EFFECT OF MONTHLY CLIMATIC VARIABILITY ON CHARACTERISTIC OF ATMOSPHERIC SURFACE LAYER – A STUDY IN QATAR

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Summary Some characteristic features of the atmospheric surface layer in coastal Qatar region have been investigated during the month of June and July, 2011 using tower based instruments. The meteorological data was collected in the New Doha International Airport (25.25N; 51.62E) at a pier 500 m into the ocean. The diurnal variation of climatic condition was estimated for these two months, and the effect of any changes in the climatic condition on the characteristic of atmospheric surface layer was studied within the framework of Monin-Obukhov similarity theory. It was found that the friction velocity decreases significantly during July, 2011 compared to June, 2011. This leads to a slightly unstable atmospheric surface layer in July, 2011. The growth of the normalized variance of the vertical velocity component indicates a slightly reduced growth rate for stable regime of flow during July, 2011. However, no appreciable effect of climatic variation can be observed for the normalized variance in the unstable regime of the atmospheric surface layer.

INTRODUCTION

Characterisation of Atmospheric Surface Layer (ASL) is of interest as it plays an important role in transport of pollutants and heat from the surface. The increased importance of Persian Gulf, with its unique geophysical conditions, in the world economy and industrialization is well recognized, but so far no atmospheric study has been carried out to explore the nature of ASL in this region. The present investigation reports the micrometeorological information of ASL measured in a pier in the approach light area in New Doha International Airport in Qatar, during June-July 2011. The characterization is presented within the framework of Monin-Obukhov similarity theory.

Monin-Obukhov similarity theory states that the normalized variances of velocity components and temperature would be a universal function of a suitably constructed stability parameter, as [1]

$$\frac{\sigma_i}{u_*} = A_i\left[1 + B_i\left(\frac{z}{L}\right)\right]^{c_i} \;;\; i = u, v, w; \tag{1}$$

where, u, v and w are the streamwise, transverse and vertical velocity components; u_* is the friction velocity; z is the vertical height, and L is the Monin-Obukhov length scale, defined as;

$$L = -\frac{1}{k}\frac{u_*^3}{\left(\frac{g}{\overline{T}}\right)\overline{w'T'}}. \tag{2}$$

In the above expressions, over bar denotes averaging, and dash denotes fluctuating components. Also, T is the potential temperature, and k is the Von-Karman constant (= 4.1). The ratio z/L is one of the most important parameters of atmospheric surface layer studies, and the atmospheric layer can be classified as unstable or stable for $z/L \le 0$ or $z/L \ge 0$, respectively.

The friction velocity u_* can be computed as $u_* = \left(\overline{u'w'}^2 + \overline{v'w'}^2\right)^{1/4}$ (3)

EXPERIMENTS

Experiments are conducted in the coastal region in Doha, Qatar, (25.25N, 51.62E) in a pier located into 500 m into the Persian Gulf. Three sonic anemometers (CSAT3) were mounted at a nominal height of z= 4.5, 8.2 and 10 m from the ocean surface, and acquire data at 20 Hz frequency simultaneously. Figure 1 shows an image of the experimental setup. The experiment is performed during June-July 2011. The range of temperature and humidity during the months of June and July were, 30^0C-35^0C, 30%-45%; and 30^0C -40^0C, 40%-70%, respectively. The wind velocity was always more than 3 m/s, ensuring fully developed turbulence. Figure 1 shows a picture of the experiment setup.

RESULTS

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Figure 2 depicts the diurnal variation of the friction velocity for June, and July, 2011. Though the diurnal variation remains approximately similar, the magnitude of friction velocity decreases significantly during July, 2011. This could be due to the low wind velocity, and any particular condition of the sea state during that month.

Figure 1: A picture of the experimental setup.

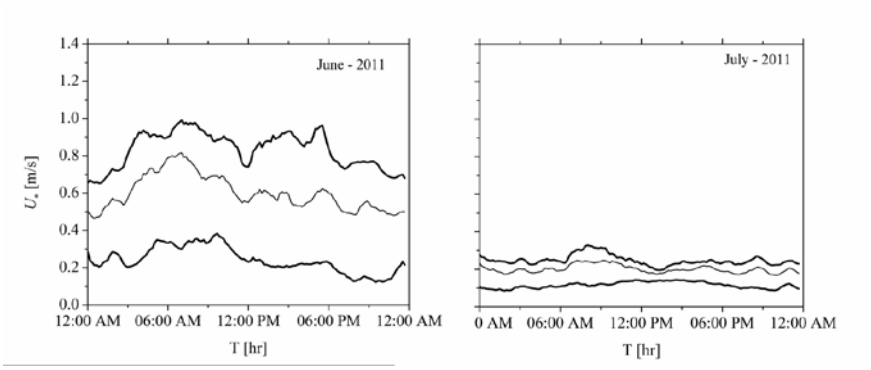

Figure 2: Diurnal course of the variation of the friction velocity for different months. The upper and lower curves in each plots represents interquartile range (IQR) between 25th and 75th percentile, i.e. 50% of data lies within this range.

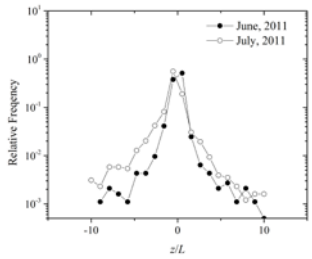

Figure 3: Frequency distribution of the stability parameter *z*/*L* binned into 1-*z*/*L* classes for the month of June, and July, 2011.

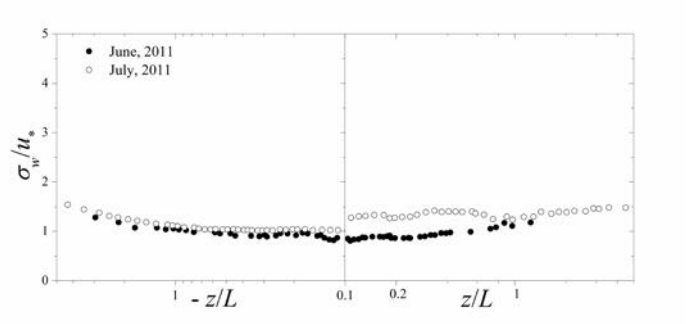

Figure 4: Variation of normalized variance of vertical velocity with stability parameter *z*/*L* for June, and July, 2011.

The frequency distribution of the stability parameter for both months is indicated in Figure 3. The peak of the distribution function moves towards unstable regime for July compared to June, 2011. This observation is in accordance with the observation from Figure 2, as Equation (2) dictates that any decrease in friction velocity u_* would push the stability parameter towards unstable regime, since $z/L \propto -1/u_*^3$.

The variation of the normalized vertical velocity parameter σ_w/u_* with *z*/*L* is shown in figure 4 for both stable and unstable regime of the atmospheric surface layer. The result indicates that the magnitude of σ_w/u_* for July, 2011 is higher for the stable regime, but exhibits a lower growth rate compared to the data from June, 2011. However, the variation of σ_w/u_* for unstable regime for June and July matches closely, and indicate negligible effect of the climatic variation in the unstable regime of the atmospheric surface layer.

CONCLUSIONS

Experiments are conducted in coastal area of Qatar in the Persian Gulf to explore variation of micrometeorological properties of atmospheric surface layer with climatic variation within Monin-Obukhov similarity theory framework. The experiments were conducted during June and July, 2011. The result indicates that the month of July is characterized by a mildly unstable atmospheric surface layer, in addition to higher vertical velocity fluctuation during stable regime. But the magnitude of the variance of vertical velocity for unstable regime does not get affected due to the climatic variation.

ACKNOWLEDGEMENT

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