GÖTEBORGS UNIVERSITET

Naturvetenskapliga fakulteten

Institutionen för biologi och miljövetenskaper

The influence of atmospheric circulation and meteorology on urban air pollution and pollen exposure

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2015

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Akademisk avhandling för filosofie doktorsexamen i Naturvetenskap, inriktning miljövetenskap, som med tillstånd från Naturvetenskapliga fakulteten kommer att offentligt försvaras fredagen den 5:e juni 2015 kl. 10:00 i Hörsalen, Institutionen för biologi och miljövetenskap, Carl Skottsbergs gata 22B, Göteborg.

ISBN: 978-91-85529-79-7

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Abstract

Urban air quality is a global health concern and is a growing problem due to large migration of people from rural areas to cities, a phenomenon occurring in many parts of the world. This means that more and more people can be expected to be exposed to high levels of air pollutants, many of which are associated with the urban environment. The exposure situation is characterised by different compounds emitted from different sources such as traffic, industry, wood burning and energy production. Air pollution levels tend to vary temporally both during the day and between seasons. Another important atmospheric constituent to consider is pollen which together with air pollutants can cause severe health effects in sensitive people. The climate and weather governs the atmospheric processes responsible for ventilation and stagnation of the air, which in turn also provides conditions for good or poor air quality. This thesis has investigated the urban air pollution levels of nitrogen oxides (NO_x = NO + NO_2), ozone (O_3), particles (PM_{10} and PNC, particle number concentration) and birch pollen levels in relation to meteorology and atmospheric circulation. In this study circulation was represented by the large scale circulation pattern called the North Atlantic Oscillation (NAO) and by the synoptic circulation classification scheme Lamb Weather Types (LWT). The city of Gothenburg has been the main location but air quality and pollen in Malmö has also been investigated. It was shown that air pollution has a strong association to the variation in weather conditions represented by both NAO and LWTs. In winter calm and stagnant air masses were associated with high levels of NO and NO_2, these conditions were more common NAO was in its so called negative mode (characterized e.g. by low wind speeds) and in LWTs associated with calm conditions and thus limited ventilation. Ultrafine particles (UFP), considered to be of large importance for health effects, are in many cases the dominating fraction in PNC. NO_x was found to be a good proxy of PNC, e.g. situations with high NO_x can be expected to have high PNC. Furthermore, the occurrence of high NO_2, O_3 and PM_{10} were co-varying very well with the occurrence of high birch pollen counts in Gothenburg. These situations were also associated with high sales of over-the-counter (OTC) antihistamines, indicating a combined effect on health symptoms represented by OTC sales, especially during calm and dry weather conditions. Finally, the usefulness of LWTs was illustrated by to their strong association with anomalies of inter-annual air pollution levels. By adjusting annual concentration/deposition trends of air pollutants for the yearly LWT variability, temporal trends were greatly improved, e.g. the relative importance of weather was quantified permitting more accurate evaluation of emission changes on air pollution levels. Furthermore, the strong association between urban air quality and atmospheric circulation shown in this thesis highlights the LWT classification as a good option to be integrated in a tool for risk assessment and information system for urban air quality including both air pollutants and pollen.

Keywords: Urban air pollution, nitrogen dioxide, particles, ozone, birch pollen, air quality standards, atmospheric circulation, synoptic weather, Lamb Weather Types, North Atlantic Oscillation, meteorology, wind speed, temperature inversions, anomalies.