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Regional and local surface ozone variations in relation to
meteorological conditions in Sweden

Akademisk avhandling

Som för avläggande av Filosofie Doktorsexamen i naturgeografi vid Institutionen för Geovetenskaper, Naturgeografi, Göteborgs Universitet, kommer att offentligen försvaras fredagen den 29 maj 2009, kl 10:00 i Stora Hörsalen, Geovetarcentrum, Göteborgs Universitet

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ABSTRACT

Air quality is strongly dependent on meteorological conditions. Atmospheric circulation encapsulates general information about local meteorological variables to some extent, and can serve as an explanatory variable for air quality at a regional or local scale. Numerical models are another useful tool for understanding the influence of meteorological factors on the chemical and physical processes involved in regional and local air quality variations. The aims of this thesis have been to: (1) investigate regional surface ozone and its correlation to atmospheric circulations by making use of synoptic weather types in southern Sweden; (2) compare numerical models performances in simulating urban meteorological conditions and apply a numerical model to urban air quality study for Gothenburg.

The study confirmed the influences of synoptic circulation on regional ozone concentrations by relating the Lamb Weather Types (LWTs) to surface ozone variations. Anticyclones, associated with atmospheric stagnation, tend to create whirling air masses and short trajectories from the European continent, which leads to effective long-range transport, enhanced local ozone photochemical production, and high-ozone levels. Cyclones, on the other hand, can also create high level ozone through frontal passages and enhanced vertical mixing. At the same time, the frequencies of cyclones and anticyclones in this region are highly anti-correlated, making cyclone frequency a skilful predictor of high ozone events. The frequency of cyclones over the past 150 years shows a high variability and showed significantly downward trend. Given the constant conditions from other factors for example emission, continuous decrease in the frequency of cyclones indicates the more occurrences of high-ozone events in southern Sweden.

A numerical model - The Air Quality Model (TAPM) - was used to simulate the complex wind system and other meteorological variables needed for air quality applications in the Gothenburg area. Compared with The PSU/NCAR fifth-generation Mesoscale Model (MM5), TAPM is able to better reproduce near-surface air temperature and wind system in Gothenburg. Both MM5 and TAPM can simulate night-time vertical temperature gradient well, but underestimate daytime vertical temperature gradient and the occurrences of low wind speed situation at night. TAPM was then used to reproduce $\text{NO}_x\text{-O}_3$ reactions and investigate the wind speed effect on spatial differences of NO_2 concentrations in the polluted urban landscape. TAPM satisfactorily simulated the relation of NO , NO_2 and ozone as well as the site differences for different wind speed categories. However, TAPM underestimated NO at certain sites due to local scale site-specific conditions and missing emissions from nearby roads and other emission sources.

KEYWORDS: LWTs, surface ozone, high-ozone events, long-range transport, TAPM, MM5, $\text{NO}_x\text{-O}_3$, Sweden.