Characteristics of cloud base height from ceilometer measurement at Dalanzadgad, Mongolia

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Abstract

Eye visible observation is used for determining cloud base heights in Mongolia. A laser ceilometer, model CL51 was installed at a weather station in Dalanzadgad in the southern Mongolia since May 2013. We analyzed data of high resolution (6 s measurements) ceilometer measurements at Dalanzadgad within the period of 2013–2016 and data of eye visible observation in the same period. The cloud vertical structure was analyzed from the dataset. The ceilometer detected single, double and three layered cloud base heights (CBH). Low clouds represent 22.7% of detected CBH, while middle clouds 56.5%, and high clouds 20.8%. For two and three layered clouds, distances between CBH of interlayer were found. When low pressure systems arrived at the country both winter and summer, the ceilometer detected low clouds with the highest frequencies of CBH at 800-1600 m, while middle clouds at 2800-3600 m.

Keywords: cloud base height, cloud occurrences, cloud cover, cloud vertical structure, cloud layers, ceilometer, low pressure system

1. Introduction

Cloud is a visible collection of particles of tiny water droplets or ice crystals suspended in the air. Without clouds, there would be no rain or snow, thunder or lighting, rainbows or halos (Ahrens, 1999). Clouds are classified on the basis of two criteria: form and height.

Ground-based instruments such as lidar, ceilometers etc are used to determine the cloud base height (CBH) (Costa-Suros et al., 2013). Ceilometer is an important instrument to accurately detect low- and middle-level clouds (Sharma, 2016). These lidar instruments are based on technology of an active remote sensing system that is consisting of a transmitter and a receiver. Short light pulses are transmitted to the atmosphere and the backscattered light allows determining CBH (Costa-Suros et al., 2013; Jugder et al., 2012; Sugimoto et al., 2002). A Dalanzadgad site locates in the southern Gobi desert area in Mongolia. Cloud occurrences are climatologically higher in summer and lower in winter in Mongolia including Dalanzadgad. Clouds are one of the indicator of synoptic situation, and its height is changing cloud deck during the passage of a frontal system (Maturilli et al., 2018).

A ceilometer was installed at the Dalanzadgad weather station in May 2013 by a support of Nagoya University, Japan and used for monitoring dust aerosol in the atmosphere.

A laser ceilometer, model CL51 by the Vaisala was installed at a weather station in Dalanzadgad (43.58°N, 104.42°E, 1470 m above the mean sea level, MSL) in the southern Mongolia since May 2013 (Kawai et al., 2015). The central wavelength of the emitted light of CL51 is about 910 nm, the vertical resolution is 10 m and backscatter profiles are stored every 6 seconds.

2. Results and discussions

2.1. Cloud occurrences

Cloud occurrences were lower in December to February and higher in June and July by both observations of ceilometer and weather observers (Fig. 1). Cloud frequencies were rising in spring months and throughout summer. Clear day frequencies were higher in winter months at Dalanzadgad.

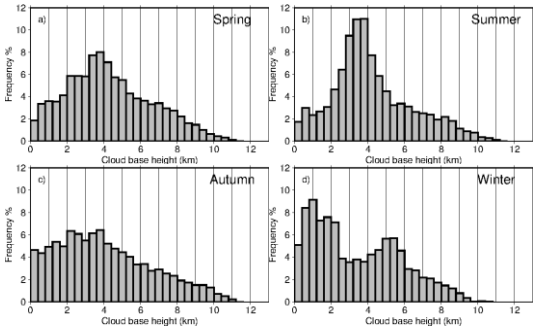

Fig. 1. Standardized single layer CBH frequencies for spring, summer, autumn and winter (MAM, JJA, SON, and DJF) in 2013-2016.

2.2. *Cloud vertical structure and CBH distributions*

For two and three layered clouds, distances between CBH of interlayer were found (Fig. 2). The mean (median) of the CBH distances for 2-layered clouds was 1573 m (1298 m). For three layers, the mean (median) distance between the lowest CBH and the middle CBH was 900 m (768 m), and between the middle and the highest CBH, 1076 m (933 m).

Low clouds represent 22.7% of detected CBH, while middle clouds 56.5%, and high clouds 20.8%. The mean and median of distributions of all CBH were 4101 m and 3785 m, respectively.

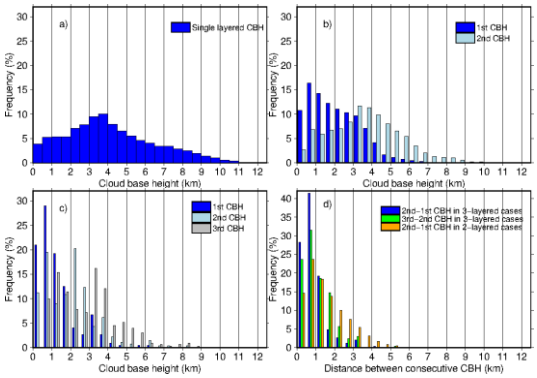

Fig. 2. Frequency distribution of CBH detected by the ceilometer at Dalanzadgad in 2013-2016. (a) single layer CBH, (b) CBH for lower and middle layers, (c) CBH for lower, middle and higher layers. (d) Frequency distribution of the distance between consecutive CBHs detected by the ceilometer in multilayered clouds.

2.3. *Case study of CBH with atmospheric conditions and satellite observation*

In this section, we explained two cloudiness cases with atmospheric conditions and satellite maps in summer including frequency distributions of CBH by the ceilometer (Fig. 3).

A low pressure system existed over Mongolia in 18-21 July 2015. At the surface, a stationary front crossed over the Dalanzadgad area. In these days, low and middle clouds detected by the ceilometer were dominant over the Dalanzadgad area. Observers of the Dalanzadgad weather station watched Cu and Cb clouds by eye observation. Cu and Cb clouds were very clearly appeared on MODIS satellite maps in 17-21 July 2015. Frequency distributions of CBH by the ceilometer show that middle clouds with heights of 3.2-4.0 km were dominant over the Dalanzadgad area in 18-20 July 2015.

3. Conclusions

In this study, we analyzed characteristics of CBH using data measured by the ceilometer at Dalanzadgad site in 2013-2015. The main conclusions are as below:

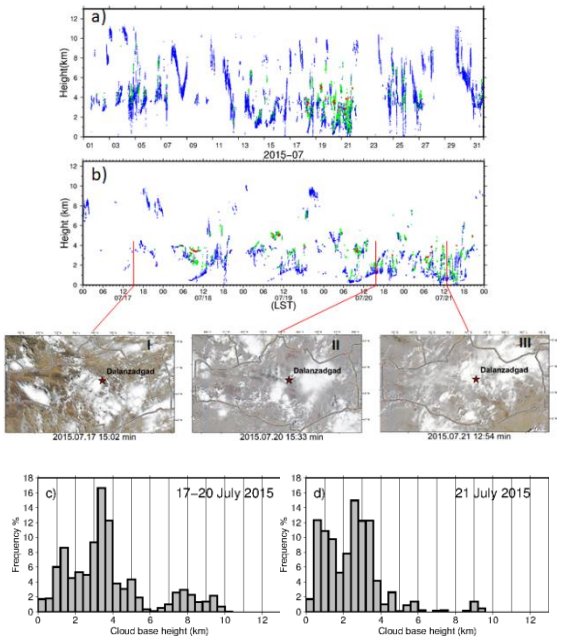

Fig. 3. (a) Evolution of the ceilometer detected CBH in July 2015, (b) A detail for 17–21 July 2015, including the periods of rain (dashed lines), (i) several cloud types by MODIS data from the AQUA satellite at 15:02 on 17 July, (ii) at 15:33 on 20 July, (iii) at 12:54 on 21 July, when clouds covered all the sky and left some rain, (c) Frequency distributions of CBH on 17-20 July, (d) Frequency distributions of CBH on 21 July.

Low cloud frequency was higher in winter, higher level middle clouds (2.4-4.8 km) occurred frequently in spring and summer, and lower level middle clouds (2-4 km) were commonly in autumn and winter. When low pressure systems arrived at the country both in winter and summer, the ceilometer detected low clouds with the highest frequencies of CBH at 800-1600 m, while middle clouds at 2800-3600 m.

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