Mustansiriyah Journal of Pure and Applied Sciences, Print ISSN: 2957-9910. Online ISSN: 2957-9929, Vol. 3, No. 3, 2024, Pages 48-65
DOI: 10.47831/mjpas.v3i3.200

MJPAS MUSTANSIRIYAH JOURNAL OF PURE AND APPLIED SCIENCES

Journal homepage:
https://mjpas.uomustansiriyah.edu.iq/index.php/mjpas

RESEARCH ARTICLE - ATMOSPHERIC SCIENCE

Relationship between surface pressure systems and atmospheric rivers over Iraq and Surrounding regions study case

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Article Info.

Article history:

Received
14 May 2024

Accepted
14 July 2024

Publishing
30 June 2025

Abstract

Heavy rainfall is closely associated with atmospheric rivers (ARs), which are long, narrow bands and ephemeral corridors with significant water vapor flux. This paper study the relation between ARs and low pressure system (L). Since there isn't a specialized study for this relationship, extreme rainfall cases were selected for the years 2023/4/11 to 2023/4/13. Which encompass the majority of Iraq and its neighbouring regions. Based on statistics from the Iraq Meteorological Organization and seismology, the amount of rain that falls over Iraq in this instance ranges from 10 to 100 mm each day, ARs mechanisms and roles in the Middle East's flooding are not well known. The links between ARs and L have been investigated through the use of vertically integrated moisture flux transfer (IVT). The results of the analysis of surface pressure system maps and the use of IVT to determine ARs indicated that, in this instance, the type of AR was weak over the Arbian Peninsula and up towards Iraq. Additionally, there was a low pressure area over the Arbian Peninsula that developed into a L and added moisture to intensify the AR, in addition to enhanced moisture from the Red Sea and North Africa. The rain gets heavier than at the first when the AR gets stronger. The presence of L together with ARs causes an increase in moisture content, which intensifies and gave depth to the ARs. However, L by itself does not always imply the existence of ARs.

The official journal published by the College of Education at Mustansiriya University

Keywords: Atmospheric Rivers (ARs), low pressure system (L), high pressure system (H), extreme rainfall, IVT.

1. Introduction

Atmospheric river (ARs) is long and narrow corridor of horizontal water vapor transport in lower troposphere Zhu & Newell (1998), Dezfuli (2020), Sadeghi (2021). Heavy precipitation often occurs in small areas and resulting from extensive systems that draw moisture from distant regions particularly in regions that are semi-arid or arid, Severe rainfall cannot be caused by localized water vapor, Consequently, moisture moves into these areas Haydarizad (2018), Barati & Heydari (2003), Mohammadi & Masoudian (2010). Extreme cases of rainfall were a significant natural disaster that devastated the Middle East's agriculture, economy, human lives, and transportation Bozkurt (2021), De Vries (2013). Research has demonstrated how ARs affect weather-related natural disasters across different regions, although little is known about their mechanisms and contribution to flooding in the Middle East Krichak (2012). de Vries (2013). Tubi (2017). Akbary (2019). similar to the

western U.S. The term "ARs" is used in recent studies to describe moisture transport. Atmospheric rivers carry 90% of the water vapor that is moved across the midlatitudes and toward the poles Dettinger (2018). In midlatitudes, cyclones are a form of cool season storm, Newell & Zhu (1994), Ralph (2004) Payne & Magnusdottir (2014). studies have investigate linked between ARs and L and they indicate that ARs are accompanied with pre cold frontal region Ralph (2006). Bao (2006). Neiman (2011). Catto & Pfahl (2013). Two are mention together in numerous study Hu (2017). Sodemann (2015). There are no studies examining the relationship between atmospheric rivers and surface pressure systems over Iraq and its surrounding areas. There are still many unanswered questions regarding the nature of the interaction between ARs and L, Ralph & Dettinger (2018). Numerous research works have examined the impact of atmospheric rivers and L on the Middle East's heavy precipitation separately. Dezfuli (2020). Salimi & Saligheh (2016), demonstrates how major floods are being caused by ARs along Iran. Shademani (2015), studied the effects of ARs on two type of intense rainfall that resulted in flooding in Iran's west and south. Aqeel Ghazi (2021) describes the physical and synoptic characteristics of torrential rains over Iraq and neighboring regions. Hayat Mahdi Aliakbar (2021) investigate how severe rains affect the estimation of probable maximum precipitation for selected areas of Iran. Baruch Ziv et al (2021) clarify the formation of cyclone over the east Mediterranean within read sea trough.

Table1: Represent nomenclature and symbols

Nomenclature & Symbols			
ARs	Atmospheric Rivers	L	Low Pressure System
H	High Pressure System		
IVT	Vertically Integrated Moisture Flux Horizontally Transport		
GMT	Greenwich Mean Time Zone		

2. Materials and methods

Iraq is a country in Asia that occupies the north eastern part of the continent. Iraq is bordered by Syria, Jordan, Turkey, and eastern Iran. The Arabian Gulf, Kuwait, and Saudi Arabia encircle Iraq's southern boundary. As shown in the following figure.

Figure.1 Represented study area

Analysis relationship between ARs with L and H linked with intense rainfall to determine the maximum amount of rainfall over Iraq and determination days with extreme rainfall from Iraqi meteorological organization and

seismology (after separating extreme rainfall event). One useful method for investigate the variations in moisture at different parts of the world is using IVT. Now a days, the IVT is widely used to detect ARs. Using IVT to identify ARs because of their high correlation with extreme rainfall during ARs events, ARs are based on IVT which is measured using meridional wind, zonal wind, and specific humidity as inputs. We take the integration from 1000 hpa to 300 hpa with 100 hpa interval for 8 levels for (q,u,v) obtained from ECMWF (ERA5) with spatial resolution 0.25° x 0.25° and hourly temporal resolution. Equation below used to track the L and H using surface pressure systems maps for 6h from Iraq metrological organization and seismology.

Equation of IVT:

$$\sqrt{(\frac{1}{g}\int_{1000}^{300} qu.dp)^2 + (\frac{1}{g}\int_{1000}^{300} qv.dp)^2} \quad (1)$$

Where u is zonal wind and meridional wind in units (m/s), q is specific humidity (kg/kg), g is the gravitational acceleration and dp is the pressure differential between two successive levels. The IVT units are Kg $m^{-1}s^{-1}$. Table below for classification of ARs Mo, R., & Lin, H. (2019).

Table2: Represent globally classification of ARs

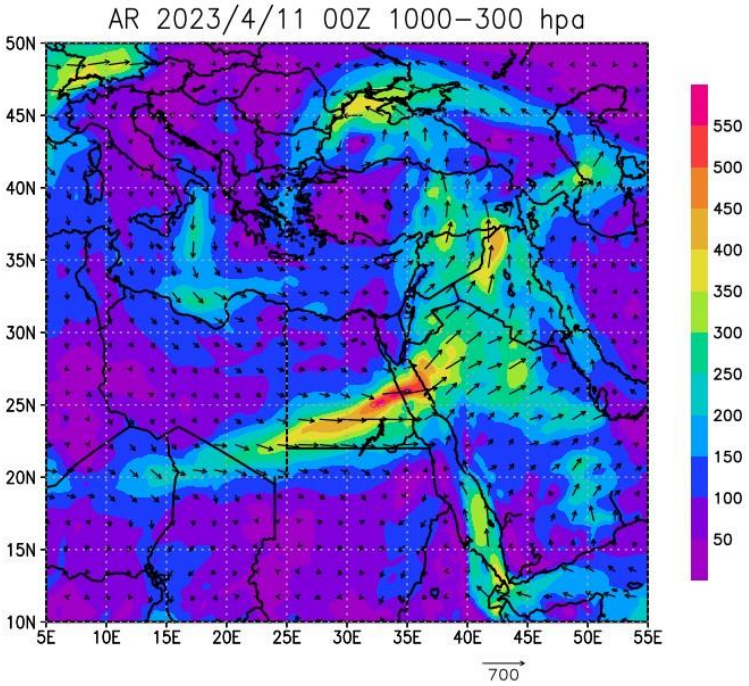
Category	**Intensity**	**Effect**	**Maximum rang of IVT kg $m^{-1}s^{-1}$**
1	Weak	mostly advantageous	Between 250-500
2	Moderate	Most advantageous but potentially dangerous	Between 500-750
3	Strong	An equilibrium between advantageous and dangerous	Between 750-1000
4	Extreme	Mostly dangerous	Between 1000-1250
5	Exceptional	Mostly harmful	More then 1250

3. Result

In the case of ARs that have a life span longer than 24 hours and a crossing distance greater than 1000 km, there is a strong association between ARs and surface pressure systems. ARs associated with L it not easy to determine its location and its intensity from L, but the strong ARs provided deepening for cyclone by supplying water vapor for lunching latent heat, often L intensify the ARs with stronger wind driven water vapor transport in this case for first day 2023/4/11 at (00:00GMT) the AR was strong over north Africa and its start to reach Arbian peninsula and its was weak over it up toward Iraq as show in figure (2-a), where surface pressure map at (00:00GMT) shows over Arbian peninsula area of low pressure. for next six hours at (06:00GMT) the AR reach Arbian peninsula as show in figure (3-a), and the area of low pressure becoming L and it becomes source of moisture for AR as illustrated in figure (3-b). For next six hours at (12:00GMT) the ARs reaching Iraq as show in figure (4-a), and the L become more deepening because existing of AR as show in figure (4-b). For next six hours at (18:00GMT) AR become moderate over Iraq with maximum IVT for ARs was ranging over some part of Iraq from (300 -600 kg m-1s-1), as show in figure (5-a). for next day in 4/12 at (00:00GMT) AR

start decaying over north Africa because area becoming high pressure area as show in figure (6-b), and AR reach max of moderate over Arbian peninsula and Iraq as show in figure (6-a). For next six hours at (06:00GMT) AR vanish over Africa because H as show in figure (7-b), and become strong over Arbian peninsula and some part of Iraq where maximum IVT for AR ranging between (700-800 kg m-1s-1) as shown in figure (7-a). For next six hours at (12:00GMT) effect of AR continue over Arbian peninsula and Iraq as show in figure (8-a), also L continue effecting on region as in figure (8-b). For next six hours (18:00GMT) the effecting of AR over Arbian peninsula become weak and over Iraq continue strong over some part of the east and north east and begin to move toward north of Iran as shown in figure (9-a). For third day 2024/4/13 at (00:00GMT), AR decaying from Iraq and region and move toward Iran as shows in figure (10-a), region become area of high pressure system as shown in figure (10-b), H becomes more affected. For next six hours (06:00GMT) it become clear the ending of AR over Iraq and Arbian peninsula because there is no moisture providing and the area become controlled by high pressure, as illustrated in figures (11-b,12-b,13-b). At the end of this case its shows not every L companied with AR but most of ARs linked with L because it's a source feeding for ARs by strong wind around L.

(a)



(b)

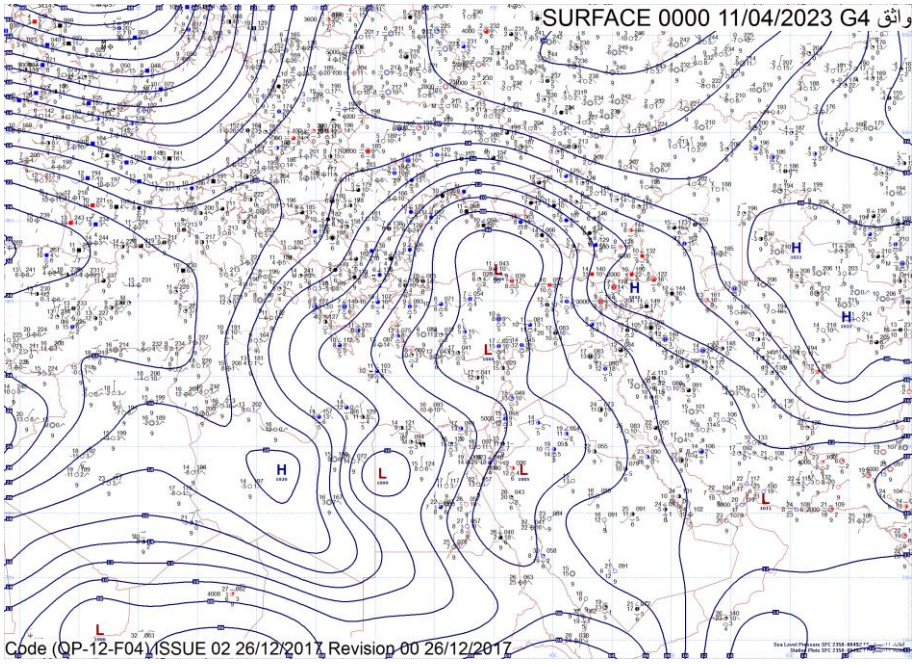
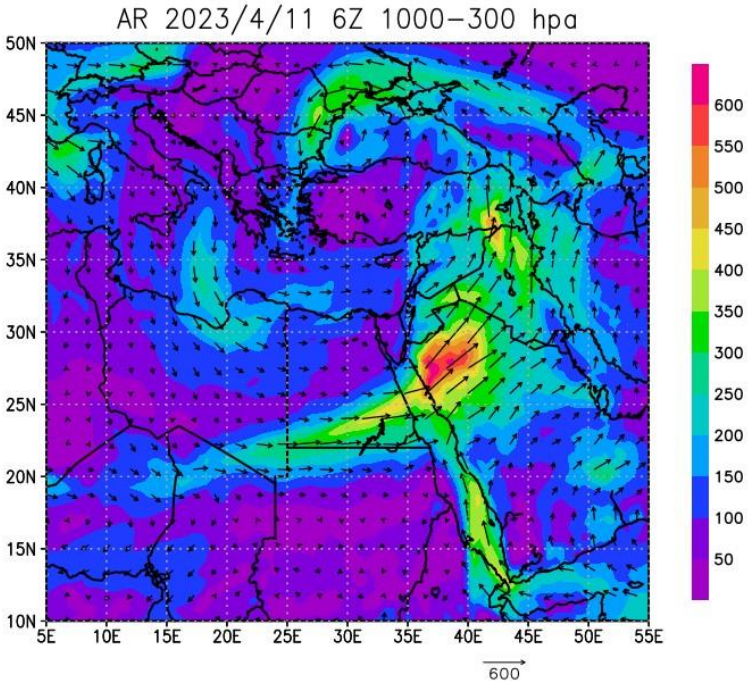


Figure. 2. Synoptic analysis for ARs with surface pressure systems 2023/4/11 at (00:00GMT)

(a)



(b)

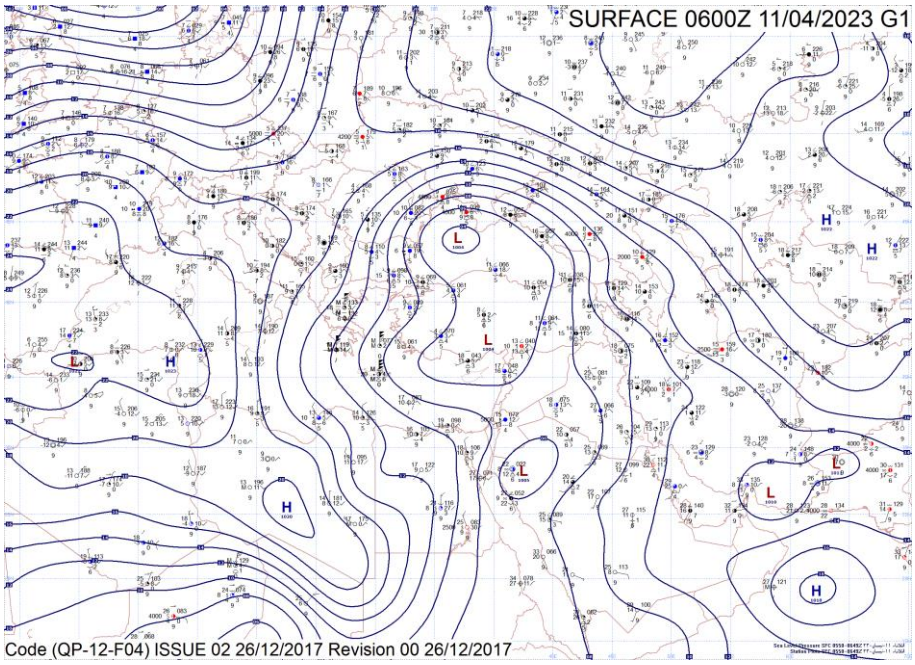
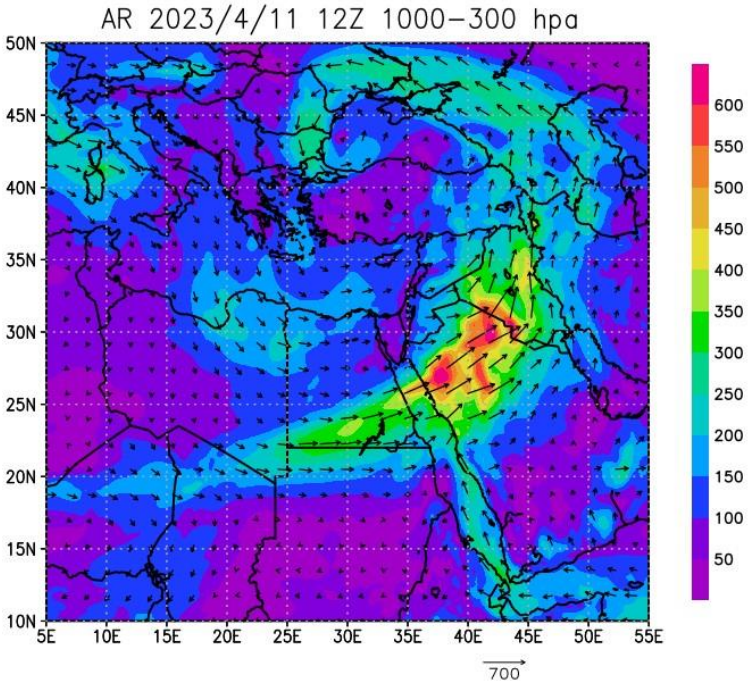


Figure. 3. Synoptic analysis for ARs with surface pressure systems 2023/4/11 at (06:00GMT)

(a)



(b)

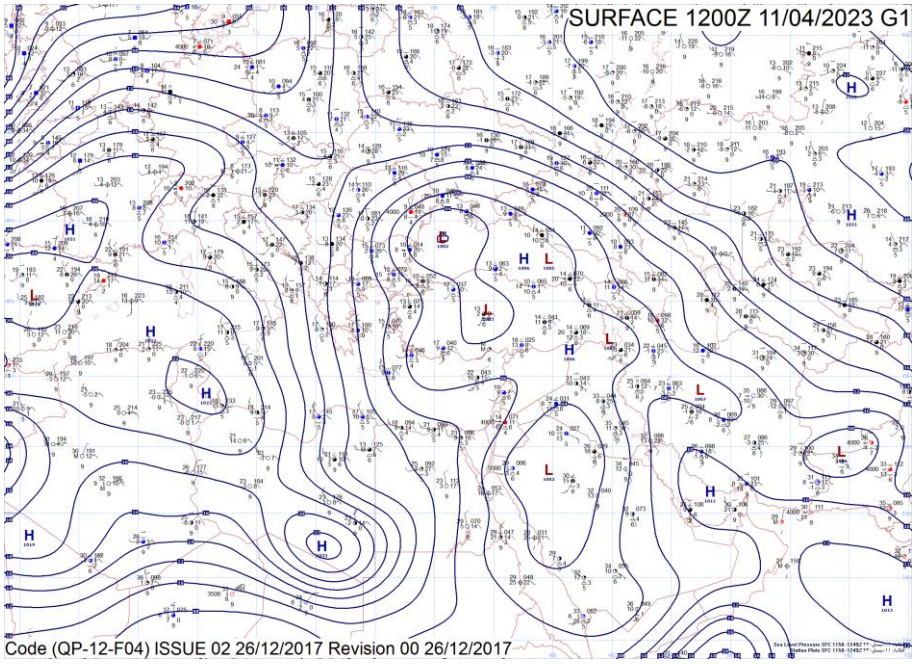
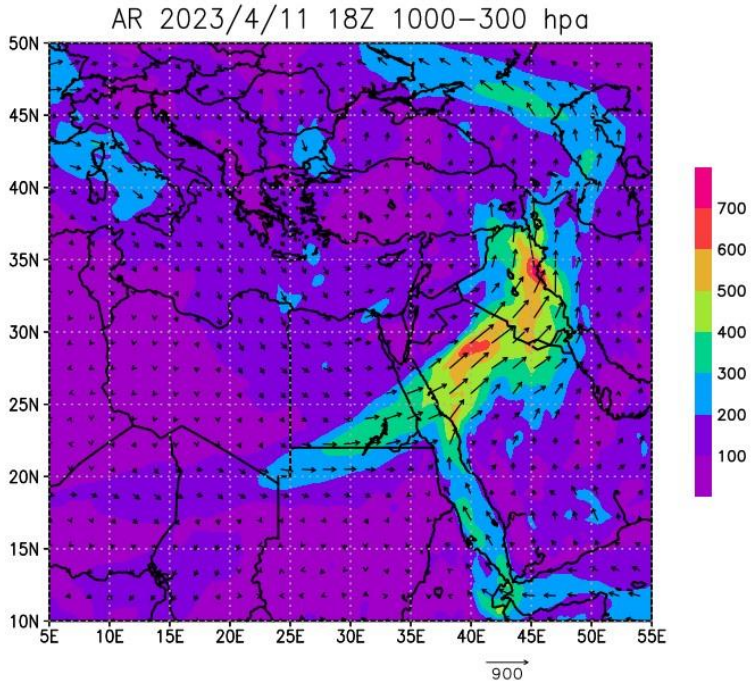


Figure. 4. Synoptic analysis for ARs with surface pressure systems 2023/4/11 at (12:00GMT)

(a)



(b)

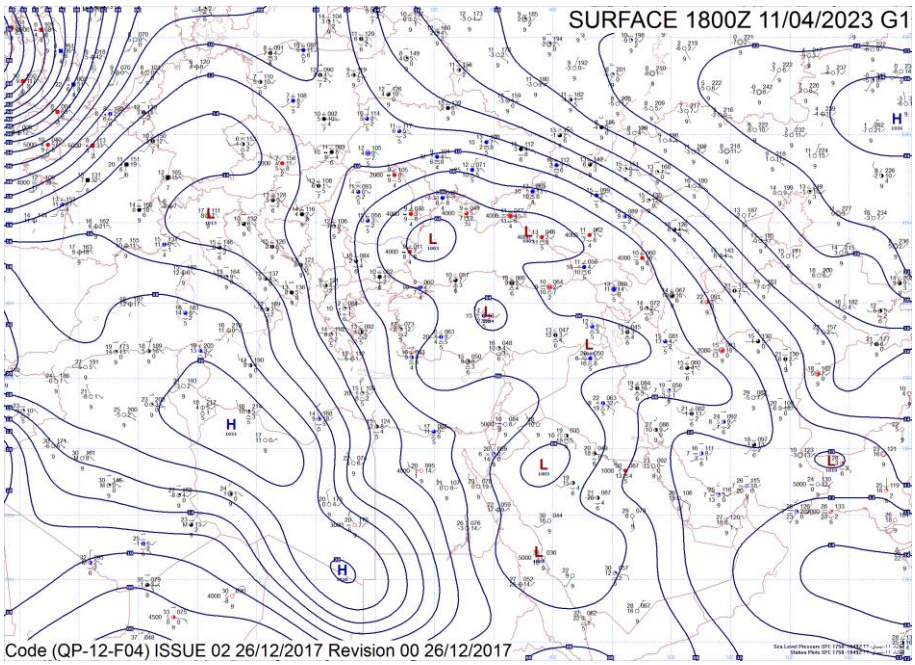
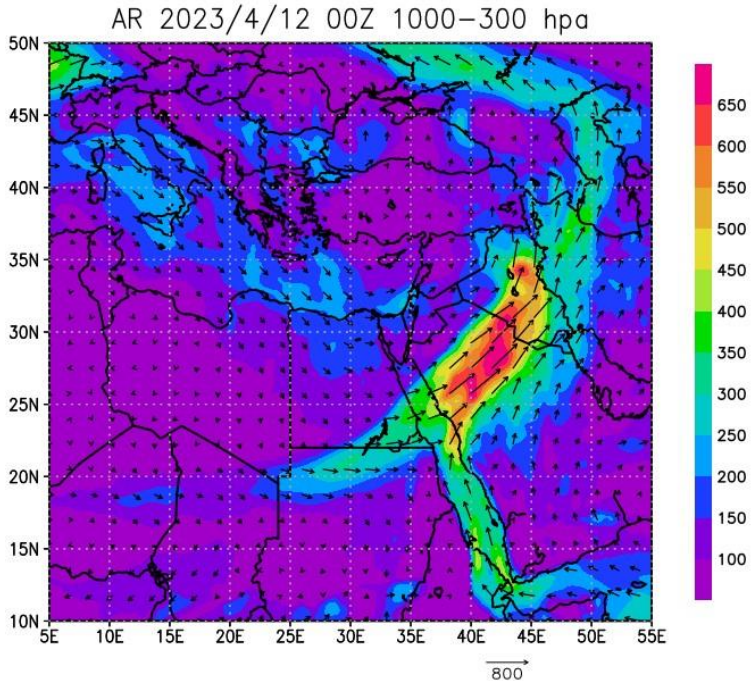


Figure. 5. Synoptic analysis for ARs with surface pressure systems 2023/4/11 at (18:00GMT)

(a)



(b)

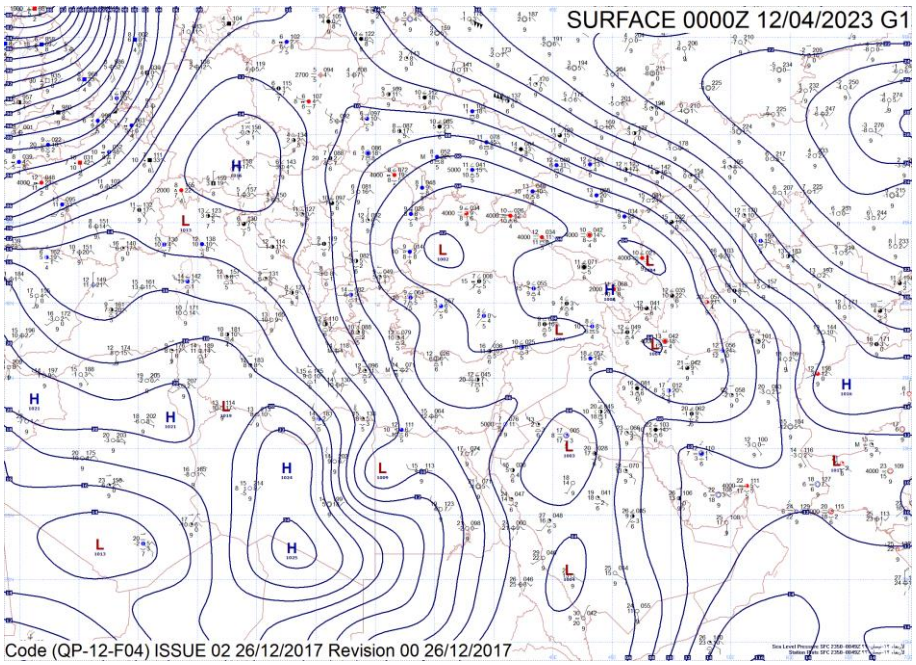
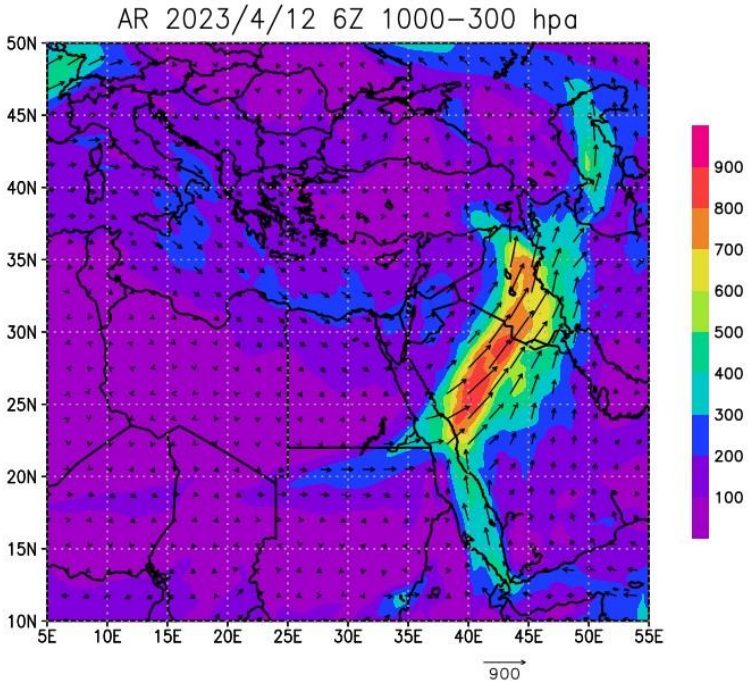


Figure. 6. Synoptic analysis for ARs with surface pressure systems 2023/4/12 at (00:00GMT)

(a)



(b)

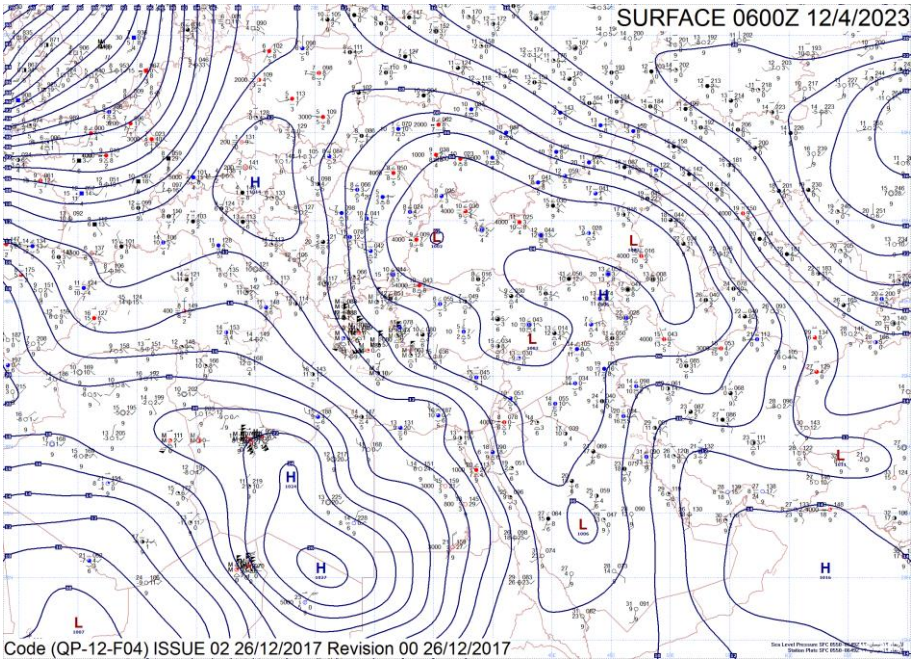
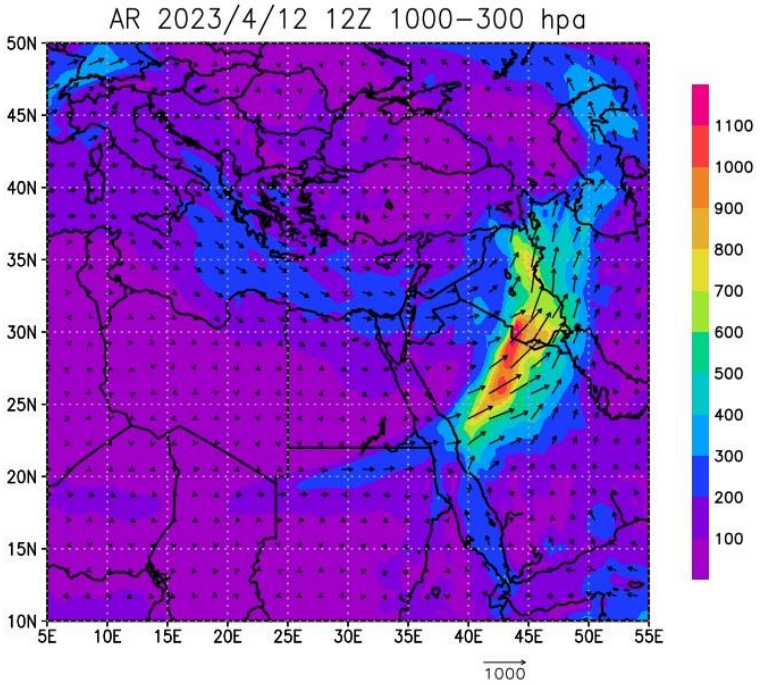


Figure. 7. Synoptic analysis for ARs with surface pressure systems 2023/4/12 at (06:00GMT)

(a)



(b)

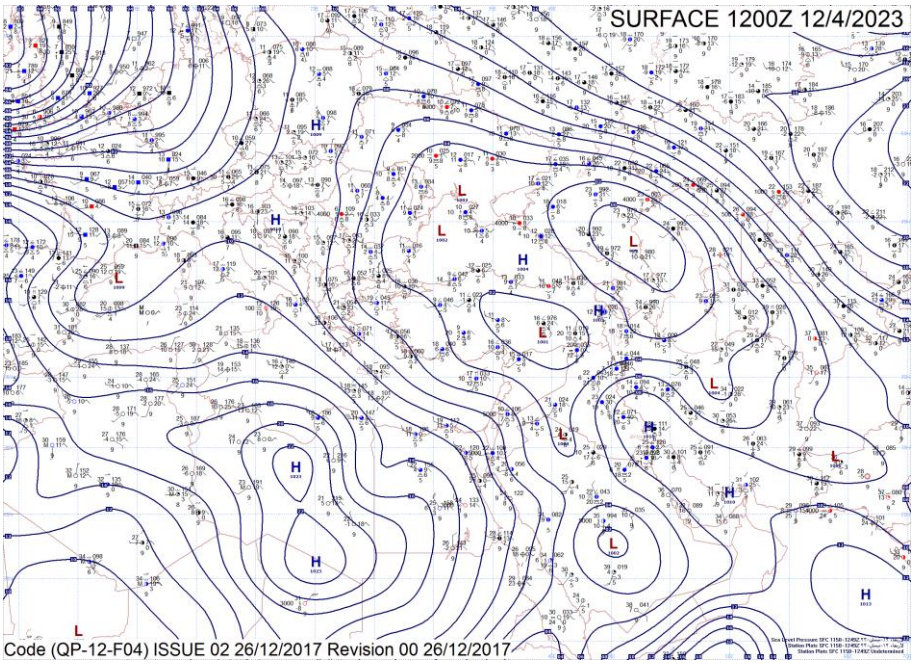
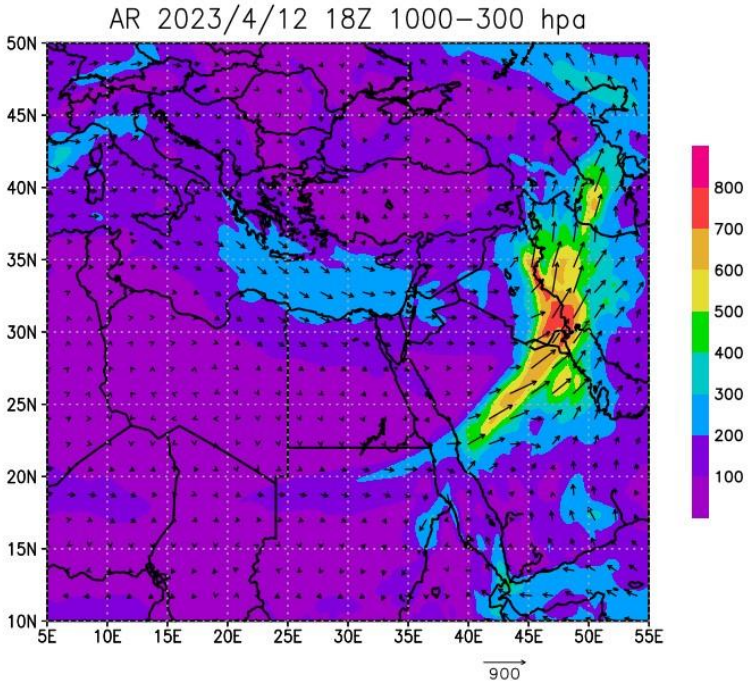


Figure. 8. Synoptic analysis for ARs with surface pressure systems 2023/4/12 at (12:00GMT)

(a)



(b)

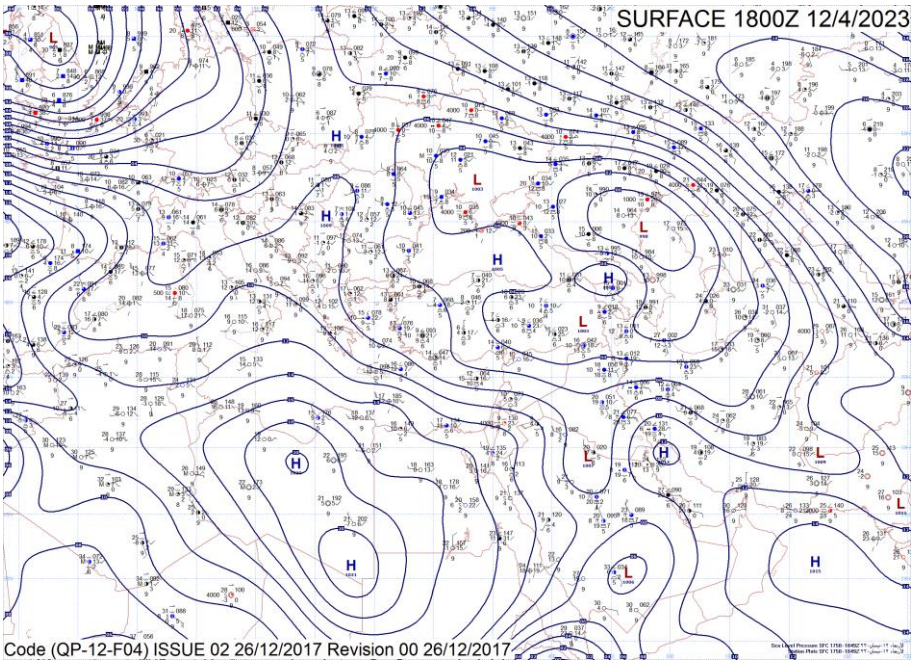
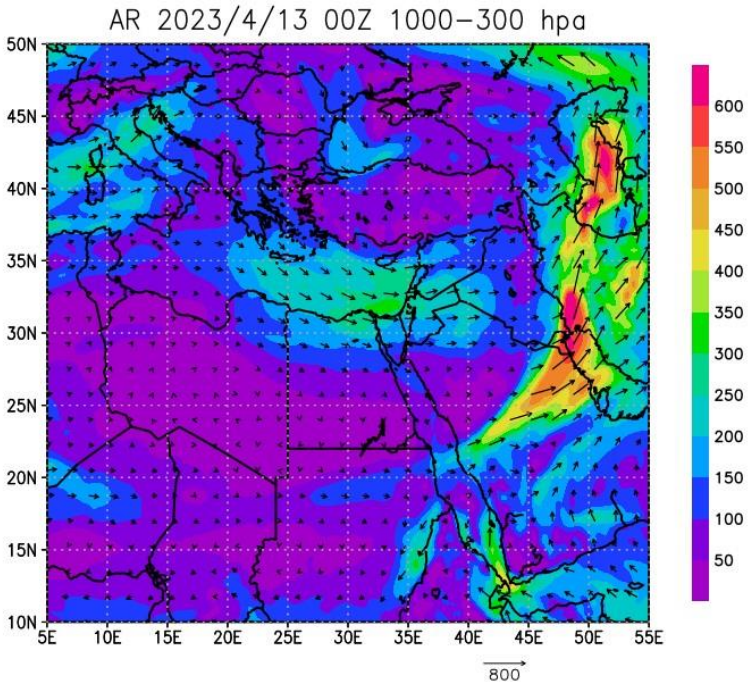


Figure. 9. Synoptic analysis for ARs with surface pressure systems 2023/4/12 at (18:00GMT)

(a)



(b)

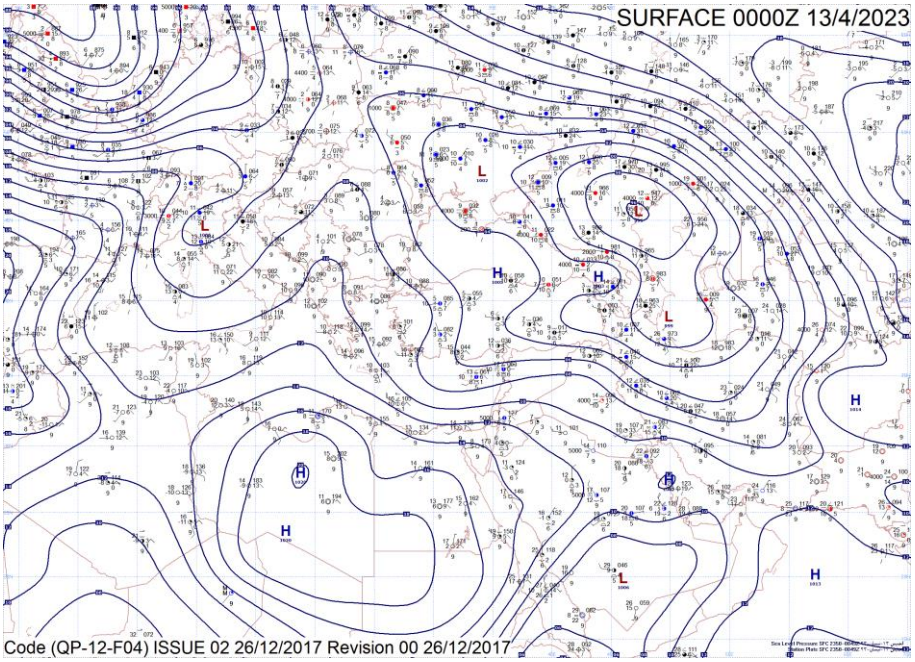
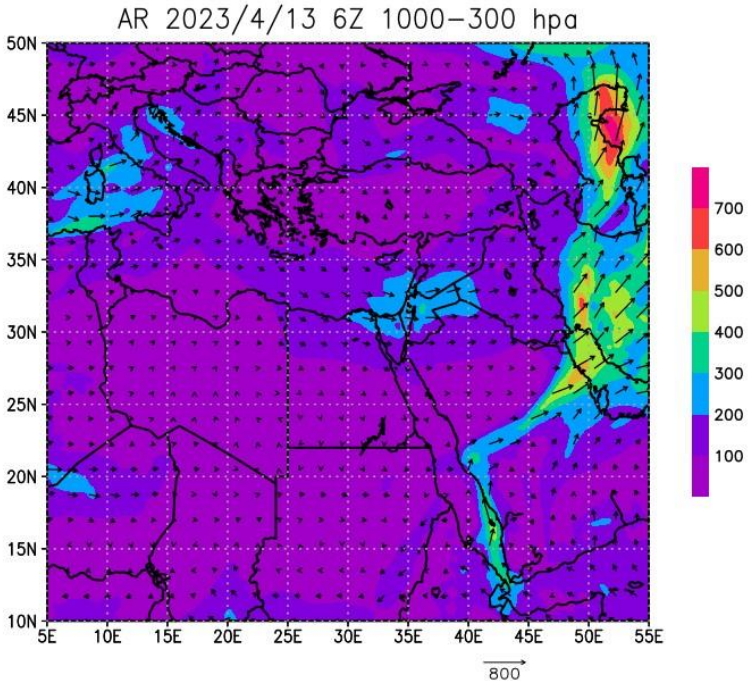


Figure. 10. Synoptic analysis for ARs with surface pressure systems 2023/4/13 at (00:00GMT)

(a)



(b)

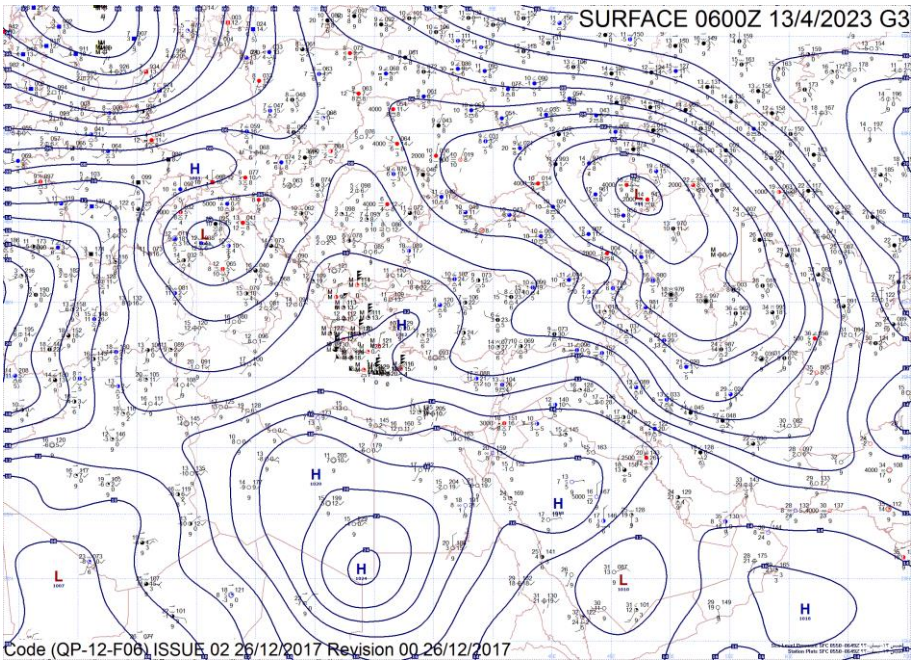
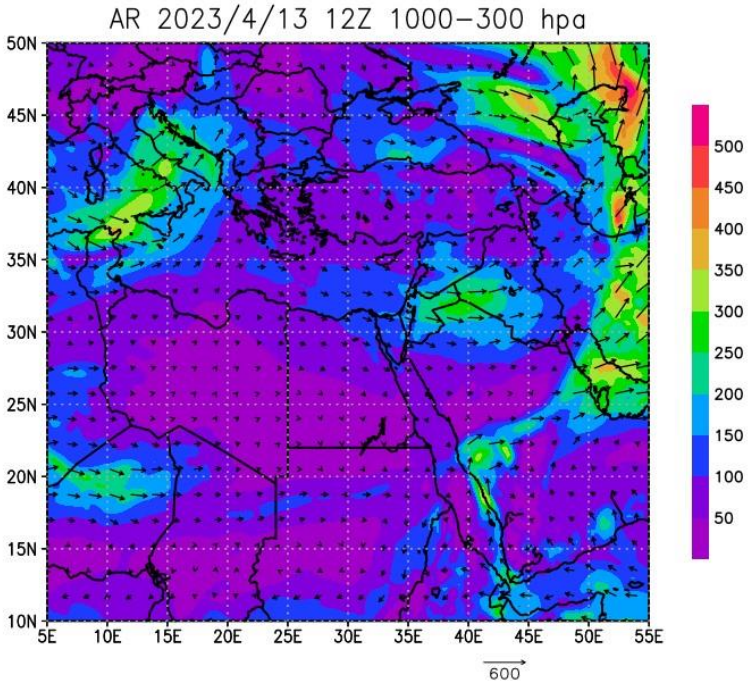


Figure. 11. Synoptic analysis for ARs with surface pressure systems 2023/4/13 at (06:00GMT)

(a)



(b)

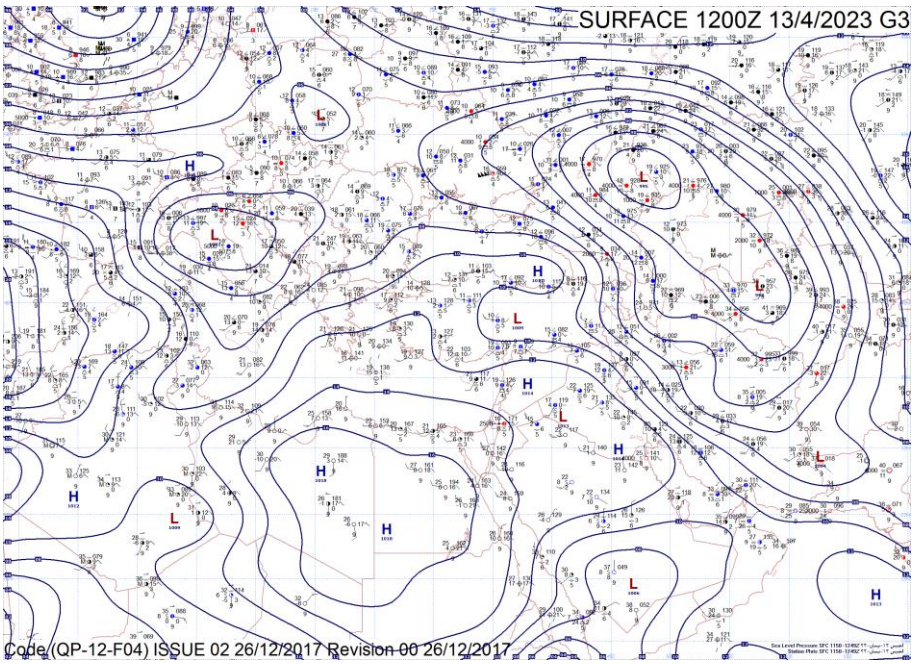
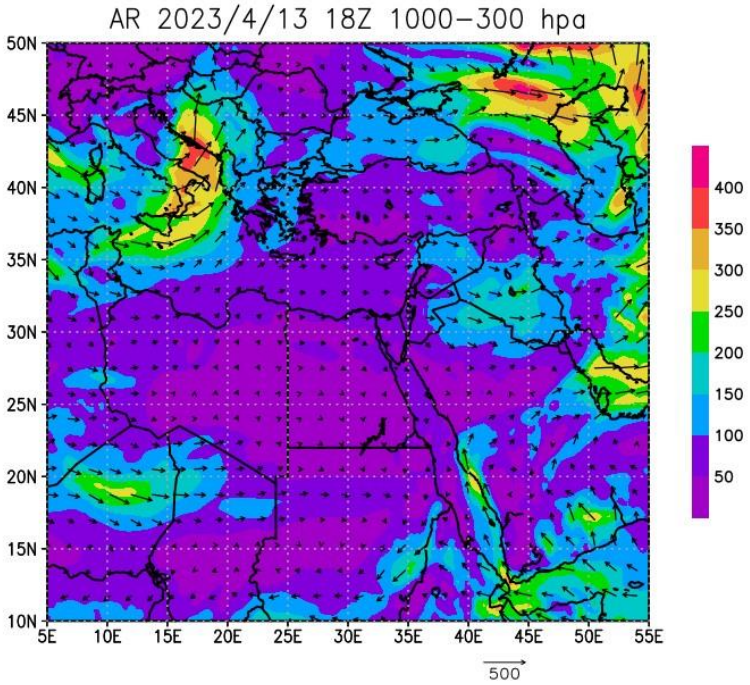


Figure. 12. Synoptic analysis for ARs with surface pressure systems 2023/4/13 at (12:00GMT)

(a)



(b)

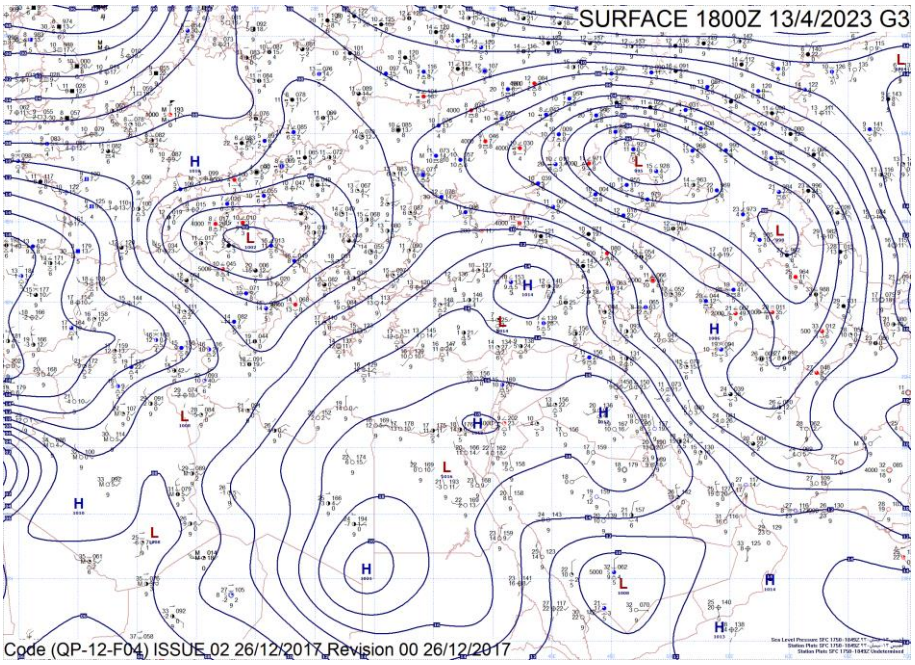


Figure. 13. Synoptic analysis for ARs with surface pressure systems 2023/4/13 at (18:00GMT)

4. Conclusion

1. Cyclone and anticyclone over Iraq and surrounding regions related to ARs most of all ARs are associated with cyclone while not all cyclone associated with ARs.

2. If AR was week accompanying rain will not be strong and depending on nature of area, AR effecting on region comes from red sea and north of Africa.

3. Case study was enhanced moisture from red sea and north of Africa there is a positive connecting between ARs and L in region where ARs gives the deepening for L by providing water vapor from laten heat releasing and L give intensity to AR by stronger wind relationship between ARs and cyclone could be critical because it difficult to determined direction and intensity of ARs from L The magnitude and direction of ARs determined from IVT.

4. Existing of H in region refer to no existing of ARs in region because the H diverge the moisture relationship between ARs and cyclone could be critical because it difficult to determined direction and intensity of ARs from cyclone The magnitude and direction of ARs determined from IVT.

Reference:

[1] A. G. Mutar, A. Khtan, and L. E. George, "Synoptic characteristics of torrential rains in southwest and southeast Iraq: A case study," Al-Mustansiriyah Journal of Science, vol. 32, pp. 1-7, 2021.

[2] D. Loudyi and S. A. Kantoush, "Flood risk management in the Middle East and North Africa (MENA) region," vol. 17, ed: Taylor & Francis, 2020, pp. 379-380.

[3] M. A. A. Rahman, "Characteristics of Rainfall in Dry and Wet Seasons in Iraq," Journal of the College of Education for Women, vol. 33, pp. 116-134, 2022.

[4] J. Kadhum, "Dynamical analysis of severe rain events over Iraq," Al-Mustansiriyah Journal of Science, vol. 30, pp. 15-22, 2019.

[5] E. Massoud, T. Massoud, B. Guan, A. Sengupta, V. Espinoza, M. De Luna, et al., "Atmospheric rivers and precipitation in the Middle East and North Africa (MENA)," Water, vol. 12, p. 2863, 2020.

[6] A. M. Abdul-Jabbar and A. K. Abdulkareem, "Predicted the Cumulative Annual Rainfall in Iraq using SDSM Modal," Al-Mustansiriyah Journal of Science, vol. 32, 2021.

[7] N. Shademani, "Investigation of the Existence and Role of Atmospheric Rivers in Creating A Flood in the West and South of Iran (Case Study: Floods 9 and 21 Nov. 2015). Master of Science Dissertation," Natural Resources and Earth Sciences, Shahrekord University, Iran, 2015.

[8] K. J. Reid, T. A. O'Brien, A. D. King, and T. P. Lane, "Extreme water vapor transport during the March 2021 Sydney floods in the context of climate projections," Geophysical Research Letters, vol. 48, p. e2021GL095335, 2021.

[9] F. M. Ralph, J. J. Rutz, J. M. Cordeira, M. Dettinger, M. Anderson, D. Reynolds, et al., "A scale to characterize the strength and impacts of atmospheric rivers," Bulletin of the American Meteorological Society, vol. 100, pp. 269-289, 2019.

[10] P. H. Gleick, "Water, drought, climate change, and conflict in Syria," Weather, climate, and society, vol. 6, pp. 331-340, 2014.

[11] M. Hawcroft, L. Shaffrey, K. Hodges, and H. Dacre, "How much Northern Hemisphere precipitation is associated with extratropical cyclones?," Geophysical Research Letters, vol. 39, 2012.

[12] H. Binder, M. Boettcher, H. Joos, and H. Wernli, "The role of warm conveyor belts for the intensification of extratropical cyclones in Northern Hemisphere winter," Journal of the Atmospheric Sciences, vol. 73, pp. 3997-4020, 2016.

[13] A. Oertel, M. Boettcher, H. Joos, M. Sprenger, H. Konow, M. Hagen, et al., "Convective activity in an extratropical cyclone and its warm conveyor belt–a case-study combining observations and a convection-permitting model simulation," Quarterly Journal of the Royal Meteorological Society, vol. 145, pp. 1406-1426, 2019.

[14] L. Gimeno, F. Dominguez, R. Nieto, R. Trigo, A. Drumond, C. J. Reason, et al., "Major mechanisms of atmospheric moisture transport and their role in extreme precipitation events," Annual Review of Environment and Resources, vol. 41, pp. 117-141, 2016.

[15] N. Esfandiari and H. Lashkari, "The effect of atmospheric rivers on cold-season heavy precipitation events in Iran," Journal of Water and Climate Change, vol. 12, pp. 596-611, 2021.

[16] C. Baggett, S. Lee, and S. Feldstein, "An investigation of the presence of atmospheric rivers over the North Pacific during planetary-scale wave life cycles and their role in Arctic warming," Journal of the Atmospheric Sciences, vol. 73, pp. 4329-4347, 2016.

[17] R. Mo and H. Lin, "Tropical–mid-latitude interactions: Case study of an inland-penetrating atmospheric river during a major winter storm over North America," Atmosphere-Ocean, vol. 57, pp.

[18] A. M. Al-Lami, Y. K. Al-Timimi, and H. K. Al-Shamarti, "Spatiotemporal analysis of some extreme rainfall indices over Iraq (1981–2017)," Scientific Review Engineering and Environmental Sciences (SREES), vol. 30, pp. 221-235, 2021.

[19] A. S. Hassan, G. Hassoon, " Influence Air Temperature and Precipitation on Climate Change in Baghdad City," Mustansiryah Journal of Pure and Applied Sciences, vol. 2, pp. 102-107, 2024.

[20] J. Chagnon, S. Gray, and J. Methven, "Diabatic processes modifying potential vorticity in a North Atlantic cyclone," Quarterly Journal of the Royal Meteorological Society, vol. 139, pp. 1270-1282, 2013.