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Characteristics of Vertical Temperature Profile over Baghdad

KEYWORDS: Troposphere, Inversion layer, Temperature inversion, inversion parameters

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ABSTRACT *In this work, the temperature inversion over Baghdad has been studied. Records of 7900 sets of eleven years radiosondes data were filtered, analyzed and processed for 100 m resolution. The data extended from the surface up to 15 km height and characterized for days and night's basis. The result shows that the lower transition layer significant at the night-time rather than day-time and occurs between 200 to 400 meters with slop of five C per 100 m above the transition layer. Moreover, the average temperature inversion depth increased by 13% from winter to summer with inversion strength of 1.5 % to 2 % respectively. Results also show that double inversions are common during the winter season. These results may explain the abundance of that dust and other aerosols which might last for many hours during the day over this area.*

1. Introduction:

Temperature inversion is relatively common in sounding areas and refers to reversal of normal temperature pattern seen in the lower atmosphere. In the wintertime, inversion occurred when cold air close to the ground is trapped by a layer of warmer air. Inversion also occurs during summer time, in particular, at nights. Lower temperature inversions are clearly appeared at Basins, Islands and Peninsula and may trap pollution and ducts RF signals.

Many researchers have investigated this phenomenon for both lower and upper atmosphere using different measurement techniques such as satellites, planes and sounding rockets. Thadathil et al. (1992) has studied the nature and possible forcing mechanism of the surface layer temperature inversion in the Arabian Sea during winter using bathythermograph data were collected from 1132 stations. The study shows that the temperature inversion layer thickness varying from 10 to 80 meters and gradient of 0 to 1.2 C°. It's also shown that the formation of the inversion is due to the forced advection of cold less slain water over slain Arabian Sea water. The possibility of using remote-sensing measurements to study the temperature inversion dynamics using microwave temperature profile was investigated by Kadygrov et al. (1999). The result shows that elevated temperature inversion base could not be detected higher than 400 m; however, inversion could be detected by radiosonde or by active methods. The analysis of the inversion heights has been studied by Sempenviva et al. (2000) using two years of measurements performed radiosonde system at the Island of Auholt in Denmark. The result shows that the evolution of the correlation coefficient between the temperature and height follows the evolution of the mixing height. The model was tested with different values of the potential temperature gradient above the inversion. The result shows that the estimated convection boundary heights compare favorably with observed heights obtained from radiosonde a scent. Nagar et al. (2001) presents a single model to estimate the convention boundary layer height and its evaluation during the daytime over a semiarid tropical station in the western part of India. A model with surface heat flux velocity and temperature as a function of time was used. Abd Elkader et al. (2008) has examined the utilization of remotely sensed data to evaluate the seasonal temperature inversion over Cairo. The result shows that the ground temperature inversion increased during wintertime while a strong anti correlation coefficient of 0.8 obtained between the ground heat fluxes and the ground temperature inversion. . Aikawa et al. (2009) has examined the measured temperature at different heights for Kobe's Port. The air temperature data were analyzed in order to study the vertical air temperature profile and to examine the validity of estimation in this study. It's found that the elevated temperature inversion layer at noon was observed in the summer while no temperature inversion layer was observed in winter. Georgaulies et al. (2009) investigated the air temperature characteristics of the atmospheric boundary layer in suburban environment to find the relationship between the meteorological variables near the surface. The result shows that the boundary-layer height is usually below in 200 m in morning hours during all seasons of the year and that also when near surface temperatures and wind speed are law too. In addition, noon heights exhaust values during summer than during winter.

In this paper, eleven years of radiosonde data over Baghdad were analyzed, processed and used to find out the temperature inversion characteristic of the vertical atmospheric layers, in particular, at the surface layer.

2. Data collection and analysis:

In general, the weather in Baghdad is almost predicted overall the seasons its hot dry at summer wet and cold at winter while spring and autumn are short. Significant discrepancy in temperature was normally recorded. The average temperatures in Iraq range from higher than 40 C in July and August to below freezing in January. The majority of the rainfall occurs from December through April and may reach 100 millimeters a year in some places. The summer months are marked by two kinds of wind phenomena: the southern dry, dusty wind with occasional gusts to eighty kilometers an hour occurs from April to early June and again from late September through November; the southeasterly steady wind from the north and northwest, prevails from mid-June to mid-September (Bashair AM 2012).

In order to characterize the temperature inversion layer, the radiosonde data recorded by the Iraqi meteorological office for the period 1973-1991 were filtered, analyzed and processed. The radiosonde is routinely carried out at two synoptic hour's 0000 and 1200 local time for each day. The lunching site is located at Baghdad airport 20Km distance south west of the city. As the meteorological data has been restricted since the first gulf war, few and limited publications were released.

More than 7900 data sets of eleven years were processed and used to identify the boundary layers from the surface up to 15 km height. The observations were the radiosonde give data at vertical resolution of 200 m these data interpolated for vertical resolution of 100 m where the temperature inversion layer was located as a sudden change in the potential temperature. The inversion depth is the height from the bottom to the top of the inversion where the laps' rate begins decreases for more than 100 m, the inversion temperature difference is therefore, the temperature gradient between

Volume : 3 | Issue : 3 | March 2013 | ISSN - 2249-555X

the top and bottom of the inversion and inversion strength is defined as the temperature difference over the inversion depth.

3. Results and discussions:

The distribution of the temperature is attributed to the relatively high solar radiation budget that generally reaches the earth during the noon in the middle latitudes leading to convictions. When the surface is wet apart of the available energy tends to be used as latent heat on the expenses of sensible heat. Air temperature can be used as a proxy of the sensible heat flux that is one of the factors that determines the atmospheric boundary-layer growth as higher temperature statistically indicates an increase of the available energy. In Baghdad January and June are the coldest and hottest months respectively. Its ideal months for understanding the wet and dry convection process associated with the evolution of the boundary layer under cold and hot weather conditions. Fig. (1) shows the vertical profile at midnights for the selected years during the winter and summer times; the average is illustrated by the solid line. It's clear that the

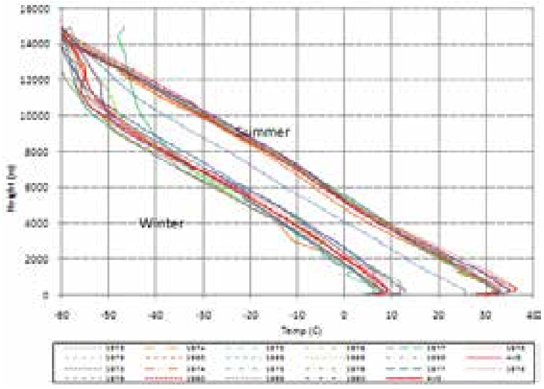

Fig. (1) Vertical profile at midnights for the selected years during the winter and summer times

inversion layer lays between 200 to 400 meters while the slope is about five C per 100 meters were recorded above the transition layer. In the summer time where the temperatures are very high and the sky almost clear, typical transition layers were recorded at midnight. The inversion layer begins to fade just after the sun rise, and it's completely disappeared at noon as shown in Fig. (2), that's because during the daytime, the surface layer of atmosphere received the heat of conduction and radiation from the earth surface which are warmed on the clear night ground surface radiate heat and cools quickly. The difference between the variation with stability in the surface layer and the higher layer is that in the surface layer, the variation is due to local processes. While it's due to interaction between different processes namely the top-down and the bottom-up process. It's also clear that the upper inversion layer in winter is lower than the inversion layer in summertime.

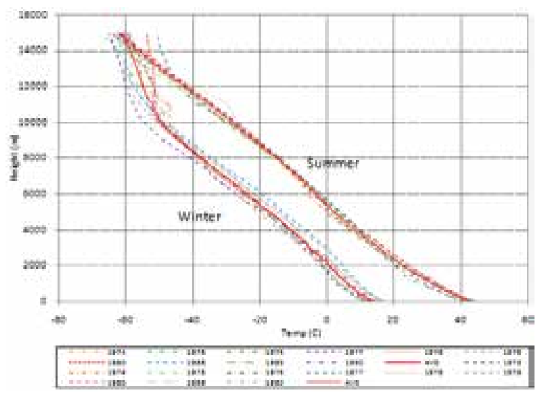

Fig. (2) Vertical profile at middays for the selected years during the winter and summer times

A close look to the transition layer shows that second inversions are existed in most of the years during the midnight, and it is clearer during the wintertime rather than summertime as shown in Fig. (3). A long term analysis of the second inversion which does exhibit a slight daily cycle is commonly observed at Baghdad during the wintertime nights. This phenomenon may be explained as the residual layer, which remains from the previous time that reaches that height. Another possible explanation for the existence of the second inversion is that at higher levels of the radiosonde might record the convention layer over the land, which may explain the daily behavior. The behavior of the lower inversion is found in the measurements where the mixed layer starts to grow just before the midnight and remains stationary at around 400 m.

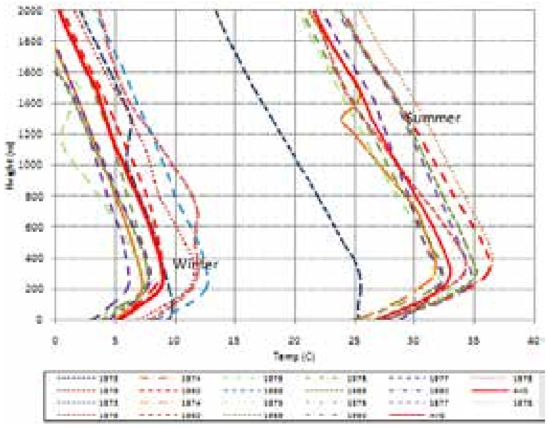

Fig. (3) Transition layer for the selected years during winter and summer midnights

Fig 4 shows the average values of the temperature inversions during midnight and midday for the winter and summer times. The variability in inversion parameters between the two seasons may be due to when the surface cools the temperature difference will be small, and the inversion will be shallow but when the surface is warm the temperature difference became significant and the temperature depth increased and positively correlated to the surface temperature. Table 1 shows the variability of the inversion parameters between the two seasons.

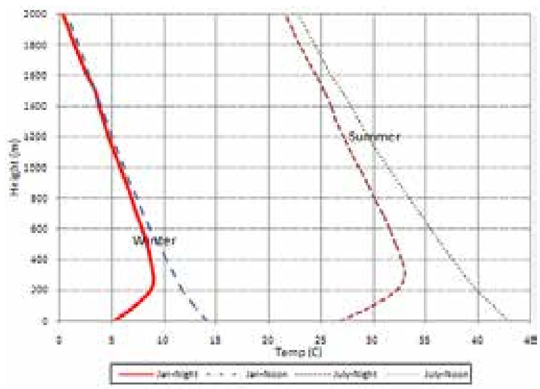

Fig. (4) Ten years average temperature inversions comparison.

Table 1 Comparison of variability in the inversion parameters.

Invasion parameter's	Winter	Summer
Surface Temperature	5.0	26
Inversion depth	260	320
Temperature difference	4.0	6.5
Inversion strength%	1.5	2

4. Conclusions:

The temperature inversion was studied for eleven years over Baghdad and leads to the following conclusions:

Volume : 3 | Issue : 3 | March 2013 | ISSN - 2249-555X

1. The temperature inversion layers are significant during the nighttime for both summer and winter while it disappears during the daytime.
2. The temperature gradients are high due to the temperature discrepancy between day and night for the two seasons.
3. The surface inversion is dominated so, no significant mixing layers are noticed.
4. Double inversions are common during winter nights.
5. The surface layers have the greatest influence on the air quality so that the dust, and the other aerosols' pollution is trapped and last for many hours as there is no room for dispersion.

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