Specific Humidity Correlation with North Atlantic Oscillation Using NCEP Reanalysis Data over Iraqi-Kurdistan Region

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Abstract

North Atlantic Oscillation (NAO) in the Northern hemisphere is a large teleconnection pattern affect on the climate of the Mediterranean countries. The aim of this research is to investigate the effect of NAO on specific humidity over Iraqi-Kurdistan region at different pressure levels using NCEP/NCAR reanalysis data. It's concluded that there is a negative correlation coefficients between NAO and specific humidity at all pressure levels. The correlation coefficients are high at high pressure levels and low at low pressure levels in Jan and Dec, no obvious behaviour for the correlations at the other months. Maximum correlations obtained in winter are in the range of pressure levels 925-1000 mb, in the pressure level range 300-600 mb at spring ,in the rage 500-600 mb for summer and at 400-600 mb in autumn , thus the NAO cause to increase the specific humidity at the mentioned pressure levels due to reach a moist air from the Atlantic to the Mediterranean and then to the region of study, also the NAO affect the specific humidity of the region at the relatively cold season more than the relatively hot season because the NAO has more activity in Cold seasons than the hot seasons .

Key words: North Atlantic Oscillation, National Centre for Environmental Prediction, National Centre for Atmospheric Research, Sea Level Pressure, Correlation.

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ارتباط الرطوبة النوعية مع ذبذبة شمال اللاطلسي في اقليم كردستان-العراق باستخدام بيانات المركز الوطني للتنبؤ البيئي

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الخلاصة

ان ذبذبة شمال اللاطلسي في نصف الكرة الشمالي هي واحدة من كبرى الظواهر المناخية التي تؤثر في مناخ دول البحر المتوسط. ان الغرض من هذا البحث هو التحري عن تاثير ذبذبة شمال اللاطلسي على الرطوبة النوعية في اقليم كردستان-العراق في مستويات ضغطية مختلفة باستخدام بيانات المركز الوطني للتنبؤات البيئية /المركز الوطني للبحوث الجوية. تبين ان هنالك معاملات ارتباط سالبة بين ذبذبة شمال الاطلسي والرطوبة النسبية في كل المستويات الضغطية, معاملات الارتباط تكون عالية في المستويات الضغطية العليا وواطئة في المستويات الضغطية السفلى في اشهر(كانون الثاني , كانون الاول) , حيث لايوجد سلوك واضح واضح لمعاملات الارتباط في الاشهر الاخرى. اعلى معاملات ارتباط تم الحصول عليها في الشتاء في المستويات الضغطية 925-1000ملي بار, في المستويات الضغطية 300-600 ملي بارفي الربيع, في المدى 500-600ملي بار للصيف وفي 400-600 ملي بار في الخريف, وهكذا فان ذبذبة شمال الاطلسي تسبب زيادة الرطوبة النوعية في المستويات الضغطية المذكورة بسبب وصول هواء رطب من الاطلسي لمنطقة المتوسط ومنها الى منطقة الدراسة, كذلك ان ذبذبة شمال اللاطلسي تؤثر على الرطوبة النوعية في المنطقة في الفصول الباردة نسبيا اكثر منها في الفصول الدافئة نسبيا وذلك بسبب ان ذبذبة شمال اللاطلسي تكون ذات نشاط اعلى في الفصول الباردة منها في الدافئة.

الكلمات المفتاحية: ذبذبة شمال اللاطلسي , المركز الوطني للتنبؤات البيئية , المركز الوطني للبحوث الجوية , مستوى سطح البحر, معامل الارتباط.

Introduction

Studies of the North Atlantic Oscillation have become a central focal point of the climate research for the next decade .The NAO is a fluctuation in the sea level pressure difference between the Icelandic low and the Gibraltar or Azores high [1]. The NAO and ENSO (El-Nino Southern Oscillation) phenomenon are two major source of seasonal to inter-decadal

variability in the global scale [2]. The NAO is one of the most predominant and recurrent patterns of the atmospheric circulation variability so variations in NAO are important to society and for the environment. The importance of NAO account for a myriad of remarkable changes in the climate over the middle and high altitude of the Northern Hemisphere, as well as in marine and terrestrial ecosystem [3].

The NAO refers to redistribution of atmospheric mass between the Atlantic and subtropical Atlantic ,and swings from one phase to another to produce large changes in the mean wind speed and direction over the Atlantic, the heat and moisture transport between the Atlantic and the neighbouring countries, and the number of storms their paths, and their weather .Agriculture harvests, water management ,energy supply and demand , and their yields from fishers ,among many other thing are directly affected by NAO [4] .

The NAO is quantified by NAO index which represents both the phase and amplitude of the NAO. The NAO index can be calculated using the flowing equations [5]:

$$slp_{st} - \overline{slp_{st}} = slp_{st\ anomaly} \quad \ldots\ldots\ldots\ldots \quad (1)$$

slp_{st} = subtropical sea level pressure

$\overline{slp_{st}}$ = Average subtropical sea level pressure

$$slp_{sb} - \overline{slp_{sb}} = slp_{sb\ anomaly} \quad \ldots\ldots\ldots\ldots \quad (2)$$

slp_{sb} = subpolar sea level pressure

$\overline{slp_{sb}}$ = Average subpolar sea level pressure

$$NAOI = \frac{slp_{st\ anomaly}}{S.D_{st}} - \frac{slp_{sb\ anomaly}}{S.D_{sb}} \quad \ldots\ldots\ldots\ldots \quad (3)$$

$S.D_{st}$ = Standard deviation of $slp_{st\ anomaly}$

$S.D_{st}$ = Standard deviation of $slp_{st\ anomaly}$

NAO index is defined by many scientists ,the index used in this study Is defined by jones (1997) based on the difference between standardized SLP between from Gibraltar

(Subtropical) and Reykjavik, Iceland (Subpolar) [6,7], Changes of more than 1ºC in the DJF averaged surface temperature are associated with a one standard deviation changes in the NAO index [3]. the winter NAO index[DJFM] time series is explained in fig. (1).

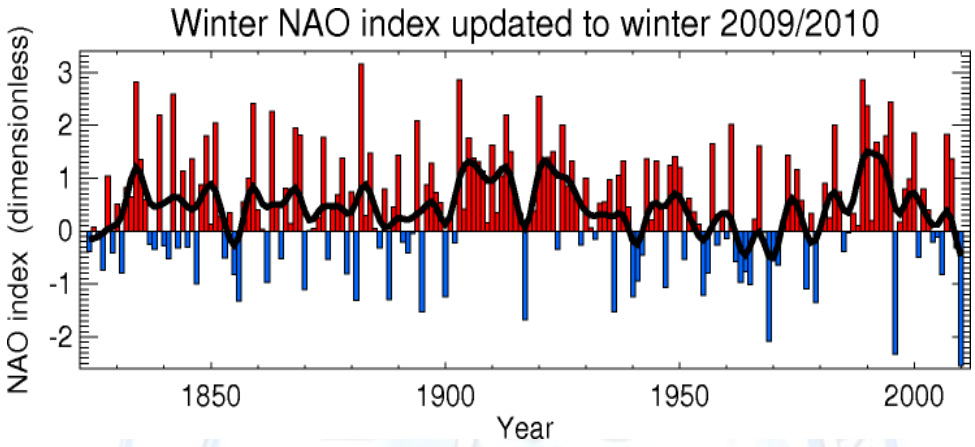

Fig. 1: The time series plot of NAO index for winter (Dec-Mar) based on normalized sea level pressure between Gibraltar and Iceland for the period (1823-2009) [8].

The negative NAO index phase shows weak subtropical high and weak Icelandic low, thus the pressure gradient is reduced, this situation leads to bring moist warm air into the Mediterranean and cold dry air to north Europe [9] . The positive NAO index phase shows a stronger than usual subtropical high pressure centre and deeper than normal Icelandic low .The increased pressure difference results in more warm and wet winters in Europe and cold dry winters in Mediterranean [10].

Tigers –Euphrates head water region (Turkey) have shown significant inter-annual to decadal variability associated with NAO. Comprehensive correlation is observed between wet (dry) years over west of Iran region with a mark negative (mark positive) phase of NAO index [11].

The correlation coefficient (r) use to test for linear association, and its a bivariate relationship which describes the relation between two variables x and y, and is given by equation 4 [12] :

$$r(x,y)=\frac{\sum xy-[(\sum x)(\sum y)]/n}{\sqrt{\left[\sum x^2-(\sum x)^2\right]/n}\sqrt{\left[\sum y^2-(\sum y)^2\right]/n}} \qquad \ldots\ldots\ldots\ldots(4)$$

The correlation coefficient value lies between –1 and +1.

Data analysis

The National centre for Environmental Prediction (NCEP) and national centre for atmospheric research have cooperated in project (denoted reanalysis) to produce a retroactive record of more than 50 years of global analysis of atmospheric fields in support of the needs of the research and climate monitory communities ,this effort involved the recovery of land surface ,ship, rawinsond, pibal, air craft, satellite and other data ,these data were then quality controlled and assimilated with a data assimilation system kept unchanged over the reanalysis period [13,14] .Balloon-born radiosond measurements are the base of the NECP reanalysis atmospheric humidity data that are available for the entire globe at each of the standard pressure levels 300,400,500,600,700,850,925,1000 mb , the data are continuously from 1941 to the present.

Monthly averages of specific humidity (q), relative humidity R.H available directly from the NCEP reanalysis, derived data provided by NOAA/OAR/ERL physical science division from its web site at: http://www.esrl.noaa.gov/psd/cgibin/data/timeseries/time- series1.pl . The data are reported with 2.5° latitude-longitude geographic resolution. The studied region is Kurdistan region located in the girded box of NCEP/NCAR reanalysis at longitude range 42.5-45 and latitude range 37.5-35.

The reanalysis data are actually the output of global weather forecasting model operated in a mode that continuously assimilates observed data from the world wide network of meteorological observations. The model interpolates meteorologically coherent values of q, RH and T into those grid boxes where there are no actual measurements [15].

Results and Conclusions

To investigate the domains of the influence of the NAO on the specific humidity at different pressure levels (300,400,500,600,700,825,950,1000 mb) over Kurdistan Iraqi region ,correlation coefficients was computed between the NAO index and the specific humidity for each month (Jan-Dec) at the mentioned pressure levels for the period 1988-2009. Figures (2 – 13) shows that there is a negative correlation coefficients between NAO index and specific humidity at all pressure levels i.e. the negative NAO phase cause to bring a relatively high humidity amounts (moist air) to the region and on the flip side the positive NAO phase causes to bring a relatively dry air at the mentioned pressure levels at all months except some weak correlations at Jul.

From the fig. 2 to fig. 13 is concluded that correlations are relatively high at high pressure levels and low at low pressure levels in Jan and Dec months i.e. the NAO cause a higher specific humidity at surface layers (high pressure levels) and low specific humidity at low pressure levels (upper air), that happened at Dec and Jan months which are the top of winter season where the NAO phenomenon are at maximum activity.

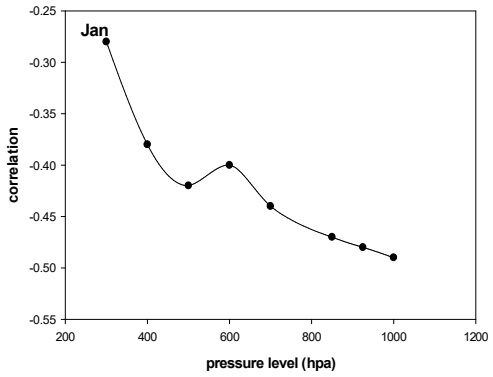

Fig. 2: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Jan

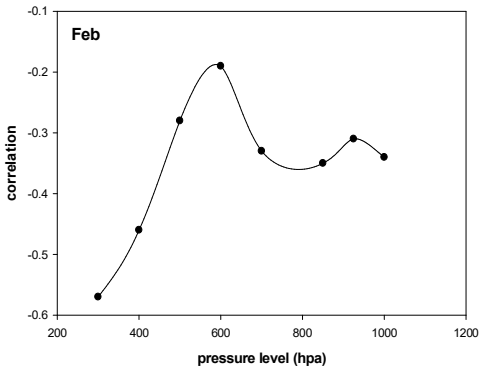

Fig. 3: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Feb

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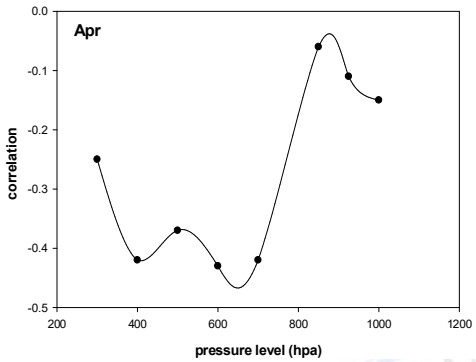

Fig. 4: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Mar

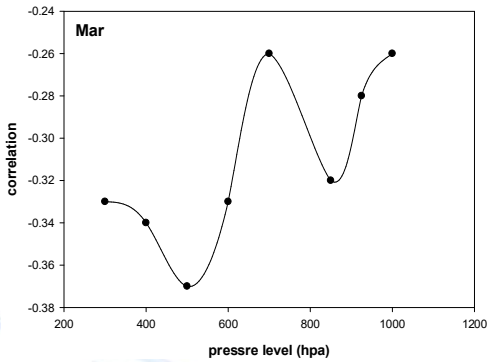

Fig. 5: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Apr

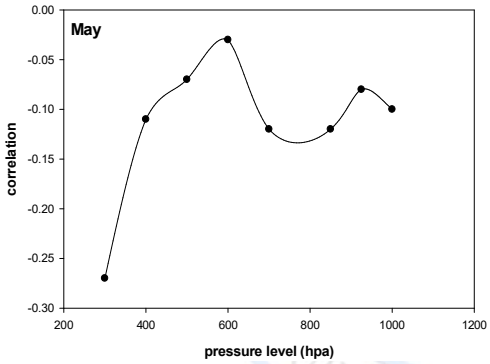

Fig. 6: Correlation coefficient of specific humidity with NAOI as a function of pressure level at May

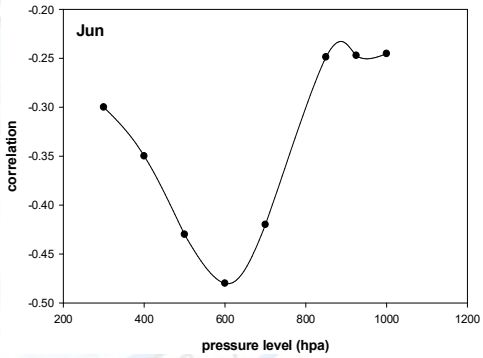

Fig. 7: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Jun

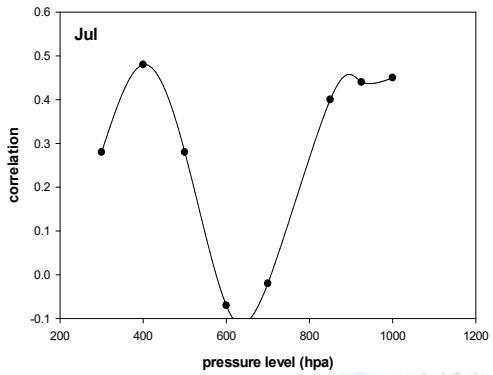

Fig. 8: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Jul

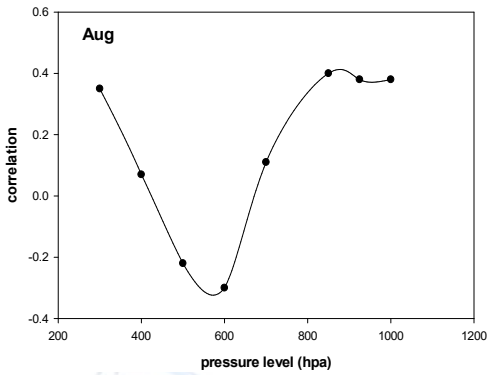

Fig. 9: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Aug

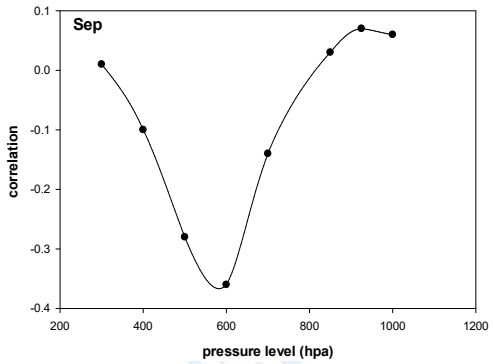

Fig. 10: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Sep

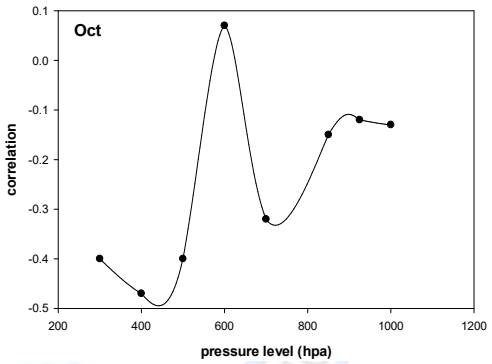

Fig. 11: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Oct

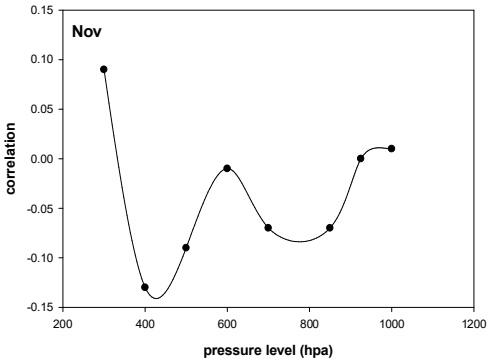

Fig. 12: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Nov

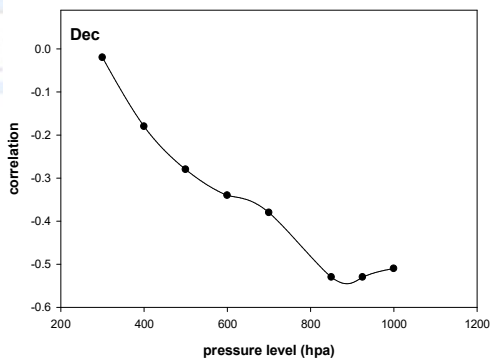

Fig. 13: Correlation coefficient of specific humidity with NAOI as a function of pressure level at Dec

Figures 3,4,5,6,7,8,9,10,11,12 shows that there is no obvious behaviour for the effect of NAO on specific humidity at different pressure levels. Figures 13, 2, 3 which are the winter months show that maximum correlation are at 925-1000 mb range except an anomaly behaviour at Feb month which is at 300 mb. Figures 4,5,6 which are the spring months (MAM) shows that the max correlation is in the range 300-600 mb. Figures 7,8,9 are summer months (JJA) the correlation at the range 500-600 mb, and max correlation at the range 400-600 mb for autumn months (SON) which is clear from the figures 10,11,12 , this means that the NAO phenomenon is more affect on specific humidity at the mentioned pressure level range where the correlation is maximum for each of the four seasons .

From the table (1) results shows that correlation coefficients have a higher value at winter months and decreased toward spring months and also for summer (except at Jun have a relatively high value) ,and then correlation coefficients again increased at autumn. i.e. the NAO is more affect on specific humidity at winter season and this activity decrees toward spring and also for summer ,but start to increase the effect at autumn.

Table (1): Average correlation coefficients of NAO index and specific humidity for the pressure levels (300-1000 mb) at each month.

Month	Correlation
JAN	-0.421
FEB	-0.353
MAR	-0.31
APR	-0.277
MAY	-0.115
JUN	-0.339
JUL	0.06
AUG	-0.05
SEP	-0.23
OCT	-0.241
NOV	-0.034
DEC	-0.344

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