European Commission

CAPTOR

Collective Awareness Platform for Tropospheric Ozone Pollution

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List of Abbreviations

EC	European Community
EEC	European Economic Community
EU	European Union
NOx	Nitrogen oxides
O_3	Ozone
R^2	Coefficient of Determination
VOCs	Organic Volatile Compounds

Executive Summary

Description of the work

The aim of deliverable D3.1 is to provide guidelines in order to ensure that the data collected by the sensing nodes deployed in CAPTOR is of the highest scientific quality possible. To this end, a number of aspects such as the location of the nodes, data treatment or maintenance of the nodes are discussed. These guidelines should be made available to the citizen science and volunteer teams for their use during deployment of the nodes.

Objectives

This deliverable covers the following topics and issues:

- Description of the technical and scientific requirements for deployment of nodes in volunteer houses.

Report on requirements and procedures for air pollution citizen science campaigns

1. Introduction

The nature and impacts of air pollution effects on human health and ecosystems are relatively well known at present. It is for this reason that monitoring and quantifying the ambient concentrations of atmospheric pollutants is of major relevance. In particular, because of the high ozone concentrations registered in rural areas, the project CAPTOR aims to produce dense and high-quality network of sensor nodes to monitor the concentrations of this type of pollutant and to determine its spatial and temporal evolution.

Tropospheric ozone is a secondary pollutant which originates from photochemical reactions linked to its gaseous precursors nitrogen oxides (NOx) and organic volatile compounds (VOCs), and solar radiation. Because of this relationship with insolation maximum ozone concentrations are generally registered in late spring and summer. Despite the fact that one of the main sources of ozone precursors is vehicular traffic (emitting NOx), the highest ozone concentrations are registered in rural areas due to the necessary reaction time for ozone to be formed in the atmosphere. As a result, the problem of ozone pollution mostly affects rural areas. At the same time, in proximity to NOx emissions ozone is rapidly consumed as it reacts with NO generating NO_2 and O_2. This complex atmospheric chemistry renders ozone monitoring a challenging task.

2. Guidelines

A number of aspects should be taken into account for the proper deployment and use of the sensor nodes with regard to ensuring the necessary data quality:

2.1 Deployment of the nodes

As a secondary pollutant, the concentrations and temporal evolution of ozone are strongly dependent on the concentrations of its gaseous precursors. Consequently, the location of the sensing nodes is a key parameter to ensure that the data acquired represent actual exposure concentrations. To ensure the representativeness of the monitoring locations the guidelines from EU directive 92/72/EEC, section 4.1, should be followed, also discussed in the ozone position paper (EC, 1999). This text provides siting criteria for macro- and micro-scale deployment of monitoring stations.

In the macro-scale, rural and rural background stations (or in the case of CAPTOR, nodes) should be located according to the distribution of population and orography. They should be representative of population and/or vegetation exposure to this pollutant. The Tables in Annex indicate the European Commission definitions regarding the objectives and overall macro-siting criteria for this and other type of stations. In the case of rural and rural background stations monitoring ozone the proximity of major emission sources of precursor gases should be avoided, such as main roads and industrial facilities, and avoiding mountain areas where the influence of thermal inversions might render the daily or 8-hour mean values not representative. Table 1 reports the minimal distances recommended between the nodes and the closest road as a function of the average daily traffic (vehicles/day). Overall, the minimum horizontal distance should in all cases be 10 m, although it is recommended that these distances are increased where possible to ensure minimum influence from NOx emissions. In the presence of NO emitted by vehicles ozone is rapidly depleted (forming NO_2 + O_2), and therefore any data collected in the vicinity of NO sources would result in the underestimation of ozone concentrations.

Table 1. Requirements concerning distance from roads for urban, suburban and rural stations monitoring ozone (EC, 1999).

Average daily traffic (vehicles/day)	Minimum horizontal distance (metres)
<10.000	>10
15.000	20
20.000	30
40.000	50
70.000	100
>110.000	>250

In the micro-scale, special attention should be paid to the location of the nodes and sensors. The nodes should be:

- Placed with the sensors facing down, to avoid the influence of precipitation;
- Located 1.5 to 4 metres above ground level (including when they are placed on a residential structure, e.g. a balcony or terrace);
- Far from any furnace, incineration flues or air-conditioning outlets;
- To avoid screening, the distance between any obstacle and the node has to be at least twice the height of the obstacle. In addition the node has to be at more than 1 metre vertically or horizontally away from any structure;
- Unrestricted airflow in an arc of at least 270 degrees around the node, except if the node is located on the side of a building, where 180 degrees clearance is required.

2.2. Technical requirements

The CAPTOR nodes have two basic technical requirements:

- Power supply: the nodes require the availability of power supply in close proximity to the node to connect it throughout the project. The location of the electricity supply should preferably be protected from the rain (e.g., under a roof). It is advisable that the power supply is prepared for outdoor use (e.g., with CETAC-type connectors).
- Wifi access: the CAPTOR nodes use local Wifi for data transmission. Wifi should be available in the vicinity of the node and have to be connected all the time. Each node will be specifically programmed (by a CAPTOR voluntary) to access the local Wifi network once it is deployed.

2.3 Maintenance and servicing

The nodes will be tested and operational before deployment. During operation, the data flows will be regularly verified by the volunteers and by the CAPTOR UPC team. Whenever a node stops sending data this will be detected by the CAPTOR platform and a request will be made to the local volunteers to check the issue. When the problem can't be solved on site the faulty node will be sent to the UPC team for servicing.

Aside from verification of the data flows, the volunteers deploying the nodes will not be required to perform any other servicing or maintenance actions.

2.4 Calibration

The nodes will be calibrated before shipment to the volunteers. Once deployed, each node will be calibrated on site at least 1 time during each summer by means of the CAPTOR travelling standard. The travelling standard is a node which will have been recently calibrated at the local air quality monitoring station, and which will be co-located with the node under assessment for a period of 3-5 days. Once the calibration is complete, the travelling standard will return to the local monitoring station and from then on to the next node. Specialised local volunteers will carry out this work.

After each summer campaign, all of the nodes (with a few exceptions) will be returned to Barcelona for calibration.

2.5 Data quality

Calibration of the CAPTOR nodes will be carried out by correlating 30-minute ozone concentrations monitored simultaneously by CAPTOR nodes and by an EU reference monitor. To this end, the nodes will be deployed for at least 1 week (7 days) at the CSIC air quality monitoring station in Barcelona. As a function of the results obtained, the nodes will be classified as:

- Good: R^2 value between reference and sensor ozone concentrations >0.70
- Average: 0.60 < R^2 <0.69
- Poor: R^2 < 0.59

Nodes classified as “good” will be validated to be used in the field work. Nodes classified as “average” will be tested for a longer period of time (another 7-day period) in order to better characterise their performance. Nodes classified as “poor” will be returned to UPC for servicing and maintenance.

3. References

EC (1999) Ozone Position Paper Final version, Working Group on Ozone Directive and Reduction Strategy Development. Luxembourg: Office for Official Publications of the European Communities.

Annex

Table 2. Macroscale siting criteria (EC, 1999).

TYPE OF STATION	MEASUREMENT OBJECTIVES	REPRESENT-ATIVENESS	MACROSCALE SITING CRITERIA
TRAFFIC	to validate emission inventories; to help determine the magnitude and type of precursors emitted by the city; to determine the exposure of humans and materials to precursors and other pollutants (fulfilment of other Daughter Directives.).	Street levels	in street canyons or at kerbsides within the urbanised area; near to motorways; where maximum precursor levels are expected; where representative measurements of pollutant levels can be obtained; This type of station is generally not appropriate for measuring ozone, due to its low representativeness. For NO_x measurements, the NO_2 Daughter Directive should be considered.
URBAN	to determine the ozone concentrations to which people and materials within the urban atmosphere are exposed (compliance analysis for human health); to know the well-mixed precursor concentrations present in the urban air shed; to verify photochemical models; to help in the development and verification of future reduction strategies; to perform trend analysis;	A few km^2	away from the influence of local emissions such as traffic, petrol stations, etc.; vented locations where well mixed levels can be measured; adequate locations such us residential and commercial areas of cities, parks (away from the trees), big streets or squares with little or no traffic, open areas characteristic of educational, sports or recreation facilities;

TYPE OF STATION	MEASUREMENT OBJECTIVES	REPRESENT-ATIVENESS	MACROSCALE SITING CRITERIA
SUBURBAN	to determine the exposure of the population and vegetation located in the outskirts of a big city to high ozone concentrations (compliance analysis for human health and vegetation); to verify photochemical models; to help in the development and evaluation of reduction strategies; to help towards a better understanding of ozone phenomenology; to perform trend analysis.	Some tens of km^2	at a certain distance from the area of maximum emissions, downwind following the main wind direction(s) during conditions favourable to ozone formation; where population, sensitive crops or natural ecosystems located in the outer fringe of an agglomeration are exposed to high ozone levels; other locations that might provide information about ozone phenomenology; Where appropriate some suburban stations also upwind of the area of maximum emissions, in order to determine the regional background levels of ozone and precursors present in the air before it enters the urbanised area. This would help in the assessment of ozone concentrations, the establishment of boundary conditions for the use of models, and also in episode forecasting.
RURAL	to determine the exposure of population, crops and natural ecosystems to sub-regional scale ozone concentrations (compliance with health and vegetation thresholds); to help in the assessment of sub-regional ozone concentrations; to help in the establishment of boundary conditions for the use of models; to help in the development and evaluation of reduction strategies; to help towards a better understanding of ozone phenomenology; to perform trend analysis of ozone and precursors;	Sub-regional levels (a few hundred km^2)	stations can be located in small settlements and/or in areas with natural ecosystems, forests or crops; representative for ozone away from the influence of immediate local emissions such as industrial installations and roads; in open area sites, but not on higher mountain tops;

TYPE OF STATION	MEASUREMENT OBJECTIVES	REPRESENT-ATIVENESS	MACROSCALE SITING CRITERIA
RURAL BACK-GROUND	to provide information on the exposure of crops and natural ecosystems to regional scale ozone concentrations (compliance with vegetation limit values); to provide information on regional ozone background concentrations; to help in the establishment of boundary conditions for the use of models; to help in the development and evaluation of long term reduction strategies; to help towards a better understanding of ozone phenomenology; to perform trend analysis of ozone and precursors;	Regional/national /continental levels (1 000 to 10 000 km^2)	Station located in areas with lower population density, e.g. with natural ecosystems, forests, far removed from urban and industrial areas and away from local emissions; avoid locations which are subject to locally enhanced formation of ground-near inversion conditions, also summits of higher mountains coastal sites with pronounced diurnal wind cycles of local character are not recommended; In general, EMEP siting criteria might be valid for this type of station.
INDUSTRIAL	to validate emission inventories; to assist in the determination of the type and magnitude of the precursors emitted by an industrial activity; to know the exposure of people and vegetation to ozone precursors and other pollutants.	Industrial area	located within or at the edge of the area of maximum industrial emissions; sited where a representative (spatial and temporal) measure of precursors can be obtained; This type of station is not appropriate for measuring ozone, due to its low representativeness. For NO_x measurements, the NO_2 Daughter Directive should be considered.