Influence of the Western Pacific Subtropical High on summertime ozone variability in East China

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Western Pacific Subtropical High (WPSH)

Boreal summer subtropical high

Li et al., 2011

East Asia summer monsoon

WPSH influences East Asian summer climate via:
- Subtropical rain belt
- Track of tropical cyclones over western north Pacific

He et al., 2016
Bermuda High variability affects US ozone

Correlation between Ozone (JJA) and Bermuda High Intensity (1993-2010)

July 850 hPa geopotential height and winds (1998-2013 mean)

Zhu and Liang, 2013

Wang Y et al, ACP, 2016

Houston Ozone: 40-50% interannual variability linked with BH-Lon

Trend:-0.33 ppbv/yr
Monitoring network in China established after 2013

MDA8 O$_3$ (JJA 2014)  JJA 2015  JJA 2016

Daily MDA8 Ozone (Yangtze River Delta)

Zhao and Wang, submitted
EOF analysis of daily ozone anomalies

Empirical orthogonal function (EOF)

MDA8 Ozone (JJA 2014)

EOF1

EOF2

North-south contrast

East-west contrast

Zhao and Wang, submitted
A few established WPSH indices

**WPSH-I (intensity index)**

\[
WPSH - I = \frac{\sum_{i=1}^{n} (H_i - H_0) \cdot \delta(H_i - H_0)}{N}
\]

\[
\delta(x) = \begin{cases} 
1, & x > 0 \\
0, & x \leq 0 
\end{cases}
\]

\[H_0 = 5880 \text{ gpm (500 hPa)}\]

**WPSH-W (westward extension index)**

\[WPSH-W = \text{Average gpm in domain1} - \text{Average gpm in domain2}\]

**WPSH-WR (west ridge point)**

Longitude where the 5880-gpm contour line reaches its most westward position (90°E - 180°E).
O$_3$ daily variability: correlated with WPSH-I

Zhao and Wang, submitted
Mechanism of negative relationship between WPSH-I and surface ozone in South China

WPSH intensity → Stronger Southwesterly winds → More water vapor and convection

- Total cloud cover
- Convective precipitation
- Temperature

UV and solar radiation → Surface ozone

RH
North-South contrast in meteorological conditions

Summertime mean (2014)

Wind speed                  RH              Cloud cover           UV

Correlation with WPSH-I

Wind speed                  RH              Cloud cover           UV

Zhao and Wang, submitted
Use model ozone on interannual time scale

Surface Ozone
- GEOS-Chem global model simulation
- MERRA 2° x 2.5°
- 1990-2015, year-to-year changes in emissions

Simulated Ozone (JJA 2014)

Simulated O3 and WPSH-I correlation

Wang et al., ACP, 2011
Interannual scale: Ozone and WPSH-I does not correlate

- Ozone domain: 24 °N - 32 °N, 115 °E - 120 °E (South China)
Interannual scale: Ozone and WPSH-I does not correlate

- Ozone domain: 24 °N -32 °N, 115 °E -120 °E (South China)
- Correlation between JJA mean surface ozone over South China and WPSH-I is not significant on interannual scale, with $r=0.14$, $p>0.05$
Interannual scale: WPSH westward extension correlates with $O_3$ variability

Westward extension of WPSH linked with east-west contrast

- Correlations between ozone and WPSH-W are significant in most of the grids.
Conclusion

- Dominant feature of surface ozone daily variability in East China is the north-south contrast
- Such contrast is associated with the WPSH intensity variability both spatially and temporally
- Drivers of this linkage are southwesterly winds and associated moisture transport
- Ozone variability on interannual scale is associated better with the position of the WPSH (westward extension) than its intensity
- Intensity and position of WPSH are not necessarily correlated on daily or interannual scale