Determination of Possible Factors That Affect the Diurnal Variation of Atmospheric Pressure

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ABSTRACT

It is well known that the Atmospheric pressure varies on solar radiation, rainfall, air temperature and humidity level. This work will suggest that solar radiation affects positively the diurnal pressure variation, but air temperature, relative humidity and rainfall affect negatively the diurnal pressure variation.

KEYWORD: Diurnal Pressure Variation

INTRODUCTION

Diurnal (or sub-daily) variations such as solar radiation, surface latent and sensible heat fluxes, surface temperature and winds, atmospheric convection, and precipitation are large in many surface and atmospheric fields These diurnal variations are especially important in air-land and air-sea interactions, which are highly non-linear and thus cannot be resolved using daily mean values. Current regional and global climate models still have difficulties in simulating the diurnal variations correctly.

The study will consider only the diurnal variation of the troposphere. Measurements of surface pressure reveal both a diurnal and a semidiurnal (12h) rhythm underlying any longer-term (synoptic) variation. This rhythm is the surface image of a diurnal tide of the entire atmosphere. A wave moves across the upper atmosphere, westward with the speed of the Sun.

Bernhard Haurwitz discovered in 1956 (Platznam, 1996) and explained it as due to the warming of the upper atmosphere (mainly the thermosphere) by the Sun. The diurnal sea level pressure variation is entirely hydrostatic, i.e. it is the result of temperature variations aloft. Upper level variations of temperature distort isobaric surfaces. Therefore, the upper level wind shows a similar diurnal cycle. This study is focused to identify the possible factors that affect the diurnal variation of atmospheric pressure. Factors considered are air temperature, solar radiation, wind speed and direction, rainfall, and relative humidity. The least surface pressure measurements in Colombo, Sri Lanka around 0400hrs and 1600hrs LST (Local Standard Time), and most around 1000hrs, and 2200hrs LST; the amplitude of the semidiurnal cycle is about 1.4 hPa. The superimposed diurnal rhythm has about half the amplitude, with a maximum at about 0600hrs and minimum at 1800hrs LST.

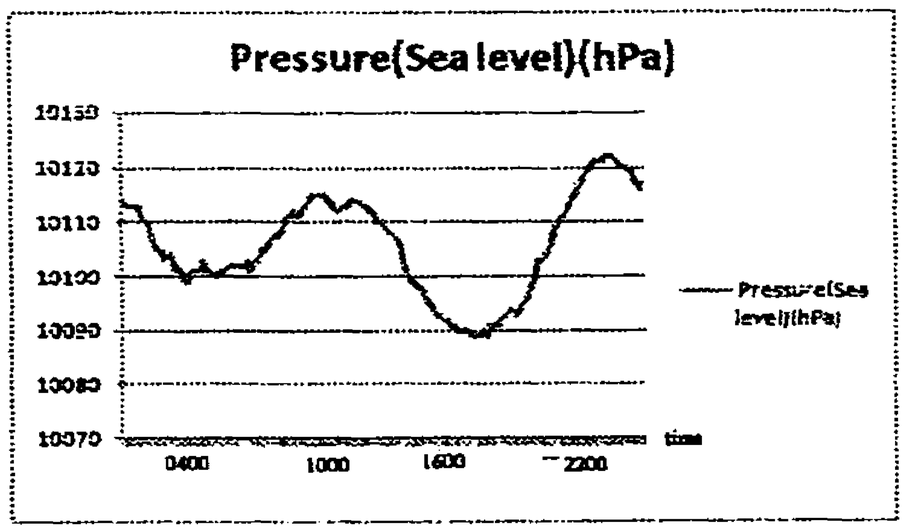

Figure 1. Diurnal pressure variations

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DATA AND COMPUTATIONAL DETAILS

The daily observed meteorological data like station pressure or sea level pressure data well recorded in every ten minutes data at AWS (Automatic Weather Station) in Department of Meteorology at Colombo. Relations between atmospheric pressure and other meteorological factors were done using
Pearson's product-moment correlation analysis, and Hypothesis testing.

Pearson's product-moment correlation analysis

The population correlation coefficient $\rho_{X,Y}$ between two random variables X and Y with expected values μ_X and μ_Y and standard deviations σ_X and σ_Y is defined as:

$$\rho_{x,y}=\frac{cov(X,Y)}{\sigma_x\sigma_y}=\frac{E[(X-\mu_x)(Y-\mu_y)}{\sigma_x\sigma_y}$$

where E is the expected value operator and cov means covariance. A widely used alternative notation for Pearson's correlation is *corr*(X,Y).

If we have a series of n measurements of X and Y written as x_i and y_i where $i = 1, 2... n$, then the *sample correlation coefficient*, can be used to estimate the population Pearson correlation between X and Y. The sample correlation coefficient is written

$$r_{xy}=\frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{(n-1)s_xs_y}$$

where x and y are the sample means of X and Y, s_x and s_y are the sample standard deviations of X and Y.(Kendall, 1955)

Hypothesis Testing

The *lower* the p-value, the *less* likely the result, assuming the null hypothesis, so the *more* "significant" the result, in the sense of statistical significance. One often rejects a null hypothesis if the p-value is less than 0.05 or 0.01, corresponding to a 5% or 1% chance respectively of an outcome that extreme, given the null hypothesis.
Let the null Hypothesis, H0, as the correlation between two variables is equal to zero.
H1: There is a correlation between pressure and other Meteorological Variables.

Table 01. Calculated Correlation Coefficients and P-Values

Meteorological Factor	Correlation coefficient Vs pressure	P-Value
Air Temperature	-0.264	0.005
Solar Radiation	0.208	0.012
Relative Humidity	-0.203	0.014
Rainfall	-0.190	0.022
Wind Speed	0.085	0.309
Wind Direction	-0.023	0.787

Case 1 : *Correlation of Air Temperature and Atmospheric Pressure*
P-Value = 0.005
P-Value (0.005) < 0.05
Reject H_0.
Since the sign of Pearson's Correlation is negative and H_0 is rejected, there is a negative correlation between Atmospheric pressure and Air Temperature.

Case 2 : *Correlation of Solar radiation and Atmospheric Pressure*
P-Value = 0.012
P-Value (0.012) < 0.05
Reject H_0.
Since the sign of Pearson's Correlation is positive and H_0 is rejected, there is a positive correlation between Atmospheric pressure and Solar Radiation.

Case 3 : *Correlation of Relative Humidity and Atmospheric Pressure*
P-Value = 0.014
P-Value (0.014) < 0.05
Reject H_0.

Since the sign of Pearson's Correlation is negative and H_0 is rejected, there is a negative correlation between Atmospheric pressure and Relative Humidity.

Case 4 : *Correlation of Rainfall and Atmospheric Pressure*

P-Value = 0.022

P-Value (0.022) < 0.05

Reject H_0.

Since the sign of Pearson's Correlation is negative and H_0 is rejected, there is a negative correlation between Atmospheric pressure and Rainfall.

Case 5 : *Correlation of Wind Speed and Atmospheric Pressure*

P-Value = 0.309

P-Value (0.309) > 0.05

Accept H_0.

Since H_0 is accepted, there is no correlation between Atmospheric pressure and Wind speed.

Case 6 : *Correlation of Wind direction and Atmospheric Pressure*

P-Value = 0.787

P-Value (0.787) > 0.05

Accept H_0.

Since H_0 is accepted, there is no correlation between Atmospheric pressure and Wind speed.

SUMMARY

The diurnal variation of pressure has sinusoidal behavior. This was happened by solar radiation because solar radiation directly affects the weather systems. It controls all the weather systems. The atmospheric pressure depends on other meteorological factors such as air temperature, humidity rainfall and etc.

The diurnal variation of pressure has sinusoidal behavior, and also it has periodic behavior, since any periodic functions can be transformed into the Fourier series, it can transform into Fourier series. Then one can create a function for Diurnal Pressure variation.

ACKNOWLEDGEMENT

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