CHAPTER V NATURAL CONDITIONS

5-1 Physical Conditions

5-1-1 Orography

The Black Sea extends in the east-west direction from longitude 28°E to 42°E, a distance of about 1,100km, and in the north-south direction from latitude 41°N to 47°N, a distance of about 650km.

The otherwise simple shape of the sea area is interrupted by the Crimean Peninsula which, from a narrow neck of land near the center of the northern side of the Black Sea, spreads out to form a land area some 180km from north to south and nearly 370km from east to west. A small area of high ground, rising to about 1,000m, occupies the south of the Crimean Peninsula. The eastern tip of the Crimea is separated from the east coast of the Black Sea by a narrow strait - the Kerch' Strait. This links the Sea of Azov, to the north-east, with the rest of the Black Sea. In the south-west, an even narrower strait, the Bosporus, joins the Black Sea to the Sea of Marmara, which in turn is joined to the Mediterranean (or, more correctly, the Aegean) by the Dardanelles.

Several European rivers flow into the north-west of the Black Sea, notably the Danube, the Dniester and the Dnieper, whilst the Don flows into the Sea of Azov in the north-east of the region.

The topography of the land area to the north of the Black Sea differs widely from that to the south and east. To the north there are many miles of level plain, rarely more than 200-300m above sea level. In particular there is the Dnieper plain, which stretches north and north-west as far as the Pripet Marshes of White Russia, and virtually uninterrupted low ground through to the Baltic Sea. There is also the plain of the River Don which extends eastwards from the Sea of Azov and joins the lower Volga basin across to the marshes at the north-west of the Caspian Sea and to the sand desert north of the Caspian. Thus there is no barrier to the direct access of air flowing to the northern part of the Black Sea from the quadrant between north-north-west and east-north-east.

On the southern and eastern sides the Black Sea is bordered by very much higher ground. To the south there is the high plateau of Turkey some 1,500m at its western end rising to over 3,000m towards the east, where there are isolated peaks to nearly 4,000m. To the east there is the north-west to south-east line of the Caucasus mountains, with considerable areas above 3,000m and peaks to over 4,500m. Mount Elbruz, the highest peak in the Caucasus, reaches 5,633m. Between these two major features is a narrow but important break which runs east-south-east from Poti on the east coast of the Black Sea to Tbilisi and on to the Caspian near Baku, with heights nowhere more than about 450m.

The western side of the Black Sea has as its main feature the great Danube basin, extending westwards (from its marshy delta in the neighborhood of Sulina) between the Transylvanian Alps and the mountain ranges of Yugoslavia and Bulgaria, and then beyond the narrows of the Iron Gate north-westwards to the Hungarian plain, beyond which it is finally shut in by the Austrian Alps and the high ground of Czechoslovakia (Carpathians). There is thus no real break in the high-ground barrier which protects the Black Sea from air flowing eastwards and south-eastwards from western Europe.

The high ground which protects the Black Sea from the south terminates in the south-west, where the Sea of Marmara and its surrounding low ground give air flowing north-eastwards from the Mediterranean and Aegean Seas as a direct access to the Black Sea.

The depth of the Black Sea is over 1,800m in its central portion, but north-west of an approximate line from Varna to Sevastopol', and in the Sea of Azov, the depth nowhere exceeds 180m. The greatest depth of the Sea of Marmara is about 1,200m but at most places the depth is less than 800m.

5-1-2 Air Mass

Turkey is halfway between the Equator and the North Pole, and therefore affected by all of the major air masses. Some of these, however, continuously affect the country both in winter and summer.

The Mediterranean, the biggest inland sea in the world, is a secondary cyclogenesis area for air masses. Since Turkey is a Mediterranean country, the sea affects all of the air masses directly or indirectly. Air masses influencing the Mediterranean affect Turkey at the same time.

Generally, Turkey is affected by two distinct types of air masses, one generated in the Mediterranean and the other passing over the Mediterranean depending upon the season. Air masses that pass over the Mediterranean undergo some changes, both thermic and dynamic. These air masses are polar (P) and tropical (T). Sometimes, Ma (Maritime arctic) air reaches and settles over Turkey. But Ma losses its main characteristics because it is affected by land, gains heat and reduces its humidity.

Besides these air masses, Turkey is mainly affected by the polar air mass in winter and by the tropical air mass in summer. Because of these air masses, the temperature differences between winter and summer are extreme.

Air masses affecting Turkey depend upon the time and changing characteristics.

(1) Continental Polar (cP) air mass

In winter, the origin of this air mass is Russia. Especially in winter, when an anticyclone settles on north Russia and Finland, it affects main parts of Europe. Sometimes it reaches Britain and the Mediterranean as well.

c	:	Continental	A	:	Arctic	T	:	Tropical
m	:	Maritime	P	:	Polar	E	:	Equatorial

In its origin, the cP air mass is dry, cold and clear (cloudless air). It meets arctic air and thereby defines a Siberian Frontal System. When it moves to the south, it gains heat and humidity and wind gusts and turbulence grow in intensity. Cumulus clouds and light snow can be observed. During the daytime, the amount of cloud increases but the sky is clear and cold at night. When it affects Turkey severely, its effect is known as a "cold wave".

When it moves onto the Mediterranean, receiving heat from the sea surface and becoming unstable, Cu and Cb clouds are generated. As a result of these developments, continuous rain and heavy showers take place. Sometimes, the cP air mass joins the cT and mT air masses and generates Mediterranean Depressions.

In summer, cP passes the northern part of the North Hemisphere and reduces the impacts over Turkey. As a whole, both the Mediterranean and Turkey are affected by mT and cT.

(2) Maritime Polar (mP) air mass

In winter, cP is generated in North America and passes the Atlantic Ocean and after undergoing transformations it enters Europe from the NW direction. This is called mP air mass. Moving to the south, the mP air mass receives heat and humidity, gains height as a result of orography and becomes unstable and, in consequence, squalls and showers are produced in Europe. Unless an Asor Anticyclone affects Europe, mP moves to the Mediterranean and generates small scale cyclone systems.

mP cools and becomes stable over the land, and when it passes over the seas, it gains humidity and becomes unstable. Generally, it is unstable and causes showers over Turkey.

To be a secondary tract, mP meets with Asor High Pressure and becomes stable. The visibility decreases because of St and Sc clouds.

In summer, it is stable over seas but unstable over the land and therefore a limited convective showers can be seen.

(3) Continental Tropical (cT) air mass

In winter, the main source areas are North Africa and Sahara Deserts. In these sources, the weather is hot, dry and stable. Moving to the north, cT meets mT, gains humidity, and becomes unstable. Sometimes, cT is responsible for a frontal system, cyclones, cyclonic storms and rainshowers.

In summer, all pressure belts move to the north, and cT has a big area in the south. North Africa, Anatolia, Asia and Southern Balkan become the main sources for cT. The source regions are dry, hot and so unstable. In summer, Turkey is mostly affected by this air mass.

(4) Maritime Tropical (mT) air mass

In winter, the source regions are the North Atlantic Ocean and the tropical areas which lie between 30 - 40^{o} latitudes. Under the effects of the Asor Anticyclone mT has its own characteristics. This air mass affects Europe and Turkey thoroughly. It supports cyclogenesis over the Atlantic Ocean.

In summer, mT has a larger area than in winter, and becomes related with cT. Polar fronts go to the north and produce aridity and cool northerly winds in Turkey.

Air masses affecting Turkey and major cyclone tracks are shown in Figs 5-1-1 and 2, respectively.

5-1-3 Weather Types

(1) General

Weather types in the Black Sea region are described both in winter and in summer.

The types are largely classified as to the air masses or the types of synoptic situation.

These synoptic maps were only available for 1200 GMT, that is, about 1400 h local time. Temperatures quoted for the various regions under each type are therefore afternoon temperatures, very nearly the day-time maxima.

A rough guide to the frequency of occurrence of each of these types is given immediately after the heading.

(2) Winter: Northerly type (N(W) type. Approximate frequency in January 11 per cent)

When an anticyclone is centred over the British Isles or Scandinavia, maritime polar air may penetrate to the Black Sea region as an almost direct northerly stream from the Baltic, on the westward side of a depression over European Russia and behind the section of the polar front (cold front or occlusion) which has reached the south of the Black Sea region (Fig. A 5-1-1).

General weather conditions. This type of situation, in which maritime polar (Baltic) air flows across the Black Sea from the north, is established by the southward movement of a section of the polar front across the Black Sea. The polar front is usually active as it crosses the

Fig. 5-1-1(a) Air-masses affecting Turkey in Summer

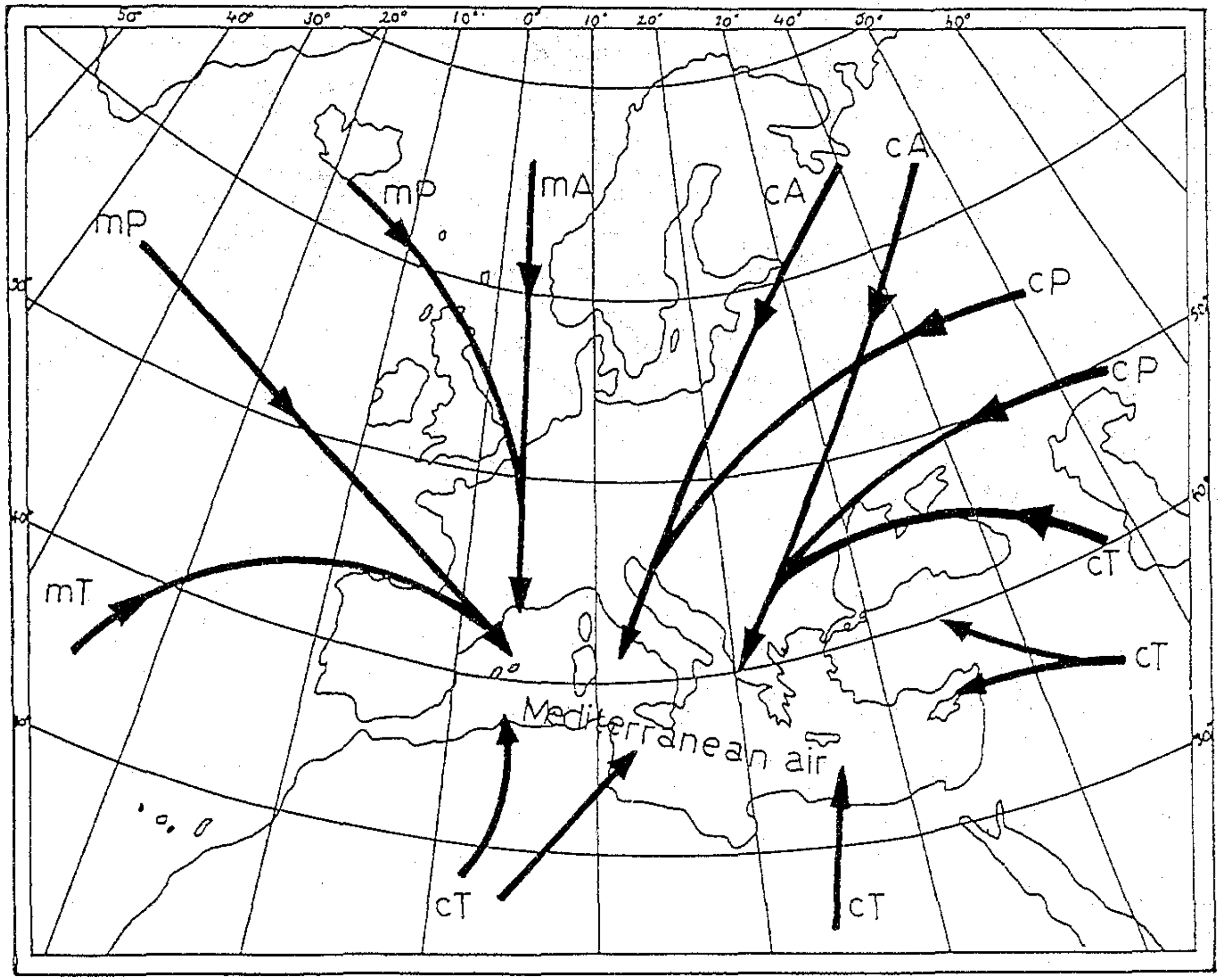


Fig. 5-1-1(b) Air-masses affecting Turkey in Winter

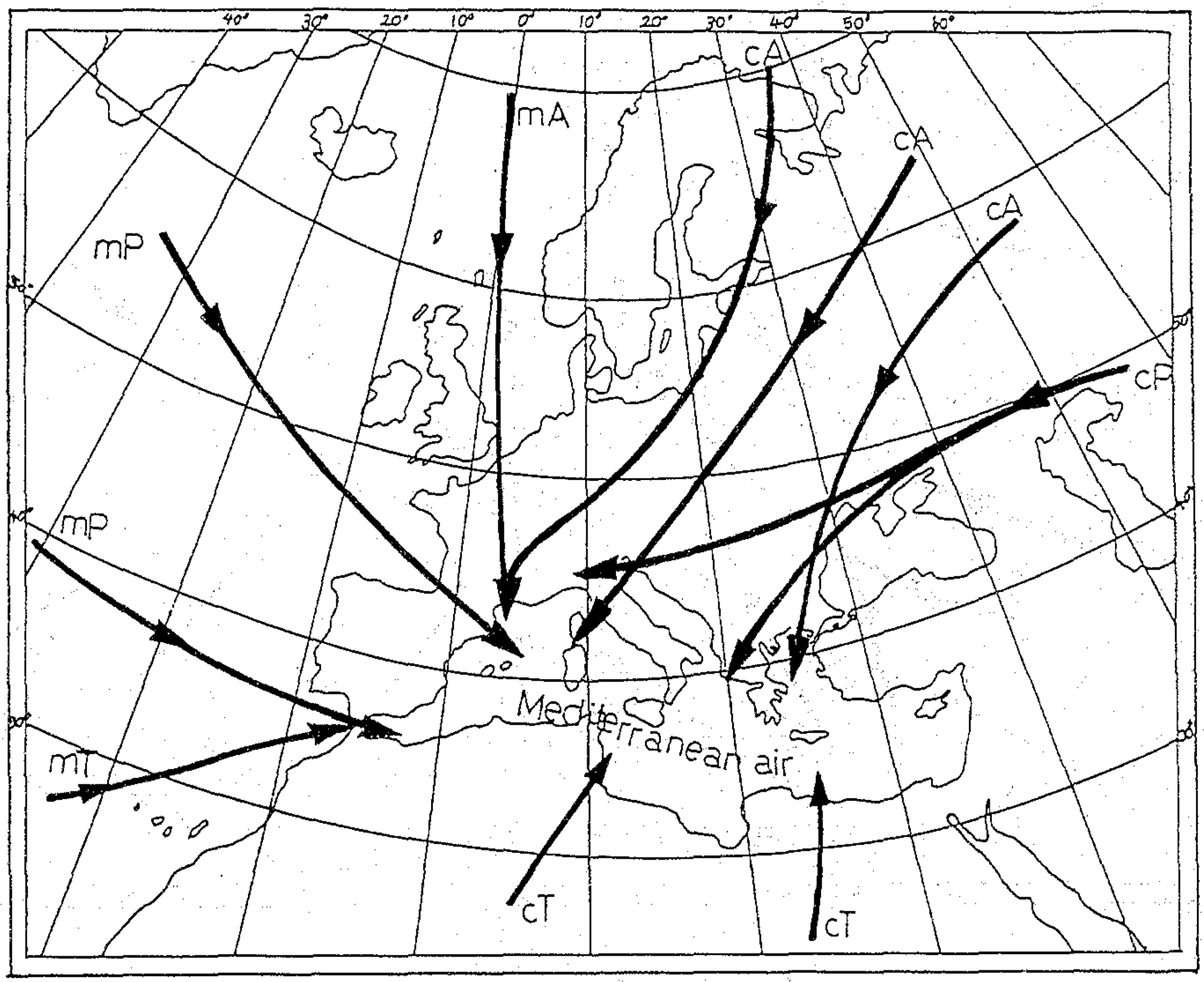
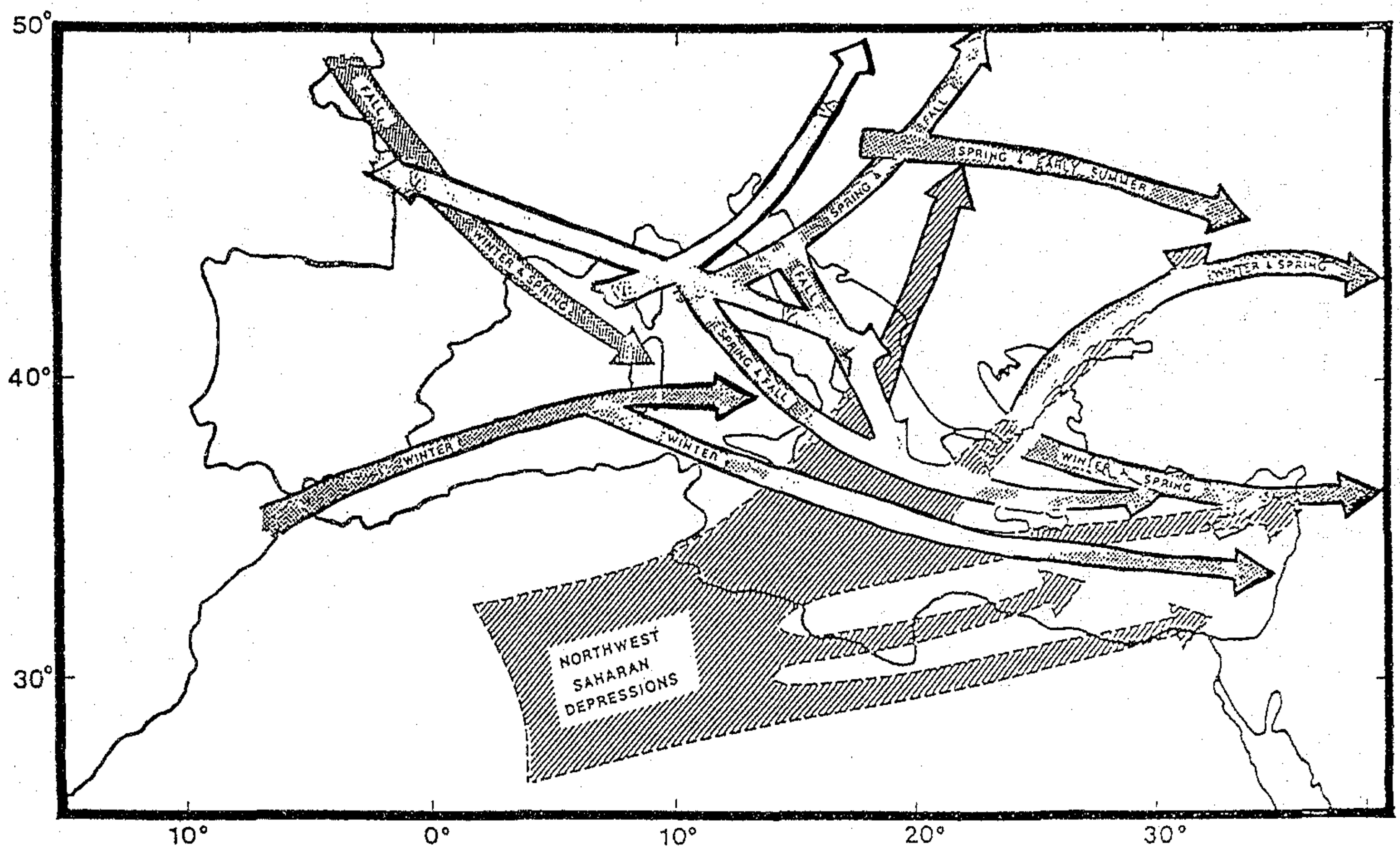


Fig. 5-1-2 Major cyclone tracks in the Mediterranean region



north of the region and gives rise to considerable snowfall which may still be present when the front reaches the north of the region and gives rise to considerable snowfall which may still be present when the front reaches the south coast, although with the higher temperatures there the precipitation usually falls as rain. When the front reaches the south coast after a passage across the Black Sea, the increasing sea temperatures often cause marked instability phenomena in the frontal zone. The conditions really typical of "Northerly Type" are those to the rear of the polar front, when a northerly stream of maritime polar (Baltic) air is established over the whole area. The southward movement of this cold unstable air mass results in an increase of instability within the air mass. Hence the Black Sea area usually experiences broken convection cloud and showers, almost invariably of snow in the north, but usually more frequent and of rain in the south. Visibility is usually good. Typical conditions are summarized below according to locality.

South coast. The passage of the cold front over the south coast is usually marked by rain of an instability type, possibly with hail and snow or sleet. When the front has moved farther south the ensuing onshore winds give little improvement; large amounts of convection clouds are common with much pannus below, usually at about 600m. Pannus as low as 150m however, occurs in precipitation, the precipitation being normally in the form of rain showers or intermittent rain, but occasionally of a more wintry character. Visibility is moderate to good except in precipitation. Afternoon temperatures are 4°C or so.

Over the sea. Even if snow showers do not occur on the north coast they will be almost certain to develop a little farther south over the sea. Cloud amount and shower frequency can be expected to increase progressively during the Black Sea crossing, probably turning from snow to rain towards the south coast. The visibility is usually good except in showers.

(3) Winter: North-easterly type (NE(W) type. Approximate frequency in January 14 per cent)

With an anticyclone centred over the Baltic-Finland area, continental polar air can approach the Black Sea from a north-easterly direction. Usually this air flows around the northwest flank of a depression in the longitude of the Urals and behind the depression's cold front, which may be either a polar or an arctic front (Fig. A 5-1-2).

General weather conditions. This type of situation brings the coldest winter periods to the Black Sea region with continental polar (Siberia) air spreading across from the north-east. The cold front which marks the onset of this situation is usually active, producing considerable snowfall in the north and sleet and rain in the south; instability phenomena are quite well marked in the frontal zone especially in the south. An important local peculiarity is apparent in the northern portion of the east coast near Novorossiysk. There, the cold front which precedes the onset of a cold north-easterly airstream is said to be inactive due to its ascent over the high ground, and produces little cloud. The conditions really typical of the "north-easterly type" are those behind the cold front when the north-easterly stream of continental polar (Siberia) air is established over the whole region. This air mass is very cold and markedly stable in the lower layers when it reaches the Black Sea, but the sea crossing gives a great increase in instability. Thus conditions are normally cold and fine but becoming cloudy with occasional showers or intermittent rain, sleet or snow after crossing the sea. Visibility is usually good except in precipitation, but in the north-east "steaming" fog or "arctic sea smoke" is experienced. Typical conditions are summarized below according to locality.

South coast. When continental polar (Siberia) air reaches the south coast, either intermittent or fairly frequent showers of sleet and rain are to be expected. The cloud is usually large in amount, often becoming a complete cover in precipitation with a base of about 450m. Visibility is usually moderate to good except in precipitation and afternoon surface temperatures are about 2°-4°C.

Over the sea. This very cold air mass crosses the Black Sea from north to south with a consequent increase in surface temperature, water content and instability. The resultant cumulus and stratocumulus cloud is not very deep, but increases in amount and depth towards the south. Thus the fine conditions present at the north coast soon give way to increasing cloud amounts and snow showers with the precipitation probably increasing in frequency and turning to rain or sleet near the south coast. In the northeast "steaming" or "arctic sea smoke" is said to occur.

(4) Winter: South-easterly type (SE(W) type. Approximate frequency in January 13 per cent)

An anticyclone over central Russia usually with a ridge to the north-west of the Black Sea can bring a stream of continental polar air to the region from the east or south-east (Fig. A 5-1-3).

General weather conditions. The onset of such conditions is rarely distinguished by any marked front; this type is therefore characterized by the south-east to north-west flow of continental polar (Caspian basin) air across the region. This air mass is appreciably warmer than continental polar (Siberia) air and reaches the Black Sea after crossing much high ground. In the south and central regions of the Black Sea the air temperature is slightly less than the normal sea temperature, thus producing fair or fine weather in the south and east, as opposed to cloud and poor visibility in the north and west where the sea temperatures are less than the air temperatures. Typical conditions are summarized below according to locality.

South coast. The inevitable descent from quite high ground usually results in the weather being fine with little or no cloud and good visibility. Afternoon temperatures are about 10°-13°C.

Over the sea. Cloud amount is usually nil in the south but increases north-westward first to broken cumulus and stratocumulus and then, still farther north, to a generally complete cover of stratocumulus with a base probably at 450m to 600m. Visibility is usually good, but in the extreme north including the Sea of Azov region, there are often patches of low stratus below the stratocumulus cloud and mist and possibly fog are present at times.

(5) Winter: Southerly type (S(W) type. Approximate frequency in January 13 per cent)

A depression may approach the Black Sea region from the Mediterranean. When it is still west of the region over the Adriatic or Romania, southerly winds ahead of the centre usually bring Mediterranean air to the Black Sea (Fig. A 5-1-4).

General weather conditions. This situation is characterized by advancing warm front or pre-warm-front conditions, and is responsible for the onset of many of the mild spells in this region in winter. The increase of upper cloud associated with pre-frontal conditions similar to those in Home Waters is well enough known to require no further description; the following regional sections therefore, focus attention on the weather, visibility and low cloud. Although there are fair or fine conditions in the east which is well away from the depression centre, this south to north flow of warm moist air produces much cloud and poor visibility in the north of the region. Typical conditions are summarized below according to locality.

South coast. With the obvious shelter from the south-west winds provided by the high ground of Turkey, this coast usually has fair weather with good visibility. Low cloud is generally of small amount but may temporarily increase to complete cover in frontal rain. There is normally considerable upper cloud, which lowers with the approach of the warm front. Afternoon surface temperatures approach 15°C.

Over the sea. In the south there is no low cloud, but with the northward advance of the air stratocumulus cloud forms, increasing and becoming a complete cover of stratocumulus or stratus towards the north coast. This regime is, however, complicated somewhat by the low cloud and rain of the frontal zone.

(6) Winter: Cyclonic type (CY(W) type Approximate frequency in January 11 per cent)

A depression from the Mediterranean may move into the centre of the Black Sea region. Usually, to the north of the Black Sea there is also a ridge from the Siberian anticyclone (Fig. A 5-1-5).

General weather conditions. Most of the disturbed cyclonic rainy spells which occur in this region in winter are the outcome of this type of situation. Frontal and cyclonic phenomena dominate the weather and clear-cut air-mass types are not-well established. However, the easterly winds to the north of the depression centre are normally comprised of continental polar (Caspian basin) air (or occasionally continental polar (Siberia) air), the warm sector is of Mediterranean air and the region behind the cold front is of maritime polar (Atlantic) air. The air flow is roughly cyclonic around the coast of the Black Sea. The various regions may be affected by onshore or by offshore winds, with their reversed orographic effects depending on the particular situation. Typical conditions are summarized below according to locality.

South coast. Offshore winds usually occur only in the early stages and in the eastern part of this coast. In these circumstances there is much upper cloud but low cloud is generally well broken or of small amount with a base about 750m. Rain occurs near the fronts and, with the cold front, precipitation of an instability type is to be expected, possibly with local hail and thunder.

On the western half of this coast, and also at a later stage the eastern half, the winds are generally onshore behind the cold front. Much cloud of a cumulus and stratocumulus type is then experienced with local orographic rain or showers. Visibility is usually good and afternoon surface temperatures, depending upon the details of the synoptic situation, are usually of the order 10°-13°C.

Over the sea. It will be noted that the January sea temperatures are slightly lower than the afternoon land temperatures quoted above for this type; consequently, conditions over the sea will in general reflect the slightly greater stability. Thus stratocumulus and (in the north) stratus cloud will probably be more extensive over the sea. Frontal precipitation over the sea will almost invariably be rain, except perhaps in the extreme north.

(7) Winter: Westerly type (W(W) type. Approximate frequency in January 6 per cent)

A fairly strong stream of air from between south-west and west may flow across the entire Black Sea area ahead of the fronts of a depression moving eastwards across Europe. In such a synoptic situation, the air mass is either Mediterranean air or what might be termed returning maritime polar (Atlantic) air which is very similar (Fig. A 5-1-6).

General weather conditions. The weather is, in general, free from precipitation and rather mild. Air temperatures are higher than normal sea temperatures and thus the air is usually stable. Except in the north, the dew-points are generally too low in relation to the normal sea temperatures for the formation of stratus or stratocumulus cloud. Typical conditions are summarized below according to locality.

South coast. The inevitable warm, stable air and offshore winds give fair or fine weather on this coast. There is little or no cloud, good visibility and afternoon surface temperatures are between 13° and 16°C.

Over the sea. Weather is usually fair or fine with small amounts of cloud. However, stratus and stratocumulus cloud forms farther north and may increase to complete cover with a base at about 450m in the extreme north particularly in the Sea of Azov area. Visibility is usually good.

(8) Winter: North-westerly type (NW(W) type. Approximate frequency in January 25 per cent)

A polar front depression may be situated fairly well to north-east of the region, with its cold front having crossed the Black Sea from north-west to south-east and with a stream of maritime polar (Atlantic) air flowing across the area from the west-north-west (Fig. A 5-1-7(a) - (c)).

Three typical synoptic charts are given to illustrate this type of weather. The differences between them are more in the nature of a time sequence than a real change of type. The first diagram shows the initial onset of the cold air, with a generally cyclonic curvature to the isobars. Later there is usually some ridge development in the cold air behind the front, sometimes with the formation of a small separate high-pressure cell. This ridge, an extension of the Azores anticyclone eastward into the cold air, is shown in the second diagram. The third shows still further development with a separate small cold anticyclone having moved east across the Black Sea.

General weather conditions. The type of weather in which maritime polar (Atlantic) air flows across the Black Sea from the west-north-west is the one most frequently experienced in this region in winter. In general, weather is such as might be expected in a stream of maritime polar (Atlantic) air. There is convection cloud by day over the land areas, orographically increased where the air flow is onshore, but little or no convection in the northern part of the sea areas where the sea temperatures are not sufficiently high. Both the east and west coasts experience better weather when ridge development takes place as shown in the second diagram (Fig. A 5-1-7(b). The east coast then has offshore winds and subsidence in the ridge is usually effective in the west . However, this improvement in cloud conditions is offset by increased probability of fog formation in the low lying areas in the north and west. The risk of fog is further increased by the type of situation illustrated in the third diagram (Fig. A 5-1-7(c)) in which these regions now suffer light onshore winds round the western flack of the small high-pressure cell. Typical conditions are summarized below according to locality.

South coast. Frontal rain, often of an instability type, occurs along this coast since the front has passed over the warmer water surface in the south of the Black Sea. Behind the cold front there is an onshore stream of maritime polar (Atlantic) air. Orographic lifting of this air mass, following its passage over the warm sea surface, results in large amounts of convection cloud, with a base from 450m to 750m, with frequent rain showers. Visibility is good except in rain showers. The development of a ridge in the west has little effect upon these conditions, but if a small separate high-pressure cell moves across to the east of the area, the winds become offshore and the weather then becomes fine. Afternoon surface temperatures on the south coast are about 10°C.

Over the sea. Only in the south or south-east part of the Black Sea are winter sea temperatures sufficiently high to give convection in maritime polar (Atlantic) air. Thus, except near the front, the northern half of the sea area usually has rather small amounts of cloud, but over the south or south-east of the area fairly large amounts of convection cloud and rain showers are likely. An exception to this general scheme is worthy of note. If a separate high-pressure cell has moved across to the east of the Black Sea region, descent of air from the high ground of Turkey, and the subsequent northward movement across progressively colder water, does not favour convectional activity. This not only reduces the cloud amounts in the south but may result in the formation of stratocumulus or even low stratus cloud and fog patches in the extreme north. This is particularly, so in the Sea of Azov where sea temperatures are very low.

(9) Winter: Col type (CO(W) Approximate frequency in January 7 per cent)

A type of situation which can occur in the Black Sea region, and which cannot conveniently be associated with any of the preceding ones, is that in which the area is dominated by a col. This situation usually arises when a polar front depression moves eastward across Europe well to the north of the Black Sea region. The tropical maritime air in its warm sector travels across France and Europe to the north of the Black Sea but is cut off from the Black Sea itself by the Alps. Ridges of high pressure from the Azores anticyclone to the west and the Siberian anticyclone to the east both fail to dominate the situation in the Black Sea region leaving there a col situation of indeterminate air-mass type (Fig. A 5-1-8).

General weather conditions. Both the eastern and western extremities of the Black Sea experience anticyclonic conditions with consequent fine weather. In the north, the low underlying surface temperatures often result in considerable amounts of stratocumulus cloud with mist and fog patches, whereas in the south, the higher temperatures give rise to convection type cloud with occasional rain or showers. Typical conditions are summarized below according to locality.

South coast. The conditions here are usually broken cumulus and stratocumulus cloud with a base at about 750m; showers may occur particularly in the regions where the wind is onshore. Visibility is good and afternoon surface temperatures are about 7°C.

Over the sea. In the extreme east where conditions are similar to a "south-easterly type" the weather is probably fine with little or no cloud and good visibility. Farther west there is likely to be well broken, shallow cumulus and stratocumulus cloud, except in the north where the lower sea temperatures may result in large amounts of stratocumulus cloud.

(10) Summer: Northerly type (N(S) type. Approximate frequency in July 16 per cent)

A depression on the polar front may move eastwards across eastern Europe slightly to the north of the Black Sea. If there is an anticyclone in the Scandinavia-Baltic region, a northerly stream of continental polar air may reach the Black Sea. The isobars immediately behind the cold front often show cyclonic curvature, but later a ridge of high pressure will usually develop (Fig. A 5-1-9).

General weather conditions. Continental polar air is not particularly cold either at the surface or in depth when it arrives at the Black Sea in summer. Thus, although the weather is generally of a covective character with local cumulonimbus clouds and showers, violent or very frequent evidence of instability is not to be expected. Typical conditions are summarized below according to locality.

South coast. The sea crossing does not impart an increase of instability to the air mass, for even in the south of the Black Sea region the sea temperatures are scarcely as high as the afternoon air temperatures inland in the north; thus violent instability is not normally to be expected. The cloud is usually broken stratocumulus or cumulus at about 900m, with local cumulonimbus cloud, mainly inland, over the higher ground, but with any appreciable ridge formation the cloud amount may well be nil. Afternoon surface temperatures are about 24°C.

Over the sea. Although this air is ostensibly polar, the long land track ensures that, in summer, on arrival at the Black Sea the surface temperatures are high and the dew-points are low. The sea temperatures are uniform and fairly high throughout the region, but they are not sufficiently high for much cumulus cloud to form; the major instability activity is associated with the high afternoon temperatures which occur inland. Conditions over the sea are thus fair or fine with small amounts of cumulus or stratocumulus cloud and good visibility.

(11) Summer: Easterly type (E(S) type. Approximate frequency in July 27 per cent)

In summer the eastward flow of continental tropical air around the northern side of the "monsoon low" of southern Asia often extends across the Black Sea; this flow may be either around a small shallow depression over the high plateau of Turkey, or around a ridge or anticyclone over Russia (Fig A 5-1-10).

General weather conditions. This type of situation brings warmer than normal conditions to the Black Sea region. The weather is fair with day-time convection cloud over land, with occasional showers and local thunderstorms. The cloud amount and the intensity of the convectional activity are both reduced if the flow across the Black Sea is predominantly anticyclonic rather than cyclonic. Typical conditions are summarized below according to locality.

South coast. The weather is fair or fine but local showers or even thunderstorms can occur well inland in the afternoon. Variable amounts of cumulus cloud with a base at about 900m form during the day, with local cumulonimbus clouds, but the amounts are usually small and sometimes nil. Visibility is usually moderate to good. If the wind is not already onshore, a sea-breeze usually develops during the afternoon restricting the maximum temperatures in the coastal regions to between 24° and 27°C.

Over the sea. The sea temperatures are, in general, appreciably lower than the afternoon air temperatures and are thus usually insufficient to cause convection cloud development; also the air mass is much too dry for stratus or stratocumulus cloud to be formed over the relatively cool sea. Consequently the weather is usually fair or fine with little or no low cloud and moderate to good visibility over the whole sea area.

(12) Summer: Westerly (Anticyclonic) type (W(S) type. Approximate frequency in July 39 per cent)

In summer the Azores anticyclone often spreads its influence far enough eastward to affect the Black Sea, sometimes with a separate anticyclone over western Europe and the Mediterranean. The polar front system is then well to the north and the air mass which reaches the Black Sea in maritime tropical air with a long land track over Europe (Fig. A 5-1-11).

General weather conditions. The weather over the whole region is generally fair or fine with convection cloud, often of small amount, over land during the day. In view of the potential instability often present in maritime tropical air when it reaches the Black Sea area local land temperatures are sufficiently high for the formation of cumulonimbus cloud and showers or even thunderstorms. Typical conditions are summarized below according to locality.

South coast. The general anticyclonic conditions increase the likelihood of afternoon sea-breezes, thus restricting somewhat the afternoon maximum temperatures and hence the degree of convection. The weather is therefore usually fair or fine with only small amounts of cumulus cloud at about 900m and good visibility. Afternoon surface temperatures are about 27°C.

Over the sea. The sea temperatures are rather lower than the afternoon land temperatures and are usually insufficient for any convection cloud development. The air is also too dry for the formation of low cloud of layer type. The weather is therefore usually fair or fine with little or no low cloud and good visibility.

(13) Summer: North-westerly type (NW(S) type. Approximate frequency in July 18 per cent)

The polar front may cross the Black Sea front north-west to south-east, followed by a north-westerly stream of maritime polar air; this is often followed by some ridge development from the west (Fig. A 5-1-12).

General weather conditions. In this type of situation the polar front is often a fairly active cold front and, although the associated rain belt may not cause widespread precipitation, the rain is of an instability type and is often accompanied by thunder. Once the front has cleared the region the situation becomes typical for the "north-westerly type", and the weather is fair or fine with broken cumulus cloud and good visibility. Prevailing conditions are summarized below according to locality.

Over the sea. The sea temperatures are generally lower than the afternoon land temperatures although the difference is small near the south coast. Thus there is usually even less convection cloud over the sea than exists by day over the land. The conditions over much of the sea are therefore fair or fine with only small amounts of cumulus and stratocumulus cloud at about 750m. In the northern half of the sea area, however, the cloud amount is less than elsewhere and may be nil. Visibility is good.

5-1-4 Atmospheric Pressure

Over the Black Sea, the atmospheric pressures are high in winter and low in summer, although there exists the low pressure in winter and the high in summer. The lowest pressures lie along the south coast in winter and the highest near the west coast in summer (Fig. 5-1-3).

The average monthly pressures range from 997 (July) to 1002 (Nov.) mb, and their deviations are smallest (5mb) in June and largest (20mb) in Dec. (Table A 5-1-1 and Fig. 5-1-4).

5-1-5 Air Temperature

On land, the annual average temperatures are highest along the southeast coast facing the Mediterranean Sea, followed by the other coasts (the Mediterranean, the Aegean and the Black Seas) and lowest in the northeast Anatolia (Fig. 5-1-5).

The mean temperatures are slightly higher over the Black Sea than those on land throughout the year (Fig. A 5-1-13).

The monthly average temperatures are lowest (6°C) in Jan. and highest (22°C) in July, and deviate 6 through 12°C (Table A 5-1-2 and Fig. 5-1-6).

Tables A 5-1-3 and 4 are the highest and the lowest temperatures, respectively, observed in Zonguldak.

5-1-6 Weather

The annual sunshine periods are longest (3000 to 3200 hr) along the southernmost latitude and shortest (1600 to 1800 hr) along the northermost, corresponding to approximately 35 and 19%, respectively, divided by the whole annual period (24 hr x 365 days = 8760 hr, Fig. 5-1-7).

The numbers of annual clear days are more than 180 days (50%) along

Fig. 5-1-3(a) Mean Monthly Atmospheric Pressure (mb) - January

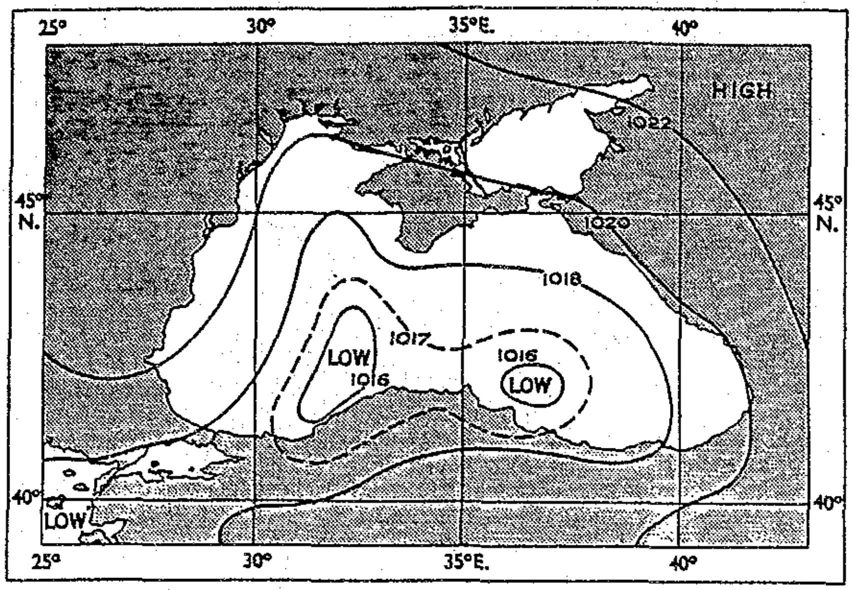


Fig. 5-1-3(b) Mean Monthly Atmospheric Pressure (mb) - July

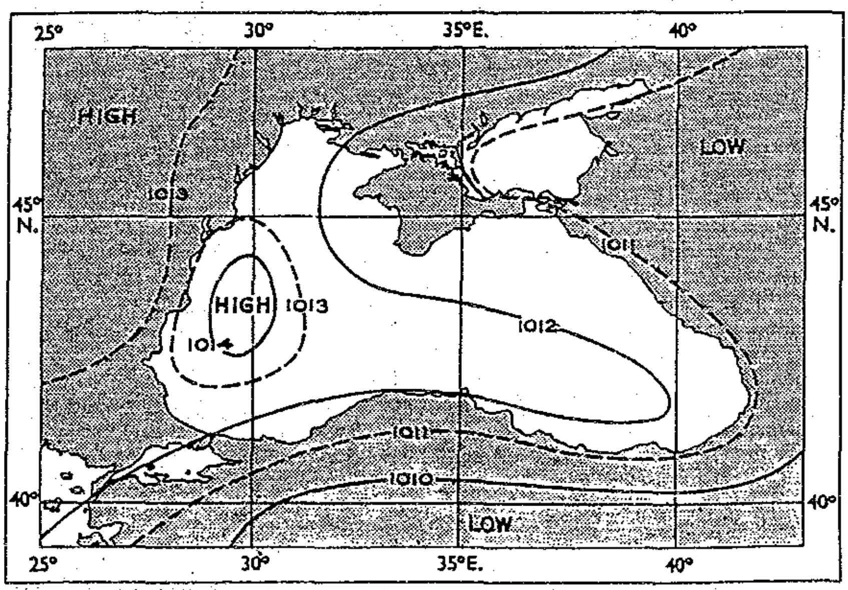


Fig. 5-1-4 Monthly Average Atmospheric Pressure (Zonguldak)

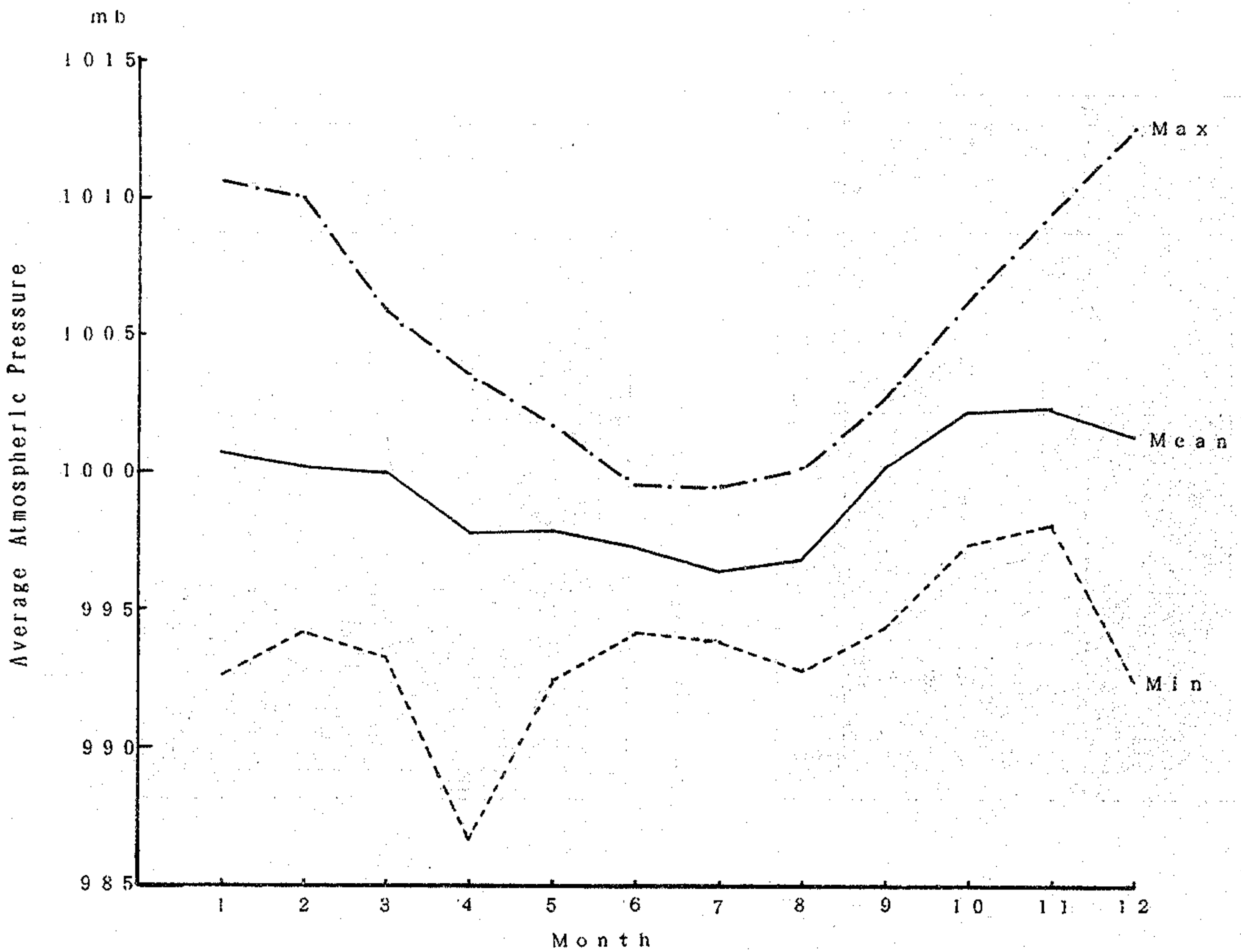


Fig. 5-1-5 ANNUAL AVERAGE TEMPERATURE (°C)

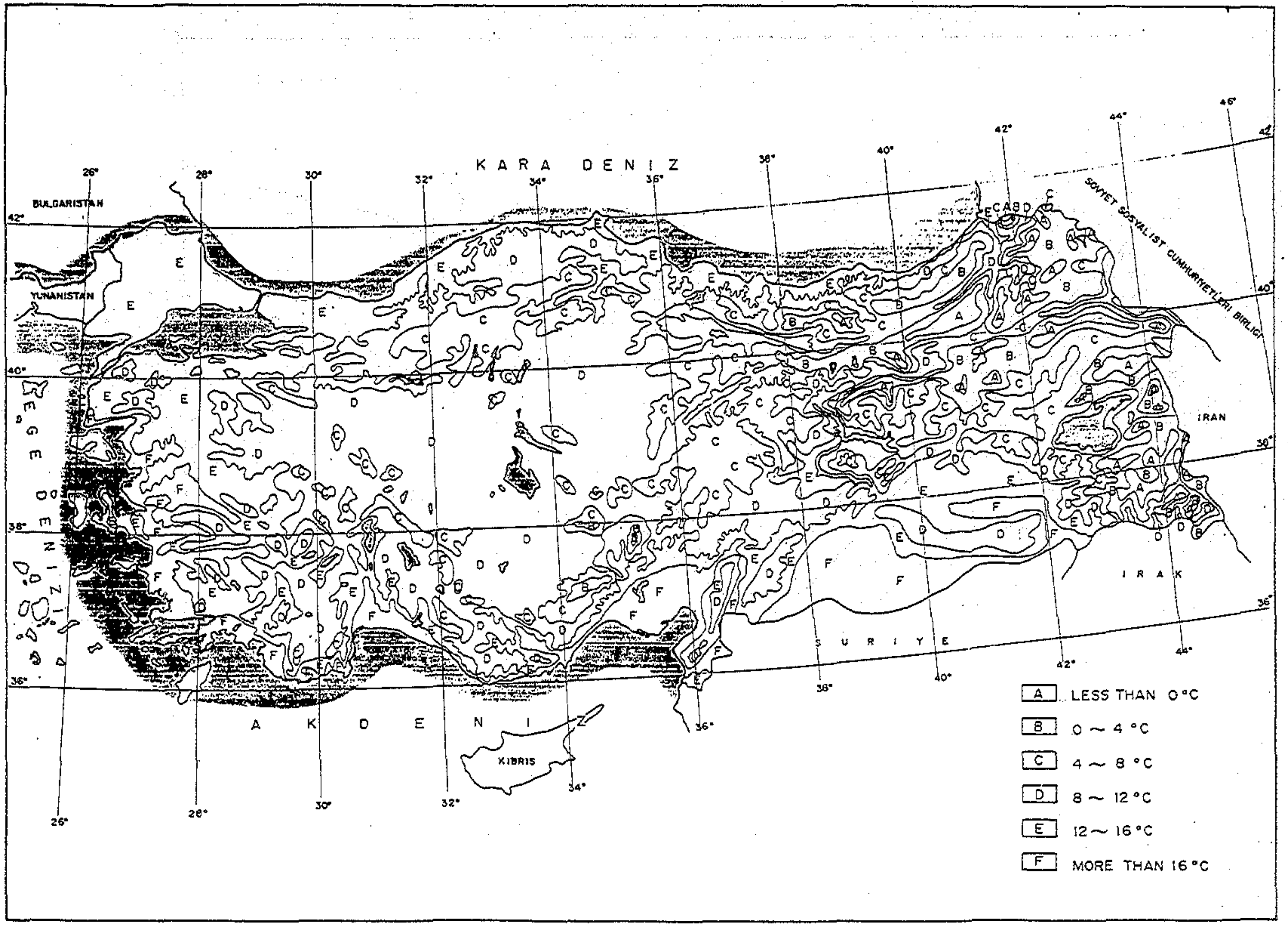


Fig. 5-1-6 Monthly Average Temperature (Zonguldak)

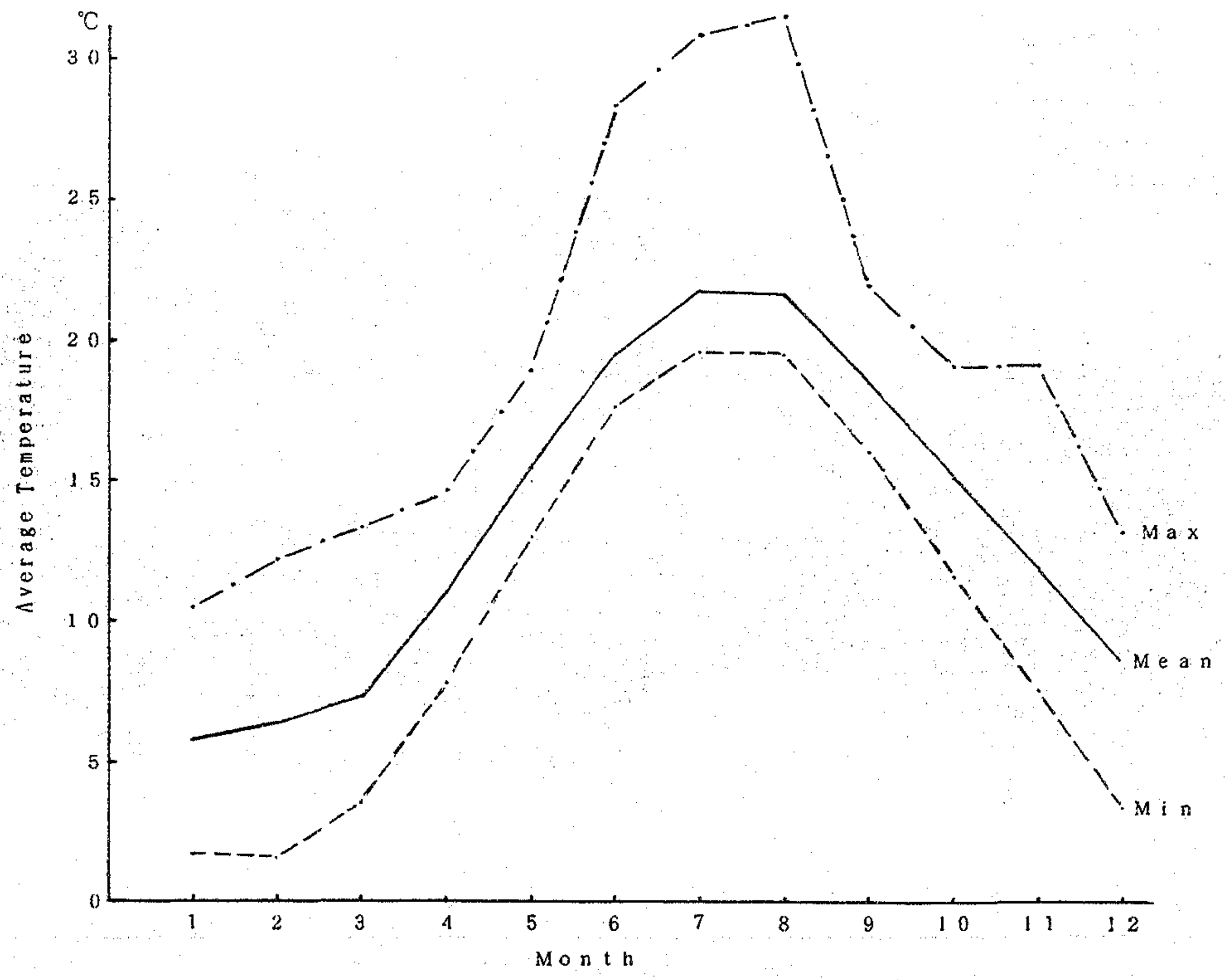
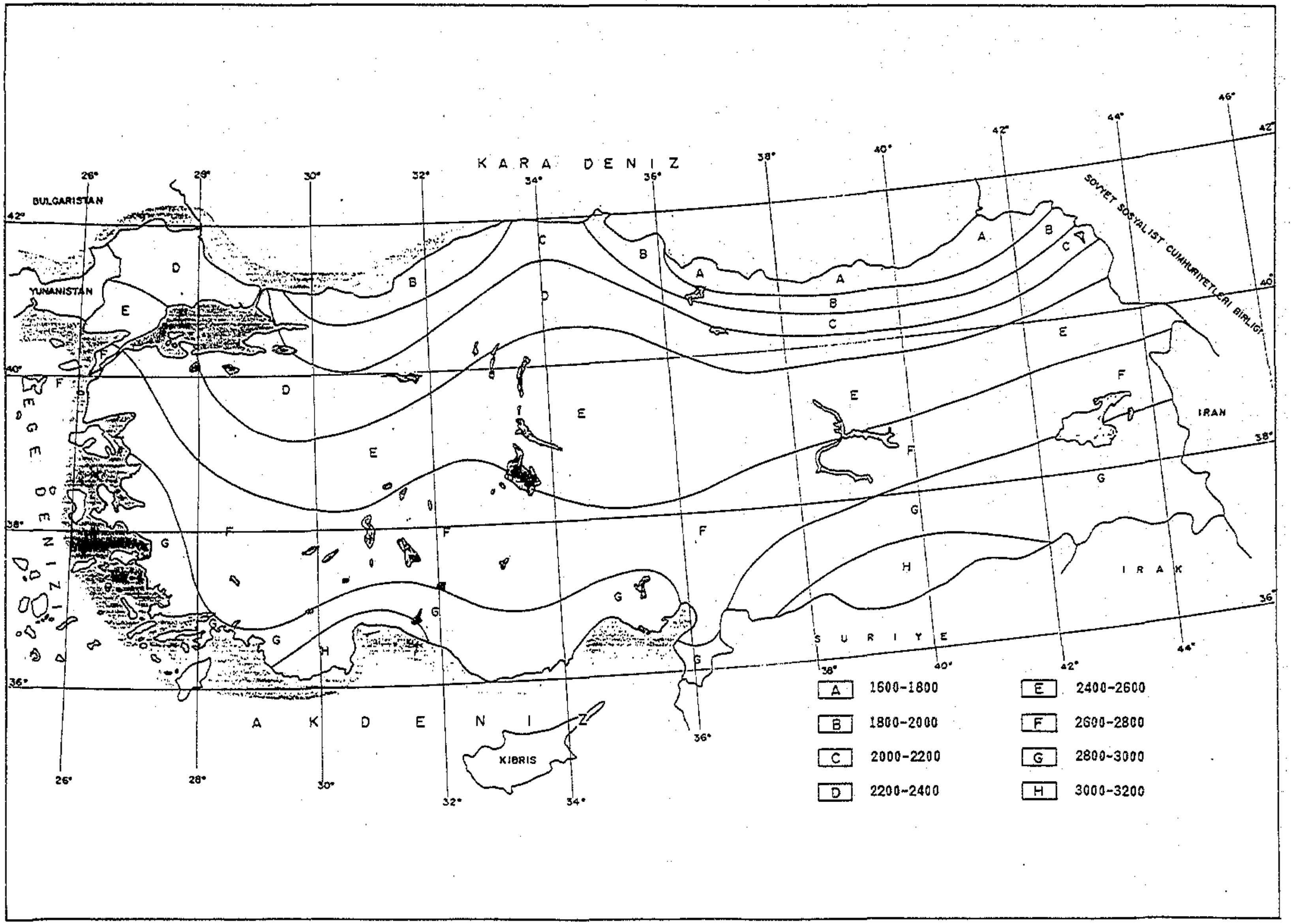


Fig. 5-1-7 ANNUAL SUNSHINE PERIOD (HOURS)



the Mediterranean coast and less than 60 days (17%) along the Black Sea coast, although their distribution is rather complicated (Fig. 5-1-8).

The amounts of cloud cover vary from less than 3.5 along the Mediterranean coast to more than 5.5 along the Black Sea coast, characterized by a slightly uneven distribution contrary to clear days (Fig. 5-1-9).

The monthly cloud amounts are lowest (3.0) in July and highest (8.0) in Jan. with their deviations of 3 to 6 in Zonguldak (Fig. 5-1-10).

The numbers of annual days covered by cloud are smallest (30 to 60 days) along the Mediterranean coast and largest (90 to 150 days) along the Black Sea coast, with the compensatory distribution to clear days (Fig. 5-1-11).

The numbers of annual freezing days are less than 20 days along the whole Turkish coasts with the exception (up to 60 days) of the infinitesimal Black Sea coast near Amasra (Fig. 5-1-12).

The numbers of average monthly foggy days lie between 0.1 (Sep.) and 5.7 (Apr.) in Zonguldak (Table A 5-1-5).

5-1-7 Precipitation

The annual average precipitations are 800 to 1250mm along the whole Turkish coasts, lowest (300 to 400mm) on the Anatolian Highland and highest (more than 2000mm) in the northeast frontier coast (Fig. 5-1-13). In Zonguldak, the annual average precipitation is approximately 1200mm and the monthly precipitations range 56mm (May) to 148mm (Dec.) with the enormous deviations of 200 to 650mm (Table A 5-1-6 and Fig. 5-1-14).

The 20 events of highest daily rainfalls are statistically analysed to estimate their recurrence periods on probability year (Tables. A 5-1-7 and 5-1-1 and Fig. 5-1-15). The correlation between duration (t in min.) and rainfall intensity (i in mm/min) is evaluated for the purpose of planning and designing sewage and discharge facilities (Table 5-1-2 and Fig. 5-1-16). The empirical formula of i-t relationship is deduced as $i=66.64/(t+15.976)^{0.896}$.

Table A 5-1-8 lists the highest snow thickness.

Fig. 5-1-8 ANNUAL AVERAGE OF CLEAR DAY (DAYS)

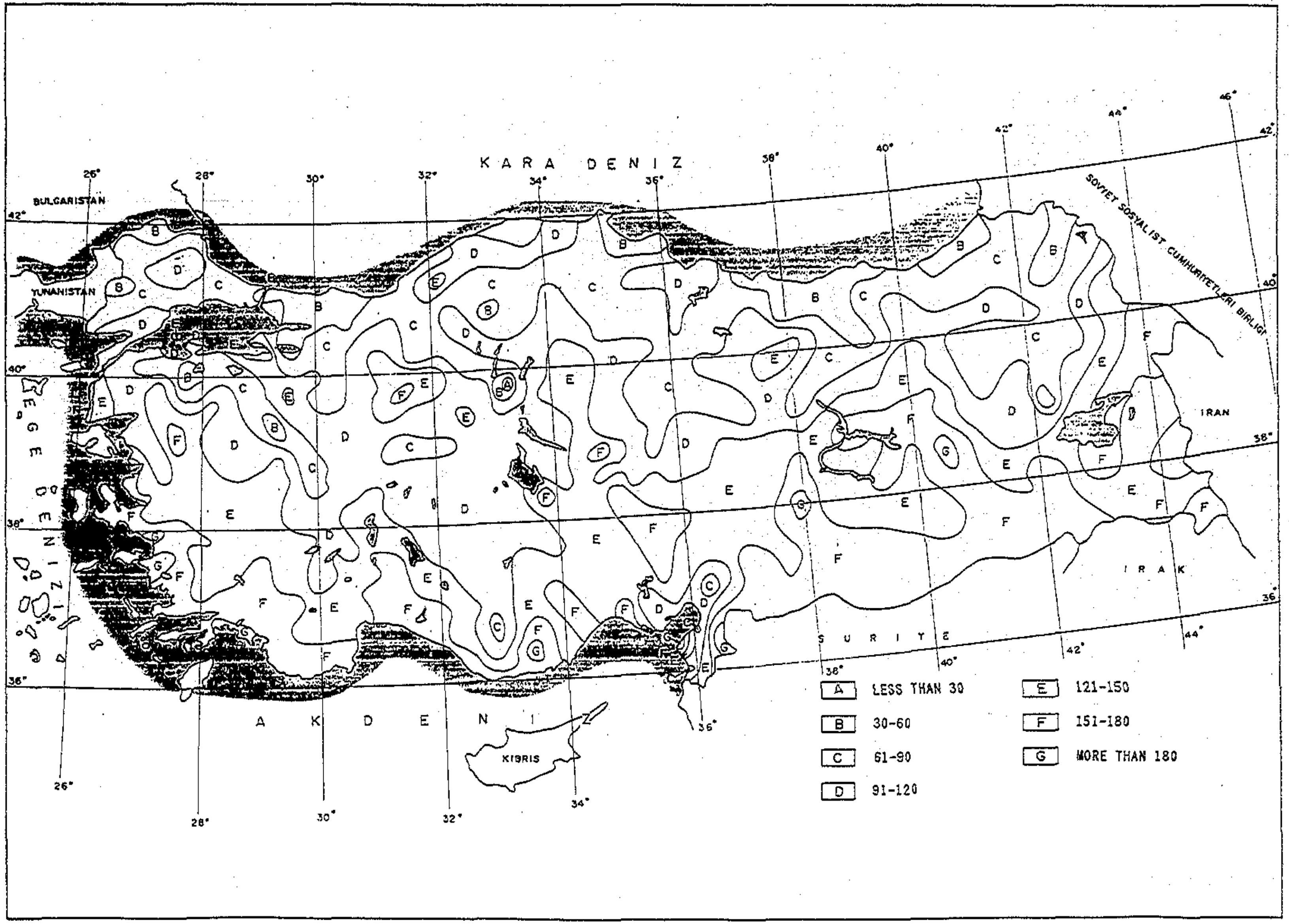


Fig. 5-1-9 ANNUAL AVERAGE CLOUD AMOUNT

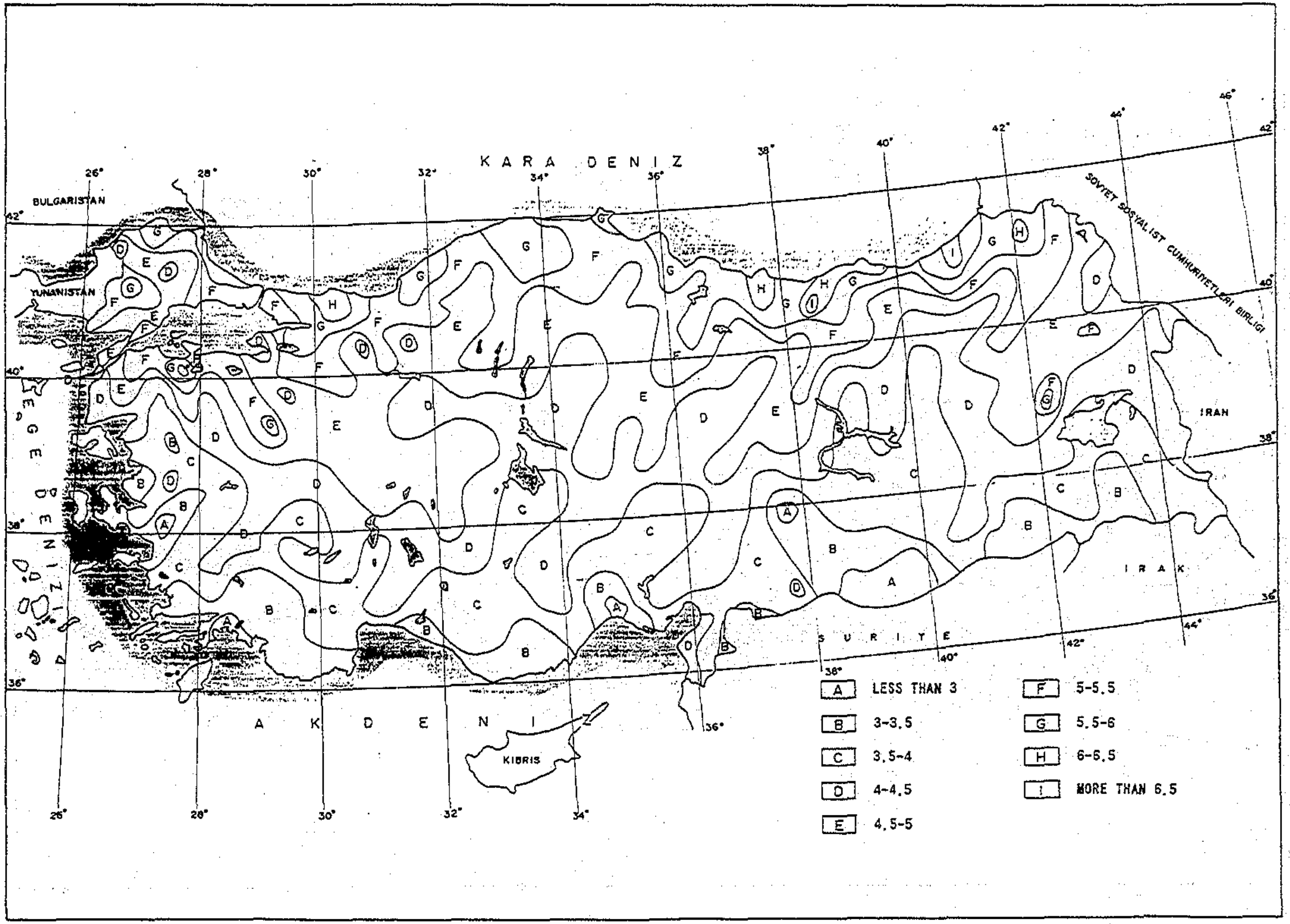


Fig. 5-1-10(a) Monthly Cloud Amount (Mean, Max, Min., 1937-1980)

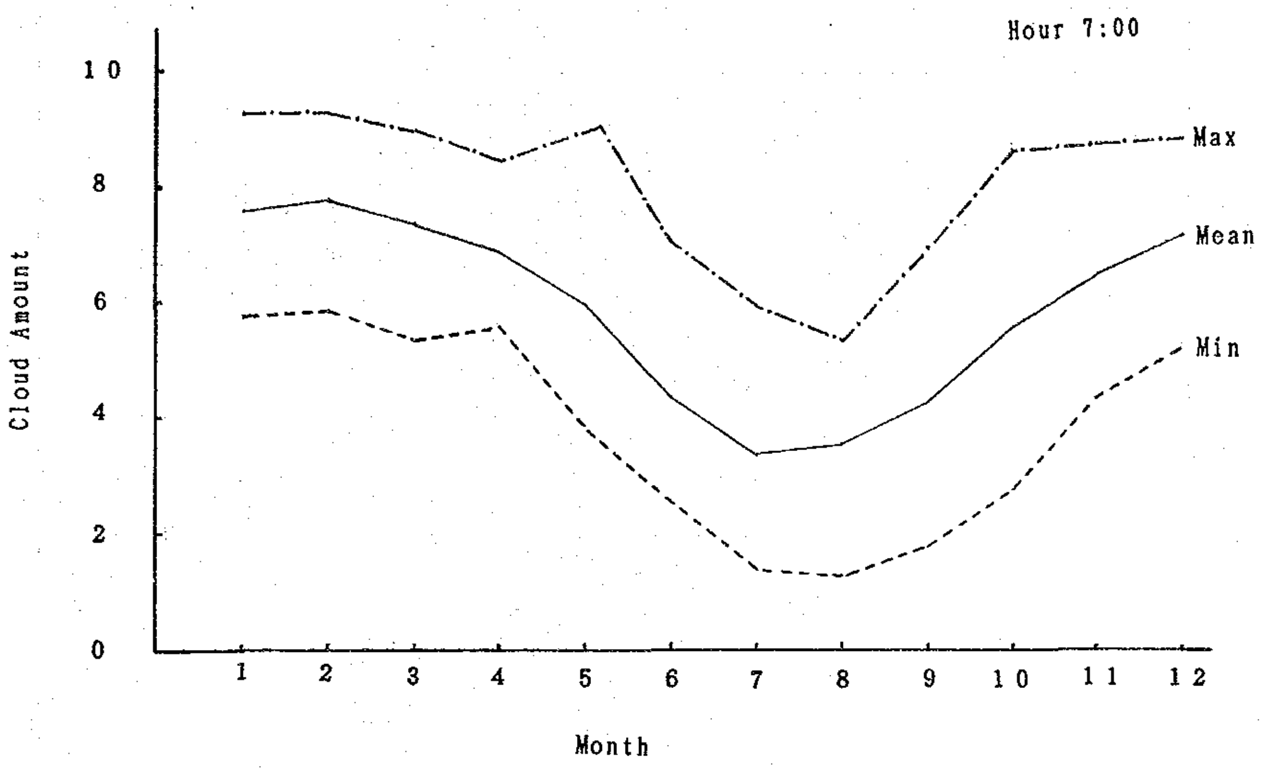


Fig. 5-1-10(b) Monthly Cloud Amount (Mean, Max, Min., 1937-1980)

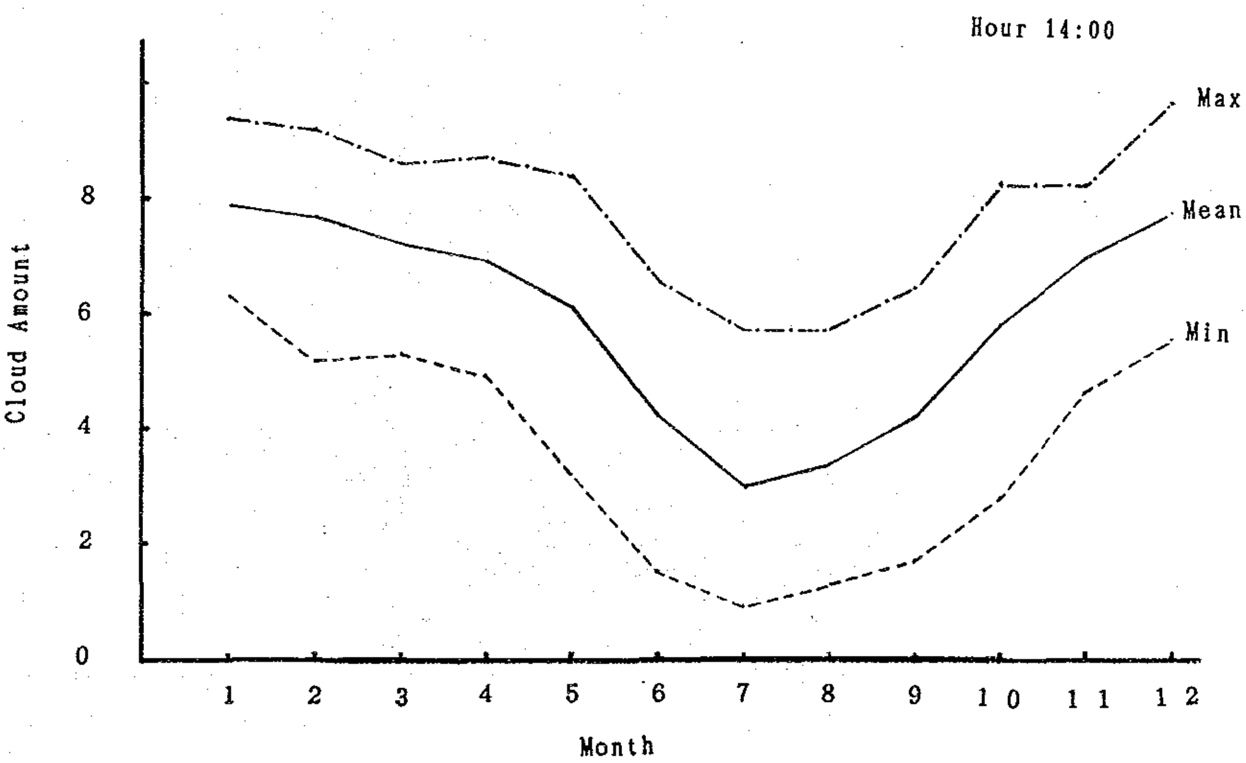


Fig. 5-1-11 ANNUAL AVERAGE NUMBER OF COVERED DAYS BY CLOUD (DAYS)

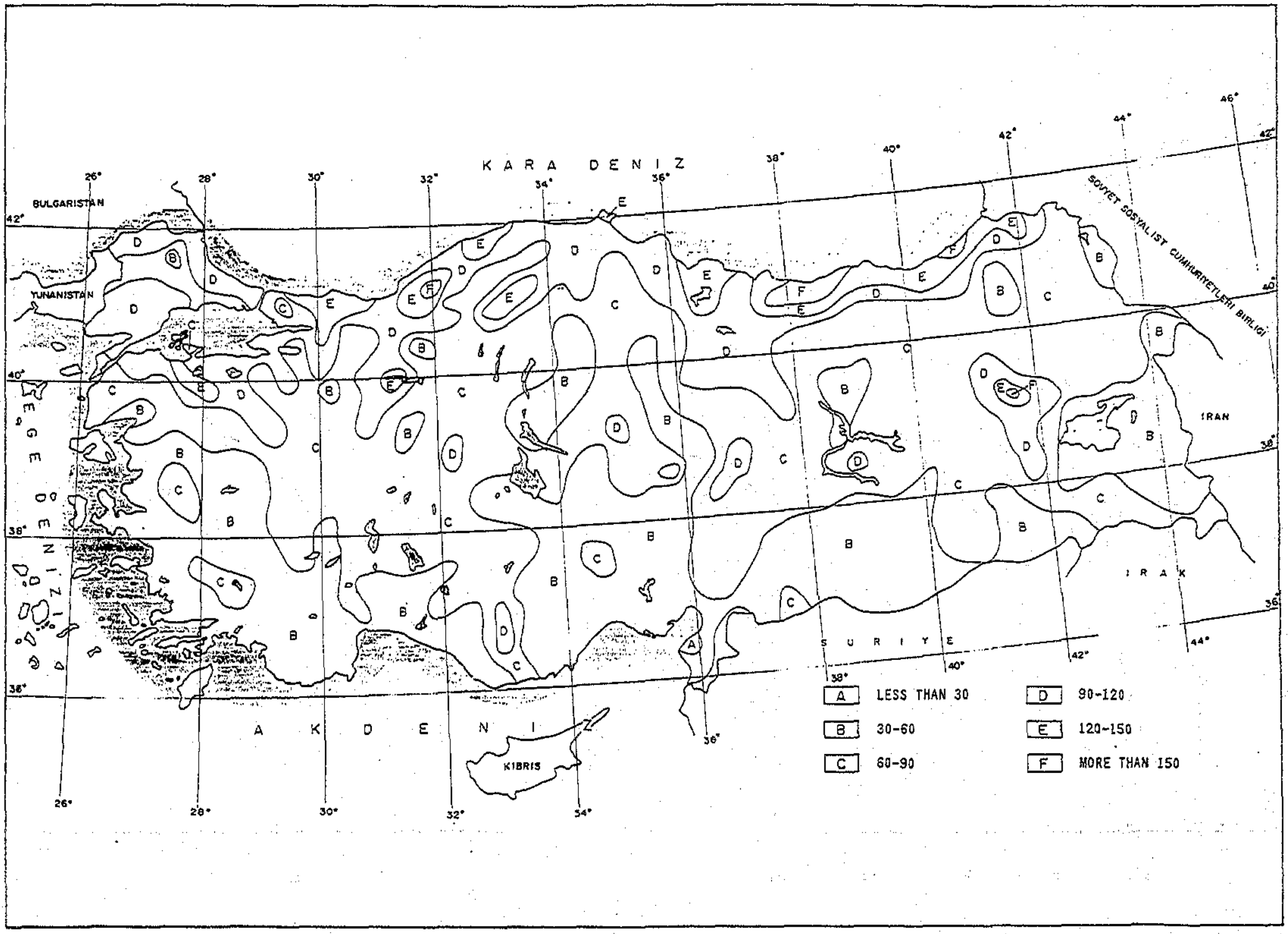


Fig. 5-1-12 ANNUAL AVERAGE OF FREEZING PERIOD (DAYS)

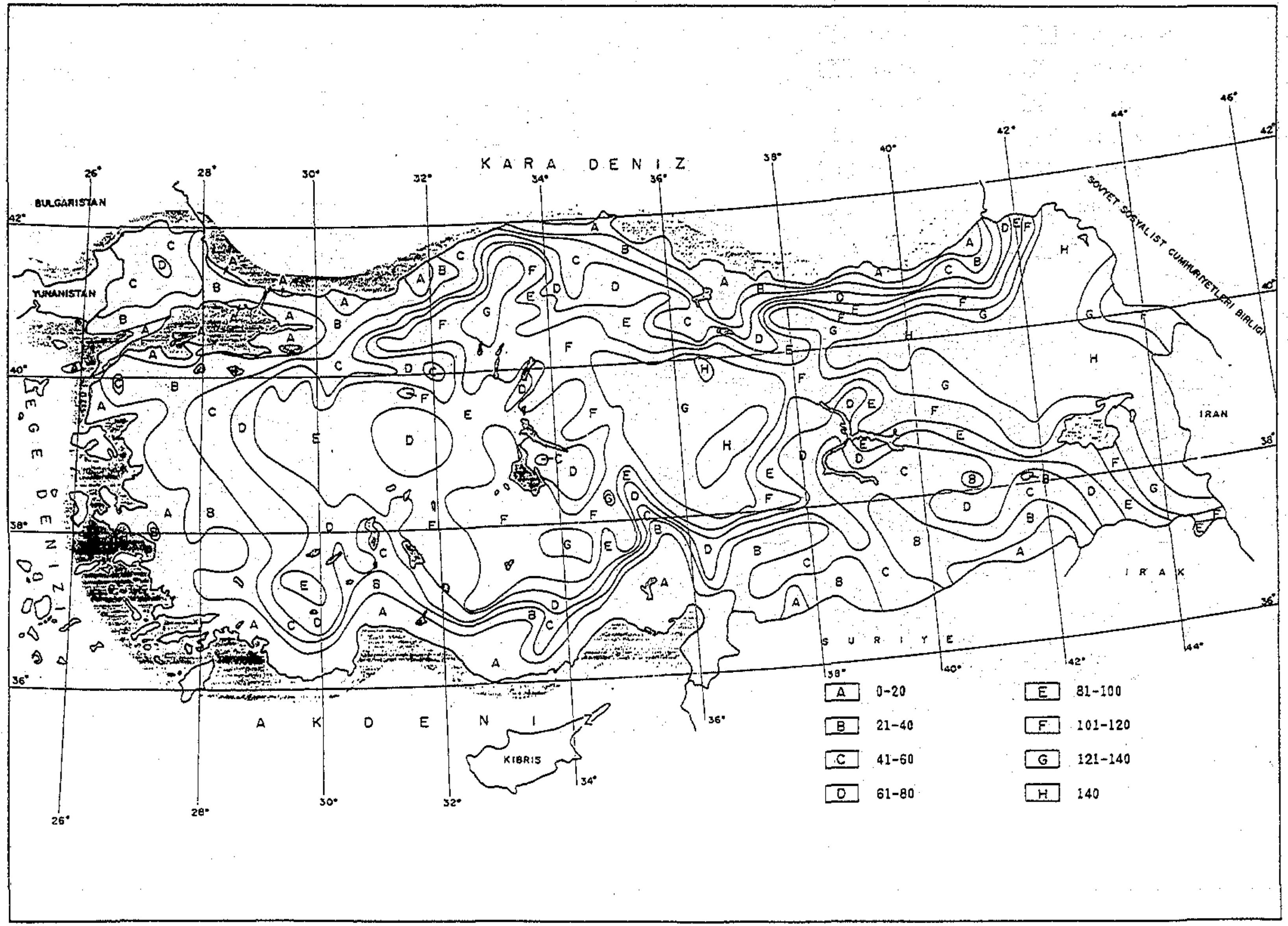


Fig. 5-1-13 ANNUAL AVERAGE PRECIPITATION (MM)

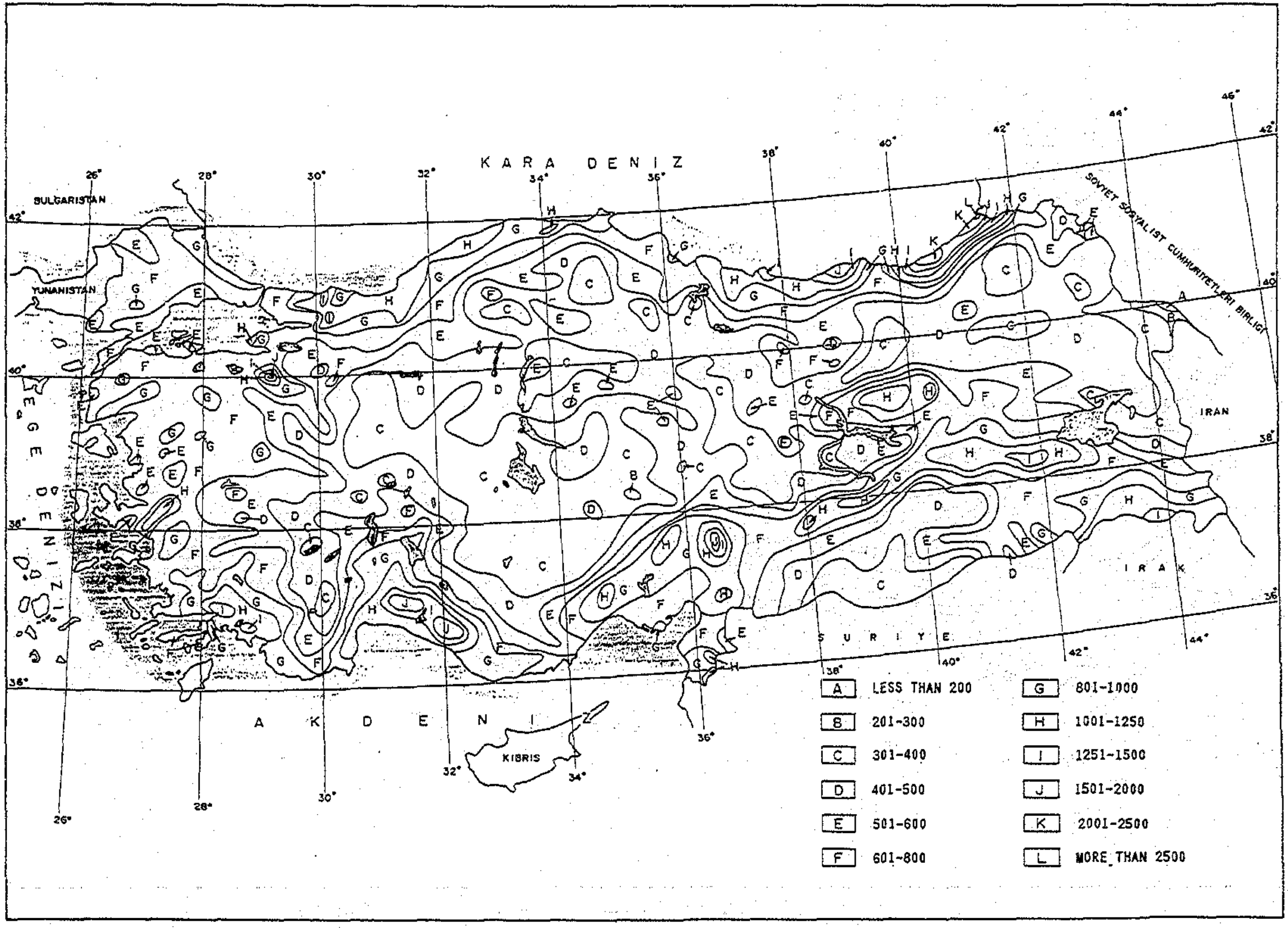


Fig. 5-1-14 Monthly Precipitation (Zonguldak)

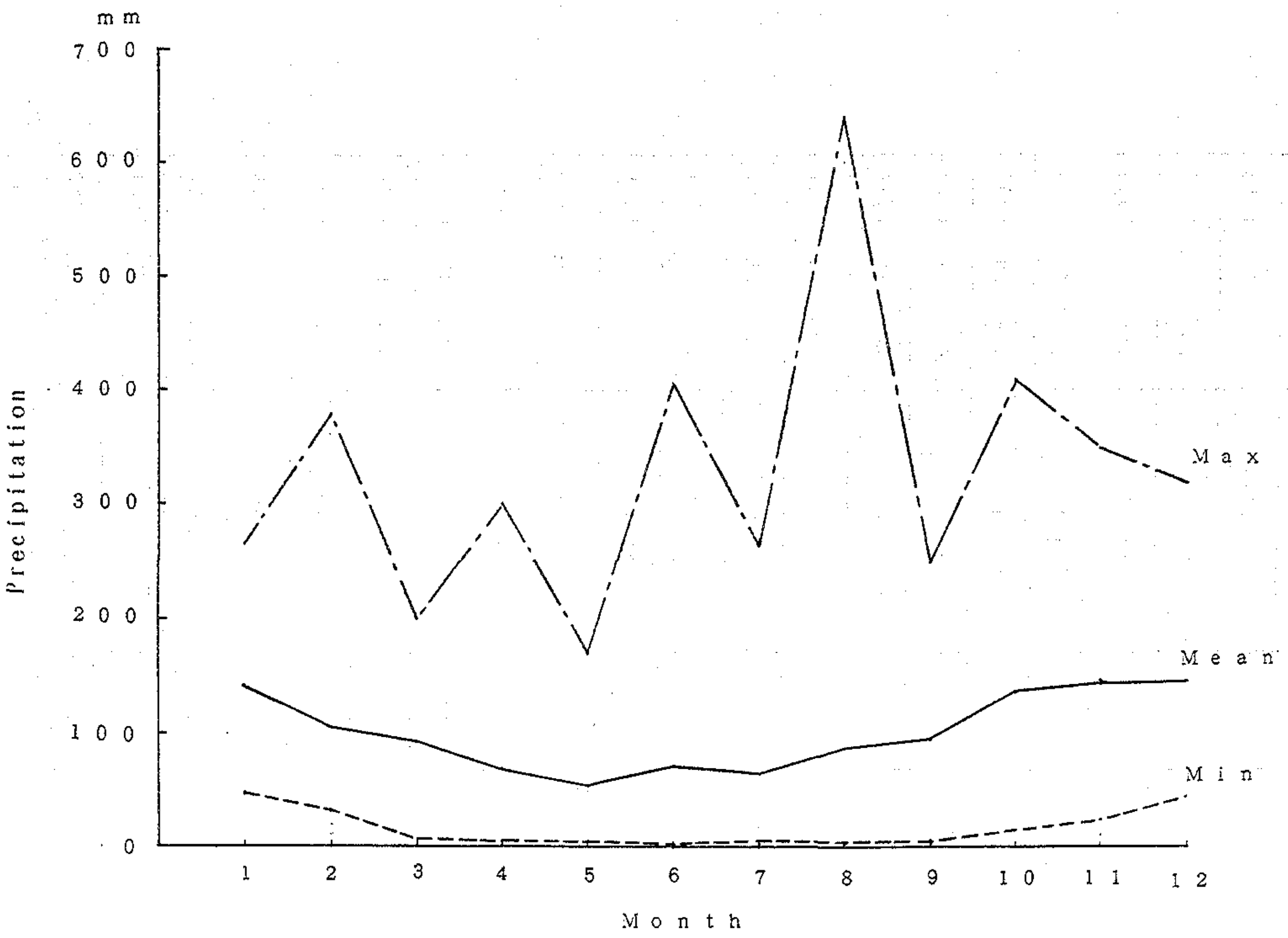
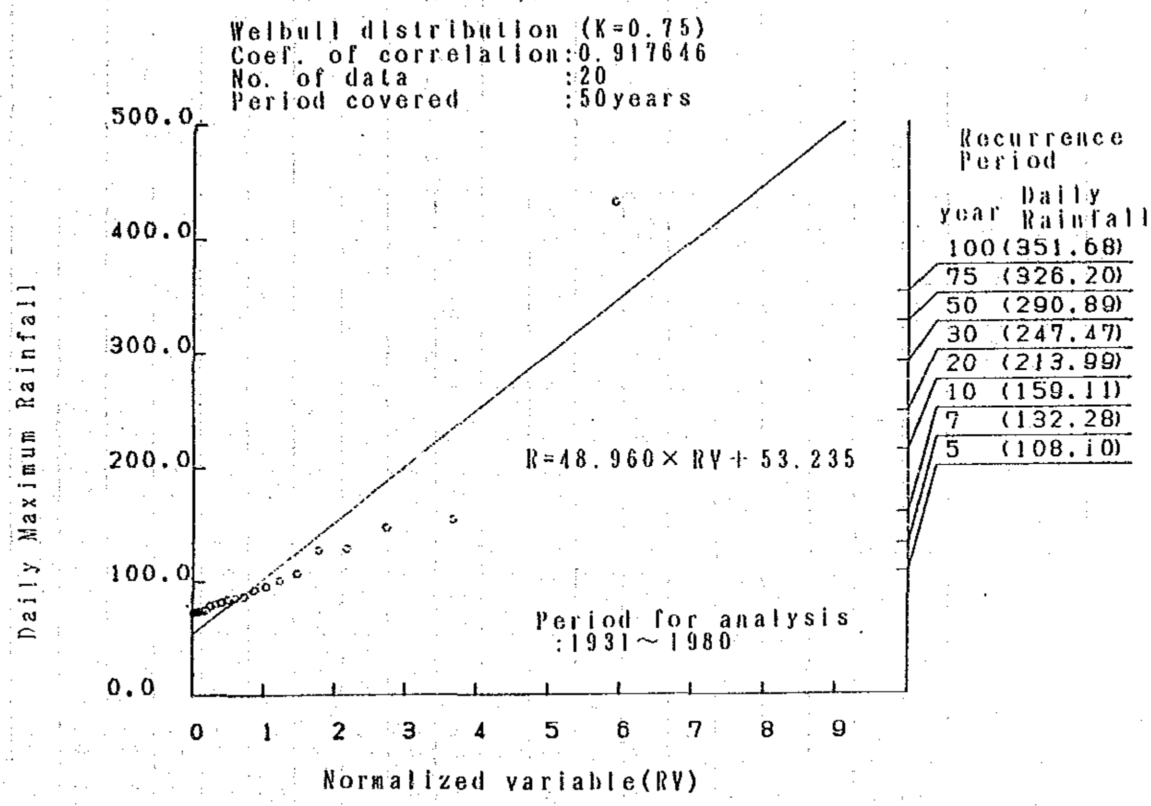


Table 5-1-1 20 Highest Maximum Daily Rainfall in Last 50 Years

No.	Daily rainfall	Date
1	431.50 mm	Aug. 1, 1955
2	153.70	Jun. 22, 1972
3	147.10	Jun. 11, 1954
4	128.80	Jul. 28, 1970
5	127.40	Oct. 20, 1960
6	106.60	Sep. 11, 1964
7	100.50	Aug. 31, 1979
8	95.10	Jun. 16, 1945
9	92.00	Aug. 11, 1966
10	86.20	Jun. 15, 1951
11	85.10	May. 1, 1975
12	83.80	Jan. 16, 1967
13	81.10	Oct. 21, 1947
14	79.90	Aug. 25, 1953
15	78.60	Aug. 16, 1974
16	74.20	Dec. 1, 1957
17	74.00	Aug. 23, 1976
18	73.90	Jul. 13, 1965
19	73.60	Nov. 23, 1961
20	72.50	Nov. 3, 1973

Fig. 5-1-15 Recurrence Period of Daily Maximum Rainfall

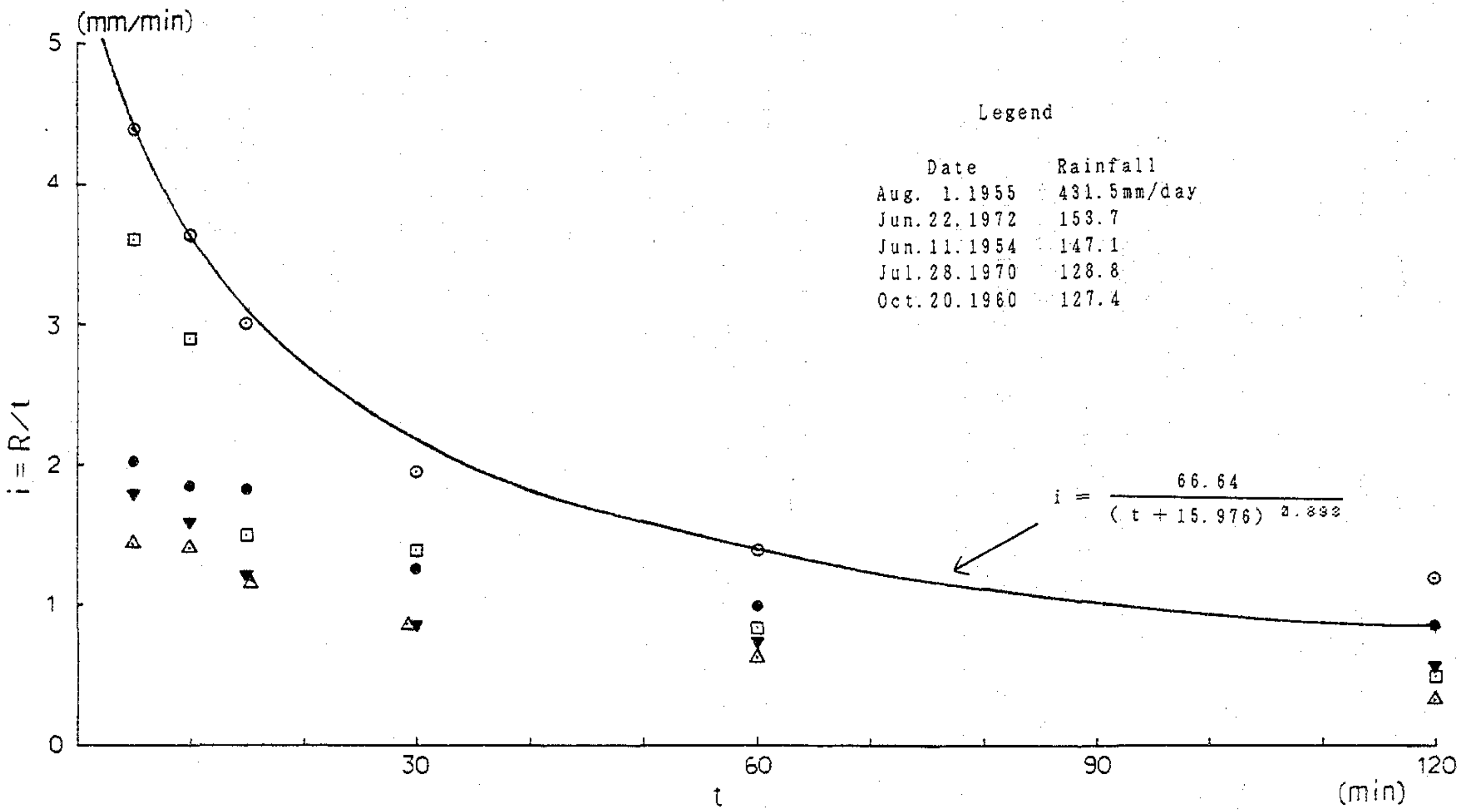


Normalized variable(RV) and Recurrence Period(year)

Table 5-1-2 I - T Relationship

No.	R & I	5min	10min	15min	30min	60min	120min	Daily Rainfall	Date
1	R(mm)	22.00	36.40	45.60	58.80	84.60	145.20	431.50	Aug. 1, 1955
	I(=R/T)	4.40	3.64	3.04	1.96	1.41	1.21		
2	R(mm)	7.20	14.30	18.40	27.40	38.60	39.60	153.70	Jun.22, 1972
	I(=R/T)	1.44	1.43	1.23	0.91	0.64	0.33		
3	R(mm)	18.90	29.00	22.50	41.20	50.20	58.50	147.10	Jun.11, 1954
	I(=R/T)	3.78	2.90	1.50	1.37	0.84	0.49		
4	R(mm)	9.00	16.10	18.30	26.10	45.80	66.90	128.80	Jul.28, 1970
	I(=R/T)	1.80	1.61	1.22	0.87	0.76	0.56		
5	R(mm)	10.20	18.70	27.70	38.20	61.60	102.80	127.40	Oct.20, 1960
	I(=R/T)	2.04	1.87	1.85	1.27	1.03	0.86		
6	R(mm)	14.00	18.00	19.00	28.00	37.00	47.60	106.60	Sep.11, 1964
	I(=R/T)	2.80	1.80	1.27	0.93	0.62	0.40		
7	R(mm)	10.00	12.10	18.50	25.60	42.90	53.50	100.50	Aug.31, 1979
	I(=R/T)	2.00	1.21	1.23	0.85	0.72	0.45		
8	R(mm)	7.70	14.60	18.60	20.40	40.60	45.70	95.10	Jun.16, 1945
	I(=R/T)	1.54	1.46	1.24	0.68	0.68	0.38		
9	R(mm)	10.50	14.40	17.70	24.20	37.60	46.00	92.00	Aug.11, 1966
	I(=R/T)	2.10	1.44	1.18	0.81	0.63	0.38		
10	R(mm)	7.50	14.50	22.00	44.00	51.20	52.70	86.20	Jun.15, 1951
	I(=R/T)	1.50	1.45	1.47	1.47	0.85	0.44		

Fig. 5-1-16 i - t Relationship (Zonguldak)



5-1-8 Humidity

In Zonguldak, monthly average relative humidity slightly fluctuates between 70% (winter) and 74% (summer) with the considerable deviations of 30 to 50% (Table A 5-1-9 and Fig. 5-1-17).

5-1-9 Evaporation

The monthly evaporations observed at Zonguldak are lowest (64mm) in March and highest (114mm) in July with a remarkable deviations between 20 and 130mm (Table A 5-1-10 and Fig. 5-1-18).

However the evaporation must be overestimated, considering the fact that the annual average precipitation (1223.8mm) is almost the same (94%) of the annual average evaporation (1147.5mm).

5-1-10 Wind

Fig. 5-1-19 is the map of ground wind in each season. In Zonguldak, the maximum or instantaneous winds are slow (11m/s) in summer and fast (18m/s) in winter averaged during 1937 to 1980 (Table A 5-1-11 and Fig. 5-1-20) .

However the annual maximum instantaneous winds reach 30 to 35 m/s. The numbers of monthly stormy days are smallest (0.2 days) in July and largest (2.3 days) in Dec. with the extraordinary monthly occurrence of 8 to 10 days in some winters (Table A 5-1-12 and Fig. 5-1-21).

In Zonguldak, the prevailing wind directions are NNW in summer and ESE in winter (Fig. 5-1-22). Nevertheless the NE winds are supposedly weakened by the influence of buildings. The annual prevalent winds blow from NNW and ESE (Fig. 5-1-23).

The NNW winds occur in the daytime and the ESE winds in the night time (Fig. 5-1-24).

In Amasra, the ENE winds are prevailing in the daytime and the SSE winds in the night time, on account of the topographical effect (Fig. 5-1-25).

Fig. 5-1-17 Monthly Average Relative Humidity (Zonguldak)

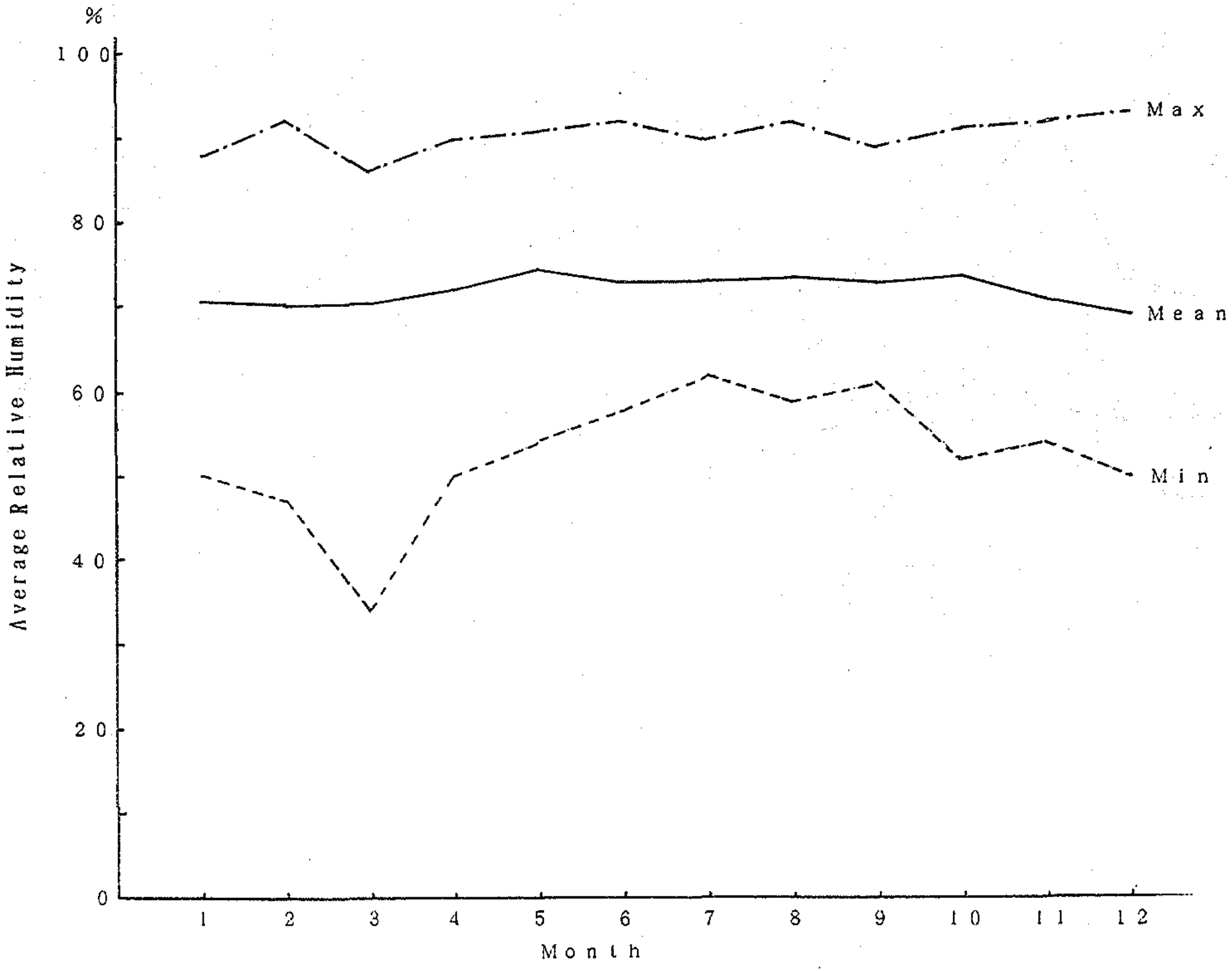


Fig. 5-1-18 Monthly Evaporation (Zonguldak)

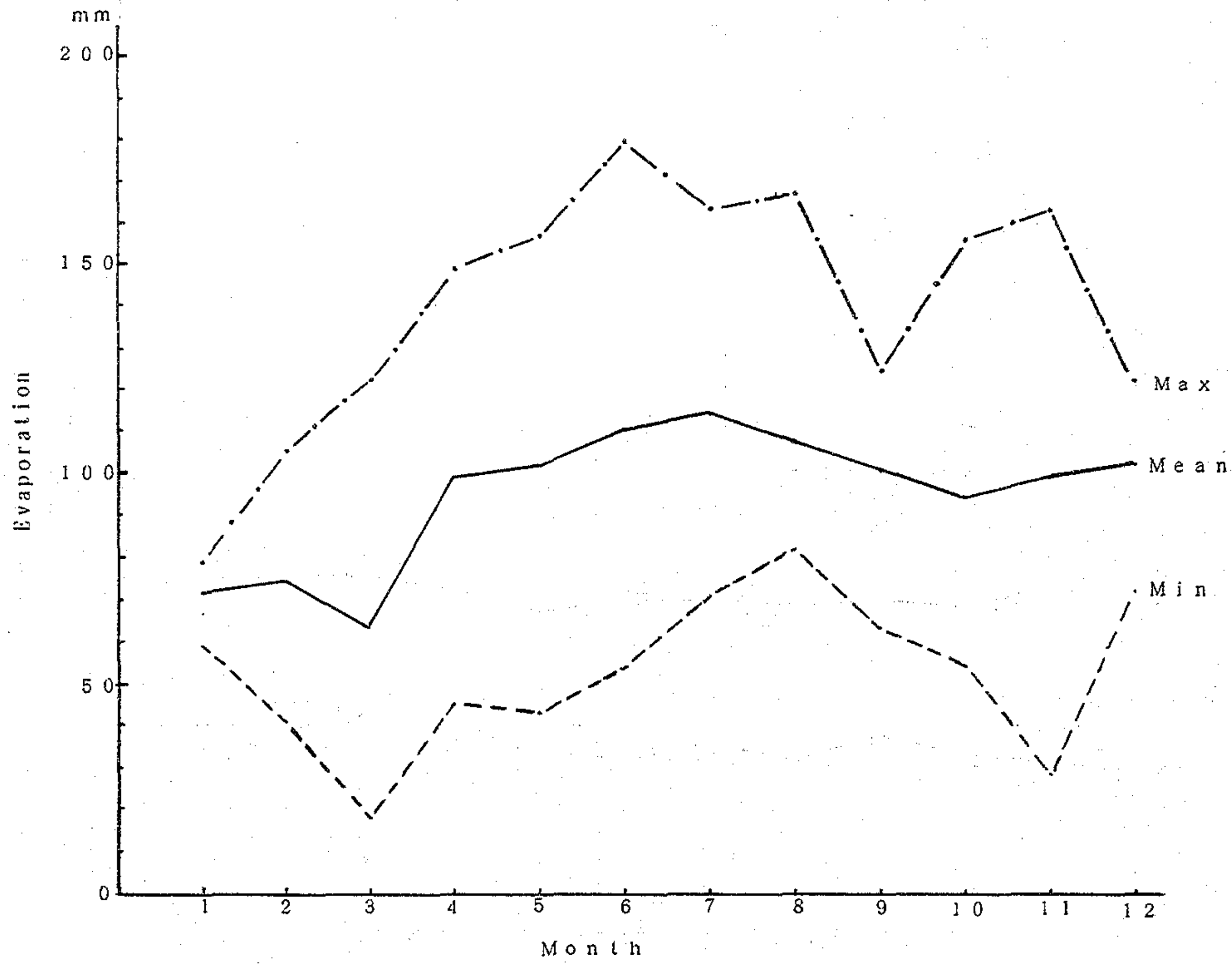
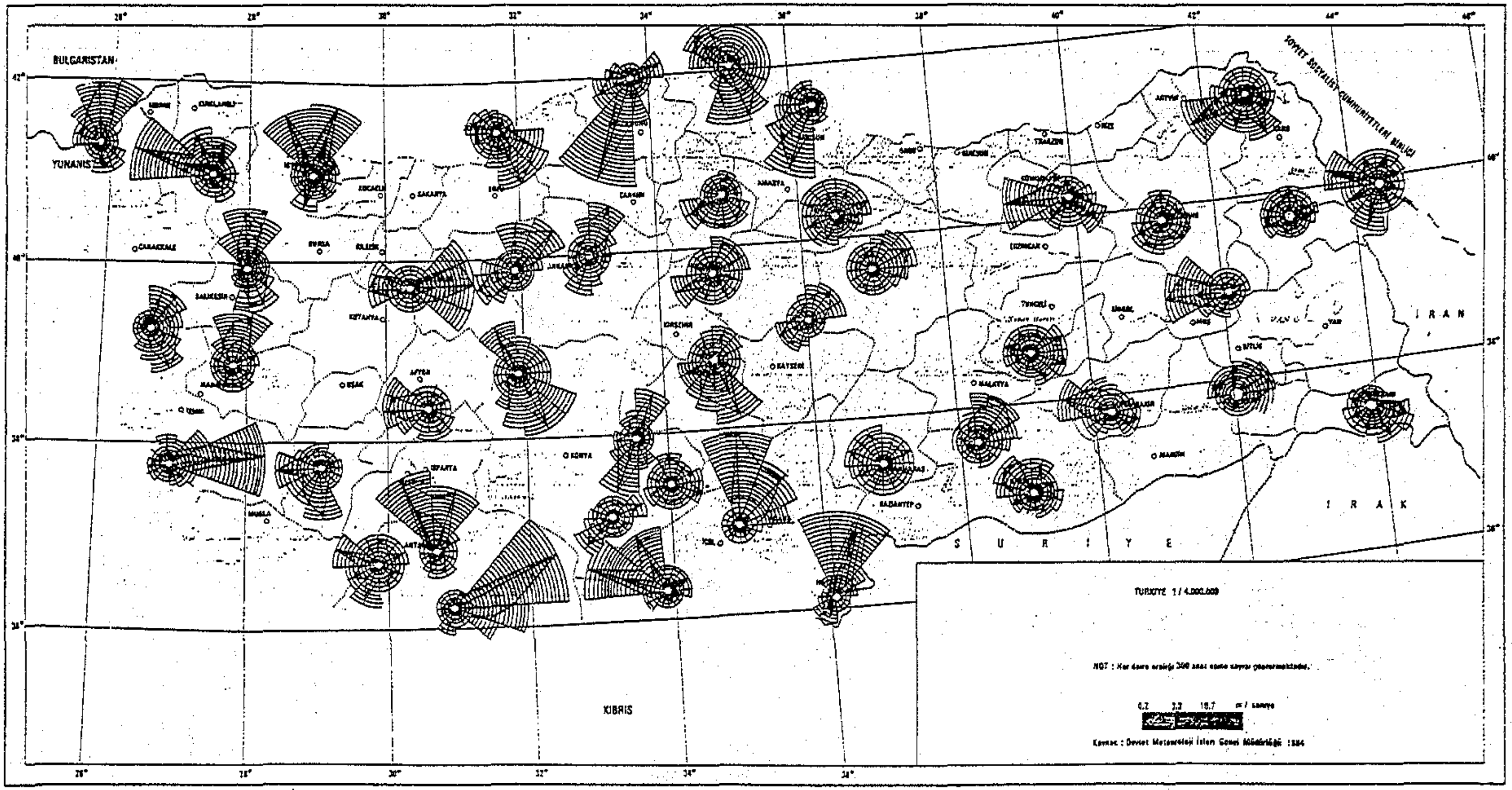
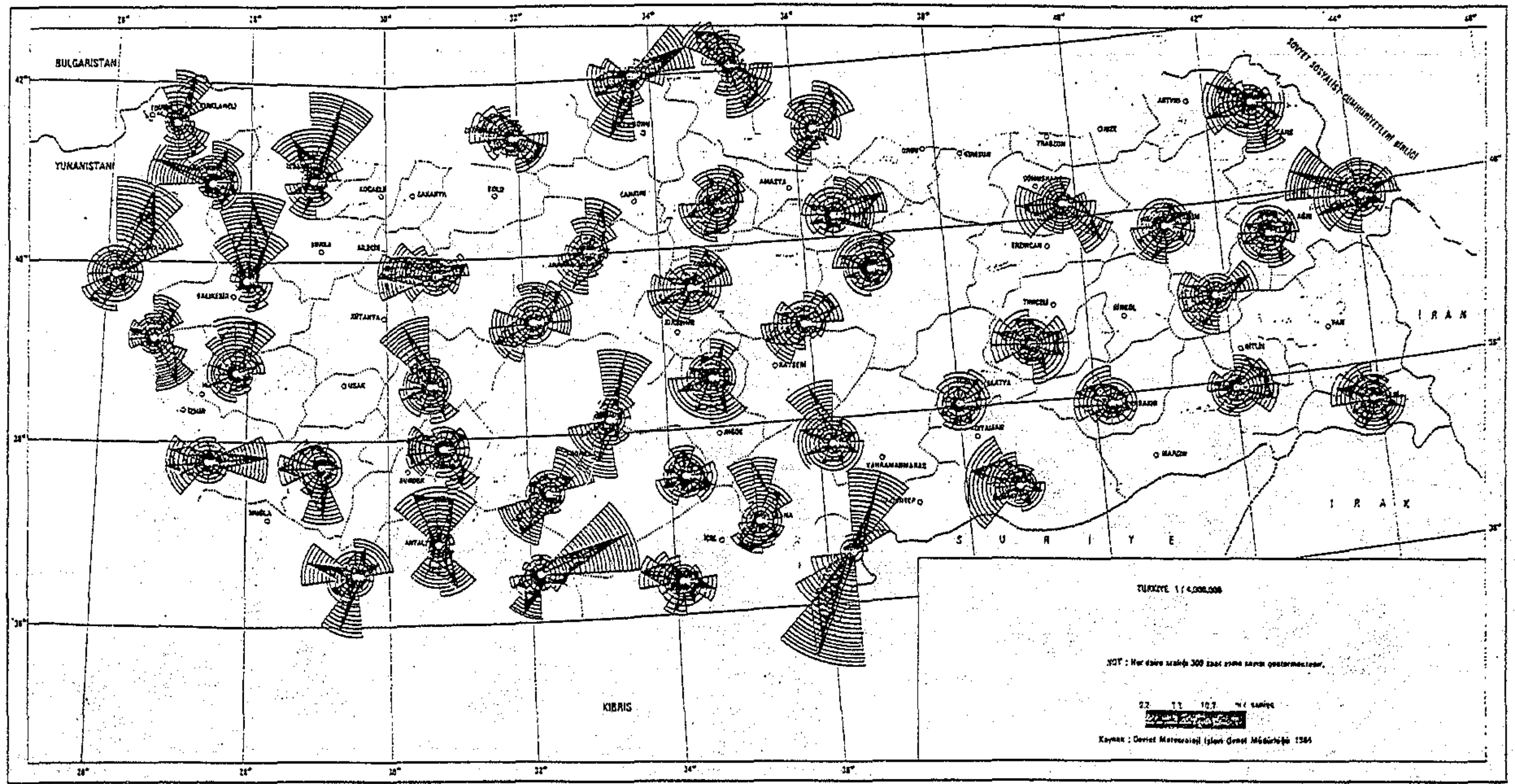


Fig. 5-1-19(a) Map of Ground Winds in Winter



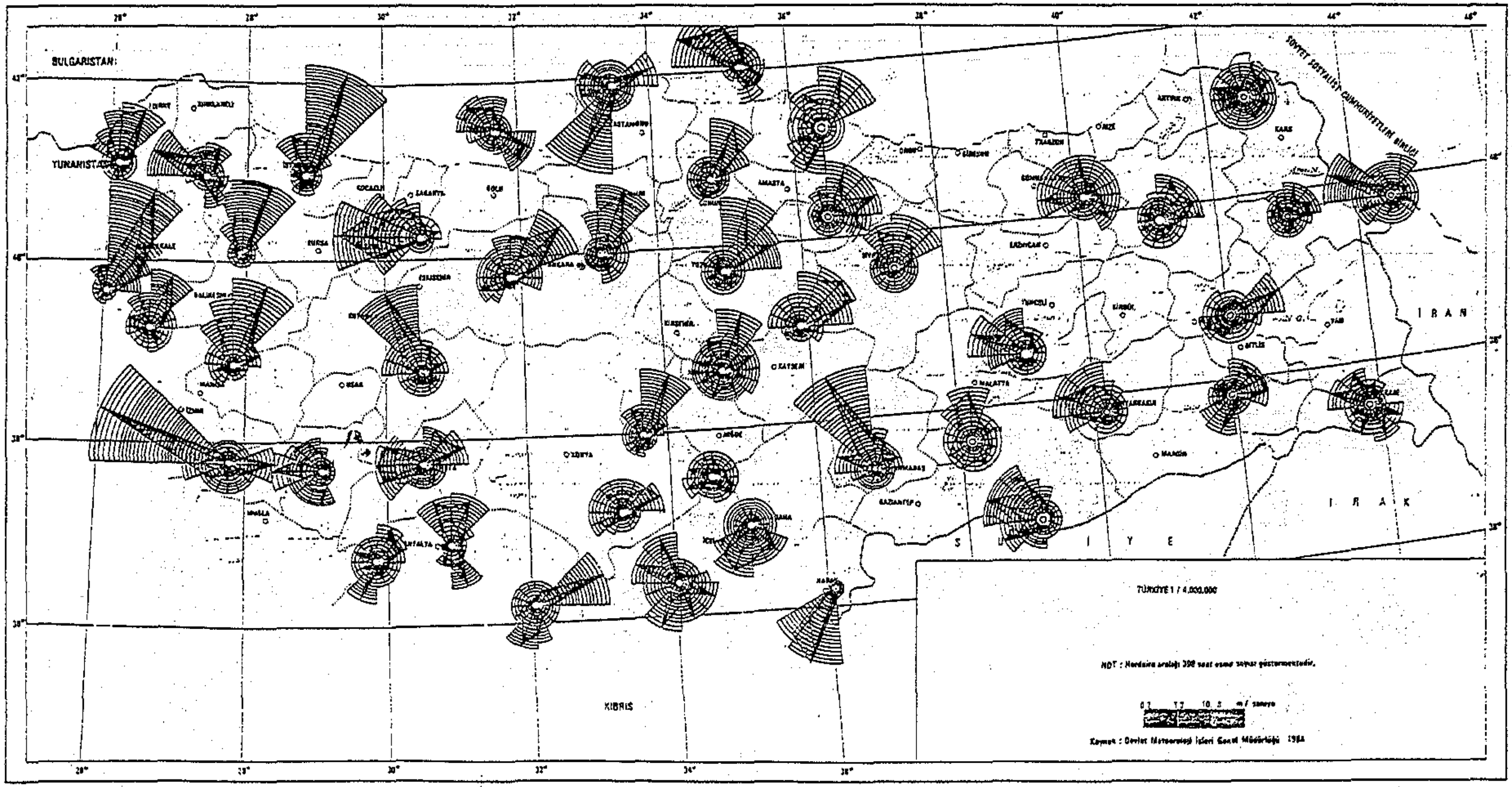
Note: every circle interval shows 300 hours blowing number

Fig. 5-1-19(b) Map of Ground Winds in Spring



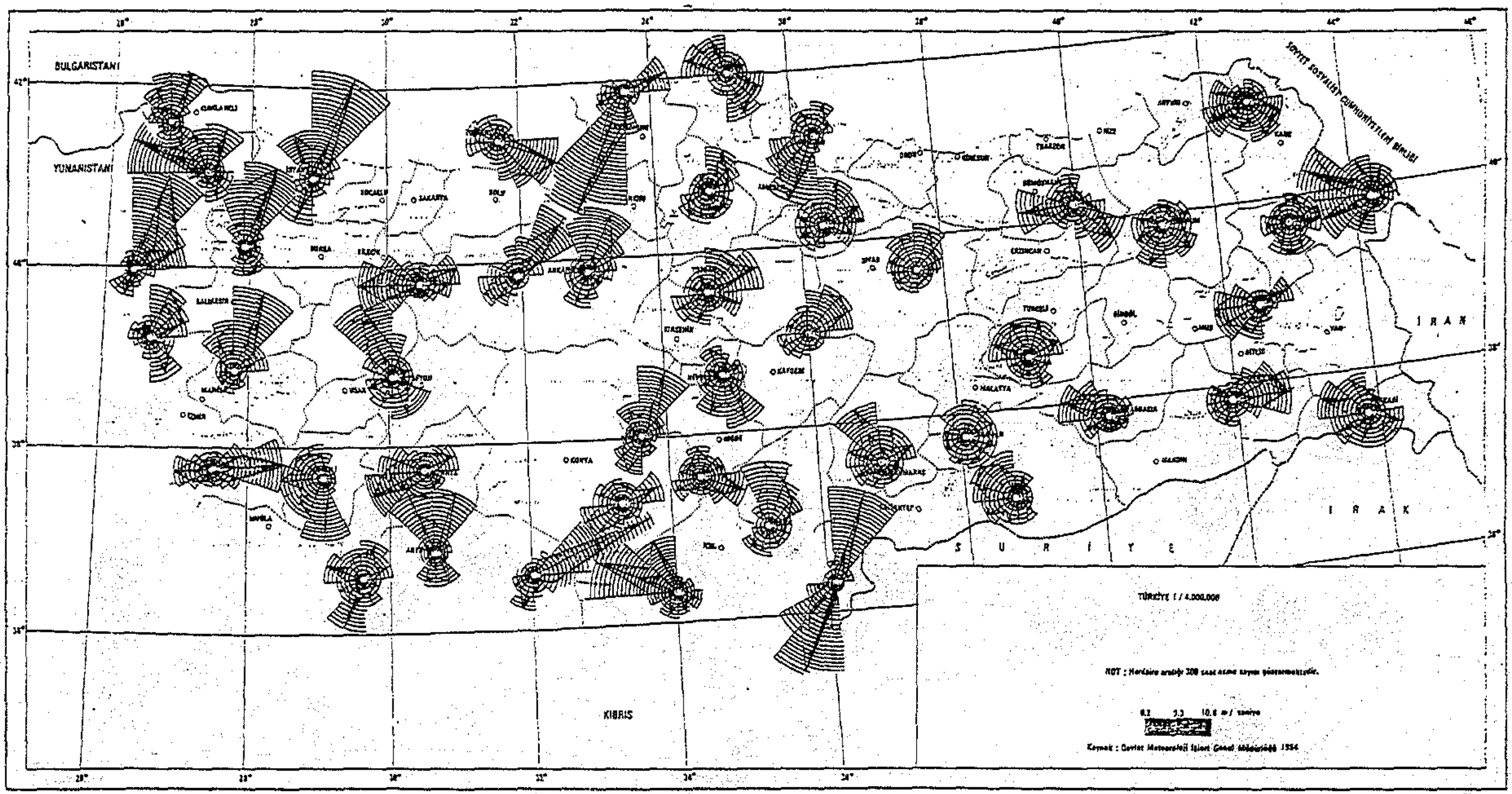
Note: every circle interval shows 300 hours blowing number

Fig. 5-1-19(c) Map of Ground Winds in Summer



Note: every circle interval shows 300 hours blowing number

Fig. 5-1-19(d) Map of Ground Winds in Autumn



Note: every circle interval shows 300 hours blowing number

Fig. 5-1-20 Monthly Wind Speed (Zonguldak)

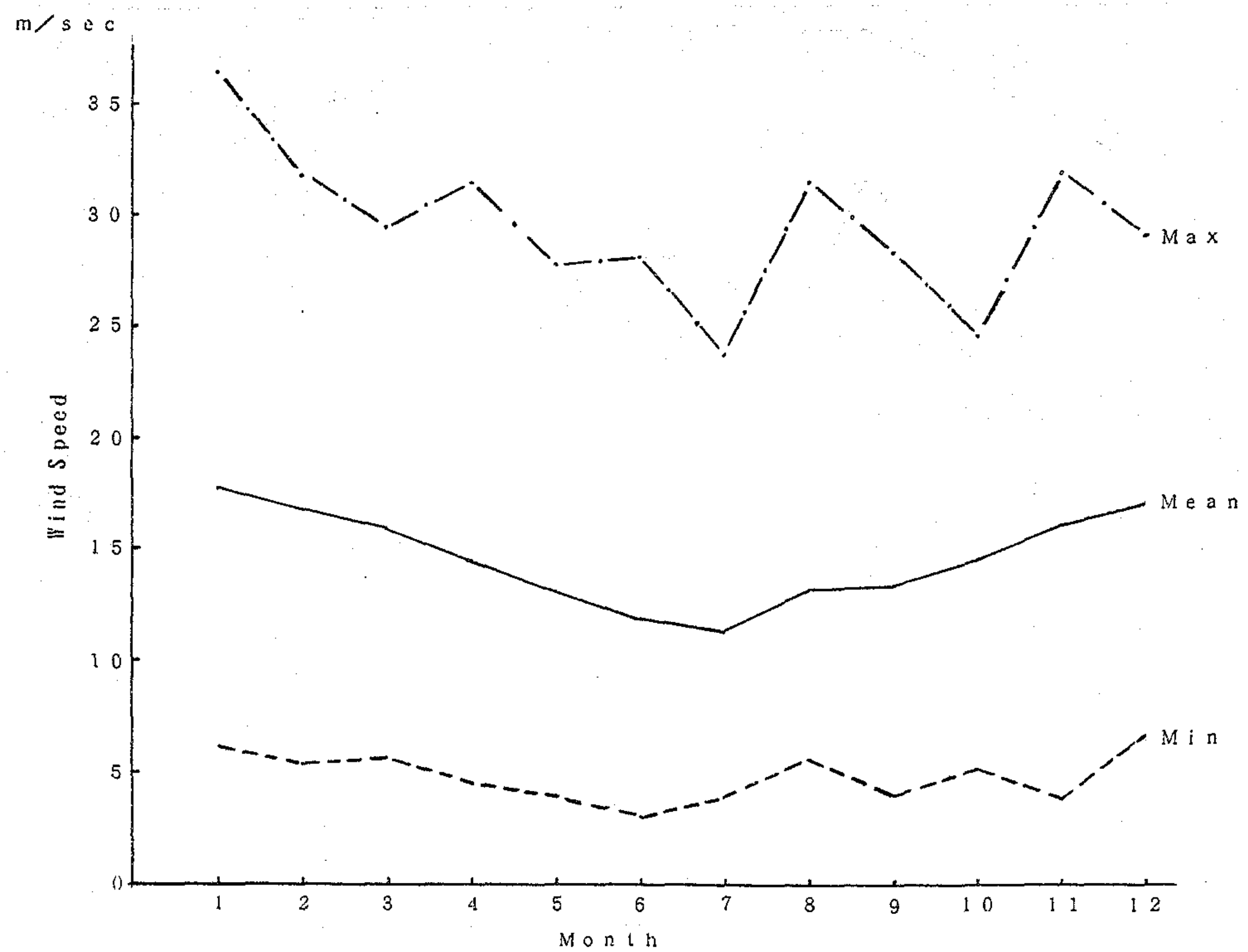


Fig. 5-1-21 Monthly Stormy Days (Zonguldak), over 17.2m/s

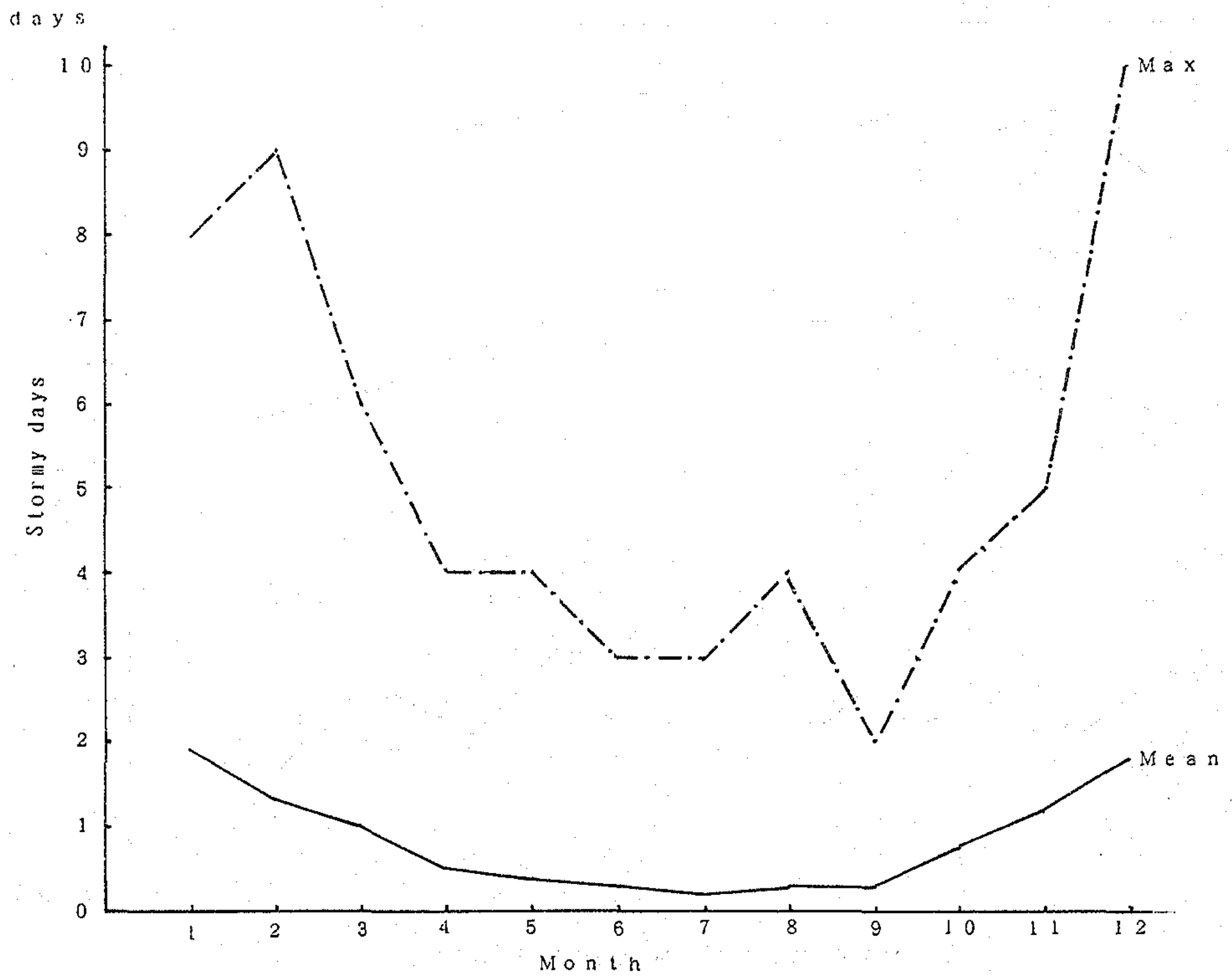


Fig. 5-1-22(a) Monthly Wind Rose (1987-1989)

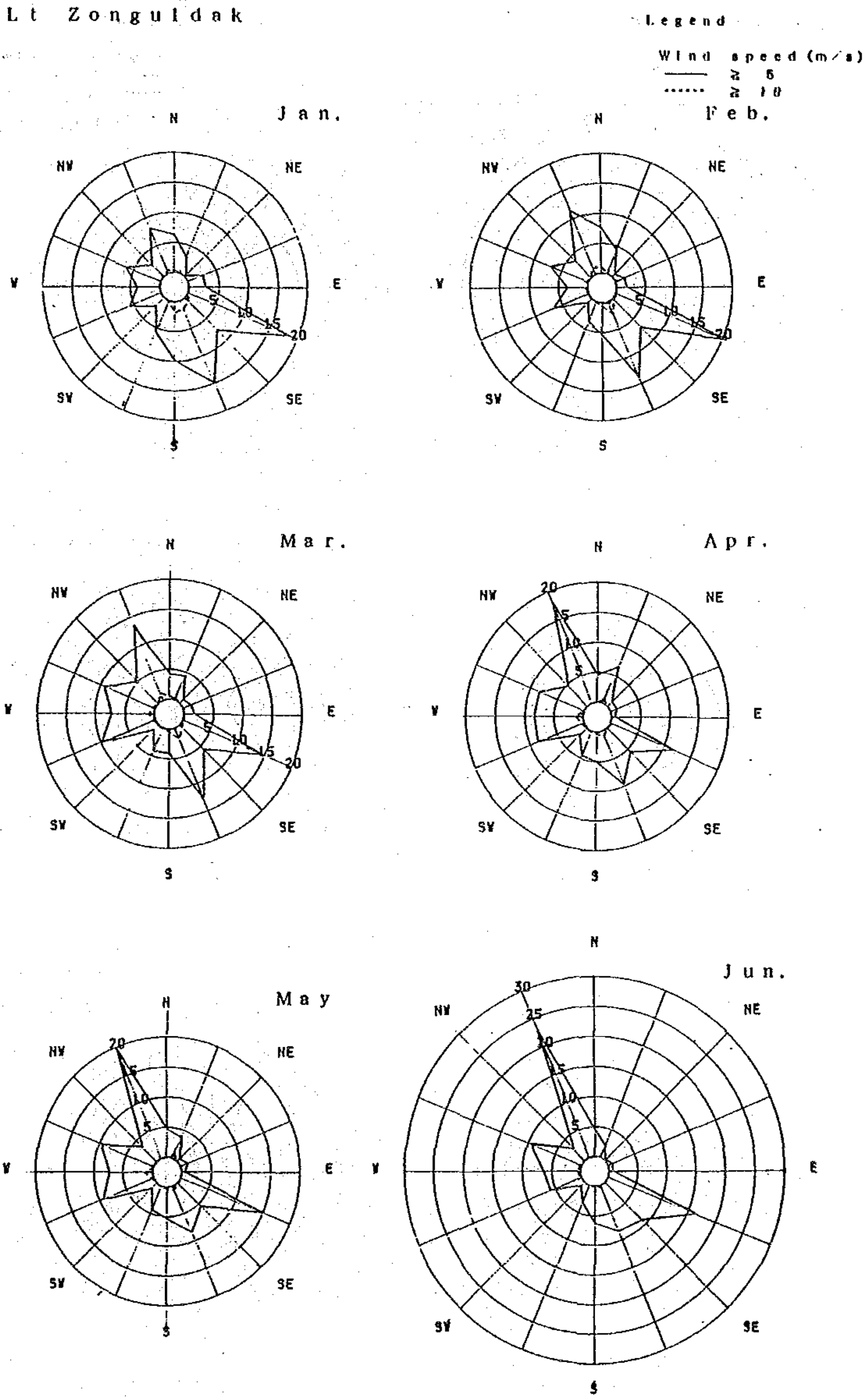


Fig. 5-1-22(b) Monthly Wind Rose (1987-1989)

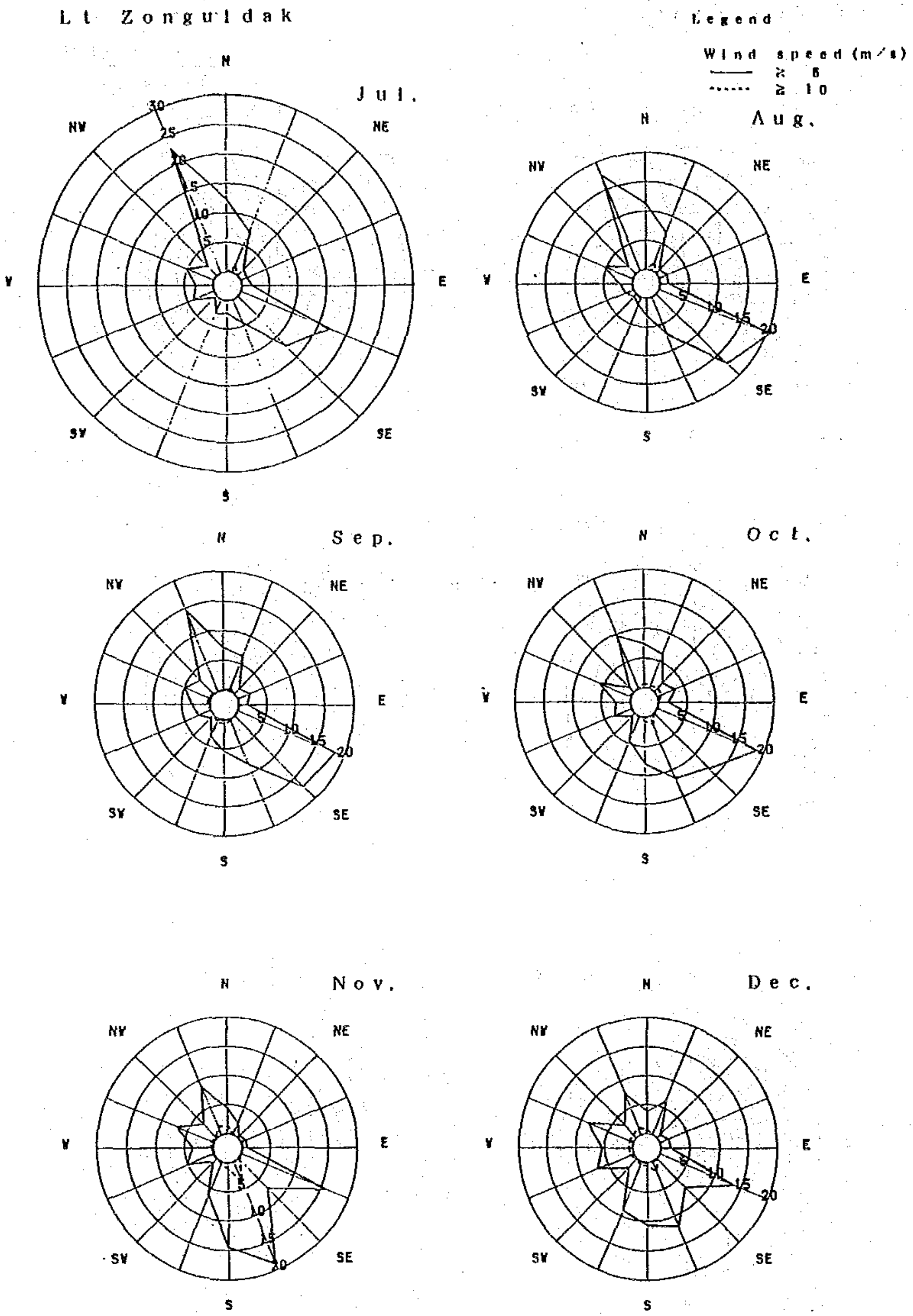


Fig. 5-1-23 Annual Wind Rose

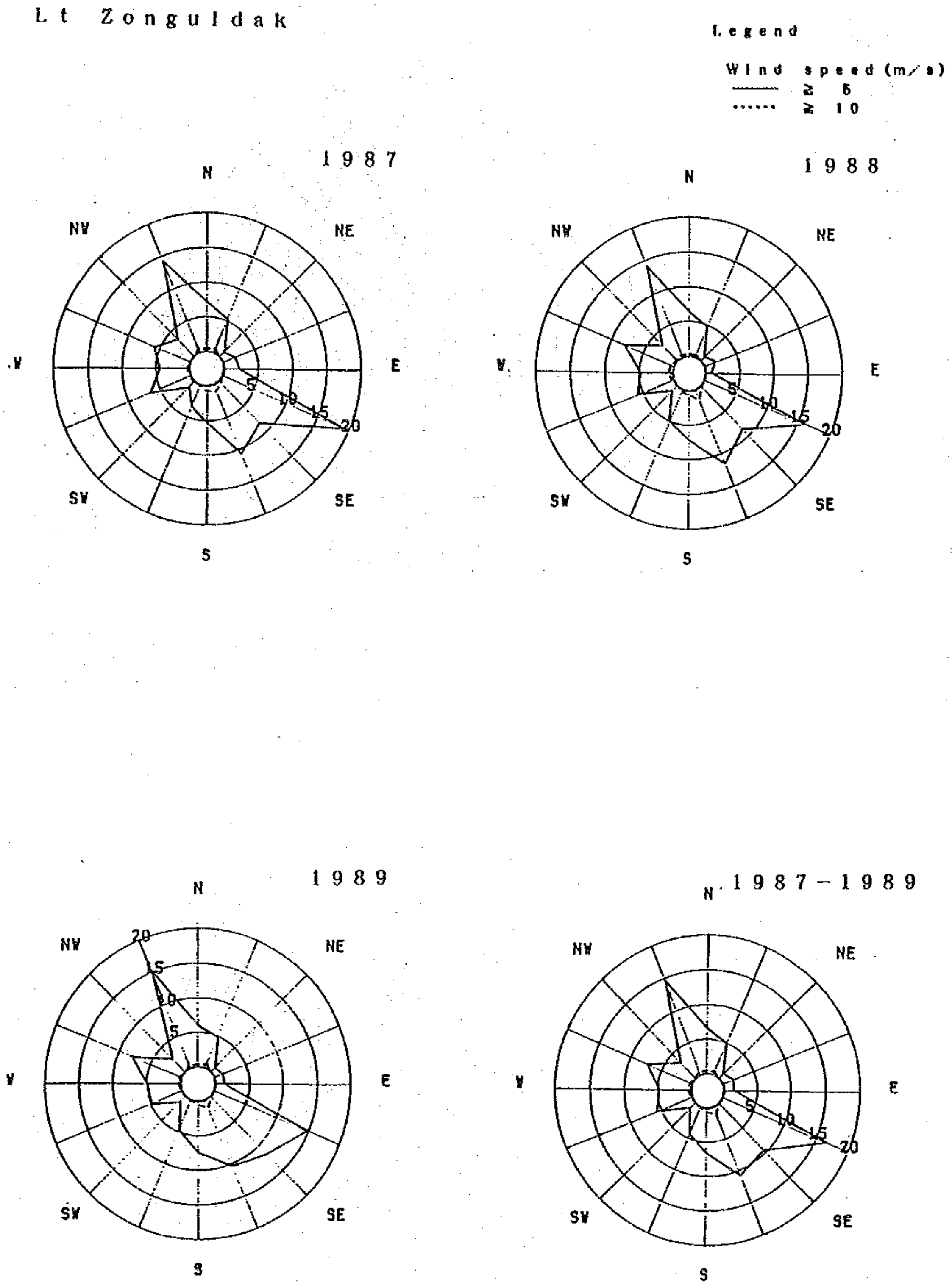


Fig. 5-1-24 Semi-diurnal Wind Rose (Zonguldak)

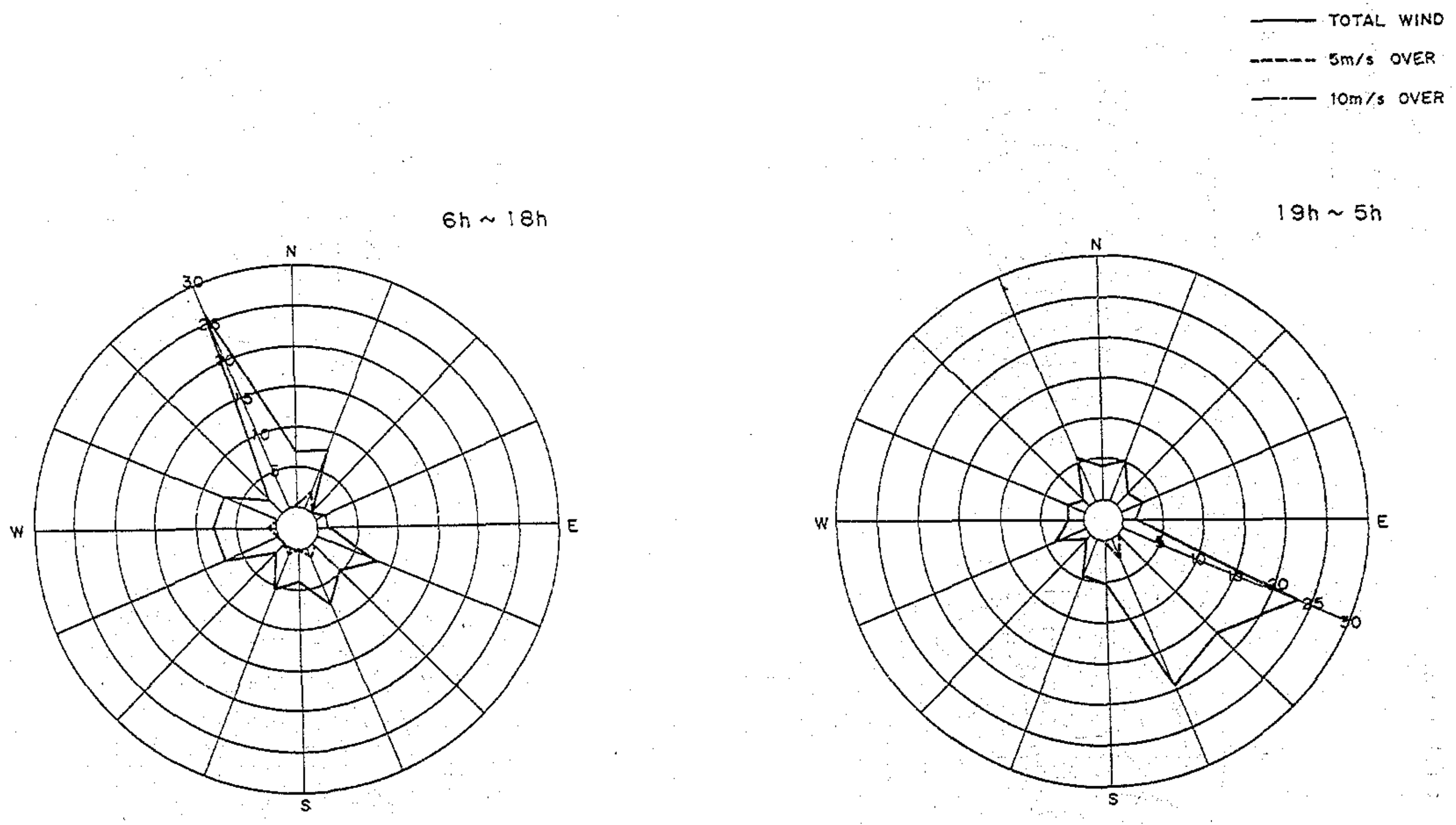
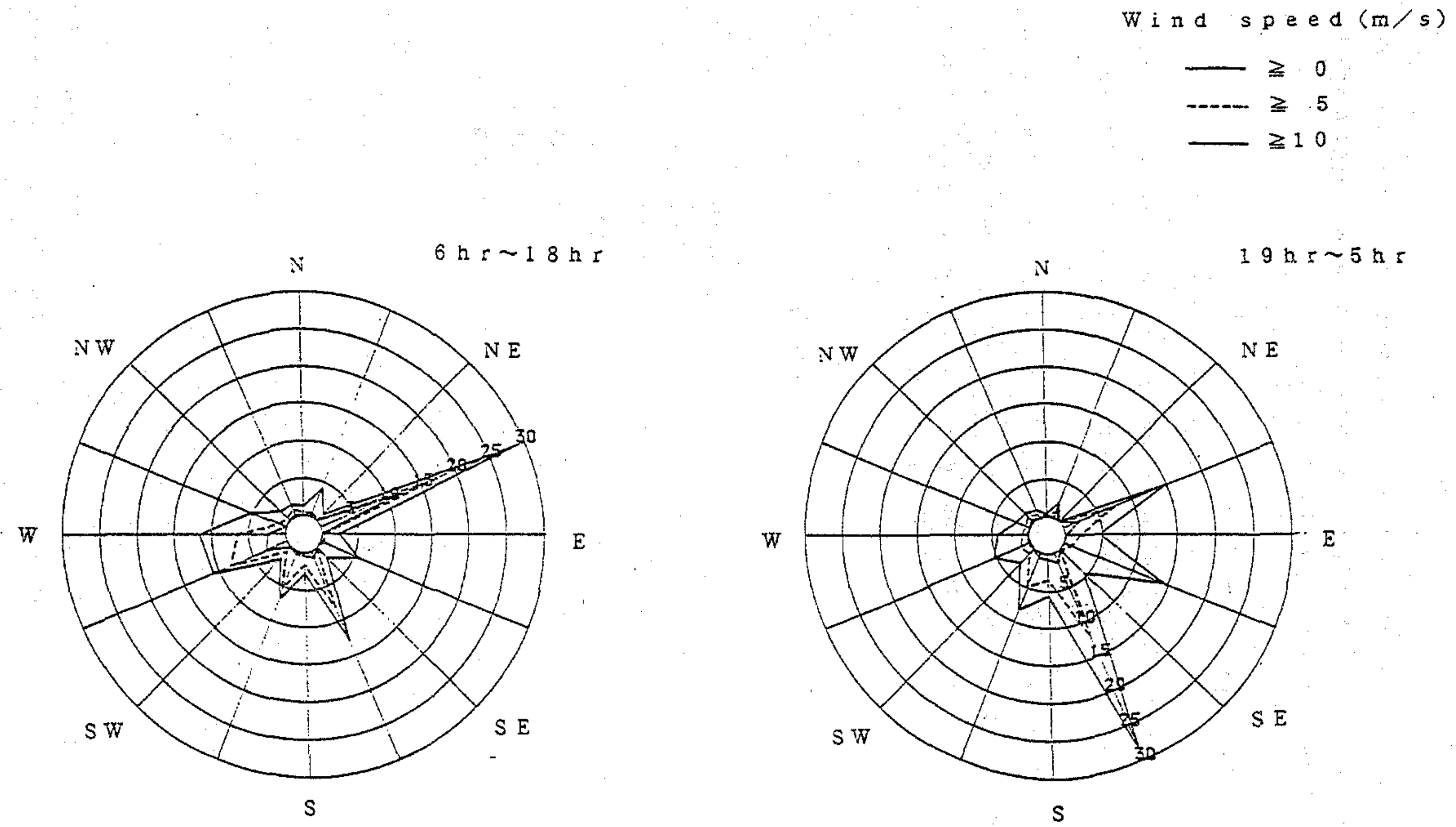


Fig. 5-1-25 Semi-diurnal Wind Rose (Amasra)



5-1-11 **Earthquake**

The seismic activity is most active (Region I) along the the hooked narrow belt connecting Van Lake and Egridir Lake through Aegean coast (Fig. 5-1-26). Filyos belongs to Region III.

5-1-12 **Filyos River**

The catchment area of Filyos River is explained with some hydrological and geological characteristics (Figs. 5-1-27 and A 5-1-14 and 15, and Tables 5-1-3 and A 5-1-13 to 16).

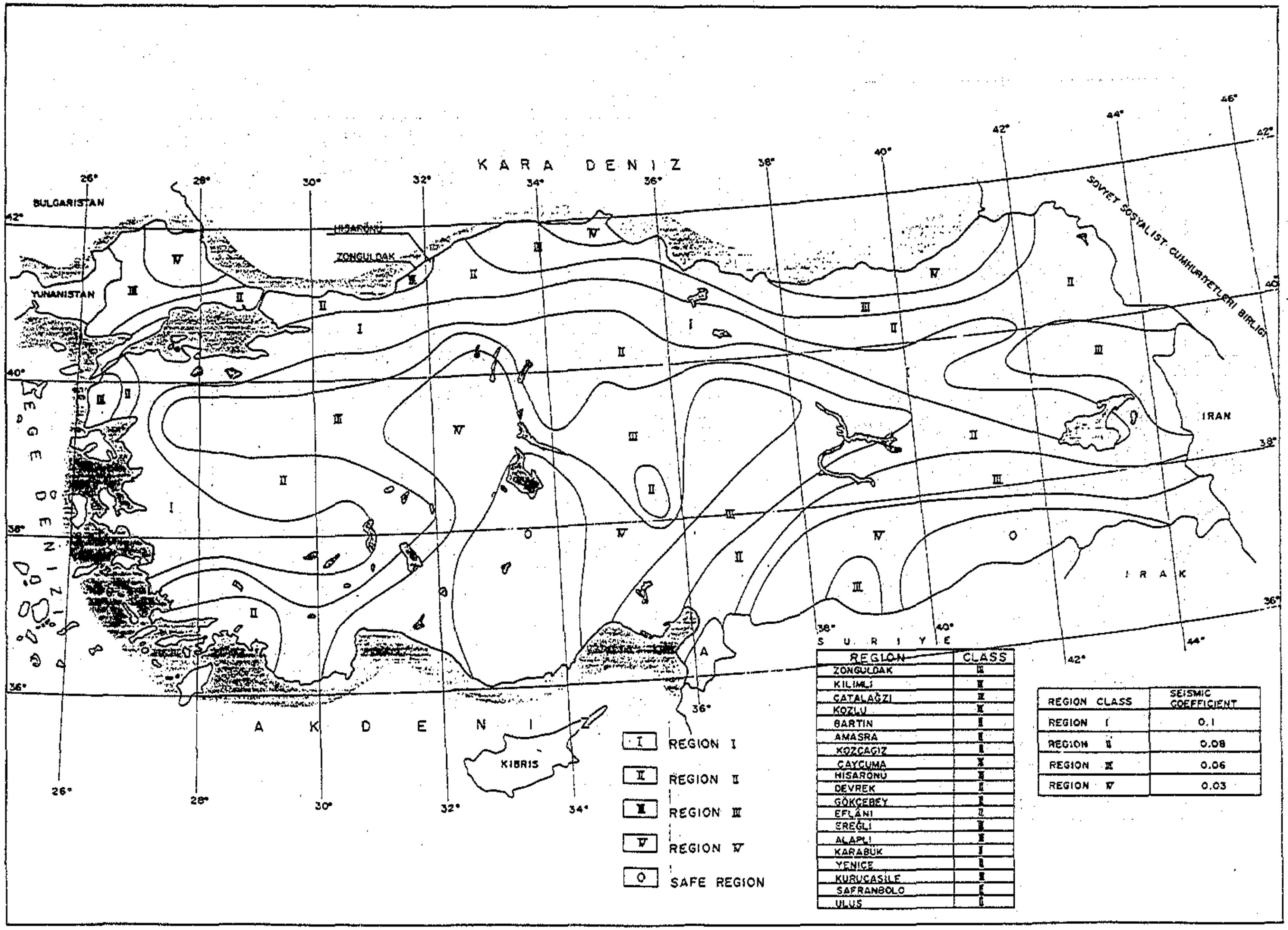
Evaporation is subtly influenced by the land use for agriculture and pasturage, and it is acordingly more practical to use hydrological data than meteorological data for the estimation of the actual evaporation out of the whole catchment of Filyos River (Table A 5-1-15).

Table 5-1-3 Discharge of Filyos River

Catchment area	13,300 km2
Annual discharge	3,269.41 hm3
Runoff ratio	0.503
Suspended material	244 t/y.km2
Annual sediment	268 t/y.km2
	(=233m3/y.km2)
Bed material load	10% of SS
Peak discharge - return period	
1140.02 m3/s	2.33 year
1643.27	5
2063.96	10
2588.02	25
2776.78	50
3362.67	100
4260	500
4647	1000

Discharge of 2,780m3/sec was recorded during a period between 21st and 26th of September, 1968 at Devecikiran Station when the railway bridge between Kayadiki and Tefen Stations was damaged seriously by the flood.

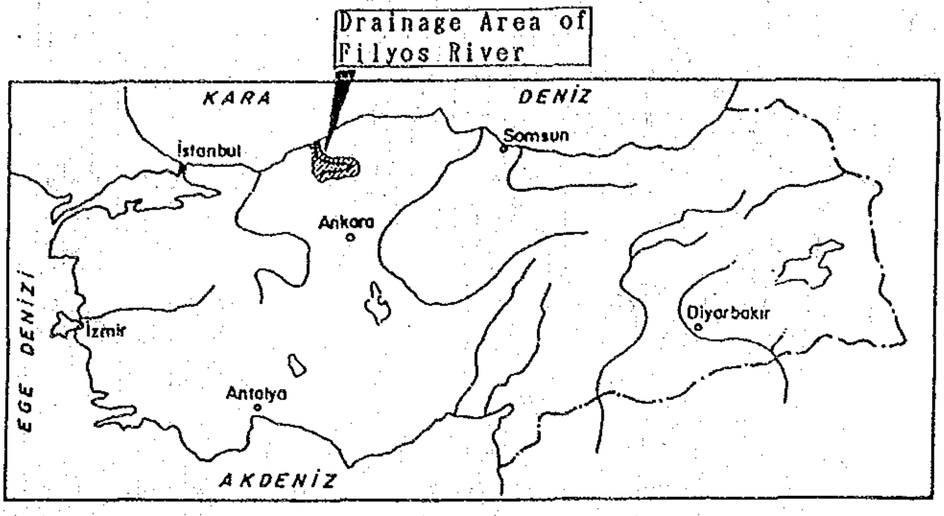
Fig. 5-1-26 SEISMIC ZONE



REGION	CLASS
ZONGULDAK	[illegible]
KILIMLI	[illegible]
ÇATALAĞZI	[illegible]
KOZLU	[illegible]
BARTIN	[illegible]
AMASRA	[illegible]
KOZCAĞIZ	[illegible]
ÇAYCUMA	[illegible]
HISARÖNÜ	[illegible]
DEVREK	[illegible]
GÖKÇEBEY	[illegible]
EFLÂNI	[illegible]
EREĞLI	[illegible]
ALAPLI	[illegible]
KARABÜK	[illegible]
YENICE	[illegible]
KURUCAŞILE	[illegible]
SAFRANBOLO	[illegible]
ULUS	[illegible]

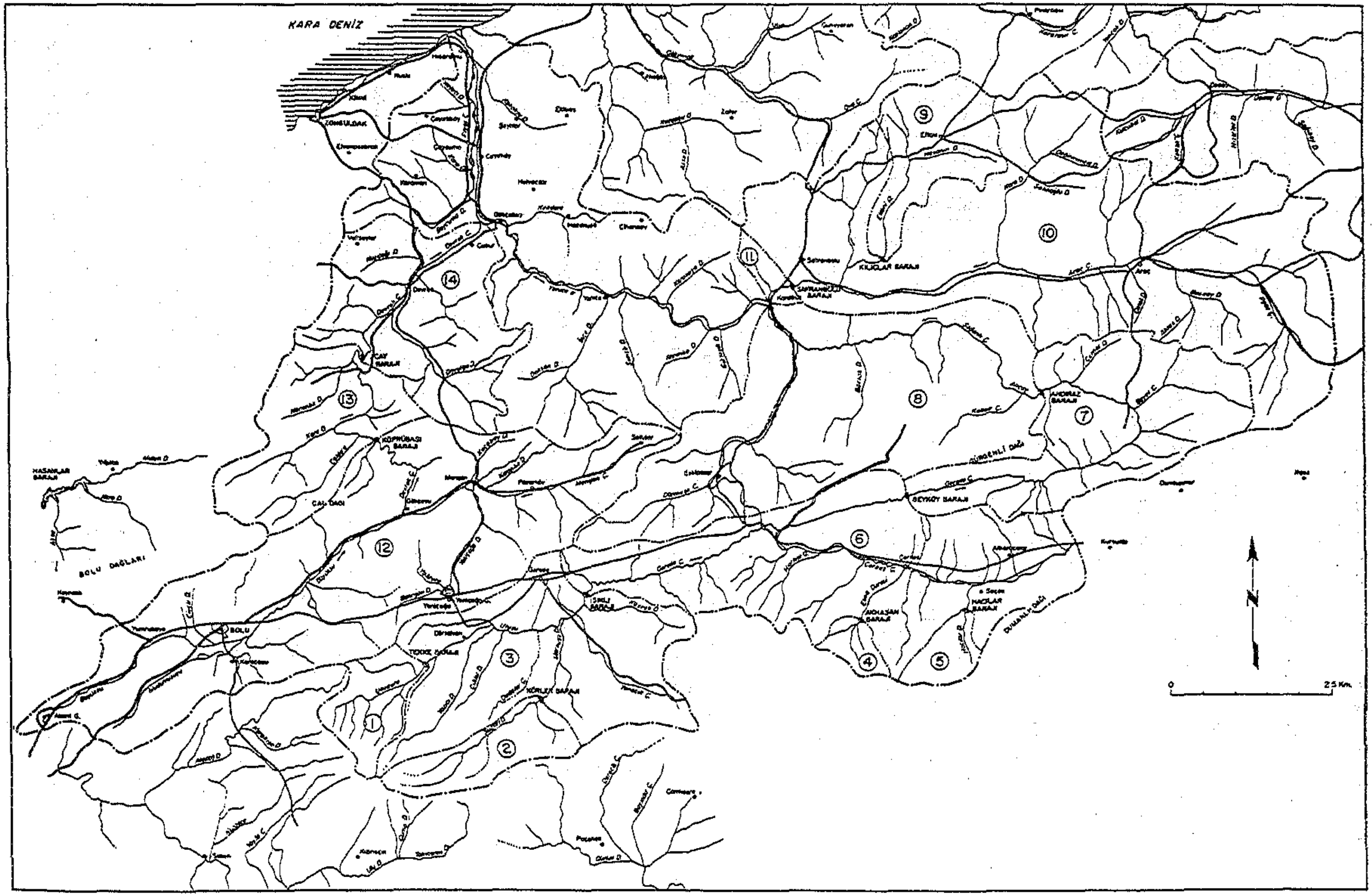
REGION CLASS	SEISMIC COEFFICIENT
REGION I	0.1
REGION II	0.08
REGION III	0.06
REGION IV	0.03

Fig. 5-1-27(a) Drainage Area of Filyos River



	Drainage Area		Intermediate Drainage Area (Ha)	Total Drainage Area (Ha)
Filyos River	① Tekke	Dam	193.75	193.75
	② Körler	Dam	206.25	206.25
	③ Işikli	Dam	912.50	1,312.50
	④ Akhason	Dam	59.37	59.37
	⑤ Hacial	Dam	93.75	93.75
	⑥ Beyköy	Dam	1,309.38	2,775.00
	⑦ Andiroz	Dam	838.12	3,613.12
	⑧ Filyos	River	1,473.68	5,086.80
Tributaries	⑨ Kiliçlar	Dam	340.62	340.62
	⑩ Safranbolu	Dam	2,409.38	2,750.00
	⑪ Araç	River	83.20	2,833.20
	⑫ Köprübasi	Dam	2,034.37	2,034.37
	⑬ Çay	Dam	387.50	2,421.87
	⑭ Devrek	River	706.25	3,128.12
	Total			13,300.00

Fig. 5-1-27(b) Drainage Area of Filyos River



5-2 Oceanographical Conditions

5-2-1 Water Temperature

The surface water temperatures are 0 to 8°C in winter and 21 to 25°C in summer, and higher in the south and east area of the Black Sea (Fig. 5-2-1). The water temperature varies annually between 7 and 24°C near Filyos.

5-2-2 Salinity

Salinity is 14‰ or 40% of oceanic water on the surface, increases proportionally to the depth down to 100m and gradually approaches to 17‰ or 50% of oceanic water in deeper layer (Table A 5-2-1 and Fig. 5-2-2).

5-2-3 Tide

The water level of the Black Sea is hardly affected by tides however it is subject to considerable changes due to variations in the volume of water discharged by the rivers and variations of wind and atmospheric pressure.

The average spring range is only 8cm in the western part. The water level rises by 60cm due to strong winds in the Bosporus and Dardanelles.

Atmospheric disturbances also cause seiches with the wave height of 5cm or more.

The water level in the Black Sea is maintained by the enormous volume of water discharged by rivers and by the relatively much rainfall over the eastern part of the Black Sea. The volume of water discharged by the Danube alone is about 300,000m^3/year, which corresponds to the rising rate of 30cm/year of water level. The surface of the Black Sea is almost invariably 40cm higher than that of the Marmara Sea and, still more, of the Mediterranean.

5-2-4 Current

In the Black Sea, the current system is characterized by a counter-clockwise circulation and an almost steady flow from the Black Sea to the

Fig. 5-2-1(a) Sea Surface Temperature (Winter)

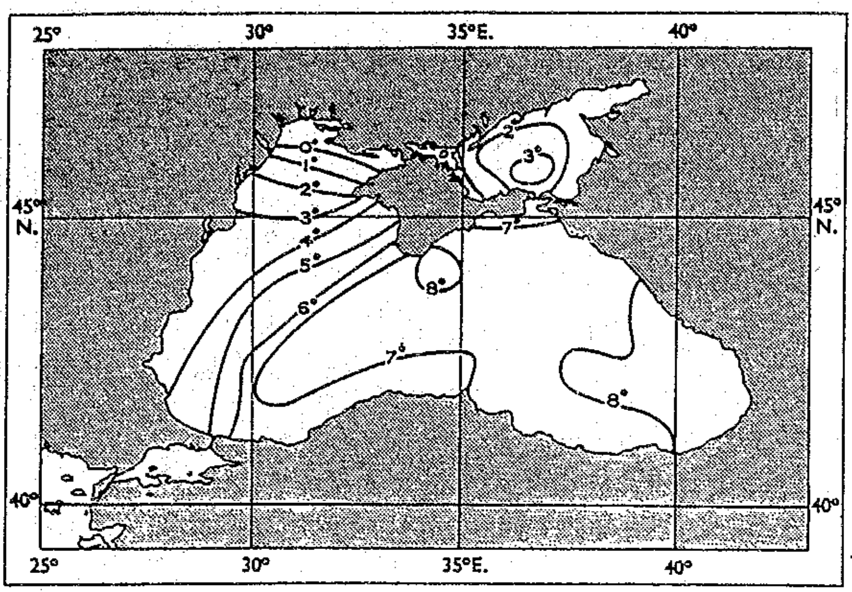


Fig. 5-2-1(b) Sea Surface Temperature (Spring)

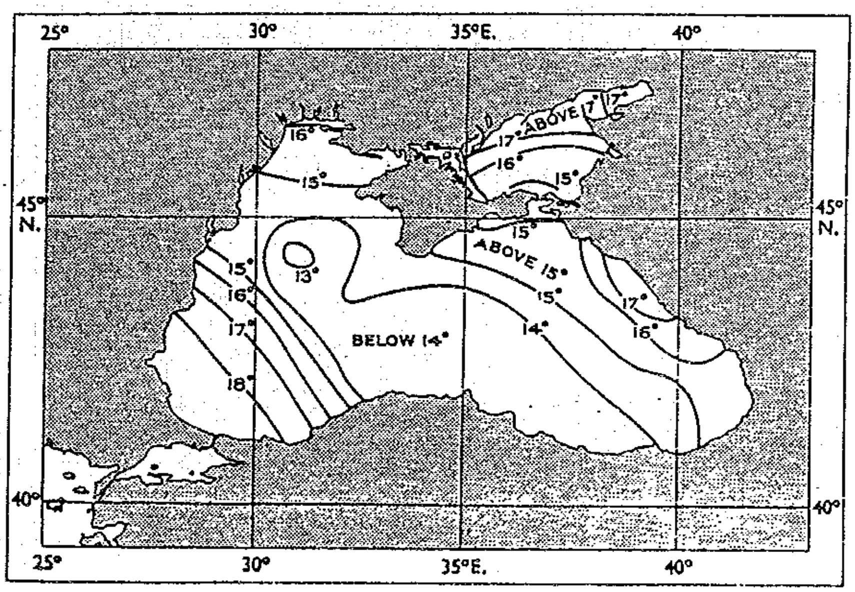


Fig. 5-2-1(c) Sea Surface Temperature (Summer)

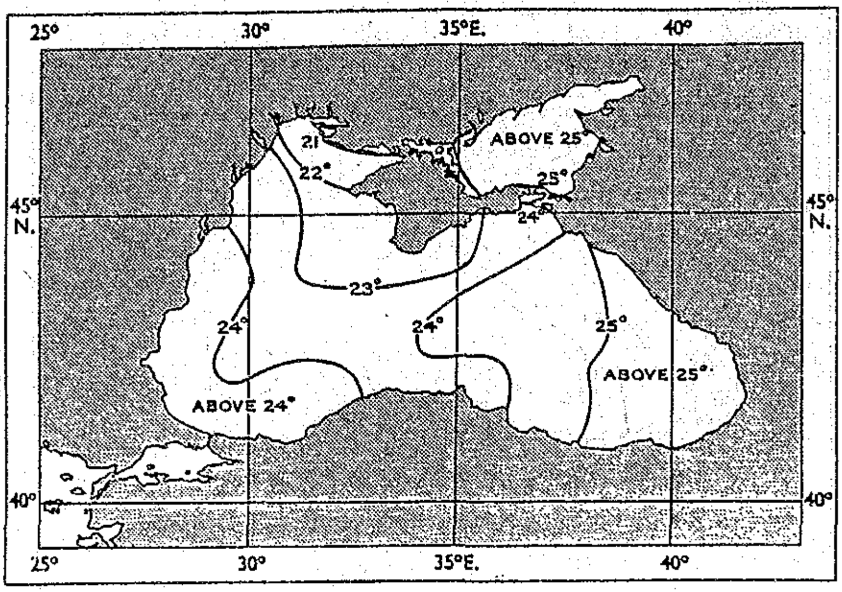


Fig. 5-2-1(d) Sea Surface Temperature (Autumn)

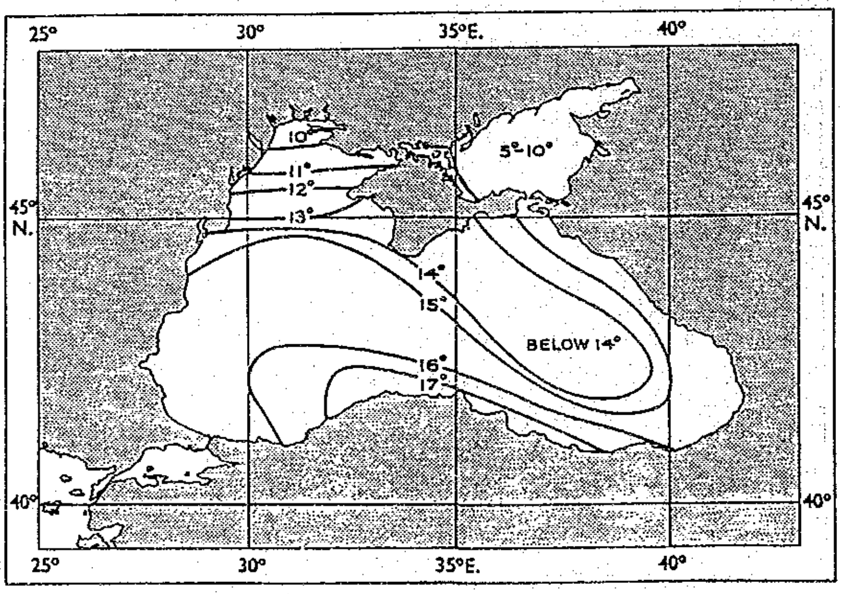
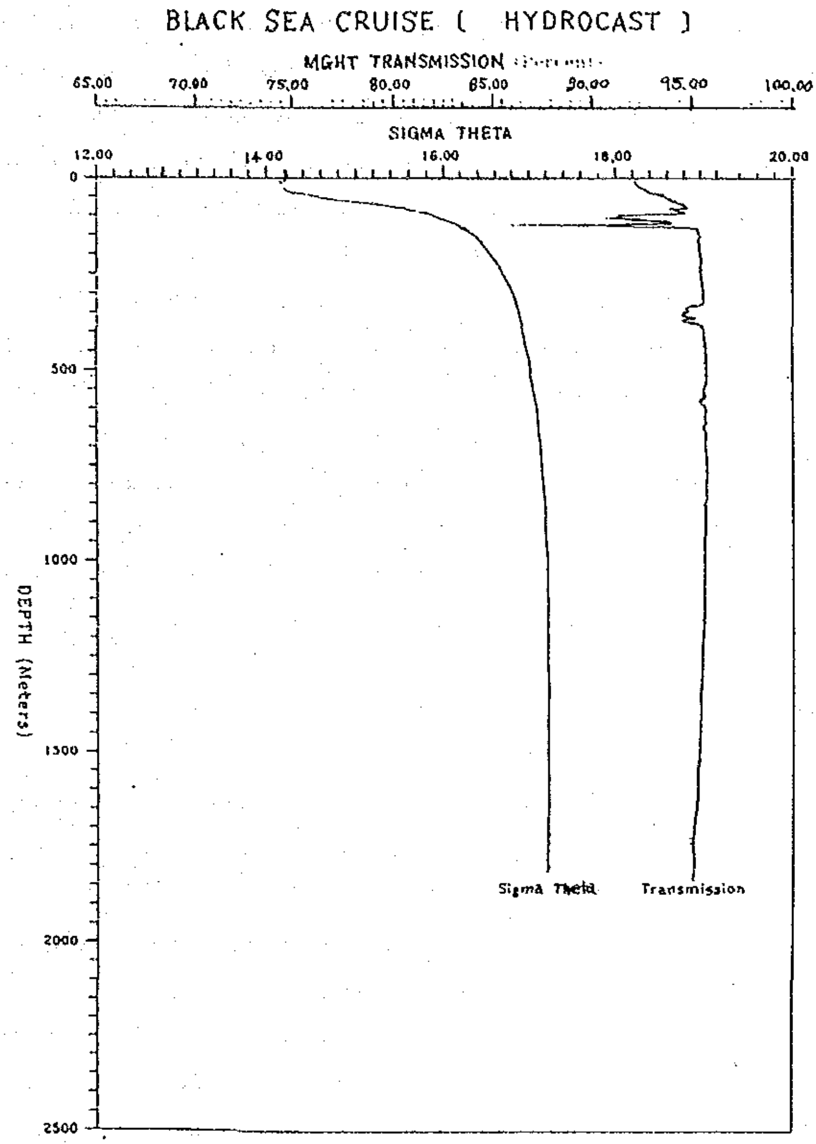


Fig. 5-2-2 Salinity



Mediterranean, through the Bosporus, the Marmara Sea and the Dardanelles (Fig. 5-2-3).

The outfolw from the Black Sea to the Mediterranean is accelerated by the prevalent N and NE winds for about 9 months of the year, but it is decelerated or even converted into the inflow under southerly winds. Below the surface outflow, there exists the slower and salter sub-surface inflow, compensating approx. one third of the outflow through both Straits.

The currents of the Black Sea are generally weak and inconstant, influenced by river discharges, winds and atmospheric disturbances. The discharge from the Dnieper flows westwards and thence southwards along the coast, receiving the outflow of the Dniester on its way (0.50 to 0.75 kt). Then the current receives a great accession of the Danube and turns its color into yellowish-green. The confluent current of river discharges sets southward and south-south-eastward and mostly flows out through the Bosporus. The remainder continues in the ENE direction along the Anatolian coast, gradually decelerating from 0.50-0.75 kt to 0.25-0.50 kt.

5-2-5 Wave

Along Turkish coast, waves have already been predicted at 15 stations, by Middle East Technical University (METU), as probable deepwater waves, which are unaffected by bathymetry (Fig. 5-2-4 and Table 5-2-1). Significant wave heights are 6 to 7m along the Mediterranean and 4.5 to 5.5m along the Black Sea for recurrent period of 50 years, predicted through synoptic map(Table 5-2-2 and Fig. 5-2-5). The deepwater waves at Amasra are applicable to Filyos (Table 5-2-3 and Fig. 5-2-6).

In 1963 to 1966, METU observed waves at Catalagzi, which are high in winter and low in summer (Table 5-2-4 and Fig. 5-2-7). Low waves with the heights less than 1m occupy the prevalence of 80 to 90% of the year.

5-2-6 Sand Drift

METU also observed sand movement at Catalagzi, where the situation is supposedly analogous to the coast near Filyos.

Fig. 5-2-3 Surface Current of the Black Sea and Sea of Azov.

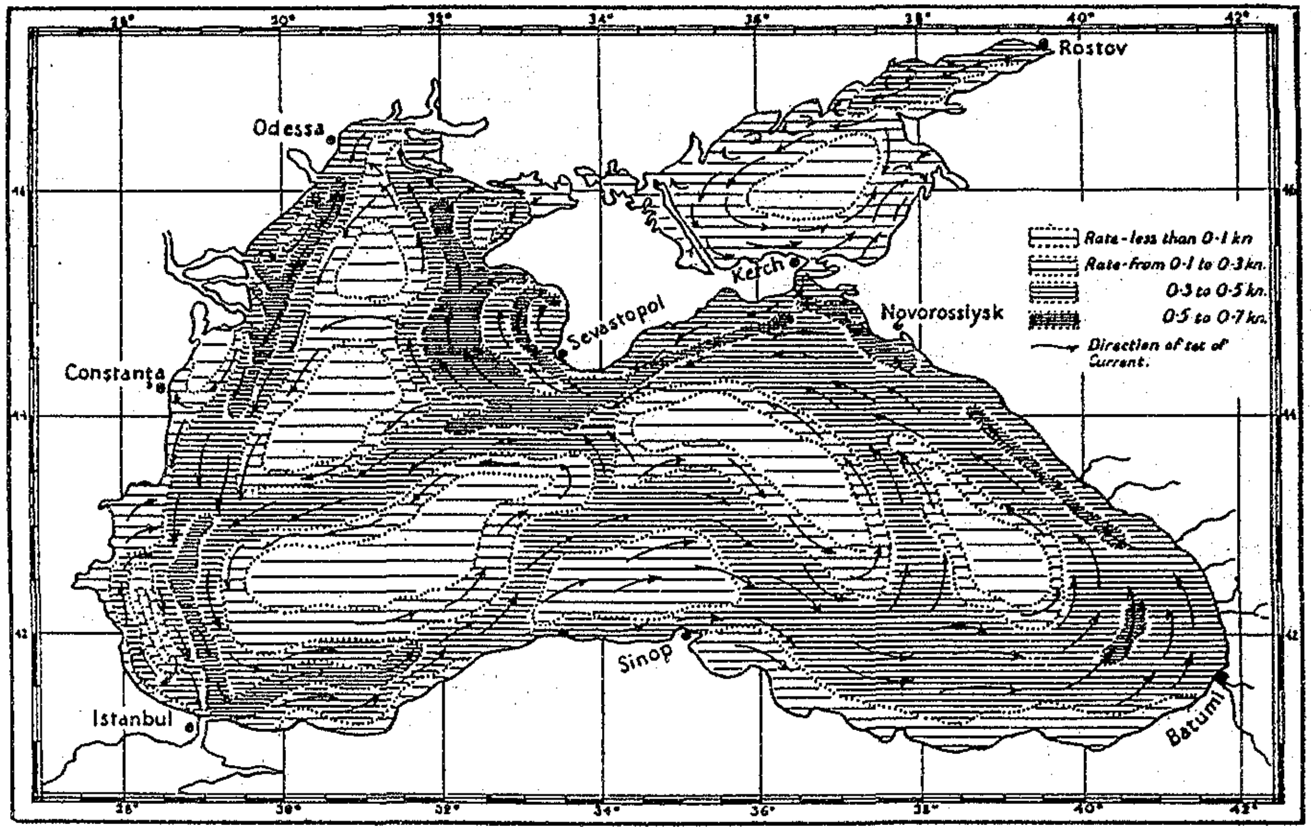


Fig. 5-2-4 Locations of Wave Prediction

Table 5-2-1 Locations of Wave Prediction

No.	Location	Sea		Organization
1	Anamur	İçel	Akdeniz	Balıkçı Barınağı
2	Titreyen Göl	Antalya	Akdeniz	Yat Yanaşma Yeri
3	Kaş	Antalya	Akdeniz	Yat Yanaşma Yeri
4	Datça	Muğla	Akdeniz	Turizm Limanı
5	Kuşadası	İzmir	Ege	Turizm Limanı
6	Babakale	Çanakkale	Ege	Balıkçı Barınağı
7	Uğurlu	Çanakkale Gökçeada	Ege	Balıkçı Barınağı
8	Güneyli	Çanakkale	Ege	Balıkçı Barınağı
9	Marmara Ereğlisi	Tekirdağ		Balıkçı Barınağı
10	Tuzla	İstanbul	Marmara	Yat Limanı
11	Amasra	Zonguldak	Karadeniz	Balıkçı Barınağı
12	Çatalzeytin	Kastamonu	Karadeniz	Balıkçı Barınağı
13	Ünye	Ordu	Karadeniz	Balıkçı Barınağı
14	Mersinköy	Ordu	Karadeniz	Balıkçı Barınağı
15	Çayeli	Ordu	Karadeniz	Balıkçı Barınağı

Table 5-2-2(a) Probable Wave (15 Locations)

No.	method	H_S (m) / T_S (s)	return period R_p (year) 10	25	50	100	direction
1	M	H_S T_S	5.17±0.10 8.62	5.81±0.14 9.14	6.28±0.18 9.50	6.76±0.21 9.86	WSW -SW, ESE
	S	H_S T_S	5.62±0.43 8.81	6.40±0.61 9.40	6.98±0.76 9.82	7.55±0.90 10.27	
2	M	H_S T_S	4.03±0.11 7.72	4.67±0.16 8.30	5.15±0.20 8.72	5.62±0.23 9.11	WSW -SW, SSW -S
	S	H_S T_S	5.56±0.51 8.81	6.08±0.73 9.21	6.46±0.91 9.50	6.84±1.08 9.77	
3	M	H_S T_S	4.18±0.19 8.24	5.44±0.27 8.76	6.25±0.33 9.40	6.86±0.39 9.84	WSW -SW, SSE -SE
	S	H_S T_S	5.36±0.23 8.55	5.79±0.34 8.89	6.11±0.42 9.15	6.43±0.50 9.56	
4	S	H_S T_S	5.25±0.24 8.47	6.08±0.34 9.12	6.70±0.42 9.57	7.31±0.50 10.0	SW -SSW,
5	M	H_S T_S	3.06±0.19 6.59	3.75±0.27 7.29	4.26±0.34 7.77	4.78±0.40 8.23	WNW -WSW, SW
	S	H_S T_S	2.82±0.48 6.29	3.36±0.69 6.87	3.77±0.86 7.27	4.17±1.02 7.65	
6	M	H_S T_S	4.05±0.07 7.29	4.47±0.09 7.66	4.78±0.12 7.92	5.08±0.14 8.17	WSW -SW, SSW
	S	H_S T_S	4.73±0.29 8.48	5.44±0.41 9.09	5.97±0.51 9.52	6.50±0.61 9.94	
7	S	H_S T_S	4.66±0.28 7.95	5.37±0.40 8.53	5.90±0.49 8.94	6.42±0.59 9.33	SW -SSW
8	S	H_S T_S	1.12±0.04 4.23	1.21±0.06 4.40	1.28±0.08 4.52	1.35±0.09 4.65	NNE -NE,W

Table 5-2-2(b) Probable Wave (15 Locations)

9	M	H_S T_S	2.78±0.06 5.99	3.13±0.09 6.36	3.38±0.11 6.61	3.64±0.13 6.86	SW, S- SSE
	S	H_S T_S	3.29±0.21 6.52	3.73±0.30 6.94	4.06±0.37 7.24	4.39±0.44 7.53	
10	M	H_S T_S	1.65±0.06 4.66	1.95±0.08 5.07	2.18±0.10 5.36	2.40±0.12 5.62	WSW -SW
	S	H_S T_S	2.36±0.13 5.58	2.64±0.19 5.91	2.85±0.23 6.14	3.05±0.28 6.35	
11	M	H_S T_S	3.43±0.09 7.12	3.81±0.13 7.51	4.09±0.16 7.78	4.37±0.20 8.04	N- NE, WNW -NNW
	S	H_S T_S	4.00±0.28 7.43	4.74±0.40 8.09	5.29±0.49 8.54	5.84±0.59 8.97	
12	M	H_S T_S	6.56±0.07 9.89	7.08±0.10 10.28	7.46±0.12 10.55	7.85±0.14 10.82	N- NE, WNW -NW
	S	H_S T_S	3.66±0.22 7.26	4.21±0.31 7.78	4.62±0.39 8.16	5.03±0.46 8.51	
13	S	H_S T_S	3.39±0.30 6.48	3.99±0.44 7.43	4.44±0.54 7.83	4.88±0.64 8.21	NW-NNW, NNE-NE
14	M	H_S T_S	2.51±0.06 6.05	2.77±0.09 6.36	2.96±0.11 6.58	3.15±0.13 6.78	NW- NNW, NNE -NE
	S	H_S T_S	3.39±0.30 6.84	4.00±0.34 7.43	4.44±0.44 7.83	4.88±0.64 8.21	
15	M	H_S T_S	1.24±0.04 4.13	1.41±0.06 4.40	1.54±0.07 4.60	1.67±0.08 4.79	WNW -NW, N- NNE
	S	H_S T_S	3.84±0.31 7.27	4.50±0.45 7.87	4.98±0.55 8.27	5.46±0.66 8.66	

M : Meteorological Data, S : Synoptic Map,

H_S & T_S : Height & Period of Significant Wave

Fig. 5-2-5 WAVE ALONG TURKISH COAST
(RECURRENT PERIOD OF 50 YEAR)

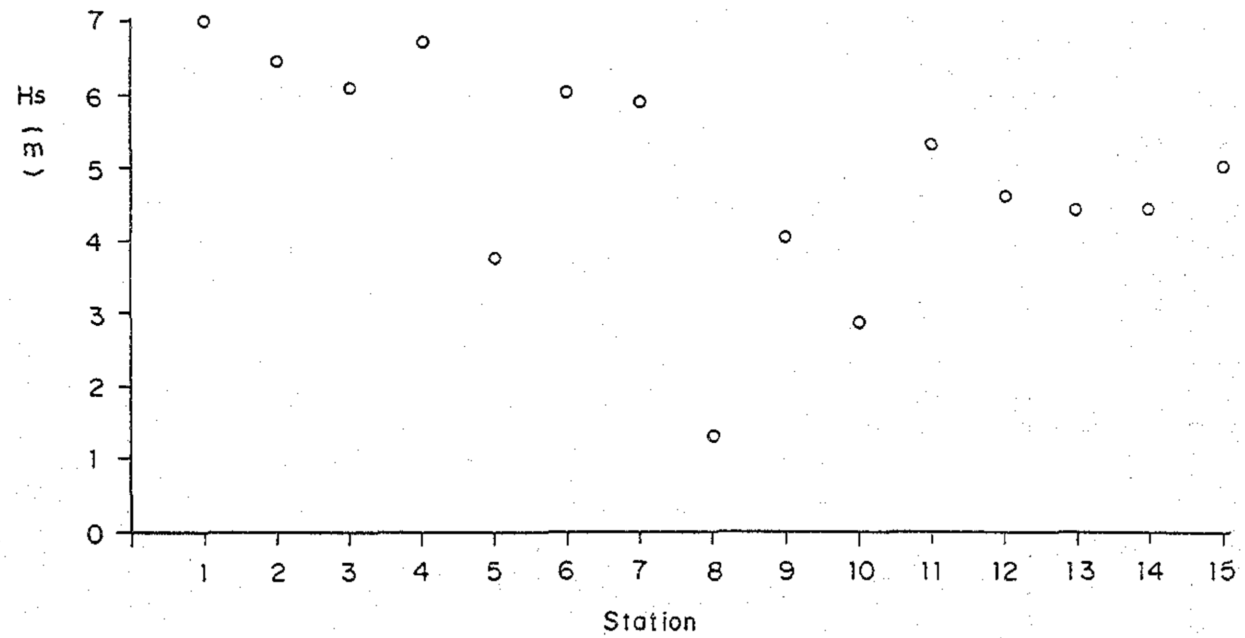


Table 5-2-3(a) Probable Wave (Amasra)

No.	year	$H_{1/3}$ (m)	$P(H_{1/3})$ (%)	direction
1	1974	2.01	5.88	WNW
2	1983	2.21	11.76	N
3	1984	2.21	17.65	NW
4	1969	2.29	23.53	NNE
5	1981	2.29	29.41	WNW
6	1978	2.47	35.29	N
7	1979	2.66	41.18	NW
8	1971	2.77	47.06	NW
9	1976	2.85	52.94	N
10	1973	2.88	58.82	WNW
11	1977	2.95	64.71	N
12	1982	2.97	70.59	NNE
13	1972	3.15	76.47	NNE
14	1970	3.19	82.35	WNW
15	1975	3.32	88.24	N
16	1980	3.45	94.12	NNW

Cizelge (5.18) "Amasra" 1969-1984 Yillari Arasindaki Yillik En Buyuk Derin Deniz Belirgin Dalga Yukseklikleri ve Gumbel Olasiliklari (Meteoroloji Istasyonu)

Table 5-2-3(b) Probable Wave (Amasra)

No.	year	$H_{1/3}$ (m)	$P(H_{1/3})$ (%)	direction
1	1978	1.74	10	N
2	1983	1.98	20	NNE
3	1981	1.98	30	WNW
4	1982	1.98	40	NW
5	1984	2.83	50	NNW
6	1979	2,86	60	NE
7	1980	3.01	70	NE
8	1977	3.26	80	NE
9	1976	4.11	90	NNE

Cizelge (5.19) "Amasra" 1976-1984 Yillari Arasindaki Yillik En Buyuk Derin Deniz Belirgin Dalga Yukseklikleri ve Gumbel Olasiliklari (Sinoptik Harita)

Fig. 5-2-6 Parobable Wave (Amasra)

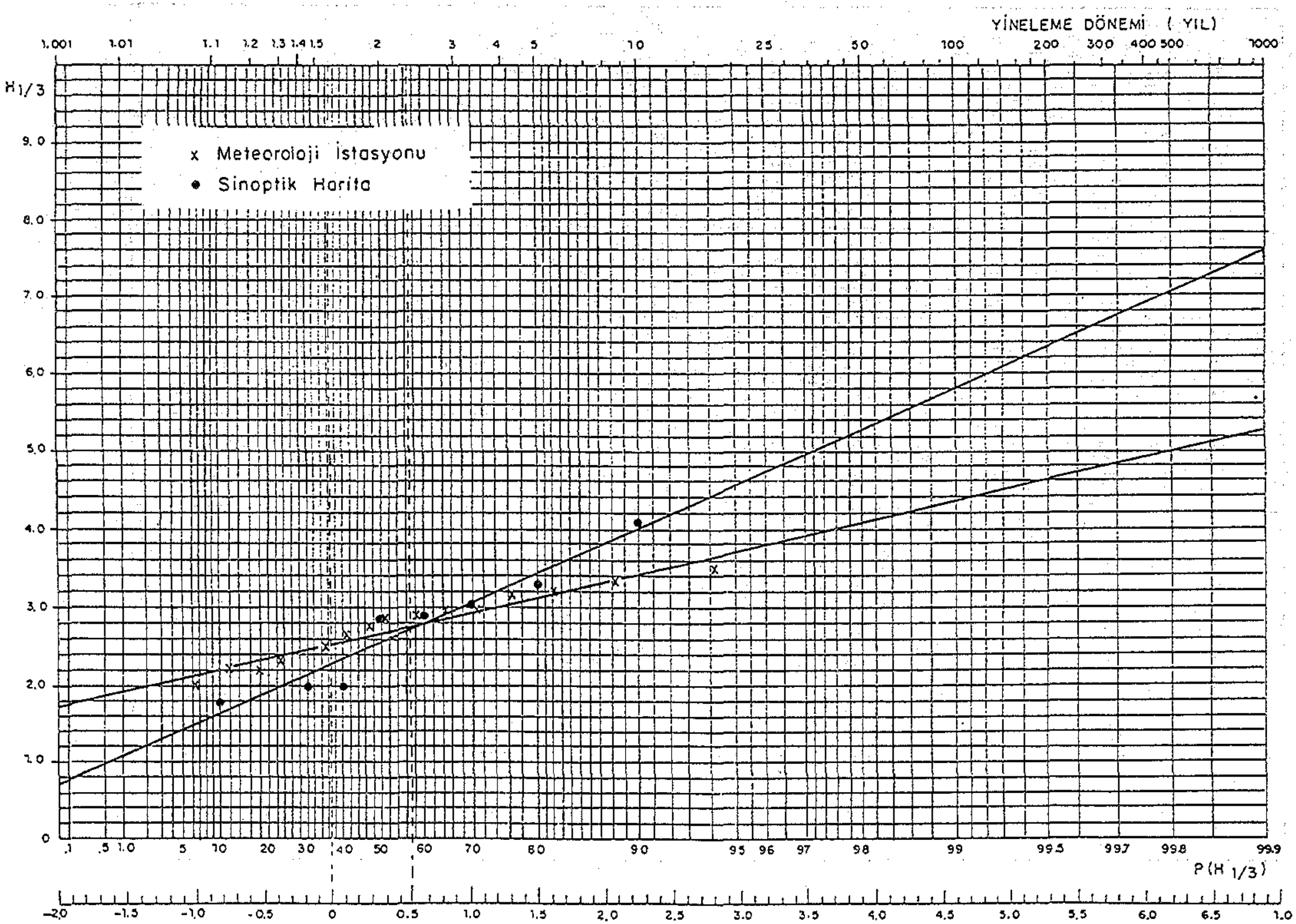


Table 5-2-4(a) Wave Observation (Catalagzi)

Season	Month	Wave Height (m)	Wave direction in open sea				Total
			NE	N	NW	W	
Autumn	Sep.- Nov. (1963)	Calm	% Frequency				87.00
		0-1	2.00	2.50	-	-	4.50
		1-2	3.90	1.70	-	-	5.60
		2-3	-	0.87	-	0.29	1.16
		3-4	0.87	0.58	-	-	1.45
		4-5	-	0.29	-	-	0.29
		> 5	-	-	-	-	
Winter	Dec.(1963) -Feb.(1964)	Calm					72.00
		0-1	3.28	4.93	0.27	-	8.48
		1-2	3.02	5.75	0.27	1.10	10.14
		2-3	0.82	3.62	0.27	0.55	5.26
		3-4	-	2.48	-	-	2.48
		4-5	-	0.82	-	-	0.82
		> 5	-	-	-	-	
Spring	Mar.- May (1964)	Calm					88.31
		0-1	1.09	4.08	1.90	-	7.07
		1-2	1.09	1.90	0.27	-	3.26
		2-3	-	0.82	-	-	0.82
		3-4	0.27	0.27	-		0.54
		4-5	-	-	-	-	
		> 5	-	-	-	-	
Summer	June - Aug. (1964)	Calm					89.67
		0-1	1.90	5.16	0.82	-	7.88
		1-2	0.27	1.36	0.82	-	2.45
		2-3	-	-	-	-	
		3-4	-	-	-	-	
		4-5	-	-	-	-	
		> 5	-	-	-	-	

Table 5-2-4(b) Wave Observation (Catalagzi)

Season	Month	Wave Height (m)	Wave direction in open sea NE	N	NW	W	Total
		Calm		% Frequency			60.20
Autumn	Sep.-Nov.	0-1	6.32	9.05	1.10	-	16.47
	(1964)	1-2	5.50	7.14	0.55	0.27	13.46
		2-3	1.65	3.30	1.10	0.55	6.60
		3-4	-	0.82	0.27	0.55	1.64
		4-5	-	0.82	0.27	-	1.09
		> 5	-	0.27	0.27	-	0.54
		Calm					89,65
Winter	Dec.(1964)	0-1	0.55	1.95	0.55	0.28	3.33
	-Feb.(1965)	1-2	0.83	2.22	-	0.28	3.33
		2-3	0.28	1.15	-	-	1.43
		3-4	-	1.15	-	-	1.15
		4-5	-	0.83	-	-	0.83
		> 5	-	-	-	-	
		Calm					94.85
Spring	Mar.- May	0-1	0.54	1.63	-	-	2.17
	(1965)	1-2	0.27	1.63	0.27	-	2.17
		2-3	0.27	0.27	0.27	-	0.81
		3-4	-	-	-	-	
		4-5	-	-	-	-	
		> 5	-	-	-	-	
		Calm					90.50
Summer	June - Aug.	0-1	1.63	3.80	0.54	0.27	6.24
	(1965)	1-2	-	0.82	1.09	0.54	2.45
		2-3	-	-	0.27	-	0.27
		3-4	-	-	-	-	
		4-5	-	-	-	-	
		> 5	-	-	-	-	

Table 5-2-4(c) Wave Observation (Catalagzi)

Season	Month	Wave Height (m)	Wave direction in open sea NE	N	NW	W	Total
		Calm		% Frequency			9.30
Autumn	Sep.-Nov.	0-1	-	47.60	28.40	11.90	87.90
	(1965)	1-2	-	0.66	1.99	-	2.65
		2-3	-	-	-	-	
		3-4	-	-	-	-	
		4-5	-	-	-	-	
		> 5	-	-	-	-	
		Calm					12.80
Winter	Dec.(1965)	0-1	-	18.10	16.00	37.20	71.50
	-Feb.(1966)	1-2	-	4.26	4.26	3.20	11.72
		2-3	-	-	3.20	1.07	4.27
		3-4	-	-	-	-	
		4-5	-	-	-	-	
		> 5	-	-	-	-	
		Calm					22.00
Spring	Mar.- May	0-1	-	19.50	11.00	36.40	66.90
	(1965)	1-2	-	3.39	4.24	0.85	8.48
		2-3	-	-	2.54	-	2.54
		3-4	-	-	-	-	
		4-5	-	-	-	-	
		> 5	-	-	-	-	
		Calm					22.90
Summer	June - Aug.	0-1	3.06	27.80	19.80	20.60	71.26
	(1966)	1-2	-	1.53	2.29	1.53	5.35
		2-3	-	-	-	1.53	1.53
		3-4	-	-	-	-	
		4-5	-	-	-	-	
		> 5	-	-	-	-	

Fig. 5-2-7(a) Wave Observation (Catalagzi)
(1963 - 1965)

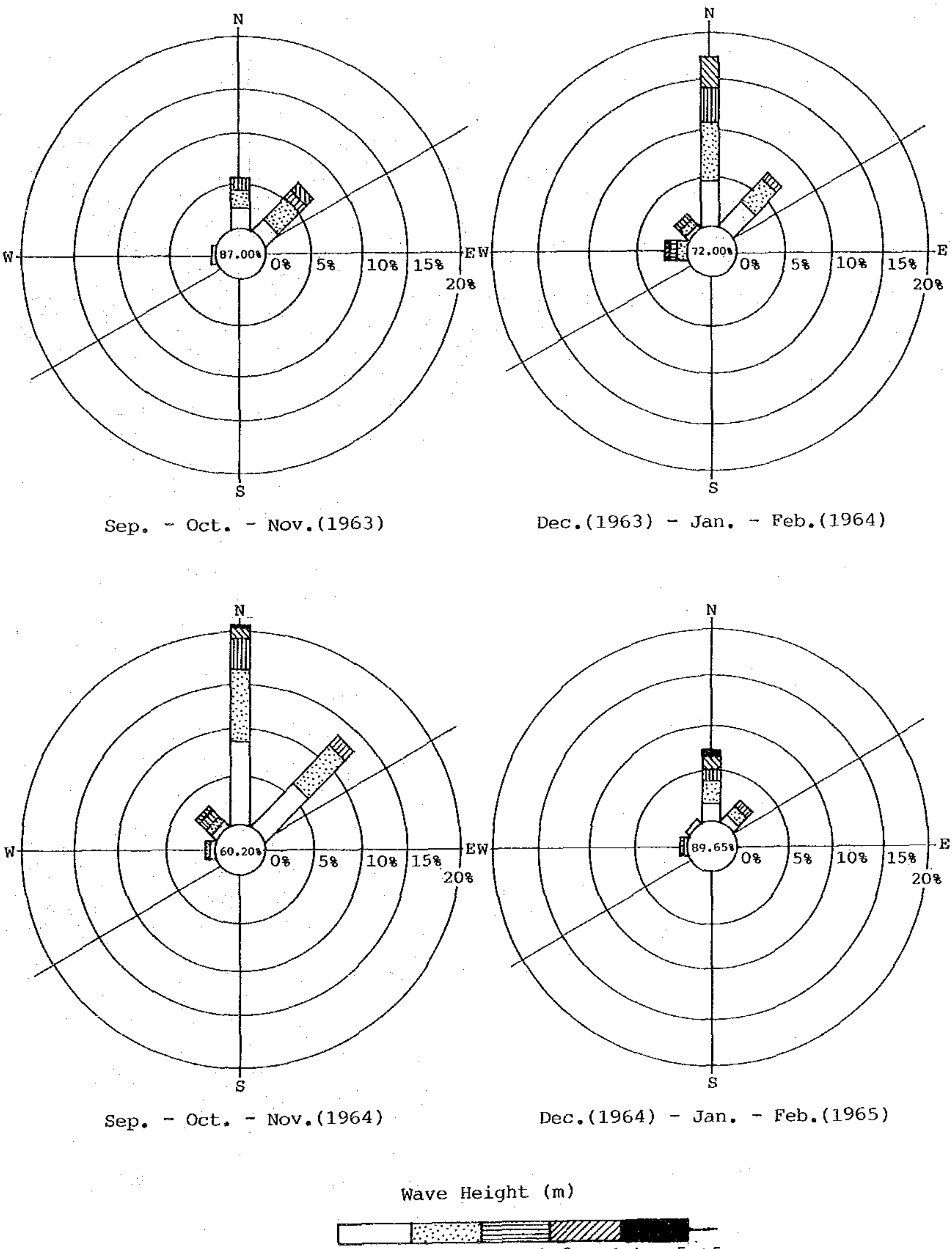
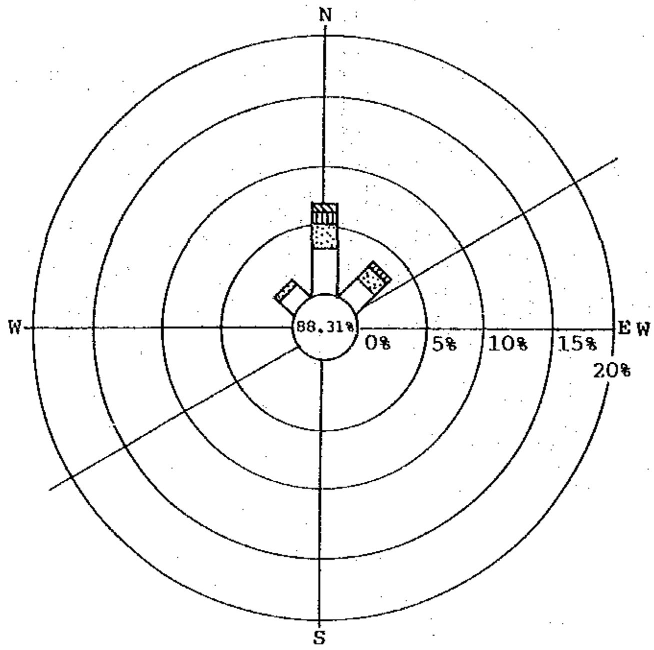
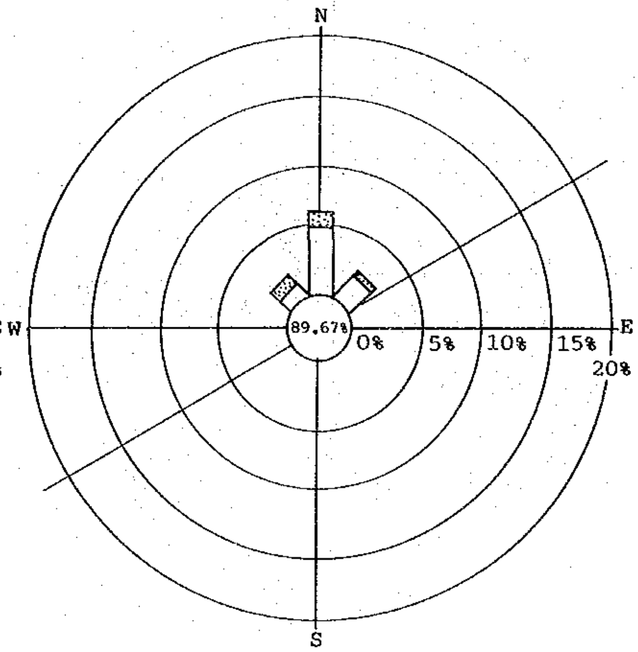


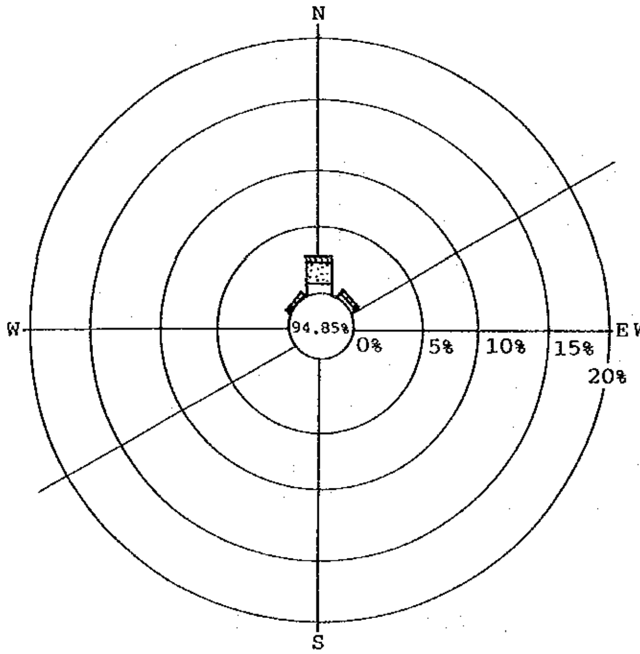
Fig. 5-2-7(b) Wave Observation (Catalagzi)
(1964 - 1965)



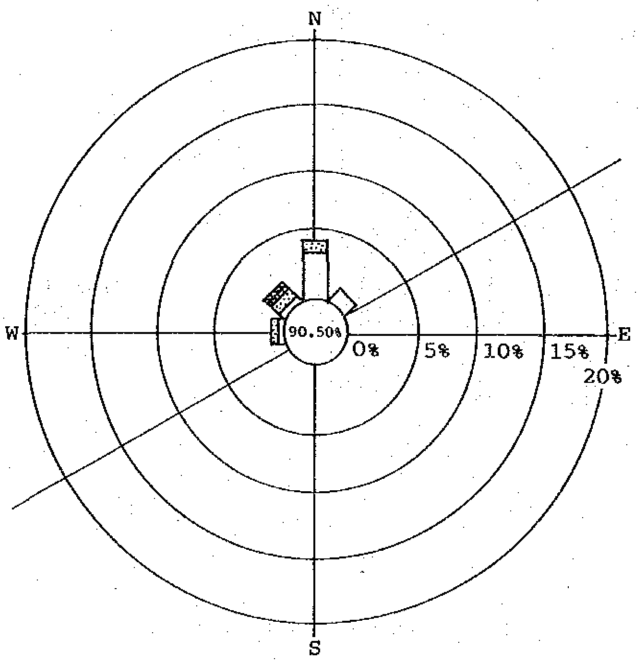
Mar. - Apr. - May(1964)



Jun. - Jul. - Aug.(1964)

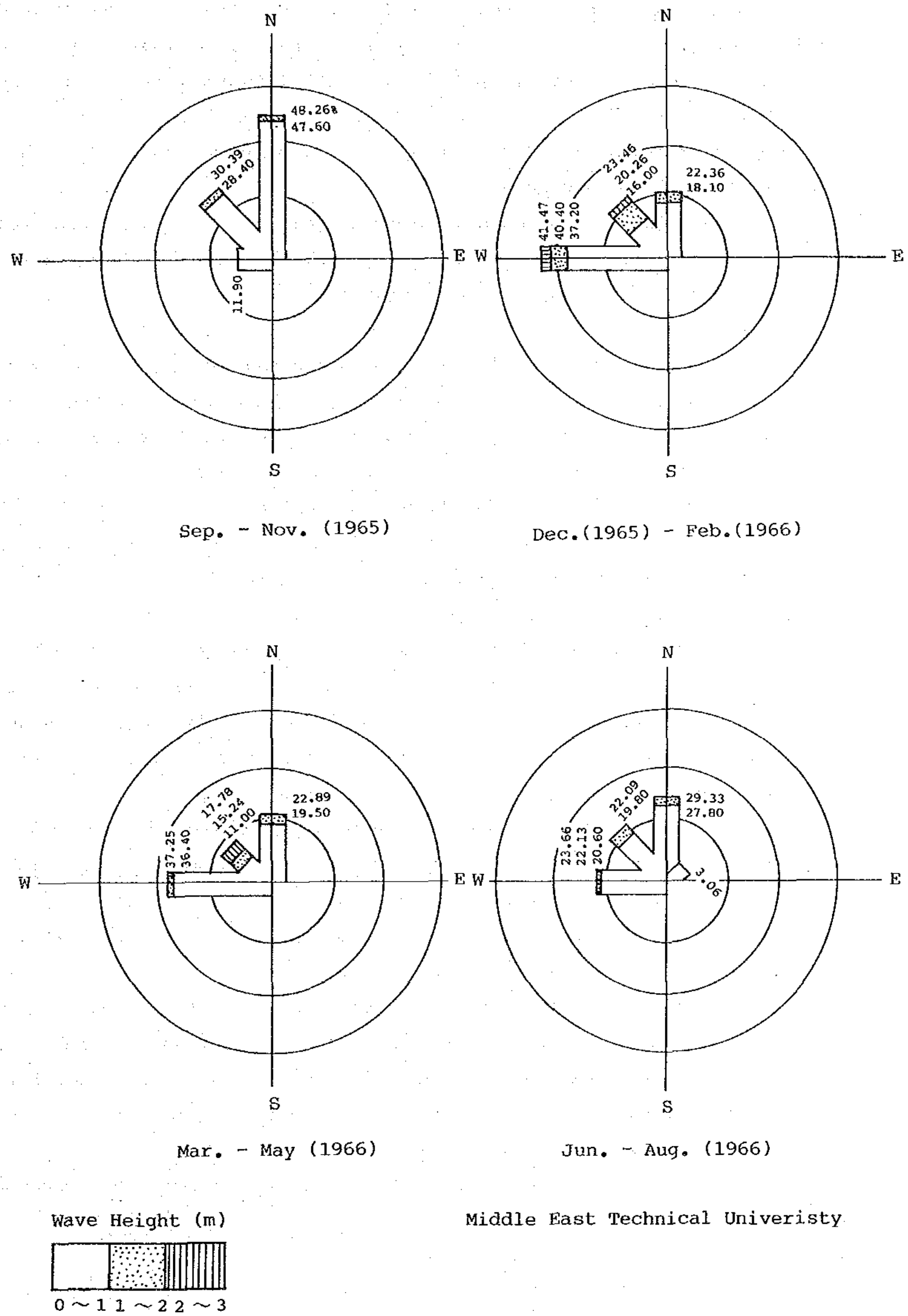


Mar. - Apr. - May(1965)



Jun. - Jul. - Aug.(1965)

Fig. 5-2-7(c) Wave Observation (Catalagzi)
(1965 - 1966)



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The main results are as follows:

(1) The prevailing winds in September-January are from N-E sector and landward. In this period prevailing wave direction is also N-NE. The general wave direction is N 10°W and N15°W (normal to coast line N30°W).

(2) At depths exceeding 2.5-3.0 m the sea bottom is fine sand. The beach material is fine and coarse gravels.

(3) Waves cause littoral currents at breaking point which carry the bottom material or hold them suspended. 1-2m high waves have the greatest effect on drifting. The natural wind currents increase drifting in the surf area.

(4) Because the prevailing winds and wave direction are 2-10 times more from east to west, net drifting is assumed to be 200,000-400,000m3 per annum. 80% of the drifting occurs in the September-February period. Drifting along the shore is mainly caused by wave direction.

(5) Drifting perpendicular to the shore also exists. Small waves carry the material to the shore in summer and fall. Storm waves erode the shore and carry away the material. Drifing perpendicular to the shore mainly depends on the wave height and period.

(6) Two factors explained in (4) and (5) are combined and cause the seasonal changes on the shore. The shore line is shortest after the storms in winter. During summer the waves restore the coast line and maximum breadth is obtained in October-November-December. Material movement starts in December.

(7) The aforementioned material movements are repeated every year in various magnitude depending on wave force and duration. In December 1.0-1.5m waves from NE cause the drifting.

(8) No significant change has been observed on the sea floor since 1947. Only seasonal changes on the sea floor occur.

(9) Changes in sea level are recorded with a gauge installed in a calm zone of Zonguldak Port. Readings were made twice a day at 0800 and 1600. Sea level was around datum line in the 1965-1966 September-January period, and increased 20-30cm during the January-June period. This can be explained as follows:

   1) Increase of river discharges into the Black Sea in winter because of precipitation and thawing.

2) Effect of tidal movements in the Mediterranean through the Sea of Marmara.

3) Sea level stays 20cm above the datum line until the end of August, mainly due to winds.

(10) Daily minor variations are caused by small tidal movements in Black Sea, and horizontal and lateral oscillations in the harbour.

(11) Possible reasons for sudden and particular increases are high winds and waves.

(12) It is concluded that the seasonal change is within 20cm. Daily variations are below 3cm.