Effect of monsoon on aerosols in East Asia and the other way around

1. Jeong, J. I. and R. J. Park (2017), Winter monsoon variability and its impact on aerosol concentrations in East Asia, Environmental Pollution, 211, 285-292.
2. Kim, M. J., S. -W. Yeh, and R. J. Park (2016), Effects of sulfate aerosol forcings on East Asian summer monsoon for 1985-2010, Geophys. Res. Lett., 43, 1364-1372, doi: 10.1002/2015GL067124.

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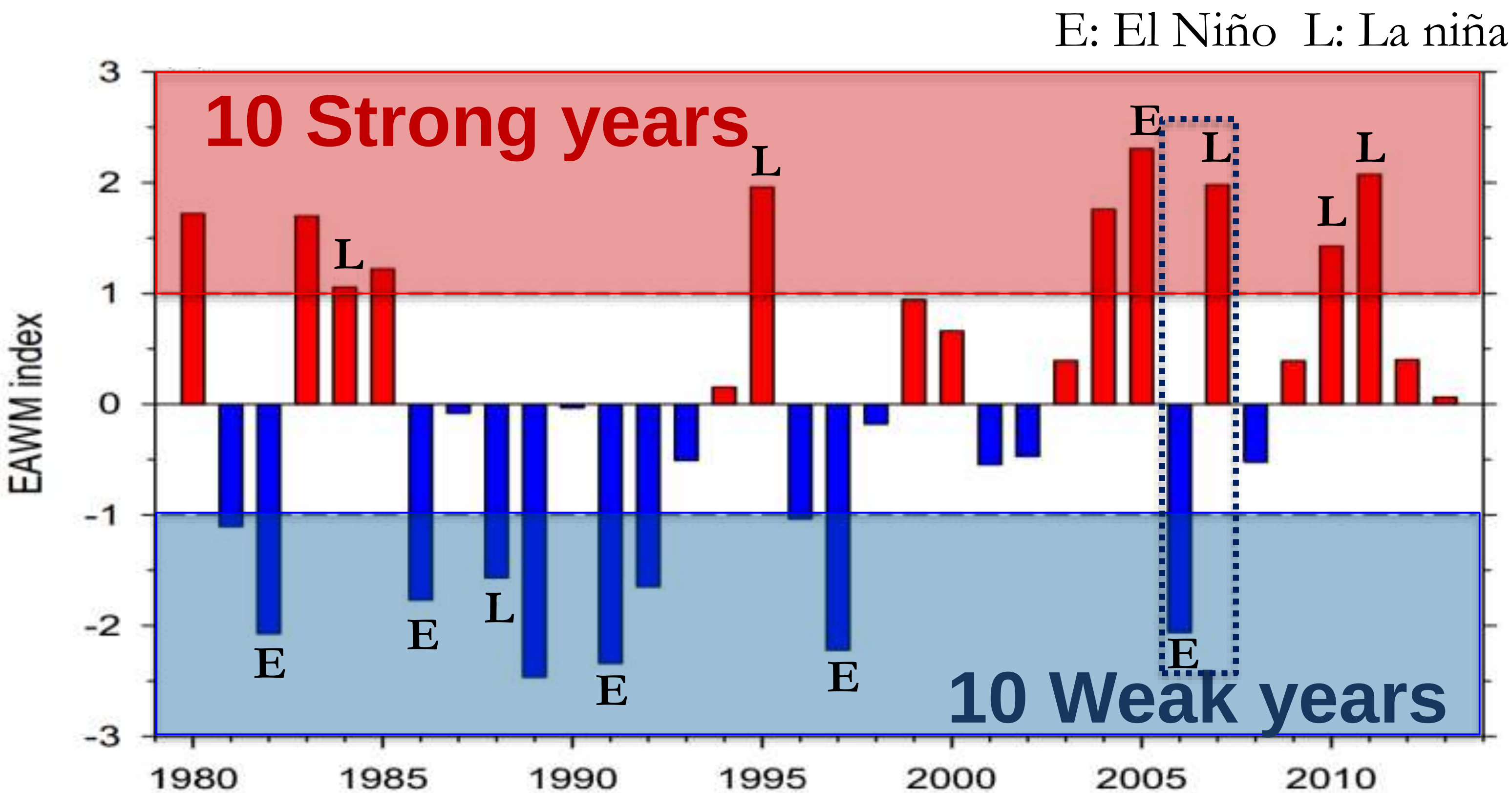
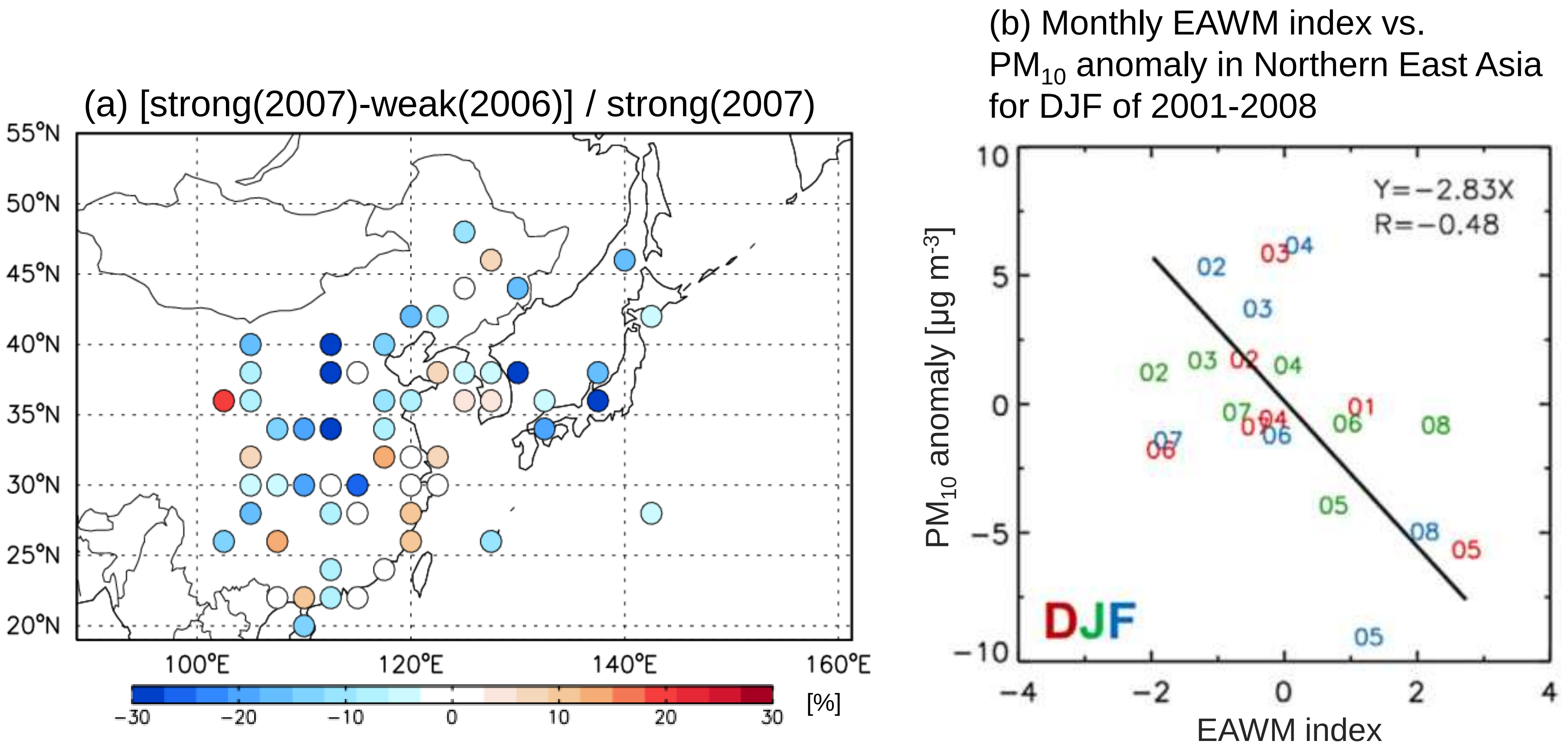
The 3rd workshop on Atmospheric Composition and the Asian Monsoon (ACAM), Jinan University, Guangzhou, China, 5-9 June 2017

Normalized East Asian Winter Monsoon Index using MERRA following Wang and Chen [2014]



- ✓ Weak (strong) EAWM cases were mostly found to be associated with El Niño (La Niña).
- ✓ We calculate the differences of aerosol concentrations averaged between over ten strong EAWM years and over ten weak EAWM years.

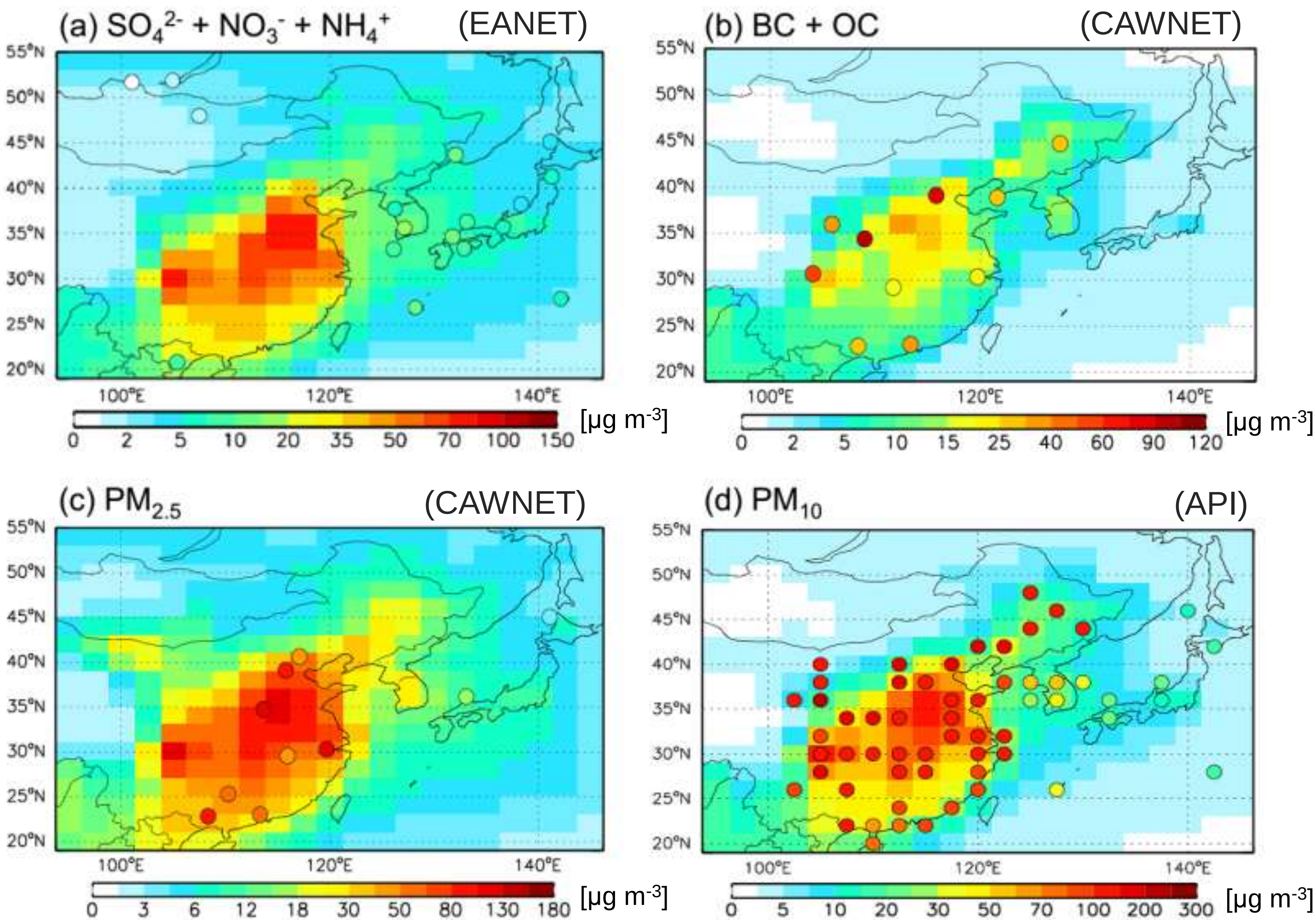
Impact of EAWM on observed surface PM10 concentrations



- ✓ Strong monsoon year in 2007 shows lower values at most sites in the northern part of East Asia.
- ✓ Observed surface aerosol concentrations have a negative correlation with the variability of EAWM for 2001-2008.

[*Jeong and Park*, 2017]

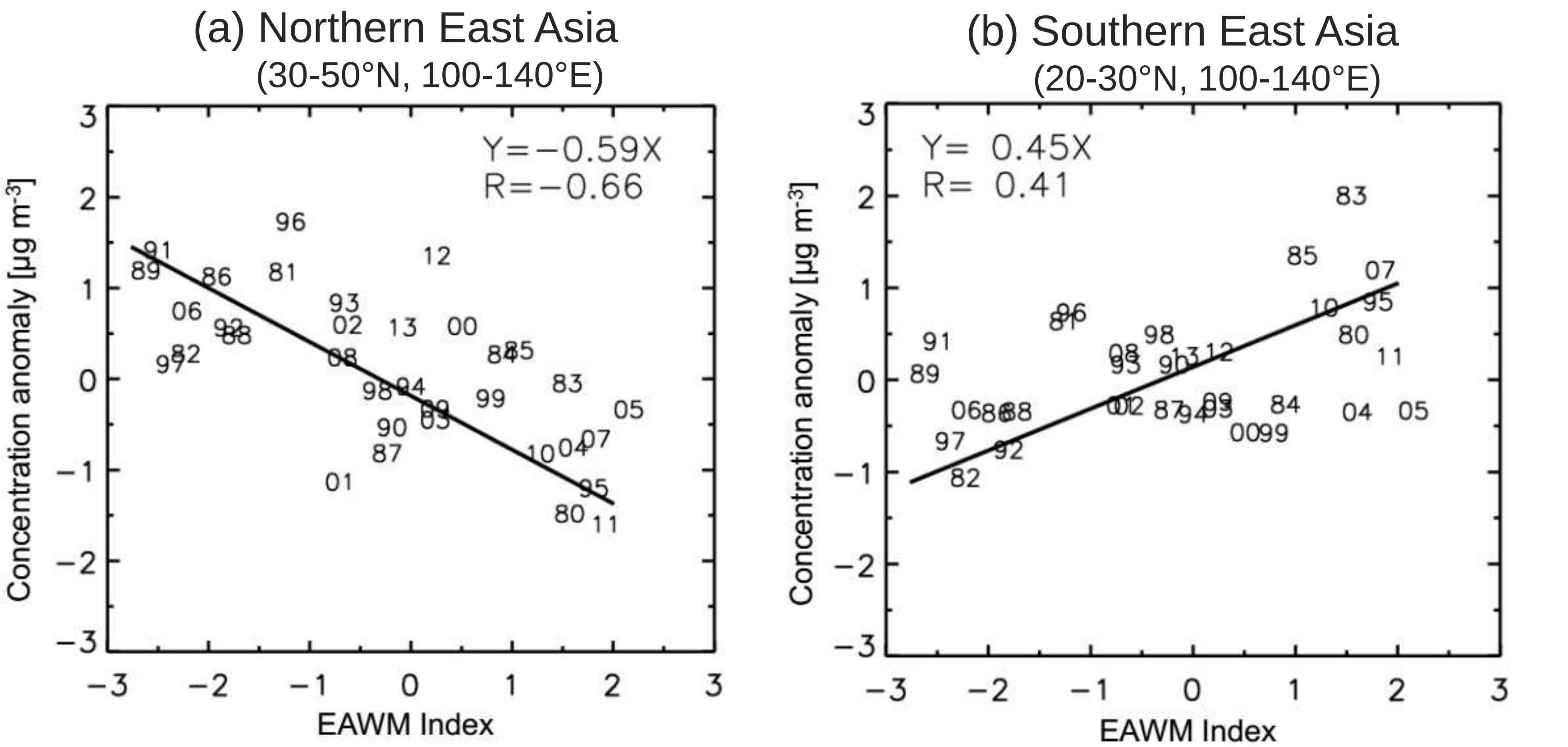
Observed vs. GEOS-Chem aerosol concentrations in Winter 2006



✓ Our model generally captures the spatial pattern of surface aerosol concentrations over East Asia.

[*Jeong and Park*, 2017]

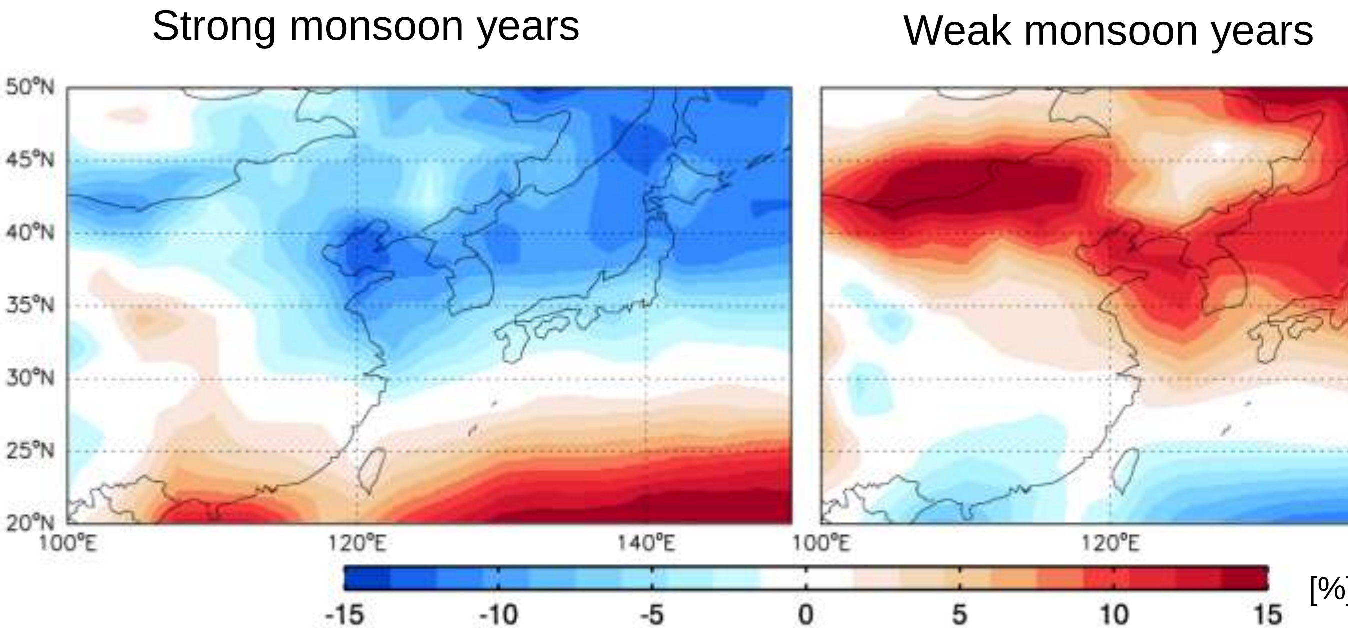
EAWM index vs. anomalies of the modeled PM2.5 concentrations over northern and southern East Asia for 1980-2013



[*Jeong and Park*, 2017]

- ✓ Northern East Asia: negative-correlation with the intensity of the EAWM
- ✓ Southern East Asia: correlate positively with the intensity of the EAWM

Percentage differences of PM2.5 concentrations for strong and weak monsoon relative to climatology



Strong monsoon years	Weak monsoon years
10% lower concentration in northern East Asia 15% higher concentration in southern East Asia	15% higher concentration in northern East Asia 10% lower concentration in southern East Asia

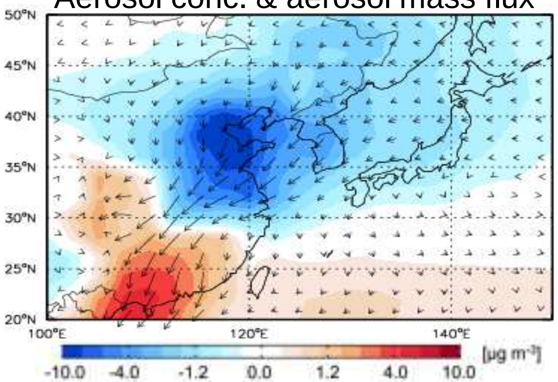
✓ Spatial-temporal variations of wintertime aerosols are highly influenced by the EAWM variability over East Asia

[*Jeong and Park*, 2017]

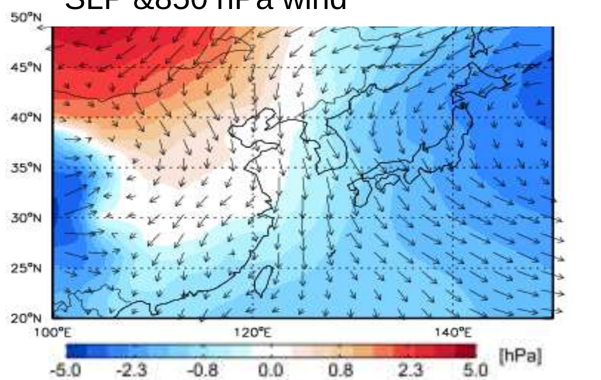
Differences of simulated PM2.5 concentrations and meteorological fields between strong monsoon years and climatology

EAWM: Wang and Chen, 2014

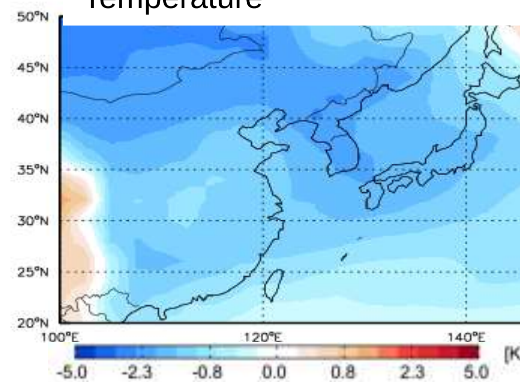
Aerosol conc. & aerosol mass flux



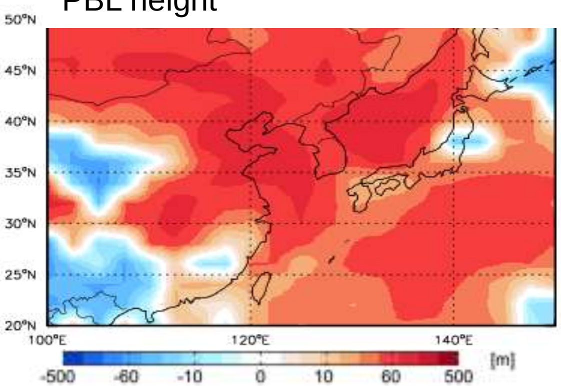
SLP &850 hPa wind



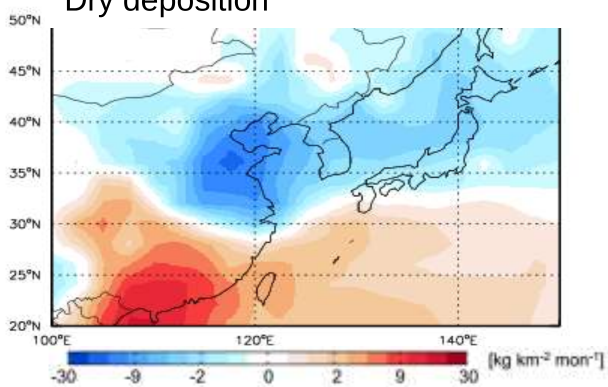
Temperature



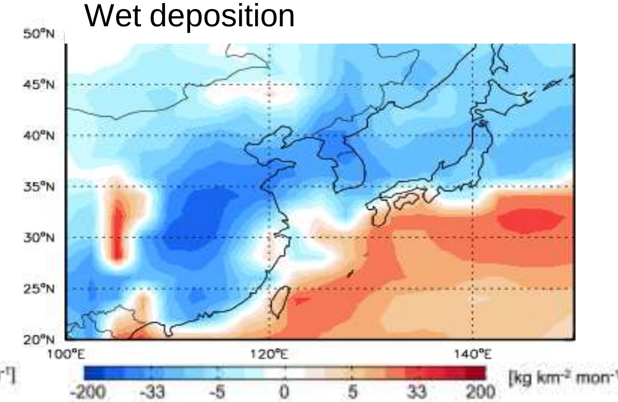
PBL height



Dry deposition

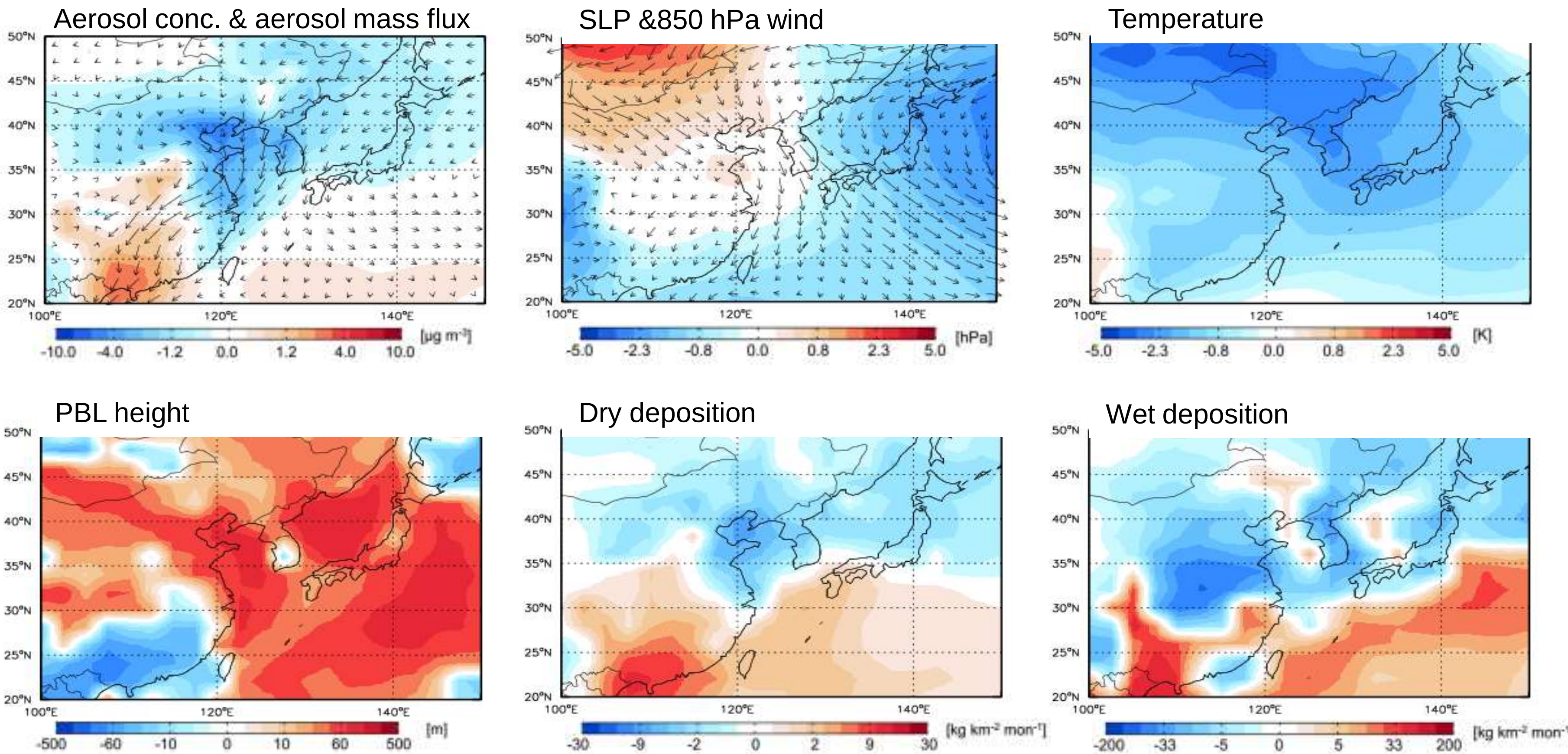


Wet deposition



Differences of simulated PM2.5 concentrations and meteorological fields between strong monsoon years and climatology

EAWM: Jhun and Lee, 2004

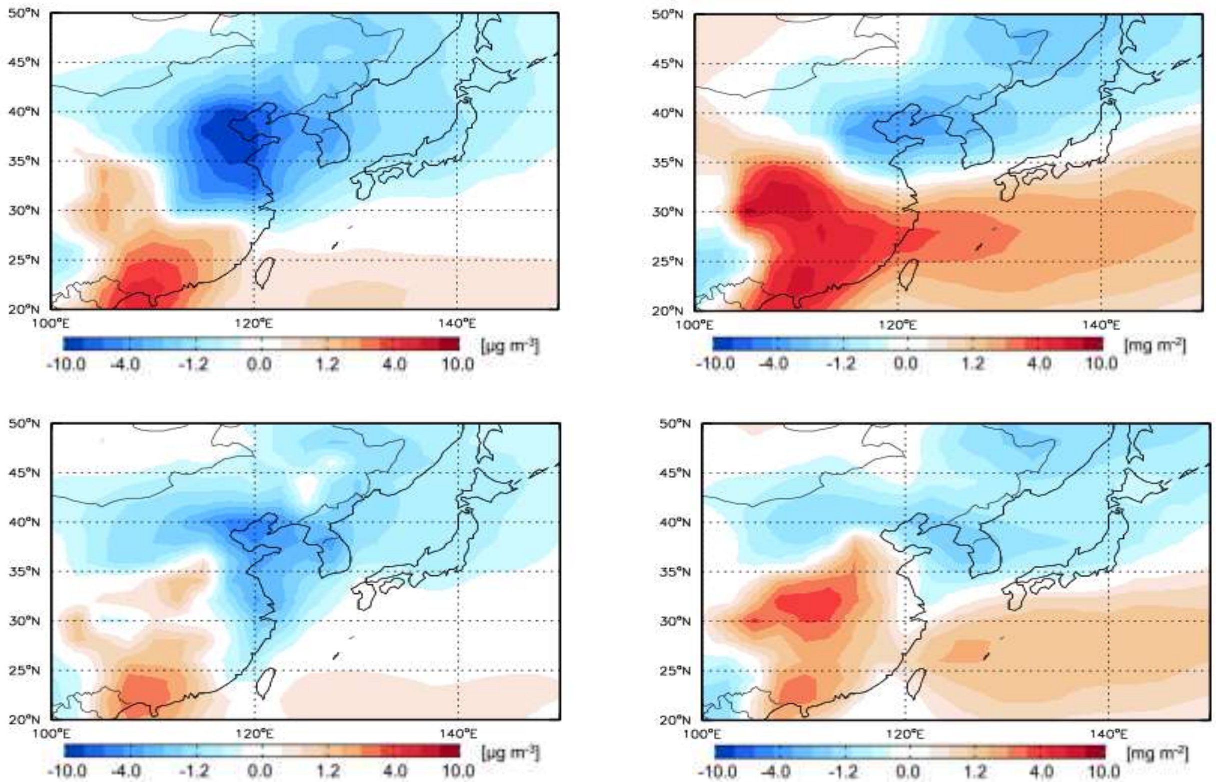


Differences of simulated PM2.5 concentrations in surface air and vertical column between strong monsoon years and climatology

Surface | Column

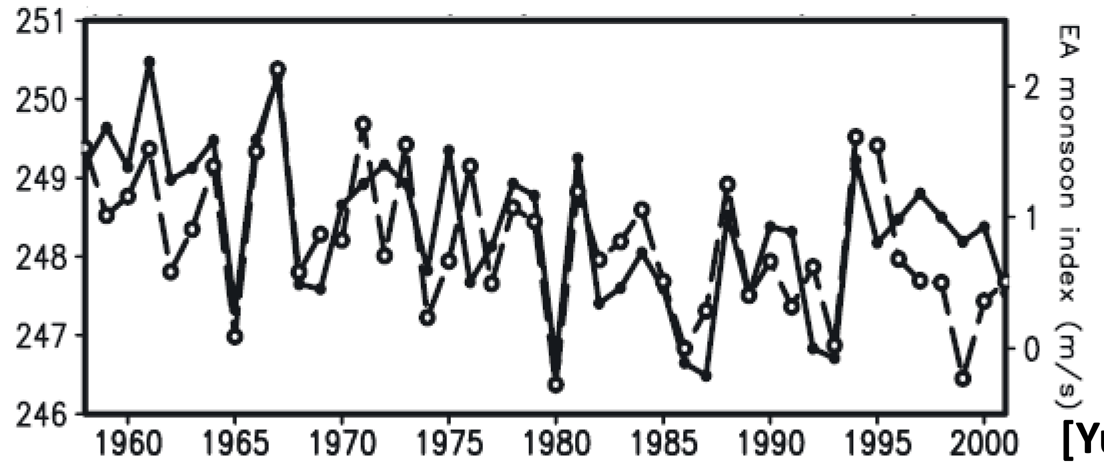
Wang and Chen, 2014

Jhun and Lee, 2004



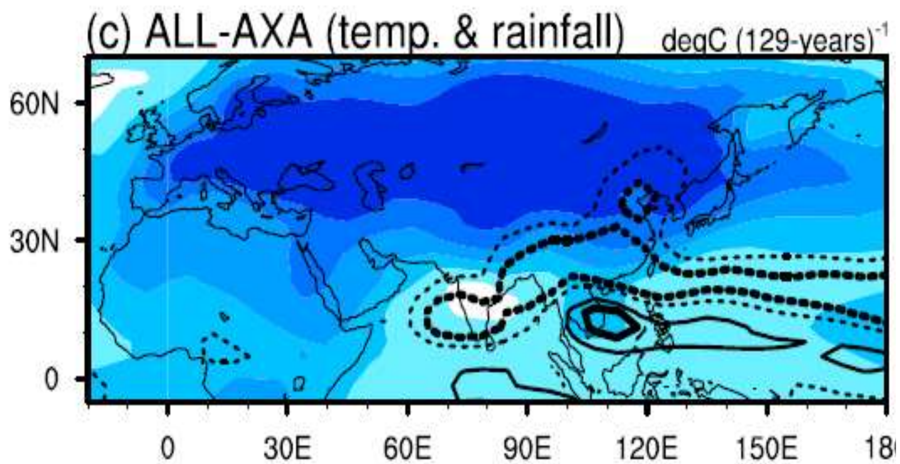
East Asian summer monsoon trend and the effect of sulfate aerosols on its change

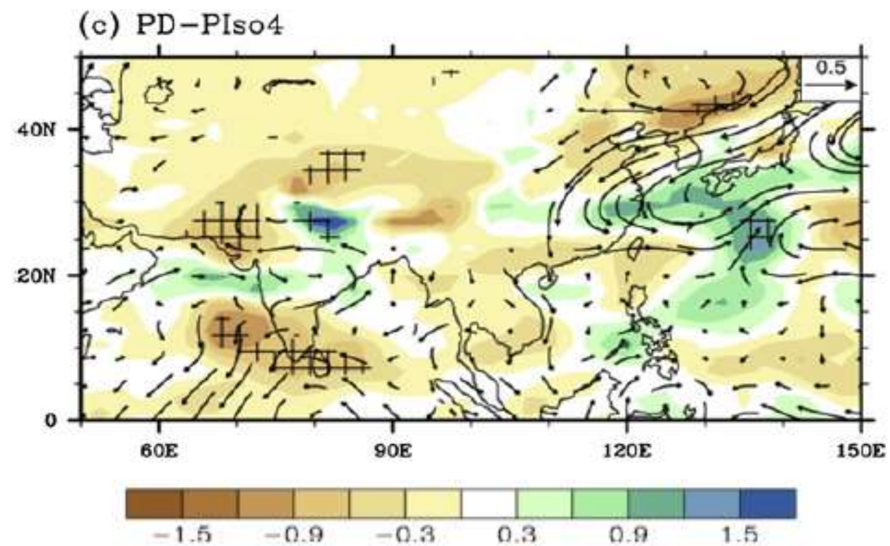
EAST ASIA SUMMER MONSOON INDEX



[Yu et al., 2004]

Effect of Sulfate aerosol on EASM





[Cowan and Cai, 2011]

[Jiang et al, 2013]

UNIFIED MONSOON INDEX

A unified monsoon index

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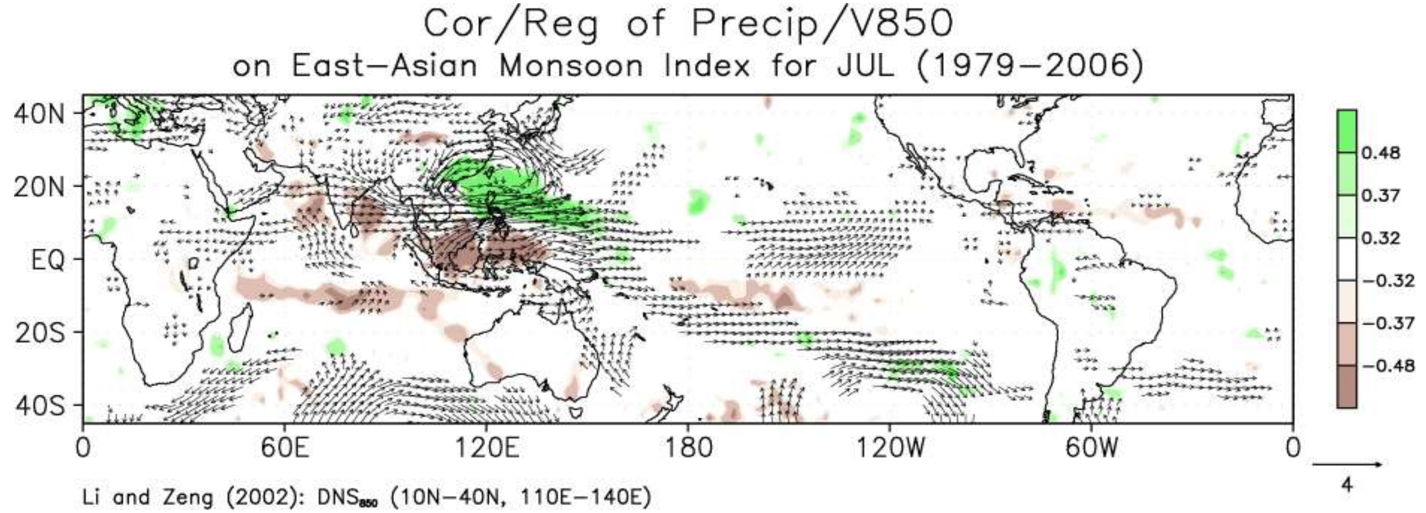
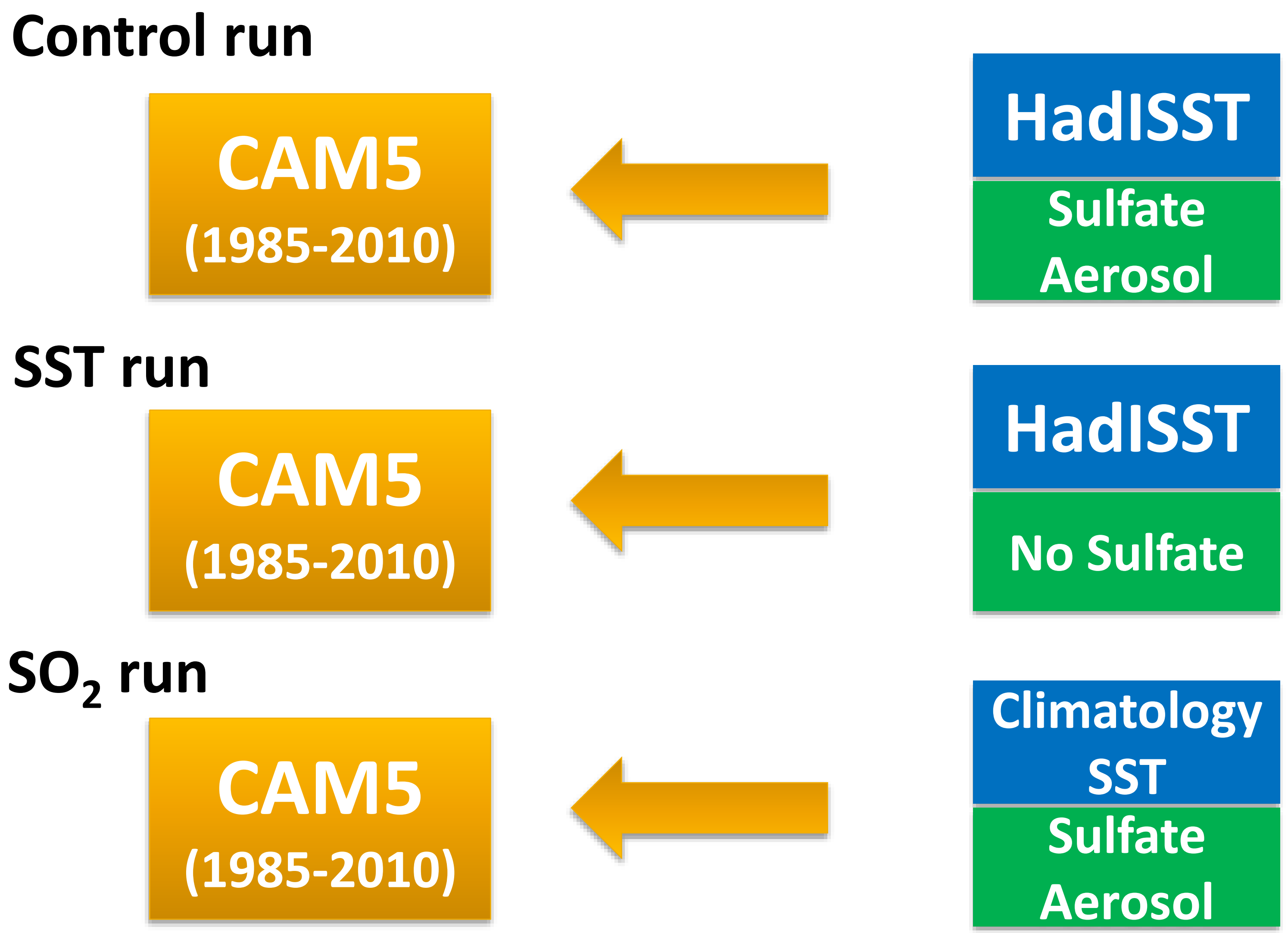
Received 1 August 2001; revised 15 November 2001; accepted 7 January 2002; published 30 April 2002.

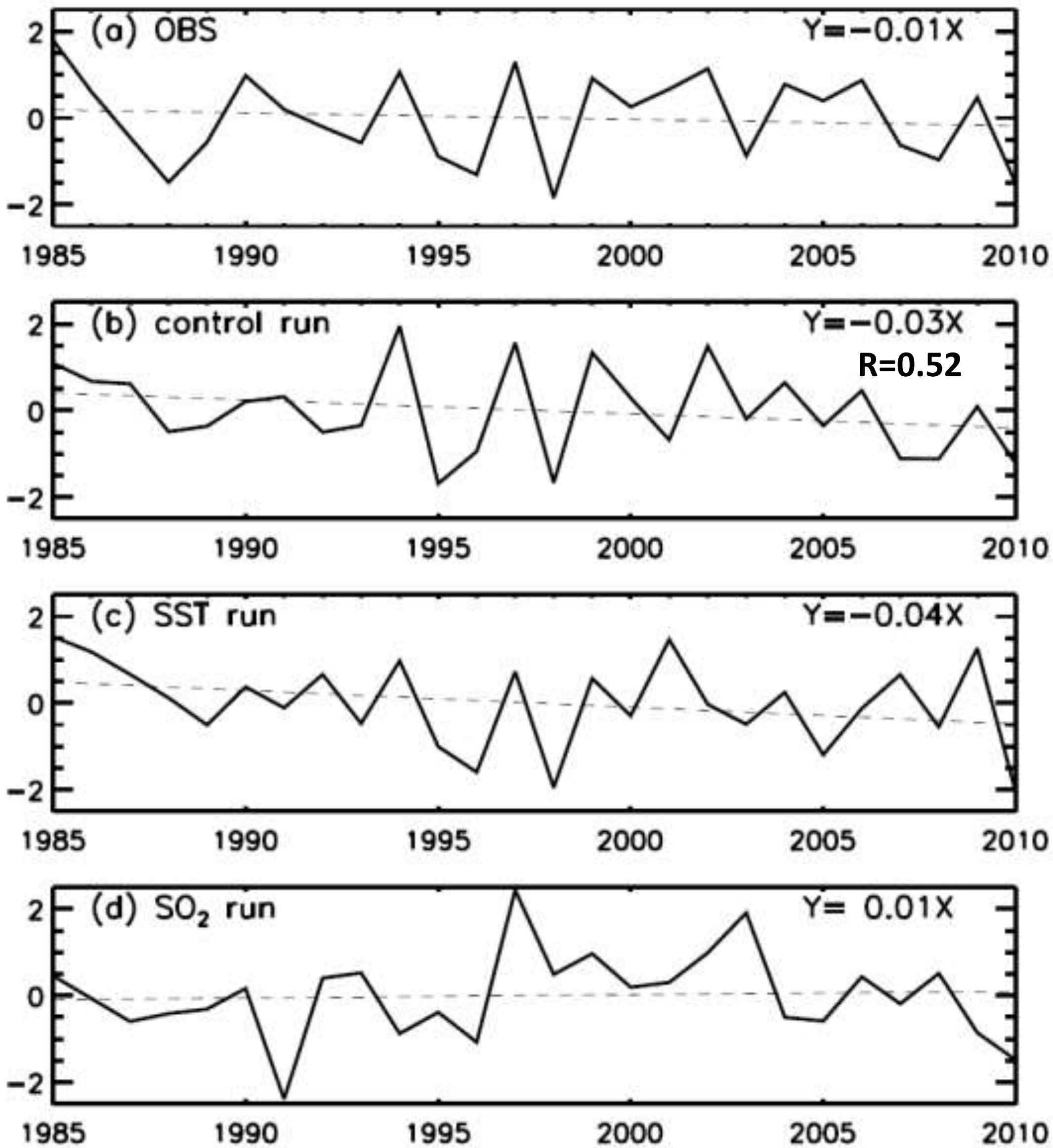
$$\mathrm{EASMI} = \frac{||\overline{\mathrm{V}}_W - \mathrm{V}_i||}{||\overline{\mathrm{V}}||} - 2 \qquad \text{where} \qquad ||\mathrm{A}|| = \left(\iint_S |A|^2\, dS\right)^{1/2}$$



CAM5 Simulations for 26 yrs



EASM INDEX TREND



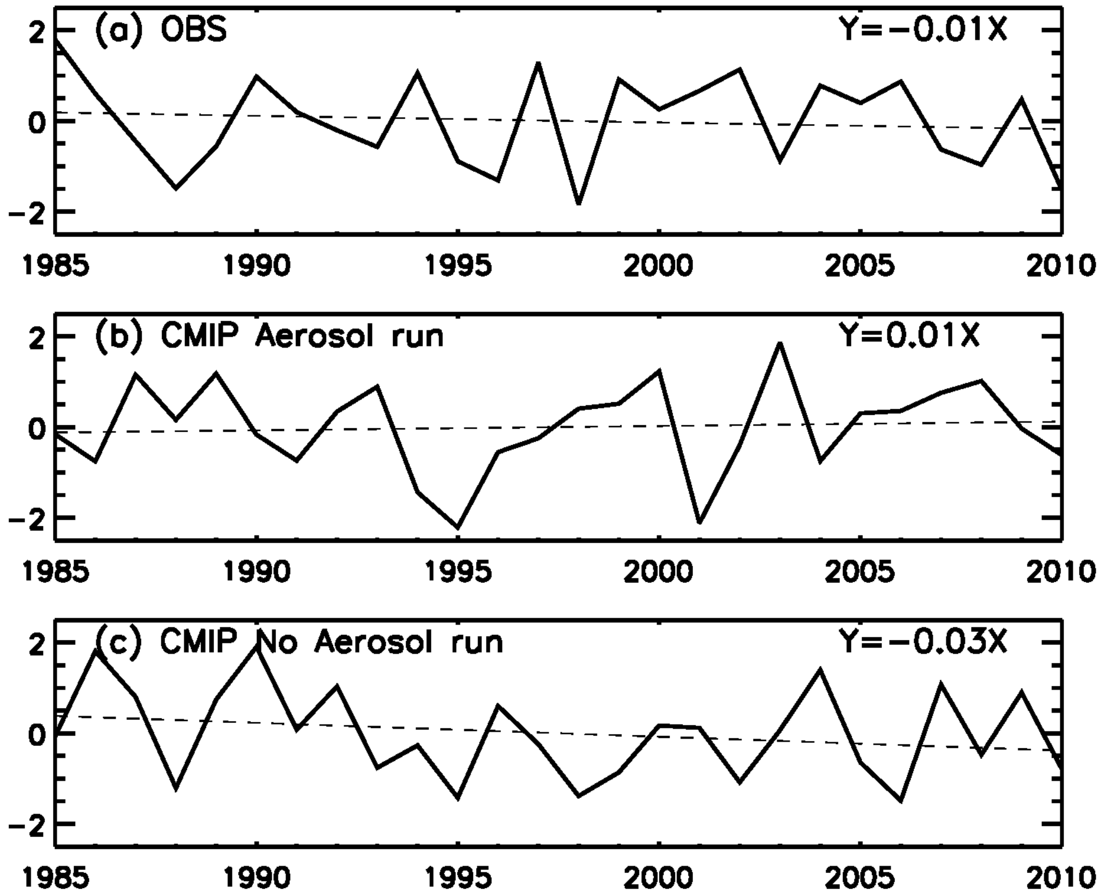
EASM index is characterized by a slight decreasing trend in the observation.

Weakening of the EASM is also found in both the control run and the SST run.

The EASM index simulated in the SO_2 run is characterized by a slightly increasing trend for 1985–2010.

[Kim et al., 2016]

EASM INDEX TREND IN COUPLED SIMULATION



Weakening of the EASM is also found in the CMIP no Aerosol run.

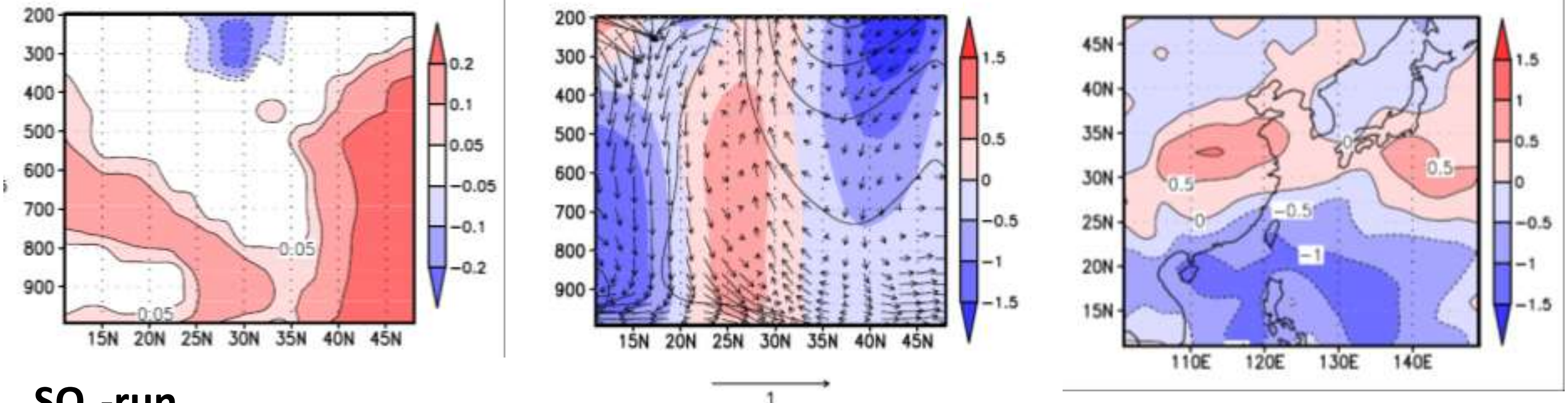
The EASM index simulated in the CMIP Aerosol run is characterized by a slightly increasing trend.

These results are consistent with those of AMIP simulation

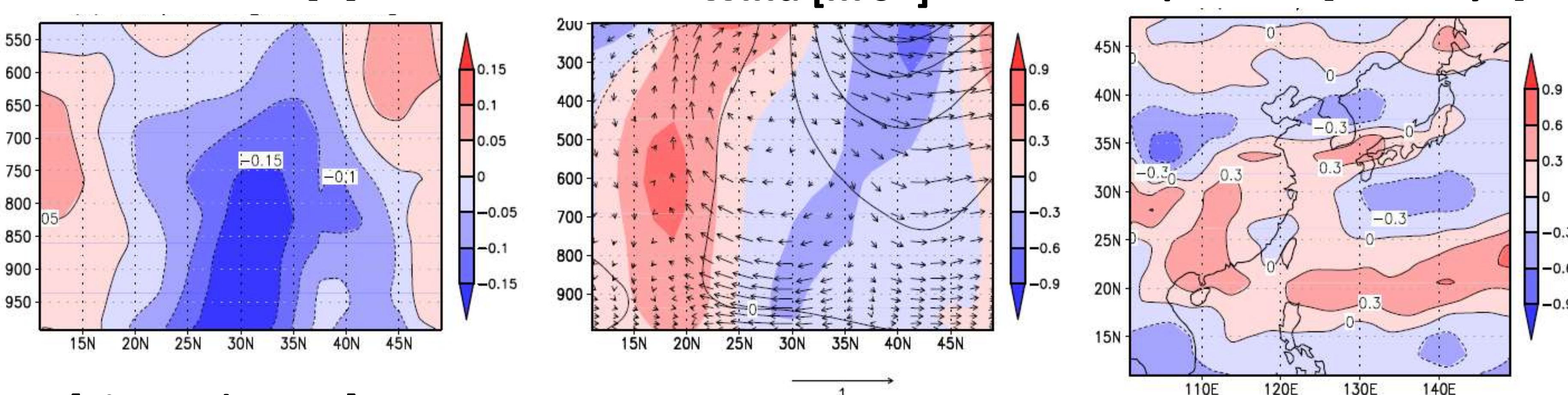
THE DIFFERENCES IN METFILEDS BETWEEN 2001-2010 AND 1985-1994

SST-run

TEMP [K] [100°E-140°E] **Wind [m s^{-1}]** **Precipitation [mm day^{-1}]**



SO_2-run **TEMP [K]** **Wind [m s^{-1}]** **Precipitation [mm day^{-1}]**

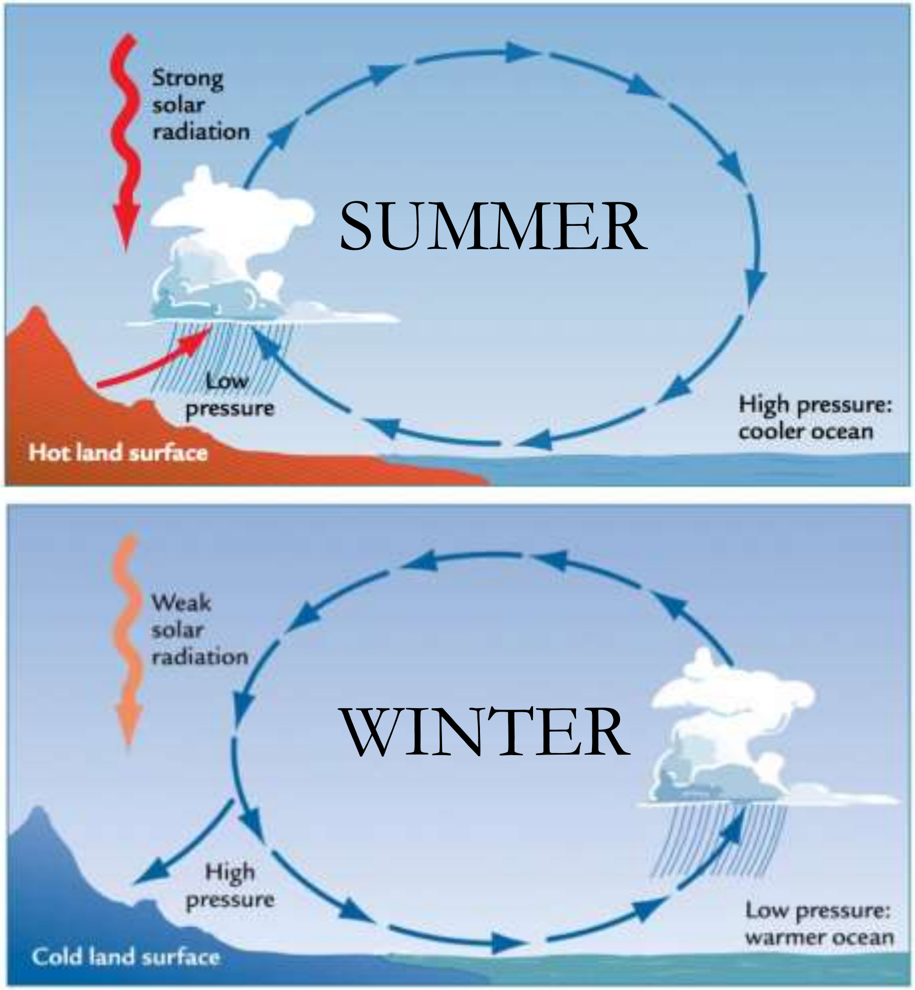


[Kim et al., 2016]

Summary

- East Asian monsoon has a significant impact on the distribution of aerosol concentrations in winter.
- Aerosol plays a role in the change of East Asian summer monsoon, which needs to be investigated further to understand the interactions between SST, aerosols, and monsoon.

Monsoon Circulation



- ✓ Monsoon is a seasonal shift in the prevailing wind direction, that usually brings with it a different kind of weather (*Xu and Li*, 2010).
- ✓ In the monsoon regions, the local weather and climate are strongly influenced by the anomalous monsoon circulation (*Hui*, 2007).
- ✓ Monsoon circulation may influence the spatial and temporal variation patterns of aerosol concentrations (*Liu et al.*, 2011).
- ✓ Many studies have quantified the impacts of monsoon circulations on aerosol concentrations over East Asia, but most have focused on summer (*Zhang et al.*, 2010; *Liu et al.*, 2011; *Zhu et al.*, 2012).

Objective and Methods

Analysis of Winter monsoon variability and its impact on aerosol concentrations over East Asia during 1980 - 2013

GEOS-Chem Global 3-D Chemical-Transport Model (v9-02-01)

- MERRA meteorological fields with 2°x2.5°, 47 vertical levels
- simulation period : 1980/81 – 2013/14 (34 years)
- H_2SO_4–HNO_3–NH_3 aerosol thermodynamics, primary organic carbon and elemental carbon, and secondary organic aerosol

Anthropogenic emissions

- INTEX-B anthropogenic emission inventory (2006)

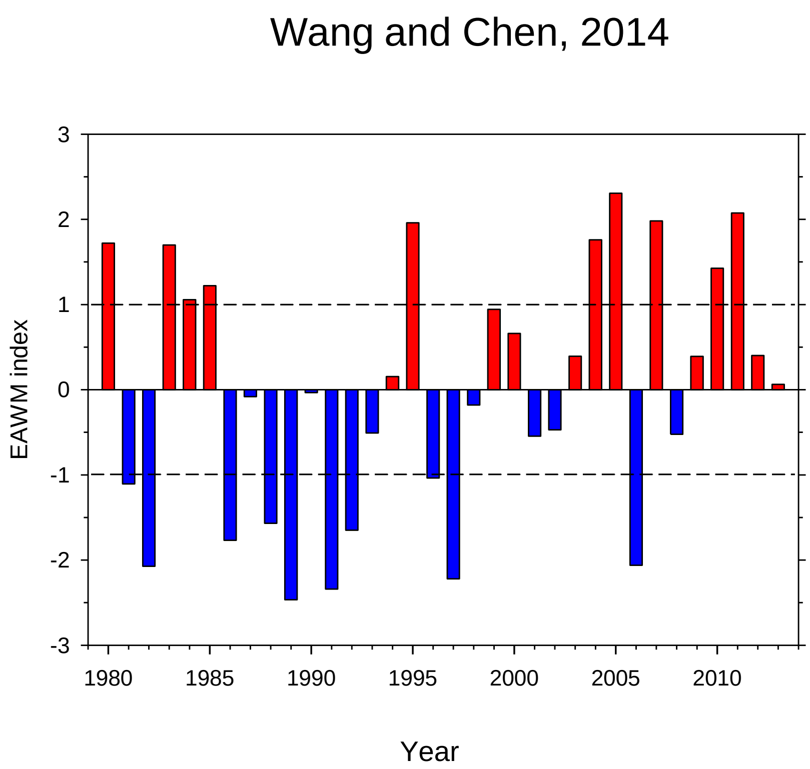
Model simulations

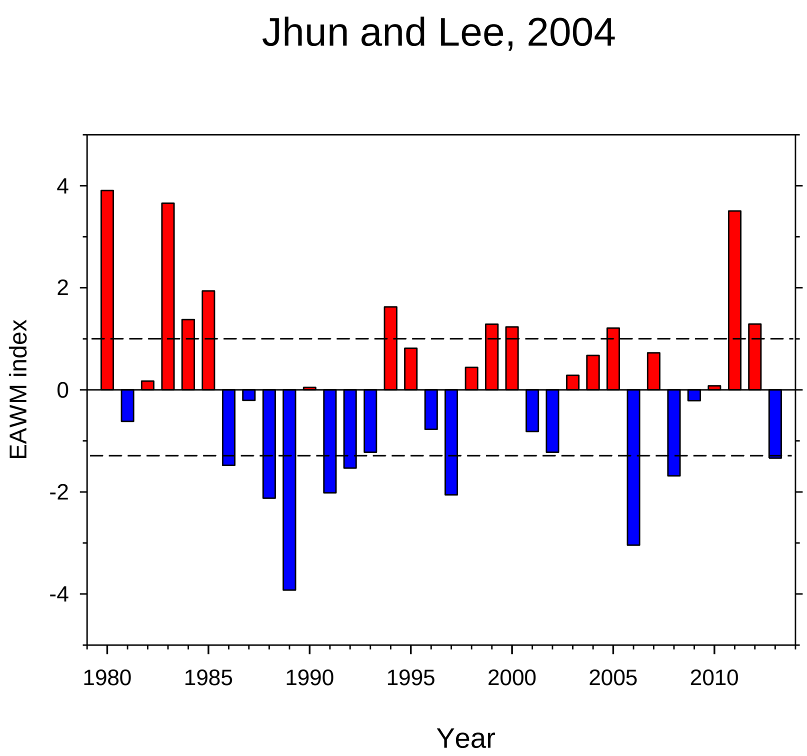
- Meteorological Variability only: Fixed anthropogenic emissions for 2006 and Meteorological fields for each year

Winter monsoon index

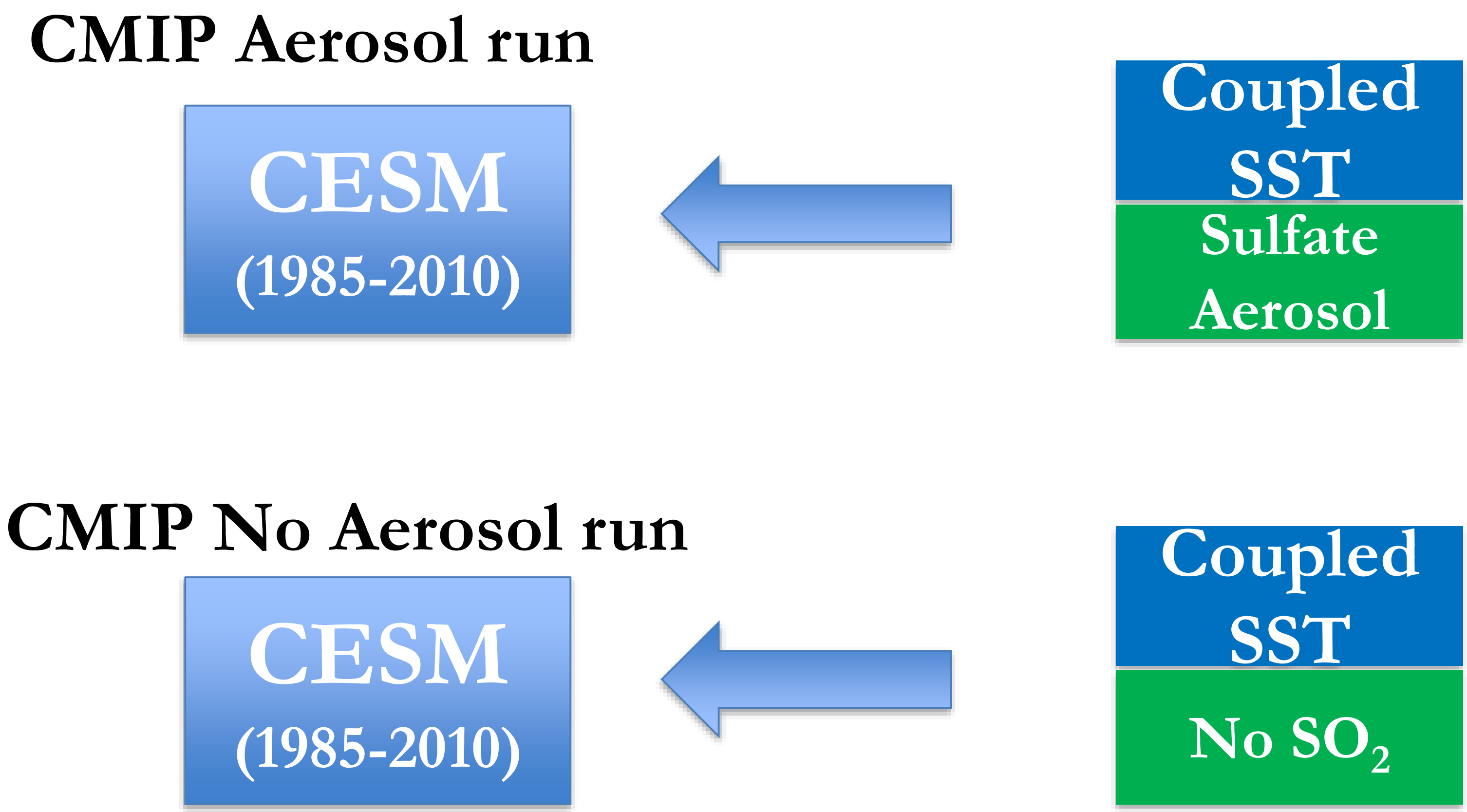
- EAWMI: East Asian Winter Monsoon Index [*Wang and Chen*, 2014]

Normalized East Asian Winter Monsoon Index





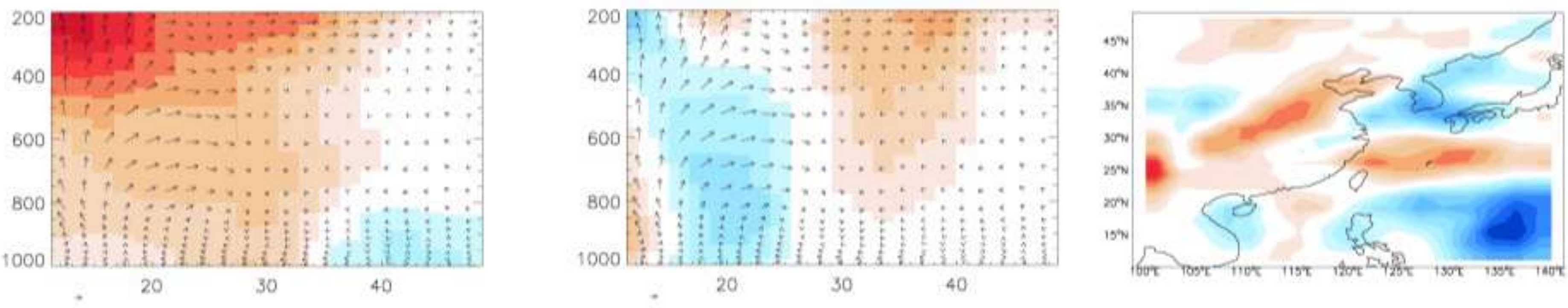
CESM Simulations for 26 yrs



THE DIFFERENCES IN METFILEDS BETWEEN 2001-2010 AND 1985-1994 IN SST COUPLED SIMULATION

No Aerosol-run

TEMP [K] **[100°E-140°E]** **Wind [m s^{-1}]** **Precipitation [mm day^{-1}]**



Aerosol-run