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Support of air pollution monitoring using Senitnel-5P data – how to improve air quality measurement network

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Nitrogen dioxide (NO_2) pollution is one of the most dangerous threats for public health. It is responsible for respiratory diseases, cardiovascular diseases, asthma, and many others. The objective of the presented study was to verify the potential of the Sentinel-5 Precursor Tropospheric NO_2 Column Number Density (NO_2 TVCD), provided by Copernicus Data Space Ecosystem, to support air pollution monitoring in Poland. The implementation of the objective was divided into three stages:

- to develop a model which estimates a ground-level NO 2 concentration;
- to find spatial representativeness area (SR area) referring to existing ground stations;
- to propose localization of new ground stations.

Model estimating a ground-level NO_2 concentration was developed in order to get spatial distribution of NO_2 pollution over whole Poland. As a input data there was used NO_2 TVCD provided by Copernicus Data Space Ecosystem as well as meteorological factors like air temperature, wind speed, planetary boundary layer height, pressure, atmospheric circulation type, wind direction, solar adiation flux from ERA-5 provided by European Centre for Medium-Range Weather Forecasts (ECMWF) and anthropogenic conditions (nightlight intensity, population, roads density). Due to the need for high computing power and a constantly working environment, CREODIAS resources were used. There were used several machine learning approach among which random forest had been found as a most accurate. The results revealed that model demonstrated MAE values of 3.4 $\mu g/m^3$ (MAPE~37%) and 3.2 $\mu g/m^3$ (MAPE~31%) for the hourly and weekly estimates, respectively.
Obtaining NO_2 ground concentration for whole Poland allowed for investigation of spatial autocorrelation of the air pollution phenomenon and determination of SR area. There were used five methods:

- Global and Local Moran's: it was found strong spatial autocorrelation (Global Moran's=0.99 and p-value <0.05). Also, ~1% of Poland NO 2 pollution does not depend on neighborhood area;
- Correlation in respect to distance: it was observed that c.a. 10% of Poland's population exposed to high levels of pollution (higher than yearly World Health Organization - WHO recommendation=10 $\mu g/m^3$) is not covered by a SR area;

- Semivariance: it was found that c.a. 12% of Poland's population exposed to high levels of pollution is not covered by a SR area.
- Similarity threshold: It was found that c.a. 7% of Poland's population exposed to high levels of pollution is not covered by a SR area.

Due to the findings above it was possible to determinate a number and localizations of the new stations. Depending on method it was found there was a need to establish from 7 to 22 new stations
in order to cover all population threaten by high NO 2 concentration.

To sum up, implementation of Sentinel-5P data as well as meteorological and anthropogenic data allowed for finding solution which could be very useful for design or improvement of air quality measurements network.