Air4EU

Air Quality Assessment for Europe: from local to continental scale

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Air4EU mapping tool: description and user guide

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5	University of Hertfordshire	UH	UK
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7	AIRPARIF	AIRPARIF	FR
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9	Environment Agency	EA	UK
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11	Enveco	ENVECO	GR
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1 Executive summary

As part of the EU 6th framework project Air4EU a web based GIS mapping tool has been developed. The mapping tool has a database containing standard features such as roads, urban areas, parks, water, and a large number of air quality maps from a number of different regions including Oslo, London, England, Europe, Athens, Prague, Paris, Rotterdam, etc. The maps displayed are chiefly derived from case studies within the Air4EU project but also include maps produced by the EMEP unified model, from individual city air quality assessment studies and from studies for EEA by the ETC/ACC. The maps address EU legislative concerns including compounds such as PM_{10}, $PM_{2.5}$, NO_2, SO_2, Benzene, etc.

The mapping tool allows maps on all scales to be displayed, along side each other if required, using a homogenous colour scaling and map projection that allows easy intercomparison of maps from different regions, of maps on different scales and of maps produced by different methodologies. It contains a number of examples of different methodologies that can be used to produce maps including modelling, interpolation of monitoring data and various data assimilation methods such as optimal interpolation, ensemble Kalman filters and regression analysis. Information on the maps and further links are also contained within the database. Maps are selected interactively based on a number of properties that include region, compound and indicator, period, mapping method and map type.

A large number of the maps are also accompanied by uncertainty maps that have been produced based on recommendations from the Air4EU project. These uncertainty maps allow the viewer to directly see the comparative quality of the maps displayed.

Features that make the mapping tool unique include:

- A database of maps that can be viewed and selected in a simple and interactive manner.
- Basic selection criteria for the maps that includes region, pollutant, assessment period and mapping method.
- Multiple viewing of maps.
- Homogenised contour colour scaling for direct comparison, with clearly defined limit values based on EU directives.
- Information and links for each map provided.
- Maps and information can be saved or printed directly.
- Maps of uncertainty can be viewed concurrently with the assessment maps.
- GIS integration allows for a more comprehensive and visual assessment.

The mapping tool is developed to encourage the harmonised presentation of maps and encourage the production of uncertainty maps associated with them. The tool provides centralised and ordered access to a mapping database and can be used to aid dissemination of mapping information for both city users and organisations involved in air quality assessment.

2 Introduction

2.1 Background

The Air4EU project has produced valuable results and recommendations for improving air quality assessment in Europe (www.air4eu.nl). In order to facilitate the widespread access of these results a web based GIS (Geographical Information System) tool was developed by the Norwegian Institute for Air Research (NILU).

The Air4EU mapping tool allows maps of air quality to be shown for a wide variety of pollutants and all spatial scales using an interactive GIS system. The maps available include case studies carried out within Air4EU as well as other contributed assessment maps. Figure 1 shows, on the left hand side, the home page layout and on the right hand side the selection tool for selecting maps from the tool database.

This report, Air4EU project deliverable D7.3, describes the technical platform and the functionalities currently implemented in the mapping tool. In addition, the report includes a description of the requirements for registering new maps in the tool database. This deliverable can also be used as a user guide. Some examples taken from the mapping tool are presented at the end of this document.

The Air4EU mapping tool is an innovative tool for dissemination purposes. The future applications and potential improvements are large. Potential improvements are discussed at the end of this report.

This deliverable is directly related to deliverable D7.4, the GIS based mapping tool web solution (see figure 1) that can be found at the following address: www.air4eumaps.info.

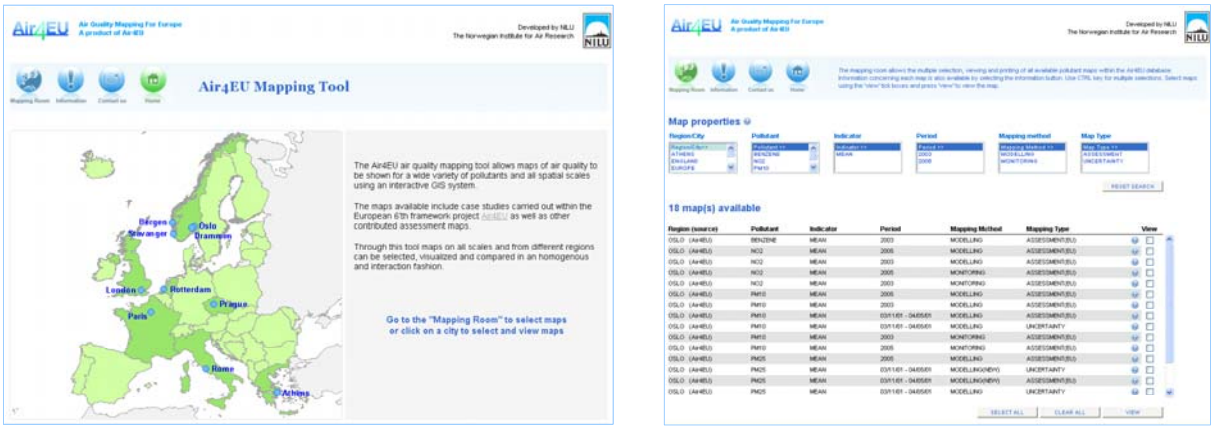


Figure 1: Left: Home page of the mapping tool www.air4eumaps.info. Right: Showing the 'mapping room' selection tool where multiple maps can be selected based on criteria defined by the user.

2.2 Aim

The aim was to deliver a web based GIS system to show air quality data fields for all scales from European to regional to urban to street scale and for any number of compounds and indicators for semi expert and expert users. In such a way that it allows accessibility in a friendly and coordinated manner.

The intention was to develop a tool to show results from the Air4EU case studies as well as maps available from other sources. Air quality maps represents air quality indicator as spatially distributed maps. For each maps there is an associated uncertainty maps based on results and methods developed from WP3-5.

3 Technical implementation of the mapping tool

3.1 Technical platform

The tool's technical platform is based on a web map server (WMS) developed by Demis (www.demis.nl), a cold fusion server, a web server, flash application technology and an Oracle database. Figure 2 shows a simplified diagram of this platform.

The flash application is used to display the air quality maps based on a GIS interface. The user can carry out simple edits of the currently displayed maps, which will be directly updated. This is achieved by the flash application that sends a request (reflecting the users choice) to the WMS using the OpenGIS WMS protocol developed by the OpenGIS consortium (www.opengeospatial.org). As a response, the WMS returns a new image displayed in the flash application.

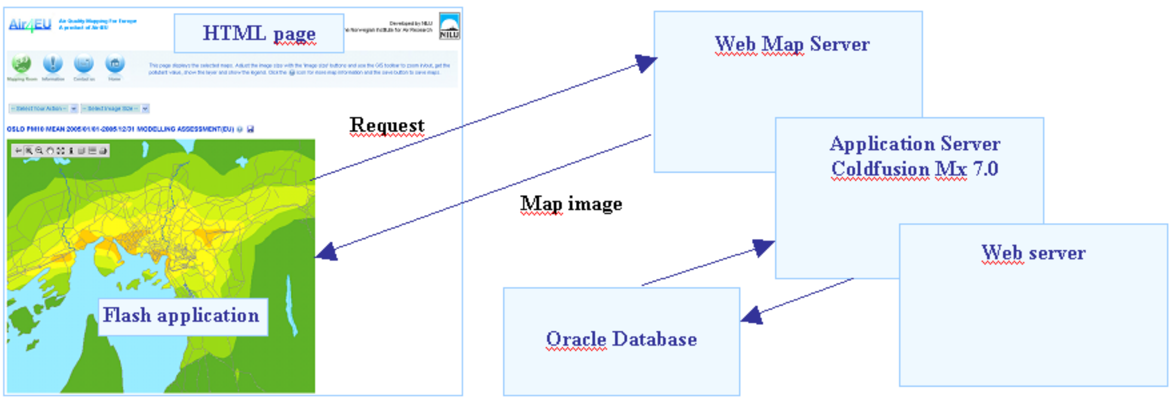


Figure 2: Air4EU mapping tool dataflow. See the text for details

The dataflow between each object of the system platform is described in detail in the following sections. In the next section, we describe how maps are created, edited and registered on the WMS. This is followed by a description of the dataflow generated for selecting and displaying maps from the database.

3.2 Creation and editing of maps

All maps were generated using a combination of ArcVIEW and MAPPER GIS softwares. The maps were created based on several GIS data sources. The main source is a GIS database from ESRI provided on a CD-ROM with the ArcVIEW license. Other sources include data from the European Environmental Agency (EEA) GIS data archive and data freely available for download from several web sites from the World Wide Web.

ArcVIEW

ArcVIEW is a well known and powerful GIS software developed by ESRI. Figure 3 shows the ArcVIEW working space and GIS toolbox. For the purpose of this project ArcVIEW was used to create, edit and harmonise all maps with a unique projection and coordinate system. We used the standard ArcVIEW project and coordinate system called ETRS LAEA 1989, which stands for 'lambert azimuthal equal area projection'. This projection is recommended by the EEA for dissemination of GIS in Europe.

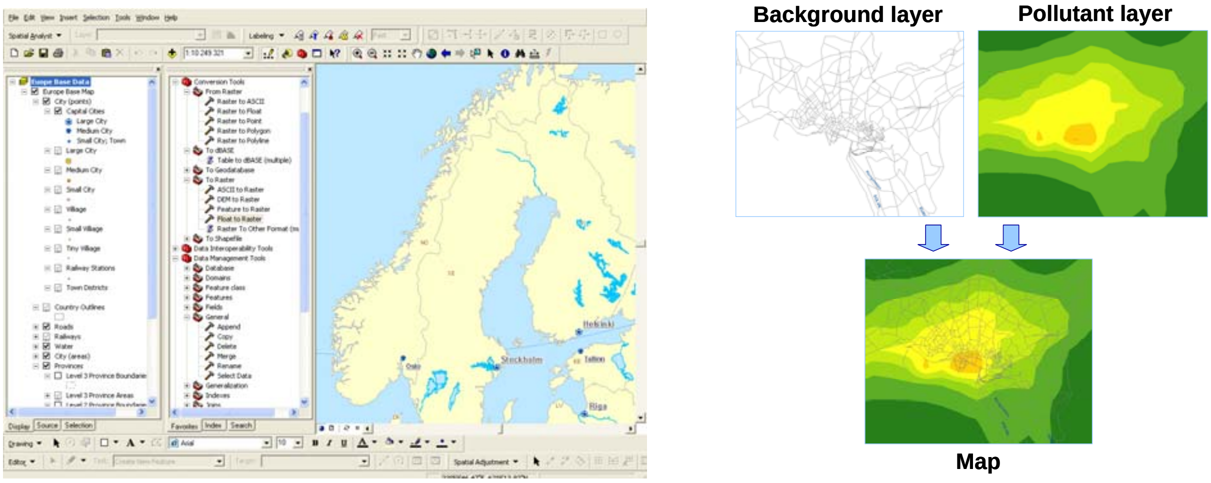


Figure 3: ArcVIEW GIS software (left). Example of a background layer and a pollutant layer used to create a map (right).

Using ArcVIEW we produced a complete dataset of so-called 'layers'. Each layer represents a specific feature such as roads, lakes, urban area or model generated air quality gridded data. These layers come in different data format such as SHAPE and ASCII GRID format. SHAPE format is used for layers representing background information such as roads, buildings or rivers. ASCII GRID format is used for gridded data generated from air quality models or other methods, hereafter we refer to these type of layer as 'pollutant layer', see figure 3 (right).

MAPPER

Further additional processing of the layer dataset was required using MAPPER, a GIS software developed by Demis (www.demis.nl). This processing was necessary so that the data could be converted to a format compatible with the web map server.

MAPPER is a general-purpose application developed by Demis using the Active Map control. MAPPER is included with other products like the Web Map Server and Active Map to use as a common tool for compiling map compositions. For our purpose we used MAPPER for editing and converting standard ESRI GIS data format. The conversion was achieved by using the import function in MAPPER, which converts SHAPE format to MPL format. ASCII GRID format were not converted, as the web map server can directly understand this format.

All layers were regrouped according their spatial coverage and saved as a unique file using MAP file format, see figure 4. MAP format is a specific Demis file format which is understood by the web map server. A MAP file is simply a text document using a specific programming language to archive information about all the layers. This information contains typically layer names, legend colour scale, legend on/off switch, label on/off switch, font, colour schemes, bounding box etc.

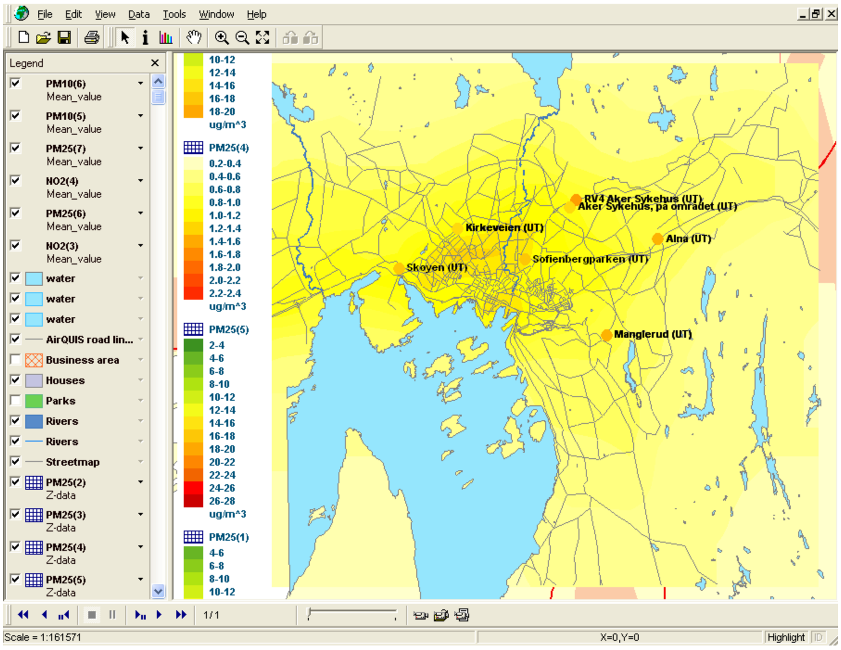


Figure 4: MAP file for Oslo (Norway) and the list of included layers on the left hand side

MAPPER allows the user, among other functionalities, to define the scale range at which each layer should appear. Small details such as street maps or houses appear at small scale, on the other hand, at large scale, high-resolution features disappear and only coarse resolution features remain.

MAPPER was used for editing colour schemes for background layers and creating a legend for each layer. Labels for street maps and urban areas were also added using the MAPPER toolbox.

Automatic MAP file generation

In order to avoid a large amount of repetitive manual editing a FORTRAN script was written that automatically sets and homogenises colour scales, legend and limit values of each MAP file. This script is run for each MAP file prior its registration on the WMS and automatically updates the pollutant layer name, the colour scale and contour spacing and a small number of other MAP file parameters. This script provides the potential for the automatic incorporation of maps in the system that can standardise MAP parameters and avoid manual implementation.

Dedicated server

After the MAP file is appropriately edited it is then registered on the web map server. All maps registered on the WMS can later be viewed on a web browser using the mapping tool.

The mapping tool is run on a dedicated server at NILU. On this server there is a folder where all MAP files and relevant GIS data (background and pollutant maps) are stored. The information contained in this folder is used to create and populate the Oracle database.

3.3 Pollutant layer naming convention and map properties

A naming convention was created for naming, in a harmonised manner, pollutant layers within the MAP file. The convention is based on a sequence of keywords. Each keyword represents a specific map property. Systemically naming the pollutant layers using a string of map properties is very useful, and is the core of the selection tool operation. The user selects one or more map properties using the selection tool user web interface, the selected map properties then define how the database will be filtered.

The pollutant layer name string of keywords is as follows:

REGION_POLLUTANT_INDICATOR_PERIOD_MAPPINGMETHOD_MAPTYPE

Where region, pollutant, indicator, period, mapping method and maptype represent the map properties. This is followed by the appropriate extension, usually *.asc for ascii format. Every keyword is separated by an underscore symbol.

Region. It is the name of the geographical area covered by the map. It can be a city, a country or a specific region, such as Oslo, England, Europe, Nederland etc. There is no limitation on the region to be shown, a new region can be added to the existing list if required.

Pollutant name. It is the name of the chemical pollutant addressed. Currently available pollutants are Benzene, CO, NO_2, O_3, PM_{10}, $PM_{2.5}$ and SO_2. The tool is flexible and additional pollutants can be added to the list.

Indicator. It describes the statistical parameter used for producing the map. Currently available indicators are: AOT, DailyMax (maximum value in the course of a continuous time interval of 24 hours), Max8hrMean (daily maximum 8-hour running mean), mean, percentile and SOMO35 (Sum of Ozone Means Over 35 ppb). Other indicators can be added.

Period. This indicates the time period, this is written using the following format yyyymmdd-yyyymmdd. There is no limitation for the period to be shown.

Mapping method. This indicates the methodology used for creating the maps. The currently available mapping methods are: monitoring, modeling and assimilation. There is no limitation on mapping methods to be shown. If necessary, additional methods can be added.

Map type. There are currently three map types available, assessment, probability and uncertainty. Other map types can be added.

3.4 Oracle database

This section describes the dataflow for populating the mapping tool Oracle database based on the maps and information registered on the WMS. This dataflow is heavily simplified but gives a relatively good overview of the main operational features, see figure 5.

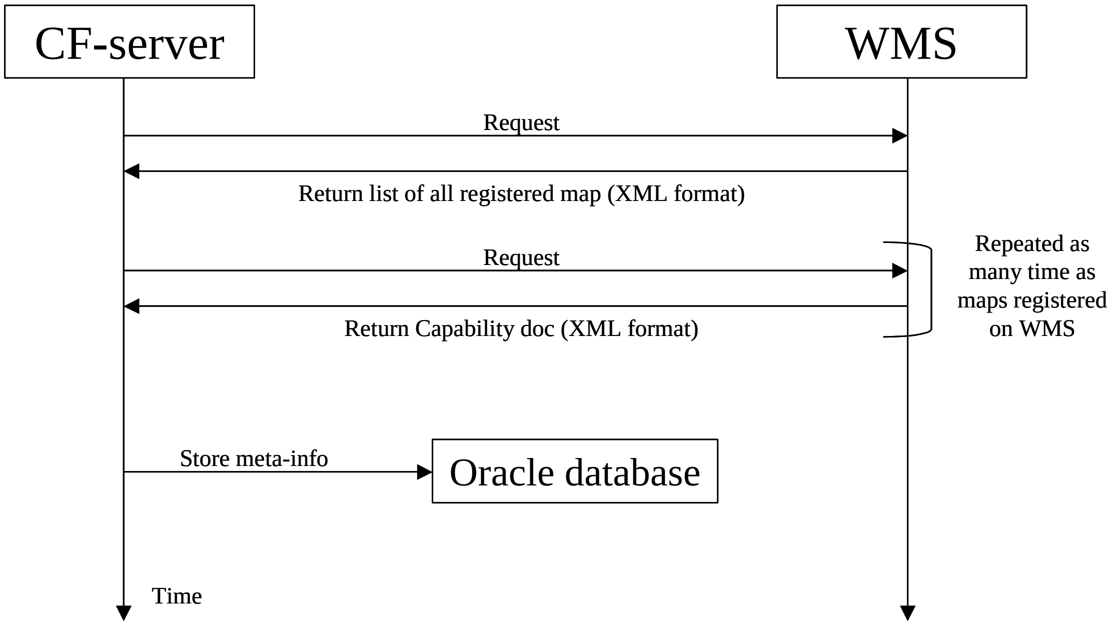


Figure 5: Flow diagram for populating the Oracle database

The dataflow begins with a query from the cold fusion server (CF-server) to the map server (WMS) requesting the list of all registered maps. The map server then returns an XML document containing the list of MAP files.

The CF-server then parses the generated XML document in the following manner:

- For every MAP file the CF-server requests the WMS to return the MAP file meta-information using the *GetCapabilities* request.
- The WMS returns an XML document, which is defined as the "capability document". This document contains information about the MAP file.

The CF-server then stores meta-information for each MAP file in the database in the following manner:

- For each capability document the CF-server creates an in-memory object which is used as a placeholder for all the data that later will be stored permanently in the database.
- The CF-server parses each capability document (XML) in order to get all the registered layers for a MAP file. Then the CF-server adds them to the in-memory object.

- For every layer, the CF-server checks the number of '_' separators in the layer name. If this number equals to 6 then the layer is flagged as a pollutant layer, otherwise it is a background layer.
- If the current layer is a pollutant layer, the CF-server requests the WMS to get extended information (if existing). The extended information is a text describing how the pollutant layer was generated and its content. This information is available in the form of an XML format document written by the author of the map. Such XML documents are stored on the mapping tool server together with the GIS data and MAP files.
- The WMS returns an XML document. If this document exists, the CF-server transforms it into HTML using XSLT.
- Finally, the CF-server persistently stores all data and information for all MAP files in the Oracle database.

Figure 6 shows the database model. It is a relatively simple model. The database is divided in three objects and a scheduler. The three objects are called MAP, LAYER and BOUNDINGBOX. The scheduler object is for keeping track of the database history but has no other specific function within the database.

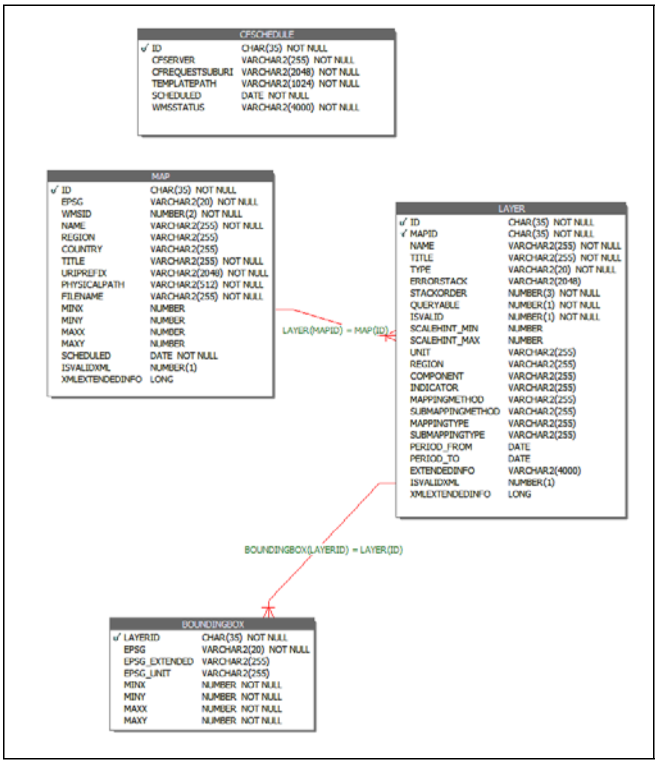


Figure 6: Database model

The MAP object contains information about maps registered on the WMS. The information includes for instance the map ID and name, the regional coverage of the map, the country name and other parameters.

The LAYER object contains detailed information about the layer. The information includes Layer ID, map ID, layer name, layer title and all layer map properties such as region, component, indicator, mapping method, mapping type etc.

The BOUNDINGBOX object contains, as the name indicates, the bounding box information of each layer. This defines which region of the map to be shown.

The three objects are related using the model shown in figure 7 below.

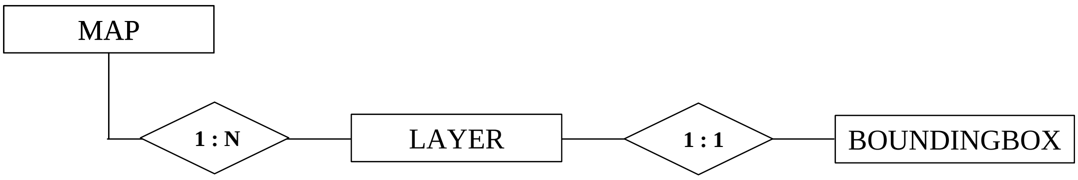


Figure 7: Database entity relationship model

3.5 The selection tool dataflow

In the previous section we described how the mapping tool database was populated. In this section we describe how to select a map from this database. Figure 8 shows the selection tool dataflow. Figure 9 shows the selection tool web interface. The dataflow is between the web browser, the cold fusion server and the database (DB). The dataflow is simplified but provides a good overview.

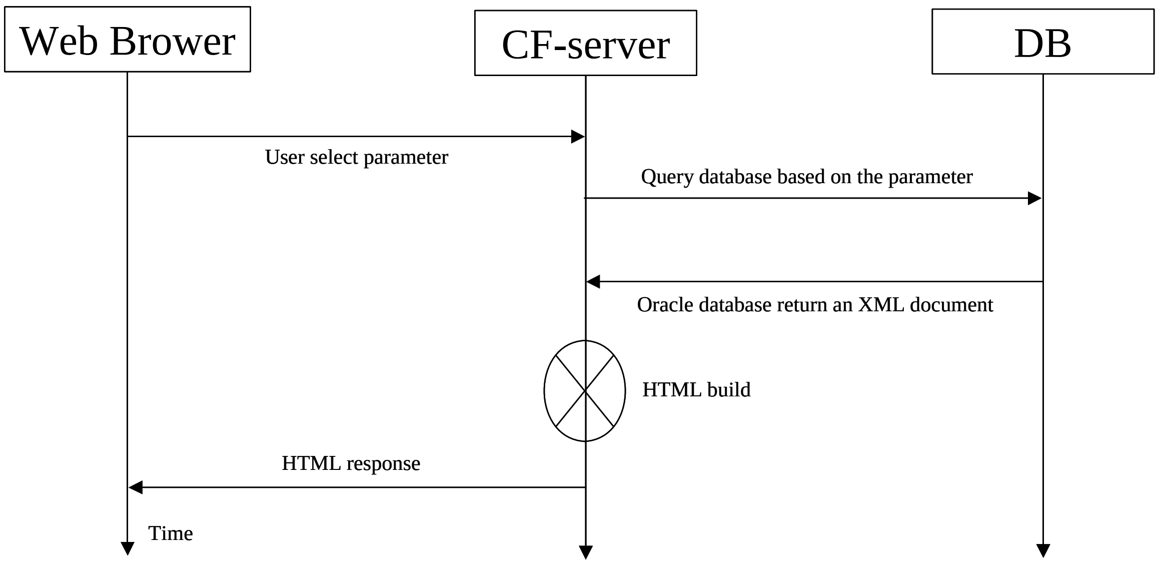


Figure 8: Selection tool dataflow

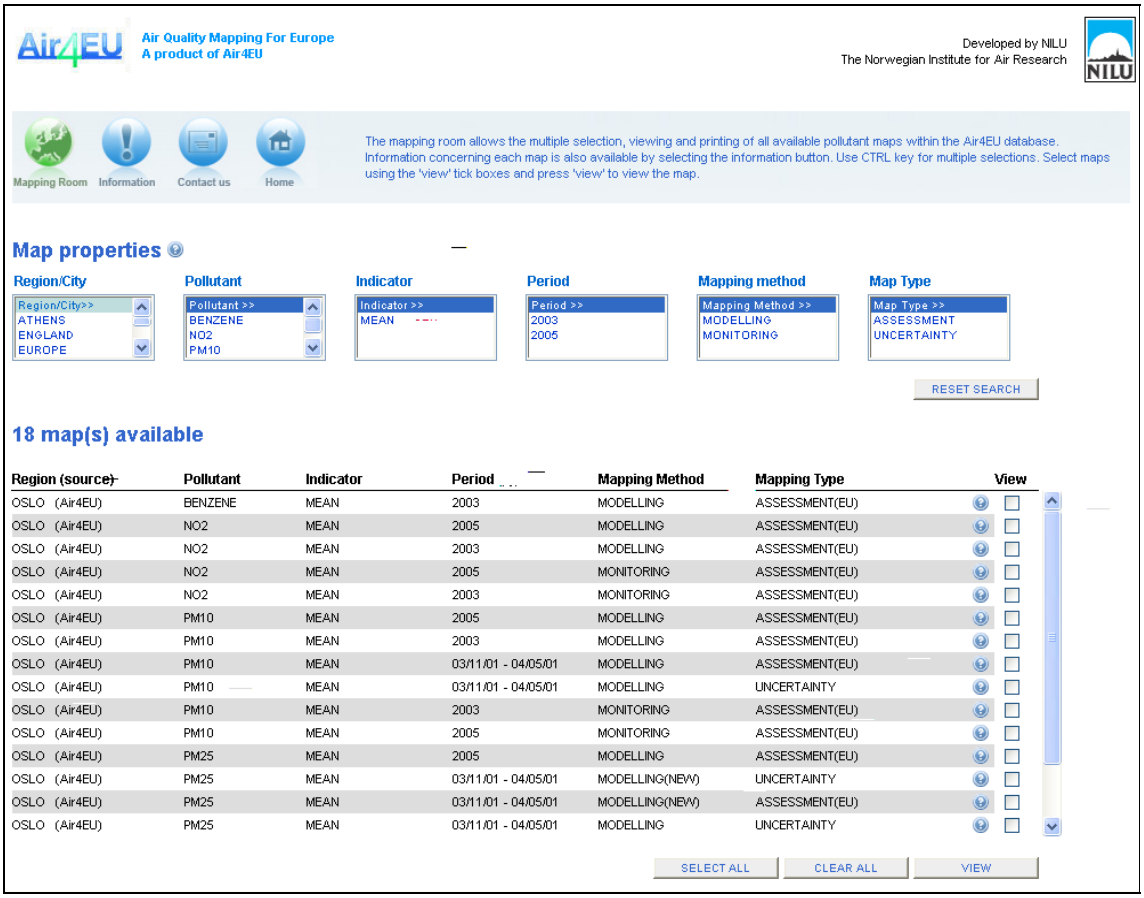


Figure 9: Selection tool web interface

The dataflow is rather simple. The user selects a list of map properties using the web interface. The web browser sends this list to the CF-server. The CF-server then sends a query to filter the database based on this list. The database returns an XML document containing the list of layer names corresponding to the map properties selected. The response to the web browser in converted to HTML, and the result is displayed as a table of the available layers, as shown in figure 9.

The next stage is to display the selected maps, this is described in the following section. The dataflow for this process is generated when the user clicks to view a map from the result table.

3.6 Display map dataflow

The user can display one or several maps by selecting a map from the selection tool result table and clicking the view button. This generates the dataflow shown in figure 10.

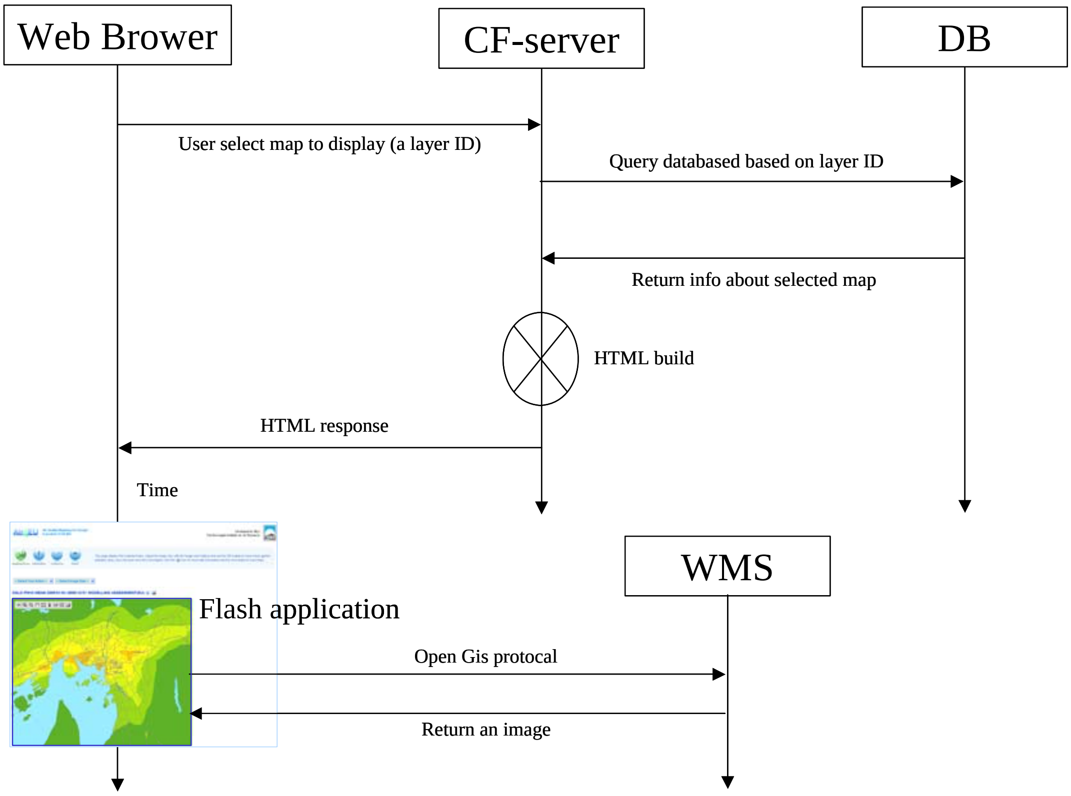


Figure 10: Display map data flow

As the user selects one or several maps from the web browser interface, this points to a list of layer ID numbers. The list is sent to the CF-server, which then sends a query to the database based on this list. The database returns, in a form of an XML document, a list of the parameters for each layer ID. These parameters are required for the flash application to function. This information is converted and imbedded in an HTML document, which generates a new user interface and displays the map.

The generated user interface contains a flash application that is dynamic on its own. Right after the new interface is generated from the dataflow, the flash application sends a request to the WMS using the Open GIS protocol based on the information extracted from the database. As a result the WMS sends back an image, which is subsequently displayed in the flash application.

The flash application is a GIS based interface. The user can edit the image by using a simple GIS toolbox. For each modification performed on the map by the user using the toolbox, a new request is sent to the WMS to get a new image.

The display map dataflow is the last link in the whole system dataflow. Each time the user makes a new selection and views new maps the whole dataflow described above is re-generated.

4 Overview of the Air4EU mapping tool functionalities

4.1 Home page

Figure 11 shows the home page layout. This page contains a short description of the purpose of the tool and an interactive map of Europe. Within the description there is a link to the Air4EU main project pages.

The map is dynamic, the user can click on a city name to access available maps for this particular city. Otherwise, the user can directly navigate to the selection tool by clicking on the 'Mapping room' icon to access all maps available.

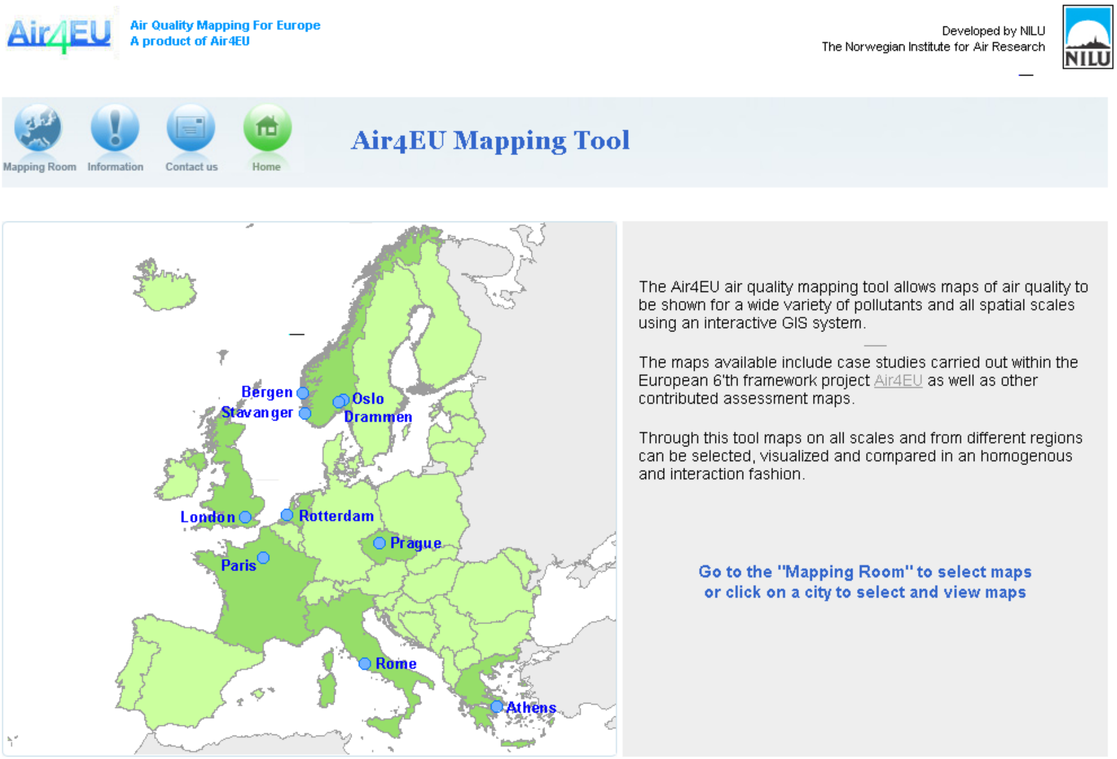


Figure 11: Air4EU mapping tool home page layout

The mapping tool contains maps for the city of Oslo, London, Rotterdam, Paris, Prague, Rome and Athens and for Europe. The countries in darker green are Air4EU participating countries, the lighter green area covers the rest of Europe.

4.2 Selection tool

The selection tool was described in detail in Chapter 3 above. Figure 12 shows additional information through this page, such as a description of the map properties. In the results table the user can also visualise detailed information about each maps by clicking on the question mark icon.

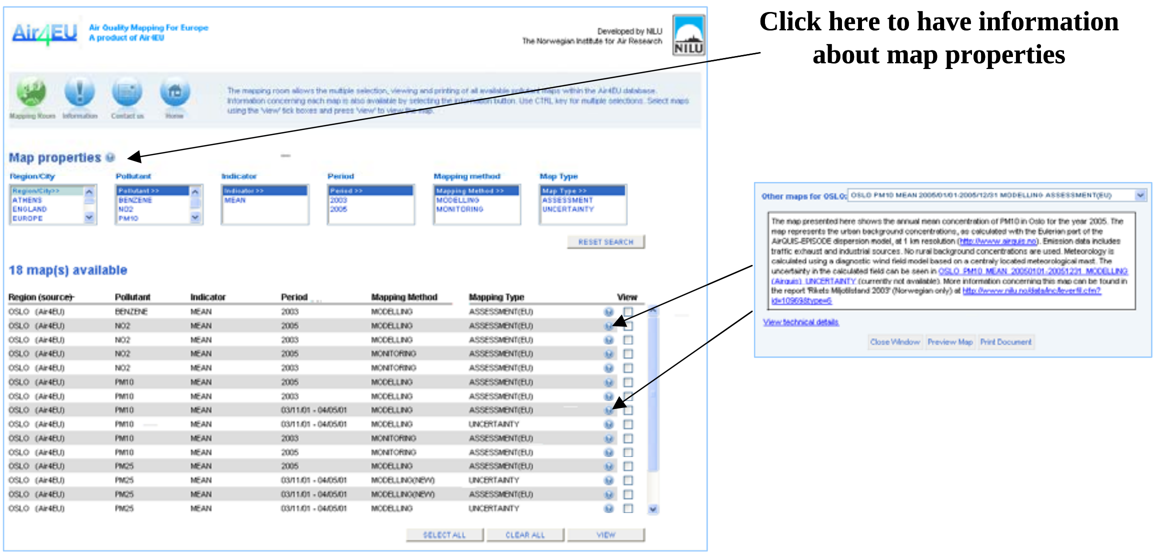


Figure 12: Selection tool and map information pop up window

4.3 Map display

One of the main added values of the system is that it enables the display of one or more maps along side each other. Figure 13 (left) displays a single map of Athens showing NO_2 average concentration for the year 2000 modelled using the OFIS model, and (right) multiple maps of air quality for Athens, SE England, Europe and Lazio.

This allows the user to view and directly compare:

- assessment maps from different regions or cities
- assessment maps of different compounds
- assessment maps on different scales
- assessment maps for different periods
- assessment maps produced using different methods
- and uncertainty maps for different mapping methods and regions.

The user can change the map scale by zooming in and out within each map, as well as editing the map by selecting or unselecting layers, viewing the legend, and print and save the edited maps. This is done by using the available GIS toolbox within each window.

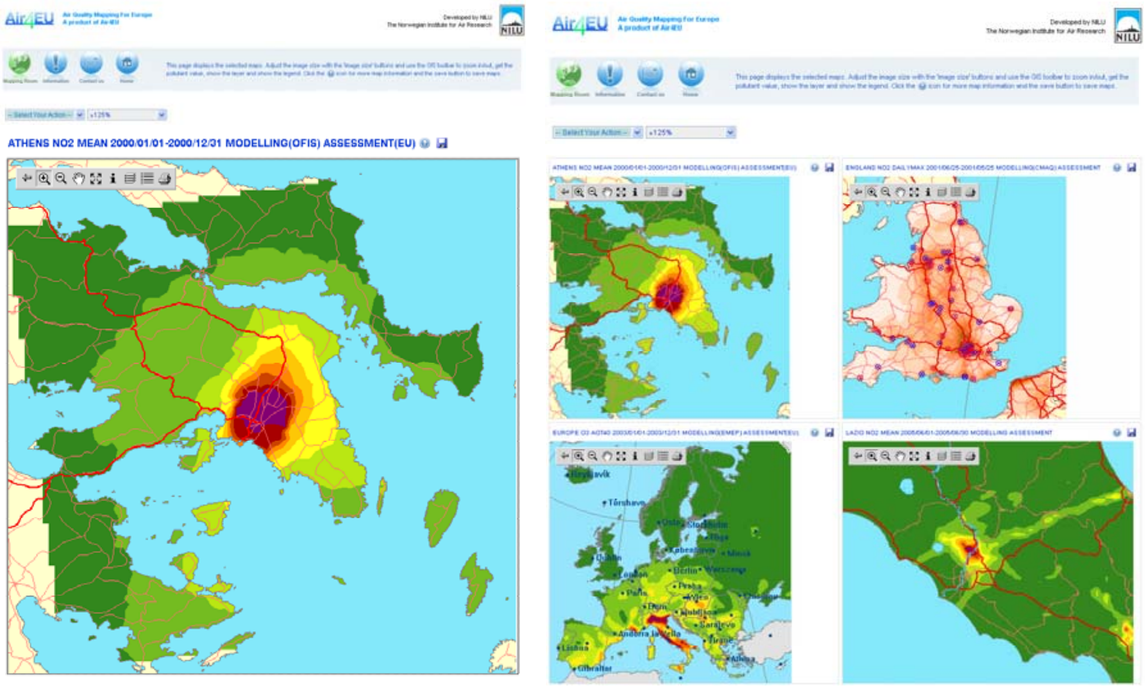


Figure 13: Screen shots showing examples of single (left) and multiple (right) interactive GIS windows. This screen shot shows air quality maps for Athens, England (UK), Europe and Lazio (Italia).

Figure 14 shows two types of mapping methods, modelling and monitoring maps. The map on the left hand side is a map of Prague showing modelled NO_2 average concentration for the year 2003 using the ATEM model. The map on the right hand side is a map of Prague monitoring network showing measured PM_{10} mean average concentration for the year 2003.

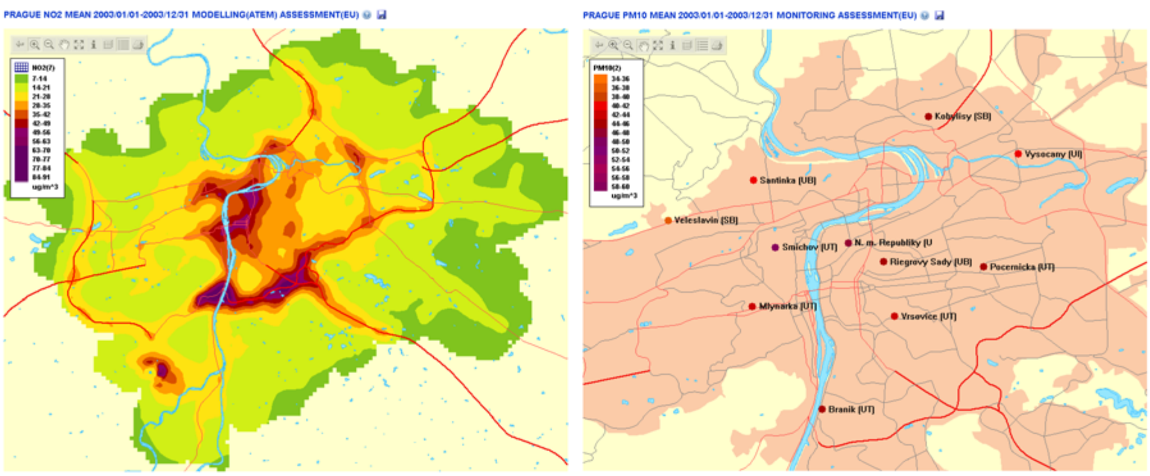


Figure 14: Example of mapping method, modelling (left) and monitoring (right) for the city of Prague

It is also possible to save or print maps displayed by using the save button. Further information about the layer is also available by clicking the question mark icon.

4.4 GIS toolbox

The interactive GIS window contains a toolbox allowing a small amount of editing. These functionalities are:

Back to previous view	View the entire map
Zoom out (Click and drag)	Select layer
Zoom in (Click and drag)	Click on map for pollutant values
Pan (Click and drag)	Show/hide legend
Print image	

4.5 The legend

The user can show or hide the legend (contour colour scaling) using the icon from the GIS tool bar. There are currently two different colour scales in place, one for assessment maps and one for uncertainty maps. More colour scales can be implemented as required.

The legend is harmonised so that maps are directly comparable. Each map may have a different contour interval, dependent on the range of concentrations, but the colour scaling has uniquely associated values for each pollutant indicator so that any particular colour indicates the same value. Within the legend of the assessment maps the pollutant level given by the European directives is indicated in red in the assessment maps. For pollutants and indicators with no official limit value the assessment colour scale is also applied but in those cases the maximum value has been arbitrarily set. The uncertainty colour scale has no limit value but a maximum value given as 50% of the limit value. Examples of these colour contours are shown in figure 15.

The optimal number of contours is 10 but this may vary, dependent on the range of the pollutant map, so that whole number contour intervals are used. The minimum allowable contour spacing is pre-specified for each pollutant and indicator. These colour scales are set using the automatic script described in section 3.2.

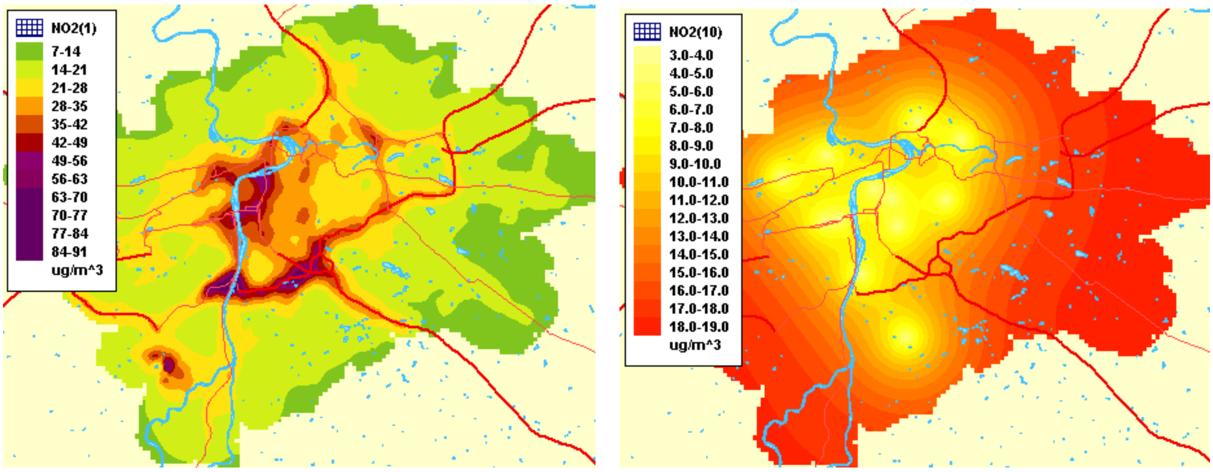


Figure 15: Example of legend colour contour scales for assessment maps (left) and for uncertainty maps (right). Both maps are of Prague but are unrelated.

4.6 Station classification

The monitoring stations are classified according to the DG Environment document on guidance on exchange of information:

http://ec.europa.eu/environment/air/pdf/guidancetoannexes97101ec.pdf

The most common used categories are:

- UB: Urban background
- UT: Urban traffic
- UI: Urban industry
- SB: Suburban background
- ST: Suburban traffic
- RNC: Real near city
- RR: Rural regional

The use of this classification allows the user to have a better understanding of the measured value from each station. Classifications should be included when monitoring data is presented.

4.7 Mapping spatial reference convention

During the mapping tool development phase we took into consideration EU guidelines for dissemination of maps in Europe. This concerns in particular the choice of the spatial reference. According to the guideline all maps (for Europe) are projected using the European spatial reference grid ETRS 1989 LAEA.

ETRS 1989 LAEA has the following characteristics: lambert azimuthal equal area projection, WSG 84 spheroid, ETRS 89 datum, 10° E Central meridian, 52° N latitude of origin, 4221000.0 false easting, 3210000.0 false northing, and the unit is meter.

EU guideline documents are available at the following websites: www.eea.eu.int , http://eionet.eu.int/gis and http://eionet.eu.int/gis/docs/EEA_GISguide_v2.doc

5 Examples

5.1 Intercomparison of PM_{10} for 4 different regions

In figure 16 an example, extracted from the mapping tool, is shown. It displays an intercomparison of yearly PM_{10} concentrations for Europe, Oslo, Prague and Rotterdam. Each map was produced using a different model. The Europe map was produced using the EMEP model. The Oslo map was produced using AirQUIS model. The Prague map was produced using the ATEM model and the Rotterdam maps was produced using the OPS model.

All maps share the same contour colour scale though the contour ranges and intervals vary between maps. The EU Directive limit value of 40 $\mu g/m^{-3}$ is seen as red, values above this are in shades of purple.

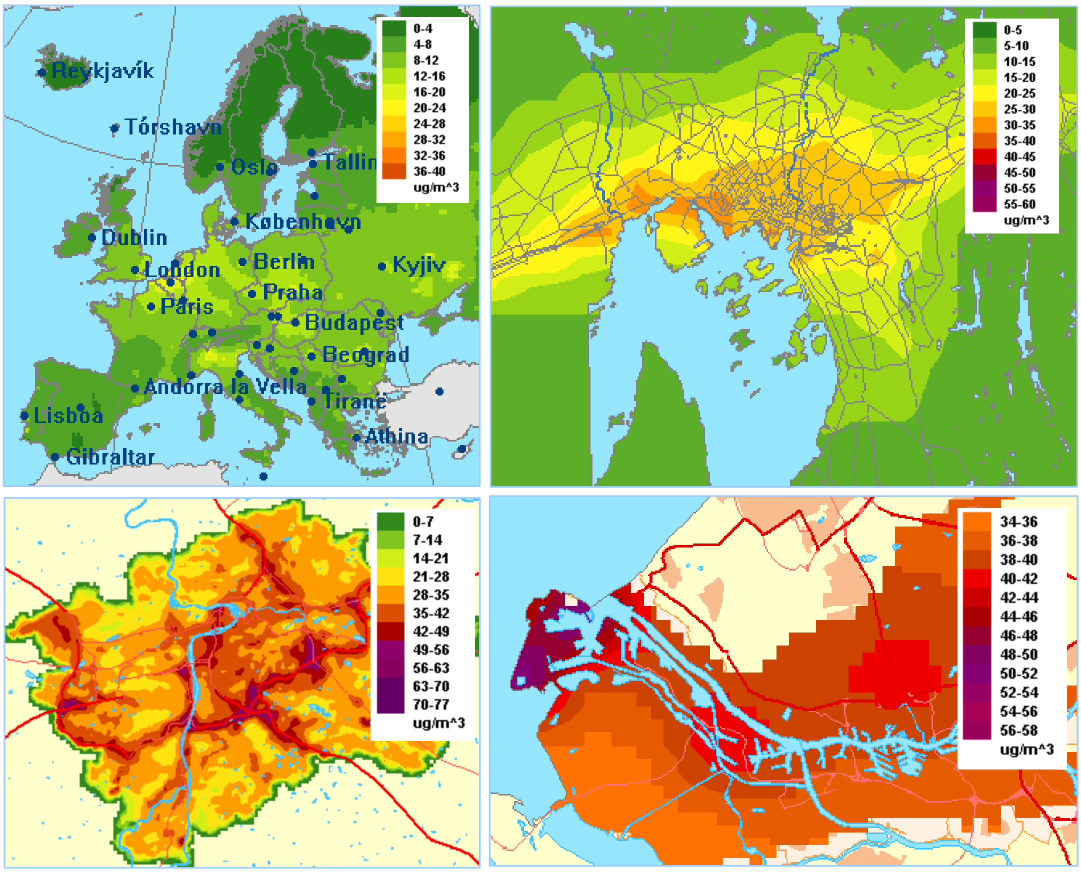


Figure 16: Intercomparison of yearly PM_{10} concentrations for 2003 in Europe (top left) using EMEP model, Oslo (top right) using AirQUIS, Prague (bottom left) using ATEM model and Rotterdam (bottom right) using OPS model

5.2 Maps plus uncertainty maps for two different methodologies

In figure 17 another example, extracted from the mapping tool, is shown. It displays a comparison of two different mapping methods used for calculating the annual mean PM_{10} concentrations for Europe in 2003. The two methods shown are calculations from the Unified EMEP model and results from data assimilation of the EMEP model using Bayesian assimilation. In addition to the concentration maps their associated uncertainty maps are also shown. In this example it is possible to compare the results of the two methods and the uncertainty related to each of the methods. By displaying the uncertainty maps along side, it is possible to make a judgment on the quality of the assessment maps displayed.

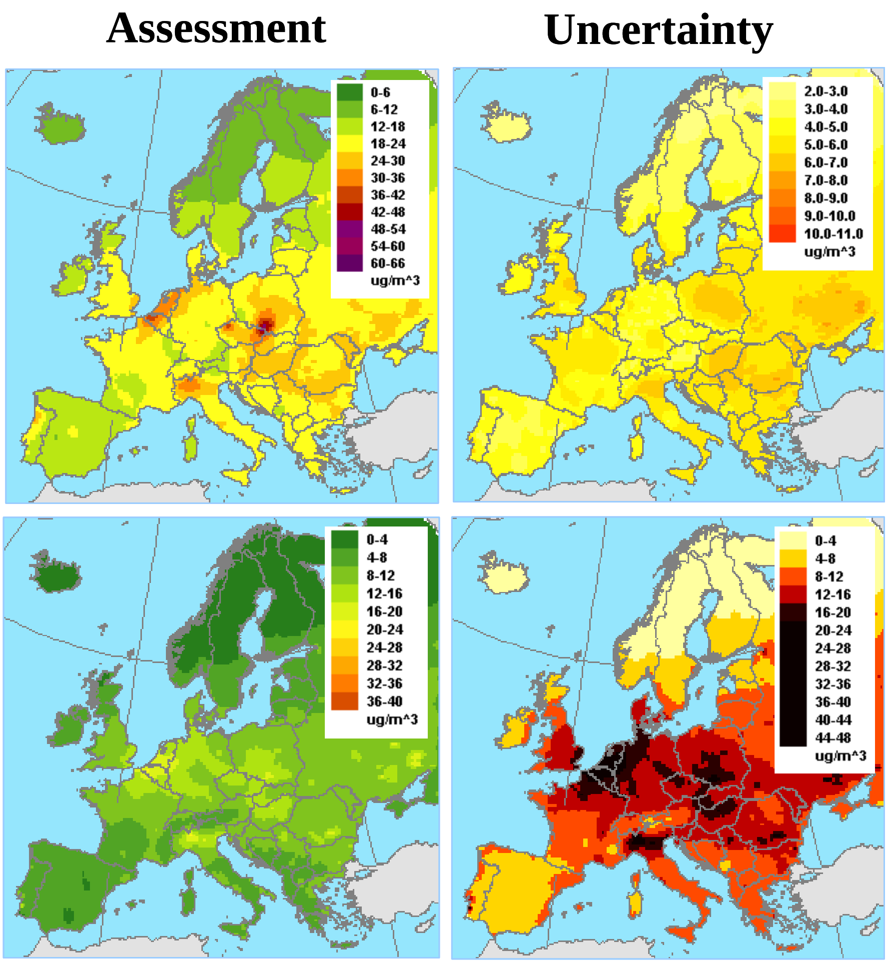


Figure 17: Comparison of 2 different mapping methods showing annual mean PM_{10} concentrations for Europe in 2003 along with their uncertainty maps. Bayesian assimilation assessment map (top left), EMEP model assessment map (bottom left), Bayesian assimilation uncertainty map (top right) and EMEP model uncertainty map (bottom right).

6 Requirements for delivery of maps

It is possible to add new maps to the mapping tool database. These data must be delivered in a specific format. There are two types of data to be considered, background map and pollutant maps. By background maps we mean features such as roads, parks, rivers, urban extent, etc, which gives the user information about the location of the map. Pollutant maps are gridded data, these data are used to produce contour plots of air quality fields.

Background maps requirements:

Feature: highway, major road, minor road, parks, water, rivers, city/urban area, industrial area, residential area, topography

File format: SHAPEFILE for all features except topography (raster format)

Projection: ETRS 1989 LAEA (projection available in Arcview)

Pollutant maps requirements:

Data format: Gridded data (raster data)

Period: No limitation but preferable yearly data

Pollutants: any but preferably legislated compounds such as PM_{10}, $PM_{2.5}$, NO_2, Benzene, CO, O_3 and SO_2.

Indicator: Mean, AOT40, SOM035, percentiles or others.

File format: ASCII GRID

Projection: ETRS 1989 LAEA (projection available in Arcview)

Information: Create a separate information file (*.xml format) for each pollutant map using the example presented in Annex 1. This can be edited in any simple text editor, for instance *wordpad*. The information provided will be shown in the mapping tool on request from the user.

The text should describe the content of the map, the region coverage, the pollutant, the date, the indicator, the methodology for producing the map and the map type. It can also include any extra information about the model or monitoring data, more details about the methods used to construct the map, and URL references to other relevant links

NOTE: When you save your text file remember to use the *.xml extension and save it as a text document file type.

Naming convention:

Pollutant maps must be named using the naming convention described in Section 3.3 of this report.

The XML document produced for each pollutant map must have the same name as its associated pollutant map.

Please use the following keyword (or similar) for each map properties:

region: PARIS, EUROPE, NORWAY, OSLO.
pollutant: PM10, PM25, O3, NO2, CO, BENZENE, SO2
indicator: MEAN, AOT40, SOMO35, PERCENTILE
period: YYYYMMDD-YYYMMDD (from-to)
mapping method: MODELLING, MONITORING, ASSIMILATION
map type: ASSESSMENT, UNCERTAINTY, VARIABILITY

examples:
OSLO_PM10_MEAN_20040201-20040301_ASSIMILATION_ASSESSMENT.asc
OSLO_PM10_MEAN_20040201-20040301_ASSIMILATION_ASSESSMENT.xml

7 Future improvements and applications

Future improvements and new functionalities are required to increase the practicability and performance of the system. A number of these future developments are given below.

Implementation of administrative web pages to facilitate the administration the system seems essential if the tool is to be used further. Currently, the system is heavy to manage and changes require manual operations from the editor. The administration pages could be password protected, open to one and several users. On these pages it would be possible to add new maps, data and upload XML document describing the data, and possibly convert these data to right formats. In addition, these pages should enable the automatic editing of the new uploaded data and harmonisation of the legend, label, colour etc.

Extraction and downloading of data from the mapping tool is another useful functionality, not currently available in the existing system. The data that could be downloaded should be air quality data in ASCII GRID format for instance.

Increased user functionalities such as the ability to add (upload) and edit data in specified formats for both maps and monitoring data. Additional functionalities for manipulating maps, including contour spacing, range, placement of legend, etc. may be useful if maps produced by the tool are to be used directly as figures for reporting. Added mapping features such as map scales can also be implemented.

Additional functionalities such as difference mapping and basic data assimilation could be implemented in the mapping tool in future versions.

Improvement of the current mapping tool database is possible so that it contains more information and allows data to be extractable by the user. Currently, the database has a relatively simple model but this can be used as a platform for further improvements.

Future applications and their related improvements will be subject to further funding and project applications. As it is, the mapping tool is already an innovative system and can serve as a platform for a more powerful GIS based web solution. Future applications of the system may include

- Use as an archiving and visualisation database for individual city authorities, institutes or modelling groups
- Application as a general mapping visualisation tool complementing monitoring information websites currently in existence
- Dissemination of maps for public awareness and as an educational tool
- With expansion of the functionalities it may be used as a centralised model assessment and visualisation tool.

8 Conclusions

The tool improves and harmonises the dissemination of mapping information for both authorities and institutions involved in air quality assessment. It allows the simultaneous presentation, and comparison, of air quality assessment maps on all scales and for any number of compounds and indicators.

The features which make the mapping tool unique are as follows:

- The database of maps can be viewed and selected in a simple and interactive manner.
- Selection criteria for the maps includes region, pollutant, assessment period and mapping method.
- Any number of maps can be simultaneously presented.
- Contour colour scaling (legend) is homogenised for direct intercomparison, with clearly defined limit values based on EU directives.
- Information and links for each map is provided.
- Maps and information can be saved or printed directly.
- Maps of uncertainty can also be viewed concurrently with the assessment maps.
- GIS integration allows for a more comprehensive and visual assessment.

The mapping tool is presented here to encourage the harmonised presentation of maps and encourage the production of uncertainty maps associated with them. The tool provides centralised and ordered access to a mapping database and can be used to aid dissemination of mapping information for both city users and institutes involved in air quality assessment.

If you wish to add maps or are interested in utilising the Air4EU mapping tool then please contact: Dr. Agnes Dudek at the following email address: agnes.dudek@nilu.no

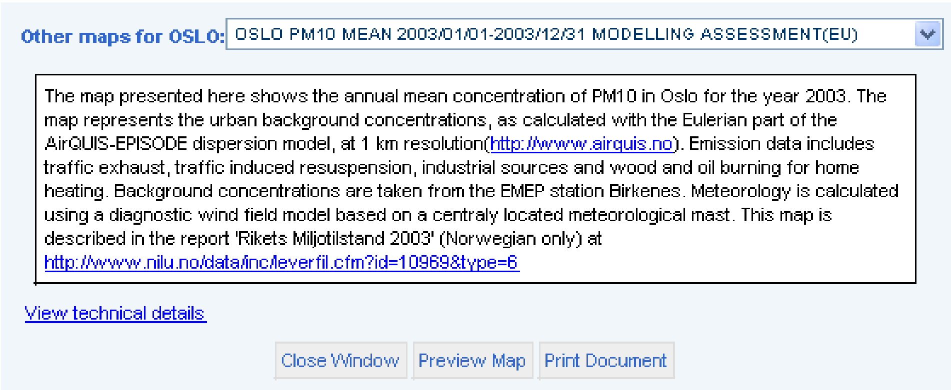
www.air4eumaps.info

Annex 1

Example XML document providing map information

```
<?xml version="1.0" encoding="UTF-8"?>
<layer>
<concentration-unit>ug/m3</concentration-unit>
<information>
<text>
       <![CDATA[
       The map presented here shows the annual mean concentration of PM10 in Oslo
       for the year 2003. The map represents the urban background concentrations, as
       calculated with the Eulerian part of the AirQUIS-EPISODE dispersion model, at
       1 km resolution(
       ]]>
</text>
<text>
       <url>
       <![CDATA[
       http://www.airquis.no
       ]]>
       </url>
</text>
<text>
       <![CDATA[
       ). Emission data includes traffic exhaust, traffic induced resuspension,
       industrial sources and wood and oil burning for home heating. Background
       concentrations are taken from the EMEP station Birkenes.  Meteorology is
       calculated using a diagnostic wind field model based on a centraly located
       meteorological mast. This map is described in the report 'Rikets
       Miljotilstand 2003' (Norwegian only) at
       ]]>
</text>
<text>
       <url>
       <![CDATA[ http://www.nilu.no/data/inc/leverfil.cfm?id=10969&type=6
```

```
        ]]>
        </url>
</text>
</information>
</layer>
```



The above XML file as it appears on the web browser