The Effect of the Zagros Mountain Range on Transporting Iraqi Dust to Western Iran using the WRF/Chem Model (Case Study)

Jalil Sahraei[a], Elham Mobarak Hassan[b], Nahid Mohammadi[c*]

[a] *Department of Physics, Razi University, Kermanshah, Iran*
[b] *Department of Environment, Islamic Azad University, Ahvaz Branch, Iran*
[c] *Department of Geomorphology, Razi University, Kermanshah, Iran*

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1. Introduction

Dust aerosols, a type of air pollution, are emitted from the arid and semi-arid areas. The Middle East constitutes the second largest desert in the world after North Africa deserts. More than 65% of the Middle East land surface has the potential for dust emission (Prospero et al. 2002). Dust storms frequently occur throughout the desert regions of the world. This event enhanced large amounts of dust into the atmosphere. Atmospheric dust plays an important role in the regional climate and environment which can affect the air quality and human health. They can scatter and absorb the solar radiation and thermal radiation at the Earth's surface and top of the atmosphere. Dust storm events may occur as a result of local meteorological events with convective systems in local scale, or synoptic-scale systems. Dust storms are not only occurred in the source region but also can be transported very far from this region. Dust aerosols are removed from the atmosphere by dry and wet deposition. The main dust sources for the west of Iran are Iraq, Syria, and Arabian Peninsula deserts. The Zagros Mountain Rang is always exposed to a dust storm by being in the vicinity of the dry and semi-arid areas of the country of Iraq, Syria, and Saudi Arabia. The modeling of dust storms is important for distinguishing its sources, prediction of dust event, simulating of formation, diffusion, transportation, and deposition of dust. The regional WRF-Chem model is used for simulation of temporal and spatial dust concentrations. Numerous dust models exist and have been applied for simulation air pollution. The WRF/Chem system is available online with the chemistry part and meteorology part running simultaneously. The chemical part and meteorological part use the same horizontal and vertical grids, time intervals, parameterizations for cloud-resolving microphysics, and sub-grid convections. The understanding of the atmospheric controls and mountain impact on dust emissions in Zagros Mountain Range is still uncertain. The focus of this work is to investigate the effect of the Zagros mountain range in dust concentration using the fully coupled chemistry within WRF (Weather Research and Forecasting), and WRF-Chem model.

*. Corresponding author: Nahid Mohammadi. Tel: +989362737779 E-mail: mohammadinahid72@yahoo.com

2. Materials and Methods

To analyze the effect of the Zagros mountain on dust storms in the west of Iran, two dust storm events which occurred between 12 and 14 April 2011 and between 16 and 18 June 2016 were selected to be investigated along with studying the horizontal visibility in several synoptic stations across the Zagros Mountains in the west of Iran and its adjacent areas. The Weather Research and Forecasting model coupled with the Chemistry module (WRF-Chem model) is implemented over the Zagros mountain range. In this study, we used the WRF-Chem model Version 3.6.1 (Grell et al., 2005) to the dust simulations. To validate the model, we compared the observations of horizontal visibility and WRF-Chem simulations over Ilam and Kermanshah synoptic stations. Meteorological observations were obtained from the country's meteorological organization. WRF/Chem model was run in three states including the natural topography, the reduced topographic height of Zagros Mountains to 1000 meters, and the removed topographic height. WRF-Chem model is configured to cover the Zagros mountain range, the Syrian desert, and the Iraq Desert with 250x160 grid points, a 7 km grid resolution, and 32 vertical levels to 50 hPa. Boundary and initial conditions are assimilated with GFS data.

3. Results and Discussion

The WRF/Chem model simulates two dust storm events in the west of Iran that occurred in April 2011 and June 2016. Simulations of dust transport tracks and satellite data highlight two main transport paths of the dust storm. In April 2011, dust storm originated from northern Saudi Arabia and southeastern Iraq, and most likely in Khuzestan province, while in June 2016, the dust originated from Iraq. These events were caused by the passage of air masses associated with low-pressure systems in deserts of the western part of the Zagros mountain range. At first, the potential of the WRF-Chem model was investigated to quantify the ability of this model to simulate dust sources and dust concentration. Although the times with low values of dust are less accurate, the comparisons between the model simulations and the horizontal observation at the two synoptic sites and the satellite measurements show that the WRF-Chem model satisfactorily resolves evolution and spatial distributions of the dust stor The three states in the WRF/Chem model simulated comprised of the natural state, the reduced topographic height to 1000 meters, and the removed topographic height. On 13 April 2011, dust was accumulated on the winding slopes of the mountain range, but the simulations for the removed topographic height show that the intensity of the dust is reduced, and it is transferred to the center and north of the country. On 17 June 2016, the dust distribution profile shows that in places where the height of the dust column is equal to or less than the height of the mountain, the dust is stopped and accumulated on the winding slopes. In cases where the height of the dust column was higher than the height of the mountain, the dust will transfer from the mountain. The dust concentration on the winding slopes is maximum. Model simulation results in the three states with different height topography indicating that the decrease in the topographic height lifts the dust towards the east of the mountain. The concentration of dust in the west of this

mountain range is propagating more toward the east. In April 2011, the spatial distribution of the simulated dust concentration showed that the mountain barrier could not wholly prevent the passage of the dust. But in the case of the second storm in June 2016, which had less dust intensity, the mountain completely stopped the transfer of the dust. However, in both cases, the maximum dust concentration was on the western slopes, which had a long shelf life in these areas.

4. Conclusion

The purpose of this research was to examine how to treat dust storms in the confrontation with the Zagros Mountain and to determine the effect of this mountain to dust in the west of Iran. In this study, the behavior of the two dust storms over the Zagros Mountains range is investigated. Simulations of the dust event with the (WRF-Chem) were verified using horizontal visibility from the country's meteorological organization. To ensure the model simulations, the dust concentration simulated by models with horizontal visibility data received from the country's meteorological organization for two synoptic stations was compared. In general, despite some errors in some hours, the results of the simulation dust conformed to the horizontal visibility. The results of the three states of simulation in the WRF/Chem model indicate that the Zagros Mountain is prevented from the progress of the dust to central regions of the country. In the natural state, the accumulation of dust in the western Zagros Mountain range is increased. The removed topographic height causes moving the dust towards the east of the mountain and the concentrations of the dust in the west of the mountain range are reduced. According to the results of this study, wind-blown mountain-mountainous areas (western slopes) experience dust storms with higher intensity and durability.

Key words: WRF/Chem, Zagros mountain range, Dust, Horizontal visibility.

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