MAUSAM, **53**, 4 (October 2002), 529-532

551.501.724

# A comparative study of temperatures of direct sunlight and air temperatures in a standard screen measured at Doha International Airport - a pilot study

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(*Received 5 October 2001, Modified 10 April 2002*)

**सार** - दोहा अंर्तराष्ट्रीय हवाई अड्डा, अरब की खाड़ी पर मानक स्क्रीन और सूर्य के सीधे प्रकाश में वायु के तापमान के बीच के अंतर का पता लगाने के लिए एक प्रेक्षणात्मक अभियान चलाया गया। इस अध्ययन के लिए, जुलाई-अगस्त, 1998 ओर जून-अगस्त, 1999 के दौरान लिए गए घंटेवार प्रेक्षणों को आधार बनाया गया है। ऊपर बताई गई अवधि में स्थानीय समय के अनुसार 0600 से 1800 बजे के दौरान लिए गए घंटेवार आँकड़ों के संबंध में स्क्रीन के तापमान (एस.टी.) और बाहर के तापमान (ओ.टी.) के बीच के अंतर का परिकलन और विश्लेषण किया गया। 1 जुलाई से 18 जुलाई, 1998 की अवधि में सूर्योदय से पहले तथा सूर्यास्त के बाद स्थानीय समय के अनुसार 1900-0500 बजे लिए गए अंतर की जाँच करने के उद्देश्य से भी ये प्रेक्षण किए गए। इस अध्ययन के परिणामों से यह पता चला है कि बाहरी तापमान और स्क्रीन तापमान के बीच के अंतरों के परिमाण अपेक्षाकृत उतने अधिक नहीं होते हैं। इसमें अधिकतम अंतर 16 जुलाई, 1999 के दिन 0900 बजे 5.1°से. पाया गया था। अनुमान के अनुसार ही सूर्य के सीधे प्रकाश का तापमान, स्क्रीन के तापमान की तुलना में सदैव अधिक होता है। यद्यपि स्थानीय समय के अनुसार सायं 0500 बजे के बाद स्क्रीन तापमान, बाहर के तापमान से अधिक पाए गए हैं। तथापि इन महीनों में सूर्यास्त का समय सायं 0600 बजे के बाद है। जून, जुलाई और अगस्त के महीनों में एस.टी. और डी.टी. के बीच का अंतर क्रमशः 1.43° से., 1.53° से. और 1.67° से. पाए गए हैं। इन महीनों में अधिकतम अंतर क्रमश 3.8° से., 5.1° से. और 4.1° से. देखे गए हैं। इस अध्ययन से यह भी ज्ञात होता है कि बाहरी तापमान (ओ.टी.) और स्क्रीन तापमान (एस.टी.) के बीच का अंतर स्थानीय समय के अनुसार प्रायः 0900-1000 बजे अधिक होता है और यह सूर्योदय एवं सूर्यास्त के दो घंटे पहले कम होता है।

**ABSTRACT.** An observational campaign was conducted at Doha International Airport, Arabian Gulf to find out difference between air temperature in a standard screen and direct sunlight. Hourly observations recorded during July-August 1998 and June-August 1999 formed the basis of the study. Difference between screen temperature (ST) and outside temperature (OT) in respect of all hourly data in the above period from 0600 to 1800 hrs of local time have been computed and analysed. In order to examine the difference before sunrise and after sunset, observations were also made during 1900-0500 hrs of local time from 1st to 18th of July 1998. Results of the study revealed that the magnitude of the differences between OT and ST is not as high as expected. The highest difference observed was 5.1° C on 16th July 1999 at 0900 hr. As anticipated, the temperature of direct sunlight between 0600 hr and 1700 hr were always higher than the screen temperature. However, after 0500 pm of local time, the screen temperatures are found to be higher than outside temperature though the sunset time in these months are after 0600 pm. The mean difference between ST and DT in June, July and August respectively found to be 1.43° C, 1.53° C and 1.67° C. The highest difference observed in these months was 3.8° C, 5.1° C and 4.1° C respectively. The study has also indicated that the difference between OT and ST is generally higher during 0900-1000 hrs of local time and lower during two hours before sunrise and sunset.

**Key words** – Air temperatures in Qatar, Doha International Airport, Summer temperatures at Doha, Difference between screen and outside temperature, Arabian Gulf.

## 1. Introduction

Is the absolute maximum temperature reported in daily weather report corresponds to maximum temperature in the open environment? A layman may think it so. But, a person who has a little meteorological knowledge will say no to it. The surface air temperature (measured at 1.25-2.0 m above ground) in a standard screen like Stevenson Screen is reported by the weatherman daily. People who are involved in out-door work, in open conditions, often think that meteorologists always report much lesser values than they experience in the field. They, perhaps, are not aware that meteorological offices report the air temperatures measured in a screen. In the absence of any observational data, it is quite difficult to say how much difference is there between these two environments. Some may think it may be as high as 10° C. So, in order to provide a scientific answer for this, a special study was

**TABLE 1**

**Mean and absolute highest difference between outside temperature (OT) and Screen Temperature (°C) during summer months of 1998 and 1999**

| Month | June 1999 | | July 1998 | | July 1999 | | August 1998 | | August 1999 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Local time (hrs) | Mean | Abs. max | Mean | Abs. max | Mean | Abs. max | Mean | Abs. max | Mean | Abs. max |
| 0600 | 0.7 | 2.1 | 0.4 | 0.8 | 0.4 | 1.0 | 0.3 | 0.8 | 0.2 | 0.6 |
| 0700 | 1.6 | 3.8 | 1.6 | 3.2 | 1.3 | 2.5 | 1.7 | 2.4 | 1.3 | 2.1 |
| 0800 | 2.0 | 3.4 | 2.2 | 4.3 | 1.7 | 3.0 | 2.3 | 3.5 | 2.0 | 3.5 |
| 0900 | 2.0 | 3.1 | 2.4 | 4.1 | 1.9 | 5.1 | 2.6 | 3.9 | 2.0 | 3.6 |
| 1000 | 1.7 | 2.5 | 2.3 | 4.3 | 1.9 | 3.1 | 2.7 | 4.1 | 2.1 | 3.5 |
| 1100 | 1.7 | 2.8 | 2.0 | 2.6 | 1.9 | 2.6 | 2.4 | 3.7 | 2.2 | 3.5 |
| 1200 | 1.8 | 3.0 | 1.8 | 3.4 | 2.0 | 3.4 | 2.2 | 3.0 | 2.1 | 2.9 |
| 1300 | 2.0 | 2.9 | 2.0 | 3.1 | 2.1 | 4.4 | 2.2 | 3.3 | 2.1 | 2.8 |
| 1400 | 2.0 | 2.6 | 2.1 | 3.0 | 2.1 | 3.1 | 2.3 | 3.0 | 2.1 | 3.1 |
| 1500 | 1.6 | 2.8 | 1.7 | 2.2 | 1.7 | 3.0 | 2.1 | 3.3 | 1.8 | 2.9 |
| 1600 | 1.0 | 1.7 | 1.1 | 1.8 | 1.1 | 2.5 | 1.6 | 2.6 | 1.6 | 2.5 |
| 1700 | 0.8 | 1.2 | 0.8 | 2.9 | 0.9 | 2.7 | 0.7 | 1.8 | 0.7 | 1.8 |

carried out at Doha, Qatar (Arabian Gulf) during summer seasons of 1998 and 1999 and the results have been presented in this note. The difference between the air temperatures measured inside the standard screen (ST) and those of the direct sunlight or outside temperature (OT) or temperature measured in non-sheltered (non-shielded) conditions is a subject of the present investigation. No rainfall occurred during the experimental period and therefore the values of OT are good representative of direct sun light temperatures.

## 2. Data

Along with the air temperature in the standard screen, temperature from an identical mercury thermometer exposed to the sunlight and hung at the same height (1.25 m) and at the same place (observatory of Doha International Airport) was recorded. During the experimental period of 1 July to 31 August 1998 and 1 June to 31 August 1999, hourly observations were taken from both the thermometers *i.e.*, (a) air temperature in the screen (ST) and (b) outside or direct sunlight temperature (OT). They were recorded from 0600 to 1800 hrs of local time (0300-1500 UTC), in the above months. Temperature readings were also made during 1900 - 0500 hrs of local time (LT) from 1 to 18 of July 1998 for examining the differences after the sunset.

## 3. Results and discussion

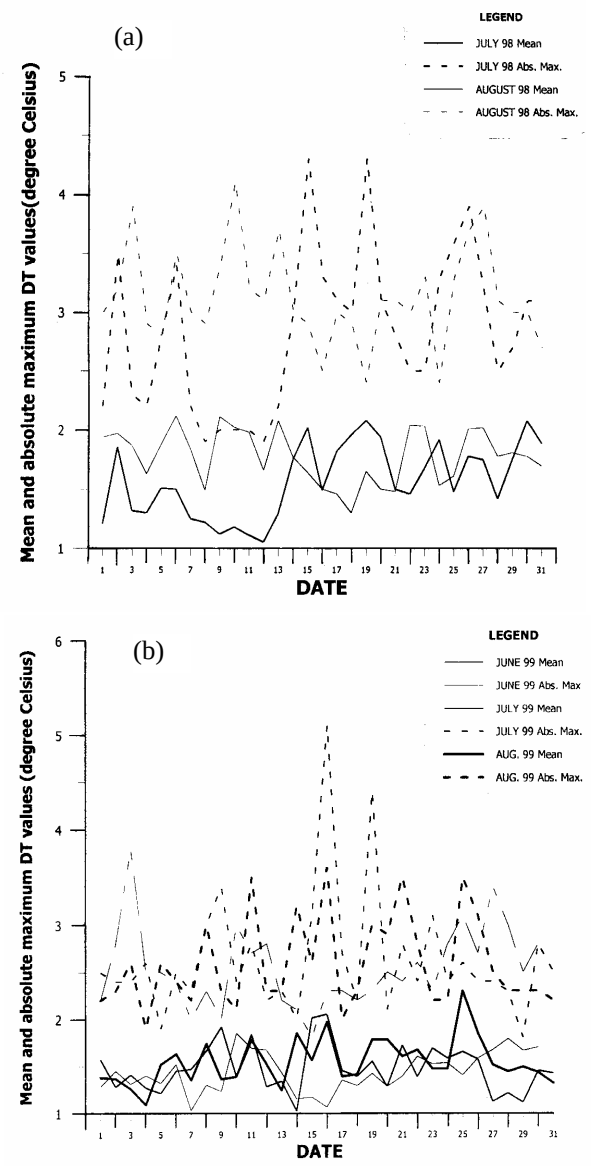
The difference in temperature (DT) between OT and ST was calculated in respect of all the hourly readings during the period of observational campaign. Table 1 present monthly average of daily means and extremes of DT's at each hour of observation for both the years 1998 and 1999. Figs. 1 (a&b) depict the daily mean and absolute maximum value of DT for 1998 and 1999 respectively. DT values have been taken as OT minus ST. The mean DT, mean maximum DT, absolute maximum difference and mean DT at 0600 and 1700 for the three summer months are given in Table 2. Monthly mean difference is the arithmetic average of all the 30 or 31 values (DTs) in the month and for all 12 hours put together in a day. Monthly mean maximum values are the average of the daily maximum value (observed at any hour) for all the 30 or 31 days in the month. Absolute maximum value is the highest value observed amongst all the daily maximum values in a month. Mean DTs at 0600 LT and 1700 LT is the average value observed at these hours in the month. From the data presented in Tables 1 & 2, the following aspects may be noted.

### 3.1. *June*

The difference in temperatures in observational hours of the day on a monthly scale in 1999 have ranged between 0.7° C (0600 LT) and 2.0° C. The average value for all the 12 hours and for the whole month is 1.43° C. It may be noted from Fig 1(b) that highest DT of 3.8° C occurred on 3 day (0700 LT). This is in contrast with the general pattern of occurrence of higher DT values between 0900-1000 hrs. The mean maximum DT for the month is found to be 2.54° C.

### 3.2. *July*

In 1998, on a monthly scale, the daily DTs in a day have ranged between 0.4° C(0600 LT) and 2.4°C (0900




**Figs. 1(a&b).** Daily mean DTs and daily absolute maximum DTs for (a) July and August 1998 and (b) June, July and August 1999

LT) with a daily mean value of 1.57° C. Highest DT value of 4.3° C was observed on 15 day and 19 day at 0800 LT and 1000 LT [Fig l(a)]. The average DT value for all the 12 hours and for the whole month works out to be 1.57° C, with a mean maximum value of 2.84° C.

In July 1999, daily range in mean DTs varied between 0.4° C (0600 LT) and 2.1° C (1300 LT) with a monthly mean of 1.48° C. Highest DT value of 5.1° C has occurred on 16 at 0900 LT [Fig. 1(b)] and the mean maximum value for the month is found to be 2.64° C. Though the absolute DT recorded in this year is higher, but the mean maximum value for the whole month is 0.2° C lower than that of the previous year. At this juncture, it is relevant to mention that the mean monthly temperatures in 1998 and 1999 (July) were 36.3° C and 35.9° C respectively; though the mean maximum temperature in both the years is same with 42.2° C.

### 3.3. *August*

The mean DT values in a day have ranged between 0.3° C (0600 LT) and 2.7° C (1000 LT) in 1998. The month's mean works out to be 1.78° C. Highest DT value of 4.1° C was recorded on 10 [Fig. l(a)] at 1000 hrs LT with month's mean maximum value of 3.13° C.

In 1999, the daily range of mean DT values have varied from 0.2° C (0600 LT) to 2.2° C at 1100 LT. In fact, the period of 0800-1400 LT had the DT range of 2.0-2.2° C. The monthly mean in this year was 1.55° C, about 0.2° C lower than the previous year. Highest DT value observed in this year was 3.6° C, on 16 day at 0900 LT. Next highest value of 3.5° C was observed on 11, 21 and on 25 of the month (0800-1100) LT [Fig 1(b)]. The monthly mean maximum value of 2.59° C of this year was much lower than the previous year's value of 3.13° C. August's mean monthly temperature in 1998 and 1999 was 36.3° C and 35.9° C respectively. However, there was very little difference in mean maximum temperatures of 1998 (41.8° C) and 1999 (41.9° C).

### 3.4. *Discussion*

It is clear from the above results that temperatures in the sunlight are always higher than in the screen, which is quite anticipated. However, the magnitude of the differences (DTs) between OTs and STs is not as high as one expected. The highest observed difference was 5.1° C, on 16 July 1999 at 0900 hrs local time. The mean DT value for the entire experimental period was found to be 1.56° C. It will be interesting to know the reasons behind the time of occurrence, but needs a detailed study. That may include wind speed, direction, relative humidity etc. In this context, one factor that may have some influence is the time from which sunrise has taken place. The mean sunrise time at Doha in June, July and August is 0444, 0453 and 0508 LT respectively. The study revealed that the higher difference between OT and ST has generally occurred between 0900-1000 hrs of local time. This is about 4.5-5.5 hrs after the sunrise. The absolute maximum surface air temperatures (STs) during the period of study have occurred between 1100-1200 LT (noon). This characteristic was reported earlier by Rao and Ali (2000). An interesting point to be noted here is that highest DTs occur about 2 hours before the highest recorded STs. Recently, Rao and Ali, 2000 and Hatwar *et al*. 2000 have brought out diurnal variation characteristics of surface

**TABLE 2**

**Statistics of monthly means, mean maximum, absolute maximum and mean DT values (°C) for 0600 LT and 1700 LT**

| Parameter | Jun 1999 | Jul 1998 | Jul 1999 | Aug 1998 | Aug 1999 |
|---|---|---|---|---|---|
| Monthly mean DT | 1.43 | 1.57 | 1.48 | 1.78 | 1.55 |
| Monthly mean max (OT) | 2.54 | 2.84 | 2.64 | 3.13 | 2.59 |
| Absolute maximum difference (Time of occurrence, LT) | 3.8 (0700) | 4.3 (0800,1000) | 5.1 (0900) | 4.1 (1000) | 3.6 (0900) |
| Mean DTs of 0600 LT | 0.7 | 0.4 | 0.4 | 0.3 | 0.2 |
| Mean DTs of 1700LT | 0.8 | 0.8 | 0.9 | 0.7 | 0.7 |

wind at Doha in different seasons. In summer months, the wind speed starts rising at about 7am and its rate of increase will be highest between 9-10 am with a peak value during 1-3 pm. On an average, the wind speed is below 10 knots up to 9 am local time and-above this value after 9 am. Perhaps, with the onset of moderate breeze conditions, the difference in DT values is decreasing. So, the strength of the wind may be one of the factors that contribute to the DT values. Of course, the intensity and the amount of total radiation received are major factors in determining the DT values.

A sharp decline in the DTs (nearly to half) was seen after 1500 LT in June and July and after 1600 LT in August. The mean sunset timing in June, July and August is 1827, 1825 and 1810 LT respectively. Keeping this in mind and to examine the DTs after sunset, additional observations from 1 to 18 August 1998 have been taken during the period 1900 LT-0500 LT. These, together with all other observations showed that OTs to be lower than STs after 1700 hrs of local time. It was found that DTs after 5 pm local time were in the range of -0.2° C to -0.7° C with an average value of -0.45° C. However, the values of DTs at 1700 LT are always higher than those observed at 0600 LT and are positive.

Frequency distribution of the values of DT for individual months is summarized in Table 3. About 48% of DTs of July and August 1998 have been found to be in the range of 1.5° C-2.4° C. In 1999, about 51% values lay in this range (June 51%, July 50% and August 57%). Only about 5% of the total DT values were found to be above 3.0° C, whereas, 7% of the total observed DTs were below 0.5° C. In all, 75% of the DT values lay in the range of 1.0-2.9° C. So, for the majority of the period, the difference in temperatures of direct sun and air temperatures in the shade is below 3.0° C.

**TABLE 3**

**Frequency distribution of the temperature difference (°C) between outside and inside screen during the summer months of 1998 and 1999**

| Range | Jun 1999 | Jul 1998 | Jul 1999 | Aug 1998 | Aug 1999 |
|---|---|---|---|---|---|
| –0.5 to –0.1 | 0 | 0 | 3 | 4 | 1 |
| 0.0 to 0.4 | 16 | 20 | 36 | 22 | 30 |
| 0.5 to 0.9 | 55 | 53 | 43 | 40 | 38 |
| 1.0 to 1.4 | 76 | 63 | 65 | 26 | 45 |
| 1.5 to 1.9 | 105 | 87 | 114 | 69 | 108 |
| 2.0 to 2.4 | 77 | 93 | 71 | 108 | 105 |
| 2.5 to 2.9 | 24 | 30 | 31 | 60 | 34 |
| 3.0 to 3.4 | 6 | 20 | 7 | 34 | 6 |
| 3.5 to 3.9 | 1 | 3 | 1 | 8 | 5 |
| 4.0 to 4.4 | 0 | 3 | 1 | 1 | 0 |
| Total | 360 | 372 | 372 | 372 | 372 |

## 4. Conclusions

Based on the observations taken in the two summer seasons of 1998 and 1999, the following broad conclusions may be made :

(*i*) Temperatures of the direct sunlight between 0600 hrs and 1700 hrs LT are always higher than the surface air temperatures in the Stevenson screen. After 5 pm of local time, the screen temperatures are found to be higher than the non-sheltered or outside temperatures.

(*ii*) The difference in the mean daily DTs in June, July and August is 1.43° C, 1.53° C and 1.67° C respectively.

(*iii*) Absolute maximum DTs observed in June, July and August in the period of study were 3.8° C, 5.1° C and 4.1° C respectively.

(*iv*) The differences (between OT and ST) are generally highest between 0900-1000 hr of local time and they are lowest two hours before sunrise and sunset.

(*v*) The absolute highest surface air temperature (ST) observed at Doha was 49.6° C in July 2000. Based on this, it may be said that temperature of the direct sun light at Doha may not exceed 55° C at any time of the year.

**References**

Hatwar, H. R., Al-Sulaiti, M. H. and Ali, A. H., 2000, "Summer Shamals over Arabian Gulf and Associated Upper Air Systems-A technical report of the Ministry of Communication and Transport", Department of Civil Aviation and Meteorology, Qatar.

Rao, P. G. and Ali, A. H., 2000, "Climate of Qatar: A Technical report of the Department of Civil Aviation and Meteorology", Doha-Qatar.