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اسطنبول – تركيا

Forecasting of Air Stability Depending on the Potential Temperature

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Abstract. The **S**tability is one of the most important subject that have an effect on weather conditions where when the atmosphere is stable, the surface of the earth cools, especially during the clear nights and when the atmosphere is unstable, the surface is heated. The aim of this research is to classify the clouds according to the atmospheric stability and the accompanying air conditions and determine the type of clouds formed in the case of stability and instability. Data were taken by temperature, dew point, atmospheric pressure and height from satellites recorded by the European Centre for Medium-Range Weather Forecasts (ECMWF) for height (32-26509.7) meter the levels of pressure (1000-20) mb, the choice of the characteristic day (15/1, 16/2, 17/3, 15/4, 15/5, 15/6, 15/7, 15/8, 15/9, 15/10, 15/11, 15/12) of the month of 2015 for the Baghdad station to obtain the largest possible number and variety of clouds and their use in the calculation of cloud cover and weather stability in terms of calculation daily change, monthly and seasonally variation of temperature and dew point, calculation of cloud cover with height, potential temperature, and atmospheric stability. The temperature change, dew point, cloud base and height were determined, and then the thickness, type and classification of the cloud were calculated. The potential temperature was also calculated with height to determine the type of air stability, as well as the calculation of atmospheric stability with the height of the cloud base and under the cloud base where the atmosphere is stable, unstable or neutral.

Keywords: Cloud cover, Forecasting, Stability, Potential temperature, Baghdad.

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1 INTRODUCTION

Clouds is a phenomenon of condensation occurring water vapor in the sky, and rely on posed in the amount of moisture and the degree of stability of the air from the wind and blowing air classroom, The types of clouds are (Abd, H. F., 1997):

- Stratus clouds class which is that when it is formed low air progressing with Stratus any form compact layers between them, cover large areas of the sky, they are horizontal proliferation rather than vertical format, usually found in the air stable, and are formed when the rush of warm air currents above the air low temperature cold, divided into two types, such as the withdrawal of Nimbo and medium clouds, and the clouds are low caste thickness was sometimes accompanied by light rain occurs when you see them in the sky.
- Cumulus clouds famous cumulus clouds presence in the air cases is stable, and that is formed by air disturbances and the influence of wind speed and severity, and named Cumulus as they pile up on top of each other on a vertical form differs from the type of class that runs horizontally, and when gathering clouds and accumulate in very large quantities This indicates the presence of rain and snow cold and sometimes, cumulus clouds cannot see the sky through which they covered entirely, but this is expected to be rainy weather with the wind when you see the clouds class and snowfall as winter months.

Can be defined Stability is a situation where the air expulsion cooler than the surrounding air at the same pressure (altitude). It will decrease air antenna expulsion.

Often stability associated with hurricanes when they are removed convection currents that make the air is reduced to give a dry, sunny conditions and instability is the case where the expulsion of air is warmer than the air surrounding it at the same pressure (altitude). Parcel of air buoyant. Will Rises air expulsion antenna, and at moisture condensation cumulus clouds will consist (associated with thunderstorms). The air parcels can be forced to rise due to divergence aloft, for example. Parcels of warm air which rise through the lower atmosphere cool adiabatically. The rate and maintenance of any vertical uplift depend upon the temperature-density balance between the rising parcel and the surrounding air. But there are situations in which air parcels will spontaneously rise or sink. The general topic heading for the set of processes that govern this spontaneous motion is “instability”.

Stability is the state in which an air parcel finds itself colder than the air surrounding it at the same pressure (elevation). The air parcel will spontaneously sink. Stability is often linked with anticyclones when any convection currents are suppressed by sinking air to give dry, sunny conditions. Instability is the state in which an air parcel finds itself warmer than the air surrounding it at the same pressure (elevation). The air parcel is buoyant. It will spontaneously rise. (If moisture is condensing, the resulting cloud will be cumulus, cumulus congestus or cumulonimbus (associated with thunderstorms)).

The air parcel is an important and useful conceptual device in atmospheric sciences. Can make a parcel by gathering together a usually unspecified amount of air and pretend the air is surrounded by an invisible boundary that insulates the parcel air from its surrounding environment. The parcel boundary, however, is flexible, permitting the air inside to expand or contract as conditions dictate (Samson, et al., 2010). When rising moist air cools through expansion, it will eventually reach its dew point. At this point condensation of vapor into drops of water occurs, and latent heat is released. The release of heat through condensation warms the air, thus, temperature drops less rapidly in rising moist air than in rising dry air. When gases are heated they expand, becoming less dense and lighter in weight. They are buoyed upward by surrounding denser gases the reason that warm air rises. Thus the warmer parcel will continue to rise. Under such conditions, the atmosphere is said to be unstable. In converse, a stable atmosphere exists when a rising parcel of air reaches a height, where through expansion, it becomes cooler than surrounding air at that altitude and sinks back to its former position. The lower atmosphere at night is usually always stable; whereas, during the daytime it is usually unstable.

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This is especially true if the weather is fair with mostly clear skies. Stable or unstable air conditions can develop under cloudy skies, but their degree of development is usually less. Can also conclude that cooling from below promotes stability, while heating from below promotes instability (Schroeder, et al., 1970).

2 THE STUDY AREA

The work was carried out with the daily temperature, dew point, pressure, and high data from the (ECMWF), specifically the model **E**CMWF **R**e **A**nalyses (ERA-Interim) (Dee, 2011). The city of Baghdad was chosen for this work located at the latitude 32.14° N and longitude 44.14° E and at a height of 31.7 m in central Iraq as shown in Fig. 1. (Jubouri, et al., 2010). Iraq determines the site's astronomer and Geographical in Systems of compression surface and upper influential type the weather and climate of Iraq's weather phenomena associated with it. The thunderstorm phenomena familiar occurrence. It is produced by small-term storm clouds with large vertical extensions Produced by clouds with vertical extensions accompanied Lightning and thunder accordingly often strong winds with the falling rain sometimes accompanied falling hail (Carpal, 1989). We cannot be called a thunderstorm as a thunderstorm unless the sound of thunder which hears an international agreement on it (Bidawid, 2003).

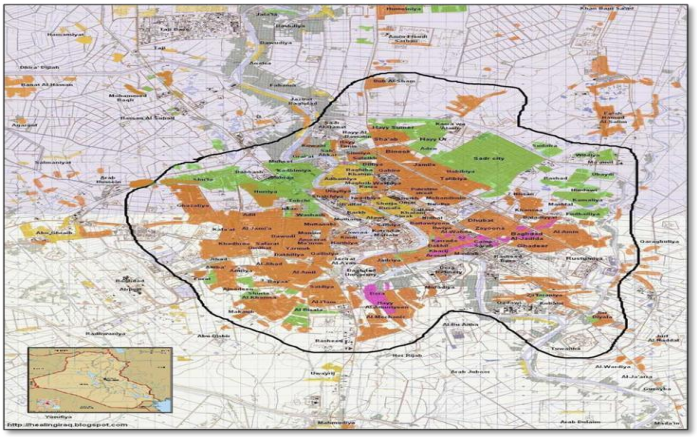

Fig. 1. Baghdad station (Google, 2017).

3 EXPERIMENT WORK

3.1 The Atmospheric stability

The resistance of the atmosphere to vertical motion. We said that stable air tends to resist vertical air movement. If a horizontally moving parcel of air is lifted or forced to rise, as over a mountain, that parcel will tend to settle back to its original level. It is heavier than the air around it; therefore, it will sink back, if possible, to the level from which it originated. If the atmosphere is unstable, any parcel of air that is lifted will tend to rise like a hot air balloon. If the atmosphere is neutral; that is, the actual temperature lapse rate equals the dry adiabatic lapse rate, a parcel of air that is lifted will be neither heavier nor lighter at a different altitude. We learned that as a parcel of air cools, its relative humidity increases. If the parcel cools enough, 100-percent relative humidity, or its dew point, will be reached at that point clouds form (Schroeder, et al., 1970). Stephen Schneider summed up the main characteristics of the ten races of clouds through the below Table 1:

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Table 1. The main characteristics of the ten races clouds (Stephen, 1996).

Cloud Type	*Symbol*	*High cloud base (km)*	*Temp. cloud base (^0C)*	*Thick. (km)*	*Case of water in the clouds*	*Rising air speed (m/sec)*
Cirrus	Ci	5-10	-30,-70	0.5-2	Ice	*0.1-0.3*
Cirrostratus	Cs	5-10	-25,-40	1-2	Ice	*0.1-0.3*
Cirrocumulus	Cc	5-12	-25,-40	0.1-0.3	Liquid or mixed	*0.3-1*
Altostratus	As	3-8	-10,-30	1-3	Ice or mixed	*0.1-0.3*
Altocumulus	Ac	2-8	-10,-30	0.1-1	Liquid or mixed	*0.3-1*
Nimbostratus	Ns	0.5-2	-10,-20	2-10	Ice or mixed	*0.3-1*
Stratus	St	0-2	-10,-20	0.1-0.5	Liquid	*0-0.3*
Stratocumulus	Sc	0-2	-10,-20	0.1-2	Liquid or mixed	*0.1-1*
Cumulus	Cu	1-4	-5,25	0.5-4	Liquid	*0.3-3*
Cumulonimbus	Cb	1-4	-5,25	2-20	Mixed	*3-30*

The temperature equals the dew point. This is Lifting Condensation Level (LCL). That's the level at which condensation can be achieved by lifting. LCL has another name as well, "cloud base". When reached cloud base, so what happens next? We're finally saturated (Samson, et al., 2010). When determining the high base cloud at the point of convergence between the curved temperature parcel and curved temperature dew point and symbolized by the symbol z_b and determine the temperature of the top cloud at divergence point curve temperature curve dew point temperature and symbolized by the symbol z_t can be find the thickness of the cloud equation (Rogers, 1984):

$$\Delta z_c = z_t - z_b \tag{1}$$

3.2 The Potential Temperature (Theta)

The potential temperature (theta) is the temperature that a sample of air would have if it were brought dry adiabatically to a pressure of 1000 mb. Potential temperature is commonly expressed in kelvins. (Whiteman, 2000; Ackerman, et al., 2013).

$$\theta = T\left(\frac{1000}{p}\right)^{286} \tag{2}$$

θ: Potential temperature in ºC.

T: Temperature in ºC.

P: pressure in mb.

Thus, whether the parcel has an upward, downward, or no acceleration depends on how the environmental potential temperature changes with height (Ahrens, 2012).

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$$\left.\begin{array}{l} \frac{d\theta}{dz} > 0 \text{ Stable} \\ \frac{d\theta}{dz} < 0 \text{ Unstable} \\ \frac{d\theta}{dz} = 0 \text{ Neutral} \end{array}\right] \quad (3)$$

4 RESULTS AND DISCUSSION

4.1 Calculation the thickness and height of the clouds in Baghdad station

While determining the height of the convergence points and the spacing between the curve of the vertical change of temperature and the curve of the dew temperature change in the Fig. 2. The thickness of the clouds that were deposited above Baghdad station was calculated for the study days of each month and the monthly rates and the seasonally rates for the year 2015 and also were classified according to their height and thickness. The appeared type of the clouds in the Baghdad station is due to the wind movement. The uneven heating of the surface of the earth causes the pressure to be degraded. A movement of wind from the high pressure zone to the low pressure zone is called the general wind. In the Baghdad station, the clouds Sc, of clouds St, and Cb clouds of accumulated marshes that accompany the unstable atmosphere. As well as the Cu clouds that accompany the stable atmosphere, the as clouds and the Ns clouds that accompanies the stable atmosphere and the clouds Ci that accompany the stable atmosphere. The city of Baghdad is characterized by a climate of semi-desert with little and fluctuating rain. In the months of January, February, October and November and the absence of clouds in the months of April, June, July, August.

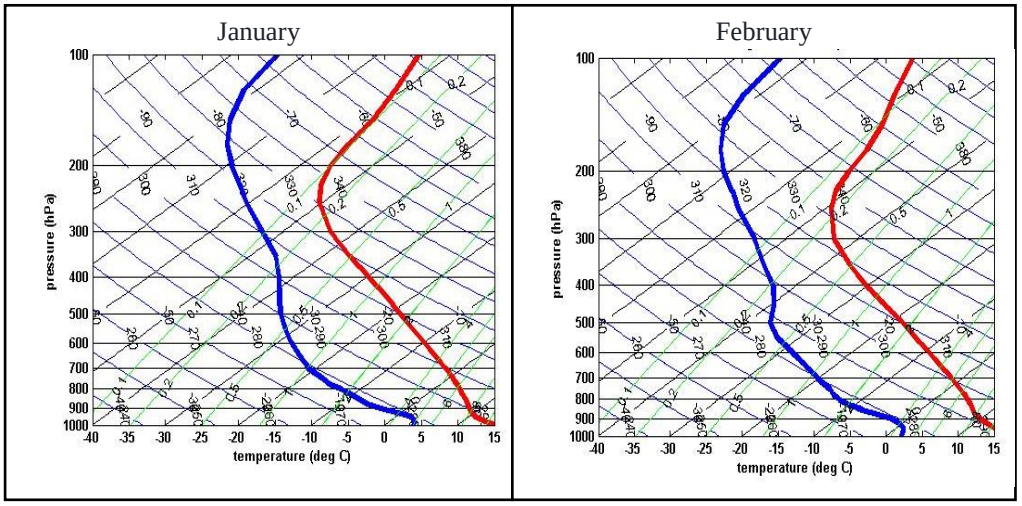

Fig. 2. The curve of the vertical change for the real temperature, the vertical change curve of the dew point temperature, the area of convergence between the two axes with the height of the monthly average in Baghdad station for year 2015.

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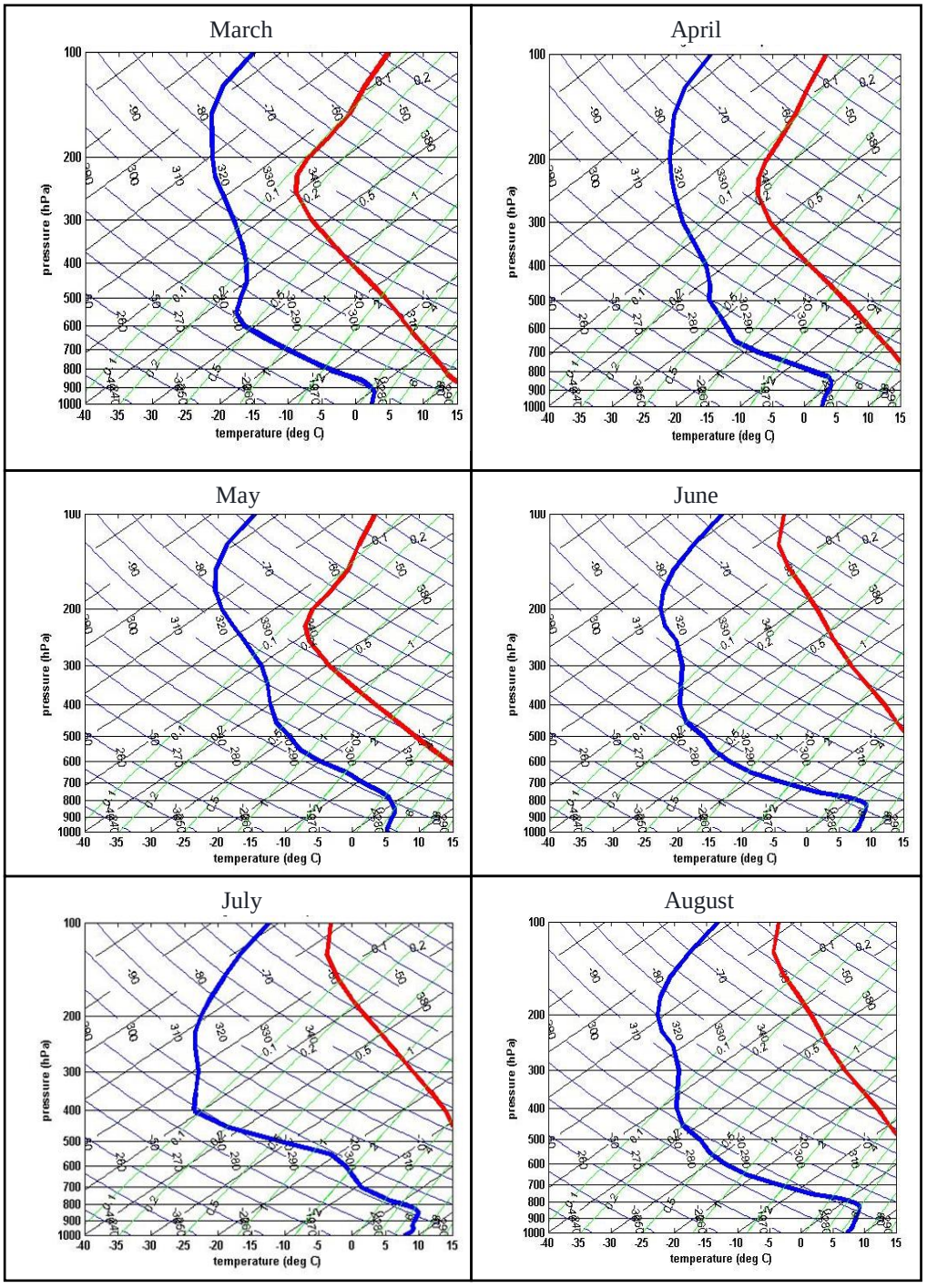

Followed Fig. 2.

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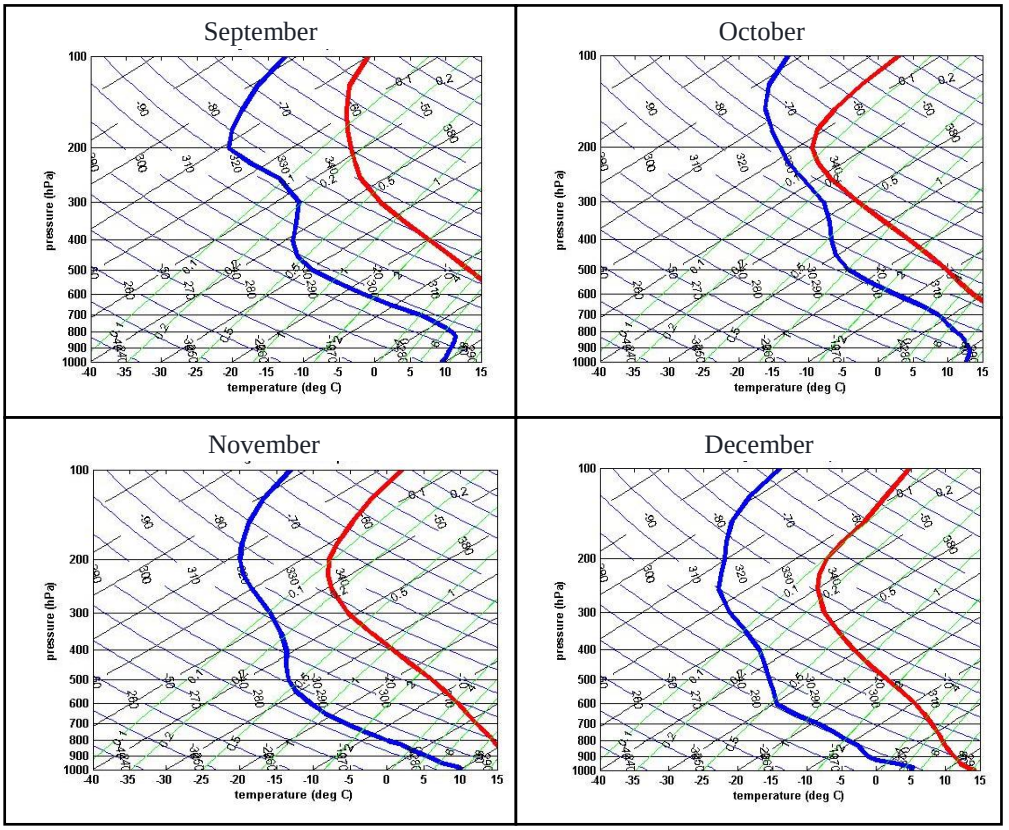

Followed Fig. 2.

4.2 Calculating the atmospheric stability depending on the potential temperature

Note through the Fig. 3. The higher the increase the less the pressure and the potential temperature increases with the increase in the height, the relationship between the potential temperature and the height of a positive relationship and its relation with pressure is inverse relationship, where the potential temperature was calculated from the Equation (2) depending on the temperature and pressure of the cloud, the stability state is calculated from the potential temperature change with the elevation of the cloud base and under the cloud base of Equation (3) to determine the stability state of the atmosphere under the cloud base and compare it with the cloud base to confirm the atmospheric stability of the cloud. Where the cloud is stable, the air temperature is slowly decreasing with altitude or may increase with altitude and when the cloud is unstable any air temperature decreases rapidly with altitude and when the cloud is neutral any relative tendency of the air parcel to rise or fall. There are many different types of stable, unstable and neutral clouds where most of the clouds in all the stations at the base of the cloud and under the base of the cloud, where Iraq lies within the subtropical regions. The climate of the subtropical regions is characterized by a warm summer to hot and cold to moderate winter with rare frosts.

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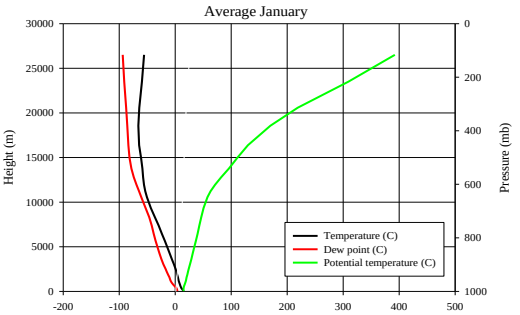
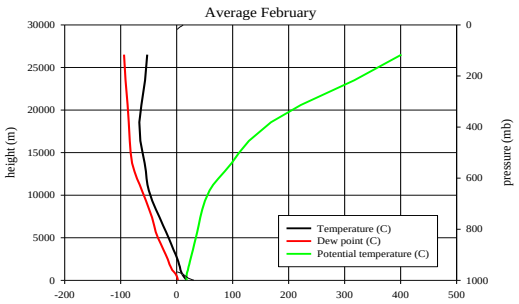
Baghdad station data			January		
Pressure base (mb)	975	350			
High base (m)	209.5	8307.7			
The temperature of the base (°C)	13.0005	-36.2268			
Dew point the base (°C)	3.3999	-3507.46			
Pressure top (mb)	875	200			
High top (m)	986.1	11946.95			
The temperature of the top (°C)	7.3966	-55.6894			
Dew point the top (°C)	-6.3488	-69.1180			
Thickness	776.6	3639.25			
Cloud type	Sc	Ci			
Cloud classification	Low	High	Pressure under the base (mb)	1000	400
dθ/dz	0.0004	0.0046	dθ/dz under the base	-0.0004	0.0041
Stability state	stable	stable	Stability state under the base	unstable	Stable

Baghdad station data			February		
Pressure base (mb)	925	300			
High base (m)	573.5	9343.55			
The temperature of the base (°C)	11.5207	-43.6193			
Dew point the base (°C)	-0.4163	-54.7299			
Pressure top (mb)	875	250			
High top (m)	986.1	10561.3			
The temperature of the top (°C)	8.1293	-49.6949			
Dew point the top(°C)	-4.7671	-62.0713			
Thickness	412.6	1217.75			
Cloud type	St	Cs			
Cloud classification	Low	High	Pressure under the base (mb)	950	350
dθ/dz	.00180	.00470	dθ/dz under the base	.00140	0.0044
Stability state	stable	stable	Stability state under the base	stable	Stable

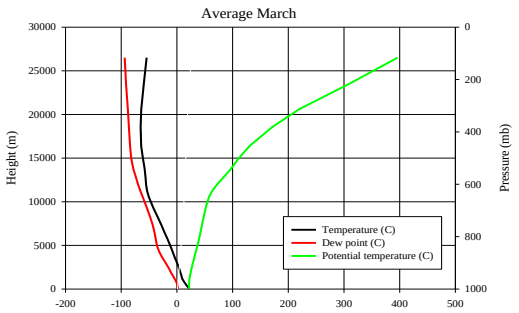
Baghdad station data		March		
Pressure base (mb)	300			
High base (m)	9343.55			
The temperature of the base (°C)	-42.6303			
Dew point the base (°C)	-54.0902			
Pressure top (mb)	225			
High top (m)	11220.7			
The temperature of the top (°C)	-53.4189			
Dew point the top (°C)	-65.5276			
Thickness	1877.15			
Cloud type	Cs			
Cloud classification	High	Pressure under the base (mb)	350	
dθ/dz	0.0046	dθ/dz under the base	0.0042	
Stability state	stable	Stability state under the base	stable	

Fig. 3. The report for the monthly average for thickness, height, type and classification of the clouds and the status of the weather stability of the base of the cloud and under the cloud base in Baghdad station for year 2015.

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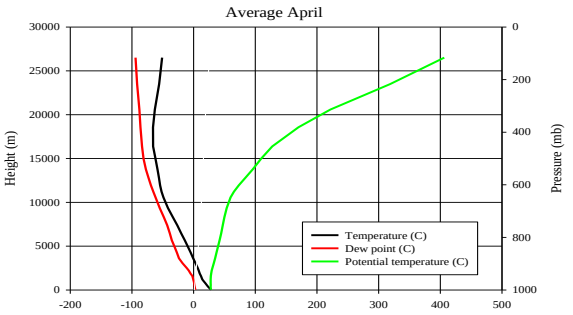
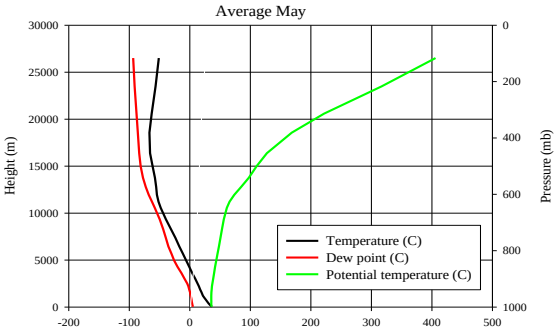
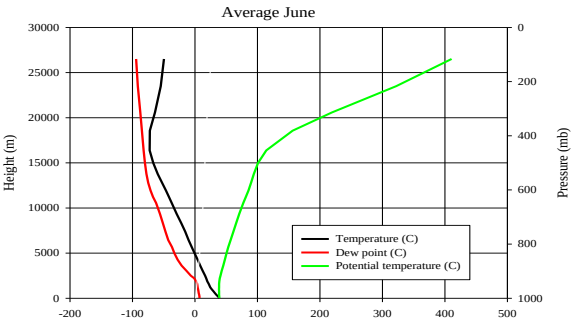
Baghdad station data		April	
Pressure base (mb)	-		
High base (m)	-		
The temperature of the base (C)	-		
Dew point the base (C)	-		
Pressure top (mb)	-		
High top (m)	-		
The temperature of the top (C)	-		
Dew point the top (C)	-		
Thickness	-		
Cloud type	-		
Cloud classification	-	Pressure under the base (mb)	-
dθ/dz	-	dθ/dz under the base	-
Stability state	-	Stability state under the base	-

Baghdad station data		May	
Pressure base (mb)	300		
High base (m)	9343.55		
The temperature of the base (°C)	-39.5254		
Dew point the base (°C)	-49.7194		
Pressure top (mb)	200		
High top (m)	11946.95		
The temperature of the top (°C)	-54.2090		
Dew point the top (°C)	-67.7399		
Thickness	2603.4		
Cloud type	Ci		
Cloud classification	High	Pressure under the base (mb)	350
dθ/dz	0.004	dθ/dz under the base	0.0028
Stability state	stable	Stability state under the base	Stable

Baghdad station data		June	
Pressure base (mb)	-		
High base (m)	-		
The temperature of the base (°C)	-		
Dew point the base (°C)	-		
Pressure top (mb)	-		
High top (m)	-		
The temperature of the top (°C)	-		
Dew point the top (°C)	-		
Thickness	-		
Cloud type	-		
Cloud classification	-	Pressure under the base (mb)	-
dθ/dz	-	dθ/dz under the base	-
Stability state	-	Stability state under the base	-

Followed Fig. 3.

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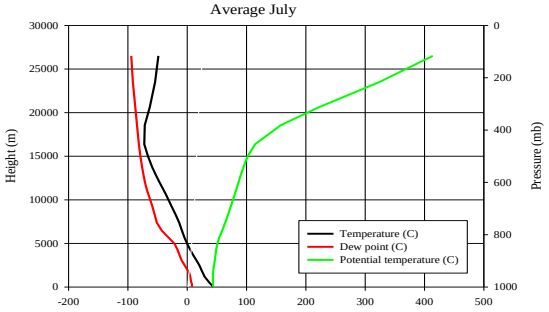
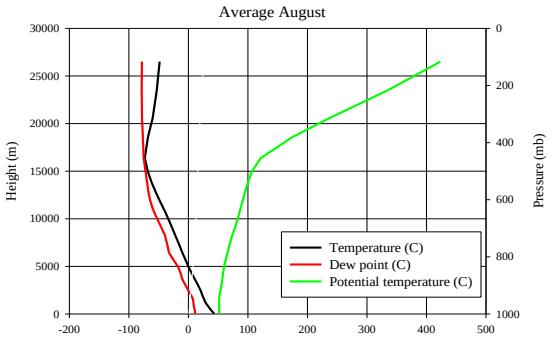
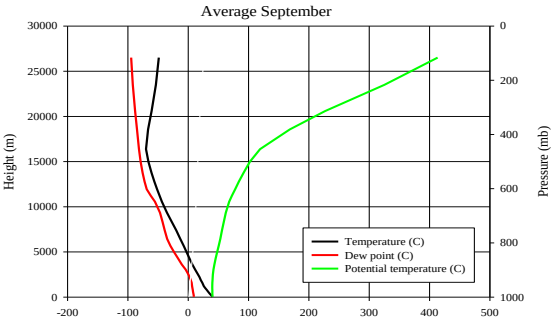
Baghdad station data		July	
Pressure base (mb)	-	Average July	
High base (m)	-		
The temperature of the base (C)	-		
Dew point the base (C)	-		
Pressure top (mb)	-		
High top (m)	-		
The temperature of the top (C)	-		
Dew point the top (C)	-		
Thickness	-		
Cloud type	-		
Cloud classification	-	Pressure under the base (mb)	-
dθ/dz	-	dθ/dz under the base	-
Stability state	-	Stability state under the base	-



Baghdad station data		August	
Pressure base (mb)	-	Average August	
High base (m)	-		
The temperature of the base (°C)	-		
Dew point the base (°C)	-		
Pressure top (mb)	-		
High top (m)	-		
The temperature of the top (°C)	-		
Dew point the top (°C)	-		
Thickness	-		
Cloud type	-		
Cloud classification	-	Pressure under the base (mb)	-
dθ/dz	-	dθ/dz under the base	-
Stability state	-	Stability state under the base	-



Baghdad station data		September	
Pressure base (mb)	300	Average September	
High base (m)	9343.55		
The temperature of the base (°C)	-35.2534		
Dew point the base (°C)	-46.7794		
Pressure top (mb)	225		
High top (m)	11220.7		
The temperature of the top (C)	-47.4369		
Dew point the top (C)	-62.0239		
Thickness	1877.15		
Cloud type	Cs		
Cloud classification	High	Pressure under the base (mb)	350
dθ/dz	0.0045	dθ/dz under the base	0.0033
Stability state	stable	Stability state under the base	Stable



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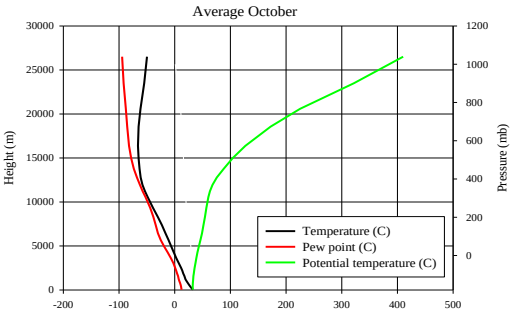
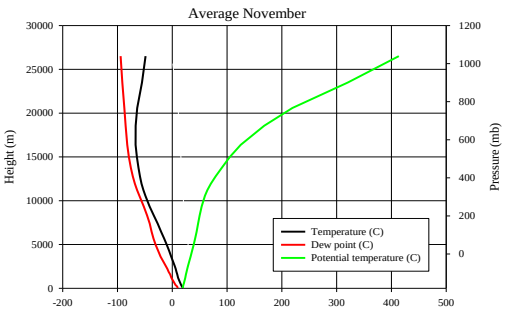
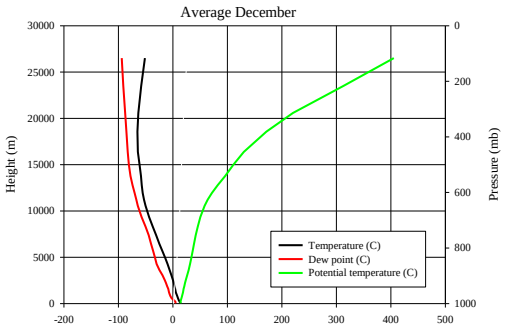
Baghdad station data			October		
Pressure base (mb)	800	400			
High base (m)	1864.65	7381.8			
The temperature of the base (°C)	15.4695	-23.0173			
Dew point the base (°C)	4.3088	-34.0963			
Pressure top (mb)	550	125			
High top (m)	4948.45	14985.7			
The temperature of the top (°C)	-6.1866	-64.8069			
Dew point the top (°C)	-18.9328	-78.1526			
Thickness	3083.8	7603.9			
Cloud type	Cu	Ci			
Cloud classification	Low	High	Pressure under the base (mb)	825	**450**
dθ/dz	0.002	0.0029	dθ/dz under the base	0.0023	**0.0028**
Stability state	stable	stable	Stability state under the base	stable	**stable**

Baghdad station data			November		
Pressure base (mb)	975	350			
High base (m)	209.5	8307.7			
The temperature of the base (°C)	17.7524	-33.6324			
Dew point the base (°C)	8.8453	-45.8461			
Pressure top (mb)	850	200			
High top (m)	1210.8	11946.95			
The temperature of the top (°C)	10.547	-56.095			
Dew point the top (°C)	-1.6797	-68.1999			
Thickness	1001.3	3639.25			
Cloud type	Sc	Ci			
Cloud classification	Low	High	Pressure under the base (mb)	1000	400
dθ/dz	0.0035	0.0035	dθ/dz under the base	0.0007	0.0032
Stability state	stable	stable	Stability state under the base	stable	stable

Baghdad station data		December		
Pressure base (mb)	975			
High base (m)	209.5			
The temperature of the base (°C)	12.2815			
Dew point the base (°C)	4.6172			
Pressure top (mb)	900			
High top (m)	779.8			
The temperature of the top (°C)	8.2055			
Dew point the top (°C)	-4.302			
Thickness	570.3			
Cloud type	St			
Cloud classification	Low	Pressure under the base (mb)		**1000**
dθ/dz	0.0031	dθ/dz under the base		**0.0001**
Stability state	stable	Stability state under the base		**Stable**

Followed Fig. 3.

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5 CONCLUSIONS

The following conclusions were reached:

1. The largest number of clouds occurred in the months of January, February, October, November, and season winter, and the disappearance of clouds in the months of April, June, July, and August.
2. It was found that the high clouds were stable base and stable under the base, medium and low clouds stable base stable and unstable under the base.
3. When the air is humid, the stability helps to form fog at the surface or low clouds St near the surface of the earth.
4. If the air is dry, the stability helps to concentrate the sand and dust in the layers near the surface of the earth, which helps to reduce horizontal visibility.
5. When the air is wet, the instability helps to form the cumulus clouds and the accumulated pile, and therefore the occurrence of thunderstorms and the occurrence of precipitation in the form of showers and may be accompanied by cold sometimes.
6. If the air is dry, the currents of the air of instability cause the occurrence of air bumps in addition to it helps to raise sand and dust according to the nature of the earth.

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