

Weather, 1960, XV, R18

THE POSSIBILITY OF ARTIFICIALLY INCREASING RAINFALL ON TENERIFE IN THE CANARY ISLANDS

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[This article is based on a report prepared by F. H. Ludlam, following a brief visit to Tenerife, at the invitation of the Governor of the island.]

TENERIFE is one of several islands forming a group known as the Canaries, which lie one to two hundred miles off the coast of North-West Africa in latitudes 28 to 29°N. Tenerife has the shape of a triangle whose short base lies from north-west to south-east and is 45 km long; the other vertex is about 80 km to the north-east. The island has a central spine of mountains reaching about 2,000 m, surmounted by the conical peak Teide, whose summit is at 3,700 m.

The Canaries lie in the north-easterly trade winds, on the east side of the semi-permanent Azores anticyclone. In this region there is normally a strong subsidence of air in the troposphere which produces a dry warm atmosphere sharply separated by an inversion (at an average height of about 800 m) from a layer in which the southward-streaming air is gently warmed by convection from the sea. At about 600 m above the sea the water vapour in the convective up-currents begins to condense and form small cumulus clouds, whose tops here and there penetrate a few hundred metres into the stable air above the base of the inversion before sinking back and dissolving (see cover photograph). From the higher parts of the island of Tenerife it is usually possible to look out over the tops of these oceanic clouds, which in the good visibility of the clean dry air above can be seen extending away to the horizon.

TABLE 1. Characteristics of the Trade Wind airstream from 9 years of daily observations at Puerto de la Cruz, 90 m above sea level near the northern shore of Tenerife

	Average at 90 m			Condensation Level	
	Temperature °C	Relative Humidity per cent	Diurnal Oscillation °C	Height above sea-level metres	Temperature °C
January ..	15.3	70	6.4	770	8.9
February ..	15.2	73	6.3	690	9.8
March ..	15.6	76	6.3	640	10.5
April ..	16.2	74	6.1	650	10.8
May ..	17.5	76	5.7	650	12.3
June ..	18.8	76	5.9	660	13.5
July ..	20.3	78	5.2	630	15.3
August ..	21.5	79	5.7	630	16.6
September ..	21.2	79	5.9	660	16.0
October ..	20.2	75	6.0	680	14.9
November ..	18.2	74	5.8	670	12.7
December ..	16.4	71	6.4	660	10.5

GARCIA-PRIETO

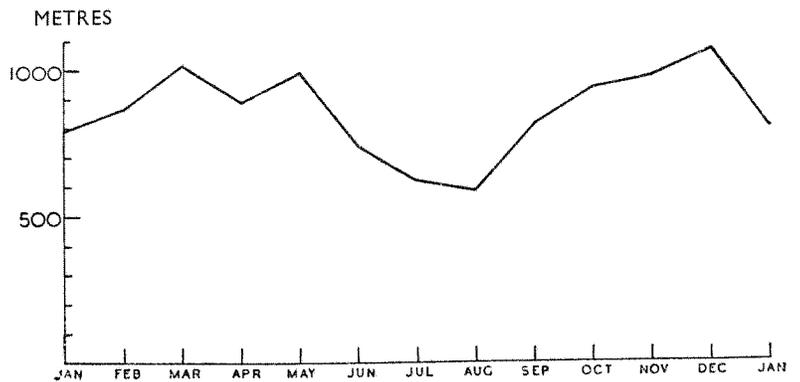


Fig. 1. The average vertical thickness of the northern slope cumulus month by month (for a 12-year period) as measured from the observatory of Izaña (2,370 m)

These clouds are brought by the trade winds against the northern slopes of the island and there moisten the vegetation. Their bases are found at about the condensation level of the air crossing the coast, which usually lies between 600 and 700 m above the sea (see Table 1). Fig. 1 shows their average thickness month by month, as measured from the mountain observatory of Izaña, and Fig. 2 shows the frequency with which the tops reach certain levels. When, as in fresh invasions of polar maritime air, the inversion is raised and they are well developed, with tops reaching heights of rather more than 1,500 m, they cause light showers. During the course of a year these account for over half of the rainfall of about 80 cm, or 30 inches, which characterizes the cloudy zone. The clouds mass inland of the northern shore, and on the coast itself showers from

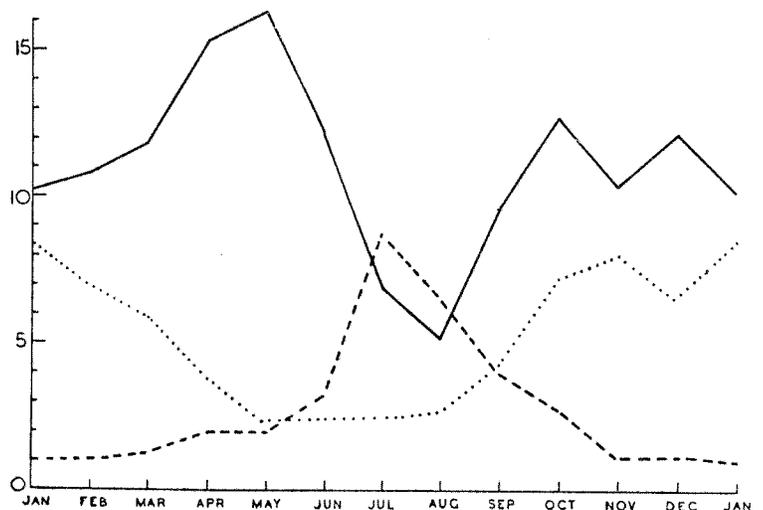


Fig. 2. Number of days per month when the northern slope cumulus (a) penetrate above 1,500 m (solid line), (b) fail to reach 1,000 m (pecked line) and (c) are absent at 1300 GMT (dotted line)

them are infrequent, while in general the clouds dissolve or shrink south of the mountains and bring no rain at all to the southern part of the island.

The remainder of the island's rainfall occurs during short periods of disturbed weather in the winter half of the year, associated with the close approach of the polar front or with the development of small cyclones off the African coast. These cyclones extend into the upper troposphere with cold cores, and contain complex cloud systems with embedded large cumulus and cumulonimbus which may cause intense and prolonged showers of up to even 30-40 cm of rainfall in a single day. Such rains may fall anywhere on the island, but probably are heaviest on the south-eastern slopes and the arid high lands, and in some degree ameliorate the dearth of rainfall there.

THE POSSIBILITY OF ARTIFICIALLY INCREASING THE RAINFALL OF TENERIFE

Very large quantities of water are used to irrigate banana- and tomato-plantations, especially in the broad Orotava valley which lies in the middle of the northern side of the island. Here the water is obtained from galleries which are driven horizontally into the mountain-side until springs are tapped; these tunnels may be more than a kilometre long and their combined length on Tenerife amounts to about 600 km. They supply the plantations with over 10^8m^3 of water each year, but because the construction of the galleries is so laborious and has continually to be repeated as some of the water sources run dry, this water is too expensive to be used by the peasants for less intensive agriculture. A more abundant and cheaper water supply would bring great direct benefits both to the plantation owner and to the peasant.

It does not seem possible that any artificial influence could be exerted on the large storms which bring occasional heavy rains to the island as a whole, but the islanders appreciate that there are modern techniques which aim at producing significant quantities of rainfall in places where clouds frequently exist, but which seemingly are not quite wet enough or otherwise sufficiently well developed to produce rain by natural processes. A situation of this kind appears to occur on the northern slopes of Tenerife, where the zone extending between heights of about 600 and 1,200 m is often engulfed by massed trade wind cumulus. A good road ascends the Orotava valley through the zone covered by these clouds, which travellers find to be dense and wet even when not producing any considerable rain. An abundance of cloud water is suggested by the poor visibility, which may be less than 50 m, and by the readiness with which beads of water collect upon the foliage of shrubs and trees. Where these drip upon the road its surface may be thoroughly wetted.

It is believed that there are two distinguishable mechanisms by which rain showers form, and accordingly that there are two basic techniques for stimulating either the one or the other in clouds where neither is quite effective.

The first mechanism operates when the cloud tops grow well above the 0°C level, and many of the cloud droplets freeze by a natural process. The water vapour then condenses preferentially upon the frozen droplets, which within a few minutes become large enough to collect the remaining droplets by

settling through and colliding with them. After some further minutes they fall through the cloud as snow pellets which usually melt into raindrops before reaching the ground. It is found as a matter of experience that no rain forms in this way unless parts of the cloud rise so high that their temperature falls below -10 to -15°C , apparently because otherwise too few of the droplets freeze. It may be possible to remedy such a deficiency artificially by seeding the clouds with pellets of solid carbon dioxide, which produces vast numbers of ice crystals wherever the temperature is less than about -2°C , or with smokes of silver iodide, which have the same effect wherever the temperature is below about -6°C . By these means showers may be stimulated from cumulus which reach above the levels where the temperature lies at -2 to -6°C , but yet which do not reach up to the colder levels at which showers form naturally.

Near the Canaries only in mid-winter do the tops of the trade wind cumulus cool below -2°C ; at this time of the year the 0°C level in the trade wind current may descend to about 2,100 m. The frequency with which the cumulus tops reach well above this level is not known, but it is reported that rime ice, a certain indication of unfrozen cloud droplets at temperatures below 0°C , occurs on about 50 days of the year at Izaña, the mountain observatory at a height of 2,370 m. However, throughout the year the height of the bases of the cumulus is remarkably constant, hardly varying from an average of between 600 and 700 m. Thus on those occasions when the cumulus might be large enough to be susceptible to this kind of seeding their vertical thickness must exceed about 1,500 m, and accordingly it seems very probable that rain will then form within them by the second mechanism, which is discussed in the following paragraph. Only if observations were accumulated which showed that on many of these occasions the clouds had a favourably low summit-temperature, and yet gave no significant natural rain, could an experiment in this kind of seeding justifiably be planned.

The second mechanism of rain formation depends upon the great disparity which is observed in the sizes of the cloud droplets. These droplets grow upon hygroscopic particles, in this region predominantly microscopic fragments of sea-spray, which themselves have a great variety of sizes, and the excessive growth of a few droplets may be encouraged either because they have an abnormally large sea-salt content, or because the turbulent air movements happen to keep them within the cloud for an abnormally long time. For these reasons it is found that a young cloud of substantial thickness contains a small proportion of droplets which are several times greater than the average size, and which collide with and collect the remainder as they settle more quickly through the cloud air. In cumulus which have a thickness of two kilometres or more and contain up-currents with speeds of a few metres/sec., thus keeping the growing droplets for a considerable time inside the cloud, they may readily reach the size of raindrops so that a shower forms. The quantity of water condensed in a cumulus and the strength of its up-currents in general increase with its size, and so also does the intensity of any shower which forms. On the other hand the thickness of a cumulus which is just large enough to produce a shower

varies from time to time and place to place between barely more than 1 to as much as a 5 or 6 km, for reasons which are imperfectly understood but are believed to be at least partly due to the very variable numbers of outsize droplets which appear early in the life of the cloud. In maritime climates abundant supplies of large sea-spray droplets appear to initiate this mechanism very efficiently and showers fall from rather shallow cumulus, whereas far inland sea-spray is absent and no showers form in cumulus several times bigger. In such places attempts have been made to provoke rain by supplying the clouds with large droplets, which is most conveniently done by dispersing finely ground salt particles (average mass 10^{-9} gm), which in the damp cloud air absorb vapour and quickly swell to the required size. Some of these experiments have been successful in provoking showers.

The maritime air of the Canary Islands may be expected to contain a concentration of sea spray particles suitable for the efficient natural formation of rain showers, which is believed to occur readily when there is one particle containing 10^{-9} gm of salt in every 1 to 10 litres of air. This expectation has been confirmed by direct measurement, using a method in which all the particles in a large volume of air are deposited upon a slide which is later placed in a damp chamber and examined under a microscope. From samples taken on several days (Table 2) it appears that within a few hundred metres of sea level

TABLE 2. Summary of salt nuclei measurements made on Tenerife

Place	Height metres	Date	Time	Number per litre of mass m or more		
				$m=2.6 \times 10^{-9}$ gm.	$m=10^{-9}$ gm.	$m=10^{-10}$ gm.
Near shore	10	25/3/58	1915	15	100	600
Hotel Taoro	100		1135	9×10^{-2}	1.5	18
Orotava	390		1700	0.2	1.2	13
Road	830		1815	1×10^{-2}	0.2	4
Izaña	2,370	27/3/58	1945	—	5×10^{-4}	9×10^{-3}
Road	830		1345	0.1	0.6	3
Shell Service Station	200		1425	0.1	0.6	4
Vilaflor	1,450	28/3/58	1920	4×10^{-2}	0.3	2
Granadilla	730		1730	1.4×10^{-2}	0.8	8
Shell Service Station	200	29/3/58	1735	0.1	1	9
Izaña	2,370	31/3/58	1210	0.7×10^{-3}	5×10^{-3}	1×10^{-1}
Orotava	390		1810	0.2	2	13
Shell Service Station	200		1730	7×10^{-2}	0.6	5
Road	900	1/4/58	1840	—	2×10^{-3}	1×10^{-2}
Tacaronte	610		1640	2×10^{-2}	0.3	3
Shell Service Station	200			3×10^{-2}	0.2	3

The nuclei were caught upon a hydrophobic slide in an impactor fed by a draught made with a vacuum cleaner, and were extracted from volumes of air varying between about 2 litres and 5 m³. The slide was subsequently placed in a humidity chamber and the nuclei masses estimated from the diameters of the solution-droplets grown upon the nuclei.

the air near the ground usually contains salt particles of mass 10^{-9} gm in a concentration of 1/litre, although at higher levels, above the trade wind inversion and the clouds, their numbers are about 1,000 times smaller. An ocean swell often produces surf along the northern shore, and in favourable lighting mists of sea spray can be seen ascending the island slopes in the on-shore winds (near the shore the concentration of sea spray particles is extremely high, and exposed objects soon become covered with a film of salty water). If this source of salt particles were to be artificially imitated it would be necessary to install at intervals of 1 km a large number of special generators each dispensing into the air finely pulverized salt at the rate of a sackful every ten minutes.

If the slope clouds which are fed by breezes carrying such abundant supplies of spray particles fail to produce a copious rainfall it must be that some other characteristics of the cloud are not favourable; for example, it may not be thick or dense enough to contain much condensed water, or individual parts of it do not last long enough to allow its bigger droplets time to complete their growth into drops of drizzle or rain. It appears that usually these clouds are not oceanic cumulus which simply drift across the coast-line and encounter the mountain-side; rather, they form a quite separate system with a marked diurnal variation which varies considerably according to the strength and direction of the general wind current. In ordinary circumstances the islands are strongly heated by the sun during the day and become much warmer than the surrounding ocean; on the desert-like volcanic heights of Tenerife the lava rock is made hot to the touch by the intense sunlight in the very clear atmosphere. The warmed air tends to rise from the island and sea breezes ascend its slopes, while a compensating subsidence occurs in the atmosphere surrounding the island. This sinking probably lowers the inversion by a few hundred metres in a zone extending 20 km or more out to sea and is accompanied by a general drying of the air, or may even bring the inversion below the normal level of the oceanic cumulus bases, so that in this zone the cumulus disappear and the island lies in a ring of cloudless sky. Over the island slopes, however, the convection is strongly enhanced, and a separate system of cumulus forms, known locally as 'the sea of clouds', whose bases are little higher than those of the oceanic clouds, but whose tops are often several hundred metres higher, reaching up to the narrow ridge of the island (Figs. 3 and 4). From the observatory of

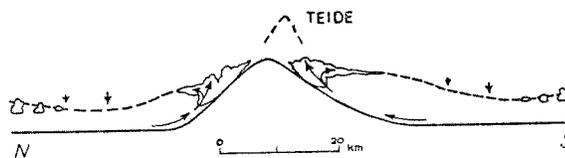


Fig. 3. North-South section through island of Tenerife on afternoon of moderate trade wind flow

Izaña one can sometimes watch first the clouds from the northern slopes and then those from the opposite side of the island engulfing the road along this ridge, as now the one or the other sea breeze gains in strength. When the

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Fig. 4. Panoramic view of moderately developed massed slope cumulus with tops at about 1,200 m; taken looking down the northern slopes of Tenerife from the main island ridge at about 1,900 m. The cumuliiform summits of the clouds on the slope merge into the flatter tops of a stratocumulus shelf which projects across the shore out to sea. Beyond the island cloud lies the clear fog and beyond this the oceanic cumulus reach to the horizon

STANDING WAVE CLOUD AT HOPE BAY, GRAHAMLAND



Photograph by B. Kemp

See note on p. 51

ND

photograph by E. Kemp

general wind currents are light the clear ring around the island is symmetrical, but in stronger northerly winds the ring tends to close on the north side, although there may still be a change in the character and level of the cloud tops as they approach the island. It is important to understand that the island clouds are individually continually dissolving and re-forming, growing in the sea breezes which ascend the island slopes and evaporating on the high sun-heated ridge or where they sink in its lee and become mixed with the warm dry air above the inversion. Consequently within each cloud there is only a limited time available for the growth of raindrops, but in general the thicker is the cloud the longer is this time and the more water is condensed in the cloud, so that showers are more likely.

Measurement of the raindrops within 'the sea of clouds' and of its thickness were made on only three occasions (Table 3), but from these and other passages through the clouds it appears that when the thickness is only about 500 metres the clouds give no precipitation and their interior seems 'dry'. As the thickness approaches 1,000 metres a light drizzle is found here and there within the cloud and beads of water collect on vegetation which catches large cloud droplets, but the amount of precipitation is insignificant. When the cloud thickness reaches 1,500 m showers of small raindrops occur within and below the cloud base, and some showers reach the lower slopes of the valley, even perhaps as far as the coast itself. In these showers the rate of rainfall reaches a few mm/hr, but probably the average rate of rainfall within and for some distance below the cloudy zone is barely 1 mm/hr.

This behaviour is in reasonable agreement with that of small convective clouds in other maritime climates, which are often found to produce showers when their thickness exceeds 1,500–2,000 m. It is interesting to compare the climate of the Canaries with that of the Hawaiian islands. The latter lie in a lower latitude (about 20°N), in the trade winds on the southern flank of the great Pacific anticyclone, but in a region characterized by a higher temperature inversion (about 2,000 m rather than about 800 m) and visited more often by tropical disturbances (which produce a rainfall over the sea of about 75 cm, as opposed to about 30 cm near the Canaries). However, the bulk of the rainfall on the islands of Hawaii falls from the sea of clouds which forms in the trade-wind current on the windward slopes; since the bases of these clouds, like those which mass on the northern side of Tenerife, lie at about 700 m, their average thickness is between 1,300 and 1,500 m, and they produce an abundant rainfall whose annual amount reaches nearly 750 cm in some places. The average intensity of these rains is several mm/hr and the maximum raindrop diameter is 1½ to 2 mm, little different from corresponding values in a Tenerife cloud of thickness about 1,500 m, in which intensities of ½ to 5 mm/hr and maximum diameters of 1 to 1½ mm were found. In Hawaii the concentration of giant sea-salt nuclei (mass of salt 10⁻⁹ gm, or more) in the sea air below the cumulus clouds has been found to be rather less than 1/litre, closely comparable to the average value near the ground on Tenerife of about 1/litre. Thus the important characteristics of the cloud air in the two places are very similar, but in Hawaii

TABLE 3. Summary of raindrop measurements made in slope cumulus on Tenerife

Date	Height, metres	Concentration per m ³ of droplets of radius			Radius of largest observed drop, microns	Rate of rainfall mm/hr
		30 to 45 μ	100 to 150 μ	> 500 μ		
23/3/58	Cloud tops					
	1,800-2500					
	1,830	9×10^4	1,000	<20	400	0.5
	1,830	2×10^3	700	<20	200	0.1
	1,760	10×10^3	700	40	540	0.2
	1,760	—	2,000	300	580	8
	1,760	10×10^3	1,000	<100	480	1
	1,760	9×10^4	600	100	730	4
	1,570	—	600	<20	280	0.2
	1,570	—	400	<20	310	0.2
	1,570	—	700	100	870	5
	1,390	5×10^3	900	<20	400	0.9
	930	—	700	<10	200	2
	930	—	400	<7	310	0.1
Cloud base	500-900 m					
29/3/58	Cloud tops					
	1900-2,200					
	1,320	—	90	—	310	0.06
	1,320	2×10^3	150	—	320	0.05
	1,320	5×10^2	100	—	340	0.01
	1,210	4×10^3	20	—	190	0.01
	1,110	1×10^3	100	—	290	0.02
	1,100	1×10^3	200	—	180	0.02
Cloud base	950-1,150 m					
31/3/58	Cloud tops					
	1,250, later 1,200					
	1,200	1×10^4	250	—	150	0.02
	1,150	5×10^3	420	—	220	0.03
	1,100	4×10^3	1,700	—	190	0.1
	1,070	9×10^3	900	—	160	0.07
	1,070	8×10^3	200	—	150	0.02
	900	3×10^3	800	—	180	0.04
	850	10×10^3	5,000	—	240	0.04
	780	7×10^3	400	—	160	0.03
	600	3×10^3	10	—	120	0.002
Cloud base	530, later 380 m					

Drizzle- and rain-drops were sampled inside the clouds on three occasions by allowing them to settle on slides exposed horizontally close to the ground. The slides were coated with gelatine impregnated with a dye (Naphthol Green B; see H. F. Liddell and N. W. Wooten, *Quart. J. R. Met. Soc.*, 83, 1957, p. 263) in which the droplets leave stains which by calibration were found to have diameters which over the whole range of drop sizes from a few microns to a few millimetres were larger than the true diameters by a factor of 2.2 ± 0.3 . A constant factor of 2.2 was used to evaluate the original drop sizes from the sizes of the stains on projected images of the slides.

the clouds frequently have a thickness of 1,500 m and the annual rainfall reaches 750 cm, whereas in the Canaries they only occasionally attain this thickness and the rainfall from them is only about one-twentieth as much.

It is not well understood why rainfall from a cloud 1,000 metres thick is inappreciable, and yet that from a cloud only 500 metres thicker may be copious. The total quantities of water vapour condensed in the clouds probably differ

by a factor of not more than two, so that the reason for the difference in behaviour must lie in the facility with which the individual cloud droplets can be aggregated together into raindrops. It may be important that in the thicker cloud the average size of the cloud droplets is rather greater, since it is believed that unless a large part of the water is held in droplets of radius greater than about 8 microns then the aggregation of droplets proceeds very slowly. A calculation suggests that an average radius of about this value may occur in the lower parts of the cumulus and that in the upper parts a small increase of cloud thickness may suffice to ensure that this value is exceeded. However, the possible importance of this effect could not be estimated confidently without a prolonged series of observations to determine the actual sizes of the microscopic cloud droplets, preferably using an aircraft to fly through the clouds, because the smaller droplets may evaporate in cloud air which touches the hill slopes. Whether the effect is important or not, it is not one which could be influenced favourably by artificial means.

On the other hand it may be that the convective stirring motions which bring droplets to the upper cloud surface, where cloud air is continually mixed into the dry surroundings and evaporated, do not allow sufficient time in a cloud of small thickness for the droplet aggregation processes to proceed to completion and produce raindrops. Here again only a lengthy and difficult investigation could confirm this effect, but equally it can be said that the processes could be hastened only by introducing into the cloud sufficient numbers of outside cloud droplets. These might within the limited time available attain the diameters of a millimetre or rather more which characterize the raindrops which fall from the thicker clouds. However, the initial diameter with which the droplets were sprayed into the cloud would need to be greater than that attained by the giant sea-spray particles, which within minutes of entering the cloud have diameters of about six-hundredths of a millimetre, and yet fail to become raindrops. If rain could be provoked by spraying into the cloud droplets of diameter one-tenth of a millimetre, with no waste in the form of smaller or larger droplets, and even if each one became a raindrop of maximum size which reached the ground without any evaporation, then even in these favourable circumstances the rainfall provoked would be only one thousand times the amount of water used in providing the seeding spray. Considering the difficulty and expense of conducting the seeding it seems most unlikely to be an economical operation. Thus on the basis of present ideas on the structure and behaviour of the sea of clouds there seems to be no practicable and economical way of stimulating rain from the shallower clouds, even though they seem heavily charged with condensed water and may in fact contain nearly as much as the thicker examples which yield a considerable natural rainfall.

DRIP WATER

It is often observed that shrubs and pine-trees in the cloudy zone collect small cloud droplets which gather into beads and drip to the ground. Probably

in this way a tree substantially increases its water supply. Moreover, the morning sunshine which occurs before the diurnal increase of the slope cloud often leaves the ground persistently warmer than the cloud air, so that within a few metres of the hill-side the smaller cloud droplets evaporate (with some improvement in the visibility) and those small raindrops which reach the ground evaporate without entering the soil. Trees reduce this loss by shading the ground and keeping it cool.

It is interesting to estimate the amount of cloud water which might be caught by a simple device consisting of several nets of wires or fine cords suspended from a height of say 10 m above the ground. Well within the cloudy zone the quantity of water condensed in the cloud air probably averages several tenths of a gram/m³ of air, and half of this, say 0.2 gm/m³, might be caught in such nets. A typical value for the speed of the wind on the slope might be 3 m/sec, so that the nets would then catch 0.6 gm/m²/sec, or, supposing the nets were 10 m high and 30 m long, about 2/3 m³/hr. If the nets were suspended above a cool, shallow trench leading to a tank or reservoir, then water might accumulate in the reservoir at the rate of a few m³ each cloudy day. This seems a sufficiently promising aid to local small-scale agriculture to justify the experiment of erecting such a net and measuring the amount of water it collects.

WATER RESOURCES OF TENERIFE

The number of raingauges installed on the island is not sufficient to provide an accurate estimate of the total annual rainfall of Tenerife, particularly in the important cloudy zone. It is interesting, however, to compare an estimate of the annual rainfall over a large part of the north of the island with the quantity of water which is drawn from the galleries which are situated predominantly in the same area. If an area is defined by drawing lines between Icod and Teide, Teide and Izaña, Izaña and Tacoronte, and Tacoronte and Icod, about 250 km² are enclosed. Over this region the average annual rainfall varies from place to place between 30 and 50 cm, and 40 cm seems a reasonable average. During a year, therefore, the total rainfall amounts to $0.4 \times 250 \times 10^6$, or 10^8 m³ of water, which is the same as the amount which is said to be drawn from the galleries. Since a considerable fraction of the rainfall is lost by evaporation and run-off it seems very unlikely that the rainfall can entirely replenish the sources of the water issuing from the galleries, which therefore may be tapping fossil water which will not last indefinitely. Since the water supply is a matter of vital importance to the island's economy, it would seem desirable to examine the water resources more closely, especially in the north of the island. As a first measure, more complete observations could be made of the distribution or rainfall in this region, simply by carefully selecting about 50 sites at which a funnel and collecting vessel can be installed; if the funnel dips into the water which is prevented from evaporating by a film of oil, then the observation of the amount of rain accumulated need be made only at intervals of a week or a month.

CONCLUSIONS

A large quantity of water vapour is condensed in the sea of cumulus clouds which frequently forms on the northern slopes of the island of Tenerife. Only rarely does this cloud attain a thickness which would ensure rain formation in other climates, but when the thickness approaches 1,500 m prolonged light showers occur. The readiness with which rain forms in the cloud is due partly to the abundant presence in the air of sea spray produced by waves breaking over the open ocean and near the shore of the island. One method of stimulating rain—seeding clouds with salty droplets—is therefore already in efficient operation. Another method—seeding with ice crystals—could be used only occasionally, when the cloud tops become high and cold enough to contain unfrozen water at temperatures below about -5°C , but the cloud thickness is then such that rain probably occurs naturally.

Although clouds rather too shallow to produce rain contain only a little less condensed water and feel 'wet', there is no known economical method of combining the small cloud droplets of these clouds into large drops which can fall to the ground as an artificial rain. Trees and other obstacles within the cloud collect the small droplets from the air which carries them, and an experiment with a large suspended wire mesh or net might show that it can collect a useful quantity of water.

It appears that rainfall may be insufficient to maintain indefinitely the supply of water used for irrigation, and it is therefore desirable that the water resources of the island should be made the subject of a careful hydrological survey. As a first step rain-collectors of a cheap and simple pattern could be used to obtain a more accurate knowledge of the annual rainfall in the north of Tenerife.

ACKNOWLEDGMENTS

Special meteorological observations on Tenerife were made by P. R. Garcia-Prieto, F. H. Ludlam and P. M. Saunders. The latter are grateful for the generous support and hospitality of the Governor of the island, and of Mr. H. Khuen-Lützow. The analysis of the observations was made by F. H. Ludlam and W. Macklin.

STANDING WAVE CLOUD AT HOPE BAY, GRAHAMLAND

(Photograph on p. 46)

This photograph was taken in the Spring of 1952 at Hope Bay, on the east coast of Grahamland. Lenticular standing wave clouds of this type are common in this area and originate in north-westerly föhn winds. In winter these winds which are generally near gale force, often precede deep depressions and temperatures rise well above freezing. The passage of a cold front is marked by a sudden backing of the wind to south westerly and an increase in speed, often to hurricane force, as cold air flows off the Grahamland plateau. Behind the front, the temperature often falls as much as 40 to 50°F in a matter of minutes.

WEATHER

A monthly magazine for all
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February 1960 Vol. XV No. 2



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Cover photograph

SMALL OCEANIC CUMULUS ABOUT 500 km NORTH OF TENERIFE, 20 March 1958.
The clouds, only 200-300 m thick, tend to lie in parallel lines (see leading article).

Weather is published by the authority of the Royal Meteorological Society and is edited by a committee of the Society, composed of the following members: T. J. Chandler (University College, London), W. G. Durbin (Meteorological Office, Uxbridge), F. H. W. Green (The Nature Conservancy, London), R. E. Lacy (Building Research Station, Garston), H. C. Shellard (Meteorological Office, Harrow), J. R. Thorp (Admiralty, London), and G. B. Tucker (Meteorological Office, Harrow).

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