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The Relationship between Disturbance of the Polar Jet Stream and the Surface Low Pressure Intensity

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Abstract

The investigations between 300 hPa level and surface charts show that there is obvious connection between the mid-latitude cyclone waves and the polar front jet stream. The work studied the relationship between polar jet stream and surface low pressure during April's months for years from 2014 to 2016 which were the polar jet passing with high frequencies over the area of study. The weather charts used which they were 300 hPa wind speed and surface pressure in addition to the surface weather phenomenon. The study presents the structure of polar jet that affects significantly in the intensity of the low pressure system at the surface. The structure did not repeat regularly during April's months for the years from 2014 to 2016 and the structure was two types which they are continuous and discontinuous. The percentage ratios for jet-structure were different from a year to another year. The discontinuous jet-structure percentages ratios were in the year 2014 about 36 %, 6 % in 2015, 92 % in 2016. The analysis of continuous and discontinuous jet-structures declared that the estimating of the surface low pressure center value needs the correcting of recognizing of the polar jet-structure. The analysis also showed the relationship between the surface low pressure system center value and the lowest polar jet geopotential height at 300 hPa level was in general decreasing geopotential height causing decreasing the low pressure center value on the surface but the structure of polar jet is important. The plotting between low pressure center value on y-axis and geopotential height value on x-axis by using SigmaPlot program offered that in April 2014 that the relationship between low pressure center and geopotential height was direct relationship with continuous jet-structure while it was indirect with discontinuous jet-structure. The mixing between continuous and discontinuous jet-structure data for the same year will distort that relationship.. In April 2015 with small ratio of discontinuous jet-type the relationship between geopotential height and surface low pressure center was direct relationship. In April 2016 with high ratio of discontinuous jet-structure the relationship between geopotential height and surface low pressure center was also direct. In April 2014 the ratio was near from middle that causing the relationship between low pressure center and geopotential height distorted. The study also revealed the low pressure center value would be less with the discontinuous jet-type if there were same geopotential height values of continuous and discontinuous jet-type.

الخلاصة

درس هذا العمل العلاقه بين التيار النفاذ القطبي والمنخفض الجوي السطحي خلال اشهر نيسان للفتره من ٢٠١٤ الى ٢٠١٦ والتي يكون خلالها اعلى عدد للايام التي يمر خلالها التيار النفاذ القطبي فوق المنطقه للمختاره للبحث. بيت الدراسه بان شكل التيارالنفاذ القطبي يوثر على عمق المنخفض الجوي السطحي. لم يتكرر شكل التيار القطبي بصوره منتظمه خلال اشهر نيسان للفتره من ٢٠١٤ الى ٢٠١٦ ولكن كان هناك تركيبان للشكل مميزان وهما التيار المتواصل في الجريان مميز متصل على طول مساره والاخر متقطع وليس لهما نسبه ثابته للمرور خلال نفس الشهرحيث انها اختلفت من سنه الى اخرى. كانت نسبه التيار المتقطع لكل حالات مرور التيار النفاذ لشهر نيسان لعام ٢٠١٤ (٣٦ %) و(٦ %) لعام ٢٠١٥ ولعام ٢٠١٦ كانت (٩٢%). ولذلك وضحت الدراسه لتخمين جيد لقيمه المنخفض الجوي السطحي يحتاج على تحليل جيد يبين شكل تركيب التيار. رسمت علاقه بيانيه بين الارتفاع الجهدي لخط مركز التيارالنفاذ ومركز المنخفض الجوي السطحي بواسطه برنامج (السكما بلوت) لاشهر نيسان للسنين من ٢٠١٤ الى ٢٠١٦. بينت العلاقه بانه على العموم كانت هناك علاقه طرديه بين المستوى الجهدي لمكز التيار و المنخفض الجوي السطحي في حاله رسم بيانت كل شكل للتيار على حده مع قيمه المخنض الجوي السطحي اما في حاله دمج بيانات الشكل المتصل مع المتقطع ورسمها مع قيمه المنخفض الجوي السطحي تتشوه العلاقه مابين طرديه وعكسيه. حيت قدمت التحليلات البيانيه لسنه ٢٠١٤ والتي كانت لها قيمه عاليه لنسبه لمرور التيار المتقطع قريبه من النصف علاقه طرديه في حاله كون التيار متصل وعكسيه في حاله كون التيار متقطع

الشكل. وفي سنه ٢٠١٥ و التي كانت فيها نسبه قليله لمرورالتيار المتقطع كانت العلاقه طردية. وقدمت بيانات العام ٢٠١٦ والذي كانت فيه نسبه عاليه لمرور التيار المتقطع كذلك علاقه طرديه ايضا. اكدت الدراسه ضروره فصل بين شكلي التيار في حاله تخمين قيمه المنخض الجوي السطحي. واخيرا بينت تحليلات الخرائط السطحيه و العليا بانه لنفس قيمه المستوى الجهدي لمركز التيار النفاذ تكون قيمه المنخض السطحي اقل (اعمق) في حاله كون شكل تركيب التيار النفاذ القطبي متقطع.

Introduction

The jet streams are upper-level fast currents of air that circulate and meander around the hemisphere which they play a key role in the general circulation of the atmosphere as well as in generating weather conditions throughout mid-latitudes [1]. The Jet streams are important because the synoptic scale disturbances tend to form in the regions of the jet stream maximum wind speed [2]. The upper air current considers jet stream when its core speed reaches 60 knots and above. The jet streams are sensible to surface temperature gradient [3].The polar jet stream is meandering of fast air current nearly at 300 hPa level due to barotropic disturbance which it considers important for the north/south transport of energy and moisture [4]. The polar jet stream is often associated with the polar front which it is the global boundary separating the cold polar air from warm subtropical air that gave it names the polar front jet stream. The polar front area considers the active weather region which it is usually on the equatorial side of the polar jet [5]. The precipitation will be significant with wide band ahead of the warm front [6]. The polar jet stream distributes the turbulence vertically between middle and upper troposphere and horizontally from the pole to equator [7].

The polar jet stream sometimes moves as coherent of a strong winds river with little meandering or a weak sort which tend to be of a wavy shape, intermittent with large amplitude [8]. These wavier jet streams are responsible at a variety of extreme weather events over Mediterranean regions [9]. The polar front jet has internal variability from year to year on decadal timescales and also its position varies in the range of 10 degrees latitudes on decadal time scale [10].

The aim of this work is to study the structure of polar jet stream and its geopotential height location to use them as indicator to estimate the intensity of surface low pressure. .

Proposed Methodology

The global forecast system (GFS) weather charts used to study the behavior of PFJ and the associated low pressure systems in Middle East (20-45)^o N, (30-60)^{o}E focusing on the middle of Iraq (see Table (1) and Figure (1) according to [11].. The included charts are surface weather charts which they depicted total precipitation and cloud cover and the 300 hPa level upper charts which they depicted geopotential height in (m), temperature gradient (Celsius/ latitudes), and core speed values in (knot) at two times (00 and 12) UTC during three years 2014-2016.

Table (1): weather stations used in this study

Iraq Regions	Station name (city)	location
middle	Haditha	34.13^o N, 42.35^o E
	Balad	34^o N, 44.15^o E
	Baghdad	33.3^o N, 44.4^o E

The surface routine weather conditions of the three stations were also studied: which they are the METAR (Meteorological Aerodrome Report) and the TAF (Terminal Aerodrome Forecast 24 hours).

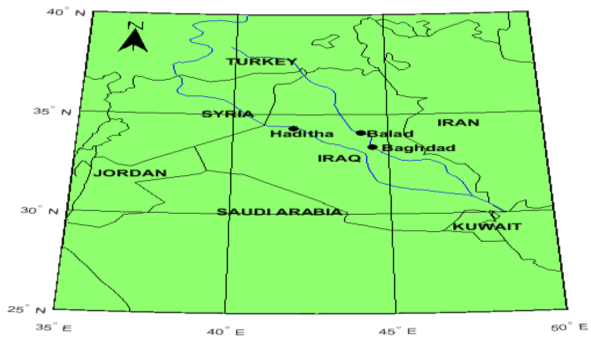

Figure (1): The locations of the surface weather stations.

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The Relationship between Low Pressure and Geopotential Height

Tables (2), (3) and (4) show the geopotential height of the location of the polar jet stream axes that associated low pressure system in Aprils during 2014, 2015 and 2016 at 00 and 12 UTC, respectively. Choosing the events depends on the existing of the polar jet stream with (60 knots and above). The table also lists the lowest surface pressure and the corresponding weather conditions in the vicinity of the three stations middle of Iraq. Analyzing presented the ratio of discontinuous jet-type in April, 2014 was (36 %) while in 2015, was nearly (6 %) and in April, 2016 was (92 %) during April 2016 at (00+12) UTC.

Table (2) Polar jet stream events and the corresponding weather at 00, 12 UTC April 2014

(a) 00 UTC

day	PFJ		Low pressure system		
	Discontinuity	Geo Potential height (m/10)	Pressure (hPa)	Weather condition at 00 UTC	The remarkable Weather condition during the day
2	No	920	1003	Nil	Thunderstorm (09 UTC)Baghdad
4	No	923	1015	Nil	Shower rain (15UTC) Baghdad
7	No	926	1010	Nil	Blowing dust (09UTC) Baghdad
8	No	925	1009	Nil	Thunderstorm (09UTC) Baghdad
10	No	928	1011	Nil	Thunderstorm (07UTC) Haditha
12	No	924	1011	Nil	Thunderstorm (12UTC) Baghdad
14	No	936	1009	Nil	Thunderstorm (06UTC) Baghdad
15	No	930	1012	Nil	Dust storm (12UTC) Baghdad
13	yes	912	1013	Nil	Thunderstorm (20UTC) Baghdad
17	yes	924	1008	Nil	Thunderstorm (23UTC) Baghdad
21	yes	920	1012	Nil	Thunderstorm (08UTC) Haditha

(b) 12 UTC

day	PFJ		Low pressure system		
	Discontinuity	Geo Potential Height (m /10)	Pressure (hPa)	Weather condition at 00 (UTC)	The remarkable Weather condition during the day
2	No	914	1002	Nil	Thunder storm (12UTC) Baghdad
4	No	924	1010	Nil	Shower rain (15UTC) Baghdad
7	No	922	1008	Nil	Blowing dust (09UTC) Baghdad
8	No	926	1009	Nil	Thunder storm (09UTC) Baghdad
10	No	924	1007	Nil	Thunder storm (07UTC) Haditha
12	No	928	1011	Nil	Thunder storm (12UTC) Baghdad
14	No	936	1010	Nil	Thunder storm (12UTC) Baghdad
15	No	934	1009	Nil	Dust storm (12UTC) Baghdad
13	yes	912	1011	Nil	Thunder storm (20UTC) Baghdad
17	yes	924	1003	Nil	Thunder storm (23UTC) Baghdad
21	yes	920	1012	yes	Thunder storm (12UTC) Baghdad

27	yes	936	1004	Nil	Rain (07UTC) Balad
28	yes	924	1005	Nil	Thunderstorm (06UTC) Haditha

28	yes	924	1006	Nil	Thunder storm (08UTC) Haditha

Table (3): Polar jet stream events and the corresponding weather at 00, 12 UTC April 2015

(a) 00 UTC

day	PFJ		Low pressure system		
	Discontinuity	Geo Potential Height (m /10)	Pressure (hPa)	Weather condition at 00 UTC	The remarkable Weather condition during the day
1	No	936	1009	Nil	Shower rain (06UTC) Baghdad
9	No	912	1001	Nil	Blowing dust (12UTC) Baghdad
10	No	912	1004	Nil	Thunder storm (03UTC) Baghdad
12	No	924	1005	Nil	Thunder storm (12UTC) Haditha
13	No	912	1009	Nil	Thunder storm (17UTC) Haditha
21	No	924	1008	Nil	Blowing dust (20UTC) Balad
22	No	914	1007	Nil	Thunder storm (23UTC) Haditha
23	No	924	1007	Nil	Thunder storm (08UTC) Balad
18	yes	924	1004	yes	Thunder storm (00 UTC) Baghdad

(b) 12 UTC

day	PFJ		Low pressure system		
	Discontinuity	Geo Potential Height (m/10)	Pressure (hPa)	Weather condition at 00 UTC	The remarkable Weather condition during the day
1	No	936	1008	Nil	Shower rain (06UTC) Baghdad
9	No	924	1008	Nil	Shower rain (18UTC) Baghdad
10	No	912	1008	Nil	Thunder storm (03UTC) Baghdad
12	No	924	1005	Nil	Thunder storm (12UTC) Haditha
13	No	924	1012	Nil	Thunder storm (17UTC) Haditha
21	No	924	1008	Nil	Blowing dust (20UTC) Balad
22	No	914	1006	Nil	Thunder storm (23UTC) Haditha
23	No	912	1007	Nil	Thunder storm (14UTC) Balad

Table (4): Polar jet stream events and the corresponding weather at 00 UTC April 2016

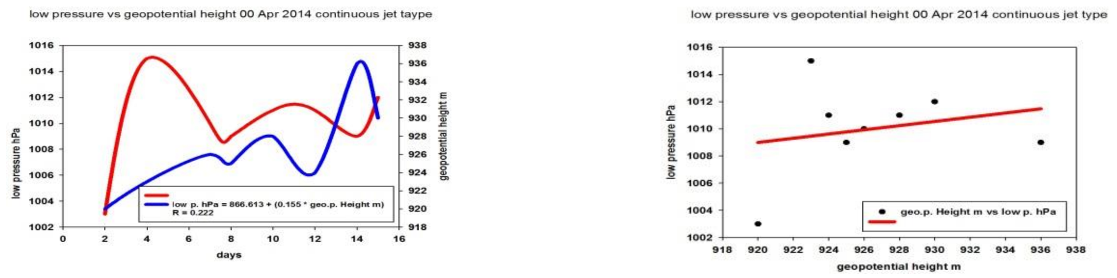
(a) 00 UTC

day	PFJ		Low pressure system		
	Discontinuity	Geo Potential Height (m /10)	Pressure (hPa)	Weather condition at 00 UTC	The remarkable Weather condition during the day
7	No	930	1008	Nil	Thunder storm (02UTC) Baghdad
9	yes	928	1006	Nil	Thunder storm (17UTC) Haditha
10	yes	926	1005	Nil	Thunder storm (15UTC) Haditha
11	yes	924	1006	Nil	Thunder storm (08UTC) Haditha
12	yes	922	1003	Nil	Rain (07UTC) Baghdad
13	yes	924	1002	Nil	Thunder storm (05UTC) Baghdad
14	yes	924	1003	Nil	Thunder storm (08UTC) Baghdad
15	yes	930	1008	Nil	Thunder storm (05UTC) Baghdad
22	yes	936	1009	Nil	Thunder storm (08UTC) Haditha
23	yes	936	1010	Nil	Thunder storm (07UTC) Baghdad
25	yes	924	1002	Nil	No Significant Weather
27	yes	930	1005	Nil	Shower rain (06UTC) Haditha

(b) 12 UTC

day	PFJ		Low pressure system		
	Discontinuity	Geo Potential Height (m /10)	Pressure (hPa)	Weather condition at 00 UTC	The remarkable Weather condition during the day
7	No	938	1012	yes	Thunderstorm (12UTC) Haditha
9	yes	928	1006	Nil	Thunderstorm (22UTC) Baghdad
10	yes	926	1006	Nil	Thunderstorm (16UTC) Baghdad
11	yes	936	1004	Nil	Thunderstorm (08UTC) Baghdad
12	yes	922	1003	Nil	Thunderstorm (08UTC) Haditha
13	yes	926	998	Nil	Thunderstorm (11UTC) Baghdad
22	yes	936	1012	yes	Thunderstorm (12UTC) Balad
23	yes	936	1007	yes	Thunderstorm (12UTC) Baghdad
25	yes	924	1004	Nil	Blowing dust (22UTC) Haditha
27	yes	930	1005	Nil	Shower rain (11UTC) Baghdad
29	yes	932	1010	yes	Shower rain (12UTC) Baghdad

(a)



(b)

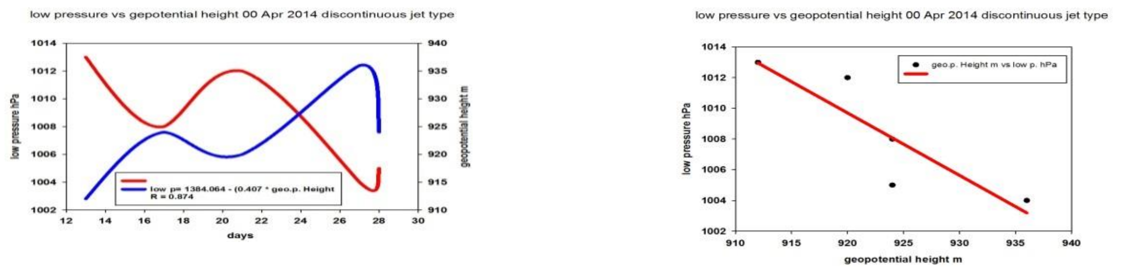
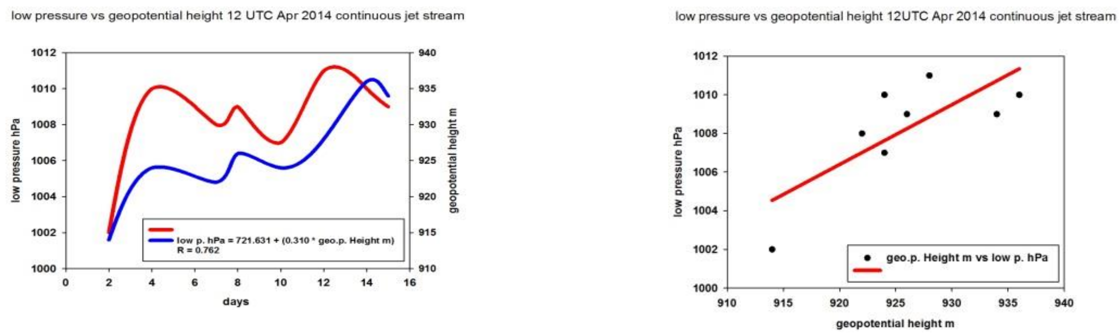


Figure (2): low pressure vs. geopotential height at 00 UTC in April 2014:
a. continuous polar jet stream type. b. discontinuous polar jet stream type

(a)



(b)

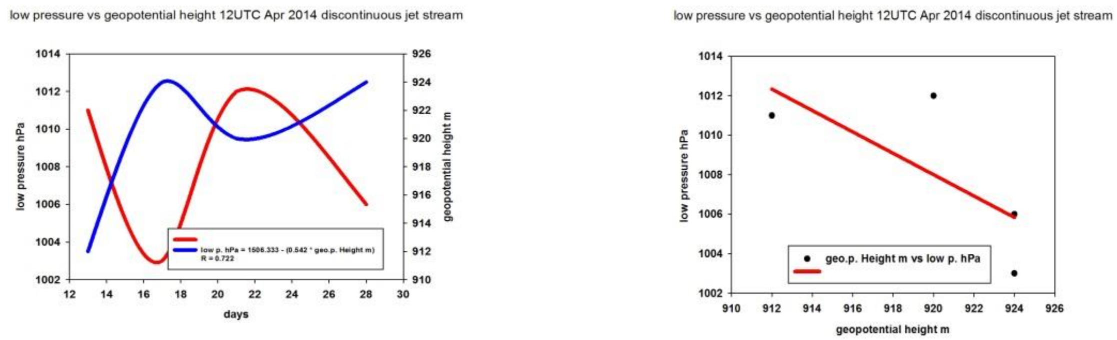


Figure (3): low pressure vs. geopotential height at 12 UTC in April 2014:
a. continuous polar jet stream type. b. discontinuous polar jet stream type.

(a)

(b)

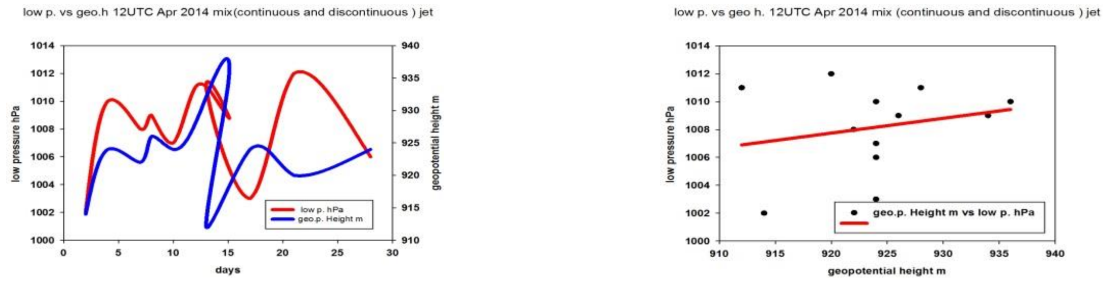
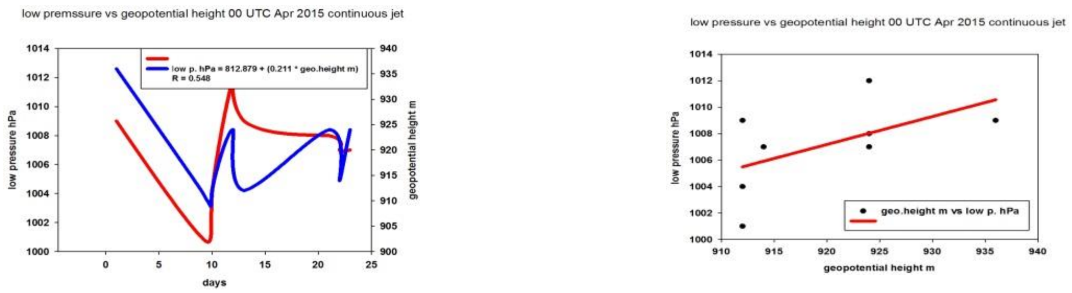


Figure (4): low pressure vs. geopotential height in April 2014: a. (Continuous + discontinuous) polar jet stream type at 00 UTC, b. (Continuous + discontinuous) polar jet stream type at 12 UTC

(a)



(b)

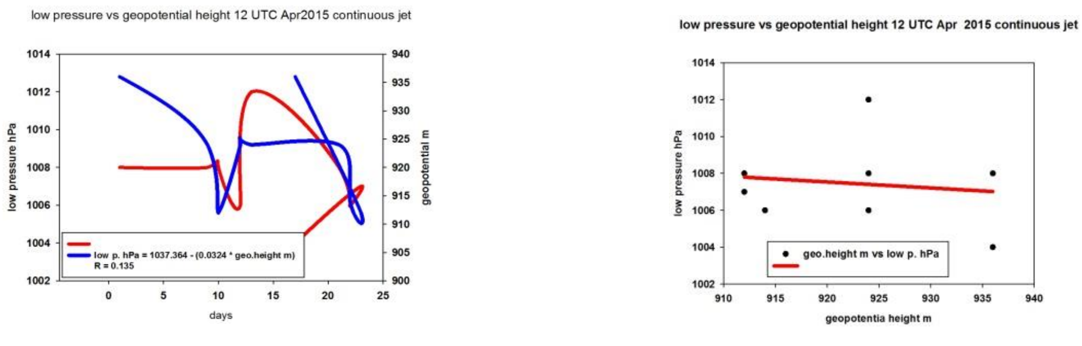
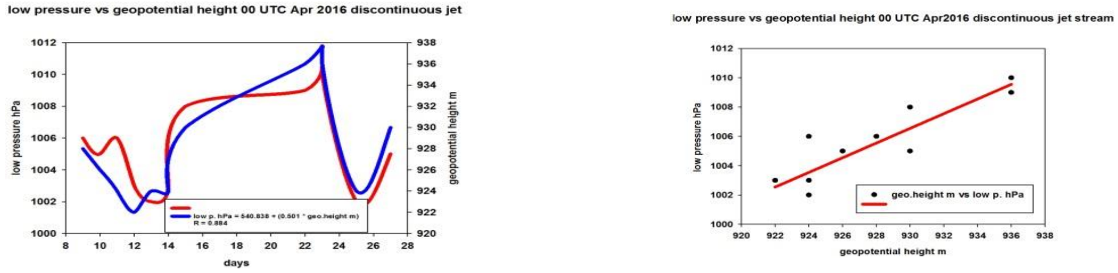


Figure (5): low pressure vs. geopotential height in April 2015: a. Continuous polar jet stream type at 00 UTC, b. continuous polar jet stream type at 12 UTC

(a)



(b)

Figure (6): low pressure vs. geopotential height in April 2016: a. discontinuous jet stream type at 00 UTC, b. discontinuous jet stream type at 12 UTC

Discussion

Analyzing data in April 2014 at two times 00, 12 UTC showed the percentage of the discontinuous polar jet-type structure was 36%. The relationship between low pressure center value in (hPa) and geopotential height (m) was direct relationship if the jet-type was continuous while with discontinuous jet-type relationship was indirect. The mixing between continuous and discontinuous jet-types data will distort the relationship that was shown through mixing between continuous and discontinuous jet-type data and plotting as curve a plot between low pressure and geopotential height offered the direct relationship in general between low pressure and geopotential height while in some points was indirect, While line plot showed the relation was to some extent indirect at 00 UTC and direct at 12 UTC as shown in Figures (2), (3) and (4).

In April 2015, the percentage ratio of discontinuous jet-type was 5.88%. By neglecting discontinuous jet-type data because they were small. The relationship between the low pressure system and geopotential height was mainly direct relationship and the jet stream is almost continuous (see Figure (5)). In April 2016, the percentage ratio of discontinuous jet-type was 92%. By neglecting the continuous jet-type data because they were small. The relationship between low pressure values and the geopotential height value was mainly direct and the jet stream is almost discontinuous (See Figure (6)). The analyzing also showed with the same geopotential height value the low pressure center was lower with discontinuous jet-type. the charts data in 9 April 2015 (00 UTC) continuous jet-type low pressure value was 1001 hPa corresponding geopotential height value 9120 m while with discontinuous jet type in 13 April 2016 (12 UTC) the low pressure was 998 hPa corresponding to geopotential height value 9260 m.

Conclusions

The polar jet-type structure affect significantly on the low pressure value at surface. The more accurate the determination of the jet-type gives the more accurate estimation of the low pressure center value at the surface. This implies that the determination of the low pressure values is rather sensitive to the geopotential height value. The structure of polar jet-type did not repeated regularly in Aprils during years from 2014 to 2016. In April 2014 The relationship between the low pressure and geopotential height was distorted because the percentage ratio of discontinuous jet-type was nearly half of the data about 36 % that will cause error with simulation any model to estimate low pressure value if there is not detecting to the jet-type correctly. In Aprils 2015 the percentage ratio of discontinuous jet-type was very little while in April 2016 the percentage ratio of discontinuous jet-type was very high that will be with little effected in model simulation to estimate low pressure from geopotential height because the jet-type was mainly same there for the detecting of jet-type correctly will be not important accidently because it is same at all month.

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