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TROPOPOZ SEVİYELERİNE GÖRE İSTANBUL ÜZERİNDEKİ HAVA KÜTLESİ ANALİZLERİ

YÜKSEK LİSANS TEZİ

Müh. Ali DENİZ

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AIR MASS ANALYSIS ACCORDING TO THE TROPOPAUSE LEVELS ON ISTANBUL

M.Sc. THESIS

Ali DENIZ , B.Sc.

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Supervisor : Doç. Dr. Fevzi ERDOĞMUŞ

Members : Doç. Dr. Yunus BORHAN

Doç. Dr. Orhan ŞEN

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CONTENTS

SUMMARY

In the studying the production and the transformation of air masses by means of synoptic charts and aerological ascents, we find that the physical properties of an air mass depend solely upon its life history. We notice, also, that some of the physical properties are apt to change rapidly and frequently according to the dynamical, kinematic, and physical state of the air, whereas other properties will remain almost constant for long periods of time.

All available soundings in this thesis studied with respect to their tropospheric and stratospheric temperature structure and with emphasis on the height and form of the tropopause.

In the purpose of this study, special emphasis will be given to the variation of the tropopause height in vertical and latitudinal direction. All available soundings of the northern hemisphere plotted and studied thoroughly.

In this thesis, a method is applied to air mass analysis. The values of temperatures which are obtained with radiosonde belong to the years of 1988, 1989 and 1990 are used at Istanbul Meteorology Station. In the troposphere, the vertical temperatures profiles have been drowen for different 11 levels from the Earth Surface up to 100 mb. Enversion or isothermal levels are called " TROPOPAUSE LEVELS ".

So that, taking into account the height of tropopause and temperature changes for 1988, 1989 and 1990 years the types of air masses that effect Istanbul is determined.

TROPOPOZ SEVİYELERİNE GÖRE 1988,1989 VE 1990 YILLARINA AİT İSTANBUL ÜZERİNDEKİ HAVA KÜTLELERİ ANALİZLERİ

ÖZET

Aşağı troposferin değişen dinamik ve termodinamik yapısına ait detaylı bilgilerin sürekli olarak elde edilmesi ve böylece hava kütlelerinin analizi, kısa ve uzun vadeli hava öngörülerinin sıhhat derecesini arttırmak bakımından çok büyük yararlar sağlayacaktır.

Sinoptik kartlar yardımıyla hava kütlelerinin tayini ve transformasyonu incelendiğinde, bir hava kütlesinin fiziksel özelliklerinin, o hava kütlesinin tarihsel yaşamına bağlı olduğu görülür. Uzun bir zaman boyunca diğer özellikler sabit kalsa bile, havanın dinamik ve kinematik koşullarından dolayı fiziksel özelliklerin bir kısmının hızlı ve sık bir şekilde değişmesi doğaldır. Bu durumda hava kütlelerinin korunumlu veya korunmlu olmayan özelliklerinden bahsedilebilir. Sinoptik hava kartları analizlerinde esas olarak , Hava Kütleleri Teorisinin 4 özelliği ile ilgilenilir [1]. Bunlar :

i) Hava kütlelerinin oluşması.

ii) Hava kütlelerinin transformasyonu.

iii) Bir günden gelecek bir güne kadar olan hava kütlelerinin belirlenmesinde bir yardımcı olarak kullanılan hava kütlelerinin korunumlu özellikleri.

iv) Farklı tipteki hava kütleleri içerisindeki ortalama veya tipik hava durumları.

Dünya çapında yaptığı hava kütleleri sınıflandırılmasında Kurz ; Poler, Orta Enlem ve Tropikal Hava Kütlelerinin mevcudiyetini belirlemiştir [2]. Woldt, 1984 ve 1985 yıllarında Berlin Üniversitesindeki Meteoroloji Bürosunda, hava kütlelerinin tipleri hakkında araştırmalar yapmıştır [3].

Hava kütlelerinin analizinde onbeşden fazla karakteristik elemandan yararlanılır. Bunların en önemlileri serbest atmosfer sıcaklığı, potansiyel sıcaklık, özgül nem ve karışma oranı, çiğ noktası sıcaklığı, görünürlük ve rüzgar yapısı gibi meteorolojik elemanlardır[4].

Bu zamana kadar hava kütlelerinin analizi için bir çok metodlar öne sürülmüştür. Bunlardan en önemlileri, potansiyel sıcaklık kriterine göre yapılan hava kütleleri analiz metodu ve Rossby diyagramları vasıtasıyla özgül nem ve karışma oranı kriterleri kullanılarak yapılan hava kütleleri analizleridir. Potansiyel sıcaklık, kuru adyabatik bir işlem boyunca korunumludur. Böylece potansiyel sıcaklık yoğunlaşma olmadığı zaman hava kütlelerinin analizinde önemli bir elemandır. Fakat yoğunlaşma olduğu zaman hava, nem adyabatik olarak hareket edecek ve buharlaşma gizli ısısının serbest kalması sebebiyle işlemler, adyabatiklikten uzaklaşacak ve potansiyel sıcaklık korunumlu olamıyacaktır. Böylece hava kütlelerinin belirlenmesinde potansiyel sıcaklığın kullanılması sınırlandırılmış olacaktır [5].

Hava kütlelerinin analizi için bir metod sunulan bu çalışmada, İSTANBUL - Göztepe Meteoroloji İstasyonundan, radyosondaj ile yapılan 1988, 1989 ve 1990 yıllarına ait yüksek hava rasatlarından elde edilen sıcaklık değerleri kullanılarak, troposfer içinde yeryüzeyinden 100 mb'a kadar olan farklı 11 tabakaya karşılık gelen düşey sıcaklık profilleri çizilmiştir. Sıcaklık verilerinin bilgisayara girilmesi ve düşey sıcaklık profillerinin çıkışları , bilgisayarda LOTUS programı kullanılarak yapılmıştır. Elde edilen bu düşey sıcaklık değişimlerinden sıcaklığın yükseklikle sabit kaldığı (izotermal durum) veya sıcaklığın yükseklikle arttığı (enverziyon durumu) yükseklikler tespit edilmiştir. Sıcaklığın yükseklikle arttığı veya sabit kalmaya başladığı bu seviyeler " TROPOPOZ SEVİYELERİ " olarak adlandırılmıştır. Böylece bu zamana kadar yapılmış hava kütleleri analizlerinden değişik bir metod olarak, tropopoz yüksekliği ve sıcaklığındaki değişmeler gözönünde bulundurularak son 3 yıl için (1988, 1989 and 1990) İstanbul'u etkileyen hava kütleleri tipleri tayin edilmiştir. Bu çalışma yapılırken daha önce yapılmış 5 farklı araştırma grubu teorik olarak belirtilmiştir. Her bir farklı araştırma grubunda farklı tropopoz yükseklikleri ve düşey sıcaklık değişiklikleri gözlenmiştir. Bu farklı 5 araştırma grubu şöyle sıralanabilir :

1) Poler enlemlerdeki araştırmalar

2) Orta enlemlerdeki araştırmalar

3) Subtropikal enlemlerdeki araştırmalar

4) Poler cephe-jeti içerisindeki araştırmalar

5) Subtropikal cephe-jeti içerisindeki araştırmalar

Poler enlemlerdeki araştırmalarda tropopoz, genellikle 300 mb seviyesinin altında oluşmuştur. Bazen 400 veya 500 mb'ın altına kadar düşebilmektedir. Ortalama tropopoz yüksekliği 370 mb (yaklaşık 8 km) ve tropopoz sıcaklığı - 49 °C dir.

Orta enlemlerdeki araştırmalarda ise tropopozun ortalama 240 mb 'da ve tropopoz sıcaklığının - 56 °C de olduğu gözlenmiştir.

Subtropikal enlemlerdeki araştırmalarda ise, ortalama tropopoz yüksekliği 100 mb 'ın biraz üzerindedir ve tropopoz sıcaklığı - 72 °C dir.

Poler-jet grubu araştırmalarında net bir tropopozu görmek çok zor olmasına karşın, subtropikal jet grubu araştırmalarında tek bir tropopozu görmek çok zordur. Yani çift tropopoz durumu vardır.

Yapılan çalışmalar sonucunda, tropopozun yüksek seviyelerde oluşması halinde aynı gün ve aynı bölge üzerinde bir yüksek basınç sisteminin gözlendiğini ve bunun tersine olarak tropopozun daha düşük seviyelerde oluşması halinde bir alçak basınç sisteminin gözlendiği sonucu elde edilmiştir ve bu elde edilen sonuçlar da tezde verilen 15 - 81 arasındaki bütün şekillerden çok açık bir şekilde görülmektedir.

Troposferin yukarı kısımlarında ve stratosferde poler cephe ile bağlantılı poler cephe jetini ve esas olarak yaklaşık 30 ° enleminde ve yaklaşık 200 mb basınç seviyesinde yerleşmiş subtropikal jeti görürüz. Bu iki jet, temelde batıdan esen rüzgar maksimumudurlar. Bu zamana kadar meteorolojide sinoptik ve teorik çalışmalar, yaklaşık 9 km'deki 300 mb yüzeyindeki atmosferik durumların araştırmaları üzerinde sınırlandırılmışlardır. Bu durum özellikle günlük değişen sinoptik çalışmalar için doğrudur. Sayısal çalışmalar, stratosferik durumlara dahil edilmiş olmalarına rağmen, bu çalışmalar bazı alanlar için temelde sınırlandırılmışlardır. Stratosferik seviyeler için yapılan dünya çapındaki yarımküreli tetkikler, meteorolojide çok nadirdirler. 300 mb'ın üzerindeki seviyeler için bütün yarımküre bilgileri kullanışlı değildirler ve böylece düşük seviyelerde gelişen stratosferik çalışmalar genel olarak açıklanmamıştır.

Tropopoz yüksekliğinin oluşumundaki farklı yapıları incelemek için farklı yarımkürelerin tropopoz haritalarının hazırlanması gerekir. Subtropikal jet içerisine dahil olan araştırmalar durumunda, çift yapılı tropopozun önerilmesiyle düşey sıcaklık gradyanında iki farklı durum görülebilir. Böylece, sıcaklık alanı, farklı iki rüzgar kuşağını belirlemede bir rehberdir. Tropopoz haritası, her iki jetin (poler ve subtropikal jet) yerleşmesiyle beraber,temelde sıcak ve soğuk troposferik hava kütlelerinin açık bir şekilde dağılımını gösteren bir avantaja sahiptir. Ayrıca sıcaklık analizleri, kuzey yarımküredeki ortalama rüzgar akımlarındaki, tropopoz yüksekliklerindeki ve tropopoz sıcaklıklarındaki hızlı değişikliklerin nasıl olduğunu açıklar [6].

Bu çalışmada, radyosondaj verileri yardımıyla elde ettiğimiz değişik tropopoz yüksekliği ve sıcaklık yapılarına göre gruplandırılan şekiller yardımıyla da tropopozun oluştuğu seviyeye göre İstanbul için hava kütleleri analizleri yapılmıştır. Elde edilen sonuçlar, aynı yıllara ait (1988, 1989 ve 1990) hem yer hem de 500 mb günlük sinoptik haritalar tek tek analiz edilerek sonuçlar doğrulanmıştır. Ayrıca şekillerde basınç yüzeylerine karşılık gelen tropopoz seviyelerinin metre olarak yükseklik değerleri, Göztepe Meteoroloji İstasyonunda elde edilen değerlerle karşılaştırılmış ve bu değerlerin birbirleriyle uyum sağladığı görülmüştür.

Böylece 1988, 1989 ve 1990 yılları için, İstanbul'da etkili olan hava kütleleri, sinoptik analizler ve tropopoz seviyelerini gösteren şekiller yardımıyla gün gün tespit edilmiş ve sayısal olarak belirlenmiştir. Sonuçta, İstanbul'da Orta Enlem Hava Kütlesinin hakim olduğu ve bunun dışında şekillerden de anlaşılacağı gibi özellikle kış aylarında değişik tiplerdeki hava kütlelerinin de İstanbul'da etkili olduğu bulunmuştur.

CHAPTER 1. THE STRUCTURE OF THE ATMOSPHERE AND THE CHARACTERISTICS OF THE TROPOPAUSE

1.1 INTRODUCTION :

Until the present time synoptic and theoretical work in meteorology has been more or less restricted to the study of atmospheric conditions up to the 300 mb surface (about 9 km). This is especially true for the daily routine synoptic work. Although numerous studies have included the stratospheric conditions, these studies are mainly restricted to certain areas. Worldwide hemispheric investigations for stratospheric levels are extremely rare in meteorology. This is partly due to the fact that complete hemispheric data for levels above 300 mb are not available, and also because the contribution of stratospheric developments to that at lower levels has not generally been considered very important.

There are certain important features in the upper atmosphere (upper part of the troposphere and the stratosphere) which should be closely studied. At these levels the polarfront jet connected with the polarfront and the subtropical jet located mainly at about 30° latitude and at a height of about 200 mb. These two jets

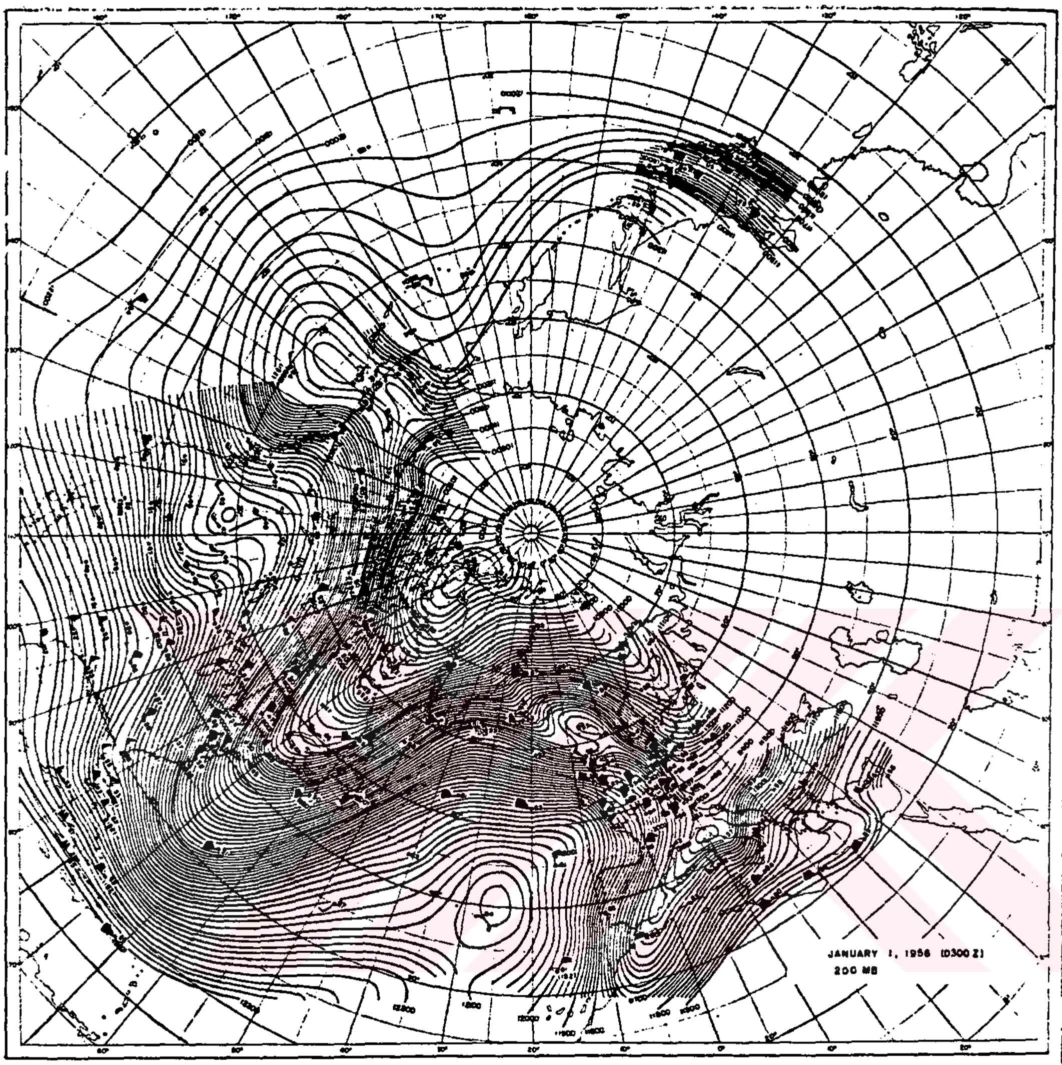

Figure 1 : 200 mb contour map of January 1 , 1956 (0300 Z). (Thick contours for every 100 dyn. m. , thin contours for every 20 dyn. m. ; Temperatures in °C and minus sign omitted. Windspeed in kts.)

are the main wind maxima of the broad westerlies. While the polarfront jet has been studied rather throughly and its hemispheric existence has been shown,the subtropical jet has not been investigated enough.

Another very important feature of the higher atmosphere is the variation of the tropopause height.

In the purpose of this study, special emphasis will be given to the variation of the tropopause height in vertical and latitudinal direction. All available soundings of the northern hemisphere plotted and studied thoroughly.

1.2 GENERAL SYNOPTIC SITUATION ON JANUARY I, 1956

It is clear that the 200 mb level is most suitable for identifying the subtropical jet, as the heighest wind speed of this phenomenon occurs close to the level. The polarfront jet can also be noticed in this level as the wind velocity remains still strong and the gradient of the contour lines shows a well marked concentration at the 200 mb level (upper polarfront). A further advantage is the well known reverse of the meridional temperature gradient, so that the temperature field is also a guide in distinguishing the two separate wind belts.

As an example Figure 1 gives the situtation on January 1, 1956 (0300 z). This analysis clearly shows a strong meandering circulation pattern. Particularly strong troughs can be noticed just off the American East Coast, over Europe and over the Japanese Islands. A weaker trough appears south of Alaska. The wind values over the North American Continent together with the gradient of the contour lines show the upper polarfront jet running across Northern Canada and going around the trough at the East Coast of America. At the same time, the high wind velocities over the Southern United States and the Caribbean Islands show the subtropical jet quite well. Over the Atlantic the polarfront jet seems to run from New Foundland to the southern part of Greenland, to the north of Iceland and into the middle of Europe.

The subtropical jet in this area continues from the Caribbean Island towards the northeast, crosses the northern part of the Atlantic Ocean and enters England. Over France the two jets nearly join, running southwest to the African West Coast and show up again over North Africa.

Figure 1 also shows the reversed temperature gradient at 200 mb. In the area surrounded by the upper polarfront the tropopause is below the 200 mb level and the temperatures belong to the polar stratosphere. South of the upper polarfront temperatures between - 50 and - 60 °C , where the tropopause is still below the 200 mb surface. Going further south the temperatures become relatively low,indicating that the tropopause intersects the 200 mb level and slopes upward to higher altitudes. Still further south the temperatures rise slightly and refer now to the higher troposphere. This can best be seen over the Atlantic area where the subtropical jet runs exceptionally far north. In this area, temperatures lower than - 60 °C are observed, indicating that most of the Atlantic is covered by a rather cold air of subtropical origin with the tropopause above 200 mb. Here the temperatures belong to the higher part of the troposphere.

1.3 THE TROPOPAUSE MAP OF JANUARY I, 1956

To study the structure in tropopause height, it was decided to prepare separate hemispheric tropopause maps. For this purpose about 200 soundings were plotted and checked for every day and for a period of seven days [1]. The height of the tropopause was computed for each individual sounding. For most of the soundings it was easy to select the tropopause level by applying the standard method. (Either a noticable change of tropospheric lapse rate to an isothermal layer or to an increase of temperature with height.) Sometimes it was difficult, to find a well defined tropopause. This was almost always true for soundings, which met either the polarfront jet or the subtropical jet close to their wind maxima. In the case of soundings going through the subtropical jet, two different breaks in lapse rate appeared, suggesting a double structure of the tropopause.

Figure 2 shows the tropopause map of January 1, 1956 (0300 z). In this map the two separate west wind belts stand out clearly in the gradient of the contour lines of the tropopause level. Two different bands picturing the break in the tropopause height connected with the existence of the polarfront-and the subtropical wind maxima can be seen all around the hemisphere. This double break in tropopause separates, in a clear manner, three different areas with different characteristic tropopause heights.

South of the subtropical break line the height of the tropopause is mostly around 100 mb or even higher.

In the area between the two breaklines the tropopause height stays around 250 mb. It is rather astonishing that the height of the tropopause does not vary by more than 50 mb in spite of the fact that the stations

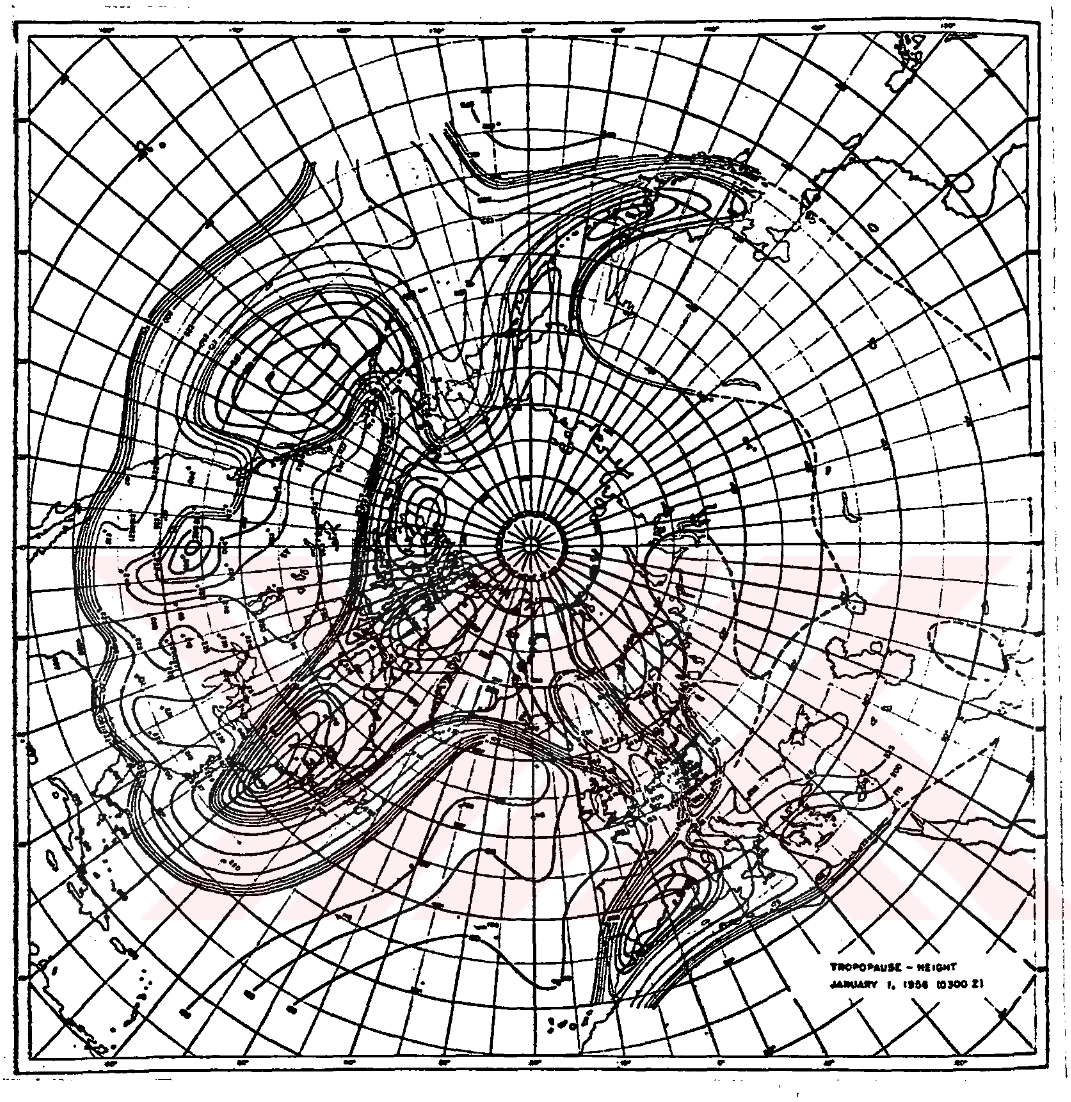

Figure 2 : Hemispheric map of tropopause height (in mb) of January 1, 1956 (0300 Z). Breaklines of tropopause height are shown by concentrations of isolines. Dashed lines over Asia give approximate continuation of the breaklines of tropopause height.

are located in widely differing latitudes. This can best be seen over the Northern American Continent where the two break lines are far apart.

In the area north of the polar break line, the tropopause heights range between 300 and 400 mb and in certain locations even as low as 500 mb. This low tropopause height not only shows above cold polar vortices, but can also be found above cold polar outbreaks in relatively low latitudes.

The tropopause map has the advantage to show in a clear manner the distribution of cold and warm tropospheric air masses, together with the location of both jets.

1.4 THE TROPOPAUSE TEMPERATURE MAP OF JANUARY 1, 1956

Figure 3 shows a similar analysis of the tropopause temperature. The breaklines in tropopause height and strong concentrations in the distribution of the tropopause temperature agree closly in location. The tropopopause temperatures south of the southern breakline remain almost constant between - 67 and - 74 °C. The same is true for the middle area between the two

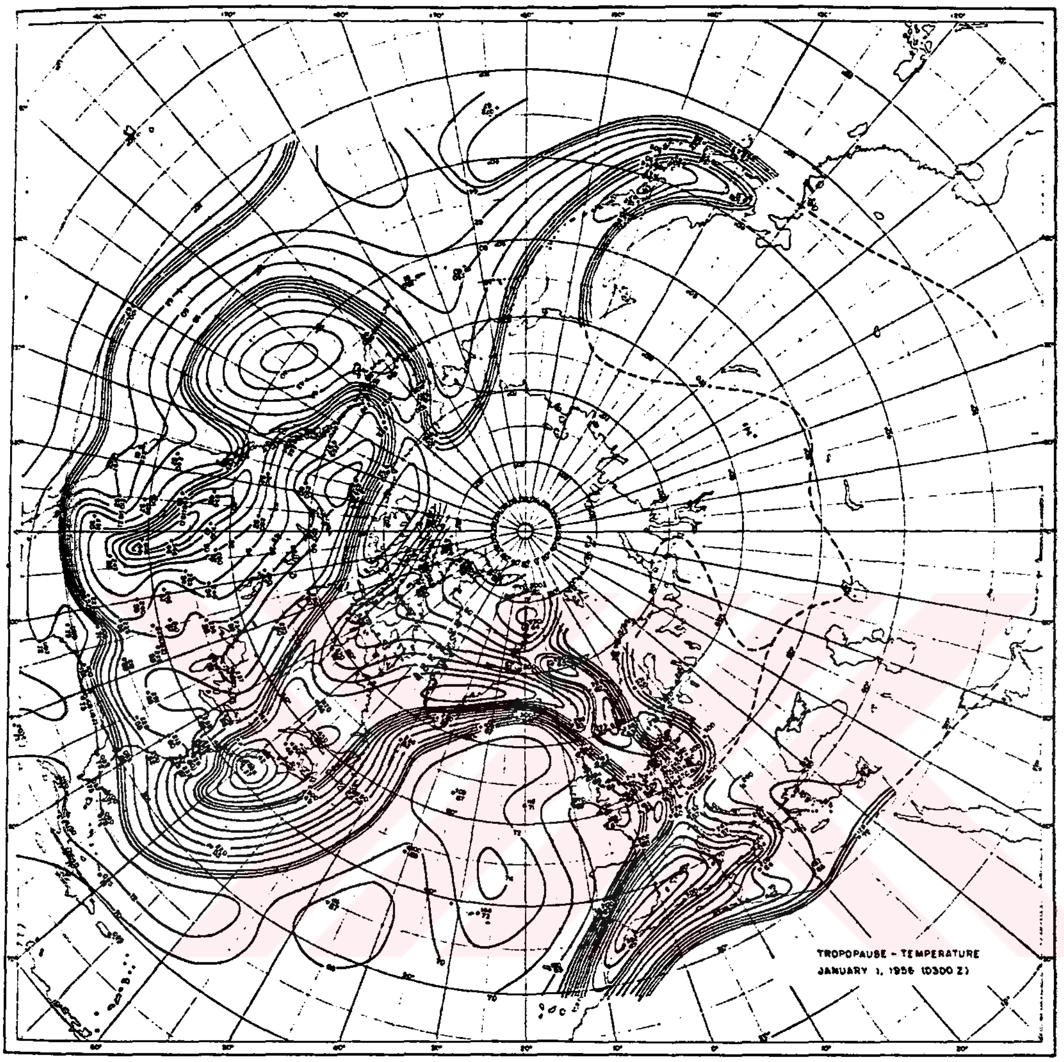

Figure 3 : Hemispheric map of tropopause temperature of January 1, 1956 (0300 Z). (For each station tropopause height in mb (three figures) and tropopause temperatures in °C (two figures) are plotted. Minus sign for temperatures omitted.) Note the striking similarity with Figure 2.

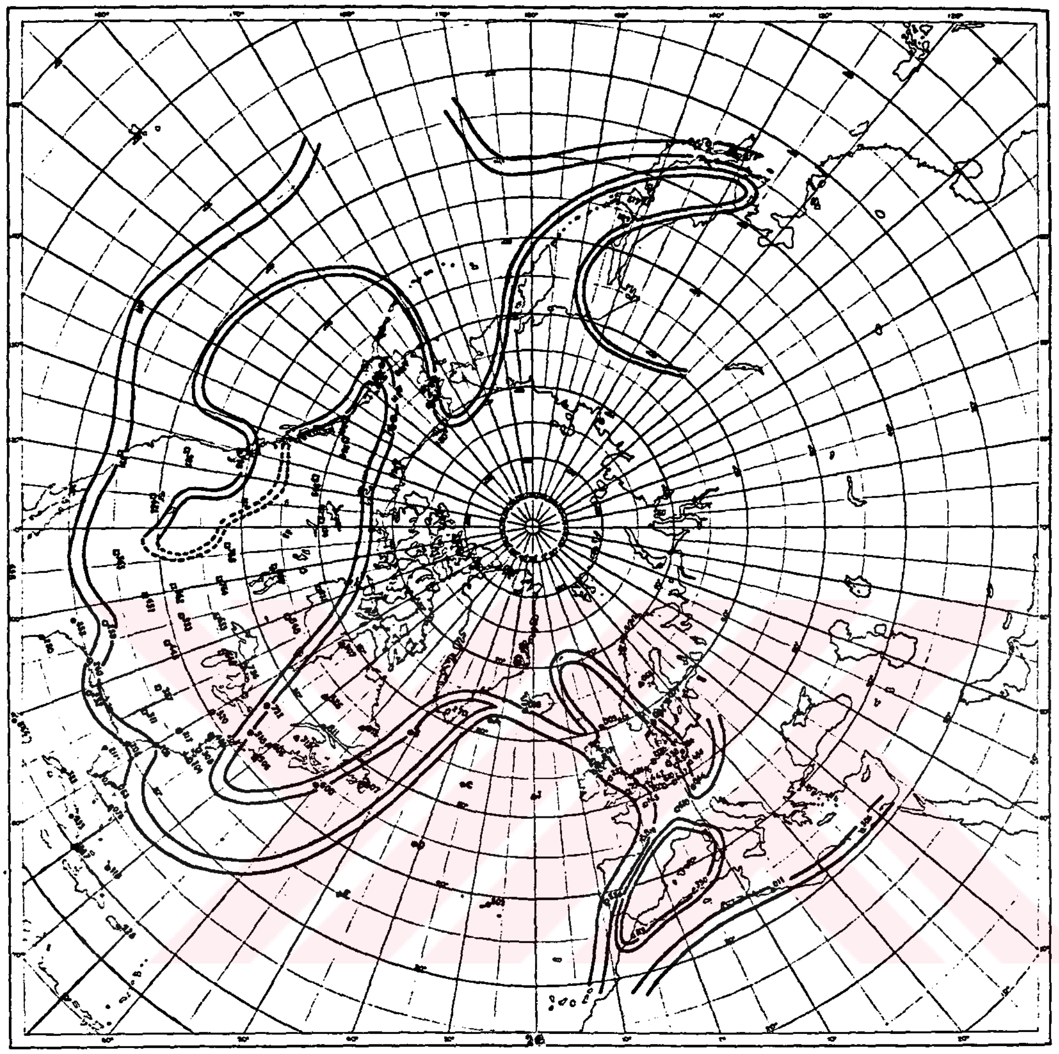

Figure 4 : The distribution of stations selected with respect to the tropopause breaklines. (The triangles : stations north of the polar breakline, squares: stations between the two breaklines , full circles : stations south of the subtropical breakline. Circles with a cross : stations inside polar breaklines, circles : stations inside the subtropical breakline.)

break lines where the tropopause temperature ranges between - 56 and - 60 °C. North of the northern break-line the tropopause temperatures are mostly higher than - 50 °C and in deep depressions of tropopause height may be as high as - 37 °C. This kind of temperature analysis offers a rather clear distinction between three very different parts of the northern hemisphere which are separated by the main wind belts or, what is the same, by the breaklines in tropopause height or by strong bands with rapid change in the tropopause temperature. With the exception of the very northern latitudes (75 to 90 °N) the close relation between tropopause height and tropopause temperature seems to be almost perfectly fulfilled in the sense that an increase of height goes parallel with a decrease in temperature or vice versa (compensation principle)[7].

CHAPTER 2. THE PRESENTATION OF DIFFERENT GROUPS OF SOUNDINGS

The structure of the tropopause height mentioned above will now be shown by presenting different series of soundings selected according to their location with respect to both breaklines. Figure 4 shows the distribution of the stations selected. The stations are divided into five groups :

a) Stations north of the polar breakline
(polar group of soundings)

b) Stations between the two breaklines
(middle group of soundings)

c) Stations south of the subtropical breakline
(subtropical group of soundings)

d) Stations close to or in the polar breakline
(soundings through polarfront jet)

e) Stations close to or in the subtropical breakline
(soundings through subtropical jet)

2.1 POLAR GROUP OF SOUNDINGS

The polar soundings and their mean are shown in Figure 5. In these soundings the tropopause usually is formed below the 300 mb level. The tropopause height is more changeable than for the two types b and c discussed later. In some cases (near the center of polar vortices and inside deep troughs) the tropopause is lower than 400 mb, sometimes even below 500 mb. In the lowest layers of the troposphere a nearly isothermal structure or strong surface inversion is found. The higher tropospheric layers posses a nearly uniform lapse rate and in the stratosphere an almost constant temperature with height or even a slight decrease (above 200 mb) is observed. The total structure (troposphere plus stratosphere) is similar in almost all the soundings. This typical form of the polar soundings is best seen in the mean soundings on the right side of Figure 5. Table I presents vertical lapse rate of the mean polar sounding.

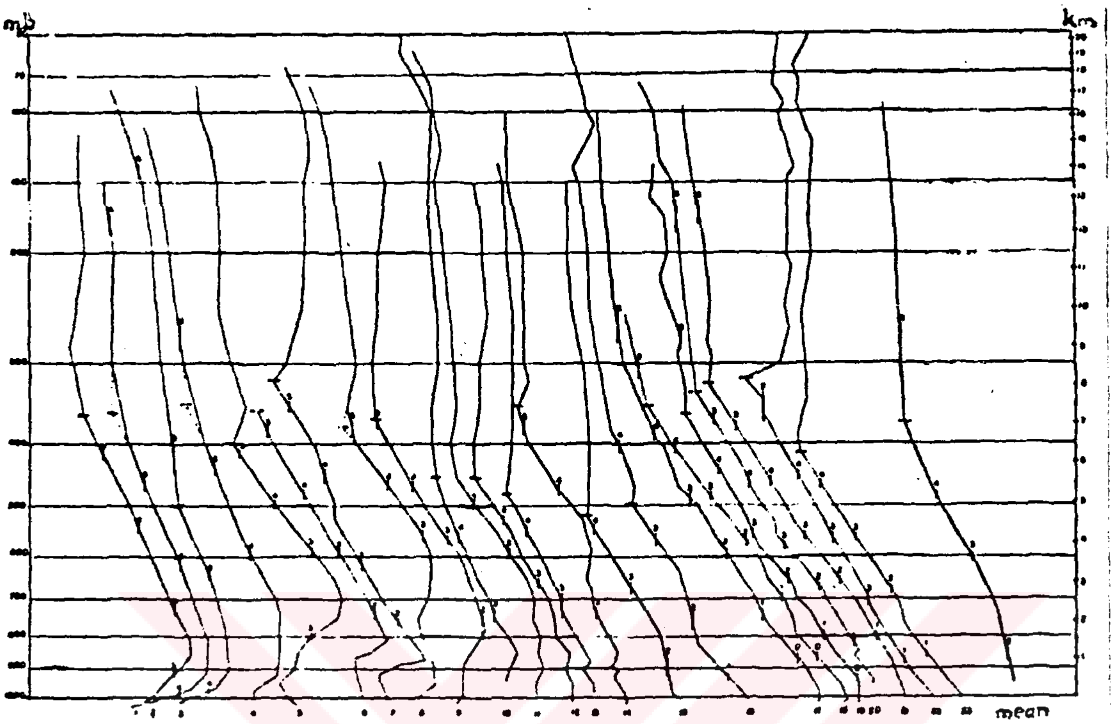

Figure 5 : The vertical temperature structure of soundings north of the polar breakline (polar group). Note the location of the tropopause below 300 mb. The -10°, -20°, -30 °C a.s.o. are indicated by 1, 2, 3 resp. Mean temperature distribution of these soundings is given on the right side.

TABLE I (hundredth of °C / 100 m.)

Layer (mb)	from	940	920	900	880	860	840	820	800
	to	920	900	880	860	840	820	800	780
		22	26	14	22	18	18	24	22
Layer (mb)	from	780	760	740	720				940
	to	760	740	720	700				700
		24	35	38	39			Mean :	25
Layer (mb)	from	700	680	660	640	620	600	580	560
	to	680	660	640	620	600	580	560	540
		41	61	65	55	67	59	81	71
Layer (mb)	from	540	520	500	480	460	440	420	400
	to	520	500	480	460	440	420	400	380
		78	70	58	58	40	55	54	35
Layer (mb)	from	380							700
	to	360							360
		39						Mean :	61
Layer (mb)	from	360	340	320	300	280	260	240	220
	to	340	320	300	280	260	240	220	200
		00	05	10	05	08	04	08	02

Layer (mb)	from	200	180	160	140	120	360
	to	180	160	140	120	100	100
		01	08	10	01	00	Mean : 05

From Table I one may see that the lower polar troposphere up to 700 mb is rather stable (mean lapse rate - 0.25 °C / 100 m.) while the upper troposphere tends towards a more unstable statification (mean lapse rate - 0.6 °C / 100 m, sometimes - 0.7 to - 0.8). The total mean tropospheric lapse rate is - 0.46 °C / 100 m. In the polar stratosphere almost isothermal conditions are present (mean lapse rate - 0.046 °C / 100 m). The mean tropopause height is 370 mb (approximately 8 km) and the tropopause temperature is -49 °C.

2.2 MIDDLE GROUP OF SOUNDINGS

Figure 6 a,b show all the soundings from stations situated between the two breaklines together with their mean. These soundings in general look rather different in their vertical structure from the ones mentioned above. The lowest parts of these soundings, approximately

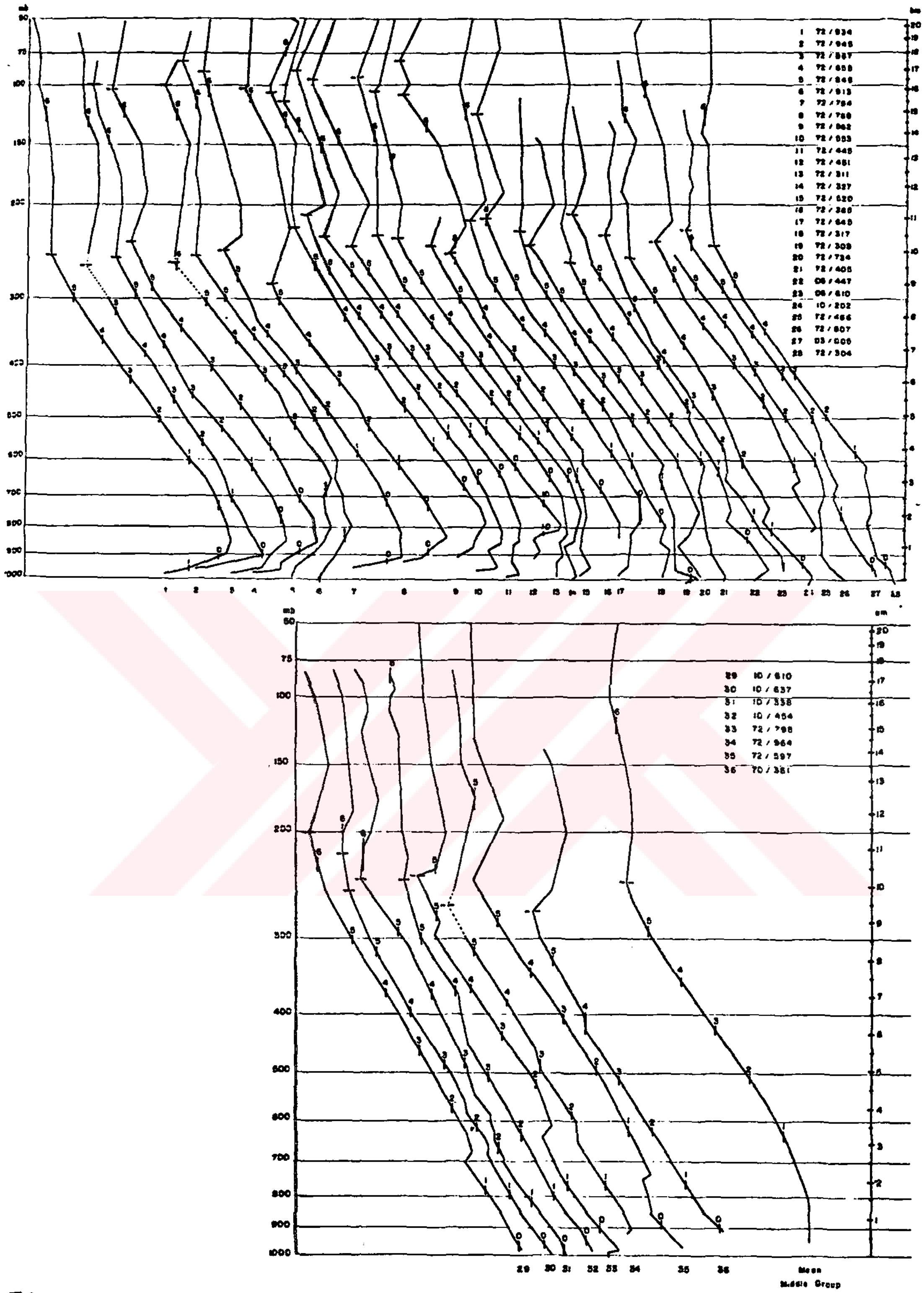

Figure 6 : The vertical temperature structure of soundings between the two tropopause breaklines (middle group). Note the location of the main tropopause between 200 and 300 mb. The -10°, -20°, -30 °C a.s.o. are indicated by 1, 2, 3 resp. Mean temperature distribution of these soundings is given on the right side.

up to 850 mb, vary considerably from one sounding to another. Often strong surface inversions are observed which partly are low level polarfront intersections. The higher tropospheric layers up to the tropopause show a surprisingly uniform vertical temperature distribution. The tropopause is found at about 240 mb and in no case seems to be above 200 or below 300 mb. At the tropopause the nearly constant vertical lapse rate of the higher troposphere chances to a more or less constant temperature with height in the stratosphere. However in the heigher stratospheric layers (from 150 mb upwards) the temperatures are mostly - 60 °C and lower. In this group of sounding only those somewhat closer to the subtropical breakline shows a small inversion just above the main tropopause. Here also slight indications of an additional rather high tropopause above 100 mb can be noticed.

TABLE II (hundredth of °C / 100 m)

Layer (mb)	from	980	960	940	920	900	880	860	840
	to	960	940	920	900	880	860	840	820
		00	00	00	00	00	00	00	12

Layer (mb)	from	820	980
	to	800	800

		16							Mean : 14

Layer (mb)	from	800	780	760	740	720	700	680	660
	to	780	760	740	720	700	680	660	640
		19	40	40	40	55	75	76	40

Layer (mb)	from	640	620	600					800
	to	620	600	580					580
		70	48	52					Mean : 52

Layer (mb)	from	580	560	540	520	500	480	460	440
	to	560	540	520	500	480	460	440	420
		72	78	70	73	69	63	73	80

Layer (mb)	from	420	400	380	360	340	320	300	280
	to	400	380	360	340	320	300	280	260
		86	83	73	85	75	76	61	62

Layer (mb)	from	260							580
	to	240							240
		40							Mean : 72

Layer (mb)	from	240	220	200	180	160	140	120	100
	to	220	200	180	160	140	120	100	80
		+18	+11	00	15	24	19	16	01

Layer (mb)	from	80	60	240
	to	60	50	50
		+06	+03	Mean : 12

Table II presents vertical lapse rates for different heights intervals of the mean sounding of this group.

The lowest layers show rather variable conditions and the mean lapse rate of - 0.14 °C / 100 m is only a result of the averaging process. Above 800 mb the lapse rate of the mean middle sounding increases with height up to about 340 mb and decreases slightly until the tropopause is reached (240 mb). A total mean lapse rate of the troposphere is - 0.64 °C / 100 m. The tropopause temperature is - 56 °C. Even in the mean sounding a slight inversion appears above the tropopause and from 170 mb upwards the temperature decreases only very little with height (- 0.12 °C / 100 m.) up to 90 mb, where a secondary tropopause level can be found. From there on the temperature remains nearly constant.

2.3 SUBTROPICAL GROUP OF SOUNDINGS

Figure 7, shows all the soundings from stations south of the subtropical jet, together with their mean sounding. These soundings possess again a rather simi-

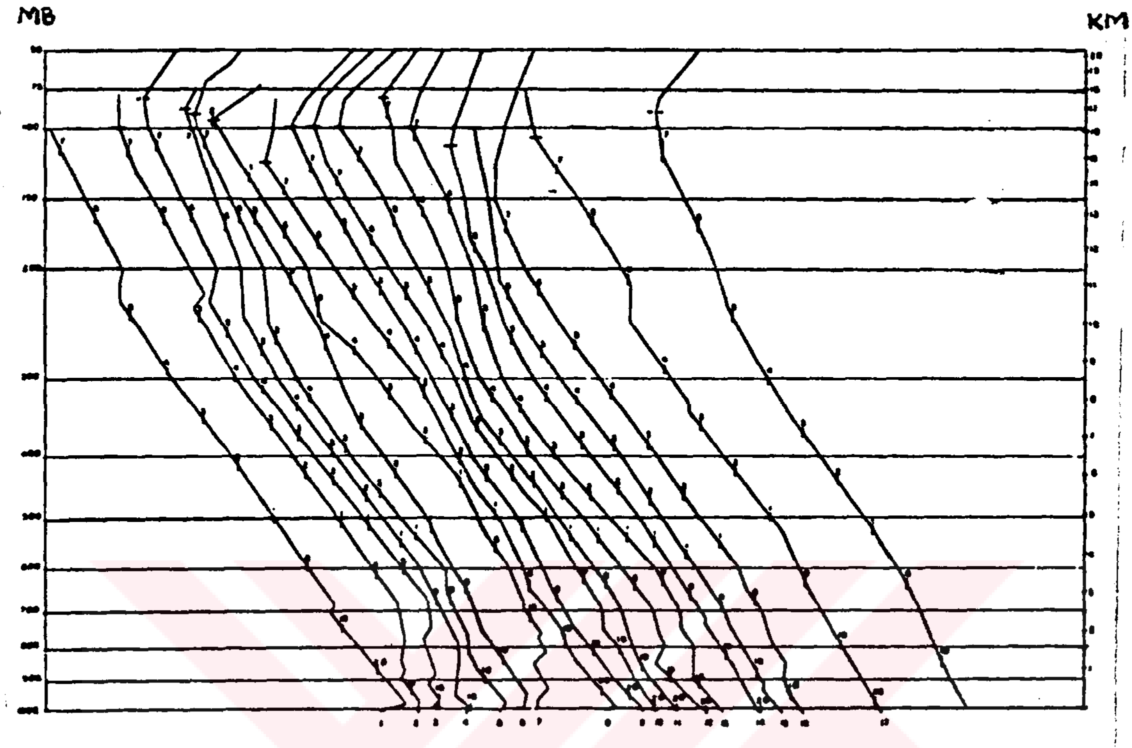

Figure 7 : The vertical temperature structure of soundings south of the subtropical breakline (subtropical group). Note the heigh level tropopause (above 150 mb). Location of -10°, -20°, -30 °C a.s.o. are indicated by 1, 2, 3 resp. Mean temperature distribution of these soundings is given on the right side.

lar vertical temperature structure. Even in the lower layers the differences in temperature are rather small. The 0 °C level is around 620 mb (approximately 4 km). The tropopause appears in all soundings at rather high altitudes (near the 100 mb level).

The vertical lapse rate seems to be quite uniform in the whole troposphere and at the tropopause levels temperatures of - 70 °C or lower are observed. A sharp break in lapse rate appears at the tropopause and from there on the temperature increases with height up to 50 mb. At the 50 mb the observed temperatures are mostly around - 60 °C. There seems to be no indication of a constant temperature with height in the stratosphere, at least not in the layer between 100 and 50 mb. Above 50 mb the observational evidence is rather poor, therefore nothing conclusive can be said about it. A study of the mean sounding shows the above described structure in a clear manner. Table III presents vertical lapse rates for different layers of this mean sounding.

In the lower troposphere (1000-600 mb) where the temperature varies more from sounding to sounding, the mean vertical lapse rate is - 0.46 °C / 100 m and from there on a rather constant lapse rate of - 0.73 °C / 100 m. extends upwards to 250 mb. At this level the lapse rate changes a little and the mean value from 250 mb to the tropopause is about the same as in the lowest layer (- 0.41 °C / 100 m). In the subtropical stratosphere the mean vertical increase of temperature with height was computed to be + 0.27 °C / 100 m. The mean tropopause is a little above 100 mb surface (exactly at 90 mb) and the tropopause temperature is -72 °C.

TABLE III (hundreth of °C / 100 m)

Layer (mb)	from	980	960	940	920	900	880	860	840
	to	960	940	920	900	880	860	840	820
		32	48	40	50	50	44	50	30
Layer (mb)	from	820	800	780	760	740	720	700	680
	to	800	780	760	740	720	700	680	660
		40	30	41	50	32	55	43	48
Layer (mb)	from	660	640	620	600				980
	to	640	620	600	580				580
		56	52	56	72			Mean :	46
Layer (mb)	from	580	560	540	520	500	480	460	440
	to	560	540	520	500	480	460	440	420
		57	72	73	67	87	66	100	71
Layer (mb)	from	420	400	380	360	340	320	300	280
	to	400	380	360	340	320	300	280	260

		81	76	69	72	73	58	82	58
Layer (mb)	from	260							580
	to	240							240
		73						Mean :	73
Layer (mb)	from	240	220	200	180	160	140	120	
	to	220	200	180	160	140	120	100	
		47	39	41	60	46	44	10	
			240-100		Mean : 41				
Layer (mb)	from	100	90	80	70	60			100
	to	90	80	70	60	50			50
		17	+13	+50	+33	+30		Mean :	27

In the area south of the subtropical breakline a typical sounding shows therefore a more or less uniform temperature decrease in the whole troposphere, which extends upwards to higher altitudes (near to 100 mb). From there on a noticeable increase of temperature with height is observed. The tropopause level is in most cases well defined. It must be clearly understood that soundings further south would show the tradewind inversion. In addition the tropopause would show up in still higher altitudes (between 90 and 60 mb) and the tropopause temperature would still decrease (in the equatorial region even as low as - 80 °C).

2.4 POLAR JET GROUP OF SOUNDINGS

In the soundings which intersect the wind maximum connected with the polarfront (Figure 8) no clear tropopause is observed. The temperature decreases mostly with height both in tropo-as well as in stratosphere. This can be seen in a lot of soundings. In some of these soundings slight tropopause indications may be seen. The form of these soundings and the breaks in lapse rate, depend very much on the exact location of the sounding with respect to the polar jet and on the steepness of the upper polarfront.

2.5 SUBTROPICAL JET GROUP OF SOUNDINGS

In Figure 9, soundings through the subtropical jet are presented. In these soundings it is also difficult to select a single tropopause. But contrary to the case of polar jet soundings, two different tropopause levels are generally present. From these, the lower one is formed around 200 mb level or a little above, while the higher one shows up at about 100 mb. Immediately after passing the lower tropopause, a frontlike temperature

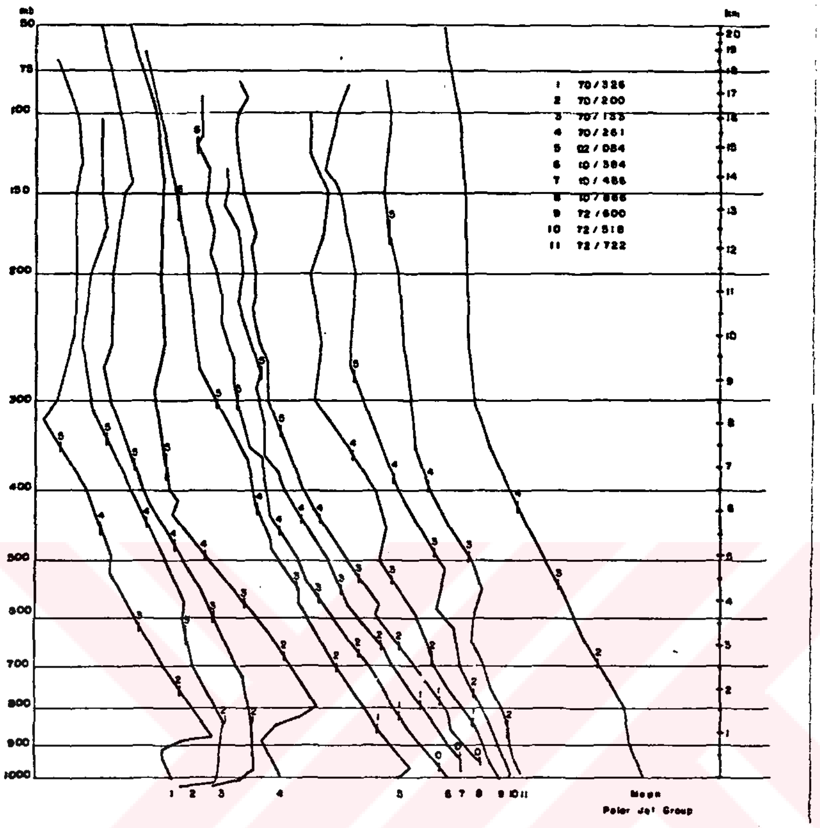

Figure 8 : The vertical temperature of soundings inside the polar breakline. The tropopause is not well defined and the temperature continues to decrease upward. The mean of these soundings is presented on the right side of the figure. The -10°, -20°, -30 °C a.s.o. are indicated by 1, 2, 3.

inversion can be noticed in most cases. This lower tropoause seems to be closely related to the level of heighest wind speed of the subtropical jet. Above this inversion the temperature falls off again sharply and at the higher tropopause this decrease changes abruptly to an increase with height. Here also it depends critically on the exact location of the sounding with respect to the subtropical jet maximum whether the lower or the higher tropopause is dominating.

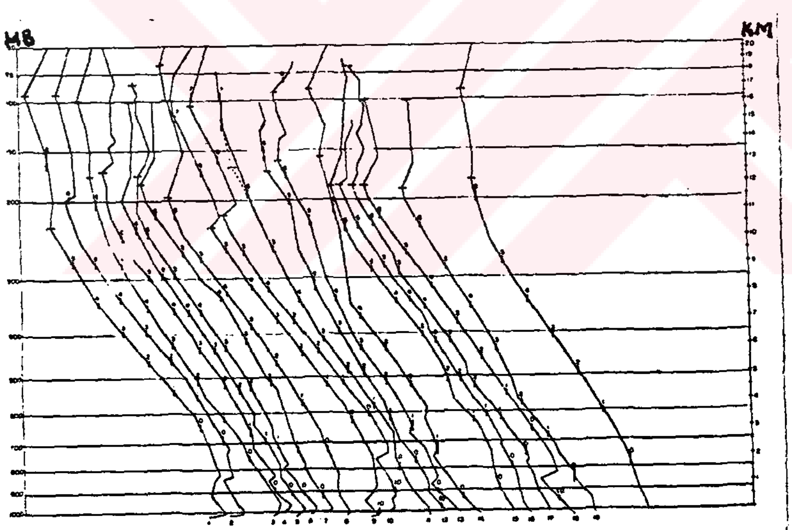

Figure 9 : The vertical temperature structure of soundings inside the subtropical breakline. Note the double tropopause level. The -10°, -20°, -30 °C a.s.o. are indicated by 1, 2, 3. The mean of these soundings is given on the right side of the figure.

CHAPTER 3. COMPARISON OF THE MEAN SOUNDINGS

Figure 10 presents the five mean soundings side by side. From this picture it is rather obvious that besides the strong baroclinicity in the troposphere between polar and middle soundings concentrated mainly in the polarfront zone an equally important baroclinicity is present in the stratosphere between middle and subtropical group, except that the horizontal temperature gradient is reversed. However, the stratospheric differences in temperature between polar and middle group are rather small.

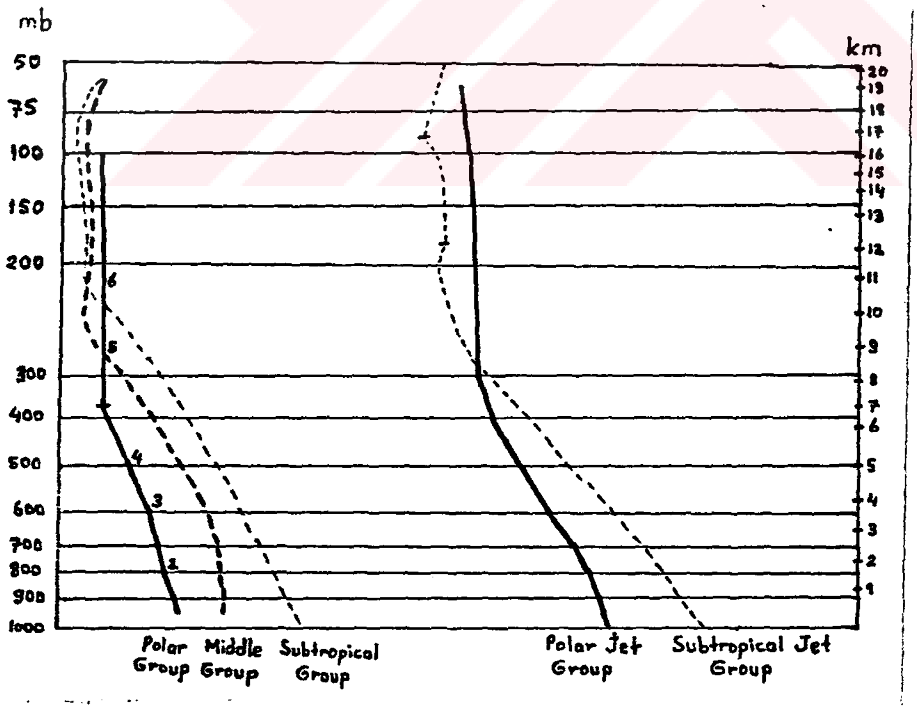

Figure 10 : Mean vertical temperature distribution of the five different groups. The -10, -20, -30 °C a.s.o. are indicated by 1, 2, 3.

For a circulation type such as that of January 1, 1956, where the subtropical jet remains mainly near latitude circle 30 °N and the polar jet is mostly far apart the two baroclinic zones are also well separated. When the subtropical systems moves northward, as e.g. over the Atlantic Ocean, then the tropospheric and the stratospheric baroclinicity are nearly superimposed. In this case the middle part disappears and the whole baroclinicity exists between subtropical and polar group in tropo- and stratosphere, but in the stratosphere in the reversed sense[8].

3.1 COMPARISON WITH OBSERVATIONS

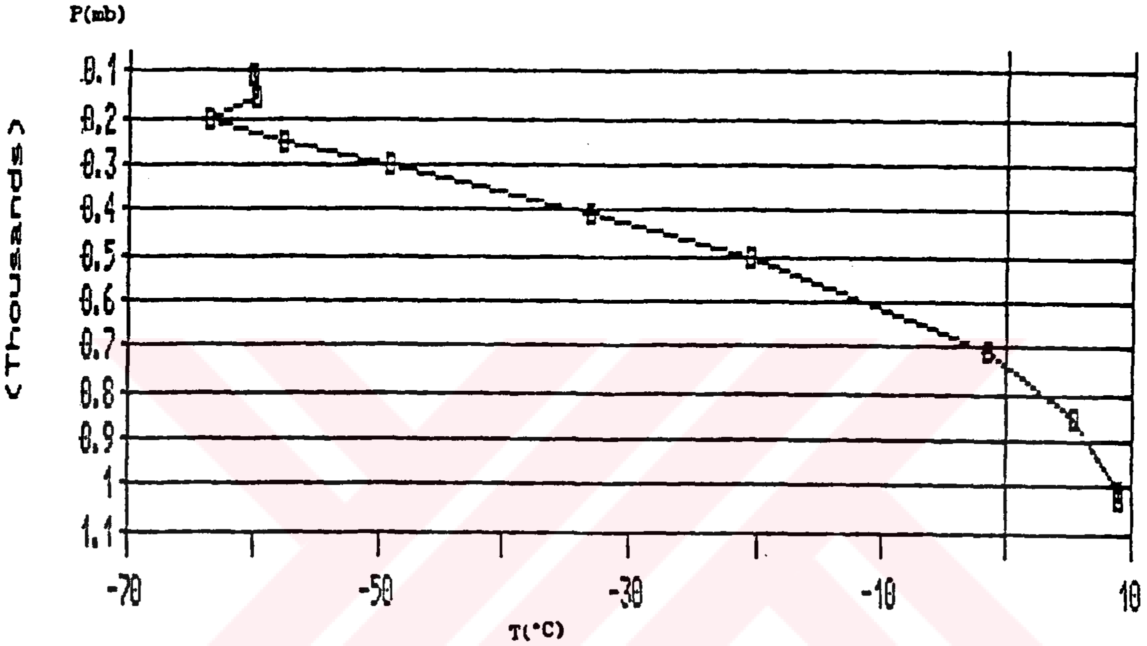

Figure 15 : January 1-2 and 6-10, 1988 ;
All over Turkey had been affected by high pressure system between these dates. The pressure in Istanbul was above 1020 mb and the pressure in our eastern region was above 1030 mb continuously.

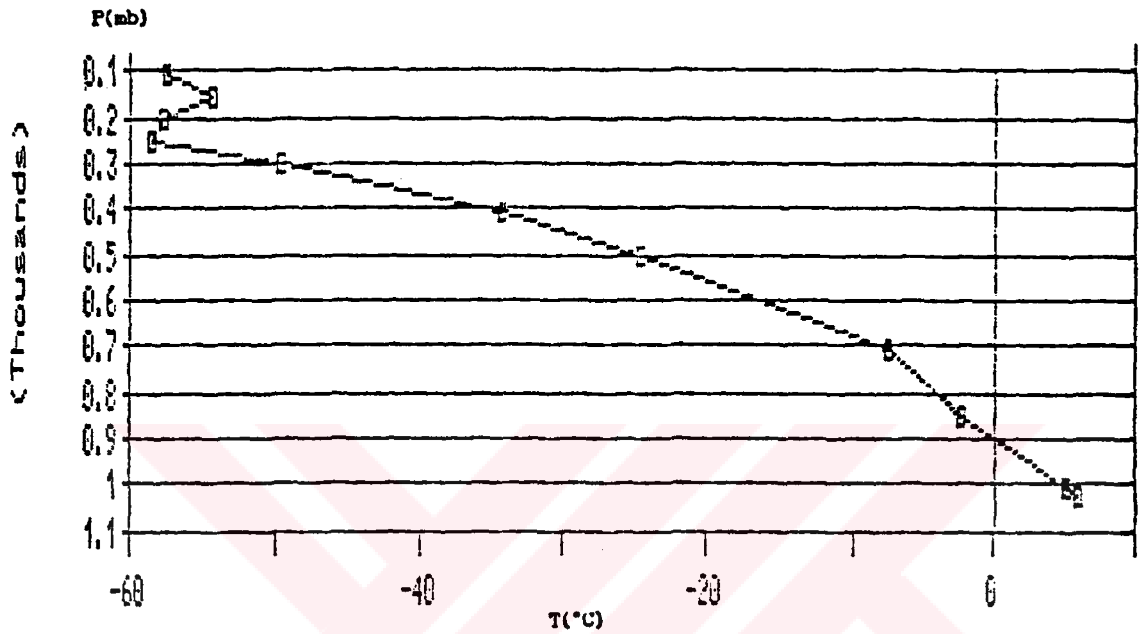

Figure 16 : January 11-13, 1988 ;
A low pressure and a frontal system which are dominated by high pressure system were observed in Istanbul. This frontal system was clearly effective in January 12.

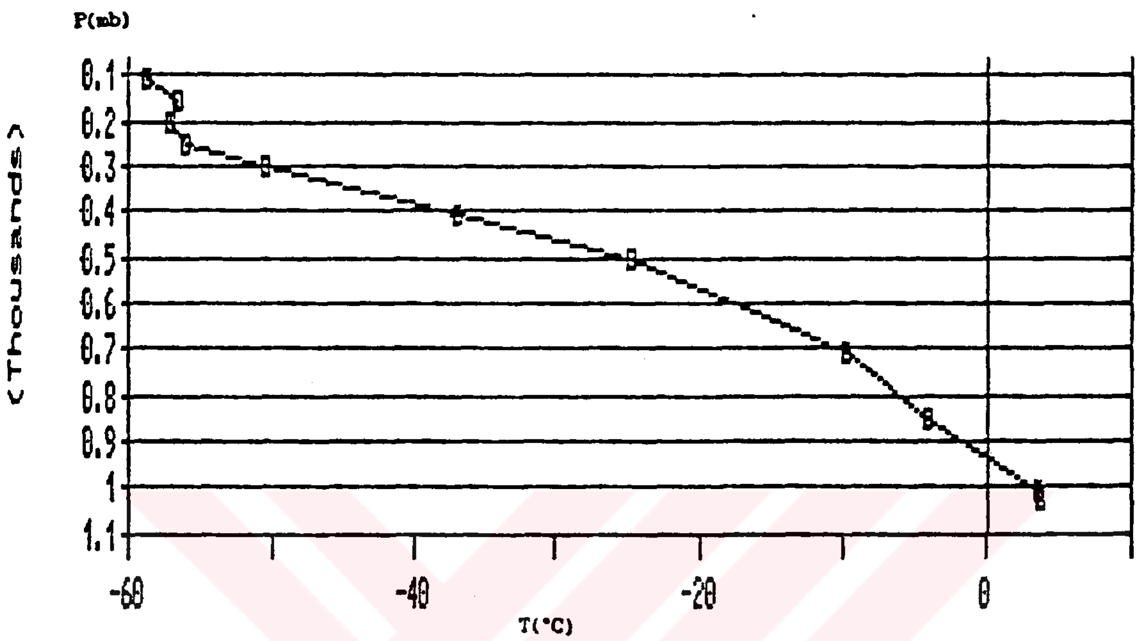

Figure 17 : January 14-21 and 22-31, 1988 ;
An effective high pressure system was observed in Istanbul. Very high pressures were reported between these dates. (1023 and 1035 mb). The front passed just over Istanbul on January 28 and January 29.

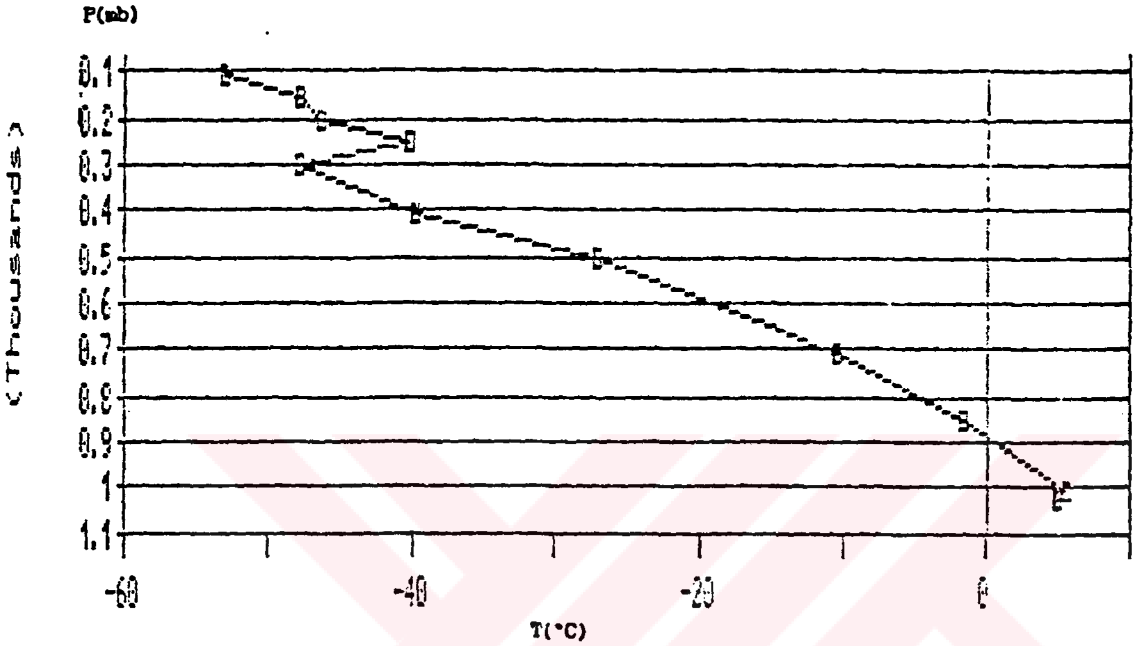

Figure 18 : February 1, 1988 ;
The low pressure system and frontal system were observed in Istanbul. At the same day, this system moved toward south. The pressure was below 1000 mb.

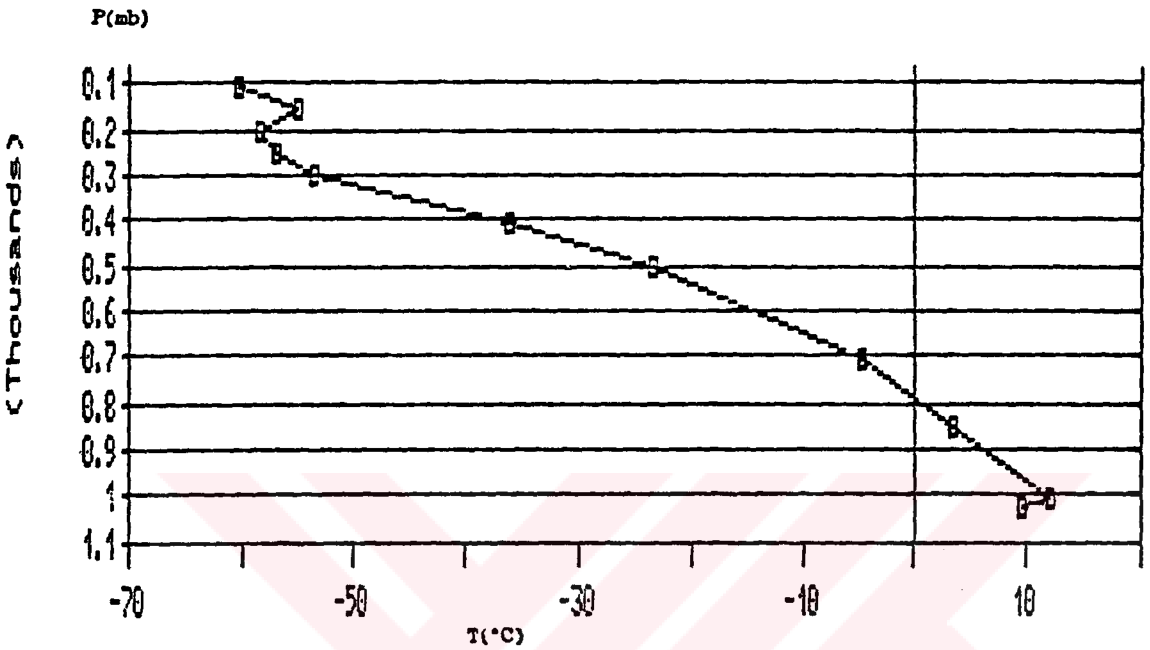

Figure 19 : February 9-10 and 14-17, 1988 ;
Generally Turkey was affected by a low pressure system and frontal system which are dominated by high pressure system. The pressure is over 1020 mb.

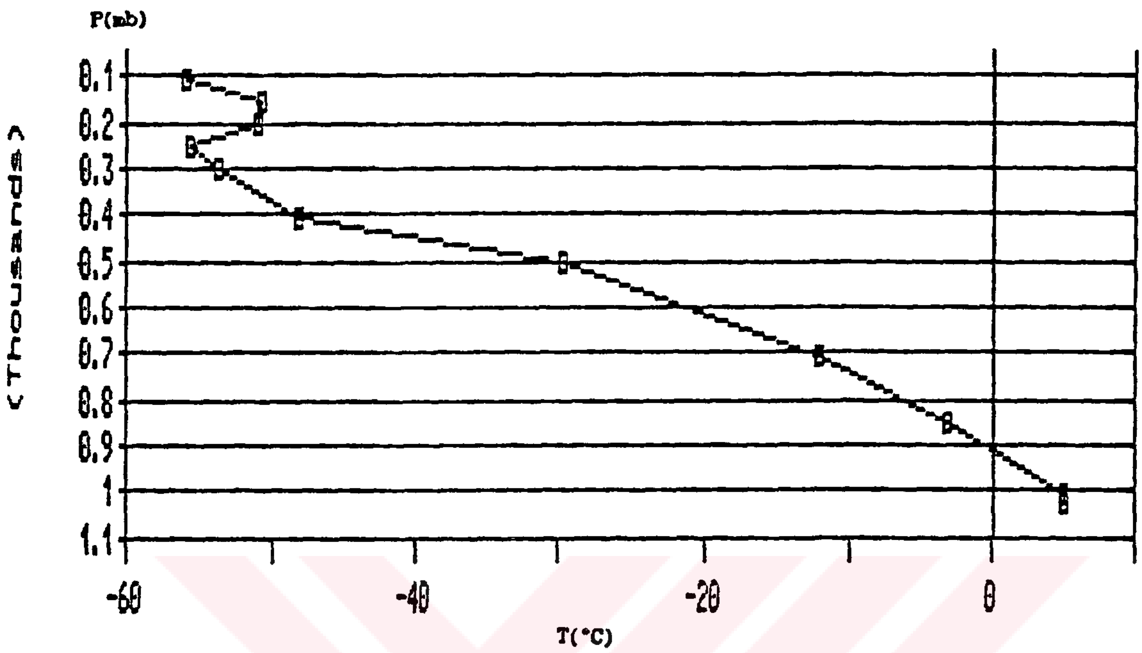

Figure 20 : From February 20, 1988 to March 21, 1988 ; A cold front belong to a low pressure system passed from Istanbul on 20 February. The pressure went dowm under 1000 mb in Istanbul.

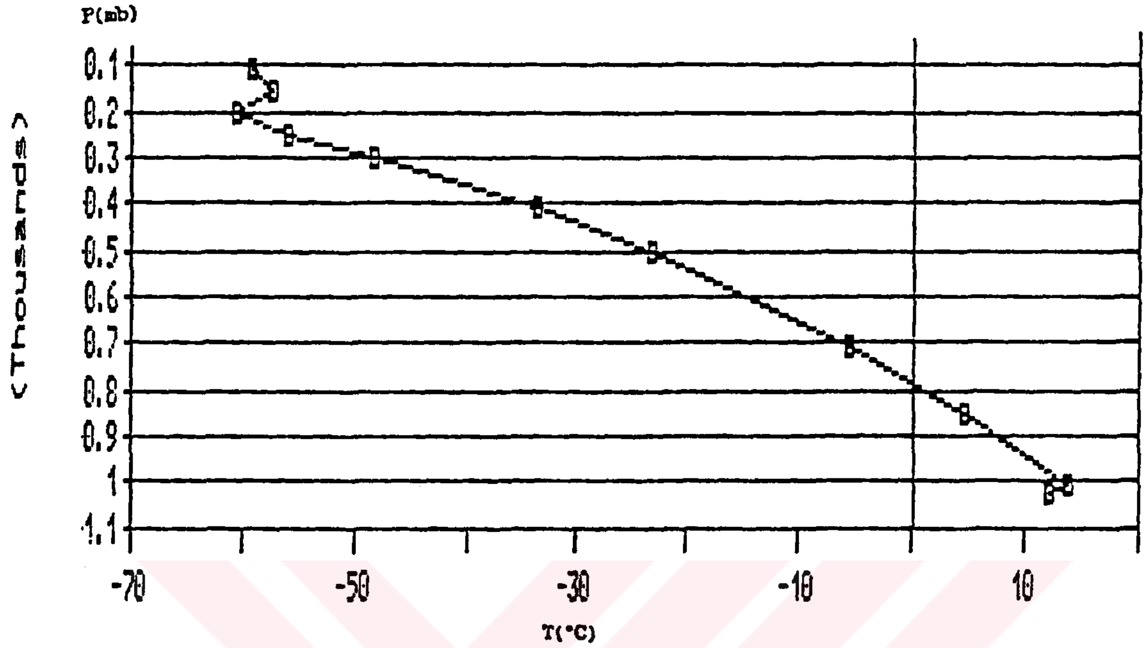

Figure 21 : April 1-4 and 5-7, 1988 ;

An effective high pressure system was observed in Turkey, the pressure went up above 1025 mb. It was observed that a frontal system was coming to Istanbul from west. This frontal system had shown itself very clearly on April 6.

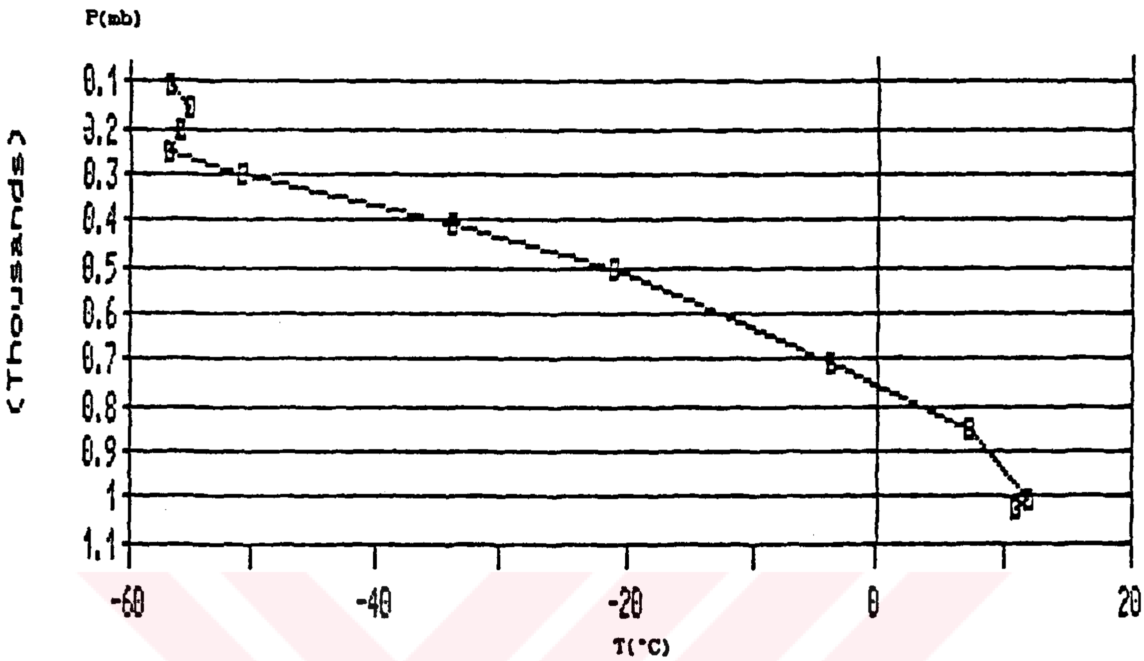

Figure 22 : April 11-12 and 19-21, 1988 ;
The frontal system which was dominated by high pressure system passed from Istanbul.

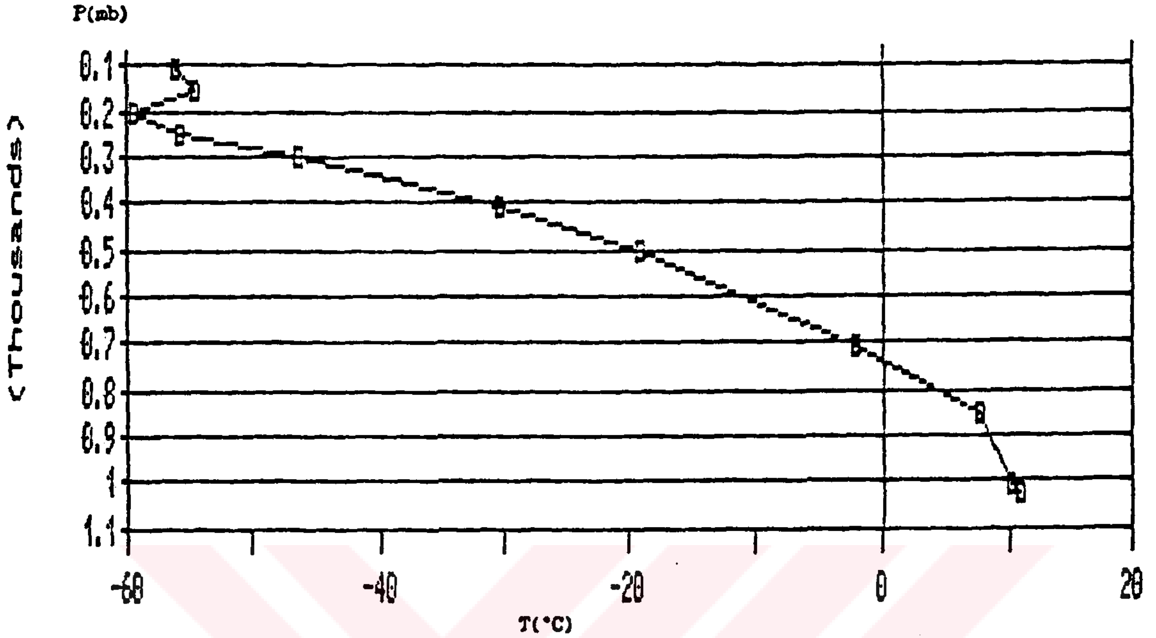

Figure 23 : From April 25, 1988 to May 9, 1988 ;

The high pressure system and frontal system affected in Istanbul. From May 3, a high pressure system was getting close to Istanbul and the pressure goes up day by day.

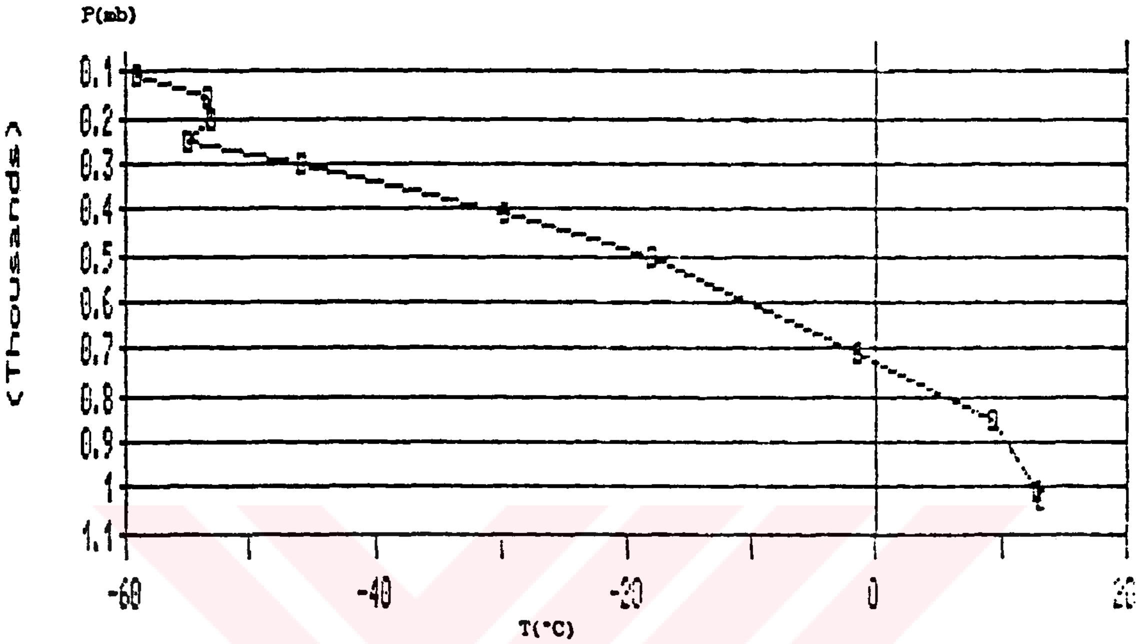

Figure 24 : May 10, 1988 ;

The low pressure system was observed.

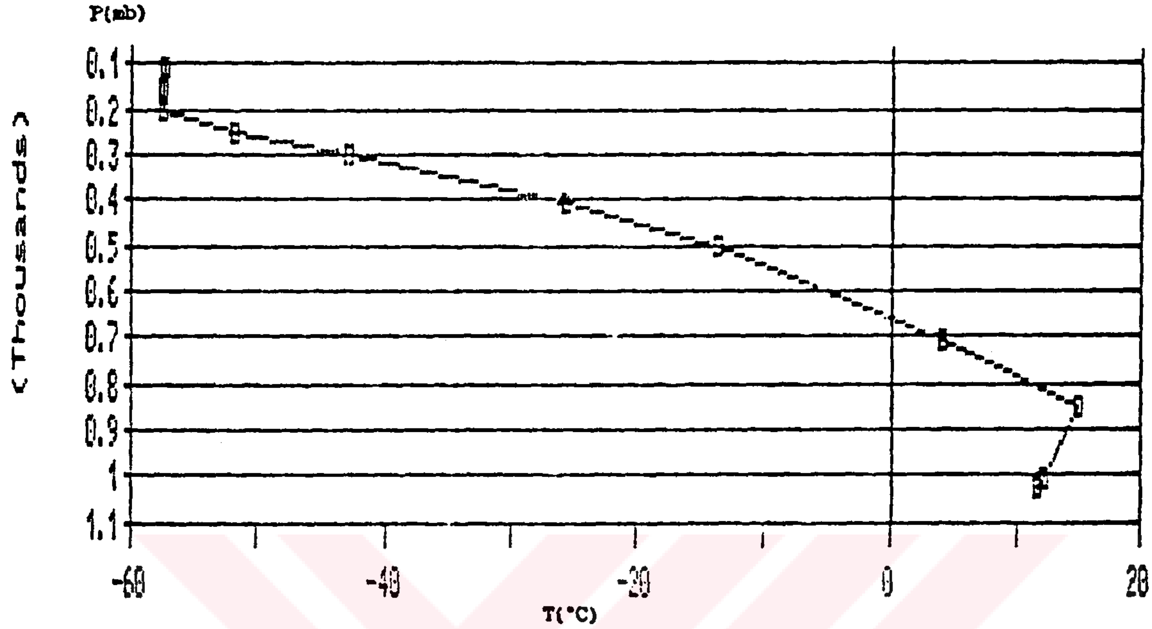

Figure 25 : May 16, 1988 ;

The high pressure system was observed in Istanbul.

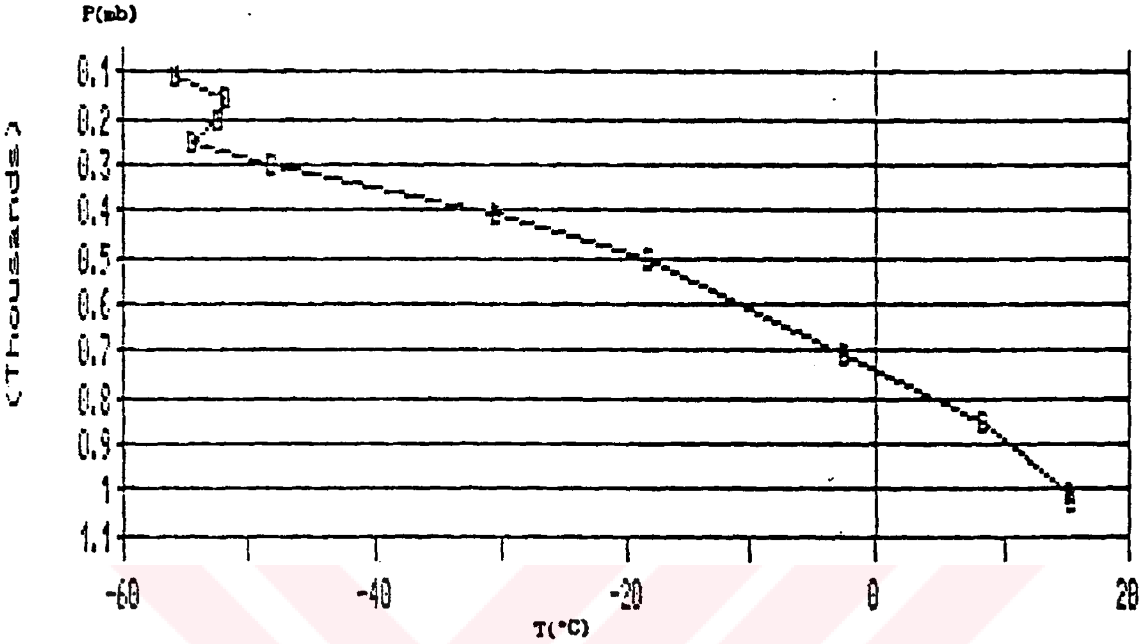

Figure 26 : May 22-23, 1988 ;

The high pressure system was observed in Istanbul.

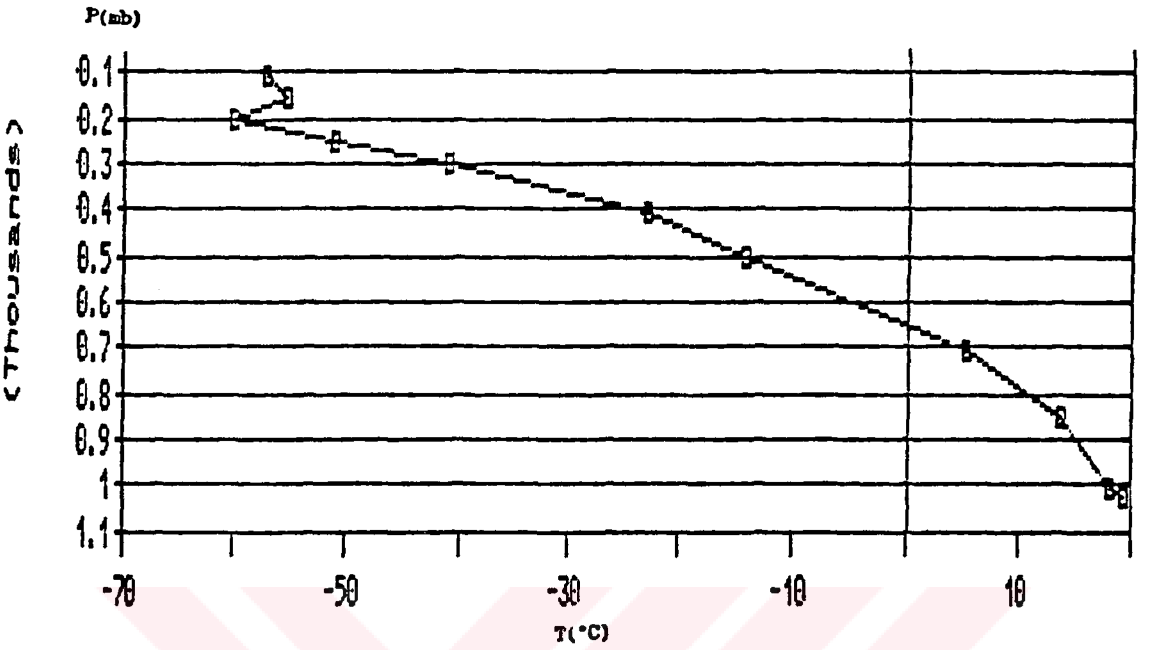

Figure 27 : June 6,7,16-19 and 25-26, 1988 ;

The high pressure system was observed in Istanbul.

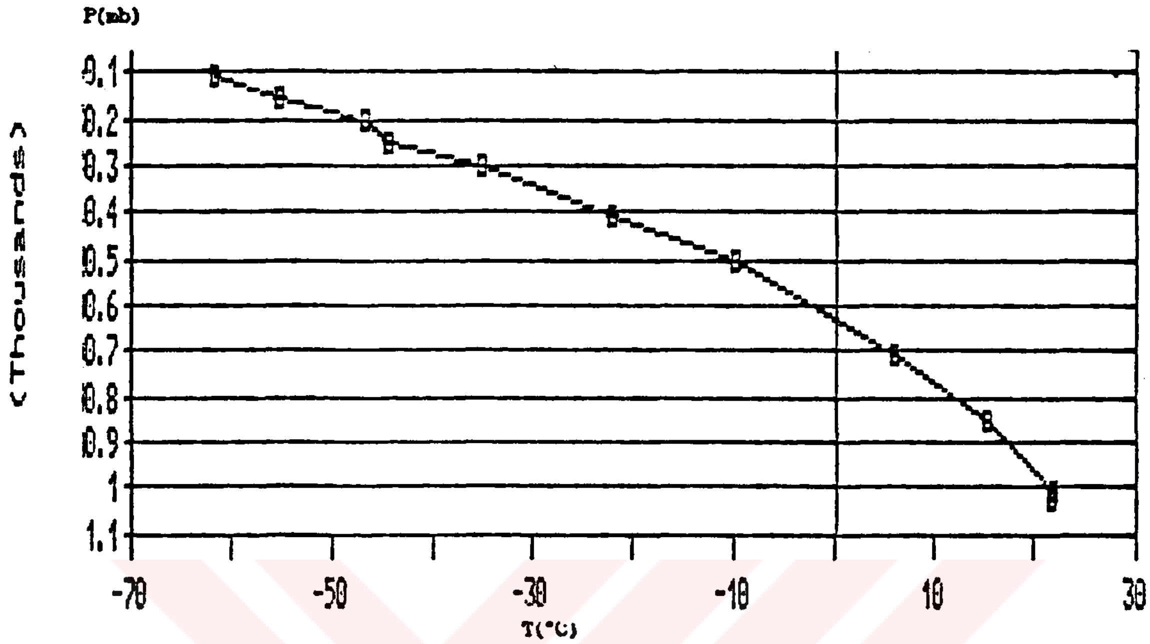

Figure 28 : From July 2, 1988 to August 27, 1988 ;
An effective high pressure system was observed in Istanbul.

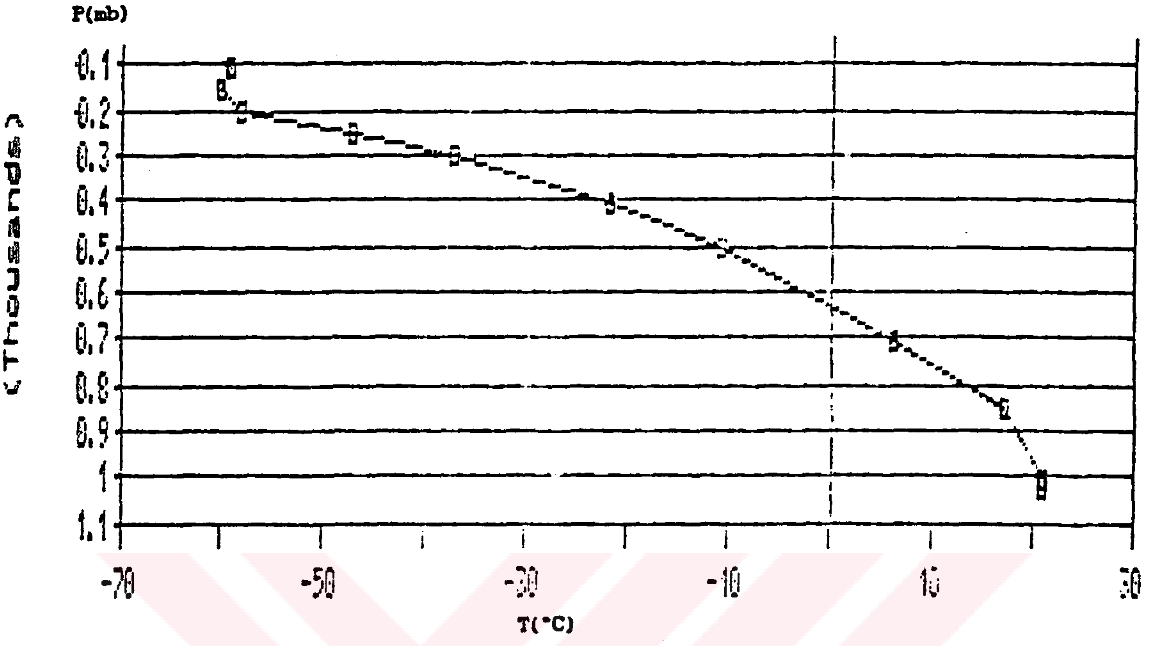

Figure 29 : September 3, 1988 ;

In Istanbul, the high pressure system was observed.

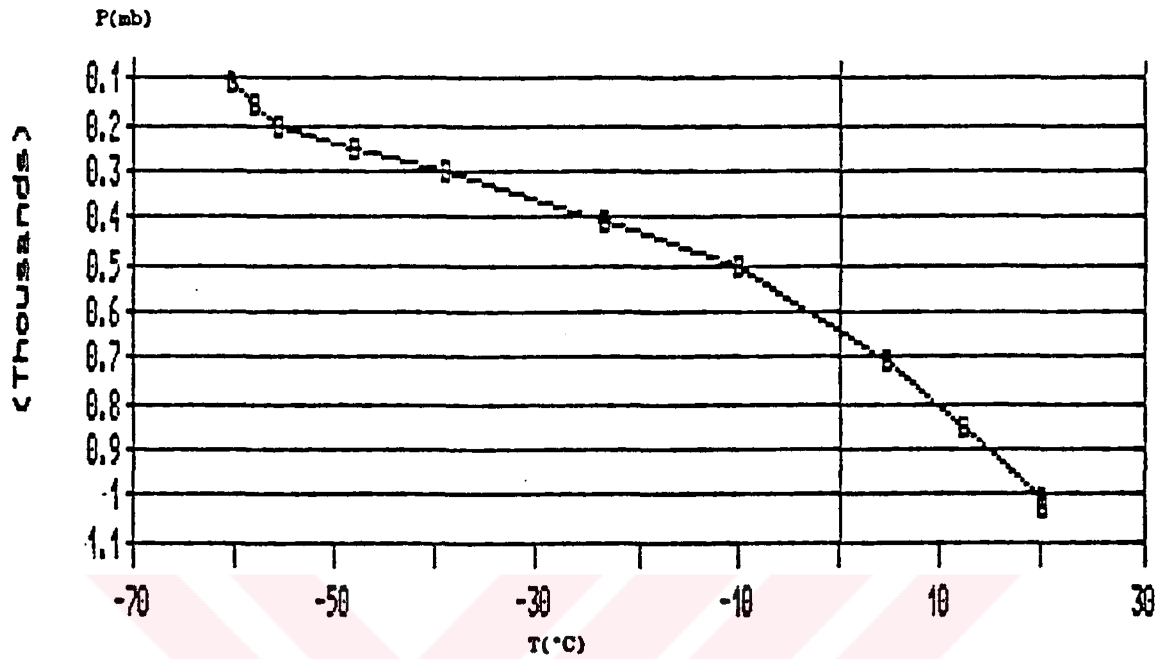

Figure 30 : September 5-19, 1988 ;
Istanbul was affected by a low pressure system and frontal system.

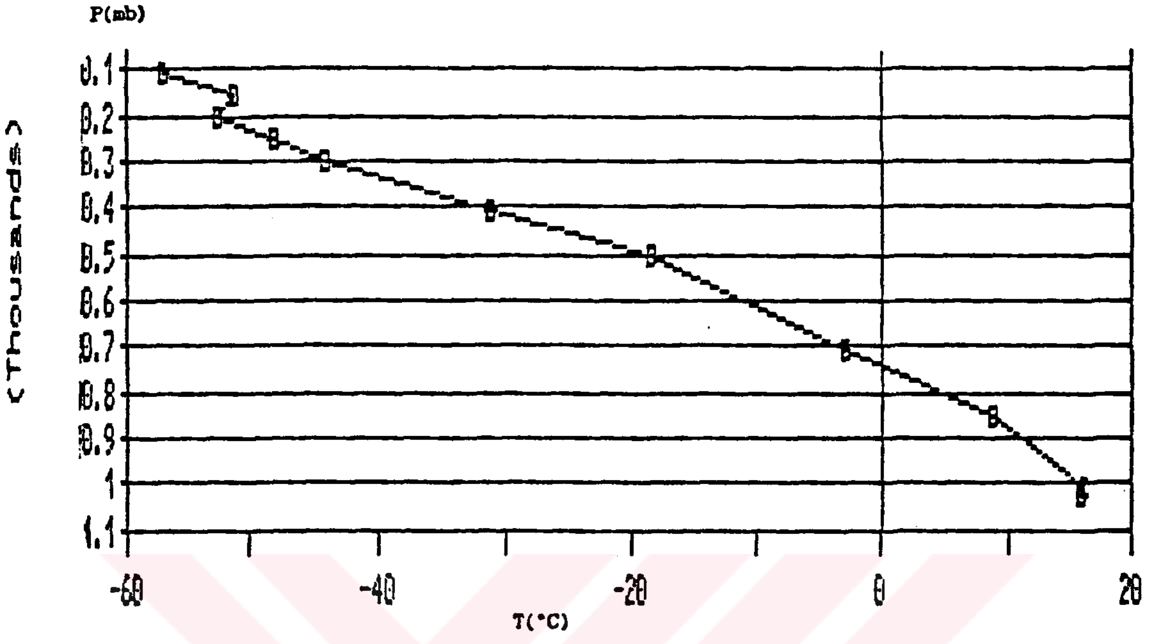

Figure 31 : From October 5, 1988 to November 2, 1988 ; In general, the low pressure system and frontal system were observed in Istanbul.

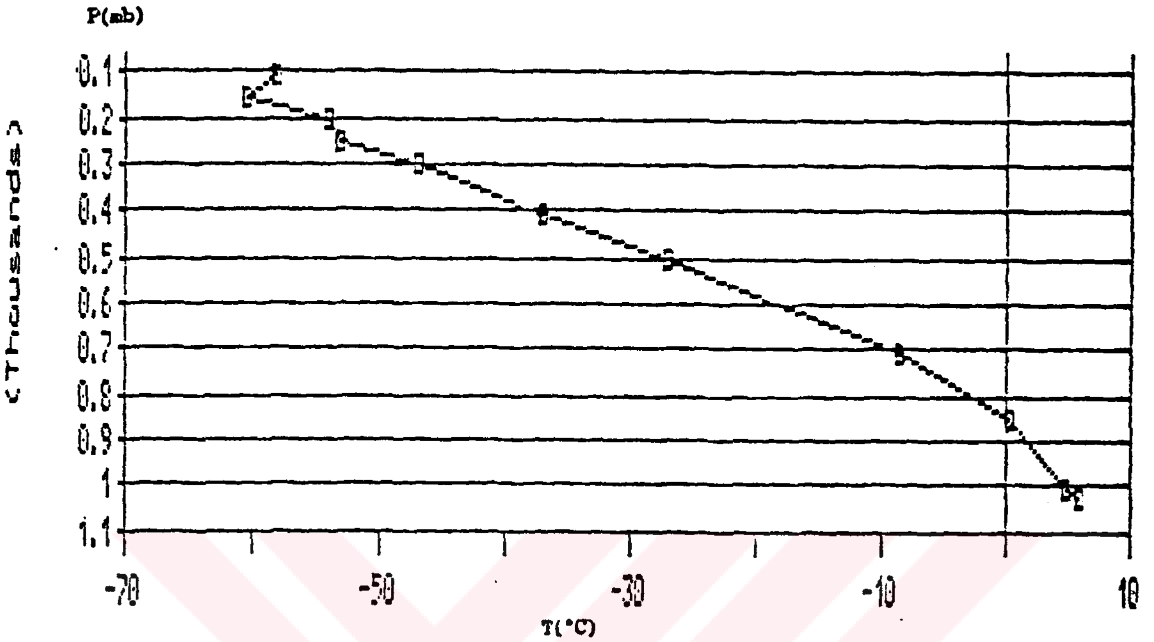

Figure 32 : November 7, 1988 ;

The high pressure system was observed in Istanbul.

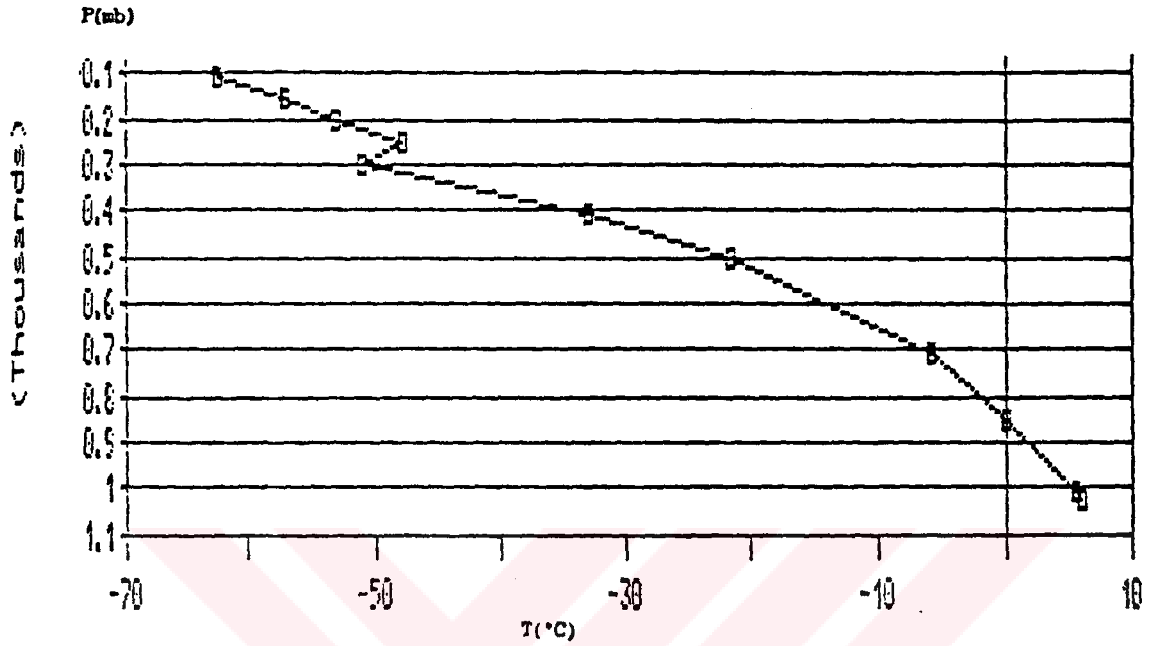

Figure 33 : November 15, 1988 ;

The low pressure system was observed in Istanbul.

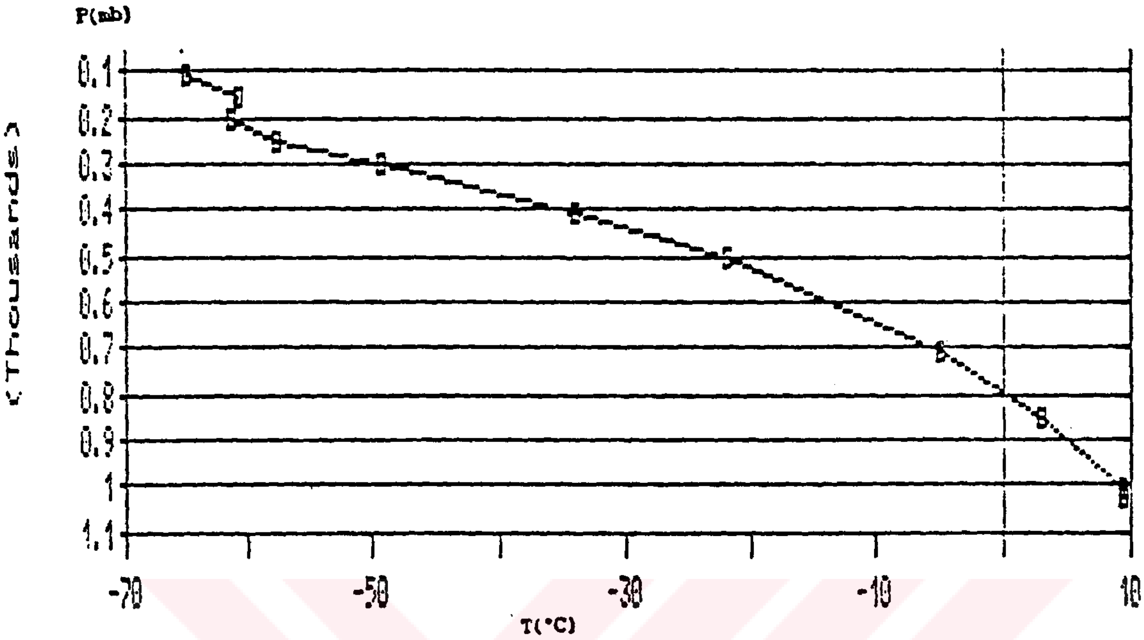

Figure 34 : November 18-26, 1988 ;

The high pressure system was observed in Istanbul.

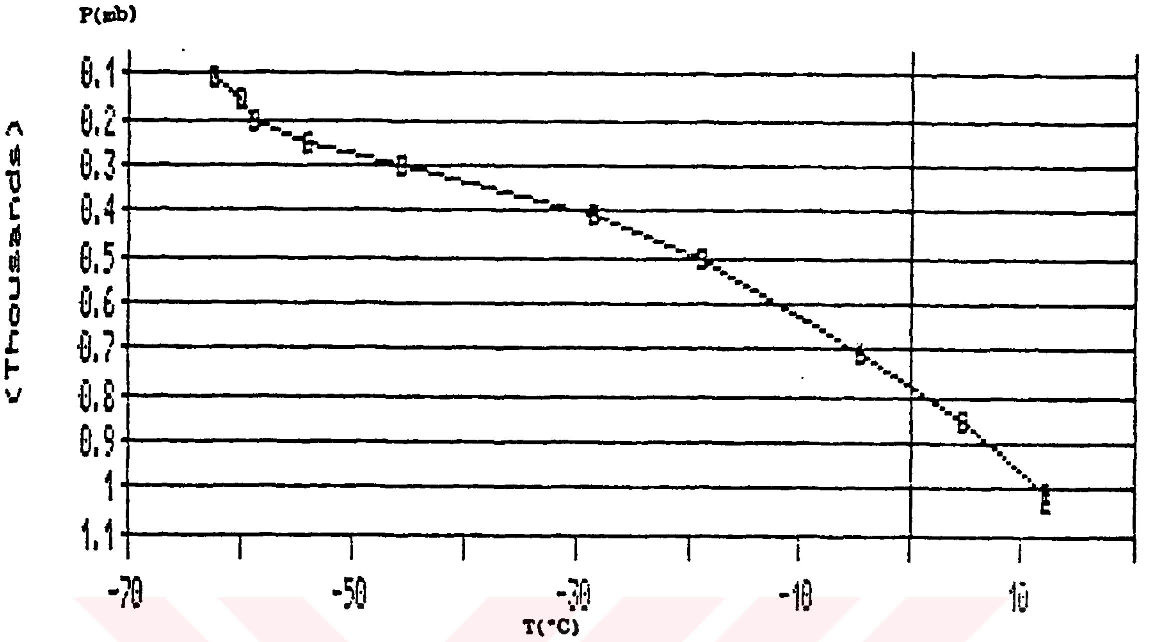

Figure 35 : December 1-4, 1988 ;

The high pressure system was observed in Istanbul.

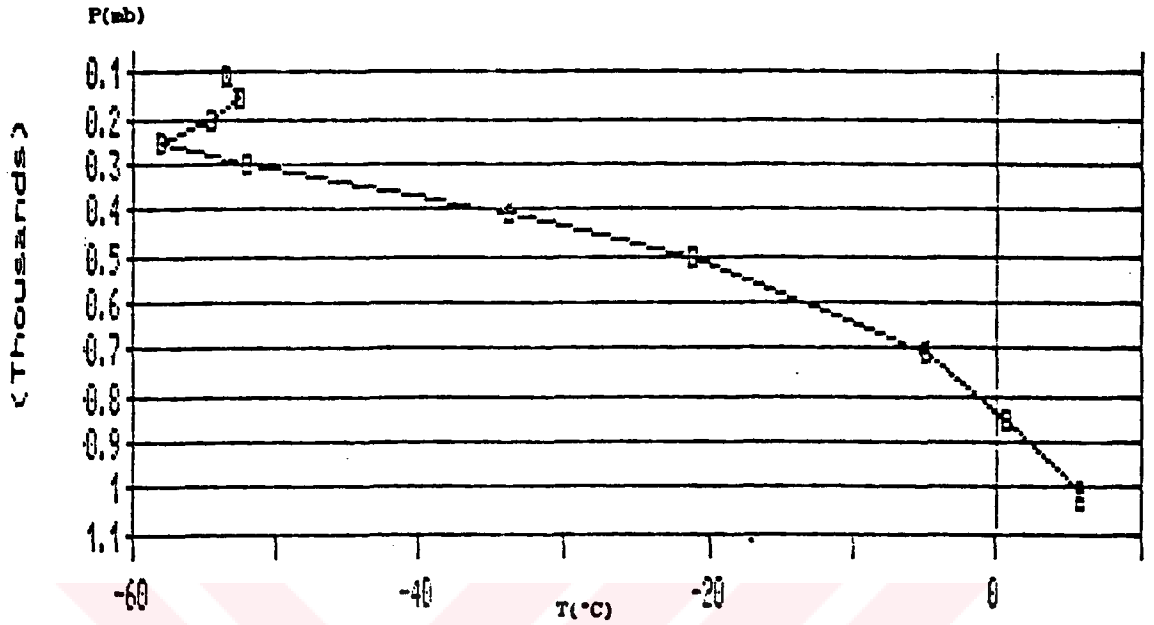

Figure 36 : December 10-12, 1988 ;

The low pressure system was observed in Istanbul.

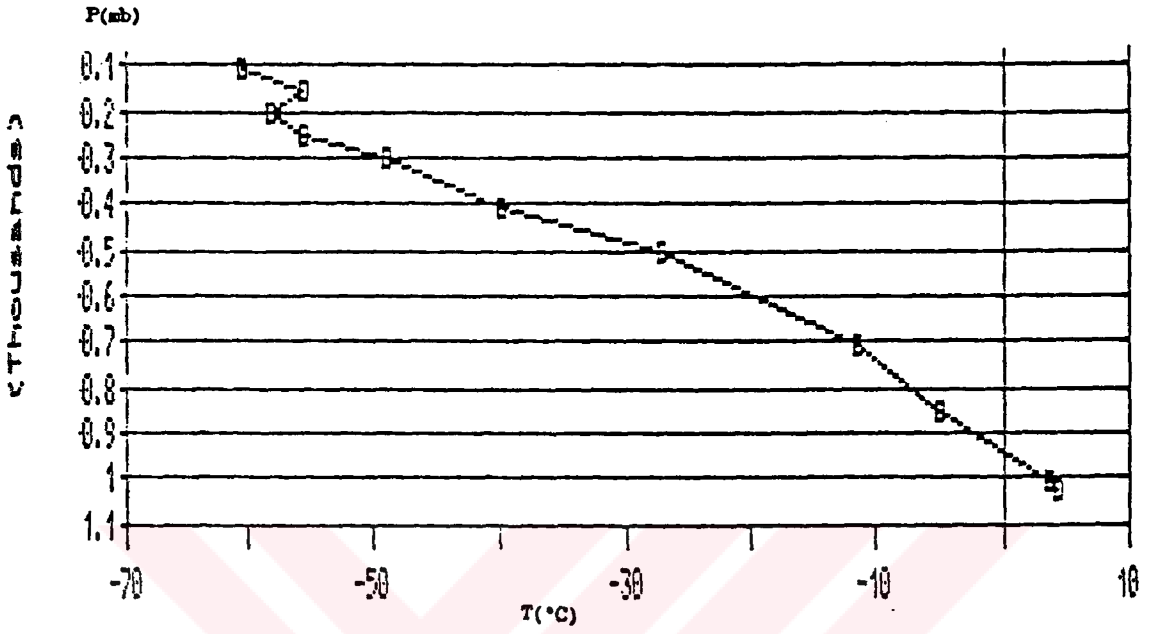

Figure 37 : December 18-19, 1988 ;

The high pressure system was observed in Istanbul.

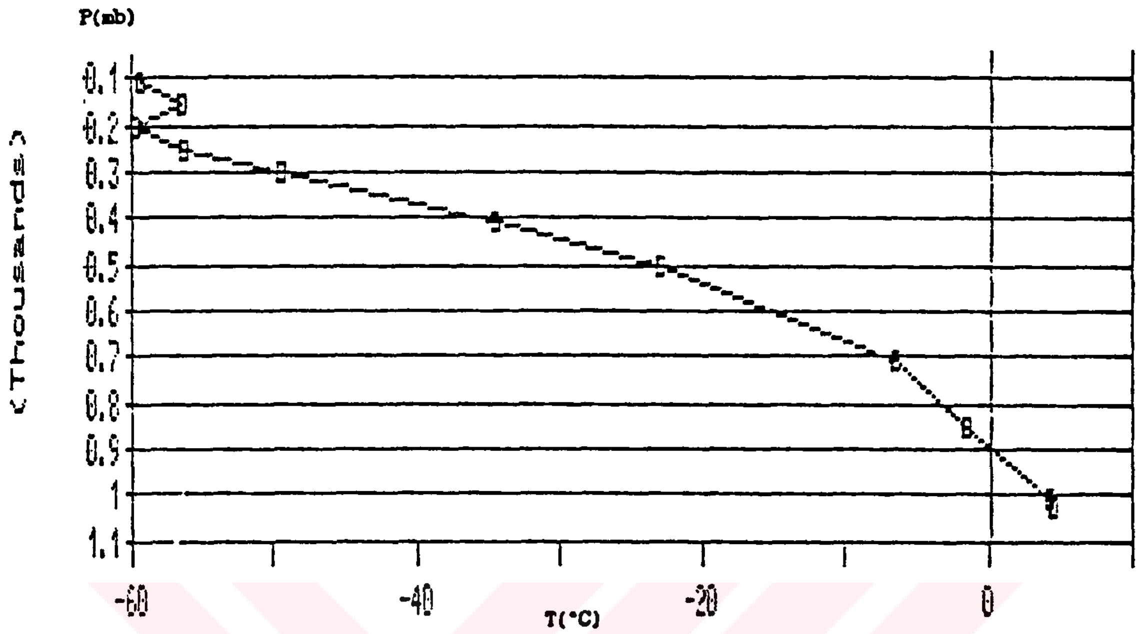

Figure 38 : January 4-7 and 10-31, 1989 ;

The high pressure system which was closing to toward Istanbul between first and third January had become more effective and Istanbul was affected by high pressure completely. The pressure was observed 1040 mb on 4 January and this value of pressure starts going 10 mb by 10 mb down day by day and the pressure went down 1010 mb approximately on 7th January and this pressure system started losing its effect in this way. On January 10,it was observed a new high pressure system that was coming towards Turkey from Balkans. It was seen that, at the beginning, the center of this pressure system was at the west of Italy and then it changes toward southwest in these dates, the pressure is between 1025 and 1035 mb.

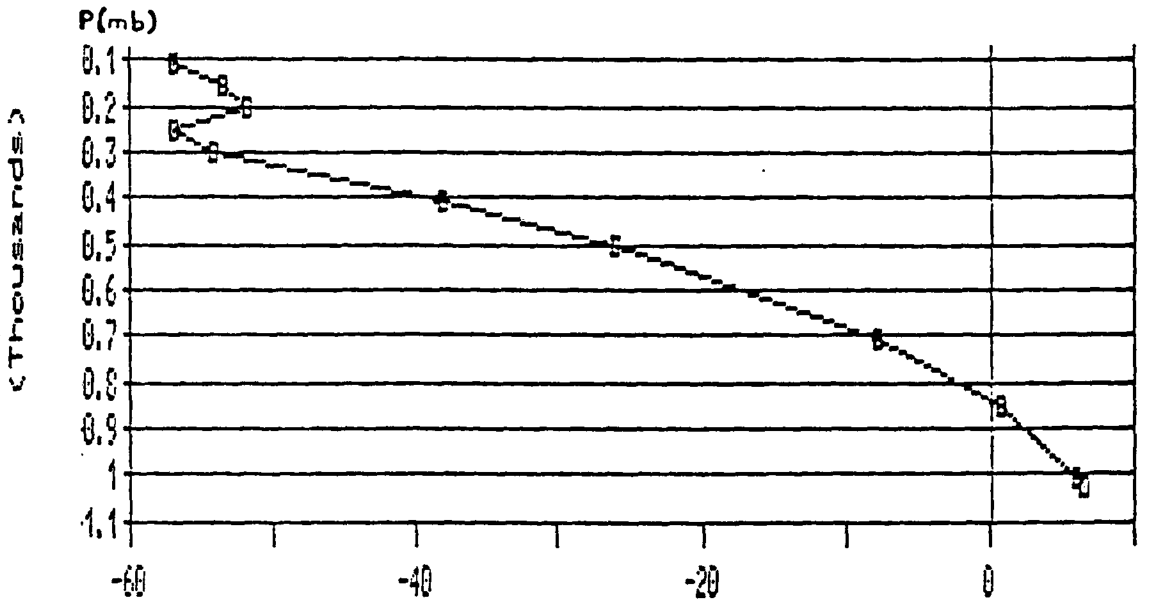

Figure 39 : March 8-14, 1989 ;
A low pressure system and frontal system which is coming from the Mediterranean were observed in Istanbul.

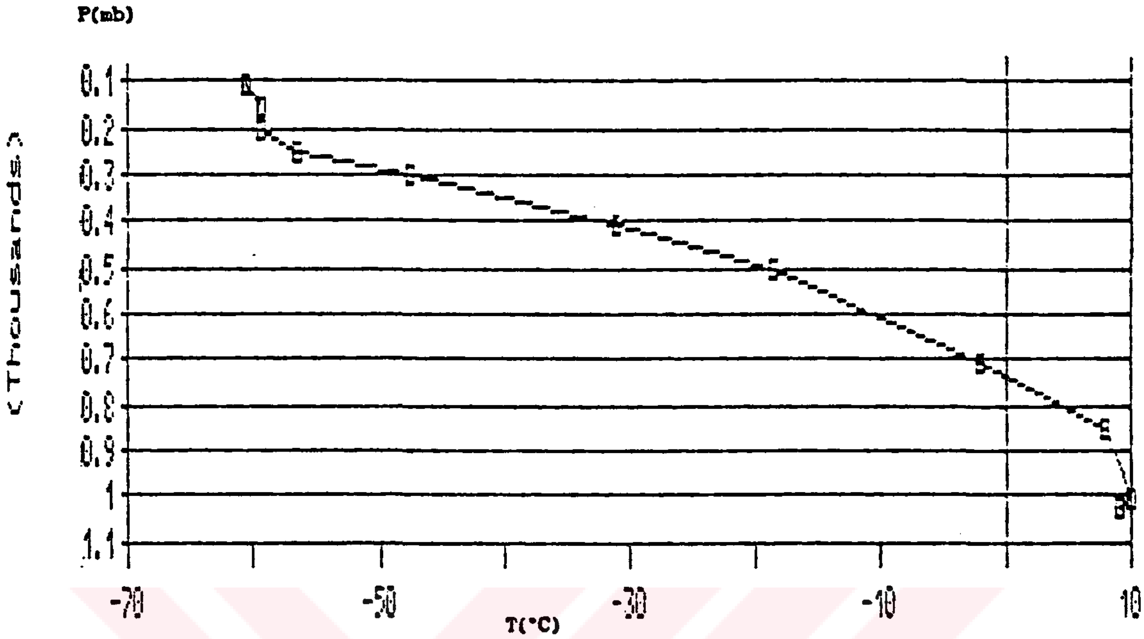

Figure 40 : March 17-18 and 23-25, 1989 ;

From March 15, the effective high pressure system begins to come from Balkans toward Istanbul. From March 18,this system goes on its motion towards East. From March 23, a low pressure system and frontal system were observed in Istanbul.

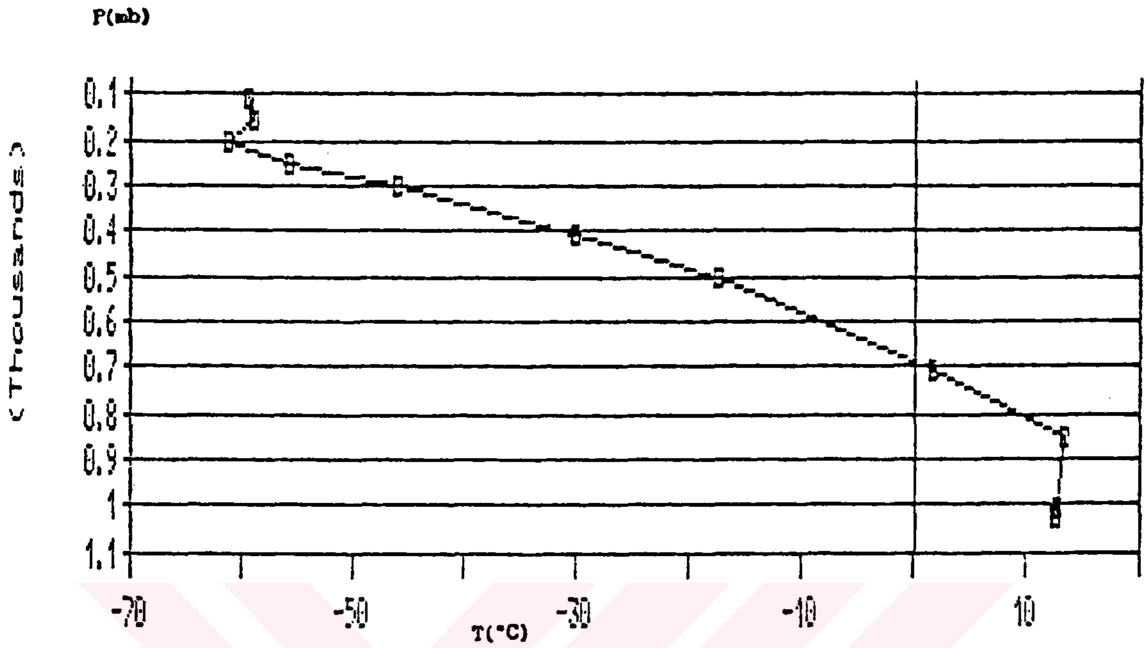

Figure 41 : April 10-15 and 20-24, 1989 ;

On April 9, a low pressure system and a frontal system were observed in Turkey. This situation is seen very clearly in the region of Marmara. Because in Istanbul, the pressure was decreased until 1000 mb. The strong effective of front is seen on April 15. From April 16, this front was gone on toward East and than a high pressure system was observed in Istanbul.

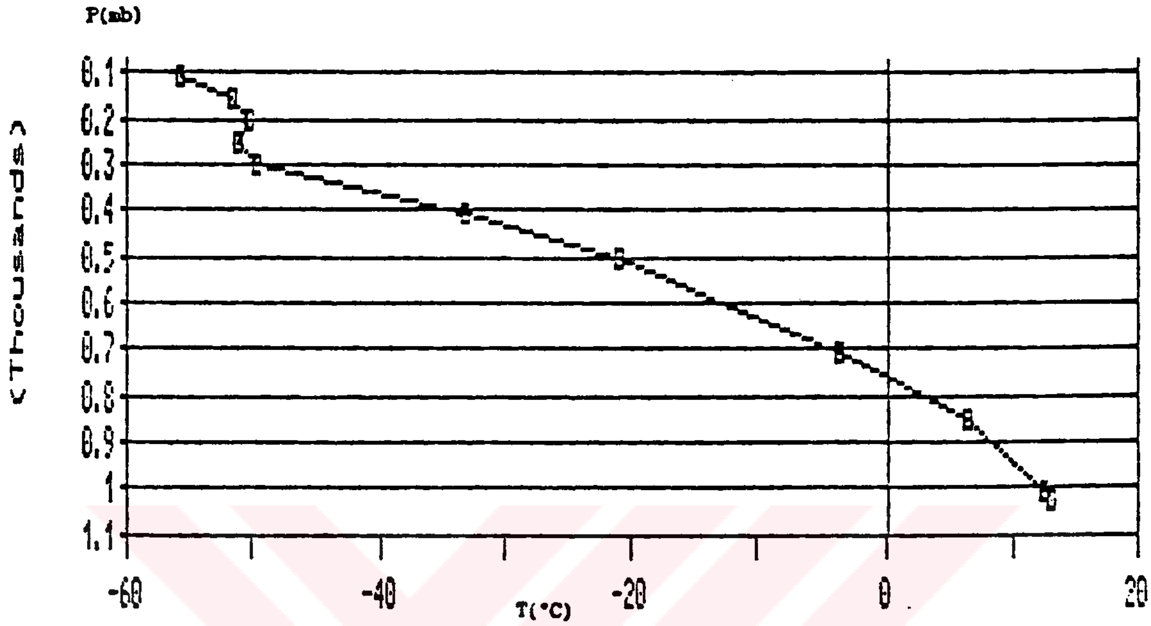

Figure 42 : May 4, 1989 ;

A low pressure system and frontal system were observed in Istanbul.

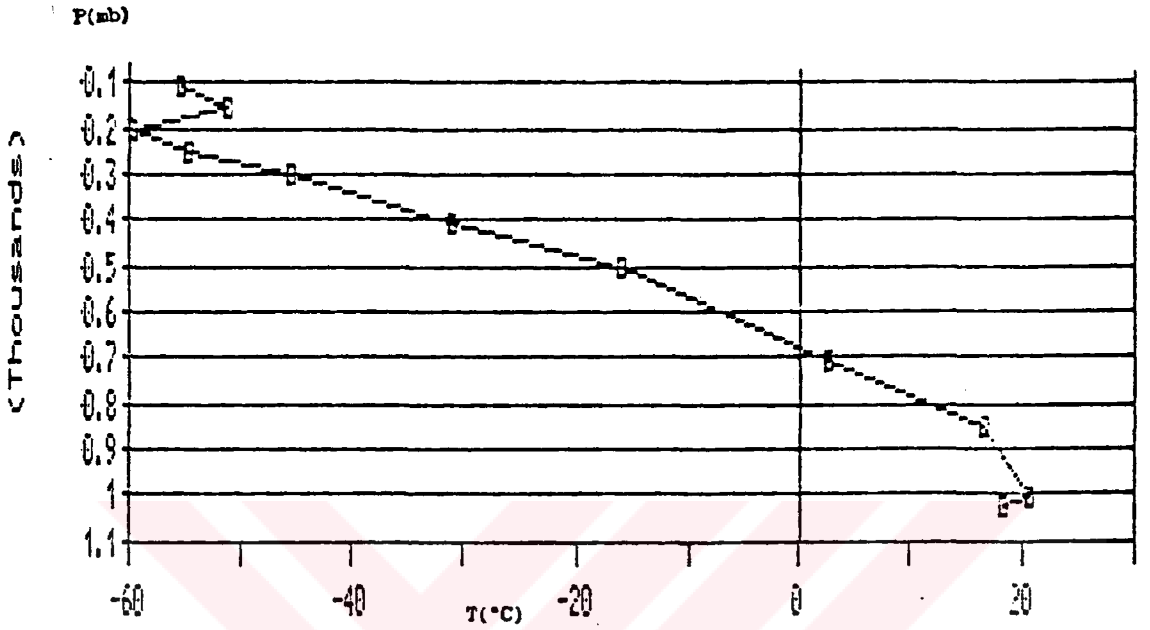

Figure 43 : May 20-21, 1989 ;

A low pressure system was observed in Istanbul.

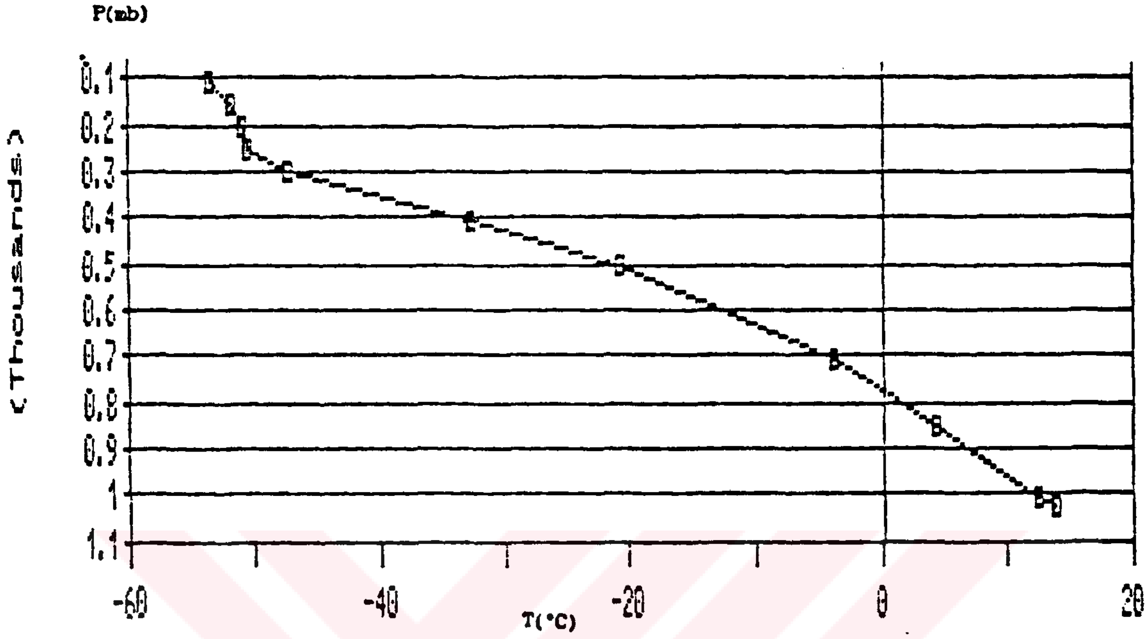

Figure 44 : May 23-25, 1989 ;

The high pressure system was observed in Istanbul.

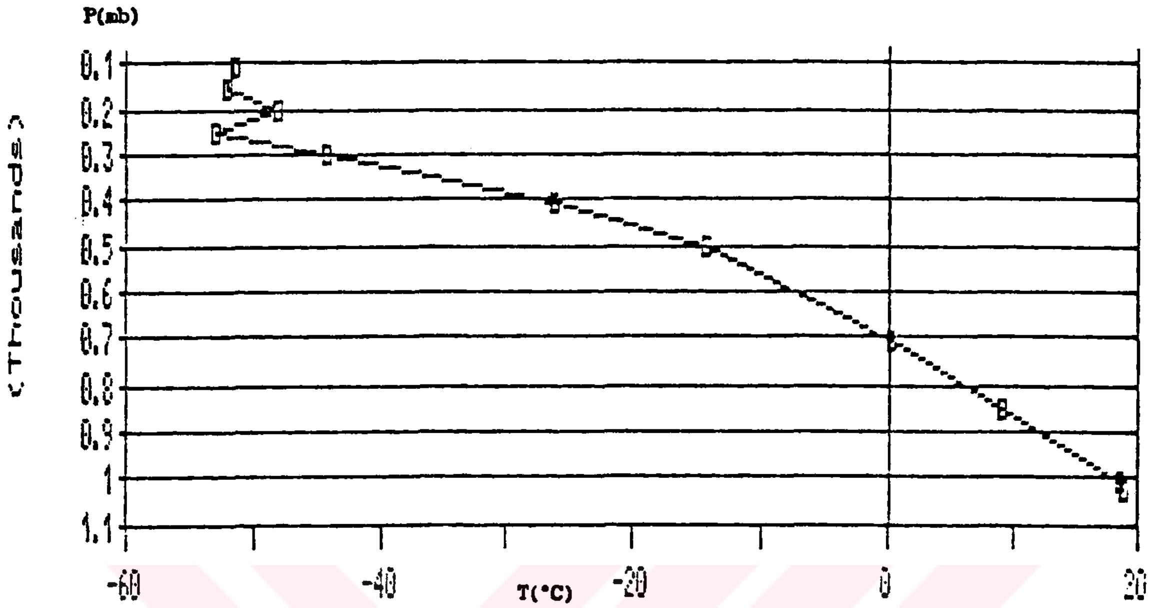

Figure 45 : June 3 and 9, 1989 ;

The low pressure system was observed in Istanbul.

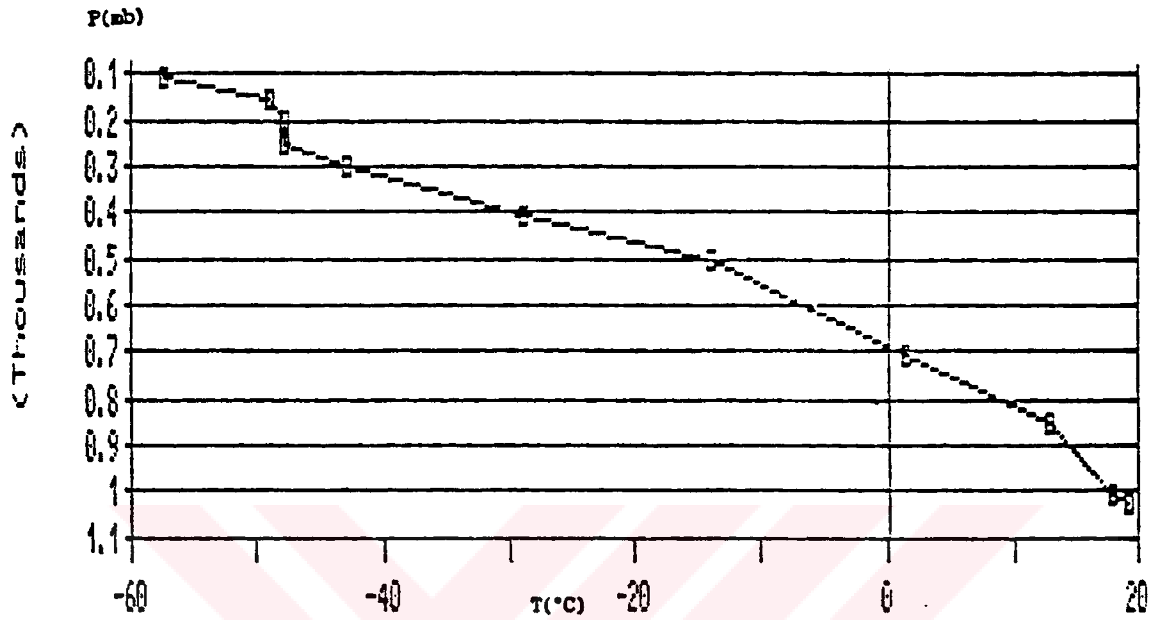

Figure 46 : June 22, 1989 ;

A low pressure system was observed in Istanbul. The pressure is 1010 mb.

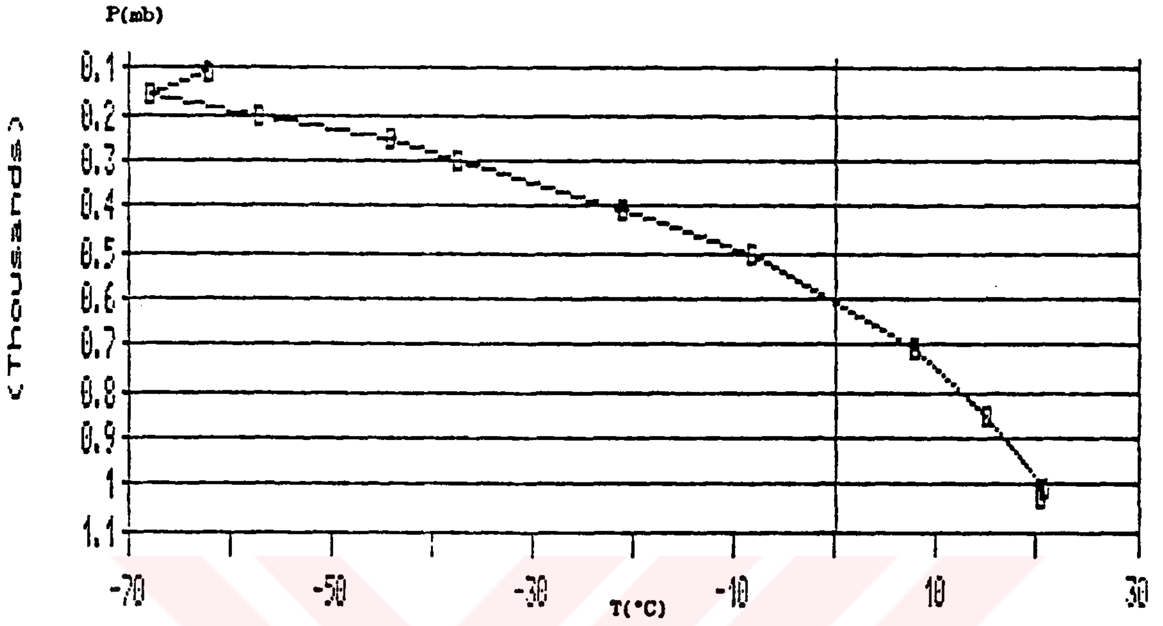

Figure 47 : August 9, 1989 ;

An effective high pressure system was observed in Istanbul.

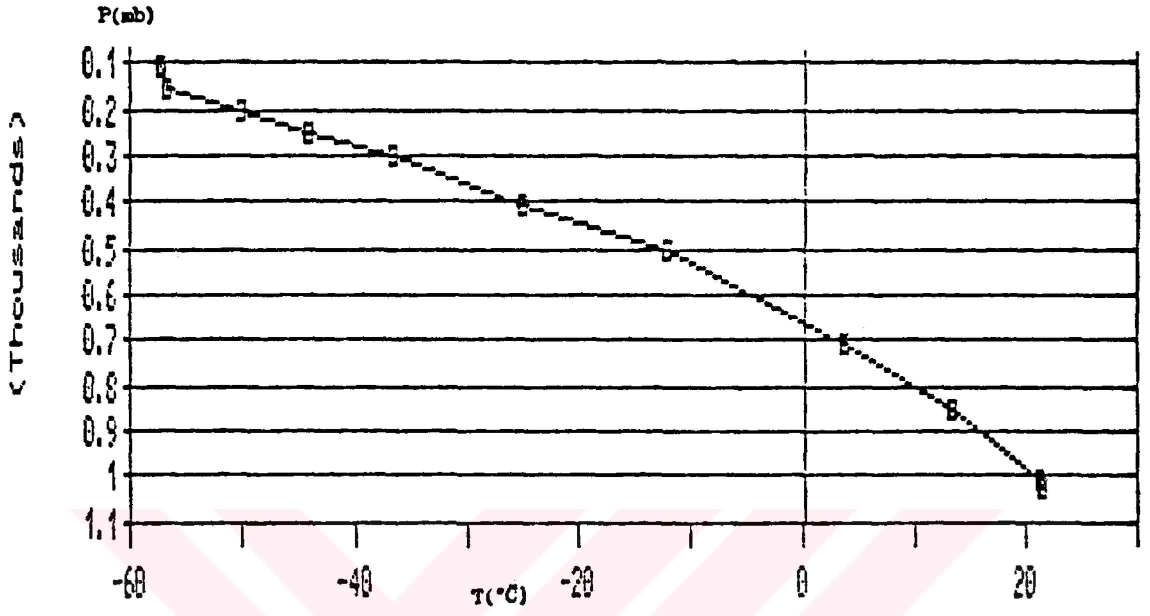

Figure 48 : September 10, 1989 ;

The high pressure system was observed in Istanbul.

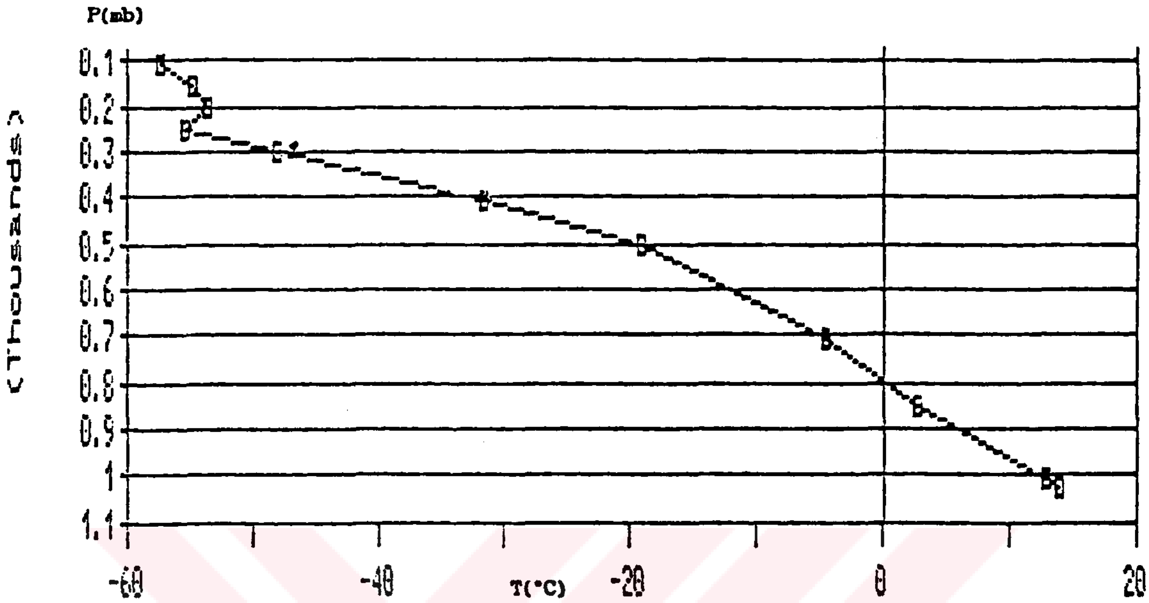

Figure 49 : October 1-2, 1989 ;

A low pressure system was observed in Istanbul.

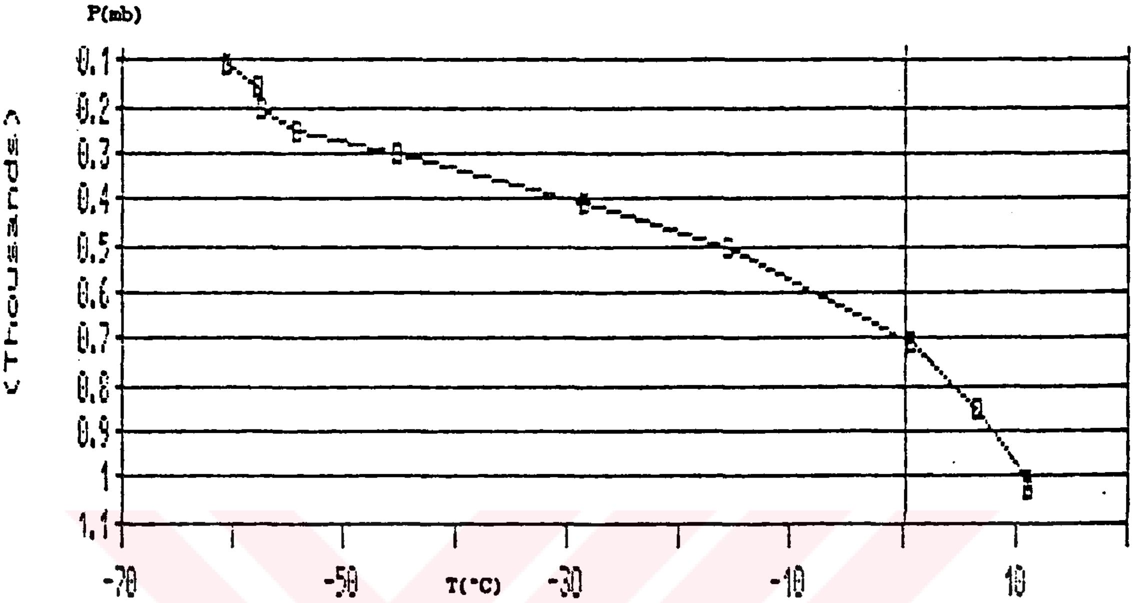

Figure 50 : October 17-29, 1989 ;
A temporary high pressure system was observed in Istanbul.

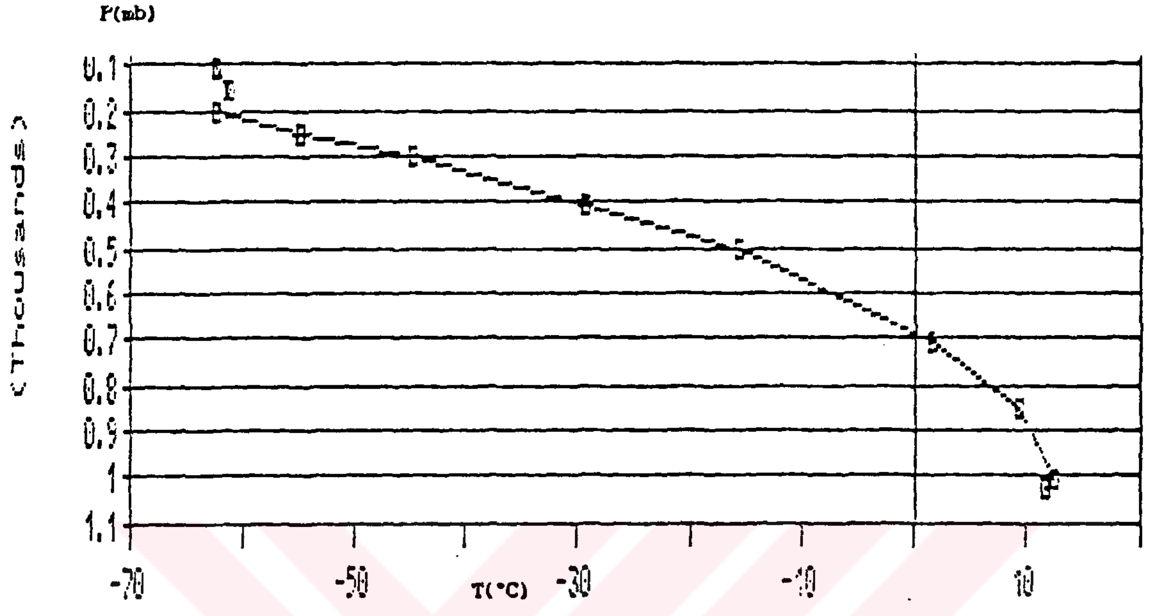

Figure 51 : November 5-6, 1989 ;

A temporary low pressure system was observed in Istanbul.

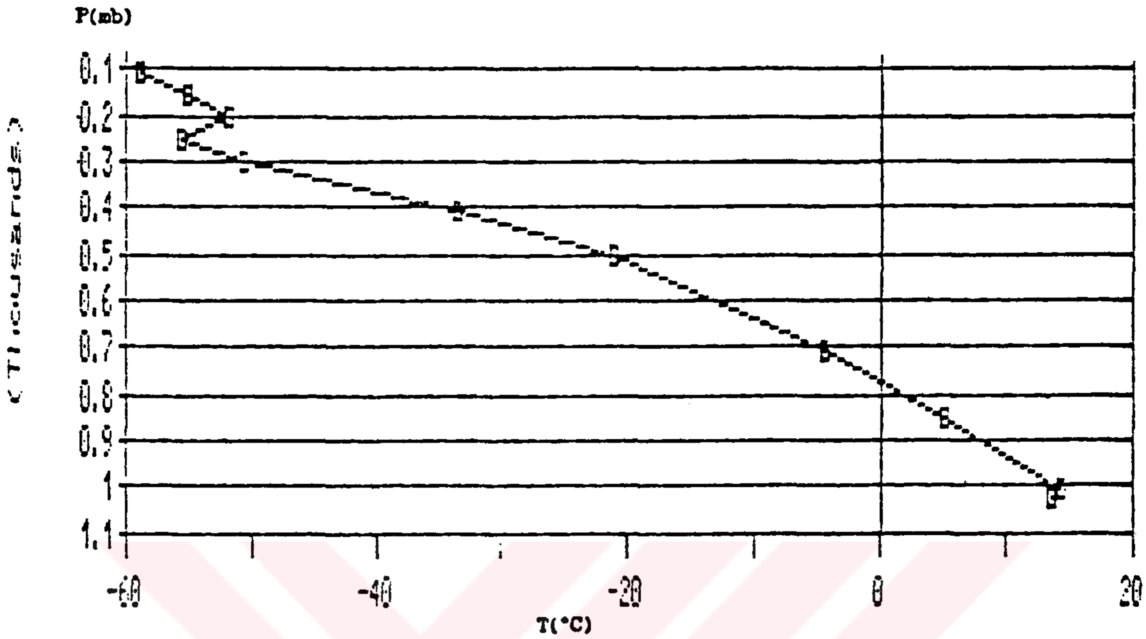

Figure 52 : November 9-10, 1989 ;

A low pressure system was observed in Istanbul.

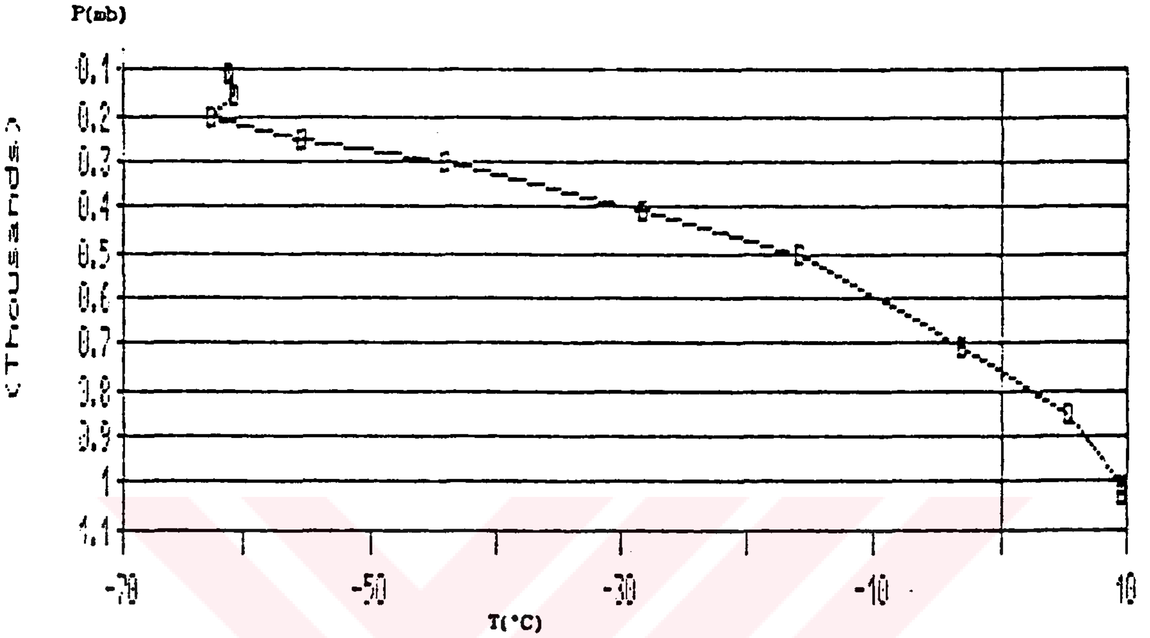

Figure 53 : November 20-21 and 23-25, 1989 ;
In general, the heigh pressure system was observed in Istanbul. From November 23, a temporary low pressure system and frontal system were observed in Istanbul.

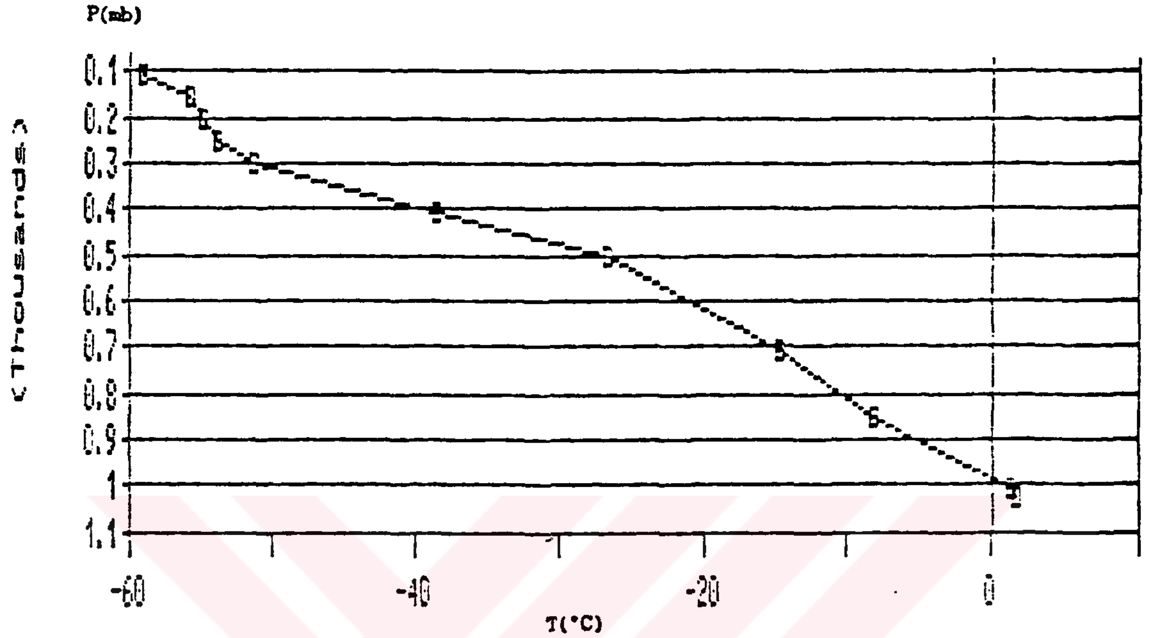

Figure 54 : December 1-3, 1989 ;
The effective heigh pressure system was observed and the pressure is above 1030 mb in Istanbul.

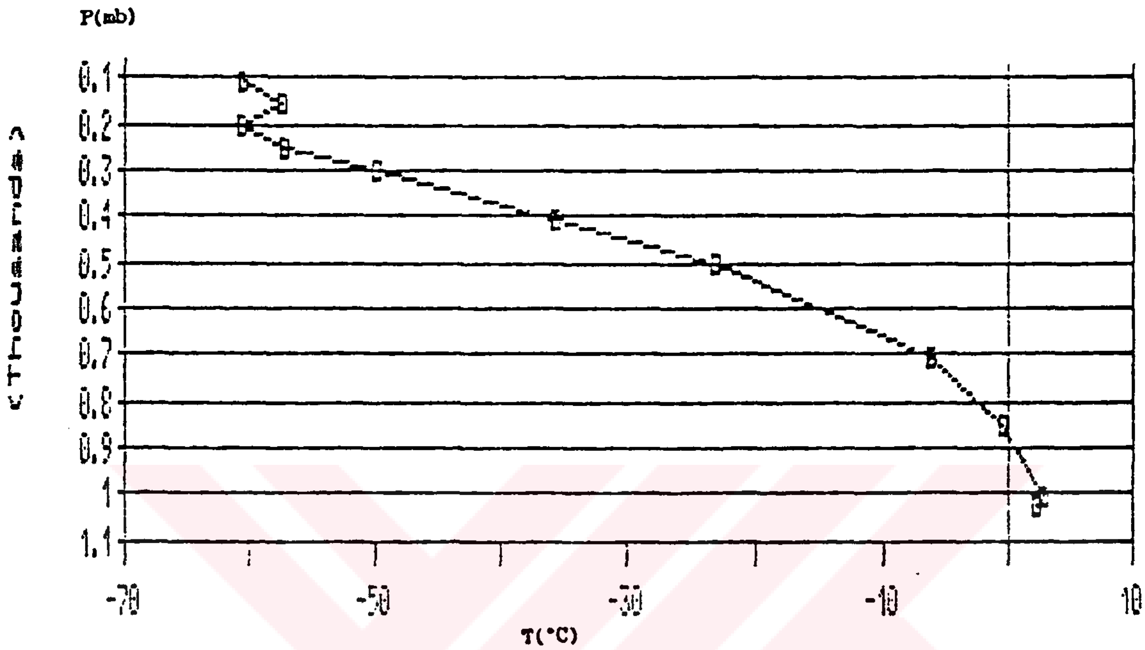

Figure 55 : December 10-12, 1989 ;

The heigh pressure system was observed.

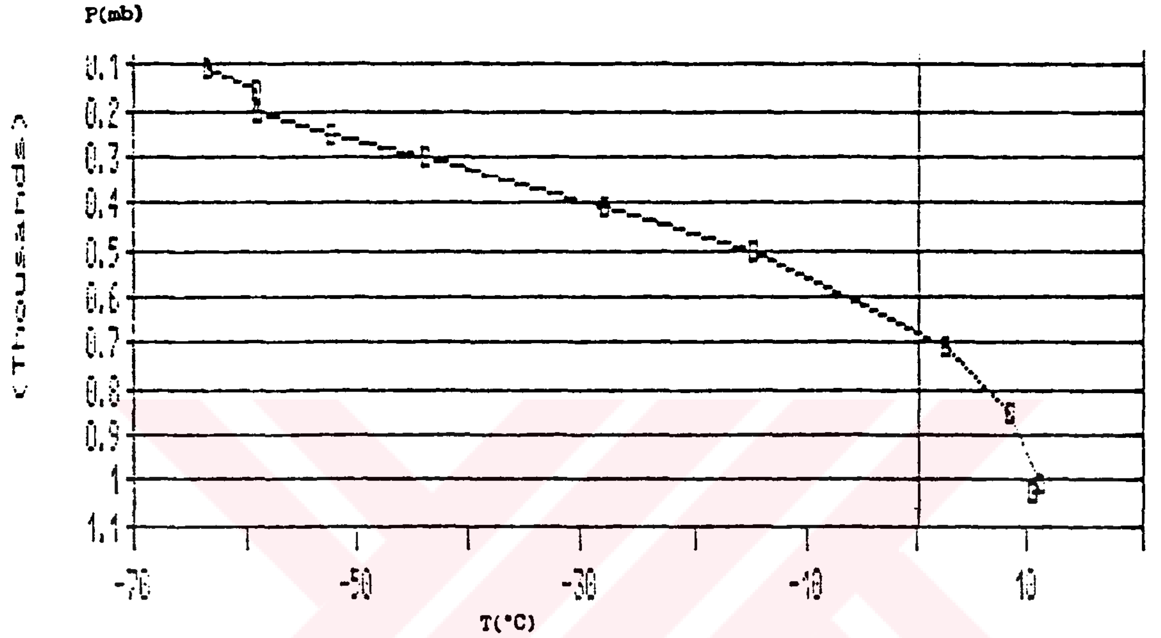

Figure 56 : December 15-22, 1989 ;

The heigh pressure system was observed in Istanbul.

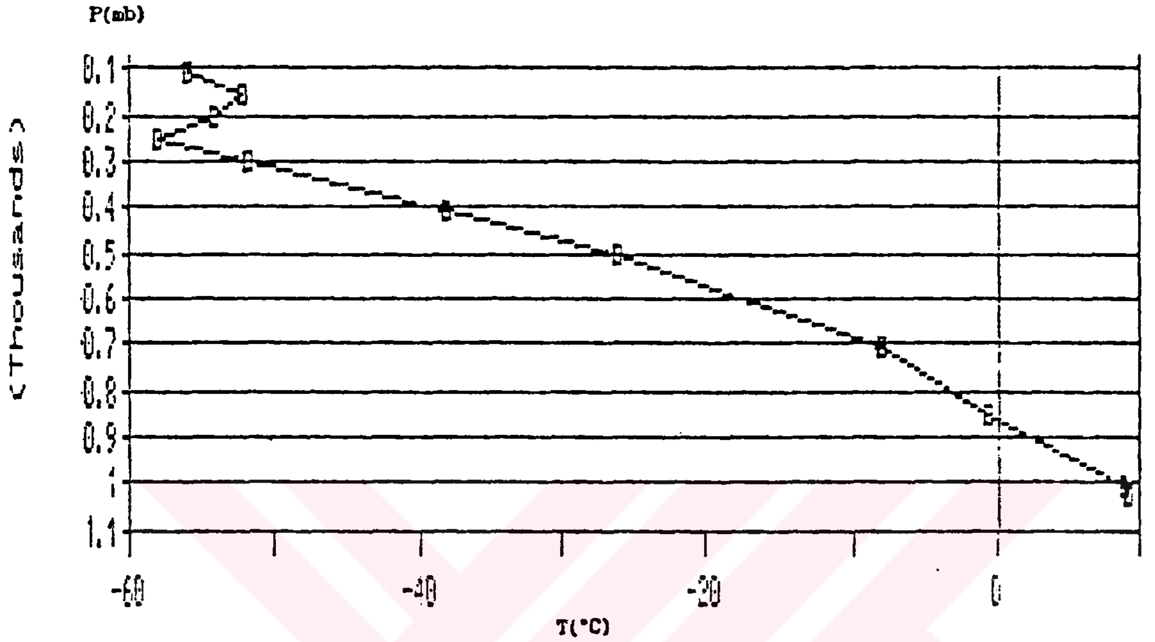

Figure 57 : December 26, 1989 ;

A low pressure system was observed.

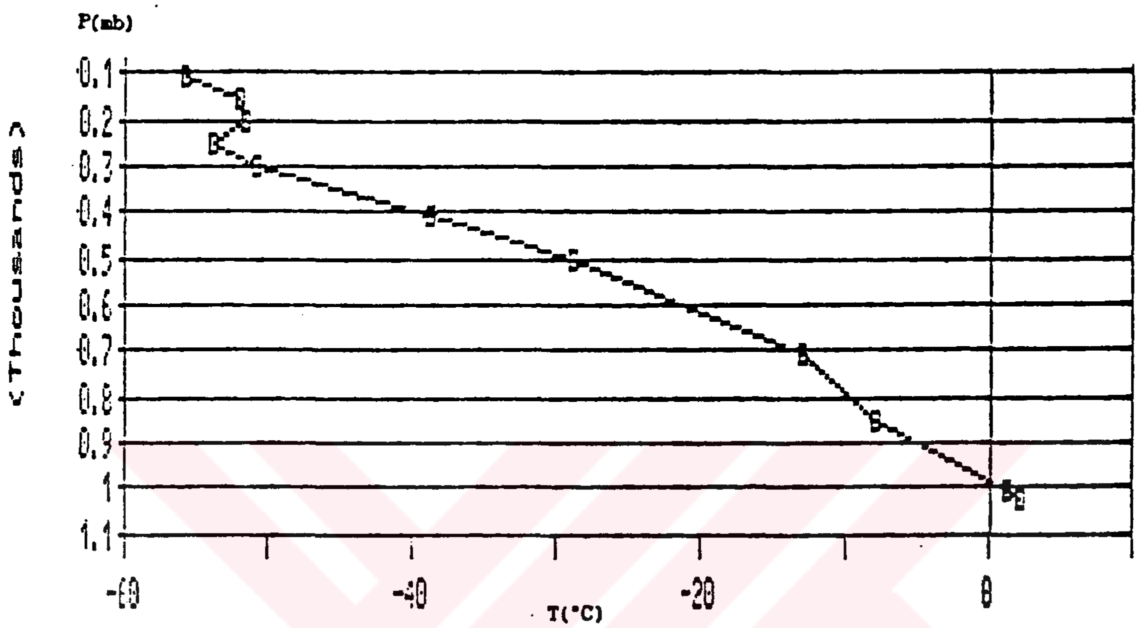

Figure 58 : January 3-5, 1990 ;

A low pressure system was observed.

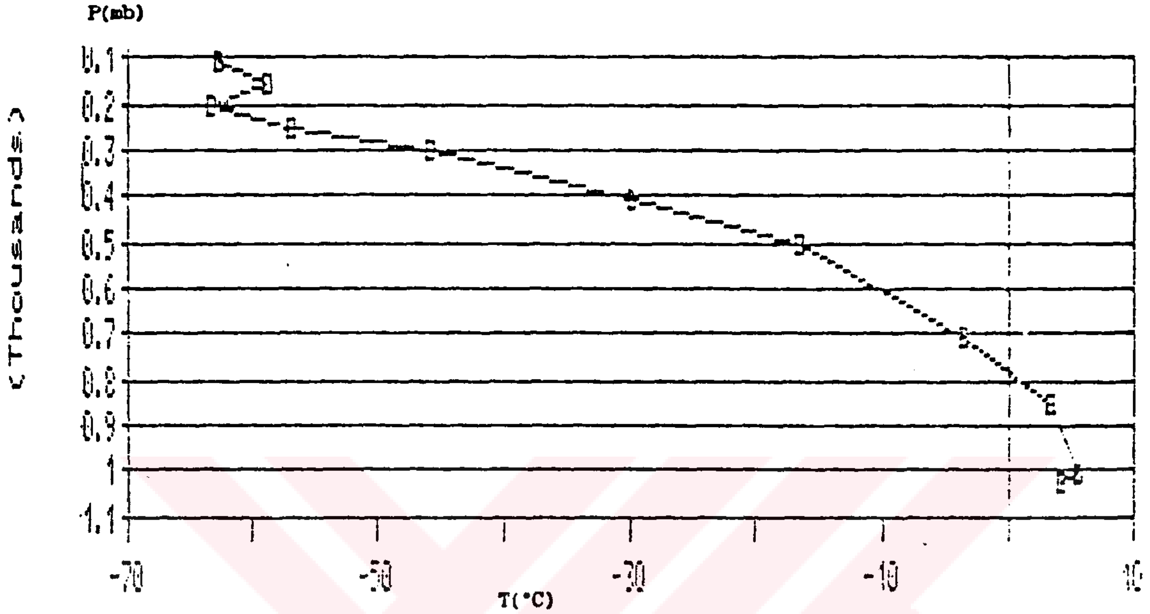

Figure 59 : January 9-13 and 17-18, 1990 ;

The high pressure system was observed in Istanbul.

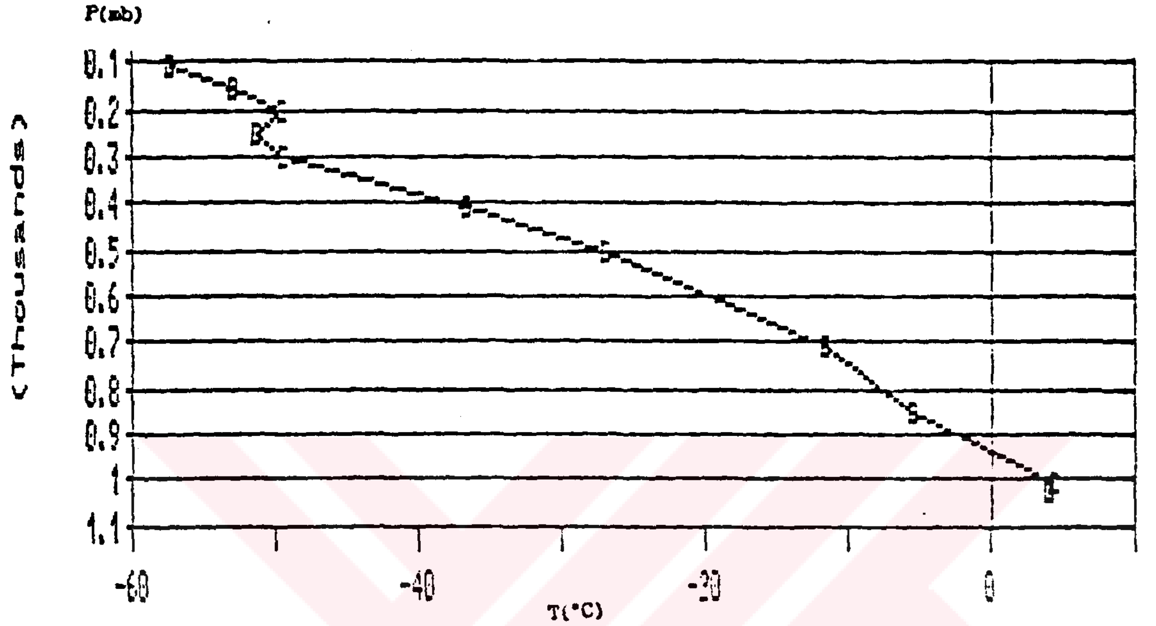

Figure 60 : January 20-23, 1990 ;

A temporary high pressure system was observed in Istanbul.

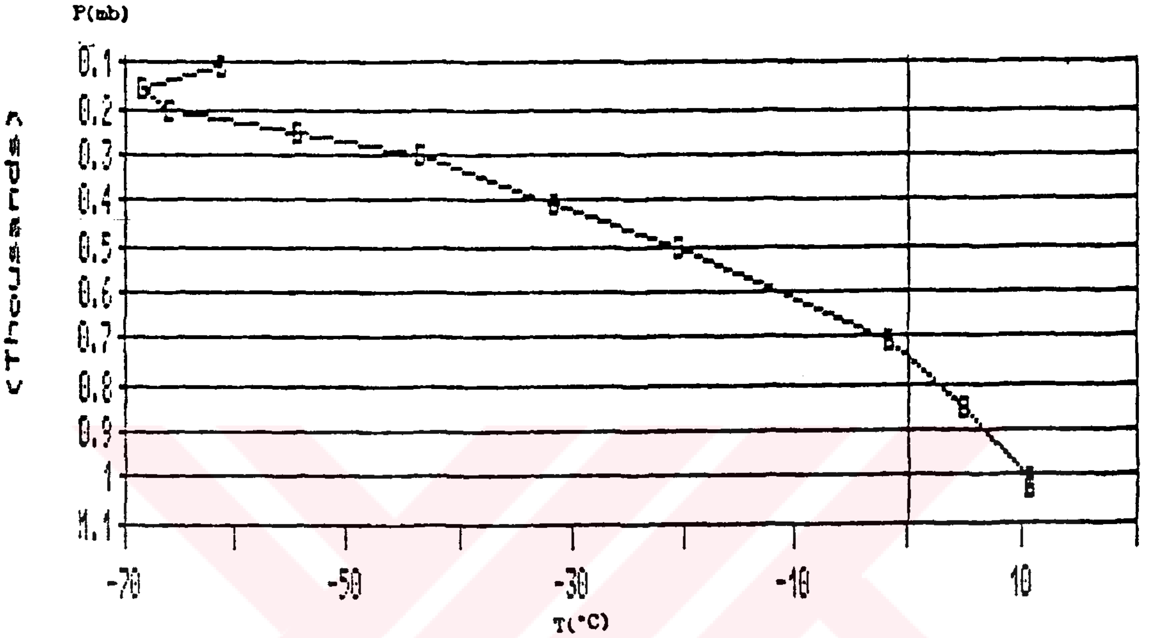

Figure 61 : January 29-30, 1990 ;

An effective high pressure system was observed in Istanbul.

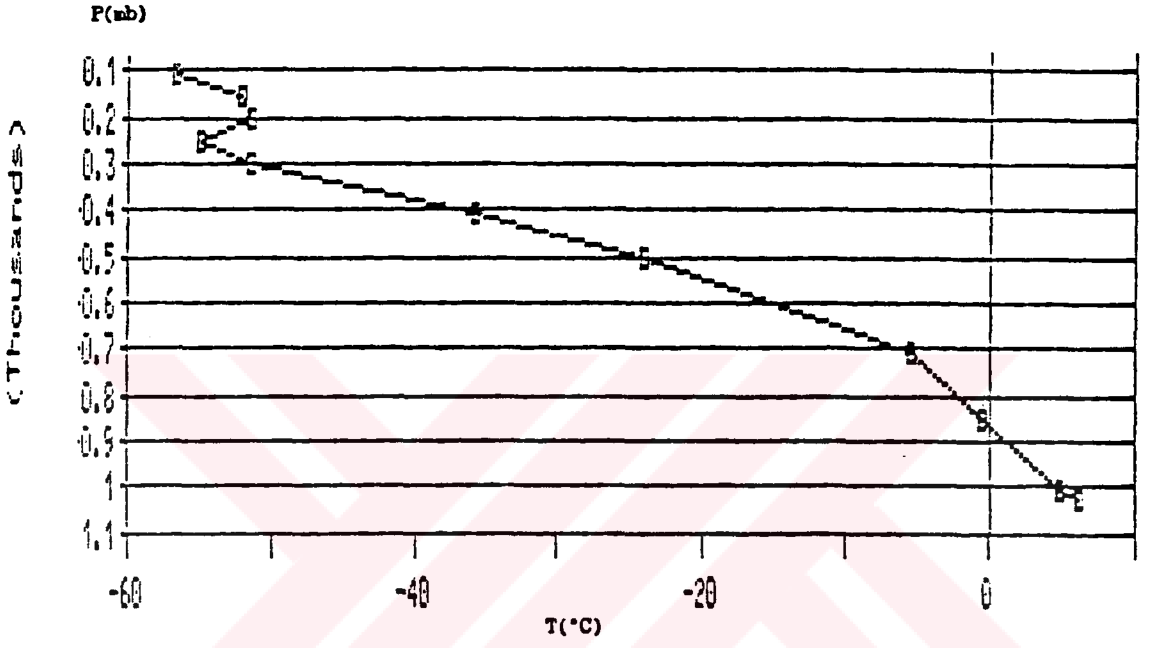

Figure 62 : February 10-15, 1990 ;

A low pressure system was observed in Istanbul.

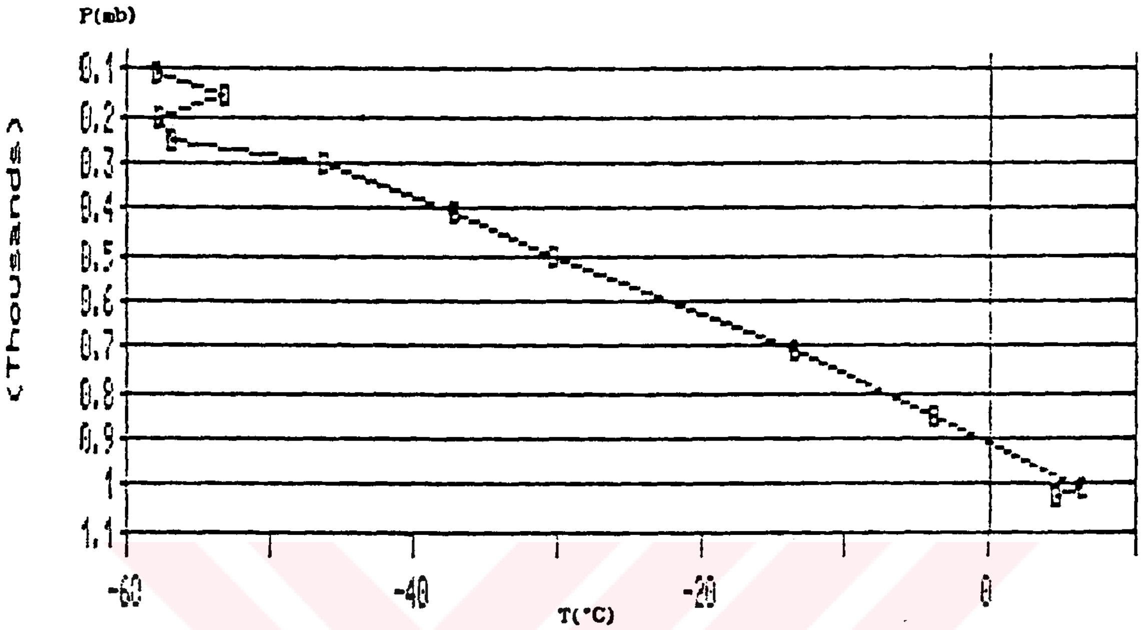

Figure 63 : February 17-18, 1990 ;

A temporary low pressure system was observed in Istanbul

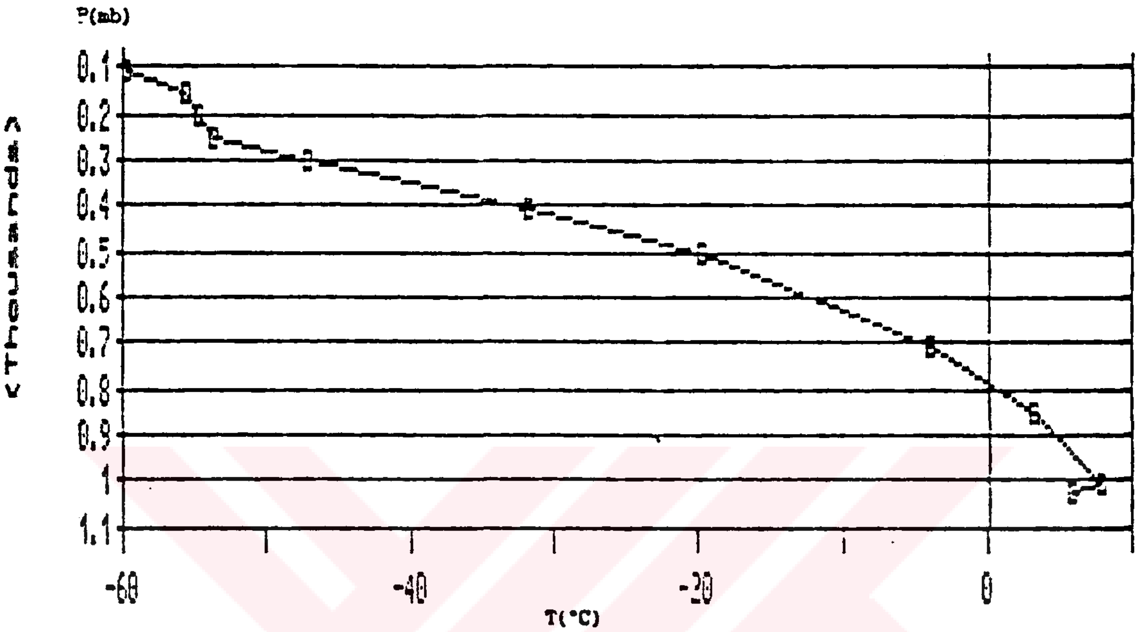

Figure 64 : February 21-27, 1990 ;

A temporary high pressure system was observed in Istanbul.

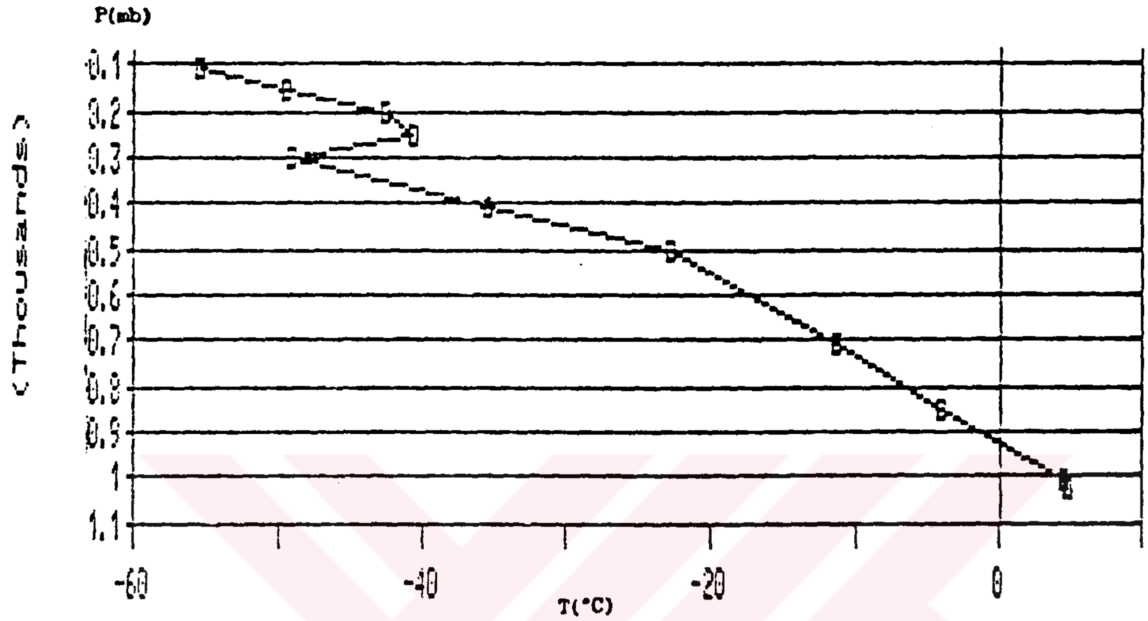

Figure 65 : March 1, 1990 ;

An effective low pressure system was observed in Istanbul.

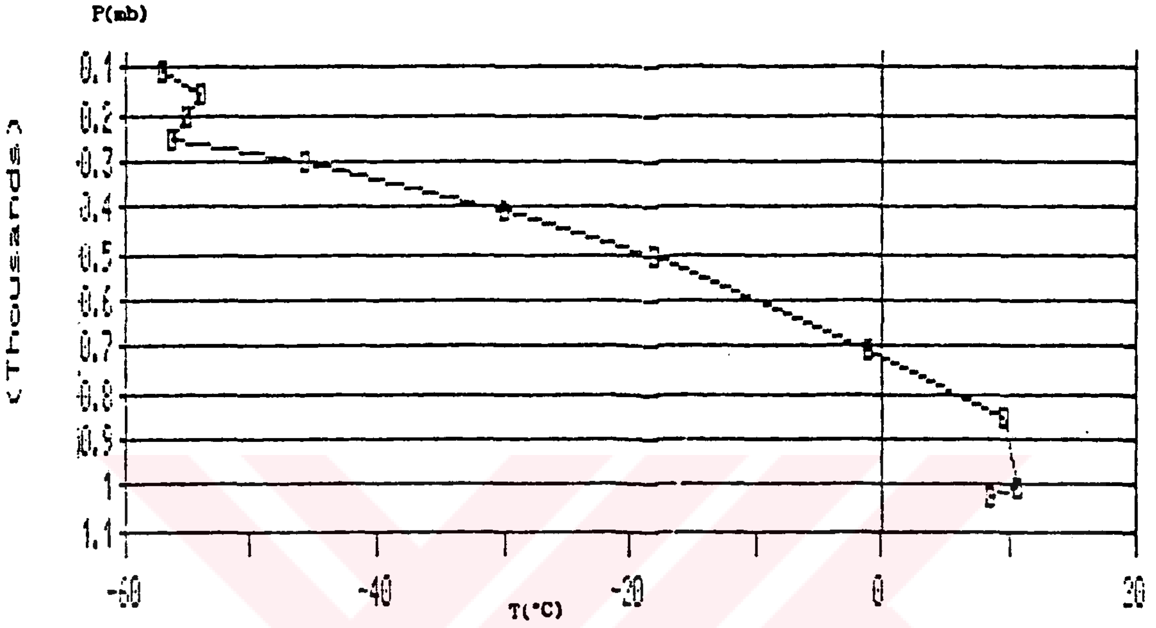

Figure 66 : March 3-4 and 9-10, 1990 ;

The low pressure system was observed in Istanbul.

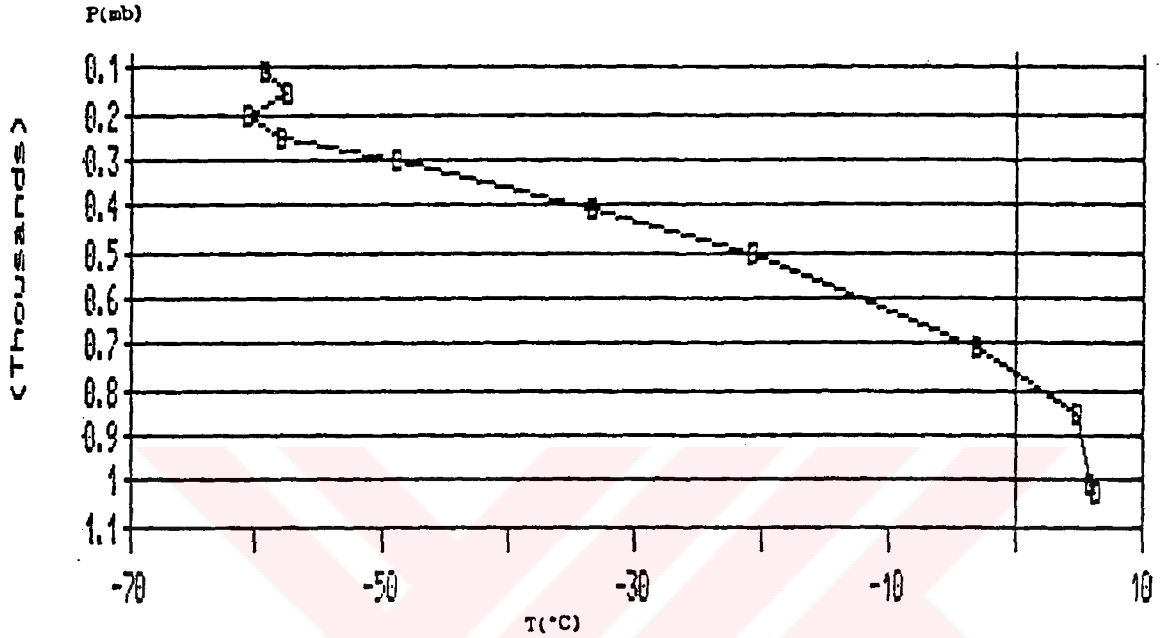

Figure 67 : March 11 and 13-21, 1990 ;

The high pressure system was observed.

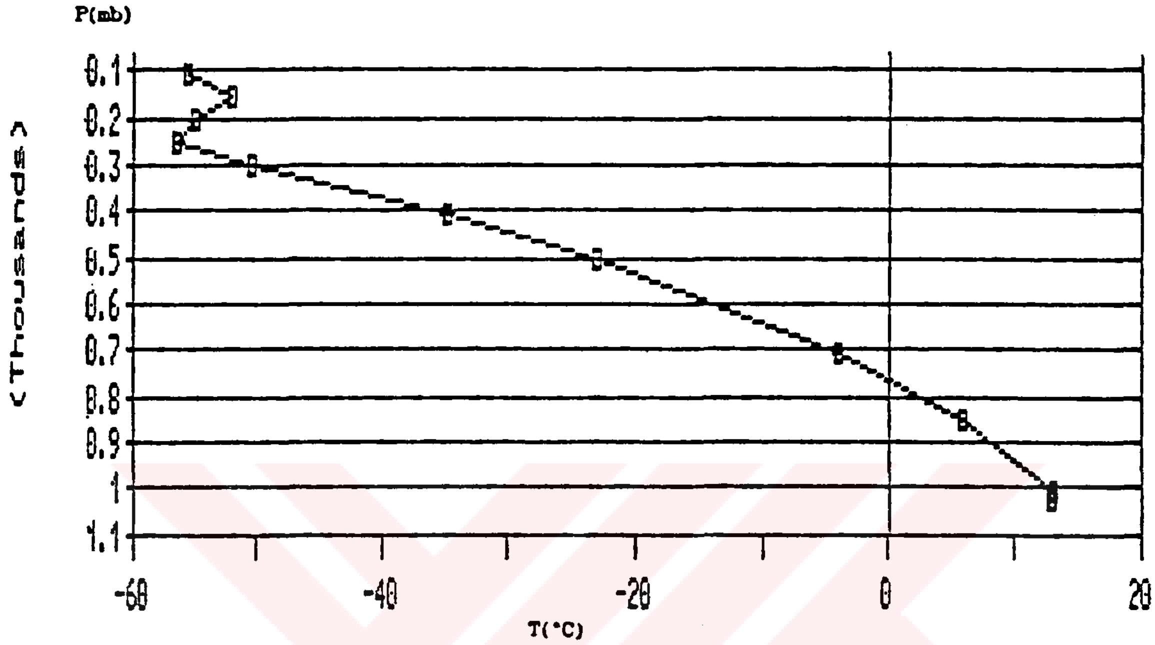

Figure 68 : April 5-6 and 10-14, 1990 ;

The low pressure system was observed in Istanbul.

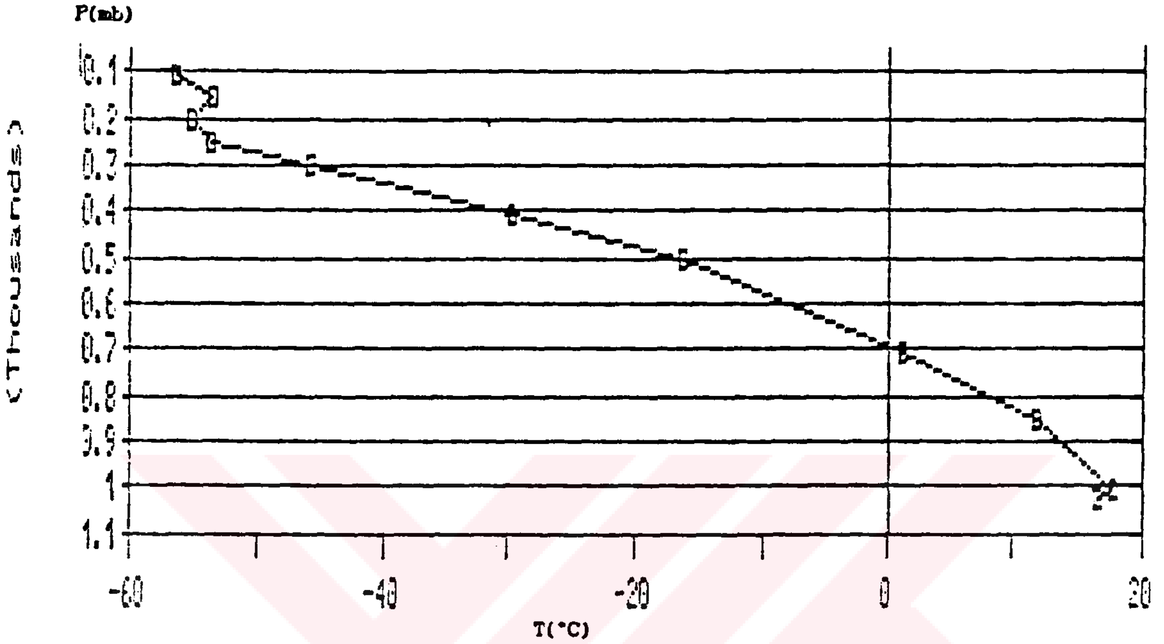

Figure 69 : April 22-26, 1990 ;

The high pressure system was observed in Istanbul.

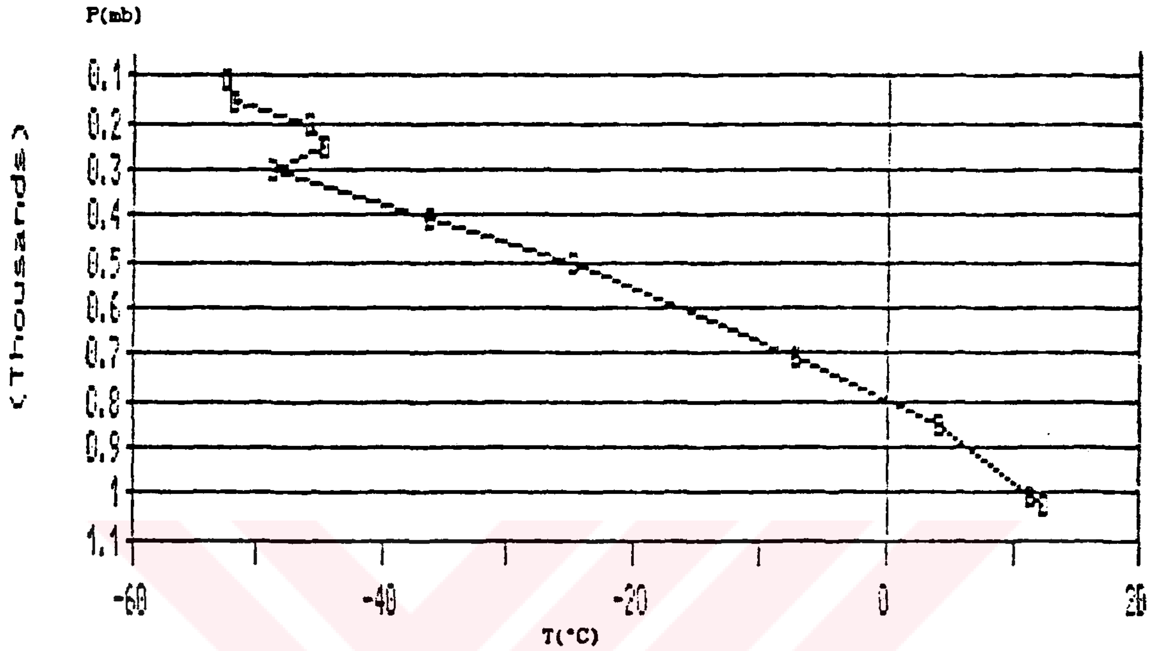

Figure 70 : April 27-30, 1990 ;

An effective low pressure system was observed in Istanbul.

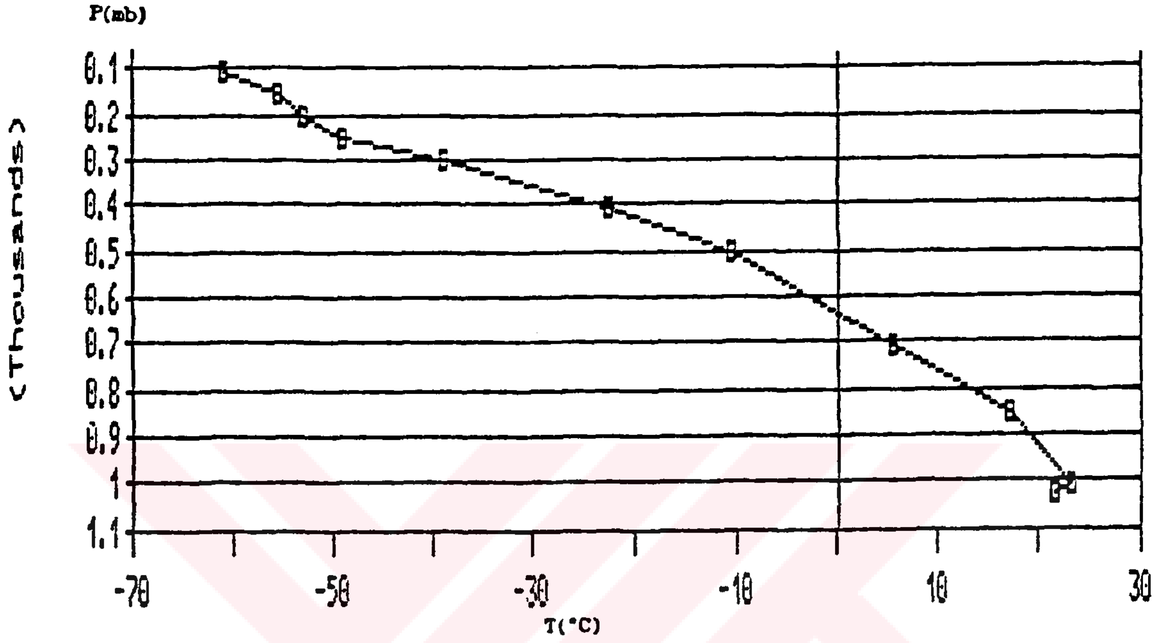

Figure 71 : June 4-31, 1990 ;

In these dates, the high pressure system affected Istanbul.

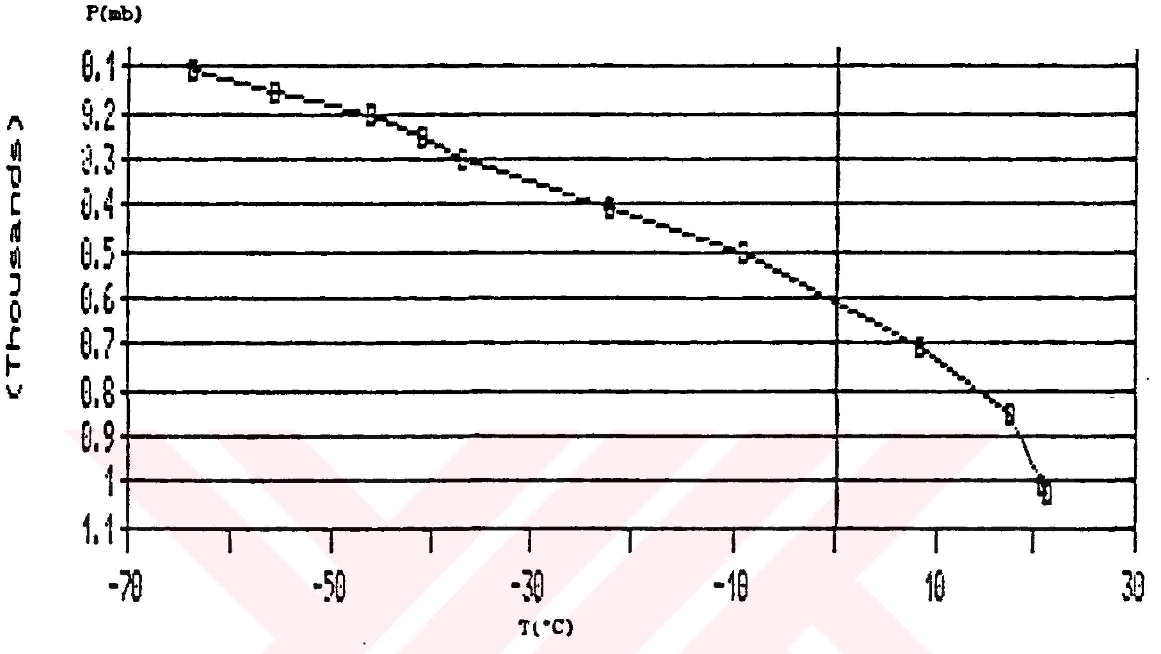

Figure 72 : From july 1, 1990 to September 13, 1990 ;
The high pressure system was observed in Istanbul.

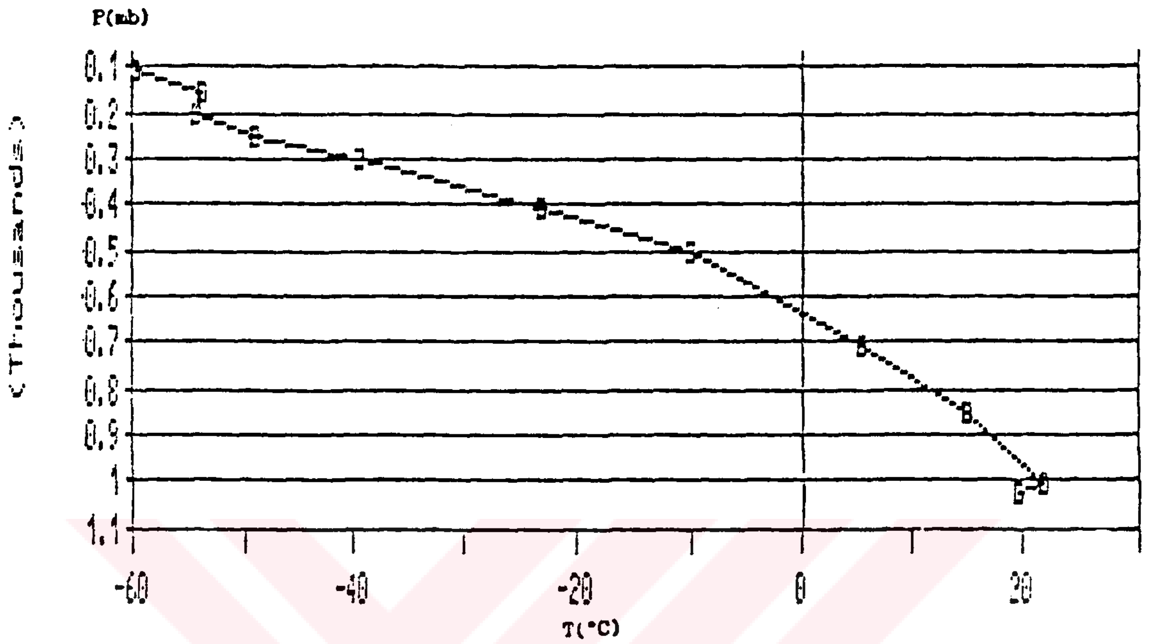

Figure 73 : September 23-24, 1990 ;

A temporary high pressure system was observed.

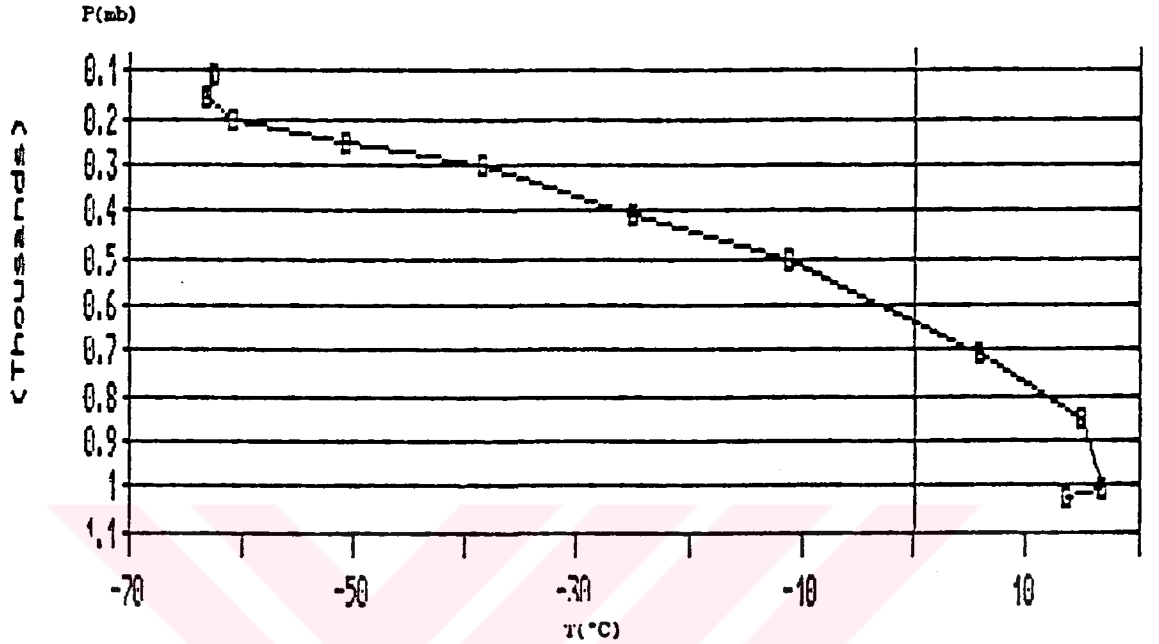

Figure 74 : October 1-26, 1990 ;

In general, The high pressure system was observed in Istanbul.

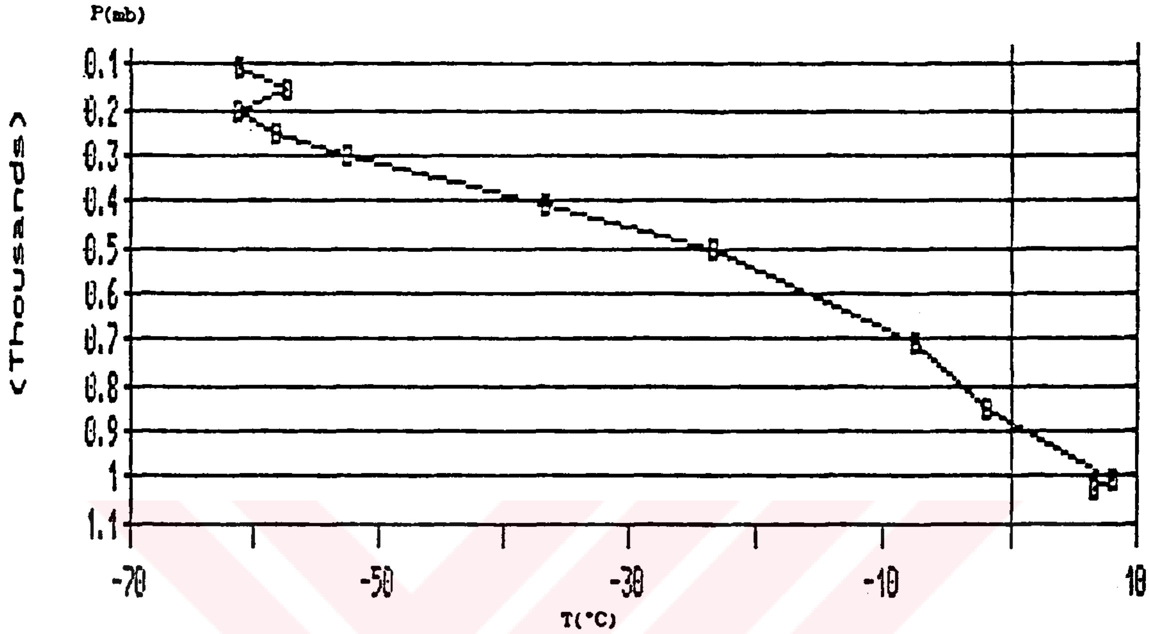

Figure 75 : November 3-12, 1990 ;

A temporary low pressure system was observed in Istanbul

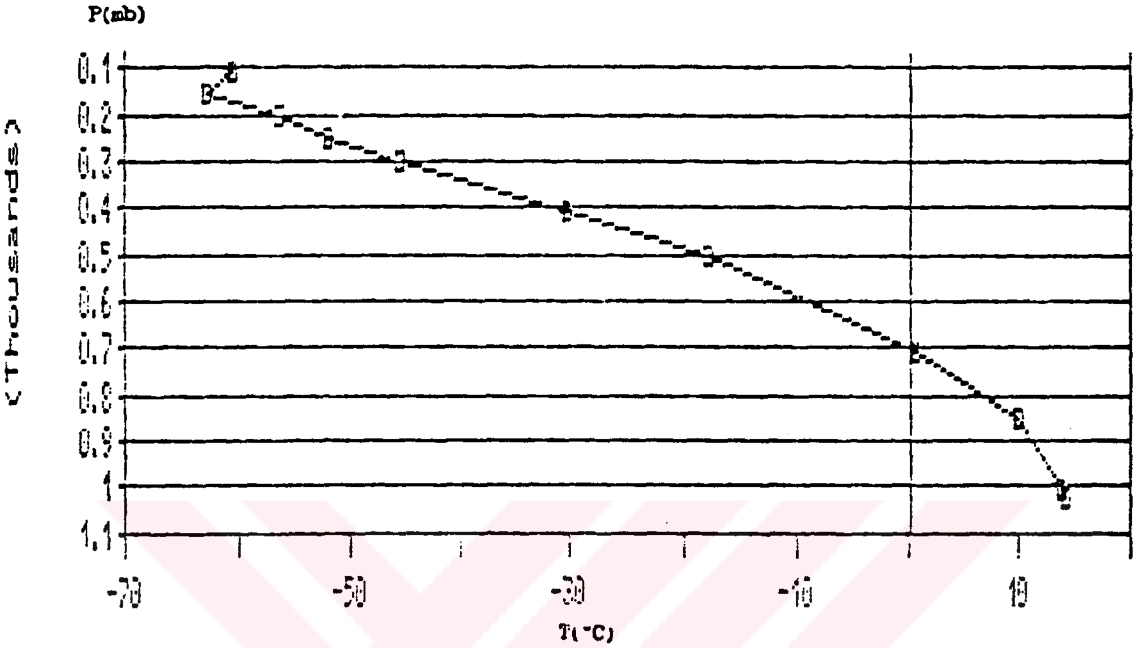

Figure 76 : November 16-17, 1990 ;

An effective high pressure system was observed in Istanbul.

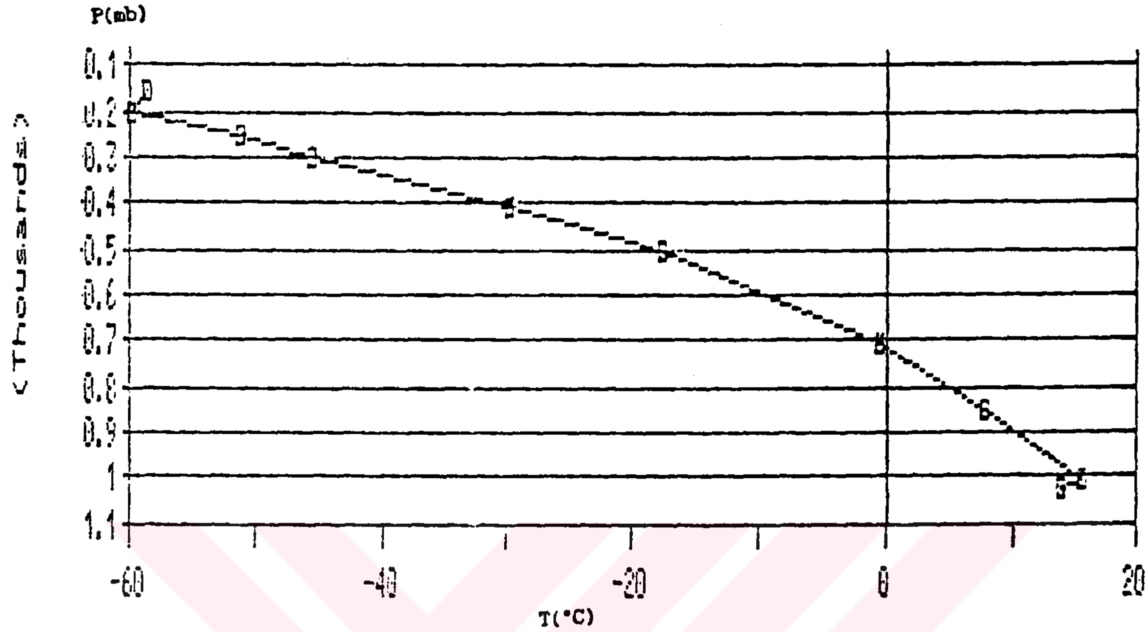

Figure 77 : November 22-26, 1990 ;

A temporary low pressure system was observed in Istanbul.

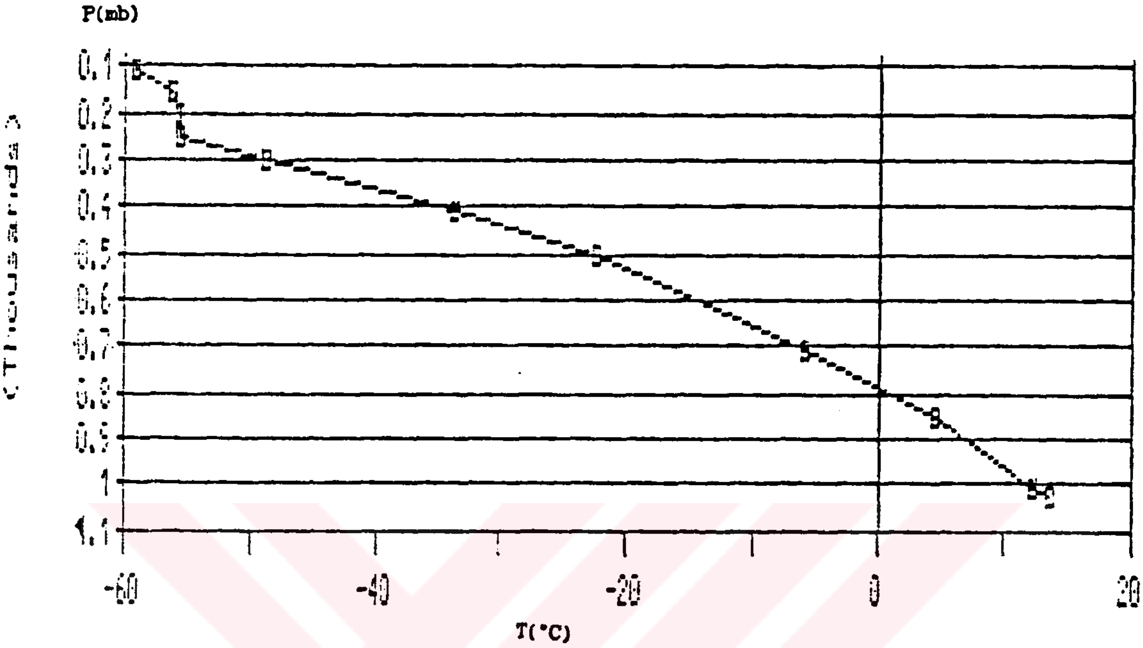

Figure 78 : December 1-3, 1990 ;

The low pressure system was observed in Istanbul.

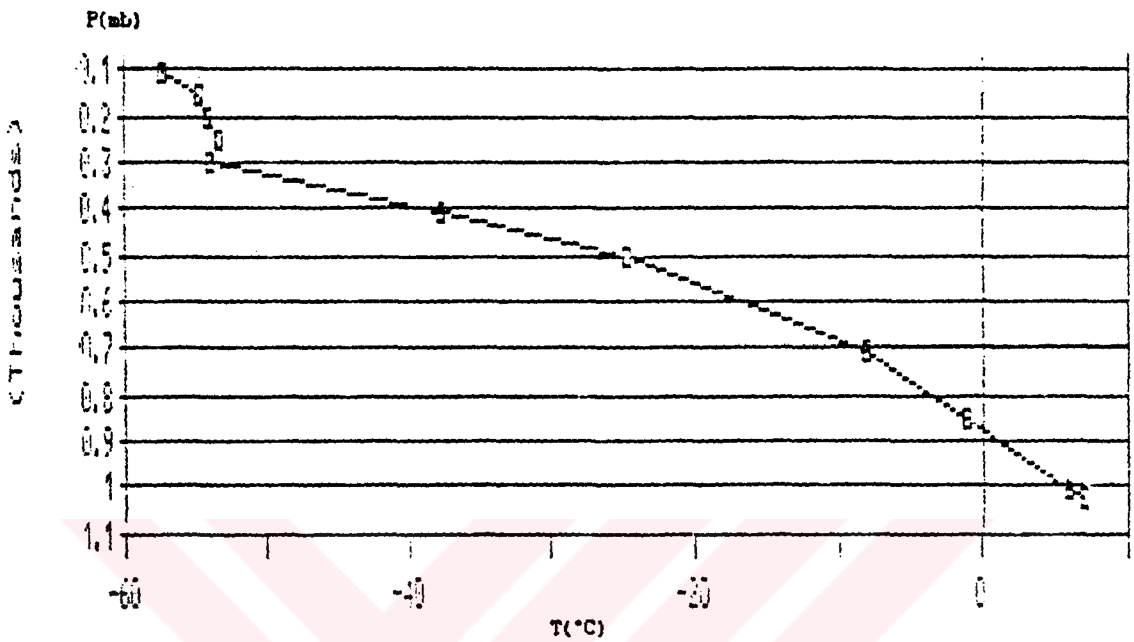

Figure 79 : December 5, 1990 ;

An effective low pressure system was observed in Istanbul.

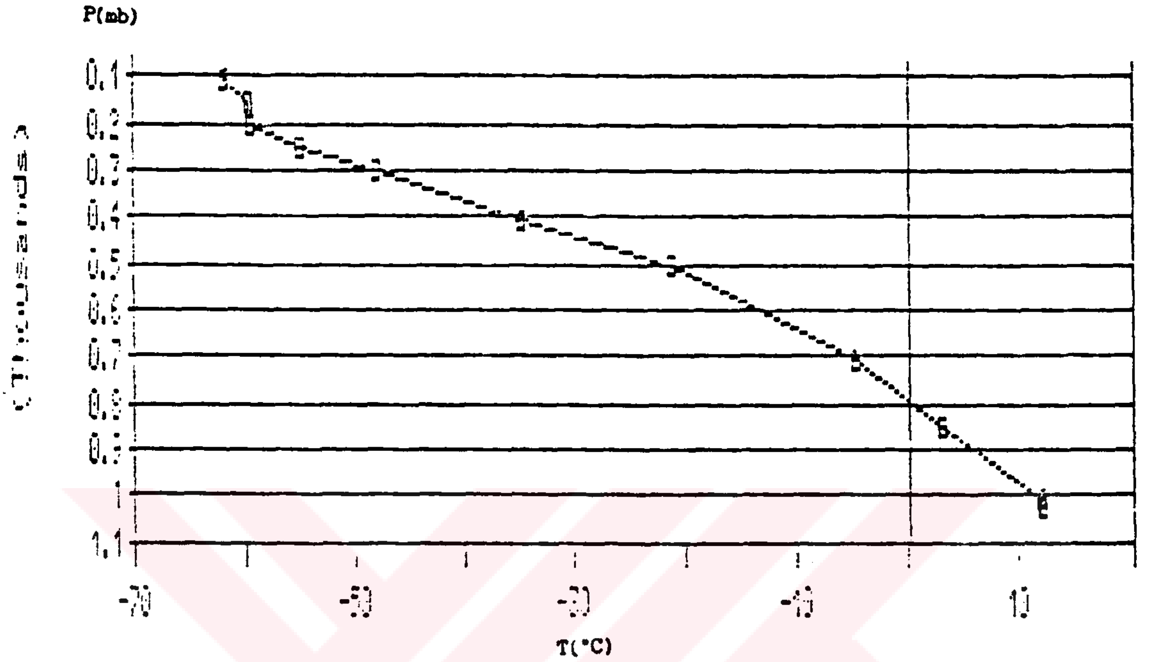

Figure 80 : December 13-15, 1990 ;

A temporary low pressure system was observed in Istanbul.

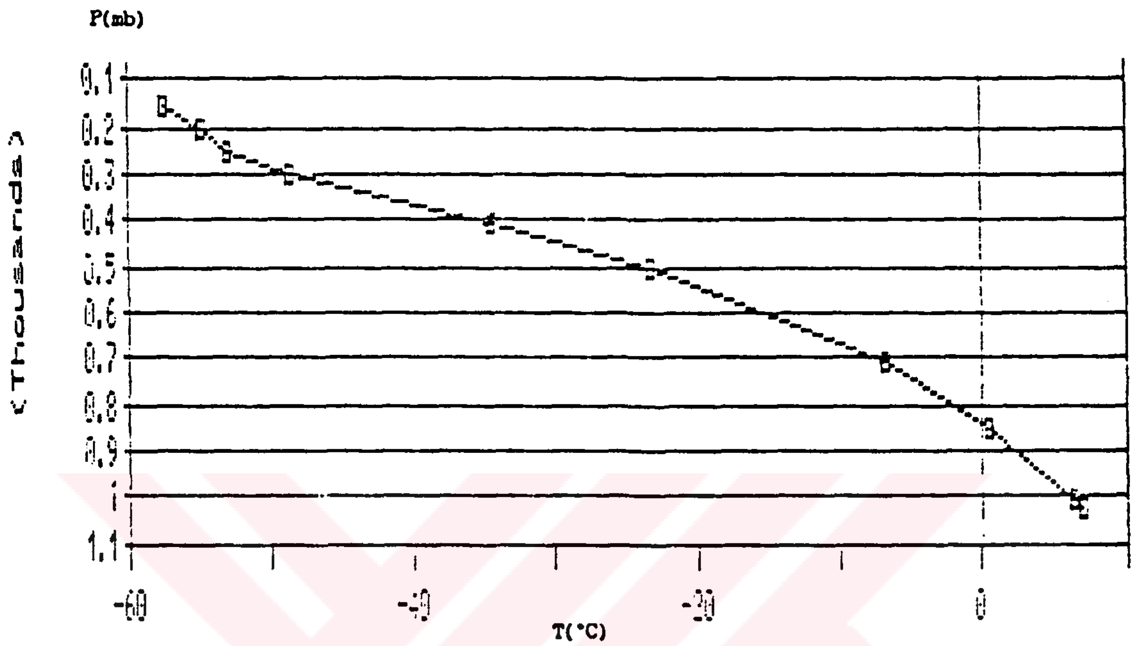

Figure 81 : December 25-30, 1990 ;

The high pressure system was observed in Istanbul.

CONCLUSION

In this thesis, the air masses is analysed according to to the tropopause levels for the years of 1988, 1989 and 1990 on Istanbul. All available soundings in this thesis studied with respect to their tropospheric and stratospheric temperature structure and with emphasis on the height and form of the tropopause. The conclusions verified by synoptic charts.

It is observed that the mean meridional air masses are generally affected on Istanbul for the years of 1988, 1989 and 1990. On the other hand, as we see from the figures the other air masses are affected on Istanbul.

The dates of polar air masses that are affected on Istanbul for the years of 1988, 1989 and 1990 ;

February 1, 1988
March 1, 1990
April 27-30, 1990
December 5, 1990
Total : 8 days

Because of the reporting of the polar air masses very few on Istanbul is that westhern pressure systems moves towards East from on the Coast of the Black Sea without affecting Istanbul.

The dates of the middle meridional air masses that are affected on Istanbul for the years of 1988, 1989 and 1990 ;

For the year of 1988 :

January	(29 days)	July	(——)
February	(14 days)	August	(——)
March	(21 days)	September	(——)
April	(18 days)	October	(25 days)
May	(4 days)	November	(13 days)
June	(8 days)	December	(5 days)

Total : 137 days

For the year of 1989 :

January	(27 days)	July	(——)
February	(——)	August	(——)
March	(12 days)	September	(——)
April	(11 days)	October	(2 days)
May	(3 days)	November	(8 days)
June	(3 days)	December	(12 days)

Total : 79 days

For the year of 1990 :

January	(14 days)	July	(——)
February	(8 days)	August	(——)
March	(14 days)	September	(2 days)
April	(12 days)	October	(——)
May	(——)	November	(15 days)
June	(——)	December	(6 days)

Total : 71 days

The dates of the tropical air masses that are affected on Istanbul for the years of 1988, 1989 and 1990 ;

For the year of 1988 :

From July 2, 1988 to August 27, 1988 (57 days)

September 3, 1988 (1 day)

September 5-19, 1988 (15 days)

November 7, 1988 (1 day)

December 1-4, 1988 (4 days)

Total : 78 days

For the year of 1989 :

May 23-25, 1989 (3 days)

August 9, 1989 (1 day)

September 10, 1989 (1 day)

December 1-3, 1989 (3 days)

Total : 8 days

For the year of 1990 :

January 29-30, 1990 (2 days)

February 21-27, 1990 (7 days)

June 4-31, 1990 (28 days)

From July 1, 1990 to september 13, 1990 (73 days)

October 1-26, 1990 (27 days)

November 16-17, 1990 (2 days)

December 25-30, 1990 (6 days)

Total : 145 days

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CURRICULUM VITAE

Ali DENİZ was born in Sakarya - Turkey on July 1, 1965. He finished high school in 1982. He undergraduated from Istanbul Technical University, Department of Meteorology in 1988. He started the master program at Istanbul Technical University in 1989.