UPDATED DOCUMENTATION OF THE EMEP GRIDDING SYSTEM V.2019

FOR THE SPATIAL DISAGGREGATION OF EMISSION DATA WITH A RESOLUTION OF 0.1°X0.1° (LONG-LAT)

Technical report CEIP 06/2019

ROBERT WANKMUELLER
Project management
Katarina Mareckova

Author
Robert Wankmueller

Layout and typesetting
Robert Wankmueller
Table of contents

1 HISTORY OF THE EMEP GRID AND CHANGES FOR THE 0.1X0.1 LONG/LAT EMEP GRID.................................................................................................................................................. 4

2 DEFINITION OF THE EMEP GRID .................................................................................................................................................................................... 7

3 THE 0.1X0.1 LONG/LAT GRIDDING SYSTEM .......................................................................................................................................................... 12

3.1 Structure and configuration of the grid calculation tool .................................................................................................................................. 13
  3.1.1 Table „SECTOR_EMISSIONS“ .................................................................................................................................................................................. 14
  3.1.1.1 Preparation of emissions as input data for the new gridding system ........................................................................................................ 15
  3.1.2 Table „BASE_GRID_ALLOCATION“ ............................................................................................................................................................. 17
  3.1.2.1 Ruleset definition of the automatized base grid allocation ...................................................................................................................... 18
  3.1.3 Result tables for individual GNFR sectors and „National_Total“ ..................................................................................................................... 19

3.2 Preparation of spatial input data ........................................................................................................................................................................... 20
  3.2.1 Reported grid data ......................................................................................................................................................................................... 20
  3.2.2 Reported LPS data .......................................................................................................................................................................................... 22
  3.2.3 Proxy base grids derived from CAMS and EDGAR .................................................................................................................................. 24
    3.2.3.1 Emission distribution maps from CAMS .................................................................................................................................................. 25
    3.2.3.2 Proxy data and emission distribution maps from EDGAR ...................................................................................................................... 27
  3.2.4 Other LPS derived from E-PRTR ................................................................................................................................................................. 30
  3.2.5 International shipping proxy derived from FMI data ................................................................................................................................. 32

3.3 Usage and functionality of the grid calculation tool .................................................................................................................................. 33

3.4 Automated checks ............................................................................................................................................................................................... 35
  3.4.1 Checks on spatial input data ........................................................................................................................................................................... 35
  3.4.2 Checks on grid results within the gridding system ................................................................................................................................ 35

4 GLOSSARY ........................................................................................................................................................................................................... 36

5 APPENDIX ........................................................................................................................................................................................................ 38

5.1 Visualizing the results of the gridding tool in ESRI ArcGIS ............................................................................................................................. 38
1 HISTORY OF THE EMEP GRID AND CHANGES FOR THE 0.1X0.1 LONG/LAT EMEP GRID

The geographical scope of EMEP is defined as “the area within which, coordinated by the international centres of EMEP, monitoring is carried out.” Since its adoption in 1984, this definition has been referred to in all protocols to the LRTAP Convention. As Parties have ratified or acceded to the EMEP Protocol, the geographical scope of EMEP has become larger and the EMEP grid has been modified in the late 1990s, in 2008 and in 2013.

From 1984 to 1998 a 150 x 150 km² polar-stereographic grid was used for EMEP reporting. From 1999 on, the grid resolution was changed to 50 x 50 km², but the area covered by the higher resolution grid remained unchanged.

In 2008, the domain covered by the EMEP grid was extended to its current expansion to also include EECCA countries and a larger part of the Russian Federation, while keeping the resolution unchanged.
New directions of air pollution assessment imply new demands in regard to the geographical scope and model grid resolution. In particular, atmospheric dispersion of a number of pollutants under CLRTAP (including ozone, PM, mercury and some POPs) has been proved to have global character and this requires assessments on a global or hemispheric scale (HTAP 2010 Assessment Report). Besides, a number of tasks related to climate change and its effect on air pollution also require consideration on wider spatial scales. Furthermore, there is increasing interest among Parties to the Convention in more detailed information on pollution levels within their territories that require assessments with higher spatial resolution on national and local scales. Given the increasing resolution in state-of-the-art atmospheric models there has been an ongoing discussion about a further modification of the EMEP grid during the last few years, which resulted in a completely new grid with respect to the domain borders, the grid cell resolution and the projection.

At the 36th session of the EMEP Steering Body the EMEP Centers suggested to increase spatial resolution of reported emissions from 50x 50 km EMEP grid to 0.1° x 0.1° long-lat in a geographic coordinate system (WGS84) to improve quality of monitoring. The new EMEP domain will cover the geographic area between 30°N-82°N latitude and 30°W-90°E longitude. This suggestion represents a balance between political needs, scientific needs and technical feasibility as of 2012 and for the next years.
Figure 3  The old (magenta) and new (green) EMEP domain borders (Source: MSC-E)
2 DEFINITION OF THE EMEP GRID

The official EMEP grid was changed from a polar-stereographic projection to a latitude-longitude projection, covering the geographic domain from 30°N-82°N latitude to 30°W-90°E longitude:

Figure 4 The new geographic EMEP domain

For this domain a 0.1°x 0.1° (long-lat) grid definition was created, which is available in different formats for all countries/areas within the new EMEP domain (see http://www.ceip.at/new_emep-grid/grid_definition).

Available formats are:

- Excel tables
- CSV files
- ESRI shape files

Each format can be downloaded for the following countries:

<table>
<thead>
<tr>
<th>Party</th>
<th>Country Code</th>
<th>Grid definition tables for 0.1°x0.1° (long-lat) grid</th>
<th>ESRI shape files with 0.1°x0.1° (long-lat) grid definition</th>
<th>Number of grid cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albania</td>
<td>AL</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>374</td>
</tr>
<tr>
<td>Armenia</td>
<td>AM</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>392</td>
</tr>
<tr>
<td>Austria</td>
<td>AT</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1144</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>AZ</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1094</td>
</tr>
<tr>
<td>Belarus</td>
<td>BY</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>3004</td>
</tr>
<tr>
<td>Belgium</td>
<td>BE</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>465</td>
</tr>
<tr>
<td>Bosnia &amp; Herzegovina</td>
<td>BA</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>661</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>BG</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1365</td>
</tr>
<tr>
<td>Croatia</td>
<td>HR</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>924</td>
</tr>
<tr>
<td>Cyprus</td>
<td>CY</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>130</td>
</tr>
<tr>
<td>Party</td>
<td>Country Code</td>
<td>Grid definition tables for 0.1°x0.1° (long-lat) grid</td>
<td>ESRI shape files with 0.1°x0.1° (long-lat) grid definition</td>
<td>Number of grid cells</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------</td>
<td>------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>CZ</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1103</td>
</tr>
<tr>
<td>Denmark</td>
<td>DK</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>893</td>
</tr>
<tr>
<td>Estonia</td>
<td>EE</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>890</td>
</tr>
<tr>
<td>Finland</td>
<td>FI</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>6808</td>
</tr>
<tr>
<td>France</td>
<td>FR</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>6884</td>
</tr>
<tr>
<td>Georgia</td>
<td>GE</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>876</td>
</tr>
<tr>
<td>Germany</td>
<td>DE</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>4943</td>
</tr>
<tr>
<td>Greece</td>
<td>GR</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>2125</td>
</tr>
<tr>
<td>Hungary</td>
<td>HU</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1218</td>
</tr>
<tr>
<td>Iceland</td>
<td>IS</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>2273</td>
</tr>
<tr>
<td>Ireland</td>
<td>IE</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1171</td>
</tr>
<tr>
<td>Italy</td>
<td>IT</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>3834</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>KZ</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>7750</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>KG</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>2391</td>
</tr>
<tr>
<td>Latvia</td>
<td>LV</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1074</td>
</tr>
<tr>
<td>Liechtenstein</td>
<td>LI</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>8</td>
</tr>
<tr>
<td>Lithuania</td>
<td>LT</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1033</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>LU</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>51</td>
</tr>
<tr>
<td>FYR of Macedonia</td>
<td>MK</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>315</td>
</tr>
<tr>
<td>Malta</td>
<td>MT</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>10</td>
</tr>
<tr>
<td>Republic of Moldova</td>
<td>MD</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>489</td>
</tr>
<tr>
<td>Monaco</td>
<td>MC</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1</td>
</tr>
<tr>
<td>Montenegro</td>
<td>ME</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>192</td>
</tr>
<tr>
<td>Netherlands</td>
<td>NL</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>617</td>
</tr>
<tr>
<td>Norway</td>
<td>NO</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>10825</td>
</tr>
<tr>
<td>Poland</td>
<td>PL</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>4329</td>
</tr>
<tr>
<td>Portugal</td>
<td>PT</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1151</td>
</tr>
<tr>
<td>Romania</td>
<td>RO</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>2931</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>RU</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>62883</td>
</tr>
<tr>
<td>Serbia</td>
<td>RS</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>1127</td>
</tr>
<tr>
<td>Slovakia</td>
<td>SK</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>698</td>
</tr>
<tr>
<td>Slovenia</td>
<td>SI</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>297</td>
</tr>
<tr>
<td>Party</td>
<td>Country Code</td>
<td>Grid definition tables for 0.1°x0.1° (long-lat) grid</td>
<td>ESRI shape files with 0.1°x0.1° (long-lat) grid definition</td>
<td>Number of grid cells</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
<td>------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Spain</td>
<td>ES</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>5644</td>
</tr>
<tr>
<td>Sweden</td>
<td>SE</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>8573</td>
</tr>
<tr>
<td>Switzerland</td>
<td>CH</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>590</td>
</tr>
<tr>
<td>Turkey</td>
<td>TR</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>8626</td>
</tr>
<tr>
<td>Ukraine</td>
<td>UA</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>7861</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>GB</td>
<td>Excel / CSV</td>
<td>Shapefile</td>
<td>4139</td>
</tr>
</tbody>
</table>

Other areas are available only as ESRI shapefiles:

<table>
<thead>
<tr>
<th>Area</th>
<th>Area Code</th>
<th>ESRI shape files with 0.1°x0.1° (long-lat) grid definition</th>
<th>Number of grid cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aral Lake in the former official EMEP domain</td>
<td>ARO</td>
<td>Shapefile</td>
<td>89</td>
</tr>
<tr>
<td>Baltic Sea</td>
<td>BAS</td>
<td>Shapefile</td>
<td>7591</td>
</tr>
<tr>
<td>Black Sea</td>
<td>BLS</td>
<td>Shapefile</td>
<td>5567</td>
</tr>
<tr>
<td>Caspian Sea</td>
<td>CS</td>
<td>Shapefile</td>
<td>4335</td>
</tr>
<tr>
<td>EMEP-external part of Russian Federation</td>
<td>RUX</td>
<td>Shapefile</td>
<td>20744</td>
</tr>
<tr>
<td>Greenland</td>
<td>GL</td>
<td>Shapefile</td>
<td>13579</td>
</tr>
<tr>
<td>Mediterranean Sea</td>
<td>MED</td>
<td>Shapefile</td>
<td>27292</td>
</tr>
<tr>
<td>Modified Remaining Asian Areas in the former official EMEP domain</td>
<td>ASM</td>
<td>Shapefile</td>
<td>17951</td>
</tr>
<tr>
<td>North Africa</td>
<td>NOA</td>
<td>Shapefile</td>
<td>16422</td>
</tr>
<tr>
<td>North Sea</td>
<td>NOS</td>
<td>Shapefile</td>
<td>12911</td>
</tr>
<tr>
<td>Remaining Asian Areas in the extended EMEP domain</td>
<td>ASE</td>
<td>Shapefile</td>
<td>34542</td>
</tr>
<tr>
<td>Remaining North-East Atlantic Ocean</td>
<td>ATL</td>
<td>Shapefile</td>
<td>239852</td>
</tr>
<tr>
<td>Rest of Aral Lake in the extended EMEP domain</td>
<td>ARE</td>
<td>Shapefile</td>
<td>312</td>
</tr>
<tr>
<td>Rest of Kazakhstan in the extended EMEP domain</td>
<td>KZE</td>
<td>Shapefile</td>
<td>26146</td>
</tr>
<tr>
<td>Rest of Russian Federation in the extended EMEP domain</td>
<td>RFE</td>
<td>Shapefile</td>
<td>39599</td>
</tr>
<tr>
<td>Rest of Uzbekistan in the extended EMEP domain</td>
<td>UZE</td>
<td>Shapefile</td>
<td>4122</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>TJ</td>
<td>Shapefile</td>
<td>1688</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>TM</td>
<td>Shapefile</td>
<td>5388</td>
</tr>
<tr>
<td>Uzbekistan in the former official EMEP domain</td>
<td>UZO</td>
<td>Shapefile</td>
<td>1021</td>
</tr>
<tr>
<td>Grid for the whole new EMEP domain (geographic area between 30°N-82°N latitude and 30°W-90°E longitude)</td>
<td>Shapefile</td>
<td>623480</td>
<td></td>
</tr>
</tbody>
</table>
Example:

Figure 5 0.1°x 0.1° grid definition for Germany

The grid definition for a country/area contains a dataset for each grid cell with information about:

- the country or area (ISO2 or a three digits abbreviation for countries and other areas which you can see in the column „Country code“ in the grid definition table above)
- the country- or area name
- the longitude position of the grid cell (centre of the cell)
- the latitude position of the grid cell (centre of the cell)
- and fraction of the grid cell (share of the cell area which belongs to the country/area, e.g. 1 for cells which are completely inside the country/area borders and e.g. 0.5 for cells where half of the area belongs to the country/area and the rest is outside the boundary)

The attribute table of the available ESRI shape files contains additional information, like spatial information for the GIS application and information about the area of the whole grid cell in km² (area) as well as the area of the relevant fraction for the country/area in km² (frac_area). In addition, not only the centre of the cells as long-lat position is given, but also the position of the 4 edges of the grid cell square.
3 THE 0.1x0.1 LONG/LAT GRIDDING SYSTEM

There is a defined folder structure for all templates, tools and data the gridding system is working with:

![Folder structure of the new gridding system](image)

**Figure 6** Structure of the 0.1x0.1 lon/lat gridding system

**Figure 7** Folder structure of the new gridding system
The individual folders and their content will be explained in detail in the following chapters.

The top folder with the name “Calculation” contains the actual grid calculation tool and all the subfolders which contain data for the calculation tool. At the moment this subfolders are defined:

- CAMS_v2018
  with proxy data derived from CAMS regional emission datasets released in 2018
- EDGAR_PROXY
  with proxy data from JRC, which is used also for the EDGAR global emission inventory
- EDGAR_v4.2
  with proxy data derived directly from EDGAR v4.2 global emission inventory datasets
- EDGAR_v4.3.1
  with proxy data derived directly from EDGAR v4.3.1 global emission inventory datasets
- EPRTR_LPS
  with LPS data from E-PRTR reporting
- FMI_SHIPPING
  with proxy data for international shipping, derived from FMI data, which is based on AIS tracking data
- Reported_Grids
  with grid data reported to the CLRTAP
- Reported_LPS
  with LPS data reported to the CLRTAP
- Templates_and_Tools
  contains database templates for the reported data and the proxies as well as tools for transferring data from the original format to the template structure

3.1 Structure and configuration of the grid calculation tool

The gridding tool is implemented in VBA code within MS Access. Each pollutant and year is separated in an individual Access database file, which contains the gap-filled emission data, the gridding configuration and the gridding results. The folder „Template_and_Tools“ contains a template of this gridding database file with the name „pollutant_year_GRID_gridyear.accdb“, which can be copied and renamed for the gridding of a certain pollutant and year. After copying the template, “year” should be replaced with the current year, “gridyear” with the year of the included gridded emissions and “pollutant” with the appropriate pollutant. To run a grid calculation the relevant database file must be copied to the folder „Calculation“ (see chapter 3.3 to learn more about usage and functionality of the grid calculation tool).

![Figure 8 Preparation of a grid calculation](image)
This Access template contains the following tables:

- SECTOR_EMISSIONS
- BASE_GRID_ALLOCATION
- A_PublicPower
- B_Industry
- C_OtherStationaryComb
- D_Fugitive
- E_Solvents
- F_RoadTransport
- G_Shipping
- H_Aviation
- I_Offroad
- J_Waste
- K_AgriLivestock
- L_AgriOther
- M_Other
- National_Total

3.1.1 Table „SECTOR_EMISSIONS“

The table “SECTOR_EMISSIONS” contains the gap-filled emissions for the specific pollutant and year to be spacially disaggregated.

The following fields are defined in this table:

- ISO2 (Type: Text, Field size: 3, PRIMARY KEY)
- emission_year (Type: Number, Field size: Integer)
- sector (Type: Text, Field size: 25, PRIMARY KEY)
- pollutant (Type: Text, Field size: 10)
- unit (Type: Text, Field size: 2)
- emission (Type: Number, Field size: Double)
- distributed (Type: Boolean)
- comment (Type: Text, Field size: 255)
- diff (Type: Number, Field size: Double)
Before the grid calculation run, only the columns “ISO2”, “emission”, “sector”, “pollutant”, “unit” and “emis-
sion” are filled with the gap-filled emissions. During the calculation the checkbox “distributed” is set as soon
as the grid calculation for a certain country/area and sector is completed. In addition detailed information
about proxy data which was used for the distribution is written to the column “comment”. The final step in the
grid calculation is a comparison of the gap-filled emissions with the aggregated sum of the related grid cells.
The difference in percent is written to the column “diff” and must always be zero, otherwise it indicates an er-
ror.

3.1.1.1 Preparation of emissions as input data for the new gridding system
Non-spatial emission data is reported annually in NFR sector tables to CLRTAP/CEIP or the EIONET central
data repository at the EEA. This reported emission data is converted to GNFR sectors and gap-filled for
countries and areas where no reported emission data is available. Afterwards it can be used as input data for
the gridding system.

For preparing the gap-filling table, data is exported from the WebDab database as CSV files and afterwards
imported to the gap-filling table:

Figure 9  Example of a “SECTOR_EMISSIONS” table after gridding

<table>
<thead>
<tr>
<th>ISO2</th>
<th>sector</th>
<th>pollutant</th>
<th>unit</th>
<th>emission</th>
<th>distributed</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>2015 A_PublicPower</td>
<td>NOx</td>
<td>Gg</td>
<td>9,069,813,306</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>AT</td>
<td>2015 I_Industry</td>
<td>NOx</td>
<td>Gg</td>
<td>26,870,193,222</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>AT</td>
<td>2015 C_OtherStationaryComb</td>
<td>NOx</td>
<td>Gg</td>
<td>11,825,866,366</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>AT</td>
<td>2015 F_RoadTransport</td>
<td>NOx</td>
<td>Gg</td>
<td>73,151,108,322</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>AT</td>
<td>2015 G_Shipping</td>
<td>NOx</td>
<td>Gg</td>
<td>0,369,616,333</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>AT</td>
<td>2015 H_AirAttention</td>
<td>NOx</td>
<td>Gg</td>
<td>1,660,406,726</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>AT</td>
<td>2015 I_Offroad</td>
<td>NOx</td>
<td>Gg</td>
<td>14,746,229,01</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>AT</td>
<td>2015 J_Waste</td>
<td>NOx</td>
<td>Gg</td>
<td>0,613,47</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>AT</td>
<td>2015 K_AgriLivestock</td>
<td>NOx</td>
<td>Gg</td>
<td>0,370,713,668</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>AT</td>
<td>2015 L_AgrOther</td>
<td>NOx</td>
<td>Gg</td>
<td>10,538,797,53</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>AT</td>
<td>2015 NATIONAL_TOTAL</td>
<td>NOx</td>
<td>Gg</td>
<td>149,123,076</td>
<td>✔</td>
<td>#Reported grid used</td>
</tr>
<tr>
<td>ATL</td>
<td>2015 G_Shipping</td>
<td>NOx</td>
<td>Gg</td>
<td>695,466,744</td>
<td>✔</td>
<td>#EDGAR proxy used</td>
</tr>
<tr>
<td>ATL</td>
<td>2015 NATIONAL_TOTAL</td>
<td>NOx</td>
<td>Gg</td>
<td>695,466,744</td>
<td>✔</td>
<td>#EDGAR proxy used</td>
</tr>
<tr>
<td>AZ</td>
<td>2015 A_PublicPower</td>
<td>NOx</td>
<td>Gg</td>
<td>21,300,014</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>AZ</td>
<td>2015 B_Industry</td>
<td>NOx</td>
<td>Gg</td>
<td>3,036,335</td>
<td>✔</td>
<td>#Reported IPS used</td>
</tr>
<tr>
<td>AZ</td>
<td>2015 C_OtherStationaryComb</td>
<td>NOx</td>
<td>Gg</td>
<td>6,406,968</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>AZ</td>
<td>2015 D_Fugitive</td>
<td>NOx</td>
<td>Gg</td>
<td>1,556,352</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>AZ</td>
<td>2015 F_RoadTransport</td>
<td>NOx</td>
<td>Gg</td>
<td>36,078,195</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>AZ</td>
<td>2015 G_Shipping</td>
<td>NOx</td>
<td>Gg</td>
<td>5,879,65</td>
<td>✔</td>
<td>#EDGAR proxy used #Reported IPS used</td>
</tr>
<tr>
<td>AZ</td>
<td>2015 I_Offroad</td>
<td>NOx</td>
<td>Gg</td>
<td>10,177,524</td>
<td>✔</td>
<td>#EDGAR proxy used</td>
</tr>
<tr>
<td>AZ</td>
<td>2015 I_Waste</td>
<td>NOx</td>
<td>Gg</td>
<td>0,85,939</td>
<td>✔</td>
<td>#EDGAR proxy used</td>
</tr>
<tr>
<td>AZ</td>
<td>2015 K_AgriLivestock</td>
<td>NOx</td>
<td>Gg</td>
<td>2,034,272</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>AZ</td>
<td>2015 NATIONAL_TOTAL</td>
<td>NOx</td>
<td>Gg</td>
<td>86,61,302,84</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>BA</td>
<td>2015 A_PublicPower</td>
<td>NOx</td>
<td>Gg</td>
<td>15,270,008,91</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>BA</td>
<td>2015 B_Industry</td>
<td>NOx</td>
<td>Gg</td>
<td>3,160,401,03</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>BA</td>
<td>2015 C_OtherStationaryComb</td>
<td>NOx</td>
<td>Gg</td>
<td>1,214,870</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>BA</td>
<td>2015 D_Fugitive</td>
<td>NOx</td>
<td>Gg</td>
<td>0,017,001,98</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>BA</td>
<td>2015 F_RoadTransport</td>
<td>NOx</td>
<td>Gg</td>
<td>8,931,08,287</td>
<td>✔</td>
<td>#EDGAR grid used</td>
</tr>
<tr>
<td>BA</td>
<td>2015 H_AirAttention</td>
<td>NOx</td>
<td>Gg</td>
<td>0,001,700,01</td>
<td>✔</td>
<td>#EDGAR proxy used</td>
</tr>
<tr>
<td>BA</td>
<td>2015 I_Offroad</td>
<td>NOx</td>
<td>Gg</td>
<td>6,408,26,015</td>
<td>✔</td>
<td>#EDGAR proxy used</td>
</tr>
<tr>
<td>BA</td>
<td>2015 I_Waste</td>
<td>NOx</td>
<td>Gg</td>
<td>0,006,406,06</td>
<td>✔</td>
<td>#EDGAR proxy used</td>
</tr>
</tbody>
</table>
The gaps are filled with emissions from different sources, like reported data for previous years, EDGAR, IIASA, ENTEC, etc. The comments column contains detailed documentation of the gap-filling for each country/area, sector and pollutant.

Afterwards the gap-filled emissions are prepared in tables per pollutant, which can be imported directly to the gridding tool:

![Figure 10 Excerpt from the 2019 gap-filling table](image1)

![Figure 11 Part of the gap-filled list of NOx emissions for 2011](image2)

The import of gap-filled emissions from the gap-filling tables to the individual gridding tool database files can be done automatically by using a macro located in the Excel file “WriteGapFilledDataToGriddingDB.xlsm”.

© CEIP/2019
### 3.1.2 Table „BASE_GRID_ALLOCATION“

The table “BASE_GRID_ALLOCATION” contains the gridding configuration for the specific pollutant and year.

The following fields are defined in this table:

- ISO2 (Type: Text, Field size: 3, PRIMARY KEY, INDEXED)
- area (Type: Number, Field size: Integer)
- sector (Type: Text, Field size: 25, PRIMARY KEY, INDEXED)
- pollutant (Type: Text, Field size: 10, INDEXED)
- base_grid (Type: Text, Field size: 60)
- lps (Type: Text, Field size: 50)

![Figure 12](image.png)

**Figure 12** Part of the configuration table for the NOx base grid allocation

For each country/area and GNFR sector combination the base grid and/or the LPS which is used for the spatial distribution must be defined. Within the gridding tool the pollutant is always the same, because each pollutant is gridded separately. In the figure above a part of the configuration table for NOx base grid allocation can be seen as an example. It is important, that the relative path to the base grid information – depending on where the gridding tool is located – must be used. In case of the configuration of a base grid and a LPS for a certain country/area and sector, both are weighted equally for the spatial emission distribution.

Because manual configuration of the base grid allocation is very time consuming, and also error-prone, it is now possible to do this allocation automatically, based on the available reported grid- and LPS data as well as other proxy data (see chapter 3.2 Preparation of spatial input data)
3.1.2.1 Ruleset definition of the automatized base grid allocation

With the button “Config BASE_GRID_ALLOCATION” in the grid calculation tool (see chapter 3.3 Usage and functionality of the grid calculation tool) an initial automatic configuration of the used proxy data can be performed. For each country/sector combination the tool is searching for available reported grid- and LPS data and for other available proxy data (CAMS, EDGAR, E-PRTR) and is automatically setting the best proxy information for a certain country/sector combination based on the following ruleset:

- Between a configured timeframe (min and max year) the system is always searching for the most current reported grid and LPS data for each pollutant/area/sector combination
- For CAMS, EDGAR and E-PRTR proxy data a certain year must be defined
- For each pollutant/area/sector:
  - Search for reported grid data within the configured timeframe and use it if available
    - For each country were reported grid data is available and it is configured that LPS information is not included in reported gridded emissions (e.g. GB), search for LPS data and use it in addition
    - If reported grid data is not available and the pollutant is a HM or POP, search for reported gridded PM10 data and use it if available
    - If reported grid data is not available and the pollutant is BC, search for reported gridded PM2.5 data and use it if available
  - If reported grid data is not available
    - If the pollutant is a HM or POP, search for PM10 proxy data in the following steps
      - If the pollutant is BC, search for PM2.5 proxy data in the following steps
      - If sector is G_Shipping, search for proxy data derived from FMI shipping emissions and use it if available
    - Otherwise search for proxy data derived from CAMS and use it if available
      - If the pollutant is not NMVOC, the sector is E_Solvents and reported grid data as well as proxy data derived from CAMS is not available, search for NMVOC proxy data derived from CAMS for E_Solvents and use it if available
      - If the pollutant is not CO, the sector is D_Fugitive and reported grid data as well as proxy data derived from CAMS is not available, search for CO proxy data derived from CAMS for D_Fugitive and use it if available
      - If the sector is K_AgriLivestock and reported grid data as well as proxy data derived from CAMS is not available, search for proxy data derived from CAMS for L_AgriOther and use it if available
    - Otherwise search for proxy data derived from EDGAR and use it if available
      - If the pollutant is not NMVOC, the sector is E_Solvents and reported grid data as well as proxy data derived from EDGAR is not available, search for NMVOC proxy data derived from EDGAR for E_Solvents and use it if available
      - If the pollutant is not CO, the sector is D_Fugitive and reported grid data as well as proxy data derived from EDGAR is not available, search for CO proxy data derived from EDGAR for D_Fugitive and use it if available
      - If the sector is K_AgriLivestock and reported grid data as well as proxy data derived from EDGAR is not available, search for proxy data derived from EDGAR for L_AgriOther and use it if available
  - Search for reported LPS data
    - If reported LPS data is available and the sector is A_PublicPower or B_Industry and proxy data derived from EDGAR is used, replace it with reported LPS data
    - If reported LPS data is available and the sector is not A_PublicPower or B_Industry and proxy data derived from EDGAR is used, use reported LPS data in addition
If reported LPS data is not available search for LPS data from E-PRTR.

If LPS data from E-PRTR is available and proxy data derived from EDGAR is used, use LPS data from E-PRTR in addition.

This ruleset can be adjusted any time if new proxy data from other sources is included or if there are new insights, which makes changes necessary or useful.

3.1.3 Result tables for individual GNFR sectors and „National_Total“

The rest of the tables (13 GNFR sector tables and a national totals table) are for the output data of the gridding process. After the gridding is done, these tables are filled with the spatial grids of the individual GNFR sectors and the national total.

The following fields are defined in this table:

- ISO2 (Type: Text, Field size: 3)
- area (Type: Number, Field size: Integer, PRIMARY KEY)
- emission_year (Type: Number, Field size: Integer)
- sector (Type: Text, Field size: 25)
- pollutant (Type: Text, Field size: 10)
- x (Type: Number, Field size: Double, PRIMARY KEY, INDEXED)
- y (Type: Number, Field size: Double, PRIMARY KEY, INDEXED)
- unit (Type: Text, Field size: 2)
- cellld (Type: Text, Field size: Text, INDEXED)

![Figure 13 Part of the calculated grid for 2015, NOx, A_PublicPower](image-url)
The column “cellId” contains an identifier which is unique for each grid cell, independent from the country/area. This is important for the visualisation of the gridding results (see chapter 5.1 Visualizing the results of the gridding tool in ESRI ArcGIS).

3.2 Preparation of spatial input data

3.2.1 Reported grid data

If available, reported grids are used for the spatial distribution of emissions among a country/area (see chapter 3.1.2.1 Ruleset definition of the automatized base grid allocation).

To be able to use the submitted grids in the new gridding system, data must be transferred from the reporting templates to Access database files the gridding system is using. This can be done automatically via an Excel-Macro (“WriteRepGridToDB.xlsm”), which has to be applied to the reported Excel files containing the reported grid data.

During this transfer, border checks are carried out, to ensure that all reported grid cells are within the country borders, and the database files are either updated (if grid data already exists for a certain pollutant and year) or created (if there is no file jet for the certain pollutant and year):
Each pollutant and year specific database contains a table with the name „REPORTED“. This table contains the following fields:

- ISO2 (Type: Text, Field size: 3, INDEXED)
- year (Type: Number, Field size: Integer)
- x (Type: Number, Field size: Double, INDEXED)
- y (Type: Number, Field size: Double, INDEXED)
- sector (Type: Text, Field size: 25, INDEXED)
- Pollutant (Type: Text, Field size: 10)
- unit (Type: Text, Field size: 2)
- emission (Type: Number, Field size: Double)
During the transformation, the decimal point character of the x and y coordinates is removed (e.g. the coordinate “-28.85” is converted to “-2885” and “38.65” is converted to “3865”), because the gridding system is using coordinates in this format.

### 3.2.2 Reported LPS data

In some cases also reported LPS data is used for the spatial distribution of emissions among a country/area (see chapter 3.1.2.1 Ruleset definition of the automatized base grid allocation).

To be able to use the submitted LPS data in the new gridding system, data must be transferred from the reporting templates to Access database files the gridding system is using. This can be done automatically via an Excel-Macro (“WriteRepLPSToDB.xlsm”), which has to be applied to the reported Excel files containing the reported LPS data.

During this transfer, border checks are carried out, to ensure that all reported large point sources are located within the country borders, and the database files are either updated – if LPS data already exists for a certain pollutant and year - or created – if there is no file jet for the certain pollutant and year:
Each pollutant and year specific database contains a table with the name „REPORTED“. This table contains the following fields:

- ISO2 (Type: Text, Field size: 3, INDEXED)
- year (Type: Number, Field size: Integer)
- lps (Type: Text, Field size: 255)
- sector (Type: Text, Field size: 25, INDEXED)
- heightclass (Type: Number, Field size: Integer)
- x (Type: Number, Field size: Double, INDEXED)
- y (Type: Number, Field size: Double, INDEXED)
- Pollutant (Type: Text, Field size: 10)
- unit (Type: Text, Field size: 2)
- emission (Type: Number, Field size: Double)

Figure 17 Part of reported NOx LPS data transferred to database

During the transformation, longitude and latitude coordinates are rounded down to one decimal place and afterwards increased by 0.05. This represents the centre of the grid cell where the LPS is located. In addition the decimal point character is removed for the database entry (e.g. the coordinate “2.905” is converted to “295” and “54.72457” is converted to “5475”), because the gridding system is using coordinates in this format.

3.2.3 Proxy base grids derived from CAMS and EDGAR

To be able to distribute country/area emissions in areas where no reported gridded emission exists, the spatial information for the distribution has to be derived from other sources and converted to so called base grids.

Currently these gaps are filled with emission distribution maps from CAMS-81\(^1\) as well as proxy data and emission distribution maps from the EDGAR project\(^2\), which CEIP is allowed to use on the basis of a collabo-

---

\(^1\) Copernicus Atmosphere Monitoring Service - Global and regional emissions (https://atmosphere.copernicus.eu/cams81-global-and-regional-emissions)
ration with JRC. With time and further development of the gridding methodology, this base grids may be replaced for certain areas and sectors with base grids derived from other sources. The gridding system is flexible enough to define the used base grid for each country/area, sector and pollutant.

3.2.3.1 Emission distribution maps from CAMS

To derive the base grid from CAMS-81 spatial distribution maps and convert it to the format where it can be used by the new gridding system, an Access tool has been developed, which can be found in the folder "Templates_and_Tools":

- "CalculateBaseGridFromCAMSGrid.accdb"

For each base grid year which should be derived from CAMS spatial distribution maps, the appropriate Access file must be copied from „Template_and_Tools“ and renamed.

![Figure 18 Derivation of base grids from CAMS data](https://example.com/image)

The tool consist of a table where original data from CAMS, which is available as ASCII/CSV files, can be imported. It also contains tables for the output of the converted base grid.

\[\text{The Emissions Database for Global Atmospheric Research (https://edgar.jrc.ec.europa.eu)}\]
The figure above shows the MS-Access tool, with the table “CAMS_PROXY” for the original CAMS proxy data. After the proxy table is filled with the proxy data from CAMS, the button “1 Data conversions” starts the conversion process:

- Coordinates must be converted from 0.05° x 0.05° (long/lat) to 0.1° x 0.1° (long/lat).
- The sector “road transport”, which is divided in 4 subsectors in CAMS (F1/F2/F3/F4) must be aggregated to one sector “F_RoadTransport”.
- Country and area codes must be converted from “alpha-3 code” to “alpha-2 code”
- Some country codes in CAMS must be allocated to an overall area to which the country is assigned in EMEP

In addition also the query “2 Sum_equal_coordinates” must be executed, to sum up equal coordinates which arose in the previous conversion process.

Because the converted data includes gridded emissions from all pollutants (NOx, NMVOC, SOx, NH3, PM2.5, PM10, CO) at this stage a copy of the Access file for each pollutant must be created.

The following steps must be performed in each of this Access pollutant files:

With the button “3 Copy to sector tables” grid data of the selected pollutant will be copied to the individual sector tables “A_PublicPower”, “B_Industry”, “C_OtherStationaryComb”, “D_Fugitive”, “E_Solvents”, “F_RoadTransport”, “G_Shipping”, “H_Aviation”, “J_Offroad”, “J_Waste”, “K_AgriLivestock”, “L_AgriOther” and “M_Other”.

After this the proxy grids can be exported with the button “Generate Proxy Data”. This will generate a proxy data file for each sector of the pollutant, which can be used directly within the gridding system.
The original data file with the MS-Access tools can be deleted after proxy data generation.

The following steps are showing the procedure to convert 2010 CAMS data for NOx from 2018 to a base grid for the gridding system as an example:

1. Copy the file “CalculateBaseGridFromCAMSGrid.accdb” from the folder “Templates_and_Tools” to the folder “CAMS_v2018”
2. Rename the file to e.g. “CAMS_v2018_2010.accdb”
3. In the new file import CAMS proxy data from the ASCII/CSV text file to the table “CAMS_PROXY”
4. Start the conversion with the button “1 Data conversions”
5. Start the query “2 Sum_equal_coordinates” to sum up equal coordinates
6. Copy the file “CAMS_v2018_2010.accdb” to a new file “CAMS_v2018_NOx_2010.accdb”
7. In the new file start the split to sector data with the button “3 Copy to sector tables”
8. Generate proxy files for each sector with the button “Generate Proxy Data”
9. Delete the file “CAMS_v2018_NOx_2010.accdb”

After the generation of proxy files for all pollutants, also the file “CAMS_v2018_2010.accdb” can be deleted

3.2.3.2 Proxy data and emission distribution maps from EDGAR

To derive the base grid from EDGAR proxy data and EDGAR spatial distribution maps and convert it to the format where it can be used by the new gridding system, two Access tools were developed, which can be found in the folder “Templates_and_Tools”:

- “CalculateBaseGridFromEDGARProxies.accdb” and
- “CalculateBaseGridFromEDGARGrid.accdb”

For each base grid which should be derived from EDGAR proxy data or EDGAR spatial distribution maps, the appropriate Access file must be copied from „Template_and_Tools“ and renamed.
Both tools consist of tables where original data from EDGAR, which is available as ASCII/CSV files, can be imported. It also contains the EMEP grid definition and a table for the output of the converted base grid.

The figure above shows the MS-Access tool, with the tables “PROXY_1”, “PROXY_2” and “PROXY_3” for the original EDGAR proxy data. This means that up to three proxy maps can be combined to calculate a certain base grid. The table “GRID_DEFINITION” contains the EMEP grid definition and “CALC_BASE_GRID” is the table for the converted base grid.

After at least one proxy table is filled with proxy data from EDGAR, the button “Calculate Base Grid” starts the conversion process, where only proxy cells which are set in “GRID_DEFINITION” are taken from the proxy tables, allocated to the appropriate country/area and weighted regarding the fraction value in the grid definition. If more than one proxy table is filled, the sum of the individual proxy data is used for the base grid weighting. Because EDGAR proxy data uses the lower left corner of a grid cell to determine a certain cell, and the CEIP system uses the centre of a grid cell, the coordinates are automatically converted for the calculation.

Cells on borders between country/area and sea are a special case, because the proxy value is distributed also in this case regarding the fraction and therefore a part is allocated to the sea and another part to the country/area. But if the proxy information is only for distribution over land areas the allocation to the sea cell
is not right. The function “No distribution over sea” takes care of this and redistributes the proxy value allocated to the sea cell to the same cell which is allocated to the adjacent land area. Of course sometimes it might also be necessary to redistribute land fractions to the sea cell, if the base grid is calculated for the distribution of emissions over sea areas. This can be done with the button “No distribution over land”.

After the proxy base grid is calculated, it can be used from the gridding system directly, without exporting the data from “CALC_BASE_GRID”. This means the Access tool for converting EDGAR proxy data to base grid information transforms to a database with base grid information for the gridding system.

Figure 23 Part of EDGAR shipping proxy data transferred to database

Because other tables, except the “CALC_BASE_GRID” table, are not used anymore after the calculation process, their content can be easily deleted with the buttons “Delete PROXY_1”, “Delete PROXY_2”, “Delete PROXY_3” and “Delete GRID_DEFINITION”. With “Delete CALC_BASE_GRID” the base grid table can be deleted if the base grid calculation should be repeated. In this case also the set flags from the table “GRID_DEFINITION” should be deleted with the button “Remove flags from GridDefinition”. This is necessary, because, after the base grid for a certain grid cell was calculated, a flag is set for this grid cell in the table “GRID_DEFINITION” to be able to stop the calculation and afterwards continue it only for the cells which were not considered so far. So if the whole base grid should be calculated again, this flags must be removed first.

Also the function to redistribute sea grid cells to land or land grid cells to sea sets a flag to each dataset in “CALC_BASE_GRID” which was considered for redistribution so far, to be able to start over if the redistribution process is interrupted. If this redistribution should be started from the beginning the flags have to be removed first with “Remove flags from CalcBaseGrid”.

The following steps are showing the procedure to convert EDGAR proxy data for population density to a base grid for the gridding system as an example:

1. Copy the file “CalculateBaseGridFromEDGARProxies.accdb” from the folder “Templates_and_Tools” to the folder “EDGAR_PROXY”
2. Rename the file to e.g. “edgar_proxy_population_2010.accdb”
3. Import EDGAR proxy data from the ASCII text file to the table “PROXY_1”
4. Start the conversion with the button “Calculate Base Grid”
5. Redistribute proxy values over sea to land with the button “No distribution over sea”
6. Delete the proxy table with the button “Delete PROXY_1”
7. Delete the grid definition table with the button “Delete GRID_DEFINITION”
8. Compress the database with the Access function “Compress and repair"

### 3.2.4 Other LPS derived from E-PRTR

To use large point sources from E-PRTR data has to be extracted from the E-PRTR database. The LPS datasets from E-PRTR must be converted to the same structure as reported LPS.

To transfer E-PRTR LPS to the Access database the Access template “EPRTR_LPS_POLL_YEAR.accdb” from the folder “Templates_and_Tools” can be used. In a copy of this file “POLL” needs to be replaced with the corresponding pollutant abbreviation (e.g. “NOx”) and “YEAR” with the emission year of the E-PRTR LPS. E.g. if E-PRTR NOx LPS emissions from the year 2012 should be transferred, the file name must be renamed to “EPRTR_LPS_NOx_2012.accdb”. The Access file contains one table with the name “EPRTR”. This table contains the following fields:

- ISO2 (Type: Text, Field size: 3, INDEXED)
- year (Type: Number, Field size: Integer)
- lps (Type: Text, Field size: 255)
- sector (Type: Text, Field size: 25, INDEXED)
- heightclass (Type: Number, Field size: Integer)
- x (Type: Number, Field size: Double, INDEXED)
- y (Type: Number, Field size: Double, INDEXED)
- Pollutant (Type: Text, Field size: 10)
- unit (Type: Text, Field size: 2)
- emission (Type: Number, Field size: Double)
For the extraction from E-PRTR LPS data from the E-PRTR database the following SQL-statements can be used (the string “YEAR” in the statements below have to be replaced by the emission year, e.g. 2012, and the string “POLLUTANT” have to be replaced by the corresponding pollutant for which LPS data should be extracted, e.g. CO):

```sql
SELECT FACILITYREPORT.CountryCode AS ISO2, 'YEAR' AS [year], FACILITYREPORT.FacilityName AS lps, "A_PublicPower" AS sector, 0 AS heightclass, ((Int([Long]*10)/10)+0.05)*100 AS x, ((Int([Lat]*10)/10)+0.05)*100 AS y, Long AS Longitude, Lat AS Latitude, POLLUTANTRELEASE.PollutantCode AS pollutant, "Gg" AS unit, [TotalQuantity]/1000000 AS emission INTO POLLUTANT_EPRTR_SECTOR_1_GNFR_A FROM (FACILITYREPORT INNER JOIN POLLUTANTRELEASE ON FACILITYREPORT.[FACILITYREPORTID] = POLLUTANTRELEASE.[FACILITYREPORTID]) INNER JOIN POLLUTANTRELEASEANDTRANSFERREPORT ON FACILITYREPORT.[PollutantReleaseAndTransferReportID] = POLLUTANTRELEASEANDTRANSFERREPORT.[PollutantReleaseAndTransferReportID] WHERE (((POLLUTANTRELEASE.PollutantCode)="POLLUTANT") AND ((POLLUTANTRELEASE.ReleaseMediumCode)="AIR") AND ((POLLUTANTRELEASEANDTRANSFERREPORT.ReportingYear) = [year]) AND
```

For A_PublicPower:

```sql
(SELECT FACILITYREPORT.MainIASectorCode AS MainIASectorCode)
```

For B_Industry:

```sql
(SELECT FACILITYREPORT.MainIASectorCode AS MainIASectorCode)
```

Where:

- A_PublicPower: MainIASectorCode = '1'
- B_Industry: MainIASectorCode = '2' OR MainIASectorCode = '3' OR MainIASectorCode = '4' OR MainIASectorCode = '6'
3.2.5 International shipping proxy derived from FMI data

The shipping data in NetCDF format was read out with the “raster” and “sp” package of R-Studio software (version 0.98.1028). The daily sum was summarized to annual sum and exported in GeoTIFF format in WGS84 projection. Pollutants Ash, EC, OC and SO4 were summed up to PM2.5.

For further processing the dataset was loaded to ArcGIS software (Version 10.4) where centroid points of each raster cell were calculated. In a next step the generated point data set was intersected with the original emep grid (as a shapefile). Only data covering both extents were taken for further calculations. Because of a marginally mismatch of the grid cell a generalize function harmonised multiple cellpoints of the shipping emission data to the EMEP raster. The mean value was assigned.

Finally the emission values were divided proportionally to each area code within the grid definition of the EMEP ESRI Shapefile and copied to proxy Access database files which can be used by the gridding system.

Figure 26 Generalization of multiple cellpoints
3.3 Usage and functionality of the grid calculation tool

The gridding tool can be managed via the form “Calculate” of the appropriate copy of the Access database „pollutant_year_GRID_gridyear.accdb“ for a certain pollutant and year (see chapter 3.1 Structure and configuration of the grid calculation tool).

After the calculation is started with the button „Start gridding“ the steps “Base grid allocation”, “Calculate Sector Grids” and “Calculate NT” are performed automatically in this order. If one step is already calculated, the system is automatically proceeding with the next step. If the calculation process is cancelled at any time, pushing the button “Start gridding” continues the process exactly from the point where it stopped.

After “Calculate NT” has been successfully finished a data export to individual CSV files for each GNFR sector and the national total is carried out automatically. This export can also be started manually via the button „Export Grid data“.

![Figure 27 Part of the NOx FMI shipping data for 2015](image)

![Figure 28 Tool for distributing gap-filled emission data](image)
Via the button “Delete Grids” the grid tables, including the calculation flags and comments in “SECTOR_EMISSIONS”, can be deleted and the calculation can be started from the beginning.

After the process is started, up to 24 hours are required (depending on the computational power).

![Diagram of grid calculation tool](image)

**Figure 29 The individual parts of the grid calculation tool**

The process can be started via the button “Start gridding”.

- If no base grid allocation is done yet, the automatized base grid allocation ist started at first.
- If the automatized base grid allocation is done, the actual gridding process to calculate the set of GNFR grids is started automatically. It starts immediately after pressing the button “Start gridding” if there is already a base grid allocation.
- Afterwards the national total grid as a sum of the GNFR grids is calculated. It starts immediately after pressing the button “Start gridding” if the GNFR grids are already calculated.
- As last step the calculated grid data is exported as CSV files. This export starts immediately after pressing the button “Start gridding” if the GNFR grids are already calculated. In addition grid data can also be exported via the button „Export Grid Data“.

3.4 Automated checks

3.4.1 Checks on spatial input data

During the transformation of reported grid and LPS data, as well as proxy data from EDGAR and E-PRTR, to the database files of the gridding system the following automated checks have been implemented so far (see also chapter 3.2 Preparation of spatial input data):

- Sector name – only the exact GNFR sector names of the template are valid. Different names (e.g. „IndustrialComb“ instead of „Industry“) are not accepted.
- LPS coordinates outside country borders are not accepted
  - Exception: in some cases LPS over sea areas are valid (e.g. drilling platforms from Norway in the North Sea)
- Grid cells outside country borders
  - Exception: in some cases grid cells over sea areas are valid (e.g. national shipping emissions from Norway and the United Kingdom in the North Sea)

3.4.2 Checks on grid results within the gridding system

For each Country/Area/Pollutant combination is checked if the grid sum of the individual sectors and the national total matches exactly the gap-filled emission values (see chapter 3.1.1 Table „SECTOR_EMISSIONS“).
4 GLOSSARY

CLRTAP
The LRTAP Convention entered into force 1983. The Convention which has 51 Parties was the first international legally binding instrument to deal with air pollution on regional bases. The aim of the Convention is that Parties shall endeavor to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution by developing policies and strategies to combat the discharge of air pollutants through exchanges of information, consultation, research and monitoring.

EMEP
The EMEP (European Monitoring and Evaluation Programme) is carried out in collaboration with a broad network of scientist and national experts. The EMEP provides scientific support to the LRTAP Convention on „Atmospheric monitoring and modeling”, „Emission inventories and emission projections” and „Integrated assessment modeling”.

CEIP
CEIP (the EMEP Centre on Emission Inventories and Projections) collects emissions and projections of acidifying air pollutants, heavy metals, particulate matter and photochemical oxidants from Parties to the LRTAP Convention, reviews submitted inventories in order to improve the quality of reported data, prepares data sets as input for long-range transport models and provides support to the Parties, UNECE secretariat and IC.

CAMS
The Copernicus Atmosphere Monitoring Service (CAMS) provides consistent and quality-controlled information related to air pollution and health, solar energy, greenhouse gases and climate forcing, everywhere in the world.

E-PRTR
The European Pollutant Release and Transfer Register (E-PRTR) is the Europe-wide register that provides easily accessible key environmental data from industrial facilities in European Union Member States and in Iceland, Liechtenstein, Norway, Serbia and Switzerland.

EDGAR
The Emissions Database for Global Atmospheric Research (EDGAR) provides global past and present day anthropogenic emissions of greenhouse gases and air pollutants by country and on spatial grid.

EMEP domain
The EMEP domain covers the geographic area between 30°N-82°N latitude and 30°W-90°E longitude.

FMI
The mission of the Finnish Meteorological Institute (FMI) is to produce high-quality observation and research data on the atmosphere and seas.

NFR
Nomenclature for Reporting

Shapefile
The shapefile format is a popular geospatial vector data format for Geographic Information System (GIS) software. It is developed and regulated by Esri as a (mostly) open specification for data interoperability among Esri and other GIS software products. The shapefile format can spatially describe vector features (points, lines, and polygons), representing for example large point sources, streets, lakes, or in this case grid cells. Each item usually has attributes that describe it. In the shapefiles for the grid definition each cell has attributes about where it is located (long and lat), the cell fraction and the country/area name.

Gridding / Spatial disaggregation
Spatial allocation of emissions among grid cells by using spatial proxy information of different sources (EMEP, EDGAR, E-PRTR, FMI, etc.)
5 Appendix

5.1 Visualizing the results of the gridding tool in ESRI ArcGIS

This chapter gives guidance on how the generated grids can be visualised in ESRI ArcGIS:

a) Generate a folder where all the ArcGIS files can be stored.

b) Store the Access database with all the sector grid tables and the national total table in this folder as “*.mdb” file, to be able to access included tables from ArcGIS.

c) Store the ArcGIS map document “BaseGrid01x01.mxd” or another already existing grid visualisation map to the new folder and rename it to “pollutant_year_GRID_gridyear.mxd”, whereas “pollutant” should be replaced with the appropriate pollutant, “year” with the current year and “gridyear” with the year of the included gridded emissions.

d) Add up the emissions of cells with the same spatial location, but different country/area allocation. This must be done because for the visualisation we need only one grid cell for each long-lat coordinate and no country/area information. This can be done in ArcGIS by doing the following for each table:

   i. Right click on the “Layers” menu entry, select “Add data…”, select the database file and choose the table you want to add (e.g. “A_PublicPower”)
   ii. Right click on the added table and select “Open” from the context menu to open the table
   iii. Go to the column “cellId” and right click to the header – from the context menu select “Summarize…”
   iv. From the appearing dialogue expand the “emission” entry at “2. Choose one or more summary statistics to be included in the output table” and set a checkmark at “Sum”
   v. Still in the summarize dialogue at “3. Specify output table” go to the folder you created for the ArcGIS data and type in the file name “pollutant_sector_year_GRID_gridyear_SUM.dbf”, whereas “pollutant” should be replaced with the appropriate pollutant (e.g. “NOx”), “sector” with the GNFR sector (e.g. “A_PublicPower”), “year” with the current year (e.g. “2016”) and “gridyear” with the year of the included gridded emissions (e.g. “2014”)
   vi. When asked if the table should be added to the map say “yes”

Repeate this for all sector tables (A_PublicPower, B_Industry, C_OtherStationaryComb, D_Fugitive, E_Solvents, F_RoadTransport, G_Shipping, H_Aviation, I_Offroad, J_Waste, K_AgriLivestock, L_AgriOther, M_Other) and the national total table

e) Link grid data from the tables to the spatial grid by doing the following:
   i. Right click on “EMEP_domain_01deg_polygon”, select “Joins and Relates” and “Join…”
   ii. At “1. Choose the field in this layer that the join will be based on” select “ID”
   iii. At “2. Choose the table to join to this layer, or load the table from disk” select the sector table you want to visualise (e.g. “NOx_A_PublicPower_2016_GRID_2014_SUM”)”
   iv. “3. Choose the field in the table to base the join on” should automatically be set to “cellId” – if not select it manually
   v. As join option select “Keep only matching records” and then say “OK”
   vi. Save the join as new layer by right click “EMEP_domain_01deg_polygon” again and select “Data” and “Export data…”
   vii. As “Export” option “All features” must be selected and as coordinate system “this layer’s source data”

---

5 Included in an ArcMap package with the base grid definitions of all countries/areas within the EMEP domain, which can be downloaded from
• Give the “Output feature class” the name “pollutant_sector_year_GRID_gridyear.shp”, whereas “pollutant” should be replaced with the appropriate pollutant (e.g. “NOx”), “sector” with the GNFR sector (e.g. “A_PublicPower”), “year” with the current year (e.g. “2016”) and “gridyear” with the year of the included gridded emissions (e.g. “2014”)
• Add the new layer to the map
• Right mouse click to the new layer and select “Properties”
• Go to “Symbology” and select “Quantities” – “Graduated colors”
• Select for “Value” “Sum_emissi” and for “Normalization” “none”
• Select as many “Classes” as you want (e.g. 15) and a “Color Ramp” of your choice (e.g. “green to red”)
• The “Symbol” should be without outline color
• Say “OK” and visualise the grid

![Image of grid visualisation](image)

**Figure 30** Example of a grid visualisation (NOx, National Total, 2017)