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CAQI Air quality index

Comparing Urban Air Quality across Borders - 2010

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Summary

To be expanded

The CAQI index is used on the www.airqualitynow.eu website since 2006. For the first time since its application it is evaluated on a large set of Airbase data. At the same time the CAQI received an update. The introduction of limit values for $PM_{2.5}$ made it necessary to accommodate that pollutant in the index. Though $PM_{2.5}$ is an important pollutant it is included as a mandatory pollutant. This is due to the way the EU $PM_{2.5}$ monitoring requirements are formulated. The fact that $PM_{2.5}$ is an auxiliary pollutant should not be seen as a sign that it is less important than the mandatory pollutants nor that it hardly determines the overall index. The CAQI is calculated for hourly, daily and yearly averaged data. The methods for daily and hourly data are quite similar.

- The new calculation grid is shown in table 10.
- Results of the *updated* CAQI calculation are shown in table 7 for hourly data. The results for daily average data are shown in table 9.

Acknowledgements

The EEA Airbase staff (Hermann Peifer and David Simoens) were very kind in making a pre-selection of stations and data, saving us a great deal of work in preparing our sample. Additional daily averaged data for PM_{10} and $PM_{2.5}$ was made available by Frank de Leeuw (PBL/EEA). The data analysis was mainly done by Hans Bartelds (DCMR).

Important

This document is not yet finished. In particular chapter 1 Introduction, chapter 2 basic concepts and chapter 5, the year average index are not yet finished. Check the project website for updates: www.citeair.eu/

The information that is to appear in Chapter 2 can largely be found in the original document describing the index. See link below. This document will eventually replace the index document that is currently on the website.

The chapters dealing with the daily and hourly index (3 and 4) are in final draft stage. They describe the old and the new calculation grid.

www.airqualitynow.eu/download/CITEAIR-Comparing_Urban_Air_Quality_across_Borders.pdf

1 Introduction

1.1 Scope of the document

1.1.1 Daily and hourly indices

The CAQI or Common Air Quality Index has been operational on the website www.airqualitynow.eu since 2006. After an initial proposal the calculation grid was revised to improve the representation of the PM_{10} concentrations. In the first version of the CAQI, the fact that PM_{10} is being measured both on an hourly and daily basis was initially not well covered and the PM_{10} grid was rather strict. This was revised after an analysis of PM_{10} data from Airbase stations. The final CAQI calculation grid is operational since 2007.

In this paper we evaluate the way the CAQI performs on a selection of urban and suburban stations. In addition we propose a calculation grid for $PM_{2.5}$. Since the CAQI was launched the air quality directives have been revised and a limit value for $PM_{2.5}$ was added. As $PM_{2.5}$ is probably the most health relevant parameter for today's urban air quality in Europe it had to be included in the CAQI calculation. However we wanted it to be in line with the existing CAQI calculation grid so we experimented with various grids.

The data used were obtained from Airbase. We used urban and suburban stations (background and traffic) where the core pollutants were monitored. We used 2006 as the year for which data were analysed. Though in 2007 there are more stations monitoring $PM_{2.5}$, 2006 was used as, on average, the concentrations were slightly higher than in 2007.

See chapter 3 for the evaluation of the CAQI performance and chapter 4 for the revised calculation grid, after inclusion of $PM_{2.5}$.

1.1.2 Year average index

Check the project website for updates: www.citeair.eu/ The year average index will be described in chapter 5.

1.1.3 Previous index document

This document replaces 'Comparing Urban Air Quality across Borders', the 2007 document describing the index. The previous document not only describes the index but also the logic why, at the time, such an index was needed. That discussion won't be repeated here. The old document is currently still available at the project website or via the short published version:

- http://citeair.rec.org/downloads/Products/ComparingUrbanAirQualityAcrossBorders.pdf
- http://dx.doi.org/10.1016/j.envint.2007.12.011

The basic working of the index is described in chapter 2.

1.2 Use of the CAQI indices in another context

Anyone wishing to use the CAQI is free to do so. However, we want potential users to notify us (at caqi@airqualitynow.eu) and establish a user agreement. This way, users can be kept informed in case of further developments concerning the index. The use of the CAQI is free of charge.

2 Basic concepts of the CAQI

2.1 History of the CAQI

The CAQI was developed in the course of the CITEAIR project (an INTEREG IIIc project) and has been around since 2006. The index was made for the purpose of comparing the air quality in European cities in real-time. At the start of the CITEAIR project we observed that many cities present their air quality in different, hard to compare, ways. Often they use an own (or sometimes nationally prescribed) air quality index but as all indices were different in logic and presentation this didn't help[1]. For the purpose of comparison we developed a new index. The main reason to add yet another index was practical and twofold:

- The index was developed to coexist next to any existing indices that people might be used to for the purpose of comparing cities on a website; it was not meant to replace existing indices.
- This way no city in no country willing to participate in the online comparison was forced to use someone else's index.

Whether this has actually contributed to the success of the index is not known but the fact is that what was started as a project idea by (and an obligation for) five cities has by now (May 2010) grown to a system (www.airqualitynow.eu) where some 85 cities voluntarily submit their data for online comparison purposes.

The CAQI was/is part of an effort to raise awareness on urban air quality. This purpose has consequences for the design of index as will be described in the next section. In the past years there have been various publications on the CAQI and the website www.airqualitynow.eu (see Annex 1). Some of them are mainly descriptive, some focus more on the reasoning behind the choices made in developing the index the way we did. In the next section we provide the reasoning behind the working of the index.

Most of the indices found in literature and on the internet cover the short-term air quality (hourly, dialy). This applies to the CAQI as well,. Indices for the long-term air quality are very rare. We provide a year average CAQI (YAQACI). This index is calculated in a completely different manner and this is described in chapter 5.

2.2 Description of the CAQI

2.2.1 Introduction

There are many ways of making an air quality index and one way is not necessarily better than the other. Making an index is a pragmatic process of reducing a variety of information on the chemical characteristics of a quite complex mixture of pollutants observed in the air into a simple (often single) figure on a scale. From a scientific point of view this is a gross generalisation and a tremendous loss of information but for communication purposes this information reduction is considered essential. However, this assumption has never been tested as far as we know. Shooter and Brimblecombe (2009), in a review article on air quality indices, mention (citing Burden and Ellis, 1996) that in Australia, public confidence in reporting on air pollution fell following the introduction of an index

How to reduce the complex information largely depends on the purpose for which the index is to be used. The exact formula's to transfer concentration readings into index classes is another matter of subjective choices though often limit values (for example ensuing form air quality legislation such as Directive 2008/50/EC) are used as guidance.

[1] For an overview of different indices in use see for example Elshout and Léger (2007) and Garcia et al. (2002). Note that index calculations become outdated so the information provided in these sources might no longer be correct!

Shooter and Brimblecombe (2009) mention two reasons for making an index: firstly linking air quality to health effects to inform the public of air quality and possible remedial actions; secondly to condense complex data to provide an information overview e.g. for the development of policy or to check compliance with standards. We formulated a third reason: drawing the public's attention to air quality issues and raising awareness.

The reasons proposed by Shooter and Brimblecombe, are in our view, problematic. In fact, in their article they discuss at length why most of the current air quality indices don't deliver what they are supposed to according these two reasons. We discuss the three reasons for having an index briefly below.

- Linking air quality to health effects

Linking air quality information to health effects is potentially a very powerful way of communicating as individual health concerns tend to be very persuasive. However there are several problems with health effects based indices. The relations between air quality and health are many, they interact in poorly understood ways and their exact nature is hard to quantify. This has several implications: the indices need to undergo frequent updates as sciences evolve (e.g. Longhurst, 2005); they can become very complex if one tries to capture pollutant interactions (e.g. Cairncross et al., 2007) and usually the simpler approach that the worst pollutant (at a given time) determines the index for that moment is followed; health effects occur over different exposure times (both short-term and long-term) and the reported index value usually refers to only one averaging time (usually daily).

Apart from these methodological concerns the problem of averaging time also has awkward communicational aspects. A health based index aiming to warn people for short-term exposure to adverse air quality is (fortunately!) mainly in the good part of the index scale, indicating that air quality is not a problem. Though this could be true from the short-term exposure point of view, the long-term exposure even to low levels of air pollution is often worrisome. Furthermore limit value exceedences for long-term exposure (e.g. year averages) are exceeded in many urban areas even if a health based air quality index is virtually continuously signalling that there are no problems. In this case a health based index adds to the confusion: visiting the website there seems to be no problem, yet an air quality action plan is needed to comply to legal standards. The US and UK air quality standards are typical examples of health based indices[2].

Though the health based index has certain problems one could argue that it is important to alert people of adverse air quality and that as such could be a reason to have such an index anyway. Shooter and Brimblecombe mention this as the principal reason to have an air quality index (and many indices started/are operated with this in mind) but they note however that these indices rarely succeed and changing people's behaviour citing Johnson (2003). They argue that forecasting, making a timelier alert might improve people's response to an index signalling a problem. Though this is obviously a technical improvement we doubt that this would considerably change the general public's response. The air quality has to be extremely poor before it poses an acute danger to the population in general. With busy agenda's it is unlikely that the average person will cancel his sports game, that a school outdoor activity that was planned long ago (involving many volunteers) is moved at short notice to a new date when pollutant levels rise, etc. The possibilities to adjust one's plans as well as the medical need to do so, are limited. Today there are better, more targeted ways to inform the select group of people that really needs to adapt their activities in the face of pollution episodes than a general index presented on a website. For example Sussex-air provides a messaging system that those in need of this kind of information can subscribe to (see www.airalert.info/Sussex/Default.aspx).

[2] Note that they differ considerably, reflecting the different appreciation of the health impact of a certain pollutant level.

- Providing simple overview information for policy formulation or monitoring

This reason for having an index hardly applies to the short-term exposure indices we frequently find on websites. The short-term indices are mainly used for informing or warning the public. However, some authorities report annually the number of days an index was above a certain level. Year average indices, as the one introduced by CITEAIR (see chapter 5) can be used to monitor if pollution levels are moving in the right direction. See Mayer et al (2008) for a policy monitoring application of the German LAQx. The policy application of an index necessarily has a longer averaging time than the alerting/informing indices. For policy formulating or monitoring one would also need to consider spatial representativeness and averaging, e.g. an index value that is population or area weighted. The communicative beauty of presenting a single index figure to mark the air quality then hides an increasingly complex calculation analysis and the implications of the index, or its changes, might be hard to interpret. Shooter and Brimblecombe raise this point as well. On the other hand, we should not forget that the sole purpose of making an index is to arrive at a single, simple (arbitrary) relative measure that, if applied consistently, gives an indication of progress or stagnation. The concern should not be that the index calculation is too complex, but that its outcome is treated as an absolute measure. (See chapter 5 for an extensive discussion).

- Drawing the public's attention to air quality and raising awareness

The public is both a victim and a source of air pollution particularly in urban areas. Traffic is often the dominant source of urban air pollution. Though in some industrialised cities the tons emitted through high stacks might be higher than the tons emitted by vehicles, the contribution of traffic to the ambient air pollution, the air people breath, often exceeds 50% and can be as high as 80%. This is particularly true for the most health relevant pollutants: the smallest particles (< PM_1) or the Elemental or Black Carbon fraction[3]. This pollution is mainly attributed to (diesel) vehicle exhaust. Local authorities therefore have a keen interest in trying to influence the behaviour and the travel choices of the urban population. Raising awareness on the sources of pollution is one way of doing so.

If awareness raising is an objective the last thing one wants is an index saying that the air quality is good whilst from the long-term exposure perspective it is not. The short-term index can therefore not be health-based. It can have alert values for pollution episodes but it also needs to have differentiation of the air quality appreciation at the lower end of the pollution scale. An example of indices without a direct link to health effects and with differentiation at the lower end of the pollution scale are for example the French and Belgium indices.

We further assumed that to entice people to visit the air quality websites and check the situation one would need an hourly index, hourly updated. This way people can see how pollution levels evolve throughout the day and can related index readings to physical events: elevated midday ozone peaks, rush-hours, etc. We also assumed that a scale with considerable differentiation (1-100) would lead to a more dynamic (interesting) presentation than a grid from 1 to 5 or 1 to 10. From a scientific point of view it hardly makes sense to derive index values with that kind of detail, it is way to pretentious, but from a communication point of view we thought it will help.

To draw specific attention to traffic as an important source, and roads as an awkward place to be (from the exposure point of view) we propose to calculate the index separately for roadside and city background situations.

[3] The exact cause of the health effects of traffic pollution or not yet known. Whether it is particle numbers, nano particles, soot, metals, or a combination is not clear. That traffic is a major source is undisputed, as is the fact that it is the smaller particle fraction.

2.2.2 The logic of the CAQI

The CAQI is not health based. The methodological disadvantages of a health based index were discussed in the previous section. Besides, the CAQI was developed to raise awareness and make air quality comparable from one city to another not to warn citizens of adverse health effects. That task was best left, according to us, to the cities own webpages with the index often tailor made to the local circumstances and a communication approach the citizens in the particular city were used to. This doesn't mean that the CAQI cannot be used as a city's sole index, the CAQI resembles a number of other indices (the French and Belgium indices for example) and if a city doesn't have an index, or if the index needs an overhaul, the CAQI could be considered. Otherwise changing local indices is not really advisable as it might confuse the users/the public.

The CAQI has a scale from 1 to 100 with lower rankings representing better air quality. Some of the higher class borders are linked to concentrations mentioned in the EU air quality directives (Directive 2008/50/EC). The large range of the scale assures changes, even at the lower end of the scale.

The CAQI has an hourly time resolution for today (except for CO), and a daily time resolution for yesterday and for forecasted concentrations. Many indices are on a daily basis because the criteria in the common legislation for the different pollutants have different averaging times. E.g. the EU directives assess hourly values of NO_2, daily average values of PM_{10}, 8-hour average values for O_3 and CO (in addition to a range of year average criteria). The hourly calculation is done for reasons outlined above.

A practical problem with the hourly index is that several cities only provide 24-hour average PM data. The EU has a PM_{10} limit value for 24-hour averaged data and some types of PM monitoring equipment cannot provide (reliable) hourly data. We have therefore derived two grids for PM_{10} and $PM_{2.5}$ data, one for hourly observations and one for daily observations. A city that produces 24-hour moving average data can participate in the hourly index by applying the daily grid. For a discussion on the consistency between the daily and the hourly grid see section 3.3.

The worst pollutant determines the index. For each pollutant a sub-index is calculated according to a grid that translates concentration measurements into a ranking on a scale from 1 tot 100 (see table 1 for the old grid). There are core pollutants (without those an index value cannot be calculated) and auxiliary pollutants. The highest sub-index value at a given time determines the overall index. This is very common for indices, in particular for indices that have an alerting role to play. Some health based indices claim that interactions between pollutants have to be considered (for proper health assessments) these indices are very complicated, academic and rarely implemented (example....).

In the way the CAQI is implemented on the website www.airqualitynow.eu the worst monitoring station in a certain city, at a given moment, determines the index value. The calculation order is: first the sub-indices per monitoring station, the overall index for each station, the highest overall index becomes the city index (same procedure for traffic and background indices).

It is calculated both for city background and traffic situations. This has two reasons. From a communication point of view this draws specific attention to the role of traffic as a source of pollution. Mostly the traffic index is higher than the background index. This is true for the traffic related primary pollutants NO_2, PM_{10} and $PM_{2.5}$. In many southern cities where ozone plays a major role, the picture is different. The fresh exhaust emission of NO converts O_3 into NO_2 and O_2. Ozone is typically higher in the countryside than the city background and is very low in street canyons. Especially in the afternoon, city background index values often exceed the traffic index in summer.

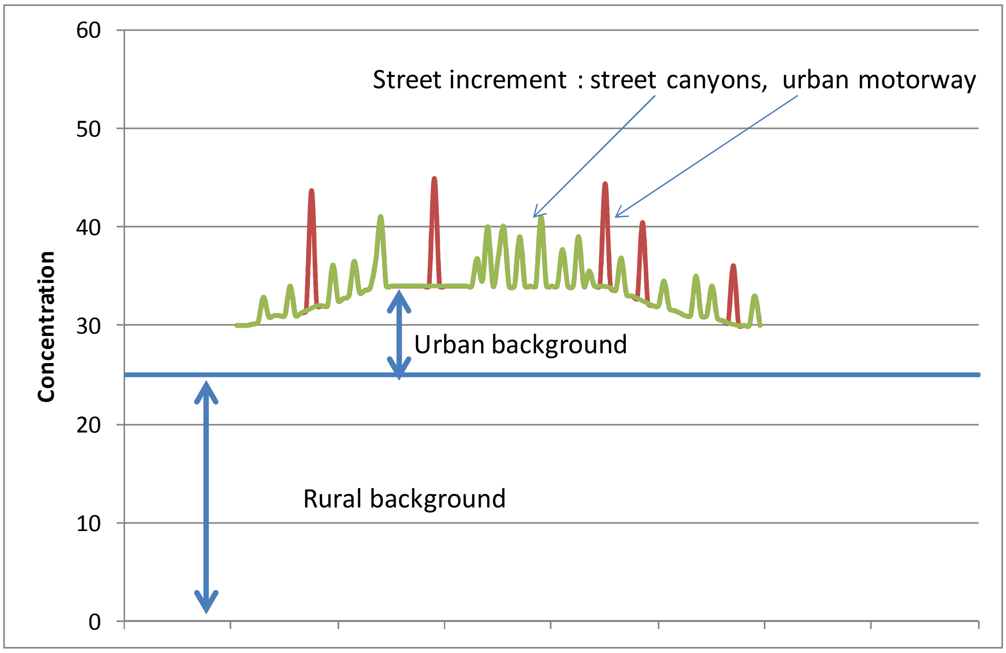

Figure 1: Concept of primary pollutant concentrations in an urban area

The second important reason is to make cities comparable (one of the CITEAIR objectives and the website www.airqaulitynow.eu). Some cities don't monitor at traffic sites, some ciites might focus on traffic as they are often the most polluted sites. If one wanted to compare city average concentrations in cities with completely different monitoring strategies the results would be flawed. By stratifying the sample into background and traffic situations the results become more comparable.

2.3 Acceptance and criticism

The CAQI is used on the website www.airqualitynow.eu. The growing participation of cities in the website can be seen as an implicit acceptance of the CAQI as well. In addition it was presented several times in international conferences and it was published in a journal and several proceedings. The very first version of the CAQI was reviewed, amongst other indices, by EEA. References to the current version of the CAQI are made in recent publications dealing with indices. Annex 1 shows a list of references to, and publications made on the CAQI (up till end of 2009).

The European project PROMOTE suggested to use the CAQI in a contract they offered to do for EEA. This has led to the use of the CAQI in the air quality part of EEA's website 'Eye on earth'.[4] In short, the CAQI is generally accepted as a useful index and that its existence is known to those interested in the field of air quality indexing.

Criticism also continues to exist:

a. having two indices alongside each other (a local one and the CAQI as an international one for comparison purposes) confuses the public, hence several organisations refuse to participate in www.airqualitynow.eu;
b. the index is not well adapted to our local situation;
c. the index is too complicated (too many pollutants);
d. the index is not good in reflecting health effects of the air quality.

Points a. and b. cannot be remedied, in fact they are the very nature of an index that aims to cater for situations in a vast range of countries and makes air quality presentation comparable. We assumed that most cities would not be willing to replace their local index and air quality presentation system by another one. In fact that is not advisable from a communication point of view. The best way forward, we assumed, was a new neutral index, marketed specifically for international comparison purposes.

Point c. could be tackled by reducing the number of pollutants to the current core pollutants and skipping completely the auxiliary pollutants. The index would then be based on $PM_{2.5}$, PM_{10}, NO_2 and O_3 (the latter not for traffic). CO and SO_2 were included, at the time, because several cities where monitoring these pollutants and occasionally they still play a role. Providing a calculation grid provides a way to compare these pollutants relative to the other pollutants. CO and SO_2 are treated as auxiliary pollutants, they are not needed to calculate the index and in most cities they don't influence the index calculation.

Point d. is a matter of choice. We have argued above and in the previous CAQI document that a health based index is communicatively awkward. Nevertheless the search for a health based index continues. See the discussion in Shooter and Brimblecombe (2009) and for an example Cairncross et al. (2007). However, a proper health based index would need to take into account pollutant interactions[5], making such an index very complicated. Furthermore it would probably also need continuous adaptations as this is still a major field of research. The main goal of the CAQI is not to warn people for possible adverse health effects of poor air quality but to attract their attention to urban air pollution and its main source (traffic). We therefor stick to the principals used and do not opt for a strong link with health effects. Health warnings could typically be a purpose of a local city index/warning system.

[4] http://eyeonearth.cloudapp.net/

[5] See for example the presentation: http://www2.stat.unibo.it/ties2009/slides/Plaia.pdf (Accessed, April 2010).

3 Use of current CAQI index

3.1 Calculation grid existing index

The calculation grid as it is in use before the addition of $PM_{2.5}$ is shown in table 1. The grid is inspired on threshold values as they occur in the EU air quality directives, on values used in similar indices and on a number of pragmatic considerations such as frequent changes also at the lower end of the pollution scale. A full discussion is given in the index document of the CITEAIR 1 project.[6] The index was initially tested on a dataset from the CITEAIR 1 core partners. For PM_{10} an additional selection of Airbase data was analysed. In this document we look at frequency distributions for all pollutants to get an impression of the message the index tends to convey (is the air pollution high or low). For this analysis we have only looked at the <u>mandatory</u> pollutants. In Annex 2 a graphical display of the relation between the grid and the concentrations is given.

Table 1: Pollutants and calculation grid for the CAQI

Index class	Grid	Traffic				City Background					
		Mandatory Pollutant			Auxiliary Pollutant	Mandatory pollutant				Auxiliary pollutant	
		NO_2	PM_{10} 1-hour	PM_{10} 24-hours	CO	NO_2	PM_{10} 1-hour	PM_{10} 24-hours	O_3	CO	SO_2
Very low	0	0	0	0	0	0	0	0	0	0	0
	25	50	25	12.5	5000	50	25	12.5	60	5000	50
Low	25	50	25	12.5	5001	50	25	12.5	60	5001	50
	50	100	50	25	7500	100	50	25	120	7500	100
Medium	50	100	50	25	7501	100	50	25	120	7501	100
	75	200	90	50	10000	200	90	50	180	10000	300
High	75	200	90	50	10001	200	90	50	180	10001	300
	100	400	180	100	20000	400	180	100	240	20000	500
Very High*	> 100	> 400	>180	>100	>20000	> 400	>180	>100	>240	>20000	>500
NO_2, O_3, SO_2:		hourly value / maximum hourly value in µg/m^3									
CO		8 hours moving average / maximum 8 hours moving average in µg/m^3									
PM_{10}		hourly value / daily value in µg/m^3									

* An index value above 100 is not calculated but reported as " > 100"

The calculation grid is used for the hourly index. In addition to the hourly index a daily index can be calculated using the maxima of the hourly sub-indices (or, in case of a city reporting PM_{10} only on daily basis, using the PM_{10} daily grid for that subindex). On the website www.airqualitynow.eu this is done for the past day (D-1) and it will be used in the forecast that is being developed. For cities that do deliver hourly PM data the daily index will be calculated based as the maximum of the hourly values. This way the readings between today and yesterday (D and D-1) are consistent.

6 http://citeair.rec.org/downloads/Products/ComparingUrbanAirQualityAcrossBorders.pdf or (for a short, published version) http://dx.doi.org/10.1016/j.envint.2007.12.011

3.2 Results of the application of the CAQI (hourly data)

Airbase data for 2006 for urban and suburban stations were used to make the analysis. Data from the following countries were used (# background, #traffic): Belgium (3, 3), Czech Republic (13, 6), Germany (4, 4), Finland (1, 3), France (3, 3), Italy (3, 3) Spain (1, 2), Sweden (3, 2), and United Kingdom (0, 1). So, 31 background and 27 traffic stations were available. For 6 cities pairs of traffic and background sites were available. For a list of the Airbase stations used, see annex 3. Note that for France and Italy no hourly values for PM were obtained so in the analysis of the hourly indices and where hourly and daily indices are compared, these stations are left out.

Table 2: Frequency (%) of the occurrence of the index and sub-index classes (hourly data)

Background						
Dominant pollutant	occurrence	Index class	Overall index	Sub-indices PM_{10}	O_3	NO_2
PM_{10}	49	0-25	27	55	64	92
O_3	45	25-50	51	32	33	8
NO_2	6	50-75	17	10	3	0
		75-100	4	2	0	0
		" >100"	1	1	0	0
Traffic						
Dominant pollutant	occurrence	Index class	Overall index	Sub-indices PM_{10}	O_3	NO_2
PM_{10}	67	0-25	35	48		63
O_3		25-50	41	34		30
NO_2	33	50-75	18	14		6
		75-100	5	4		0
		" >100"	1	1		0

Table 2 shows the average occurrence (of the sample) of the different classes for the sub-indices. As can be seen, the majority of the sub-indices are in the first class, indicating that pollution is very low (NB: sample average). In fact medium or higher pollution occurs in less than 13% (background station) and 19% (traffic station) of the observed hours. In particular NO_2 seems to score very low. The index therefore seems to convey that pollution by the individual pollutants is generally low. If we look at different stations in different countries there is some variation around the mean, partly explained by climate differences (e.g. ozone is higher in the southern countries) but the results are reasonably consistent. How representative the selected stations are for the whole of Europe's urban agglomeration is not known. However, we don't have an alternative dataset and there is no prior reason to believe that the sample is not representative. It must be noted that very big cities are scarce in the sample. See Annex 4 for sample calculations per country.

If we look at the total index, based on the principal that the worst sub-index determines the overall index, the outcome is of course different. For the overall hourly index 'low' (26-50) is the dominant class. As could be expected, the rating at traffic stations is lightly higher than that at background stations.

3.2.1 Sensitivity class borders

To test the sensitivity of the 'message' the index conveys we changed the class borders slightly, e.g. 0-20 very low; 21-40 low; 41-70 medium; 71-100 high. The overall picture doesn't change much. The second class ('low') becomes the dominant one and there is a 12% rise in medium pollution cases. See table 3 for the sample of hourly background data.

Overall the index conveys the message that the air quality is fairly good. The pollution qualification is low or very low in 76 % of the cases (64% when the class borders are adjusted). We believe that this is a fair message to convey: remember that this index deals with short-term exposure (hourly/daily). The short-term exposure is often, luckily, not a problem. The long-term exposure, and that is where the yearly limit values are meant for, is different of course.

Table 3: Frequency(%) of the occurrence of the index and sub-index classes (hourly data) using stricter, class boundaries (Background)

Index class	Overall index	Sub-indices PM10	O3	NO2
0-20	12	43	49	85
20-40	52	36	41	14
40-70	29	18	9	1
70-100	6	3	0	0
" >100"	1	1	0	0

3.3 Results of the application of the CAQI (daily data)

The daily sub-indices are calculated as the daily maximum of the hourly sub-indices, except for PM_{10}. For PM_{10} the daily average concentration is calculated and the PM_{10} daily average calculation grid is applied. The daily index is therefore leads to higher values than the hourly index. This can be seen when comparing tables 2 and 4.

Table 4: Frequency (%) of the occurrence of the index and the sub-index classes; daily index as maximum of hourly index (O_3, NO_2) and daily average (PM_{10})

Dominant pollutant	Back-ground	Traffic	Index class	Background				Traffic		
				Overall index	Sub-indices			Overall index	Sub-indices	
					PM10	O3	NO2		PM10	NO2
PM10	70	80	0-25	3	11	28	63	4	8	23
O3	28		25-50	48	41	60	35	35	34	54
NO2	2	20	50-75	38	36	11	2	42	40	20
			75-100	10	9	1	0	16	16	3
			" >100"	2	2	0	2	2	2	0

Recall that there are two ways to calculate a daily index for PM_{10} that are meant to give (on average) similar results. To verify this assumption in this sample we compared the index based on the daily maximum of the hourly concentration for PM_{10} on the one hand, and the index based on the daily average concentration (with the grid for daily averages) on the other. See Table 5. for the results. If we compare tables 4 and 5, there is reasonable agreement between the two approaches. The frequency distribution of the overall index is very similar. The same holds for the frequency distribution of the PM_{10} sub-indices. If we look the dominant pollutant of the overall pollutant it seems that using the daily average PM_{10} concentration makes PM_{10} slightly more dominant (in this sample). However, for different stations the results are quite different and this is further elaborated in Annex 6. For maximum consistency between cities, the daily sub-index for PM should be based on the daily average concentration (and using the daily grid) also for cities that deliver hourly PM data. For maximum consistency between today's observation for a city and for yesterday or the forecast that is to be developed the maximum hourly concentration for PM_{10} should be used. The latter is implemented on www.airqaulitynow.eu

ERROR: undefined
OFFENDING COMMAND: '~

STACK: