Variation of diurnal Turbulence Kinetic Energy using sonic anemometer observation: a case study Ledeng, Bandung

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Abstract— Sonic anemometer observation was performed on 29 - 30 September 2014 in Ledeng, Bandung to see diurnal variations of Turbulence Kinetic Energy (TKE) that occurred in this area. The measured sonic anemometer was the wind velocity components u , v , and w . From the observation result, it can be seen that the diurnal variation that happened was quite significant. The maximum TKE occurs during the daytime when atmospheric conditions tend to be unstable. TKE values was small at night when atmospheric conditions are more stable than during the daytime.

Keywords—*diurnal variation, boundary layer observation, turbulence kinetic energy*

I. INTRODUCTION

Turbulence is a movement of random rotation in a relatively short time [3]. Turbulence greatly affects the boundary conditions of an atmosphere because turbulence transfers energy and heat, vertically and affects the stability of a layer. One way to know the energy of a turbulence is to look for a deviation of a velocity component from its average [1]. Using Reynolds average, the velocity component can be divided into mean and perturbation parts. From the perturbation results, we can calculated Turbulence Kinetic Energy (TKE). TKE is the kinetic energy possessed by a turbulent. By looking at the kinetic energy of turbulence, we can observe the intensity of the turbulence that occurs.

II. METHODOLOGY

Data used in this research is data from observation of sonic anemometer (Fig. 1). This observation was conducted on 29 September 2014 from 19.00 Indonesia Western Standard Time (IWST) to 30 September 2014 at 19.00 IWST in the area of Indonesia University of Education (UPI), Ledeng, Bandung (Figure 2) at coordinates $6^{\circ} 51' 48'' S$, $107^{\circ} 35' 40'' E$ (Figure 2). Observation of wind velocity components performed every minute with duration of 24 hours. From observation using the sonic anemometer, we get u , v , and w wind components data,

which will then be used to calculate TKE in the area for 24 hours.

Often happens, conditions that allow surface airwaves to form wind shears locally, resulting in the formation of turbulence [1]. Therefore, the phenomenon of airwaves in the boundary layer can be associated with the propagation of heat turbulence and the spread of pollutants. The turbulence of the boundary layer is generally influenced by diurnal cycle variations, so the turbulence values in daytime and night will be different [3]. Turbulence is also affected by the stability of the atmosphere in the boundary layer. The stability of the atmosphere is the tendency of air to resist vertical movement or to resist the turbulence that occurred [2]. The stability of the atmosphere depends on the temperature gradient. If the temperature is high, a lot of turbulence phenomenon are expected.

Fig. 1. Sonic Anemometer used in this research observation.

$$K = \frac{1}{2} \times (u^2 + v^2 + w^2) \quad (1)$$

There is a relatively easy way to simplify fluid motion parameters to measure turbulence in the boundary layer. It is by averaging the observed wind velocity for a time range above 30 minutes to one hour [1]. By averaging the wind velocity, we can eliminate positive and negative deviations from wind velocity (Fig. 3). By using Reynolds averaging, we can separate a stream into its mean and turbulent parts as described in equations (2), (3), and (4).

$$u' = U - \bar{U} \quad (2)$$

$$v' = V - \bar{V} \quad (3)$$

$$w' = W - \bar{W} \quad (4)$$

$$\frac{MKE}{m} = \frac{1}{2} \times (\bar{U}^2 + \bar{V}^2 + \bar{W}^2) \quad (5)$$

$$\frac{TKE}{m} = \frac{1}{2} \times (u'^2 + v'^2 + w'^2) \quad (6)$$

III. RESULT AND DISCUSSION

Fig. 4. Time-series data of Turbulence Kinetic Energy (TKE) during one-day observation. It appears that the peak of turbulence occurs during the daytime.

Through the *TKE* values, we know the intensity of turbulence phenomena that occur. During the day, the *TKE* value reaches its maximum point at 13.00 IWST due to unstable atmospheric conditions. At night, atmospheric conditions tend to be more stable than daytime, so the *TKE* values are much lower.

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