Supplementary material for
Multi-type air pollutant emission inventory of non-road mobile sources in China for the period 1990–2017

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Diesel consumption of construction machinery

\[ Y = \frac{P \times LF \times hr \times 860 \times 10^{-3}}{\eta \times q} \]  

where \( Y \) is the diesel consumption of construction machinery \( (10^4 \text{ ton}) \), \( P \) is the power of construction machinery \( (10^4 \text{ kW}) \), \( LF \) is the load factor \((0.75)\) (Hou et al., 2019), \( hr \) is the average activity time \((h)\) of construction machinery in one year \((770)\) (MEPC, 2014), \( 1 \text{ kWh} = 860 \text{ kcal} \), \( q \) is the calorific value of diesel, and \( \eta \) is diesel engine efficiency \((0.35)\) (Zhang, 2007).

No statistical data were available on the total power of construction machinery of construction enterprises in various regions of China for the period 1990–1992. In this study, the proportion of the total power of construction machinery of construction enterprises to the total power of machinery of construction enterprises in various regions of China in 1993 was used to calculate the missing data. The method for calculation of the total power of machinery of construction enterprises in various regions of China during 1991–1992 is shown in Eq. (2):

\[ P = P1 + P2 \]  

where \( P \) is the total power of machinery of construction enterprises, \( P1 \) is the total power of machinery and equipment owned by state-owned construction enterprises, and \( P2 \) is the total power of machinery and equipment owned by collective-owned construction enterprises.
The method for calculation of the total power of machinery and equipment owned by construction enterprises in various regions of China in 1990 is shown in Eq. (3):

\[ P = R \times N \]  

(3)

where \( P \) is the total power of machinery and equipment owned by construction enterprises, \( R \) is the power of machines per labourer, and \( N \) is the number of staff and workers.

**Diesel consumption of agricultural machinery**

There were no agricultural diesel consumption data available for the period 1990–1992. Therefore, these data were obtained by estimation through linear fitting of the data from 1993–2003, as shown in Fig. S1.

In certain years, relevant activity data for some provinces and cities in China were missing from local statistical yearbooks. The missing data were estimated based on the proportion of provincial data to total national data in neighbouring years.

**Power of other agricultural machinery diesel engines.**

\[ P_1 = P - P_2 \times \xi - P_3 \times \xi - P_4 \times \xi - P_5 \times \xi - P_6 \]  

(4)

where \( P_1 \) is the power of other agricultural machinery diesel engines \((10^4 \text{ kW})\), \( P \) is the total power of agricultural machinery diesel engines \((10^4 \text{ kW})\), \( P_2 \) is the total power of
large- and medium-sized tractors ($10^4$ kW), $P_3$ is the total power of small tractors ($10^4$ kW), $P_4$ is the total power of harvesting machines ($10^4$ kW), $P_5$ is the total power of vessels ($10^4$ kW), $P_6$ is the total power of diesel engines for diesel-powered agricultural drainage and irrigation machinery ($10^4$ kW), and $\zeta$ is the ratio of the total power of diesel engines to the total power of agricultural machinery.

In this study, the category of agricultural machinery was subdivided into different emission standards based on the principles of division of emission standards and the simulated survival curves of agricultural machinery. Owing to the lack of sales data for both irrigation/drainage machinery diesel engines and combine harvesters, it was assumed that the average power of irrigation and drainage machinery diesel engines is approximately equal to that of small tractors, and that the average power of a combine harvester is approximately equal to that of large- and medium-sized tractors. Therefore, the divisions of emission standards for drainage and irrigation machinery diesel engines were consistent with that of small tractors, and the division of emission standards for combine harvesters was consistent with large- and medium-sized tractors.

**Diesel consumption of vessels**

$$Y = r \times T \times q$$  \hspace{1cm} (5)

where $Y$ is the fuel consumption for passenger transport by inland river/coastal vessels ($10^4$ ton), $r$ is the passenger-kilometres by inland river/coastal vessels ($10^4$ passenger-km), $T$ is the average weight of vessel passengers and carry-on baggage (80 kg/person).
(Feng et al., 2014), $q$ is the fuel consumption per 10,000 tkm of inland river/coastal vessels (kg/10^4 tkm).

The method for calculation of the fuel consumption of cargo vessels is shown in Eq. (6):

$$Y = r \times q$$  \hspace{1cm} (6)

where $Y$ is the fuel consumption for inland river/coastal cargo vessels (10^4 ton), $r$ is the freight ton-kilometres by inland river/coastal vessels (10^4 tkm), $q$ is the fuel consumption per 10,000 tkm of inland river/coastal vessels (kg/10^4 tkm).

The parameters of fuel consumption per 10,000 km of inland and coastal vessels were divided into two cases: different provinces and units directly under the State Maritime Administration. Regarding the total turnover data of the direct totals after calculating the fuel consumption, the annual fuel consumption was distributed to provinces and cities based on the proportion of a province’s turnover to the national turnover. Vessel passenger and freight data were missing for 1994 and 2017. This study collected the total passenger and freight data of the waterway transportation industry in those years, and then calculated the proportion of inland river and coastal passenger and freight data of the provinces and cities in the neighbouring years to the passenger and freight data of the waterway transportation of each province. Finally, the missing data were estimated based on the calculated ratio.

The method for calculation of the fuel consumption of fishing vessels is shown in Eq.
(7):

\[ Y = \frac{P \times LF \times hr \times 860 \times 10^{-3}}{(\eta \times q)} \]  

where \( Y \) is the diesel consumption of fishing vessels (10^4 ton), \( P \) is the power of fishing vessels (10^4 kW), \( LF \) is the load factor (0.75) (Hsieh et al., 2009), \( hr \) is the average activity time (h) of construction machinery in one year (1300) (Yu et al., 2008; Song, 2015), 1 kWh = 860 kcal, \( q \) is the calorific value of diesel, and \( \eta \) is diesel engine efficiency (0.35) (Feng et al., 2014).

There were no statistical data for 2017 for the power of motorized fishing vessels. The data for 2017 were obtained through linear estimation using data from 1990–2016, as shown in Fig. S2.

**Diesel consumption of diesel locomotives**

\[ F = N \times F_i \]  

where \( F \) is the total tonnage of railway locomotives (ton), \( N \) is number of railway locomotives, and \( F_i \) is the average total tonnage of freight locomotives (ton).

\[ F = F_1 + F_2 + F_3 \]  

where \( F \) is the total tonnage of railway locomotives (ton), \( F_1 \) is the total tonnage of
diesel locomotives (ton), $F_2$ is the total tonnage of electric locomotives (ton), and $F_3$ is the total tonnage of steam locomotives (ton).

\[ \eta = \frac{F_3}{F} \]  

(10)

where $\eta$ is the proportion of diesel locomotives in the national total of railway locomotives, $F_1$ is the total tonnage of diesel locomotives (ton), and $F$ is the total tonnage of railway locomotives (ton). The value in 2014 was used to estimate the proportion of diesel locomotives in subsequent years.

The methods for calculation of the fuel consumption of diesel locomotives for railway passengers and freight are shown in Eqs. (11) and (12), respectively:

\[ Y_1 = Q \times T \times q \times \eta \times \frac{t_1+t_2}{t_1} \]  

(11)

\[ Y_2 = Q \times T \times q \times \eta \times \frac{t_1+t_3}{t_1} \]  

(12)

where $Y_1$ and $Y_2$ represent diesel consumption for passenger and freight transport by diesel locomotives, respectively ($10^4$ ton), $Q$ is the passenger/freight-kilometres by railways (100 million passenger-km), $T$ is the average weight of locomotive passengers and carry-on baggage (80 kg/person) (Feng et al., 2014), $q$ is the oil consumption by diesel locomotives (kg/10^4 tkm), $\eta$ is the proportion of diesel locomotives in the national total of railway locomotives, $t_1$ is the static load of freight cars (97.6 ton) (Feng
et al., 2014), $t_2$ is the weight of the passenger car itself (879.4 ton) (Feng et al., 2014), and $t_3$ is the weight of the fright car itself (23 ton) (Feng et al., 2014).

For the statistical data of cargo turnover not allocated to provinces and cities from 2003–2014, this study allocated this year’s data to provinces and cities based on the proportion of cargo turnover of each province and city to the total national cargo turnover.

**Calculation of agricultural machinery emissions**

The engine-power-based approach was used to calculate the emissions of all agricultural machinery except agricultural transport vehicles, as shown in Eq. (13):

$$E_i = \sum_{j} \sum_{k} \sum_{n} \left( P_{j,k,n} \times G_{j,k,n} \times LF_{j,k,n} \times hr_{j,k,n} \times EF_{j,k,n} \right) \times 10^{-6}$$

where $E_{j,k}$ is the total emission (ton) of pollutant $i$, $P_j$ is the population of agricultural machinery $j$, $k$ is the emission standard, $n$ is the power segment, $G$ is the average installed engine power (kW), $LF$ is the load factor (0.65) (MEPC, 2014), $hr$ is the average activity time (h) of agricultural machinery in one year, $EF$ is the corresponding emission factor (g/kwh). The pollutants ($i$) comprised CO, NOx, HC, PM$_{2.5}$, PM$_{10}$, BC, OC, and VOCs; the activity time ($hr$) was obtained from the technical guidelines and literature (Fan et al., 2011; MEPC, 2014); and the population ($P$), average installed engine power ($G$), and emission factor ($EF$) were as described in Sect. 2.2 and 2.3.
Calculation of agricultural transport vehicle emissions

The method used for calculation of the emissions of agricultural transport vehicles was similar to that adopted for on-road vehicles, as shown in Eq. (14):

\[ E_i = \sum_j \sum_k (P_{j,k} \times EF_{j,k,n} \times M_{j,k}) \times 10^{-6} \]  

(14)

where \( E_i \) represents the emission (ton) of pollutant \( i \), \( P_{j,k} \) is the population of agricultural transport vehicle \( j \) in stage \( k \), \( M_{j,k} \) is the average annual number of kilometres travelled (km) (three-wheeled transport vehicles and low-speed trucks: 23,000 and 30,900 km, respectively) (MEPC, 2014), and \( EF \) is the emission factor (g/km). The pollutants \( i \) comprised CO, NO\(_x\), HC, PM\(_{2.5}\), PM\(_{10}\), BC, OC, and VOCs, and the population \( P \) and emission factor \( EF \) were as described in Sect. 2.2 and 2.3.

Calculation of SO\(_2\) emissions from non-road equipment

Calculation of SO\(_2\) emissions was based on the mass balance algorithm, as shown in Eq. (15):

\[ E = 2 \times Y \times S \times 10^{-6} \]  

(15)

where \( E \) is the SO\(_2\) emissions of non-road equipment, \( Y \) is the annual fuel consumption (kg), which is described in Sect. 2.2, and \( S \) is the sulphur content of the fuel (Table S8 in the Supplementary material).
Calculation of emissions of pollutants other than except SO2 from non-road equipment (except agricultural machinery and agricultural transport vehicles)

The CO, NOx, HC, PM$_{2.5}$, PM$_{10}$, BC, OC, and VOCs emissions from non-road equipment other than agricultural machinery and agricultural transport vehicles were estimated based on fuel consumption, as shown in Eq. (16):

\[
E = Y \times EF \times 10^{-6}
\]  

(16)

where \( E \) is the CO, NOx, HC, PM$_{2.5}$, PM$_{10}$, BC, OC, and VOCs emission of the non-road equipment, \( Y \) is the annual fuel consumption (kg), which is described in Sect. 2.2, and \( EF \) is the emission factor, which is described in Sect. 2.3.

Uncertainty analysis

The 95% CI and CV are calculated using Eqs. (17) and (18), respectively (Wang et al., 2016).

\[
CI_x = \mu_x \pm 1.96 \frac{\sigma_x}{\sqrt{n}}
\]  

(17)

\[
CV_x = \frac{\sigma_x}{\mu_x}
\]  

(18)

where \( CI_x \) is the 95% confidence interval of \( x \), \( CV_x \) is the confidence of variation of \( x \), \( \mu_x \) is the arithmetic average of \( x \), \( \sigma_x \) is the standard deviation of \( x \), \( n \) is the number of observations of \( x \), \( x \) is emission factor.
| #  | Authors/Year         | Time   | Region              | Pollutants                                      |
|----|----------------------|--------|---------------------|------------------------------------------------|
| 1  | Zhang et al. (2010)  | 2006   | Pearl River Delta   | CO, NOx, PM10, VOCs, and SO2                  |
| 2  | Kui (2013)           | 2010   | Beijing-Tianjin-Hebei | CO, NOx, PM2.5, PM10, VOCs and SO2          |
| 3  | Ning and Li (2016)   | 2000-2012 | China                  | CO, NOx, HC and PM10                      |
| 4  | Wang et al. (2016)   | 2012   | China               | CO, NOx, HC and PM                          |
| 5  | Li (2016)            | 2013   | China               | CO, NOx, HC and PM                          |
| 6  | Xie and Zheng. (2016) | 2014 | Nanjing             | CO, NOx, PM2.5, PM10, VOCs, and SO2         |
| 7  | Zhang et al. (2017a) | 2014   | Nanchang           | CO, NOx, HC, PM2.5, PM10, and SO2            |
| 8  | Li (2017)            | 2013   | China               | CO, NOx, PM2.5, PM10, VOCs, and SO2         |
| 9  | Lu et al. (2017)     | 2014   | Yangtze River Delta | CO, NOx, PM2.5, PM10, VOCs, and SO2         |
| 10 | Zhang et al. (2017b) | 2015   | Tianjin            | CO, NOx, HC, PM and SO2                     |
| 11 | Bian et al. (2018)   | 2014   | Guangdong          | CO, NOx, PM2.5, PM10, VOCs, and SO2         |
| 12 | Fan et al. (2018)    | 2015   | Sichuan            | CO, NOx, HC, PM2.5 and PM10                 |
| 13 | Huang et al. (2018)  | 2014   | Yangtze River Delta | CO, NOx, PM2.5, PM10, VOCs, and SO2         |
| 14 | Xu et al. (2019)     | 2015   | Jiangsu            | CO, NOx, PM2.5, PM10, VOCs, and SO2         |
| 15 | Jiang et al. (2019)  | 2015   | Urumqi             | CO, NOx, PM2.5 and VOCs                     |
| Type                                                                 | Unit   | Source                                           | Year       |
|----------------------------------------------------------------------|--------|--------------------------------------------------|------------|
| Total power of machinery and equipment owned by construction enterprises\(^a\) | 104 kW | China Statistical Yearbook on Construction China Statistical Yearbook Sichuan Statistical Yearbook | 1993–2017 |
| Total power of machinery and equipment owned by state-owned construction enterprises\(^c\) | 104 kW | China Statistical Yearbook on Construction China Statistical Yearbook Chongqing Statistical Yearbook | 1991–1992 |
| Total power of machinery and equipment owned by collective-owned construction enterprises\(^d\) | 104 kW | China Statistical Yearbook on Construction China Statistical Yearbook Chongqing Statistical Yearbook | 1991–1992 |
| Power of machines per laborer                                        | kw/person | China Statistical Yearbook                      | 1990       |
| Staff and workers                                                     | 104 persons | China Statistical Yearbook                      | 1990       |

\(^a\)Starting from 2004, statistics on machinery and equipment owner refer to construction machinery and equipment.

\(^b\)Chongqing municipality was founded in 1997, and relevant activity level data of Chongqing municipality from 1990 to 1996 were obtained by searching the local statistical yearbook.

\(^c\)With horsepower converted to kilowatt by 1 horsepower= 0.735 kilowatt.

\(^d\)After accounting, the sum of the two is the total power of machinery of construction enterprises.
Table S3. Types and sources of activity data.

| Type                                      | Unit  | Source                                                                 | Year     |
|-------------------------------------------|-------|------------------------------------------------------------------------|----------|
| Agricultural diesel consumption           | 104 t | China Rural Statistical Yearbook                                       | 1993–2017|
|                                           |       | Chongqing Statistical Yearbook<sup>b</sup>                            |          |
|                                           |       | China Agriculture Statistical Report                                    |          |
| Number and power of larger and medium-sized tractor and small tractor/agricultural drainage and irrigation machinery/harvesting machine | 104 unit | China Agricultural Machinery Industry Yearbook                        | 1990–2017|
|                                           | 104 kW| China Statistical Yearbook                                             |          |
|                                           |       | China Rural Statistical Yearbook<sup>b</sup>                          |          |
|                                           |       | Tibet Statistical Yearbook<sup>c</sup>                                |          |
|                                           |       | Chongqing Statistical Yearbook<sup>b</sup>                            |          |
|                                           |       | China Agriculture Statistical Report                                    |          |
| Number of three-wheeled transport vehicle/Low-speed truck | 104 t | China Agricultural Machinery Industry Yearbook                        | 1990–2017|
| Total power of agricultural machinery     | 104 kW| China Agricultural Machinery Industry Yearbook                        | 1990–2017|
|                                           |       | China Statistical Yearbook                                             |          |
|                                           |       | China Rural Statistical Yearbook<sup>b</sup>                          |          |
|                                           |       | Tibet Statistical Yearbook<sup>c</sup>                                |          |
|                                           |       | Chongqing Statistical Yearbook<sup>b</sup>                            |          |
|                                           |       | China Agriculture Statistical Report                                    |          |
| Total power of diesel engine              | 104 kW| China Agricultural Machinery Industry Yearbook                        | 1990–2017|
|                                           |       | China Statistical Yearbook                                             |          |
|                                           |       | China Rural Statistical Yearbook<sup>b</sup>                          |          |
|                                           |       | Tibet Statistical Yearbook<sup>c</sup>                                |          |
|                                           |       | Chongqing Statistical Yearbook<sup>b</sup>                            |          |
|                                           |       | China Agriculture Statistical Report                                    |          |
| Sales of larger and medium-sized tractor/small tractor | unit | CEIC Global Databases                                                  | 1995–2015|
| Sales of three-wheeled transport vehicle/Low-speed truck | unit | China Automotive Industry Yearbook                                     | 1995–2015|

<sup>a</sup>To avoid double counting, fishing vessel diesel consumption has been subtracted from agricultural diesel consumption.

<sup>b</sup>Chongqing municipality was founded in 1997, and relevant activity level data of Chongqing municipality from 1990 to 1996 were obtained by searching the local statistical yearbook.

<sup>c</sup>In some years, the statistical data of Tibet province is missing from the national statistical data, which can be obtained by searching the local statistical yearbook.
| Type                              | Unit          | Source                                      | Year         |
|----------------------------------|---------------|---------------------------------------------|--------------|
| Passenger-kilometers by inland river vessels | 104 passenger-km | Year Book of China Transportation & Communications, Sichuan Statistical Yearbook | 1990–1993, 1995–2016 |
|                                  |               | CEIC Global Databases                       |              |
| Freight ton-kilometers by inland river vessels | 104 t-km      | Year Book of China Transportation & Communications, China Ports Yearbook, Sichuan Statistical Yearbook | 1990–1993, 1995–2017 |
|                                  |               | CEIC Global Databases                       |              |
| Passenger-kilometers by coastal vessels | 104 passenger-km | Year Book of China Transportation & Communications, Sichuan Statistical Yearbook | 1990–1993, 1995–2016 |
|                                  |               | CEIC Global Databases                       |              |
| Freight ton-kilometers by coastal vessels | 104 tkm       | Year Book of China Transportation & Communications, China Ports Yearbook, Sichuan Statistical Yearbook | 1990–1993, 1995–2017 |
|                                  |               | CEIC Global Databases                       |              |
| Power of fishing vessel          | 104 kw        | China Agricultural Machinery Industry Yearbook | 1990–2016    |
|                                  |               | Year Book of China Transportation & Communications |      |
| Fuel consumption per 10,000 TKM of inland river/coastal vessels | kg/104tkm | Year Book of China Transportation & Communications | 1990–2007 |

*The statistical data of 2001 were wrong, and the average values of 2000 and 2002 were used for calculation. After 2006, the data will not be counted and 2006 data will be used for estimation.

*Chongqing municipality was founded in 1997, and relevant activity level data of Chongqing municipality from 1990 to 1996 were obtained by searching the local statistical yearbook.

*Before 1999, the data were divided into directly under the jurisdiction of state and sub-total of provinces.
| Type                                | Unit      | Source                                      | Year       |
|-------------------------------------|-----------|---------------------------------------------|------------|
| Passenger-kilometers by railways    | 100 million passenger-km | China Statistical Yearbook, Year Book of China Transportation & Communications, Chongqing Statistical Yearbook | 1990–2017 |
| Freight ton-kilometers by railways  | 100 million tkm | China Statistical Yearbook, Year Book of China Transportation & Communications, Chongqing Statistical Yearbook | 1990–2017 |
| Number of railway locomotives       | unit      | Year Book of China Transportation & Communications | 1990–2017 |
| Average total tonnage of freight locomotives<sup>a</sup> | ton       | China Statistical Yearbook                  | 1990–2014 |
| Oil consumption of diesel locomotives<sup>a</sup> | kg/104 tkm | China Statistical Yearbook                  | 1990–2014 |
| Static load of freight cars<sup>b</sup> | ton       | China Statistical Yearbook, China Railway Yearbook | 1990–2016 |

<sup>a</sup>After 2014, the data will not be counted and 2014 data will be used for estimation.

<sup>b</sup>After 2016, the data will not be counted and 2016 data will be used for estimation.

<sup>c</sup>Chongqing municipality was founded in 1997, and relevant activity level data of Chongqing municipality from 1990 to 1996 were obtained by searching the local statistical yearbook.
| Class                        | Pre-Stage I | Stage I      | Stage II     | Stage III  |
|------------------------------|-------------|--------------|--------------|------------|
| Agricultural                 |             |              |              |            |
| machinery                    | ~2008.10.1  | 2008.10.1    | 2010.10.1    | 2016.4.1   |
| Larger and medium-sized      | ~2010.10.1  | ~2016.4.1    | ~           | ~          |
| tractor                      |             |              |              |            |
| Small tractor                | ~2008.10.1  | 2008.10.1    | 2010.10.1    | 2016.4.1   |
|                             | ~2010.10.1  | ~2016.4.1    | ~           | ~          |
| Agricultural drainage and    | ~2008.10.1  | 2008.10.1    | 2010.10.1    | 2016.4.1   |
| irrigation machinery         | ~2010.10.1  | ~2016.4.1    | ~           | ~          |
| Harvesting machine           | ~2008.10.1  | 2008.10.1    | 2010.10.1    | 2016.4.1   |
|                             | ~2010.10.1  | ~2016.4.1    | ~           | ~          |
| Others                       | ~2008.10.1  | 2008.10.1    | 2010.10.1    | 2016.4.1   |
|                             | ~2010.10.1  | ~2016.4.1    | ~           | ~          |
| Three-wheeled transport      | ~2007.1.1   | 2007.1.1     | 2008.1.1~    |            |
| vehicle                      | ~2007.1.1   | ~2008.1.1    | ~           |            |
| Low-speed truck              | ~2007.1.1   | 2007.1.1     | 2008.1.1~    |            |
|                             | ~2007.1.1   | ~2008.1.1    | ~           | ~          |
Table S7. Assuming the emission standard determination method after two years of delay.

| Class                          | Pre-Stage I | Stage I       | Stage II      | Stage III     |
|-------------------------------|-------------|---------------|---------------|---------------|
| Agricultural machinery        | ~2011.1.1   | 2011.1.1      | 2013.1.1      | 2018.1.1      |
| Larger and medium-sized tractor | ~2013.1.1   | ~2018.1.1     | ~             | ~             |
| Small tractor                 | ~2011.1.1   | 2011.1.1      | 2013.1.1      | 2018.1.1      |
| Agricultural drainage and irrigation machinery | ~2013.1.1   | ~2018.1.1     | ~             | ~             |
| Harvesting machine            | ~2011.1.1   | 2011.1.1      | 2013.1.1      | 2018.1.1      |
| Others                        | ~2013.1.1   | ~2018.1.1     | ~             | ~             |
| Three-wheeled transport vehicle | ~2009.1.1   | 2009.1.1      | 2010.1.1~     | ~2010.1.1~    |
| Low-speed truck               | ~2009.1.1   | 2009.1.1      | 2010.1.1~     | ~2010.1.1~    |

*aThe standards implemented in 2008 or 2010.10.1 are assumed to be implemented in 2009 or 2011.1.1 for data processing.

*bThe standards implemented in 2010 or 2012.10.1 are assumed to be implemented in 2011 or 2013.1.1 for data processing.

*cThe standards implemented in 2016 or 2018.4.1 are assumed to be implemented in 2016 or 2018.1.1 for data processing.
Table S8. Sulfur content of the fuel.

| Non-road equipment | Fuel type | Sulfur content (mg/kg) | Year       |
|---------------------|-----------|------------------------|------------|
| diesel engine       | diesel    | 2000                   | 1990–2002  |
|                     |           | 500                    | 2003       |
|                     |           | 350                    | 2004–2006  |
|                     |           | 350                    | 2007–2017  |
| Coastal vessels     | heavy oil | 27000                  | 1990–2017  |
Table S9. Emission (Gg) inventory from non-road mobile sources in China (2017).

| Provinces | CO   | NOx  | HC   | PM$_{2.5}$ | PM$_{10}$ | BC   | OC   | VOCs | SO$_2$ |
|-----------|------|------|------|------------|-----------|------|------|------|--------|
| Beijing   | 7.02 | 22.5 | 2.20 | 1.24       | 1.26      | 0.85 | 0.26 | 3.05 | 0.38   |
| Tianjin   | 17.6 | 63.0 | 5.52 | 5.50       | 5.93      | 2.63 | 0.83 | 9.06 | 35.4   |
| Hebei     | 178  | 296  | 44.8 | 20.2       | 21.2      | 12.1 | 0.37 | 50.6 | 18.2   |
| Shanxi    | 63.6 | 108  | 16.8 | 6.55       | 6.82      | 4.11 | 0.12 | 18.8 | 100.0  |
| Inner Mong | 73.9 | 123  | 17.0 | 9.86       | 10.3      | 3.82 | 0.18 | 17.2 | 0.89   |
| Liaoning  | 61.1 | 141  | 15.9 | 11.0       | 11.6      | 5.98 | 4.88 | 20.4 | 25.5   |
| Jilin     | 62.3 | 100  | 14.3 | 8.67       | 9.08      | 5.13 | 1.62 | 15.3 | 0.74   |
| Heilongjiang | 86.3 | 141  | 19.2 | 12.4       | 13.0      | 7.39 | 2.34 | 20.6 | 1.32   |
| Shanghai  | 21.7 | 121  | 7.56 | 13.4       | 14.7      | 5.27 | 1.67 | 16.0 | 119.0  |
| Jiangsu   | 127  | 335  | 35.5 | 25.9       | 27.2      | 14.9 | 4.70 | 48.9 | 59.8   |
| Zhejiang  | 85.5 | 353  | 27.2 | 32.2       | 34.9      | 14.8 | 4.66 | 47.1 | 197.0  |
| Anhui     | 178  | 332  | 43.5 | 26.6       | 27.8      | 15.6 | 4.93 | 48.4 | 16.9   |
| Fujian    | 47.3 | 204  | 15.2 | 19.2       | 20.8      | 8.49 | 2.68 | 27.0 | 126.0  |
| Jiangxi   | 37.1 | 83.7 | 10.4 | 5.61       | 5.81      | 3.55 | 1.12 | 12.0 | 2.35   |
| Shandong  | 227  | 387  | 56.2 | 29.0       | 30.4      | 17.0 | 5.33 | 64.9 | 23.7   |
| Henan     | 226  | 363  | 53.3 | 28.3       | 29.5      | 17.3 | 5.43 | 59.3 | 2.64   |
| Hubei     | 110  | 231  | 28.5 | 17.8       | 18.6      | 10.6 | 3.35 | 34.3 | 18.2   |
| Hunan     | 69.3 | 165  | 19.9 | 10.2       | 10.5      | 6.89 | 2.16 | 25.7 | 1.23   |
| Guangdong | 79.5 | 267  | 24.1 | 22.9       | 24.5      | 1.14 | 3.59 | 37.6 | 113.0  |
| Guangxi   | 49.1 | 125  | 13.3 | 9.51       | 10.0      | 5.46 | 1.72 | 17.4 | 21.5   |
| Hainan    | 13.3 | 45.6 | 3.75 | 4.16       | 4.52      | 1.82 | 0.58 | 5.63 | 19.1   |
| Chongqing | 38.0 | 85.3 | 10.6 | 5.85       | 6.05      | 3.64 | 1.15 | 12.2 | 1.39   |
| Sichuan   | 49.8 | 122  | 14.5 | 7.43       | 7.58      | 5.23 | 1.64 | 19.4 | 1.42   |
| Guizhou   | 32.0 | 64.9 | 9.63 | 3.69       | 3.80      | 2.50 | 0.78 | 11.6 | 0.45   |
| Yunnan    | 49.7 | 99.9 | 12.7 | 7.21       | 7.45      | 4.72 | 1.49 | 15.5 | 1.06   |
| Tibet     | 13.7 | 19.9 | 3.19 | 1.77       | 1.87      | 1.03 | 0.33 | 3.27 | 0.06   |
| Shaanxi   | 45.2 | 88.8 | 11.9 | 5.53       | 5.72      | 3.61 | 1.13 | 14.2 | 1.33   |
| Gansu     | 57.4 | 93.9 | 13.8 | 6.87       | 7.18      | 4.20 | 1.32 | 15.2 | 0.76   |
| Qinghai   | 11.1 | 20.9 | 2.62 | 1.68       | 1.75      | 1.03 | 0.32 | 3.01 | 0.16   |
| Ningxia   | 15.2 | 23.6 | 3.66 | 1.76       | 1.85      | 1.07 | 0.34 | 3.97 | 0.24   |
| Xinjiang  | 43.5 | 77.6 | 10.1 | 6.40       | 6.69      | 3.87 | 1.22 | 11.1 | 0.91   |
| Total     | 2176 | 4704 | 567  | 368        | 388       | 208  | 65.5 | 710  | 811.0  |
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Fig. S1. Agricultural diesel consumption in China (1993–2003).

Fig. S2. Power of fishing vessels in China (1990–2016).