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WWW.AIRQUALITYNOW.EU, A COMMON WEBSITE AND AIR QUALITY INDICES TO COMPARE CITIES ACROSS EUROPE

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Abstract: Air quality is a public concern. This is partly due to the "right to know" principle embodied in European legislation. Despite this common legislation, the way air quality is being interpreted and communicated differs considerably. For specialists raw monitoring data for Europe are available but these are not usable by the general public. Easy to understand and internationally comparable air quality information from one city to another is scarce: there are almost as many air quality indices as air quality monitoring networks. The CITEAIR II project (Common information to European Air, INTERREG IVc) facilitates the comparison of urban air quality in near real-time by introducing common air quality indices at hourly, daily and annual scales and by developing a forecast for those indices for D+0 and D+1.The implementation was based on a common website www.airqualitynow.eu using readily available simple IT-solutions. This paper describes those tools which both aimed at presenting the air quality of the participating cities in a comparable way and not to replace more targeted local information. Their added value is to provide, for the first time, a European and comparable picture of the air quality in near real-time easily accessible through a common platform and presentation of the results. The website is designed to receive and display data from any city wanting to join. The main part is dedicated to compare the cities index values using different time scales (hourly, daily or annual) and two types of exposure thanks to a background and a traffic index. In addition, space is offered to cities for presenting themselves according to a common template, providing background information on their specific air pollution situation and associated reduction measures. Participating is easy: cities upload their data through ftp and the indices calculations are automatically made. The website provides a dynamic picture of the air quality and is updated each hour enticing viewers to make repeated visits. However, participation with only a daily update or with yearly data is feasible as well.

Key words: *air quality index, public information, website, European platform.*

INTRODUCTION

In order to inform the public and to fulfill the legal obligation of providing information on air quality, a large number of cities and countries have started over the past years to display monitored or modeled air quality data on the internet. For most of the monitoring organizations, the internet is the easiest way to meet the dissemination of information requirements of the European (and/or national) legislation. The fact that so much air quality information is available on the internet makes it tempting to compare different cities in different countries. This proves particularly difficult. Apart from technical websites such as the European Environmental Agency's ozone website (http://ozone.eionet.eu.int) and Airbase (http://airbase.eionet.eu.int), there are no possibilities to compare cities/countries side by side. Even if one surfs from one site to the other, comparison is not easy: air quality is presented in different ways using different interpretation criteria and a different typology of stations, which is usually not clearly explained.

The most widespread way to interpret air quality on websites is the use of an index ranging from good to bad to make the detailed measurements in micrograms more understandable for the general public. A review of existing websites and the associated air quality indices shows that the way air quality is interpreted differs considerably across the world. More surprisingly, even amongst the EU member states who share common legislation, the indices used do vary.

To facilitate the international comparison of near real time air quality, the CITEAIR project (co-funded first by INTERREG IIIC then by INTERREG IVc, http://citeair.rec.org) has developed a common operational website www.airqualitynow.eu where cities can display their air quality information side by side. Firstly, the project aimed at making air quality comparable across Europe and using www.airqualitynow.eu to rely on common air quality indices (hourly, daily and annual), keeping in mind that the general public is the end user. The new development of the CITEAIR project will lead to the implementation of a forecast of the common air quality indices available to any city that has joined the common web site. This paper presents the CITEAIR common website, its set of indices and the development of the forecast.

1. COMPARING EUROPEAN CITIES THANKS TO A COMMON WEBSITE

The CITEAIR common website www.airqualitynow.eu was launched in March 2006. It is meant to be an interesting complement to the cities own websites. The website and the corresponding indices have not been launched to replace existing websites nor indices. Their added value is to provide for the first time a European and comparable picture of the air quality at first glance, up to date and understandable by anybody for:

- three time scales (on a hourly, daily and an annual basis),
- and two types of public exposure to air pollution (background and traffic conditions).

In addition, for those cities that are not yet on the internet, and/or do not currently use an index, "air quality now" and its indices could be their primary platform to easily provide information to the public and the local authorities. A space is also offered to cities for presenting themselves according to a common template, providing background information on their specific air pollution situation and associated reduction measures.

The website is operational with currently more than 60 cities feeding their data (see fig. 1). The process to join has been made easy. Based on the data sent by the cities through an agreed ftp format, the indices calculations are automatically done inside www.airqualitynow.eu. The full procedure is detailed on the "join us" page. However, not every city has its own monitoring network or both traffic and background stations, and not everyone is able to deliver data in near real time. If cities want to participate in only one of the indices, can only deliver data on a daily basis, or even only present year-averaged data, they can

still join the website. Different sections of the website provide a platform to compare different data (year average, daily, hourly). Participation is therefore not limited to those with their own automatic monitoring network. Other cities are invited to join and upload their data as well.

Www.airqualitynow.eu does not aim to replace more targeted existing local information. This would be an unrealistic ambition as in many cities the public has got used to the local, tailor-made index. The proposed common indices are, by the nature of the fact that they are common to a wide area, a non-specific compromise. CITEAIR envisages that there is room for two sources of air quality information on the internet: a local website, in the national language with a dedicated presentation (often using a well established and known local index); and a common website aimed at comparing - in near real time - the air quality in your own city to the air quality in other European cities. Moreover, to facilitate an international use, www.airqualitynow.eu is now available in four European languages: English, French, Dutch and Spanish, while other European translations are under preparation.

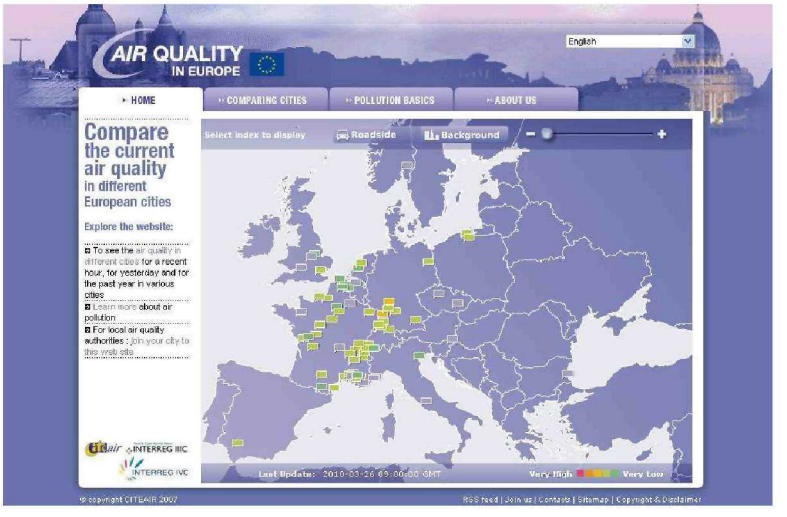

Figure 1: Home page of the CITEAIR common web site www.airqualitynow.eu presenting the comparison of air quality in European cities through common indices (background situation for the 26/03/10 at 11:30 pm).

2. INTERNATIONAL COMPARISON OF CITIES THANKS TO COMMON AIR QUALITY INDICES

2.1 A common daily and hourly index (CAQI)

As already explained, comparing air quality in different cities is a tricky issue. Is the air quality being determined in the same way (this mainly applies to particulate matter) and at comparable locations? This is not an issue that the CITEAIR project and its indices can solve. Its common website will take for granted whatever a city supplies as input data. As a first step to improve comparability, the indices will be reported both for roadside and city background locations. This is considered an important improvement over city averages: some monitoring networks are designed to monitor or spot areas of poor air quality (with possibly a high number of roadside stations) whereas others are aimed at providing an average city picture.

The Common Air Quality Index (CAQI) consists of both a daily and an hourly index. In the website the daily index is shown for the past day (D-1). For the current day, the hourly index is available, and is updated every hour. A daily index for today needs forecasting or 'nowcasting', a facility that is not available in each city with a monitoring network, hence the option of an hourly index will be available soon (see section 3). The hourly index is also a reasonably dynamic parameter, enticing repeated visits to a website.

The CAQI is calculated according to the grid in figure 2, by linear interpolation between the class borders. The final index is the highest value of the sub-indices for each component. As can be seen there are two CAQI-s: one for traffic monitoring sites and one for city background sites.

The traffic index comprises NO_2 and PM_{10}, with CO as an auxiliary component. The background index obligatory comprises NO_2, PM_{10} and O_3, with CO and SO_2 as auxiliary components. In most cities the auxiliary components will rarely determine the index (that is why they are auxiliary) but in a city with industrial pollution or a seaport, SO_2 might occasionally play a role. Benzene is considered a long-term exposure issue. The number of cities with online monitoring of benzene is limited and it is therefore not included in the short-term indices.

The choice of the classes in the CAQI is inspired by the EU legislation and based on a compromise

Common air quality index calculation grid

Index Class	Grid	ROADSIDE INDEX				BACKGROUND INDEX					
		Mandatory pollutant			Auxiliary pollutant	Mandatory pollutant				Auxiliary pollutant	
		NO2	PM10 1 hour	PM10 24 hours	CO	NO2	PM10 1 hour	PM10 24 hours	O3	CO	SO2
Very High	>100	>400	>180	>100	>20 000	>400	>180	>100	>240	>20 000	>500
High	100	400	180	100	20 000	400	180	100	240	20 000	500
	76	201	91	51	10 001	201	91	51	181	10 001	301
Medium	75	200	90	50	10 000	200	90	50	180	10 000	300
	51	101	51	26	7 501	101	51	26	121	7 501	101
Low	50	100	50	25	7 500	100	50	25	120	7 500	100
	26	51	26	13	5 001	51	26	13	61	5 001	51
Very Low	25	50	25	12	5 000	50	25	12	60	5 000	50
	0	0	0	0	0	0	0	0	0	0	0

- NO2, O3, SO2: hourly value / maximum hourly value in µg/m3
- PM10: hourly value / maximum hourly value or adjusted daily average in µg/m3
- CO: 8 hours moving average / maximum 8 hours moving average in µg/m3

Figure 2: Pollutants and calculation grid for the CAQI

between the participating cities. The dividing line between medium and high is often linked mainly to the values mentioned in the directives: alert thresholds (SO_2, NO_2, O_3) or air quality objectives when available on a daily basis (CO and PM_{10}). Class borders were regularly spaced for the main components. PM10 is an exception. To avoid that the CAQI is completely dominated by PM_{10} the value of 50 $\mu g/m^3$ as a daily average was positioned as the bordering line between low and medium. For the setting of the CO and SO_2 borders additional inspiration was sought from Cairncross and John and the DAPPS index [2004] which aims to define the component sub-indices based on the relative risks attributed to each component.
The CAQI resembles the French ATMO index and it differs substantially from for example the UK and US-EPA indices. It therefore shares the drawbacks of the ATMO: no clear link with health effects, fairly arbitrarily qualitative interpretation of hourly values. But it also shares its advantage: frequently changing index values that capture the hour-by-hour changes and make a website dynamic. The latter was of overriding importance as raising awareness is a key objective of the common website. De Leeuw and Mol [2005] compared the CAQI to a number of other indices.

Figure 3: CAQI results for the cities part of CITEAIR and details of the CAQI results for the agglomeration of Paris on www.airqualitynow.eu.

Whereas the calculation grid for hourly and daily values is the same for most components, PM_{10} poses a particular problem. Consistency had to be found between the hourly and the daily index scales. Many networks only report 24-hour (moving) average data. This different averaging time implies that their concentration readings are always lower than those for the networks reporting true hourly values. In order to solve this problem, a selection of 52 urban and suburban monitoring stations from Airbase for the period 2001-2004 has been used to calculate the ratio between daily maximum hourly concentration and daily average concentration. This average ratio appears to be 0.55. Based on a wide selection of stations, it is used to link the hourly and daily index scales
Figure 3 presents how the CAQI is displayed on www.airqualitynow.eu for the almost 70 current participating cities and the possible comparisons for a particular day and hour enabled by the index for two time scales and two types of exposure. As an example, the details of the CAQI calculation for Paris through its sub-indices are also provided.

2.2 A common year average index (YACAQI)

Year average indices are not very common in air quality reporting but they are nevertheless a useful indicator for non-experts, facilitating the comparison of cities at a glance. Comparing cities by their individual pollutant levels is difficult as one city might be better on one pollutant and worse on the other. In addition, some cities might monitor different pollutants than others. Even comparing progress in a single city from one year to the other is difficult as progress might be made for one pollutant whereas in another field things might have deteriorated. A year average index is a huge simplification but it does provide an easy way to make some kind of relative assessment on the position of one city to the other or for one city from year to year.
In CITEAIR the way of making such a medium term index is the "distance to target" principle. One advantage of the distance to target principle is that each parameter considered contributes to the index (unlike the principle where the worst parameter determines the index). A distance to target indicator calculates, for each pollutant, a ratio of how far the actual measurement is away from the target value, for example a limit value. The overall index/indicator is the average of the sub-indices. A distance to target index is based on policy targets or limit values. The limit and target values have important implications both for environmental policy makers and for the public. Besides, they do have a link to health risks: in Europe they are most

of the time related to the recommendations of the World Health Organisation [2005]. The distance to target way of making an index is the year average index presented in this paper and used on www.airqualitynow.eu.

Table 1: Calculation basis for the year average index.

Pollutant	Target value / limit value	Calculation
NO_2	Year average is 40 µg/m^3	Year average / 40
PM_{10}	Year average is 40 µg/m^3	Year average / 40
	Max. number of daily averages above 50 µg/m^3	Year average / 31
	35 days with ≈ year average of 31 µg/m^3	
Ozone	25 days with an 8-hour average value >= 120 µg/m^3	# days with 8-hour average >=120 / 25
SO_2	Year average is 20 µg/m^3	Year average / 20
Benzene	Year average is 5 µg/m^3	Year average / 5
CO	-	Not calculated

Like the hourly and daily index, the Year Average Common Air Quality Index (YACAQI) is calculated for traffic and city background sites. It is up to each city what they want to contribute (monitored or modeled data). In most cases, the cities choose to provide data from one or more monitoring sites. When a city provides data from several sites, each index is based on the average of the data from the number of sites.

The calculation of the sub-indices is detailed in table 1. Sub-indices are calculated for each pollutant by dividing the actual year average by the EU limit or target value. The overall city index is the average of the sub-indices for NO_2, PM_{10} (both year average and daily averages) and ozone for the city background index. For the traffic year average index the averages of the sub-indices for NO_2 and PM_{10} (both year average and daily averages) are being used. The other pollutants, if data are available, are used in the presentation of the YACAQI but do not enter the calculation of the city average index. They are treated as additional pollutants like in the hourly and daily indices. The main reason is that not every city is monitoring the full range of pollutants. Furthermore for SO_2 we expect that the situation in different kinds of cities is very far apart, being no problem in most cities and a concern in others. Figure 4 presents how the YACAQI is displayed on www.airqualitynow.eu for a selection of cities, for two types of exposure, over a number of years, and the details for Paris. This type of presentation provides valuable additional information when comparing two cities or the same city over two years. At a glance it becomes evident what the main problems are and where progress for the situation is satisfactory.

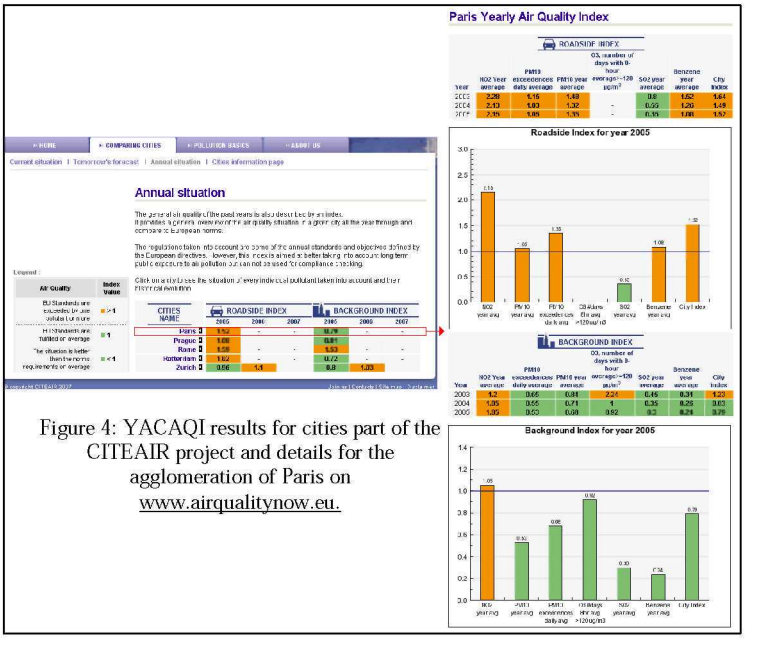

Figure 4: YACAQI results for cities part of the CITEAIR project and details for the agglomeration of Paris on www.airqualitynow.eu.

3. DEVELOPMENT OF A FORECAST FOR THE COMMON AIR QUALITY INDEX

CITEAIR II is developing and implementing a forecast for the CITEAIR II air quality daily index with three levels of complexity to meet the needs and requirements of European cities:

- Level 1: "Easy approach": the objective is to individually forecast air quality for each mandatory pollutant at the monitoring stations in order to derive a forecast air quality index at the city scale. The methodology is based on local statistical adaptation of PREV'AIR large (European) scale forecasts. It consists in writing concentrations at each monitoring station as a multi-linear function of PREV'AIR large scale outputs, past measurements and other relevant quantitative or qualitative predictors
- Level 2: "Mid-level approach": the objective is to produce a forecast index map over the city. Locally forecast concentrations resulting from level 1 are spatialised by geostatistical kriging methods. Auxiliary variables known over the whole area (e.g. emission inventories, population, land cover, meteorological fields) and correlated to concentrations are introduced in the estimation to enhance the map precision. This approach requires a rather homogeneous distribution and a sufficiently large number (at least >15) of monitoring points over the city and its surroundings.
- Level 3: "Sophisticated approach": the objective is to forecast air quality over the whole city at fine-scale resolution. This approach is based on high resolution chemistry transport models implemented with proper emission patterns and relevant chemical schemes. European chemistry transport model outputs are used as boundary conditions for the model area.

Which level a city applies depends on the local conditions and resources. Nevertheless, the level 1 was designed to be available to forecast the CITEAIR air quality indices for every city in www.airqualitynow.eu. The forecasted indices will be displayed on the common website for D+0 and D+1.

As an example, Figure 5 displays a comparison of the daily CAQI forecast for D+0 between:

- the large scale (European), low resolution (50*50km^2) PREV'AIR system;
- the level 1 forecast derived within the CITEAIR II framework;
- the index computed based on observations; the observations are relative to year 2009, whereas the statistical model is built on 2008.

The comparison is performed here for the city of Rotterdam.

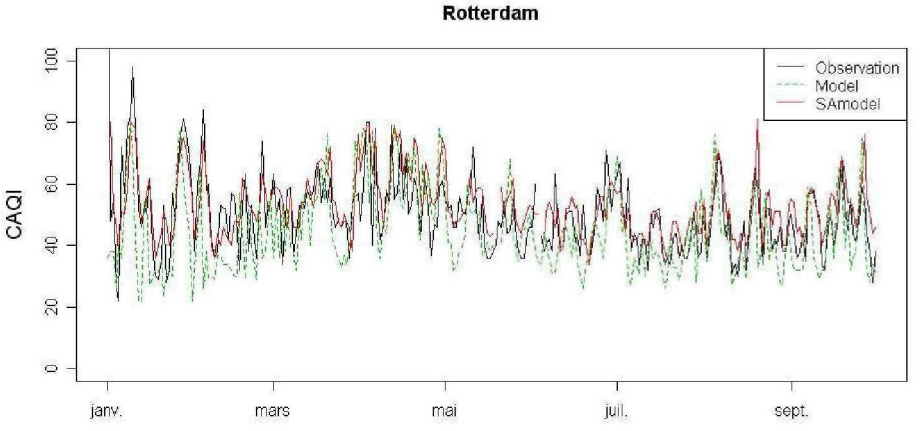

Figure 5: Comparison over year 2009 for the city of Rotterdam of the daily CAQI forecast for D+0 between: the European, low resolution PREV'AIR system output (in green); level 1 forecast (in red) derived within the CITEAIR II framework; the index computed based on observations (in black).

From this figure, one can see that level 1 approach substantially improves the CAQI forecast. The underlying statistical model is based in this specific case on a very limited set of predictive variables: measurements of the day before and European model outputs. Other models – based on a larger set of predictive variables such as meteorological parameters – have also been built, and in most cases, they give satisfactory results in term of forecast comparison to observations.

4. CONCLUSION

Full details on the elaboration of CAQI and YACAQI, as well as sample application, are available on www.airqualitynow.eu. Maps of forecasted concentrations of the pollutants of main concern derived from PREV'AIR have already been added and will be soon complemented by forecasted air quality indices during the life time of CITEAIR II. Further developments of these common tools will concern: participation of new cities and new media partnerships to display the indices, integration of $PM_{2.5}$ in the indices according to the CAFE directive, as well as translations in several EU languages.

Cities are engaged in communication with the public, not only because of legal obligations but also to raise awareness. This implies that air quality issues have to be presented in an attractive and educational way. The possibility to compare your own local air quality to a number of other European cities is an asset in this respect. The purpose of common indices and website is not to replace more detailed local information nor to check EU regulation compliance but to complement it. The added value is to provide, for the first time, a European and comparable picture of the air quality in near real-time, forecasted and understandable by anybody. In addition, the provision of separate indices for two types of environmental conditions and three time scales is a methodological innovation. It could also be an alternative to raise public awareness for cities which do not already operate a website.

ACKNOWLEDGEMENTS

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