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Modelling VOC source impacts on high ozone episode days observed at a mountain summit in Hong Kong under the influence of mountain-valley breezes

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HIGHLIGHTS

- An observation based photochemical model simulates a multiday O_3 event in Hong Kong.
- Positive Matrix Factorization of the measured VOC identified local emission sources.
- Vehicle emissions and power generation identified as main precursors to O_3 formation.

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ABSTRACT

A top-down approach to evaluate high ozone (O_3) formation, attributed to different emission sources, is developed for anti-cyclonic conditions in a region of Hong Kong influenced by meso-scale circulations. A near-explicit photochemical model coupled with the Master Chemical Mechanism (MCMv3.2) is used to investigate the chemical characteristics in the region. Important features have been enhanced in this model including the photolysis rates, simulated by the National Center for Atmospheric Research (NCAR) Tropospheric Ultraviolet and Visible (TUV) Radiation Model, as well as hourly variation of Volatile Organic Compound (VOC) concentration input from on-site sampling. In general, the combined model gives a reasonably good representation of high O_3 levels in the region. The model successfully captured a multi-day O_3 event in the autumn of 2010. Source apportionment via Positive Matrix Factorization (PMF) was carried out on the sampled VOC data, to determine the major sources in the region. Based on the outcomes of the PMF source apportionment, a sensitivity analysis using the developed photochemical model was conducted and used to estimate O_3 reduction under different source removal regimes. Results indicate that vehicular emissions are the dominant VOC source contributing to O_3 formation. This study has demonstrated a potentially efficient secondary pollutants control methodology, using a combined field measurements and modelling approach.

1. Introduction

Air pollutants of major health concern, including ambient O_3, NO_x ($NO + NO_2$), sulphur dioxide (SO_2) and particulate matter (PM), have recommended limits of their concentrations applicable across all WHO regions (WHO, 2006). These pollutants are regulated at the national level, though defined limits differ from Nation to Nation. In Hong Kong, the Air Quality Objectives (AQO) for major air pollutants, including ambient ozone (O_3), were established in 1987 under the Air Pollution Control Ordinance (APCO) stipulated by the Hong Kong Environmental Protection Department (HKEPD). The current guideline for ambient O_3, a major constituent of photochemical smog, is 122 ppb (240 μg m^{-3}, 298.15 K and 1 atm) and the hourly average O_3 level should not exceed the standard more than three times a year.

Although guidelines have been in place for more than 2 decades, the continued growth in rapidly developing regions of the world means that air pollution remains a current major concern. There are

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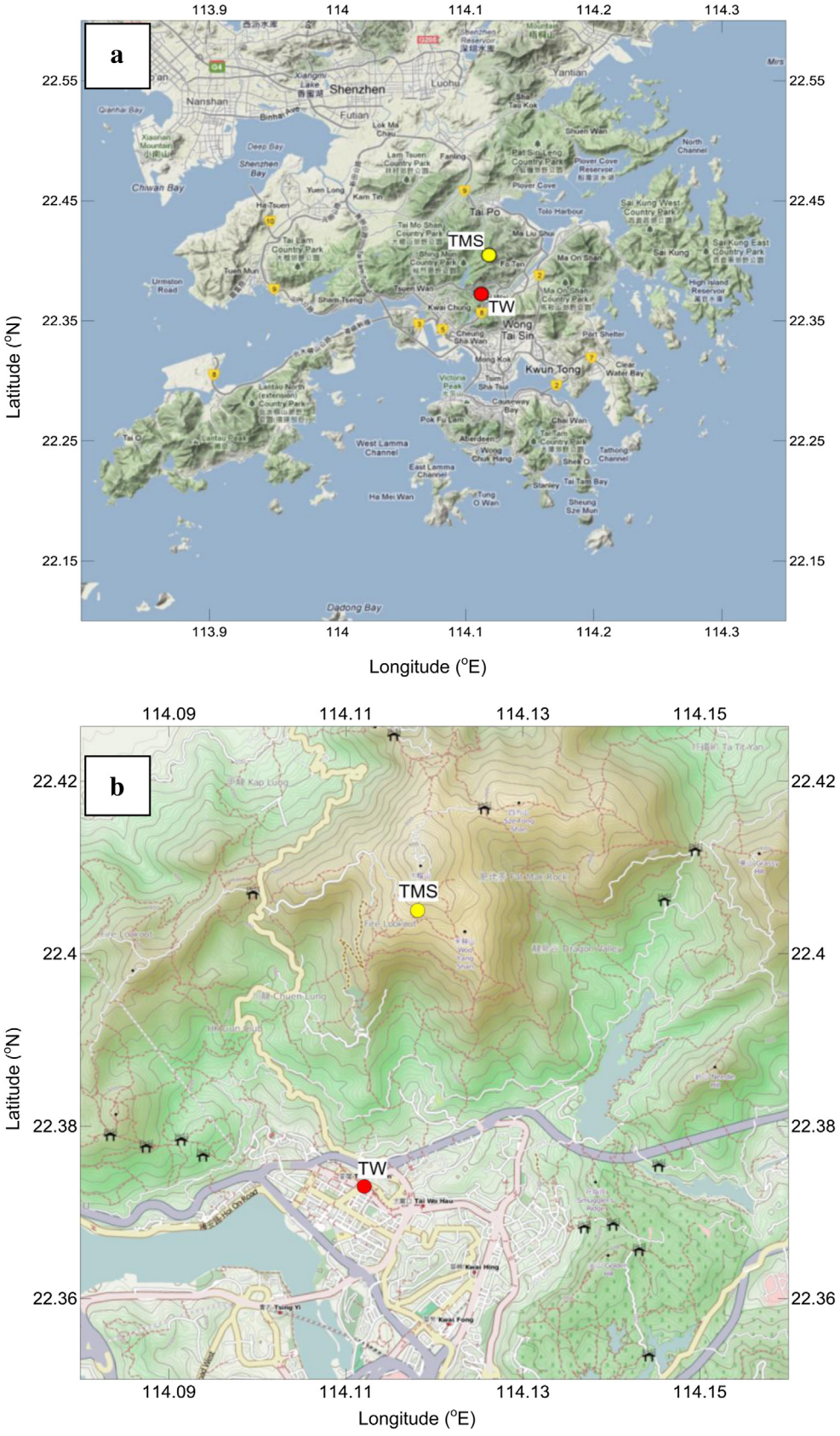

Fig. 1. Map showing (a) Hong Kong (HKSAR) and (b) topographic features and the sampling sites at TW and TMS (Quantum GIS Development Team, 2012).