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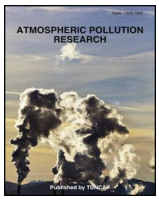

A first annual assessment of air quality modeling over Lebanon using WRF/Polyphemus

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ABSTRACT

Air quality is modelled at high resolution over Lebanon (5 × 5 km) and Beirut (1 × 1 km) using the WRF/Polyphemus modeling system for the year 2014. The observation data collected from the recently deployed national air quality monitoring network as well as ground measurement from a long-term campaign are used to evaluate both models performance. Statistical indicators are calculated and compared to a selection of performance criteria from the literature. Accordingly, the modelled results are satisfactory and within the range of the literature for both the meteorological parameters as well as air quality pollutants. For the meteorological model, some biases are observed for the wind components especially during winter, as better statistics are obtained during summer. As for the air quality, the model satisfied commonly used performance criteria for O3 and PM2.5. However, the model underestimates the carbon monoxide values in urban regions and overestimates sulfur dioxide and it appears that these biases results mainly from the emission inventory and the meteorology. Also, EC and OC components of $PM_{2.5}$ are evaluated. The results highlight an underestimation of OC, which could relate to the sensitivity of the chemical mechanism to the temperature, the boundary conditions, or the emission inventory.

1. Introduction

Across the globe, the degraded outdoor air quality has been a major problem in developing and developed countries alike, causing 3.7 million premature deaths worldwide per year in 2012 (WHO, 2014). Since then, worldwide awareness of the dangers of the situation has been increasing significantly and stricter legislations were put in place, along with more elaborate emission reduction strategies (EU, 1998, 2002, 2007, WHO, 2005, 2006). The most common pollutants to exceed the regulations in many regions of the world and contribute to serious health risks are ozone (O_3) and particles, especially the fine particulate matter ($PM_{2.5}$). The former is characterized by a high oxidative potential and is thus capable of causing inflammations in the respiratory system (Seinfeld and Pandis, 2006; Sportisse, 2010). The latter can penetrate deep into the respiratory system due to its small size, thus reaching the blood through the alveoli. Increased mortality risks from $PM_{2.5}$ intoxications are observed in newborns and the elderly (Kampa and Castanas, 2008; Anderson et al., 2012; WHO, 2013; Kim et al., 2015). To assess the population exposure to pollution in different regions, a continuous tracking of ambient concentrations for the most common pollutants is needed. Currently, such information can be provided by ground-based measurements such as Air Quality Monitoring Networks (AQMN), satellite-based measurements and air quality modeling. In most developing and non-developed countries, observational data are not always available, as AQMN can be very costly. Consequently, air quality modeling is an important tool to provide a better understanding of the situation. However, it remains a challenging task due to: (1) the absence of emission data in many developing and non-developed countries where emission control strategies are nonexistent and air quality related legislations are not enforced thus continuous or regular emissions monitoring is scarce (MoE/UNDP/GEF, 2015a), (2) the complexity of the atmospheric processes, (3) the wide variety of species that influence pollutants such as O_3 and $PM_{2.5}$.

During the past few years, Lebanon, an eastern Mediterranean country characterized by dense urban cities with no public transport infrastructure and poor air quality management, witnessed increasingly

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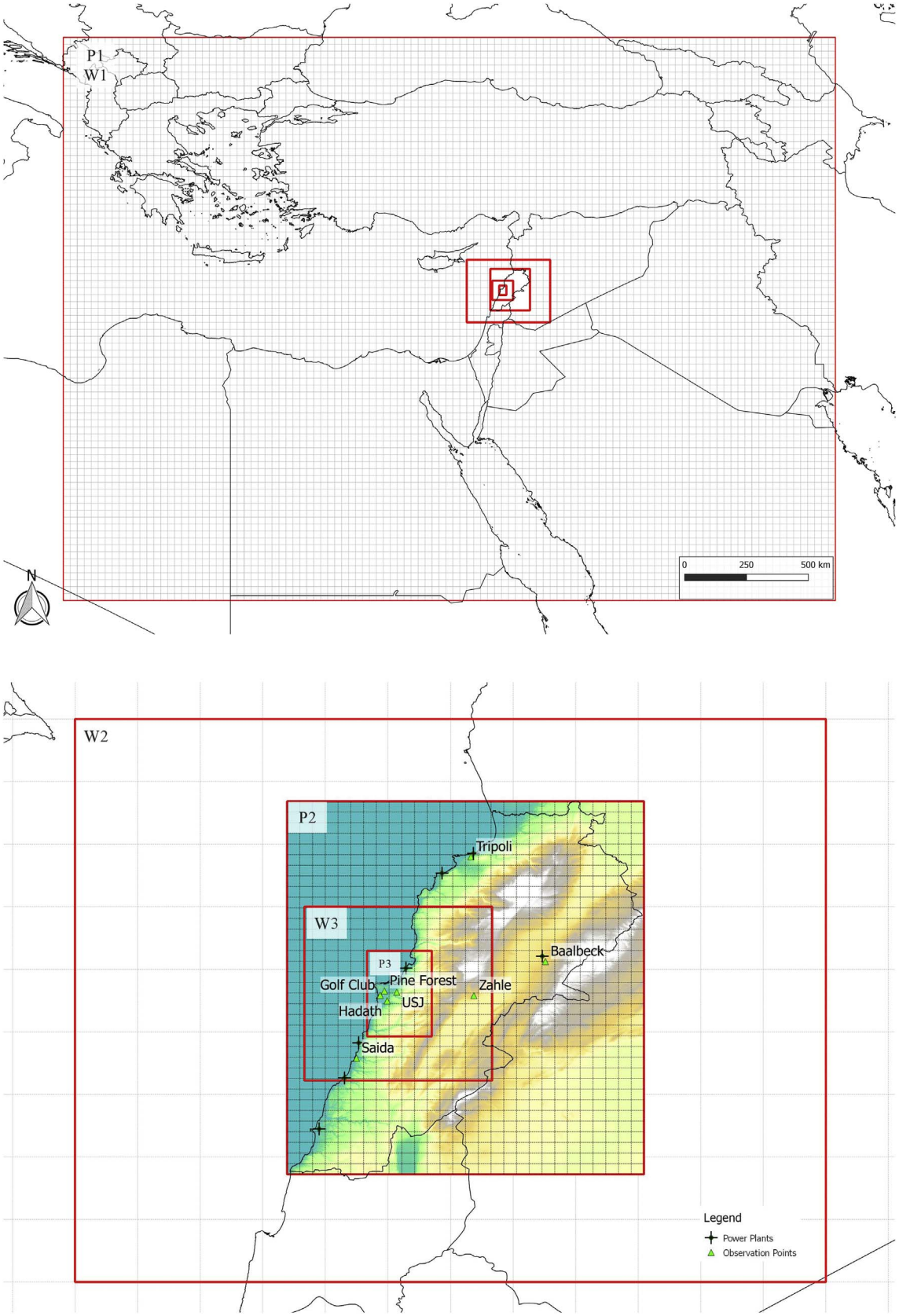

Fig. 1. The modelled domains of this study (W1, W2 and W3: WRF domains for the MENA region, Lebanon, and Beirut respectively; P1, P2 and P3: Polyphemus domains for the MENA region, Lebanon, and Beirut respectively).