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Investigation of Multiscale and Unsteady Characteristics of Deep Foehn Events Over Alborz Mountains

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Abstract

The Foehn characteristics and its temporal evolution events are investigated using a combination of observations, synoptic analysis and simulation data in the Alborz Mountains in northern Iran. These events have caused an extensive and high-intensity fire in the Gilan and Mazandaran forests in northern Iran. The results indicate that a mechanically-driven Foehn occurred in Alborz Mountains during 4-5 December 2012 and 3-9 January 2013 events. On the synoptic scale, the Foehn event occurred due to existence of a high pressure over the interior regions of Iran and lee cyclone over the southern Caspian Sea.

A strong pressure gradient in south-north direction across the Alborz Mountains is shown which was followed by a rapid increase in the intensity of the southerly wind in leeward side of the Alborz Mountains. Moreover, this study clarifies that, on these cases, the synoptic scale circulation is largely responsible for the flow characteristics over the Alborz Mountains, and temperature variability during Foehn event depends on large-scale advection and the source region of the flow. The results suggest that, the mountain waves excited over the northern slopes of the Alborz Mountains are the primary source of the localized southerly wind maximum around the lee side of Alborz.

1– Introduction

Foehn, a dynamic downslope wind phenomenon, has captivated the interest of scientists for over a century. Foehn winds occur in the presence of strong synoptic-scale flow that develops across mountain ranges, such as the Alps. Local air quality, surface air temperature and humidity are strongly influenced by the presence of Foehn.

Researches have identified two main mechanisms for the occurrence of Foehn around the world. First appears when wet air rises over the windward slope of a mountain and the latent heat of condensation is added to climbed air. The heat of the process is known as heating in lee stations, when air descent on the lee slope. This type is called the thermodynamic Foehn. The second mechanism occurs when a low-level inversion has been blocked in the windward side of a mountain and the upper drier layers descent in leeward (Brinkmann, 1971; Smith, 1979). This type is called blocking Foehn or mechanically forced Foehn.

While there is information about this type of winds in different parts of the world, especially the Alps in Europe, and the Rocky Mountains in North America, but there isn't detailed studies on this phenomena in Iran and we are often based on experience. In this study, to learn more about Foehn in Alborz, time

2– Methodology

Here, Foehn has been studied in southern Alborz Mountain range in northern Iran through a combination of observational, reanalysis and simulation data. To understand the structure of Foehn, reanalysis data of global forecasting system (FNL) have been used. In this study, changes in the specifications and synoptic conditions due to Foehn winds were investigated in a ten-year period (2001-2011). To this end, meteorological parameters such as potential temperature, relative humidity, pressure, wind speed and direction of number of stations in north and south of Alborz were examined during the course which were taken from the Islamic Republic of Iran Meteorological Organization (IRIMO). We used this data to provide a summary of the weather conditions on the north-south slopes of Alborz Mountains. Finally synoptic analysis used to investigate of weather conditions on regional scale during Foehn.

3– Study Area

Stations selecting is based on the area of study and of its impact range. As mentioned above, one of the most important effecting parameters on our study area as an example of Foehn wind is sharp rise of temperature and reducing of relative humidity on leeward of Alborz. So stations are selected so that they represent the weather condition on both sides of Alborz. Thus, Mehrabad (35 41N, 51 19E) station as windward, Rasht (37 19N, 49 37E) and Gorgan (36 51N, 54 16E) stations as leeward were chosen, in which Foehn occurs (Fig. 1).

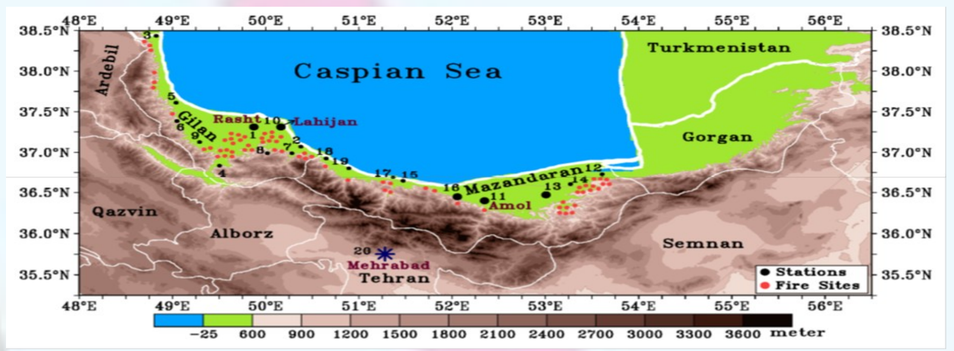

Figure 1. Area of study

4– Results

Studying of number of Foehns in versus of intensity of them for leeward eastern and western stations and average value of northern stations showed that there is an inverse relationship as estimate functions of them has been drawn in Fig. 2. Temperature changes (°C) on horizontal and Foehn numbers on vertical axes is characterized.

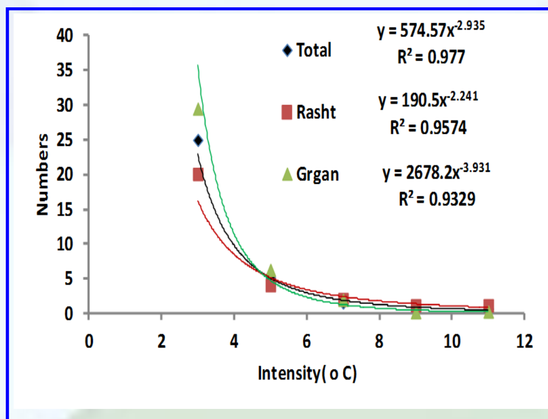

Figure 2. Comparison of Foehn numbers and their intensity between 2001-2009 for Rasht, Gorgan stations and average value of northern stations.

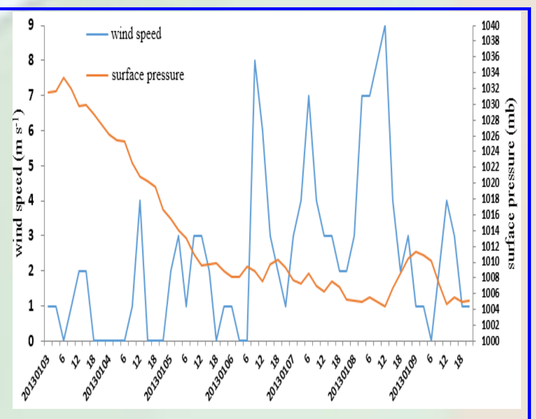

Figure 3. wind speed changes (m s^{-1}) and surface pressure (mb) in Rasht station for 4-6 December 2013.

One of the studied Alborz Mountains Foehns was occurred in Gilan province in 3-9 January 2013. Following figures show some meteorology parameters changes for that.

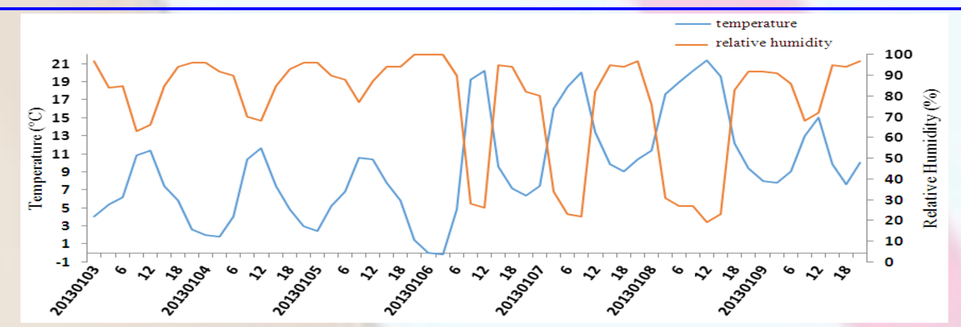

Figure 4. Temperature (°C) and relative humidity (%) changes in Rasht station for 3-9 January 2013.

Contours of potential temperature on 850 and 700 mb, surface pressure, geopotential height on 850 mb, relative humidity and cross section of potential temperature on longitude 52° in 6 January 2013 have been shown in figures 5-7. Pressure gradient between high pressure (1016 mb) in center of Iran and low pressure (1008 mb) over Caspian sea facilitate air flowing over Alborz mountains during Foehn. A ridge on west and northwest of Iran and a trough on Caspian Sea has been located on 850 mb level. Considering temperature maps shows increasing of temperature for leeward stations when Foehn had occurred. Also maps of relative humidity show decreasing of it, however because of precipitation, relative humidity had been increase windward of Alborz.

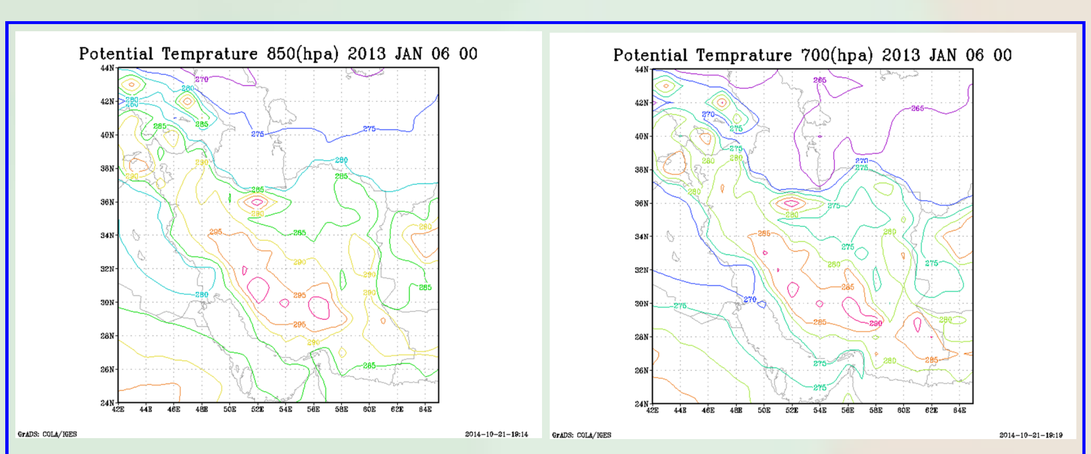

Figure 5. Contours of potential temperature (K) on 850 and 700 mb in 2013 JAN 0600.

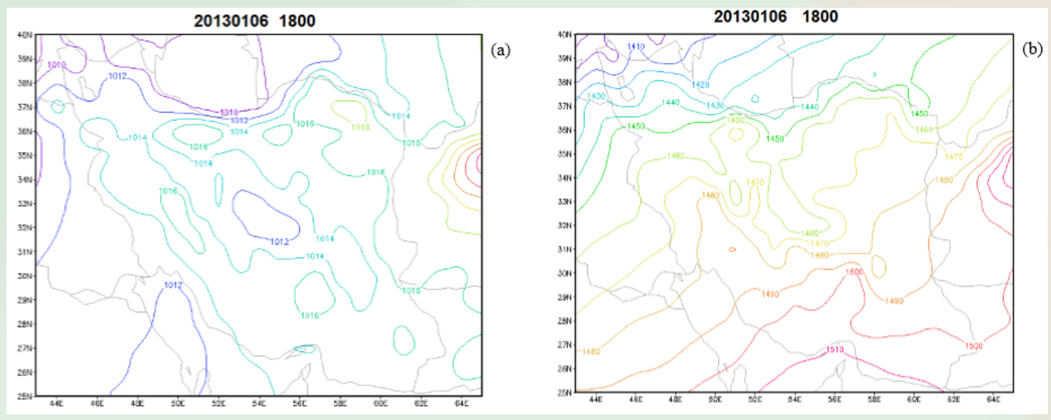

Figure 6. (a) Contours of sea level pressure with contour interval 2 mb and (b) geopotential height on 850 mb with contour interval 20 dm in 2013 JAN 0618.

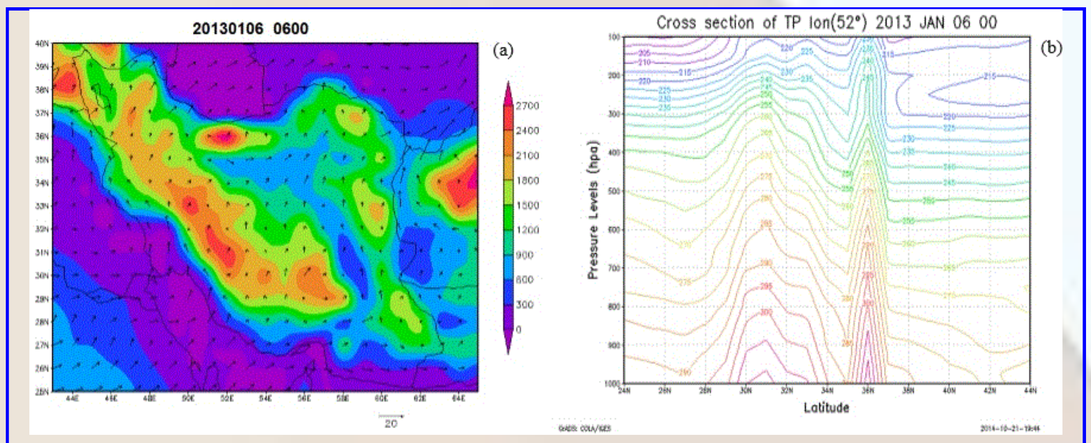

Figure 7. (a) Relative humidity and wind vectors (m s^{-1}) on surface and (b) cross section of potential temperature on longitude 52° 2013 JAN 0600.

5-Conclusion

The results indicate that a mechanically-driven Foehn occurred in Alborz Mountains during 3-9 January 2013. On the synoptic scale, the Foehn event occurred due to existence of a high pressure over the interior regions of Iran and lee cyclone over the southern Caspian Sea.

References

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