CEIP umweltbundesamt

Methodologies applied to the CEIP GNFR gap-filling 2018

Part I: Main pollutants and Particulate Matter (NO_x, NMVOCs, SO_x, NH_3, CO, $PM_{2.5}$, PM_{10}, PM_{coarse}) of the years 2000 to 2016

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1. Introduction

The EMEP Centre on Emission Inventories and Projections (CEIP) operates the UNECE/EMEP emission database (WebDab) which contains information on air pollutant emissions and projections from the Parties to the LRTAP Convention (UNECE 1979). Among these data sets, also emissions used in EMEP models (gap-filled emissions) and gridded emissions in Google maps are available from the CEIP website (www.ceip.at, CEIP 2018).

Data used by CEIP were reported by the Parties to the LRTAP Convention as sectoral emissions (NFR14) and National Total emissions according to the UNECE guidelines for reporting emissions and projections data under the Convention on long-range transboundary air pollution, Annex I (UNECE 2014). For the use by CEIP, the sector data were aggregated to 13 GNFR sectors. In several cases, no data were submitted by the countries, or the reporting is not complete or contains errors. Before these emission data can be used by modelers, missing or erroneous information have to be filled in. To gap-fill those missing data, CEIP typically applies different gap-filling methods. After the gap-filling, sector emissions are used for spatial emission mapping, i.e. the EMEP grid.

This documentation describes the gap-filling methods that have been used for the 2000 to 2016 GNFR inventory (as prepared in 2018) for NO_x, NMVOCs, SO_x, NH_3, CO, $PM_{2.5}$, PM_{10}, PM_{coarse}. It illustrates reasons of replacements of reported data, discusses problems of the procedure and gives an overview on the data availability and gap-filling of each country or area.

2. Summary of the process

The first step is to collect the official submissions by the Parties to the LRTAP Convention. All submissions received up to 13th April 2018 were used as a basis for the gap-filled data set. Parties report their emission inventories to the LRTAP Convention as sectoral emissions (NFR14) and National Total emissions according to the UNECE guidelines for reporting emissions and projections data under the LRTAP Convention, Annex I (UNECE 2014).

The second step is to aggregate the sector data to 13 GNFR sectors. The third step is plausibility checks of all reported data. If plausibility was not given, reported data were replaced (see section 4). The checks comprise:

- Time series comparison of the reported data with previously reported data, gap-filled data from 2017, CRF data (EU 2013) and expert data from IIASA (IIASA 2014), TNO (Kuenen et al. 2014), EDGAR (JRC 2013)
- Comparisons of the ratio of the reported data to population data and to GDP data with all other Parties
- Comparison of the reported sectoral distribution among the Parties
- Comparison of the reported sectoral distribution with expert data, CRF data, previously reported data of the respective country, and with the mean sector distribution from the 2017 gap-filled data set of all countries
- Comparison of the sum of sectors with the National Total
- Comparison of $PM_{2.5}$ and PM_{10}

The next step is the gap-filling or change of the inventory. Gap-filling or replacement of data is applied if

(1) no data are submitted by a Party,
(2) the reporting is not complete,
(3) the data are erroneous,
(4) there is no reporting obligation for a certain area and thus no reported data are available.

After that step, the inventory is completed and will be used for the WebDab database (data as used in EMEP models) and for spatial emission mapping, i.e. the EMEP grid.

3. Gap-filling methods

3.1. Gap-filling of National Total data

If no submission is made, first data of previous submissions are checked for plausibility. If previous reported data are plausible and complete, extrapolation of these data is done. This can be done either by extrapolation of sector data and the National Total is then calculated by the sum of the sectors, or by extrapolation of the National Total, and the sector data are then splitted up using a distribution of another year or an expert distribution. Data for PM_{coarse} are not reported but in all cases calculated as the difference between PM_{10} and $PM_{2.5}$. When this results in negative values for PM_{coarse}, data of $PM_{2.5}$ or PM_{10} are replaced (see Table 4.2).

If no previous reported data are available or the data are not plausible, different estimates were made. These estimates comprise extrapolation of (previous reported or expert) data by using population or GDP data ([1]) of the respective country. Further, (inter-, extrapolation or copy from previous years of) expert data and reported CRF data were used.

Available data for comparison are:

- IIASA data: Data from the GAINS model (Greenhouse Gas and Air Pollution Interactions and Synergies) were provided by the International Institute for Applied Systems Analysis (IIASA 2014). Two data sets (on NFR level) were provided by IIASA:
  - One was generated in spring 2014 and covers the period from 1990 to 2010 (i.e. 1990, 1995, 2000, 2005 and 2010)
  - The other data set was generated in October 2014 and covers the period 2005 to 2030 (i.e. 2005, 2010, 2015, 2020, 2025 and 2030)

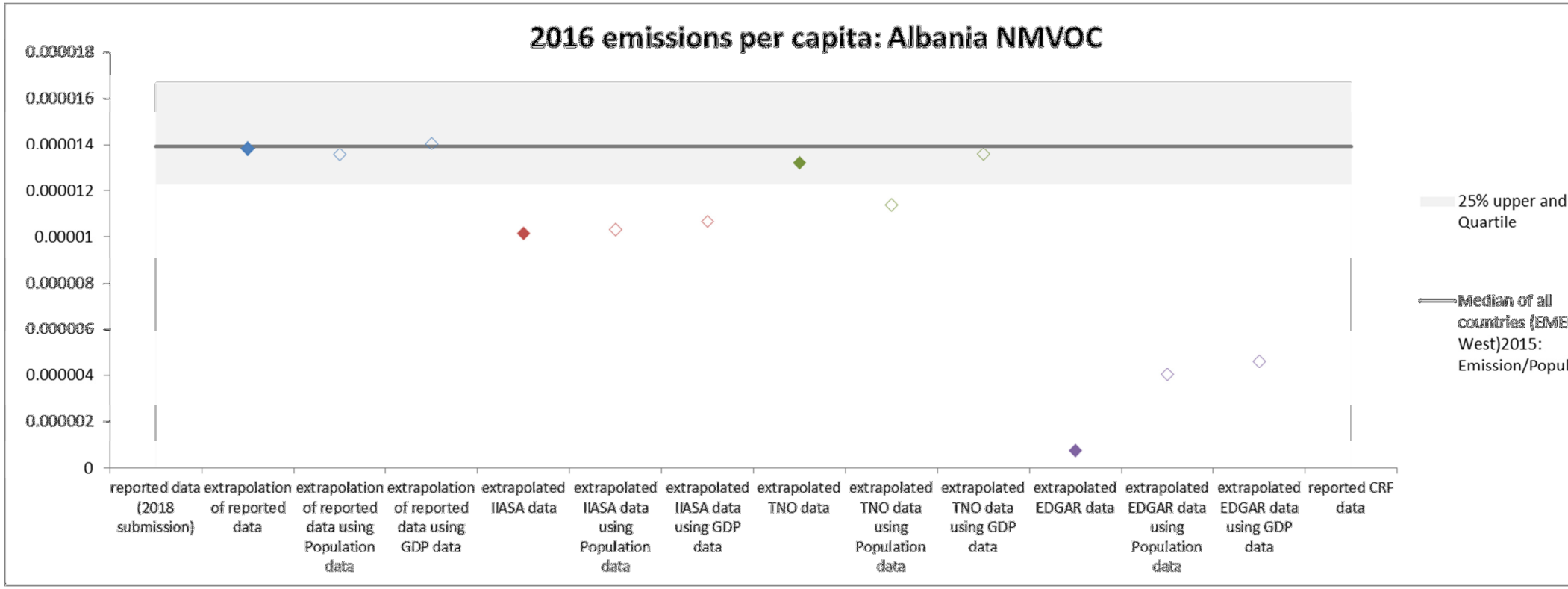
  The data were converted to GNFR level by CEIP. Not for all Parties the second data set was available. If both data sets were available for the overlapping years (2005 and 2010) the data set from October 2014 was used.
- CRF data under the EU Greenhouse Gas Monitoring Mechanism (EU 2013) reported by the Parties in 2018.
- TNO data: expert estimates from the Dutch institute TNO (Kuenen et al. 2014) for the years 2003-2009.

([1]) Population data from database: Population estimates and projections (Last Updated: 12/18/2017). Indicator: Population, total. Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.
GDP data from database: World Development Indicators (Last Updated: 03/01/2018). Indicator: GDP, PPP (constant 2011 international $).

- EDGAR data: expert estimates from the Emission Database for Global Atmospheric Research (JRC 2016) for the years 2000 to 2010.
- MSC-W data: For a few sea/lake areas expert estimates for the year 2006 from the Meteorological Synthesizing Centre - West are available (MSC-W 2006).

In several cases, not only one estimate is given for a country. To facilitate the choice of the estimate for the gap-filling, ratios for each pollutant between emissions and population data and GDP were calculated by using data of the gap-filled inventory from 2017 (separate for EMEP West and EMEP East countries, for the country grouping see Table 9.1) for the year 2015. The distance of the different estimates to this ratio shows how similar the estimates are to the mean. An example for NMVOC estimates of Albania is shown in Figure 3.1.

Figure 3.1 Example for different NMVOC estimates for Albania



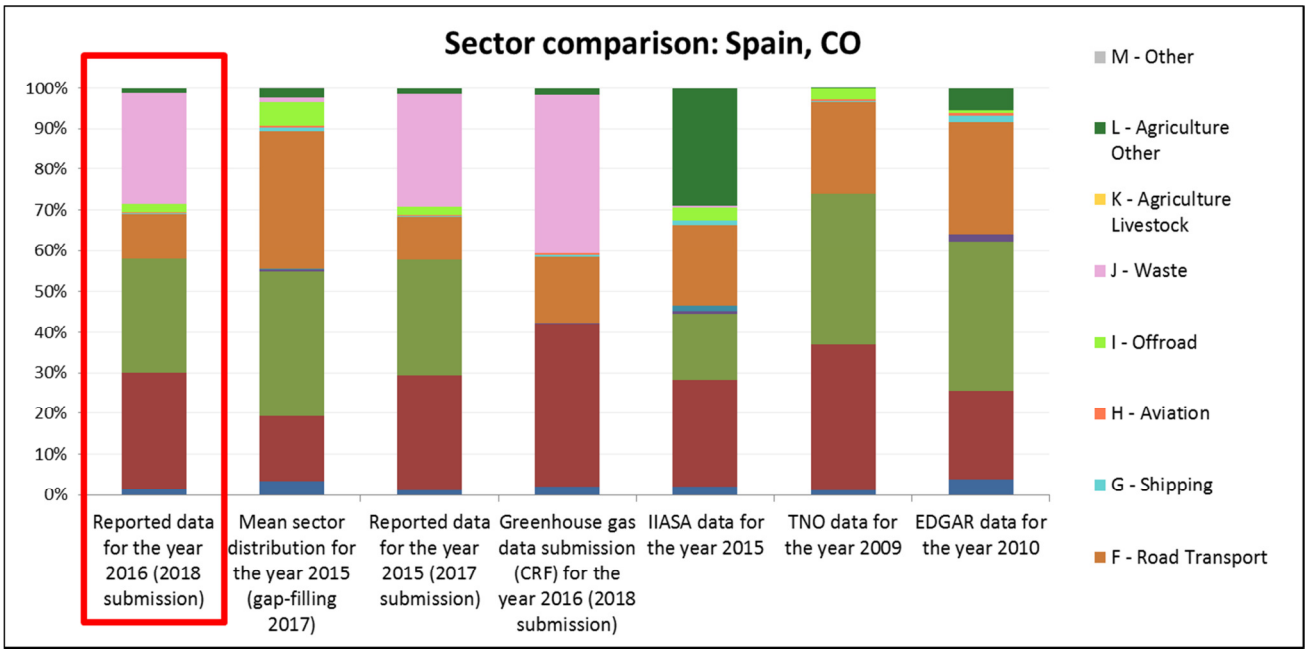
Note: reported data from the 2018 submission and reported CRF data from 2018 were not available from Albania.

3.2. Gap-filling of sectoral data

Estimates on the sectoral distribution of the emissions are available from IIASA (2014), TNO (Kuenen at al. 2014), EDGAR (JRC 2013), CRF (EU 2013), from previous reported submissions and a mean sector distribution from the 2017 gap-filled data set of all countries.

In case of a missing or erroneous sector distribution, all available sector distributions for a country (reported and expert estimates) were compared, and the most suitable distribution chosen for splitting up the National Total into GNFR sectors. An example for the sector comparison is shown in Figure 3.2.

Figure 3.2 Example for sectoral distributions of CO emissions from different reported data sets and expert estimates for Spain



3.3. Gap-filling effects

Figure 3.3, Figure 3.4 and Figure 3.5 show examples on the effects of the gap-filling. Figure 3.3 shows time series of Malta for NO_x as reported with their submission in 2018, and after the gap-filling. Figure 3.4 and Figure 3.5 show the sectoral distribution as reported and after gap-filling of NO_x and $PM_{2.5}$ emissions in the year 2016 for all countries.

Figure 3.3 Reported and gap-filled time series of NO_x emissions from Malta

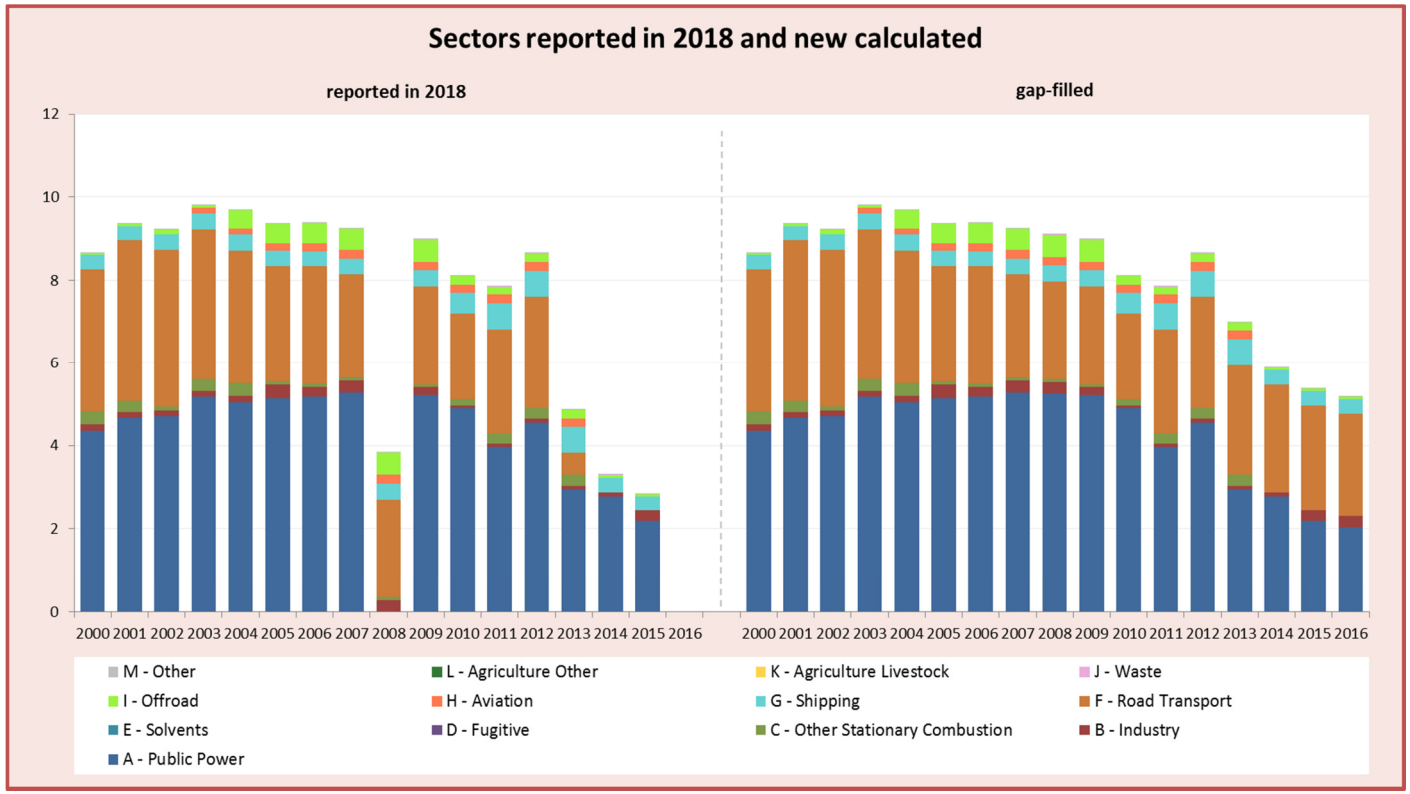


Figure 3.4 Reported and gap-filled sectoral distributions of NO_x emissions in the year 2016

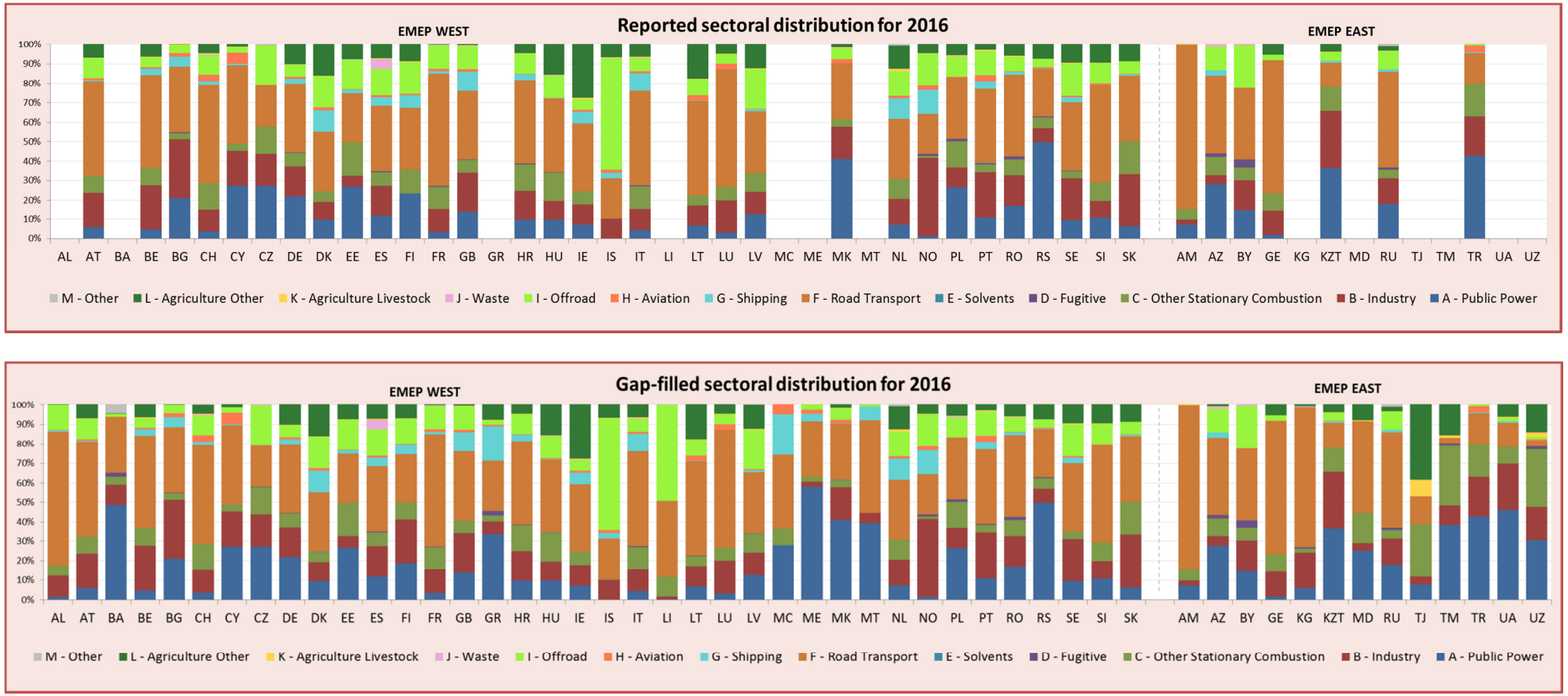
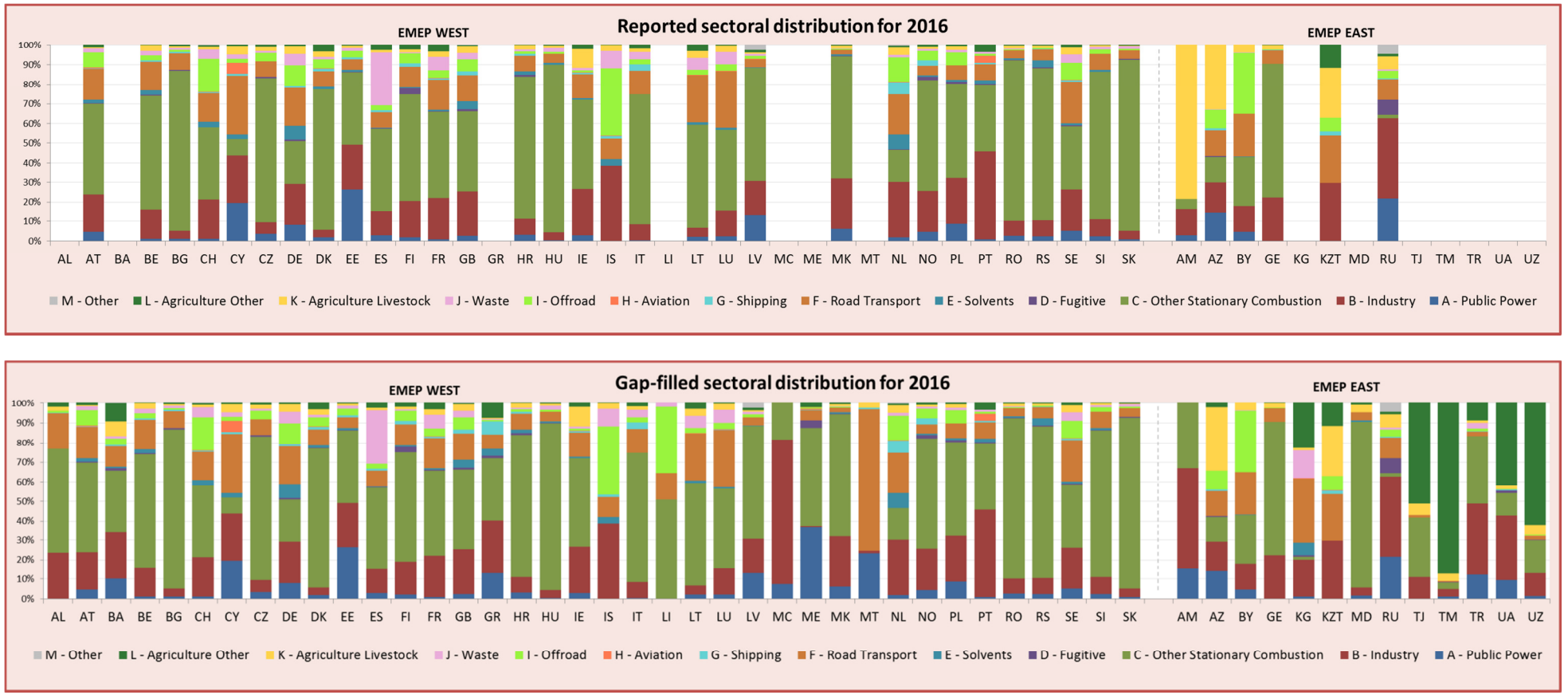


Figure 3.5 Reported and gap-filled sectoral distributions of $PM_{2.5}$ emissions in the year 2016

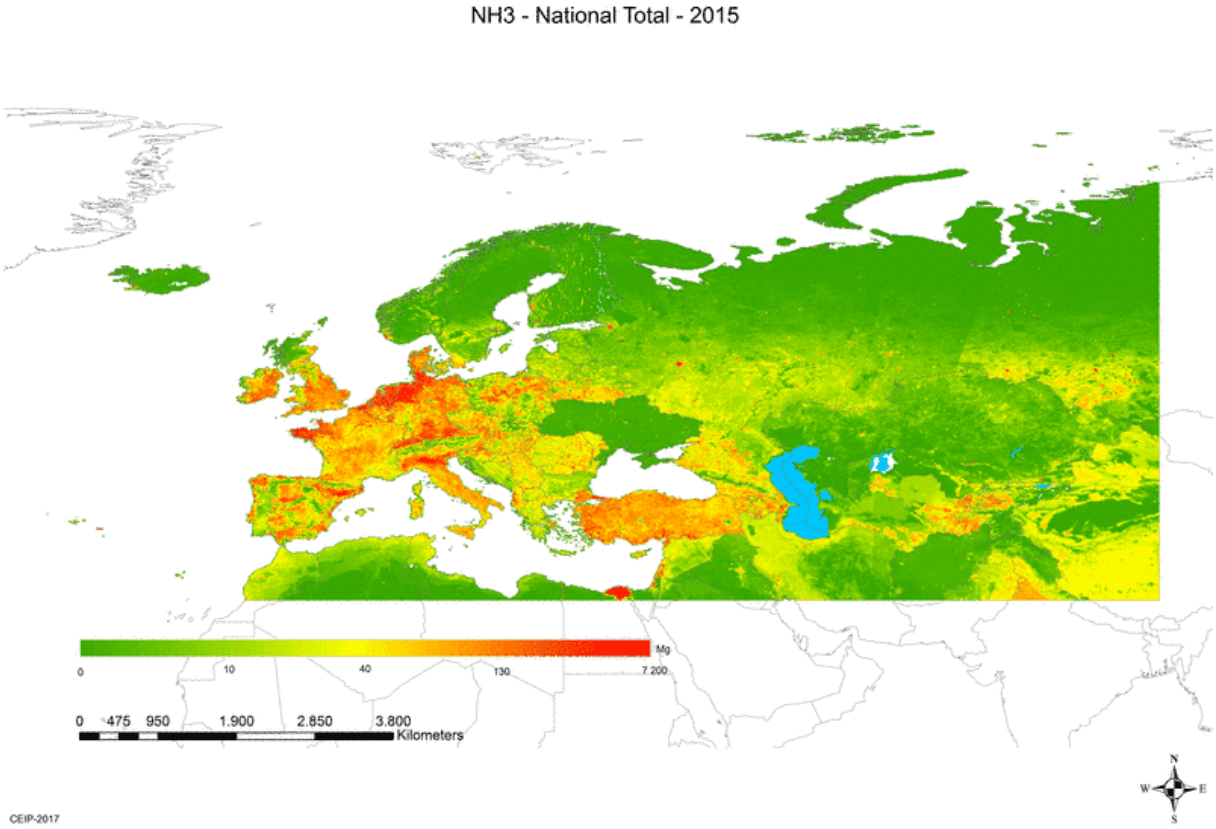


4. Reasons for replacement of reported data

4.1. Replacements of data

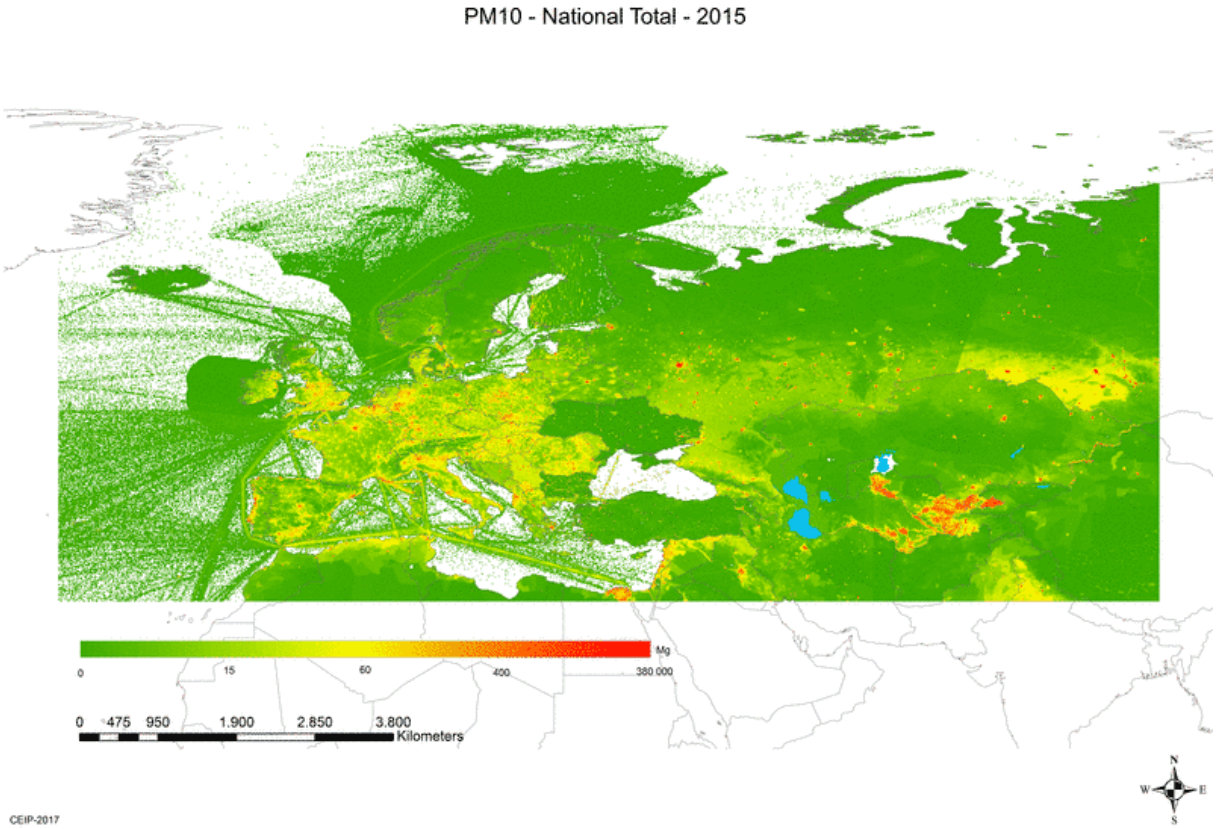
In cases, where data are in all probability erroneous, these data are replaced. If data in such cases will not be replaced, it is likely to get a wrong picture in gridded maps. As example, Figure 4.1 shows not replaced NH_3 data of the Ukraine in gridded maps of the year 2015. In that case, the reported National Total was far too low (compared with expert estimates and with the data of other countries).

Figure 4.1 Example for too low National Total emissions of the Ukraine, showing a peculiar picture in gridded maps: NH_3 emissions of the year 2015



Another example is shown in Figure 4.2, where the National Total seem to be correct, but an unusual sector distribution of PM_{10} data of the Ukraine and Turkey led to a conspicuous picture.

Figure 4.2 Example for unusual sector distribution of the Ukraine and Turkey, reflected in gridded maps: PM_{10} emissions of the year 2015



In 2018, data of 17 countries were (partly) replaced (including replacements of $PM_{2.5}$ and PM_{10} because of negative values for PM_{coarse}). Table 4.1 provides an overview of all replaced data of the gap-filled inventory 2018, including a short rationale. For more information see section 0, information of the respective country.

Table 4.1 Overview of and reasons for replaced data

Country	Pollutant	Year(s)	NT, Sectors,…	Reason
Armenia	SO_x	2007, 2014, 2016	Sector data	Sector distribution showed strong discrepancy to expert data (especially the share of sector B)
Armenia	NH_3	2007, 2014, 2016	Sector data	Sector distribution showed strong discrepancy to expert data
Armenia	NH_3	2016	National Total	National Total adjusted to sum of sectors (error correction and because of replaced sector data)
Armenia	CO	2007, 2014, 2016	Sector data	Sector distribution showed strong discrepancy to expert data (especially the share of sector B)
Armenia	$PM_{2.5}$, PM_{10}	2007, 2016	Sector data	Sector distribution showed strong discrepancy to expert data and reported data of other years
Armenia	$PM_{2.5}$, PM_{10}	2007, 2014, 2016	National Total	National Total data showed strong discrepancy to expert data
Azerbaijan	NO_x	2005-2006	Sector B	Error correction

Azerbaijan	NMVOC	2001-2004	Sector B	Error correction
Azerbaijan	SO_x	2000-2014	Sector A	Error correction
Azerbaijan	NO_x, NMVOC	2000-2008, 2015-2016	National Total	Sum of new, gap-filled and corrected sector data
Azerbaijan	SO_x	2000-2014	National Total	Sum of new, gap-filled and corrected sector data
Azerbaijan	NH_3	2015-2016	National Total	Sum of new, gap-filled sector data
Azerbaijan	$PM_{2.5}$	2000-2006, 2015-2016	National Total	Sum of new, gap-filled sector data
Azerbaijan	PM_{10}	2000-2016	National Total	Sum of new, gap-filled sector data
Azerbaijan	CO	2000-2006	National Total	Sum of new, gap-filled sector data
Georgia	SO_x, NMVOC	2000-2006	National Total	Sum of new, extrapolated sector data
Georgia	SO_x	2007-2016	Sector data	Sector distribution showed strong discrepancy to expert data (especially the share of sector B)
Georgia	CO	2007-2012	Sector data	Sector distribution showed strong discrepancy to expert data and reported data of other years
Georgia	$PM_{2.5}$, PM_{10}	2007-2012	Sector data	Sector distribution showed strong discrepancy to expert data and reported data of other years
Georgia	$PM_{2.5}$, PM_{10}	2007-2012	National Total	National Total adjusted to sum of sectors
Kazakhstan	NO_x	2005, 2009, 2012-2015	National Total	National Total adjusted to sum of sectors
Kazakhstan	NMVOC	2009	National Total	National Total adjusted to sum of sectors
Kazakhstan	SO_x	2000-2016	Sector F	Error correction
Kazakhstan	SO_x	2000, 2005, 2009-2016	National Total	National Total adjusted to sum of sectors
Kazakhstan	NH_3	2010	Sector B	Error correction
Kazakhstan	NH_3	2001-2004, 2005-2010	National Total	National Total adjusted to sum of sectors
Kazakhstan	CO	2005, 2009-2015	National Total	National Total adjusted to sum of sectors
Lithuania	NO_x, SO_x, NH_3, CO	2012	National Total	Due to gap-filling of missing sector data, the National Totals were corrected by the sum of sectors
Lithuania	NMVOC	2000-2004, 2012	National Total	Due to gap-filling of missing sector data, the National Totals were corrected by the sum of sectors
Lithuania	$PM_{2.5}$, PM_{10}	2000-2016	National Total	Due to gap-filling of missing sector data and PM correction, the National Totals were corrected by the sum of sectors
Republic of Moldova	NO_x, NMVOC, $PM_{2.5}$,	2000-2016	National Total	National Total adjusted to sum of sectors

	PM_{10}, CO			
Malta	NO_x	2013-2015	Sector F	Error correction
Malta	NO_x	2008, 2013-2015	National Total	National Total adjusted to sum of sectors (because of changes in/gap-filling of sector data)
Malta	NMVOC	2014-2015	Sector F	Error correction
Malta	NMVOC	2014-2015	National Total	National Total adjusted to sum of sectors (because of changes in/gap-filling of sector data)
Malta	SO_x	2014-2015	National Total	National Total adjusted to sum of sectors (because of gap-filling of sector data)
Malta	NH_3	2010, 2015	National Total	National Total adjusted to sum of sectors (because not equal to sum of sectors, and because of gap-filling of sector data)
Malta	CO	2000-2015	National Total, Sector data	National Totals and sector distribution showed strong discrepancy to expert and reported CRF data
Malta	$PM_{2.5}$, PM_{10}	2014-2015	Sector F	Error correction
Malta	$PM_{2.5}$	2002, 2008-2009, 2014-2015	National Total	National Total adjusted to sum of sectors (because of changes in/gap-filling of sector data)
Malta	PM_{10}	2002, 2008, 2009, 2013-2015	National Total	National Total adjusted to sum of sectors (because of changes in/gap-filling of sector data)
Russian Federation	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, CO	2002-2009	Sector data	Missing sectors, Sector distribution showed strong discrepancy to expert data and reported data of other years
Turkey	CO	2016	Sector data	Sectors incomplete, therefore new split of the National Total into sectors like 2015 sector distribution
Turkey	PM_{10}	2000-2016	Sector data	Sector distribution showed strong discrepancy to expert data (especially the share of sector B)
Ukraine	NO_x, NMVOC, NH_3, CO	2002-2015	National Total, Sector data	National Totals and sector distribution showed strong discrepancy to expert data. For the years 2002-2007, the sum of sectors did not equal to the National Total
Ukraine	SO_x	2010-2013	National Total	Due to gap-filling of missing sector data, the National Totals were corrected by the sum of sectors
Ukraine	SO_x	2002 to 2007	Sector data	Sectors incomplete, therefore new split of the National Total into sectors like extrapolated sector distribution
Ukraine	$PM_{2.5}$, PM_{10}	2002, 2004-2005, 2010-	National Total, Sector data	National Totals and sector distribution showed strong discrepancy to expert

		2015		data. For the years 2002-2007, the sum of sectors did not equal to the National Total

4.2. Replacements due to discrepancies of $PM_{2.5}$ to PM_{10}

Data for PM_{coarse} are calculated as the difference between PM_{10} and $PM_{2.5}$. When this results in negative values for PM_{coarse}, data of $PM_{2.5}$ or PM_{10} are replaced. An overview of all replacements of gap-filled or reported data is given in Table 4.2. In all cases, in a later step the National Totals were corrected (e.g. by the sum of the sectors).

Table 4.2 Overview of changes of $PM_{2.5}$ or PM_{10} values due to discrepancies

Country	Pollutant	Year(s)	Sectors	Change
Azerbaijan	PM_{10}	2000-2016	Sector F	Missing data gap-filled
Bulgaria	PM_{10}	2000-2016	Sector H	Missing data gap-filled
Belarus	PM_{10}	2016	Sector H	Missing data gap-filled
Georgia	$PM_{2.5}$	2011-2012	Sector A	Replacement of gap-filled $PM_{2.5}$ data with PM_{10} values
Iceland	$PM_{2.5}$	2000-2012	Sector C	Replacement of $PM_{2.5}$ data with PM_{10} values
Ireland	PM_{10}	2000-2016	Sector D	Missing data gap-filled
Lithuania	$PM_{2.5}$	2000-2016	Sector G	Replacement of $PM_{2.5}$ data with PM_{10} values
Lithuania	PM_{10}	2000-2016	Sector H	Missing data gap-filled
Luxembourg	$PM_{2.5}$	2000-2016	Sector J	Replacement of $PM_{2.5}$ data with PM_{10} values
Malta	$PM_{2.5}$	2000-2010	Sector B	Replacement of $PM_{2.5}$ data with PM_{10} values
Malta	$PM_{2.5}$	2000-2004	Sector F	Replacement of $PM_{2.5}$ data with PM_{10} values
Malta	$PM_{2.5}$	2014	Sector I	Replacement of $PM_{2.5}$ data with PM_{10} values
The Former Yugoslav Republic of Macedonia	PM_{10}	2000-2016	Sector H	Missing data gap-filled
Russian Federation	$PM_{2.5}$	2000-2009	Sector C	Replacement of gap-filled $PM_{2.5}$ data with PM_{10} values
Russian Federation	$PM_{2.5}$	2000-2002, 2006-2009	Sector G	Replacement of gap-filled $PM_{2.5}$ data with PM_{10} values
Slovakia	$PM_{2.5}$	2000-2004	Sector H	Replacement of $PM_{2.5}$ data with PM_{10} values

5. Improvements of the gap-filling procedure

Most countries (30 of 51 countries) submitted data that seem to be complete and plausible. Problems occur especially, where no data at all are available, or when submitted data are not plausible.

In autumn 2017, a new tool was developed that simplify comparisons of emission data with other countries, expert data and previously reported and gap-filled data. Comparisons comprise National Totals, sector data, and data in relation to population and GDP data. This new tool was used for the gap-filling 2018.

6. Data availability and gap-filling method per country

6.1. Albania (AL)

The submission provided from Albania was not in standardized format and was not adaptable and thus not useable. From previous submissions, data up to the year 2015 are available.

NO_x, SO_x

Sector distribution up to 2007 seems to be plausible, whereas from 2008 to 2015 data for some sectors are missing. As the National Total data of the years 2003 to 2007 are similar to estimates from TNO, National Totals and sector distributions from the years 2000 to 2007 are used from Albania's previous submission. National Totals for the years 2008 to 2009 are taken from TNO estimates. National Totals from 2010-2016 are extrapolated data from TNO estimates (2003-2009). The sector distribution reported by Albania in a previous submission for the year 2007 is used to split the National Totals of the years 2008-2016.

NMVOC, $PM_{2.5}$, PM_{10}, CO

National Totals of the years 2003 to 2008 are similar to estimates from TNO, and sector distribution up to 2008 seems to be plausible. Therefore, National Totals for the year 2009 is taken TNO estimates. National Totals from 2010-2016 are extrapolated data from TNO estimates (2003-2009). The sector distribution reported by Albania in a previous submission for the year 2008 was used to split the National Totals of the years 2009-2016. To avoid negative values for PM_{coarse}, all data for $PM_{2.5}$, which resulted in higher numbers than PM10, were equaled to PM_{10}.

NH_3

National total and sector distribution from previous submissions seem to be plausible up to 2015. Data for 2016 are estimated by extrapolation of the last ten years (2005-2015) and using the sector distribution of the year 2015.

6.2. Armenia (AM)

Armenia provided with its 2018 submission data for National Total and sectors for the year 2016. From previous submissions, National Total data for the years 2000-2003, 2007 and 2014, and sectoral data for 2007 and 2014 are available. For $PM_{2.5}$ and PM_{10}, only data for the years 2007 and 2014 are available.

NOx, NMVOC

National Total and sectoral data of missing years were inter- and extrapolated. In cases when the extrapolation resulted in negative values, this was corrected to 0.

SO_x

National Total data of missing years were interpolated. Concerning the sector distribution, one single sector (Industry) contributed to a very huge amount of the emissions (2016: 99.96 %). Further, the sector distribution differs strongly to expert estimates from IIASA, TNO and EDGAR, and to the mean sector distribution from the 2017 gap-filled data set of all countries. Therefore, the sector distribution from TNO for the year 2008 is used to split the National Totals of all years, as this distribution is from all expert estimates most similar to the originally reported data.

NH_3

National Total data reported for the year 2016 are extraordinary high. These data are over ten times higher than the data reported for the year 2014 and also much higher than all expert estimates.

National Total data of the years 2000 and 2001 are very low. Therefore, National Total data for the years 2000, 2001 and 2016 were extrapolated (2000, 2001: 2002-2007; 2016: 2007-2014). National Total data of all other missing years were also extra- and interpolated. As only a few sectors were reported and the contribution of one single sector (Agriculture Livestock) was very huge (2014: 99.93 %), the extrapolated GAINS (IIASA 2014) sector distribution for 2015 is used to split the National Totals of all years, as this distribution is from all expert estimates most similar to the originally reported data.

$PM_{2.5}$, PM_{10}

National Totals seem to be far too low compared with expert estimates. Therefore, National Total data of all years are replaced with (inter-, extrapolated) data from the GAINS model (IIASA 2014). The sector distributions reported for the year 2016 differ strongly to expert estimates from IIASA, TNO and EDGAR, and to the mean sectoral distribution. Further, for PM10 the sum of the sectors are not equal to the National Total. The sector distribution for the years 2014 is plausible. Thus, this distribution was used to split the distribution of all years.

CO

National Total data of missing years were interpolated. Concerning the sector distribution, one single sector (Road transport) contributed to a very huge amount of the emissions (2016: 98.4 %). Further, the sector distribution differs strongly to expert estimates from IIASA, TNO and EDGAR, and to the mean sector distribution from the 2017 gap-filled data set of all countries. Therefore, the sector distribution from the GAINS model (IIASA 2014) for the year 2010 is used to split the National Totals of all years, as this distribution is from all expert estimates most similar to the originally reported data.

6.3. Austria (AT)

The data of Austria reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.4. Azerbaijan (AZ)

The data of Azerbaijan reported for the years 2000 to 2016 seemed to be plausible, but for several sectors data were missing.

NO_x, NMVOC

Data for some sectors (2000-2006: Sector C, G, I; 2000-2008: Sector J; 2015-2016: Sector L) were missing and thus were extrapolated. Data for the Sector “B – Industry” seemed too low for the years 2001 to 2004 (NMVOC) and 2005 to 2006 (NO_x), respectively. These data have been replaced and gap-filled by extrapolated data (NMVOC: 2005-2016, NO_x: 2007-2016) up to the year 2000. The National Totals of the years 2000 to 2008 and 2015 to 2016 were replaced by the sum of the sectors.

SO_x

Data for some sectors (Sector C and G) were missing for the years 2000-2006 and thus were extrapolated. Data of the Sector “A - Public electricity and heat production” of the years 2000 to 2014 seemed to be far too low and thus were replaced by the copy of the value for the year 2015. The National Totals of the years 2000 to 2014 were replaced by the sum of the sectors.

NH_3

Data for the sector “L - Other emissions from agriculture” were missing for the years 2015 to 2016 only and thus were extrapolated. The National Totals of these years were replaced by the sum of the sectors.

$PM_{2.5}$ and PM_{10}

Data for some sectors (2000-2006: Sector C, G and I; 2015-2016: Sector L) were missing and thus were extrapolated. Data of the Sector "F – Road Transport" of the whole time series were missing for PM_{10}. These data were copied from $PM_{2.5}$. The $PM_{2.5}$ National Totals of the years 2000 to 206 and 2015 to 2016, and the PM_{10} National Totals of the whole time series were replaced by the sum of the sectors.

CO

Data for some sectors (Sector C, G and I) were missing for the years 2000-2006 and thus were extrapolated. The National Totals of the years 2000 to 2006 were replaced by the sum of the sectors.

6.5. Bosnia and Herzegovina (BA)

No reported data were available.

NO_x, NMVOC, NH_3, $PM_{2.5}$ and PM_{10}

The estimates used to calculate NO_x, NMVOC, NH_3, $PM_{2.5}$ and PM_{10} National Total data were (inter-, extrapolated) estimates from the GAINS model from October 2014 (IIASA 2014). For NO_x, NMVOC and NH_3, also the (inter-, extrapolated) sector distribution from the GAINS model was used. For PM2.5 and PM10, the mean sector distribution from the 2017 gap-filled data set of all countries was used to split the National Totals of all years.

SO_x, CO

National Totals of SO_x and CO were gap-filled using extrapolation of TNO data. For CO, also the sector distribution from TNO was used, whereas the years 2000-2002 and 2010-2016 were extrapolated using 2003-2009 data. For SOx, the mean sector distribution from the 2017 gap-filled data set of all countries was used to split the National Totals of all years.

6.6. Belgium (BE)

The data of Belgium reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.7. Bulgaria (BG)

The data of Bulgaria reported for the years 2000 to 2016 seemed to be complete and plausible. Only for the sector "H – Aviation", data for $PM_{2.5}$ were reported but for PM_{10} were missing. Thus, $PM_{2.5}$ data were copied for PM_{10} for the whole time series, and the National Total of PM_{10} was replaced by a new National total including the sector H.

6.8. Belarus (BY)

Belarus reported data up to the year 2016. However, only data for the years 2007-2012 and 2014-2016 seem to be complete, and the sum of sectors equal to the National Total (except for NMVOC in the year 2012 and PM_{10} in 2015). Therefore, emissions for the years 2000-2006 were replaced by extrapolations of the data from the years 2007 to 2016, and data for the year 2013 were replaced by interpolated data from the years 2012 and 2014. In cases when the extrapolation resulted in negative values, this was corrected to 0. The National Totals for 2000 to 2006 and 2013 are assessed by the sum of the sectors. To avoid negative values for PM_{coarse}, missing data for PM_{10}, were equaled to $PM_{2.5}$ and thus the National Total of PM_{10} was corrected by the sum of the sectors.

National Total data of NMVOC for the year 2012, and of PM_{10} for the year 2015 were replaced by the sum of the sectors of the respective year, as for these pollutants and years the sum of sectors did not equal to the National Total. Further, SO_x data of the year 2009 for the sector "A – Public electricity and heat production" were divided by 10 as these data were extraordinary high and seemed to be a decimal error. The National Total data for SO_x of the year 2009 were adjusted.

6.9. Switzerland (CH)

The data of Switzerland reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.10. Cyprus (CY)

The data of Cyprus reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

The sector distribution of SO_x is rather unusual, with a large contribution of the sector "A – Public electricity and heat production". Further review is recommended here.

6.11. The Czech Republic (CZ)

The data of the Czech Republic reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.12. Germany (DE)

The data of Germany reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.13. Denmark (DK)

The data of Denmark reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.14. Estonia (EE)

The data of Estonia reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.15. Spain (ES)

The data of Spain reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.16. Finland (FI)

The data of Finland reported for the years 2000 to 2016 seemed to be plausible. Only for SO_x for the years 2002 and 2006 the National Total did not equal to the sum of the sectors. Data for sector "B-Industry " were not reported for SO_x in these years. Therefore, the difference between the reported National Total and the sum of all other sectors was used to gap-fill emissions of the sector "B – Industry" for 2016.

6.17. France (FR)

The data of France reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.18. The United Kingdom (GB)

The data of the United Kingdom reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.19. Georgia (GE)

Georgia reported in 2018 data from 2007 to 2016. Further, National Total data for the years 2000 to 2006 are available for all pollutants except PMs.

NO_x

For NO_x, the data seemed to be complete and plausible. As the sector distributions of the years 2007 to 2012 differ to the sector distributions of the years 2013 to 2016, extrapolations of the years 2007-2012 were used to gap-fill the years 2000 to 2006 (Sector distribution).

NMVOC

Data seemed to be complete and plausible for the years 2007 to 2016. Data for the years 2000 to 2006 seemed to be far too high. As the sector distributions of the years 2007 to 2012 differ to the sector distributions of the years 2013 to 2016, sector extrapolations of the years 2007-2012 were used to gap-fill the years 2000 to 2006, and the National Totals were replaced by the sum of the extrapolated sectors.

SO_x

Within the reported sector distribution, the sector "Industry" is dominating with 88 % for the year 2016, and up to 97 % in some other years. This distribution differs strongly to expert estimates from IIASA, TNO and EDGAR, and to the mean sector distribution from the 2017 gap-filled data set of all countries. For this reason, data were replaced by sector data and National Totals from EDGAR for the years 2000 to 2010, as this turn out as the most appropriate estimates. The years 2011 to 2016 were extrapolated, whereas negative data were avoided by the copy of data of the previous year. National Totals of the years 2011 to 2016 were calculated by the sum of the sectors.

NH_3

For NH_3, the data seemed to be complete and plausible. The missing sector distribution for the years 2000 to 2006 was made by extrapolation of the sector distribution 2007 to 2016 (In cases when the extrapolation resulted in negative values, this was corrected to 0).

$PM_{2.5}$, PM_{10}

National Total data and sector distribution for the years 2013 to 2016 seemed to be complete and plausible. Data for the years 2007 to 2012 differs strongly to the National Totals and sector distributions of the years 2013 to 2016, to expert estimates from IIASA, TNO and EDGAR, and to the mean sector distribution from the 2017 gap-filled data set of all countries. Thus, sector extrapolations of the years 2013-2016 were used to gap-fill the years 2000 to 2012. In cases when the extrapolation resulted in negative values, this was corrected to 0. To avoid negative values for PM_{coarse}, all data for $PM_{2.5}$, which resulted in higher numbers than PM10, were equaled to PM_{10}. The National Totals for 2000 to 2012 were calculated by the sum of the sectors.

CO

For CO, only the sector distribution 2013 to 2016 seemed to be complete and plausible. The sector distribution for the years 2007 to 2012 differs strongly to expert estimates from IIASA, TNO and EDGAR, to the mean sector distribution from the 2017 gap-filled data set of all countries and to the reported sector distribution of the years 2013 to 2016. Thus, the sector distribution of the year 2016 was used to split the National Totals of the years 2000 to 2012.

6.20. Greece (GR)

Greece provided no submission in 2018. From previous submissions, data up to the year 2015 are available. The data seemed to be complete and plausible. The year 2016 was gap-filled by extrapolation of reported data (2000-2015), whereas negative data were avoided by the copy of data of the previous year. For that reason, the National Totals for NMVOC and SO_x then were calculated by the sum of the sectors.

6.21. Croatia (HR)

The data of Croatia reported for the years 2000 to 2016 reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.22. Hungary (HU)

The data of Hungary reported for the years 2000 to 2016 reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.23. Ireland (IE)

The data of Ireland reported for the years 2000 to 2016 reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

PM_{10} values of the sector “D – Fugitive emissions” were missing. Thus, $PM_{2.5}$ data of the whole time series were copied for PM_{10}, and the PM_{10} National Totals from 2000 to 2016 were replaced by the sum of the sectors.

6.24. Iceland (IS)

The data of Iceland reported in 2018 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.25. Italy (IT)

The data of Italy reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.26. Kyrgyzstan (KG)

Kyrgyzstan provided no submission in 2018. From previous submissions, sectoral data and National Totals for the years 2010 to 2012, 2014 and 2015 are available, and National Total data for the years 2000 to 2005.

NO_x, SO_x, NH_3, $PM_{2.5}$, PM_{10}

Previous reported data differ in National Totals and sector distribution strongly to expert estimates from IIASA and EDGAR. Thus, expert estimates were used: (Inter-/extrapolated) National Total and sector distribution estimates from GAINS from spring 2014 (IIASA 2014).

NMVOC, CO

Previous reported data differ in National Totals and sector distribution strongly to expert estimates from IIASA and EDGAR. Thus, expert estimates were used: (Inter-/extrapolated) estimates from GAINS from spring 2014 (IIASA 2014). For the sector distribution, the distribution of the (extrapolated) EDGAR data were used for CO, and the 2017 gap-filled data set of all countries was used to split the National Totals of NMVOC.

6.27. Kazakhstan (KZT): Kazakhstan (KZ) and Rest of Kazakhstan in the extended EMEP domain (KZE)

Kazakhstan reported with its 2018 submission data for the whole time series.

Data between KZ and KZE are splitted up by 15 % vs. 85 %.

NO_x, NMVOC, CO

For the years 2001 to 2004 and 2006 to 2008, no National Totals were reported and for the same years plus 2009 the data for the sectors “A - Public electricity and heat production”, “B - Industry combustion” and “C - Other stationary combustion” were missing. Further, data from “International and national inland shipping” are missing for the years 2005 to 2007. The NOx National Totals of the years 2009 and 2012 to 2015, the NMVOC National Total of the year 2009 and the CO National Totals of the years 2005 and 2009-2015 do not equal to the respective sum of the sectors.

Therefore, missing sector data were interpolated and National Totals were calculated by the sum of sectors (years 2001 to 2004 and 2006 to 2009). To avoid differences between sum of sectors and National Total data, the NOx National Totals of the years 2005, 2009 and 2012 to 2015 were replaced by the sum of the sectors. For NMVOC, only the National Total of 2009 was replaced. For CO, the National Totals of the years 2005 and 2009 to 2015 were replaced by the sum of the sectors.

SO_x

For the years 2001 to 2004 and 2006 to 2008, no National Totals were reported and for the same years plus 2009 the data for the sectors “A - Public electricity and heat production”, “B - Industry combustion” and “C - Other stationary combustion” were missing. Further, data from “G - International and national inland shipping” are missing for the years 2005 to 2007. The National of the year 2011 do not equal to the respective sum of the sectors. For SOx, Kazakhstan reported a very huge amount on road transport emissions, especially for the categories “Light duty vehicles” and “Heavy duty vehicles and buses”. It is assumed, that this is due to a decimal error: For NOx, which is an important pollutant for road transport, road transport emissions are not extraordinary high within these categories compared to other sectors or categories.

Therefore, missing sector data were interpolated and National Totals were calculated by the sum of sectors (years 2001 to 2004 and 2006 to 2009). The data of the road transport sector have been divided by 10. The National Totals of all years are then (re-)calculated by the sum of the sectors, which means that the data for the National Totals of the years 2000, 2005 and 2009-2016 were replaced.

NH_3

National Total data are reported for all years and equal to the sum of sectors of all years but the year 2010. Sector data of the sector "Industry combustion" are missing for the years 2001-2004 and 2006-2009 and seem to be erroneous in the year 2010, as data for this year are extraordinary high, and subtraction of these data would effect that the sum of the sectors equal to the reported National Total for this year.

Thus, data of the category "B – Industry combustion" were interpolated for the years 2001-2004 and 2006 to 2010, whereas data for the year 2010 were replaced. National Totals for these years were replaced by the sum of sectors.

$PM_{2.5}$, PM_{10}

Reported $PM_{2.5}$ and PM_{10} emissions were very low, and the National Total differed strongly to expert estimates. Thus, the reported National Total data have been replaced. Estimates from EDGAR were used. Sectoral distribution was gapfilled (by interpolation) for category "B – Industry combustion" for the years 2001-2004 and 2006-2009 and "G - International and national inland shipping" for the years 2005-2007, as these years were missing. The sectors "F – Road Transport" and "H – Aviation" were copied from $PM_{2.5}$ to PM_{10}, as no emissions for these sectors were reported for PM_{10}. Then, the sector distribution of the $PM_{2.5}$ time series was used to split the new National Totals of $PM_{2.5}$ and PM_{10} of the respective year.

6.28. Liechtenstein (LI)

Liechtenstein provided no submission in 2018. From previous submissions, data up to the year 2015 are available. The data seemed to be complete and plausible. The year 2016 was gap-filled by extrapolation of reported data (2000-2015), whereas negative data were avoided by the copy of data of the previous year. For that reason, the National Totals for SO_x and NH_3 then were calculated by the sum of the sectors.

6.29. Lithuania (LT)

The data of Lithuania reported for the years 2000 to 2016 seemed to be plausible. Only of the sector "B – Industry", data for the year 2012 were missing (all pollutants), and of the sector "L – Other emissions from agriculture" data for the years 2000 to 2004 for NMVOC and PMs were missing. These were extra- and interpolated. PM_{10} of the sector "G – Shipping" was smaller than $PM_{2.5}$, thus $PM_{2.5}$ data were replaced by PM_{10} data. For the sector "H – Aviation", PM_{10} data were missing at all. Thus PM_{10} data were gap-filled by data from $PM_{2.5}$.

The National Total of the years 2000 to 2004 (NMVOC), 2012 (all pollutants) and 2000-2016 ($PM_{2.5}$, PM_{10}) were replaced by the sum of the sectors.

6.30. Luxembourg (LU)

The data of Luxembourg reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed. PM_{10} of the sector "J – Waste" was smaller than $PM_{2.5}$ in the

years 2000-2016, thus $PM_{2.5}$ data were replaced by PM_{10} data and the National Total adjusted (sum of sectors).

6.31. Latvia (LV)

The data of Latvia reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.32. Monaco (MC)

Monaco provided no submission in 2018. From previous submissions, data up to the year 2015 are available. The data seemed to be complete and plausible. The year 2016 was gap-filled by extrapolation of reported data (2000-2015), whereas negative data were avoided by the copy of data of the previous year. For that reason, the National Total for SO_x then was calculated by the sum of the sectors.

The NH_3 emissions of Monaco are rather unusual, with up to 97 % of the emissions occurring in the sector “G - International and national inland shipping”. Further review is recommended here.

6.33. Republic of Moldova (MD)

The Republic of Moldova provided no submission in 2018. From previous submissions, data up to the year 2015 are available. Sectoral data seemed to be complete and plausible, same as for the National Total data of NH_3 and SO_x. The National Totals of NO_x, NMVOC, $PM_{2.5}$, PM_{10} and CO did not equal to the sum of the sectors. Therefore, National Totals of NO_x, NMVOC, $PM_{2.5}$, PM_{10} and CO have been replaced by the sum of the sectors. The year 2016 was gap-filled by extrapolation of reported data (2000-2015).

6.34. Montenegro (ME)

Montenegro provided no submission in 2018. From previous submissions, data up to the year 2011 are available. These data seemed to be complete and plausible. The years 2012 to 2016 thus were gap-filled by extrapolation of reported data (2000-2011), whereas negative data were avoided by the copy of data of the previous year. For that reason, the National Total of the year 2016 for NMVOC then was calculated by the sum of the sectors.

The SO_x emissions of Montenegro are rather unusual, with up to 96 % of the emissions occurring in the sector “A - Public electricity and heat production”. Further review is recommended here.

The NH_3 emissions of Montenegro are rather unusual, as the share of sector “L - Other emissions from agriculture” is very low. Further review is recommended here.

6.35. The Former Yugoslav Republic of Macedonia (MK)

The data of the Former Yugoslav Republic of Macedonia reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

PM_{10} values of the sector “H – Aviation” were missing. Thus, $PM_{2.5}$ data of the whole time series were copied for PM_{10}, and the PM_{10} National Totals from 2000 to 2016 were replaced by the sum of the sectors.

The sector distribution of SO_x is rather unusual, with a large contribution of the sector "A – Public electricity and heat production". Further review is recommended here.

6.36. Malta (MT)

Malta provided no submission in 2018. From previous submissions, data up to the year 2015 are available. These data seemed to be plausible, but some sector data for some years are missing. The year 2016 was gap-filled by extrapolation of reported data (2000-2015), whereas negative data were avoided by the copy of data of the previous year. For that reason, the National Totals of the year 2016 for all pollutants then were calculated by the sum of the sectors.

NO_x

The sector "F – Road Transport" is unusual low for the years 2013 to 2015 and the share of this sector differ strongly to expert estimates from IIASA, TNO and EDGAR, as well as to the reported share of the previous years. Thus, data for the sector "F – Road Transport" were replaced by extrapolated reported data from the years 2000 to 2012.

Some sector data of the years 2008 and 2013 to 2015 have been gap-filled (inter-, extrapolation) or replaced, therefore the National Totals of these years have been replaced by the sum of the sectors.

NMVOC

The sector "F – Road Transport" is unusual low for the years 2014 to 2015 and the share of this sector differ strongly to expert estimates from IIASA, TNO and EDGAR, as well as to the reported share of the previous years. Thus, data for the sector "F – Road Transport" were replaced by extrapolated reported data from the years 2000 to 2013.

Some sector data of the years 2014 and 2015 have been gap-filled (extrapolation) or replaced, therefore the National Totals of these years have been replaced by the sum of the sectors.

SO_x

Some sector data of the years 2014 and 2015 have been gap-filled (extrapolation, copy of data from previous years), therefore the National Totals of these years have been replaced by the sum of the sectors.

NH_3

Some sector data of the year 2015 have been gap-filled (extrapolation), therefore the National Totals of these years have been replaced by the sum of the sectors. Further, the National Total of the year 2010 was replaced by the sum of the sector data, as this wasn't equal before.

CO

The reported data (National Totals and sector data) are very inconsistent, and for some years the sector "F – Road Transport" is dominating with up to 97 % of share. The National Totals and sector distribution differ strongly to expert estimates from IIASA, TNO and EDGAR, and to the mean sector distribution from the 2017 gap-filled data set of all countries. For this reason, data were replaced for all years. Reported CRF data were used.

$PM_{2.5}$, PM_{10}

The sector "F – Road Transport" is unusual low for the years 2014 to 2015 and the share of this sector differ strongly to expert estimates from IIASA, TNO and EDGAR, as well as to the reported

share of the previous years. Thus, data for the sector "F – Road Transport" were replaced by extrapolated reported data from the years 2000 to 2013.

For $PM_{2.5}$, some sector data of the years 2002, 2008, 2009, 2014 and 2015 have been gap-filled (interpolation) or replaced. Further, data of the sector "B – Industry" for the years 2000-2010, of the sector "F – Road Transport" for the years 2000-2004 and of the sector "I – Offroad" for the year 2014 have been replaced by data from PM_{10}, as $PM_{2.5}$ data were originally higher than those. Therefore the National Totals of the years 2000-2010 and 2014-2015 have been replaced by the sum of the sectors.

For PM_{10}, some sector data of the years 2002, 2008, 2009, 2013-2015 have been gap-filled (interpolation) or replaced, therefore the National Totals of these years have been replaced by the sum of the sectors.

6.37. The Netherlands (NL)

The data of the Netherlands reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.38. Norway (NO)

The data of Norway reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.39. Poland (PL)

The data of Poland reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.40. Portugal (PT)

The data of Portugal reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.41. Romania (RO)

The data of Romania reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.42. Serbia (RS)

The data of Serbia reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

The sector distribution of SO_x is rather unusual, with a large contribution of the sector "A – Public electricity and heat production". Further review is recommended here.

6.43. Russian Federation in the former official EMEP domain (RU)

The Russian Federation reported National Total data of the years 2000 and 2002 to 2016 ($PM_{2.5}$ and PM_{10}: only 2002-2016), and sectoral data for the years 2002 to 2016. However, for the years 2002 to 2008, sector data seemed to be not complete as several sectors were missing and the sum of the sectors did not equal to the National Total.

NO_x, NMVOC, SO_x, NH_3, CO

The National Total of the year 2001 was interpolated. Sectoral distribution of the years 2000 to 2009 were extrapolated (2010-2016), in which negative values were corrected to 0, and the sector distributions were adjusted to the National Totals. In doing so, the sector distribution of the years 2002 to 2009 was replaced.

Within the sector distribution of CO of the Russian Federation, the sector "F – Road Transport" is rather large, whereas the sector "C – Other Stationary Combustion" is small. Further review is recommended here.

$PM_{2.5}$, PM_{10}

The National Totals of the years 2000 and 2001 were extrapolated (2002-2016). Sectoral distribution of the years 2000 to 2009 were extrapolated (2010-2016), in which negative values were corrected to 0, and the sector distributions were adjusted to the National Totals. In doing so, the sector distribution of the years 2002 to 2009 was replaced. For the sectors "C – Other Stationary Combustion" (years 2000-2009) and "G – Shipping" (years 2000-2002, 2006-2009), $PM_{2.5}$ data have been replaced by data from PM_{10}, as $PM_{2.5}$ data were originally higher than those.

Within the sector distributions for $PM_{2.5}$ and PM_{10} of the Russian Federation, the sector "C – Other Stationary Combustion" is rather small. Further review is recommended here.

6.44. Sweden (SE)

The data of Sweden reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.45. Slovenia (SI)

The data of Slovenia reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.46. Slovakia (SK)

The data of Slovakia reported for the years 2000 to 2016 seemed to be complete and plausible. Therefore no gap-filling was performed. PM_{10} of the sector "H – Aviation" was smaller than $PM_{2.5}$ in the years 2000-2004, thus $PM_{2.5}$ data were replaced by PM_{10} data and the National Total adjusted (sum of sectors).

6.47. Tajikistan (TJ)

No reported data were available. Sector data and National Totals were gap-filled using EDGAR data for the years 2000 to 2010, and extrapolation of these data for the years 2011 to 2016.

6.48. Turkmenistan (TM): Rest of Turkmenistan in the extended EMEP domain (TME) and Turkmenistan in the former official EMEP domain (TMO)

No reported data were available. Sector data and National Totals were gap-filled using EDGAR data for the years 2000 to 2010, and extrapolation of these data for the years 2011 to 2016.

6.49. Turkey (TR)

Turkey reported data for all pollutants except $PM_{2.5}$. The reported data of NO_x, NMVOC, SO_x and NH_3 seemed to be complete and plausible.

$PM_{2.5}$, PM_{10}

The sector distribution for PM_{10} shows an extraordinary high share of the sector "B – Industry", and the sector distribution differ strongly to expert estimates from IIASA, TNO and EDGAR. Therefore, the sector distribution was replaced by the (extrapolated) sector distribution from TNO to split the National Total of all years into sector data.

Data for $PM_{2.5}$ were gap-filled using (extrapolated) sector data and National Totals from TNO.

CO

In the year 2016 some sectors data were missing and the sum of the sectors did not equal to the National Total. Therefore, the sector distribution from the year 2015 was used to split the National Total of 2016.

6.50. Ukraine (UA)

The Ukraine provided no submission in 2018. From previous submissions, data up to the year 2015 are available. These data have already been used in 2017 to provide gridded maps, and for most pollutants (NO_x, NMVOC, NH_3, $PM_{2.5}$, PM_{10}, CO), data of the Ukraine showed an unusual picture within the maps.

NO_x, NMVOC, $PM_{2.5}$, PM_{10}

National Totals seem to be too low for the most years compared with expert estimates. The reported sector distributions differ strongly to expert estimates from IIASA, TNO and EDGAR, and to the mean sectoral distribution. Further, the sum of the sectors of the years 2002 to 2007 was not equal to the National Totals. Therefore, National Total and sector data of all years are replaced or filled with EDGAR data for the years 2000 to 2010 and with extrapolated sectoral EDGAR data for the years 2011 to 2016. The National Totals from 2011 to 2016 were calculated by the sum of the sectors.

SOx

Data seemed to be complete and plausible for the years 2008, 2009, 2014 and 2015. For the years 2010 to 2013, some sector data (Sectors F, G, H and I) are missing. Sector data of the years 2002 to 2007 are very incomplete and the sum of the sectors do not equal to the National Totals. Therefore, missing sector data of the years 2010 to 2013 are interpolated and the National Total was corrected by the sum of sectors. Sector data of the years 2000 to 2007 were replaced or filled by a split of the National Total using extrapolated sector distributions (2008-2015) (In cases when the extrapolation resulted in negative values, this was corrected to 0). Data of the year 2016 were extrapolated (2008-2015) (In cases when the extrapolation resulted in negative values, this was corrected to 0).

NH3

National Totals seem to be too low for the most years compared with expert estimates. The reported sector distributions differ to expert estimates from IIASA, TNO and EDGAR, and to the mean sectoral

distribution. Further, the sum of the sectors of the years 2002 to 2007 was not equal to the National Totals. Therefore, National Total and sector data of all years are replaced or filled with IIASA data for the years 2000, 2005, 2010 and 2015 and with inter-, extrapolated IIASA data for the years 2001-2004, 2006-2009, 2011-2014 and 2016.

CO

National Totals seem to be too low for some years compared with expert estimates. The reported sector distributions differ to expert estimates from IIASA, TNO and EDGAR, and to the mean sectoral distribution. Further, the sum of the sectors of the years 2002 to 2007 was not equal to the National Totals. Therefore, National Total and sector data of all years are replaced or filled with TNO data for the years 2003 to 2009 and with extrapolated TNO data for the years 2000 to 2002 and 2010 to 2016.

6.51. Uzbekistan (UZ): Rest of Uzbekistan in the extended EMEP domain (UZE) and Uzbekistan in the former official EMEP domain (UZO)

No reported data were available. Sector data and National Totals were gap-filled using EDGAR data for the years 2000 to 2010, and extrapolation of these data for the years 2011 to 2016), whereas negative data were avoided by the copy of data of the previous year.

7. Data availability and gap-filling method for other regions

7.1. Sea regions: Atlantic Ocean (ATL), Baltic Sea (BAS), Black Sea (BLS), Caspian Sea (CAS), Mediterranean Sea (MED), North Sea (NOS)

Emissions for the sea regions were calculated using TNO shipping estimates adjusted with FMI data (Finish Meteorological Institute, FMI 2017) for 2015 (and 2011) and trends from the ICCT Report (Olmer et al. 2017).

Caspian Sea

For the Caspian Sea, FMI shipping data (FMI 2017) for 2015 were used and adjusted with the GDP trend of Kazakhstan.

7.2. Aral Lake: Rest of Aral Lake in the extended EMEP domain (ARE), Aral Lake in the former official EMEP domain (ARO)

For the Aral Lake, inter- and extrapolated data from EDGAR data for 2000, 2005 and 2010 was used. For shipping, FMI shipping data (FMI 2017) for 2015 were used and adjusted with the GDP trend of Kazakhstan.

7.3. Russian Federation in the extended EMEP domain (RUE): Rest of Russian Federation in the extended EMEP domain (RFE) and EMEP-external part of Russian Federation (RUX)

To calculate emissions for the Russian Federation in the extended EMEP domain, aggregated and interpolated grid emissions from EDGAR for 2000, 2005 and 2010, extrapolated with the GDP trend for the Russian Federation, was used.

7.4. Remaining Asian Areas in the extended EMEP domain (ASE) and Modified Remaining Asian Areas in the former official EMEP domain (ASM)

To calculate emissions for the remaining Asian Areas in the extended EMEP domain, aggregated and interpolated grid emissions from EDGAR for 2000, 2005 and 2010, extrapolated with the GDP trend for China, was used.

7.5. North Africa (NOA)

To calculate emissions for North Africa, aggregated and interpolated grid emissions from EDGAR for 2000, 2005 and 2010, extrapolated with the GDP trend for Morocco, was used.

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9. EMEP Country Codes

AL	Albania
AM	Armenia
AOE	Arctic Ocean in the extended EMEP domain
ARE	Rest of Aral Lake in the extended EMEP domain
ARO	Aral Lake in the former official EMEP domain
AST	Asian areas in the extended EMEP domain (ASM+ASE+ARO+ARE+CAS)
AT	Austria
ATL	Remaining North-East Atlantic Ocean
ATX	EMEP-external Remaining North-East Atlantic Ocean
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BAS	Baltic Sea
BE	Belgium
BG	Bulgaria
BLS	Black Sea
BY	Belarus
CA	Canada
CAS	Caspian Sea
CH	Switzerland
CY	Cyprus
CZ	Czech Republic
DE	Germany (FGD+FFR)
DK	Denmark
EE	Estonia
ES	Spain
EU	European Union
FFR	Former Federal Republic of Germany (FGD+FFR = DE)
FGD	Former German Democratic Republic (FGD+FFR = DE)
FI	Finland
FR	France
GB	United Kingdom
GE	Georgia
GL	Greenland
GR	Greece
HR	Croatia
HU	Hungary
IE	Ireland
IS	Iceland
IT	Italy
KG	Kyrgyzstan
KZ	Kazakhstan in the former official EMEP domain (KZ+KZE = KZT)
KZE	Rest of Kazakhstan in the extended EMEP domain (KZ+KZE = KZT)
KZT	Kazakhstan (KZ+KZE)
LI	Liechtenstein
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
ME	Montenegro
MED	Mediterranean Sea
MK	FYR of Macedonia
MT	Malta
NL	Netherlands
NO	Norway
NOA	North Africa
NOS	North Sea
PL	Poland
PT	Portugal
RFE	Rest of Russian Federation in the extended EMEP domain (RUX+RFE = RUE)
RO	Romania
RS	Serbia
RU	Russian Federation in the former official EMEP domain (RUO+RUP+RUA+RUR)
RUA	Kaliningrad (RUO+RUP+RUA+RUR = RU)
RUE	Russian Federation in the extended EMEP domain (RFE+RUX)
RUO	Kola & Karelia (RUO+RUP+RUA+RUR = RU)
RUP	St.Petersburg & Novgorod-Pskov (RUO+RUP+RUA+RUR = RU)
RUR	Rest of the Russian Federation (RUO+RUP+RUA+RUR = RU)

RUX	EMEP-external part of Russian Federation (RUX+RFE = RUE)
SE	Sweden
SI	Slovenia
SK	Slovakia
TJ	Tajikistan
TM	Turkmenistan (TMO+TME)
TME	Rest of Turkmenistan in the extended EMEP domain (TMO+TME = TM)
TMO	Turkmenistan in the former official EMEP domain (TMO+TME = TM)
TR	Turkey
UA	Ukraine
US	United States
UZ	Uzbekistan (UZO+UZE)
UZE	Rest of Uzbekistan in the extended EMEP domain (UZO+UZE = UZ)
UZO	Uzbekistan in the former official EMEP domain (UZO+UZE = UZ)

Table 9.1 Countries of the EMEP West and EMEP East region

EMEP West countries	AL, AT, BA, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LI, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK
EMEP East countries (9 EECCA countries + TR)	AM, AZ, BY, GE, KG, KZT, MD, RU, TR, UA
Non-EMEP EECCA countries (CLRTAP not ratified)	TJ, TM, UZ

Note: EECCA = Eastern Europe, Caucasus and Central Asia