THE 'HESS-BREZOWSKY' CONCEPT APPLIED IN THE NORTHERN PART OF MOLDOVA BETWEEN 2000 TO 2018

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Abstract. The 'Hess-Brezowsky' concept applied in the northern part of Moldova between 2000 to 2018.
This paper presents the general aspects linked with the atmospheric circulation and how to determine the air-circulation types based upon the 'Hess-Brezowsky' concept over the northern part of Moldova to get in an easily way the pluvial risks. Once the classification is done, there were shown the evolution of atmospheric circulation from the annual to seasonal level by weights. In the wake of study into the studied area, the most representative types were Through over Central Europe; followed by those from North-Westerly Cyclonic; Westerly Cyclonic; and South-Westerly Cyclonic. Also, during the cold half-yearly, by importance was North-Easterly into Anti-Cyclonic type.

Keywords: Hess-Brezowsky, atmospheric patterns, cyclonic pattern, the northern part of Moldova.

1. INTRODUCTION

Classification is one the most used method in the atmospheric sciences. The classifications of atmospheric circulation patterns are a specific research area within synoptic climatology (Gorica, 2010). Only conditionally, the atmospheric circulation can be regarded as a system with clearly defined subsystems, and each of its classifications is conditional (Huth et al., 2008).

In this context, the factors that are trigging one of some weather's aspect are the sea level pressure (surface), the geopotential height at 500 hPa (middle troposphere), and the meridional velocity at 300 hPa geopotential (upper troposphere) above some areas such as Europe (Hess and Brezowsky 1977; James 2007). Changes in occurrence frequencies and durations of weather patterns as well as their sequences are already evident and can be likely linked to the ongoing climate changes due to the difference of warming rates between land and ocean (Kysely 2008; Werner et al. 2008; Cahynova and Huth 2009; Hoy et al. 2012; Kucerova et al. 2016; Hoffmann 2017; Murawski et al. 2018).

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At the level of Romania's climate, the atmospheric circulations and their influences were studied over time by different authors with diverse methodologies and techniques to approach (Sfîcă et al., 2015). This study evaluates the weight of air-masses movements following the Hess-Brezowsky pattern over northern part of Moldova from 2000 to 2018. *Once found the dominant air-masses movement, other studies can be undertaken to point out a possible trigger of severe weather events such as thunderstorms, excessive rainfall, blizzards, etc.* (Hattermann et al., 2018; WMO 2019).

2. DATA AND METHODS USED

The Grosswetterlagen (GWL) classification was proposed by Baur et al. (1944), improved, and later revised by Hess and Brezowsky (1952, 1977). This one includes a large area of analysis with very accurate details. This classification is particularly fitted for the central part of Europe. The form of the major relief deeply transforms the treats of the general atmospheric circulation in Central Europe. For the Northeastern part of Romania, a significant role is played by the bending of the wind streamlines in the outer Carpathic sector. This bending was demonstrated for the first time in 1988 by Nicolae Ion-Bordei for the Great Carpathians Curvature from Romania. In doing so, for this paper was used the concept Hess-Brezowsky – Grosswetterlagen (HB-GWL) what includes 29 weather types (table 1).

For this study, there were taken into account the daily synoptically patterns from January 1st, 2000 to December 31st, 2018. All that database was made following the maps from **http://www1.wetter3.de/archiv_gfs_dt.html**. Concretely, there were followed the spreading of the atmospherical areas and classified by the Hess-Brezowsky pattern. Interprets of results were made from the annual to the season's level. In this way, all the types were taken into account by highlighting the most extreme weights recorded between 2000 to 2018 in the northern part of Moldova (Suceava, Botosani, Iasi, and Neamț Counties)

In the future, by identifying the synoptic types according to the Hess-Brezowsky classification, there will intend to make a ranking of them for a longer time-interval to make a useful tool to forecast and assets as better possible all the severe weather phenomena in the northern part of Moldova.

Table nr.1. The 29 (Grosswetterlagen) types structures

The 29 Grosswetterlagen structures with English definitions		
Type	**Indicative**	**What do they represent**
West	**WA**	Westerly, Anti-cyclonic
	WZ	Westerly, Cyclonic
	WS	Westerly, Southern
	WW	Maritime Westerly (Block E. Europe)
South	**SWA**	South-Westerly, Anti-cyclonic
	SWZ	South-Westerly, Cyclonic
	SA	Southerly, Anti-cyclonic
	SZ	Southerly, Cyclonic
	TB	Low over the British Isles
	TRW	Trough over Western Europe
	SEA	South-Easterly, Anti-cyclonic
	SEZ	South-Easterly, Cyclonic
North-westerly and North	**NWA**	North-Westerly, Anti-cyclonic
	NWZ	North-Westerly, Cyclonic
	NA	Northerly Anti-cyclonic
	NZ	Northerly, Cyclonic
	HNA	Icelandic High, Ridge C. Europe
	HNZ	Icelandic High, Trough C. Europe
	HB	High over the British Isles
	TRM	Trough over Central Europe
North-easterly and Est	**NEA**	North-Easterly, Anti-cyclonic
	NEZ	North-Easterly, Cyclonic
	EA	Easterly, Anti-cyclonic
	EZ	Easterly, Cyclonic
	HFA	Scandinavian High, Ridge C. Europe
	HFZ	Scandinavian High, Trough C. Europe
	HNFA	High Scandinavia-Iceland, Ridge C. Europe
	HNFZ	High Scandinavia-Iceland, Trough C. Europe
Blocking	**HM**	High over Central Europe

3. RESULTS AND DISCUSSIONS

The impact of namely air-masses movement over daily activities is significant. In that way, it's crucial to know the paths followed by air-masses that can trigger severe weather events (Veira et al. 2013, Artuso et al., 2015).

3.1 Annual

Analyzing the Hess-Brezowsky concept shows that in the northern part of Moldova during the year, the most significant air-masses movements are represented by TRM (Through over Central Europe), with a weight of 8.80% (fig.1).

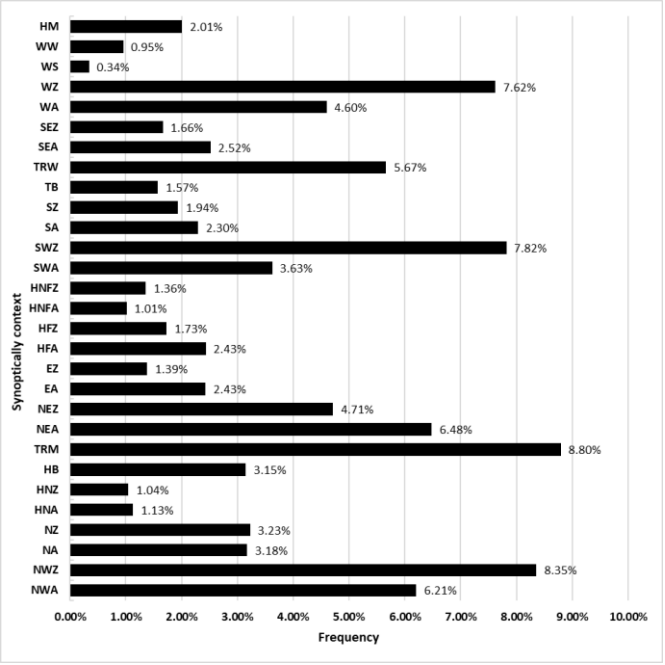


Fig. 1. The annual frequency of the air circulation types in the northern part of Moldova between 2000 to 2018

This is followed by the NWZ (North-Westerly, Cyclonic) type with a weight of 8.35%, SWZ (South-Westerly, Cyclonic) type with 7.82%, and WZ (Westerly, Cyclonic) with 7.62%. These facts show very well that mobile North-Atlantic low-areas highly link the weather's pattern over Central Europe (implicit over the northern part of Moldova) at the annual's level. When North-Atlantic low-areas are coupled with high-areas centered over the northern part of Europe, there will be the main key to trigging the Mediterranean cyclogeneses.

The action of low-areas over the central Mediterranean Sea basin represents a crucial factor in weather patterns' evolution over the Central-South-Eastern part of Europe. The SWZ (South-Westerly, Cyclonic) type in Romania is associated with low-areas over western and central parts of Europe by many times.

Also, significant values were owned by NWA (North-Westerly, Anti-cyclonic) type, with a value of 6.21%, and those by TRW (Trough over Western Europe), with 5.27%. These types are associated with severe storm in warm period.

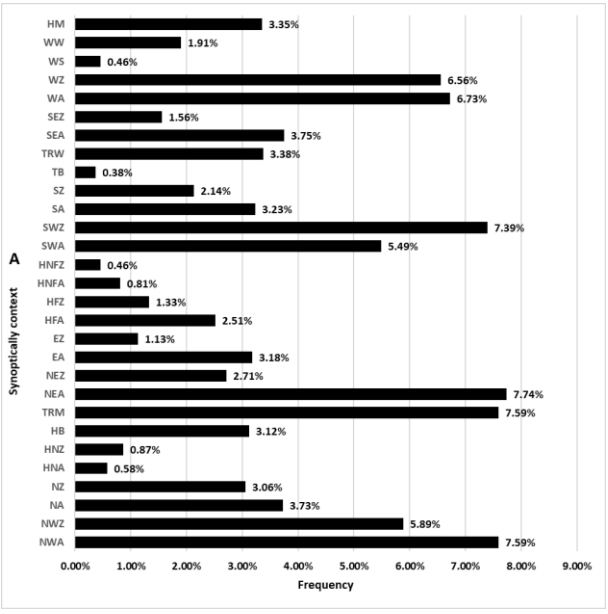
All of those shown in figure 1 were regrouped following the classification proposed by Fallot (2000); Gerstengarbe and Werner (2005), and James (2007) in North and North-Westerly type, which represents 35% of all air-masses movements over the northern part of Moldova during 2000 to 2018 period Next, South type with 27%, North-Easterly and Easterly with 22%, and

Westerly with 14%. The Blocking pattern over Central parts of Europe weighted 2%.

3.2 Semestrial

Relating aspects to the atmospheric movement can be noticed and analyzed better half-yearly or seasonally. In this way, there can be noticed aspects regarding the system's pressure at the local level.

Within the ***cold semester*** into the studied region, an important weight was represented by NEZ (North-Easterly Cyclonic) type, with 7.74%, followed by TRM (Through over Central Europe) and NWA (North-Westerly Anti-cyclonic) types, both of them with a weight of 7.59%, SWZ (South Westerly Cyclonic) type with 7.39%, WZ (Westerly Cyclonic) type with 6.56%, and WA (Westerly Anti-cyclonic) type with 6.73% (fig. 2 A). All of those weight shown during the cold semester demonstrates that the northern part of Moldova is placed at the border of the anti-cyclonic areas (highs over Russian Plain or Pre-Caspian Plain – by actions of Siberian Highs) who occur into the eastern and north-eastern part of the continent (by NEA type) and those of low pressure, placed over the Mediterranean Sea (by TRM and SWZ types). Also, the weather in the northern part of Moldova during the cold semester is influenced by the actions of Azores High and the low-areas who are active over the Atlantic Ocean and the northern half of Europe.



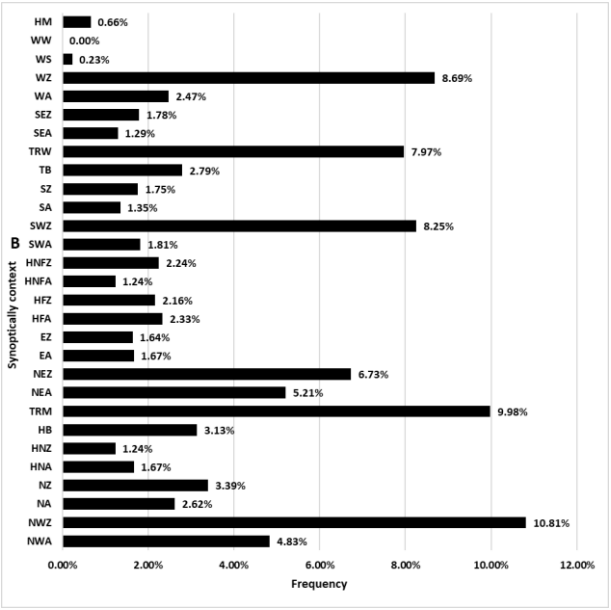


Fig. 2. The semestrial frequency of the air circulation types in the northern part of Moldova between 2000 to 2018 (A – cold and B – warm semester)

Due to a more intense atmospheric velocity, the ***warm semester*** shows the zonal movement's highest weight. In such cases, the most representative type is NWZ (North-Westerly, Cyclonic), with 10.81%. The TRM (Trough over Central Europe) type owns a weight of 9.98%, followed by the WZ (Westerly, Cyclonic) type with 8.69%. Representative weights are also associated with the following types: SWZ (South-Westerly, Cyclonic) – 8.25%, TRW (Trough over Western Europe) – 7.97%, NEZ (North-Easterly, Cyclonic) – 6.73% (fig. 2B)

All of those type shown above are linked with a cyclonic action over the western half of Europe (associated with SWZ or TRW) and, at the same time, that the lands get more quickly warm than the water and the possibility to develop locally low-areas over Central parts of the continent, such TRM – the main trigger of severe weather events (thunderstorms and hailstorms) over Central-South-Eastern part of Europe. (Cazacioc, 2007; Axinte, 2019; Ilie et. al, 2020a, 2020b).

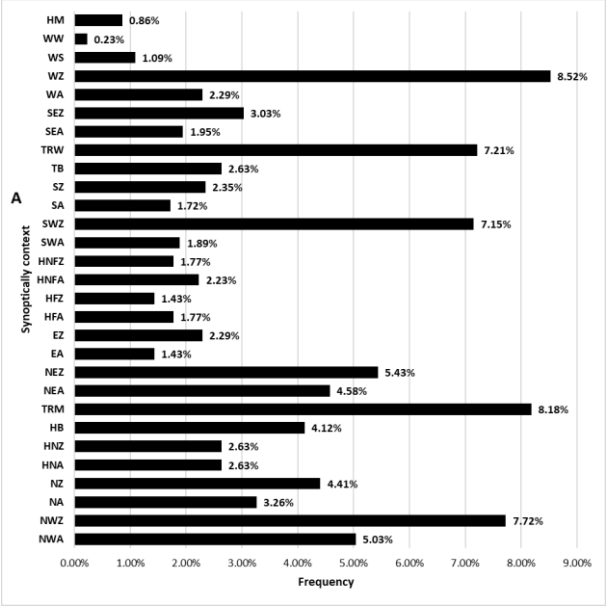
3.3 Seasonally

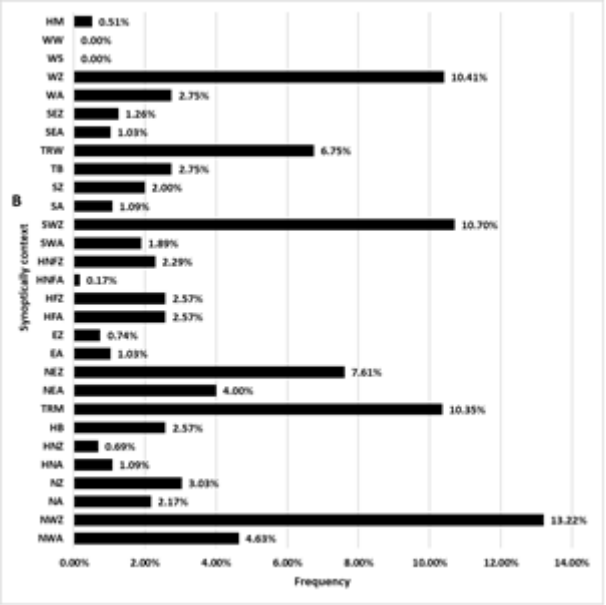
A good sight about these correlations is made when they come about their evolution during the seasonal level. Therefore, once the atmospheric circulation gets more intense during the ***spring***, an increase of the westerly type can be noticed. As a result, in springtime over the northern part of Moldova will

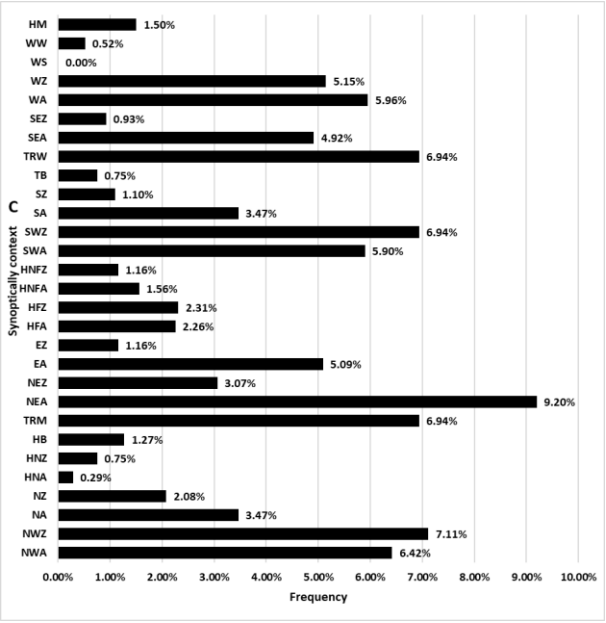
prevail the WZ (Westerly Cyclonic) type, with 8.52%. This is followed by TRM (Trough over Central Europe) type with 8.18%, NWZ (North-Westerly, Cyclonic) type – 7.72%, TRW (Trough over Western Europe) type – 7.21%, and SWZ (South-Westerly, Cyclonic) type – 7.15% (fig. 3 A).

During the ***summer***, over the studied area, by importance, there are the Hess-Brezowsky classification types: NWZ (North-Westerly, Cyclonic) with 13.22%, followed by those from SWZ (South-Westerly, Cyclonic) with a weight of 10.70%. Also, an important weight was owned by WZ (Westerly Cyclonic) with 10.41%, TRM (Trough over Central Europe) – 10.35%, and NEZ (North-Easterly, Cyclonic) – 7.61% and EZ (fig. 3B). All the NWZ, SWZ TRM, and WZ types are linked with low-areas over the Atlantic Ocean. In the northern part of Moldova, those types are associated with severe weather phenomena such as severe thunderstorms and the most representative hailstorms. Also, the NEZ and EZ types are linked with the retrogressive cyclones, which have the highest occurrence rate in June, May, and July, respectively. Such types (NEZ, EZ) are associated with the most representative amounts of precipitation in the studied region (Apostol, 2008).

The occurrence of NEZ, EZ even the SEZ type were linked with major floods in the northern part of Moldova in July 2005 and 2008 (Romanescu, Stoleriu, 2013), and June 2010.




B
Synoptically context
HM 0.51%
WW 0.00%
WS 0.00%
WZ 10.41%
WA 2.75%
SEZ 1.26%
SEA 1.03%
TRW 6.75%
TB 2.75%
SZ 2.00%
SA 1.09%
SWZ 10.70%
SWA 1.89%
HNFZ 2.29%
HNFA 0.17%
HFZ 2.57%
HFA 2.57%
EZ 0.74%
EA 1.03%
NEZ 7.61%
NEA 4.00%
TRM 10.35%
HB 2.57%
HNZ 0.69%
HNA 1.09%
NZ 3.03%
NA 2.17%
NWZ 13.22%
NWA 4.63%
0.00% 2.00% 4.00% 6.00% 8.00% 10.00% 12.00% 14.00%
Frequency


C
Synoptically context
HM 1.50%
WW 0.52%
WS 0.00%
WZ 5.15%
WA 5.96%
SEZ 0.93%
SEA 4.92%
TRW 6.94%
TB 0.75%
SZ 1.10%
SA 3.47%
SWZ 6.94%
SWA 5.90%
HNFZ 1.16%
HNFA 1.56%
HFZ 2.31%
HFA 2.26%
EZ 1.16%
EA 5.09%
NEZ 3.07%
NEA 9.20%
TRM 6.94%
HB 1.27%
HNZ 0.75%
HNA 0.29%
NZ 2.08%
NA 3.47%
NWZ 7.11%
NWA 6.42%
0.00% 1.00% 2.00% 3.00% 4.00% 5.00% 6.00% 7.00% 8.00% 9.00% 10.00%
Frequency

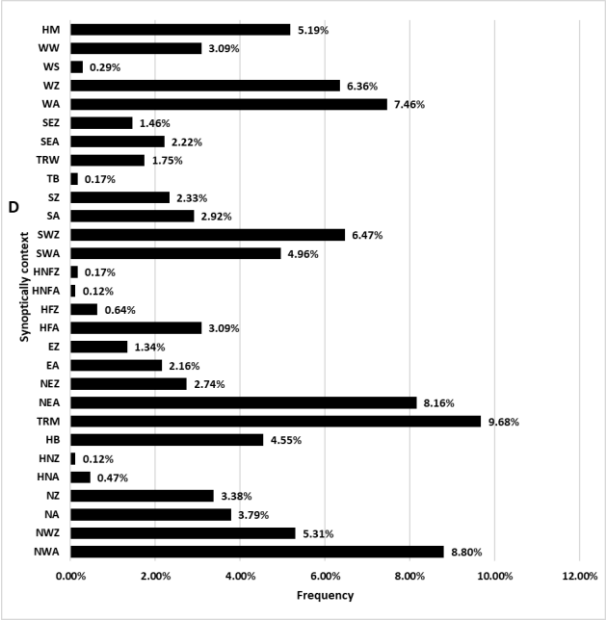


Fig. 3. The semestrial frequency of the air circulation types in the northern part of Moldova between 2000 to 2018 (A – Spring, B – Summer, C – Fall, D - Winter)

In the ***fall***, once the anti-cyclonic activity increase over Europe, into the studied area by importance is the NEA type (North-Easterly, Anti-cyclonic), with 9.20%. Not-negligible weights are owned by follows types: SWZ (South-Westerly, Cyclonic) and TRW (Trough over Western Europe), both of them with 6.94%. Also, by importance were NWZ (North-Westerly, Cyclonic) type with 7%, NWA (North-Westerly, Anti-cyclonic) type with 6.42%, WA (Westerly, Cyclonic) type with 5.96%, and WZ (Westerly Anti-cyclonic) type with 5.15% (fig. 3C).

During the ***winter***, the most significant types in the northern part of Moldova were NWA – 8.80%, NEA – 8.16%, WA – 7.46%, SWZ – 6.47%, WZ – 6.36% (fig. 3D).

4. CONCLUSIONS

This paper highlighted the atmospheric movements' weights over the northern part of Moldova by Hess-Brezowsky classification during 2000 to 2018 time period by annual – half-yearly – seasonal level.

Annual, over the northern part of Moldova, the most significant weights were linked with TRM – 8.80%, NWZ – 8.35%, and WZ – 7.62%. Those facts

show very well that mobile North-Atlantic low-areas are highly linked with the weather's pattern over Central Europe.

Significant weights were associated with NEZ – 7.74%, TRM and NWA – 7.59, SWZ – 7.39% during the cold half-yearly. By interest were NWZ – 10.81%, TRM – 9.98%, WZ – 8.69%, SWZ – 8.25% in the *warm half-yearly*.

In the *spring*, the most representative types were WZ – 8.52%, TRM – 8.18%, NWZ – 7.72%. In the *summer*, important weights were associated with NWZ – 13.22%, SWZ – 10.70%, WZ – 10.41%. In the *fall* there were NEA prevailed with 9.20%, SWZ, and TRM – 6.49%. In the *winter* in the northern part of Moldova was TRM – 9.68%, followed by NWA – 8.80%, NEA – 8.16%, WA – 7.46%.

ACKNOWLEDGEMENTS

This research was developed within the Doctoral School of Geosciences from 'Alexandru Ioan Cuza' University, Iasi, Department of Physical Geography, thorough Postdoctoral Program of Advanced Research.

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