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Monitoring the occurrence of frost through an analysis of air masses in south west basins of Iran

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Abstract

Frost is one of the atmospheric phenomena which seriously threaten crop production. It also causes numerous accidents in mountainous roads. In this research the Spatial Synoptic Classification SSC method was employed to classify the type of air masses. For the classification, such meteorological data as: temperature, dew point, mean sea level pressure, cloudiness, direction and speed of wind were collected for a period of 45 years from 1961 to 2005. For a classification of air masses a discernment method was applied and while typical characteristics of seed days being used as input for this discernment function method. The results indicated that, spring season air masses, Dry Polar (DP) air masses, Moist Polar (MP) and Moist Moderate (MM) air masses have contributed most to the occurrence of advection frosts respectively. Dry Polar air masses bore the lowest temperature and dew point, along with northerly and easterly wind components and a clear sky. These air masses caused the occurrence of the most severe and most extensive advection frosts in south west basins of Iran.

Keywords: Air masses; Spatial Synoptic Classification SSC; Principal Component Analysis (PCA); Advection Frosts; Iran

1. Introduction

Chill and frost are natural hazards that cause a lot of damage to agricultural production all over the world. As an example in February 1951, onset of arctic cold air mass caused severe frost in Lower Rio Grand Valley of the United States, Marshall (2002). Rosenberg (1962) quoted that anticyclone radiation frosts which occur within the homogeneous air masses during calm and fair nights have been differentiated, by Biel (1961), from the advection frosts which result from large scale air mass transfers. Vithkevish (1963) found that the expansion of north westerly cold winds by air masses is the main cause of frosts occurrences in Europe and Kazakhstan. To study the cold weather attack in China, Ding (1987) analyzed the macro scale patterns and the circumstances of air mass transportation and intrusion of cold air trough to equator.

Chilling and frosts are two atmospheric phenomena that cause irreparable damage to agriculture sector as well as to road transport. A main cause of advection frosts in Iran is the outbreak of cold air masses from higher latitudes which accompanied by cold and high speed northerly and easterly winds. Many studies have been carried out in relation to frequency of frost occurrences, but research on the aspect of synoptic patterns which cause advection frosts in Iran is very rare. Baraty (1996) studied the synoptically occurring patterns which cause spring

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frosts in Iran. He quoted that a movement of pressure systems from high latitudes towards Iran cause severe and expanded frosts while also the standing trough in eastern coast of Mediterranean Sea often being a clue to occurrence of frost at the same day in Iran. Alijani (1993) quoted that Siberian high pressure is the prevailing phenomena during cold period in Asia. He found that Siberian high pressure is formed around Balkan Lake during the beginning period of cold season and then, gradually along with proceeding winter season, becomes more developed. Then during maximum activity sends some troughs to Middle East controlling the climate of the region, including Iran at its eastern part of Zagros Mountains. An analysis of the first fall and last spring advection frosts was done in Azerbaijan provinces in Iran through ASMERC (2004). In this study advection frosts were determined based on a use of synoptic maps and a study of meteorological elements at different time hours.

During recent years, focuses have been on air mass characteristic and air flows that have caused transport of air masses. In this regard, putting together of multivariate statistical method and synoptic studies gives better results. Use of multivariate statistical techniques in the synoptic climatology studies was first introduced by Lorenz (1966), and Christenson (1966). In this regard, Kalkstein (1987) arranged a model on the basis of air masses. They applied Spatial Synoptic Classification SSC in most of their climatologically oriented research. Fattahi (2005) in order to make an identification and classification of the air masses with relation to dry spells used the SSC method. For classification of air masses he applied such surface data as air temperature, dew point temperature, daily range of temperature, saturation deficit, QFF pressure, direction and speed of wind, cloudiness, as well as precipitation.

During the last two decades, SSC method has been widely used for testing climate change, determination of spatial patterns of air masses in relation to frosts, recognition of the synoptically studied pattern changes over glaciers, etc. Because of difficulties involved in forecasting advection frost through statistical methods, synoptically oriented study of frost has attained its due importance.

An analysis of air mass characteristics as well as their frequencies during spring season can help to distinguish precisely the type of frosts. Therefore, on the basis of origin, path of movement, persistency, extension of air masses, advection frosts in the area under study could be identified. Then the patterns that cause the occurrence of advection frosts can become known and the results applied to frost monitoring.

The objective of this research is to distinguish, through SSC method, the origin and main track of air masses which cause advection spring frosts.

In this study, in order to decrease the number of variables, Principal Component Analysis method and for a classification of seed days Clustering Discriminate Analysis was employed.

2. Materials and methods

The procedure of SSC method is quite complex. The reader is referred to Kalkstein (1986) for detailed explanation. SSC is a hybrid classification scheme that includes manual initial identification of air masses or weather types, followed by automated classification as based on these identifications (Frakes and Yarnal, 1997).

SSC requires an initial identification of the major air masses that traverse the region. It also requires an identification of their typical-meteorological characteristics. The SSC method categorizes days within the following six types, namely, Dry Polar (DP), Moist Polar (MP), Dry Tropical (DT) Dry Moderate (DM) Moist Moderate (MM) and Moist Tropical (MT), Kalkstein (1998). The nomenclature is designed to identify the character, rather than source region of the air mass. Dry Polar air is synonymous with continental polar; it is the coldest and sometimes the driest air-mass in a region. Dry Moderate air is typically an adiabatically warmed Pacific air mass. Dry Tropical defines a hot and very dry air mass. Moist Polar air is cool and humid with overcast conditions, and frequently accompanied by easterly winds. In the East, this air mass is synonymous with maritime polar conditions around the northern flank of a mid-latitude cyclone. Moist Moderate is also associated with overcast, humid conditions, but while temperature and dew points are much higher owing to the close proximity of the responsible front. Moist Polar and Moist Moderate air masses may persist for many days over a locale if frontal movement is particularly lethargic. Moist Tropical air mass, commonly recognized as maritime tropical, represents warm, humid conditions found frequently in the warm sector of an open wave cyclone or the western flank of a subtropical anticyclone. Atmospheric instability and convective activity are common within the air mass.

The foundation of the SSC method is dependent upon the proper identification of seed days for each station. They represent the days with typical meteorological characteristics of a given air mass prevalent at that location. Seed days are quite homogeneous within sites but their meteorological characteristics vary considerably among sites. These days can be applied to classification of other days.

Selecting of seed days was done through a precise assessment of temperature and humidity variables, surface synoptic maps as well as 850 HPa level. Seed days groups for every air mass are selected according to such characteristics as variations of temperature, difference between air temperature and dew point temperature, direction and speed of wind (U and V components) as well as mean cloud cover.

Pressure patterns and flow lines arrangement at sea level and 850 HPa charts present a transfer of special air masses to the study area. In other words any weather pattern can be distinguished through variation in air flow, circulation pattern, front pattern, along with internal flow in air masses. In this method, beginning stage, path, and ending stage of air masses were also recognized, and then pressure patterns as well as air masses differentiated from each other. If separation of air masses from pressure patterns is desired, the classification method enables us to reproduce the previously defined patterns.

Data used in this research were provided by the Computer Center at the I.R. of Iran Meteorological Organization (IRIMO). Time scale of the data contains observations of six hour intervals consisting of 0300, 0900, 1500, and 2100 UTC observations. Variations under observation are air temperature, dew point temperature, daily range of temperature, saturation deficit, daily means of air pressure (station level pressure, QFE & sea level pressures, QFF), wind direction and speed, as well as daily mean of cloud cover. Air and dew point temperatures show the thermal and humidity characteristics, while pressure identifies the patterns of surface flow. In this attempt synoptic charts at surface and 850 HPa level were studied. Maps are on a daily basis and extracted from Data Center of National Center Environmental Prediction (NCEP). Geographical characteristics of the stations under study along with their statistical periods are presented in table (1) and the location of the stations given in figure (1).

Table 1. Geographical characteristics of meteorological stations under study

Number	Station	Longitude		Latitude		Elevation	Period of the study
1	Ilam	46°	25´	33°	38´	1360	1971-1999
2	Khoram abad	48°	22´	33°	29´	1125	1961-1999
3	Esfahan	51°	40´	32°	37´	1550	1961-1999
4	Dezful	48°	23´	32°	24´	143	1961-1999
5	Shahre kord	50°	51´	32°	17´	2045	1961-1999
6	Ahwaz	48°	40´	31°	20´	22	1961-1999
7	Yasoj	51°	41´	30°	50´	1831	1987-1999
8	Abadan	48°	15´	30°	22´	6	1961-1999
9	Shiraz	52°	36´	29°	32´	1481	1961-1999
10	Boushehr	50°	50´	28°	59´	20	1961-1999

2.1. Principal component analysis

Principal component analysis is a statistical method which establishes a special relation, under an assumption model, between numerous variables which seem unrelated to each other and while gathering all dependent variables in one group. The advantage of this method is that while the number of variables is abated, the initial value of variance in primary variables will be preserved. Analyzing the original variables creates new components which contain liner orthogonal sets from the original variables. Each set represents a small part of total variance which is displayed through specially related values. This method preserves original and significant components while causing a decrease in the variables. Thus one of the results of principal component analysis is decreasing the dimensions of data. In fact, principal component analysis is a multivariate statistical technique which converts a set of data that are linearly related to each other, to a set of orthogonally oriented axes or factors. Then a significant part of data variance can be explained by a small number of main factors. This substantially decreases the quantity of data. The Principal Component Analysis calculation stages are as follows:

A: Selection of data and variables
B: Formation of data matrix of n×p in which n is the number of days and p the number of variables. It should be mentioned that Principal Component Analysis method can be applied to both variables and days.
C: Formation of data correlation matrix, on the basis of equation (1)

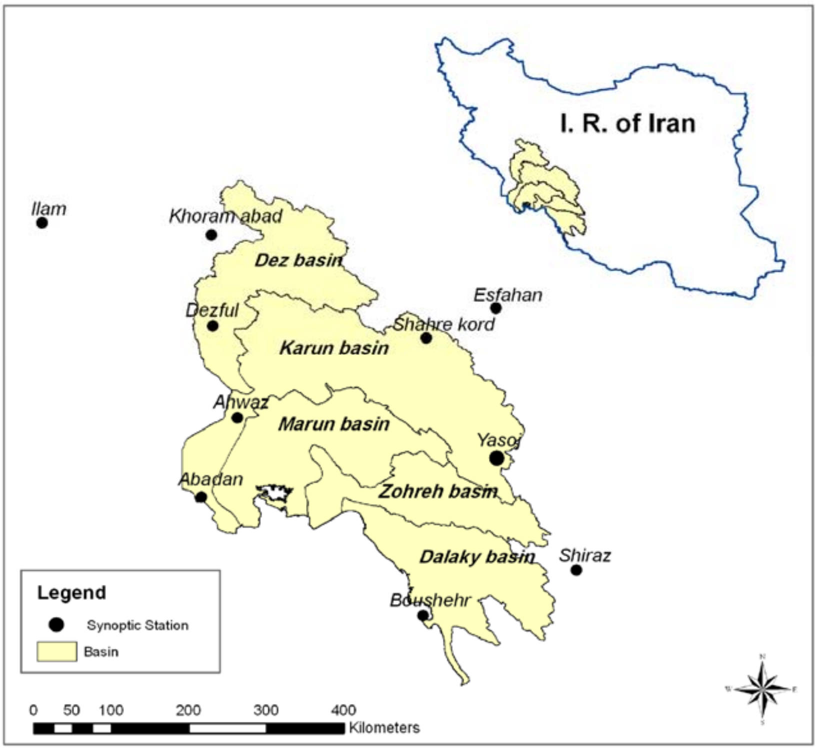

Fig. 1. Location of the study area, Iran

$$r_{xy} = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{N_{sx}.sy} \quad (1)$$

This matrix is symmetrical. Diagonal coefficients of the matrix are equal to unity because it explains the correlation of every variable with respect to itself. But other coefficients are less than zero. From this matrix one can find which variables benefit from strong and which from a weak correlation.
D: To determine the number of factors, test of Cattle is employed. Special values or explain variance are drawn adversely to the number of factors, while factors at the end of axes being ignored.

2.2. Clustering discriminate analysis method

Researchers in their studies often need to classify variables in similar categories for recognition of the physical properties and their dimensions. Clustering analysis method is employed in different types of climatological studies. Key and Crane (1986) applied this method in a daily form for classification of geopotential elevation patterns. Clustering should be done following the principal component analysis for certainty of linearity in independence of input variables. If clustering method is directly used for row variables, obscure results may be found because created classification as according to dependent data will cause highly correlated variables, exert severe influence on classification, in comparison to other data. So Clustering Analysis should be done following the Principal Component Analysis to convert input variables to components which are linearly independent. When the structure of category is identified beforehand (characteristics of seed days), the discriminate analysis method is convenient. This method which points out to a confined widespread of statistical methods plans simultaneously to measure differences between two or among several groups of days (observations), with regard to one or several variables.

The main target of the method is to attribute new days to previously identified categories, through use of classification rules. These rules which are of discriminate function nature, are calculated to recognize the group to which the observations (days) belong. Using the covariance matrix and mean values of the variables selected, discriminate analysis develops classification functions, which in turn are used to identify which group best fits the characteristics of an individual day. The discriminate analysis is based upon the development of a set of linear equations described as follows as based on Lachenbruch (1975) and Klecka (1980):

$$h_k = b_{ko} + b_{kj} \times X_i + b_{k2} \times X_2 + \ldots + b_{kp} \times X_p \quad (2)$$

where h_k is the value (score) of the discriminate function for group k, X_i is the value of the discriminating variable *i* (i.e. temperature, dew point, etc.) up to p number of variables, and b_{kj} represents coefficients which modify the function so that it closely resembles the true group variability. The functions are evaluated for each group in each case. These coefficients are derived so that the group scores are as different as possible. The coefficients for discriminate classification functions are derived as follows:

$$b_{ki} = (n_t - y) \times \sum_{j=1}^{p} a_{ij}^{*} \times X_{jk} \quad (3)$$

Where (b_{ki}) is the coefficient for variable *i* in the equation corresponding to group *k*, X_{jk} is the value of the discriminating variable, a^{*}_{ij} is an element from the inverse of the covariance matrix.

$$a_{ij} = \sum_{k=1}^{y} \sum_{m=1}^{nk} (X_{ikm} - \bar{X}_{ik})(X_{ijm} - \bar{X}_{jk}) \quad (4)$$

where *y* is the number of groups, n_k the number of elements in group *k*, $\bar{X}_{ik}$ is the mean of values in the k^{th} group, and X_{ikm} is the value of variable *i* for case m in group *k*. The inverse of this matrix is then computed to determine the a^{*}_{ij} values. The constant term in equation (2), b_{ko}, is defined as:

$$b_{ko} = -0.5 \times \sum_{j-1}^{p} b_{kj} \times X_{jk} \quad (5)$$

A separate discriminate function is derived for each group and evaluated for each day. The day is then classified into the group with the highest score (i.e. the largest h_k).

2.3. Analysis of advection frosts temperature gradient (Climatic characteristic of cold air masses)

Factors that cause advection frosts, are firstly related to air mass transfer; besides, the origin of air mass, thermal and humidity characteristics, as well as the properties of the areas where air mass transfer occurs, affect the genesis and persistence of the frosts.

Climatic characteristics of air masses change from site to site, and vary by increasing distance from the origin. Speed of changes in the air mass has a significant relationship with elevation, longitude, latitude, as well as path of the air mass movement Kalkstein (1986). For example, mean temperature of cold and dry air mass (DP) at 0300 UTC in January shows severe gradient, as varying from -19 to 6°C in Share-Kord and Bushehr stations respectively.

In order to calculate the gradient of air mass changes multivariate linear regression model was employed. The most important independent variables in this model are: elevation and latitude of stations under study. Average climatic characteristics of air masses are considered as dependent variables. General situation of the model is as follows:

$$y = a + B_1 X_1 + B_2 x_2 + \ldots + B_m X_m \quad (6)$$

where y function is the climatic characteristic of considered air mass and X_i represents the independent variables. B_i figures are the optimum values in which, by least square method, the difference between observed (y_i) and analogue values y=f(xi) is at its minimum.

In other words selection of (a) and (b) coefficients is in such a way that the sum of square deviations is minimized. In equation (6), xi represents independent variables. This function should fit to a series of observational data in a way that square of differences between observed y_i and analogue values are minimized. In other words, by sampling the existing data for x and y values, a and b coefficients can be calculated. Through this estimation and by using sample data, values of fitting y should become available. The closer the fitting values of y are to real values in the sample, the better the above model will fit.

2.4. Circulation patterns of cold air masses

In order to get a correct recognition of cold air masses which cause a downfall of cold air to the region, in this stage, several samples of cold and dry, as well as cold and moist air masses with regard to their synoptically patterns are assessed. Then the origin, path, and situation of pressure systems of air masses that cause the advection frosts during spring season are distinguished and studied. These air masses are consisted of dry polar (DP) and moist polar (MP). Samples of circulation patterns of cold air masses are shown in figure (2).

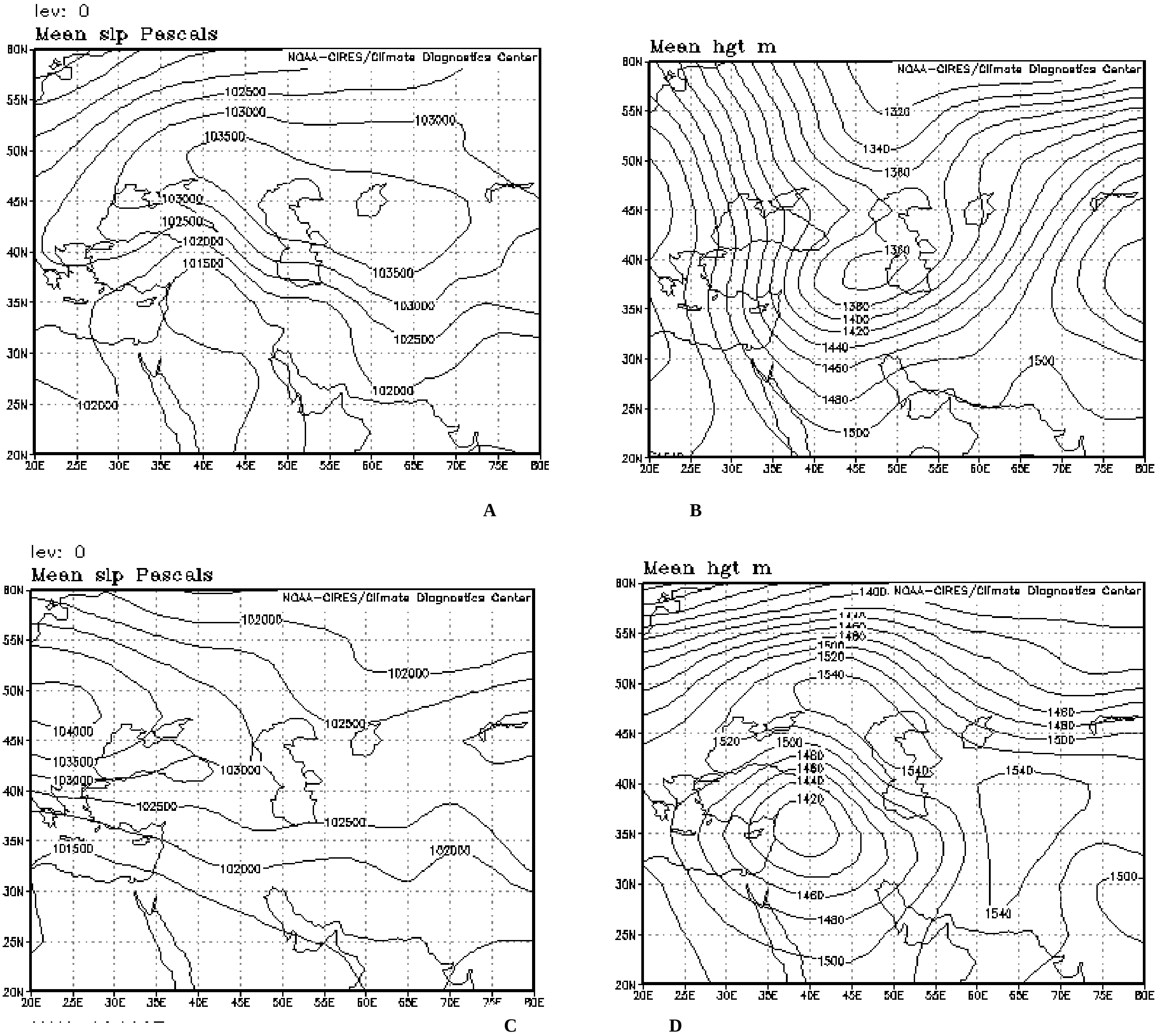

Fig. 2. Sample of circulation pattern of cold air masses
A: Dry and cold (DP) air mass pattern (Sea Level Pressure SLP)
B: Dry and cold (DP) air mass pattern (850mb level map)
C: Moist and cold (MP) air mass pattern (Sea Level Pressure SLP)
D: Moist and cold (MP) air mass pattern (850mb level)

2.5. Pressure pattern of cold and dry air masses (DP)

Investigations on sea level pressure and 850mb level synoptic maps show that if a high in 850mb chart forms on Scandinavia in the northern part of Europe, and the extension of east-west axes of the center is more than 40 degrees of longitude, then causes higher latitude cold weather transfer to east with anticyclonic circulation. Then this cold weather transfer flows to lower latitude by north and north westerly directions. The north part flows to this high transfer from north regions of Europe, Scandinavia, and north part of Eastern Europe to eastern part of Europe and west Russia. Then the flow orientation gradually turns to north westerly, north, and north easterly and shifts to the polar cold weather and sometimes cold weather of southern margin of Arctic Ocean, to Iran and Afghanistan. The flows are gently transferred to lower latitude then they adjust and extend to east of Black Sea and to Middle East.

This cold and dry air mass is accompanied with very low temperature and humidity. At the eastern part of this high, a trough forms which the center of it is in the 75 degrees north latitude. Position of this trough is an important factor for sustaining the Siberian High Pressure and the form of the high depends on the situation of the trough. Existence of a high at 850 HPa level is the reason for increasing cold weather depth above the region. But if this cold weather is in the form of a trough, then the depth of cold air is not so deep. It should be mentioned that because of high altitudes in regions such as the Republic of Azerbaijan, North West and North East of Iran, and Afghanistan, 850 HPa level is not so distant from the surface. So existence of troughs or highs will be another indicator of the depth of arctic continental cold weather. It should be noticed that the trough at this level forms especially over the Republic of Azerbaijan, Caspian Sea, and Aral Sea. If trough line is prolonged along a meridian, the high pressure axis which forms on the surface, over or at the eastern part of the Aral Sea, has north-south axis and the extension of this high transfer continues up to south regions of Pakistan. If the axis of this trough is diagonal, then the currents of air will transfer to the southern latitudes affecting only north regions, north slopes of Alborz Mountain, and Khorasan Province. Therefore the deeper the trough, the more intense the high formed at the surface and on the basis of northern and southern current situations, west part or whole parts of Iran are under the influence of very cold and dry arctic continental air mass.

2.6. Circulation pattern of cold and moist polar (MP) air mass

Formation of Moist Polar (MP) air masses is similar to Dry Polar, their main difference being related to path of movement over either land or sea.

3. Results and discussion

Onset of European arctic and northern arctic air masses causes entry of cold weather to the country. Systems that originate from Scandinavian Peninsula accompany these air masses. These cold systems bring with them chill and cloudiness. (MP) causes rainfall at the study region. (DP) and (MP) cause coldness and windy conditions. Cold occurrence due to entry of these air masses is called cold advection. Usually this cold weather develops and invades after transfer of a cold front. It generally progresses ahead of an air mass with high pressure and lasts for days.

Table (2) shows mean thermal and humidity characteristics of cold air masses (DP and MP) in March, April, and May. As shown in this table, the spatial variations of cold air masses are very severe and therefore intense gradients are expected from North to South in the region.

Table (3) shows formulas of thermal gradient of cold air masses (DP and MP) during the months of spring. R^2 values indicate the relationships being significant at P=0.05. The results obtained from the formulas indicate one degree increase in latitude to cause a reduction of 0.3 to 1.2 degree Celsius in cold air mass temperature. It should be mentioned that in early March, mountainous areas of the region are covered with snow and therefore transfer of air masses through these areas causes them to become colder. Formulas related to variations of arctic dry and arctic moist cold air masses show intense decreasing gradient for air temperature. So, for instance mean temperature (at 0300 UTC) decreases from 5 to7 degrees Celsius for each 1000 meter increase in elevation are not far from expectation. In other words, nocturnal radiation is more in uplands and north latitudes, so occurrence of severe inversions is common. Difference of morning temperature in cold air masses between north (mountainous areas) and south (coastal areas) of the study region has its highest value, the highest rate belonging to dry

Table 2. Mean of selected variables of cold air mass in March, April, and May at stations under study

		Time UTC	Variable	Esfahan	Shiraz	Busher	Shahre kord	Khoramabad	Abadan
Mar	DP	0300	Temperature (˚C)	-03.2	-1.4	8.3	-7	-3.5	4.7
	MP			-0.8	0.8	10.2	-4.5	-0.7	7.5
Apr	DP			2.2	2.4	11.9	-2.6	0.7	9.1
	MP			4.6	4.7	13.8	-0.5	3.1	12
May	DP			8.2	8.4	15.2	-0.9	5.2	14.9
	MP			9.6	9.8	18.1	3.5	7.4	17.4
Mar	DP	0900	Temperature (˚C)	7.3	8.9	17.3	6.4	9.8	17.8
	MP			10.1	13.8	19.8	9.2	11.8	19.2
Apr	DP			12.9	15.5	20.4	12.5	16.2	22.4
	MP			15.4	18	24.7	14.7	17.3	24.8
May	DP			19	22.1	23.4	18.8	21.4	24.7
	MP			19.4	24.2	26.7	19	23.6	26.6
Mar	DP	1500	Temperature (˚C)	8.4	10.5	16.1	5.5	9.3	18.4
	MP			10.3	12.5	17.7	7.6	11.5	19.3
Apr	DP			13.7	14.5	18.4	10.7	15.3	23.1
	MP			15.6	16.6	23.2	13	16.5	25.9
May	DP			19.2	20.7	24.7	17.5	20.3	25.2
	MP			19.7	23	26.5	17.2	21.5	28.1
Mar	DP	0300	Dew point (˚C)	-8.9	-5.1	4.8	-10.5	-6.3	0.6
	MP			-7.7	-4.9	7	-8.2	-3.3	3
Apr	DP			-4.8	-2.7	6.9	-7.2	-1.8	3.2
	MP			-2.2	-1.5	10.7	-4.7	0.9	7.7
May	DP			-0.8	0.9	11.1	-4.2	2.6	9.1
	MP			3	2.4	13.5	-2.3	3.7	11.4
Mar	DP	0900	Dew point (˚C)	-8.8	-6	6.5	-9	-4.3	-3.9
	MP			-9.1	-5.4	9.1	-8.1	-2.4	0.11
Apr	DP			-5.5	-5.1	11.3	-7.6	-0.9	-3.3
	MP			-4.2	-1.6	14.2	-5.8	2.1	2.6
May	DP			-4	-4.7	12.6	-5.8	3.3	2.9
	MP			0.9	-1.9	14	-2.7	4.9	5.6
Mar	DP	1500	Dew point (˚C)	-10.1	-7	9.1	-10	-4.9	-4.1
	MP			-9.6	-6.2	11	-8.6	-2.9	1
Apr	DP			-5.7	-4.2	11.3	-8.1	-1.1	-2.4
	MP			-5.3	-2.7	14.2	-5.7	1.4	2.9
May	DP			-5.1	-2.9	13.9	-5	3.8	2.8
	MP			-1.4	-2.8	15.2	-3	4.6	6.1
Mar	DP	mean	Diurnal Tem. range (˚C)	14.3	17.5	11.9	17.1	16.7	16.2
	MP			13.9	16.3	11	16.9	15.8	14.7
Apr	DP			14.2	16.6	12.6	17.7	17	16.5
	MP			14.2	14.9	10.5	17.9	16.9	16.9
May	DP			15.2	18.1	13.2	20.8	19.3	14.5
	MP			13.1	18.5	13	18.6	18.2	16.6
Mar	DP	0900	Saturation deficit	16.2	18.9	11.8	15.4	14.2	21.7
	MP			19.2	18.2	10.5	17.3	14.1	19.1
Apr	DP			18.4	20.6	12.7	20.2	16.5	25.7
	MP			19.6	19.7	10.4	20.5	15.1	23.3
May	DP			23.1	26.9	11.6	24.5	18.1	22.4
	MP			18.3	26.1	12.7	21.5	16.5	20.5
Mar	DP	mean	Daily cloud cover (eighth)	1.8	1.7	1.9	1.6	1.8	1.8
	MP			1.9	1.8	2.2	1.9	2.5	2.1
Apr	DP			1.9	1.7	1.7	1.7	1.9	1.7
	MP			2.2	2.1	1.9	2.3	2.4	1.9
May	DP			1.7	1.6	1.7	1.3	1.8	1.6
	MP			2.3	1.9	2.2	2.1	2.3	1.8
Mar	DP	mean	Pressure	1022.1	1019.3	1018.6	1019.2	1019.3	1018.6
	MP			1018.7	1017	1016.7	1015.8	1016.5	1017.2
Apr	DP			1016.2	1016.6	1015	1017.6	1015.4	1018.1
	MP			1014.8	1015.2	1013	1014.2	1014	1014.3

Table 2. continuation

		Time UTC	Variable	Esfahan	Shiraz	Busher	Shahre kord	Khoramabad	Abadan
May	DP			1011.4	1013.2	1010.5	1010	1015.2	1013.5
	MP			1010.1	1011.1	1009	1009	1013.8	1010.7
Mar	DP	mean	Daily rainfall	0.14	0.07	0	0.1	0.17	0.05
	MP			0.18	0.12	0.15	0.8	0.66	0.38
Apr	DP			0.22	0.05	0	0.06	0.05	0.02
	MP			0.36	0.1	0.1	1.1	0.84	0.04
May	DP			0.1	0.08	0.04	0.1	0.04	0.01
	MP			0.9	0.17	0.07	1.9	0.4	0.04

polar air masses. For example, in dry polar air masses, mean air temperature at 0300 UTC, shows a severe gradient from north to south while at 0900 UTC the gradient decreases. The reason for temperature decrease in dry arctic air mass at noon is due to the high radiation energy in upland in the first stage and moisture injection into the air mass in southern regions in the second stage. In March, because of reduction in sun elevation (rather than April and May) and a decrease in incoming daily energy, the variations are more severe. Results of this research show the possibility of weather situation distinction on the basis of future data by studying synoptic systems movement along with recognition of the characteristics of cold air masses. This is very important especially in the environmental issues, such as frost studies. Thus, due to importance of chill and frost in agriculture, transport, and environmental development precise studies of the influence of dry polar and moist polar cold air masses on frost phenomena, and on length of frost period are suggested. Besides, the focus should be on the patterns that causes the movement of these cold air masses to other vulnerable regions. Finally the results could be applied in agricultural management, development, as well as in safe transportation.

Table (3): Equations of thermal gradient related to variations of cold air masses in south-west regions of Iran in the period (1961-1999). Statistical significance at the 95% confidence level (P=0.05)

Elevation: X_2 Latitude: X_1

Air mass	Variable	March	R^2	April	R^2	May	R^2
Dry arctic air mass (DP)	Mean Temperature 0300 UTC	$y=38.5 - 1.07 X_1 -0.005 X_2$	0.97	$y=35.5 - 0.84 X_1 -0.005 X_2$	0.95	$y=40.9 - 0.86 X_1 -0.005 X_2$	0.89
	Mean Temperature 0900 UTC	$y=29.3 - 0.3 X_1 -0.005 X_2$	0.98	$y=26.7 - 0.18 X_1 -0.004 X_2$	0.94	$y=34.1 - 0.33X_1 -0.003 X_2$	0.85
	Mean Dew Point Temperature 0300 UTC	$y=35.3 - 1.09X_1 -0.005 X_2$	0.97	$y=21.4 - X_1 0.54 -0.005 X_2$	0.96	$y=19.6 - 0.3 X_1 -0.007 X_2$	0.98
	Mean Dew Point Temperature 0900 UTC	$y=27.7 - 0.88 X_1 -0.004 X_2$	0.69	$y=22 - X_1 0.59 -0.005 X_2$	0.64	$y=-2.3 - 0.35 X_1 -0.008 X_2$	0.74
Polar air mass (MP)	Mean Temperature 0300 UTC	$y=35.6 -0.9 X_1 -0.005 X_2$	0.98	$y=35.3 - 0.75 X_1 -0.005 X_2$	0.95	$y=25.3 - 0.24 X_1 -0.006 X_2$	0.96
	Mean Temperature 0900 UTC	$y=46.6 -0.91 X_1 -0.004 X_2$	0.99	$y=39.4 - 0.51 X_1 -0.004 X_2$	0.97	$y=64.4 - 1.2 X_1 -0.002 X_2$	0.97
	Mean Dew Point Temperature 0300 UTC	$y=22.9 - 0.6 X_1 -0.006 X_2$	0.95	$y=17.1 -0.26 X_1 -0.007 X_2$	0.97	$y=15.1 - 0.08 X_1 -0.007 X_2$	0.97
	Mean Dew Point Temperature 0900 UTC	$y=26.8 -0.74 X_1 -0.006 X_2$	0.79	$y=29 - 0.68 X_1 -0.006 X_2$	0.73	$y=12.6 - 0.90 X_1 -0.006 X_2$	0.77

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