Exploring potential causes, consequences and visualizing evolution of major air pollutant emissions over EU28

Jules Sauvinet, Marine Ruiz

Fig. 1. Main view of the visualization: 12 small maps of EU28 colored according to ammoniac emissions on the top and 12 small maps of EU28 showing quantity used of Nitrogen fertilizers from 2003 to 2014.

Abstract— From now on, the media talks about environmental issues on a daily basis. Pollution peaks have become commonplace in large metropolises and air pollution is becoming a subject that is increasingly affecting citizens. As pollution is not only a visual or olfactory discomfort, it is now the main environmental health risk in the world. On average, it causes the premature death of 7 million people worldwide, including 600 000 in Europe and more than 50 000 in France, according to the World Health Organization, the Ministry of the Environment and the Environment. European Environment Agency. We propose here a model which allows to visualize the evolution of the emissions of the main harmful pollutants during 12 years and to explore the potential causes and consequences. For instance, does it seems to be an obvious correlation between the fines particles emissions and pulmonary diseases?

Index Terms—Air pollution, Pollutant, Ammoniac, Sulphur oxides, Non-methane volatil organic compounds, Nitrogen oxides, Particule matters, EU28, Ecology, Health.

1 INTRODUCTION(1P)

The emissions of most harmful air pollutants has globally decreased over the past 25 years in European Union (see the figure 2 below). Nevertheless, emissions remain very high, particularly in some countries whose economy depends on sectors responsible for the discharge of certain pollutants. While some countries have taken stock of the issue and taken steps to reduce their emissions, others are struggling to keep pace with economic and political conflicts. As a result, there are regularly many pollution peaks in major European cities, posing serious problems for the environment and health.

The model we are proposing has two parts.

The first is to be able to visualize the evolution of pollution in the European Union countries for 6 pollutants identified by Eurostats as among the most dangerous for the environment and health: Ammonia (NH3), Sulfur Oxides (SOx) Nitrogen Oxides (NOx), Non-methane volatile organic compounds (NMVOC), Fine Particles less than 2.5um (PM2.5), and Fines Particles less than 10um (PM10).

In order to be able to visualize the evolution of the emission of these pollutants, we have developed an interface composed of 12 small maps from the European Union countries to 28 concerning 12 recent years (the data we have of the pollutants range from 1990 to 2014, and these are more complete the longer the time). The user chooses the pollutant from which he wishes to consult changes in the list of 6 specified earlier. Then, each small map (see the figure 3 below) is colored according to a scale of color more or less intensely depending on the amount of pollution rejected per inhabitant. The countries whose data we do not have are colored gray. The color scale is constructed from two minimum and maximum values which are the minimum and maximum rejected pollution values by a country during the 12 years considered. Ainsi, l'utilisateur peut observer l'volution de la pollution pour comparer les pays entre deux pays ou bien pour un młme pays pour deux annes diffrentes. Les small maps lui donne une vue d'ensemble lui indiquant la tendance gnrale de l'volution de la pollution pour les 12

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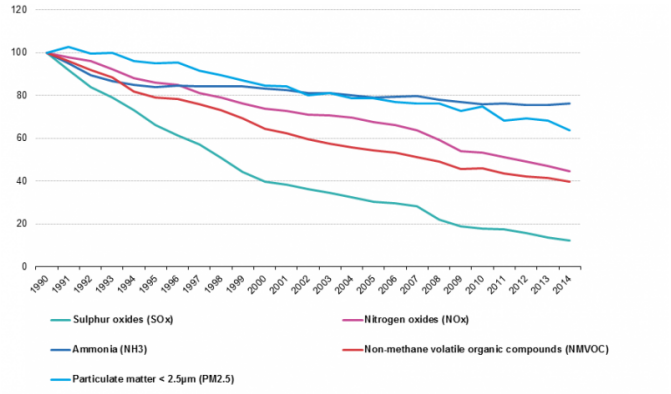

Fig. 2. A visualization of the data from **??**. The image is from [**?**] and is in the public domain.

Fig. 3. A visualization of a small map. The image is from our visualisation.

annes et le polluant considr. De plus l'chelle de couleur permet d'isoler nettement les pays qui ont une mission bien plus leve que les autres (e.g. l'Irlande sur la figure 3).

The second part of our model is the exploration of the potential causes and consequences of pollution among those that we propose. Once the pollutant has been chosen, the user can choose from a list what we will call a comparison measure. For example, for ammonia, the user can choose from the "Nitrogen Fertilizer" measure. A second set of 12 small maps is then made showing this time the evolution of the measure considered for the maximum 12 years common with those of the pollutants whose data are available.
Thus, by comparing the intensity of the coloration of the two series of small maps, the user can identify if there is a potential link between the pollutant and the measure considered. First, it is possible to observe if over a year the color nuances correspond and potentially indicates a correlation for the target year. Secondly, it is possible to observe whether the evolution trends (growth, decay, stagnation) are connected (similar, or opposite). The goal is to invite the user to wonder but obviously does not affirm the observed link.

2 Related Work (1p)

- Note that each author needs to have a separate entry in author footer on the bottom-left corner of the first page, merging two people (even if from the same institution) is not permitted.

- The style uses the hyperref package, thus turns references into internal links. We thus recommend to make use of the "`\autoref{reference}`" call (instead of "`Figure~\ref{reference}`" or similar) since "`\autoref{reference}`" turns the entire reference into an internal link, not just the number. Examples: **??** and **??**.

- The style automatically looks for image files with the correct extension (eps for regular LaTeX; pdf, png, and jpg for pdfLaTeX), in a set of given subfolders (figures/, pictures/, images/). It is thus sufficient to use "`\includegraphics{CypressView}`" (instead of "`\includegraphics{pictures/CypressView.jpg}`").

- For adding hyperlinks and DOIs to the list of references, you can use "`\bibliographystyle{abbrv-doi-hyperref-narrow}`" (instead of "`\bibliographystyle{abbrv}`"). It uses the doi and url fields in a bibTeX entry and turns the entire reference into a link, giving priority to the doi. The doi can be entered with or without the "`http://dx.doi.org/`" url part. See the examples in the bibTeX file and the bibliography at the end of this template.

  Note 1: occasionally (for some LaTeX distributions) this hyper-linked bibTeX style may lead to **compilation errors** ("`pdfendlink ended up in different nesting level ...`") if a reference entry is broken across two pages (due to a bug in hyperref). In this case make sure you have the latest version of the hyperref package (i. e., update your LaTeX installation/packages) or, alternatively, revert back to "`\bibliographystyle{abbrv-doi-narrow}`" (at the expense of removing hyperlinks from the bibliography) and try "`\bibliographystyle{abbrv-doi-hyperref-narrow}`" again after some more editing.

  Note 2: the "`-narrow`" versions of the bibliography style use the font "PTSansNarrow-TLF" for typesetting the DOIs in a compact way. This font needs to be available on your LaTeX system. It is part of the "paratype" package, and many distributions (such as MikTeX) have it automatically installed. If you do not have this package yet and want to use a "`-narrow`" bibliography style then use your LaTeX system's package installer to add it. If this is not possible you can also revert to the respective bibliography styles without the "`-narrow`" in the file name.

  DVI-based processes to compile the template apparently cannot handle the different font so, by default, the template file uses the `abbrv-doi` bibliography style but the compiled PDF shows you the effect of the `abbrv-doi-hyperref-narrow` style. **Note 2:** the "`-narrow`" versions of the bibliography style use the font "PTSansNarrow-TLF" for typesetting the DOIs in a compact way. This font needs to be available on your LaTeX system. It is part of the "paratype" package, and many distributions (such as MikTeX) have it automatically installed. If you do not have this package yet and want to use a "`-narrow`" bibliography style then use your LaTeX system's package installer to add it. If this is not possible you can also revert to the respective bibliography styles without the "`-narrow`" in the file name.

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3 Project Description (2p)

We organized our Web Page into 3 parts: first, a header which describes the project, then an area with 12 small maps of the European countries, showing pollution-related data, thanks to the pollutant list, the legend and the colours. On the top of this area, there is a title which displays the name of the pollutant. Finally, an other area with the same 12 small maps, this time to show pollutant-related data such as causes, consequences or correlations to the emission of the pollutant selected.

To be more accurate, next to the 12 pollutant small maps, there is a button radio list of 6 pollutants. By default, when the Web Page is loaded, the pollutant on top of the list is selected. When an other button radio of the list is selected, the 12 small maps are updated, as well as the legend and the title. So, we have a dynamic visualization of pollutant emission evolution in time.

Likewise, in the measure map area, there is a list of measures available, and when an other measure is selected, all the area is updated. The origin of the emission is different for each pollutant, so to maximize the relevance of the comparison between pollutant and measure, we offer a different list of measures for each pollutant. Thats why, when the pollutant changes the list also does. Moreover, the number of maps for pollutants and measures depends on the data we have. In fact, when we did not have any data for a year, we preferred not to represent the map of this year at all instead of showing a total grey map. We only selected the years for which we had some data for both pollutant and measure. If we have some data available for more than 12 years since 2001, we take into account the data for the 12 more recent years (for example, from 2003 to 2014). Conversely, if since 2001 we have less than 12 years of available data, we take all the data we have since 2001. So, according to the pollutant and the measure selected, there are more or less maps. All of these choices enable us to have a dynamic visualization. Indeed, we maximize information by deleting non-pertinent elements. For example, the user avoids losing time with comparisons between pollutant and measure which may lead to nothing and his eye will not be caught by some grey small maps that do not bring any piece of information.

Then, we have chosen to normalize our data because the most populated countries pollute than the least populated countries. If we colour the small maps with the untreated data, the legend will be slanted. Then, to solve this problem, we offer two types of data normalization. By default, when the Web Page is loaded, the population normalization is selected, but its possible to change it with the two buttons radio. When density is selected, all of the 24 small maps are updated, as well as the two legends. Conversely, its possible to return to population normalization selecting the population button radio.

3.1 Visualization description

- Les 12 maps polluants avec la lgende
  - Si on choisit un autre polluant dans la liste, les maps se mettent jour
  - Permet le dynamisme de la vizu des polluants.
- Les 12 maps de mesure avec la lgende
  - Si on choisit une autre mesure dans la liste, les maps se mettent jour et on affiche les maps uniquement avec les annes sur lesquelles nous avons des donnes et polluant et mesure slectionns dans la limite de 12 annes
  - Permet le dynamisme de la vizu des mesures.
  - permet de maximiser linformation grce aux annes dynamique, on sadapte aux donnes et non linverse, on naffiche jamais de map toute grise
  - Si on choisit un autre polluant, la liste des mesures est modifi pour proposer des mesures intressantes comparer avec le polluant
  - Permet de maximiser les comparaisons, on enlve ce qui nest pas pertinent pour que lutilisateur ne perde pas de temps inutilement

- la normalisation des donnes
  - Si on change la normalisation des donnes, les 24 maps et la lgende se mettent jour
  - Les pays les plus peupl pollue plus, il faut faire un pourcentage
- laffichage des valeurs
  - Quand on passe la souris sur un pays de nimporte quelle map, polluant comme mesure, le nom du pays apparat et les annes sont remplaces par la valeur sur les 24 maps (les annes o il ny pas de donnes pour le pays, rien ne saffiche)
  - Lagencement de la vizu permet ds le premier regard de se faire une ide de la corrlation mais afficher les valeurs sur les 24 maps permet de faire un ide rapide de lvolution de la donne. On peut aussi comparer son volution avec lautre donne (corrlation, anti-corrlation, rien)
  - on a une liste de tous les pays qui sont pris en compte
  - on peut cocher ou dcocher tous les pays de la liste suivant si lon veut les visualiser ou non.
  - La lgende se met jour si cela est ncessaire. Le pays devient gris sur toutes les maps, et passer la souris dessus ne change rien la Vizu.
  - certains pays biaisent la lgende en ayant des valeurs extrłmes. On peut donc choisir de ne pas prendre en compte ce pays et ainsi obtenir une chelle plus raffine. On peut de ce fait faire une coloration de seulement quelques pays si on le souhaite

3.2 Choice of the measures

We chose 18 measures that we considered relevant regarding the pollutants we selected :

- Cancer death (Morts de cancers)
- Pesticides (Pesticides)
- Nitrogen fertilizers
- Potassium fertilizers
- Phosphore fertilizers
- Environmental tax (Taxe environnementale)
- Transport tax (Taxe transport)
- Primary production of electricity (Production primaire d´nergie)
- Primary production of renewable electricity (Production primaire d´nergie renouvelable)
- Primary production of oil (Production primaire de ptrole)
- Primary production of gas (Production primaire de gaz)
- Primary production of coal (Production primaire de charbon)
- Nuclear heat (Production primaire d'nergie nucleaire)
- Heart diseases deaths (Morts de maladies cardiaques)
- Diesel motor cars (Moteurs de voitures diesel)
- Petrol motor cars (Moteurs de voitures ptrole)
- Length of hospitals stays for lung diseases (Jours d́hospitalisation pour maladie pulmmonaire)

We first searched for each pollutants the possible causes and consequences of the emissions. Then we tried to find adapted measures in the database for eurostats.
For the Ammoniac pollutant, we identified that the major sector produces rejects was the agriculture (figure 3).
Etc.. Pesticides et engrais.

For the particules matters pollutants (PM2.5 and PM10), we identified that the major sector produces rejects cas diesel combustion ...
.
Etc.. Pesticides et engrais.

Since countries are specialized in producing certains type d'nergie etc..

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4 Evaluation (optionnel)

On pourrait dire qu'on l'a fait tester notre famille/amis c'est deja ca.

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5 Discussion (1/2p)

We will discuss here the potential improvements we have imagined for our visualization and that we have not had time to develop.

5.1 Technical points

First of all, from a technical point of view, it is possible that the visualization is not a satisfactory rendering on all the supports due to the dimensions of the screens. As the various graphics components do not all have flexible dimensions, their size and positioning may be different from those we have defined from our screens, hindering the readability and efficiency of the visualization.

5.2 Getting more visual clue

In addition, we thought about being able to display graphs of changes in pollution values and the chosen measure of a country for all the years of which we have data available. When the user clicks on a country on a small map, a graphic would appear in a container at the bottom of the visualization, giving an extra visual key to observe the correlation and evolution of the data.

Moreover, we thought of giving an additional visual key to compare values across all countries, bidding on the information provided by the color scales. When the user clicks on a country, two value tables for all other countries for the current year are displayed for the pollution values and the current measure. Not all users have clear interpretations of the differences between colors, which would have allowed some users to more accurately visualize the targeted country according to the others and thus reach a wider audience. Nevertheless, since the visualization is already rich in the number of visual elements, the added information could also overload the information and obscure the view of the user

5.3 Getting more information

Moreover, we have imagined that we can integrate the notion of respect for ecological norms to highlight countries that do not respect it and thus highlight the relevance of European environmental policy. Non-compliant countries could have an additional visual code such as being covered by hatching or dotted lines.

We also thought we could add more pollutants. To do this, we would have had to extend our knowledge of the field of air pollution in order to choose those with relevance for comparison with our measurement data. Similarly, we wanted to add further measurement data (particularly in the field of health), including data moving away from commonly established correlations (eg diesel cars and fine particle rejection), thus showing the consequences of probably less well-known pollution. However, the available data are often not available and not always easily interpretable for non-specialists in the field of pollution.

Another idea was to be able to navigate through all the common years available for the polluting / measuring combination with a 12-year sliding beach slider. That would have enabled us to make full use of our data. In addition to this idea of enriching the temporal dimension, we would have liked to be able to propose a monthly time scale in addition to the annual scale to observe with more refinement the peaks of pollution. Unfortunately, no asser data is available today with such a fine time dimension.

Finally, one possibility would have been to use a finer geographical breakdown, such as that proposed by the NUTS2 regional division format) or the NUTS3 format (departmental format). However, the scale of small maps is no longer suitable for reading a visualization with depictions of such fine geographical areas. It would have been necessary to reduce the number of small maps by removing years. It is a compromise to find, providing maximum information without drowning the user, while maintaining legibility and complexity allowing the visualization to remain fast and dynamic for a comfort of use.

6 Conclusion

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