An investigation of cloud base height in Chiang Mai

S Peengam and K Tohsing
Laboratory of Tropical Atmospheric Physics, Department of Physics, Faculty of Science, Silpakorn University, Muang, Nakhon Pathom 73000, Thailand

E-mail: P.Sahussa@gmail.com

Abstract. Clouds play very important role in the variation of surface solar radiation and rain formation. To understand this role, it is necessary to know the physical and geometrical of properties of cloud. However, clouds vary with location and time, which lead to a difficulty to obtain their properties. In this work, a ceilometer was installed at a station of the Royal Rainmaking and Agricultural Aviation Department in Chiang Mai (17.80° N, 98.43° E) in order to measure cloud base height. The cloud base height data from this instrument were compared with those obtained from LiDAR, a more sophisticated instrument installed at the same site. It was found that the cloud base height from both instruments was in reasonable agreement, with root mean square difference (RMSD) and mean bias difference (MBD) of 19.21% and 1.58%, respectively. Afterward, a six-month period (August, 2016-January, 2017) of data from the ceilometer was analyzed. The results show that mean cloud base height during this period is 1.5 km, meaning that most clouds are in the category of low-level cloud.

1. Introduction
Clouds are small water droplets or ice particles condensed floating in the atmosphere. Clouds are important for the attenuation of solar radiation reaching to the earth surface [1]. The variations of clouds impact on weather and meteorological characteristics. Generally, clouds have several types depending on size of the droplets and cloud base height (CBH). The cloud base height is important to an aviation [2], meteorological data analysis and a change of solar radiation. The cloud base height can be measured in several methods. For example, the observation by human but it requires an experienced person or meteorologist and difficult to observe clouds at the night, and the measurement by ceilometer, radiosonde, satellite or Lidar [3 – 6]. Relative humidity (RH) and dewpoint temperature from radiosonde, backscatter profiles from ceilometer and Lidar were used to calculate cloud base height [7, 8]. The ceilometer is used to measure the cloud base height and other cloud properties in many regions. Giovanni et al. [9] presented the comparison of the measured cloud base height from two ceilometers with the cloud base height calculated by a new algorithm using the back scatter profile from ceilometer. Costa- Surós et al. [10] purposed the statistical study of cloud base height over Spain using ceilometer during a 4-year period (2007-2010). It was found that in summer cloud occurrence minimum and cloud vertical structure over Spain was single layer cloud.

In Thailand, there is the lack of cloud base height data due to the limitation of a ground-based measurement. In this work, the cloud base height measured by the CS135 ceilometer was analyzed and then compared with that obtained from Micro Pulse Lidar.
2. The instruments and data

The ceilometer (model CS135, Campbell Scientific) was installed at a station of the Royal Rainmaking and Agricultural Aviation Department in Chiang Mai (17.80° N, 98.43° E, 1120 m a.s.l) since 21 August 2016 (Figure 1(a)). The ceilometer can measure the CBH at the maximum range up to 10 km for every 15 seconds. This ceilometer uses the NIR laser at the wavelength 905 nm and it can observe four layers of the CBH. Other technical details of the ceilometer are summarized in Table 1. The cloud base height data from this instrument were compared with those obtained from Micro Pulse Lidar (MPL) installed at the same site (Figure 1(b)). The MPL is an eye-safe lidar system for detecting the cloud base height, profiling atmospheric cloud and aerosol scattering developed by National Aeronautics and Space Administration (NASA) (see Table 1.). This Lidar is a part of MPL-NET (Micro-Pulse Lidar Network) and the data available on https://mplnet.gsfc.nasa.gov.

In order to observe the sky condition such as cloud cover ranged from clear sky to overcast sky and probability of precipitation, a sky view (model PSV-100, PREDE) is used to collect the sky images for this purpose. This sky camera captures the sky hemisphere for every one minute and hemispherical images for the sky view are shown in Figure 3 (lower panel).

![Figure 1. (a) CS135 ceilometer. (b) Micro Pulse Lidar (MPL)](image)

Table 1. Specifications of Campbell Scientific CS135 and Micro Pulse Lidar

| Instrument Performance          | Campbell Scientific CS135 | Micro Pulse Lidar |
|---------------------------------|---------------------------|-------------------|
| Laser Type                      | InGaAS                    | Nd-YAG            |
| Wavelength                      | 905 nm                    | 532 nm            |
| Laser safety                    | Class 1M                  | Not specified     |
| Laser pulse energy              | Maximum 4800 nJ           | 6-10 µJ           |
| Maximum Reporting Range         | 10 km                     | 25 km             |
| Minimum Reporting Resolution    | 5 m                       | 5 /30 /75 m       |
| Pulse duration                  | 100 ns                    | Not specified     |

3. Results and discussion

3.1 Cloud base height from CS135 ceilometer

The cloud base height data from ceilometer during the period of August 2016 – January 2017 was analyzed and presented in Figure 2(a) as the percentage of different cloud base height and the cloud occurrence (%) (Figure 2(b)). The results show that the height of most clouds is less than 1000 m and 2000 m in 54% and 81% respectively. The mean cloud base height during this period is 1500 m, which mean that most clouds are in the category of low level cloud. It was also observed that most cloud
were stratiform. Figure 2(b) shows the percentage of cloud occurrence in this measuring period. From the end of August 2016 to October 2016, the cloud occurrence is found to be 60% for wet season, and from November 2016 to January 2017 is about 30% for dry season.

**Figure 2.** (a) Percentage of the cloud base height from CS135 ceilometer, (b) Cloud occurrence from the CS135 ceilometer during August 2016 - January 2017

### 3.2 Comparison of cloud base height between CS135 and MPL

The comparison of the cloud base height obtained from CS135 ceilometer and MPL for every 10 minutes on 1 September 2016 is shown in Figure 3 (upper panel). Yellow points represent the CBH from CS135 and blue points from MPL. In Figure 3 (lower panel) show the corresponding sky images captures by the sky view at 6:30 am (a), 12:00 am (b) and 6:00 pm (c) respectively, which showed the overcast sky on that day. For the whole period (August 2016-January 2017), the comparison from both instruments is shown in Figure 4. It was found that the cloud base height from CS135 ceilometer and MPL was in reasonable agreement with a coefficient of determination ($R^2$), mean bias difference (MBD) and root mean square difference (RMSD) and of 0.94, 1.58% and 19.21%, respectively.

**Figure 3.** Cloud base height from ceilometer CS135 (yellow) and MPL (blue), pictures from sky view (a) 1 Sep 2016 6:30 am, (b) 1 Sep 2016 12:00 am and (c) 1 Sep 2016 6:00 pm
4. Conclusion
In this work, a six-month period (August 2016-January 2017) of the cloud base height measured by CS135 ceilometer was analyzed. The mean cloud base height during this period is 1,500 m corresponding to the low-level cloud. The statistical analysis of cloud base height showed that the cloud occurrence varied from wet season to dry season. After that, the cloud base height from this ceilometer and MPL was compared. The resulting comparison shows that the cloud base height from both instruments was in reasonable agreement, with MBD, RMSD and $R^2$ of 1.58%, 19.21% and 0.94, respectively.

References

[1] Esmaiel M 2015 Journal of Environmental Science and Engineering, B 4, pp 216-226
[2] Hirsch E, Agassi E and Koren I 2011 Atmospheric Measurement Techniques, 4, pp 117-130.
[3] Gaumet J L, Heinrich J C, Cluzeau M, Pierrard P, Prieur J 1998 Journal of Atmospheric and Oceanic Technology, 115, pp 37-45.
[4] Kirk D P, Junhong W and William BR 1995 American Meteorological Society, 8, pp 550-568.
[5] Som S, Rajesh V, Munn VS, Prashant K, Prateek K, Pradeep K T, Shyam L and Yashwant BA 2016 Atmospheric Measurement Techniques, 9, pp 711-719.
[6] Aaron J P and Richard L 2009 AMS Fourth Symposium on Lidar Atmospheric Applications.
[7] Costa-Surós M, Calbó J, González J A and Long C N 2014 Atmospheric Measurement Techniques, 7, pp 2757-2773.
[8] Shiv R P, Wolfgang S and Allan I C 1992 Applied Optics, 31, pp 1488-1494
[9] Giovanni M, Conor M, and Colin D. O’Down 2009 Atmospheric and Oceanic Technology, 27, pp 305-318.
[10] Costa-Surós M, Calbó J, González J A and Martin-Vide J 2013 Atmospheric Research, 127, pp 64-76.