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


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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 PM$_{10}$ concentrations

(a) [strong(2007)-weak(2006)] / strong(2007)

(b) Monthly EAWM index vs. PM$_{10}$ anomaly in Northern East Asia for DJF of 2001-2008

- 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]
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

(a) Northern East Asia
(30-50°N, 100-140°E)

Y = -0.59X
R = -0.66

(b) Southern East Asia
(20-30°N, 100-140°E)

Y = 0.45X
R = 0.41

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

[Jeong and Park, 2017]
Percentage differences of PM2.5 concentrations for strong and weak monsoon relative to climatology

<table>
<thead>
<tr>
<th>Strong monsoon years</th>
<th>Weak monsoon years</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% lower concentration in northern East Asia</td>
<td>15% higher concentration in northern East Asia</td>
</tr>
<tr>
<td>15% higher concentration in southern East Asia</td>
<td>10% lower concentration in southern East Asia</td>
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</tbody>
</table>

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

- Aerosol conc. & aerosol mass flux
- SLP & 850 hPa wind
- Temperature
- PBL height
- Dry deposition
- Wet deposition
Differences of simulated PM2.5 concentrations in surface air and vertical column between strong monsoon years and climatology

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

Effect of Sulfate aerosol on EASM

(C) ALL-AXA (temp. & rainfall) degC (129-years)^{-1}

[Cowan and Cai, 2011]

(c) PD-PIso4

[Jiang et al., 2013]
A unified monsoon index

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\[
\text{EASMI} = \frac{||\overline{V}_w - \overline{V}_i||}{||\overline{V}||} - 2 \quad \text{where} \quad ||A|| = \left( \int_S |A|^2 \, dS \right)^{1/2}
\]

Cor/Reg of Precip/V850

Li and Zeng (2002): DNS\textsubscript{era} (10N–40N, 110E–140E)
CAM5 Simulations for 26 yrs

Control run
CAM5 (1985-2010) → HadISST
SST run
CAM5 (1985-2010) → HadISST
SO₂ run
CAM5 (1985-2010) → Climatology
SST → Sulfate Aerosol
No Sulfate
Sulfate Aerosol
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]
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.

[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]
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)
- $\text{H}_2\text{SO}_4$–$\text{HNO}_3$–$\text{NH}_3$ 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
Normalized East Asian Winter Monsoon Index

Wang and Chen, 2014

Jhun and Lee, 2004
CESM Simulations for 26 yrs

CMIP Aerosol run

CESM (1985-2010) → Coupled SST Sulfate Aerosol

CMIP No Aerosol run

CESM (1985-2010) → Coupled SST No SO₂
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