Leszek Ośrodka, Ewa Krajny, Marek Wojtylak

Zakład Meteorologii, Klimatologii i Ochrony Atmosfery IMGW-PIB

Short-term air pollution forecast as an element of air quality management in the region of the PL-CZ-SK, AIR TRITIA border.

Application of artificial intelligence methods in the protection of the atmosphere

INTRODUCTION

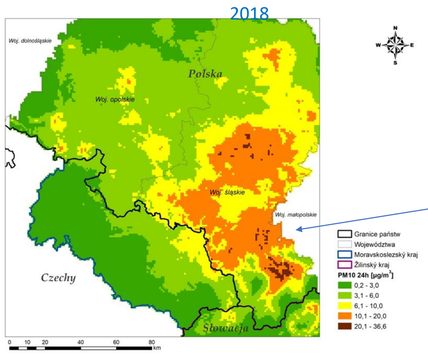
One of the main objectives of AIR TRITIA project "Uniform approach to the air pollution management system for functional urban area in Tritia Region" was to develop an air quality prediction system in the cities of Tritia region.
According to the provisions of the project, the objective of the system was to inform about predicted (one hour) concentration of air pollutants. This was due to the fact that the Directive 2008/50/EC of the European Parliament and of the Council of May 21st 2008 on ambient air quality and cleaner air for Europe implemented in the legislation of the EU member states requires that the member states draw up short-term action plans in order to reduce the risk or to decrease the duration of such occurrence if the specific region (area of agglomeration) is at risk of air pollution level exceeding one or several alarm thresholds listed in the annexes to the aforementioned Directive.
While the directive does not list air quality forecast as an instrument to implement short-term plans, use of such forecasts is increasingly becoming a good practice at the age of dynamic development of weather forecasts and due to the fact that informing the public of any threats resulting from health risks associated with air pollution.

OBJECTIVE OF THE WORK:

Objective of the work **is d**eveloping a model of the short-term AQ forecast for cities in the region of the border triangle Poland (PL) - Czech Republic (CZ) – Slovakia (SK) (Ostrava, Opava, Żylina, Opole, Rybnik)

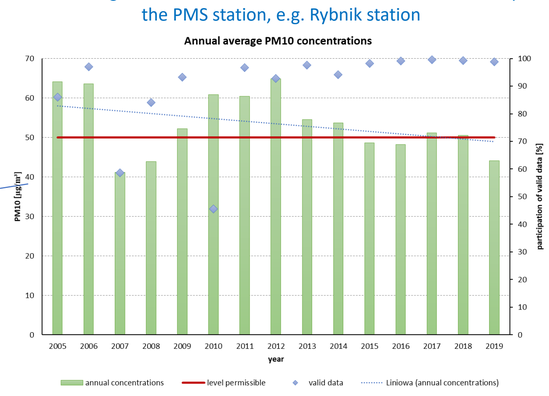
AIR QUALITY DIAGNOSIS IN THE AIR TRITIA REGION

Spatial distribution of PM10 of average daily concentrations in 2018



source: Ekometria sp. z o.o. dla IMGW-PIB – model CALPUFF

Annual average PM10 concentrations in 2005-2018 on the example of the PMS station, e.g. Rybnik station



AQ FORECAST METHOD

A detailed analysis of forecasting opportunities (see: report) for TRITIA region has resulted in an air quality forecast model based on advanced statistical methods (data mining) and on numerical weather prediction.
The data mining process includes three fundamental stages:
•preliminary exploration,
•building a model, which includes evaluation and verification,
•implementation and use of the model for new data to acquire the predicted values or classifications.
Long-term studies of meteorological conditions and concentration of pollutants, mostly particulates, have shown high correlation between air quality and values of certain meteorological elements. The most important ones include air temperature, wind speed and direction, precipitation, relative and absolute air humidity, atmospheric pressure, cloud cover, fog occurrence, vertical air temperature stratification, inversion occurrence (see: chapter 2). Weather, and temperature in particular, controls emission and the conditions of pollution dispersion.
The elements listed above can be identified in COSMO LM numerical forecast. The forecast covers three subsequent days and is updated every six hours. A high number of available forecasts, for at least 5 years, allows to find a sufficient number of accurate forecasts.

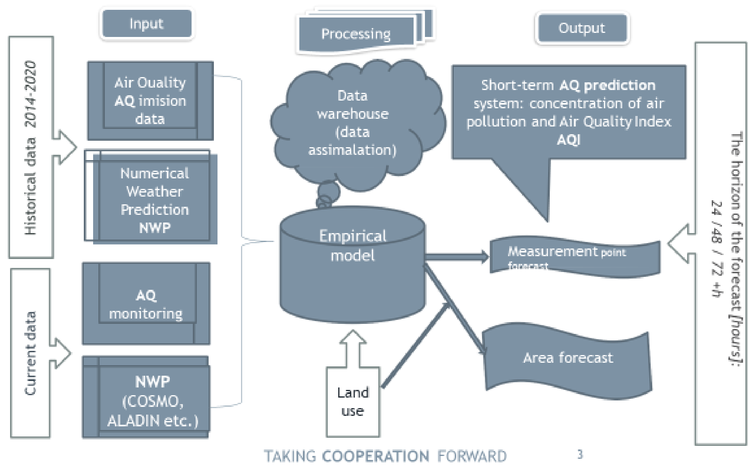
Forecast assumptions

Air quality forecasts are based on the following assumptions:
•*Purpose of prediction* (air quality forecast) – air pollution level over 72 hours (3 subsequent days);
•*The location of prediction* is a specific point (city).
Five cities have been selected for the forecast: Opava, Opole, Ostrava, Rybnik, Žilina;
•*Predictive data* necessary to draw up an exploration forecast;

- current numerical weather forecast for the prediction location;
- historical weather forecast set over the course of several years (at least 5) of the prediction location;
- a sequence of air pollution measurements at the dates corresponding to the historical weather forecasts, preferably close to the prediction locations.

This stage of drawing up weather forecasts includes generating a set of output data in the form of forecast PM_{10} and $PM_{2.5}$ particle concentration over time as well as forecast hourly and daily air quality index over time. Ultimately the index shall be based on the European Air Quality Index (EAQI). However, as the index currently does not include hourly forecasts, CAQI index is used.

The idea of creating an AQ forecast



Forecast creation algorithm

The current weather forecast is prepared and presented every hour h = 0, ..., 23, for 3 consecutive days in the form of a vector with 12 co

F1 (h) = atmospheric pressure

F2 (h) = meridional component of the wind direction per 10 m

F3 (h) = latitude component of the wind direction per 10 m

F4 (h) = wind speed per 10 m

F5 (h) = air temperature per 2 m

F6 (h) = 2 m dew point temperature

F7 (h) = complete cloud cover

F8 (h) = low cloudiness

F9 (h) = water vapor pressure

F10 (h) = relative humidity

F11 (h) = Total rainfall for the last hour

F12 (h) = Total snowfall for the last 3 hours)

- ❖ Historical forecasts were prepared in a similar way and we denote them Fdmr (h), where d - day, m - month, y - year. A set of historical f viewed and the similarity of the F forecast and the Fdmr historical forecast are calculated.
- ❖ The concept of the similarity of weather forecasts to the actual meteorological situation is based on the concept of a fractional distance.
- ❖ The similarity coefficient is expressed by the formula:

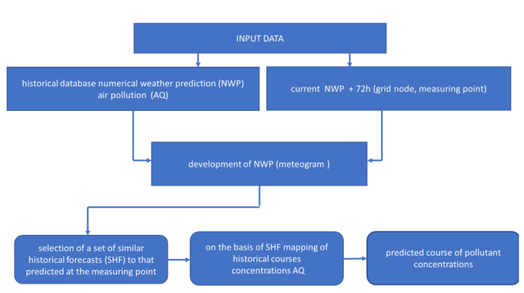
$$dist(F, F^{dmr}) = \sqrt[k]{\sum_{h=0}^{23}\sum_{i=1}^{12} w_{hi}\left|F_i(h) - F_i^{dmr}(h)\right|^k}$$

where 0 <k <1, [whi] is a weight matrix and is a configuration item. For the most similar forecasts ever,

measured pollutant concentration values are available.

These measurements are agglomerated to obtain an hourly run in the day of the forecast air quality

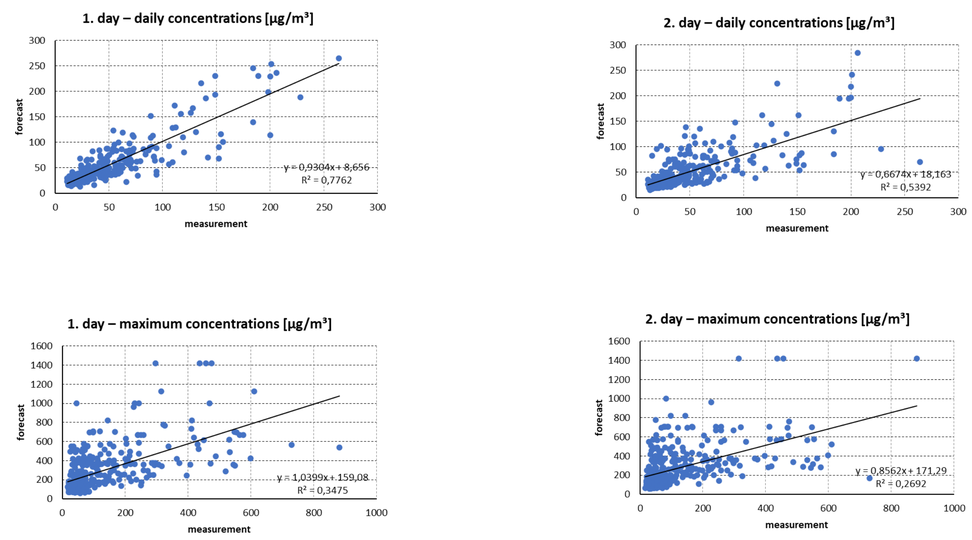
Operation of the AQ forecasting system for AIR TRITIA



RESULTS

Comparison of the forecast with the measurement Hourly mileage during CET PM10 in mg / m3 - Rybnik station January 18, 2019

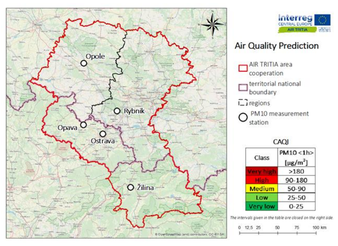
Comparison of the forecast with the measurement Daily and maximum concentrations in the PM10 day in mg / m3 - Rybnik station 2019. **r.**

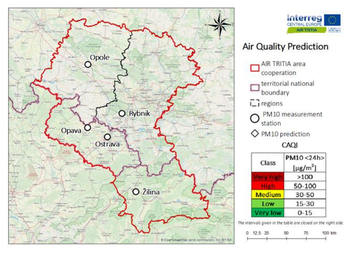


Comparison of the forecast of exceeding the daily limit value with the measurement. Rybnik 2019 .

Comparison of the accuracy of the forecast of the average daily concentration of PM10 with the measurement at the PMS station

		Concentrations measured at the PMS station			
Prediction of concentrations per PMS station	period	the first 24 hours		another 24 hours	
	concentration range µg/m³	≤50	>50	≤50	>50
	≤50	78,6 %	6,8%	74,8%	7,9%
	>50	2,2%	12,3%	6,3%	11,2%





Air quality forecasting system — Info CAQI Index EN

CAQI Index

Category	Concentration of 1h PM10 [µg/m³]	Concentration of 1h PM2.5 [µg/m³]	Health information
Very high	> 180	> 100	Air quality is extremely unhealthy, persons sensitive to air pollution* should absolutely avoid leaving the house, others should minimize the amount of time spent outdoors, all outdoor physical activity is strongly discouraged
High	91 - 180	51 - 100	Air quality is unhealthy, persons sensitive to air pollution* should avoid leaving the house, others should minimize the amount of time spent outdoors, all outdoor physical activity is discouraged
Average	51 - 90	31 - 50	Air quality is average, air pollution poses a certain threat to persons sensitive to air pollution*, who might feel some health effects, others should reduce the amount of time spent outdoors, in particular if they observe symptoms such as coughing or irritated throat
Low	26 - 50	16 - 30	Air quality is acceptable, air pollution might pose a threat to persons who are particularly sensitive to air pollution*, good conditions for outdoor activity
Very low	0 - 25	0 - 15	Air quality is satisfactory, air pollution poses no threat to human health, perfect conditions for outdoor activity

* Children and older people, persons with heart diseases and respiratory illnesses, asthmatics and persons particularly sensitive to air pollution

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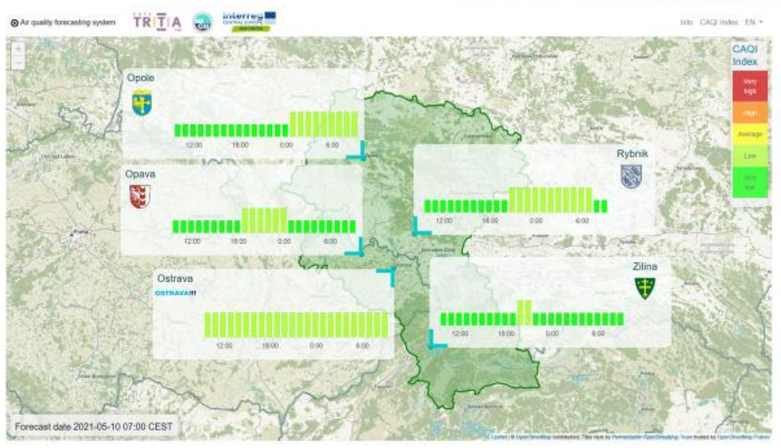
Visualization of the forecast now → http://air-tritia-test.herokuapp.com/pl



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