



STUDY OF GEOPOTENTIAL HEIGHT VALUES AND ITS INRACTION WITH TEMPERATURE DEGREE OVER BAGHDAD CITY, IRAQ

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Abstract

Atmospheric air motion depends on energy that given from the sun, this energy leads to heat up air and make it expand in the atmosphere which will cause pressure disruption. Higher temperature effect on geopotential height values in atmospheric layers, the geopotential height (GH) is consider as a very important factor in pressure system movements, therefore it is very important in atmospheric prediction processes. This research depends on meteorological data of temperature and geopotential height given from European center for medium range weather forecasting (ECMWF) over Baghdad and Dubai cities for winter and summer seasons to the period from (2000) to (2012) in order to show the effect of temperature between summer and winter as well as the effect of global warming on geopotential height values and also the effect of geographic region on these values. The result showed that any increasing in temperature lead to increase the rate of geopotential height in summer seasons as compared with winter seasons, these increment by compare it between Baghdad city and Dubai city the result showed that it is larger over Baghdad as compared with Dubai, the result also showed that the increasing in (GH) values on (500hpa) is larger than (700hpa), and when testing the effect of global warming on (GH) values on summer the result showed that the values of (GH) was increased along the time and this informing that the effect of global warming is very effective factor on pressure system movement.

Key words: Geopotential height, Temperature, Global warming, ECMWF.

Introduction

Geopotential height (GH) is consider as an effective variable that has wide relation with other variables and phenomenon and it gives good and clear indicates about understanding many atmospheric cases, many studies can depend on it to reach logical solution about phenomenon and turbulence that occur in the atmosphere, its indication is high when using long range forecasting because it shows clear variation with long period of time especially from one season to another, also the general behavior of (GH) can provide an indication about the turbulence of many variables by the dependence on showing its equal lines (Yang *et al.*, 1998). Resent study depend on spatial analyses of geopotential height, the increase and decrease in (GH) of one level is correlated with the fluctuation of earth magnitude, so can define geopotential height by the vertical height according to sea level of one point, and it a result of the variation of geometric height by the effect of earth surface magnitude, therefore can be considered as a height depended on gravity. Geopotential height has a wide relation with temperature, humidity, wind speed and the initiation and declination of high and low pressure systems as well as other atmospheric parameters (Jacobs *et al.*, 1968). From this point the researchers started studying this variable because it has wide importance in agriculture, industrial and economical branches, so the importance of this variable is very huge from its relation with many variables and phenomenon, also it dependable by global research because it included in prediction equation of the atmosphere, and by knowing geopotential height values along one pressure level and the change in thickness of pressure level will produce troughs and ridges that located in the opposite side of low and high pressure systems, therefore it has large effect on air system movement in the atmosphere as well as the movement of

general circulation model by depending on the following equation which called hypsometric equation,

$$\Delta z = z_2 - z_1 = (R/g) \bar{T} \ln(p_1/p_2) \quad \dots(1)$$

Above equation show that the thickness or the difference between two levels of geopotential height is correlated with the mean value of temperature of this level (Holon *et al.*, 2004).

From other side the climate change effect and the increasing in global temperature was increased over Middle East region which involves Baghdad city as mentioned in some previous studies that led as to test the effect of this increasing on (GH) values over (Hazem *et al.*, 2019).

Historical Review

Many studies was made about geopotential height (GH) variable dealing of its relation with some other variables and phenomenon, it was depended on number of correlation coefficients and mathematical equations of statistical methods, in spite of there is no other similar study to our study especially in middle east region but we will produce some researches which have relation with our work, for example scientist (Buell, 1972) produce a study about correlation coefficient between the value of wind speed and geopotential height lines at same level, he worked on the relation depending on geostrophic wind equation up word of boundary layer which gives good indication about the behavior of this variable using spatial differential equations to get the solution of this numerical relation, it is possible to benefit from this study to understand the correlation of geopotential height with other variables and describe it (Buell *et al.*, 1972). After that (Maurice on 1976) made analytic study of geopotential height lines at (500 hpa) level on north hemisphere, the study involves data for ten years started from (1970) and existed from (90⁰) to (20⁰) latitude "it insist on the

region that have effective indication", the data was made to be correlated with the timing of winter and summer seasons then the behavior of these lines was correlated with the types of atmospheric waves depending on numerical relations to understand increasing and decreasing value of its length and frequency with geopotential height values, after that the study compared the result between summer and winter over the study period (Maurice *et al.*, 1976). Another scientist (John palmer on 1996) studied seasonal numerical weather models depending on taking nine ensembles from seasons to get good calculation about ensemble volume and select the perfect model of seasonal forecasting, he used sea surface temperature (SST) as a variable which taken from forecasting model of European center for medium range weather forecasting (ECMWF) of five years period from (1986) to (1990) that include warm and cooled periods, the study insist on the period that has indicates about the anomaly, he reached to that the seasonal forecasting model has good accuracy in the region of the north of pacific ocean and north America in winter seasons, for summer season the accuracy appear in the region of north Atlantic ocean and Europe (Cedo *et al.*, 1996). Kripalani on 1998 showed the relation between geopotential height value and monsoon rain in India, the study focused on (500 hpa) level especially for long period from (1958 to 1990), he found that there was a positive correlation coefficient in January and February months and the highest relation was in march (Kripalani *et al.*, 1998).

Material and Methods

As showed before, the study deal with geopotential height (GH) values over Baghdad and Dubai cities, the study used two main levels (500 hpa) and (700 hpa) because they are the most important levels in prediction process from their positioning in the middle of troposphere that have big effect on atmospheric turbulence, also they gives complete description about this layer (Simmons *et al.*, 2000), as well as the availability of their data in the research centers for the period from (2000 to 2012), so this is good in testing weather forecasting and showing the behavior of geopotential height. Resent study depend on (ERA-40) from (ECMWF) center to obtain the data of temperature and geopotential height, this model is considered as a highly dependable model by researches and many scientist used it in their researches to get accurate and accepted results, the analysis of this model was made in very skill way to make weather maps and help to produce more weather system analysis in the period that cannot easy get its data (Belen *et al.*, 2002).

This study deal with two cities (Baghdad, Dubai) that located on different latitudes with both levels (500 hpa) and (700hpa) for summer and winter, then it compare the change in geopotential height values between these two points to show the effect of the change of latitude and altitude on geopotential height values as well as the effect of climate change on the behavior of geopotential height, so that the study insist on calculating the value of these changes between summer and winter and comparing these changes between these two points and trying to find an explanation of the resulted changes, also calculate the increasing for each level separately, then show which level has larger expanding value and show which expanding is stronger on (700 hpa) or on (500 hpa) to get indications about the behavior of these two levels and when the strongest effect and then trying to provide logic explanation about these changes .

Result and Discussion

Analysis of (GH) expanding rates.

After making suitable calculations to obtain seasonal geopotential height (GH) averages for each summer and winter of both levels (700 and 500 hpa), the study calculated table (1- a,b) of geopotential height value with years over Baghdad city which located on (33^o) latitude line for winter and summer seasons separately, these values was taken by determining a point that has knowing longitudinal and latitudinal position, then calculating the value of (GH) on this point, table (1-a) show the value of expanding rate on (700 hpa) from the surface for each year by subtracting the value of (GH) on winter from its value on summer to get increasing rate on same year in summer season that caused by the expanding, this table also show the value of the expanding in (500 hpa) layer to the surface, where it calculated in the same method by subtracting the value on winter from its value on summer. In same way table (2- a,b) was calculated for Dubai which located on the (25^o) latitude line, therefore it calculated the expanding values for (500 hpa) and (700 hpa) separately which let as compare between these two point on different latitudes.

The result shows that the value of geopotential height (GH) has been increased in summer as compared with winter seasons because we found on table (1-a) that the value of geopotential height for (700 hpa) over Baghdad city on (2000) was increased from (3021)m on winter to (3091m) on summer, same result for (500 hpa) which increased from (5561)m on winter to (5781)m on summer for same year on table (1-b). For Dubai, same work was made for (700 hpa) and it found that the value of geopotential height is higher on summer as compared with winter, for example on same year (2000) the value of geopotential height was (3076) on winter but it increased to (3080) on summer by seeing table (2-a), and it found that the value of (GH) at (500 hpa) for Dubai on the same year too was (5681) m on winter but for summer season this value also increased to reach (5771) m on table (2-b), from these tables we confirms that is the same behavior for every case which can be seen clearly, where it a result by increasing of troposphere layer that caused by higher temperature in summer and that led to increase geopotential height rate for each layer.

When compare expanding rate between Baghdad and Dubai we can notice that expanding is higher for Baghdad as compared with Dubai, for example expanding rate for Baghdad city did not exceed (110m) for (700hpa) and (290m) for (500hpa) while for Dubai city it did not exceed (30m) for (700hpa) and (115m) for (500hpa), from this can conclude that the region with lower latitudes has higher expanding rate than upper latitude regions, this may because the height of the atmosphere is graduated from lower level on the pole to higher level over tropical regions, so this lead to increase expanding rate of the largest amount of air over Baghdad city as compared with lowest amount of air over Dubai. From other side, by showing the value of (500hpa) and (700hpa) expanding for every single level can clearly see that the expanding of (700hpa) from the surface is lower as compared with (500hpa) separately, for example Baghdad city in (2002) on table (1-a) record (70m) of the expanding while (500hpa) was higher and it record (225m) on table (1-b). For Dubai city at the same time on (2002) from table (2-a) we found that the value of (700hpa) level recorded (10m) and it larger than its value for (500hpa) for the same year which

record (85m) on table (2-b), from all that we can say these values of extension increase by increasing vertical height and its value always record higher on (500hpa) as compared with (700hpa) level.

Table 1 : Geopotential height values and its expanding rates over Baghdad city for summer and winter seasons along study periods, a- for 700 hpa, b- for 500 hpa.

Table (a)

Year	winter GH values	Summer GH values	Expanding rate
2000	3021	3091	70
2001	2991	3101	110
2002	3026	3096	70
2003	2996	3091	100
2004	3026	3101	75
2005	2996	3081	85
2006	3011	3101	90
2007	3026	3091	65
2008	3046	3101	55
2009	3001	3081	80
2010	2986	3091	105
2011	3006	3101	100
2012	3021	3101	80
2013	3011	3091	80

Table (b)

Year	winter GH values	Summer GH values	Expanding rate
2000	5561	5781	220
2001	5521	5791	270
2002	5561	5786	225
2003	5521	5776	255
2004	5566	5796	230
2005	5511	5776	265
2006	5531	5786	255
2007	5561	5771	210
2008	5596	5801	205
2009	5491	5781	290
2010	5501	5781	280
2011	5536	5791	255
2012	5541	5786	245
2013	5531	5771	240

Table 1 : Geopotential height values and its expanding rates over Dubai city for summer and winter seasons along study periods, a- for 700 hpa, b- for 500 hpa.

Table (a)

Year	winter GH values	Summer GH values	Expanding rate
2000	3076	3080	4
2001	3061	3071	10
2002	3071	3076	10
2003	3076	3080	4
2004	3056	3086	30
2005	3066	3071	10
2006	3061	3086	25
2007	3061	3076	15
2008	3081	3083	12
2009	3061	3063	12
2010	3051	3081	30
2011	3066	3091	25
2012	3076	3080	4
2013	3066	3076	10

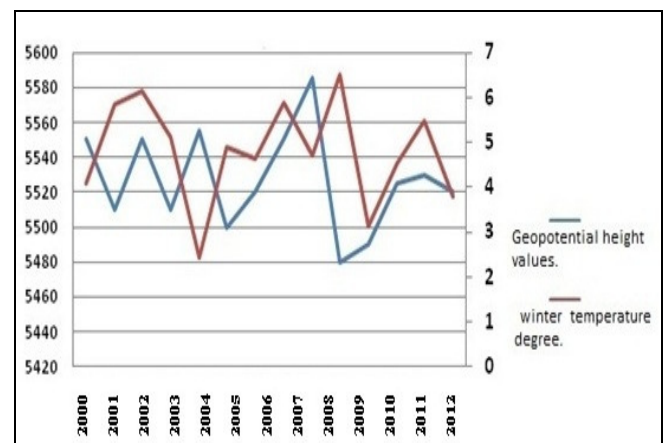
Table (b)

Year	winter GH values	Summer GH values	Expanding rate
2000	5681	5771	90
2001	5671	5756	85
2002	5686	5771	85
2003	5656	5771	115
2004	5681	5781	100
2005	5681	5756	75
2006	5671	5766	95
2007	5656	5761	105
2008	5691	5771	80
2009	5676	5751	75
2010	5676	5766	90
2011	5681	5771	90
2012	5681	5766	85
2013	5681	5766	85

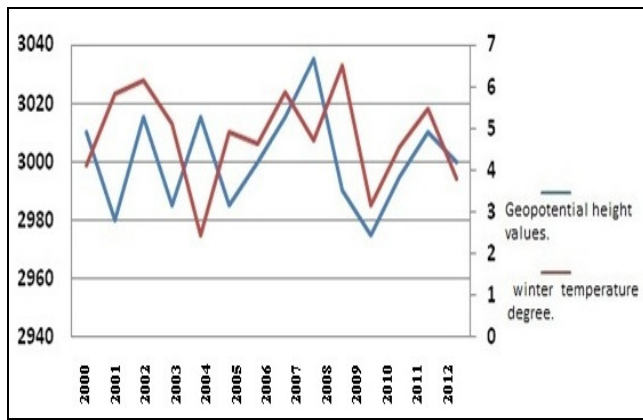
By showing the extension values of (500 hpa) comparing with extension values of (700 hpa) from the surface, so these tables show how the extension of (500 hpa) sometimes reach to double value or more than this as compared with (700 hpa) for all study years, comparing tables also show the difference of expanding value between Baghdad and Dubai which located on different latitude level, so it provide easy comparison showing that the value of expanding rate for Baghdad city is more than for Dubai and the column of expanding rate for (500 hpa) is longer than its length for (700 hpa).

By drawing diagrams (1, 2, 3, 4) which provide a comparison between temperature rates and geopotential height values of both seasons and for (500 hpa) and (700 hpa) levels over Baghdad city, they show that there is high correlation between changes in temperature rates and geopotential height values, so both of them fluctuate in harmonic behavior and it clearly showed over all study years from (2000) to (2013), this inform that the temperature degree is directly effect on (GH) values in all cases.

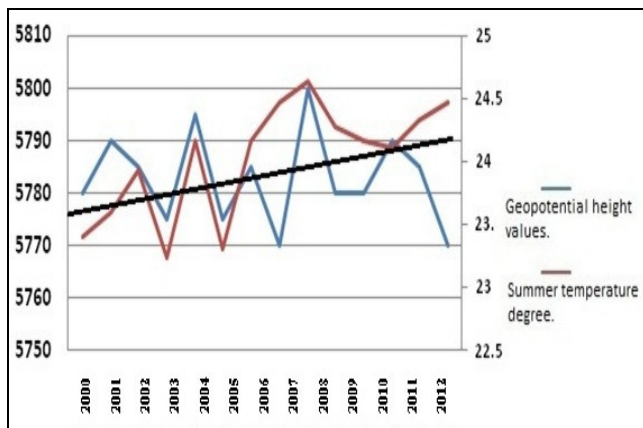
Also diagrams (3 and 4) showing geopotential height trend with time over all study years for both (500 hpa) and (700 hpa) pressure levels, they showing that the (GH) trend over Baghdad city was increased from its past values over time for both pressure levels because of increasing in temperature rates as a result of climate change impactation.



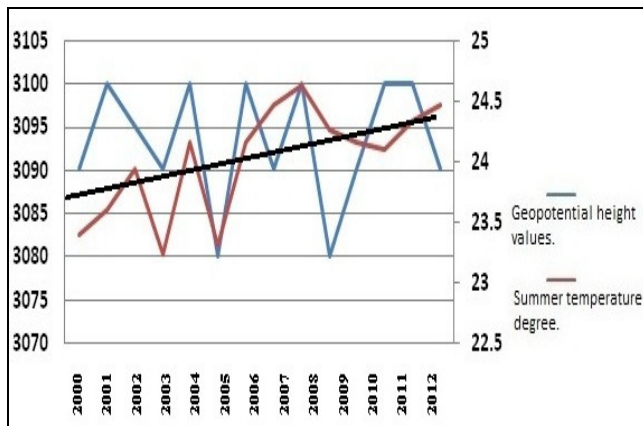
Diagrams 1 : Comparison between temperature rates and (GH) values for winter seasons with time over Baghdad city for (500 hpa).



Diagrams 2 : Comparison between temperature rates and (GH) values for winter seasons with time over Baghdad city for (700 hpa).



Diagrams 3 : Comparison between temperature rates and (GH) values for summer seasons with time over Baghdad city showing general trend for (500 hpa).



Diagrams 4 : Comparison between temperature rates and (GH) values for summer seasons with time over Baghdad city showing general trend for (700hpa).

Conclusions

Temperature degree has large effect on geopotential height value, so the value of geopotential height increase in summer as compared with winter because of temperature increasing, and this increment is larger in lower latitudes as compared with higher latitudes. The result also showed that expanding rate for atmospheric layers is larger on (500 hpa) as compared with (700 hpa). From other side there is a coherence between the behavior of temperature and geopotential height fluctuation wave, also the effect of global warming and the increase in temperature rates over years is very important factor that affect on both levels by increasing of geopotential height values over time and this improve that the climate change effects on atmospheric system very well.

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