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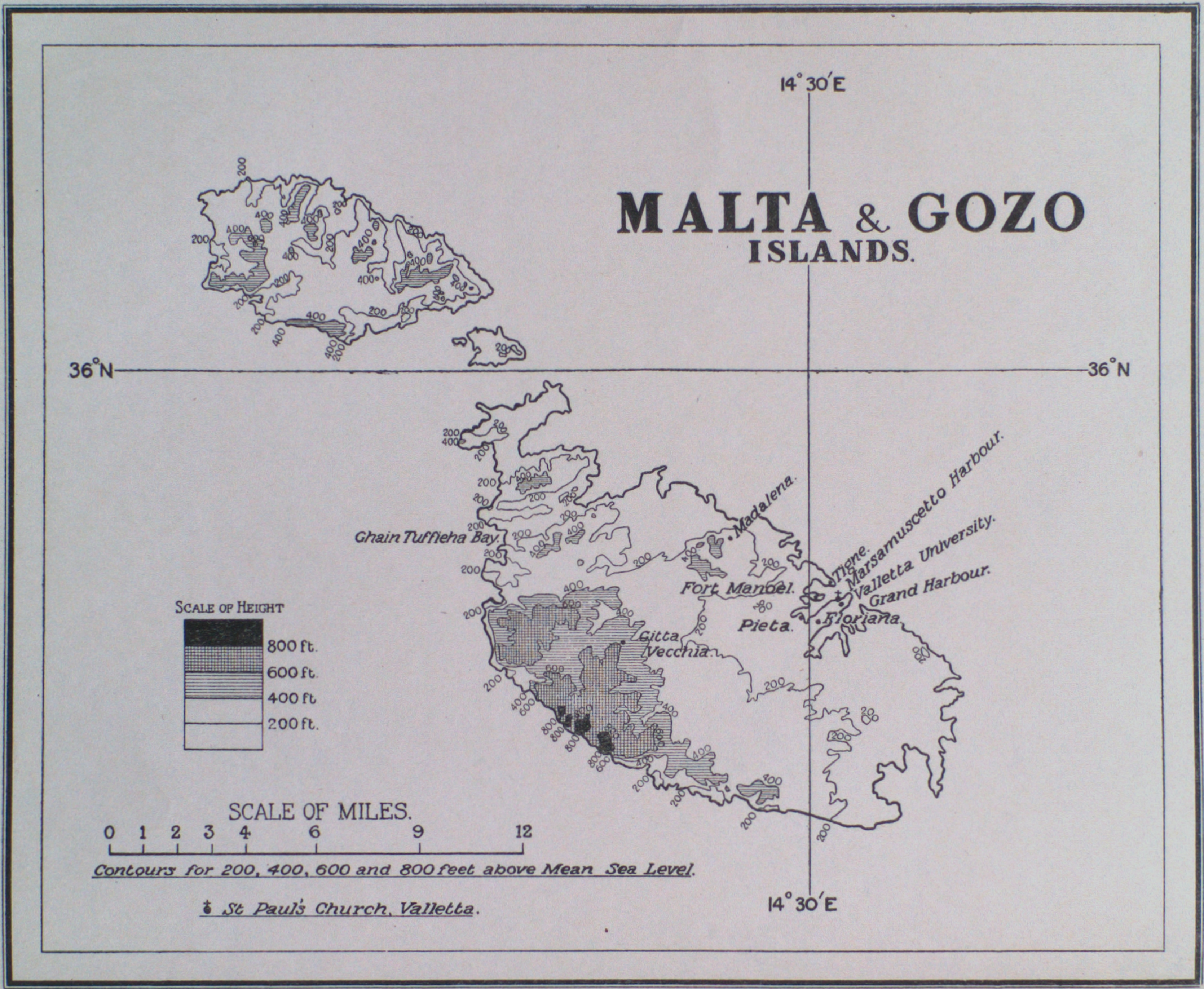

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A STUDY OF VISIBILITY AND FOG AT MALTA

By J. WADSWORTH, M.A.

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A STUDY OF VISIBILITY AND FOG AT MALTA

§ 1—Introduction

The island of Malta lies in the centre of the Mediterranean Sea in latitude 35° 54′ N. and longitude 14° 31′ E. of Greenwich. Its area is only 95 square miles, but its surface is rather diversified and reaches at its highest point a height of 800 feet above sea level. The atmosphere at Malta is usually very clear because there are no large towns or industrial centres producing smoke in great quantities near the island and the visibility is therefore normally good. In addition, fog is very infrequent. The following description of visibility at Malta refers to the years 1919–25 and includes a statistical summary, a cursory analysis of conditions producing thick fog and a few individual examples. Fuller details are contained in a manuscript compilation which is available for reference in the library of the Meteorological Office. Effects due to illumination are disregarded. The observations employed are estimates of the horizontal range of vision towards the sea from a point on the northern coast of the island 200 feet above sea level.* There are no visibility objects such as an inland observatory possesses, so that the estimates may at times be false; but in general we may assume that the magnitude of the distance estimated by the observer does correspond roughly to the degree of transparency of the atmosphere and varies with it in the same sense. The investigation was simplified by the fact that the observer was always estimating the visibility in one direction, northwards, so that complications which arise from variations in visibility in different directions relative to the sun's rays were practically eliminated. In addition to the estimated observations the author has also discussed some observations of the horizon made at selected points at known heights above sea level.

PART I—STATISTICAL SUMMARY

§ 2—Visibility Data

The observations summarized in this section were made at the University in Valletta during the five years 1919–24. As mentioned in the introduction they are estimates of the horizontal range of vision towards the sea from the roof of the University looking north or north-east, the height of the observer above sea level being 200 feet. The observer has presumably been guided in his estimates by the distances of objects along the coast; in particular a headland of the neighbouring island of Gozo is visible from the University, a distance of 14 miles. The distance of the visible horizon from the University roof on clear days with average atmospheric refraction is about 18 miles and this distance of visibility is the greatest which ever appears in the records. In good visibility it should presumably be interpreted as 18 miles or more. The times of observation are 7, 13 and 18h. G.M.T., corresponding to 8 a.m., 2 p.m. and 7 p.m. local time in Malta. The evening observations are made after dark except in summer, and have therefore been disregarded except in summer, since they are not comparable with observations made by daylight. All other observations have been included in the general analysis without exception.

§ 3—Method of Analysis

Analysis of the observations was made by means of tables of frequencies showing the relation between visibility and other meteorological elements such as wind, cloud, humidity and pressure, the final results being given in condensed form as averages. The median value has been used to express average visibility because the irregular class intervals employed in the frequency tables excluded the use of an arithmetic mean† (1). The median distance of visibility has previously been used by Dr. F. J. W. Whipple, who defines it as the distance at which an object would be

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* I am indebted to Professor T. Agius, M.D., Rector of the University, for permission to use original registers at the Observatory.

† The numbers in brackets refer to the bibliography on p. 23.

visible as often as not. Dispersion and skewness were derived from the quartiles (2). The coefficients of dispersion and skewness enable the reader to form an idea of the distribution of the observations from which any particular median value has been derived; but their inclusion makes the tables voluminous and they have accordingly been suppressed except in Table II.

The observations of wind, pressure, humidity and cloud which have been employed in the statistical analysis refer to the University and upper winds refer to Pietà.

§ 4—Diurnal and Seasonal Variation

The diurnal and seasonal variations of visibility at Malta are shown in Tables I and II, which contain percentage frequencies of observations within fixed limits and median values of the visibility. The frequencies at 7h. during the winter months November to February closely follow the figures obtained on the supposition that the distribution of the observations is entirely fortuitous, whereas at 13h. in the autumn months September and October there is a marked preponderance of observations of very good visibility. The median values show that the visibility at 7h. G.M.T. is generally best in autumn when the average is 12 miles and least good in winter when the average is 9 miles. It improves in the course of the forenoon

Table I—Percentage Frequencies of Observations within specified limits of Horizontal Visibility towards the Sea at Valletta, Malta, 1919-24

	G.M.T.	Estimated visibility (miles)					Number of observations
		0—2	3—4	5—8	9—14	15—18	
		%	%	%	%	%	
March–April	7h.	8	11	22	38	21	273
	13h.	5	7	18	41	29	258
May–August	7h.	4	9	27	36	25	608
	13h.	1	6	23	40	30	536
	18h.	nil	7	22	37	34	570
September–October	7h.	6	5	19	36	33	299
	13h.	1	2	14	30	53	290
November–February	7h.	8	12	30	32	19	596
	13h.	4	5	25	31	35	526
Year	7h.	6	10	26	35	24	1776
	13h.	3	5	21	35	36	1610
Chance distribution	—	11	11	28	33	17	—

Table II—Diurnal and Seasonal Variation, Valletta, Malta, 1919-24

G.M.T.		March–April	May–August	Sept.–Oct.	Nov.–Feb.	Year	Chance distribution
7h.	Median visibility (miles)	10·4	10·8	12·2	9·2	10·5	9·0
	Quartile deviation	4·5	4·3	4·1	4·4	4·5	4·5
	Skewness (limits ±1)	−·13	−·02	−·13	+·04	−·04	nil
	No. of observations	273	608	299	596	1776	—
13h.	Median visibility (miles)	11·9	12·1	15·1	12·1	12·6	—
	Quartile deviation	3·9	3·7	3·1	4·3	3·9	—
	Skewness (limits ±1)	−·10	−·09	−·52	−·13	−·16	—
	No. of observations	258	536	290	526	1610	—
18h.	Median visibility (miles)	—	12·4	—	—	—	—
	Quartile deviation	—	3·9	—	—	—	—
	Skewness (limits ±1)	—	−·12	—	—	—	—
	No. of observations	—	570	—	—	—	—

to an average value of 12 miles at 13h. in winter, spring and summer and a distinctly higher average value of 15 miles at 13h. in autumn. The high negative value of the coefficient of skewness at 13h. in autumn indicates that the observations are crowded together in the upper quartiles and more scattered in the lower quartiles. Visibilities estimated at two miles or less never occur at 18h. in summer and scarcely at all at 13h. in summer and autumn.

Although the visibility at Malta normally improves during the forenoon this rule does not apply always and it is necessary to be able to distinguish the exceptions, an important case arising when the visibility on a specific occasion is poor or bad in the early morning. This case is treated statistically in Table XVI which refers to days on which the visibility at 7h. G.M.T. was estimated to be four miles or less, excluding days on which rain was falling at the times of observation (7h. and 13h.). The atmospheric obscurity under consideration is thus due to haze, mist or fog. The results are not very definite but they show the following tendencies :—

The visibility will improve :—

(i) if the wind is calm at 7h. ;
(ii) if the sky is clear or contains detached cloud between 7h. and 13h. ;
(iii) if the pressure is high (*i.e.*, exceeds 1020 mb. at sea level) ;
(iv) during September and October.

The visibility will not improve :—

(i) if the wind is SE. at 7h. ;
(ii) if the wind force at 7h. exceeds a certain value ;
(iii) if the sky is continuously overcast between 7h. and 13h. ;
(iv) if the barometer is low (*i.e.*, pressure less than 1010 mb. at sea level).

§ 5—Visibility in Relation to other Meteorological Elements

(*a*) *Surface wind.*—The relation between visibility and wind direction at Malta is shown by the median values in Table III. In all seasons there is an improvement during the forenoon irrespective of the direction of the wind and a tendency to reduce or obliterate at 13h. the differences in average visibility which exist between the various wind directions at 7h. The results for different seasons of the year are as follows.

In spring at 7h. the highest average visibility occurs when the wind is from N. and the lowest when the wind blows from S. or SE., the maximum and minimum values of the median being 16 miles and 5 or 6 miles. In the afternoon the median visibility ranges from 10 miles with SE. winds to 13 miles with winds from various other directions. The median visibility with N. winds appears to decrease between 7h. and 13h. which is exceptional. On a calm morning the observed visibility has a wide range of values.

In summer at 7h. the highest median visibility is 13 miles with W. winds ; while the lowest values are 8 miles with E. and SE. winds and 5 miles with a calm. At 13h. the range is 10–13 miles, E. and SE. winds being again at a disadvantage ; while at 18h. the maximum and minimum values of the median are 15 miles with SW. winds and 10 miles with E. winds. The maximum of 15 miles with SW. winds is an outstanding value for summer : it is supported by a high negative coefficient of skewness and relatively small dispersion.

In autumn at 7h. the minimum values of the median visibility are 5 miles with calms and 9 miles with winds from S. and there are two maxima of 15 miles with NW. winds and 14 miles with NE. winds. At 13h. there is little difference between the average visibility with different directions of wind, the range being 16 miles with NW. winds to 13 miles with SW. and W. winds.

In winter the maximum value of the median visibility at 7h. is 15 miles with winds from N. and the minima are 7 miles with SE. and S. winds and 5 miles with calms. At 13h. the median visibility has a maximum value of 16 miles with N. winds, but assumes lower values (9 or 10 miles) if the wind is from E. or S.

Hence the visibility during autumn, winter and spring is best on the average when the wind is northerly and least good when the wind is southerly or south-easterly, or calm at 7h.; but in summer the best visibility occurs with W. or SW. winds and the poorest with E. winds.

TABLE III—VISIBILITY AND DIRECTION OF SURFACE WIND, VALLETTA, MALTA, 1919–24†

(This table gives median visibilities in miles corresponding to different directions of wind)

	G.M.T.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm
March–April	7h.	**16**	10	10	6	*5*	11	11	11	9
	13h.	**13**	11	11	*10*	13	13	13	12	—
May–August	7h.	11	9	*8*	8	10	12	**13**	11	5
	13h.	13	12	*10*	10	12	**13**	12	13	—
	18h.	13	13	*10*	12	14	**15**	14	11	—
Sept.–Oct.	7h.	12	14	12	12	*9*	13	12	**15**	5
	13h.	15	15	15	15	14	*13*	13	**16**	—
Nov.–Feb.	7h.	**15**	10	8	*7*	7	9	9	11	5
	13h.	**16**	14	9	10	*9*	10	11	15	5

With regard to the force of the surface wind the median values show that visibility decreases on the average when the wind becomes strong. The visibility is usually at its best when the wind is light (force 2–3 on the Beaufort scale)*; but at 13h. in spring and 18h. in summer the maximum coincides with calms or very light winds (force 0–1), while at 13h. in autumn it coincides with moderate or fresh winds (force 4–5). The deterioration of visibility with strong winds is more marked in spring and summer than in autumn and winter; but it also depends on wind direction, the lowest average visibilities due to this cause being in the SE. quadrant in winter and in the NE. and SE. quadrants in summer.

TABLE IV—VISIBILITY AND FORCE OF SURFACE WIND, VALLETTA, MALTA, 1919–24

Wind force (Beaufort)	Median visibility (miles) G.M.T. 7h.	Median visibility (miles) G.M.T. 13h.	Number of observations G.M.T. 7h.	Number of observations G.M.T. 13h.
0—1	10	13	621	301
2—3	11	13	820	922
4—5	9	11	281	330
6 or more	6	7	54	57
Total	—	—	1776	1610

† For the numbers of observations used see Table XV.

* These results are only qualitative as regards wind force because the anemobiagraph at the University was defective for a time, its indications of wind velocity being too low.

TABLE V—VISIBILITY AND SURFACE WIND, VALLETTA, MALTA, 1919–24

Direction and force of surface wind		Median visibility (miles)					Number of observations				
		May–August			November–February		May–August			November–February	
		7h.	13h.	18h.	7h.	13h.	7h.	13h.	18h.	7h.	13h.
NE.	0—1	11	13	15	7	15	70	58	66	11	14
	2—3	11	12	10	13	16	40	95	35	33	34
	4 or more	7	6	—	12	11	10	6	3	29	20
SE.	0—1	9	11	12	5	8	28	29	34	25	15
	2—3	8	11	12	10	12	45	55	41	42	45
	4 or more	5	5	6	5	7	13	15	19	34	25
SW.	0—1	11	13	15	7	8	36	9	32	49	23
	2—3	12	13	14	9	11	23	25	20	69	73
	4 or more	—	—	—	7	11	3	3	nil	5	16
NW.	0—1	12	14	13	9	10	79	20	70	67	18
	2—3	13	13	12	11	15	167	141	184	146	142
	4 or more	10	10	11	9	11	68	80	65	77	98

(*b*) *Relative humidity.*—The median visibility increases in value as the relative humidity of the surface air diminishes, so that very dry air is usually associated with very good visibility; but the converse is not true because the relative humidity may range up to 90 per cent. if the visibility is very good and even exceeds that figure in a few rare cases at 7h. in winter.

TABLE VI—VISIBILITY AND RELATIVE HUMIDITY, VALLETTA, MALTA, 1919-24

Relative humidity	Median visibility (miles)		Number of observations	
	G.M.T.		G.M.T.	
%	7h.	13h.	7h.	13h.
100—90	4	4	137	39
89—80	9	7	569	189
79—70	11	12	668	492
69—60	13	14	286	517
59—50	15	15	86	260
49—40	15	14	25	82
39—30	14	15	5	24
29—20	—	16	—	3
Total	—	—	1776	1606

(*c*) ***Pressure.***—The median visibility is relatively high if the barometer is high and also improves to a greater extent during the forenoon.

TABLE VII—VISIBILITY AND PRESSURE, VALLETTA, MALTA, 1919–24

Pressure at sea level (mb.)	Median visibility (miles)		Number of observations	
	G.M.T.		G.M.T.	
	7h.	13h.	7h.	13h.
Below 1001	3	7	13	10
1001—1005	7	9	39	44
1006—1010	7	9	170	157
1011—1015	10	12	608	572
1016—1020	11	14	653	574
1021—1025	11	14	253	209
Above 1025	10	14	39	41
Total	—	—	1775	1607

(*d*) *Cloud*.—The result of grouping the observations of the winter* halt year according to the form of low cloud is shown in Table IX, using skies not less than four-tenths clouded. The highest median visibilities are associated with the presence of cumulus clouds and the lowest visibilities with stratus and nimbus.

An increase in the total amount of sky covered, including all types of high, medium and low cloud, corresponds with a diminution of the median visibility. The highest median visibility at 13h. corresponds with a sky quarter to half clouded.

TABLE VIII—VISIBILITY AND CLOUDINESS, VALLETTA, MALTA, 1919–24

Tenths of sky covered	Median visibility (miles)		Number of observations	
	G.M.T.		G.M.T.	
	7h.	13h.	7h.	13h.
0— 1	12	13	413	326
2— 3	12	14	228	218
4— 6	10	14	352	283
7— 8	11	12	201	242
9—10	6	8	371	286
Total	—	—	1565	1355

TABLE IX—VISIBILITY AND LOW CLOUD, VALLETTA, MALTA, 1922–24

Form of low cloud	Median visibility (miles)		Number of observations	
	G.M.T.		G.M.T.	
	7h.	13h.	7h.	13h.
Stratus and fracto-stratus	3	—	5	3
Strato-cumulus	10	11	37	26
Various forms of stratus and cumulus together	10	13	61	49
Cumulus and fracto-cumulus ..	13	14	25	62
Cumulo-nimbus and cumulus ..	12	14	31	47
Cumulo-nimbus	10	9	36	31
Nimbus and cumulo-nimbus ..	10	11	18	15
Nimbus	3	4	9	8
Sky less than four-tenths covered with low cloud	12	15	209	190

(*e*) *Temperature*.—The median visibility in the winter half year, October to March, increases if the temperature of the air at the surface falls below the normal for the time of year and decreases if the temperature rises above normal. The reverse effect is observed in the summer half year.

TABLE X—VISIBILITY AND TEMPERATURE, VALLETTA, MALTA, 1923–24

Departure of surface temperature from normal (7h. G.M.T.)	Median visibility (miles)		Number of observations	
	Apr.–Sept.	Oct.–Mar.	Apr.–Sept.	Oct.–Mar.
°F.				
−11 to − 8	9	13	2	9
− 7 to − 3	11	12	87	92
− 2 to + 2	12	12	200	219
+ 3 to + 7	13	6	66	37
+ 8 to + 11	14	6	9	3
Total	—	—	364	360

* There is little or no cloud at Malta in the summer.

(*f*) *Upper winds.*—The visibility at the surface in summer, May to August, and winter, November to February, was compared with the direction of the wind at 2000 feet, 5000 feet and 10,000 feet. In summer the best median visibility was found to be associated with winds in the NW. quadrant at 2000 feet and 5000 feet; but the differentiation between the various quadrants was small and practically vanished altogether at 10,000 feet. In winter, with more pronounced differentiation, the maximum and minimum values of the median visibility were associated with winds in the NE. and SE. quadrants respectively at 2000 feet and 5000 feet; while at 10,000 feet in almost complete absence of winds from SE. and NE. the results show that NW. winds are more favourable for good visibility than SW. winds.

With regard to the speed of the wind at 2000 feet the median visibility decreases as the speed of the wind increases.

A comparison with the type of upper wind structure showed that the highest median visibility was associated with a reversal or great change of wind in the upper layers; but again the summer results show little differentiation and there were only five examples of reversal in winter. A low median visibility was obtained in winter when the upper winds showed considerable increase of velocity without much change of direction compared with the surface.

TABLE XI—VISIBILITY AND UPPER WINDS, VALLETTA, MALTA, 1922–24 (7h. G.M.T.)

Height (feet)	Direction of upper wind	May–August NE.	SE.	SW.	NW.	Nov.–Feb. NE.	SE.	SW.	NW.
2000	Median visibility (miles)	11	9	11	12	15	7	10	12
	Number of observations	52	23	39	108	24	20	69	103
5000	Median visibility	12	11	10	13	15	9	10	13
	Number of observations	49	20	37	96	11	8	55	67
10000	Median visibility	12	12	12	13	13	12	8	13
	Number of observations	36	9	22	79	4	3	37	34

Wind speed at 2000 feet (miles per hour)	Median visibility 0—30	Median visibility >30	Number of observations 0—30	Number of observations >30
May–August	12	8	220	13
November–February	12	10	172	47

Type of upper wind structure (after Cave)	Median visibility May–Aug.	Median visibility Nov.–Feb.	Number of observations May–Aug.	Number of observations Nov.–Feb.
A—Solid current, or little change from the direction and velocity at the surface over a large range of height	12	12	50	43
B—Considerable increase of velocity without much change of direction	11	7	36	21
C—Decrease of velocity with height	13	9	10	6
D—Reversal or great change in upper layers	13	15	26	5
E—Upper wind crossing lower wind (NW. or SW.)	8	13	20	12
F—Light variable winds all the way up	11	9	17	2
All ascents	12	11	159	89

(*g*) *Changes of pressure and distance travelled by the air.*—The effect of a change of pressure on the visibility in a given sample of air was investigated by means of trajectories which were computed by Mr. W. J. Fowler using gradient winds taken from the International Section of the British *Daily Weather Report*. The results show that the highest median visibilities at 7h. G.M.T. at Malta occurred in air which had not undergone any change in pressure in the interval since 18h. of the preceding day ; but if a change in pressure had occurred then a rise was more favourable for good visibility than a fall. The results are probably obscured by the fact that if the pressure changes are appreciable the winds may be strong, so that the visibility falls off in any case. This method is open to objection because visibility in the surface air is compared with trajectories in the free air at an altitude of 1500 to 2000 feet ; but in winter when there is active convection over the Mediterranean and the average wind does not change very much with increase of height above the earth's surface the trajectories derived from gradient winds probably give a fair approximation to those derived from surface winds.

TABLE XII—VISIBILITY AND PRESSURE CHANGES, MALTA, 1923–24

Pressure change (mb.)		Median visibility (miles)		Number of observations	
		Apr.–Sept.	Oct.–Mar.	Apr.–Sept.	Oct.–Mar.
Previous 13 hours	−10 to − 6 ..	6	6	1	1
	− 5 to − 1 ..	11	11	18	32
	nil ..	13	13	26	11
	+ 1 to + 5 ..	12	12	36	45
	+ 6 to +10 ..	6	9	1	4
Previous 24 hours	−10 to − 6 ..	4	7	2	6
	− 5 to − 1 ..	13	10	29	29
	nil ..	11	13	14	12
	+ 1 to + 5 ..	13	12	22	33
	+ 6 to +10 ..	6	12	2	8

NOTE : The numbers in this table refer to a given sample of air arriving at Malta at 7h. G.M.T. and the pressure changes are derived from the trajectory of the sample in the previous 24 hours.

The trajectories were also used to determine how the visibility varied according to the distance which the air had travelled in the past 24 hours. Since visibility at Malta decreases on the average when the wind becomes strong the investigation was restricted to trajectories originating not more than 500 miles away, so that the average wind speed did not exceed 21 miles per hour. It was found that high median visibility was associated with long trajectories in winter and the reverse effect in summer. With trajectories longer than 500 miles the resulting median visibility showed a tendency to fall.

TABLE XIII—VISIBILITY IN A GIVEN SAMPLE OF AIR ARRIVING AT MALTA IN RELATION TO DISTANCE TRAVELLED, 1923–24

Distance travelled in past 24 hours (miles)	Median visibility (miles)		Number of observations	
	Apr.–Sept.	Oct.–Mar.	Apr.–Sept.	Oct.–Mar.
0—100	14	9	12	4
100—200	13	11	27	14
200—300	11	12	13	15
300—500	11	12	11	18
Total	—	—	63	51

§ 6—Discussion

The visibility of terrestrial objects is modified by the presence of suspended impurities in the atmosphere and by local variations in the optical properties of the pure air itself. The suspended impurities consist of small particles of dust, smoke, water or other substances. The observations recorded at Malta give the sum total of these two effects without affording any means of distinguishing between them (12).

The diurnal variation in visibility observed at Malta is probably associated with convectional movements of air which are controlled by insolation of the surface of the island by day. Such movements cause the dispersal of suspended impurities which may have accumulated in the undisturbed surface layers of air by night and diminish the surface humidity (3, 13). This process is limited, however, to the island and its immediate neighbourhood, because the temperature of the surface of the sea does not vary much between day and night. Hence we conclude that mist or haze which disperses during the forenoon is limited to the immediate vicinity of the island and would not be observable on the open sea, a result which is confirmed by observation. Thus when the visibility in the early morning at Malta is poor owing to the presence of mist or haze on the island or its coasts the chances of improvement depend on insolation and convection. If, however, poor visibility in the early morning co-exists with a strong wind it is probable that the obscurity in the atmosphere extends to the open sea as well and the visibility in such a case would not be expected to improve as the day advances.

Northerly winds in the northern hemisphere should generally be associated with good visibility because they tend to acquire a lapse rate of temperature in the vertical which is favourable for convection, while in addition the air in northerly winds behind a depression is undergoing an increase of pressure. In southerly winds the conditions are reversed (3). The observations at Malta conform to this point of view except in summer when the controlling factor seems to be the relative humidity. In summer the driest winds are those between S. and W. and these winds give the highest average visibility; while winds from E. which are the most humid give the lowest average visibility. The probable cause of this is the presence of small hygroscopic nuclei composed of sea salt which deliquesce, if the relative humidity exceeds 75 per cent, forming small drops of liquid (14, 4). The inclusion of observations made during rain does not appreciably modify the relations given between visibility and wind direction, because the rainfall at Malta which occurs chiefly in winter does not depend appreciably on the direction of the wind (15).

Table XIV—Relative Humidity and Direction of Surface Wind

(The table gives median values of relative humidity in percentages.)

	G.M.T.	Direction of surface wind N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm	All directions
May–August ..	7h.	77	75	**82**	75	71	72	*70*	73	71	74
	13h.	69	66	**73**	60	*51*	55	55	63	—	63
	18h.	73	68	**78**	73	67	65	*61*	69	55	68
Nov.–Feb. ..	7h.	*75*	84	82	84	**85**	82	82	79	86	82
	13h.	74	76	**81**	78	73	*72*	75	74	75	75

It is found that low average visibility occurs at Malta if the wind is strong. This effect may be due to blown spray (3); but since it varies according to wind direction it may also involve differences in optical properties due to differences of upper air structure (12, 22, 23).

The occurrence of very good visibility with relative humidities exceeding 80 per cent might conceivably be due to a partial absence of hygroscopic nuclei; but it is rarely observed except at 7h. and may simply mean that measurements of relative humidity at that hour on the island itself are unsuitable as a basis for comparison with observations of visibility towards the sea. On the 23rd of March, 1922, thick fog, probably a thick dust haze, was reported at Malta when the relative humidity was very low.

TABLE XV—NUMBERS OF OBSERVATIONS USED IN TABLES III AND XIV

	G.M.T.	Direction of surface wind									Total
		N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm	
March–April	7h.	13	23	28	27	25	33	60	58	6	273
	13h.	22	27	30	26	24	25	50	54	—	258
May–August	7h.	71	49	51	35	26	36	92	222	26	608
	13h.	94	65	56	43	15	22	72	169	—	536
	18h.	62	42	56	38	25	27	118	201	1	570
April–Sept.	7h.	22	23	36	32	23	22	47	67	27	299
	13h.	33	31	54	25	24	28	31	63	1	290
Nov.–Feb.	7h.	30	43	43	58	54	69	135	155	9	596
	13h.	37	31	42	43	38	74	110	148	3	526

The importance of convection is indicated by the association of good visibility with cumuliform clouds. If strato-cumulus alone is present indicating turbulent motion rather than convection on a large scale the average visibility is less good than for cumulus ; and it is also less good for clear skies which may include examples of small lapse rate of temperature in the vertical.

TABLE XVI—PERCENTAGE FREQUENCIES OF OBSERVATIONS WITHIN SPECIFIED LIMITS OF VISIBILITY TOWARDS THE SEA AT 13H. G.M.T. AT VALLETTA ON DAYS WHEN THE VISIBILITY AT 7H. WAS ESTIMATED TO BE 4 MILES OR LESS OWING TO THE PRESENCE OF HAZE, MIST OR FOG, 1919–25

(A) *Observations grouped according to direction of surface wind*

Estimated visibility at 13h. (miles)	Wind direction at 7h.				
	NE.	SE.	SW.	NW.	Calm
0— 4	37	51	35	33	15
5— 8	37	31	27	40	54
9—18	27	18	37	26	31
Number of observations. .	30	65	51	42	26

(B) *Observations grouped according to force of surface wind*

Estimated visibility at 13h. (miles)	Wind force at 7h.		
	0—1	2—3	4 or greater
0— 4	21	54	64
5— 8	40	36	22
9—18	40	10	14
Number of observations	119	59	36

(C) *Observations grouped according to state of sky during forenoon*

Estimated visibility at 13h. (miles)	State of sky between 7h. and 13h.		
	Clear	Broken sky	Overcast
0— 4	28	32	57
5— 8	43	37	26
9—18	29	31	17
Number of observations	61	103	46

(D) *Observations grouped according to pressure at mean sea level*

Estimated visibility at 13h. (miles)	Pressure at 7h. G.M.T. in millibars		
	1010 or less	1011—20	Above 1020
0— 4	65	35	11
5— 8	21	40	41
9—18	15	26	49
Number of observations	48	129	37

(E) *Observations grouped according to time of year*

Estimated visibility at 13h. (miles)	March to April	May to August	September to October	November to December	Year
0— 4	47	33	26	39	37
5— 8	23	43	35	37	35
9—18	30	23	39	24	27
Number of observations	47	60	31	76	214

NOTE:—Days with precipitation at 7h. or 13h. are omitted.

TABLE XVII—SUMMARY OF STATISTICAL RESULTS

	Median visibility: *Best*	Median visibility: *Least good*
1. Time of year	Autumn	Winter
2. Time of day	Afternoon	Early morning
3. Direction of surface wind (except summer)	N. or NW.	S. or SE.
Direction of surface wind (summer)	W. or SW.	E.
4. Force of surface wind	Light	Strong
5. Humidity of surface air	Low	High
6. Pressure at M.S.L.	High	Low
7. Amount of cloud	Sky clear—½ clouded	Overcast
8. Type of low cloud	Cumulus	Stratus or nimbus
9. Upper winds—direction	Northerly	Southerly
10. Upper winds—velocity at 2000 ft.	<30 m.p.h.	>30 m.p.h.
11. Temperature at surface (winter)	Below normal	Above normal
Temperature at surface (summer)	Above normal	Below normal
12. Change of pressure	Nil or rise	Fall
13. Distance air has travelled in 24 hours (limit 500 miles)—		
(Winter)	Great	Short
(Summer)	Short	Great
14. Type of upper wind structure (after Cave)	Reversal or great change in upper layers	——

§ 7—Föhn Effect

When the wind blows from SW. on summer evenings the visibility at Malta becomes exceptionally good. This result suggests a föhn effect, because the highest part of the island lies to the south-west of the University directly in the track of SW. winds. It is not a föhn in the true sense of the word because although the hills at Malta often have some thin cloud over them even in summer the author has never heard that light rain or drizzle has fallen from them. But we may suppose that the air in SW winds has such vertical stability in summer (15) that it fails to surmount the steep cliffs on the south-west coast and deviates to the sides instead, thus allowing air to descend from above on the gentle eastern slopes of the hills and arrive at the University as a SW. wind which has been warmed and dried dynamically (12, 16). In addition the air which has descended is less likely to be contaminated than the surface air by reason of its origin. In these circumstances the headland of Gozo is doubtless seen with great clearness from the University. Convection at 7h. and 13h. would tend to destroy the föhn effect.

It is possible, of course, that the föhn effect is fictitious because the air which descends is due to rise again to its former level after leaving the island on the lee side ; and it is also possible that good visibility is a normal accompaniment of SW winds at Malta in summer quite apart from any interference due to the island. But it is remarkable that so definite a maximum of visibility should occur with SW. winds at an hour when föhn effects, if existent, should become most prominent.

PART II—VISIBILITY OF THE HORIZON

§ 8—Method employed

In 1924 I suggested the use of a method of measuring visibility at Malta which would overcome the difficulties due to an absence of fixed objects at sea. The method consists in observing the horizon simultaneously at several stations situated at different altitudes above sea level and depends in principle on the increase in the distance of the visible horizon in clear weather with increase of altitude of the observer. When the weather is uniformly hazy it is possible to reach a height above the earth's surface at which the horizon, while still remaining visible at lower altitudes, disappears owing to the thickness of air interposed between it and the eye of the observer. This effect is due to scattering of light by small particles suspended in the atmosphere and the horizon disappears because the contrast between it and the sea becomes obliterated (5). When fog or mist occurs locally on the coasts of the island the observers at high-level stations above the fog will observe a horizon which is clear while those at lower stations report fuzzy or invisible horizons. The observations of the horizon can therefore be used to deduce the presence of mist or fog occurring locally ; they also give a measure of the visibility over the open sea away from the island.

By courtesy of the Commandant the necessary observations were made by personnel of the Royal Artillery stationed at Madalena Fort and Tigne Point. The heights of the observation posts and corresponding distances of the horizon in clear weather assuming average refraction in the atmosphere are given in the following table :—

Position of observer	Height above sea level (H)	Distance of horizon in miles (D)
Tigne Point A	15–20 feet	6
,, ,, B	70–80 feet	12
Madalena Fort	400 feet	28

The height H in feet and the distance D in miles are connected by the relation $D = 1{\cdot}42\sqrt{H}$.

The principle of the method is illustrated in Fig. 1.

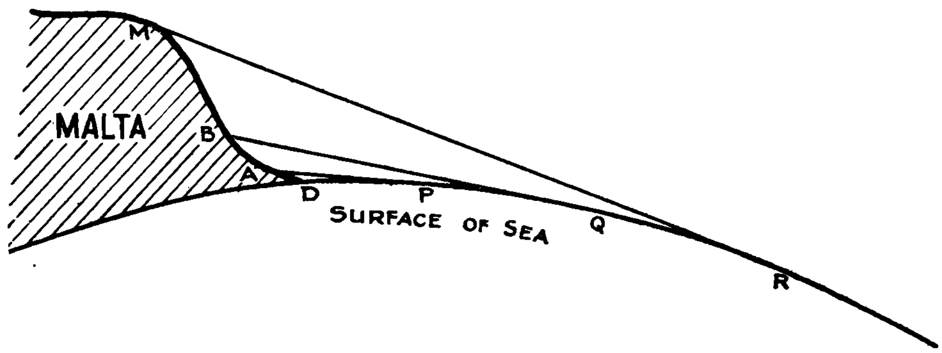

FIG. 1—OBSERVATION OF THE HORIZON

The curved line DPQR represents the surface of the earth and the shaded area represents Malta seen in profile, D being at sea level on the coast. The positions of Madalena Fort and the observing posts at Tigne are represented by M, B and A respectively. The lines AP, BQ and MR which may be slightly curved owing to atmospheric refraction are tangential to the earth's surface, *i.e.*, the surface of the sea, and represent lines of vision to the horizon, their lengths being the distances of the visible horizon from the observing stations.*

Various cases may arise. If the atmosphere is quite clear all three points P, Q, R on the horizon will be visible from their respective stations: if there is uniform haziness R may become invisible while P and Q still remain in sight: if there is mist or haze locally at D then P and Q may be obscured while observers at M can still see R. Finally if there are patches of mist or haze locally on the open sea either of the points P, Q or R may disappear separately.

The condition of the horizon was described in the reports by using one of the terms "sharp," "fuzzy" or "invisible." The extreme terms "sharp" and "invisible" were fairly definite: the intermediate term "fuzzy" describes conditions which vary over a wide range but its use was found to be necessary because the horizon is often neither "sharp" nor completely "invisible."

§ 9—SUMMARY OF OBSERVATIONS

A brief summary of observations of the horizon during a period of one year in 1924–25 is given in Tables XVIII and XIX. The first of these tables gives the percentage frequency of occasions on which the visibility of the horizon at Madalena was better than at Tigne and therefore shows the frequency of occurrence of coastal mist or fog. It will be seen that mist or fog on the coast is more frequent in winter than in summer and tends to disappear by midday.†

The second table contains a summary in percentage form of the observations recorded at each of the three stations. This table shows that the visibility of the horizon at Madalena is much better in winter than in summer, but does not vary between 7h. and 12h. G.M.T.; while at Tigne A the conditions are the reverse, namely, no appreciable change between winter and summer but an improvement between 7h. and 12h. Tigne B occupies an intermediate position and exhibits both diurnal and seasonal change.

Hence the visibility on the open sea in the neighbourhood of Malta exhibits a variation which is seasonal but not diurnal. It is better in winter than in summer

* These distances vary in individual cases if the conditions of refraction in the atmosphere become abnormal by variations in the lapse-rate of temperature. Mr. D. Brunt points out that there will also be effects due to humidity. The general results obtained in the following pages by treating the observations collectively are probably true in the main.

† This result is probably unaffected by rainfall which would on the average affect all stations equally.

TABLE XVIII—PERCENTAGE FREQUENCIES OF OCCASIONS WHEN THE VISIBILITY OF THE HORIZON AT MADALENA WAS BETTER THAN AT TIGNE, 1924–25

	April–September		October–March	
	Madalena better than Tigne	Total number of days	Madalena better than Tigne	Total number of days
G.M.T.	%		%	
7h.	6	164	28	175
12h.	4½	156	16	168

and may be of the order 30 miles or more. Near the coast, however, the visibility tends to improve during the forenoon, showing evidence of diurnal variation which is doubtless associated with the occurrence of mist or fog in the early morning. The vertical thickness of air affected by morning mist, estimated from the heights of the observing stations, is of the order 100 or 200 feet† but definitely less than 400 feet.

TABLE XIX—PERCENTAGE FREQUENCIES OF OBSERVATIONS OF THE HORIZON AT MALTA, 1924–25

Observing station and height above sea level		April–September				October–March			
		Sharp	Fuzzy	Invisible	No. of observations	Sharp	Fuzzy	Invisible	No. of observations
	G.M.T.	%	%	%		%	%	%	
Tigne A .. .. 15-20 feet	7h.	38	56	6	164	44	51	5	176
	12h.	52	44	4	156	55	41	4	168
Tigne B .. .. 70-80 feet	7h.	23	70	7	164	42	50	8	176
	12h.	36	58	6	155	51	44	5	168
Madalena .. .. 400 feet	7h.	9	60	31	183	50	42	8	181
	12h.	9	67	25	183	50	45	5	181

These results are not in conflict with the results previously deduced from observations made at the University, because the latter refer to visibility seawards from the University itself and are therefore influenced by the presence of local mist or fog on the coast; whereas the observations of the horizon give a method of deducing the conditions which exist at sea away from the island.

§10—COMPARISON WITH UNIVERSITY

The degree of correlation at 7h. G.M.T. between the visibility deduced from observations of the horizon and the visibility according to reports from the University is shown in the following table of frequencies, omitting those cases in which the visibility of the horizon at Madalena was better than at Tigne, *i.e.*, cases in which local mist or fog was supposed to exist.

† The estimated observations at the University also exhibit diurnal variation.

TABLE XX—VISIBILITY OF THE HORIZON AT MALTA, 1924–25

	Visibility at University (miles)	Numbers of observations showing correlation with University: Tigne Point — Horizon not visible from A	Tigne Point — Horizon not visible from B	Madalena Fort — Horizon not visible	Madalena Fort — Horizon visible
	0—2	2	—	1	3
Winter	3—4	—	—	4	10
7h. G.M.T.	5—8	—	3	5	13
	9—14	—	—	—	60
	15—18	—	—	—	24
	0—2	3	—	3	—
Summer	3—4	1	1	4	2
7h. G.M.T.	5—8	3	—	12	8
	9—14	1	—	25	45
	15—18	—	—	3	24

The agreement between the two sets of observations is not very close. The lower visibilities are very infrequent at Malta and there were only five cases in winter in which " horizon B " was invisible. In these cases, however, the two sets of observations support each other.

The observations omitted in the previous table, *i.e.*, those in which mist or fog was supposed to exist locally were also compared with the University observations, without however, showing close agreement ; but we should not expect close agreement in these cases because the University Observatory is 200 feet above sea level.

§11—VISIBILITY ON THE OPEN SEA IN RELATION TO WIND DIRECTION

The relation between visibility over the open sea and the direction of the surface wind is shown in Table XXI, using the observations of the horizon at Madalena Fort and the record of wind at the University in Valletta. The table gives percentage

TABLE XXI—VISIBILITY OF THE HORIZON AT MADALENA FORT, MALTA, IN RELATION TO WIND DIRECTION AT THE UNIVERSITY, VALLETTA, 1924–25 (7h. G.M.T.)

(The table gives percentage frequencies within each quadrant.)

	Horizon from Madalena Fort (altitude 400 feet above M.S.L.)	NE.	SE.	SW.	NW.	
		%	%	%	%	
Summer (April-September)	Invisible	46	52	19	25	
	Fuzzy	54	41	70	63	
	Sharp	nil	7	11	12	
Number of observations . .	. . . .	28	27	27	101	Total 183
		%	%	%	%	
Winter (October-March) . .	Invisible	8	12	13	3	
	Fuzzy	43	41	47	39	
	Sharp	49	47	40	58	
Number of observations . .	. . . .	37	32	45	67	Total 181

frequencies of occurrence of the various conditions of the horizon corresponding with winds in each of the four quadrants.

The lowest visibilities in summer occur when the wind is NE. or SE. ; while in winter the visibility is better than in summer whatever the direction of the wind and reaches its maximum when the wind is NW.

§12—Summary of Results

In conclusion, the results obtained from horizon observations are as follows :—

(i) Mist or fog on the coast of Malta is more frequent in winter than in summer, but tends to disappear by midday.

(ii) The visibility at sea in the neighbourhood of Malta away from the coast is usually better in winter than in summer.

(iii) Visibility over the open sea near Malta exhibits no diurnal variation.

(iv) Diurnal variation of visibility at Malta is due to the presence of mist or fog on the island itself or in its immediate vicinity which disperses during the forenoon.

(v) The vertical thickness of coastal mist or fog in the early morning is of the order 100 or 200 feet and definitely less than 400 feet.

(vi) The distance of visibility over the open sea near Malta in winter may be 30 miles or more.

(vii) When the visibility is good or very good the estimates given by the University are usually lower than those derived from the observations of the horizon.

(viii) Visibility over the open sea reaches a maximum in winter with NW. winds and a minimum in summer with E. winds.

PART III—THE OCCURRENCE OF FOG

At Malta thick fog is infrequent. It is observed at times in the early morning over the island and at other times, chiefly in summer, on the open sea in the form of banks of fog. The frequencies given in Table XXII show how the incidence of mist or fog at 7h. G.M.T. at the Observatory varies according to the direction of the surface wind and the time of year. The frequencies are greatest in winter and least in summer and there is a tendency for mist or fog to be associated with southerly winds in winter and calms in late summer and autumn. But the numbers of occasions are all rather small. In the months of January and February in ten years there

Table XXII—Frequency of Mist or Fog at 7h., G.M.T. at the University, Malta, 1901–12

(The numbers in this table are reduced to a basis of ten years.)

	Direction of surface wind.									
	Calm.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Total
January	1	—	1	—	3	9	3	—	—	17
February	1	1	—	1	5	6	—	3	—	17
March	1	—	3	1	3	1	1	—	—	10
April	1	1	1	5	2	3	—	—	1	14
May	—	1	3	3	2	1	—	2	2	14
June	—	1	2	2	4	—	1	—	3	13
July	2	1	1	2	—	2	1	—	—	9
August	3	—	—	—	3	2	2	—	—	10
September	1	—	1	3	—	3	3	1	—	12
October	4	—	—	—	6	1	1	—	1	13
November	4	1	—	2	1	2	—	—	—	10
December	1	—	—	1	2	1	2	—	—	7
Year	19	6	12	20	31	31	14	6	7	146

were 34 observations of mist and fog, *i.e.*, an average of one observation in 18 days, while in July and August and also in November and December the frequency was about half that figure.

There were 23 examples of thick fog, including banks of fog at sea, during the period September, 1922, to July, 1925. The presence of fog is apparently associated with the juxtaposition of masses of air of different temperatures and humidities: many of the examples indicate that fog may be formed in shallow depressions in the vicinity of a weak cold front (c.f. 6). Other examples, chiefly in summer, occurred in regions of light and indefinite barometric gradients, the fog being then mostly in the form of banks or patches. The following paragraphs contain descriptions or brief notes concerning some of the examples treated in the investigation.

An interesting example of the formation of fog occurred on the 12th of September, 1922, during the forenoon. The sky was clear or nearly so at first and there was Ci-Cu. and A-Cu. during the morning. Banks of fog drifted along from NW. past the mouth of the Marsamuscetto Harbour although the surface wind at Floriana appeared to be still SE. at first. Some St. cloud came up from west at 17h. G.M.T. and the sky was overcast at 18h. with cloud at 5000 or 6000 feet. The wind changed from light SE. at 7h. to light NW. at 13h., freshening in the evening and becoming squally and continuing NW. all night. The relative humidity changed from 87 per cent at 7h. on the 12th to 68 per cent at 7h. on the 13th with a corresponding fall in temperature from 78° F. to 73° F.; while the barometer which was unsteady on the 12th had risen 4 mb. during this interval. On the morning of the 13th there was excellent visibility with clear sky and rather rough sea.

The synoptic chart showed that there was high pressure over Spain (1020 mb.) and also over Crete (1016 mb.). Shallow depressions were present over the Tyrol

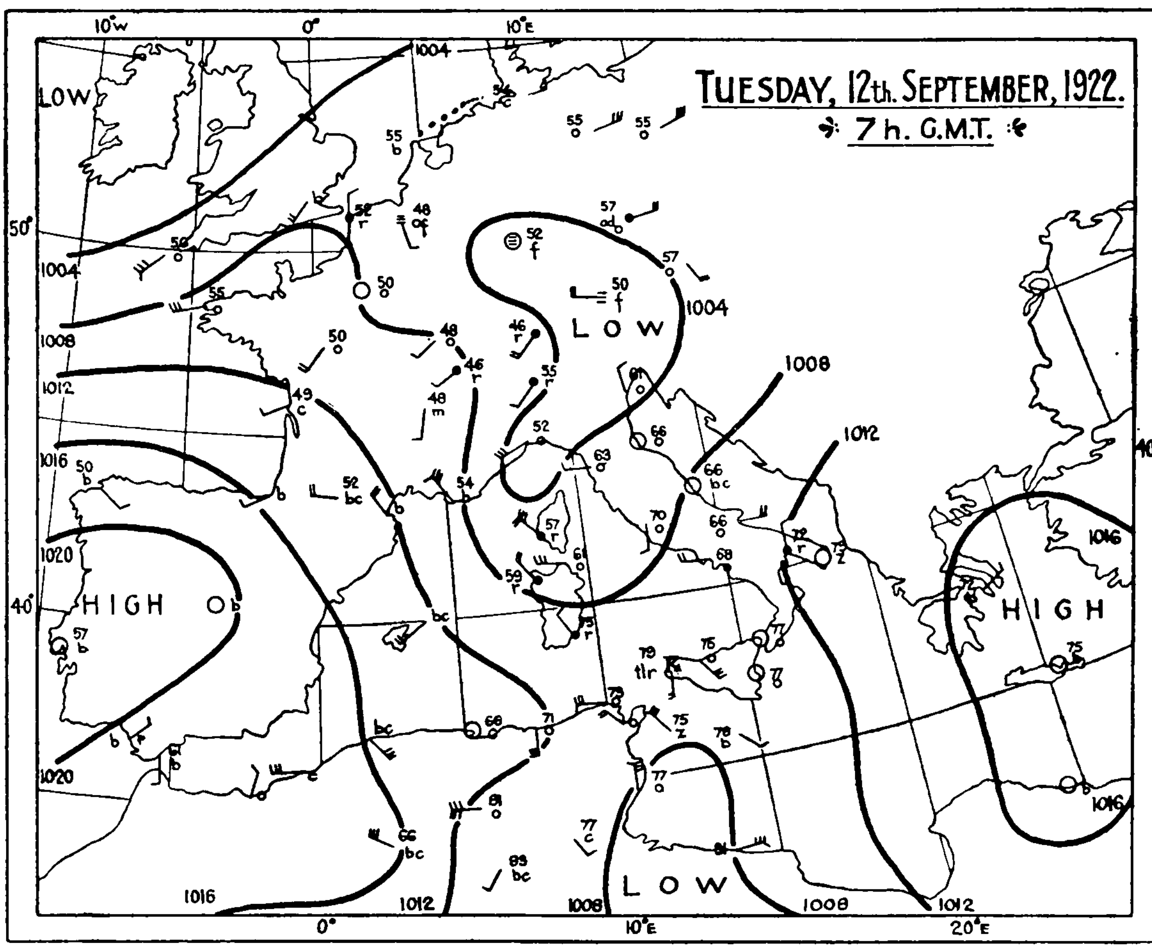

FIG. 2.

(1003 mb.) and Tripoli (1008 mb.) with a shallow trough of low pressure over the Tyrrhenian Sea. A cold front was indicated moving from west across the central Mediterranean towards Sicily and Malta.

The banks of fog observed at Malta on this occasion were associated with the passage of a cold front which had already passed Pantelleria at 7h. G.M.T. The cold front was probably in the form of a shallow wedge of cold air moving eastwards with descent of cold air taking place down its sloping surface. Two pilot-balloon ascents in the forenoon, by the method of the single theodolite, each gave abnormally high velocities of wind, suggesting the presence of descending currents which had diminished the upward velocity of the balloons and so vitiated the results of the computation. In the evening according to pilot-balloon and cloud evidence the depth of cold air over Malta had increased to 5000 feet. The high midday temperature of 85° F. on the 12th is attributable to overlying warm air, the surface layer of cold air being shallow and virtually obliterated at first by convection. The midday temperature on the following day with a depth of cold air exceeding 5000 feet was only 76° F. Similarly the increase in the surface NW. wind by convection within the cold air was not effective until the evening of the 12th and the marked improvement in the visibility was likewise delayed, the visibility remaining poor or moderate so long as convection in the cold air was restricted to a shallow surface layer, or alternatively until the rise in barometric pressure had become effective. The unsteady barometer on the 12th is additional evidence for the presence of the inversion implied in the supposition of a shallow cold front (6.) The synoptic situation is shown in Fig. 2.

Another example occurred on the 15th of September, 1922. There was thick fog at Malta in the early morning followed later in the day by A-Cu. and A-St. and in the evening some rolls of St-Cu. which came up from SW. and W. The wind blew light E. at 7h., changed to W. in the evening and freshened from NW. during the night. The barometer was unsteady during the evening. The next day showed a fall in temperature and relative humidity and very good visibility. Pressure was high to the west of Spain but the gradients of pressure were slight and indefinite near Malta. The fog at Malta again appears to be associated with an advancing cold front. It seems that when a cold front is as far south as the latitude of Malta the cold air penetrates under the warm air in a very shallow layer giving rise to a surface inversion favourable for the formation of fog at night.

Some banks of fog occurred at Malta during the morning of the 9th of October, 1922. They appeared to be associated with a discontinuity between winds from SE. and winds from SSW. representing the warm sector of a depression, an unsteady barometer again suggesting the existence of an inversion of temperature aloft. By 13h. of the 10th cool dry NW. winds had arrived and the visibility became very good. There were shallow depressions over Italy and North Africa and high pressure over Crete.

Another good example occurred on the 28th of February, 1924, when thick fog was observed in the early morning. The sequence of weather at Malta was as follows: Light southerly winds prevailed on the 26th with good visibility; and there was Ci-St. at 7h. which increased and thickened to A-St. in the evening when the sky was overcast and the wind freshened. The sky cleared at night. Next day (27th) there were light winds from SE. and the weather was warm and damp, the temperature at 7h. showing a rise of 5° F. over the previous day. The sky was clear but the atmosphere hazy. There was fog in the early morning of the 28th which intensified after 7h. before clearing away finally in the early forenoon. The air was still hazy after the fog and the sky became overcast with St. and Cu. but cleared again later as the wind freshened from W. The visibility improved fairly rapidly in the afternoon and small cumuli formed about 15h. G.M.T. During the night there were squally NW. winds and heavy showers.

The synoptic chart showed a region of high pressure to the west of Ireland (1027 mb.) and west of Spain (1024 mb.) and high pressure over the Black Sea and Syria (1024 mb.). There was a depression over Malta (1000 mb.).

The sequence of weather on the 26th indicated the approach of a warm front which had arrived at the surface on the 27th and was not yet occluded. The fog of of the 28th appears to have formed within the area of the warm sector since there were strong SW. winds above it. A cold front arrived at Malta later in the day (28th). Like the preceding cases it seems to have been in the form of a shallow wedge of cold air which may even have arrived already at the time of the fog as a thin surface layer, thus giving the necessary inversion. When the depth of cold air had become greater some small cumuli formed at 15h. G.M.T. The cold air behind the front came from Russia and the Balkans. The visibility on the morning of the 29th was only moderately good.

An interesting example of fog bank resembling the summer type occurred on the 3rd of May, 1924. There were NE. winds during the morning which changed temporarily to S. at midday when a bank of fog was observed over the sea to the north and north-east of Malta. The sky was clear apart from traces of St-Cu. and Ci. in the evening and the visibility was generally good. The change of wind to S. was accompanied by a marked fall in relative humidity and a decrease in the rate at which the temperature was rising. The bank of fog thus appeared to lie on the boundary between a mass of dry air from S. and damper air from NE. A small anticyclone over Sicily and Malta moved eastwards during the day.

The remaining examples will be only briefly indicated. In eight cases there were banks or patches of fog in the vicinity of Malta which occurred chiefly in regions of light gradients of pressure but two of these examples were assignable to feeble cold fronts. Nine other examples occurred in which there was thick fog at Malta in the early morning or evening (two cases) and of these examples three were assigned to feeble cold fronts, three to a change of wind and the remainder to light indefinite gradients of pressure. Another example in which there was haziness out at sea like fog was also assigned to a feeble cold front.

PART IV—EXCEPTIONAL VISIBILITY

A cursory analysis was made in which the wind at Malta and the distribution of pressure in Europe and the Mediterranean were examined in relation to exceptional visibility at Malta. During a period of $2\frac{1}{2}$ years (1922–25) several examples of excellent visibility were found to occur in autumn when the wind was moderate or strong in force from NW., while other examples occurred when the air over Malta was considered to be " polar " in type or when the air was very dry. There was one example in winter in which exceptional visibility was associated with towering cumulus just before the passage of a vigorous cold front (c.f. structure of cold front given by M. A. Giblett, 25). With regard to distribution of pressure it was found that a depression over Italy or the western Mediterranean or a trough of low pressure over northern Italy may be accompanied by exceptional visibility at Malta ; and also a col formation of pressure over Malta.

PART V—MISCELLANEOUS EXAMPLES

(1) *19th of June*, 1923.—Cold air associated with a depression over Scandinavia reached Mahon on the 17th and ultimately arrived at Malta during the forenoon of the 19th. The wind freshened from NW. in the surface layers and the observations at 13h. G.M.T. on the 18th and 19th showed a fall in temperature of 3°F. and a decrease in humidity from 73 per cent to 57 per cent. A pilot-balloon ascent at 10h. on the 19th showed that the NW. current was only about 1500–2000 feet deep and indicated a WSW. wind above it with a layer of light winds in between. The visibility at Malta was only moderate with an indefinite haziness and did not improve when the first cold air arrived.

(2) *24th of October*, 1923.—There were light SW. winds at Malta and a clear sky except a small amount of Fr-Cu. over the island. Good visibility prevailed during the day but was preceded by smoke haze in the creeks at sunrise which was blown away seawards as the wind freshened. The local nature of this haze was shown by

observations made by Capt. R. Forbes-Bentley. He states that Mount Etna was visible soon after sunrise from the deck of the mail steamer at a point not far from Malta. Pressure was relatively high in the Mediterranean on this date with light gradients.

There are numerous examples of smoke haze locally in the creeks and Grand Harbour, especially in autumn and winter. In some cases the haze intensifies after sunrise before disappearing. On the 24th of January, 1925, Capt. Forbes-Bentley, who was going by steamer to Gozo, again observed thick haze in the Grand Harbour but reported a clear atmosphere out at sea.

(3) *29th of March*, 1924.—The sky at first contained Ci-Cu. and A-Cu. The wind which was SW. force 2 backed to E. and freshened, the sky meanwhile becoming clear. The wind direction then changed gradually to W. (through S.) with a lull in between which was followed by W. winds equal in force to the E. winds. The barometer fell rapidly and then rose rapidly again, the minimum pressure being 994 mb. Visibility remained good throughout these changes apart from dust derived from the island. The changes of wind and pressure suggest a small revolving storm which had come from North Africa. The next day (30th) it appeared to be near Candia.

A similar small depression occurred in mid-August, 1924, without impairing the visibility except perhaps temporarily on the morning of the 17th.

(4) *6th–10th of May*, 1924.—Excellent visibility was observed at Malta on the 6th accompanied by low relative humidity, clear sky and light variable SE. winds. Mount Etna had been visible from Malta under similar conditions the previous morning (5th). The wind increased at midnight (6th–7th) when the autographic instruments showed a slight rise in temperature and slight fall in relative humidity and there was a fresh SSE. wind the following morning (7th) with much dust which caused considerable deterioration in visibility on the island itself. The following day (8th) the wind changed gradually to NW. between 12h. and 14h. G.M.T. and continued to blow fairly strong from NW. on the 9th. Pilot balloon ascents showed that the NW. winds were confined to the surface layers ; above them at 3000–5000 feet the wind was SW. Meanwhile the visibility was not very good owing to the presence of haze, but it had improved the next day (10th) when the NW. current had deepened. The sky was overcast with high cloud on the 8th and low cloud (St-Cu.) on the 9th with a few drops of rain at 17h. and again with high cloud on the 10th which cleared in the afternoon. A considerable fall in temperature was associated with the NW. winds, the maximum temperatures falling from 83°F. on the 8th to 68° F. on the 9th.

The changes just described were associated with the passage of a small depression eastwards from North Africa. Simultaneously an area of high cloud (Ci.) over North Africa was observed to be advancing eastward and later arrived at Malta. There was an abrupt rise in pressure at 6h. G.M.T. on the 8th and the barometer was unsteady on the 8th and 9th but had not begun to rise continuously till the evening of the 9th.

SUMMARY

A statistical survey extending over five years shows that good visibility at Malta is associated with northerly winds, low relative humidity and high barometric pressure. Other favourable factors are the presence of cumulus cloud or alternatively an almost total absence of cloud. The effect of the force of the wind varies according to the wind direction, but in general the visibility deteriorates if the wind becomes strong, especially in easterly winds ; yet if the wind is NW. and strong the visibility may often be exceptionally good. On summer evenings the visibility at the Observatory in Valletta becomes very good if the wind is from SW. and this is regarded as a föhn effect. Diurnal and seasonal effects are also present and the visibility normally becomes good or very good in the afternoon, especially in autumn. The diurnal effect is due to convection, but it tends to be suppressed if the wind is strong or the sky continuously overcast or if the wind blows from SE.

Observations of the sea horizon at selected points at various altitudes above sea level indicate that the visibility over the open sea undergoes a variation which is seasonal but not diurnal; while the diurnal changes in visibility seawards from Malta are due to the existence of mist or haze in the immediate vicinity of the island. Visibility over the open sea is normally very good in winter with NW. winds and is of the order 30 miles or more.

Thick fog is very rare. It is observed over the island in the early morning and less frequently in the evening and also over the open sea in the form of banks or patches. Its frequency at the Observatory is approximately one observation in 18 days in January and February and about half that figure in July and August. It occurs in shallow depressions near a feeble cold front or in regions of light and indefinite barometric gradients in summer; but in the latter case it is also probably a boundary phenomenon between masses of air of different temperatures and humidities.

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