April. 2015. Vol. 3. No. 01 ISSN 2311-2484
International Journal of Research In Earth & Environmental Sciences

http://www.ijsk.org/ijrees.html

# TO THE QUESTION ABOUT TYPIFICATION OF SYNOPTIC PROCESSES OVER THE TERRITORY OF UKRAINE

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**ABSTRACT**

*The main focus of the given article is the analysis of the synoptic processes over Ukraine in the medium seasonal months between 1992 and 2012 period. The elementary circulation mechanisms introduced by B.L. Dzerdzeevskiy, V.M. Kurganskaya and Z.M. Vitvitskaya are taken as the primary methodological tool.*

***KEYWORDS: synoptic processes, elementary circulation mechanisms (ECM), typing the atmospheric circulation, the criteria of similarity.***

## INTRODUCTION

In the conditions of modern climate change the interest in studying trends of shaping the future of wind conditions and its extreme manifestations, as well as the use of wind energy opportunities instead of traditional, but already limited oil, gas and coal reserves, the prediction of the future state of the atmosphere is a priority.

Excluding changes in circulation that occurred in the late XX - early XXI century, that resulted in an increase in the number and area occupied by the cyclones, and in the decrease in anticyclone regions in Asia and the Arctic (Kononova, 2009), it is difficult to anticipate the future state of the SYNOPTIC processes that determine the weather for any part of the European territory, including Ukraine.

The aim of the investigation is studying the dynamics of change of the circulation processes over the territory of Ukraine through typification the SYNOPTIC situations over the specified region for the period 1992-2012.

## MATERIALS AND METHODS OF RESEARCH

The catalogue of typical SYNOPTIC processes over the territory of Ukraine for the period from 1992 to 2012 for the central months of the season, performed at the Department of theoretical meteorology and meteorological forecasts of the OSEU, and calendar of elementary circulation mechanisms (ECM), made by Dzerdzeevskiy B. L. (Ibid) are used as the source materials. To clarify specific SYNOPTIC situations SYNOPTIC maps of all levels (surface, at-925, at-850, at-700 and at-500) from the archive Armsin of the Department were also used.

To substantiate the selected typifications before proceeding the analysis of changes in atmospheric circulation for the period, let us briefly examine existing classifications of SYNOPTIC processes; some of them are supplemented by directories for long periods, which determines their scientific and practical value. The classifications of Wangenheim-Girs, Dzerdzeevskiy-Kurganskaya-Witwitskaya, E. A. Isaeva, L. A. Vitals, A. F. Dubuque, Y. B. Khrabrov (Bagrov, 1973; Vasiukov S.A., Zverev N.I., Ped D.A, 1962; Gruza G.V., Rankova E.L., Oesterle G.R, 1976) can be attributed to the typification of the atmospheric processes.

The main feature, by which the typification of the atmosphere circulation at extratropical latitudes by B. L. Dzerdzeevskiy [Kononova, 2009] is done, is the presence or absence of blocking processes in the hemisphere, their direction and quantity. There 4 circulation groups, 13 types, 41 subtypes and elementary circulation mechanism - ECM (the basic unit of typification). The number indicates the type of ECM, the first letters of the alphabet (a, b, c, d) mean ECM differences within the same type in the directions of the Arctic invasion or breakout of southern cyclones, and the letters "W" (winter) and "S" (summer) - seasonal variations of ECM in sign of the pressure fields over the oceans and continents. Only in types 4, 9 and 10 winter ECM are denoted by the first letters of the alphabet (4A, 9b and 10A). For each type of ECM dynamic circuits are composed (the movement of cyclones and persistence of anticyclones, maps of average pressure and temperature of air at sea level, maps baric topography and average temperature of the layer at the level AT-500). A detailed description of each ECM (Kononova, 2009), which can be used to

analyze the dynamic scheme and the annual course of the duration of ECM is given.

L. A. Katz performed typification, taking into account the circulation characteristics of the average troposphere. L. V. Klimenko (1976: 106) proposed the SYNOPTIC-climatological classification. He applied a climatological parameter. Almost all of the aforementioned typifications used one principle - the principle of similarity, although with varying degrees of implementation of this principle by different authors.

Next we give a more detailed description of the classification of SYNOPTIC processes over Ukraine, which can be used either in operational forecast (Zubkovych, 2010; Ivus, 1998: 112; 2009, 2012) or for studying the dynamics of changes of the circulation conditions over the studying area.

The structure of the macrocirculation conditions typical for Ukraine, including regional features of SYNOPTIC processes, which are formed on the macrocirculation background and lead, in combination with local physical and geographical conditions (Lipinski, Dyachuk, Babichenko, 2003), to establishment of the wind mode, are reduced to six main types and 17 subtypes (Ivus, 1998, 2009, 2012).

Type 1. Peripheral atmospheric processes, which include transfers of all directions: subtype 1.1 - West and North-West, subtype 1.2 – southern, subtype 1.3 - East and subtype 1.4 - North migration.

Type 2. The cyclonic circulation. This type includes the area of low pressure located over Ukraine (subtypes 2.1 and 2.2).

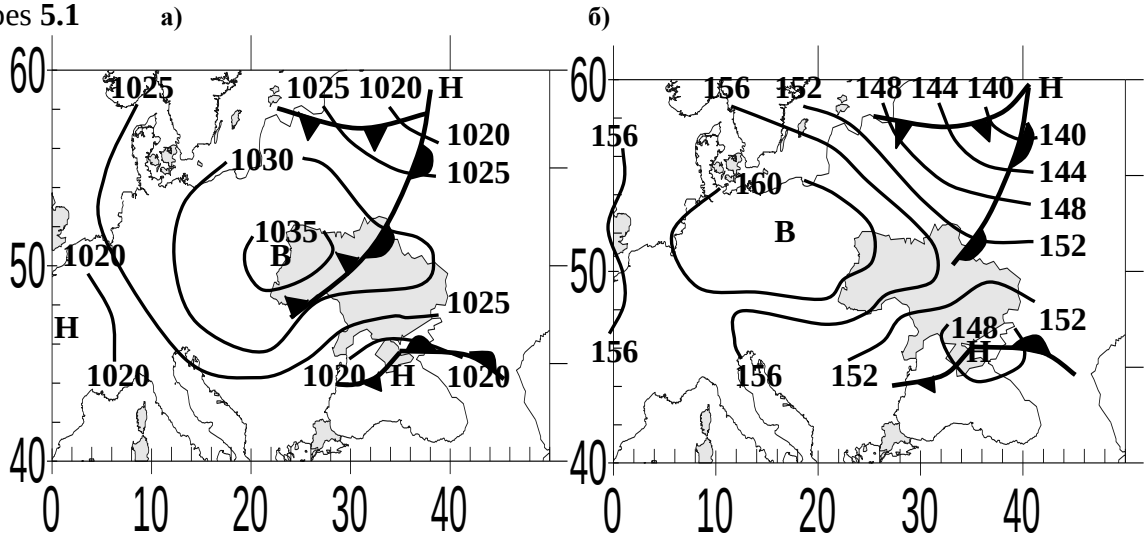
Type 3. Anticyclonic circulation. This type (subtypes 3.1, 3.2, 3.3) is an anticyclone, which is oriented to the West and East and the low gradient field of high pressure.

Type 4. Low gradient pressure fields (subtypes 4.1 and 4.2).

Type 5. Peripheral atmospheric processes associated with the passage of atmospheric fronts (subtypes 5.1, 5.2, Fig. 1).

Type 6. Cyclonic circulations with large pressure gradients ($\partial P/\partial n \geq 2{,}5$ hPa/111 km). This type of ranked into four subtypes (Fig. 2).

Subtypes **5.1**




**S**ubtypes **5.2**

April. 2015. Vol. 3. No. 01 ISSN 2311-2484
International Journal of Research In Earth & Environmental Sciences

http://www.ijsk.org/ijrees.html

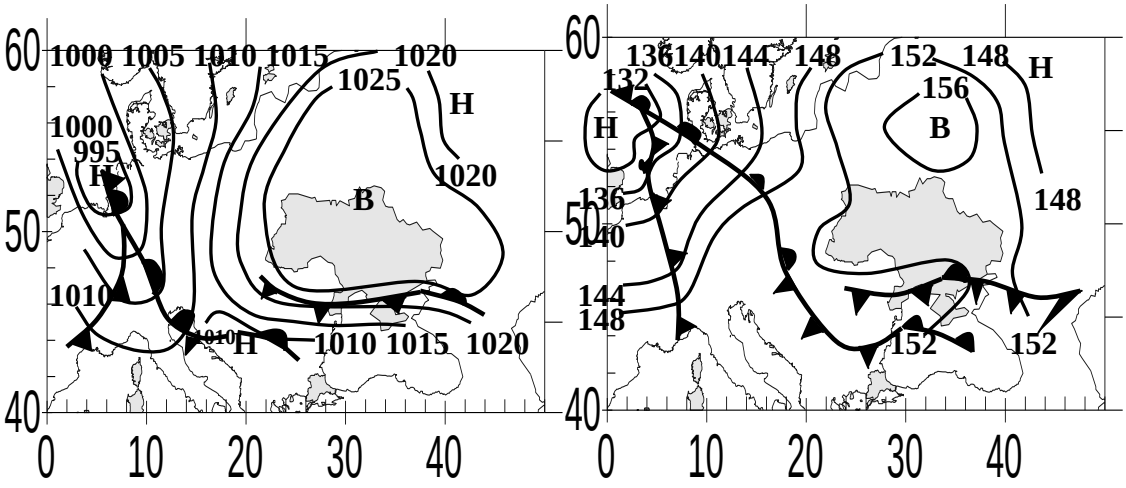



Fig. 1 – subtypes of synoptic processes 5. Maps: ground (a) and AT-850 (b)

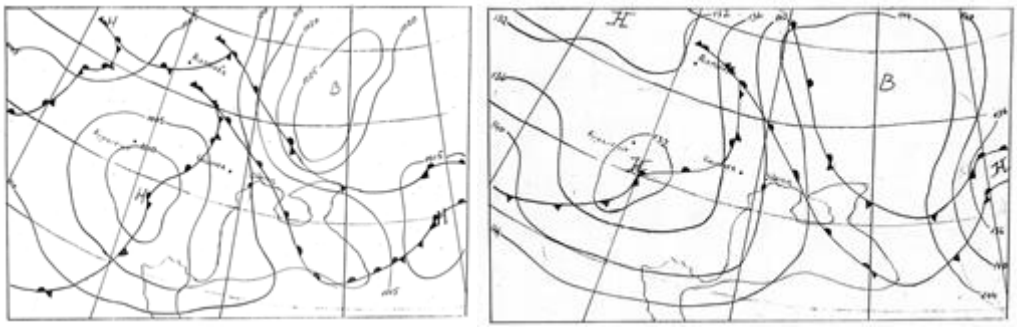
According to archival samples the frequency of occurrence of the above types (subtypes) of SYNOPTIC situations for 21 years (1992-2012) is calculated, the original number is divided into four five-year period by season. The data given in table 1 and 2 show that during the year, despite the decrease of the frequency of occurrence of SYNOPTIC processes related to types 1-4 and responsible for the formation of weak wind over the Ukraine [5-7], their frequency remains high.

So the conditions for the preservation of stagnations, especially in industrial areas must be considered.

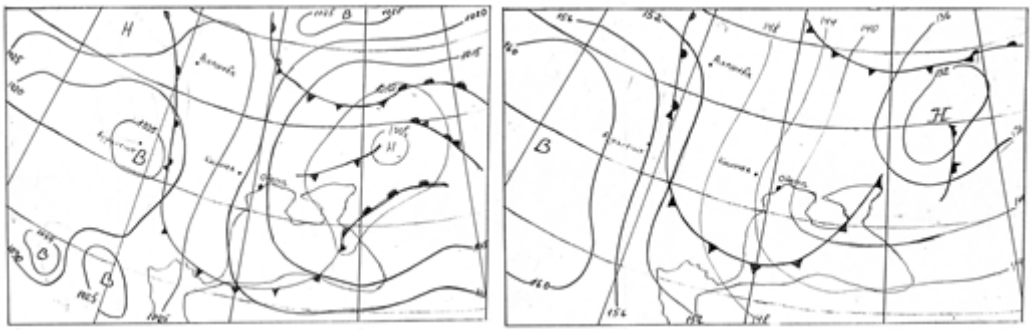
Let's consider the circulation conditions change with the seasons.

In January during the study period, the frequency of occurrence of peripheral processes (type 1) decreased from 47,0% to 11.6%, whereas type 6 increased from 9,1 to 51-42 %, i.e. a situation with large pressure gradients defined the weather over Ukraine more often. This circumstance indicates the increasing of the wind speed, caused, apparently, by the exit of the Mediterranean cyclones over Europe and by the blocking effect of the crest of the Siberian anticyclone. This fact indicates ( table 3) the combination of types of ECM: 5s, 12 KB and 13 h in 2003-2007. The winter season exceeds 100 days in the third five-year plan.

**Subtype 6.1** **a)** **b)**



**Subtype 6.2**



**Subtype 6.3**

April. 2015. Vol. 3. No. 01 ISSN 2311-2484
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http://www.ijsk.org/ijrees.html

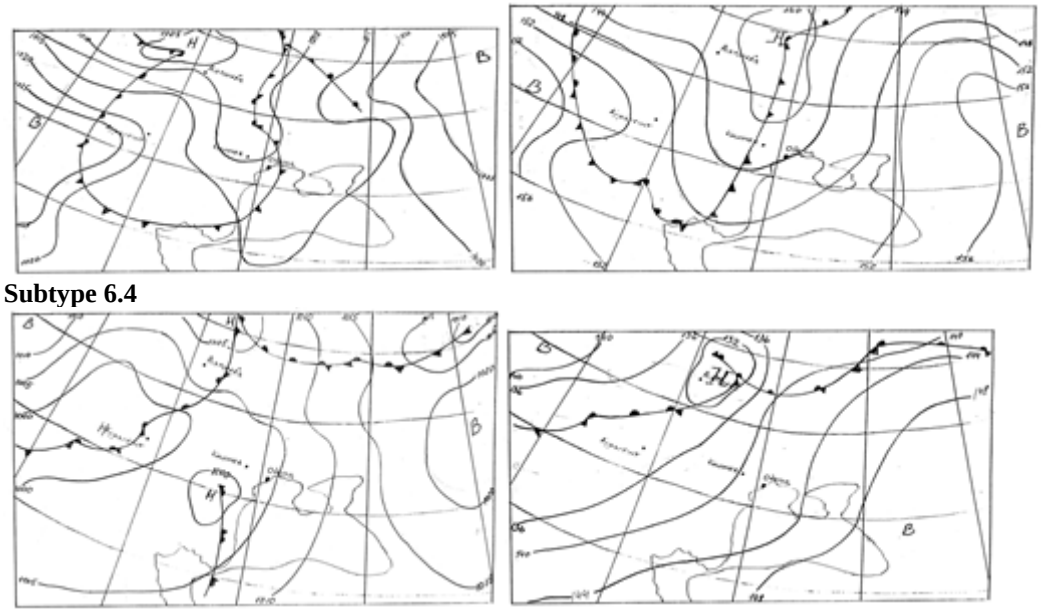


Fig.2 Synoptic processes of 6th type. Maps: ground (a) and AT (b)

In April (table 1) the decrease in the frequency of peripheral processes without fronts 1.5 times and increase situations with fronts in 8 times is marked. Compared with the period 1993-1997 the increase in the number of cases of the 3rd type, due to ECM subtypes 9 a, 12 a and 13 l is observed. Number of types (subtypes) of ECM in transitional seasons often ranges from 19-20 in spring (though in 2008 there were only 7 types) to 16-21 (2008 - 6 types) in the autumn.

**Table 1 – Repeatability (%) types (subtypes) of synoptic processes. Ukraine. January, April. 1993-2012.**

| Synoptic processes | | Month of the year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | January | | | | April | | | |
| Type | Subtype | 1993-1997 | 1998-2002 | 2003-2007 | 2008-2012 | 1993-1997 | 1998-2002 | 2003-2007 | 2008-2012 |
| 1 Peripheral processes | 1 | **47,0** | **43,8** | **17,4** | 11,6 | **42,4** | **33,6** | **29,4** | **26,0** |
| | 1.1 | 22,0 | 14,4 | 11,6 | 3,2 | 10,1 | 1,6 | 6,0 | 3,3 |
| | 1.2 | 6,1 | 9,8 | 1,9 | 5,2 | 17,2 | 5,7 | 3,4 | 14,7 |
| | 1.3 | 8,3 | 5,2 | 1,3 | 2,6 | 8,0 | 15,6 | 8,0 | 7,3 |
| | 1.4 | 10,6 | 14,4 | 2,6 | 0,6 | 7,1 | 10,7 | 12,0 | 0,7 |
| 2 Cyclonic activity | 2 | 3,0 | 7,2 | 3,9 | 11,6 | 8,1 | 14,8 | 9,3 | 5,3 |
| | 2.1 | 1,5 | 3,9 | 1,9 | 2,6 | 3,0 | 10,7 | 8,0 | 2,7 |
| | 2.2 | 1,5 | 3,3 | 2,0 | 9,0 | 5,1 | 4,1 | 1,3 | 2,6 |
| 3 Anticyclonic Activity | 3 | 11,4 | **24,2** | **14,8** | **12,9** | 10,1 | **22,9** | **21,3** | 15,3 |
| | 3.1 | 0,8 | 11,1 | 1,3 | 5,8 | 0,0 | 6,6 | 7,3 | 6,7 |
| | 3.2 | 3,8 | 0,7 | 2,6 | 3,2 | 1,0 | 2,4 | 2,7 | 1,3 |
| | 3.3 | 6,8 | 13,4 | 10,9 | 3,9 | 9,1 | 13,9 | 11,3 | 7,3 |
| 4 Small pressure gradients | 4 | **12,1** | 9,2 | 4,5 | 10,3 | 10,1 | 9,0 | 6,0 | 12,0 |
| | 4.1 | 3,8 | 4,6 | 1,9 | 1,3 | 3,0 | 4,9 | 4,7 | 8,7 |
| | 4.2 | 8,3 | 4,6 | 2,6 | 9,0 | 7.1 | 4,1 | 1,3 | 3,3 |
| 5 Peripheral processes | 5 | **17,4** | 2,0 | 8,4 | 11,6 | 2,0 | 14,8 | 14,0 | 16,7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| with the passage of fronts | 5.1 | 12,9 | 2,0 | 3,2 | 3,9 | 2,0 | 8,2 | 5,3 | 8,7 |
| | 5.2 | 4,5 | 0,0 | 5,2 | 7,7 | 0,0 | 6,6 | 8,7 | 8,0 |
| 6 Cyclonic circulation with large pressure gradient | 6 | 9,1 | **13,6** | **51,0** | **42,0** | **27,3** | 4,9 | **20,0** | **24,7** |
| | 6.1 | 0,0 | 1,1 | 14,8 | 18,7 | 7,1 | 1,6 | 4,0 | 8,0 |
| | 6.2 | 2,3 | 4,6 | 20,6 | 8,4 | 1,0 | 1,6 | 11,3 | 11,4 |
| | 6.3 | 3,8 | 4,6 | 7,8 | 9,7 | 7,1 | 0,0 | 2,7 | 3,3 |
| | 6.4 | 3,0 | 3,3 | 7,8 | 5,2 | 12,1 | 1,7 | 2,0 | 2,0 |

Summer weather over the territory of Ukraine is determined mainly by peripheral processes without fronts (type 1), although their frequency is halved from 41.6 % in 1993-1997 to 21.3% in 2008-2012 (table 2), but the frequency of types 5 and 6 dramatically increases (respectively 4 and 7 times). Anticyclonic circulation is fixed over Ukraine equally often: from 19,4 to 26.5 %. In July only 10-13 types of ECM form the pressure field, basically, they are 13 l, 9 a and 10 b. When ECM 10 b is in the southern regions of Eastern Europe, the cold air is distributed to the West and the core of high pressure formed in it can be combined with the ridge of the Azores anticyclone extended to Europe. In the period 2003-2008 the reduction of type 13 l is marked (from 53.5 to 30.9 %), i.e. meridionale South circulation. Depression at 13 l has not a narrow strip, as at ECM 13 W, and is a part of a very extensive region of low pressure, which covers most of the extratropical latitudes of the Northern hemisphere, including the territory of Ukraine. The Azores anticyclone remains in the southern latitudes of the Atlantic Ocean, and its crest stretches for Western Europe.

**Table 1 – Repeatability (%) types (subtypes) of synoptic processes. Ukraine. July, October. 1993-2012.**

| Synoptic processes | | Month of the year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | July | | | | October | | | |
| Type | Subtype | 1993-1997 | 1998-2002 | 2003-2007 | 2008-2012 | 1993-1997 | 1998-2002 | 2003-2007 | 2008-2012 |
| 1 Peripheral processes | 1 | **41,6** | **33,6** | **25,8** | **21,3** | **40,5** | **27,8** | **25,8** | **23,5** |
| | 1.1 | 4,4 | 1,6 | 12,9 | 1,9 | 14,6 | 10,6 | 8,4 | 8,5 |
| | 1.2 | 2,7 | 5,7 | 5,8 | 0,6 | 9,1 | 5,3 | 8,4 | 7,2 |
| | 1.3 | 8,8 | 15,6 | 5,2 | 14,9 | 8,4 | 3,3 | 6,4 | 1,3 |
| | 1.4 | 25,7 | 10,7 | 1,9 | 3,9 | 8,4 | 8,6 | 2,6 | 6,5 |
| 2 Cyclonic activity | 2 | 11,5 | 14,8 | 7,8 | 3,2 | 1,4 | 5,3 | 4,5 | 5,9 |
| | 2.1 | 11,5 | 10,7 | 4,5 | 3,2 | 0,7 | 2,0 | 1,3 | 3,9 |
| | 2.2 | 0,0 | 4,1 | 3,3 | 0,0 | 0,7 | 3,3 | 3,2 | 2,0 |
| 3 Anticyclonic activity | 3 | **26,5** | **22,9** | **19,4** | **25,8** | **25,9** | **26,5** | **18,7** | **21,6** |
| | 3.1 | 9,7 | 6,6 | 16,8 | 8,4 | 8,4 | 5,3 | 5,2 | 4,6 |
| | 3.2 | 2,6 | 2,4 | 0,0 | 1,3 | 1,4 | 2,7 | 1,9 | 3,9 |
| | 3.3 | 14,2 | 13,9 | 2,6 | 16,1 | 16,1 | 18,5 | 11,6 | 13,1 |
| 4 Small pressure gradients | 4 | 14,2 | 9,0 | 13,5 | 11,0 | 7,7 | 8,0 | 4,5 | 9,1 |
| | 4.1 | 8,0 | 4,9 | 10,3 | 5,2 | 1,4 | 3,3 | 0,6 | 2,6 |
| | 4.2 | 6,2 | 4,1 | 3,2 | 5,8 | 6,3 | 4,7 | 3,9 | 6,5 |
| 5 Peripheral processes | 5 | 3,5 | 14,8 | **16,1** | **16,1** | **16,8** | **24,5** | **20,7** | **18,3** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| with the passage of fronts | 5.1 | 3,5 | 8,2 | 9,7 | 12,9 | 8,4 | 5,3 | 12,3 | 7,2 |
| | 5.2 | 0,0 | 6,6 | 6,4 | 3,2 | 8,4 | 19,2 | 8,4 | 11,1 |
| 6 Cyclonic circulation with large pressure gradient | 6 | 2,7 | 4,9 | **17,4** | **22,6** | 7,7 | 7,9 | **25,8** | **21,6** |
| | 6.1 | 0,9 | 1,6 | 6,4 | 9,7 | 0,7 | 2,0 | 7,1 | 9,8 |
| | 6.2 | 0,0 | 1,6 | 9,0 | 7,7 | 3,5 | 3,3 | 12,9 | 4,6 |
| | 6.3 | 0,0 | 0,0 | 2,0 | 5,2 | 2,1 | 2,6 | 5,2 | 4,6 |
| | 6.4 | 1,8 | 1,7 | 0,0 | 0,0 | 1,4 | 0,0 | 1,2 | 2,6 |

October (table 2), as well as July, has high repeatability of peripheral processes (type 1), although their frequency has decreased from 40.5% to 23.5% for the last five years. Baric fields with fronts and large pressure gradients began to form more often (3 times). The number of peripheral processes (type 5) with the fronts (2-5 %) increased slightly and the number of anticyclonic circulation (type 3) decreased (4-6 %)

This SYNOPTIC situation over Ukraine is in good agreement with the types of ECM that forms (table 3) the circulation field in October. ECM 13 C is prevalent in this month (decreasing by 2003-2007), then secretes ECM 12 a (growth doubled to 2003-2007) and, finally, ECM 8 GB manifests quite often (to 9.7 %). ECM 12 occurs mostly during the transition from the cold half-year to the warm half-year (table 3, IV and X), when the Arctic anticyclone reaches its greatest power. There can be four Arctic invasions and breakouts of southern cyclones. This baric field not only causes a temperature and wind mode over the territory of the invasion, but is also the cause of severe hydrometeorological events (ohss) associated with the wind. ECM 8 GB also forms of ohss. At ECM 8 GB between widely spaced from each other the blocking anticyclones there is an area of low pressure over Western Europe and adjacent seas, which is supported by cyclonic activity in the Arctic front and the cyclones of the Atlantic ocean and the Mediterranean sea that pass through Western Europe to the North-East of European Russia, capturing West Ukraine. The maximum duration of this type is in October.

As known (Kononova, 2009) significant pressure gradients are observed at types of ECM 13 h and 13 l, which throughout the studying period are characterized by high activity, that creates favorable conditions for the formation of strong winds, heavy snow storms, dust storms, squalls and other hazards. ECM 12 a and ECM 9a responsible for the processes over the studied region, also create significant pressure gradients. As noted above, Arctic fronts at ECM 9 descend far to the South, creating a large temperature contrasts and contributing to the occurrence of ohss.

In conclusion, it should be noted that it is supposed to illustrate the relationship of SYNOPTIC processes and types of ECM over Ukraine with different circulation indices, such as A. L. Katz, Arctic oscillation (AO), North Atlantic oscillation (NAO) and others, during the studying period.

## CONCLUSIONS

An analysis of the SYNOPTIC situations over the territory of Ukraine and ECM for the twenty-year period of the end of XX - beginning XXI centuries allows you to:

- to identify the most probable atmospheric processes that form weather conditions in Ukraine in the last decades;
- to highlight the processes and the types responsible for the observed wind speed increasing and the intensification of ohss associated with wind.

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