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Dissertation Abstract „The role of meteorological conditions affecting PM_{10} concentrations in urbanized areas with complex topography on the example of Kraków"

Air quality has a significant impact on human living conditions, ecosystems, and processes associated with climate changes. The level of air pollution measured in the near-ground troposphere depends on the interactions of three main factors: 1) pollutants emission, 2) their physical and chemical transformations, and 3) their dispersion conditions in the atmosphere. Dispersion conditions depend both on synoptic situation and local topography. Abundant air pollution with particulate matter is a significant problem in both Europe and in Poland. Unfortunately, in Poland, the air quality problem has been present for many years, as indicated by the increased annual average value of PM_{10} concentrations in agglomerations in Poland in relation to the annual average determined for cities in the European Union in the period 2000-2019. The area of southern Poland (Silesian and Lesser Poland Voivodships) in terms of poor air quality distinguishes itself particularly in comparison with Europe. This doctoral dissertation raises the issue of dispersion conditions influenced by atmospheric processes modified by relief and land use. The dissertation is a collection of five thematically related articles published in scientific journals included in the Journal Citation Reports.

The main objective of the research described in this dissertation is to quantify the influence of weather conditions on a local and regional scale on the spatial and temporal distribution of PM_{10} air pollution in a large, urbanized area located in a concave however, slightly varied landform, which is the Kraków agglomeration. The analysis was carried out using the latest measurement techniques and research methods. The research was carried out using meteorological and air quality measurements from the ground as well as in the vertical profile, results of numerical forecasts of meteorological models, meteorological reanalyses and types of atmospheric circulation.

The first results presented in the **article A1** allowed quantitative comparison of different configurations of numerical weather prediction models in terms of predicted air temperature and thermal stratification of the atmosphere for the area with varied relief and land cover. The research allowed to extract the characteristic synoptic situations accompanying overestimation of the forecasted air temperature, as well as to verify the hypothesis on improvement of the forecast quality by changing the resolution of the computational grid (spatial and vertical resolution of the model). Unfortunately, the problem of representing the stable atmospheric layer in operational numerical models is more complex and requires further developments.

The analysis of meteorological conditions and air quality that accompany the appearance of the foehn wind in the cold season presented in the **article A2** allowed us to assess the role of the foehn wind on the dynamics of the urban boundary layer in Kraków. The study confirmed that in the case of Kraków, the key factor modifying weather conditions on a local scale is the relief. It influences the interaction of foehn winds with the urban boundary layer causing improvement or deterioration of pollution dispersion conditions in the city. The hypothesis presented in the doctoral dissertation that advection of warm air masses from the southern sector negatively affects the dispersion conditions in Kraków is not fully correct. The realized research made it possible to distinguish three types of foehn transport dependent on the local atmospheric conditions and foehn properties (intensity and direction of air movement): 1) air flow over the valley; 2) wind penetration into the valley from the East or South; 3) occurrence of gravitational waves accompanying the foehn wind causing spatial differentiation of turbulence within the city.

As part of the scientific studies, research was carried out on the vertical profiling using unmanned aerial vehicles to improve this measurement method and identify its strengths and weaknesses. The research results presented in the **article A3** formed the basis for the realization of further studies on the vertical profile of the atmosphere.

The results of the balloon measurement campaign for the Krakow area presented in the **article A4** allowed identification of atmospheric factors shaping the vertical dispersion of pollution in an urbanized valley. The hypothesis was verified that the occurrence of wind shear in the valley contributes to the deterioration of aerosanitary conditions by modifying the height of the mixing layer. The research indicated that the occurrence of strong wind shear can cause an increase in the height of the mixing layer, removal of pollution at the disappearance of convective motions, but also limits the development of the mixing layer through separation of air masses in and above the valley (wind shear above the inversion layer).

The **article A5** constitutes a summary of the research. The study was carried out to estimate quantitatively the influence of atmospheric circulation on air quality in Kraków and its possible application for air quality forecast in the city. The results of the research allowed us to determine the relationship between individual weather elements and the level of pollution in the city. The research carried out with the use of Random Forests model indicated that apart from well-known parameters such as air temperature, wind speed and vertical gradient of air temperature, the key factors determining the level of PM_{10} pollution concentration are the vertical gradient of relative air humidity and wind shear in the lowest troposphere layer.

The presented studies do not fully elaborate the research problem. However, they can be used to realize further scientific research of the influence of atmospheric phenomena on air quality for urban areas characterized by significant diversity of relief and land use. The presented research results can also contribute significant insight to the modeling of pollutant dispersion conditions, especially air quality forecasts.

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Piotr Zelina