Report 3

Characteristic features of the cloud distribution over the Northern Icefield in December, 1983

HIROSHI KONDO and CHOTARO NAKAJIMA

Disaster Prevention Research Institute, Kyoto University, Uji, 611 Japan

Abstract. The west side of the Patagonia Icefield is almost always overcast but on the east side it is often clear. Owing to this characteristic cloud distribution the meteorological environment differs strikingly on each side. During the observation period clouds due to cyclones or fronts approached the western coast approximately at the same latitude as the jet stream. After that they shifted northward when troughs passed over this region, according to the deepness of the trough but as far as latitude 35°–40°S at the most. The latitudinal cloud distribution in December, 1983 showed its maximum at latitude 50°S.

The cloud amount and type was almost the same in the west side and over the icefield but in the east it differed very much. The averages of total cloud amount were 8.6, 8.6 and 5.5 respectively from the west side. The patterns of the lower and middle cloud distribution were classified into 3 types: (1) few clouds in every areas; (2) only on the east side the cloud amount was relatively low; (3) every areas were overcast. The frequencies of occurrence were respectively 8%, 55% and 25%. The first type occurred when ridges passed over this region and a mid-latitude anticyclone extended to the SE. The third type was due to cyclones or fronts when intense troughs passed. The difference between the second and the third cases is considered to be due to the cloud top height over the icefield. In the second case the height was low and clouds vanished in the downward current when they passed over the mountain range.

Precipitation due to cyclones or fronts accounted for almost 80% of the total precipitation on the west side and over the Icefield and almost all of that on the east side. This is one reason why precipitation on the east side is less than that on the west side.

1. Introduction

The Patagonia Icefield is located in the southern part of South America. This region is under the influence of mid-latitude westerlies and cyclones which approach frequently from the South Pacific Ocean. Due to these conditions, the west side of this area is almost always overcast but the inland area is often clear. This characteristic cloud distribution exerts a great influence on the Patagonia Icefield. For instance, much precipitation is brought to the west side by these clouds, and their existence screens the glaciers from solar radiation and affects the ablation process.

In this paper the features of the cloud distribution and its relation to precipitation over the icefield are described as one of the studies to investigate the accumulation and ablation mechanism of the glaciers of Patagonia.

2. Observation sites and data source

Cloud observation was carried out at the Base Camp and Upper Camp of San Rafael Glacier (BC and UC) and the Base Camp of Soler Glacier (SL), which were shown in Maps 2 and 3 (see front page). Its period is shown in Table 1 in Report 4. Taking the regions of vision from

Table 1. Cloud distribution types from west to east and their times, relative frequency and main date of occurrence.

Type	Lower and middle cloud amount			Times of occurrence	Relative frequency	Main date of occurrence
	West side	Over the Icefield	East side			
I	0–1	0–1	0–1	8	8%	13, 15, 17
II	7–10	7–10	0–6			
	9–10	9–10	7–8	53	55%	18–19, 30–1
III	8–10	9–10	9–10	24	25%	21–22, 24–26, 29
	Others			12	12%	20, 27

these three observation sites into consideration, the results of these sites are considered to represent the cloud conditions respectively on the west and east sides and over the icefield.

In order to analyze the large scale cloud distribution in December, satellite images of geostational satellite GOES-E of the U.S.A. were used. They were received by the Chilean Navy. They were usually received three times a day at 6:00, 9:00 and 15:00 for infrared (IR) and sometimes once a day at 15:00 for visual (VIS). The surface and 500 mb weather charts published by the Chilean Meteorological Office were also used to analyze the synoptic condition.

3. Cloud activity and the synoptic conditions

Many cyclones approaching this area are accompanied by a remarkable cloud band extending along the front, sometimes an extraordinary long cloud band as shown in Figure 1 was seen. These fronts, on the average, reach approximately up to latitude 35°S in Chile in the

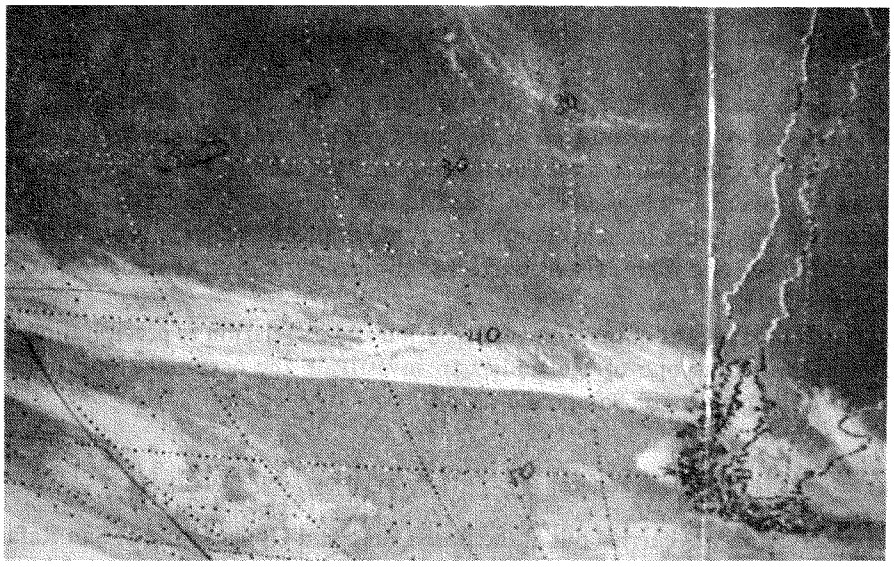

Fig. 1. The satellite image in IR over the southwestern part of South America at 9:00 (local time) on December 22, 1983.

summer months (Fuenzalida, in press). The movements of cloud areas accompanied by these cyclones or fronts are shown in Figure 2 (a), along longitude 74°W which corresponds to the western coastal line of Chile. These areas were obtained from IR satellite images as their spiral forms or cloud bands. The vertical lines indicate the time of these images and their thick parts show the extent of the cloud areas. Figures 2(b) and 2(c) show respectively the time-latitude cross section of the 500 mb height and the surface pressure in December along the same longitude.

Figure 2 shows that intense troughs passed over longitude 74°W at 500 mb on the 12th, 22nd, 26th and 29th, when low pressure areas extended northward at the surface. The position of the strong wind zone at 500 mb was about latitude 50°–55°S, 55°–60°S and 45°–50°S respectively in early, middle and late December. This strong wind zone is considered to be the lower part of the upper atmosphere jet stream. The positions of cloud areas brought by cyclones were almost at the same latitude as the jet stream. After they appeared in this region, their location at the coast often moved northward, when troughs passed over this region, ex-

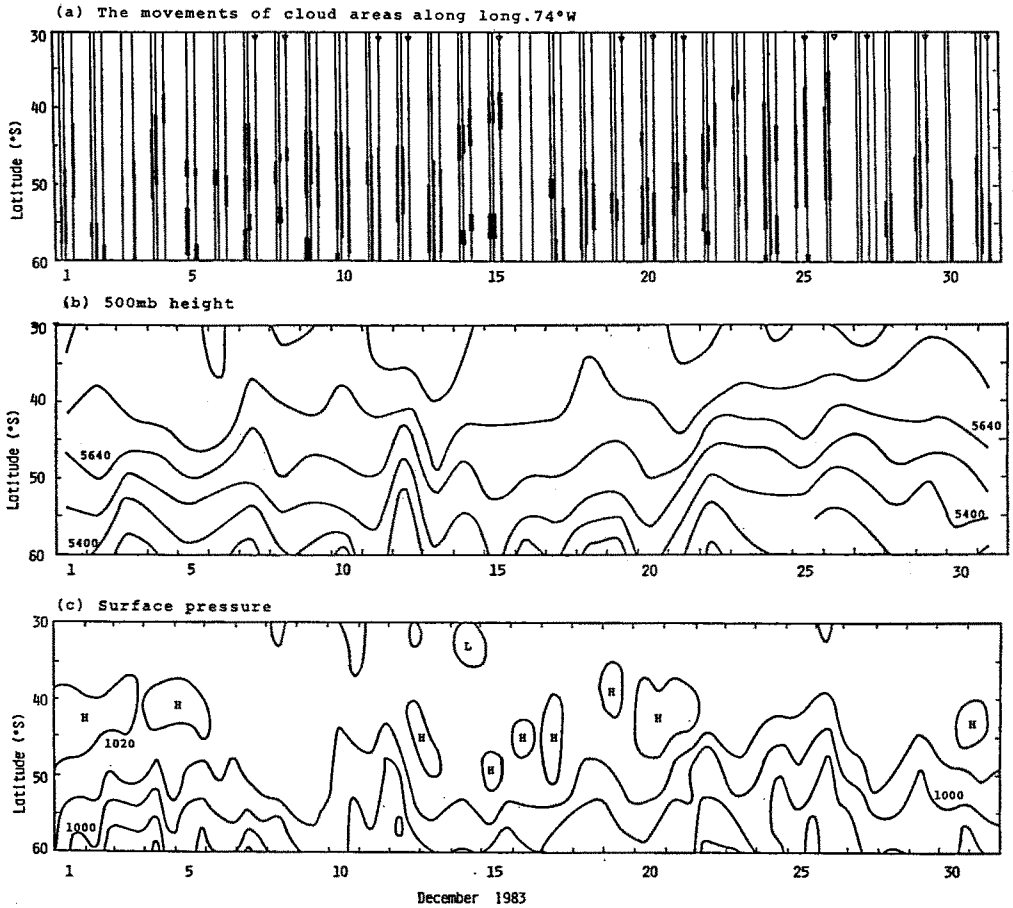

Fig. 2. (a) (above) Cloud distribution due to cyclones or fronts along longitude 74°W in December. The graphic symbols ▽ indicate the time of images in VIS. (b) (middle) The time latitude cross section of 500 mb height along longitude 74°W in December. The contour intervals are 120 m. (c) (below) Same as (b) except for surface pressure. The pressure intervals are 20 mb.

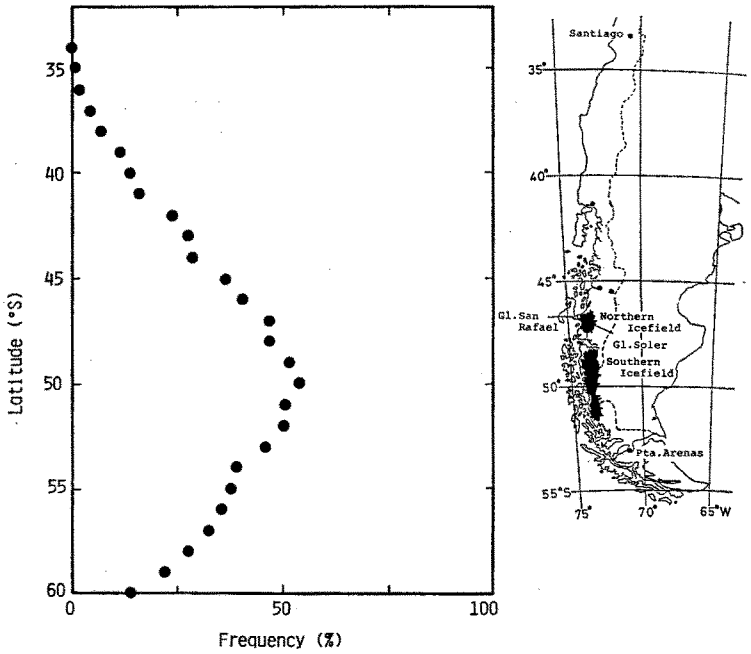

Fig. 3. Cloud distribution due to cyclones or fronts at each latitude along longitude 74°W in December.

cept on the 4th and 12th. That is, generally, the cloud areas due to the cyclones approached this region along the jet stream, and they often moved northward with the passage of troughs according to their deepness but as far as latitude 35°–40°S at the most.

The mean latitudinal distribution of clouds due to cyclones or fronts is shown in Figure 3 along longitude 74°W in December 1983. The horizontal axis indicates the frequency of cloud cover at each latitude. The peak of frequency was around latitude 50°S. This is considered to be controlled by the position of the jet stream and expected to follow its seasonal variation. In this period the maximum frequency coincided with the central part of the Southern Icefield. The distribution curve is similar to that of precipitation in the same season (YASUNARI, 1980); this matter is discussed in section 5.

4. Cloud distribution over the Northern Icefield

The tendency of the cloud amount and type was almost the same in areas both on the west side and over the icefield, but was strikingly different on the east side. In the former area, there were almost always low and medium height clouds of mainly covective type. Upper level Cc, Ci and Cs clouds were rarely seen. In the latter area, it was mainly clear and upper level clouds could be seen frequently. The typical diurnal variation did not appear in every area. The averges of total cloud amount from December 12 to January 2 were 8.6, 8.6 and 5.5 respectively from the west side and those of the low and medium height clouds were 8.4, 8.4 and 4.6 respectively.The averages both on the west side and over the icefield were almost the same but those on the east side were relatively low.

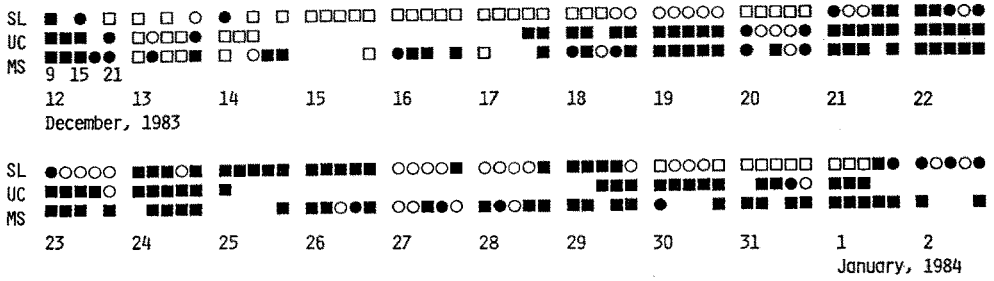

Fig. 4. Lower and middle cloud amount at MS, UC2-3 and SL from December 12 to January 2, every 3 hours from 9:00 to 21:00. The graphic symbols ■ means clould amount of 9–10, ● 7–8, ○ 2–6 and □ 0–1.

Figure 4 shows low and medium height cloud distribution from west to east with four classes of cloud amount. These distribution patterns were classified mainly into three types: (1) few clouds in every area; (2) only on the east side the cloud amount was relatively low; and (3) every area was overcast. Hereafter these three types will be called type I, II and III respectively. Each type is shown in Table 1. Although blanks in Figure 4 are cases without data, the sky is presumed to have been clear on the 15th from solar radiation data, and overcast on some of the 25–29th from continuous precipitation data. Other cases were assumed to be the same on the west side and over the icefield.

In order to find the relation between the three distribution types and the large scale weather conditions, data in Figures 2 and 4 were compared and some interesting results were obtained. Type I occurred when the mid-latitude anticyclone in the Eastern Pacific extended to the SE as far as about 50°S with the passage of upper atmospheric ridges. Periods of type III almost corresponded to periods when the extent of cloudy areas spread over the latitude of 47°S in Figure 2 (a), as the results of their northward shifting with the passage of intense troughs. In this period the cloudy area extended to the inland area. On the contrary, in type II

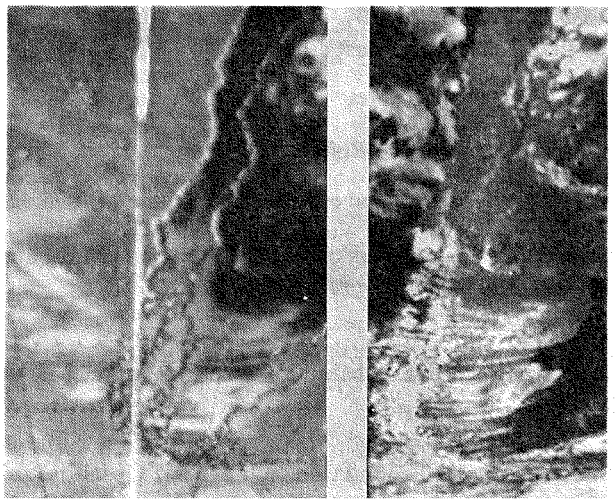

Fig. 5. The satellite images in IR (left side) and VIS (right side) over the southern part of South America at 15:00 (local time) on December 27.

Table 2. Precipitation frequency, amount and average intensity at MS and UC3 in two cases due to cyclones or fronts (shown as A) and others (shown as B) from 00:00 on 18th to 16:00 on 29th.

	MS			UC3		
	Frequency	Amount	Average intensity	Frequency	Amount	Average intensity
A	61	164.0 mm (82.6%)	2.7 mm/h	70	185.5 mm (77.1%)	2.7 mm/h
B	28	34.5 mm (17.4%)	1.2 mm/h	54	55.0 mm (22.9%)	1.0 mm/h
Total	90	198.5 mm		124	240.5 mm	

period, there was no remarkable cloudy area near 47°S except on the 21st and 23rd. But on the satellite images in VIS, cloudy areas can be seen in the coastal region in every case. One case is shown in Figure 5. This means that the cloud top temperature was high, so that the cloud top height in this period is considered to have been low. It can be said from these facts that the clouds due to cyclones or fronts extend also in the east side, but the clouds in other situations vanish by the downward current when they pass over the mountain range since their cloud tops are not so high. This case occurred about half of the time and caused the difference in the average cloud amount between the west and east sides.

5. Relation to precipitation

As one of the characteristics of the precipitation distribution, the amount and frequency of precipitation in the two different cases were estimated. Table 2 shows the cases due to cyclones or fronts (A in the table) and not due to a distinct synoptic scale disturbance (B) at sites MS and UC3 from 00:00 on the 18th to 16:00 on the 29th for every hour. The periods of the two cases are determined by the satellite images. At each site heavy precipitation occurred mainly in case A, accounting for almost 80% of the total amount. In each case both the amount and frequency at UC3 were more than those at MS. Those at site SL cannot be compared exactly but case B occured frequently. This is one reason why the precipitation amount on the east side is less than that on the west side.

References

FUENZALIDA, H. (in press): "Chile essence and evolution". Institute of Regional Studies of the University of Chile, 27–35.

YASUNARI, T. (1980): Taikijunkankei to hyogakei (The relation between the atmospheric circulation and the glacier system). Chikyu, **2**(3), 180–188.

Resumen. Rasgos característicos de la distribución de nubes sobre el Hielo Patagónico Norte en Diciembre, 1983

El sector sur de Sud América es la senda de ciclones del Océano Pacífico Sur y muchos de los ciclones que se aproximan a esta zona vienen acompanados por un frente frío y por una banda de nubes entremedio. Las variaciones de la nubosidad a lo largo de la longitud 74°

W en Diciembre 1983, se muestra en la Fig. 2(a). La línea vertical de la figura indica la hora de la imagen por satélite en IR recibido por la Armada de Chile desde el satélite geostacional GOES-E de EE. UU. y la parte gruesa de cada línea vertical muestra la extensión de la nubosidad causada por el ciclón o el frente. Esta figura muestra que en muchos casos el área de nubes que se aproximaba cerca de la latitud 55°S se movía hacia el norte y desaparecía hacia los 35°–40°S.

Del 12 de Diciembre al 2 de Enero se llevó a cabo observaciones de nubes en el Campamento Base en el Glaciar San Rafael (vertiente occidental), Campamento Alto sobre el Campo de Hielo y en el Campamento Base en el Glaciar Soler (vertiente oriental) en forma simultánea cada 3 horas desde las 9h a las 21h hora local. La nubosidad baja y media en estas tres zonas se muestra en la Fig. 4. La variación diurna no apareció en todas las zonas. Los promedios de la nubosidad total en el período eran 8,6, 8,6 y 5,5 respectivamente, de occidente a oriente. Está claro que los promedios son prácticamente iguales en la vertiente occidental y sobre el Campo de Hielo. Está distribución de diseños a lo largo de la dirección W-E se clasificó mayormente en tres tipos. El primer tipo es el caso de escasa nubosidad en todas las zonas. El segundo es el caso cuando sólo la vertiente oriental estaba con cielo despejado y el tercer caso es aquel cuando todas las zonas estaban cubieltas. El primer tipo de distribución ocurría en períodos cuando el anticiclón de latitudes medias del Océano Pacífico se extendía en la dirección SE, mientras que el tercer tipo prácticamente correspondía con el caso cuando la extensión de la nubosidad está sobre la latitud 47°S en la Fig. 2(a), esto es, cerca de los puntos de observación. Por el contrario, en el período del segundo tipo, no hay ningún área de nubes sobresaliente cerca de los 47°S en la Fig. 2(a), pero en las imágenes por satélite en VIS simultáneamente se puede confirmar la existencia de nubes sobre el área costera. Por tanto se considera que la altitud de la capa superior de nubes en el período del segundo tipo no era muy grande. Esto es, en el caso de nubes producidas por ciclones o por sus frentes, las nubes se extienden sobre la cadena de montañas del Campo de Hielo hacia la zona oriental tierra adentro. Las nubes cuyas cimas no eran tan altas debieran desaparecer debido a la corriente descendente después que cruzan la cadena de montañas.

La frecuencia de la distribución de nubes a lo largo de los 74°W causadas por ciclones o frentes en Diciembre de 1983 se muestra en la Fig. 3. Se observa que la frecuencia máxima se ubicó alrededor de la latitud 50°S. Esta curva de distribución es similar a la curva de la distribución media de la precipitación en la misma estación.