Haze pollution levels exhibit short-term seesaw behavior over North China Plain

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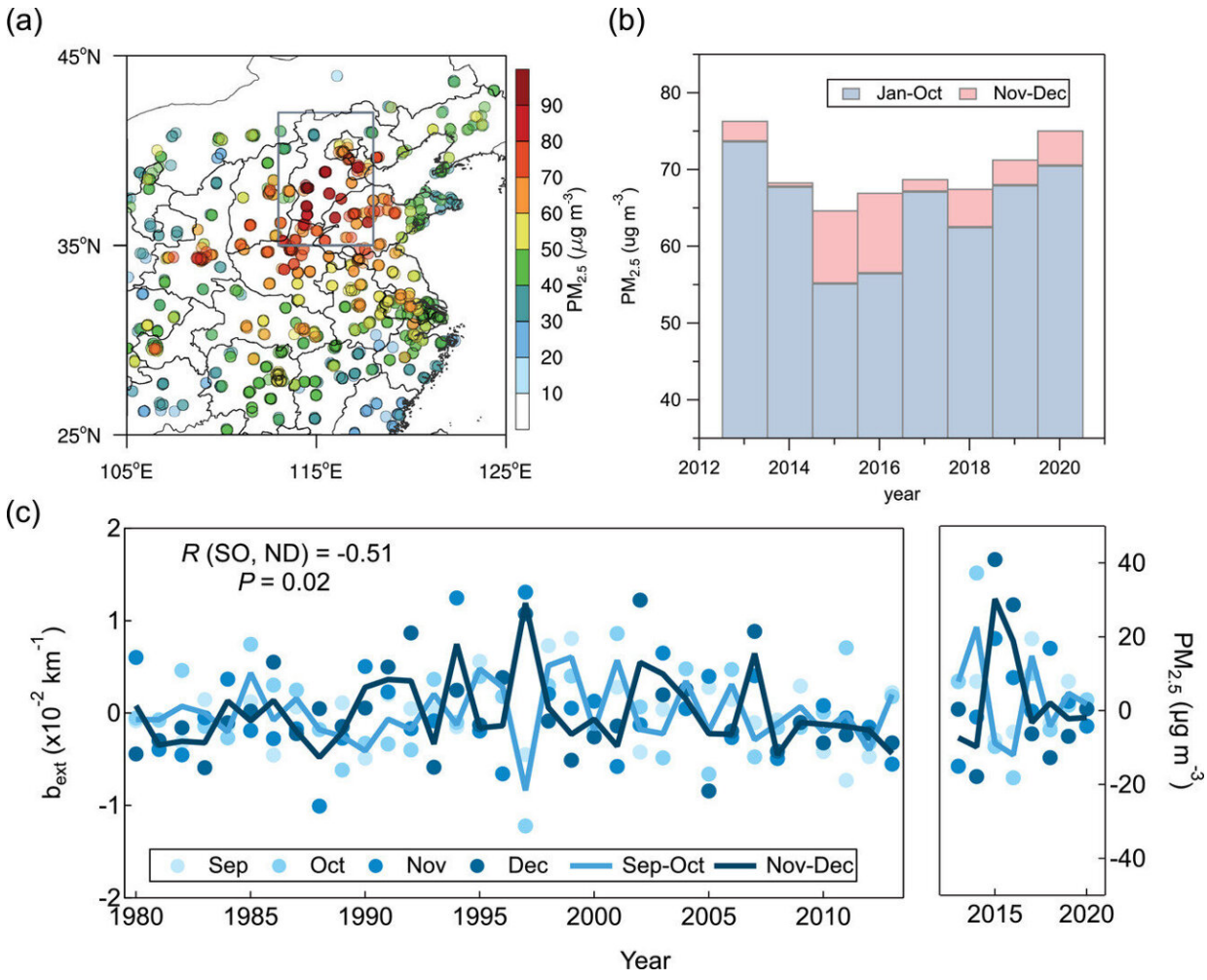

(a) $PM_{2.5}$ concentration averaged in 2013–20. The rectangular box indicates the NCP region. (b) Annual mean $PM_{2.5}$ concentration and the contribution from ND over the NCP. The original data have been detrended. (c) Atmospheric extinction coefficient (1980–2013) derived from visibility and $PM_{2.5}$ concentration data (2013–20) in September to December over the NCP on the

subseasonal scale. The unit for extinction coefficient is km^{-1}, and for $PM_{2.5}$ concentration it is $\mu g\ m^{-3}$. R indicates the correlation coefficient between SO and ND with P = 0.02. Credit: *Atmospheric and Oceanic Science Letters* (2022). DOI: 10.1016/j.aosl.2022.100274

A haze frequently hangs over China, particularly over the highly populated North China Plain in the autumn and winter months. The concentration of haze pollution particulates ($PM_{2.5}$) in this region has reached over twice the national standard for safe air quality. Chinese scientists probed deeper into the haze pollution patterns and observed a short-term "seesaw" phenomenon in autumn and early winter, with high pollution levels in September and October coupled with low haze levels in November and December—or vice versa.

The researcher's observations, published recently in *Atmospheric and Oceanic Science Letters*, provide new insight into the sub-seasonal variability of air quality over the North China Plain (NCP). The study also implies a possible new approach to predicting haze over the region and eventually improving air quality control.

Stricter emission control policies in recent years have mitigated haze over the NCP, but still half of the most polluted cities are located in the region. Haze in the NCP is more frequent and intense in autumn and winter owing to weather conditions and human activity. Though previous studies revealed seasonal and year-to-year variations of haze pollution over this region, little has been understood about its behavior on sub-seasonal time scales.

"From the perspective of air quality, the $PM_{2.5}$ level in the year's final months matters greatly to the air quality status of the year as a whole," said Aijun Ding, a professor from the Joint International Research

Laboratory of Atmospheric and Earth System Sciences in the Nanjing University School of Atmospheric Sciences. "Therefore, short-term forecasts of 1-2 months of air pollution are often needed."

Using an almost 40-year dataset of visibility measurements and $PM_{2.5}$ observations, researchers observed a "seesaw" phenomenon in the behavior of haze pollution: if pollution levels are down in September and October, haze is typically more severe in November and December. In other years, they observed the opposite: high pollution levels in September and October with lower haze in the last two months.

Regional and large-scale atmospheric circulation patterns in the NCP dictate that months with poor air quality usually exhibit higher relative humidity, lower near-surface wind speeds, and other weather conditions that allow air pollutants to linger, leading to enhanced haze pollution—but the short-term, or sub-seasonal, seesaw haze phenomenon strays from this pattern.

To explore why they were seeing the abrupt reversal of circulation, researchers conducted composite analyses for a number of years where the seesaw haze pollution affect was stark.

They found that the phenomenon is linked not by long-term processes, but by sudden changes in the movement of the atmosphere, which is regulated by a large-scale atmospheric pattern originating from abnormal sea surface temperatures in the North Atlantic Ocean.

The seesaw relationship provides greater insight into the prediction of haze variability on multiple scales, as well as the possibility of efficient short-term mitigation of haze to meet annual air quality targets in China.

"Winter is the season with the most severe haze pollution in eastern China, and it is the only chance for cities to conduct intensified air

quality measures to meet their annual air quality targets," said Ding. "The findings of this article provide a simple and potentially feasible way to achieve this goal."

Upcoming hurdles include parsing the physical and chemical interactions of haze pollution on a sub-seasonal scale, said Ding. Further studies will include numerical simulations of global climate-chemistry models that incorporate ocean processes. The researchers will use these models to better understand how gradual atmospheric changes are affected by sea-air interactions and can influence sub-seasonal haze.

"Our ultimate goal is to comprehensively understand the climate impact on haze pollution from a multi-scale perspective, and to provide more scientific support for efficient air quality management," said Ding.

More information: Lian Xue et al, Subseasonal reversal of haze pollution over the North China Plain, *Atmospheric and Oceanic Science Letters* (2022). DOI: 10.1016/j.aosl.2022.100274

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