CLOUD MEASUREMENTS WITH AN ALL-SKY CAMER A SYSTEM FOR INVESTIGATING LONG-TERM VARIABILITY OF CLOUD PROPERTIES AT SOUTH POLE

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Abstract
Since December 2005, an all-sky camera system has been used to acquire images for monitoring cloud conditions at the Amundsen-Scott South Pole Station. The project has been conducted in collaboration with the NOAA Global Monitoring Division. The system is comprised of an ARO Model PSV-100 that includes a 3-color CCD camera with a fish-eye lens and a laptop computer for acquiring JPEG images. The camera was placed on the roof-top of the Atmospheric Research Observatory (ARO) and programmed to collect images at 10 minute intervals continuously each year during the sunlit period from October to March. Measurements were made from 18 December, 2005 until 24 March, 2017. The purpose of this study, only the data collected during November through February were analyzed to avoid issues related to low sun angles and very cold temperatures. An analysis method proposed by Yabuki et al. (2014) was applied to obtain the cloud fraction from the all-sky images. This paper, variability of the South Pole cloud fraction will be shown for the Antarctic summer season for the last decade. Figure 1 depicts monthly mean cloud fraction at South Pole derived from the all-sky camera measurements made from December 2005 to February 2017. The result shows large variation of cloud fractions for both month-to-month and from year-to-year. Consequently, no clear trend is manifested in the decade long time series.

Cloud Measurement at South Pole
Location: ARO (89.98S, 24.8W, 2810m)
Term: 18 December 2005 – 24 March 2017
Instrument: ARO Model PSV-100

Objectives:
1. Climates of total cloud fractions
2. Relationship between cloudiness and meteorological parameters

Result 1
Long-term variation of cloud fraction
From decade-long cloud measurements at South Pole, a temporal variation of cloud fraction was obtained as shown in Figure 1. The figure reveals large variability in cloud fraction from month-to-month and year-to-year. Figure 2 shows monthly time series of the cloud fraction for each austral summer, 2005 to 2017. There is no significant trend in either monthly or yearly variations.

Result 2
Relationship between cloud fraction and near-surface air temperature
Following the analysis by Stone et al. (1989) and Dutton et al. (2004), the relationship between cloud fraction and air temperature measured normally at 2m was investigated. Using monthly mean cloud fraction and 2m temperature as shown in Figure 4, correlation coefficients (R) for November, December, January, and February were obtained, shown in Figure 5. Positive correlations were found for the summer months, except for December.

Result 3
Relationship between cloud fraction and AAOI
The Antarctic Oscillation Index (AAOI) is one of the best indicators of the general atmospheric circulation around Antarctica. Therefore, a relationship between monthly mean cloud fraction and AAOI was investigated. (http://www.cpc.ncep.noaa.gov) was investigated. Figure 6 and Figure 7 show the correlation of monthly mean cloud fraction versus AAOI and a scatter plot of them, respectively. No significant correlation was found during the period of observation.

Summary
The cloud measurements at South Pole, using an all-sky camera system, have revealed the following:
1. Long-term variation of cloud fraction showed no statistically significant trend, but an approximate, seven-year oscillation was observed.
2. Positive correlation between cloud fraction and surface air temperature was found for the summer months, except for December.
3. A relationship between cloud fraction and the Antarctic Oscillation index was not manifested for the period of observation.

From these preliminary results, the monthly mean cloud fraction appears to be influenced by the local atmospheric environment rather than the atmospheric circulation on a regional scale.

Figure 1. Time series of monthly mean cloud fraction for December 2005 – February 2017.

Figure 2. Monthly variation of cloud fraction for each year since 2005 to 2017.

Figure 3. Same as Fig. 1, but with trend analysis. Annual trend is filled with the solid line of a harmonic function indicated at the top. Dashed line indicates only a linear trend.

Figure 4. Relationship between cloud fraction and near-surface air temperature.

Figure 5. Correlation between cloud fraction and surface air temperature for November, December, January, and February. (R) is the correlation coefficient.

Figure 6. Relationship between cloud fraction and AAOI.

Figure 7. Relationship between monthly mean cloud fraction versus AAOI and a scatter plot of them, respectively.

References
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Figure 4. Relationship between cloud fraction and near-surface air temperature.

Figure 5. Correlation between cloud fraction and surface air temperature for November, December, January, and February. (R) is the correlation coefficient.