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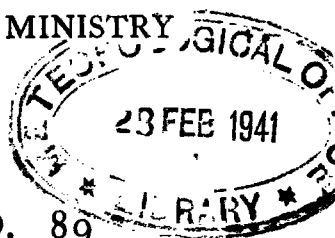
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# ABNORMAL VISIBILITY AT MALTA

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## ABNORMAL VISIBILITY AT MALTA.

By A. C. Best, M.Sc.

**Introduction.**—Abnormal values of any meteorological element are of interest and when they occur they seldom escape notice. In this respect visibility is rather different from the other elements. Isolated cases of abnormally good visibility, up to 200 miles, are on record but they do not appear to occur as frequently as abnormal values for wind, temperature, rain, etc. Perhaps this is because comparatively few meteorological stations have definite visibility marks at distances of the order of 100 miles, and in fewer cases still do both the geometry of the situation and the transparency of the atmosphere permit objects at such a distance to be seen. From this point of view the Meteorological Office at Malta is very fortunate. The point from which observations of visibility, sky, etc. are usually made is about 230 ft. above mean sea level. A few degrees east of north and at a distance of about 130 miles is Mount Etna in Sicily. This mountain is situated in a range of hills about 5,000 ft. high running roughly east to west, and a second range about 3,000 ft. high leaves this first range at a point almost due north of Malta and continues in a south-south-east direction. On occasions Mount Etna can be seen, and on more frequent occasions some of the hills in Sicily are visible.

In a footnote to a letter in the *Meteorological Magazine* for April, 1922 the Editor mentions an occasion in 1784 when the top of Mount Etna was mistaken for a new island by the inhabitants of Malta, and sailors and fishermen hurried out to take possession of it.

It is rather difficult to state with certainty at what distance lies that range of hills which is occasionally visible as there appear to be no means of deciding just which part of the ranges is visible, but it seems safe to say that when the hills are seen the visibility is at least 80 miles. For the sake of brevity these hills will be referred to subsequently simply as Sicily.

The distance of the horizon for a height of 230 ft. is about 19 miles, and for 7,900 ft. about 11½ miles.\* Thus, neglecting refraction, that part of Mount Etna which is above 7,900 ft. should be visible on suitable occasions. Since the height of the peak is about 10,700 ft. this gives a visibility mark standing about 2,800 ft. above the horizon at a distance of 130 miles.

The object of this note is an attempt to elucidate the conditions under which the hills in Sicily or Mount Etna can be seen.

**Hours of Observation.**—The results given below are based upon observations extending over the period October 1, 1928 to 1938. During the greater part of this period routine observations were made at 0700, 1300 and 1800 G.M.T. (0800, 1400 and 1900 L.S.T.). These were supplemented by observations at 0400 and 1000 G.M.T. from April 21, 1936 and by hourly observations throughout the whole 24 hours from April 1, 1938. Since a continuous watch

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\* See "Meteorological Glossary," 3rd edition, p. 112. Horizon.

for these distant visibility marks has never been maintained it may be that one could have seen either the Sicilian hills or Mount Etna on occasions other than at the standard observation hours. The attitude of the observing staff towards the visibility of these distant objects, however, suggests that very few occasions during the hours of duty would be missed, and in fact there have been many entries in the pocket register indicating that either Sicily or the mountain has been seen at times other than at those laid down for the standard observations.

On the other hand there must have been many occasions when the visibility was sufficiently good for the hills to be seen but they were obscured by clouds. This, of course, would apply mainly to the winter months since June, July and August are almost cloudless. Thus we may assume that the figures given below certainly underestimate the number of occasions on which the visibility was of the order of 100 miles, especially in the winter.

The data have been obtained by examining the records for the Meteorological Office at Malta during the period stated above and selecting those occasions on which either the Sicilian hills or Mount Etna or both were reported as being visible.

It should be borne in mind that the top of Mount Etna is snow covered and the peak appears as a white triangle against the sky. The Sicilian hills on the other hand appear as a dark ridge on the horizon. Probably this accounts for the fact that on thirteen occasions Mount Etna was observed but the hills, though nearer, were not visible. This difference between the two cases would be most marked at or just before dawn, when the light from the sun strikes the mountain at right angles to the line of sight with most of the neighbourhood still in twilight.

**Monthly Frequencies.**—Table I shows the total number of days in each month of the year for the ten-year period under review on which Sicily and Mount Etna have been observed.

TABLE I—NUMBER OF DAYS DURING TEN YEARS OCTOBER 1, 1928-38  
ON WHICH SICILY AND MOUNT ETNA WERE OBSERVED

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sicily ..	14	8	8	4	2	4	4	2	5	10	23	29
Etna ..	2	2	2	1	2	0	1	0	0	1	0	2
Sicily and Etna ..	11	3	2	2	3	1	2	0	0	3	5	4

It is immediately obvious that, despite the cloudless skies in the summer, the chance of seeing either Mount Etna or Sicily from Malta is very much greater in winter than any other time of the year.

**Time of Day.**—The records were examined to see what time of day is most favourable for these abnormal visibilities. For this purpose the day was divided into five periods of three hours each,

as shown in Table II, and the number of occasions upon which Sicily and Mount Etna were observed during each of these periods was determined. If the pocket register showed that Sicily was visible at 0700 G.M.T. then that occasion was assigned to the period 0400 to 0700, but if there was a note stating that Sicily was visible from (for example) 0600 to 0900 then that day was assigned to each of the periods 0400 to 0700 and 0700 to 1000. Naturally, on most occasions there was no record of when Sicily (or Mount Etna) ceased to be visible. During the years when observations were made only at 0700, 1300 and 1800 this would tend to give low figures for the period 0700 to 1000 and 1300 to 1600. Any occasion when Sicily and Mount Etna were both visible was assigned to both columns in Table II.

TABLE II—DISTRIBUTION OF OCCASIONS WHEN MOUNT ETNA OR SICILY WAS VISIBLE DURING THE DAY

*Totals for ten years*

Time, G.M.T.	Number of Occasions	
	Sicily	Mount Etna
0400 to 0700 .. ..	72	28
0701 „ 1000 .. ..	25	18
1001 „ 1300 .. ..	39	11
1301 „ 1600 .. ..	34	5
1601 „ 1900 .. ..	22	4

There is little doubt that the low figure for the period 0701 to 1000 in the Sicily column is quite accidental and is probably due to the circumstances mentioned above. It is quite clear that the chance of observing Sicily or Mount Etna from Malta is greatest in the early morning. We thus have the rather odd fact that the frequency of abnormally good visibility is greatest at the same time of day that fog is most frequent.

It may be mentioned here that since the inception of observations throughout the twenty-four hours Mount Etna has been observed on three occasions before sunrise. On June 1, 1938 (sunrise at Malta 0346) Sicily and Mount Etna were clearly visible at 0300 and 0400 but faded shortly afterwards. On July 7 (sunrise 0351) the peak of Mount Etna only was visible from 0340 for about thirty minutes, and on the following day Mount Etna was visible from 0305 to 0410 and Sicily from 0305 to 0800. It is probable of course that Mount Etna fades shortly after dawn owing to the poor contrast between a snow-covered mountain top and a light sky.

**Source of Air Supply.**—An attempt has been made to determine the source of the air supply at Malta on these occasions of abnormal

visibility. Due partly to the fact that the number of reporting stations south of Malta is very small it is very difficult, in some cases, to decide the origin of the air. This is particularly the case when the air reaches Malta from a southerly direction, i.e. from some part of northern Africa. However, of the 162 cases examined the source of the air supply in the lower layers was eventually allocated as follows :—

From central and east Europe, either direct or after passing over the western Mediter- ranean .. .. .	101	cases
From some part of northern Africa .. ..	19	"
From France or the British Isles and passing over the north-west Mediterranean ..	12	"
From the west and north-west Mediterranean	4	"
Unclassified .. .. .	26	"

Bearing in mind the fact that most cases of abnormal visibility occur during the winter months it is clear that the chance of abnormally good visibility is greatest in a cold air stream. The significance of these figures is not quite as great as would appear at first sight, since the air over Malta has very frequently come from central or east Europe.

**Wind Direction and Velocity.**—The surface wind velocity and direction at whichever of the hours 0700, 1300 and 1800 was nearest to the time at which Sicily or Mount Etna was observed have been examined with the results shown in Table III.

TABLE III—WIND AT THE STANDARD HOUR OF OBSERVATION  
NEAREST TO TIME OF ABNORMAL VISIBILITY

Direction	Calm	NE.	SE.	SW.	NW.				
No. of cases	11	41	13	36	61				
Velocity (Beaufort Force)	0	1	2	3	4	5	6	7	
No. of cases	..	..	11	22	48	49	24	6	1

These figures give very little help in deciding upon the conditions necessary for abnormally good visibility. The frequency of directions corresponds fairly closely to the average frequency of wind direction at Malta except that the number of SE. winds is rather low, and the table showing velocities merely confirms the fact that force 2 to 3 is the most usual wind at Malta. Thus as regards wind we can say only that a SE. wind is unfavourable for abnormally good visibility.

**Temperature, Relative Humidity and Weather.**—Average values of temperature and humidity (during the period 1926 to 1936) for 0700, 1300 and 1800 for each month were available. For each of the 162 occasions of abnormal visibility under discussion the temperature and relative humidity at the standard observing hour

nearest to the time at which the abnormal visibility was reported, were compared with the average for the month. The results are as follows :—

*Temperature.*—In 110 cases temperature was below average, the difference being 3° F. or more in 64 cases. In 49 cases temperature was above average, the difference being 3° F. or more in 22 cases. In three cases temperature was equal to the average value.

*Relative Humidity.*—In 98 cases relative humidity was below average, the difference being 15 per cent. or more in 33 cases. In 56 cases relative humidity was above average, the difference being 15 per cent. or more in 10 cases. In eight cases relative humidity was equal to the average.

Clearly considerations of temperature and relative humidity (at the surface) will not indicate necessary and sufficient conditions for abnormally good visibility, but the chances of such visibility are considerably increased when temperature and relative humidity are appreciably below the average for the time of year.

*Weather.*—When Sicily or Mount Etna was observed at a time other than a standard observation hour there was seldom any direct indication in the pocket register of the weather at the time. Accordingly the entries in the register for the routine observing hour nearest to the time of the abnormal visibility were examined and also the entries of "weather since last observation." It appeared that these conditions were not necessarily associated with any particular type of weather. Naturally the weather during the summer months was nearly always fine with very little cloud, and during the winter months it varied from cloudless to cloudy. Of the 162 days under consideration there were 52 cases when precipitation was reported either at or near the station, and either at the nearest routine observing hour or since the last observation. Most of the rainfall in Malta is of the instability type, so it appears that an unstable atmosphere is at least not unfavourable to abnormally good visibility. This is supported to some extent by the fact that on six occasions the appropriate weather reports indicated either thunder or lightning or both.

*Temperature and Relative Humidity in the Upper Air.*—One of the differences between summer and winter in Malta lies in the average values of the lapse rate of temperature in the upper air. Owing to the greater frequency of inversions in the lower layers during the summer, the average lapse rate up to about 3,000 ft. is much steeper in winter than in summer. Thus the average lapse of temperature from 1,000 ft. to 3,280 ft. is about 8·6° F. in January and only 3·6° F. in July. The relative magnitude of these figures is about the same if the layer between the surface and 3,280 ft. is considered, but for the present purpose it seems better to exclude surface readings which may be subject to purely local variations. At greater heights the difference between the average lapse rates is

very small, the average values of the temperature differences between 3,280 ft. and 9,840 ft. being about  $19\cdot3^{\circ}\text{F.}$  in January and  $20\cdot7^{\circ}\text{F.}$  in July.

Bearing in mind the fact that a tangent to the earth's surface from the Meteorological Office Malta lies below a height of 3,280 ft. for about 90 miles, it would seem that the very much greater frequency of occasions of abnormal visibility in winter as compared with the summer might be explained by the difference between the average lapse rates in the lower layers for the two seasons. If this is so one would expect the fact to be confirmed by an examination of the lapse rates on the occasions of abnormal visibility. Unfortunately temperatures in the upper air at Malta are available for only 63 of the 162 occasions under consideration, and the results of these do not give decisive confirmation of the suggestion put forward above.

Owing to the small number of occasions of abnormal visibility on which upper air temperatures were also available it was considered useless to examine individual months separately, and the results have accordingly been divided into two groups, viz. those for the winter months October to March comprising 55 occasions and eight occasions during the summer months April to September. The average values of the temperature differences for the winter occasions, viz.  $8\cdot6^{\circ}\text{F.}$  from 1,000 ft. to 3,280 ft. and  $20\cdot8^{\circ}\text{F.}$  from 3,280 ft. to 9,840 ft., are very similar to the average values for January. The few summer occasions shewed an average lapse of  $3\cdot5^{\circ}\text{F.}$  from 1,000 ft. up to 3,280 ft. and of  $17\cdot8^{\circ}\text{F.}$  from 3,280 ft. to 9,840 ft.

The position as regards lapse rates can be summarised as follows. Consideration of the relative frequency of abnormally good visibility in winter and summer and also of the relative average lapse rates in the layer of air from 1,000 ft. to 3,280 ft. suggests that conditions of abnormally good visibility are usually associated with steep lapse rates in the layer of air through which the path of light passes. Examination of the available upper air temperatures for the occasions of abnormally good visibility in winter neither confirms nor refutes this suggestion. Yet it must be remembered that lapse rates greater than the average in winter which might be expected to coincide with occasions of abnormally good visibility would probably be associated with convective cloud which would obscure the distant visibility marks, though the transparency of the atmosphere might be greater than on some occasions upon which they are visible. The number of occasions of abnormally good visibility in summer on which upper air temperatures are available are too few to permit conclusions to be drawn, but they indicate that although a steep lapse rate may be favourable to great transparency in the atmosphere it is certainly not necessary.

The values of the relative humidity provide little help in solving the problem. The average values up to 3,280 ft. are 76·0 per cent.

and 62.1 per cent. for January and July respectively, and the corresponding figures for winter and summer occasions of abnormally good visibility are 74.3 per cent. and 56.2 per cent. respectively. The only conclusion to be drawn from these is that, provided the relative humidity is not near the saturation point, a lower value is not necessarily productive of greater visibility.

**Long Periods of Abnormally Good Visibility.**—There were a number of cases in which conditions of abnormally good visibility persisted for several days. The records have been examined for those periods when either Mount Etna or Sicily was observed on three or more consecutive days, or alternatively three or more days not consecutive but with breaks of not more than one day of non-observance. There were thirteen such periods, the number of days in a period varying from three to six. Ten of these periods occurred in the months November to February, one in March, one in April and one in July. Two of these spells of abnormal visibility will be described in some detail as examples.

The best of the winter type was the period December 30, 1933 to January 3, 1934. On December 30, anticyclones were centred over the Azores and over north-west Russia with a complex depression extending from the Tyrrhenian Sea to the Adriatic Sea. The ridge of high pressure joining the two anticyclones was very feeble, and on the 30th there was some doubt as to whether air was reaching Malta from the British Isles or from Europe. By the next day, however, the ridge had become more marked, extending across the British Isles, and the track of the air approaching Malta was definitely from eastern Europe around the complex depression. During subsequent days the ridge gradually drifted southwards to France and Germany. The depression over the Tyrrhenian and Adriatic Seas drifted very slowly southwards and by January 3 extended from the Tyrrhenian Sea to the Ionian Sea. Subsequently it moved away slowly eastwards.

During the morning of December 30 an occlusion of the cold front type extending southwards from a centre over the Tyrrhenian Sea passed eastwards across Malta, the wind changing from SSW. to WNW. At 0700 the visibility was between  $6\frac{1}{4}$  and  $12\frac{1}{2}$  miles. At 1300 Sicily was visible. From December 30 to January 3 every observation reported either rain or hail either at the time or since the preceding observation, the rainfall totals for the periods 0700 to 1800 being 0.3 mm., 3.6 mm., 5.2 mm., 3.1 mm., and 7.5 mm. on the five days respectively. Sicily was observed at some time every day, twice in the afternoon and three times in the early morning, and on January 3 Mount Etna was reported to be "very clear" at 0915. Lightning was reported once, during the afternoon of the 30th. Most of the visibility observations at the routine observing hours reported a visibility greater than 31 miles unless it was actually raining at the time.



Unfortunately the only upper air temperature for Malta during this period is for the early morning of January 3. On that day the readings gave temperatures 48° F. at the surface, 49° F. at 1,000 ft., 48° F. at 1,640 ft., 41° F. at 3,280 ft., and then temperature fell off regularly to 17° F. at 9,840 ft., the average relative humidity up to 6,560 ft. being 77 per cent. Surface temperatures were about 5° F. lower than the average for the time of year and relative humidities about 5 per cent. higher than average.

Another case of some interest occurred on July 7, 8, and 9, 1938. On this occasion a ridge of high pressure extended from north-west Russia to Tunisia, the air at Malta having travelled from Russia via the Black Sea area. During the three days the only cloud seen was a trace early on the 7th. All visibility reports indicated a visibility greater than 18 miles and some greater than 31 miles. Mount Etna was seen round about dawn on the 7th, both Mount Etna and Sicily early on the 8th, and Sicily only, very clearly, during the afternoon of the 9th. The only upper air temperatures available are for the early morning of the 8th. The figures for this day show a temperature of 76° F. at the surface, 79° F. at 1,000 ft., and 74° F. at 3,280 ft., after which the temperature decreased fairly regularly to 55° F. at 9,840 ft. and 44° F. at 14,760 ft. The relative humidity up to 14,760 ft. was almost uniform with an average value of 45 per cent. Surface temperature increased from about 6° F. below average on the 7th to about 10° F. above average on the 9th.

To conclude, some particulars will be given of an occasion when the air was drawn from Africa. The occasion chosen consists of one day only, April 12, 1935. Anticyclones were situated over Libya and between Madeira and Portugal and a trough of low pressure associated with a depression over north-west France extended across the western Mediterranean to Algeria. At 0700 the upper wind at Malta was light between W. and NW. up to 4,000 ft., after which it veered to NNW. The general trend of the isobars indicated that the air, in the lowest few thousand feet at any rate, had come from Algeria, though scarcity of observations did not permit its history to be traced back any further. Upper air temperatures are available for the early morning. At the surface temperature was 56° F., at 1,000 ft. 67° F., at 1,640 ft. 66° F., and at 3,280 ft. 61° F., after which temperature fell off to 39° F. at 11,480 ft. Relative humidities were remarkably low above the surface, varying between 39 per cent. and 15 per cent. from 1,640 ft. to 8,200 ft. The average relative humidity from the surface to 11,480 ft. was 43 per cent. The sky was cloudless during the whole day. Mount Etna was "clearly visible" from 0400 to 0515 and again at 0930 whilst at 1130 Sicily and Mount Etna were both "clearly visible."

