Atmospheric teleconnection linking winter air stagnation and haze extremes in China with regional Arctic sea ice decline

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Severe Haze Pollution in China During Winter

MODIS Aerosol Optical Depth (Deep Blue & Dark Target)

Pollution Potential Index (PPI):

\[
PPI = \frac{r_1 \times WSI + r_2 \times ATGI}{|r_1| + |r_2|}
\]

WSI: standardized surface wind speed index;
ATGI: standardized air temperature gradient index;
\(r_1/r_2\): correlation coefficients between PM\(_{10}\) and WSI/ATGI;

\(r_1 = -0.73\)
\(r_2 = 0.70\)

Correlations between PPI and Air Pollution Indices

| Index       | Data Availability | WSI (1981-2015) r | p-value | ATGI (1981-2015) r | p-value | PPI (1981-2015) r | p-value |
|-------------|-------------------|--------------------|---------|--------------------|---------|--------------------|---------|
| PM\(_{10}\)-ECP | 2005-2015         | -0.73              | <1E-2   | 0.70               | <1E-2   | 0.92               | <1E-3   |
| PM\(_{2.5}\)-BJ  | 2010-2015         | -0.80              | 0.01    | 0.58               | 0.09    | 0.79               | 0.07    |
| Vol          | 1981-2013*        | -0.63              | <1E-3   | 0.36               | 0.17    | 0.62               | <1E-3   |
| Terra AOD    | 2001-2015         | -0.43              | 0.08    | 0.33               | 0.26    | 0.44               | 0.08    |

(Zou et al., SA, 2017)
Climate Sensitivity Experiments Using WACCM

- **Climate Sensitivity Experiment Settings**

| Boundary forcing | CTRL | SENSall | SENSr1 | SENSr2 | SENSr3 |
|------------------|------|---------|--------|--------|--------|
| Sea Ice          | Clim.| 2012 ASON Arctic SIC | 2012 ASON R1 SIC | 2012 ASON R2 SIC | 2012 ASON R3 SIC |
| SST              | Clim.| 2012 ASON Arctic SST  | 2012 ASON R1 SST  | 2012 ASON R2 SST  | 2012 ASON R3 SST  |

- **Regional Circulation and PPI Responses**

(a) MCA_Z500

(b) ECP_PPI

(Zou et al., ACP, 2020)
CMIP6 Simulations and Future Projections

- Arctic SIE and PPI in CMIP6 Model Ensembles (historical/SSP5-8.5 scenarios)

![Diagram showing Arctic SIE and PPI trends across different CMIP6 models and future projections.]
Thank you

Cryosphere
- SIC/SST
- East Siberian and Chukchi seas

Circulation
- EU
- MCA Mode

Ventilation
- WSI
- ATGI
- PPI

Haze Pollution
- PM$_{10}$/PM$_{2.5}$
- ViI
- AOD

Abstract

Recent studies suggested significant impacts of boreal cryosphere changes on wintertime air stagnation and haze pollution extremes in China.