Climate Change of Iran: A Synoptic Approach

Reza Doostan*
Assistant Professor of Climatology, Ferdowsi University of Mashhad, Mashhad, Iran
Bohloul Alijani
Professor of Climatology, Kharazmi University, Tehran, Iran

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1. Introduction

Climate change refers to the increase or decrease in the average climatic factors over a long period of time (i.e. more than 30 years). Today, climate change has become a human concern and the scientific community are already aware of this fact. Global temperature has followed an unprecedented increase over the last hundred years. Based on synoptic climatology, climatic parameters and its changes are related to atmospheric patterns. In the atmospheric upper levels, the role of dynamic factors and atmospheric circulation is dominant (Alijani, 2006; Yarnal, 1993). "Understanding climate change through atmospheric patterns is closer to reality. The surface pressure patterns affect the moisture and the heat of the earth's surface, and there is uncertainty in climate change" (Lolies, 2007, p. 361). The arrival of the wave of westerly winds follows the cold period and the instability of weather in Iran. The study of Iran's climate change with synoptic patterns during the cold period is of great importance. Part of the studies in the literature include the investigation of climate change in the behaviors of climatic indices, the positive trend of North Atlantic Oscillation since 1979-1989 and northern hemisphere activity centers (Mote, 1998; Ostermeier &Wallace, 2003; Rauthe, Hense, & Paeth, 2004), the positive trend of the Mediterranean Oscillation Index, the negative trend of meridional circulation of Mediterranean and non-trend of the Eastern Atlantic Jet in the late 1980s (Dunkeloh, 2003), the shift of the East/West Center of Asian Summer index to the northwest and southeast and the reduction of their power after 1970 (Wu, 2002), the positive trend of East Atlantic Western Russia index, a reduction of pressure in high-pressure center of Siberia after 1970 (Panagiotopoulos, Shahgedanova, Hannachi, & Stephenson, 2005), the negative trends of North Atlantic Oscillation in winter, an increase in anticyclone and a decrease in cyclone in Europe since 1960 to the early 1990s related to the severity of zonal flow (positive index) from 1960s to early 1990s, and an increase in the maintenance of pressure patterns and the stronger blockings in the 1990s with the rising trend of Summer anti-cyclones (Kysely & Huth, 2006), the positive trend of North Atlantic Oscillation and the Azores center for the 500 Hp Europe is over the past 40 years in winter and spring (Casty, Raible, Stocker,Wanner, & Luterbacher,

* Corresponding Author: Email :doostan@um.ac.ir

2007). The aim of this study is thus to identify the climate change in Iran in relation to the atmospheric indices in the middle levels.

3. Methodology

The climatic indices of the cold period (Alijani & Doostan, 2015) were determined through analyzing the daily data of the reconstructed geo-potential height of 500 Hp from 1948 to 2010 in fall (September, October, & November) and winter (December, January, & February) collected from the database of the National Centers for Environmental Prediction-National Center Atmospheric Research (NCEP-NCAR) with a resolution of 2.5 degrees for geographic areas of 10 to 70 degrees in north and 10 to 80 degrees in east (725 cells) using Principal Component Analysis. The changes of indices were investigated along with the factor scores or their time series in 500 Hp. This series was investigated on daily, o, monthly, yearly, and five-day average scales during the study period; however, according to the lack of trend at all scales, annual time series in autumn and winter were used to study the changes along with the selection of a prediction model. This series shows the changes of each of the indices during the study period. To examine the trends in time series, the Box Jenkins models were used. The changes of each of the series over time were determined and the appropriate model for the series was fitted. This statistical model predicts the future time series for each of the indices.

4. Discussion

Climatic indices of autumn are located from Western Europe to Western Mediterranean, from Northern Siberia to the Balkans, and from Central Siberia to Central Asia. Given the order of climatic importance in Iran, indices of Northern Siberia, Western Europe, Anatolia, Central Asia and Central Siberia are in autumn. In winter, climate indicators are located on Central Asia, Western Mediterranean, the North Sea, Eastern Mediterranean, and Central Siberia. “These centers control the climate of Iran with special atmospheric patterns during the cold half of the year” (Alijani & Doostan, 2012, p. 255). The results showed that the time series of climate indices of the cold period lack a trend, and the index of Central Asia has a weak and insignificant trend. The time series of first order having a negative autocorrelation show the annual fluctuations (yearly changes). The time series of indices during autumn and winter with autoregressive model show distribution best fitting and validity. This model is the best predictor of changes in the time series; the predictive modeling of the time series of Northern Siberia index is the autoregressive sixth order (AR 1, 6). The time series of Western Europe is matched with the third-order autoregressive model (1, 3) AR. The time series of Anatolia index are in conformity with the sixth-order autoregressive model. The time series of Central Asia are totally in conformity with the fourth-order autoregressive model AR (1, 4). Of all the ARIMA models, the autoregressive model is the best model of predicting the climate changes in the winter time series of Central Asia, Western Mediterranean, and the North Sea indices in which the time series of indices are in conformity with the time series of predicting modeling.

5. Conclusion and Suggestion

Indices of the cold period are in conformity with the location of the frequent westerly winds pattern in atmospheric middle layers with trough, ridge, cutoff low, and the blocking of westerly wind arrangement. These geographic regions in the atmospheric middle layers with the stable and unstable atmosphere and the movement of air masses control the climate in their surrounding areas. The time-series of these indices do not show any significant positive or negative changes during the study period (63 years) in autumn and winter. The temporal behavior of these indices include the annual changes and variability. In addition, the negative first-order autocorrelation in relation to the whole time-series has confirmed the annual changes (yearly) of the indices. These results are in agreement with the previous studies in other regions of the planet, including the insignificant change of climatic indices in the Middle East, the Caspian Sea pattern (in accordance with the position of Western Europe-North-Sea Caspian Index in this study), the Eastern Mediterranean, and the Mediterranean Oscillation Index in 500 Hp level (Dunkeloh, 2003), the lack of trend of pressure patterns in 500 Hp in Europe and North Atlantic (Casty, Raible, Stocker, Wanner, & Luterbacher, 2007), and the insignificant changes in pressure patterns in 500 Hp level in Iran. Box-Jenkins models indicated these changes and fluctuations in each of the time series and confirmed the lack of a significant trend in this series. Fluctuations in each of the time series of climate indices in Iran are in conformity with autoregressive (AR) model. This model can predict future changes in the time series with different orders in each series.

Keywords: Climate change, Climatic index, Pressure pattern, Box-Jenkins Model.

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