Photographic Cloud Observations[1, 2]

1. Introduction

Lapse-time photographs of clouds over the saddle area between Mauna Loa and Manua Kea and the northeast coast of the Island of Hawaii were taken during "Project Shower", from 21 October to 4 December 1954. The purpose of the photographs was to provide a continuous daytime record of cloud conditions over these areas. The camera site was located about 30 miles from the coast at 9,000 feet above sea level on the northeast slope of Mauna Loa (see Location Map).

Two 16 mm movie cameras, adapted for single frame operation, were used. The cameras were housed in small shelters mounted several feet above the ground on pipes. A clock, similarly mounted, was placed such that it appeared in the pictures of both cameras. Each camera was equipped with a small battery operated timing unit which triggered the shutter once every two minutes.

One of the cameras was directed toward an azimuth of 20 degrees such that the summit of Mauna Kea was just included in the left border of the pictures. The second camera was directed toward an azimuth of 60 degrees. The combined fields of view of the two cameras covered about 80 degrees of the northeast quadrant.

2. Summary of Observations

Data were obtained on most days of the project period although numerous interruptions of the record occurred due to operational difficulties. In condensing the information contained in the films, primary emphasis was given to describing variations in the windward orographic cloud, one of the principal objects of investigation in Projects Shower. Certain dimensional characteristics of the cloud, chosen to reflect these variations, were assigned arbitrary ranges of values intended to serve as indices of relative development.

Secondary orographic cloud types, which occurred less frequently but nevertheless exhibited interesting characteristics are not described here.

Normal conditions were interrupted during the period 27—29 November by the occurrence over the Island of an upper cold low, locally termed a "Kona" storm. The photographic observations were too sparse to afford a good description of the complex array of clouds present on those days.

During trade wind conditions an orographic cloud normally appears over the windward slopes of Hawaii, extending frequently into the saddle between Mauna Loa and Mauna Kea. Vertical development was usually limited by a temperature inversion. Variations in the depth and horizontal extent of this cloud are closely related to rainfall over the area.

Only the westward (leeward) portion of the orographic cloud appeared in the field of view of Camera I covering the saddle area and Mauna Kea. Three characteristics of this portion of the cloud were recorded; the intersections of the upper and lower cloud boundaries with selected topographic features, and the westward penetration of the cloud into the saddle.

Each of the topographic features used in

[1] Prepared by L. E. Eber, present affiliation: U.S. Fish and Wildlife Service, Stanford University, Palo Alto, California.

[2] Published with the approval of the Director as Technical Paper No. 246 of the Pineapple Research Institute of Hawaii.

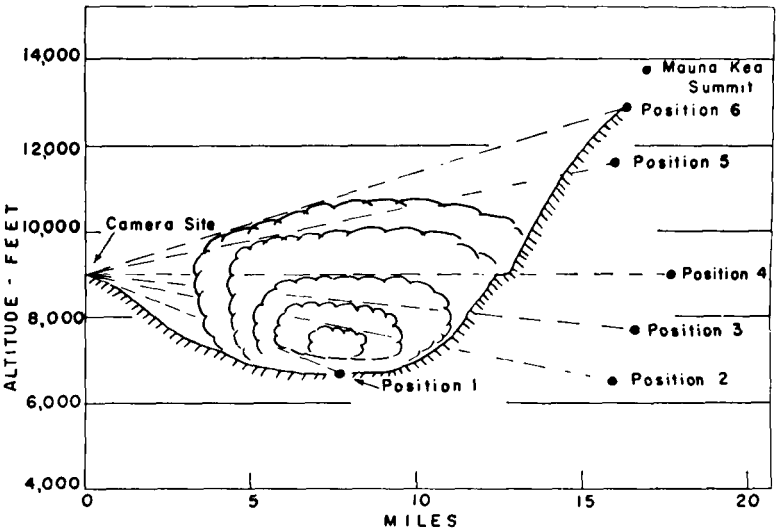

Fig. 1. Vertical cross section through camera site and Position 6. Projected locations of Positions 1 to 5 are also indicated, along with possible cloud sections for various base and top positions.

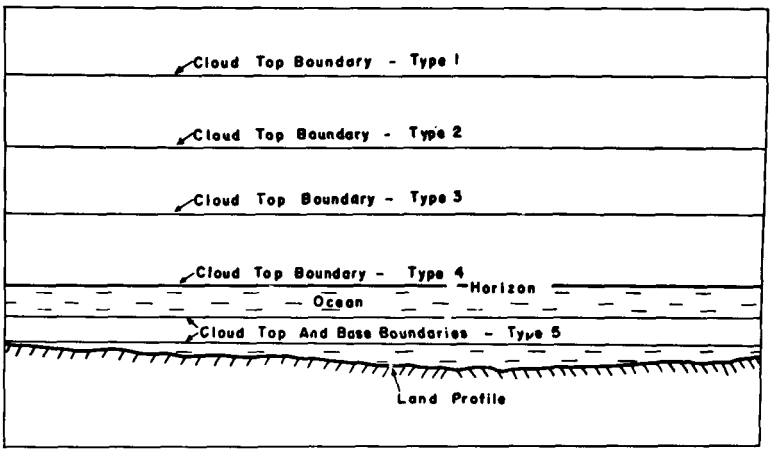

Fig. 2. Cloud classification system for Camera II. Land profile and the horizon are shown as they appear in the photographs. Description of cloud types is given in the text.

connection with upper and lower cloud boundaries was assigned a position number in the range from 0 to 6. Fig. 1 is a vertical cross section through the camera site and position 6, showing also the projections of positions 1—5 onto the cross section. Position 0, not shown in the diagram, was used to indicate cases where the line of sight angle between the camera and the cloud base was below that to position 1.

The westward penetration of the cloud into the saddle was recorded on a scale of 1—5 indicating the distance across the frame, in fifths of the frame width, reached by the westward cloud boundary. At the center of the saddle the camera's field of view subtended a horizontal distance of about 5 miles.

Orographic cloud conditions toward Hilo, as recorded by Camera II, were classified into seven Types. With the exception of Type 6, the type numbers simply indicate relative degrees of development as determined by the

Table 1. Photographic Observations of the Orographic Cloud over Windward Hawaii and the Mauna Kea—Mauna Loa Saddle

Date	Saddle Area (Camera I)					Toward Hilo (Camera II)			
	Period of observation		Position of		Westward extent	Period of observation		Cloud type	Movement from
	From	To	Top	Base		From	To		
Oct. 21	14.10	14.25	6	0	5	13.30	14.50	1	—
	14.25	16.00	4	1	5	14.50	17.30	2	—
	16.00	16.20	4	0	5				
Oct. 22	At	10.30	4	2	2	10.00	13.50	2	—
Oct. 23	11.25	15.00	3	3	1	10.30	16.30	2	—
	15.00	15.30	4	3	2				
Oct. 24	10.45	11.30	4	1	5	14.00	16.00	3	S
	11.30	12.25	3	2	5				
	12.25	13.15	6	2	5				
	13.15	14.00	6	0	5				
	14.00	15.30	6	1	5				
	15.30	17.10	4	1	5				
Oct. 25	10.00	13.50	CLEAR			08.00	08.30	0	—
	13.50	16.30	3	2	1				
	16.30	17.15	3	1	4				
Oct. 26	08.00	11.20	6	0	5	13.00	15.00	1	—
	11.20	13.00	Rain and cloud at site			17.30	17.45	1	—
	13.00	15.00	6	0	5				
	15.00	17.30	Rain and cloud at site						
	17.30	17.45	3	0	5				
Oct. 27	10.00	11.30	2	1	1	11.30	13.40	4	E
	11.30	13.00	CLEAR			13.40	15.00	2	—
	13.00	14.00	4	2	1	15.00	15.20	1	—
	14.00	15.00	6	1	5	15.20	16.00	0	—
	15.00	16.00	6	0	5				
Oct. 28	08.00	10.00	2	0	5	11.15	12.30	0	—
	10.00	12.30	6	0	5	12.30	15.00	1	—
	12.30	14.00	6	1	5	15.00	17.00	0	—
Oct. 29	11.30	13.45	4	2	3	13.30	18.00	6	—
	13.45	16.45	obscd	2	4				
	16.45	17.30	obscd	0	3				
Oct. 30	10.00	10.45	CLEAR			11.30	12.30	4	—
	10.45	11.45	3	2	1	12.30	17.30	3	NE
	11.45	14.30	4	2	2				
	14.30	17.30	4	1	3				
Oct. 31	10.45	11.30	CLEAR			09.00	17.00	5	Diverging
	11.30	15.00	3	2	4				
	15.00	17.30	4	1	5				
Nov. 1	09.00	11.30	CLEAR			09.00	17.00	5	Diverging
	11.30	12.30	3	2	2				
	12.30	16.45	4	3	2				
	16.45	17.00	2	1	2				

Table 1 (cont.)

Date	Saddle Area (Camera I)					Toward Hilo (Camera II)			
	Period of observation		Position of		Westward extent	Period of observation		Cloud type	Movement from
	From	To	Top	Base		From	To		
Nov. 2	09.00	11.00	CLEAR			09.00	12.30	4	—
	11.00	12.15	3	1	4	12.30	17.00	6	—
	12.15	13.00	4	1	5	17.00	17.30	4	—
	13.00	13.40	obscd	1	5				
	13.40	15.00	4	1	4				
	15.00	17.00	obscd	2	5				
	17.00	17.30	3	2	4				
Nov. 3	09.00	14.30	CLEAR			08.00	11.00	4	—
	14.30	16.00	3	2	2	11.00	15.00	5	—
Nov. 4	11.30	12.45	CLEAR			08.00	11.00	4	SE
	12.45	17.00	3	2	2	11.00	13.45	5	SE
	17.00	17.30	2	1	2	13.45	17.15	6	SE
Nov. 5	08.00	17.00	CLEAR			08.00	15.30	4	SE
	17.00	17.30	2	1	1	15.30	17.30	5	SE
Nov. 6	07.30	10.00	1	0	5	11.30	15.00	3	—
	10.00	10.30	CLEAR						
	10.30	13.00	3	2	4				
	13.00	13.50	3	1	5				
Nov. 7	12.00	17.10	6	0	5	Missing data			
	17.10	17.30	3	1	5				
Nov. 8	07.30	10.00	2	1	5	Missing data			
	10.00	11.30	CLEAR						
	11.30	15.00	3	2	3				
	15.00	17.30	CLEAR						
Nov. 9	07.30	09.00	2	0	5	Missing data			
	09.00	13.00	CLEAR						
	13.00	17.00	3	2	4				
	17.00	17.30	2	0	5				
Nov. 10	07.30	08.00	4	0	5	Missing data			
	08.00	12.00	CLEAR						
Nov. 11	11.30	12.30	CLEAR			Missing data			
Nov. 12	11.30	13.30	CLEAR			11.00	17.00	5	—
						17.00	17.30	4	—
Nov. 13	Missing data					08.00	11.30	4	SE
						11.30	17.30	5	Diverging
Nov. 14	11.00	16.20	3	2	5	08.00	16.30	4	NE
	16.20	17.00	3	1	5	16.30	17.30	3	NE
Nov. 15	10.30	12.00	CLEAR			07.00	17.00	4	SE
	12.00	15.50	3	2	1	17.00	17.30	5	SE
	15.50	16.45	3	2	4				

Table 1 (cont.)

Date	Saddle Area (Camera I)					Toward Hilo (Camera II)			
	Period of observation		Position of		Westward extent	Period of observation		Cloud type	Movement from
	From	To	Top	Base		From	To		
Nov. 16	10.00	10.30	CLEAR			07.00	12.00	4	SE
Nov. 19	11.00	13.00	CLEAR			11.00	17.30	5	Diverging
	15.00	16.30	CLEAR						
Nov. 20	11.00	14.00	CLEAR			07.00	11.00	5	—
	17.00	17.20	CLEAR						
Nov. 21	10.45	15.30	CLEAR			07.00	11.00	4	SE
	15.30	17.30	3	2	2	11.00	17.30	5	SE
Nov. 22	09.15	11.00	CLEAR			08.00	11.30	5	E
						11.30	18.00	4	E
Nov. 30	10.00	10.45	Rain and cloud at site			Missing data			
	10.45	17.20	3	2	5				
Dec. 2	16.00	17.00	Rain and cloud at site			Missing data			
Dec. 3	11.10	15.00	6	0	5	Missing data			
	15.00	16.00	6	1	5				
	16.00	17.30	4	0	5				
Dec. 4	10.30	11.30	3	1	5	Missing data			
	11.30	17.00	3	2	3				

Notes: An entry of "6" under "Position of Top" means the angle of sight (elevation angle) to the cloud top was equal or greater than that to position 6.

"Obscd" means the orographic cloud in the saddle was obscured by small cumuli drifting up the mountain toward the camera site.

Cirrus was recorded by the cameras on 29 Oct., 4 Nov., 21 Nov., 22 Nov., 30 Nov., and 4 Dec.

150th Meridian Time used throughout.

percent of picture area covered by the orographic cloud. The scheme is partially illustrated by fig. 2, which represents the field of view of Camera II. Type 0, not shown in the diagram, was used to indicate conditions where the cloud top boundary extended above the top of the picture. Cloud base boundaries associated with Types 0 through 4 were generally at or below the land profile. Type 6 was used to indicate a special situation characterized by weak and broken development of the orographic cloud and by small cumuli drifting up the mountain slopes toward the camera site. In general, lower type numbers reflect greater vertical and horizontal cloud development.

During projection of the films taken with Camera II the direction of motion in the orographic cloud toward Hilo could sometimes be estimated. Since the camera was pointed east-northeast, motion across the picture from right to left was recorded as southeast. Motions approximately toward the camera was recorded as east or northeast. On some occasions characterized by Type 5 conditions, diverging motion was evident. In these cases it appeared that air in the cloud layer split as it approached the Island, flowing around Mauna Kea and Mauna Loa rather than ascending toward the saddle.

Daily conditions and fluctuations in the windward orographic cloud were summarized following the classification system outlined above and are given in Table 1. Times of observations were listed separately for the regions covered by the two cameras due to the irregular operations of the latter.