Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 04-2023
DOI 10.17605/OSF.IO/EYTDA

VARIATION OF DEWPOINT TEMPERATURE OF KURDISTAN REGION OF IRAQ

RADHWAN FAREEQ HUSSEIN
Department of physics, Faculty of Science, University of Zakho, Kurdistan region-Iraq.
Email: radhwan.hussein@staff.uoz.edu.krd

DIYAR AHMAD BLEEJ
Department of physics, Faculty of Science, University of Zakho, Kurdistan region-Iraq.
Email: diyar.bleej@uoz.edu.krd

SUZAN MAHAMAD HAJI
Department of physics, Faculty of Science, University of Zakho, Kurdistan region-Iraq.
Email: suzan.haji@uoz.edu.krd

ALAN IBRAHIM SAEED
Department of Environmental Sciences, Faculty of Science, University of Zakho, Kurdistan region-Iraq.
Email: alan.saeed@uoz.edu.krd

Abstract

Statistical analysis of dew point temperature and other meteorological parameters are very important for climatic variability. Seasonal and annual data of dew point temperature for some meteorological stations in Kurdistan region of Iraq were analyzed to determine their magnitude and trends using statistical linear regression method with (SPSS) program and the inverse distance weighting (IDW) interpolation method of (ArcGIS). The spatial analysis shows that seasonally the highest and lowest values were recorded at Erbil and Amedi stations of (13.41 ^{o}C, -1.39 ^{o}C) at summer and winter seasons respectively, and for mean annual variation the maximum and minimum mean values of dewpoint also recorded at Erbil and Amedi stations of (9.02 ^{o}C, 2.61 ^{o}C), respectively. Temporally, the seasonal dewpoint temperature trends have positive variation at most of stations, while in Duhok, Zakho and Pirmam stations have negative trend value at summer season. Seasonally, Kalar station has maximum positive trend with value of (0.741 ^{o}C/year), on the other hand, the minimum dewpoint trend of (-0.292 ^{o}C/year) detected at Pirmam station. The annual trends were positive at all of stations in study area with significance correlation for most stations, the highest and lowest increasing trend were recorded at Kalar and Duhok stations of (0.361 ^{o}C/year, 0.071 ^{o}C/year) respectively.

Keywords: Dewpoint Temperature, Regression, GIS, Climate, Kurdistan Region

1. INTRODUCTION

Climate change has become the most important environmental matter of concern in the last hundred years of the world because of its direct and indirect effects on human life. Global warming is caused by rising greenhouse gas levels in the atmosphere which has a large probability of affecting the hydrological cycle. Temperature is an important factor in identifying climatic change caused by industrialization and urbanization (Wahab 2016). According to the fourth assessment report of the Inter-Governmental Panel on Climate Change IPCC reports and climate scientists evaluated that the earth's mean surface air temperature increased by 0.74 ˚C throughout the twentieth century (IPCC 2007). According to the report, human activities that increase greenhouse gas

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 04-2023
DOI 10.17605/OSF.IO/EYTDA

emissions are responsible for to increase in average global surface temperature (Stocker et al. 2013).

The main key to understanding the dynamical and radiative aspects of climate change is changes in the atmosphere's humidity (Held IM & Soden BJ 2000). Humidity is the quantity of water vapor in the air, it counts for just around 1/10,000th of the total quantity of water in the universal hydrological cycle.

Some factors affect the temperature and absolute water vapor in the atmosphere, such as the increasing number of residents, human activities, transportation tools, electric generators, industry, factories, petroleum companies, etc., because they are increasing the number of atmospheric greenhouse gases. The number of residents of the Kurdistan region-Iraq has increased rapidly and heavily in recent years, resulting in a significant increase in greenhouse gas emissions, which contribute to global warming.

The temperature of Dew point is the temperature at which the water vapor existing in the air condenses into water droplets or dew at constant air pressure. Dew point with relative humidity are tools used in prognoses of weather and to express the moistures amount in the air, they are different. Dew point expresses the moisture level of air, while Relative humidity represents the percentage of degree of air saturation. This means that the higher the dew point temperature, the air have more moisture and vice versa. When the dewpoint temperature becomes closer to air temperature the air becomes more humid (Yousif and Tahir 2013).

Dew point temperature usually has been the most commonly used parameter for measuring humidity. It is a significant tool for forecasting both relative and specific humidity. So, any change in dew point temperature results a change in amount of relative humidity (Van Wijngaarden and Vincent 2004). Therefor the water vapor of air is the strongest influence to the atmospheric greenhouse effect, so that any changes in the dew point temperatures in air would have significant implications for climate change.

Dew point have large influence on cloud formation, fog, and smog, as well as also has an impact on atmospheric vision (Ahrens 2000). Moreover, humidity is the most serious dangerous factor in the global because it influences changes in precipitation intensity and geographical distribution (Wentz et al. 2007). These changes have directly and indirectly dangerous impacts on human health patterns and psychology. In addition, it affects environmental natural disasters such as earthquakes, volcanic eruptions, hurricanes, tsunamis, floods, droughts, etc.(Morsy and El Afandi 2021). Dewpoint temperature, relative and absolute humidity has the potential to be extremely useful tools in climate study (Abdulwahab 2015). Nevertheless, a limited studies have been done to examine the variation of dew point temperature and relative humidity to precipitation and air temperature. Different studies have been done in most parts in the world, and they observed an increasing patterns of Dewpoint temperature and relative humidity. (Robinson 2000) observed the trend variation of dew point temperature in different stations of USA, and he found an increasing in seasonally dewpoint temperature for period (1951–1990). (Gaffen and Ross 1999) showed an increase in Dewpoint temperature and specific humidity over most of USA in winter, summer and

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 04-2023
DOI 10.17605/OSF.IO/EYTDA

spring season. (Seidel et al. 2007) concluded a decreasing trend in Dewpoint temperature in Summit of Mount Washington of New Hampshire. (Talaee, Sabziparvar, and Tabari 2012) analyzed an increase in relative humidity and dew point temperature in northern and southern Iran's coastal regions by (1.03 and 0.28 %/decade,0.29 and 0.15 °C/ decade) respectively over the period 1966-2005.(Mortuza et al. 2014) assessed spatiotemporal changes in dew point temperature from 1961 to 2010 through Bangladesh and they determined that on the annual, pre-summer and winter season scales, the dew point temperatures time series doesn't have significant downward trend at seasonal and annual series at any of the stations.

The main goal of this study was to analyze the spatial and temporal variation of seasonal and annual mean Dew point temperature at different locations in Kurdistan Region of Iraq depending on data of meteorological stations using geographic information system (GIS) interpolation method and parametric linear regression method with SPSS program.

2. STUDY AREA AND DATA

The study area is focused on the Iraqi Kurdistan region. It is situated in the north part of Iraq; the geographical coordinates of the Kurdistan region are approximately between longitudes (43° and 46°) East and latitudes (35°N and 37°) North in the Northern Hemisphere as represented in table (1). It shares boundaries with Turkey in the (northern), Iran(eastern), Syria (western), and other the governorates of Iraq (southern) as shown in figure (1).

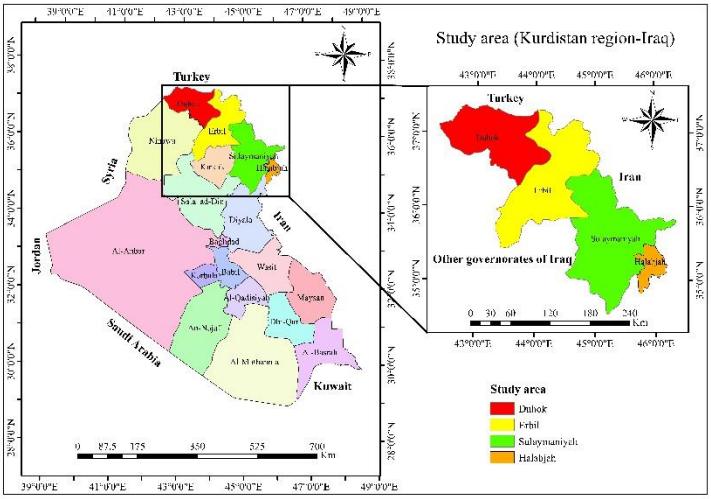


Figure 1: Study area (Kurdistan Region of Iraq)

The study area has a continental climate, which is hot and dry in summer, while it is cold and rainy in winter, and the spring and autumn are short transitional seasons (MUSTAFA 2018).

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 04-2023
DOI 10.17605/OSF.IO/EYTDA

Table 1: Geographical coordinates of selected stations in study area

Weather station	X-Longitude (East)	Y-Latitude (North)	Elevation (m)
Amedi	43° 29'	37° 5'	1195
Duhok	42° 59'	36° 55'	569
Zakho	42° 40'	37° 8'	433.8
Erbil	43° 59'	36° 11'	470
Pirmam	44° 11'	36° 23'	1088
Halabja	45° 59'	35° 10'	621
Chamchamal	44° 49'	35° 31'	710
Kalar	45° 19'	34° 40'	217
Sulaymaniyah	45° 26'	35° 33'	884.8

For the current study, the annual and seasonal mean dewpoint temperature data of nine selected stations have been obtained from the Erbil General Directorate of Meteorology and Seismology (EGDMS), these stations have been selected depending on the data availability. The parametric regression method with SPSS program has been used to analyze the seasonal and annual dew point temperature data temporally, and the spatial variations were analyzed using the inverse distance weighted (IDW) interpolation (ArcGIS) or (ArcMap) program.

Kurdistan region-Iraq has a variety of natural elevations, because it is surrounded by the biggest and highest mountains along its borders. The geographic coordinates of selected meteorological stations of study area are demonstrated in figure (2).

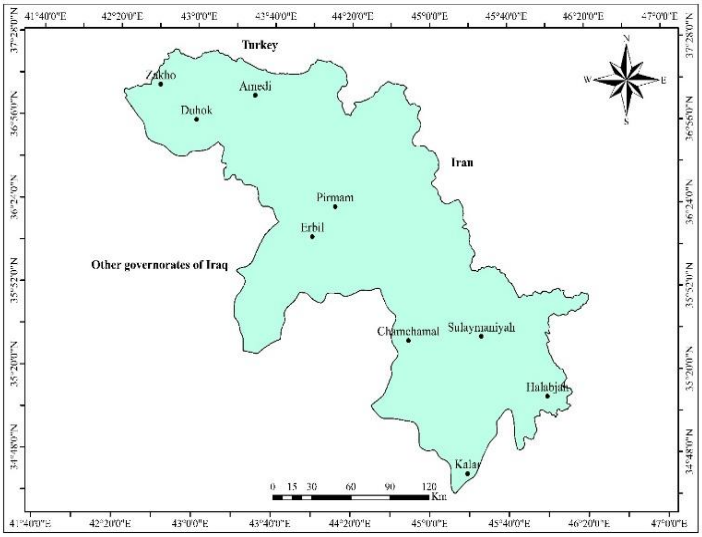


Figure 2: Location of Selected Meteorological Stations

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 04-2023
DOI 10.17605/OSF.IO/EYTDA

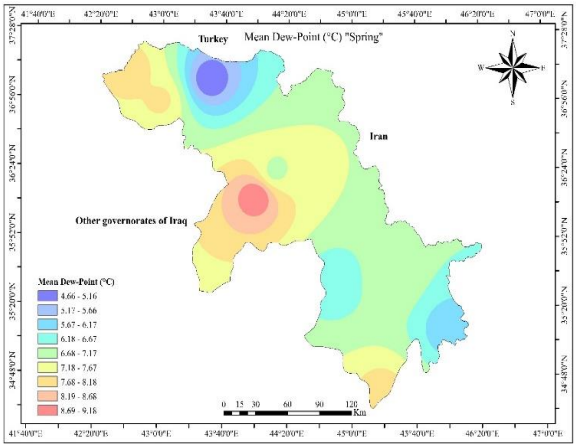
3. RESULTS AND DISCUSSION

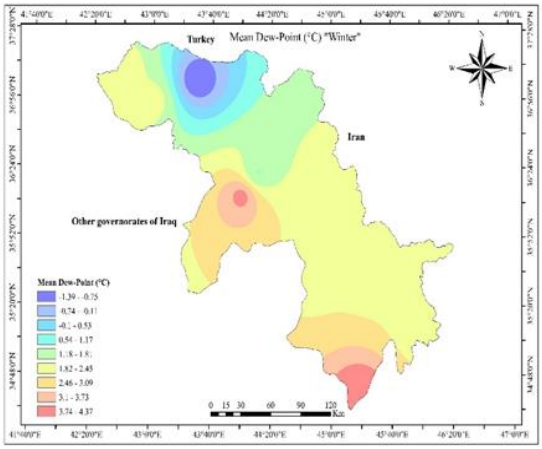
Seasonal and annual dewpoint temperature averaged over the Kurdistan region of Iraq during the period (2006-2020) as shown in table (2). The Geographical Information System (GIS) was used to map the spatial distribution of annual and seasonal dew point temperature for study area, these maps were analyzed by the inverse distance weight (IDW) interpolation method.

The minimum and maximum mean values of dewpoint temperature that have been recorded at Amedi and Erbil stations are (-1.39ºC and 13.41ºC) in winter and summer, respectively. While dewpoint temperature levels increased across the study area during the summer season, which is the hottest season in the country, in this season dewpoint value varies from was 2.22ºC to 13.41ºCin all stations. In the winter season, the values of dew point were decreased at all weather stations, which is ranged between -1.39ºC and 4.37ºC at Amedi and Kalar stations respectively. According to meteorological data, the smallest and biggest annual mean dewpoint temperature values were (2.61ºC and 9.02ºC) at Amedi and Erbil stations, respectively.

Table 2: Descriptive statistics for annual and seasonal dew point temperature of study area

Stations	Winter		Spring		Summer		Autumn		Annual	
	Mean	C.V %	Mean	C.V %	Mean	C.V %	Mean	C.V %	Mean	C.V %
Amedi	-1.39	-95.04	4.66	20.33	5.27	19.66	1.91	88.85	2.61	43.22
Duhok	2.11	62.08	7.80	16.21	11.19	16.79	7.37	25.29	7.12	15.56
Zakho	2.07	92.60	7.91	22.12	9.97	11.29	7.31	27.52	6.81	15.31
Erbil	3.94	39.55	9.18	15.91	13.41	13.32	9.54	13.53	9.02	12.65
Pirmam	1.16	117.03	7.00	30.73	12.33	13.89	9.57	46.27	7.51	17.35
Halabja	1.98	42.96	5.79	26.57	2.22	40.02	2.74	71.78	3.18	23.82
Chamchamal	2.33	47.60	6.25	17.79	7.69	13.08	6.26	22.65	5.64	17.03
Kalar	4.37	32.58	7.96	25.32	7.08	52.80	6.00	31.26	6.35	23.58
Sulaymaniyah	2.20	59.38	7.05	19.79	9.51	12.13	7.20	18.29	6.49	16.07





Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 04-2023
DOI 10.17605/OSF.IO/EYTDA

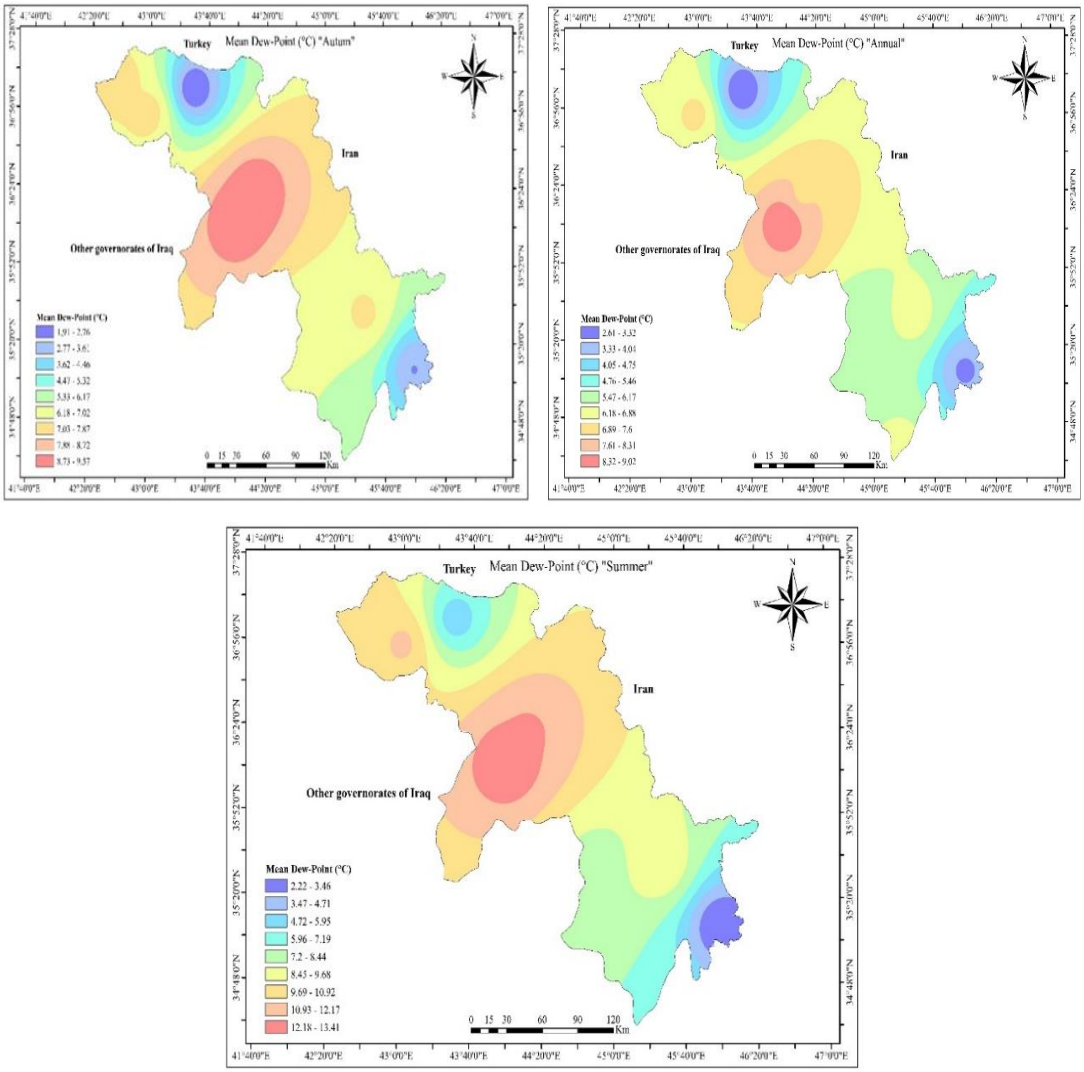


Figure 3: Shows the spatiotemporal variability of annual and seasonal dew point temperature of Kurdistan region-Iraq (ºC)

In the second part, the regression analysis has been used for annual and seasonal mean dewpoint temperature to detect the trends of their time series, as shown in table (3), the slope of the linear regression analysis for annual dewpoint temperature was positive for all stations with high correlation coefficient (R) at most of stations, the largest value of slope was detected in Kalar station of (0.361 ºC/year). For seasons, most of stations have positive trend of dewpoint except in summer season which have negative dewpoint trends in Duhok, Zakho and Pirmam stations, maximum dewpoint slope in summer season recorded in Kalar station of (0.741 ºC/year) with low correlation value. For winter season, the highest slope with significant correlation is calculated at Zakho station of (0.307 ºC/year). The maximum slope value at spring season is (0.537 ºC/year) at Kalar station with significance correlation, while for autumn season the maximum slope recorded at Amedi station of (0.510 ºC/year).

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 04-2023
DOI 10.17605/OSF.IO/EYTDA

Table 3: The values of correlation coefficient R with statistics b (degree centigrade per year) of linear regression method for seasonal and annual dew point temperature time series.

Stations	Winter (ºC / Year)		Spring (ºC / Year)		Summer (ºC /Year)		Autumn (ºC / Year)		Annual (ºC / Year)	
	R	b	R	b	R	b	R	b	R	b
Amedi	0.442	0.370	0.372	0.223	0.498	0.327	0.476	0.510	0.500	0.357
Duhok	0.704	0.206	0.429	0.121	-0.129	-0.054	0.027	0.011	0.287	0.071
Zakho	0.717	0.307	0.528	0.207	-0.396	-0.100	-0.192	-0.086	0.351	0.082
Erbil	0.758	0.264	0.507	0.165	0.628	0.251	0.360	0.104	0.769	0.196
Pirmam	0.645	0.196	0.444	0.214	-0.764	-0.292	0.251	0.248	0.313	0.091
Halabja	0.205	0.081	0.576	0.410	0.741	0.305	0.152	0.138	0.665	0.234
Chamchamal	0.304	0.111	0.721	0.265	0.160	0.053	0.177	0.083	0.404	0.128
Kalar	0.088	0.058	0.576	0.537	0.428	0.741	0.126	0.109	0.521	0.361
Sulaymaniyah	0.425	0.154	0.538	0.208	0.728	0.233	0.452	0.165	0.657	0.190

Figure (4) shows the seasonal comparison profile for Erbil station, which are represent the multi time series for all seasons, it's clear that summer season has highest value of dew point temperature then Autumn, Spring and winter have lower dew point value.

The trend direction of seasonal and annual dew point temperature at Erbil station is illustrated in figure (5), it can be seen that the increasing trend is clear during all seasons and annual time series, especially at summer and winter seasons with high correlation coefficient. Also, for annual time series, the increasing trend is obvious with high correlation coefficient (R=0.769).

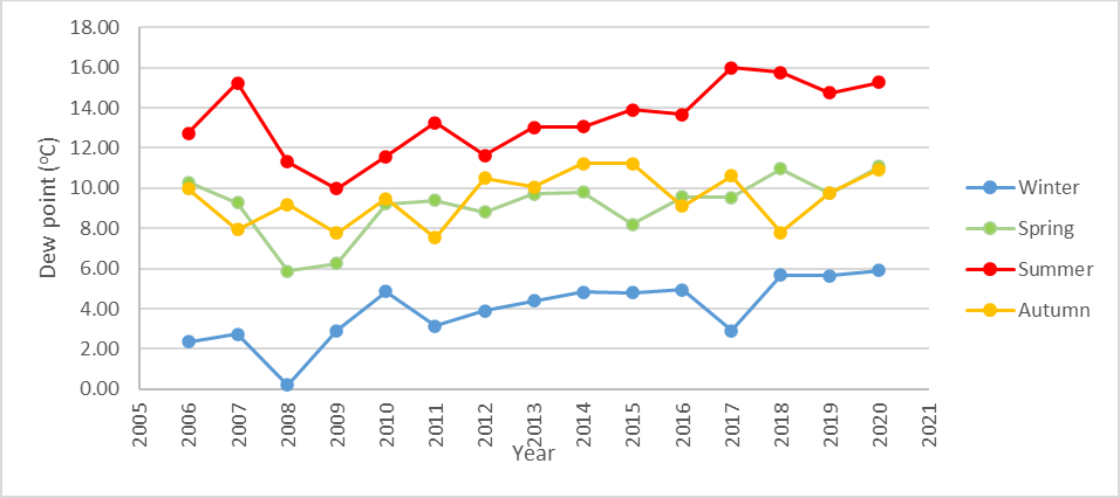


Figure 4: Seasonal variation of Dew point temperature for Erbil station

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 04-2023
DOI 10.17605/OSF.IO/EYTDA

Figure 5: Time series and trend line of Annual and seasonal dew point Temperature at Erbil Station

4. CONCLUSION

The present research focuses on seasonal and annual variations of dew point temperature at nine stations in Kurdistan region of Iraq. The average dewpoint temperature of seasonal and annual time series trends was analyzed using statistical regression method with SPSS program. On the other hand, the inverse distance weighting (IDW) interpolation method of (ArcGIS) (version 10.4.1) was used to show dewpoint temperature maps of study area. The spatial results of mean seasonal

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 04-2023
DOI 10.17605/OSF.IO/EYTDA

dewpoint temperature showed that the greatest value is recorded in the summer season with a value of (13.41^{o}C) at Erbil station, while the smallest value was recorded in the winter season of (-1.39 ^{o}C) at Amedi station. According to the annual analysis, the highest dewpoint temperature value was (9.02^{o}C) at Erbil station and the lowest value was (2.61 ^{o}C) at Amedi station, which is the coldest and highest region in study area. The results of the temporal analysis showed that the dewpoint temperature have positive trend values for all stations seasonally and annually except Duhok, Zakho and Pirmam stations at summer season with Zakho station at Autumn season have negative trend. The annual regression slop is positive for all stations with high correlation coefficient at most of stations, Kalar station has maximum slop value of (0.361 ^{o}C/year) with good correlation coefficient, and Duhok station recorded minimum trend value of (0.071^{o}C/year). Seasonally, the highest regression slop was detected at Kalar station of (0.741 ^{o}C/year) with the lowest trend was detected at Pirmam station of (-0.292 ^{o}C/year) during the summer season. Generally, dewpoint temperature has been changed seasonally and annually in study area, this means that the study area is suffering from climate change.

References

1. Abdulwahab, H Alobaidi. 2015. “Analysis of Relative Humidity in Iraq for the Period.” *International Journal of Scientific and Research Publications*.
2. Ahrens, C. Donald. 2000. “Third Edition Essentials of Meteorology.” : 464.
3. Al-Khalidi, J., D. Bakr, A. Hadi, and M. Omar. 2020. “Investigating the Linkage between Precipitation and Temperature Changes in Iraq and Greenhouse Gas Variability.” *Journal of the Earth and Space Physics* 46(3): 199–212.
4. Al-Timimi, Yassen K., and Aws A. Al-Khudhairy. 2018. “Spatial and Temporal Temperature Trends on Iraq during 1980-2015.” *Journal of Physics: Conference Series* 1003(1).
5. Gaffen, Dian J., and Rebecca J. Ross. 1999. “Climatology and Trends of U.S. Surface Humidity and Temperature.” *Journal of Climate* 12(2–3): 811–28.
6. Held IM & Soden BJ. 2000. “Water Vapor Feedback and Global Warming 1.” *Annu. Rev. Energy Environ* 25: 441–75.
7. IPCC, Climate Change. 2007. “The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.” *Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA* 996(2007): 113–19.
8. Morsy, Mostafa, and Gamal El Afandi. 2021. “Decadal Changes of Heatwave Aspects and Heat Index over Egypt.” *Theoretical and Applied Climatology* 146(1–2): 71–90. https://doi.org/10.1007/s00704-021-03721-x.
9. Mortuza, Md Rubayet et al. 2014. “Evaluation of Temporal and Spatial Trends in Relative Humidity and Dew Point Temperature in Bangladesh.” *Arabian Journal of Geosciences* 7(12): 5037–50.
10. Mstafa and Nawbahar F. 2018. “Aridity Index Based on Temperature and Rainfall Data for Kurdistan Region-Iraq.” *The Journal of The University of Duhok* 21(1): 65–80.
11. Robinson, Peter J. 2000. “Temporal Trends in United States Dew Point Temperatures.” *International Journal of Climatology: A Journal of the Royal Meteorological Society* 20(9): 985–1002.

ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 04-2023
DOI 10.17605/OSF.IO/EYTDA

12. Seidel, Thomas M, Andrea N Grant, Alexander A P Pszenny, and Daniel J Allman. 2007. “Dewpoint and Humidity Measurements and Trends at the Summit of Mount Washington, New Hampshire, 1935–2004.” *Journal of Climate* 20(22): 5629–41.
13. Stocker, Thomas F et al. 2013. “IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.”
14. Talaee, P. H, A. A. Sabziparvar, and Hossein Tabari. 2012. “Observed Changes in Relative Humidity and Dew Point Temperature in Coastal Regions of Iran.” *Theoretical and Applied Climatology* 110(3): 385–93.
15. Wahab, Basim Ibraheem. 2016. “Spatial Variation of Monthly Temperatures as an Indicator of Climatic Change in Iraq.” *Diyala Journal For Pure Science* 12(4-part 1).
16. Wentz, Frank J., Lucrezia Ricciardulli, Kyle Hilburn, and Carl Mears. 2007. “How Much More Rain Will Global Warming Bring?” *Science* 317(5835): 233–35.
17. Van Wijngaarden, William A, and Lucie A Vincent. 2004. “Trends in Relative Humidity in Canada from 1953–2003.” *Bull. Am. Meteorol. Soc*: 4633–36.
18. Yousif, Tawhida A, and H M Tahir. 2013. “The Relationship between Relative Humidity and the Dew Point Temperature in Khartoum State, Sudan.” *Journal of Applied and Industrial Sciences* 1(5): 20–23.