ΜΕΤΕΩΡΟΛΟΓΙΑ.— **On the Etesians Over the Aegean,** *by C. C. Repapis, C. S. Zerefos, B. Tritakis* *. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Ἠλ. Μαριολοπούλου.

## INTRODUCTION

The Aegean basin extends some 600 km in the north-south direction, with a narrow waist at the latitude of Athens that is less than 200 km wide. The lowest layer of the atmosphere is confined to this channel by the mountains of Greece and Anatolia, which form an effective barrier almost 1 km in height. The north-south channeling of the flow in the surface layers of the atmosphere above the Aegean channel is shown by the prevalence of northerly or southerly winds in the wind roses at all the observing stations within the Aegean (Mariolopoulos, 1938, Katsoulis, 1970).

In Figure 1a are drawn isohypses of the 1 km in height, which form the before mentioned effective barrier in the Aegean channel. In the same figure the plotted arrows correspond to the prevailling wind vector direction at most of the observing stations in the Aegean basin. Perhaps it was this characteristic channeling of the winds in the Aegean that led Aristotle to the mistaken generalization that winds blow predominantly from northerly or southerly directions (Lee, 1962).

In the summer months a vast heat low forms over the valley in central Iraq which, like the heat low in south Asia further to the east, is contained by a high mountain chain to the north. The pressure distribution in July at sea level, covering the area from the longitude of Azores eastward to Iran and bounded by the latitude circles 20° N and 60° N is shown in Figure 2. The analysis was done by using monthly mean

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Revised version of a study by Mantis, Repapis, Zerefos, Tritakis from the Contributions of the Research Center for Atmospheric Physics and Climatology, Academy of Athens, No 1 - 1977, Athens 1977.

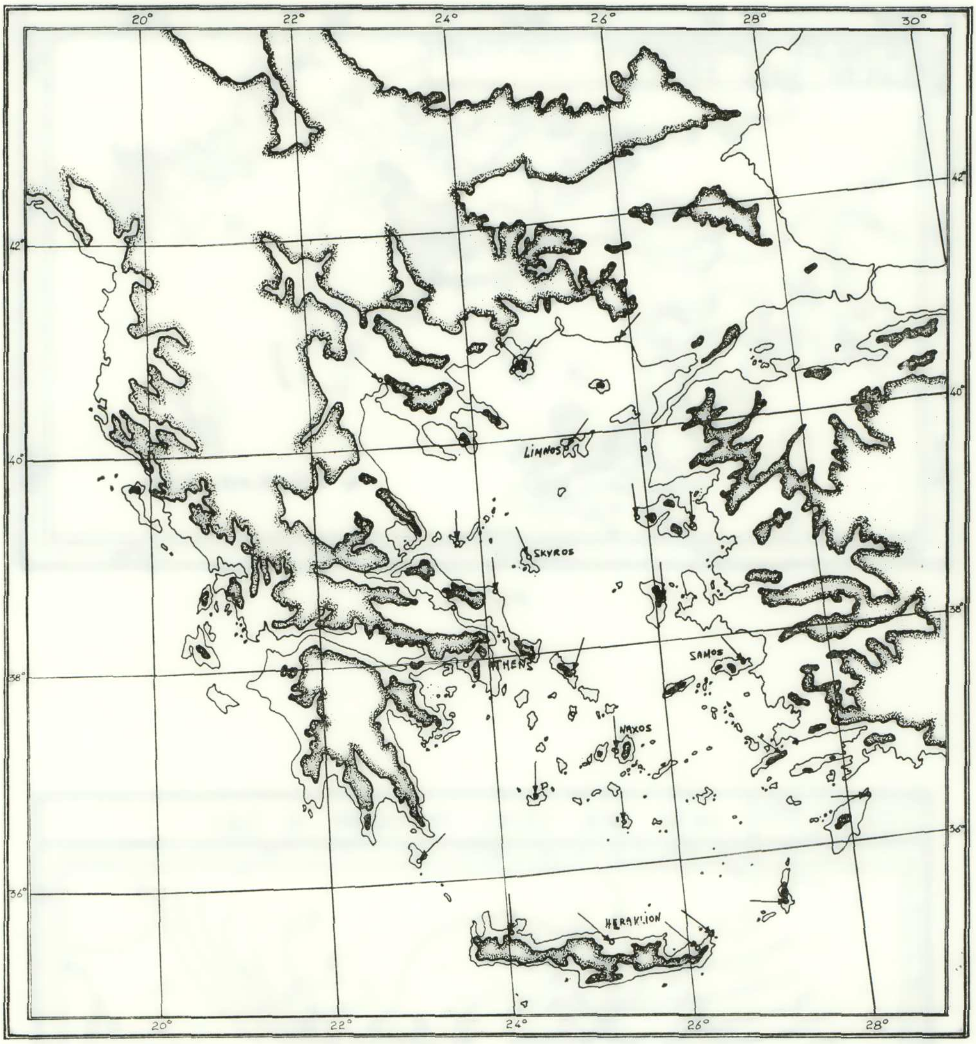


Fig. 1a.

sea level pressure data in the period 1951 - 1960 from all reporting stations at altitudes less than 200 meters published in «World Weather Records».

The pressure distribution at sea level shown in Figure 2 sets up a monsoon-like circulation in the eastern Mediterrenean which in the Aegean, where it is confined to a more restricted channel, results in

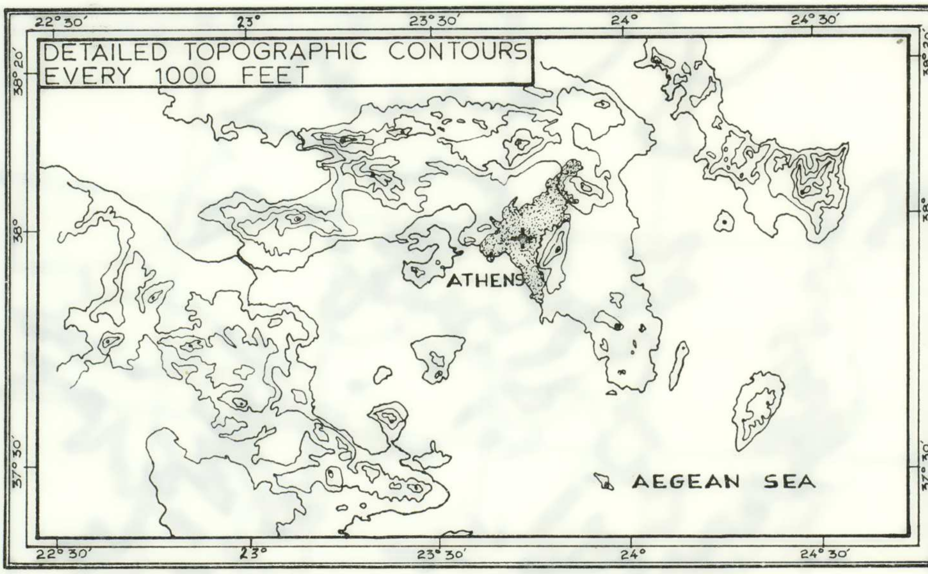
DETAILED TOPOGRAPHIC CONTOURS
EVERY 1000 FEET
ATHENS
AEGEAN SEA
22° 30′
23°
23° 30′
24°
24° 30′
38° 20′
38°
37° 30′

Fig. 1b.

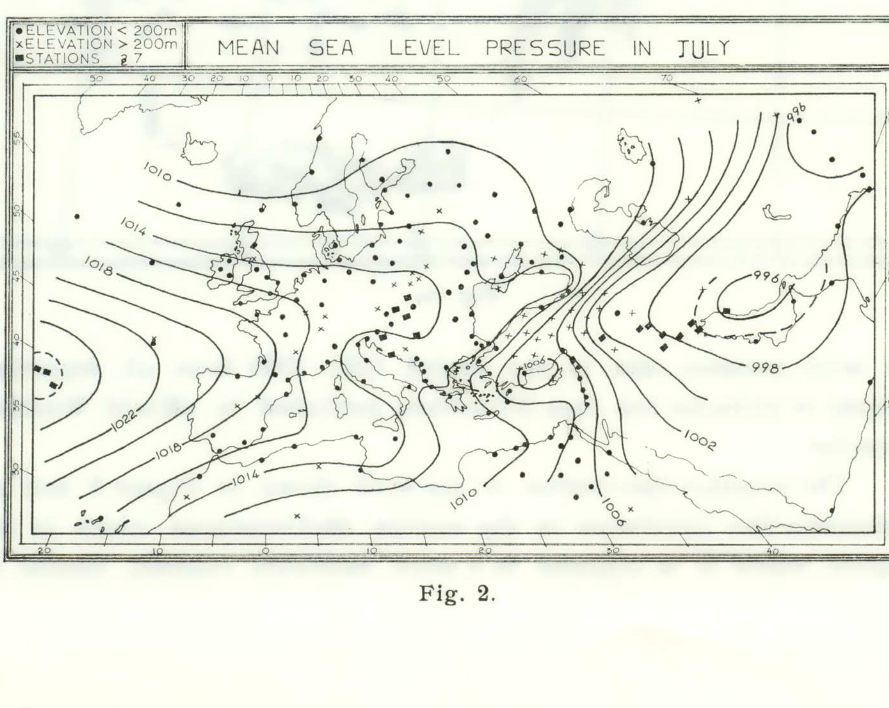
• ELEVATION < 200m
× ELEVATION > 200m
■ STATIONS ≧ 7
MEAN SEA LEVEL PRESSURE IN JULY
1010
1014
1018
1022
1006
1002
998
996
1006

Fig. 2.

a northerly wind that is remarkable for its persistence and intensity. These annually recurring winds were called Etesians [1] by the ancient Greeks (Mariolopoulos, 1972) which in the Greek language is translated as annually recurrent.

A further unusual characteristic of the Etesians in the Aegean, and one which causes some confusion in terminology, are the periods of enhanced Etesians. Within the narrow waist of the Aegean, periods of gale winds ($\geqslant 6$ B) are relatively frequent and when reference is made to the Etesians it is often not clear whether the author intends the term to mean the general monsoon background or whether it is to be used in the more restricted sence to the periods of unusually high north winds. The present study attempts to provide a quantitatively statistical description of the Etesians to clarify the question of the variation of the monsoon background and its relation to the spatial and temporal variation of the conditions of enhanced Etesians.

Data: We have reviewed and compiled data on the Etesians from a number of sources most prominent among these are the studies by Mariolopoulos (1938), Karapiperis (1954), Metaxas (1970) and Katsoulis (1970). The detailed statistical study, however, is limited to the decade (1961 - 1970 and to the wind observations at three Aegean stations namely, Naxos, Skyros and Limnos as well as at Athens observatory by using data tabulations of the National Meteorological Service. Athens itself does not lie within the main Aegean basin but only taps the northerly flow by way of a narrow channel between mount Parnis and mountain complex of Penteli and Hymetos. Athens observatory was considered here not only for its data reliability but for reasons which are to be discussed later in the text.

## VECTOR WIND STATISTICS APPLIED TO SUMMER WINDS IN THE AEGEAN BASIN

The advantage in using vector wind statistics instead of conventional wind roses has been stressed in a series of papers by Crutcher

1. The term «Etesians» comes from the Greek «Etesiae» (Liddel - Scott, Dictionary for Greek Language). Modernizations such as «Etesian» or «Etesian day» e.t.c. are not used in this report.

(1956, 1957) and Crutcher and Baer (1962). In the case of surface winds, their distributions may be quite distorted as to pattern and it is doubtful if a single wind rose would adequately describe the distributions. More specifically as far as the monsoon-type Etesians are concerned, their non-circular distribution is better understood through vector wind statistics which in addition reflect details of the local topography at the stations considered.

In the following a detailed bivariate statistical analysis on the Etesians was restricted, however, to the wind observations at three Aegean island stations (Naxos, Skyros, Limnos) and at Athens observatory. These three islands were selected because of their data reliability and their location in the channel of the Etesians. Athens observatory was considered here to check for previous definition on a «Day of Etesians» at Athens, which, according to Karapiperis (1948) is defined as the day during which northerly winds overwhelm the local sea breeze at Athens observatory (note the north-south channeling imposed by the local topography at Athens in Figure 1b).

Although the statistical analysis on vector winds has been extensively discussed by Crutcher (1956, 1957) for the sake of clarity we briefly summarize here the statistical parameters which are used throughout this report. Thus a set of winds is treated as a set of vectors defined by their orientation and x and y components. Actually air motion is three-dimentional but the vertical wind component is small and for purposes served here it may be ignored. The mean vector wind is represented by $\overline{\mathbf{V}}$ (the bar above a letter denotes an averaging process, while the thick letter means a vector quantity) and the standard vector deviation $\sigma_v$ which is defined as follows:

$$\sigma_v^2 = \left[\frac{\Sigma v^2}{n} - \overline{\mathbf{V}}^2\right]$$

which is analogous to:

$$\sigma^2 = \left[\frac{\Sigma v^2}{n} - \overline{V}^2\right]$$

where $\sigma$ is the conventional standard deviation of wind speeds, n the number of observations, $\Sigma v^2$ the sum of the squares of the speeds and $\overline{V}$ the mean wind speed.

In the event of normal parent distributions of the winds their actual distribution about the mean vector wind may either form the pattern of an ellipse or in its limiting case a circle. The decision on ellipticity or circularity of the wind distribution stands on Mauchly's criterion which determines the ellipticity of the distribution by knowing the standard deviations ($\sigma_x$ and $\sigma_y$) of the wind components ($v_x$ and $v_y$) along the x and y directions as well as the correlation coefficient p between $v_x$ and $v_y$ (Crutcher, 1957). If p equals zero and $\sigma_x^2 = \sigma_y^2$ the distribution is circular; in all other cases the distribution is elliptical. In the case of an elliptical distribution, the angle of rotation $\Psi$ between the coordinates and the ellipse axes is given by the equation:

$$\tan 2\Psi = 2p\sigma_x \sigma_y / (\sigma_x^2 - \sigma_y^2).$$

An important parameter in vector wind statistics is the constancy of the wind represented by q. The constancy is defined by the ratio of the vector mean wind speed ($\overline{\mathbf{V}}$) to the scalar mean wind speed ($\overline{V}$) multiplied by 100. It is evident that the constancy is a measure of persistence in wind direction.

Table 1 summarizes the monthly vector wind statistical results obtained at the three island stations from May through September at 14:00 L. T. i. e. near the time of maximum wind speed.

From Table 1 it appears that non circularity in the wind distribution is evident at all months in all three stations at 14:00 L. T. From July to September, the constancy q reaches remarkably high values and it is interesting to note that q increases with north-south distance as we move from Limnos to Skyros and Naxos. This is an important result because at those high q-values, even a small difference in q is important. Limnos is located at the top and the broader part of the channel and this may explain the relatively lower constancy found at Limnos. The broad scale channeling in the Aegean basin results to an increase in the speed (and constancy) of the Etesians as we move from Limnos to Skyros and Naxos; at Naxos an additional local topographic channeling enhances more the Etesians and this topography is also responsible for the remarkably high q-values at Naxos (see also Fig. 1a).

Table 2 summarizes the vector wind statistical results at Athens observatory. The calculations of Table 2 were based on daily average

TABLE 1

| Station | Month | N$^{O}$ of Observ. | $v_x$ m/s | $v_y$ m/s | $\sigma_x$ m/s | $\sigma_y$ m/s | $\overline{V}$ m/s | $\hat{\vartheta}$ | q ‰ | $\Psi$ | Type of distribution |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NAXOS WMO CODE N$^{r}$ 732 37° 06′ N, 25° 24′ E | May | 301 | 0.16 | 2.01 | 2.32 | 5.58 | 2.02 | 4° | 37 | — 11° | NON CIRC |
| | June | 288 | 0.22 | 3.47 | 2.07 | 4.56 | 3.48 | 4° | 65 | — 10° | » » |
| | July | 300 | 0.03 | 5.58 | 2.89 | 3.61 | 5.58 | 0° | 85 | — 5° | » » |
| | Aug. | 297 | 0.66 | 5.46 | 2.69 | 4.24 | 5.50 | 7° | 83 | — 6° | » » |
| | Sep. | 292 | 0.22 | 5.56 | 2 67 | 4.53 | 5.57 | 2° | 82 | — 6° | » » |
| SKYROS WMO CODE N$^{r}$ 684 38° 54′ N, 24° 33′ E | May | 307 | — 0.70 | 2.23 | 4.00 | 4.51 | 2.34 | 343° | 41 | 20° | NON CIRC |
| | June | 290 | — 0.98 | 3.32 | 3.71 | 3.81 | 3.46 | 344° | 60 | 43° | » » |
| | July | 302 | — 1.99 | 4.94 | 4.12 | 3.32 | 5.32 | 338° | 78 | — 20° | » » |
| | Aug. | 304 | — 1.09 | 4.81 | 3.76 | 3.47 | 4.93 | 347° | 77 | — 34° | » » |
| | Sep. | 290 | 0.10 | 4.97 | 4.21 | 3.70 | 4.97 | 1° | 74 | 13° | » » |
| LIMNOS WMO CODE N$^{r}$ 651 39° 53′ N, 25° 04′ E | May | 302 | — 0.11 | 0.04 | 4.13 | 4.41 | 0.11 | 290° | 2 | — 37° | NON CIRC |
| | June | 290 | — 0.21 | 1.64 | 3.89 | 4.05 | 1.65 | 353° | 31 | — 42° | » » |
| | July | 298 | 1.24 | 3.87 | 4.50 | 4.00 | 4.06 | 18° | 62 | 36° | » » |
| | Aug. | 297 | 1.14 | 4.06 | 4.26 | 3.53 | 4.22 | 16° | 67 | 29° | » » |
| | Sep. | 292 | 1.79 | 3.32 | 4.43 | 3.75 | 3.77 | 28° | 61 | 34° | » » |

TABLE 2

| Station | Month | N° of observ. | $v_x$ m/s | $v_y$ m/s | $\sigma_x$ m/s | $\sigma_y$ m/s | $\overline{V}$ m/s | $\hat{\vartheta}$ | q °/o | Ψ | Type of distribution |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ATHENS WMO CODE Nr 714 37°58'N, 23°43'E | May | 341 | —0.17 | —0.13 | 1.14 | 1.99 | 0.22 | 233° | 12 | —13° | NON CIRC |
| | June | 330 | —0.40 | 0.44 | 1.35 | 2.16 | 0.44 | 355° | 21 | —25° | » |
| | July | 341 | 0.33 | 1.47 | 1.57 | 2.45 | 1.51 | 13° | 55 | —24° | » |
| | Aug. | 341 | 0.35 | 1.54 | 1.55 | 2.59 | 1.58 | 13° | 57 | —21° | » |
| | Sep. | 330 | 0.39 | 1.41 | 1.79 | 2.69 | 1.47 | 15° | 57 | —28° | » |

wind speed and direction, instead of wind observations at 14:00 L.T., because these data were readily available to us.

Figure 3 shows the elliptical wind distributions at all four stations calculated from the data of Tables 1 and 2. The effect of local topog-

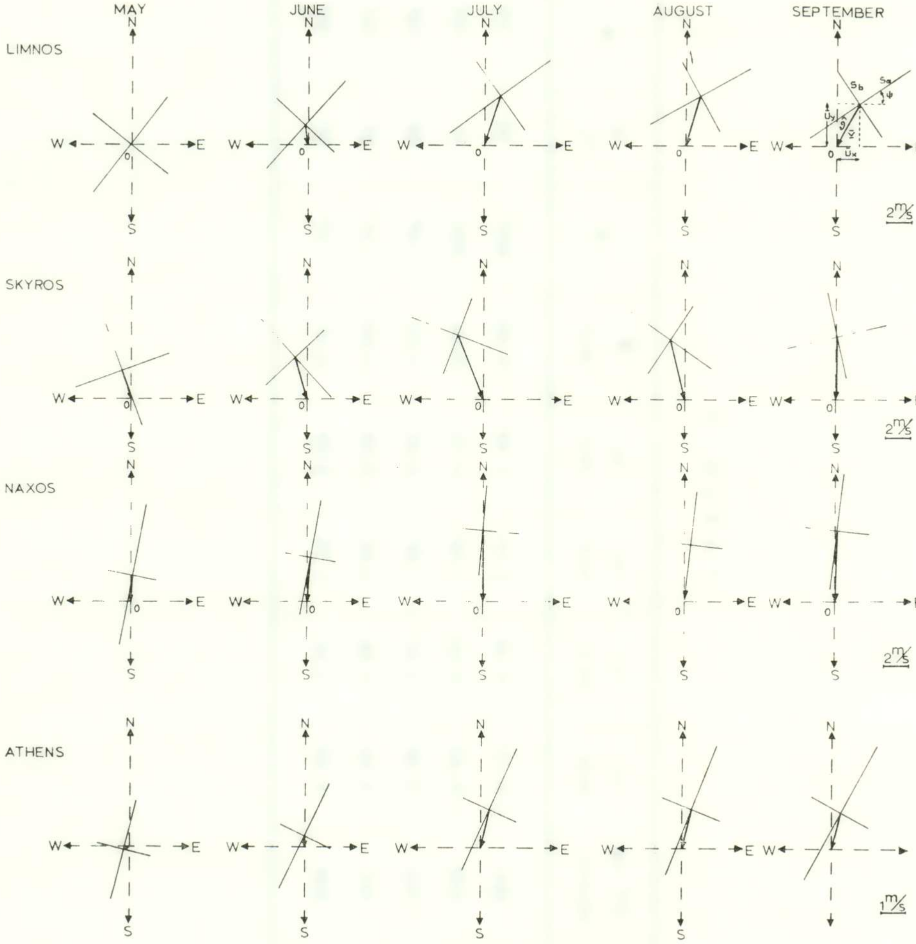


Fig. 3.

raphy on the monthly mean vector wind at Naxos and at Athens can be seen at a glance from the ellipses of Figure 3 which are to be compared with the local channels shown in Figure 1a. At Athens and Naxos, $\sigma_x$ is consistently lower than $\sigma_y$ and the angle of rotation $\Psi$ has at all months the same sign. The local topographic effects on the wind distributions at these two stations are also seen by the alignment between $\overline{\mathbf{V}}$ and the major axis of each ellipse.

Local topographic effects are not clear at Skyros and Limnos where $\sigma_x$ is not so different than $\sigma_y$ and in addition, especially at Skyros, the orientation of the major axes of the ellipses is not consistently the same in all months.

## DIURNAL AND SEASONAL VARIATION OF THE ETESIANS

The calculations of the various vector wind statistics shown in Table 1 (14:00 L.T.) were repeated to include observations at 08:00 L.T. and 20:00 L.T. These results at the three islands in question are plotted altogether in Figure 4 (a) so that we can get a preliminary idea on both the diurnal and seasonal buildup of the Etesians.

From Figure 4 (a) it appears that the seasonal buildup of the north wind component, being rather abrupt from May to July, it remains approximately on the same level from July through September at all hours. However, at the northern edge of the Aegean channel (Limnos) the Etesians start to decline as early as late August (see also Figure 8). Thus, one may expect that local breezes will be more clearly seen when the background of the Etesians is still in the process of development. Indeed this is evident in the months of May and June at Limnos, where the wind direction veers from east at 08:00 L.T. to west at 14:00 L.T. and becomes east again at 20:00 L.T. Such a diurnal change in wind direction may be attributed to a sea breeze effect. This is not, however, the case at Skyros and Naxos where no change in wind direction appears between 08:00 L.T. and 14:00 L.T. in May and June.

After the background of the Etesians is established (July though September) the diurnal variation of the $v_y$ wind component is still evident with maximum values around 14:00 L.T. (Katsoulis, 1970, Metaxas, 1970) and with amplitude of the order of 2 m/s. This can not, however, be attributed to a sea breeze effect (due to the land mass of the island) since the wind direction at 08:00 L.T. and 14:00 L.T. is about the same.

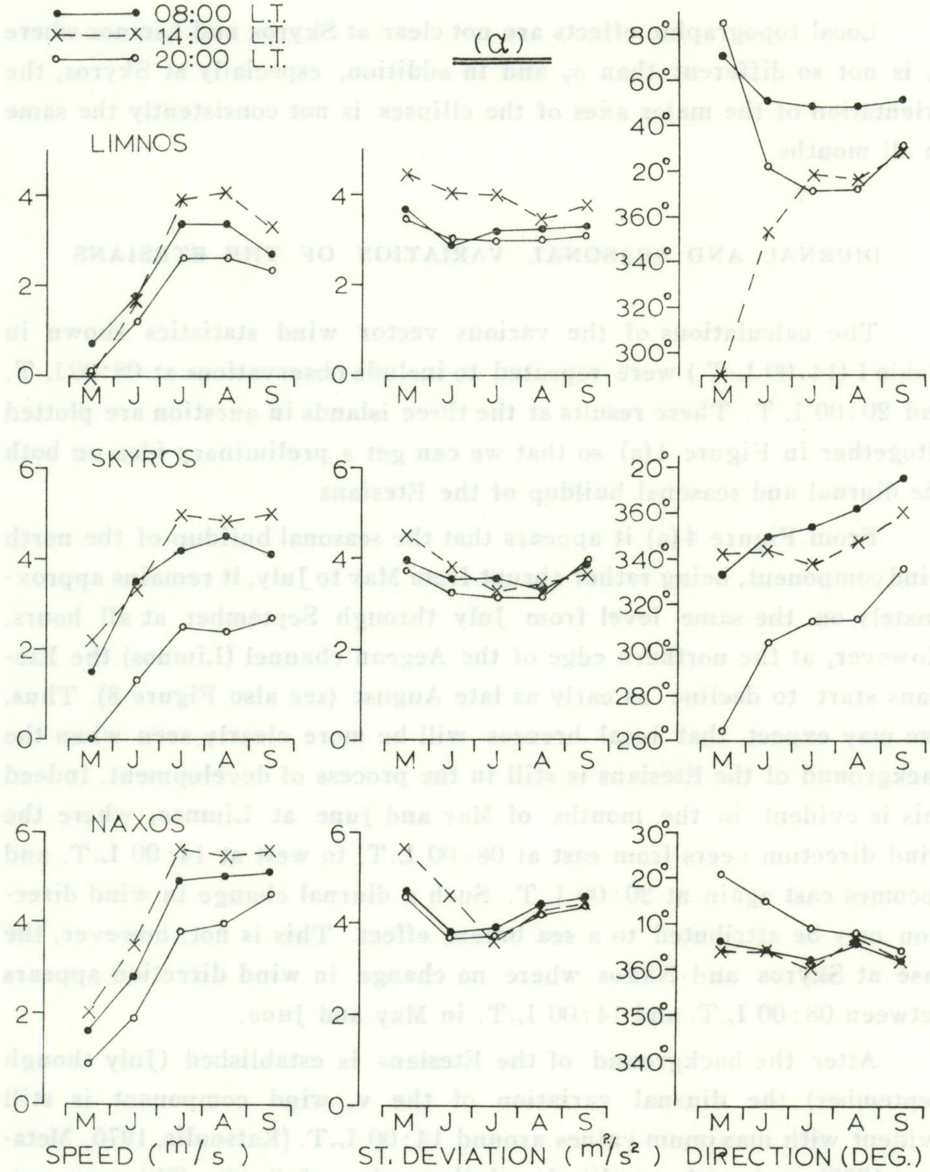
08:00 L.T.
14:00 L.T.
20:00 L.T.
(α)
LIMNOS
SKYROS
NAXOS
M J J A S
SPEED (m/s)
ST. DEVIATION (m/s²)
DIRECTION (DEG.)

Fig. 4a.

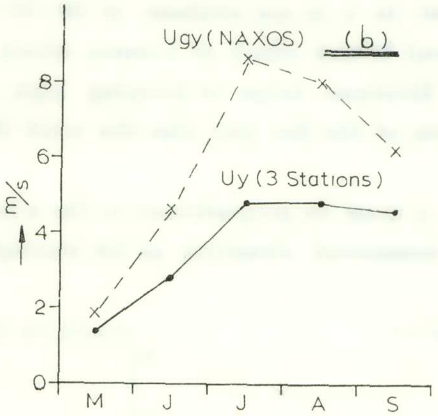


Fig. 4b.

The diurnal and seasonal variation of the mean vector wind ($\overline{\mathbf{V}}$) its direction and constancy at the three islands in question are shown in Figure 5. Evidently the values of q in that Figure display the north-south variation of q versus time. From Figure 5 it appears that over the central and northern Aegean basin there is a pronounced seasonal variation of the Etesians ranging from low values in May to high values from July through September. Another point of interest is the N - S gradient in q clearly seen at 14:00 L.T. and 20:00 L.T.; as mentioned earlier q has lower values at Limnos and maximum values at Naxos of

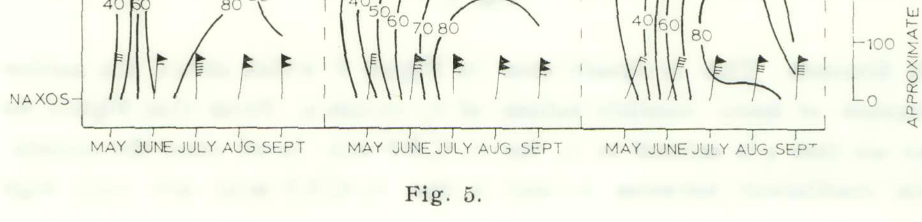


Fig. 5.

comparable magnitude to the constancy in the Trade Wind region. The north-south gradient in q is not evident at 08:00 L.T. because of the already discussed land breeze effect at Limnos which, being in the same direction with the Etesians, helps in keeping high persistence in wind direction at this time of the day (see also the wind direction in May and June in Fig. 5).

By definition, q must be proportional to the wind component which better describes a monsoonal situation as for example $v_y$ in the case of

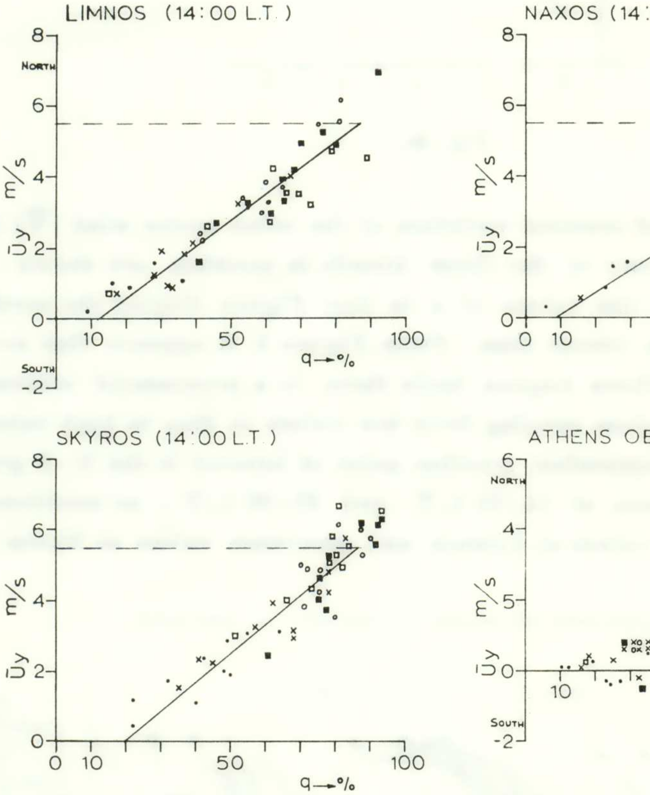


Fig. 6.

the Etesians. This is clearly seen in Figure 6 which shows the scatter diagram of mean monthly values of $v_y$ versus q. From that Figure we can see that q is related to $v_y$ for $v_y \leqslant 5.5$ m/s. In all cases the correlation coefficient between $v_y$ and q (for $v_y \leqslant 5.5$ m/s) are very high

($r = 0.93$) and the least square lines follow approximately the same equation ($q = a + bv_y$, with $9 < a < 19$ and $12 < b < 15$ at all three islands). For mean monthly $v_y$-values greater than 5.5 m/s (very rare at Limnos) q tends to become independent on $v_y$.

From the previous discussion we conclude that the background of the Etesians (see also Fig. 2) strengthens from May through June and is well established from July to September. This monsoon type of circulation results to unusual northerly surface winds which reach maximum speeds in the narrow waist of central Aegean (NNE at Limnos, NNW at Skyros and N at Naxos). An objective measure of the background of the Etesians in the central Aegean may reasonably be the mean geostrophic wind (Vg) calculated, for example, at a central Aegean island. Island Naxos has been chosen to calculate mean monthly values of Vg by using monthly mean sea level pressure data at a triangle of stations surrounding Naxos (Hellinikon airport, Samos island and Herakleion in Crete). The seasonal variation of the geostrophic north wind component at Naxos is shown in Figure 4(b). It may be seen from that Figure that $Vg_y$ or the broadscale average $v_y$ (averaged over Limnos, Skyros and Naxos) both describe fairly well the seasonal buildup of the Etesians and in the following paragraph we shall try to do a number of comparisons between $Vg_y$ and $v_y$ at the different stations under study.

## MONTHLY AND SEASONAL COMPARISONS BETWEEN NORTH WIND COMPONENTS OVER THE AEGEAN IN SUMMER

Table 3 shows the correlation coefficients obtained between north wind components based on monthly values in the decade 1961 - 1970. Two sets of correlations are shown in that Table: one set is obtained by using monthly mean data from May through September (M - S) while the other set is based on data from July through September (J - S). Monthly mean $v_y$-values at Athens observatory were calculated from daily averages. Monthly mean $v_y$ data at the three islands were calculated from wind observations at 14:00 L. T.

All correlation coefficients reported in Table 3 are statistically different from zero at a better than the .01 confidence level. From Table 3 it appears that the seasonal buildup of the Etesians from May to July

TABLE 3

| | Athens | Naxos | Skyros | Limnos | $V_{gy}$ Naxos |
|---|---|---|---|---|---|
| Athens | 1 | 0.80 (M - S)<br>0.60 (J - S) | 0.79 (M - S)<br>0.70 (J - S) | 0.83 (M - S)<br>0.70 (J - S) | 0.83 (M - S)<br>0.69 (J - S) |
| Naxos | | 1 | 0.86 (M - S)<br>0 60 (J - S) | 0.88 (M - S)<br>0.69 (J - S) | 0.88 (M - S)<br>0.65 (J - S) |
| Skyros | | | 1 | 0.89 (M - S)<br>0.82 (J - S) | 0.85 (M - S)<br>0.60 (J - S) |
| Limnos | | | | 1 | 0.88 (M - S)<br>0.71 (J - S) |

is larger than their intraseasonal variation, because (M - S) correlations are higher than corresponding (J - S) correlations. Another point to mention is that a single station at a given month is not going to be as good a measure of the broad scale intensity of the Etesians in that month, since the correlation coefficients between stations (J - S) although statistically significant, they are not all too high. On the other hand, the average $v_y$ at two stations, one located near the top and broader part of the channel (Limnos) the other being located at the center and narrower part of that channel (Naxos) must be considered as representing better the broadscale intensity of the Etesians than one single station. Obviously the same is true if one considers the average $v_y$ at three stations (Limnos, Skyros and Naxos). Table 4 shows the correlation coefficients obtained between the average $v_y$'s at two or three stations and the different north wind components by using monthly mean data from July, August and September.

From Table 4 we see that the correlation coefficients are higher than those shown in Table 3 for the same months (J - S). We see also that the 3-station average $v_y$ is highly correlated with the $v_y$ at each individual station. Monthly averages of $Vg_y$ at Naxos can not explain more than 55% of the total variance of the broadscale background. From the same Table it appears also that $v_y$ averages at any two out of the three islands considered here, explain about 60% of the variance of the

TABLE 4

| | Average north wind components at Naxos and Limnos | Average north wind components at Naxos and Skyros | Average north wind components at 3 island stations |
|---|---|---|---|
| $Vg_y$ in Central Aegean | 0.74 | 0.71 | 0.73 |
| $v_y$ Limnos | | 0.83 | 0.93 |
| $v_y$ Skyros | 0.77 | | 0.88 |
| $v_y$ Naxos | | | 0.86 |
| $v_y$ Athens | | | 0.74 |

north wind component at the third island. Thus, the first tentative conclusion is drawn on the geostrophic wind at Naxos: Monthly $Vg_y$ data in the central Aegean can represent the broadscale background for no more than about 60%.

The statistically significant correlations between $Vg_y$ and $v_y$ at all islands (Table 3) implies that there is an approximate geostrophic balance in the north-south wind components, while there is no such balance in the east-west direction, since all correlation coefficients between $Vg_x$ and $v_x$'s are very low.

## ENHANCED ETESIANS AND THE BACKGROUND WINDS

As mentioned in the introduction an unusual characteristic of the Etesians in the Aegean and one that causes some confusion in terminology are the periods of enhanced Etesians. It is interesting to investigate separately the cases of enhanced Etesians (referred to in the following as gale Etesians) and compare them with the background winds.

In the synoptic nomenclature a wind is classified as gale wind when its force is greater than 6 Beaufort (between 11 m/s and 13 m/s). As a consequence, it seemed reasonable to objectively define at the first place the gale Etesians to be the summer Aegean winds with force greater than 6 B.

During the main period of the Etesians, from July through September, when their broadscale background is well established, the correlation coefficients obtained between the monthly number of gale Etesians at all three islands and the monthly $Vg_y$ - values at Naxos are very low ($r = 0.2$). This indicates that the variance of the background as measured by the $Vg_y$ in the central Aegean, can not explain the variance of the gale Etesians. On the other hand, the monthly number of gales at each island explains a fair percentage of the total variance of $v_y$ at the same island ($r = 0.55$). In view that monthly $v_y$ - values at individual islands are explained by nomore than 50 % of the variations of the broadscale background, one may think that a high portion of the remaining 50 % of the unexplained variance may be attributed to the gale Etesians. Thus, a month with high $v_y$ value is expected to have an appreciable number of gales and vice versa. We should also note that the monthly number of gales at one island does not explain more than 10 % of the variance of gale Etesians at another island, i. e. the monthly number of gale Etesians is more a local phenomenon at each island not necessarily related to sudden enhancements of the broadscale background.

## COMPARISON BETWEEN THE ETESIANS IN THE AEGEAN AND WIND MEASUREMENTS AT ATHENS

Athens basin does not lie within the main Aegean basin but only taps the northerly flow by way of a narrow channel between mount Parnis and mountain complex of Penteli and Hymetos. From the previous discussion we recall that surface winds at Athens observatory are determined by the local topography having a pronounced north-south orientation. As a result, sea breeze is in opposition to the northerly winds at Athens and its development is often strong enough to produce a southerly or a southwesterly wind during the day (Met. Office, 1962). These local features led Karapiperis (1948) to define a day as characteristic of the Etesians as the day during which uninterrupted northerly winds constantly blow at Athens observatory. The observatory is located at a hill (h = 107 m) near the southern-central part of the Athens basin.

Karapiperis compiled a list of dates baptized «Days of Etesians» which fulfilled the before mentioned criterion by using wind records from the Dines anemograph installed at Athens observatory. The number of days in each month, taken from Karapiperis' list will be referred to in the following as parameter « L ». This parameter averaged over the warmer part of the year (May - October) was found to approximatelly parallel, on longer time scales, the course of different solar activity indices (Karapiperis, 1948, Xanthakis, 1976). A question now arises: how good is the correlation between this parameter and the background of the Etesians? Or, wind measurements at Athens are suitable for measurements of the intensity of the Etesians in the Aegean?

From Tables 3 and 4 we can see that $v_y$ at Athens explains about half of the total variance of the Etesians at individual islands and the same percentage of the variance of the broadscale background. As with the islands, (M - S) correlation coefficients between $v_y$ at Athens and the islands are higher than (J - S) correlations, which means that a rather abrupt seasonal buildup from May to July is also evident at Athens.

TABLE 5

| | $v_y$ Athens | $V_{gy}$ | $v_y$ 3 stat. | $v_y$ Naxos | $v_y$ Skyros | $v_y$ Limnos |
|---|---|---|---|---|---|---|
| L | 0.86 | 0.73 | 0 74 | 0.60 | 0.64 | 0.77 |

Table 5 summarizes the correlation coefficients obtained between the parameter L and various north wind components in the Aegean. From Table 5 we conclude that parameter L is also a good predictor of the Etesians explaining about half of the variance of their background. By definition parameter L is expected to be sensitive to the extremes of the background which, however, are not related to the local gales as mentioned in the previous paragraph. It is thus expected that L will not be related to the local gales and indeed this is the case (r = 0.4).

From the above discussion it follows that either one of $v_y$ or L at Athens is a good measure of the Etesians explaining about half of the total variance of their background. This is also true when the above correlations were repeated with mean seasonal (J - S) data, i. e. half of the overall variability of the Etesians from season to season may be represented by wind measurements at Athens.

VARIANCE SPECTRUM ANALYSIS OF THE ETESIANS

Before discussing the power spectra of the north wind components in the Aegean, it is usefull to get first an idea on the total variability of the Etesians at different time scales. Table 6 shows the variance of

TABLE 6

**Total variance ($m^2/s^2$) at 14:00 L. T.**

| | Naxos | Skyros | Limnos | Number of observations |
|---|---|---|---|---|
| Daily values | 17.17 | 12.25 | 14.17 | 920 |
| Monthly values | 1 80 | 1.82 | 1.82 | 30 |
| Seasonal values | 0.98 | 0.59 | 1.16 | 10 |

$v_y$ (in $m^2/s^2$) calculated from July through September by using daily, monthly and seasonal values. As it appears from that Table the day to day variability is very large compared with the variability from month to month or from season to season. Even the variance in the steady months July and August in 1967 ($\sigma^2 \sim 6.25$ $m^2/s^2$) is at least three times the variance from month to month, i. e. most of the day to day wind variance occurs with travelling disturbances. From Table 6 we also conclude that it is difficult to judge a season as being a «high season» of Etesians because in all stations seasonal values vary little (especially at Skyros).

Our next task is to examine the variance contributed by the seasonal buildup of the broadscale background. This is done by comparing the zero lag spectral estimates between power spectra of $v_y$ from May through September and from July through September. For a given year, this difference (denoted as $\Delta s_0$) will be proportional to the intensity of the seasonal buildup of the Etesians.

Figure 7 shows the course of $\Delta s_0$ at Naxos and Limnos during the decade from 1961 to 1970. As it appears from Fig. 7 the variance due to

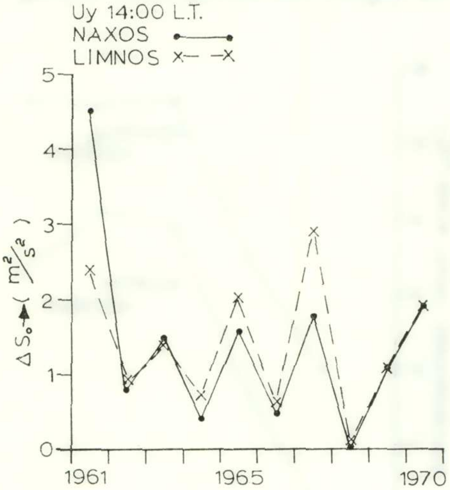


Fig. 7.

the seasonal buildup is approximately the same at both stations, although the shape of the intraseasonal variability from month to month is not so similar at these two stations. Indeed, the intraseasonal change of the background at Naxos or Skyros (central Aegean) can be approximated by an ascending straight line which levels - of by July, while at Limnos (north Aegean) the background starts braking down as early as in late August (see also Figure 8).

The two types of seasonal variation one at the central and narrower part of the Aegean, the other at the top and broader part of the channel shown in Fig. 8 are verified not only by the observations but as well by comparing for each year the value of $\Delta s_0$ with the quantity:

$$\left[\frac{v_J - v_M}{2}\right]^2 \times \frac{10}{24}$$

which is obtained by integrating the variance of two straight lines knowing their mean ($v_J$ and $v_M$ are monthly means of $v_y$ in July and May). One may thus expect that $\Delta s_0$ would fit better the integrated variance of the two straight lines at Naxos than at Limnos. Indeed this is seen by the higher correlation existing between them at Naxos ($r = 0.88$) as compared to their correlation at Limnos ($r = 0.75$).

From the above short outline is follows that the stronger the seasonal buildup is ($\Delta s_0$) the higher the background during the main season of

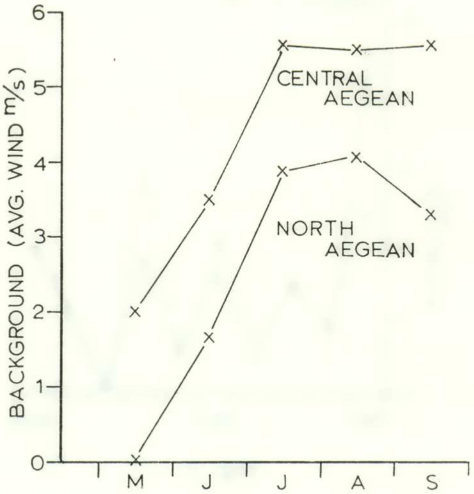


Fig. 8.

Etesians will be. Indeed the correlation between $\Delta s_0$ at Naxos or Limnos is highly correlated with the $Vg_y$ at Naxos ($r = 0.80$). On the other hand, while $\Delta s_0$ explains about 50% of the variance of $v_y$ (J - S) at Naxos, only 20% of the variance of $v_y$ (J - S) at Limnos is explained by the strength of the seasonal buildup, perhaps because of the different patterns of seasonal change at these two stations shown in Fig. 8. Another point to mention is that $\Delta s_0$ at Naxos or Limnos is not related to the seasonal number of gale days (J - S) at these islands ($r < 0.5$).

Returning to Figure 7 we see that the year 1968 have had a negligible seasonal buildup ($\Delta s_0 \sim 0.0\ m^2/s^2$) at both stations. Indeed that year was very peculiar at all stations with minimum values of $v_y$, q, number of gales etc. This does not, however, imply that a year with low or high seasonal buildup of the Etesians will necessarily have extremes in the summer wind statistics. For example, year 1963, having almost average $\Delta s_0$ in that decade, have had high values of $v_y$, q, Nr of gales at both stations.

We now come to compare the total variance $\sigma^2$ in each season (day to day variability from July through September) with some of the previously discussed predictors of the Etesians such as $\Delta s_0$, $Vg_y$, q, etc. As we saw before, the stronger the seasonal buildup is, the stronger the background in July-September will be and the lower the day to day variability since the correlations between $\sigma^2$ and $Vg_y$ or $\Delta s_0$ are negative ($r = -0.60$ and $r = -0.45$ respectively). The higher the background is the higher the persistence in wind direction will be (high q) and the lower the day to day variability from July through September, or in other words the background sets in and it does not fluctuate too much (correlation coefficient between q and $\sigma^2$ is $-0.86$).

All the above correlations were based on Naxos' data. Although the results obtained by using data at Limnos are approximately the same, in general corresponding correlation coefficients are lower at Limnos than at Naxos. Different results are, however, found between $\sigma^2$ and q at Limnos which are uncorrelated implying that persistence in wind direction at Limnos is independent on local short term fluctuations of the north wind component. It is also interesting to note that at Limnos the seasonal number of gale days is highly correlated with $\sigma^2$ in the months July, August and September ($r = 0.70$) which means that half of the wind variance at Limnos is produced by the local gales. This final result is not true at Naxos, perhaps because strong winds are much more frequent at Naxos than at Limnos.

Next the seasonal spectra were calculated, based on daily $v_y$ data at Naxos and Limnos which were used to calculate the average spectrum for each station obtained by averaging the spectral estimates pertaining to the same harmonic. Two kinds of spectra are shown in Fig. 9, one group refers to the months from May through September (histograms) while the other group correspond to the main period of the Etesians from July through September (continuous curves). Individual spectra (not shown here) all show that there are periods with more than one day above normal north wind speeds in the Aegean.

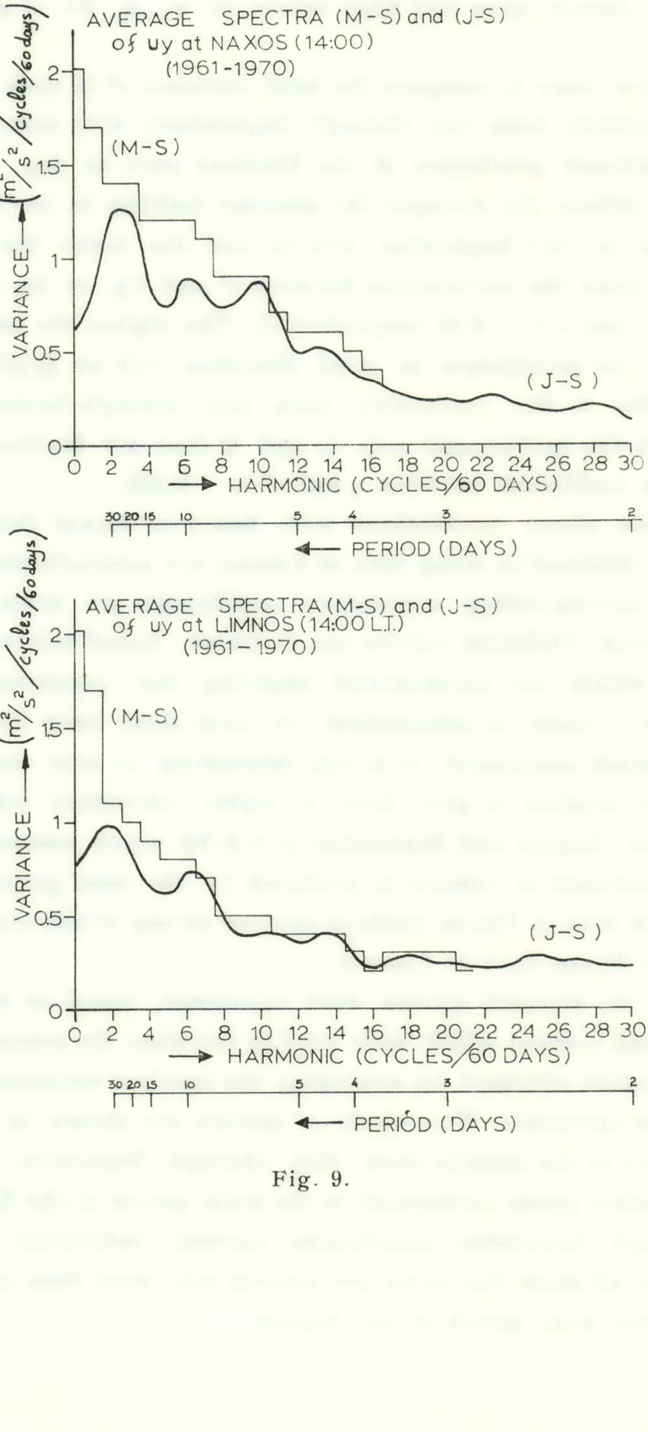
AVERAGE SPECTRA (M-S) and (J-S)
of uy at NAXOS (14:00)
(1961-1970)
(M-S)
(J-S)
VARIANCE → (m²/s² /cycles/60 days)
HARMONIC (CYCLES/60 DAYS)
PERIOD (DAYS)
AVERAGE SPECTRA (M-S) and (J-S)
of uy at LIMNOS (14:00 L.T.)
(1961-1970)
(M-S)
(J-S)
VARIANCE → (m²/s² /cycles/60 days)
HARMONIC (CYCLES/60 DAYS)
PERIOD (DAYS)

Fig. 9.

The comparison of the average spectra at Naxos and Limnos implies that at Naxos, there are more pronounced sequences of enhanced Etesians lasting for three days, than they are at Limnos (6-day period in Naxos' spectrum). In Fig. 9 we can see again the similarity between the average $\Delta s_0$ at the two stations. At the moment we may tentatively conclude that at periods of a few days with above normal Etesians, there is a different pattern of day to day variability over the central and north Aegean.

When looking at individual seasonal spectra we can see that, although they are quite different as to pattern, when suitably grouped they give us some interesting information on the distribution of variance with frequency. Two kinds of groupings were considered here: The first grouping of spectral estimates included the years of above normal Etesians (1961, 1963, 1965 and 1970 at Naxos; 1962, 1963 and 1967 at Limnos). The second grouping of the spectral estimates includes below normal or normal seasons of Etesians (1962, 1964, 1966, 1967 and 1969 at Naxos; 1965, 1966, 1969 and 1970 at Limnos). The year 1968 is studied separately since it has been the weakest year in the decade 1961 - 1970. The before mentioned spectral groupings are shown in Figure 10 with frequency, on a logarithmic scale and the ordinate is spectral density times freqnency, so that equal areas represent equal variance. From the comparison between the spectra in Fig. 10 the following tentative generalizations can be made:

At both stations most of the wind variance is found at periods less than 15 days or in other words, most of the north wind variance is contributed by Etesians blowing at sequences from 2 days up to about one week. Also shown in that Figure is the percentage of the variance (area) contributed by each spectral region. These regions are:

First Spectral Region (Includes sequences of Etesians lasting for less than 3 days): High variability blurred by the noise or the background continuum at both stations. No significant difference in relative variance between high or low seasons.

Second Spectral Region (Includes sequences of Etesians with duration between 3 days and one week): Higher variability at Naxos than at Limnos. Also higher variance in the high season as

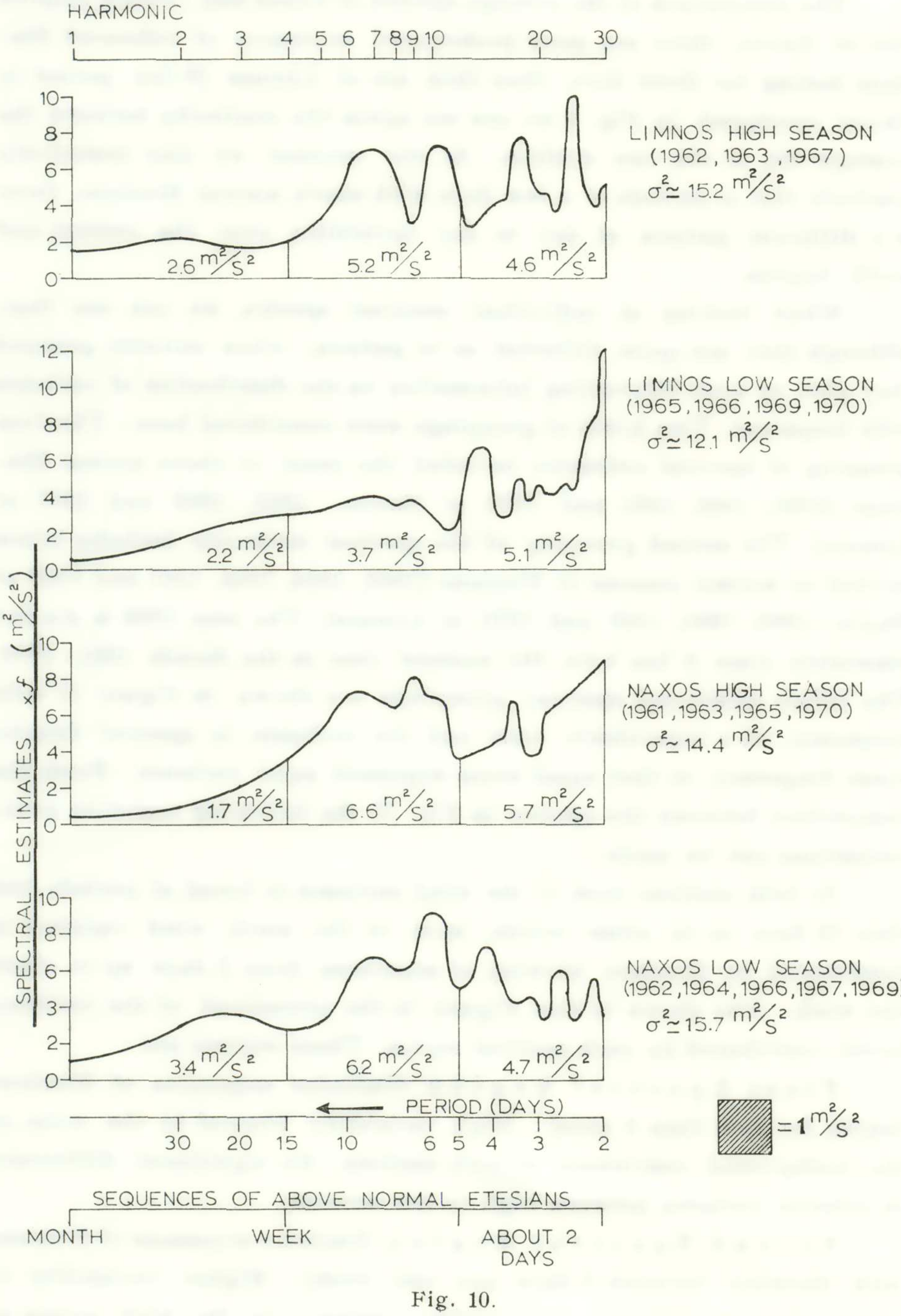
HARMONIC
1 2 3 4 5 6 7 8 9 10 20 30
LIMNOS HIGH SEASON
(1962, 1963, 1967)
σ² ≃ 15.2 m²/s²
2.6 m²/s²
5.2 m²/s²
4.6 m²/s²
LIMNOS LOW SEASON
(1965, 1966, 1969, 1970)
σ² ≃ 12.1 m²/s²
2.2 m²/s²
3.7 m²/s²
5.1 m²/s²
SPECTRAL ESTIMATES ×f (m²/s²)
NAXOS HIGH SEASON
(1961, 1963, 1965, 1970)
σ² ≃ 14.4 m²/s²
1.7 m²/s²
6.6 m²/s²
5.7 m²/s²
NAXOS LOW SEASON
(1962, 1964, 1966, 1967, 1969)
σ² ≃ 15.7 m²/s²
3.4 m²/s²
6.2 m²/s²
4.7 m²/s²
PERIOD (DAYS)
30 20 15 10 6 5 4 3 2
= 1 m²/s²
SEQUENCES OF ABOVE NORMAL ETESIANS
MONTH
WEEK
ABOUT 2 DAYS

Fig. 10.

compared to the variance during a low season of Etesians. At Limnos this difference is much pronounced.

Third Spectral Region (Includes sequences of Etesians lasting between one week and one month : At these long periods, the contribution of the seasonal change is appreciable at Limnos (recall Fig. 8) so there is not so much difference between the high and the low season of Etesians. This is not, however, the casė at Naxos where the high season has very small power at these long periods implying that a high season of Etesians, once established, it does not fluctuate too much. On the other hand a low season of Etesians at Naxos has more power at these long periods.

Some characteristic spectra for three individual seasons are shown in Figure 11. In that Figure continuous lines correspond to the spectra at Naxos and dashed lines to those at Limnos. The years 1963 and 1968 were respectively the highest and the lowest year at both stations in the decade 1961/70, while the year 1962 was selected as being higher at Limnos and lower at Naxos, as compared to the normal.

The «high» season in 1963 has the same gross features to those previously discussed in Fig. 10. It is seen, however, from the high frequency spectral region, that the Etesians blow in a wave packet fashion because their high frequency variance is symmetrically organized at periods less than about 5 days. The low season in 1968 has all typical characteristics of low Etesians discussed in Fig. 10, the only exception being that the noise is extended to relatively longer periods at Naxos. The year 1962 was a high year of Etesians at Limnos, and the spectrum resembles very much to the high season spectrum at Limnos seen in Fig. 10. The same year was below average at Naxos, though not too weak, resembling thus to its corresponding spectrum in Fig. 10, although at each frequency the variance contributed lies between the two extreme values of 1963 and 1968.

From the above discussion we conclude that there are summer storms in the Aegean basin which have longer life times than typical winter storms since, above normal sequences of Etesians are found at a wide range of periods from a few days up to about one week or more. It must be pointed out that there is a tendency in the spectra to be grouped according to the strenght of the seasonal mean statistics of the

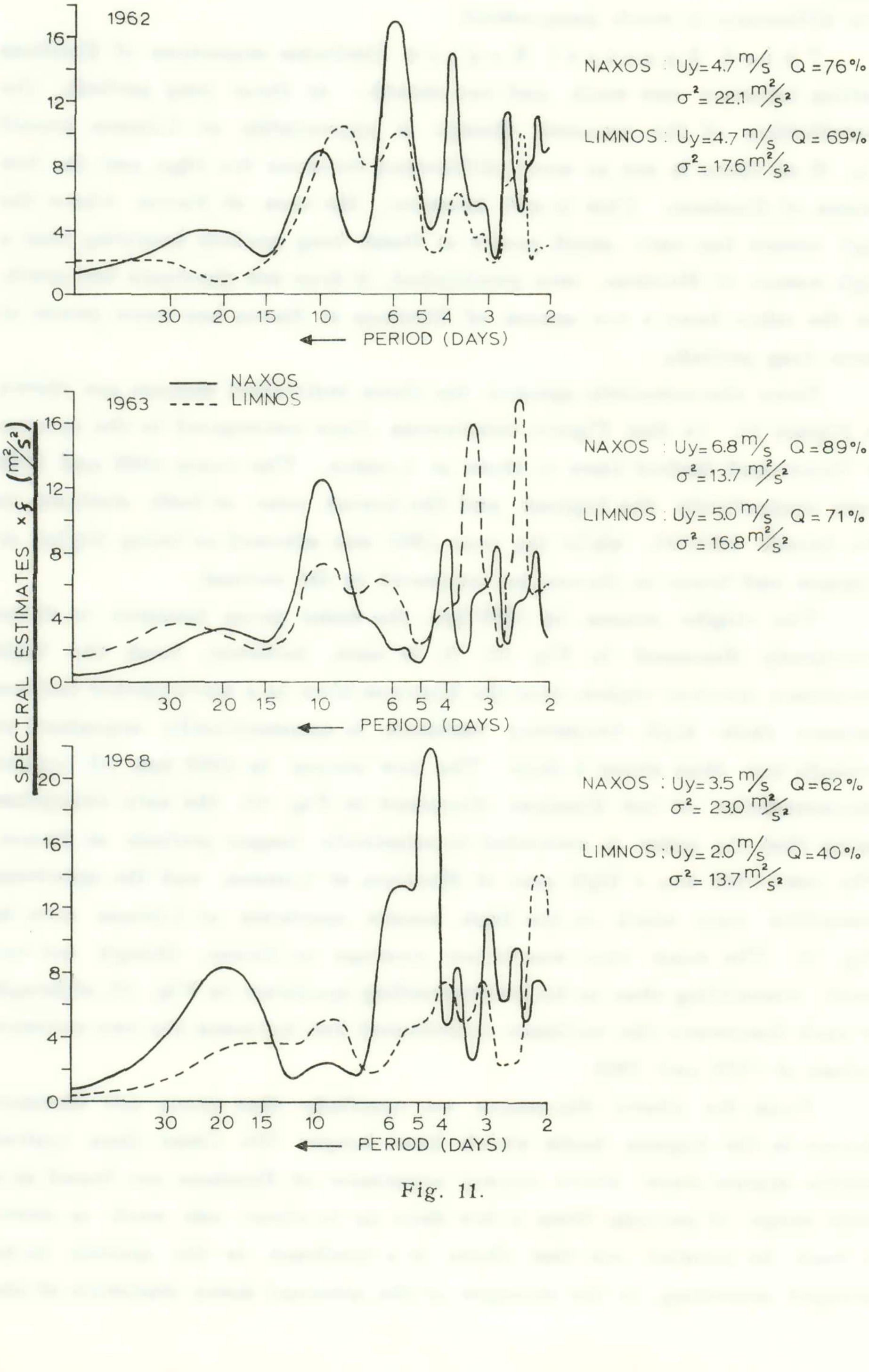
1962
NAXOS : Uy=4.7 m/s Q=76%
σ²=22.1 m²/s²
LIMNOS : Uy=4.7 m/s Q=69%
σ²=17.6 m²/s²
PERIOD (DAYS)
1963
NAXOS
LIMNOS
NAXOS : Uy=6.8 m/s Q=89%
σ²=13.7 m²/s²
LIMNOS : Uy=5.0 m/s Q=71%
σ²=16.8 m²/s²
SPECTRAL ESTIMATES × ς (m²/s²)
1968
NAXOS : Uy=3.5 m/s Q=62%
σ²=23.0 m²/s²
LIMNOS : Uy=2.0 m/s Q=40%
σ²=13.7 m²/s²
PERIOD (DAYS)

Fig. 11.

Etesians, so that each summer is organized by the background and/or the sequences of strong or weak north winds in the Aegean channel.

## BROADSCALE PRESSURE SYSTEMS RELEVANT TO THE ETESIANS

It has long been recognized that in the summer months the prevailling northerly winds over the Aegean are associated with the continental depression over southwest Asia and its extension over Asia Minor and maintained by the relatively high pressures over southern Europe at this time of the year (Mariolopoulos, 1938, Karapiperis, 1954, Met. Office, 1962). Konstantakopoulos (1959) pointed out that the heat low over Iraq, combined with the high pressures prevailling over the northern Balkans in summer play the major role in the seasonal buildup of the Etesians.

More recently, Metaxas (1977) examined the anomalies from the long-term average of the mean monthly pressure field at months of «high» and «low» Etesians, selected, correspondingly, from high or low monthly L-values. We should notice that, as mentioned earlier, parameter L is by definition an index sensitive to the extremes and it approximately explains half of the total variability of the background of the Etesians in the Aegean. Metaxas' analysis showed that at high L-values in July and August, the regions with persistent and statistically significant possitive pressure anomalies are centered over the northern Balkans, while negative pressure anomalies at the surface do not seem to be statistically significant over the valley of Iraq. On the other hand, at low L-values, as was to be expected, negative surface pressure anomalies are found over the northern Balkans and positive surface pressure anomalies (significant in July) are found near the valley in central Iraq. In all cases, high or low L, statistically significant surface pressure anomalies are found over the northeast Atlantic (except for the high Julys).

Although the above analysis throws some light to the identification of certain significant pressure areas at months of high or low L-values, it does not, however, give information on the relation between the major pressure centers seen in Figure 2 with the broadscale background of the Etesians as measured for example by the average $v_y$ at three Aegean stations. This problem can be tentatively and partly investigated in the decade 1961/70 by comparing the background of the northerly flow in the Aegean (average $v_y$ at three stations) with the departures from the mean of the decade of the monthly m. s. l. pressures averaged over two distinct geographical areas, namely, the northern Balkans and the valley in central Iraq. The following low altitude stations (elevation less than 200 m) were considered in these computations which were restricted to the months July, August and September :

N o r t h e r n B a l k a n s : Beograd 44°48′N, 20°28′E), Split (43°31′N, 16°26′E), Zagreb (45°49′N, 15°59′E), Budapest (47°31′N, 19°01′E), Szeged (46°15′N, 20°09′E), and Miskolc (48°08′N, 20°48′E).

V a l l e y o f I r a q : Baghdad (33°20′N, 44°24′E), Kut El Hai (32°10′N, 46°02′E), Najaf (31°59′N, 44°19′E), Nasirya (31°01′N, 46°14′E) and Basrah (30°34′N, 47°47′E).

From the before mentioned correlation analysis it appears that 45% of the total variance of the background of the Etesians is explained by the monthly m. s. l. pressure departures from the mean of the decade 1961/70 averaged over northern Balkans ($r = 0.66$). There is also an appreciable anticorrelation between the background the Etesians and the monthly m. s. l. pressure departures over the valley of Iraq ($r = -0.54$). As it is to be expected higher correlations will exist between background of the Etesians and the pressure differences between northern Balkans and the valley of Iraq. ($\Delta P_{B,I}$). A number of comparisons were tried between $\Delta P_{B,I}$ and different parameters related to the Etesians such as, $Vg_y$ at Naxos, $y_y$ averaged over three stations, the parameter L and the monthly number of gale Etesians at Naxos and Limnos, all shown in Table 7.

From Table 7 we see that the pressure difference between northern Balkans and the valley of Iraq explains a high percentage of the total variance of the broadscale background of the Etesians in the Aegean. This is not true, however, as far as the monthly number of gale Etesians are concerned, the variance of which, can not be explained by the fluctuations from month to month of the broadscale background of the Etesians. Another point to mention is that the above correlations were repeated by using monthly m. s. l. pressures averaged over Azores and they were all found to be statistically insignificant.

TABLE 7

**Correlation coefficients between North Aegean winds and pressure difference between North Balkans and the valley of Iraq ($\Delta P_{B,I}$).**

| Average $v_y$ 3 stations (isles) | $V_{gy}$ at Naxos | L | Gales at Naxos or Limnos |
|---|---|---|---|
| 0.74 | 0.67 | 0.63 | 0.30 |
| Variance Explained % | | | |
| 55 | 45 | 40 | 9 |

Several other correlations were tried between the Etesians and different m. s. l. pressures averaged over high or low surface pressure areas, the more impotant of which are summarized in Figure 12. In that

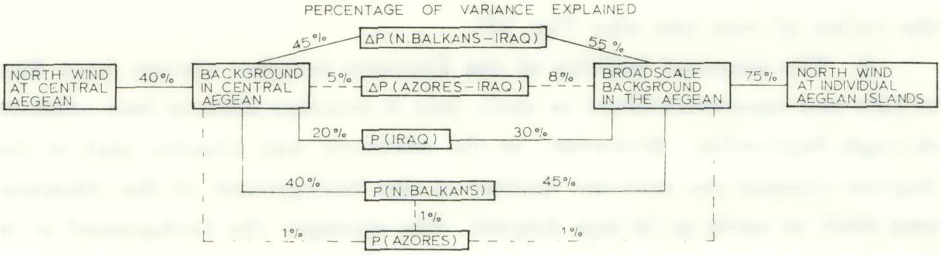


Fig. 12.

Figure numbers correspond to the squares of the correlation coefficients (percentage of the total variance explained in each case). From the previous discussion and Figure 12 which speaks by itself, the following tentative conclusions can be made :

1. Monthly m. s. l. pressures averaged over the northern Balkans (high pressures) or over the valley of Iraq (low pressures) are correlated with monthly values of the broadscale northerly winds in the Aegean.

2. More than half of the total variance of the broadscale background of the Etesians in the Aegean is explained by the pressure difference between northern Balkans and the valley of Iraq.

3. The pressure difference between Azores and the valley of Iraq does not seem to have any influence on the variability from month to month of the broadscale background of the Etesians.

## CONCLUSIONS

The results of the present report may be summarized as follows :

1. There is a north-south channeling of the flow in the surface layers of the atmosphere above the Aegean basin created by the effective barriers of 1 km in height which are formed by the mountains of Greece and Anatolia. In the summer months a vast heat low which is formed over the valley in central Iraq, combined with the high pressures over northern Balkans, sets-up a monsoon-like broadscale circulation which in the Aegean, were it is restricted to a narrower channel, results to northerly winds known as Etesians. More than half of the total variance of the broadscale background of the Etesians in Aegean is explained by fluctuations in the pressure difference between northern Balkans and the valley of Iraq (see also Fig. 12).

2. The seasonal buildup of the Etesians is rather abrupt from May to July and once established in early July it remains more or less constant through September. However, at the northern and broader part of the Aegean channel the seasonal decline of the background of the Etesians may start as early as in late August. The stronger the background is in the central Aegean the more constant it will remain from July through September.

3. Vector wind distributions in summer at individual stations show remarkably well the effect (if any) of the local topography on the surface winds. Vector wind distributions in the summer months over the Aegean are elliptical. There exists a north-south gradient in mean vector wind speed and constancy in the northerly wind components which reach maximum values in the narrow waist over central Aegean (Naxos). For a given month the persistence in the northerly wind direction (constancy) of the Etesians is remarkably high and may reach values as high as 95%. There is a relation between the constancy and the monthly mean wind speed $\bar{v}_y$, for values of $\bar{v}_y$ less than 5.5 m/s. For greater val-

ues the constancy of the Etesians tends to become independent on the mean wind speed.

4. Local sea breeze effects are found at Limnos but not at Skyros or Naxos. The diurnal variation of the north wind components in the Aegean has amplitude of about 2 m/s with maximum values observed around 14:00 L.T.

5. Monthly $Vg_y$ data at Naxos (central Aegean) can represent the broadscale background of the Etesians for no more than about 55%. Also the average of monthly $v_y$ data at three stations, which form a triangle located in the Aegean channel, are better measures of the broadscale background of the Etesians explaining about 75% of the total variance of $v_y$ at individual stations. At all islands there is geostrophic balance only in the north-south direction.

6. On a monthly basis the number of gale Etesians (see text) can not be explained by fluctuations of the broadscale background. These gales, however, explain a good percentage of the total variance of daily $v_y$'s at each station.

7. Wind measurements at Athens are good predictors of the Etesians in the Aegean. Half of the total variability of the Etesians from one season to other may be represented by wind measurements at Athens ($v_y$ or L).

8. The variability of the Etesians from day to day is several times greater than the variability from month to month or from season to season, i.e. most of the day to day wind variance occurs with travelling disturbances. Taking out a season as being a high season of Etesians is a difficult task since in all stations seasonal $v_y$ - values very little.

9. The stronger the abruptness of the seasonal buildup is, the higher the background of the Etesians will be during the coming months July, August and September. The strength of the seasonal buildup $\Delta s_0$ (measured by the difference between the zero-lag estimates of (M - S) and (J - S) spectra) is the same in the north and central Aegean. The more abrupt the seasonal buildup is, the lower the day to day variability of the Etesians will be, as a result of a well established high background.

10. Half of the total variance of daily $v_y$ - values in July through September is explained by the seasonal number of gale Etesians in the northern part of the Aegean. This is not true, however, in the central

and narrower part of the channel perhaps because strong winds are much more frequent there.

11. There are allways periods with more than one day of above normal Etesians in the Aegean. Spectral analysis revealed that there are different patterns of variability over central and north Aegean at periods around 3 days. Most of the variance of daily north wind values is contributed by Etesians blowing at sequences from 2 days up to about one week or more implying that during the summer there are storms in the Aegean with longer life times than typical winter storms.

12. There is a tendency in the spectra of daily $v_y$ - values to be grouped according to the strength of the seasonal vector wind statistics, so that each summer is organized by the background and/or the sequences of strong or weak north winds in the Aegean basin.

ACKNOWLEDGEMENTS

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ΠΕΡΙΛΗΨΙΣ

Κατὰ τοὺς θερινοὺς μῆνας, τὸ δημιουργούμενον ἐκτεταμένον θερμικὸν χαμηλὸν εἰς τὴν κοιλάδα τοῦ Ἰρὰκ συνδυαζόμενον μετὰ τῶν κατὰ τὴν ἐποχὴν ταύτην ἐπικρατουσῶν ὑψηλῶν πιέσεων ὑπὲρ τῶν βορείων Βαλκανικῶν χωρῶν, ἐγκαθιδρύει Μουσσωνικοῦ τύπου ἀτμοσφαιρικὴν κυκλοφορίαν μεγάλης κλίμακος. Ἡ τοιαύτη ἀτμοσφαιρικὴ κυκλοφορία, περιοριζομένη εἰς τὸν ὑπὸ τοῦ ἀναγλύφου δημιουργούμενον δίαυλον τοῦ Αἰγαίου, ἔχει ὡς ἀποτέλεσμα τὴν κατὰ τὸ θέρος ἐγκαθίδρυσιν ἀνέμων ἐκ βορείων διευθύνσεων γνωστῶν ὡς «Ἐτησίων Ἀνέμων» ἀπὸ τῆς ἀρχαιότητος. Ἡ Μουσσωνικὴ αὕτη κυκλοφορία ἡ ὁποία δημιουργεῖ τὸ ὑπόβαθρον τῶν Ἐτησίων, παρουσιάζει ὡς γνωστὸν διακυμάνσεις περὶ τὴν μέσην τιμὴν ταύτης. Εὑρέθη ὅτι πλέον τοῦ ἡμίσεος τῶν διακυμάνσεων τοῦ ὑποβάθρου τῶν Ἐτησίων ἑρμηνεύεται ὑπὸ τῶν ἀντιστοίχων διακυμάνσεων εἰς τὴν διαφορὰν τῆς πιέσεως (ἀνηγμένης εἰς τὴν μέσην στάθμην τῆς θαλάσσης) μεταξὺ τῶν βορείων Βαλκα-

νίων καὶ τῆς κοιλάδος τοῦ Ἰράκ. Ἐπίσης εὑρέθη ὅτι αἱ ἀπὸ μῆνα εἰς μῆνα διακυμάνσεις τῆς ἀτμοσφαιρικῆς πιέσεως ὑπὲρ τὸν ἀντικυκλῶνα τῶν Ἀζορῶν τυγχάνουν ἀσυσχέτιστοι πρὸς τὸ ὑπόβαθρον τῶν Ἐτησίων ἀνέμων.

Εἰς τὴν παροῦσαν μελέτην τὸ ὑπόβαθρον τῶν Ἐτησίων ἐξετιμήθη εἴτε διὰ τοῦ εἰς τὴν νῆσον Νάξον ὑπολογιζομένου Γεωστροφικοῦ ἀνέμου, εἴτε διὰ τῆς μέσης τιμῆς τῆς βορείου συνιστώσης τοῦ ἀνέμου εἰς τὰς νήσους Λῆμνον, Σκῦρον καὶ Νάξον, ἥτις καὶ προσεγγίζει πρὸς τὸ πραγματικὸν ὑπόβαθρον τῶν Ἐτησίων εἰς τὸ Αἰγαῖον.

Ἡ ἐποχικὴ ἀνοικοδόμησις τοῦ ὑποβάθρου τῶν Ἐτησίων γίνεται ἀποτόμως ἀπὸ τοῦ Μαΐου μέχρι τοῦ Ἰουλίου, ἐνῷ ἀπὸ τοῦ Ἰουλίου μέχρι καὶ τοῦ Σεπτεμβρίου τὸ σύστημα τῶν Ἐτησίων παραμένει καλῶς ἐγκαθιδρυμένον. Ἀπὸ τὰ τέλη τοῦ Σεπτεμβρίου ἄρχεται ἡ ἀποικοδόμησις τοῦ ὑποβάθρου τῶν Ἐτησίων, ἡ ὁποία εἰς τὸ βόρειον Αἰγαῖον δυνατὸν νὰ ἀρχίσῃ καὶ ἐνωρίτερον, τ. ἔ. ἤδη ἀπὸ τὸ τέλος Αὐγούστου.

Κατὰ τοὺς μῆνας Ἰούλιον, Αὔγουστον καὶ Σεπτέμβριον, κατὰ τοὺς ὁποίους ὡς ἐλέχθη τὸ σύστημα τῶν Ἐτησίων εἶναι καλῶς ἐγκατεστημένον, οἱ βόρειοι ἄνεμοι εἰς τὸ Αἰγαῖον πνέουν μετὰ ἐκπληκτικῆς ἐμμονῆς ὡς πρὸς τὴν διεύθυνσιν αὐτῶν, ἡ δὲ σταθερότης τῆς διευθύνσεως αὐτῶν δύναται νὰ λάβῃ, εἰς δοθέντα μῆνα, λίαν ὑψηλὰς τιμὰς μέχρι καὶ 95%.

Ἐπίσης εὑρέθη ὅτι αἱ διακυμάνσεις τοῦ κατὰ μῆνα ἀριθμοῦ ἡμερῶν μετὰ σφοδρῶν Ἐτησίων (ἐντάσεως μεγαλυτέρας τῶν 6 B) δὲν εἶναι δυνατὸν νὰ ἑρμηνευθοῦν ἐκ τῶν διακυμάνσεων τοῦ ὑποβάθρου τῶν Ἐτησίων. Παρὰ ταῦτα ἕνα μεγάλο μέρος τῆς ἀπὸ ἡμέρας εἰς ἡμέραν διακυμάνσεως τῆς βορείας συνιστώσης τοῦ ἀνέμου εἰς δοθέντα Σταθμὸν ἑρμηνεύεται ὑπὸ τῶν σφοδρῶν Ἐτησίων. Δεδομένου ὅτι ἡ ἀπὸ ἡμέρας εἰς ἡμέραν διακύμανσις τῆς ἐντάσεως τῶν Ἐτησίων εἶναι ἀρκετὰς φορὰς μεγαλυτέρα τῆς ἀπὸ μῆνα εἰς μῆνα διακυμάνσεως αὐτῆς, συνάγεται ὅτι αἱ βραχείας διαρκείας διακυμάνσεις τῶν Ἐτησίων ὀφείλονται εἰς τὴν διέλευσιν τῶν συνοπτικῶν συστημάτων.

Γενικῶς εὑρέθη ὅτι τὸ μεγαλύτερον ποσοστὸν τῆς διακυμάνσεως τῶν Ἐτησίων δημιουργεῖται ὑπὸ συρμῶν διαδοχικῶν Ἐτησίων πνεόντων ἐπὶ μερικὰς ἡμέρας ἢ καὶ ἐπὶ μίαν ἑβδομάδα, ἀποτέλεσμα τὸ ὁποῖον ὑποδηλοῖ ὅτι τὰ κατὰ τὸ θέρος συνοπτικὰ συστήματα εἰς τὸ Αἰγαῖον ἔχουν μεγαλύτερον χρόνον ζωῆς ἀπὸ ἐκεῖνα κατὰ τὸν χειμῶνα.

Τέλος εἰς τὴν μελέτην ταύτην, ἐρευνῶνται μεταξὺ ἄλλων καὶ ἡ ἐπίδρασις τοῦ ἀναγλύφου ἐπὶ τῆς διευθύνσεως τῶν Ἐτησίων, ἡ ἡμερησία πορεία τόσον τῆς ἐντάσεως ὅσον καὶ τῆς διευθύνσεως αὐτῶν εἰς τὸ Αἰγαῖον, τέλος δὲ ἐπιχειρεῖται μία πρωτότυπος διὰ τὴν ἀνεμολογίαν ἀξιολόγησις τῶν Ἐτησίων διὰ τῆς χρήσεως τῆς φασματικῆς ἀναλύσεως.

Θὰ πρέπει τέλος νὰ σημειωθῇ ὅτι ἕνα μεγάλο μέρος τῶν ὑπολογισμῶν ἐγένετο εἰς τὸ Κέντρον Ἀστρονομίας καὶ Ἐφηρμοσμένων Μαθηματικῶν τῆς Ἀκαδημίας Ἀθηνῶν τὸ ὁποῖον καὶ ἐφιλοξένησεν πρὸ ὀλίγων μηνῶν τοὺς συγγραφεῖς τῆς παρούσης μελέτης.

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