Study of local winds over Tehran using WRF in ideal conditions

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Abstract

Wind is the carrier of pollutants and any other gaseous or particle matters in the atmosphere. Stable atmosphere with low wind provides favourable conditions for high contamination of pollutants in urban areas. The importance of mesoscale atmospheric flows in air pollution dispersion has been recognized in the past three decades and has been the focus of intensive research; both observational and numerical. Mesoscale or local scale circulations are more prominent when the synoptic pressure gradients are weak, allowing horizontal temperature contrasts to develop, which in turn lead to mesoscale pressure perturbations. Tehran, a city which is situated at the southern foothills of the Alborz Mountain chain has an average elevation of 1500m, and covers an area of 864 km². Alborz Mountains have a significant influence on the dynamics and thermodynamic modification of wind regime over the city. At the same time, the Urban Heat Island effect (UHI) can cause its own mesoscale flow, complicating an already complex local scale flow. The topography and the urban fabric can cause slope flows, mountain flows, and valley flows amongst many other factors. This paper focuses on the use of state-of-the-art atmospheric numerical model – The Weather Research and Forecasting (WRF) – in an ideal situation to study the characteristics of the mesoscale flow systems that prevail over Tehran when air quality is unfavourable. So average sound of Radiosonde at Mehrabad station, for almost all the fair days of cold seasons from 2005 to 2008 was selected as an ideal initial condition and boundary condition with 10 × 10 km spatial and 12-hour temporal resolution. The simulations were carried out for a 3-day period in December 2005 when an aircraft, due to low visibility caused by high concentration of air pollution, crashed 2 miles away from the end of runway into an inhabited area. Three simulations were prepared. For the first experiment, called control run, we used the default urban setting of Tehran. In the second simulation, urban properties of Tehran were removed completely from the land-use fed to the model to investigate the effect of urban area on thermally induced circulation in Tehran. This simulation was called NoURB simulation. To investigate the role of the roughness in the urban area, a 3rd simulation was prepared. In this simulation, which was referred to as HiFric simulation, three urban categories were used; class 31 of USGS land use/land cover was used for “Low Intensity Residential”, which included areas with a mixture of constructed materials and vegetation. These areas were most commonly included as single-family housing units in which the population densities were lower than those in high intensity residential areas. Class 32 of USGS represented “High Intensity Residential” which included highly developed areas where people resided in large numbers. Finally class 33 of USGS was used for “Commercial/Industrial/Transportation”, which included infrastructures (e.g. roads, railroads, etc.) and all highly developed areas not classified as High Intensity Residential. The results indicated that urban areas near complex topography can increase transfer of material (pollution) and energy from boundary layer to the free atmosphere. Besides the ideal simulation, we investigated some observational aspects of the transition time by wind persistence charts. The results showed that we have a 2 to 3-hour lag time at the evening transition of northern and southern part of the city which could improve the pollution potential in this period. This fact may play an important role in Tehran megacity management.

Keywords: local winds over Tehran, WRF, complex topography, air pollution transport

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