**Tables and Figures included in the Supplementary**

**Tables:**

Table S1. Description of SAPRC-99 NMVOC emitting species from anthropogenic sources

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Table S3. Monthly profiles used for each component emission inventory in MIX

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Table S5. Sector definition of MIX and source mapping matrix in the mosaic process

Table S6 – Table S14. Monthly emissions by sectors and Asian regions in 2010 (summarized in “acp-2015-947-MIX-monthlyemissions.xlsx”)

Table S15. New emission standards published/revised in China between 2006 and 2010

**Figures:**

Figure S1. Comparison of MIX, REAS2 and EDGAR v4.2 emission estimates for China in 2008 by species and by sector

**Table S1. Description of SAPRC-99 NMVOC emitting species from anthropogenic sourcesa**

|  |  |
| --- | --- |
| Species in SAPRC-99 | Description |
| ACET | Acetone |
| ALK1 | Primarily ethane |
| ALK2 | Primarily propane and acetylene |
| ALK3 | Alkanes and other non-aromatic compounds that react only with OH, and have kOH between 2.5 × 103 and 5 × 103 ppm-1 · min-1 |
| ALK4 | Alkanes and other non-aromatic compounds that react only with OH, and have kOH between 5 × 103 and 1 × 104 ppm-1 · min-1 |
| ALK5 | Alkanes and other non-aromatic compounds that react only with OH, and have kOH greater than 1 × 104 ppm-1 · min-1 |
| ARO1 | Aromatics with kOH < 2 × 104 ppm-1 · min-1 |
| ARO2 | Aromatics with kOH > 2 × 104 ppm-1 · min-1 |
| BACL | Biacetyl |
| BALD | Aromatic aldehydes (e.g., benzaldehyde) |
| CCHO | Methyl Hydroperoxide |
| CRES | Cresols |
| ETHE | Ethene |
| GLY | Glyoxal |
| HCHO | Formaldehyde |
| IPRD | Unsaturated aldehydes other than acrolein and methacrolein |
| MACR | Methacrolein |
| MEK | Ketones and other non-aldehyde oxygenated products which react with OH radicals slower than 5 × 10-12 cm3 molec-2·sec-1 |
| MEOH | Methanol |
| MGLY | Methyl Glyoxal |
| MVK | Methyl Vinyl Ketone |
| NROG | Unreactive organic chemicals |
| NVOL | Nonvolatile organic chemicals |
| OLE1 | Alkenes (other than ethene) with kOH < 7 × 104 ppm-1 · min-1 |
| OLE2 | Alkenes with kOH > 7 × 104 ppm-1 · min-1 |
| PHEN | Phenol |
| PRD2 | Ketones and other non-aldehyde oxygenated products which react with OH radicals faster than 5 × 10-12 cm3 molec-2·sec-1 |
| RCHO | Lumped C3+ Aldehydes |

aSource: Carter, 2000.

**Table S2. Description of CB05 NMVOC emitting species from anthropogenic sourcesa**

|  |  |
| --- | --- |
| Species in CB05 | Description |
| ALD2 | Acetaldehyde |
| ALDX | Propionaldehyde and higher aldehydes |
| ETH | Ethene |
| ETHA | Ethane |
| ETOH | Ethanol |
| FORM | Formaldehyde |
| IOLE | Internal olefin carbon bond (R-C=C-R) |
| MEOH | Methanol |
| NVOL | Nonvolatile organic chemicals |
| OLE | Terminal olefin carbon bond (R-C=C) |
| PAR | Paraffin carbon bond (C-C) |
| TOL | Toluene and other monoalkyl aromatics |
| UNR | Unreactive VOCs |
| XYL | Xylene and other polyalkyl aromatics |

aSource: <http://www.camx.com/files/cb05_final_report_120805.aspx>

**Table S3. Monthly profiles used in each component emission inventory**

|  |  |  |  |
| --- | --- | --- | --- |
| Inventories | Sub-sectors | Monthly profiles | Data source |
| REAS2 | power plants | monthly power generations | not specified |
|  | residential combustion | stove operations based on surface temperatures | not specified |
|  | residential non-combustion | n/a | n/a |
|  | industrial combustion | monthly production of industrial products and fossil fuels | not specified |
|  | industrial non-combustion | monthly production of industrial products and fossil fuels | not specified |
|  | on-road vehicles (cold-start) | monthly emission factors and removal efficiencies dependent on ambient temperatures | n/a |
|  | on-road vehicles (other sources) | n/a | n/a |
|  | off-road transportation | n/a | n/a |
|  | domestic shipping | n/a | n/a |
|  | agriculture (Japan) | JEI-DBa monthly emissions | JEI-DB |
|  | agriculture (other regions) | n/a | n/a |
|  | waste | n/a | n/a |
|  | human | n/a | n/a |
| MEIC | power | monthly power generations | NBSb (Liu et al., 2015) |
|  | industrial heating | industrial production / GDP | NBS |
|  | residential heating | stove operations based on surface temperatures | NBS |
|  | industrial boiler | industrial production / GDP | NBS |
|  | residential combustion | stove operations based on surface temperatures | NBS |
|  | iron and steel | industrial production / GDP | NBS |
|  | cement | industrial production / GDP | NBS |
|  | other industrial process | industrial production / GDP | NBS |
|  | on-road vehicles | monthly emission factors modeled by IVEc | IVE model |
|  | motorcycles | monthly emission factors modeled by IVEc | IVE model |
|  | off-road | n/a | n/a |
|  | solvent use - industry | industrial production / GDP | NBS |
|  | solvent use - residential | n/a | n/a |
|  | agriculture | monthly emission fractions based on PKU-NH3 inventory | process-based model (Huang et al., 2012) |
|  | waste | industrial GDP | NBS |
| PKU-NH3 | fertilizer | monthly emission factors developed considering the soil pH, temperature, etc. | not specified |
|  | livestock | monthly emission factors developed based on surface temperature | not specified |
|  | chemical industry | n/a | n/a |
|  | waste disposal | n/a | n/a |
|  | compost | n/a | n/a |
|  | traffic | n/a | n/a |
|  | human excrement | n/a | n/a |
| ANL-India | power generation | monthly power generations | RBId, CSOe |
|  | industry | industrial production index / GDP | RBI, CSO |
|  | residential | stove operations based on surface temperatures | not specified |
|  | transport | volume of passenger and freight transported by ship, railway, etc. | RBI, CSO |
| CAPSS | all subsectors | n/a | n/a |

a JEI-DB, Japan Auto-Oil Program (JATOP) Emission Inventory-Data Base

b NBS, National Bureau of Statistics, http://www.stats.gov.cn/tjsj/

c IVE model, International vehicle emission model

d RBI, Reserve Bank of India

e CSO, Central Statistical Organization

**Table S4. Spatial proxies used in each component emission inventory**

|  |  |  |  |
| --- | --- | --- | --- |
| Inventories | Sub-sectors | Spatial proxies | Data source |
| REAS2 | power plants (large ones) | plant locations | CARMAa |
|  | power plants (small ones) | total population | GPW v3b |
|  | residential combustion (fossil fuel) | total population | GPW v3 |
|  | residential combustion (biofuel) | rural population | GRUMP v1c, GPW v3 |
|  | residential non-combustion | total population | GPW v3 |
|  | industrial combustion | total population | GPW v3 |
|  | industrial non-combustion | total population | GPW v3 |
|  | on-road vehicles | road network | DCWd |
|  | off-road transportation | rural population | GRUMP v1, GPW v3 |
|  | domestic shipping | total population | GPW v3 |
|  | agriculture | total population | GPW v3 |
|  | waste | total population | GPW v3 |
|  | human | total population | GPW v3 |
| MEIC | power | plant locations | Google Earth (Liu et al., 2015) |
|  | industrial heating | industrial GDPe, urban populationf | NBSg, LandScanh, urban/rural extentsi |
|  | residential heating | urban population | NBS, LandScan, urban/rural extents |
|  | industrial boiler | industrial GDPe, urban populationf | NBS, LandScan, urban/rural extents |
|  | residential combustion (fossil fuel) | urban population | NBS, LandScan, urban/rural extents |
|  | residential combustion (biofuel) | rural population | NBS, LandScan, urban/rural extents |
|  | iron and steel | industrial GDPe, urban populationf | NBS, LandScan, urban/rural extents |
|  | cement | industrial GDPe, urban populationf | NBS, LandScan, urban/rural extents |
|  | other industrial process | industrial GDPe, urban populationf | NBS, LandScan, urban/rural extents |
|  | on-road vehicles | vehicle populatione, road networkf | China Digital Road-network Map (Zheng et al., 2014) |
|  | motorcycles | vehicle populatione, road networkf | China Digital Road-network Map (Zheng et al., 2014) |
|  | off-road (agriculture machinery) | machine powere, rural populationf | NBS, LandScan, urban/rural extents |
|  | off-road (construction) | total GDPe , urban populationf | NBS, LandScan, urban/rural extents |
|  | off-road (others) | total population | NBS, LandScan |
|  | solvent use - industry | industrial GDPe, urban populationf | NBS, LandScan, urban/rural extents |
|  | solvent use - residential | urban populatione , urban populationf | NBS, LandScan, urban/rural extents |
|  | agriculture (fertilizer) | fertilizer usee, rural populationf | NBS, LandScan, urban/rural extents |
|  | agriculture (livestock) | meat consumptione , rural populationf | NBS, LandScan, urban/rural extents |
|  | waste | total population | NBS, LandScan |
| PKU-NH3 | fertilizer | developed based on consumptions and gridded emission factors | not necessary |
|  | livestock (free-range, intensive) | rural population | not specified |
|  | livestock (grazing) | grassland land cover | not specified |
|  | chemical industry | equally distributed | not specified |
|  | waste disposal | rural population | not specified |
|  | compost | land cover class | not specified |
|  | traffic | equally distributed | not specified |
|  | human excrement | rural population | not specified |
| ANL-India | power generation | plant locations | Global Energy Observatory and Google Earth |
|  | industry | gridded emissions in EDGAR v4.1 | JRC/PBL, 2010 |
|  | residential (coal) | urban population | GRUMP, LandScan, HYDEj |
|  | residential (biofuel) | rural population | GRUMP, LandScan, HYDE |
|  | residential (other sources) | total population | LandScan, HYDE |
|  | transport (on-road) | road network | DCW |
|  | transport (off-road) | cropland cover | Global Cropland Dataset (Ramankutty and Foley, 1999) |
| CAPSS | electricity generating utility (EGU) combustion | plant locations | Continuous Emission Monitoring System (CEMS), Stack Emission Management System (SEMS) |
|  | combustion in other energy industries | plant locations | CEMS, SEMS |
|  | combustion in manufacturing industries | plant locations for point sources, population data / number of employees for area sources | not specified |
|  | non-industrial combustion plants | plant locations for point sources, population data / number of employees for area sources | not specified |
|  | production processes | plant locations for point sources, population data / number of employees for area sources | not specified |
|  | storage and distribution of fuels | plant locations for point sources, population data / number of employees for area sources | not specified |
|  | solvent use | population data / number of employees | not specified |
|  | road transport | traffic volume, spatial traffic allocation index | traffic volume survey |
|  | other mobile sources and machinery | railroad network, sailing routes, urban / agricultural areas, construction areas | not specified |
|  | waste treatment and disposal | plant locations | not specified |
|  | agriculture | population data | not specified |

a CARMA, Carbon Monitoring for Action database (Wheeler and Ummel, 2008)

b GPWv3, Gridded Population on the World (CIESIN et al., 2005, 2011)

c GRUMP v1, Global Rural-Urban Mapping Project (CIESIN et al., 2005, 2011)

d DCW, Digital Chart of the World (DMA, 1993)

e proxies used to distribute provincial emissions to county

f proxies used to distribute county-level emissions to grids

g National Bureau of Statistics, http://www.stats.gov.cn/tjsj/

h LandScan Global Population database (ORNL, 2006, 2009)

i urban / rural extents developed by Schneider et al. (2009)

j HYDE, History Database of the Global Environment (Goldewijk et al., 2011)

**Table S5. Sector mapping from regional emission inventories to MIX**

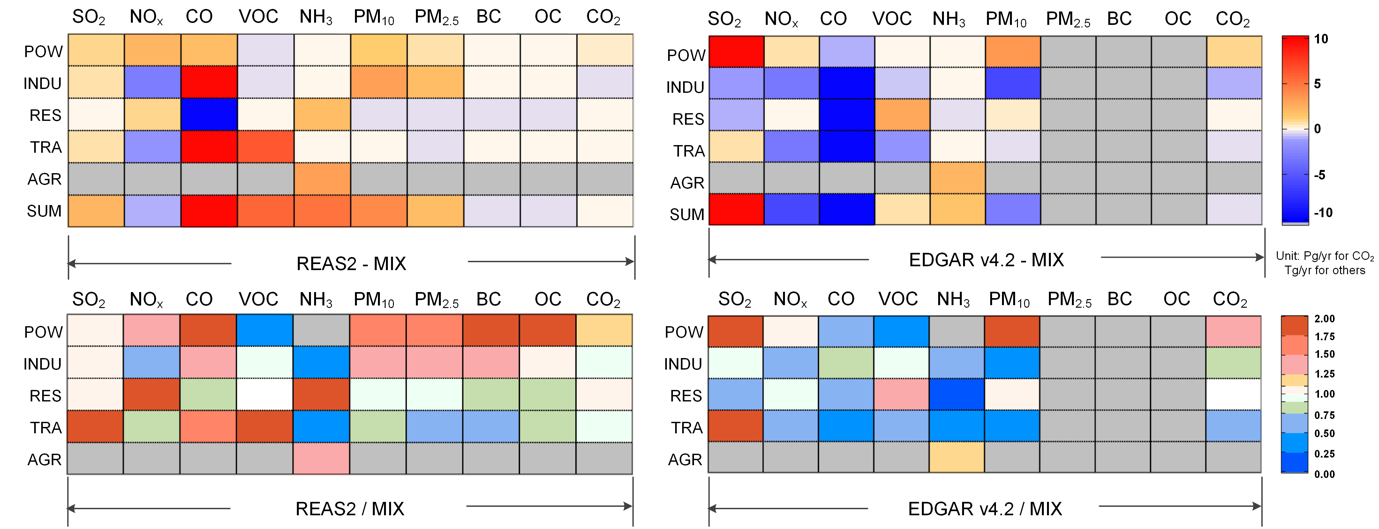
|  |  |  |  |
| --- | --- | --- | --- |
| Inventories | Sub-sectors | MIX-sectors | IPCC codes |
| REAS2 | power plants | power | 1A1a |
|  | residential combustion | residential | 1A4 |
|  | residential non-combustion | residential | 3 |
|  | industrial combustion | industry | 1A1bc, 1A2 |
|  | industrial non-combustion | industry | 2A, 2B, 2C, 2D, 3, 1B |
|  | on-road vehicles | transportation | 1A3b |
|  | off-road transportation | transportation | 1A3c, 1A3e |
|  | domestic shipping | transportation | 1A3d |
|  | agriculture | agriculture | 4B, 4D |
|  | waste | residential | 6A, 6B |
|  | human | residential | n/a |
| MEIC | power | power | 1A1a |
|  | industrial heating | industry | 1A1bc |
|  | residential heating | residential | 1A1bc |
|  | industrial boiler | industry | 1A2 |
|  | residential combustion | residential | 1A4 |
|  | iron and steel | industry | 1A2, 2C |
|  | cement | industry | 1A2, 2A |
|  | other industrial process | industry | 2A, 2B, 2C, 2D, 1B |
|  | on-road vehicles | transportation | 1A3b |
|  | motorcycles | transportation | 1A3b |
|  | off-road | transportation | 1A3c, 1A3d, 1A3e |
|  | solvent use - industry | industry | 3 |
|  | solvent use - residential | residential | 3 |
|  | agriculture | agriculture | 4B, 4D |
|  | waste | residential | 6A, 6C |
| PKU-NH3 | fertilizer | agriculture | 4D |
|  | livestock | agriculture | 4B |
|  | biomass burning | n/a |  |
|  | chemical industry | industry | 2B |
|  | waste disposal | residential | 6A, 6B, 6C |
|  | agricultural soil | n/a |  |
|  | N-Fixing crop | n/a |  |
|  | compost | agriculture | 6D |
|  | traffic | transportation | 1A3b |
|  | human excrement | residential | n/a |
| ANL-India | power generation | power | 1A1a |
|  | industry | industry | 1A1bc, 1A2, 2A, 2B, 2C, 2D, 3, 1B |
|  | residential | residential | 1A4, 6A, 6B, 6C |
|  | transport | transportation | 1A3b, 1A3c, 1A3d, 1A3e |
|  | forest & savanna burning | n/a |  |
|  | agriculture waste burning | n/a |  |
| CAPSS | electricity generating utility (EGU) combustion | power | 1A1a |
|  | combustion in other energy industries | industry | 1A1bc |
|  | combustion in manufacturing industries | industry | 1A2 |
|  | non-industrial combustion plants | residential | 1A4 |
|  | production processes | industry | 2A, 2B, 2C, 2D |
|  | storage and distribution of fuels | industry | 1B |
|  | solvent use | industry / residential | 3 |
|  | road transport | transportation | 1A3b |
|  | other mobile sources and machinery | transportation | 1A3c, 1A3d, 1A3e |
|  | waste treatment and disposal | residential | 6A, 6C |
|  | agriculture | agriculture | 4B, 4D |
|  | fugitive dust | n/a |  |

**Table S6 – Table S14: Monthly emissions by sector by Asian regions. They are summarized in the “acp-2015-947-MIX-monthlyemissions.xlsx”.**

**Table S15. New emission standards published/revised in China between 2006 and 2010a**

|  |  |  |
| --- | --- | --- |
| Sources | Standard code | Year of implementation |
| *Stationary sources* | | |
| Coal industry | GB20426-2006 | 2006 |
| Bulk gasoline terminals | GB20950-2007 | 2007 |
| Gasoline filling stations | GB20952-2007 | 2007 |
| Electroplating | GB21900-2008 | 2008 |
| Synthetic leather and artificial leather industry | GB21902-2008 | 2008 |
| Ceramics industry | GB25464-2010 | 2010 |
| Aluminum industry | GB25465-2010 | 2010 |
| Lead and zinc industry | GB25466-2010 | 2010 |
| Copper, nickel, cobalt industry | GB25467-2010 | 2010 |
| Magnesium and titanium industry | GB25468-2010 | 2010 |
| *Mobile sources* | | |
| Tri-wheelers and low speed diesel trucks | GB19756-2005 | 2006 |
| Diesel vehicles | GB17691-2005 | 2007 |
| Light duty gasoline vehicles | GB18352.3-2005 | 2007 |
| Off-road machinery | GB20891-2007 | 2007 |
| Motorcycles | GB14622-2007 | 2008 |
| Gasoline transportation | GB20951-2007 | 2007 |
| Motorcycles (evaporative) | GB20998-2007 | 2008 |
| Heavy duty gasoline vehicles | GB14762-2008 | 2009 |

aMinistry of Environmental Protection of the People’s Republic of China, available at: http://kjs.mep.gov.cn/hjbhbz/bzwb/dqhjbh/



**Figure S1. Comparison of MIX, REAS2 and EDGAR v4.2 emission estimates for China in 2008 by species and by sector**

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