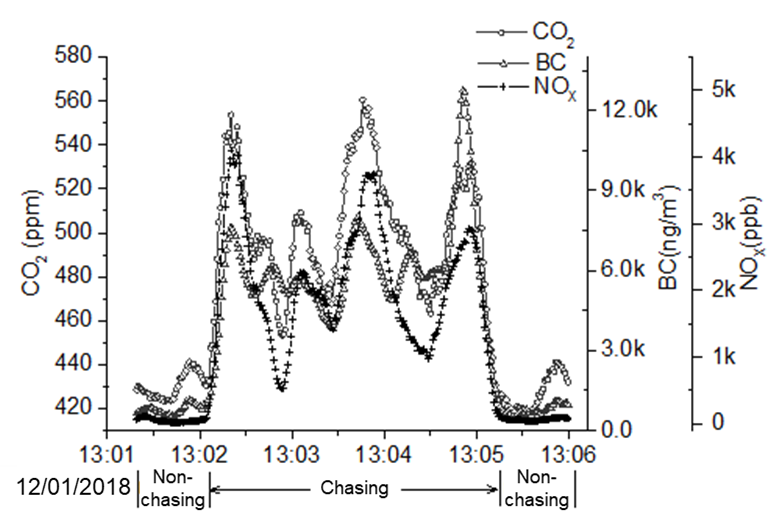
Supplementary Information



**Fig.S1.** An example of data series for “chasing” and “non-chasing” measurements.

**Table S1**. Estimated fuel-based emission factors of LDGVs compared with reported literature values a.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study** | **Test Year** | **Cities/**  **Country** | **Method** | **Emission standard** | **Speed**(km/h) | **NOx** (g/kg) | **CO** (g/kg) | **BC** (g/kg) | **PN** (1015/kg) |
| **This work**  **‘CO-rich’** | 2018 | Chengdu, China | Mobile platform | Fleet-averaged | 30 | 2.23  [1.72-2.76] b | 50.32  [48.89-51.91] | 0.023  [0.019-0.027] | 0.32  [0.10-0.54] |
| **Chinese studies** | | | | | | | | | |
| Yang et al., 20181 | 2008-2016 | 7 cities in China | PEMS | China 1 | 31.7 | 10.8 <5.8> | 195.0 <138.7> |  |  |
| China 2 | 26.3 | 5.0 <3.8> | 70.3 <26.0> |  |  |
| China 3 | 31.3 | 1.8 <0.1> | 9.9 <0.1> |  |  |
| China 4 | 36.2 | 1.1 <0.5> | 19.6 <14.4> |  |  |
| Zheng et al., 20172 | 2009-2012 | Beijing | PEMS | China 4 Non-TWC | 31 | 34.9 <9.1> | 134.9 <9.1> |  |  |
| China 4 TWC | 31 | 0.5 <0.3> | 13.6 <12.1> |  |  |
| Huang et al., 20173 | 2015-2017 | Shanghai, China | Chassis Dynamometer | China 2 | 33.5 | 15.5 <12.7> | 134.9 <166.7> |  |  |
| China 3 | 33.5 | 8.9 <12.7> | 50.0 <71.2> |  |  |
| China 4 | 33.5 | 0.9 <0.8> | 14.1 <15.5> |  |  |
| China 5 | 33.5 | 0.3 <0.2> | 13.2 <9.7> |  |  |
| Wu et al., 20174 | 2010 | Beijing | Chassis Dynamometer | China 1 | 31 | 9.6 | 189.4 <57.1> |  |  |
| China 2 | 31 | 7.6 | 63.3 <26.4> |  |  |
| China 3 | 31 | 1.8 | 22.0 <12.7> |  |  |
| China 4 | 31 | 0.5 | 10.2 <7.3> |  |  |
| Shen et al., 20145 | 2011-2012 | Beijing, China | PEMS | China 1 | 30.3 |  |  | 0.18 <0.15> |  |
| China 2 | 28.6 |  |  | 0.04 <0.04> |  |
| China 3 | 31.3 |  |  | 0.01 <0.01> |  |
| China 4 | 31.2 |  |  | 0.00 <0.00> |  |
| **EU studies** | | | | | | | | | |
| COPERT6 | 2018 | Europe | Model | Euro 1 | 30 | 6.45 | 73.94 | 0.02 |  |
| Euro 2 | 30 | 3.47 | 36.67 | 0.02 |  |
| Euro 3 | 30 | 1.36 | 31.36 | 0.01 |  |
| Euro 4 | 30 | 0.85 | 10.45 | 0.01 |  |
| Euro 5 | 30 | 0.85 | 10.45 | 0.01 |  |
| Carslaw et al., 20117 | 2007-2010 | UK | Remote sensing | Euro 1 | 31 | 9.55 |  |  |  |
| Euro 2 | 31 | 1.97 |  |  |  |
| Euro 3 | 31 | 0.76 |  |  |  |
| Euro 4 | 31 | 0.76 |  |  |  |
| Euro 5 | 31 | 0.45 |  |  |  |
| **U.S. studies** | | | | | | | | | |
| Larson et al., 20178 | 2017 | Seattle, WA | Mobile platform | Fleet-averaged | 26 | 3.2  [2.8-3.6] | 22.4  [19.7-25.0] | 0.016  [0.011-0.021] | 0.19  [0.13-0.25] |
| Park et al., 20169 | 2010 | Three cities in California | Mobile platform | Fleet-averaged | 40 | 2.0 <3.4>,  3.8 <3.8>,  3.5 <3.9>c | 15.2 <53.8>,  36.8 <85.6>,  46.6 <117.9> | 0.01 <0.02>,  0.02 <0.02>,  0.02 <0.06> | 0.23 <0.64>,  0.50 <0.97>,  0.41 <0.98> |
| May et al., 201410 | 2014 | California | Chassis Dynamometer | Pre-LEV | 39.6 | 11.5 <6.8> | 122.9 <92.0> | 0.02 <0.03> |  |
| LEV1 | 39.6 | 5.3 <5.7> | 39.9 <41.3> | 0.02 <0.03> |  |
| LEV2 | 39.6 | 0.5 <0.7> | 13.7 <11.1> | 0.02 <0.02> |  |
| Kozawa et al., 201411 | 2009-2011 | LA, CA | Mobile platform | Fleet-averaged | 39.6 | 2.7<0.4>, 4.0<0.3> d | 24<1.6>, 27<3.1> | 0.015<0.011>  0.067<0.031> | 0.28<0.31>, 0.58<0.30> |

a. [ ] = 5th-95th percent confidence limits, < > = reported standard deviation.

b. Confidence limits estimated via blocked bootstrap (see section 3.3 for details).

c. Values for West Hollywood, Boyle Heights, Southeast Los Angeles

d. Lowest and highest mean values and their corresponding standard deviations for multiple campaigns

**Table S2.** Estimated fuel-based emission factors of HDDTs compared with reported literature values.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study** | **Test Year** | **Location** | **Method** | **Emission standard** | **Speed (km/h)** | **NOx (g/kg)** | **CO (g/kg)** | **BC (g/kg)** | **PN (1015/kg)** |
| **This work**  **‘Normal-emission feature’** | 2018 | Chengdu, China | Mobile platform | Fleet-averaged | 55 | 33.25  [32.56-33.84] | 3.74  [1.63-6.16] | 0.19  [0.15-0.22] | 3.31  [2.87-3.65] |
| **This work**  **‘High-emission feature’** | 2018 | Chengdu, China | Mobile platform | Fleet-averaged | 55 | 104.50  [75.96-147.99] | 28.70  [2.78-91.00] | 2.52  [1.78- 3.59] | 15.67  [11.20-22.24] |
| **Chinese studies** | | | | | | | | | |
| Yang et al., 20181 | 2008-2016 | 7 cities | PEMS | China I | 36.3 | 36.2 <8.5> |  |  |  |
| China II | 28.4 | 36.6 <14.6> |  |  |  |
| China III | 27.5 | 42.7 <15.1> |  |  |  |
| China IV | 30.6 | 42.1 <10.9> |  |  |  |
| Zheng et al., 201512. | 2015 | Beijing | PEMS | China II | 40 |  |  | 2.22 <0.25> |  |
| China III | 40 |  |  | 0.61 <0.74> |  |
| China IV | 40 |  |  | 0.45 <0.58> |  |
| China V | 40 |  |  | 0.15 <0.01> |  |
| Wang et al., 201213 | 2012 | Beijing and Chongqing | Mobile platform | Fleet-averaged | 60~70 | 40.0 a  [31.7-48.1]  47.3  [38.1-62.5] |  | 1.1  [0.7-1.6]  0.4  [0.2-0.8] |  |
| Wu et al., 20174 | 2017 | China | EMBEV model | China I | 40 | 47.3 <11.8> |  |  |  |
| China II | 40 | 36.6 <16.1> |  |  |  |
| China III | 40 | 34.6 <5.6> |  |  |  |
| China IV | 40 | 34.6 |  |  |  |
| China V | 40 | 24.2 |  |  |  |
| **EU** | | | | | | | | | |
| COPERT6 | 2018 | Europe | Model | Euro III | 60 | 27.4 | 6.6 | 0.45 |  |
| Euro IV | 60 | 19.7 | 3.5 | 0.11 |  |
| Euro V | 60 | 15.6 | 6.7 | 0.14 |  |
| **U.S. studies** | | | | | | | | | |
| Haugen et al., 201814 | 2017 | CA | OHMS b | Fleet-averaged | 11.3 | 27.6 <0.4> c  18.6 <1.2> | 1.7 <0.3>  2.8 <0.4> | 0.03 <0.01>  0.06 <0.003> | 0.22 <0.026>  0.77 <0.095> |
| Larson et al., 20178 | 2017 | Seattle, WA | Mobile platform | Fleet-averaged | 26 | 14.8  [9.9-21.9] | 18.9  [8.0-35.3] | 0.40  [0.29-0.58] | 4.3  [2.9-6.2] |
| Preble et al., 201515 | 2013 | Oakland, CA | Mobile platform | Fleet-averaged | 48.3 | 15.4  [14.5-16.3] |  | 0.28  [0.23-0.33] | 2.5  [2.0-3.0] |
| Bishop et al., 201516 | 2013 | CA | OHMS | Fleet-averaged | 7.7~16.8 | 20.7 d  [19.1-22.3], 20.3  [18.9-22.1] | 2.3  [1.5-3.1],  5.1  [4.7-5.5] | 0.02  [0.014-0.026]  0.23  [0.17-0.29] |  |
| May et al., 201410 | 2014 | California | Chassis Dynamometer | DPF | 30.2 | 8.2 <6.8> | 7.2 <5.4> ×10-4 | 0.3 <0.7> |  |
| non-DPF | 30.2 | 23.6 <13.1> | 0.2 <0.1> | 8.8 <6.6> |  |

a. Values for Chongqing and Beijing.

b. OHMS is short for On-Road Heavy-Duty Measurement System.

c. Values for separate measurements at the Port of LA and Cottonwood weigh station in Northern CA.

d. Values for separate measurements at the Port of Los Angeles and at a Northern California I-5 weigh station.

**Table S3.** Loadings, eigenvalues and proportion variances of two principal components for chasing data excluding high-emitters.

|  |  |  |
| --- | --- | --- |
| **Pollutants** | **NOx/CO2-rich feature** | **PN/BC-rich feature** |
| PN | 0.492 | 0.620 |
| NOx | 0.913 | 0.115 |
| BC | 0.010 | 0.869 |
| CO | 0.115 | -0.228 |
| CO2 | 0.933 | 0.008 |
| Eigenvalues | 2.026 | 1.158 |
| Proportion Variances | 0.394 | 0.243 |

**Table S4.** Comparison offuel-based emission factors of the two HDDT emission features derived before and after excluding high emitters from the chase dataset.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Feature** |  | **NOx, g/kg**  **[95% CI]** | **CO, g/kg**  **[95% CI]** | **BC, g/kg**  **[95% CI]** | **PN, 1015/kg**  **[95% CI]** |
| **NOx-rich**  **‘Normal emission feature’** | Before excluding high emitters | 33.25  [32.56-33.84] | 3.74  [1.63-6.16] | 0.19  [0.15-0.22] | 3.31  [2.87-3.65] |
| After excluding high emitters | 33.30  [32.59-33.88] | 3.13  [1.29- 5.05] | 0.12  [0.08-0.14] | 4.71  [4.21-5.15] |
| **PN-BC-rich ‘High emission feature’** | Before excluding high emitters | 104.50  [75.96-147.99] | 28.70  [2.78-91.00] | 2.52  [1.78- 3.59] | 15.67  [11.20-22.24] |
| After excluding high emitters | 40.81  [29.56-60.68] | 6.39  [1.51-9.83] | 1.07  [0.83-1.41] | 5.91  [4.52-8.02] |

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