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## CLOUD OBSERVATIONS AT ANTARCTICA

1. Clouds are common at all points of observation in Antarctica alternating with frequent periods of calm and clear weather. Most cloud forms are a variation of stratus although stratocumulus are often seen in summer time (Rumney 1968), Cumulus cloud is very rare but Cirrus cloud is often widespread and forms at much lower levels than in temperate regions. Reliable cloud observations are very difficult during blizzard since the sky invariably remains obscured.

Frequency analysis of cloud cover, individual types, clear and obscured sky condition is very useful in climatological studies. Such information is of practical utility for certain astronomical purposes.

2. *Data* — The cloud data utilized in the present study were visually collected by the author who was a wintering member of the sixth Indian Scientific Expedition to Antarctica (1986-1987). Daily eight synoptic observations were recorded on almost all days. A total of 2831 cloud observations were made during the period January to December 1987 at *Dakshin Gangotri* (70°00′ S, 12°05′ E), Indian Research Station at Antarctica.

3. *Results* — Frequency of daily cloud amount and the frequency of clouds in different layers of the troposphere was computed. The results obtained have been presented monthwise under different seasons in Tables 1 & 2. Mean daily cloud amount is given in Table 1 while the per cent frequency of clear and obscured sky is given in Table 2. While observing/recording the medium and high clouds it was presumed that these clouds were present only to the extent they were visible *i.e.*, unmasked by the lower level clouds. This assumption introduces some error in the statistics (as worked out in this paper) of medium and high clouds when low clouds predominate since under such condition higher cloud(s) could be present in more amount than estimated. But this error is an inherent shortcoming of the ground-based visual observational method and therefore, should be borne in mind while interpreting the results. However, considering the low frequency of occasions when low clouds were predominant (less than 10%) the above error appears to be acceptable and may not affect the general conclusions emerging out of the present study.

The terms 'clear-sky-day' and 'obscured-sky-day' as used in the present study are defined as follows. A day was classified as a clear-sky-day when no cloud was observed in any of the 8 synoptic observations. Usually calm condition prevails on such fine weather days. A day was termed as obscured-sky-day when in four or more successive synoptic observations the sky had remained obscured. On such days when a few observations had varying amounts of clouds and the remaining clear, they were classified as partly cloudy or cloudy based on the mean cloud amount of the day in question.

**TABLE 1**

**Frequency analysis of cloud amount**

| Season and month | Mean daily cloud amount, *N* (octas) | Number of days with: 1/8-4/8 (octa) Fair weather or partly cloudy | 4/8-7/8 (octa) Cloudy | 8/8 (octa) Overcast | Clear sky Fine weather | Obscured sky Blizzard (or fog) | Total number of days |
|---|---|---|---|---|---|---|---|
| | | **Summer** | | | | | |
| Nov | 5.1 | 09 | 13 | 08 | 00 | 00 | 30 |
| Dec | 4.0 | 15 | 06 | 07 | 01 | 00 | 29 |
| Jan | 4.1 | 19 | 07 | 04 | 00 | 00 | 30 |
| | | **Autumn** | | | | | |
| Feb | 5.3 | 10 | 06 | 12 | 00 | 00 | 28 |
| Mar | 4.9 | 11 | 11 | 08 | 00 | 01 | 31 |
| | | **Winter** | | | | | |
| Apr | 4.1 | 14 | 12 | 03 | 01 | 00 | 30 |
| May | 3.6 | 12 | 12 | 01 | 01 | 05 | 31 |
| Jun | 1.7 | 21 | 01 | 00 | 03 | 05 | 30 |
| Jul | 2.2 | 15 | 06 | 01 | 04 | 05 | 31 |
| Aug | 3.0 | 17 | 06 | 01 | 02 | 05 | 31 |
| | | **Spring** | | | | | |
| Sep | 2.0 | 14 | 04 | 00 | 09 | 03 | 30 |
| Oct | 3.7 | 11 | 11 | 03 | 04 | 02 | 31 |
| Total | | 168 | 95 | 48 | 25 | 26 | 362 |
| % | | 46 | 26 | 13 | 7 | 7 | 99 |

4. *Discussion*

4.1. *Cloud cover* — Mean daily cloud cover was maximum in autumn followed by summer. It was significantly less in spring and winter. The sky was overcast on 13% of the days, cloudy (4-7 octa) on 26% of the days and was partly cloudy (1-4 octa) on 46% of the days in 1987. (Total number of days of observation =362). The criterion for classifying the days into the above categories was the mean daily cloud amount.

TABLE 2

**Frequency (%) of the observations of clouds in different layers of the troposphere or clear sky or obscured sky. When there were clouds in more than one layer, only the predominating cloud was counted**

(Total number of observations = 2831)

| Season and month | High clouds | Middle clouds | | Low clouds | | | Clear sky | Obscured sky |
|---|---|---|---|---|---|---|---|---|
| | Ci/Cc/Cs | Ac | As | Sc | St | Cu | | |
| | | | | **Summer** | | | | |
| Nov | 28.9 | 20.5 | 23.4 | 2.1 | 5.0 | — | 14.6 | 05.4 |
| Dec | 33.6 | 23.3 | 11.2 | 1.3 | 9.4 | — | 18.8 | 02.2 |
| Jan | 27.2 | 39.0 | 6.1 | 12.3 | 8.3 | 0.9 | 4.4 | 1.8 |
| Mean | 29.9 | 27.6 | 13.6 | 5.2 | 7.6 | 0.3 | 12.6 | 3.1 |
| | | | | **Autumn** | | | | |
| Feb | 26.1 | 31.3 | 16.6 | 6.6 | 10.9 | — | 0.5 | 8.1 |
| Mar | 11.9 | 33.6 | 20.4 | 3.4 | 3.0 | — | 11.1 | 16.6 |
| Mean | 19.0 | 32.5 | 18.5 | 5.0 | 7.0 | — | 5.3 | 12.4 |
| | | | | **Winter** | | | | |
| Apr | 25.0 | 17.4 | 19.5 | 7.2 | 1.3 | — | 23.7 | 5.9 |
| May | 11.4 | 15.5 | 17.1 | 2.9 | 1.6 | — | 32.7 | 18.8 |
| Jun | 09.8 | 9.4 | 7.2 | 2.1 | 1.3 | — | 46.8 | 23.4 |
| Jul | 14.2 | 14.2 | 6.9 | 5.7 | 0.8 | — | 42.5 | 15.8 |
| Aug | 16.7 | 6.9 | 15.4 | 1.6 | 2.8 | — | 34.1 | 22.4 |
| Mean | 15.4 | 12.7 | 13.2 | 3.9 | 1.6 | — | 36.0 | 17.3 |
| | | | | **Spring** | | | | |
| Sep | 22.2 | 10.5 | 7.1 | 0.4 | 0.8 | — | 45.6 | 13.4 |
| Oct | 26.7 | 17.4 | 11.7 | 2.0 | 6.1 | — | 23.9 | 12.1 |
| Mean | 24.5 | 14.0 | 9.4 | 1.2 | 3.5 | — | 34.8 | 12.8 |
| Annual Mean | 22.2 | 21.7 | 13.7 | 3.8 | 4.9 | — | 22.3 | 11.4 |

Seven per cent of the days were absolutely free from cloud when fine weather prevailed. The sky was obscured on 7% of the days mostly due to blizzards.

4.2. *Cloud types*—Frequency analysis of cloud cover based on the mean daily cloud amount suffers from a short-coming *i.e.*, for example, if a day is classified as partly cloudy it fails to show whether the whole day was partly cloudy with each of the 8 observations having 1-4 octa cloud or a few observations were 'clear sky' and the remaining having varying amount of clouds. In Antarctica it frequently happens that the sky is clear for most of the day but becomes overcast in a short time or *vice versa*, such that 6 or 7 observations may be having $N=0$ but one or two observations may have $N=8$; when average is taken, $N$ for the whole day works out to 1-2 octas and thus the day is classified as partly cloudy. This does not give a clear picture of the occurrence of clouds. Frequency analysis of cloud type based on individual observation will throw light on the relative occurrence of different types of clouds and also overcomes the above problem by segretating observations when clouds were seen and were not seen.

From Table 2, it is seen that in 22.3% of the observations the sky was observed to be clear, on 11.4% of the occasions it was obscured most frequently due to blowing snow. On a few occasions thick fog was the reason for obscured sky. In the remaining 66.3% of the observations there were clouds in the sky. Most frequently observed clouds were the medium clouds (35.4%). High clouds were dominating the sky in 22.2% of observations while low clouds were predominant in only 8.7% of the observations.

The cloud types most frequently observed were Stratus (*Stratus fractus* and *Stratus fractus* of bad weather). Altostratus (*Altostratus translucidus* and *Altostratus opacus*), Altocumulus (*Altocumulus translucidus* and *Altocumulus duplicatus*) and Cirrostratus (*Cirrostratus fibratus* and *Cirrostratus nebulosus*). Another type of Cirrus cloud commonly observed was the Cirrus below 45° and Cirrus above 45°. These clouds were seen in the form of bands converging towards one or two points of the horizon.

Reference

Rumney, G.R., 1968, Climatology and the world's climates, The Macmillon Co., Collier-Macmillon Ltd., London.

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