Climatic Analysis and Tracking of Comprehensive Dust Storms in the South and Central Iran

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Introduction

Dust storms as one type of dust events are in most cases the result of turbulent winds, including convective haboobs. These winds can raise large quantities of dust from desert surfaces and reduce visibility to less than 1 km. This dust storm reaches concentrations exceeding 6000 mg/m3 in severe events. The major dust source regions are the areas of arid and hyper-arid, with mean annual precipitation of less than 100 mm.

The temporal and spatial investigation of dust storms shows the interference of various factors in their occurrence and expansion. These factors are divided into two groups; environmental and human parameters. The climatic (such as low rainfalls, high evaporation, intense wind, drought and atmospheric general circulation) and geological (for example lithology such as Quarts, Clay, Silicate and feldspar) factors are natural parameters, and factors such as over-grazing and crop production, degradation of vegetation, increasing growth of population, war and political problems are human parameters.

Much of the current interest in dust storms is related to their possible role in the systems and subsystems of the earth. Dust loadings may affect air temperatures through the absorption and scattering of solar radiation. It may affect cloud formation, convectional activity, sulphur and carbon dioxide levels in the atmosphere, and influence geo-chemistry cycle, soil evolution and desertification.

Dust storms are one of the destructive climatic phenomena affected by various climatic elements such as pressure, precipitation, wind, temperature and evaporation. These phenomena impose much damages to human health, industrial and agricultural installation, population centers and communication ways. The recognition of source regions, creation and expansion style of dust storms and their relation to atmospheric circulation patterns are fundamental factors in reduction of their damages. In the recent decades, trend of dust storms has been increased in Iran, particularly in west and southwest areas. This factor is also raised the necessity of dust study in these areas more than before.

Frequency and intensity of dust storms in west and southwest parts of Iran has made this phenomenon one of the most principal environmental hazards of these regions. According to the extent of dust storms and their enormeous effects on health, economy, environment and agriculture and their increasing trend has drew the attention of many researchers. The recent study is carried out by data analysis of dust storms from Iran Meteorological Organization Earth Database.

Materials and Methods

In the research, environmental and circulatory databases were used to analyze the synoptic systems of Comprehensive Dust Storms in the South and Center of Iran. At first, the number of dust days was determined using climatic data of more than 30 synoptic stations in a 9-year period, from 2002 to 2009. Then, their

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circulation patterns were identified and plotted.The circulation patterns of extreme dust days was also identified and plotted in the study area. The meteorological data including the middle and upper atmosphere data such as the sea level pressure, level of 500 hPa geo-potential height, wind direction, vertical velocity, surface temperature and the subtropical wind profiles were received at 100-1000 hPa height from NCEP/NCAR database. They were drawn for 0-80 longitude and 10-70 latitude using GRADS software. Then, visibility, wind direction and velocity, relative humidity and precipitation were extracted for each day. WRPLOT VIEW VERSION 5.3 software was used for wind rose drawing by wind storms with direction and speed. HYSPLIT model was employed to recognize the origin of dust storms and wind flow routing in Shiraz, Fasa and Bushehr stations.

Results and Discussion

In the recent decades, the global effectiveness of dust storms has become increasingly apparent, so that, major advances have been occurred in sources, transport paths with many impacts both on humans and the environment, their frequency at different time scales. Earth database investigations show that one of the most extreme dust storms was occurred in year 2008 in terms of visibility reduction and durability of dust storm days in the period of this study. The June 10 in 2008 is the most extreme dust storm day with visibility of less than 500 meter in the stations. The mentioned dust storm as one of the most intense dust storms of the recent years can help recognize the atmosphere patterns causing this phenomenon and tracking of the winds transmitting aerosols.

The results of the middle and upper atmospheric circulation shows that the westerlies occurred in 2008 June 10 with a low pressure center in the east Iran and high pressure in the North Africa (Figs. 1 and 2). These conditions caused the entrance of dust into the study region.

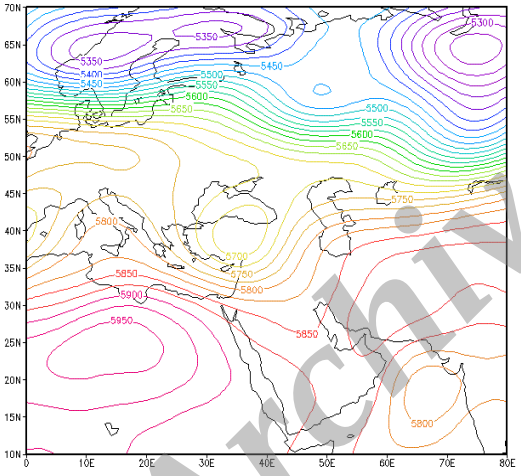

Fig. 1. map of 500 hPa at 10/6/2008

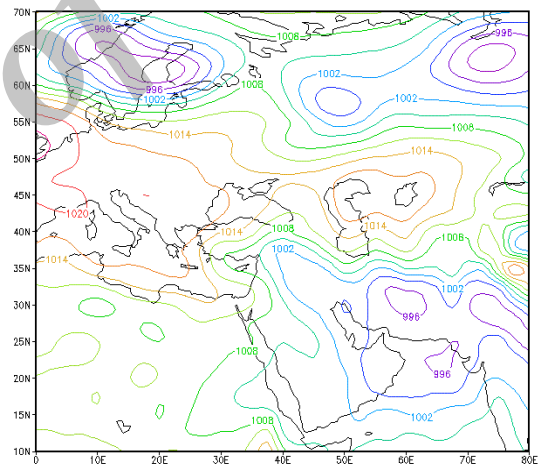

Fig. 2. map of sea level pressure at 10/6/2008

The isothermal map of sea surface represents the ascendancy of 50 degrees curve on the center of Iran. The isothermal map of 42.5 degrees is also on the East Saudi Arabia.The curves of 40 degrees have dominated on Iraq and Syria where causes temperature increase and drought air in the region.

Omega map of sea surface at June 10, 2008, indicates the -0.1 contour in Central regions of Iran. This shows the downward air flow in the area. Moreover, the central core of the upward flow, with contour of 0.2, is dominant in the North Saudi Arabia, Iraq and Syria. This illustrates an air mass with ascending movement in these areas.

The patterns related to humidity represent relative humidity of 10% in Iran. The specific humidity is also very low and is equal to 0.004 which represent minimum rates of humidity and very high drought causing or increasing dust storms in the studied day.

The results of wind flow routing by HYSPLIT model showed that the origin of dust storm mass had been in North West of Iraq and east Syria. They had entered Iran with a north west-south east direction (Figs. 3 and 4).

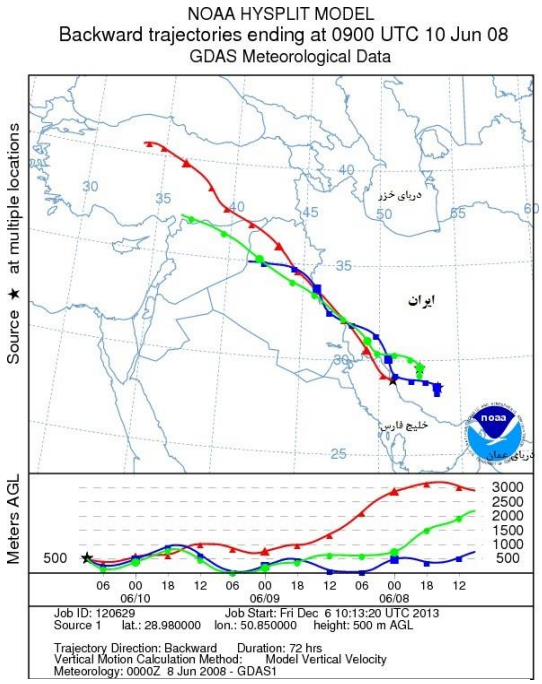

Fig. 3. Map of backward trajectories ending at 10/6/2008

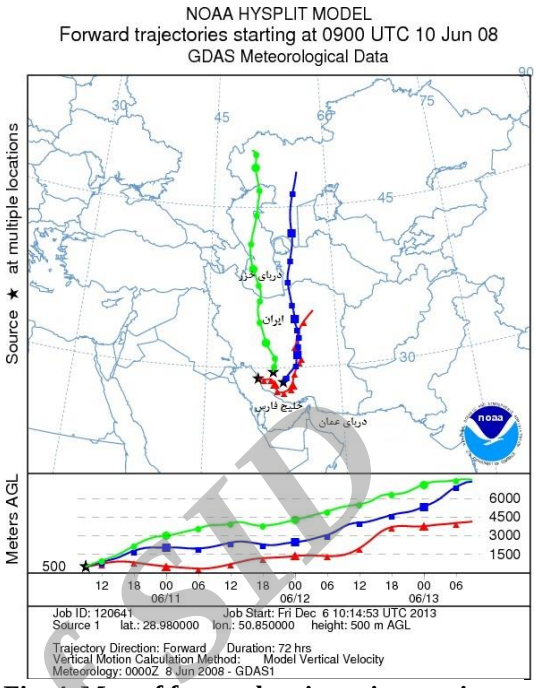

Fig. 4. Map of forward trajectories starting at 10/6/2008

Conclusion

The study about the circulation patterns transferring dust storms in the South and Center Iran is highly important. For example, the west region of Iran isn't a source of dust because of natural characteristics such as mountainous areas, high rainfalls and dense vegetation. But, dust storms of this region are non-local. This region is the transport path of climatic systems into Iran, and accepts the effectiveness of these systems. According to source regions of Iran, dust storms are usually dominated over hyper-arid lands of Iraq, Saudi Arabia, Syria and North Africa. This study is a connective step between large scale circulation patterns and temporal and spatial activities of dust storms in the South and Central parts of Iran.

This study has examined the relationship between large scale synoptic patterns and variability of space-time dust storm activities in Iran. The study has used synoptic maps of sea level pressure circulation patterns, 500 hPa geo-potential height, wind direction data, vertical velocity, and surface temperature with geo data of dust storms in the studied stations and wind flow tracking model. It can be concluded that dynamic models can be presented by consensus of various specialists for this destructive environmental phenomenon.Use of the capability of satellite imagery and dust storm investigatation can be of great importance for the future studies. In general, the results of this research show that wind flow routing model and atmosphere studies have the suitable capability for recognition and monitoring of dust storm paths.

Keywords: dust storm, tracking, synoptic analysis, wind flow routing.