Considerations of Changing the EMEP Grid

Document prepared by the EMEP Centres MSC-W, MSC-E, CEIP and CIAM
Summarised by Chris Dore.
Date: February 2012 (& May 2012).

Abstract

At the thirty-fifth session of the EMEP Steering Body the EMEP Centres were asked to prepare a document summarizing their viewpoints concerning modifications of the official EMEP grid (and in particular grid resolution,) grid projection and grid domain).
The EMEP Centres suggest a change of the official EMEP grid to a latitude-longitude projection, covering the geographic domain 30°N-82°N latitude and 30°W-90°E longitude.
A new emissions gridding system has to be developed for emissions with the TFEIP.
The gridding of emissions for models should be performed by CEIP, possibly using the reported gridded emissions where available and proxy data and LPS data where reported grids are not available.

Introduction

In 2008, the domain covered by the EMEP grid was extended to its current domain to also include EECCA countries and a larger part of the Russian Federation (Figure 1).

Developments in air pollution assessment imply new demands in regard to the geographical scope and model grid resolution:

- Atmospheric dispersion of some pollutants is global, which requires assessment on a global or hemispheric scale (HTAP 2010 Assessment Report).
- A number of tasks related to climate change and its effect on air pollution also require consideration on wider spatial scales.
- There is increasing interest among Parties to the Convention for more detailed information on pollution levels within their territories that require assessments with finer spatial resolution.

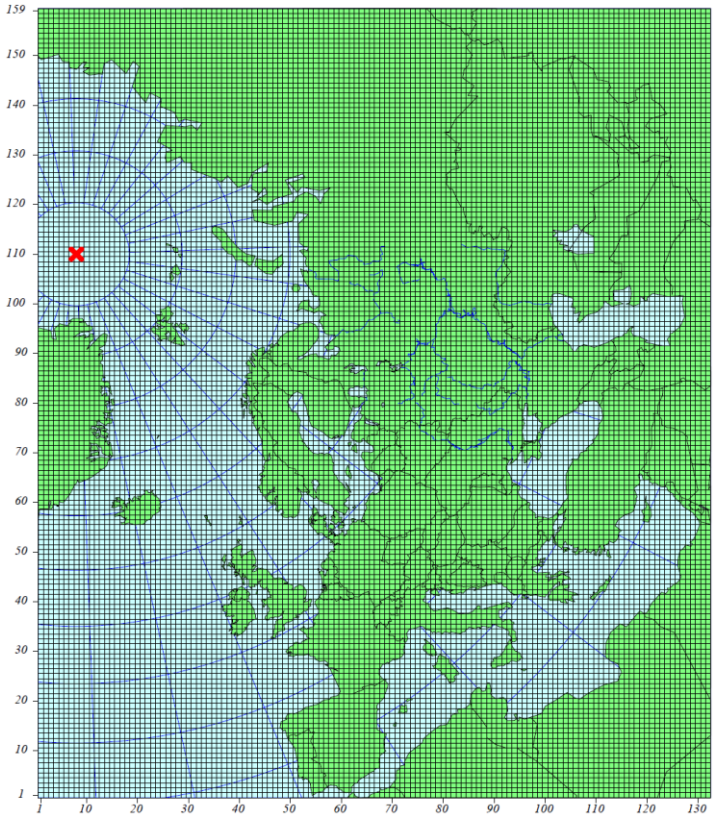

Figure 1: Map of the extended 50 × 50 km^2 grid, which has been in use since 2008.

Given the increasing resolution in state-of-the-art atmospheric models there has been ongoing discussion about modifying the EMEP grid. The main issues related to the change of the EMEP grid can be divided into:

- **Change of the grid projection**: from the current polar-stereographic grid to a regular latitude-longitude grid
- **Increase of the grid resolution**: from the current 50 × 50 km^2 to finer resolutions
- **Change of the domain**

Grid projection

Table 1 below summarizes the pros and cons of using one of two different grid projections.

Table 1: Pros and cons of the two projections currently under consideration. Red font: specific to EMEP model runs; green font: specific to emission data/reporting; blue font: specific to provision of meteorological and other input data.

	Pros	**Cons**
Latitude-longitude grid	1. Enables consistent model studies from regional to global scales 2. Same grid as that of the meteorological data (IFS), i.e. no interpolation of meteorology required 3. Easily comparable to other emission data (EDGAR, TNO, APMoSPHERE) 4. Most commonly used grid throughout the scientific community (e.g. TF HTAP, the Climate community), i.e. easier exchange of data with other communities (increased usefulness of EMEP data to the scientific community, etc.)	1. Strongly varying grid size 2. Inclusion of countries outside EMEP within the model domain inevitable 3. Transition phase from one projection to another implies substantial changes of software, creating additional error sources. In addition, there will be a 'cut' in the trend series
Polar-stereographic grid	1. Grid size does not vary significantly over the model domain 2. Inclusion of countries outside EMEP within the model domain can be avoided, at least to some extent, by rotation and translation of the grid	1. Interpolation of meteorology is required 2. Different from common projection (i.e. lat-lon) of other input data bases, such as meteorology, land use, population density, etc.

Spatial resolution and geographical domain

The EMEP MSC-W model has for several years been run on a polar-stereographic grid with 50 × 50 km^2 resolution. Given increasing computational power, it has been considered for some years to increase the resolution of the EMEP model simulations to better account for chemical and physical processes that occur on spatial scales smaller than 50 km.

The additional accuracy to be gained from higher resolution depends on how accurately the input data (emissions, meteorology, surface properties, etc.) are defined, and to what extent the various assumptions made in the model (e.g. hydrostatic approximation) still hold when the spatial scale of the model grid is reduced. The EMEP MSC-W model is capable, for example, of simulating air pollution and deposition on 10 × 10 km^2 resolution, as has been demonstrated in earlier EMEP status reports, or even at 5 × 5 km^2 resolution as has been demonstrated in the EMEP4UK project (e.g. Vieno et al., 2009, 2010).

However, the improvement highly depends on the quality of appropriate input data (meteorology, emissions data etc.), and therefore refinement of the model grid should be accompanied by a corresponding increase in input data quality/resolution. Reporting of emissions from LPS by all Parties could significantly improve flexibility and accuracy of gridded emissions.

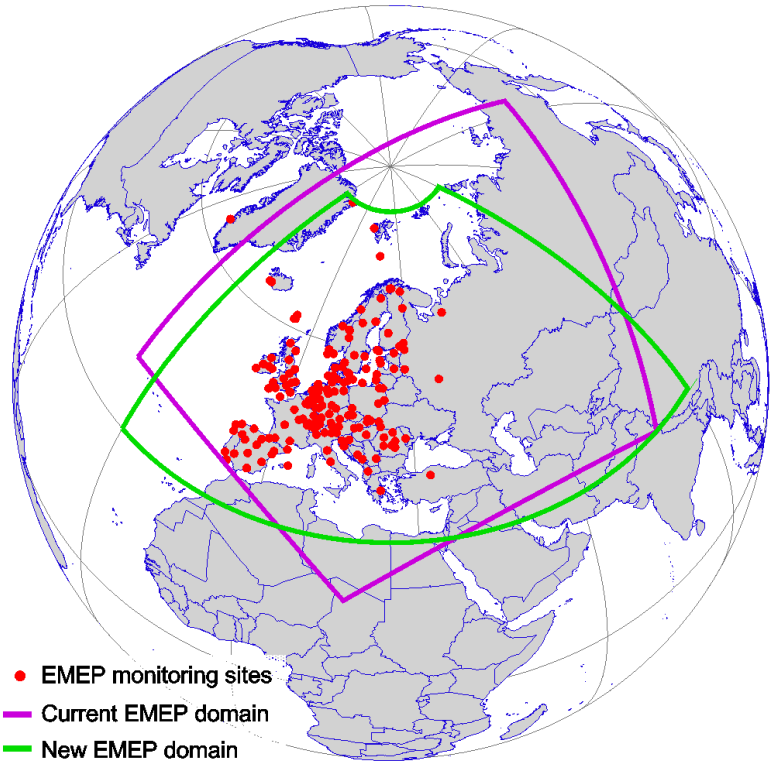

Figure 3: Current and suggested future EMEP domains. Magenta line: current EMEP domain in the polar-stereographic projection; green line: suggested EMEP domain in the latitude-longitude projection (30°N-82°N, 30°W-90°E); red circles: EMEP monitoring sites.

Comparison of some characteristics of different model grids (including the current EMEP grid), are shown in Table 2 below.

Table 2. Characteristics of the current EMEP grid and some lat-lon grids. Quantitative values of the lat-lon grids correspond to the domain 30°N-82°N, 30°W-90°E

Grid type	Projection	Grid size	Number of grid cells	Size of grid cell at 40°N (Italy)	Size of grid cell at 60°N (Scandinavia)
Current EMEP	PS	159 × 135	~21,500	40 × 40 km^2	50 × 50 km^2
0.5° × 0.5°	lat-lon	240 × 104	~25,000	43 × 56 km^2	28 × 56 km^2
0.4° × 0.4°	**lat-lon**	**300 × 130**	**39,000**	**34 × 44 km^2**	**22 × 44 km^2**
0.2° × 0.2°	**lat-lon**	**600 × 260**	**156,000**	**17 × 22 km^2**	**11 × 22 km^2**
0.1° × 0.1°	lat-lon	1200 × 520	624,000	9 × 11 km^2	6 × 11 km^2

Several studies have shown that the EMEP modeling centres can provide more accurate results with increased resolution if more detailed input data is used. Significant improvements of modeling results can be achieved on a national/local scale with spatial resolution refined down to several kilometers. Therefore, fine grid resolution (0.1° × 0.1° or even finer) could be used for various research purposes.

Gridding of emissions

Data from EMEP are intended to be useful for other users beyond the EMEP modelling centres, also in the years to come. Most national modellers and agencies require resolutions that are much finer than 50 × 50 km2, in particular for population exposure to air pollution, and health effect studies.

If EMEP status calculations are to be done on resolutions down to 0.1°× 0.1°, emissions should be prepared on a resolution at least as fine as this. It is, however, not clear whether the countries should be asked to report emissions with a specific resolution/projection. There are several (long term) possibilities that should be discussed within TFEIP, the Bureau and the Steering Body:

1) Countries are asked to report gridded emissions on 0.1°× 0.1° resolution following the same procedures as today.
2) The gridding is done completely by CEIP – a gridding system based on proxy data has to be developed.
3) A gridding system is developed by CEIP (same as 2) but countries are also asked to report fine scale emissions plus LPS. The gridded emissions from the system is used to check the reported emissions, and if the quality is found acceptable, the reported emissions substitute the gridded emissions from the system.

The three alternatives are presented in Table 3, together with pros and cons.

Table 3: Pros and Cons of Different Strategies for Gridding Emissions.

Alternatives	Pros	Cons
1. 0.1° × 0.1°, Parties report gridded data + LPS (same system as today)	Relatively Easy to manage.	Limited flexibility. Not possible for all countries.
2. Gridding done by CEIP	Flexible wrt resolution/projection. Consistent data sets. Parties have to report LPS emissions	High work load for CEIP. Countries get less ownership to data. Need to develop procedures for QA/QC of gridded data.
3. Gridding done partly by CEIP, partly by countries	Flexible wrt resolution/projection	High work load for CEIP. Limited possibility for quality check of gridded data.

Only approximately half of the countries currently report gridded data. However, many of the countries that report gridded emissions do already have them available on a very fine scale (1 km or similar), or they have the systems available to do so. Therefore, it might not be a much larger burden to ask countries to report emissions on a finer scale (e.g. 0.1°× 0.1°). On the other hand, it cannot be expected that countries that do not report gridded emissions today will report emissions on finer scale. Indeed, specifying a specific grid might not be the best solution, as model runs will have different resolutions depending on their purpose.

To ensure maximum flexibility, a gridding system could be developed at CEIP, similar to the systems developed by TNO and VITO (REFS). In these emission gridding systems, proxy data (e.g. road traffic maps, position of power plants etc.) are used to grid the emissions. As such proxy data are available on a very fine resolution, a system that is flexible with respect to resolution could be set up (e.g. there could be a possibility to choose either 0.1 or 0.2 degree resolution). Another advantage is that emissions across Europe would be gridded in a consistent way, also for those countries that do not deliver gridded data. A disadvantage is that in many cases the best knowledge about the emissions is found in the countries themselves, and a centralized gridding centre may not provide the best gridded emissions for all countries. Also, the setup of such a system would require a substantial amount of work. To ensure flexibility of the gridding system Parties have to report information on LPS.

The third alternative also requires the setup such a gridding system. However, the reported fine scale emissions could replace the emissions from the centralized system if the quality is found acceptable (the emissions from the centralized system could be used to check the reported data). During the transition period to the new gridding system Parties have to report gridded data in agreed resolution (e.g. 0.1x0.1 or 0.2x0.2) plus information on LPS, gridding of emissions by CEIP can be considered for countries which cannot produce gridded data.

It should be noted that the benefits from application of highly resolved emissions gridding can be neglected by insufficient information and poor quality of the original data (e.g. absence of information on Hg speciation, congener composition of POP emissions etc.) Therefore, priorities of the work on emissions data processing and resource allocation at the initial stage should take into account specifics of the pollutants.

Conclusions

As computational power increases, the development of atmospheric models throughout the scientific community is going towards finer resolutions. Keeping EMEP 'state-of-the-art' and useful for modelling for LRTAP and for national users of EMEP products (emissions, modelling tools, and model results) should be among EMEP's aims.
In modifying the EMEP grid, two issues can be distinguished:

- Changing the grid projection type (polar-stereographic vs latitude-longitude)
- Increasing the grid resolution (e.g. 25 × 25 km^2 or finer).

In addition, the system for reporting of gridded emissions may be considered as a separate issue.

As far as projection is concerned, a strong argument in favour of a latitude-longitude projection is the possibility to perform consistent model simulations on different geographical scales (from global to national/local) without loss of accuracy connected to interpolation from one projection to another. The additional argument is that the Unified EMEP model of MSC-W can then be run on the native grid of the underlying NWP data (ECMWF-IFS), while using the EMEP emissions without interpolation. Also, the data (both reported emissions and EMEP model results) could be better compared to all other emission data bases known to us. While it is acknowledged that the lat-lon projection does have disadvantages, our view is that these are compensated by the benefits, which is why we recommend the transition to a lat-lon grid.

It has been shown with the MSC-E models that increase of the grid resolution does lead to improvement of the model results if sufficiently detailed input data are available. From a modelling point of view it seems reasonable to organize EMEP simulations on different scales with spatial resolution depending on the task of concern (e.g. 1° × 1° for global, 0.2° × 0.2° for regional, and 0.1° × 0.1° or even better for national/local scale) and with direct consistent links between the scales.

Further, there is an increasing need to couple models and indeed emission inventories of different scales, and finer-scale emissions greatly facilitates such exercises. We recommend that CEIP together with TFEIP and the other centres investigate and propose the best solution for gridding of emissions; either to keep the system we have at present (countries report gridded emissions every fifth year) but at finer scale (e.g. 0.1 × 0.1°), or develop a centralized gridding system based on proxy data.

The EMEP Centres suggest to the EMEP Steering Body to make an appeal at its thirty-sixth session to change the official EMEP grid to 0.2 × 0.2° latitude-longitude resolution, covering the

geographic domain 30°N-82°N latitude and 30°W-90°E longitude, starting from 2013 or as soon as possible. This suggestion represents a balance between political needs, scientific needs and technical feasibility as of 2012 and for the next few years. However, the particular choice of the grid resolution requires additional research and more extensive discussion involving different assessment communities (emission experts, modelers, effects community etc.)

The EMEP Centres also suggest that EMEP SB invites Parties to report gridded emissions plus LPS data in the new scale /resolution from 2013 or as soon as possible.

The changes in gridding system will require revision of Reporting Guidelines (or EB decision) and possibly also relevant chapter in the EMEP/EEA Inventory Guidebook.

References

Vieno, M.; Dore, A. J.; Wind, P.; Marco, C. D.; Nemitz, E.; Phillips, G.; Tarrason, L. & Sutton, M. A. Sutton, M. A.; Reis, S. & Baker, S. M. (ed.) Application of the EMEP Unified Model to the UK with a horizontal resolution of 5x5 km2 Atmospheric Ammonia. Detecting Emissions Changes and Environmental Impacts, Springer, 2009, 367-372.

Vieno, M.; Dore, A. J.; Stevenson, D. S.; Doherty, R.; Heal, M. R.; Reis, S.; Hallsworth, S.; Tarrason, L.; Wind, P.; Fowler, D.; Simpson, D. & Sutton, M. A. Modelling surface ozone during the 2003 heat wave in the UK Atmos. Chem. Physics, 2010, 10, 7963-7978.