Determining the Beginning of Summer Season in Iran on the Basis of Abrupt Northward Jump of the Subtropical Jet Stream over the Middle East

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Received: 27 July 2016
Accepted: 5 December 2016

1. Introduction

A season is a certain time of a year that is distinguished by alternation in timing and intensity of the solar radiation and atmospheric conditions (Zolfaghari, 2005). A natural season is a certain time of the year which can be separated by homogeneous weather type (Alsop, 1989). Considering the importance of season's determination, nowadays different methods have been using to determine the natural seasons by means of various parameters (Alijani, 1997). The methods are as follow:

Astronomical method: This method is determined based on the apparent motion of the sun. The beginning of the season happens in a fraction of a second. Nowadays, in addition to the astronomical definition, other definitions based on weather and climate criteria are required for determining the seasons that are known as climatological method (Zolfaghari, Masoompour Samakoush, Jaliliyan, & Fathniya, 2013).

Climatological method: This method uses the climatic variables along with the apparent motion of the sun. According to this method, a season is a certain time of the year which a weather phenomenon is happening regularly (Alijani, 1997).

Jet stream is a permanent member of the general circulation of the atmosphere that makes rapid flow of air in the tropopause (Kington, 1999; Kraus, 1999; Phillips, 1999). Jet streams have been used as a valid indicator to determine the beginning and the end of the natural seasons in some parts of the world. Sheng (1986) expressed that the abrupt changes of the subtropical jet stream over the Eastern Asia can be an indicator for separating natural seasons in the China. Kutie and Kay (1992) showed that the abrupt changes in the behavior of subtropical jet stream over the Middle East can be the main factor for occurrence of summertime climate change over the whole area. Also, the structure of large-scale atmospheric circulation over the Southwest Asia during warm period of the year has been investigated by Mofidi and Zarrin (2013). They introduced three atmospheric indices to determine the beginning and the ends of

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summer season over the Middle East. They found that the summer season is starting around June 3rd and it ends around October 15th, based on the jet index (Mofidi & Zarrin, 2012).

2. Study Area

In this study, the zonal wind component at 200 hPa from National Center for Environmental Prediction/National Centers for Atmospheric Research (NCEP/NCAR) reanalysis dataset at 2.5×2.5 degree global grids and 17 pressure levels for 30 years (1981-2010) have been employed. The data have been used for a 91-day period (April 16 to July 15) to clarify the behavior of upper troposphere jet stream over the Middle East in the early summer to identify the beginning of the summer season for the area.
For better and more accurate determining the position of the subtropical jet in the Middle East, with simple random sampling (random numbers table), 3 years were selected through 30 years to determine the scope of the study (1988, 1998, 2010). For study of each of these three years and the 91-days period, first, the day by day location of subtropical jet were pictured in an area larger than the Middle East (3×91=273 image). Then, the original location and preferred range of subtropical jet in the region were selected after evaluation. The beginning of the summer was the result of 27.5 °N-42.5 °N and 35 °E-65 °E to study of the behavior of the subtropical jet.

3. Material and Methods

The criteria for assigning subtropical jet jump is that every year during the advancing of the warm season, jet core has a sudden north jump up to the 3 to 5 degrees of latitude and place on summer position, only in a few days (Mofidi, 2007; Mofidi & Zarrin, 2012). After that jet does not return to lower latitude and stays on the same higher latitude.
First, 30 separate script and output images were obtained for 91-days of each 30 years. Subtropical jet stream jump and the beginning of the summer of each year is determined by observing these images. Then, geostatistics functions were defined that gave us an output text files for study area. These output files displayed a series of numbers that tells us about maximum velocity, latitude and longitude of zonal wind components:
Function amax: This function displays the greatest velocity in each script for that coordinates.
Amax (u, lon=35,lon=65, lat=27.5, lat=42.5)
Function amaxlocY: In this function, the Y-axis location of coordinates (latitude) is determined.
AmaxlocY (u1, lon=35, lon=65, lat=27.5, lat=42.5)
Other plots were made with these numerical outputs. The exact time of subtropical jet jump can be determined by using these plots and output images together.

4. Results and Discussion

After preparing the image and numeric outputs, the start and the end days for each year jet jump were converted to Julian day and the beginning of the summer were determined by using two methods:

A-The beginning of the summer season based on the time of start of the jet jump

In this way, the start time of the summer subtropical jet stream jump for each 30 years were converted to the Julian day and then were averaged. Finally, June 1 (3 weeks earlier than the date of astronomy) was determined for the beginning of the summer in the study area.

B-The beginning of the summer season based on the time of the end jet jump

In this way, in addition to the start time, the end time of jet jump for each year also was converted to Julian day and then was averaged. This method is more accurate because in addition to the start time, the end time also is taken into consideration. According to this method, the period between June 1 to June 9 was the most likely timeframe for the start of the summer season due to the behavior of subtropical jet. The middle of this time frame, that is June 5 (about 17 days earlier than the date of astronomy), was determined for the beginning of summer in the study area.

5. Conclusion

Results of this study showed that the climatic average beginning time of the summer does not match with the date of astronomy (June 22). It occurs since about 21 days earlier, i.e. June 1 (based on the start time of the jump) until 17 days earlier, i.e. June 5 (based on the end time of the jump) in the Middle East region. Chi-square calculations showed that this start date was not incidental. Actually, large-scale atmospheric circulation in area is in such a way that the beginning of the summer is earlier than the date of astronomy in this region.

Key words: Large-scale atmospheric circulation, Subtropical jet, Beginning of the summer, Middle East, Zonal wind component.

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