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Surface-based nocturnal air temperature inversions in southern Poland and their influence on PM_{10} and $PM_{2.5}$ concentrations in Upper Silesia

Abstract

Surface-based nocturnal temperature inversions (SBTIs) are key contributors to urban air pollution events, particularly during winter. This study investigates the frequency, structure, and impact of SBTIs on PM_{10} and $PM_{2.5}$ concentrations in Upper Silesia, southern Poland, using meteorological data from 2001 to 2020. SBTIs were detected based on temperature gradients between 2m and 88m heights, with a defined threshold of +0.5 K/100m. On average, SBTIs occurred on 47% of nights annually in Sosnowiec and 59% in Wrocław, peaking in summer but causing the most severe air pollution during winter. The typical inversion depth ranged between 50 and 300 meters. The mean annual PM_{10} concentration in the Upper Silesia region was 49 $\mu g/m^3$, ranging from 18 $\mu g/m^3$ in summer to 73 $\mu g/m^3$ in winter. During nights with strong inversions, PM_{10} concentrations increased significantly, reaching up to 137 $\mu g/m^3$, which is approximately 189% of the average winter concentration. $PM_{2.5}$ concentrations showed similar but less pronounced increase under strong stability conditions. Synoptic analyses indicated that polar continental air masses, stable high-pressure systems, and weak geostrophic winds strongly favored inversion formation and pollutant accumulation. These results demonstrate that surface-based inversions, reinforced by synoptic-scale weather patterns and surface cooling, are major drivers of wintertime smog episodes in Upper Silesia.

Keywords:

Surface-based nocturnal temperature inversions (SBTIs)

Reference:

Niedźwiedź, T., Łupikasza, E. B., Małarzewski, Ł., & Budzik, T. (2021). Surface-based nocturnal air temperature inversions in southern Poland and their influence on PM_{10} and $PM_{2.5}$ concentrations in Upper Silesia. *Theoretical and Applied Climatology*, 146, 897–919. https://doi.org/10.1007/s00704-021-03752-4