Figure S1. Monthly mean PM2.5 in December 2015 (Fig. S1a) and 2016 (Fig. S1c), and the difference between the anomaly of January 2016 (Fig. S1b) and 2017 (Fig. S1d) (relative to January from 2015-2017) and the previous December anomaly
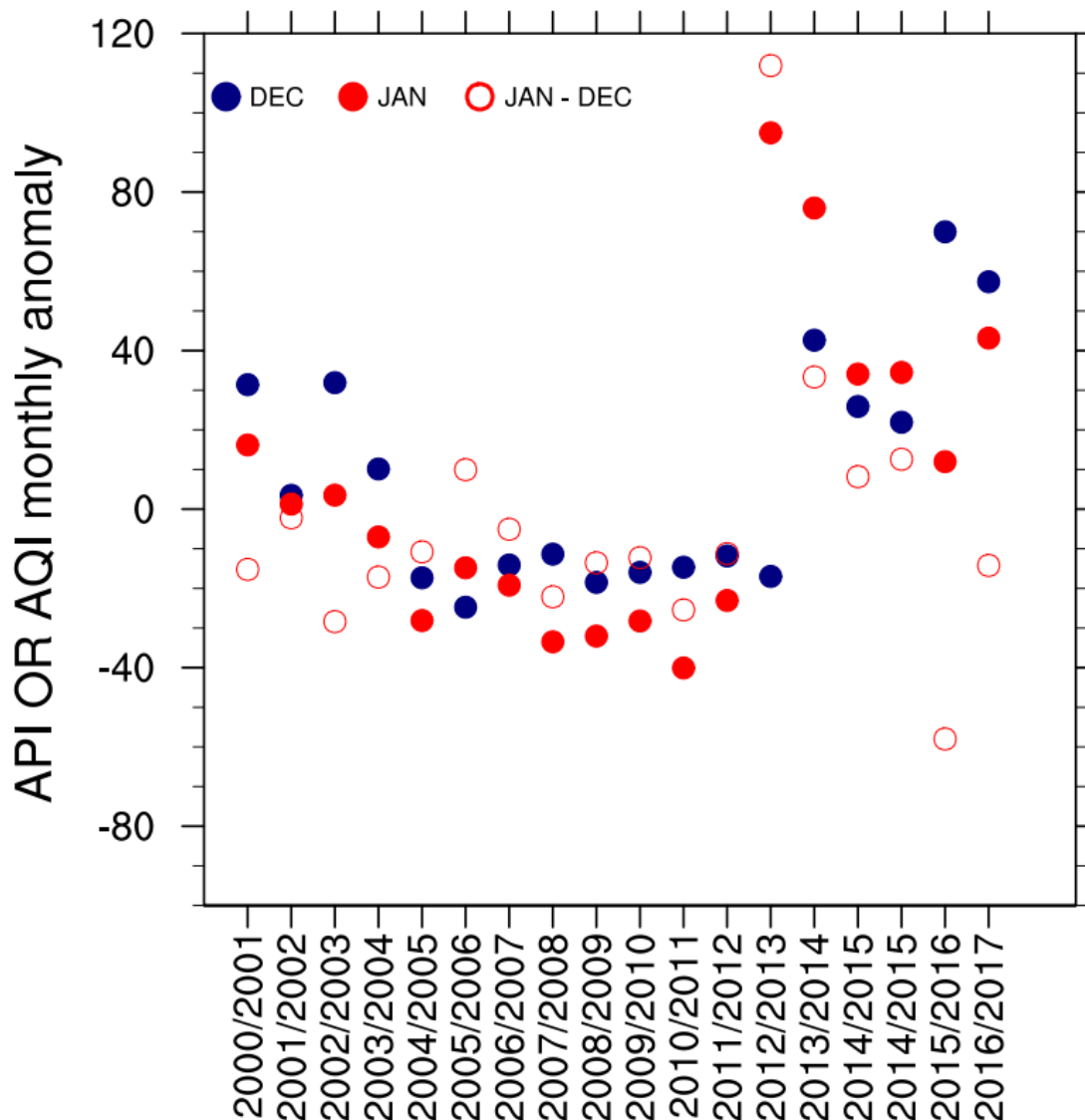
Fig. S2. Monthly mean anomaly of PM2.5 between the adjacent December (solid blue) and January (solid red) as well as the change (hollow red circle) from December to January during 2000-2017 over North China. The data from 2000-2014 was based on air pollution index (API; http://datacenter.mep.gov.cn/), and the data for 2014-2017 was based on air quality index (AQI; http://www.pm25.in). For December (January), the anomaly is relative to 2000-2014 (2001-2015) fifteen-year respective monthly mean value. The data for December 2014 and January 2015 was shown twice, with the former one from API, and the latter one from AQI, and they are relatively comparable.
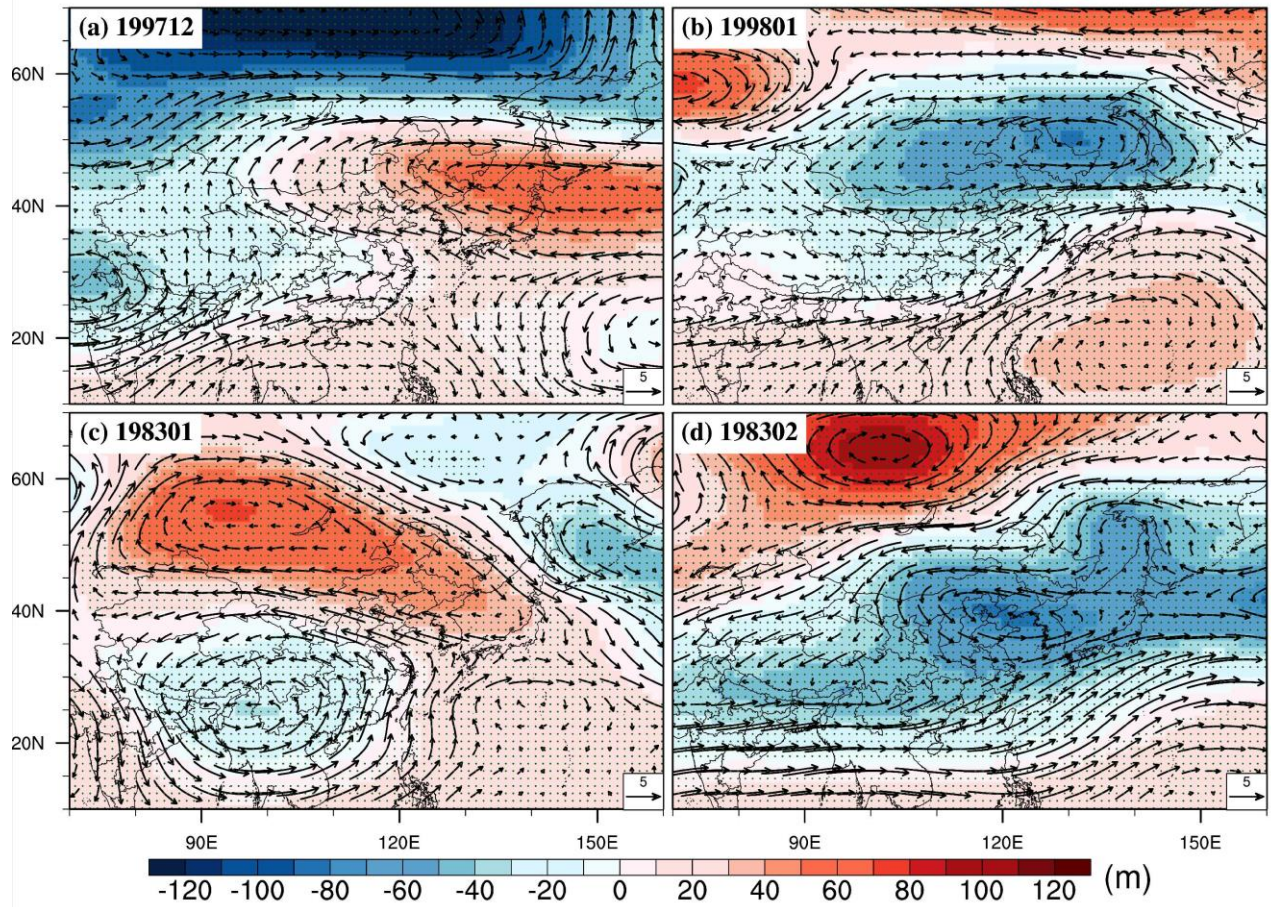
Fig. S3. Anomaly of geopotential height and wind vector at 500 hPa. (The anomaly is relative to 1987-2016). Areas within 90% of confidence interval are masked in white.

A bug fix in the original Meteorology-Chemistry Interface Processor (MCIP) program

The Meteorology-Chemistry Interface Processor (MCIP) was used to post-process WRF results and prepare the input for CMAQ (Otte and Pleim, 2010), with the latest version of 4.3. During the process, we found a code bug in MCIP 4.3 when processing WRF output with MODIS land use 21. The bug was related to one type of land use named percentage of urban area (PURB). Starting from WRF/WPS version 3.8, land use was set up by default to the 21-class IGBP MODIS, which provides better and more detailed land use information compared to previously used data from United States Geological Survey (USGS). However, due to a bug in

MCIP (getluse.f90; see the information below), PURB was set to missing value denoted using large positive or negative values shown in Fig. S4a. After fixing the problem (code fix in the information provided below), PURB looks reasonable (Fig. S4b). The incorrect PURB resulted in completely erroneous eddy diffusivity, leading to low $PM_{2.5}$ concentration such as in December 2015 (Fig. S5b) compared with observed concentration in Fig. S5a. After fixing the bug, the concentration of PM2.5 was corrected and matched the observations much better (Fig. S5c, the same as Fig. 6b in the manuscript). This error occurred when MCIP 4.3 was used to process WRF/WPS runs with version 3.8.1 or later, using the default 21 types of MODIS land use. Without the bug fix, the CMAQ simulations produced not only low concentrations of ozone, but also erroneous values for many other variables.
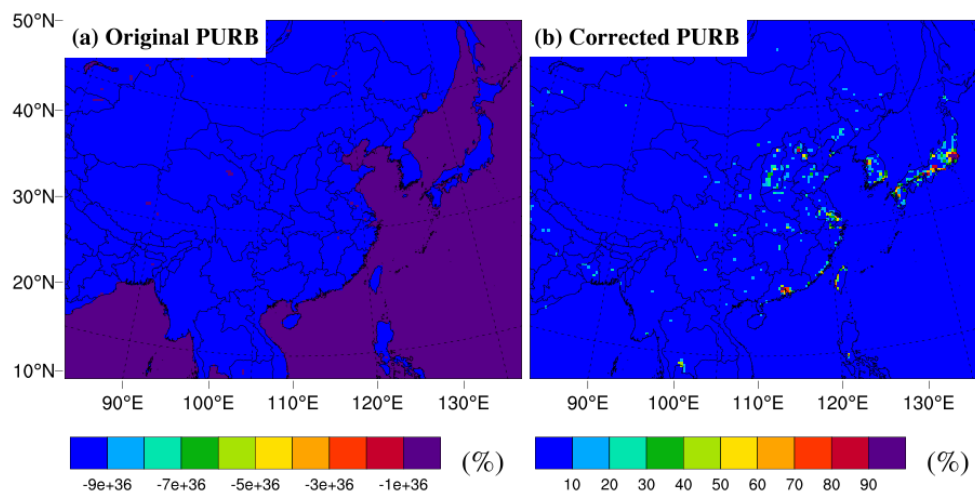

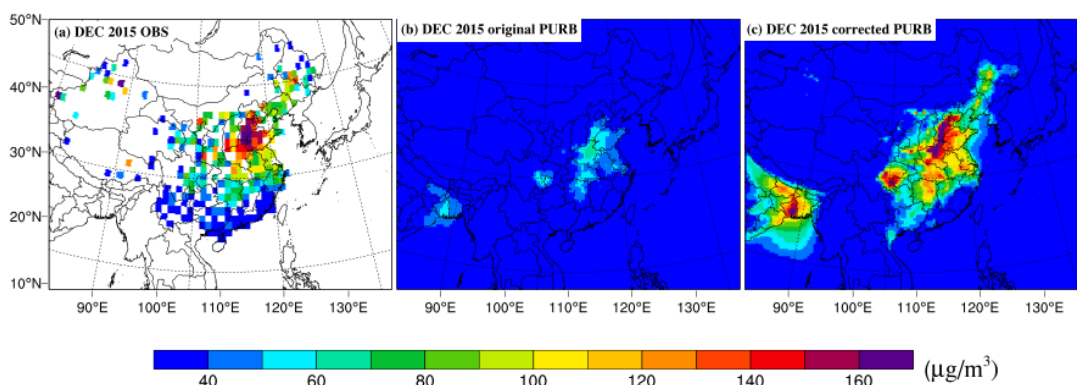Fig. S4. Spatial distribution of PURB: pre-fix and after-fix of code bugs in MCIP

Fig. S5. Spatial distributions of monthly mean PM2.5 concentration in December 2015 for observations (Fig. S5a), CMAQ results with the original PURB (Fig. S5b) and the corrected PURB (Fig. S5c)

getluse.f90:

```fortran
    IF ( nummetlu == 33 ) THEN
         xpurb(col,row) = ( ( xluse(col,row,13) + xluse(col,row,31) +    &
                     xluse(col,row,32) + xluse(col,row,33) ) /  &
                     (1.0 - xluse(col,row,met_lu_water)) ) * 100.0
        ELSE IF ( nummetlu == 20 ) THEN
         xpurb(col,row) = ( xluse(col,row,13) /  &
                     (1.0 - xluse(col,row,met_lu_water)) ) * 100.0
        ENDIF
```

It should be revised to:

```fortran
    IF ( nummetlu == 33 ) THEN
         xpurb(col,row) = ( ( xluse(col,row,13) + xluse(col,row,31) +    &
                     xluse(col,row,32) + xluse(col,row,33) ) /  &
                     (1.0 - xluse(col,row,met_lu_water)) ) * 100.0
        ELSE IF ( nummetlu == 20 ) THEN
         xpurb(col,row) = ( xluse(col,row,13) /  &
                     (1.0 - xluse(col,row,met_lu_water)) ) * 100.0
        ELSE IF ( nummetlu == 21 ) THEN
         xpurb(col,row) = ( xluse(col,row,13) /  &
                     (1.0 - xluse(col,row,met_lu_water)) ) * 100.0
        ENDIF
```