FORECASTING SYSTEM - KATOWICE

Deliverable D.T2.2.4

Final Version
30/09/2020

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Description of the aims

Forecasting systems (1 per each city) able to announce the SAPEs, to categorize them (per different level of pollution) and to evaluate the realiability and effectiveness of provisional systems (linked to AWAIR-APP D.T2.2.7)

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1. The air quality forecasting system managed Chief Inspector of Environment Protection (GIOŚ)

In Poland, air quality monitoring system is based on regional environmental monitoring programs. These programs developed by the Regional Departments of Environmental Monitoring (RWMŚ) define the air quality monitoring system in a given region. This system is mainly based on networks of measuring stations located as needed in key points of the region. The criteria for the location of measuring stations are specified in the provisions of the Regulation of the Minister of the Environment of 8 June 2018 on assessing the levels of substances in the air, in particular Annexes 2 and 3 (Journal of Laws of 2018, item 1119). The GIOŚ decides on the location of measuring stations and their measurement program.

In accordance with the provisions of the Environmental Protection Law (Journal of Laws of 2018, item 799) and implementing regulations, the Chief Inspectorate of Environmental Protection measures the concentrations of sulfur dioxide, nitrogen dioxide, nitrogen oxides, benzene, carbon monoxide, ozone, PM10 suspended dust and PM2.5 and the measurements of lead, arsenic, cadmium, nickel and benzo (a) pyrene in PM10 dust. At selected city stations, the composition of PM10 dust is also measured in terms of the content of 6 polycyclic aromatic hydrocarbons (PAHs) (apart from the previously mentioned benzo (a) pyrene). Under SEM, measurements of cations (Na +, K +, Ca2 +, Mg2 +, NH4 +), anions (SO42-, NO3, Cl-), organic and elemental carbon in PM2.5 dust and total mercury measurements are also carried out in areas remote from emission sources. gas.

The results of 1-hour automatic measurements of air pollution are available on the "Air Quality" portal in the Current Measurement Data module and in the GIOŚ "Air Quality in Poland" mobile applications available for Windows, Android and iOS operating systems. Data from manual measurements are made available on the "Air Quality" portal in the Measurement data bank tab. The results of manual measurements of PM10 and PM2.5 dust are made available after about 1-1.5 months from the sampling and this is due to the procedures related to the performance of this type of measurements.

Currently, in Poland, air quality measurements are carried out on 2017 measuring stations, including 1113 automatic stations. The total number of air quality measurement stations in Poland is approx. 280, including approx. 190 automatic stations, the data of which are made available on an ongoing basis on the "Air Quality" portal and in the GIOŚ mobile applications.

Zones where air quality is assessed

The assessments are made into 46 zones for all pollutants in accordance with Art. 87 (2) of the Environmental Protection Law (Journal of Laws of 2018, item 799, as amended).

For the purposes of determining the appropriate assessment method in individual zones, including the number of stations, their measurement scope and location, the CIEP carries out the so-called multi-annual air quality assessments pursuant to Art. 88 sec. 2 Page 5 of the Act of 27 April 2001 - Environmental Protection Law (Journal of Laws of 2018, item 799).

Currently, the zone is:

1. agglomeration with a population of more than 250 thousand;
2. a city with a population of over 100,000;
3. the rest of the voivodeship, not included in cities with more than 100,000 inhabitants and agglomerations.

In the metropolitan area of Katowice, there are a total of 6 measuring stations of CIEP.

Presentation of the forecasting system

1. Forecasts are presented on two websites:
   - Chief Inspectorate for Environmental Protection (GIOŚ) - http://powietrze.gios.gov.pl
   - National Institute for Environmental Protection (IOŚ-PIB) - http://ios.edu.pl/jakosc-powietrza
2. Chief Inspectorate for Environmental Protection (GIOŚ) website provides:
   - forecast of 1-hour concentrations (with modeling animation every 1 hour) (PM10, NO2, SO2, O3),
   - forecast of 24-hour average daily concentrations (PM10, NO2, SO2) (static map - without animation),
   - forecast of the maximum daily concentration (maximum 1-hour values among all 24 results for a given point for a selected day (PM10, NO2, SO2, O3) (static map - without animation),
   - forecast of the maximum 8-hour moving average concentration (only for O3) (static map - without animation).
3. National Institute for Environmental Protection (IOŚ-PIB) website provides:
   - maps of the average daily AQI for the next three days,
   - trend of AQI changes in voivodeship cities,
   - animation of AQI distribution over Poland.
4. Data are updated daily in the morning, for the next three days.

2. Polish air quality index

The Chief Inspectorate of Environmental Protection (GIOŚ) presents on its website data on air quality based on the Polish air quality index.

The current method of presenting the Index was based on determining the Index of the general air condition based on the worst individual index among pollutants measured at a given measuring station. Consequently, in the winter period, when PM10 / PM2.5 particulate matter was the most decisive pollutant, and no automatic measurement of PM10 and / or PM2.5 dust concentrations was carried out at a given station, the general index was "very good" or "good". At that time, other nearby measuring stations where particulate matter measurements were taken indicated poor air quality (index status of "bad" or "very bad"). On the other hand, in the spring and summer periods, when ozone is the decisive pollutant, the lack of measurement results for this pollutant concentration at a given station could lead to misinterpretation of the results.

Therefore, the Chief Inspectorate for Environmental Protection (GIOŚ) has introduced a new method of calculating the Polish Air Quality Index. The index calculation algorithm takes into account the role of the pollutant dominant at a given time in a given area.

In the new Index, the entry "No index" was introduced and marked in gray. The "lack of index" indicates that no automatic pollution measurements are carried out at a given station, which at a given time determines the air quality in the voivodeship. In the autumn and winter period, it concerns suspended dust PM2.5 / PM10, in the spring and summer period - ozone. Currently, the air quality index has 6 levels describing the state of air quality in a given area.

if there is no measurement from the last hour, it is the measurement from last 2 or 3 hours

If, in the voivodeship, e.g. at 12.00, air quality is determined by suspended dust PM10 / PM2.5, and the dust is not measured at a given station, the general index for this station

is not determined and the marker will be gray. For the remaining stations that measure dust concentrations, the presentation of the results is analogous to the current one.

If, in the voivodeship, e.g. at 12.00, the air quality is determined by ozone and ozone is not measured at a given station, the General Index for this station is not determined and the marker will be gray. For the remaining stations measuring ozone concentrations, the presentation of the results is analogous to the current one.

If at a given station, e.g. at 12.00, the air quality is determined by pollution other than particulate matter or ozone (e.g. benzene or NO2), this pollution determines the value of the General Index.

If all air pollutants measured at a given station are at very low concentration levels ("Very good"), the system provides for the presentation of the Air Quality Index "Very Good" even for those stations where the pollution determining air quality in the voivodship is not measured.

Category	Health informations
Very good	The air quality is very good, air pollution does not pose a threat to health, conditions are very favorable for any outdoor activities, without restrictions.
Good	Air quality is satisfactory, with air pollution causing little or no health risk. You can stay in the open air and do any activity, without restrictions.
Moderate	The air quality is acceptable. Air pollution can pose a health risk in special cases (for the sick, the elderly, pregnant women and young children). Moderate conditions to outdoor activity.
Sufficient	Air quality is good, air pollution is a health risk (especially for the sick, the elderly, pregnant women and young children) and

Category	Health informations
	can have negative health effects. Reduction (shortening or staggering) of outdoor activities should be considered, especially if the activity involves prolonged or increased physical exertion.
Bad	The air quality is bad, sick people, the elderly, pregnant women and young children should avoid being outdoors. The rest of the population should minimize any physical activity in the open air - especially those requiring prolonged or increased physical effort.
Very Bad	Air quality is very bad and has a negative impact on health. Sick people, the elderly, pregnant women and young children should absolutely avoid being outdoors. Remaining population should limit outdoor activities to the necessary minimum. Any physical activity outside is discouraged. Long-term exposure to airborne substances increases the risk of changes, e.g. in the respiratory, cardiovascular and immune systems.
No data	"No Index" corresponds to a situation where no particulate matter or ozone measurements are currently carried out at a given measuring station, and one of them is currently the decisive air pollution in the region. The Air Quality Index is then not determined and the color of the points on the map of the current measurement data changes to gray. The station, despite the lack of a specific Index, is still visible and it is possible to check all other measurement results.

Additionally, the Chief Inspectorate of Environmental Protection (GIOŚ) introduced a new range of threshold values for ozone. The Index class thresholds for the remaining pollutants remain unchanged. The ranges are shown in the table below and refer to 1 hour concentrations.

Indeks jakości powietrza	PM10 [µg/m^3]	PM2,5 [µg/m^3]	O_3 [µg/m^3]	NO_2 [µg/m^3]	SO_2 [µg/m^3]	C_6H_6 [µg/m^3]	CO [mg/m^3]
Bardzo dobry	0 - 20	0 - 13	0 - 70	0 - 40	0 - 50	0 - 6	0 - 3
Dobry	20,1 - 50	13,1 - 35	70,1 - 120	40,1 - 100	50,1 - 100	6,1 - 11	3,1 - 7
Umiarkowany	50,1 - 80	35,1 - 55	120,1 - 150	100,1 - 150	100,1 - 200	11,1 - 16	7,1 - 11
Dostateczny	80,1 - 110	55,1 - 75	150,1 - 180	150,1 - 200	200,1 - 350	16,1 - 21	11,1 - 15
Zły	110,1 - 150	75,1 - 110	180,1 - 240	200,1 - 400	350,1 - 500	21,1 - 51	15,1 - 21
Bardzo zły	> 150	> 110	> 240	> 400	> 500	> 51	> 21
Brak indeksu	Indeks jakości powietrza nie jest wyznaczony z powodu braku pomiaru zanieczyszczenia dominującego w województwie.						

3. Performance of the forecasting system in the Katowice FUA

The forecasting system is based on a deterministic model of dynamics and atmospheric chemistry, which allows calculations to be made from a local scale to a regional scale, up to the global scale (GEM-AQ),The system uses data contained in the Central Emission Base.

The results of mathematical modeling of transport and transformation of substances in the air in the form of digital files are prepared every day by National Institute for Environmental Protection (IOŚ-PIB) and transmitted to the Chief Inspectorate for Environmental Protection (GIOŚ) inNetCDF format (Network Common Data Form).

The results are processed in the Chief Inspectorate for Environmental Protection(GIOŚ)information technology resources to maps of the distribution of concentrations of individual airpollutants and presented on the website

Air pollution forecasts are made in a grid with a nominal resolution of 0.025x0.025 degrees (about 2.7km x 1.6km) reaching a minimum of 100 km beyond the country's borders.

Air pollution forecasts are presented for next three days. The forecasts concern such substances as : PM10, SO2, NO2, O3.

In order to obtain information, among others on the spatial distribution of concentrations of individual pollutants, the measurements may be supplemented with the results of mathematical modeling of pollutant spread. Data from measurement stations are collected in the national JPOAT2.0 database located at the Chief Inspectorate for Environmental Protection (GIOŚ).

AWAIR partnership agreed in assessing the performance of the forecasting systems used in the three FUAs using a common set of indicators. The specific set of indicators, in addition to Pearson correlation coefficient calculated between measured and forecasted concentration of PM10, partners agreed on two selected sets of statistical indices. The first group includes Mean Error (ME, which corresponds to the bias), Mean Absolute Error (MAE), and Root Mean Square Error (RMSE) calculated with the following formulas (where predicted and observed daily values are indicated as Piand Oi, respectively):

$$\mathrm{ME} = \frac{1}{N}\left(\sum_{i}(P_i - O_i)\right)$$

$$\mathrm{MAE} = \frac{1}{N}\left(\sum_{i}|P_i - O_i|\right)$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{N}\sum_{i}|P_i - O_i|^2}$$

The second group focuses on the performance of the forecasting system in predicting PM10 exceedances at different thresholds (50, 75 and 100 µg/m3) and includes indices based on a contingency tables. The selected indices are Probability Of Detection (POD), False Alarm Ratio (FAR) and Threat Score (TS). Here below the definitions:

$$POD = \frac{A}{A + C}$$

$$FAR = \frac{B}{A + B}$$

$$TS = \frac{A}{A + B + C}$$

where “A”, “B”, “C” are the entries of the 2x2 contingency table and stand for the number of “hits” (events observed and predicted), “false alarms” (events predicted, but not observed) and “misses” (events observed, but not predicted) at each selected threshold. The evaluation of the results was based on two months in the winter period

2020-2021. Only 2 days with PM10 concentrations above 75 µg/m3 and no with concentrations above 100 µg/m3 were observed. Therefore, the selected indices (POD, FAR, TS) were calculated taking into account only the threshold 50 µg/m3. The calculated statistical indices are reported in tables below:

	d0	d1	d2
ME	12,6	10,9	13,1
MAE	14,4	15,9	20,4
RMSE	19,1	22,5	33,7

>50 µg/m3	d0	d1	d2
POD	1	0,9	1
FAR	0,47	0,53	0,35
TS	0,53	0,45	0,65

Results showed that the model predict the PM10 for d0, d1 and d2 with satisfactory efficiency. It is important to highlight that the performance assessment was specific for the Katowice FUA only for a certain period of the year and therefore it should not be considered as a general performance assessment of the model