METEOROLOGY OF THE LA PALMA AIRPORT

Rotor Cumulus above La Palma Airport in the morning of April 10, 2002

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WESTERN CANARY ISLANDS CMT

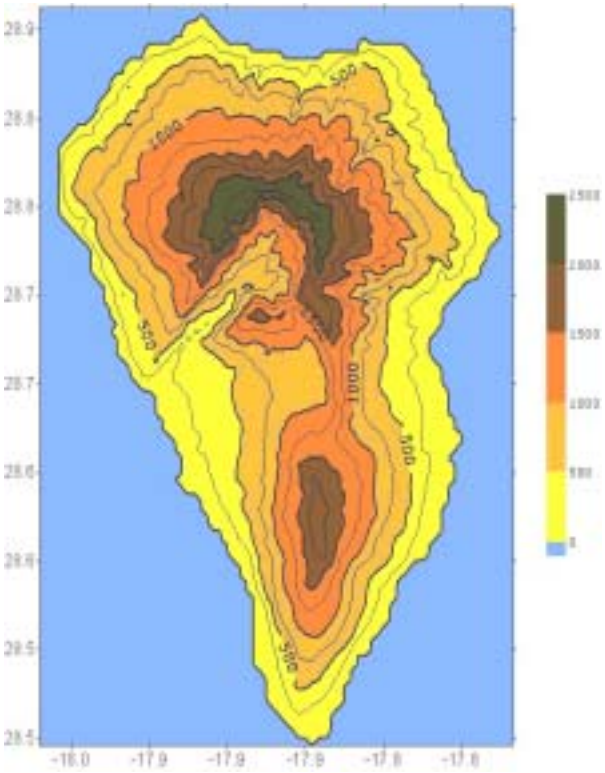
CONTENTS

View from an aircraft cockpit during an approach manoeuvre to header 01. Courtesy of AENA

INTRODUCTION. GEOGRAPHICAL ENVIRONMENT AND CLIMATE

The La Palma Airport is located 38 m. above sea level, next to the South-eastern coastline of the island of La Palma, 7 Km south of the capital, Santa Cruz de La Palma. The runway has a N-S orientation, with a deviation of 10º, so that the header indicators are 01(North) and 19(South). Its geographical coordinates are 28º36'48'' latitude N and 17º45'37'' longitude W. Its ICAO location indicator is GCLA and the synoptic is 60005.

The topographic map and the satellite photograph show the layout of the island relief. Also shown are the location of the Airport, Santa Cruz de La Palma and the main mountain ranges of the island.



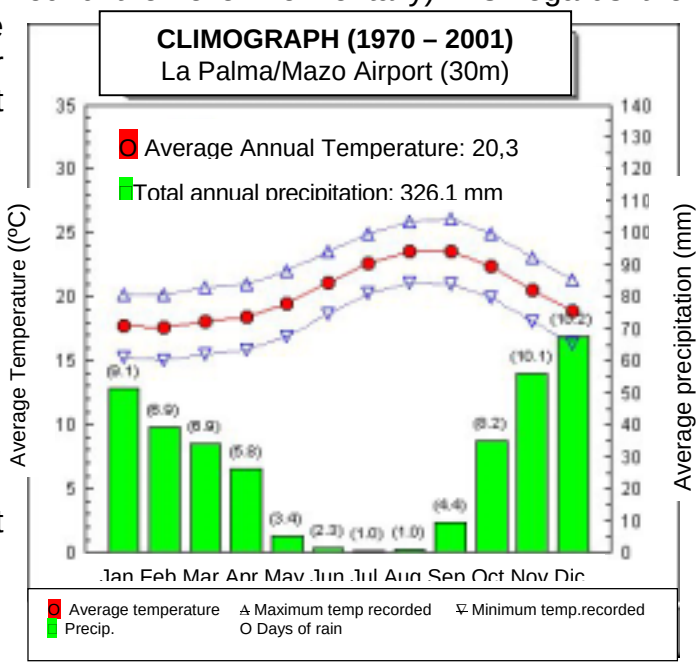
It can be seen that the island is crossed by a question mark-shaped mountain range, so that from the shores of Fuencaliente, on the south, we will first meet the Cumbre Vieja at 1,949 m. above sea level. Then, still heading north, the highest point falls to the Cumbre Nueva, with a quite regular height of about 1,400 m for approximately 7 km. From this point on, the relief rises again around the imposing Taburiente Caldera, reaching 2,426 m. (Roque de los Muchachos), then bending southwest it falls towards the coasts of Tazacorte.

Notable in this relief configuration is the lower height of the Cumbre Nueva with respect to the two massifs to the North and South. As will be seen below, this is important in situations with winds from the W, as it determines a hill over which the wind must pass at high speed. The aerial photograph taken from Tenerife shows this situation. In the background are the peaks of La Palma; the massif on the left is the Cumbre Vieja, the one on the right is the Cumbres de la Caldera de Taburiente and in the middle is the Cumbre Nueva, barely appreciable in the photograph because of its lower height.

La Palma above the sea of clouds. Aerial view from Tenerife (in the foreground)

The influence of the island relief on the behaviour of the meteorological variables in the Airport surroundings is naturally great, as regards both the wind and the cloudiness and precipitations. In the case of wind, the synoptic flow at low levels is affected by the relief, and the actual wind in the Airport can be very different from the synoptic wind. The effects of the relief on the wind can be of shielding, strengthening (by confluence), attenuation (by difluence) or change of direction (as the flow must surround the relief horizontally). As regards the clouds and precipitations, the relief can favour or inhibit their formation and development near the Airport.

The La Palma Airport has a subtropical maritime nature, with permanently mild temperatures and small annual and daily thermal variations. At its altitude, there are no frosts nor physical mechanisms producing fog. The annual number of storms in the Airport is very low.



METEOROLOGICAL SITUATIONS AFFECTING THE LA PALMA AIRPORT AND THEIR EFFECT ON AERONAUTICAL OPERATIONS

As it is impossible to consider all situations affecting the island of La Palma and the Airport in particular, much less to analyse the various possibilities in each situation, the following description deals with the most common effects caused on the Airport by the different types of weather in the Canary Islands, with an emphasis on those arriving from the Northeast due to their great frequency, and from the West, as, although infrequent, are those that tend to create the greatest difficulties for aeronautical operations.

Although the use of technical terms has been avoided, a glossary of terms is provided at the end to aid its comprehension.

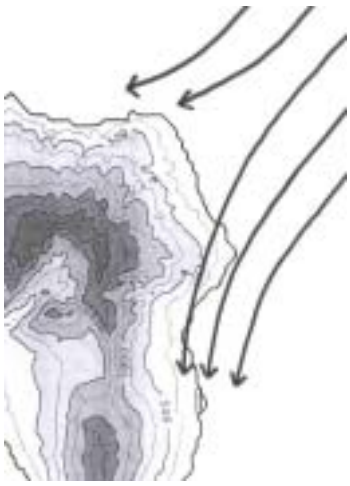
1- North-easterly Situations. Synoptic wind from 020 to 060 º (local name: "*breezy weather*")

The most common meteorological situation in the Canary Islands is that of "Trade Winds", i.e. when the Azores anticyclone is located at its normal position, near said archipelago, creating a NE wind in the Canary Islands. This situation is especially frequent in the summer, and is nearly constant in the month of July.

Wind at the Airport

- If the pressure gradient is small, the actual wind is obtained by the vector sum of the synoptic flow and the local breezes, so that it comes from the 4th quadrant during the night and early morning, from between 340º and 350º, and from the 1st quadrant in the daytime, almost always from between 020º and 030º.

- If the gradient is greater the breeze has almost no effect on the actual wind at the Airport, so that the wind is approximately the same as the synoptic in direction and speed, by day as well as by night.



The greater the N component of the trade winds, the stronger the wind is at the airport, as the flow lines tend to align with the peaks to the North, accelerating by confluence (due to the continuity equation for ideal fluids, which states that the speed of a fluid will increase if the cross section through which it must pass is smaller), reaching the airport with a strong N component, as shown in the figure.

However, the greater the E component the more air is deflected towards the North of the island, tending to leave a windward still area by difluence in which the Airport is located.

In this type of situation the wind blows almost longitudinally to the runway, so that it does not represent much of a problem, even if it is strong or gusty. However, if the pressure gradient is large and the N component is strong, the winds can blow hard and the proximity of the relief to the runway causes turbulence in the approach, which despite not causing greater difficulty are often notified by the pilots.

Cloudiness and meteorological phenomena

In general, skies have stratocumulus or cumulus clouds with a short vertical extent, due to the presence of a thermal inversion that in the summer is located at about 1,000 m and in the winter is somewhat higher. The photograph shows a common situation: the stratified clouds characteristic of the trade winds tumbling leeward of the Cumbre Nueva, on the West of the island.

The "sea of clouds", tumbling over the regions of western La Palma, leeward of the prevailing trade winds, creating a typical "cascade of clouds".

The amount of cloud cover mainly depends on the humidity of the air mass carried by the trade winds, which in turn generally depends on the extent of its continental origin. Thus, as a rule, the greater the N component of the trade wind, the greater the distance travelled over the sea by the air masses it carries, and thus the greater the low level humidity and the inversion altitude. Therefore, the cloud development and quantity are also greater. On the contrary, the greater the E component of the trade wind, the air masses will have a more continental nature, bringing a higher temperature and a lower humidity and

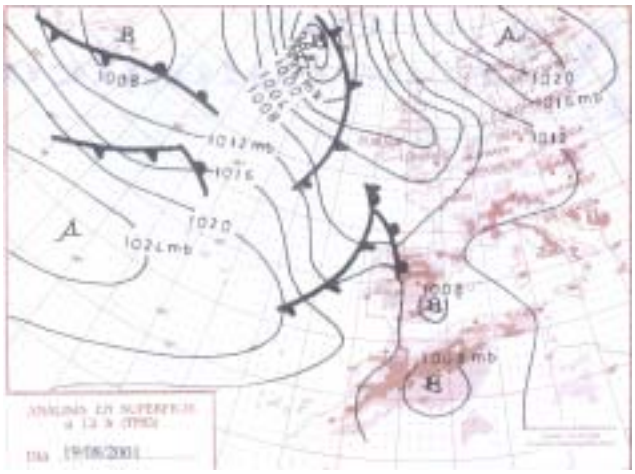
cloudiness (which tends to be more stratified), and the visibility tends to be lower due to the presence of particles from the African continent.

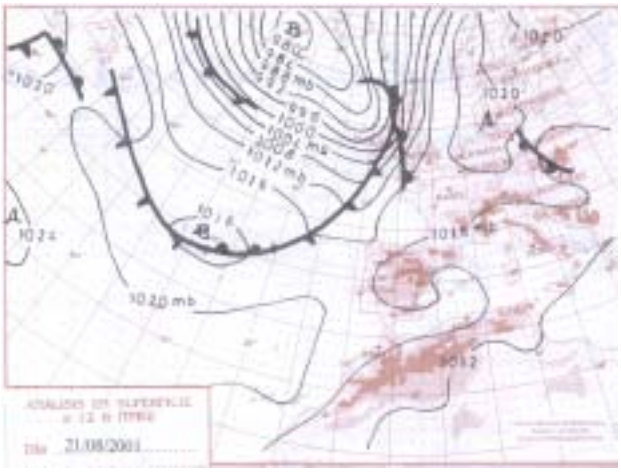
Occasionally, if the trade winds have a marked N component they will carry remains of frontal systems from higher latitudes, which will generally arrive as low level clouds causing precipitations, which are generally weak at the Airport.

These situations do not generally cause phenomena that affect aeronautical operations. However, in situations with very gentle trade winds (low pressure gradient) with the arrival of the remains of a frontal system carried by them, as the front moves slowly over the ocean it will acquire a great humidity and reach La Palma with low base clouds and precipitations. This situation can last several hours, given the slow displacement speed of the front. In this context, significant low visibility conditions can appear because of the precipitations, which are generally in the form of small drops, reducing the visibility even further. In addition, the low cloud ceiling (as low as 300 feet) can hinder the approach.

Example of 21-8-2001

The map of 19-8-01 shows that the Canary Islands are affected by a NNE wind flow, with a low pressure gradient and a low-activity cold front located farther North. Two days later, at noon 21-8-02 the remains of this front reached La Palma as clouds with a very low base. The isobaric map shows what is apparently a typical August day, anticyclonic with a weak NE flow. No perturbations are near the Canaries and in fact, above the inversion at about 1500 m, the sky is clear. In principle, there were no conditions that might affect operations in the La Palma airport. However, the residual clouds of the cold front brought by the trade wind left the Airport inoperative for several hours.



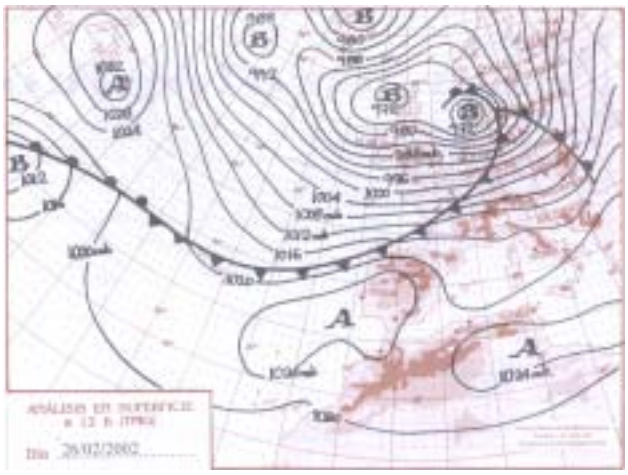


The METAR of 14 Z was the following:

GCLA 211400Z 02008KT 0300 –DZ OVC005 23/21 Q1021 NOSIG=

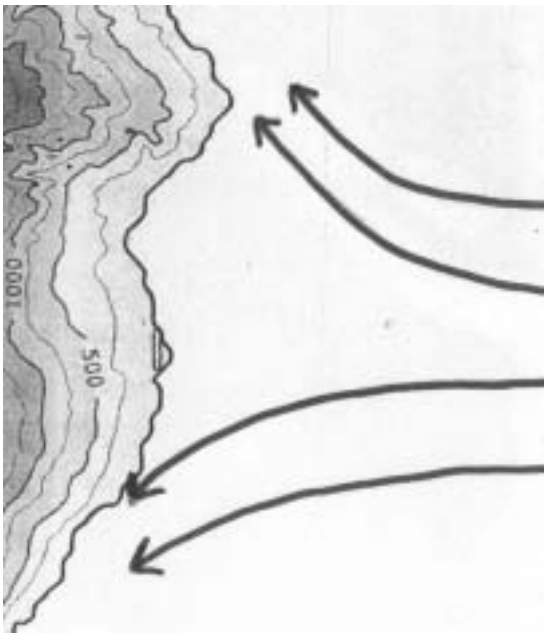
2- Easterly situations. Synoptic wind between 070 and 110º ("African weather")

At times, the anticyclone extends eastward, sending toward the islands an E wind from the Sahara desert, drier and warmer.



Wind at the Airport

The winds resulting from this situation are generally gentle and changing, given the difluence of the surface current, as shown in the figure. It may occur that there is barely any wind in the East of the island, where the airport is located, so that the breezes will prevail, while in the West of the island there are strong gusty E winds, by the same mechanism affecting the airport when there are W winds, as explained in point 5 (winds between 240 and 300º).



Only in situations with very strong and extraordinary East storms, such as that affecting the Canary Islands on 7 and 8 January 1999 when a deep cyclone was placed South of the islands, there can be recorded at the Airport strong E winds crossing the runways, probably because the flow is so strong that the air is not accumulated windward and the majority of the surface air mass passes over the peaks without slowing down much by difluence. But even in these extraordinary cases, the winds are not gusty, nor do they affect aeronautical operations significantly.

Cloudiness and meteorological phenomena

Skies generally show little or no cloud cover. The visibility is reduced by the presence of particles in suspension arriving from the African continent, causing haze, although this is more common with South-easterly weather.

In general, the air mass arriving from the African continent, as it is warmer, will be located above the colder and more humid surface mass. The result is a thin surface maritime layer under the warm, dry continental layer. Between these layers there is a thermal inversion which, due to the thinness of the humid surface layer, will be very low, as will be the base of any clouds that form. These clouds will be stratified and relatively thin, so that they will not cause precipitations. However, because of their low level, they can hinder the approach of aircraft. The satellite photo shows a haze episode over the Canary Islands.

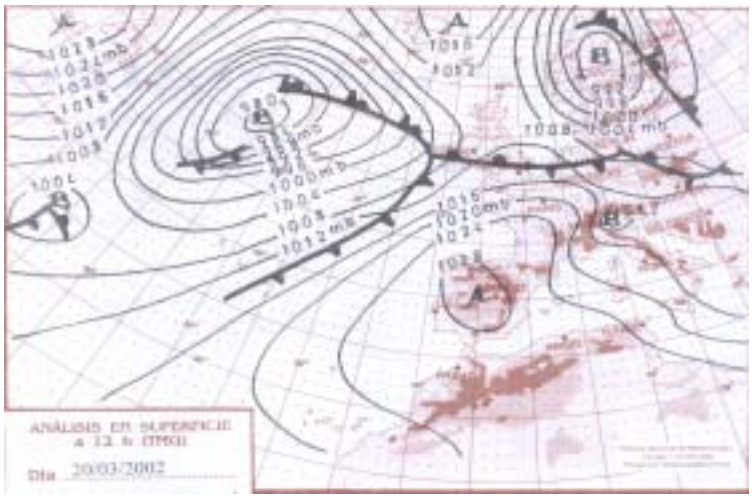
"Calima" episode in the Canary Islands

Example of 26 February 2002

The isobaric map at 12 GMT (page 8) shows that the archipelago is in a full anticyclonic situation, with a low E flow. The airport had weak changing winds throughout the entire day and scarce cloud cover (CAVOK was determined in nearly all METAR reports). The inversion was very low, as there was a thin colder and more humid maritime layer. The night cooling caused a thin layer of stratocumulus under the inversion with its base at 1200 feet (360m.) that prevented the approach of the last flight.

3- South-easterly situations. Synoptic wind between 120 and 160º ("Gomero weather")

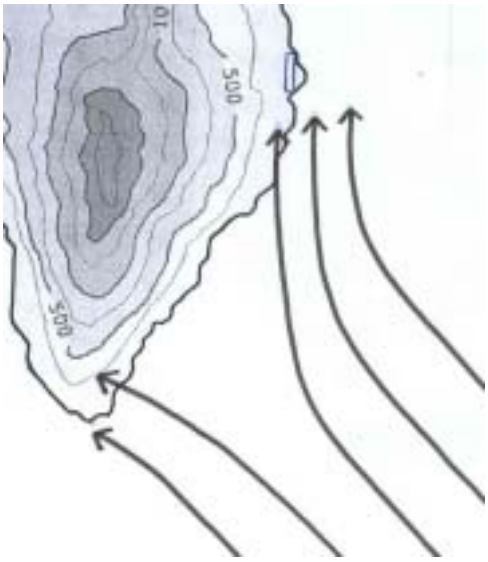
This is the case when the anticyclone is Northeast of the archipelago, sending very warm and dry continental air masses from the Southeast.



Wind at the Airport

As in the previous case, due to the difluence, the winds are weak and changing, with a prevalence of S component winds and breezes.

The greater the S component of the synoptic wind, the lower the flow deflected to the South of the island and the more that is deflected to the North, parallel to the East coast of the island. It arrives at the airport as a S wind (180º), generally without gusts, parallel to the landing strip, so that there are generally no problems for the flights that land on header 19, as at header 01, the normally operative one, there would be a tail wind.



Cloudiness and weather phenomena

SE situations can bring sand and dust particles to the Canary Islands archipelago from the Sahara desert sandstorms, creating haze in the La Palma airport that can be intense and last several days.

This haze can hinder landings, and in extreme cases make landings impossible, although the latter is very infrequent.

As these are dry air masses, the presence of low level clouds is generally null. However, occasionally these situations are accompanied by perturbations in the higher levels of the atmosphere, with the presence of middle and high level clouds that occasionally are convective and storm-like, but which always have a high base.

The precipitations and storms caused by these perturbations, which generally arrive from the Southwest, do not affect aircraft operations as the cloud base is very high, precipitations are in the form of large drops that do not reduce visibility much, electrical discharges are generally from cloud to cloud and, in any case, the duration of the precipitations is short. However, it may occur that there are strong downward currents (downbursts) under the clouds that are hard to see for pilots, as the atmosphere is so dry that there is no rain to warn of their existence.

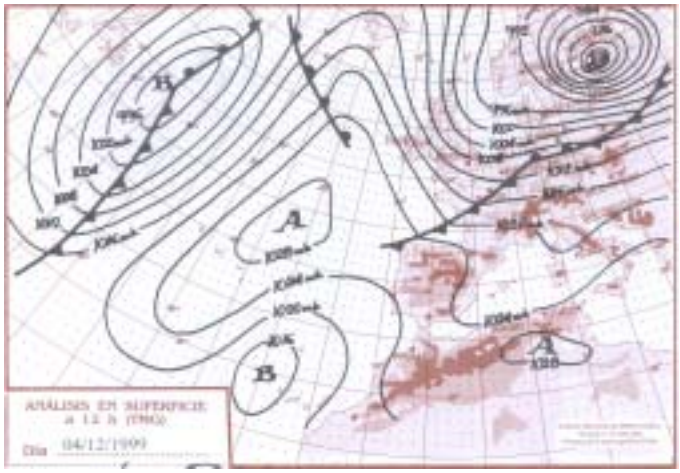
Example of 20-3-02

The surface map at 12 UTC of 20-3-02 (previous page) shows the anticyclone located over the Iberian peninsula, sending a weak SE flow to the islands. In the early morning, haze entered with a reduction of visibility at 7,000 m. The wind remained weak and variable throughout the day, except in an interval between 16 and 19 hours in which it blew from the S at 11 to 13 knots. The METAR of 07 h. shows the low wind speed, the reduced visibility at 7,000 m. due to the haze, the lack of clouds and the very dry nature of the air mass (due to the large difference between the temperature and the dew point):

GCLA 200700Z VRB04KT 7000 SKC 21/01 Q1020 NOSIG=

4- Southerly situations. Synoptic winds between 170 and 190º ("Herreño weather")

These situations arise when there is a cyclone to the West of the Canary Islands. Most situations with Southerly weather are short in duration, as they preceded the passage of a front, after which the wind tends to roll to the SW and then to the W.



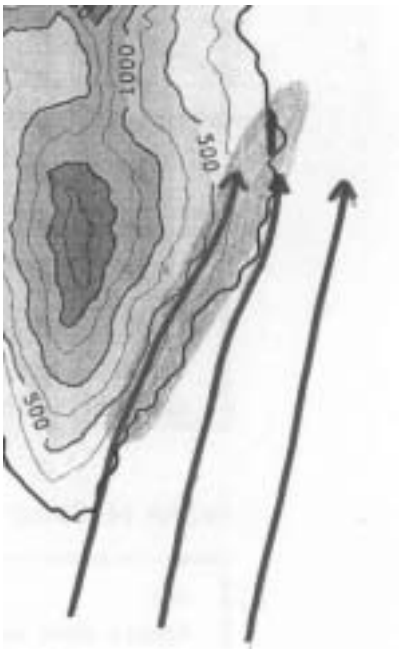
Wind at the Airport

The wind tends to align itself with the Cumbre Vieja (see figure) and thus to blow from 180º. The flow tends to tighten, so that the wind force can be considerable and gusts may occur. As these are S winds, the operative header is 19 so that the wind is practically longitudinal to the track, not causing too many problems.

Cloudiness and weather phenomena

The typical situation is a sky with few low level convective clouds, without causing problems for aeronautical operations.

However, with situations of this type the considerable southern relief of the island can give rise to one of the most spectacular weather phenomena that can be observed near the La Palma airport. It is possible for certain atmospheric conditions favourable to convection to coincide with the very humid and warm (tropical) nature of the surface air mass and the convergence of humidity in the East of the island as it is somewhat leeward of the flow. In these conditions, the Southern relief of the island acts as an effective ramp that greatly enhances the development of clouds in an extremely localised area. This results in the formation of a cloud mass with a very low base and great vertical extent, that can remain stuck in the South-eastern coasts of the island (shaded area in the figure) leaving enormous amounts of precipitations in a long and narrow strip, while nearby the sky has little cloud cover. The airport is in the Northern limit but within this strip, in the area of discharge of this cloud, and can record heavy and persistent precipitations (above 100 mm in 24 hours).



It may be the case that even when there is heavy rainfall there are no problems in the airport, as the base of the cloud is rarely under 1000 feet (300 m). In addition, the narrowness of the cloud

means that the visibility is only reduced right next to the airport, but not in the approach performed from the header 19 from the south, as it is usually less affected by showers during “herreño” weather episodes.

Example of 30 January 1996

The day of 30-1-96 and those following constitute a typical example of the passage of a very active storm area located on that day to the West of the island, later moving away from it to the Northeast, which successively caused winds from the S, SW, W, NW and N. For this reason, it will be taken as an example for the situations described in what follows.

More specifically, on 30-1-96, with the centre of the storm to the West of the island, a frontal system crossed the island from West to East, with S winds in the first few hours and heavy rainfall in the Airport, this wind rolling to the SW during the morning and later to the W. The METAR for 06 Z was:

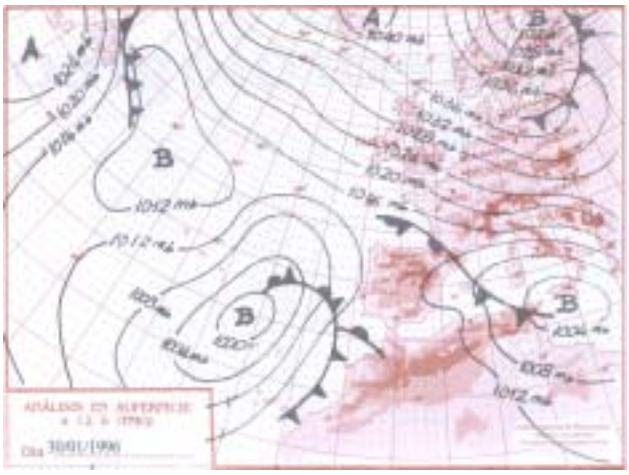
GCLA 300600Z 17028G40KT 7000 +RA FEW013 OVC030 17/16 Q1006 TEMPO 5000 SHRA=

Episode of 3 and 4 December 1999

During the days of 3 and 4 December 1999 the synoptic flow of the island of La Palma was from the S (see map for 4-12-99, page 11). 159.6 mm of precipitation were measured at the La Palma airport in the form of scattered showers over both days. However, there were no incidents related to operations of the aircraft, which landed at header 19. The extraordinarily local nature of the precipitations, despite their great intensity and persistence, can be seen by comparing the 159.6 mm at the airport with the values recorded in nearby stations, where no rain fell or minute amounts were measured, such as the 0.2 mm measured in a meteorological station placed 4 km to the north. It cannot be easy to find another location where a repetitive atmospheric phenomenon occurs that gives rise to such great differences always in the same place and at such short distances, particularly in the case of continued and not storm-related rain.

5- South-westerly situations. Synoptic wind between 200 and 230º (“Cabrito weather”)

These generally occur when storms arrive from the southwest, placing themselves during their usual displacement to the northeast at the northwest of the island of La Palma. In general, their duration is short, barely a few hours as the wind tends to roll to the W and then to the NW.

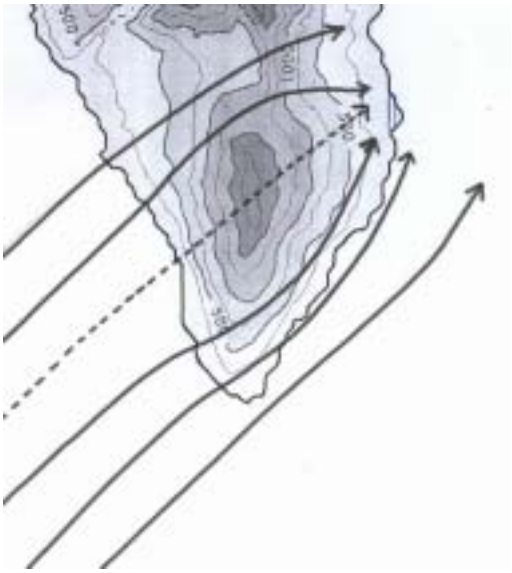


Wind at the Airport

The atmospheric situation

created at the airport with Southwest situation can be described as chaotic. The chaos caused by these situations is such that, although certain typical behavioural patterns can be described for the wind, the fact is that “anything” can happen, even both headers showing strong winds from the same direction but completely opposite in sense for several minutes.

The common case is that as the wind changes from S to SW and then to W, part of the surface flow continues to arrive at the airport from the South, aligned with the coastline and giving rise to a 180-190º wind that persists in header 01.

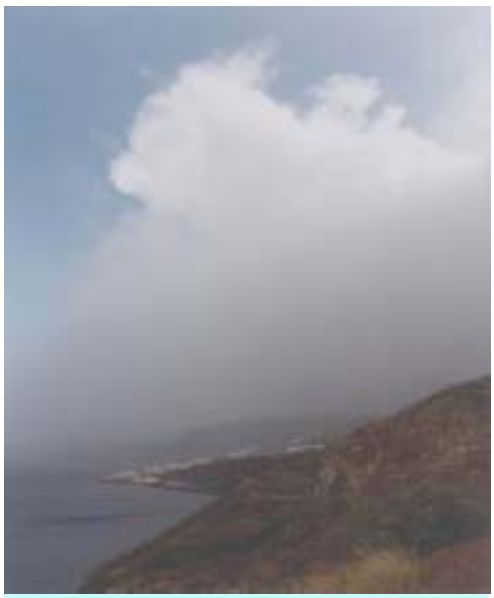


However, it is also the case that if the synoptic wind is strong the flow above the surface (at low levels) can be deflected and cross above the Cumbre Nueva, beginning to cause W wind gusts that begin at header 19. Sporadically, calm periods may appear, or SW gusts arriving from the flow that passes above the Cumbre Vieja (discontinues line in the figure). In this way, header 01 can show winds of 180-200º and simultaneously header 19 can indicate strong and gusty winds from the W. This is all mixed with occasional calm periods or strong SW gusts in any of the two headers.

As regards their incidence on aeronautical operations, while the wind reaching the airport does so surrounding the island on the S, it does not affect the aircraft, which land at header 19. However, when W gusts appear in this header, it is left inoperative, and as the header 01 has wind from the S or SSW, this is, tail winds, it is not operative either, so that aeronautical operations at the airport are impossible at such time.

Cloudiness and weather phenomena

The sky, as the wind, has a chaotic behaviour. The cloud cover is generally trapped in the peaks without affecting the Airport, which is leeward. However, isolated showers carried by the wind can reach the track, without important reductions in visibility nor effects on the aircraft that wish to land. With the arrival of fronts, or if the instability is considerable, showers can appear that may be storm like and reduce visibility, although these are generally short. The photograph shows the area of the Airport and Santa Cruz de La Palma (in the foreground) affected by a shower descending from the La Palma peaks.



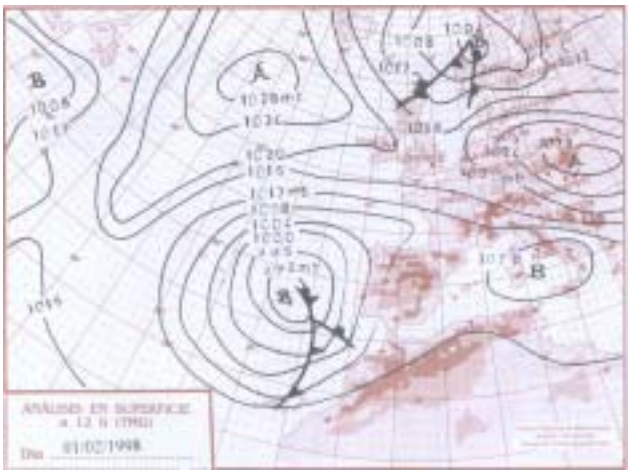
Shower in the La Palma Airport

Example of 30-1-96

The map for 30-1-96 (page 12) shows the centre of the storm to the Northwest of the archipelago, with SW winds in the island of La Palma. No METAR coded SW winds, as the flow surrounded the island on the South, passing directly from showing S winds to strong W winds after noon.

6- Westerly situations. Synoptic wind between 240 and 300º ("back weather")

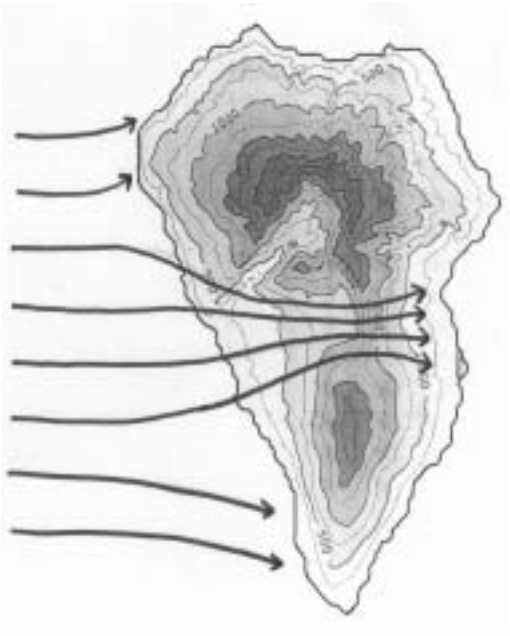
When a storm is located to the North of the Canary Islands, the wind flow arrives from sectors between 240 and 300º, and the situation of greatest risk to aeronautical operations is produced in the La Palma airport, possibly preventing any aeronautical movements for entire days.



Wind at the Airport

With W winds on the La Palma island, its peculiar relief generates extreme conditions in the area of the airport due to the wind flow being blocked in both horizontally and vertically.

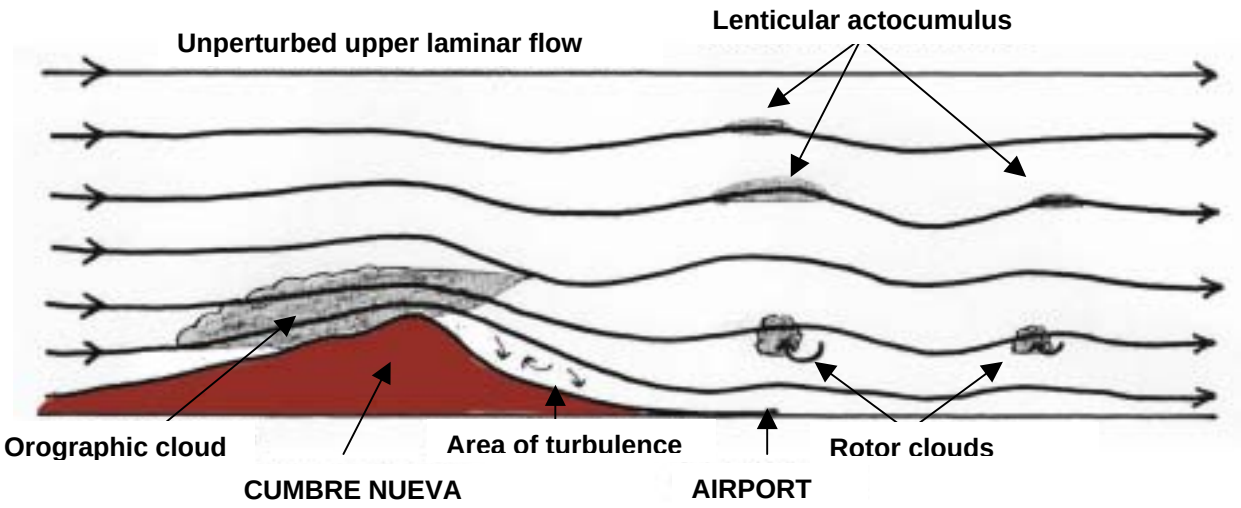
Horizontally, although the airport is left in the shadow area with respect to the surface flow, the figure on the left shows that the flow placed somewhat above is forced to pass over the Cumbre Nueva, being squeezes between the Cumbre Vieja on the South and the peaks of the Taburiente caldera on the North.



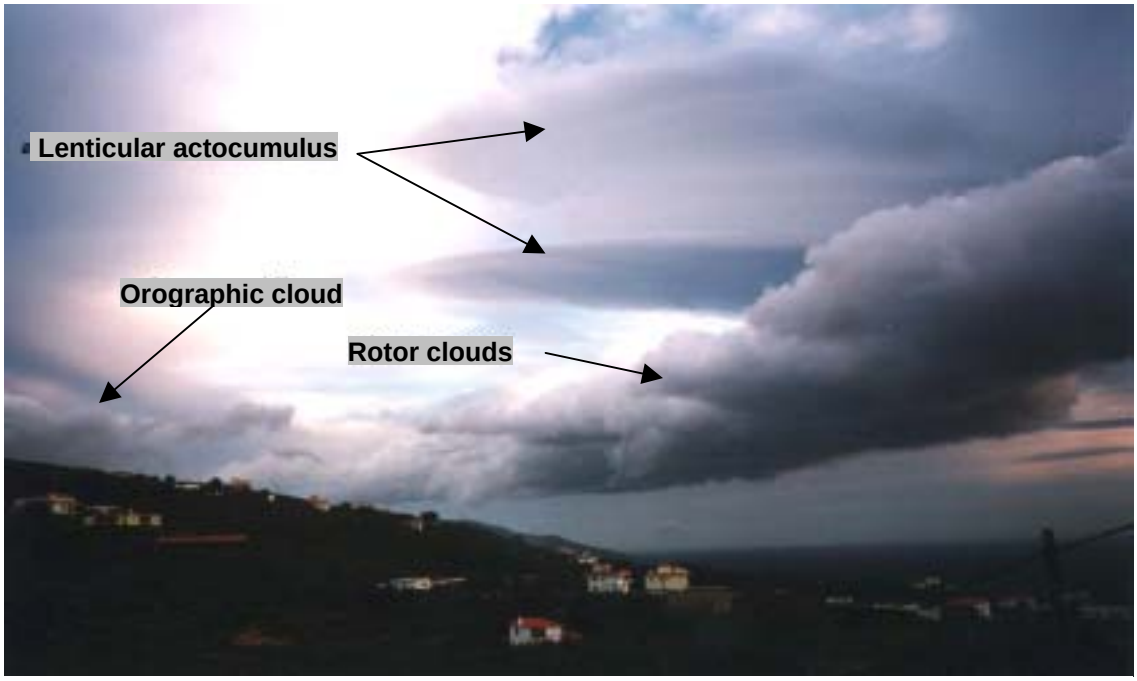
In a vertical sense, the blocking in is between the Cumbre Nueva (that forces it to rise to an altitude of 1,400 m) and the upper laminar flow that is not perturbed by the presence of the mountain range. The upper unperturbed laminar flow is at a height above the peak equivalent to half the range amplitude measured at its average altitude (Barry), which in the case of the Cumbre Nueva is about 4,400 m above the mountain, or 5,800 m above sea level. The following figure shows the vertical blocking in and the cloudiness associated to the case of stable stratification at middle levels.

In this way, the island relief acts as a funnel through which the wind is forced to pass, accelerating greatly (continuity equation), and the upper part of the Cumbre Nueva becomes a tunnel through which the air passes at great speeds.

Leeward, on the eastern part of the island where the airport is located, very complex phenomena occur, considering that the air behaves as a gas that is released after being subjected to a high pressure. Shearing, turbulence, gustiness, mountain waves, rotors and other effects occur, their intensity depending on several factors such as the dynamic state of the atmosphere, the pressure gradient, the stability of the air, the altitude of the thermal inversion, the pressure and barometric trends, etc.



An analysis and comprehension of the phenomena accompanying the various episodes of strong W winds in the island of La Palma, and of the behaviour of the wind and the airport, has a two fold interest: meteorological, in order to know the mechanisms of the appearance of mountain waves and related phenomena; and aeronautical, given the great danger and importance of these phenomena to aviation in general.



Wave clouds generated with West winds in the East of La Palma, as per the sketch of the previous figure.

Provided below, exclusively on the basis of experience, are described the patterns apparently shown by the wind. These should be seen more as questions than as proven conclusions.

Superimposed Altocumulus Lenticularis

-If the pressure gradient is very large, the wind crossing the Cumbre Nueva reaches the airport continuously. This accelerated wind is also very gusty and turbulent, as it drops 1,400 m. in a short distance, so that mountain waves with rotor clouds often appear leeward, parallel to the peak line, many times at low altitude directly above the airport. As they arrive continuously and with strong gusts, as shown by the METAR reports, in general crews do not even attempt approach operations, so that there is generally no risk unless a pilot that is not aware of the turbulent nature of these winds attempts to land.

Rotor whose top part tends to arrange into stratified layers when it reaches stable areas

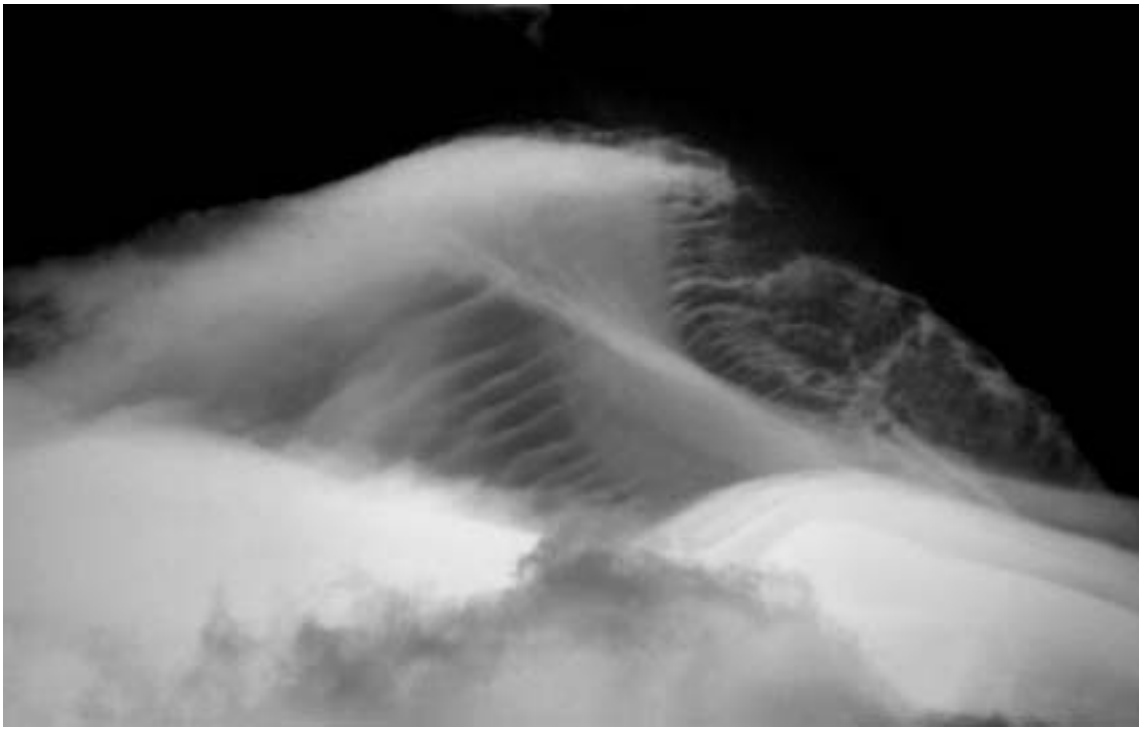
- When the synoptic wind is not so strong the flow is above the airport, which will be calm, yet with strong winds, turbulence and wind shear a short height above the landing strip, with more or less sporadic gusts in both headers (more frequent in header 19 as it is more exposed). This situation is much more dangerous, as the METAR may record gentle winds with variable direction, even calm, yet there can be strong wind shears close above the approach path, or even worse, the arrival of a flight may coincide with one of the sporadic intervals of strong gusts, in which case the risk of accident can be high.

As regards the atmospheric pressure, it seems that with an equal wind force if the pressure is very low (values under 1005 hPa) or if there it tends to fall, W winds will be more dangerous, and vice versa. Thus, pre-front situations occur in which the anemometers indicate winds that are not too strong and the aircraft struggle to land. However, in post-front situations (pressure rising and catabatic winds, more stable and laminar) even if there are somewhat strong W winds in the surface the aircraft land and the wind shear is not noticed.

As regards the inversion, in general winds are stronger in its absence, while when it is present winds tend to be vertically above the airport, without reaching the surface.

Cloudiness and weather phenomena

In situations with W winds, orographic clouds often form that are stuck windward, in the western part of the island, and thus do not affect the airport.



Detail of the top part of a rotor cumulus

According to several factors, such as the wind force, the humidity and the stability of the air, clouds for leeward are formed in the crests of the mountain waves. In extreme cases, rotors are formed that can be vertically above the airport at a low height. The rotor clouds generated in them will then remain static, revolving about its axis, and the turbulence in the airport area will be very high.

It is common for spectacular Lenticular Altocumulus clouds to form above these clouds, sometimes several superimposed along the same vertical line, with strange shapes that sometimes resemble flying saucers (see photographs of this section and the cover, taken in the area near the airport).

The scarce rains only reach the airport when the strong winds carry the precipitations from the clouds located at the peaks. Only when a frontal system passes or when the instability is high they may be significant, in any case without reducing the visibility greatly so that they have no effect on aeronautical operations, more so as these are already prevented by the wind force.

Spectacular lenticular cloud at sunset in the La Palma airport

Example of 30 and 31-1-96

Although episodes of strong W winds in the La Palma airport preventing or hindering aeronautical operations occur several times a year, particularly in the winter months, the situation used in the example of 30-1-96 is extraordinary because of the speed attained by the wind. After the front passed at noon, the already W winds remained strong and gusty for the entire afternoon. The METAR recorded at 19 Z was truly spectacular:

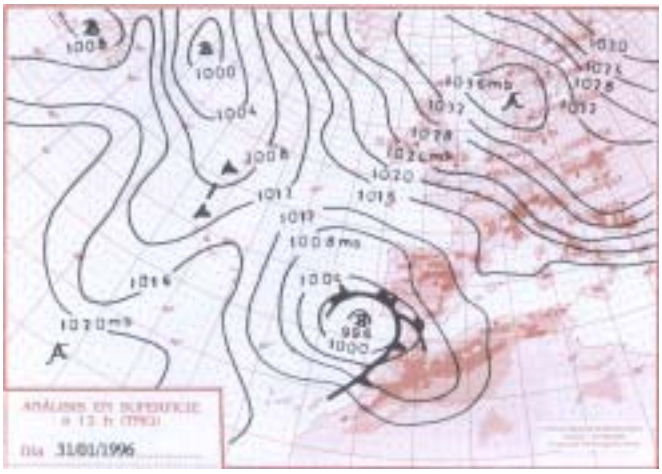
GCLA 301900Z 27043G61KT 9999 FEW025 SCT120 21/12 Q1001 WS ALL RWY TEMPO 5000 SHRA=

7- North-westerly Situations. Synoptic wind between 310 and 330º ("calderetero weather")

This weather, quite common in winter months, occurs both when the Azores Anticyclone moves slight to the South and when the storms passing to the north of the archipelago are located northeast of La Palma.

Wind at the Airport

The high peaks surrounding the Taburiente Caldera prevent the arrival of these winds at the airport, so that the airport generally has gentle and variable winds, with the breezes prevailing, which in the daytime blow from the SE, this is, completely opposite to the NW overall synoptic flow. This situation is shown in the figure, where the airport is seen in a calm area and in which the broken arrows show the daily breezes from the sea to the land, opposite to the prevailing NW flow.



Occasionally, there is a spectacular drop in the wind force when it changes from W to NW, as there is a limit direction value for the synoptic wind (about 300º) in which the airport changes from being in the strong W winds situation described in the previous case to a calm situation that seems odd after hours of strong winds.

In these situations the wind does not represent a problem for aeronautical operations.

Cloudiness and weather phenomena

As the airport is leeward and protected by the high peaks of the Taburiente caldera, the cloudiness is scarce and the visibility is excellent, so that the airport is perfectly operative. Only weak precipitations will occur near the airport if a frontal system passes.

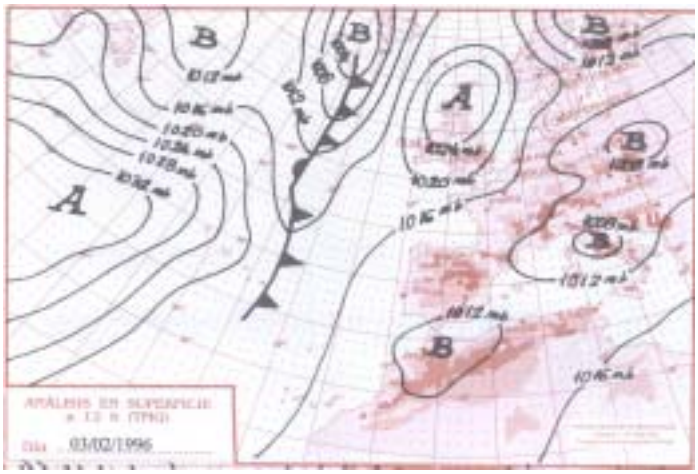
Example of 31-1-96

The map of page 18 shows that on 31-1-96 at 12 Z, the centre of the storm used as an example for the previous cases was located to the northwest of La Palma, with NW winds on the island. In early hours the wind was still trapped in the Cumbre Nueva, staying strong and gusty from the W in the airport. However, by noon the airport was in the shade of the high peaks of the Taburiente caldera, with breezes beginning to blow, so that the METAR of 15 Z showed that the true wind in the airport was a gentle wind from the ESE, opposite to the general synoptic flow prevailing in the island at the time:

GCLA 311500Z 11005KT 9999 FEW025 20/12 Q1013 NOSIG=

<u>8- Northerly situations. Synoptic wind between 340 and 010º ("Northerly weather")</u>

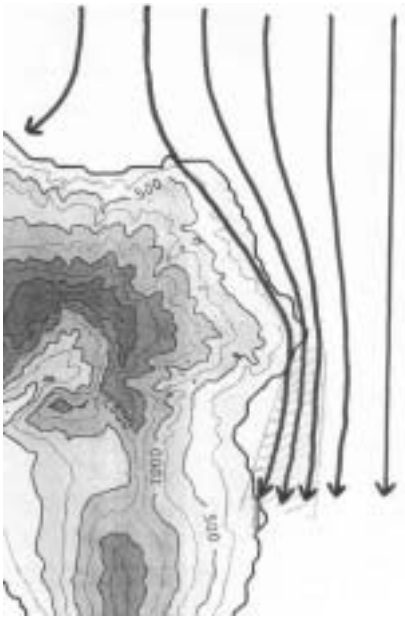
This situation, which can now be included in the alisio winds situations, is produced in an intermediate situation between the northwest situation of the previous point and the alisio situation.



Wind at the Airport

Once again, there is a limiting direction value after which the airport is no

longer in the shade of the peaks to the north, and becomes affected by the N flow. This value is about 350º, so that while the synoptic flow is between 340 and 350º the airport will remain in the shade area of the La Caldera peaks to the north, bringing gentle winds and breezes in the airport.



However, when the synoptic wind changes to more from the N, or if it is near the limit and the day breeze is added to it, the airport is no longer in the shade and will be in the transition area between calm and free N flow (see figure, in which the gusty area is shaded). This area tends to show important wind gusts. Therefore, after this critical value there is another sudden change from calm to strong gusts, now from the N. It is not necessary for the pressure gradient to be high for the gusts to be strong.

These situations do not prevent aircraft from landing, as when the wind begins to blow hard it does so longitudinally to the runway. However, while the strong N gusts remain the turbulence generated in the approach is significant and pilots occasionally report wind shear, so that this situation is not entirely incident free.

Cloudiness and weather phenomena

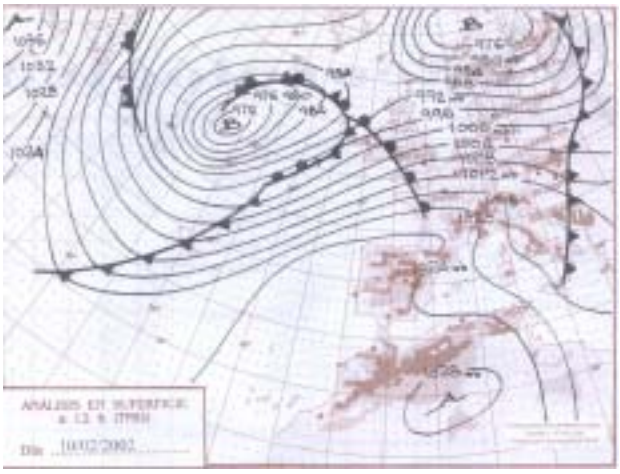
While the airport is in the shade of the relief, the cloudiness that the alisio wind can bring will circulate over the sea to the E of the airport's position, so that the airport is cloud free. When it is in the N wind flow, it can be affected by the low level clouds and showers may occur in the airport, which may be important if fronts pass or if the instability is marked, yet generally do not affect aeronautical operations.

Example. Day 3-2-96

An example of gusty N winds in the airport, with a low pressure gradient in the surroundings of the La Palma island, is provided by the typical situation beginning on 30-1-96 used as example. The isobaric map of 12 Z of 3-2-96 (page 19) shows the great separation between the isobaric lines, which do not lead to expect strong winds in La Palma. However, there were gusty winds in the airport during the entire day, as can be seen from the METAR recorded at 06 Z:

GCLA 030600Z 36024G34KT 9999 BKN030 15/10 Q1012=

9- Calm situations. Weak synoptic wind.



When the Canary Islands are in the centre of an anticyclone or in the flat low area, the pressure gradient above the islands can be neglected, so that the breeze regime sets in tending to balance the thermal differences between the sea and the islands inland.

This type of situations practically does not exist in the summer months, in which the alisio situation is almost constant. This can be seen in the wind frequency table attached at the end (APPENDIX II) which shows that in the summer months there is a nearly complete prevalence of N component winds.

Wind at the Airport

In the airport, the night breeze, locally known as the terral, blows from the inside of the island towards the sea, with a WSW direction, while the day breeze from the sea to the land typically blows from the ESE.

The typical sequence in one day dominated by the breeze regime is one in which during the early morning, as the island slowly cools down, the force of the land breeze also increases at the same rate, until it reaches the maximum speed when the minimum day temperature is reached, this is, at dawn. When the sun rises and the island warms up the land breeze loses strength quickly, until the wind is calm when the land and sea temperatures are equal, generally between 9 and 10 in the morning. After this time the day breeze begins to blow gently, increasing in the afternoon to fall in the night, the wind being calm again at about 8 or 9 in the evening, at which time the terral blows again and the process begins again.

Although these winds blow transversally to the landing strip they are not strong nor gusty, so that they do not affect aeronautical operations.

It may be that on the coldest winter days the terral wind blows much harder (over 10 knots) so that METAR reports can lead those unaware of the dominant synoptic situation to believe incorrectly that the situation may be a complicated one with W winds, when in fact there is a gentle wind and breezes situations.

Cloudiness and weather phenomena

In these situations the cloudiness is generally scarce near the airport. If there is some instability and humidity in the low layers, the sea and mountain breezes form daily evolution clouds in the island peaks, which due to the small size of the island never form storms; in any case, the precipitations which may occur are always weak when they reach the airport.

CONCLUSIONS

The La Palma airport is in a meteorologically privileged area, due to the low occurrence of weather phenomena that significantly affect aeronautical operations, such as fog, storms, intense precipitations, etc. and to the good orientation of the runways with respect to the prevailing winds. The wind regime at the airport can be summarised as follows:

As La Palma is such a high island and its peaks are oriented in a N-S sense, and the landing strip is also oriented in a N-S sense, the wind flows reaching the island tend to align with the peaks and therefore blow with a strong N or S component in the airport, their strength increasing by confluence but without harming aeronautical operations as they blow longitudinally to the track. In the case of synoptic winds transverse to the airport, it tends to lie in the calm area, wither by difluence in the case of E component winds or by the shielding of the high island peaks for winds from sectors between SW and NW. Only when there are flows with a strong W component and sufficient force to reach the airport area, which is leeward, are there episodes of strong cross winds which, due to the particular relief layout, are extremely dangerous for aeronautical operations. The remaining cases of transverse winds occur when, in the absence of a significant synoptic wind, the land and sea breezes regime is established, which has no effect on the operations in the aerodrome.
The island of La Palma and its airport in particular constitute an excellent laboratory for studying the influence of relief on meteorological variables, and on how wind flows at several levels are affected by a great mountain elevation, with phenomena of great interest and complexity worthy of independent study, such as the “herreño” and those associated to strong W winds. This is due to the size and geographical position of the island, which is free of geographical accidents for many kilometres towards the sectors from which the air masses generally arrive, so that they arrive with little perturbation after travelling many kilometres over open ocean. Added to this is an exception relief that makes it one of the highest islands in the world in relation to its surface area.

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Acknowledgements:
Many thanks to all who helped me finish this work.
To my brother Juan Carlos (Barcelona GPV) and my friends Leopoldo Alvarez and Cristo J. Alejo (Las Palmas GPV) for proofreading the document, and for their support and suggestions. To my colleagues at the Western Canaries CMT, particularly Juan José Bustos and Carmen Rus, for their contributions and for giving it is definitive finish. To Gero Steffen for the photographs he has kindly loaned me. To María José Torres and her parents for their support and teachings on the intricacies of the word processor. To Pablo Batista for sharing with me for years his knowledge and fondness for the extraordinary climate of La Palma.
Lastly, a special thank you to my wife for her continued encouragement of my love of Meteorology.

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Photographs
-The satellite photograph of the calima in the Canary Islands (page 9) was obtained from the web page: www.geocities.com/TheTropics/Paradise/5607/2canarias_viasatelite.jpg
-The aerial photograph of the airport (page 2) was contributed by the La Palma airport.
-The cloud cascade (page 6), mountain waves (page 15) and lenticular clouds (page 17 – bottom) photographs were contributed by Gero Steffen.
-Remaining photographs of clouds are by the author.

APPENDIX I – GLOSSARY OF TERMS

Wind shear:

Large change in the direction and/or speed of the wind over a short horizontal or vertical distance.

Pressure gradient:

Refers to the variation experimented by atmospheric pressure at sea level per unit distance.
Its importance lies in that the greater the pressure gradient, the greater the wind force, so that in an isobaric map (as that accompanying the text), the closer the isobaric lines the greater the pressure gradient and thus the wind speed, and in the opposite sense.

Thermal inversion:

Normally, in the lower layers of the atmosphere the temperature falls with the altitude. When the temperature increases with the altitude in a layer of the atmosphere, this layer is said to have a thermal inversion.
This is a very important phenomenon, as it prevents any vertical air displacements so that the clouds below it can only develop vertically until the height of the base of the inversion layer.

METAR:

Meteorological report issued from an Aeronautical Meteorological Office for the usual aviation purposes. It includes a codified description of the meteorological conditions existing at the airport at the time it is issued.
The popular information section of the Instituto Nacional de Meteorología (National Meteorology Institute) (www.inm.es) includes a decodification guide.

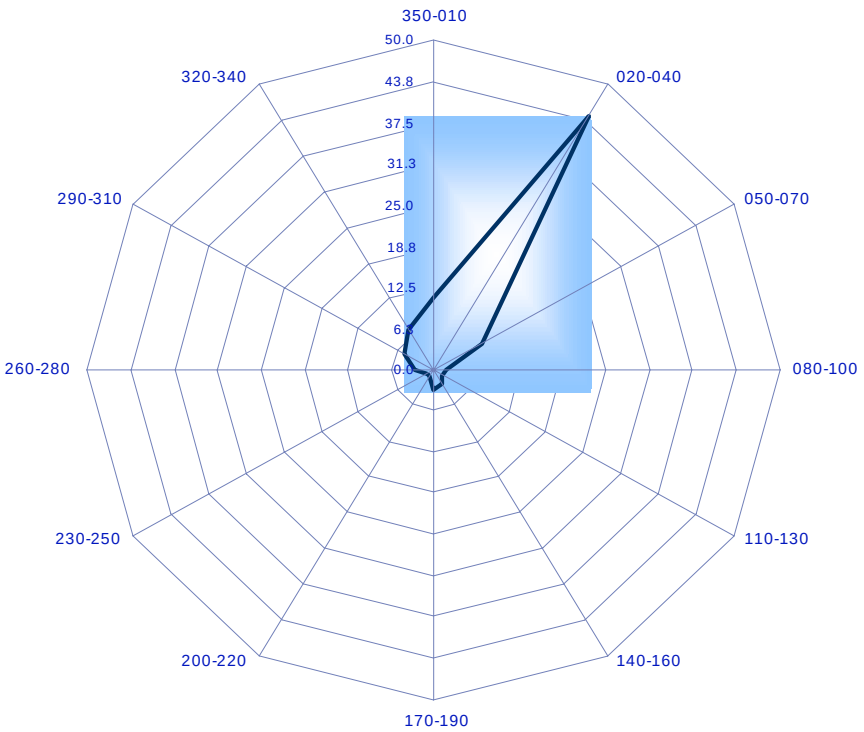
Synoptic wind:

Wind resulting from the equilibrium of the following forces: that due to the horizontal pressure gradient, that caused by the rotation of the Earth (Coriolis), the centrifugal force and friction.
It can be deduced from an isobaric map, as it blows nearly parallel to the isobars with a slight deviation towards the low pressure centres.

APPENDIX II – MONTHLY WIND FREQUENCIES

Period of record: 1983 - 1992. Observations from 06 to 18 UTC.

DIRECTION OF THE WIND in degrees	WIND FREQUENCIES												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Yearly
Calm	13.0	17.2	12.1	14.0	15.0	6.9	0.9	3.0	10.5	12.3	14.3	14.5	11.1
Variable	0.1	0.3	0.3	0.5	0.0		0.1	0.2	0.1	0.7	1.0	0.8	0.4
350-010	8.4	9.6	13.8	9.7	8.2	9.8	14.5	18.9	11.8	9.0	8.8	7.0	10.8
020-040	34.9	34.7	45.7	46.4	44.8	60.5	73.4	59.7	43.4	35.8	30.4	23.3	44.4
050-070	8.1	6.6	5.9	7.0	10.7	10.2	5.4	6.9	11.1	10.4	6.7	6.8	8.0
080-100	1.8	1.7	1.1	1.7	4.3	1.6	0.3	1.2	2.4	3.0	2.1	2.3	2.0
110-130	1.6	1.6	1.2	2.1	2.2	0.9	0.2	0.6	1.6	2.1	1.9	1.8	1.5
140-160	2.5	2.9	2.0	3.5	2.8	0.8	0.1	0.9	3.0	4.2	3.5	4.1	2.5
170-190	4.6	4.3	2.5	4.0	1.7	1.2	0.1	0.3	2.6	3.7	4.4	8.4	3.2
200-220	1.9	0.8	1.4	0.6	0.1	0.1	0.1	0.1	0.2	0.8	1.9	2.8	0.9
230-250	1.0	0.7	0.8	1.0	0.7	0.2	0.1	0.3	0.4	0.6	2.3	2.5	0.9
260-280	4.0	3.2	1.9	1.4	2.3	1.0	0.2	0.6	1.9	3.7	5.2	6.1	2.6
290-310	9.6	7.0	3.2	2.7	2.5	1.6	0.6	1.3	3.5	6.7	8.6	10.8	4.8
320-340	8.5	9.4	8.2	5.4	4.6	5.2	4.1	6.0	7.5	6.9	8.9	8.9	7.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0



Variable: 0.8 % Calm: 14.5 %