

Abstract

From October to December 2015, Beijing-Tianjin-Hebei (BTH) region had experienced several severe haze events. In order to assess the effects of the regional transportation on the air quality in Beijing, the air monitoring data (PM_{2.5}, SO₂, NO₂ and CO) was collected and analyzed with various statistical models. The results show that, the cities were clustered into three or two groups, mainly according to the topographic conditions and pollution level. The Granger causality test results indicate that, Beijing was strongly influenced by southern cities. More importantly, further analysis suggests that the air pollutants in Beijing were strongly affected by regional transportation, as the local sources only contributed 22.94%, 23.16%, 21.01% and 25.12% of PM_{2.5}, SO₂, NO₂ and CO concentrations, respectively. And the major foreign source for Beijing was from Southwest (Baoding and Shijiazhuang) direction, accounting for more than 40% of all these air pollutants. Then, linear regression models were constructed to capture the interdependency among the multiple time series. It shows that the observed air pollutant concentrations in Beijing were well consistent with the model-simulated results. Thus, by combining various statistical models, it may not only be able to quickly evaluate the local and regional source contributions for a particular city, but also to predict the air qualities of any city on a regional scale.

Study area



Fig. 1 Location and topography map of BTH region in China, including 13 cities: Beijing (BJ), Baoding (BD), Cangzhou (CZ), Chengde (CD), Handan (HD), Hengshui (HS), Langfang (LF), Qinhuangdao (QHD), Shijiazhuang (SJZ), Zhangjiakou (ZJK), Tianjin (TJ), Tangshan (TS), and Xingtai (XT).

Results

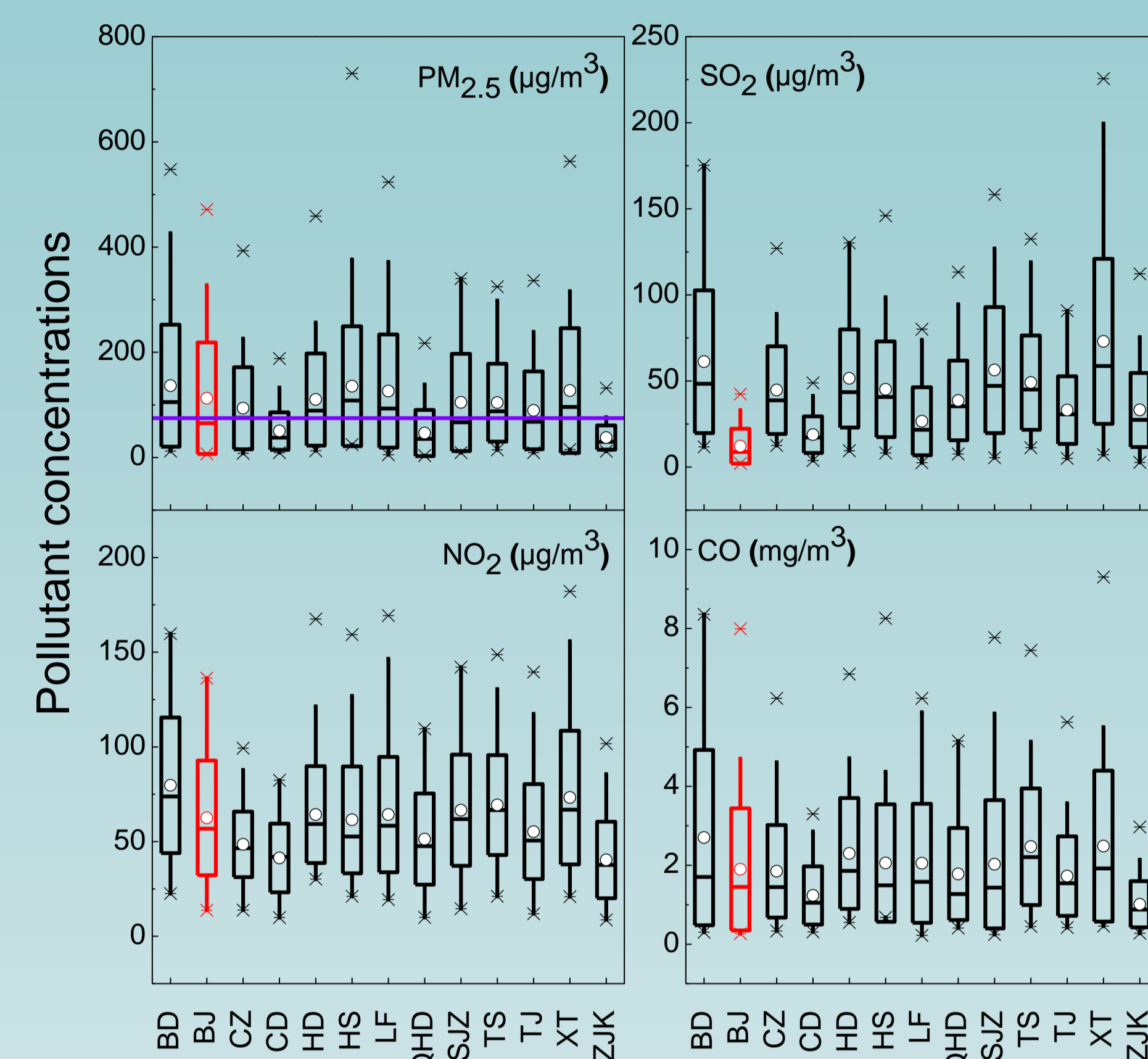


Fig. 2 Box chart of air pollutant concentrations in the BTH region.

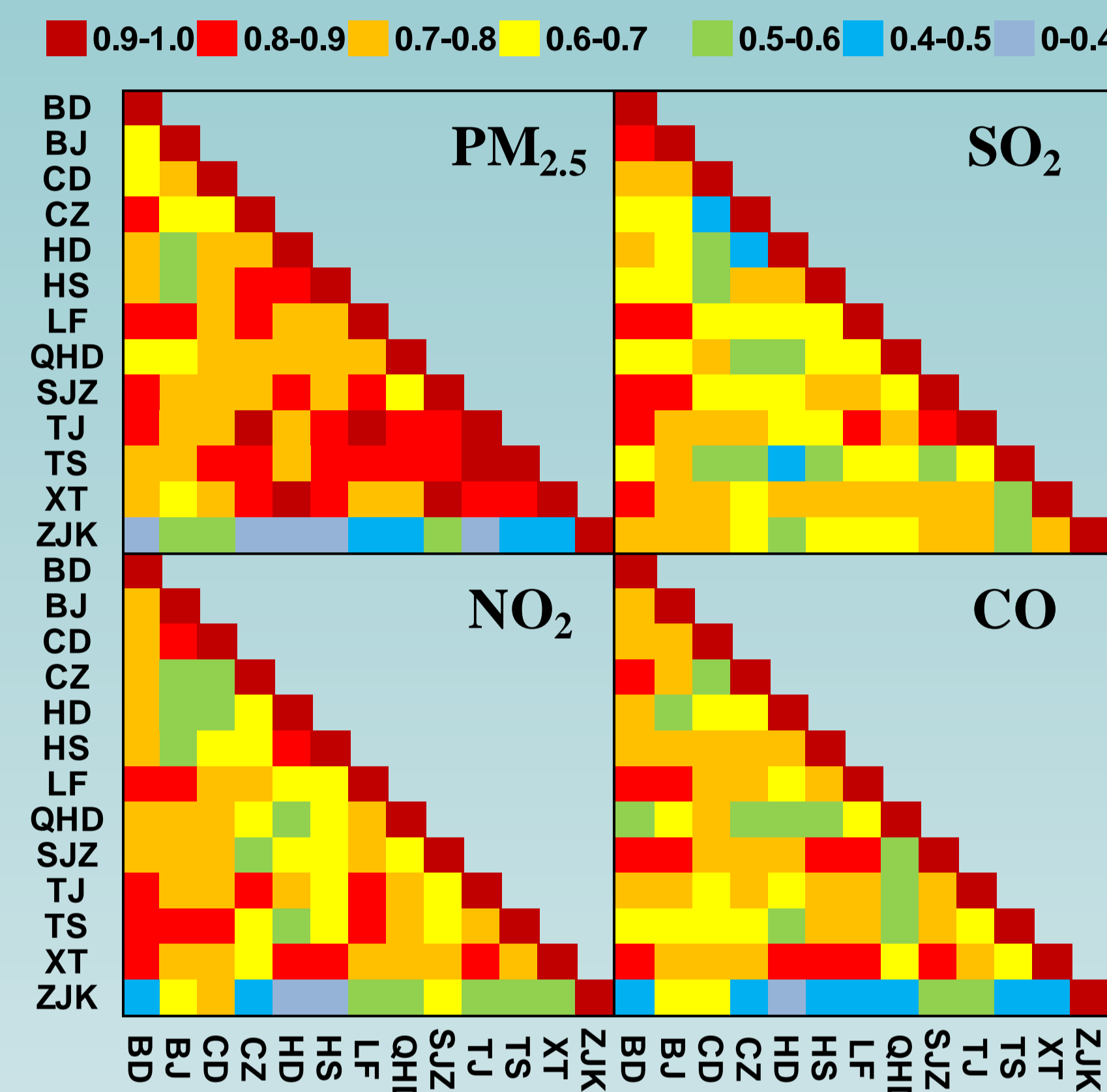


Fig. 3 Pearson correlations of pollutant concentrations among cities.

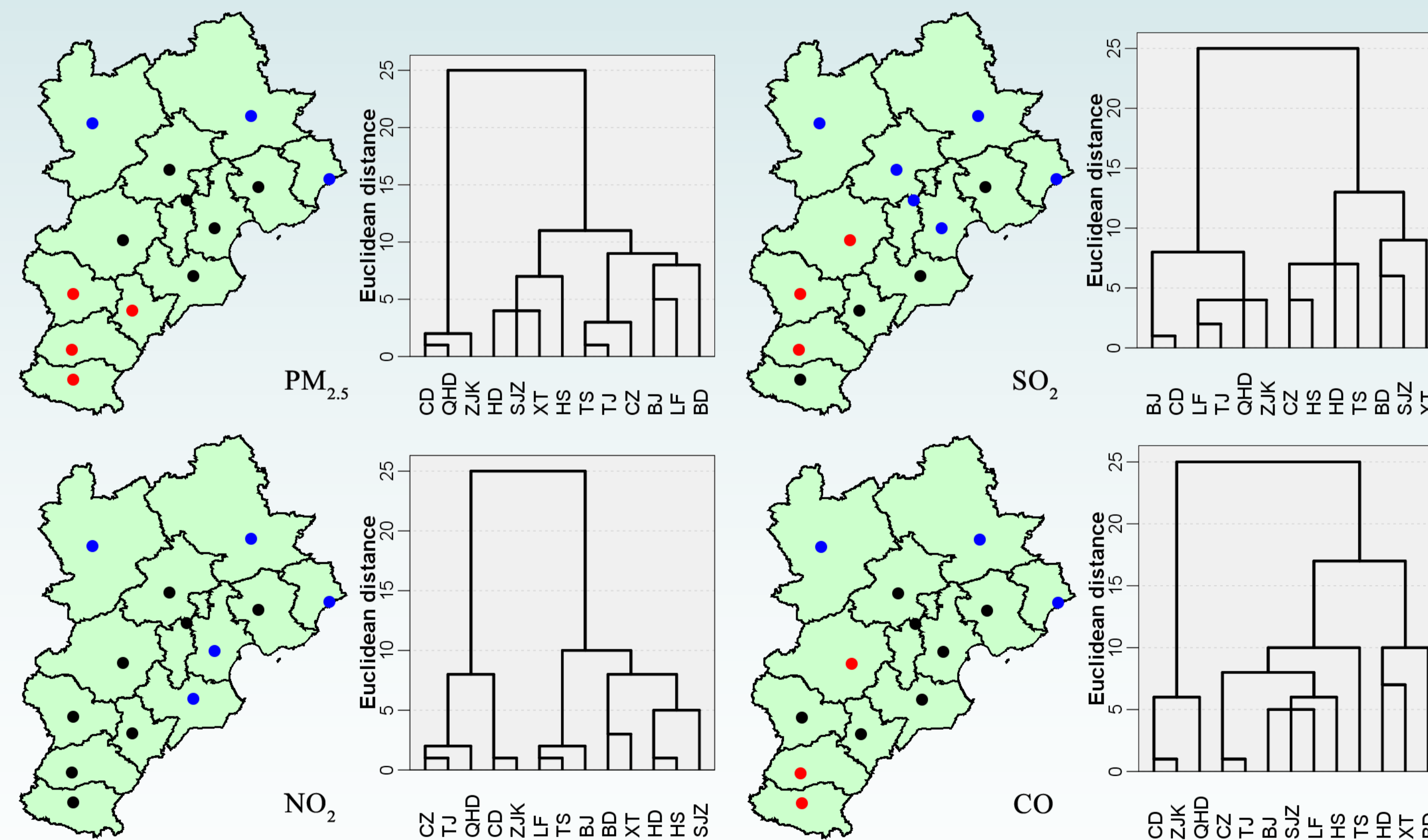


Fig. 4 Results of cluster analysis on hourly pollutant concentrations using Euclidean distance. CD, ZJK and QHD, which locate at Yanshan mountains, make up one group for both PM_{2.5} and CO data; construct another group with low emission cities for SO₂ data or coastal cities for NO₂ data, respectively.

Results

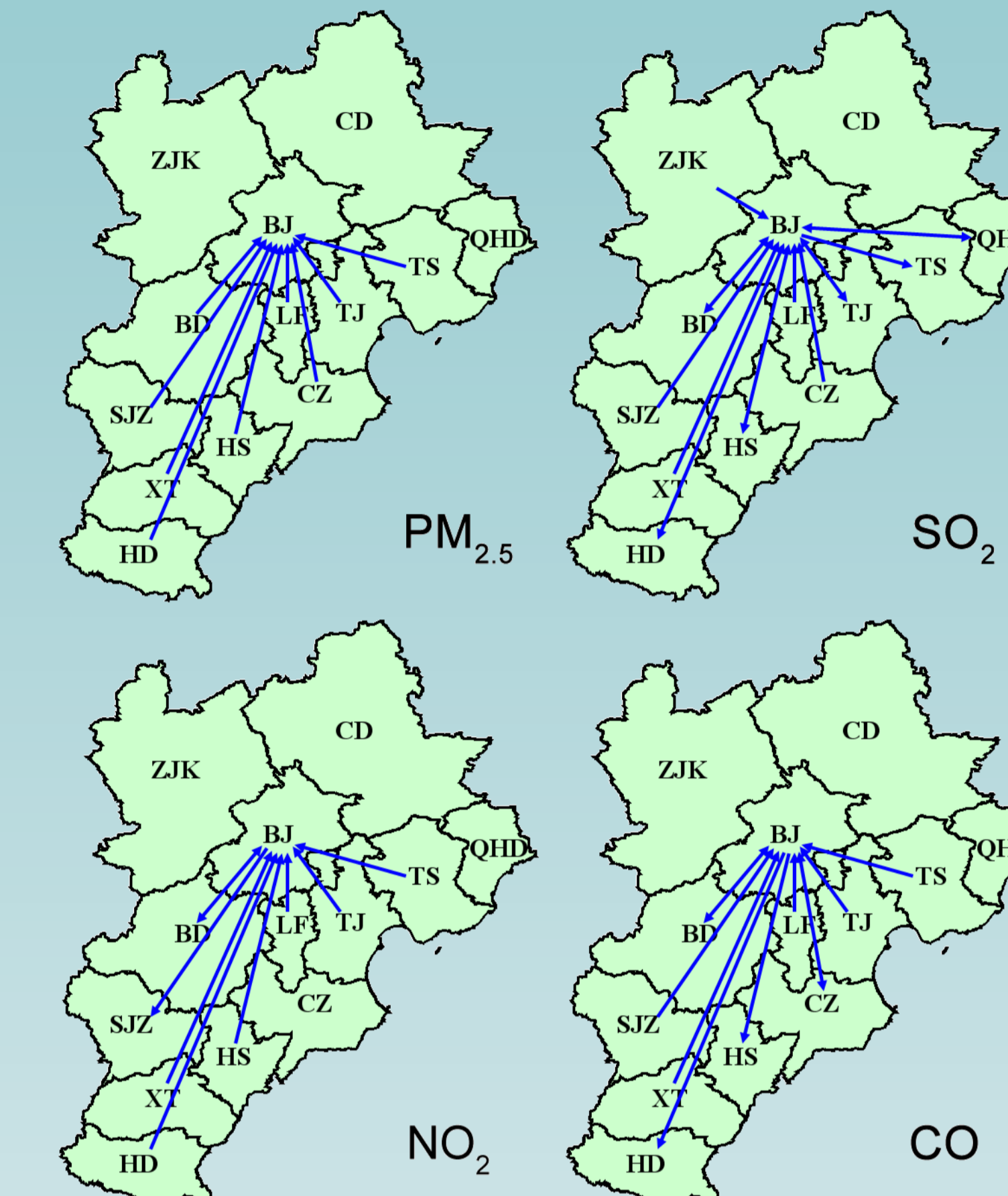


Fig. 5 Results of Granger causality test of pollutants between Beijing and other cities. Arrow indicates the direction of causality.

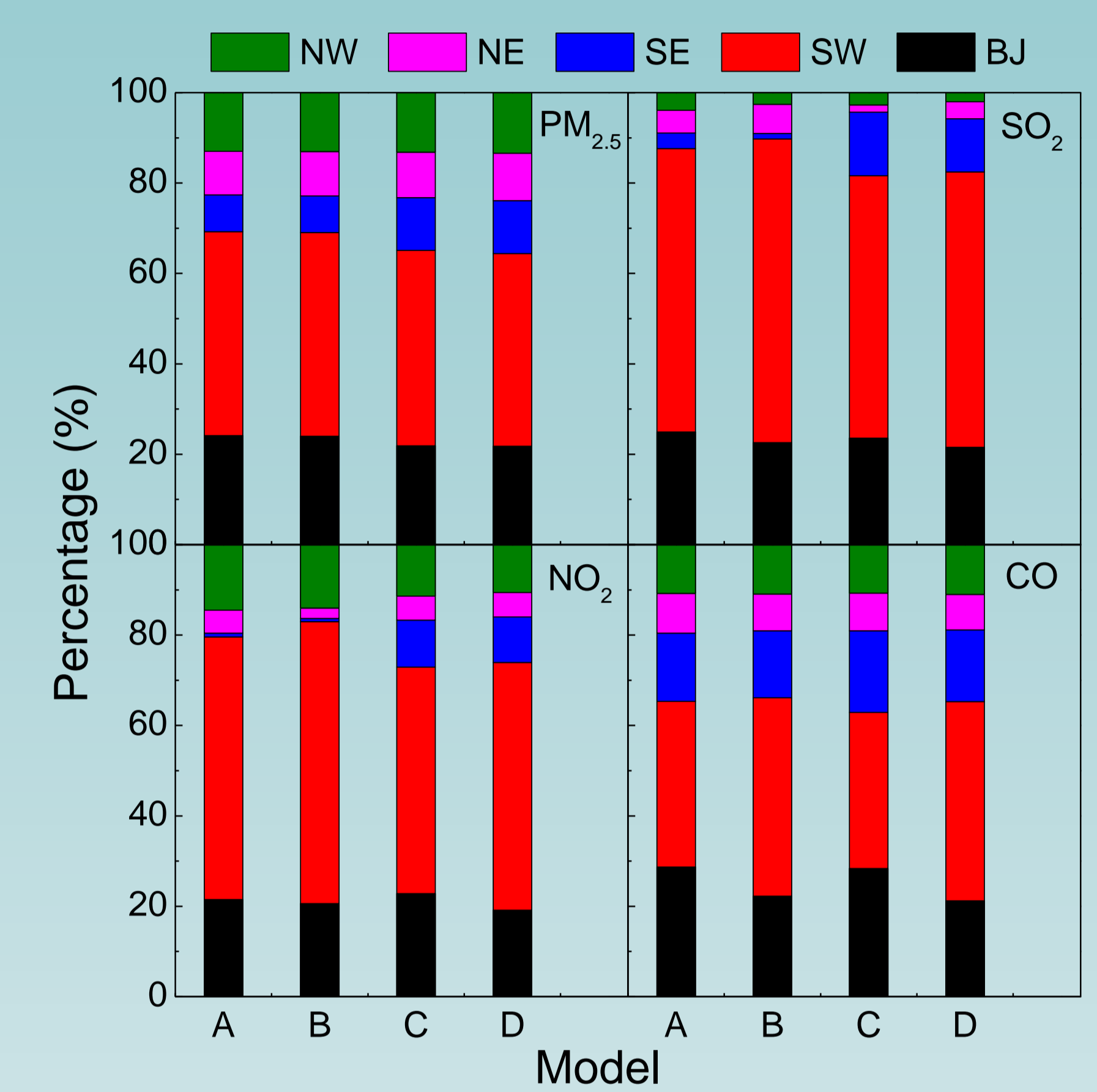


Fig. 6 Local and regional source contribution of pollutants to Beijing. NW, NE, SE, and SW represent four major directions.

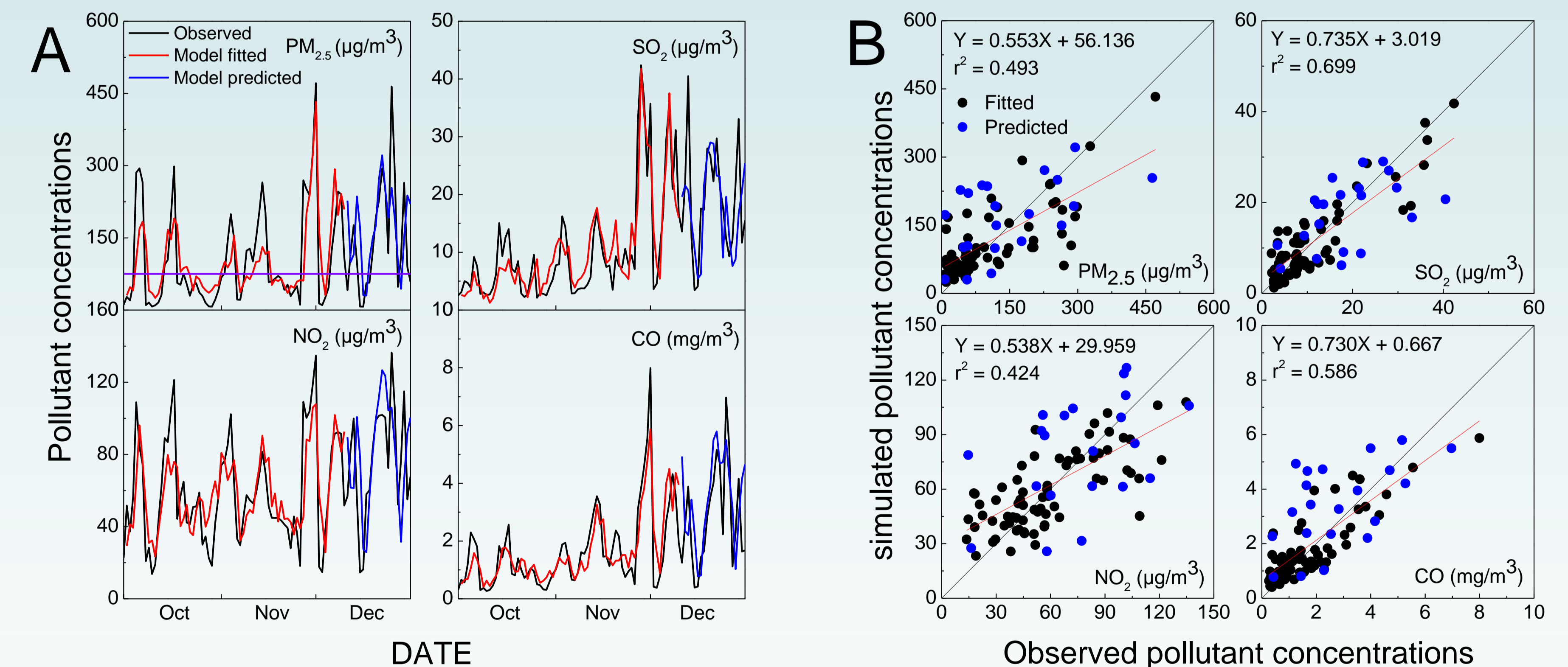


Fig. 7 Comparison between the observed and model-simulated pollutant concentrations in Beijing. (A) Time series; and (B) Scatter plots.

Conclusions

- The semi-basin topography plays an important role in regional transport of air pollutants in the BTH region.
- The air quality in Beijing was strongly influenced by southern cities.
- Multiple time series analysis could be a useful tool for evaluating the source contribution and predicting the air pollutant concentrations.