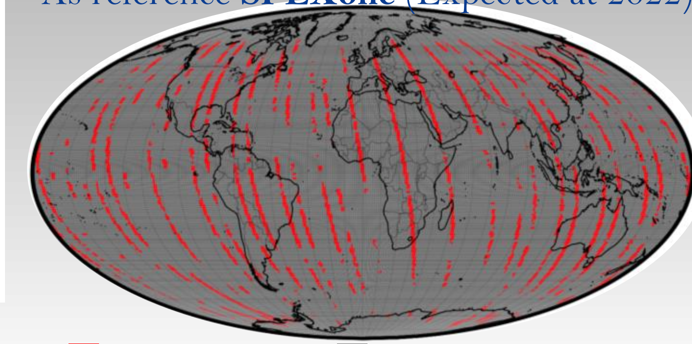
Observations even in cloudy conditions



As reference **POLDER** (2006-2013)



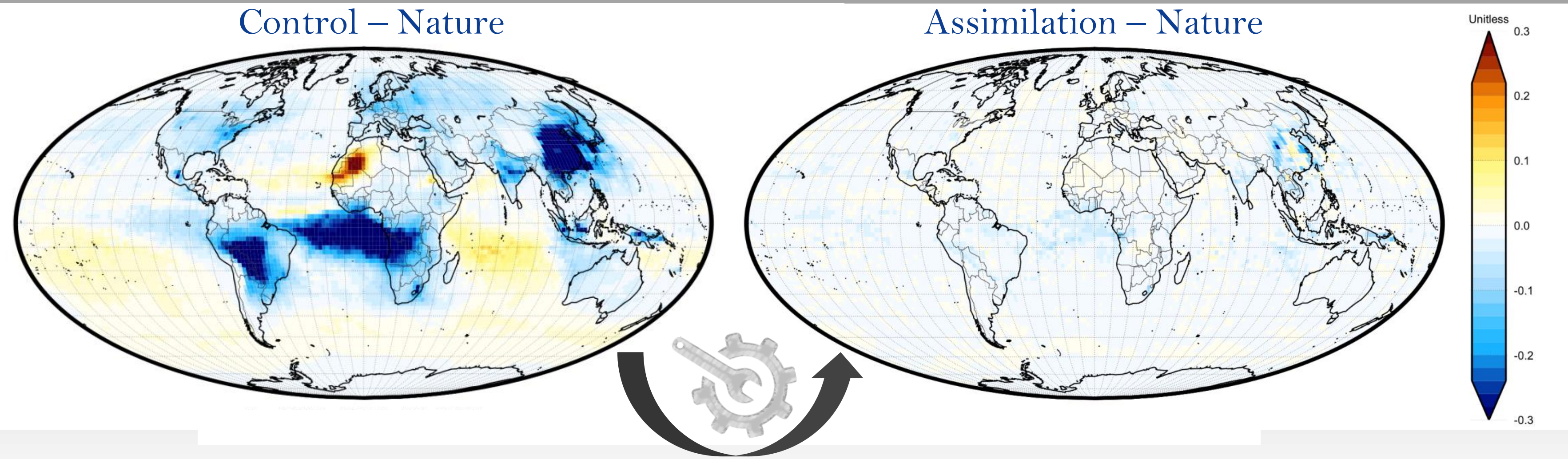
As reference **SPEXone** (Expected at 2022)



Observations No Observations

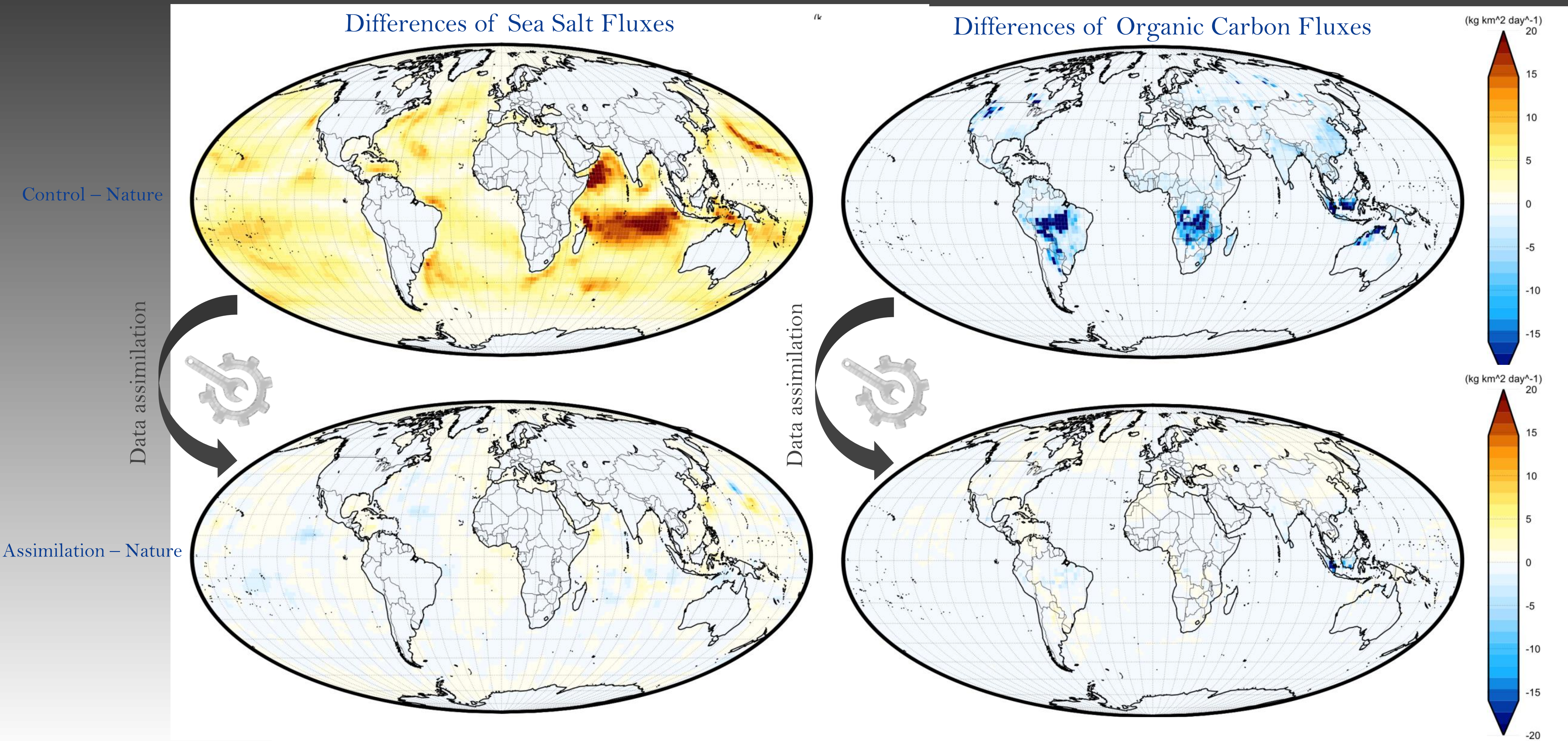
Differences of AOD$_{550}$ between
Control – Nature

Differences of AOD$_{550}$ between
Assimilation – Nature



Data assimilation

Emission Estimation under an OSSE…

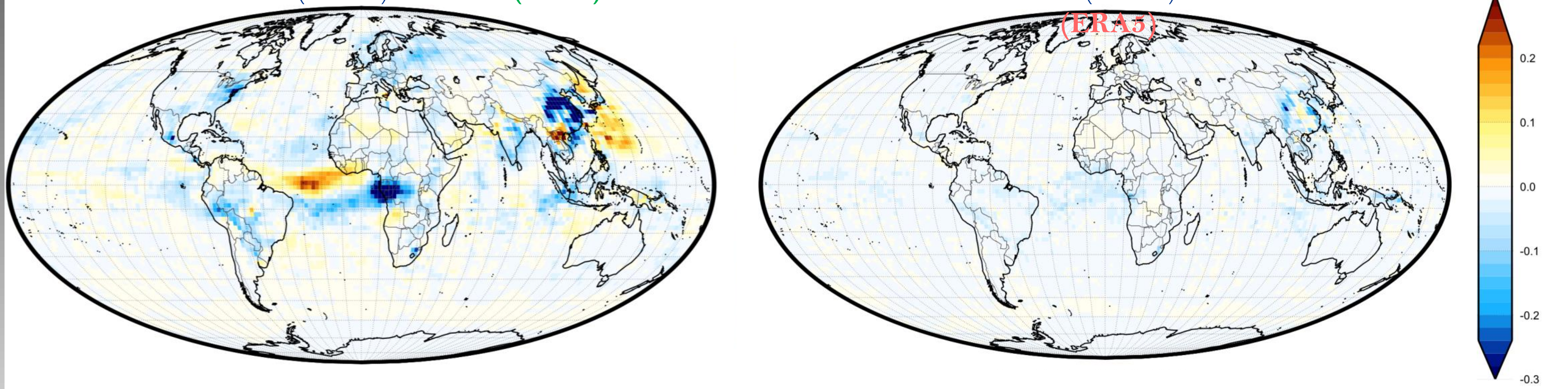


The role of **Meteorology**…

All experiments (Nature, Control, Assimilation) are nudged to ERA5 reanalysis meteorology.
But what if Nature was nudged to $\mathbf{ERA_i}$ while Control & Assimilation to $\mathbf{ERA_5}$?

Differences of AOD_{550} between
Assimilation (ERA5) – Nature **(ERAi)**

Differences of AOD_{550} between
Assimilation (ERA5) – Nature **(ERA5)**



Data assimilation is able to correct biases originating from emissions.
Although, as expected, it is not able to correct biases originating from other factors, in this case meteorology.

Outside of an OSSE framework these biases cannot be quantified and we have to be aware that are there!

The role of Prior Correction…

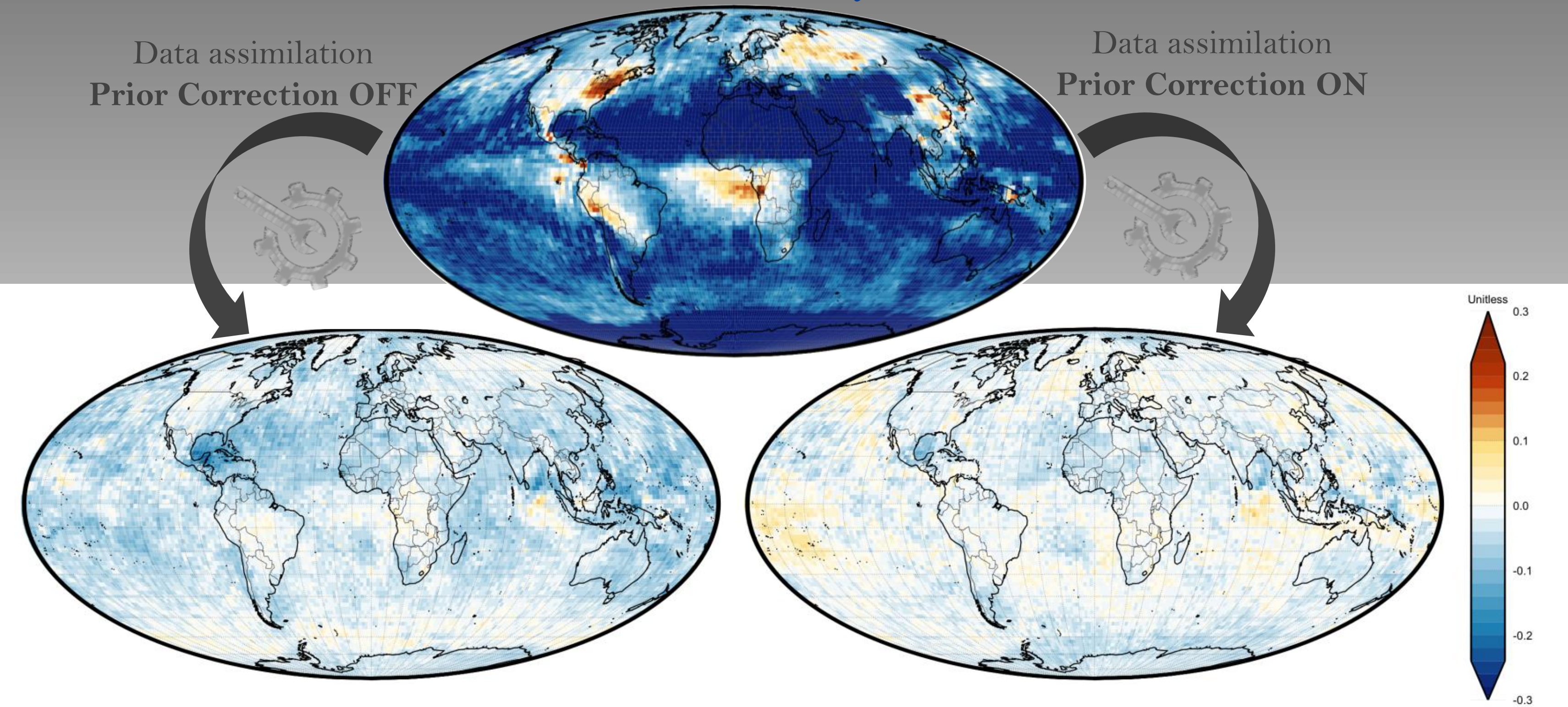
Prior (first guess) of emissions can significantly affect the performance of a data assimilation experiment.

Prior Correction is just a method to improve data assimilation results.
Instead of setting prior emissions equal to Control,
we adjust them based on the emissions estimated (analysis) the previous day.

Differences of $AE_{550\text{-}865}$ between
Control – Reality

Data assimilation
Prior Correction OFF

Data assimilation
Prior Correction ON



For example, with prior correction we get a slight improvement in our already quite low bias in AE as well as in AOD and SSA (not shown)

Conclusions

Developed the first data assimilation system
for **aerosol emission estimation** on ECHAM-HAM.

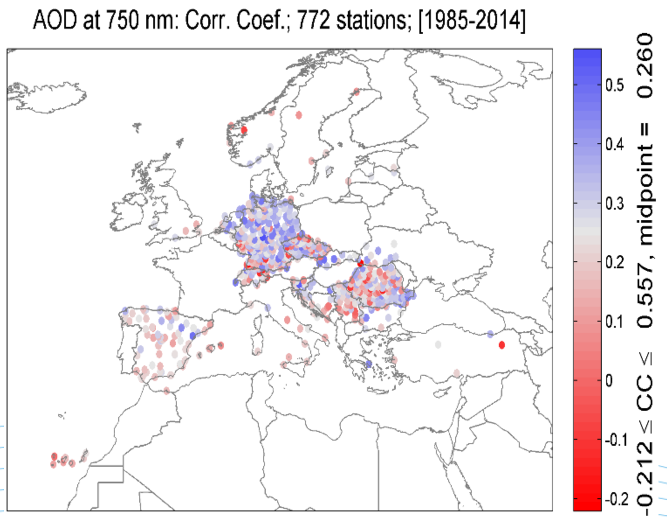
Using OSSEs:

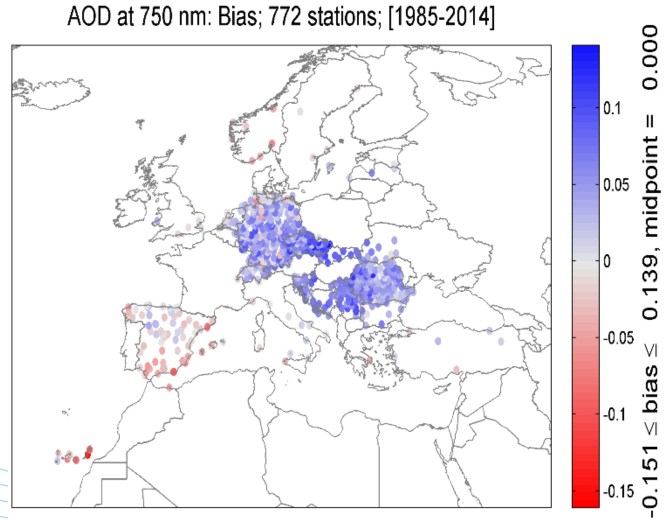
- Successfully estimated emission with observations (AOD, AE, SSA) utilizing a ”Perfect” satellite setting.
- Addressed the important role of meteorology in aerosol data assimilation (1st test on Nature Run complexity).
- Developed a prior correction method which improves data assimilation emission estimation.

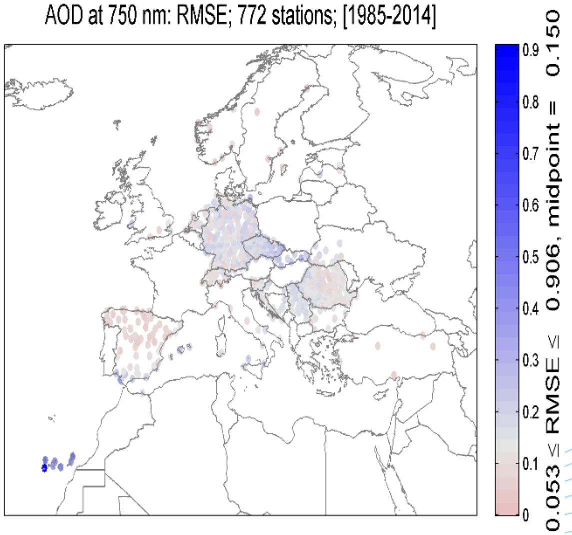
Future Work

- Emission estimation using past (POLDER) and future (SPEXone, HARP-2 & OCI) observation capabilities.
- Sensitivity studies on Nature Run complexity (e.g. different emission inventories and schemes)
- Sensitivity studies on data assimilation temporal cycles.

Sunshine-duration AOD vs ECHAM over Europe: **brightening period (1985-2014)**



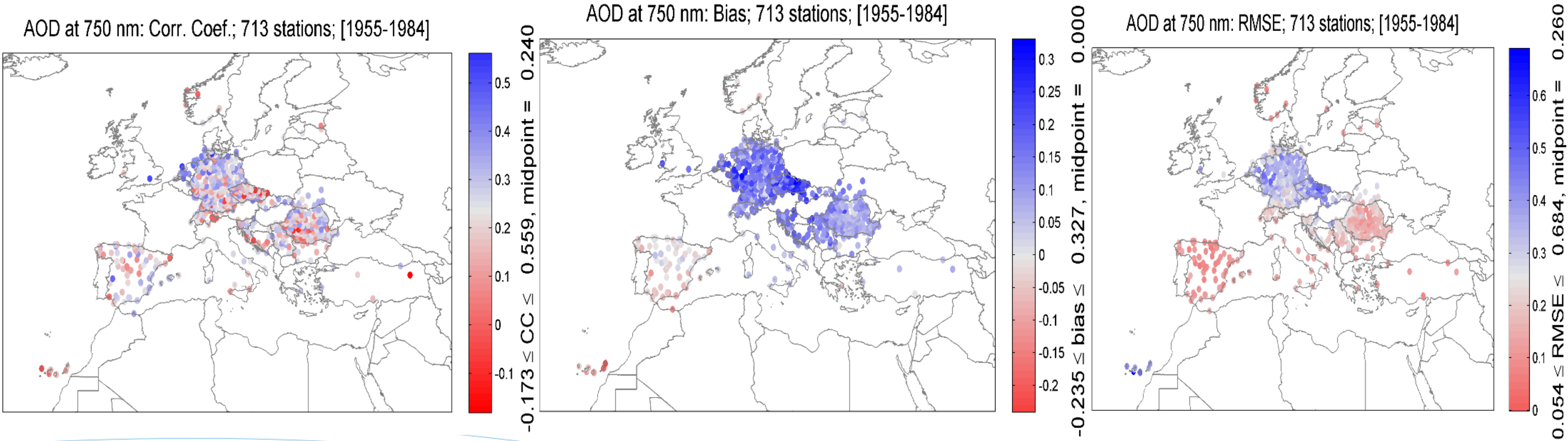




- Reasonable agreement between ECHAM simulations and SD-AOD retrievals
- Regional differences between Middle and Southern Europe probably due to dust emissions
- AOD in Middle Europe is mainly driven by SO4 and water whereas in the Southern Europe also dust, sea salt and BC have a clear impact

W. Wandji, T. Mielonen, H. Kokkola and A. Arola

Sunshine-duration AOD vs ECHAM over Europe: dimming period (1955-1984)

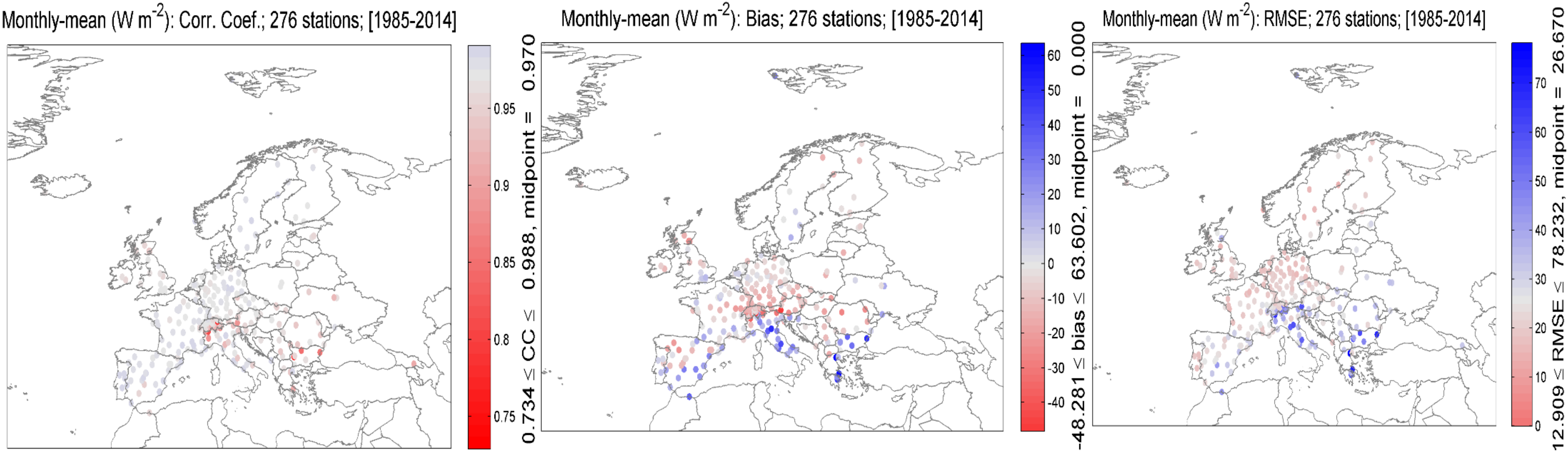


- The performances depends on the time period

W. Wandji, T. Mielonen, H. Kokkola and A. Arola

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

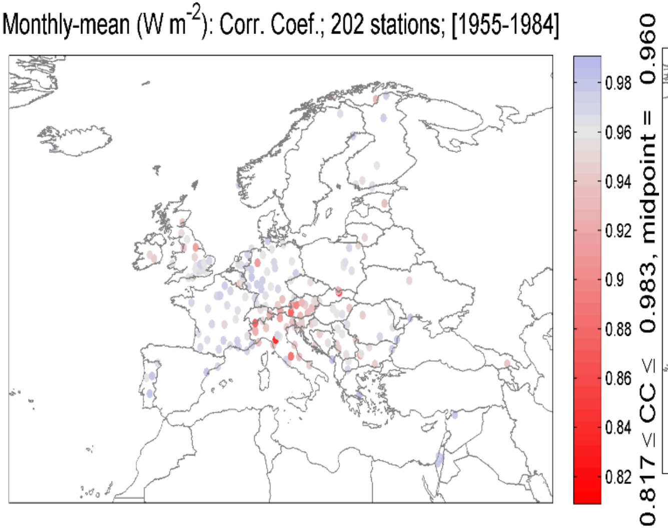
GEBA vs ECHAM irradiances over Europe: brightening period (1985-2014)

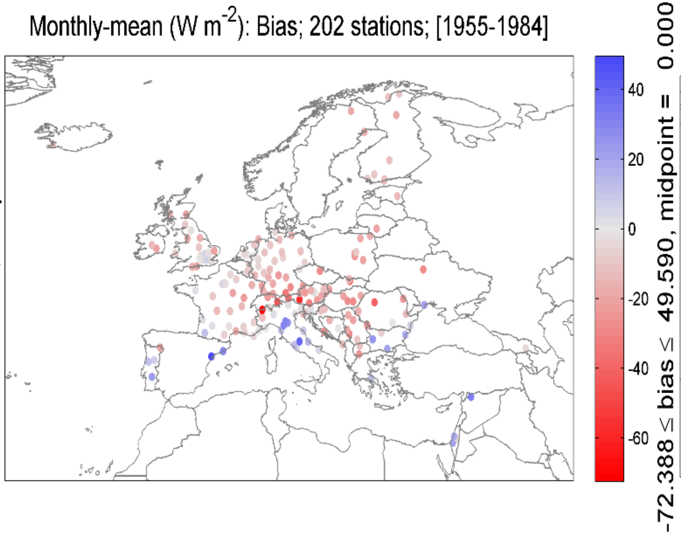


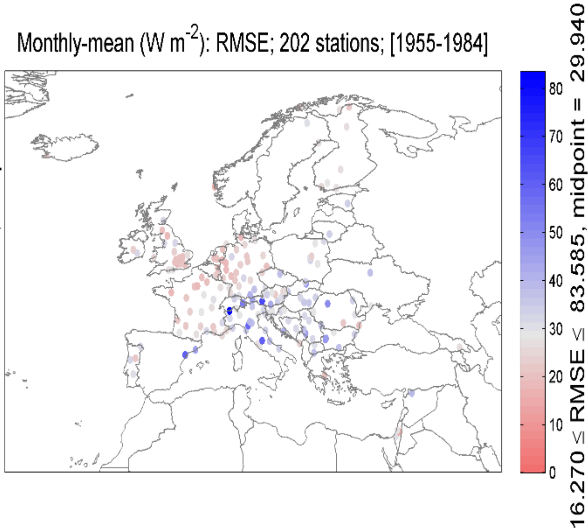
- Reasonable agreement between ECHAM simulations and ground-based observations
- Gradual regional differences between North, Middle and Southern Europe

W. Wandji, T. Mielonen, H. Kokkola and A. Arola

GEBA vs ECHAM irradiances over Europe: dimming period (1954-1985)







- The performances depends on the time period

W. Wandji, T. Mielonen, H. Kokkola and A. Arola

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Conclusions and *perspectives*

- Comparisons on AOD and irradiances have been carried out between ECHAM simulations and SD-AOD retrievals and GEBA measurements
- Reasonable agreement depending on the regions due to spatial and temporal AOD.
- Clear influence of dust emissions possibly not very well taking into account in ECHAM
- *Further investigations should be done to explain discrepancies on AOD and SSR*
- *Extension of the study as many sites as possible in other regions of the world such as Africa, America (North & South), Australia and Asia.*
- *Comparing results with other findings from the literature*

The contributions of short-lived climate pollutants to global climate change since the pre-industrial era

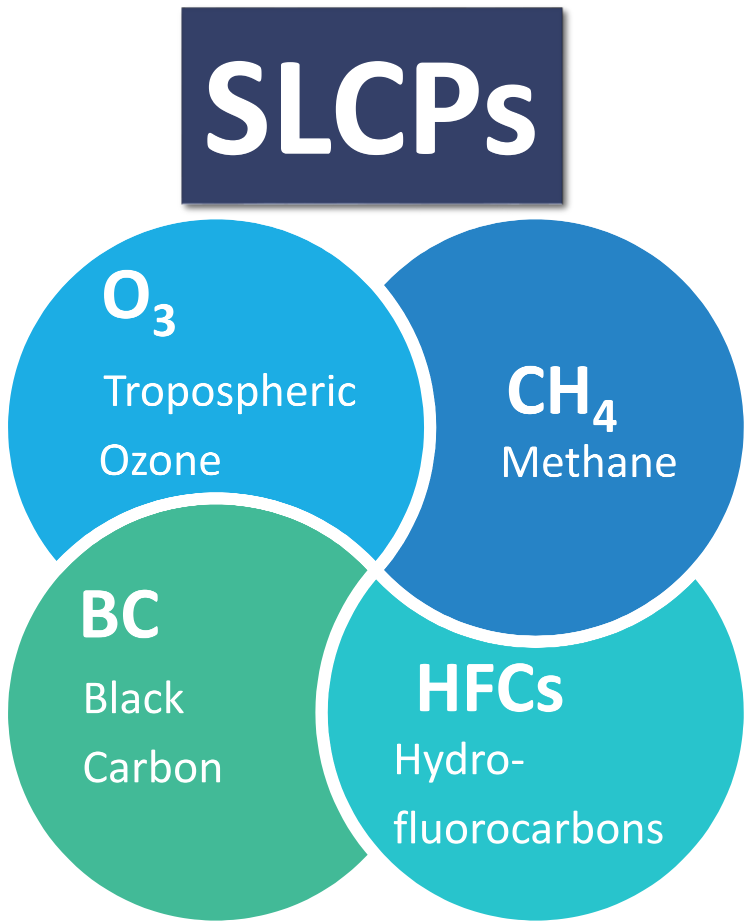
BING XIE; HUA ZHANG

2020/10/14

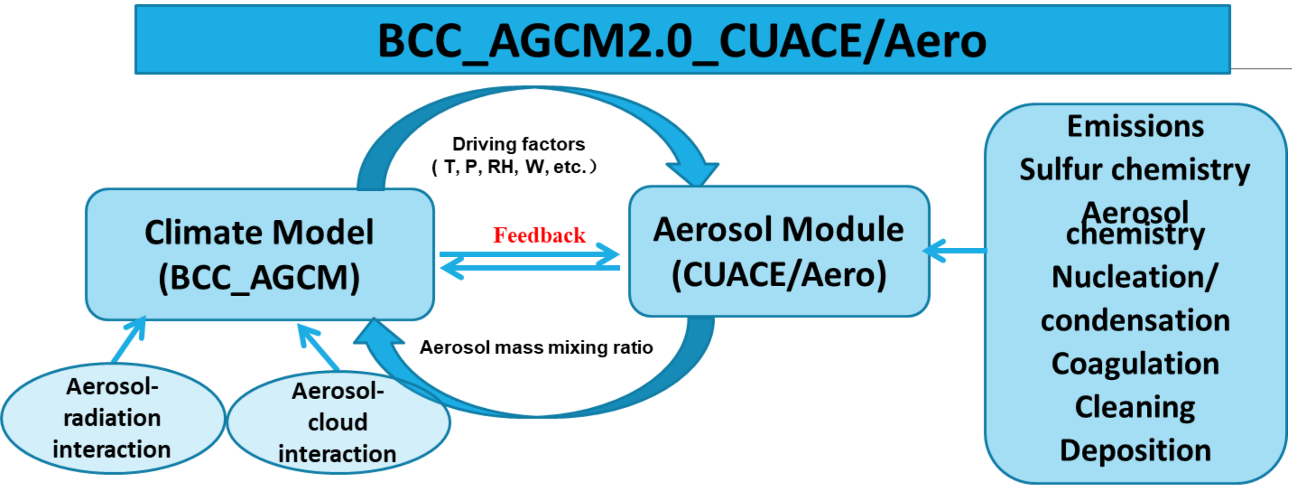
Introduction

Short-Lived Climate Pollutants (SLCPs)

SLCP is a set of warming climate forcers, which are gases and particles that can affect the climate by modifying the global energy budget and influence human health, and have a relatively short lifespan in the atmosphere compared to carbon dioxide and other longer-lived gases.



Model and Experimental design



The framework of the aerosol-climate coupled model used in this work

Six sets of experiments to calculate

ERFs :

$ERF_{1850}/S_{ERF2010}/C_{ERF2010}$

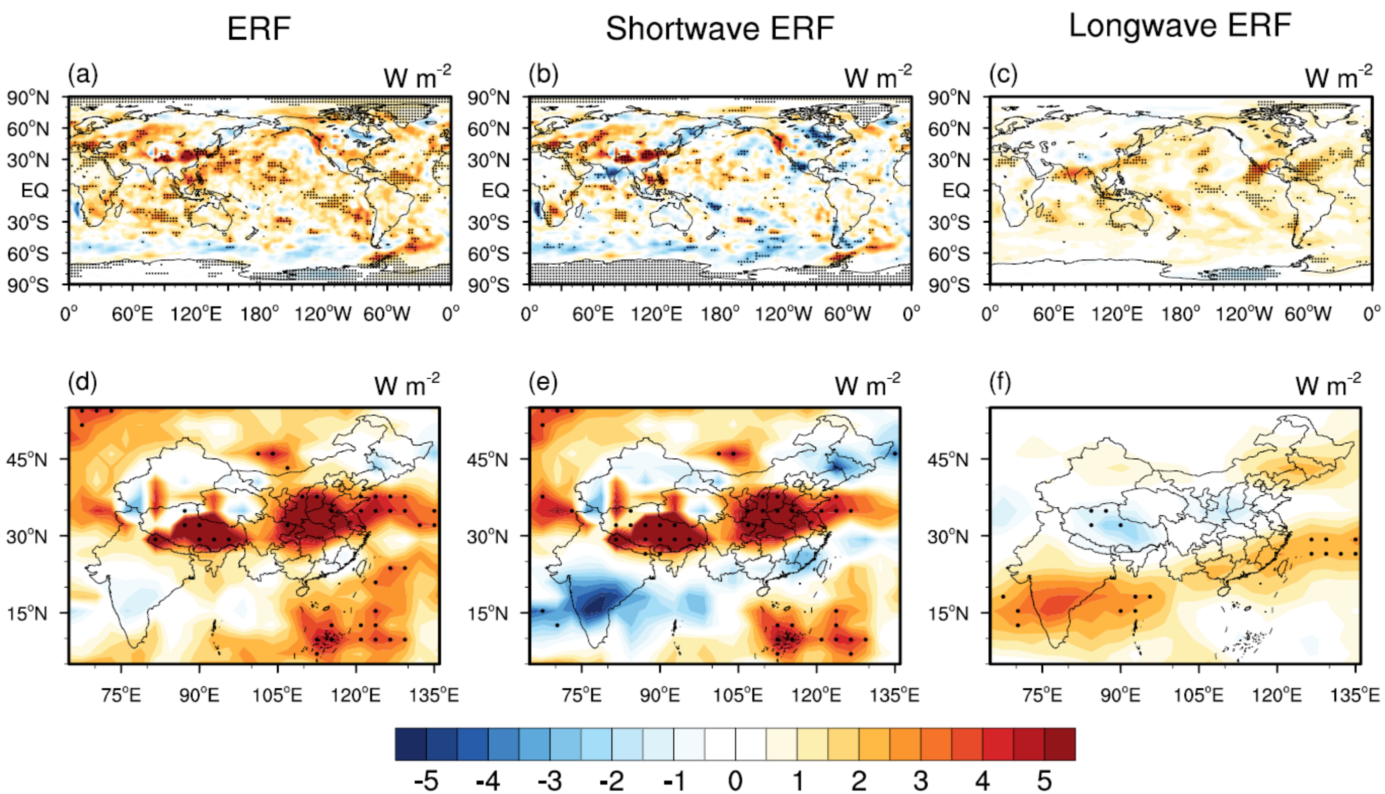
Climate Response:

$CR_{1850}/S_{CR2010}/C_{CR2010}$

Test Name	CO_2 concentration	SLCF concentration	Sea temperature	Running time
ERF_{1850}	1850	1850	Prescribed SST①	15 years
$S_{ERF2010}$	1850	2010	Prescribed SST	15 years
$C_{ERF2010}$	2010	1850	Prescribed SST	15 years
CR_{1850}	1850	1850	Slab ocean model②	70 years
S_{CR2010}	1850	2010	Slab ocean model	70 years
C_{CR2010}	2010	1850	Slab ocean model	70 years

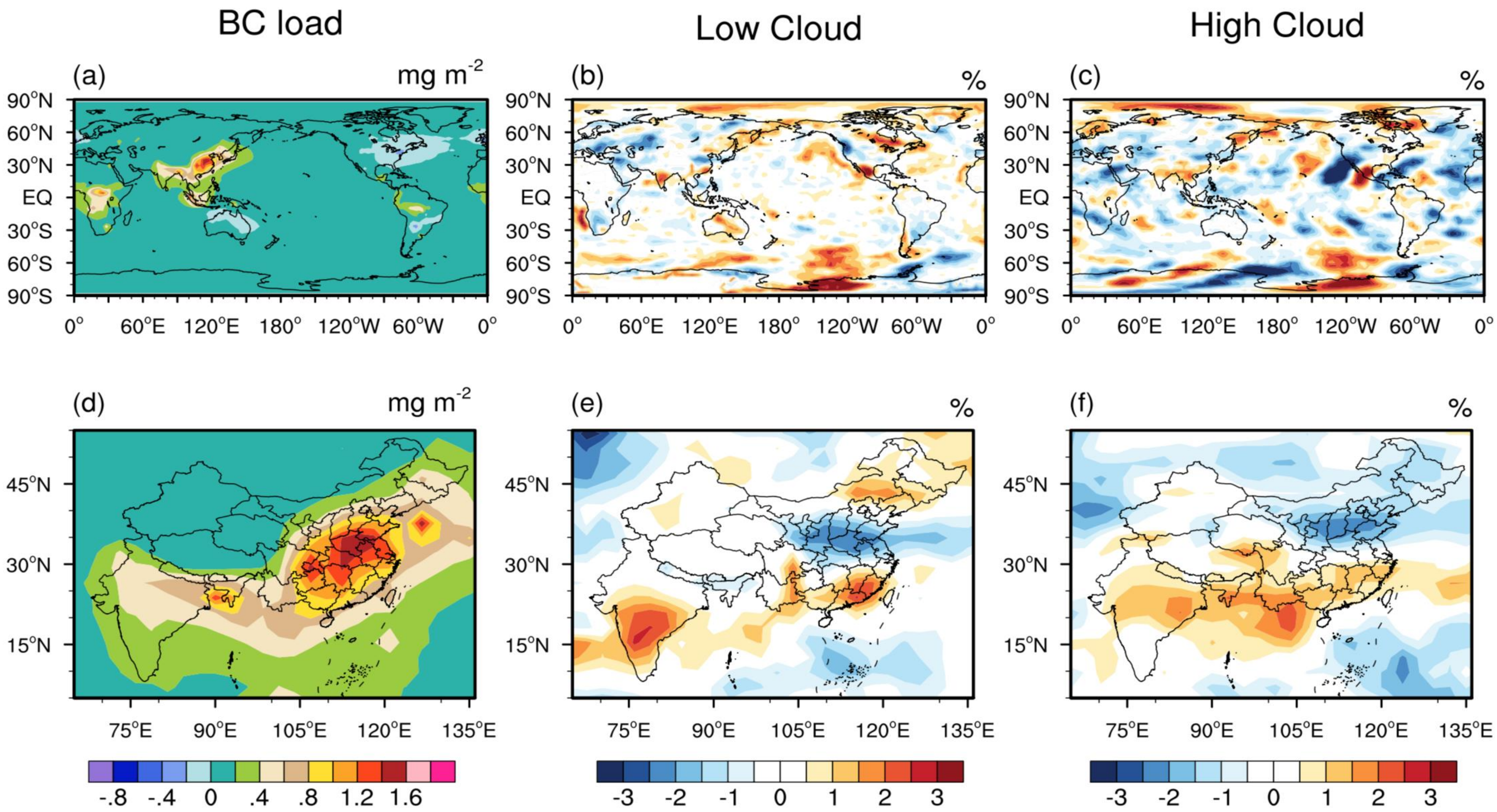
Results

Effective Radiative Forcing



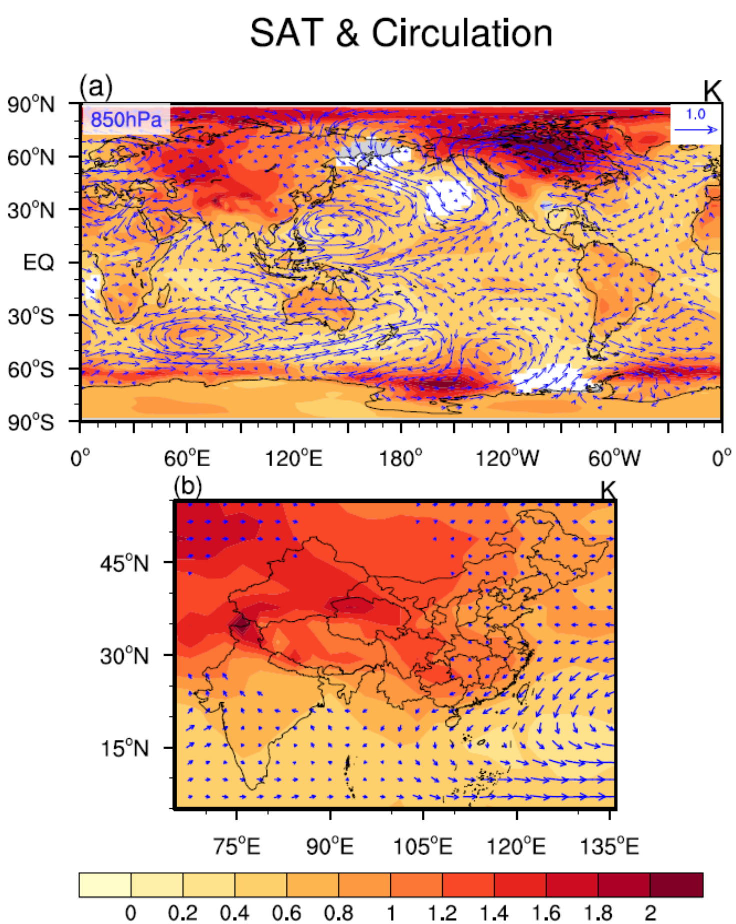
Annual mean ERF (left column), shortwave ERF (middle column), and longwave ERF (right column), which are obtained by the difference between $S_{ERF2010}$ and ERF_{1850}

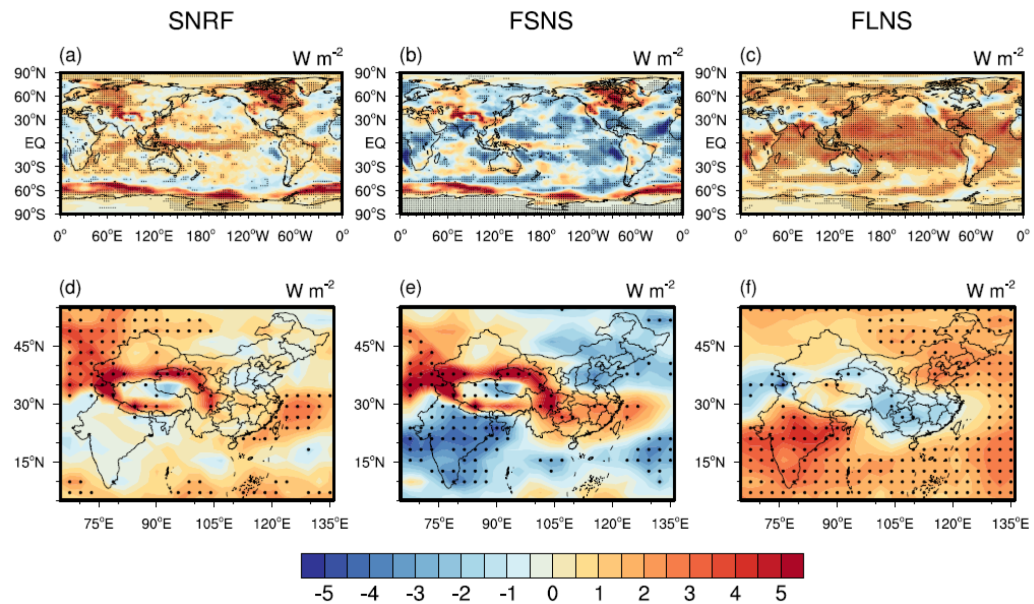
Results



Annual mean differences of BC loading (left column), low cloud (middle column), and high cloud (right column) between $S_{ERF2010}$ and ERF_{1850}

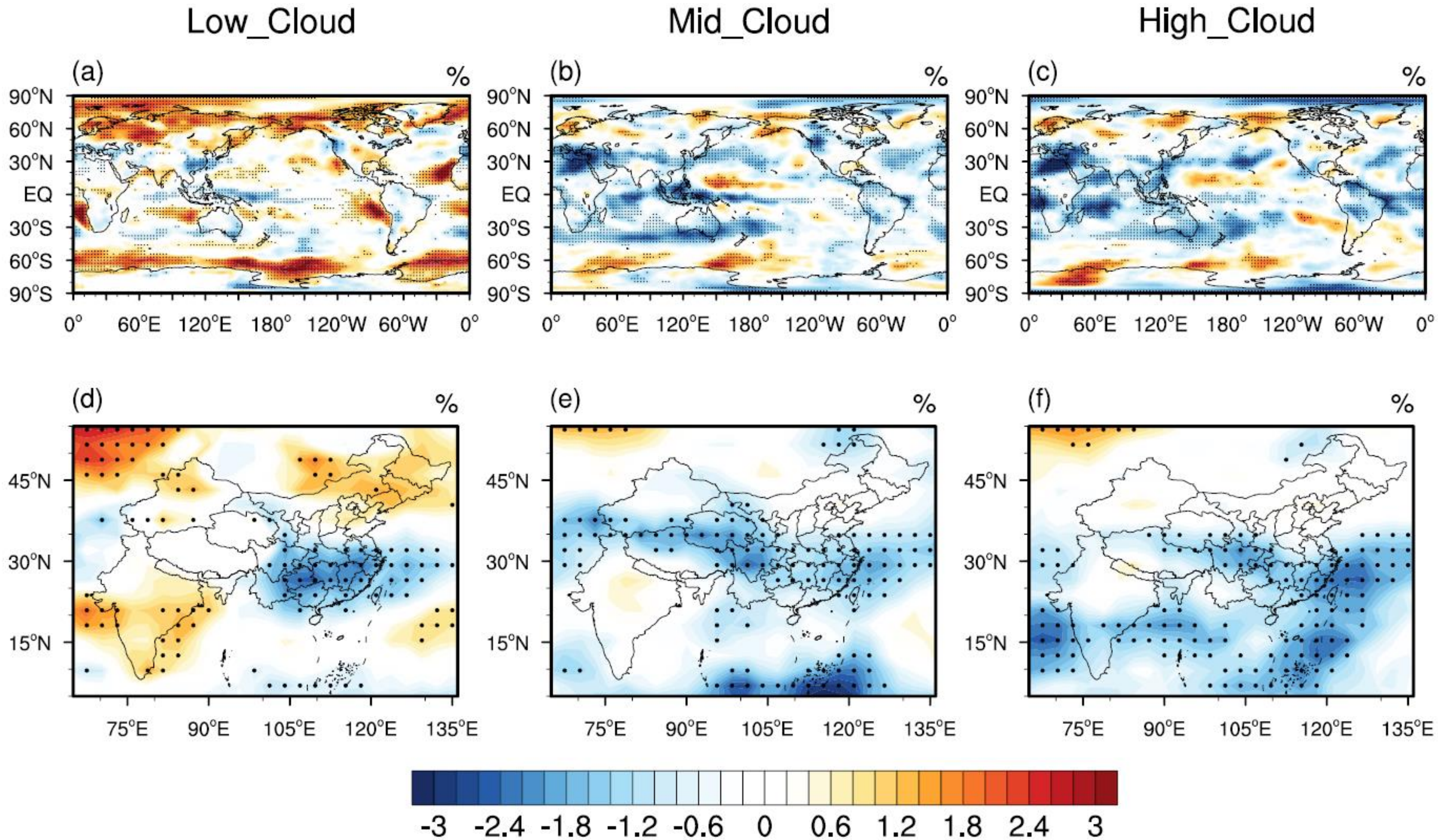
Results





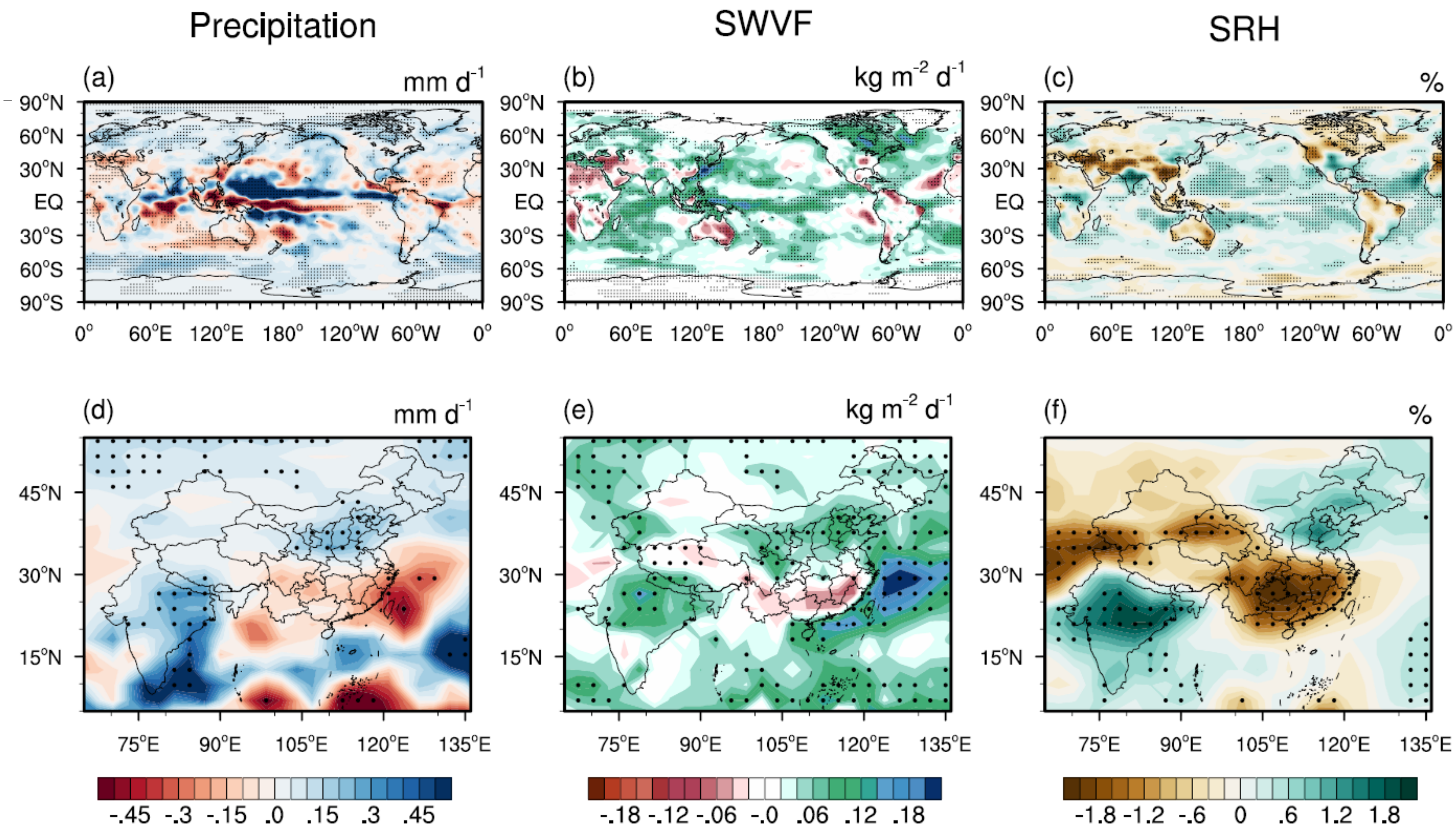
Annual mean differences of surface air temperature (Left) and SNRF/FSNS/FLNS (Right) between S_{CR2010} and CR_{1850}.

Results



Annual mean differences of low (left column), middle (middle column), and high (right column) cloud covers between S_{CR2010} and CR_{1850}.

Results



Annual mean differences of precipitation (left column), SWVF (middle column), and SRH (right column) between SCR2010 and CR1850.

Thank you!

南京信息工程大学
Nanjing University of Information Science & Technology

Impacts of domestic emissions and regional transport on aerosol concentration, radiative forcing and climate

Yang Yang

School of Environmental Science and Engineering
Nanjing University of Information Science and Technology

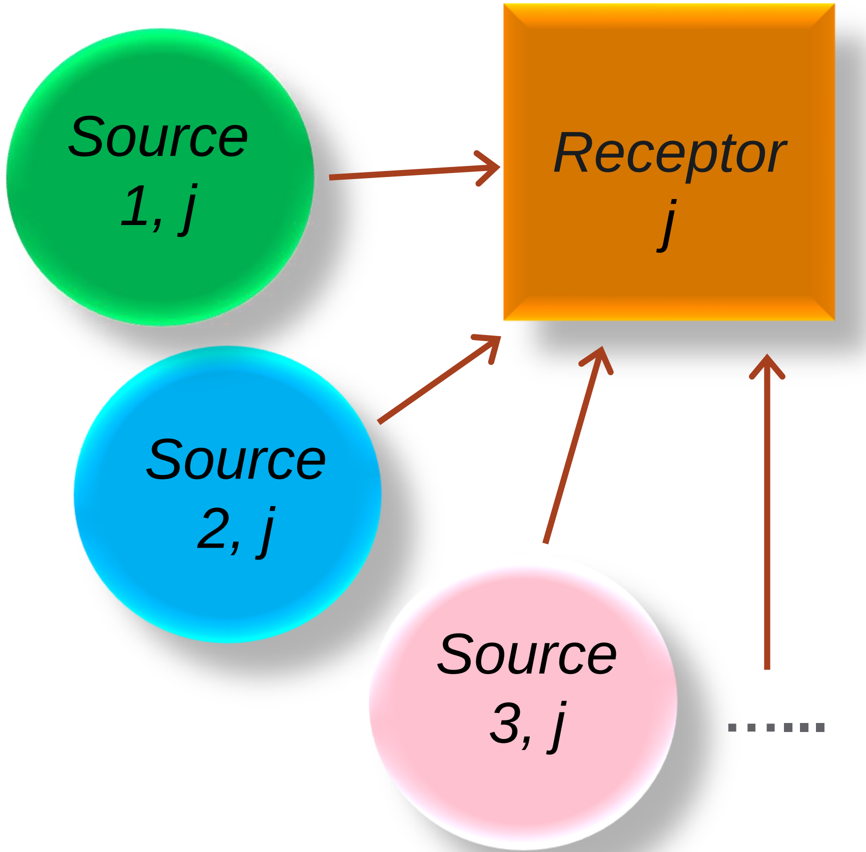
October 1, 2020

CAM5-EAST Model

NCAR CESM-CAM5

+

Explicit Aerosol Source Tagging:



Explicit Aerosol Source Tagging (EAST)

BC Tagging in CAM5.1

Wang et al. JGR (2014)

↓

BC Tagging in CAM5.3

Yang et al. ACP (2017a)

↓

Sulfate Tagging in CAM5.3

Yang et al. ACP (2017b) | Yang et al. JGR (2018)

↓

CAM5-EAST (BC, POM, SOA, Sulfate) -> EAM-EAST / CAM6-EAST

Yang et al. Sci. Rep. (2018)	Yang et al. Earth's Future (2018)	Yang et al. ACP (2020)	Ren, Yang* et al. ACP (2020)
↑	↑	↑	↑
China	**U.S.**	**Europe**	**Arctic**

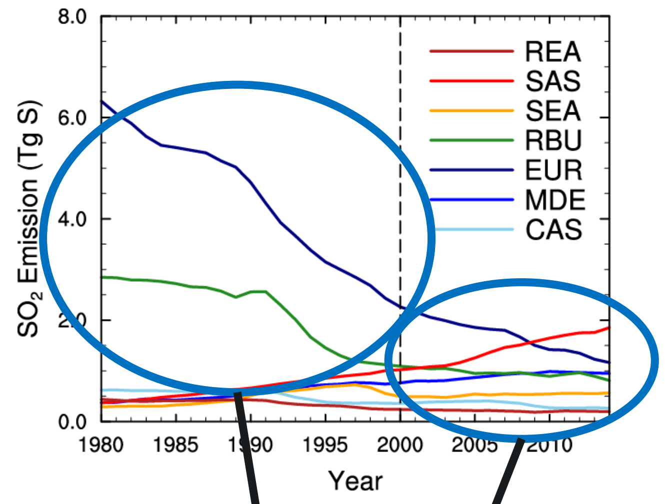
Slowdown of foreign emission reduction together with weakening winds intensify $PM_{2.5}$ by 25%

Δ: 2000-2014 vs. 1980-2000

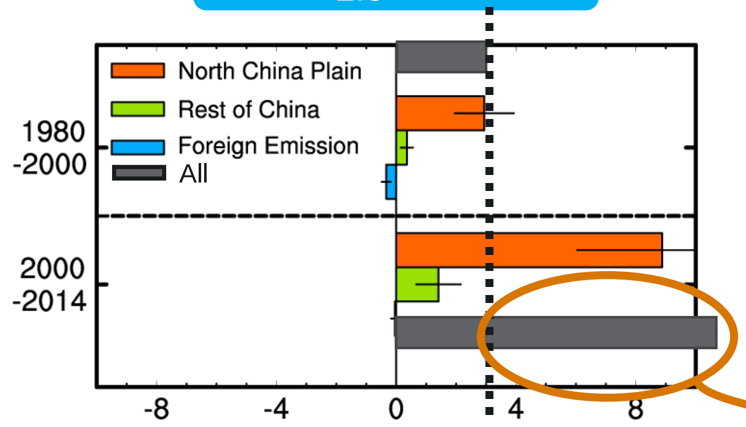
$$100\% = \frac{\Delta TR_{DOM}}{\Delta TR} + \frac{\Delta TR_{FOR}}{\Delta TR} + \frac{\Delta TR_{MET}}{\Delta TR}$$

75% | 6% | 19%

Foreign SO_2 Emission



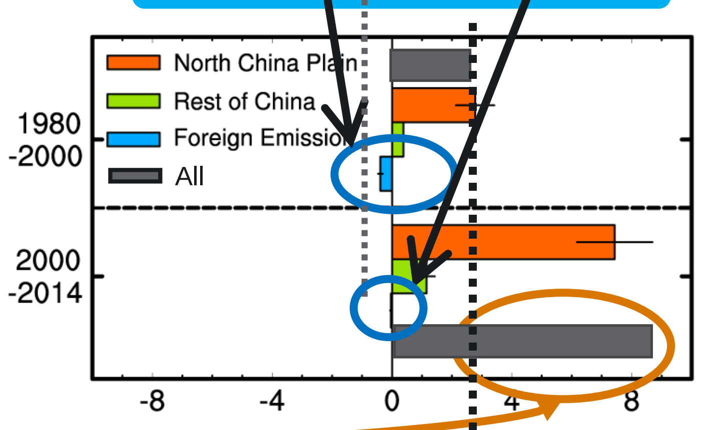
$PM_{2.5}$ Trend



$PM_{2.5}$ Contribution Trend
(μg m^{-3} $decade^{-1}$)

Remove meteorological influence

Normalized Trend



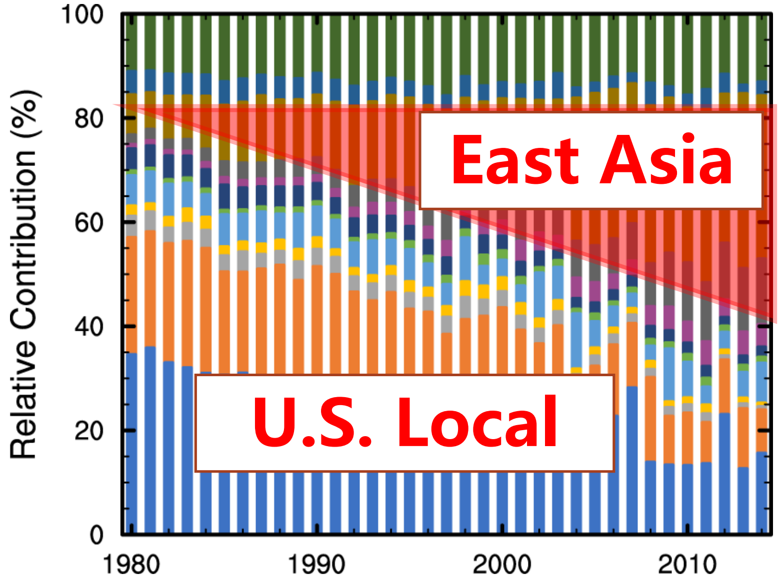
Trend of Normalized $PM_{2.5}$
(μg m^{-3} $decade^{-1}$)

China

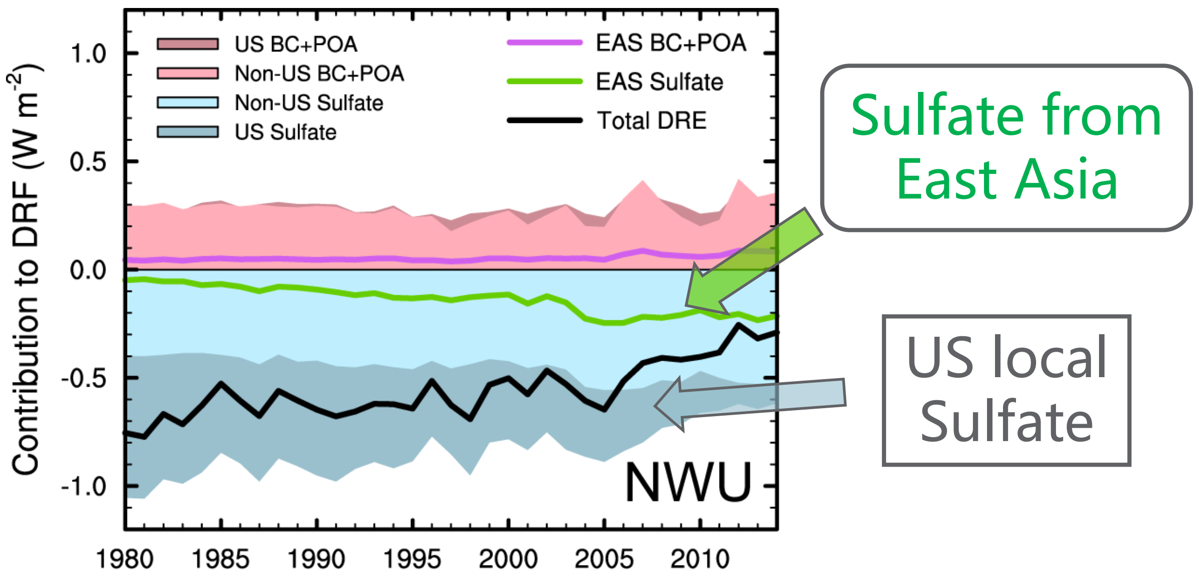
Yang, Y. et al., Sci. Rep. (2018)

Increases in emissions from E. Asia mitigated the warming effect induced by reductions in U.S. emissions by 25% in western US

Relative Contribution to $PM_{2.5}$ Column Burden in US (%)



Aerosol DRF in US

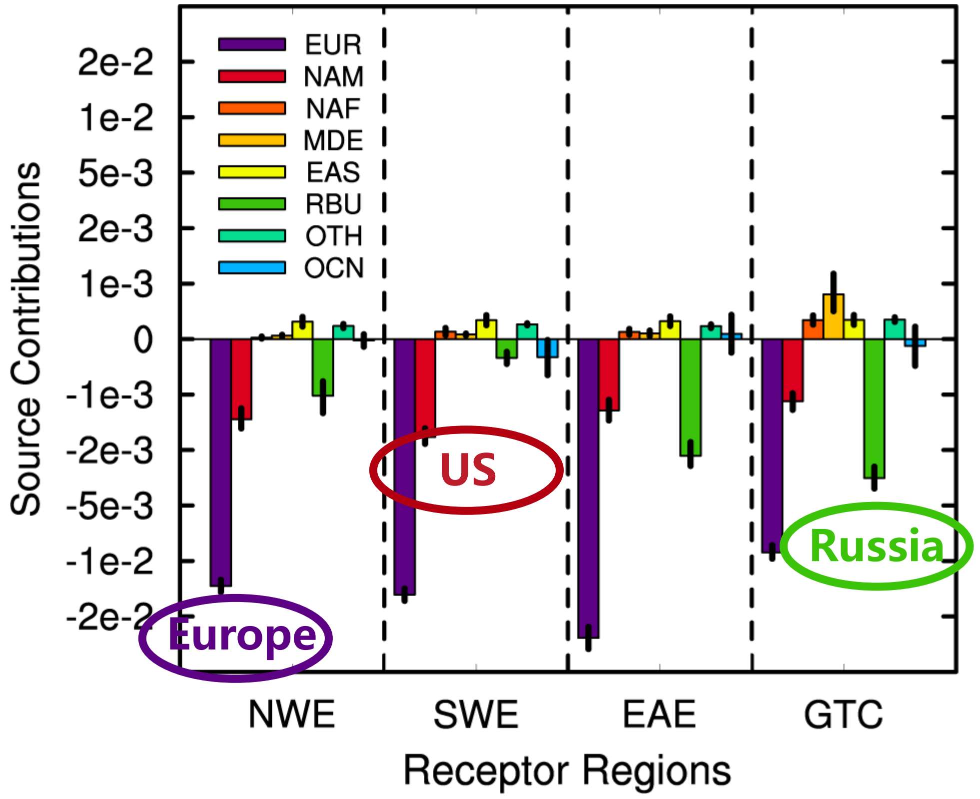


U.S.

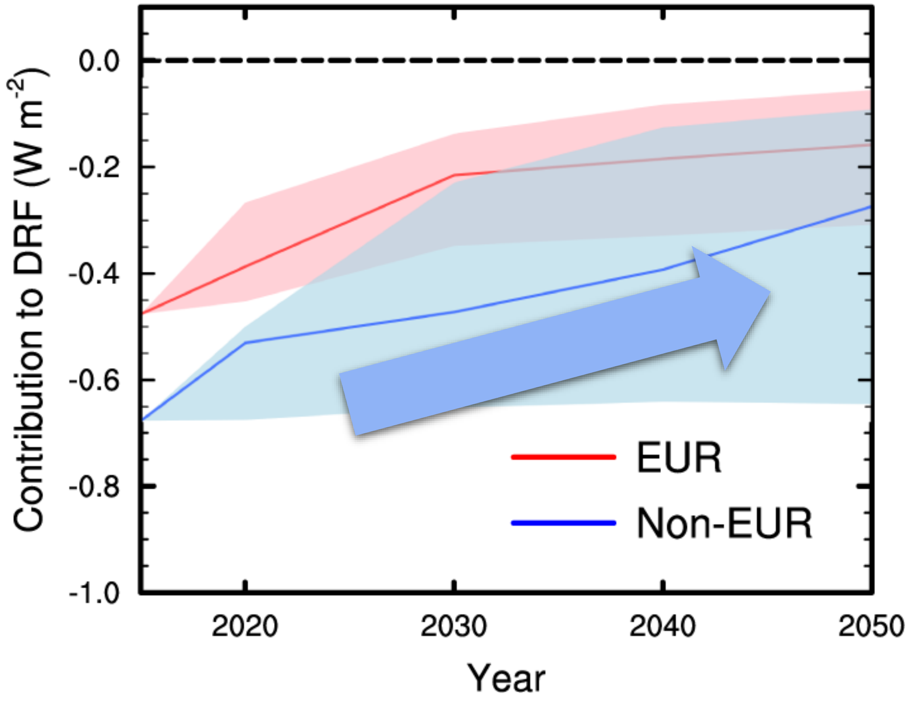
Yang, Y. et al., Earth's Future (2018)

Future changes in non-European emissions are as important as European emissions for causing possible regional climate change

AOD trends in Europe contributed by individual sources



Future sulfate DRF in Europe from local and non-local sources



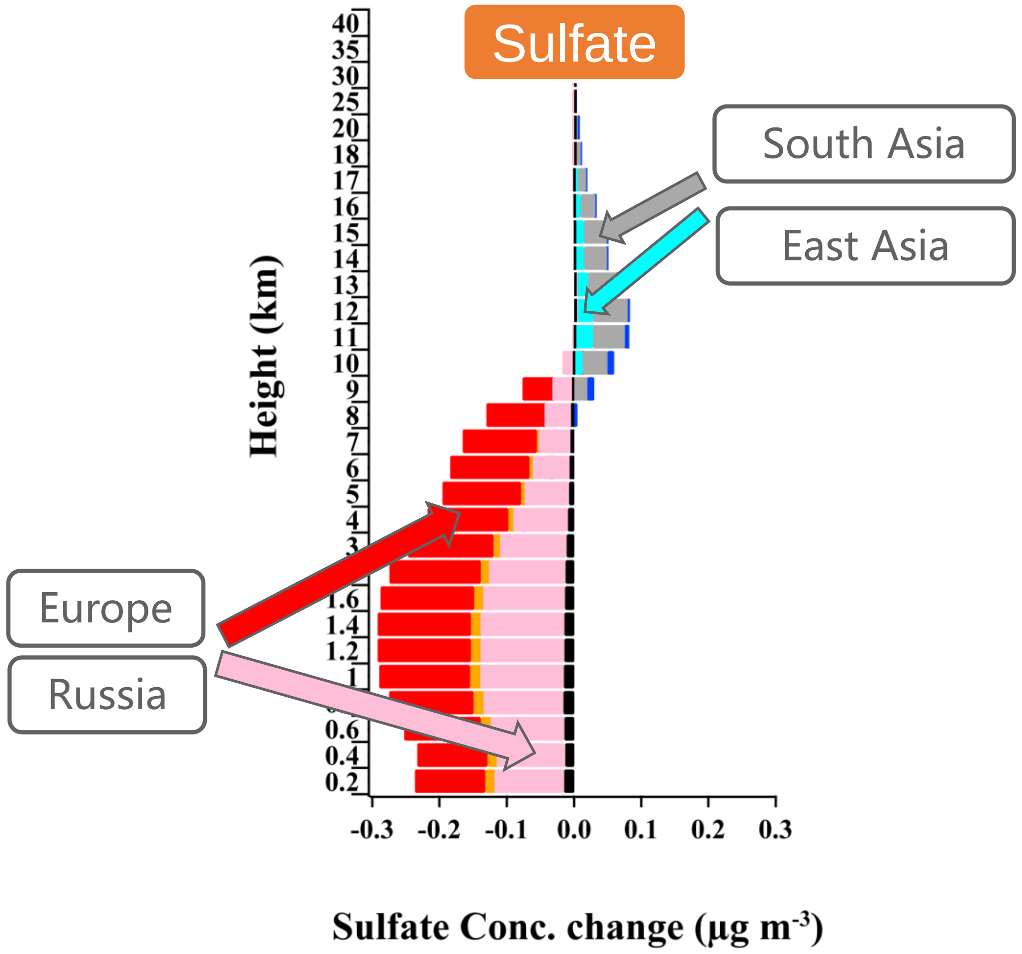
Non-EUR ≈ EUR

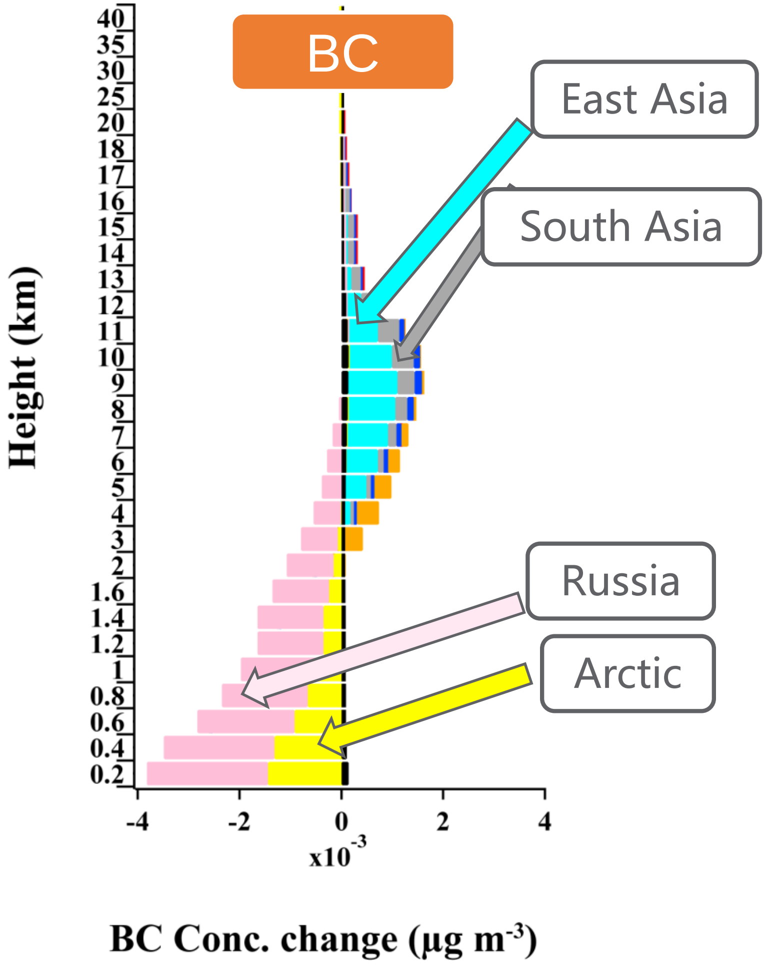
Europe

Yang, Y. et al., ACP (2020)

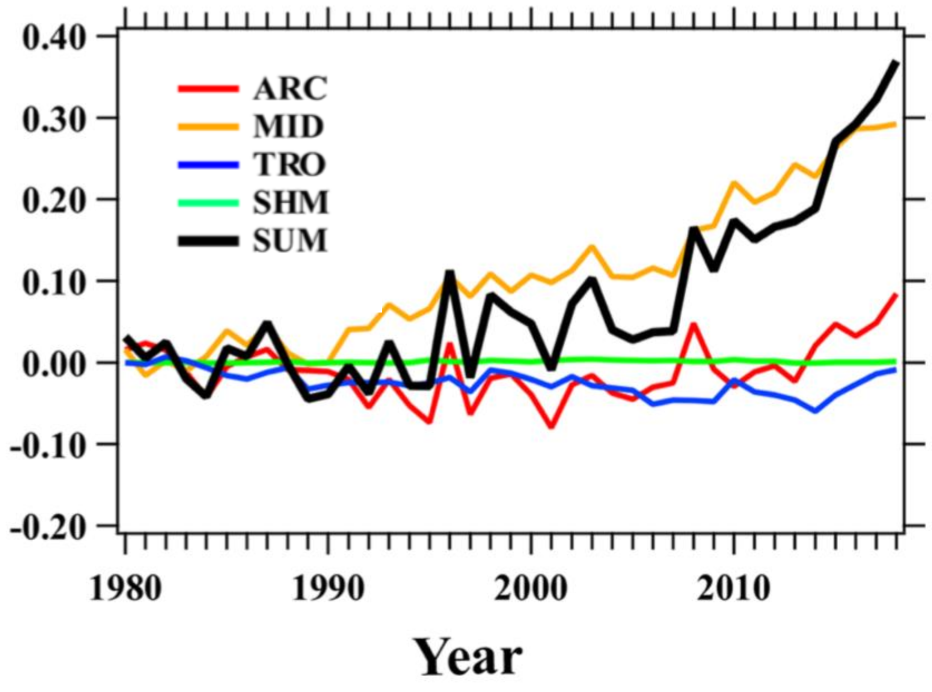
Sulfate and BC produced an Arctic surface warming of +0.30 K, explaining approximately 20 % of the observed Arctic warming since the early 1980s.

Aerosol vertical concentration change between 1980–1984 and 2014–2018 in the Arctic





Estimated response in surface temperatures to changes in sulfate and BC



Arctic

Ren, Yang*, et al., ACP (2020)