National Hydrometeorological Service - Skopje

CLIMATE MAPS

NEEDED FOR IMPLEMENTATION OF EUROPEAN STANDARDS (EUROCODES) IN THE REPUBLIC OF NORTH MACEDONIA

July, 2020

CLIMATE MAPS

INTRODUCTION

Knowing the climate and adapting human activities to its impacts is a general national interest of every country and every society. The National Hydrometeorological Service (NHMS) as an entity in the Ministry of Agriculture, Forestry and Water Economy (MAFWE) is responsible for meteorological measurements and observations in the Republic of North Macedonia, in line with the standards of the World Meteorological Organization (WMO).

This analysis describes the methodology used by the NHMS to prepare the climate maps through which the Eurocodes should be adopted and implemented in the Republic of North Macedonia, as defined in the following European standards:

- MKC EN 1991-1-3 General actions - snow loads
- MKC EN 1991-1-4 General actions - wind actions and
- MKC EN 1991-1-5 General actions - thermal actions.

These European standards provide recommendations for determining the characteristic values for snow load, wind load and maximum and minimum air temperatures, which are an important component affecting buildings and other structures. Of particular interest is the impact assessment in order to avoid major material and human damages, which may occur due to demolition of certain structures because of miscalculated or underestimated load value, but equally important is to control the cost of construction by not overestimating the load values.

CLIMATE MAPS DEVELOPMENT METHODOLOGY

In accordance with European norms prescribed by the European Committee for Standardization EN-1990, Article 4, paragraph 4.1.2 (7) P note 2 "The characteristic value of climatic actions is based upon the probability of 0.02 (2%) of its time-varying part being exceeded for a reference period of one year. This is equivalent to a mean return period of 50 years for the time-varying part."

The statistical preparation of climate data is a very complex procedure because the data has to be adapted to the specifics of the regions that are subject of analysis. In order to define the characteristic values, it is sufficient to analyze the statistics of the annual maximums/ minimums, with a focus on a certain discrete set of meteorological data comprising one value for each year of meteorological observations.

The procedure usually involves the following steps:

1. Selection of meteorological stations sufficient to provide full coverage of the territory in terms of space, but also in terms of altitude at which meteorological variables are measured (maximum and minimum air temperature, basics of wind speed, weight or

height and density of snow cover), provided a condition that there is a long time series of measurements (30-50 years);

2. Defining and homogenizing a series of extreme annual values for the variable under consideration;

3. Selection of the most appropriate distribution of extreme values, such as Gumbel distribution, distribution of extreme values, Weibull distribution, Frechet, etc., taking into account the "later" suitability of the obtained value that will represent the variable;

4. Review and verification of the series of extreme values in order to obtain characteristic values of meteorological variables;

5. Spatial interpolation and drawing of climate maps;

6. Explanation of climate maps with identification of homogeneous climate regions: each climate region is characterized by a special relation to the characteristic value of the climate variable as a function of altitude.

THERMAL ACTIONS

The relief structure of the Republic of North Macedonia impacts the development of atmospheric activity, the regime of meteorological elements, as well as their distribution, and thus the climate regime. Meteorological elements represent the physical state and physical phenomena of the atmosphere.

Air temperature is an element that varies in time and space and it shows the temperature of the ground layer of the atmosphere that mostly depends on the influence of the Sun. It is measured at 2m above the ground. The maximum air temperature is measured with a maximum mercury thermometer for a period of 24h (from 21:00 the previous day to 21:00 in the current day). The minimum air temperature is the lowest measured value in a period of 24h (from 21:00 the previous day to 21:00 in the current day) and is measured with a minimum alcohol thermometer. The unit of measurement for air temperature is degree Celsius (° C).
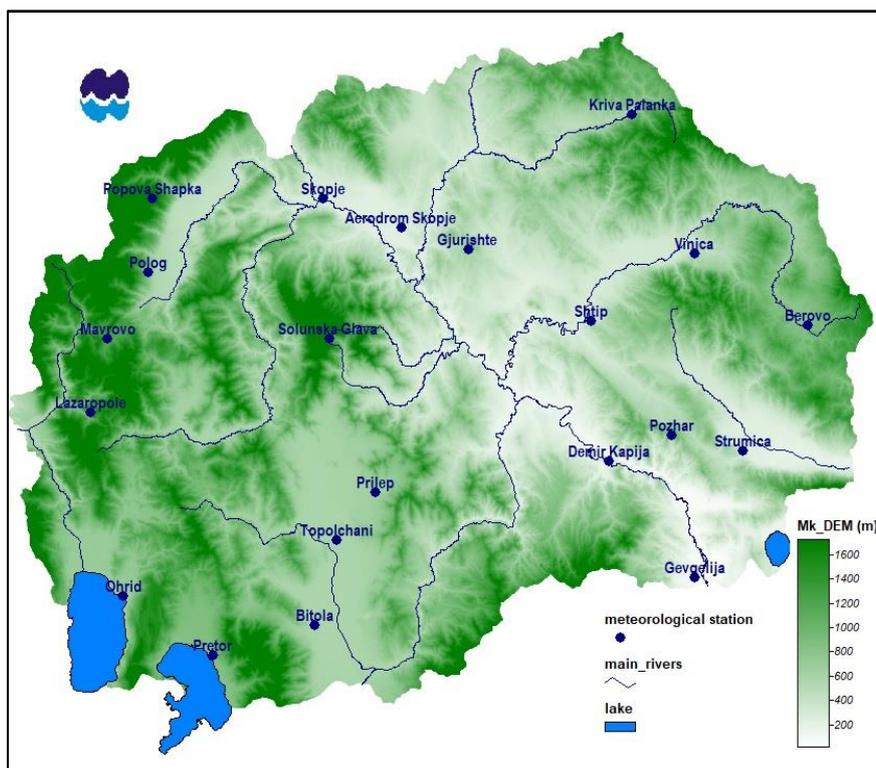
Figure 1: Meteorological station network used to develop climate maps

For this analysis, data on annual absolute maximum and annual absolute minimum air temperature from 21 meteorological stations were used, selected to meet the spatial geographical distribution of the entire territory. The network of meteorological stations is shown in Figure 1, and their geographical characteristics in Table 1.

	Meteorological station	Latitude	Longitude	Altitude (m)
1	Skopje	42°00'59"	021°23'59"	302.0
2	Aerodrom Skopje	41°57'42"	021°37'17"	234.0
3	Bitola	41°02'30"	021°21'13"	589.0
4	Shtip	41°45'13"	022°10'49"	326.6
5	Ohrid	41°06'53"	020°47'50"	758.0
6	Prilep	41°20'01"	021°33'13"	675.0
7	Demir Kapija	41°24'31"	022°17'50"	126.0
8	Gevgelija	41°08'48"	022°30'09"	61.0
9	Kriva Palanka	42°12'12"	022°19'52"	690.0
10	Strumica	41°26'31"	022°39'55"	223.45
11	Berovo	41°43'00"	022°50'56"	837.0
12	Lazaropole	41°32'14"	020°41'45"	1337.0
13	Pretor	40°58'50"	021°03'53"	916.1
14	Pozhar	41°28'16"	022°26'17"	1030

4

15	Vinica	41°52'37"	022°30'44"	509.0
16	Topolchani	41°14'25"	021°25'57"	842.0
17	Mavrovo	41°42'09"	020°45'26"	1281.0
18	Polog	41°51'03"	020°52'14"	874.3
19	Popova Shapka	42°00'57"	020°52'44"	1784.0
20	Solunska Glava	41°42'14"	021°24'18"	2540.0
21	Gjurishte	41°53'55"	021°50'10"	861.1

*Table 1: Geographic characteristics of the meteorological stations*

A 30-year series of homogenized data for the period 1981-2010 has been processed. Homogenization of meteorological data is a process of calibration of measured meteorological data, which removes unnatural factors that have contributed to the change of values. Data inhomogeneity can arise from multiple sources. The air temperature varies with altitude, so small changes in the location of meteorological stations can lead to a false increase or decrease in temperature. Development technology requires a change in measuring instruments and/or sensors that also may cause inhomogeneity. Most of these changes cause certain deviations in the series of local meteorological data, while some (mostly urbanization) result in gradual deviations in macro-climatic characteristics. Therefore, before analyzing meteorological variables, it is recommended to remove their inhomogeneity. For that purpose, the HOMER method of homogenization was used, which is interactive semi-automatic software where homogeneous series of meteorological variables are obtained through statistical calculations and graphs.

After homogenization of the parameters, Gumbel distribution is applied to the annual absolute values of maximum and minimum air temperatures, processed according to the previously explained procedure, and then characteristic values are determined for a period of 50 years, with a probability of occurrence of 2%. The distribution of extremes according to Gumbel allowed to display the characteristic values for the maximum and minimum temperature through three zones, where each is characterized by an appropriate ratio obtained by regression analysis. The statistical calculation of the characteristic values for the 50-year return period at the points of meteorological stations is exact. There are no large deviations in the spatial interpolation of the maximum temperature, but the local conditions have greater influences on the minimum temperature.

Graphs 1, 2 and 3 show the temperatures and their linear dependence on altitude. On the graphs we can see that the maximum temperatures with altitude obviously decrease, but there is also a trend of increase in the characteristic values of minimum temperatures as altitude gets higher.
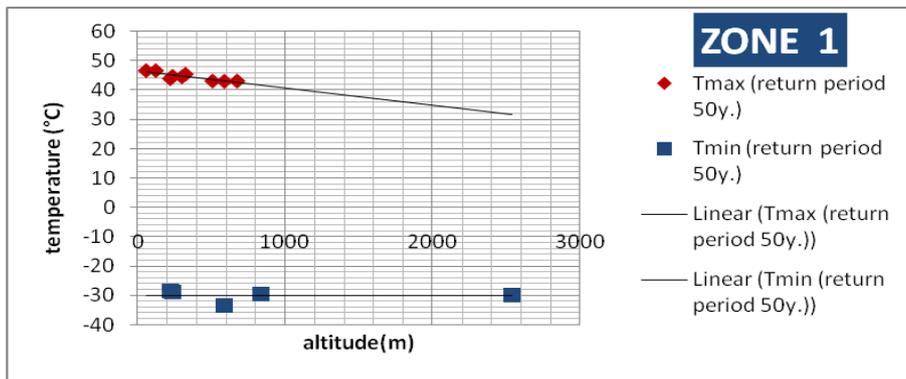
Graph 1: Change of characteristic values of temperatures for 50 years return period in zone 1
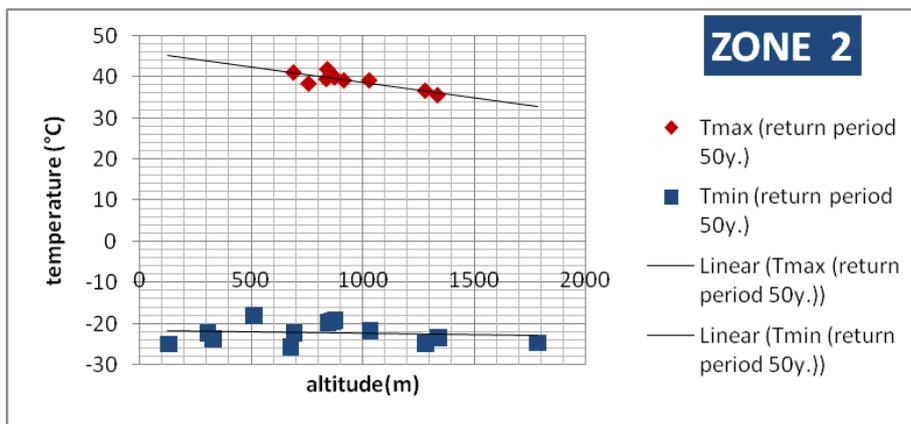
Graph 2: Change of characteristic values of temperatures for 50 years return period in zone 2
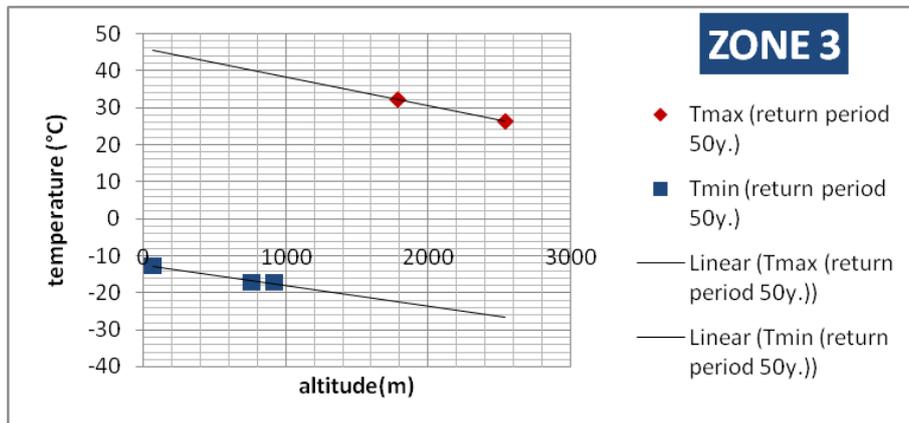
Graph 3: Change of characteristic values of temperatures for 50 years return period in zone 3

Kriging geostatistical method of interpolation is applied for spatial distribution of the obtained characteristic values of the absolute maximum air temperature. The most acceptable approach for displaying the maximum temperature distribution with a 50-year return period is the division of the Republic of North Macedonia into 3 zones, according to the isolines

(Figure 2). Hereby we have zone 1 where the maximum temperature reaches above 42.5°C, zone 2 with a maximum temperature between 34.0°C and 42.5°C and zone 3 where the maximum temperature is below 34.0°C. The characteristic values for the maximum temperature vary between 26.0°C on the mountain massif of Jakupica and 47.0°C in the southern region in the vicinity of Gevgelija. The hottest regions according to this analysis are in the surroundings of the cities of Gevgelija, Skopje and Shtip.
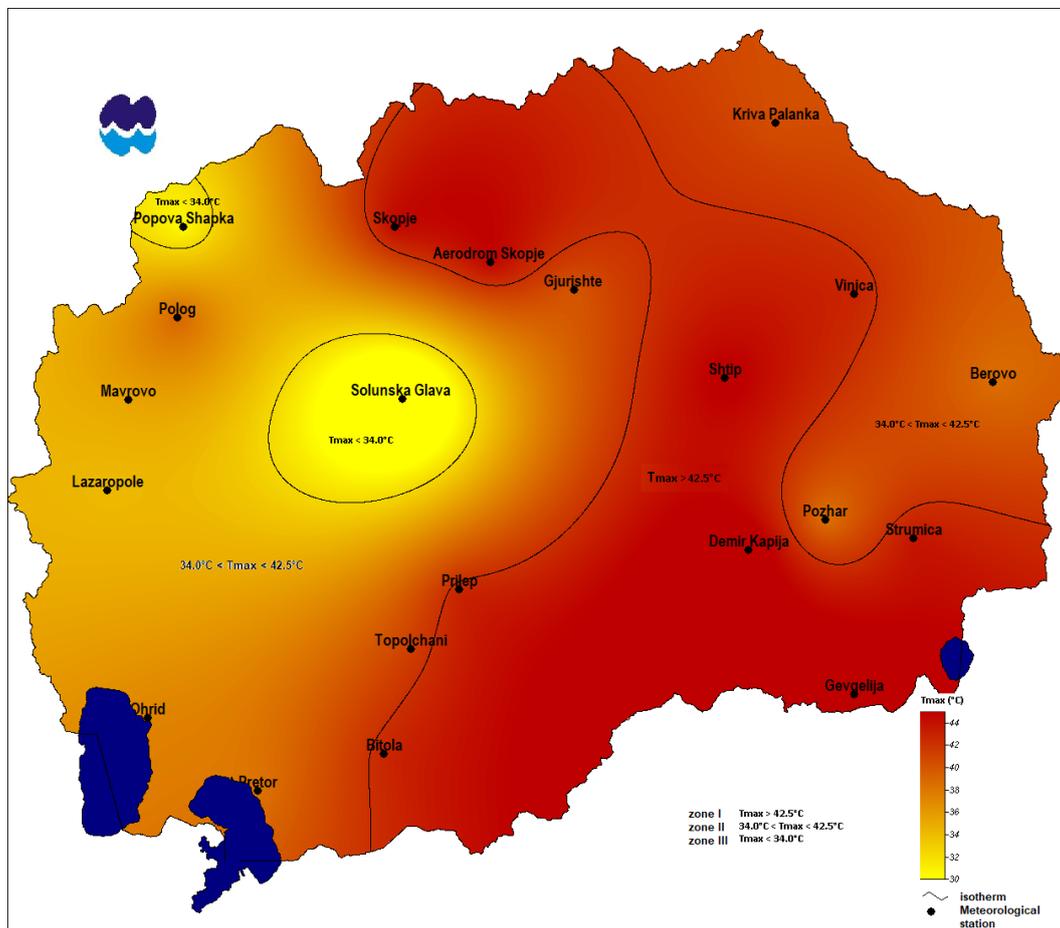

Figure 2: Characteristic value of maximum air temperature with a probability of occurrence of 0.02% (° C)

Due to the complex orography it is much more difficult to analyze the minimum temperatures, especially due to the inversions that occur in winter in the valleys when the cold air comes down. An example of this is the Pelagonija region, in the southern part where despite the spatial proximity of Bitola and Prilep there is a significant difference in minimum temperatures. That is why the division of the zones as per the isolines of the 50-year return period of the minimum temperature includes the coldest zone 1 which refers to the mountain massif Jakupica in central part of North Macedonia, Maleshevo mountains in the east and Baba mountain in the Pelagonija region where the minimum temperature is lower than -27.0 °C. Zone 2 covers most of the territory of the Republic, and the minimum temperature in this zone ranges from -27.0°C to -18.0°C. Gevgelija and Ohrid-Prespa region belong to the third zone. In this zone the minimum temperature is higher than -18.0°C.

Figure 3 shows the spatial distribution of the obtained characteristic values of the absolute minimum temperature. After applying the kriging geostatistical method of interpolation, the map of minimum air temperatures with a probability of occurrence of 2% was obtained.
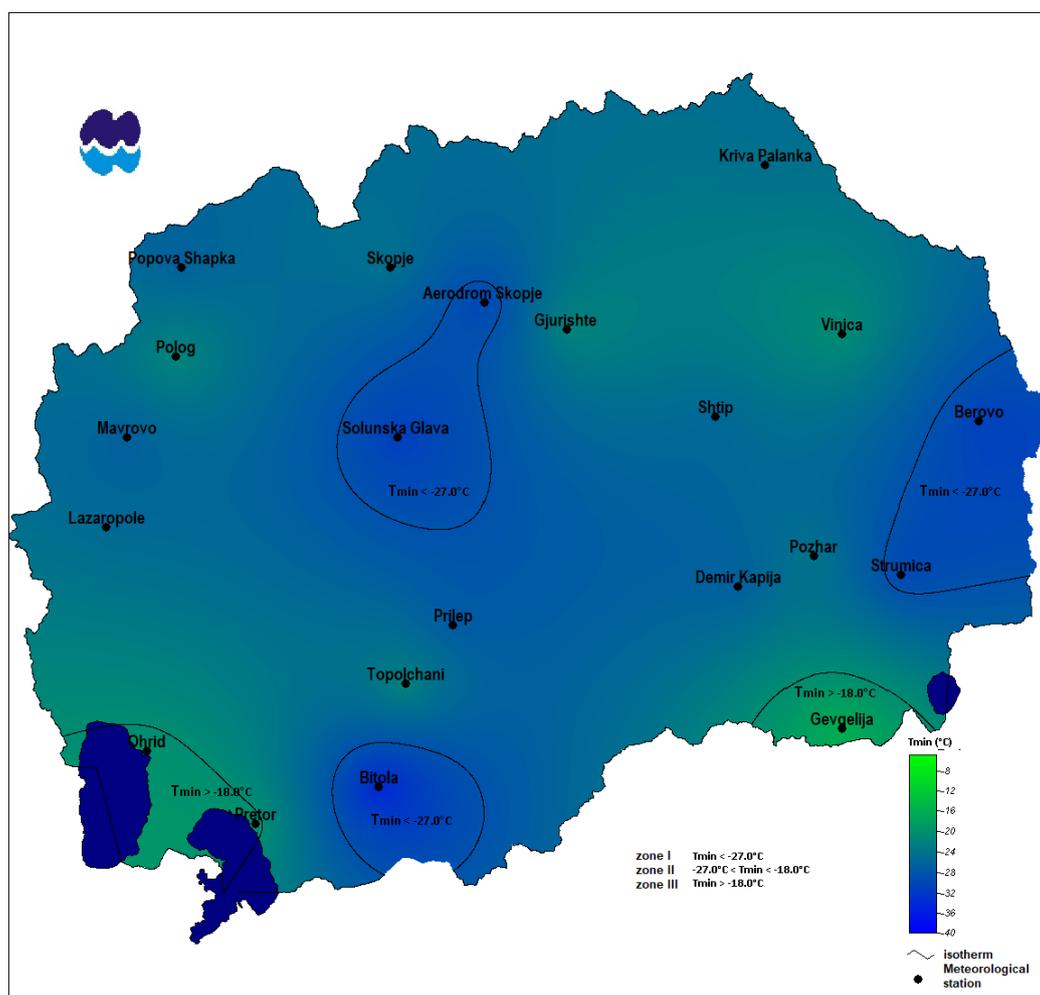

Figure 3: Characteristic value of minimum air temperature with a probability of occurrence of 0.02% (°C)

The characteristic values of the minimum temperature obtained with the above procedure range from -13.0°C to -33.0°C. Table 2 shows the characteristic values of the maximum and minimum temperature calculated for a return period of 50 years, with a probability of occurrence of 0.02.

	Meteorological station	$Tmax^{50}$ (° C)	$Tmin^{50}$ (° C)
1	Skopje	44.5	-22.2
2	Aerodrom Skopje	44.7	-28.7
3	Bitola	43.0	**-33.5**
4	Shtip	45.4	-23.6
5	Ohrid	38.3	-17.2
6	Prilep	43.1	-25.6

7	Demir Kapija	**46.6**	-24.9
8	Gevgelija	**46.6**	-12.8
9	Kriva Palanka	41.0	-22.3
10	Strumica	43.9	-28.5
11	Berovo	39.4	-29.6
12	Lazaropole	35.5	-23.3
13	Pretor	39.1	-17.2
14	Pozhar	39.1	-21.7
15	Vinica	43.1	-18.0
16	Topolchani	41.8	-19.7
17	Mavrovo	36.6	-24.8
18	Polog	39.8	-19.1
19	Popova Shapka	32.2	-24.6
20	Solunska Glava	26.3	-29.8
21	Gjurishte	40.6	-19.4

Table 2: Characteristic values of the maximum and minimum temperature with probability of occurrence 0.02

SNOW LOADS

Precipitation is a form of condensed or sublimated water vapor in the air that falls on the ground (rain, snow, hail) or is formed on the ground (dew, ice, hoarfrost). The distribution of precipitation reaching the Earth is with significant inequalities over relatively short distances. Precipitation varies in shape, in total amount, in intensity and in timing. Precipitation of ice crystals, most of which are branched like snowflakes when the air temperatures is around zero is called snow. Snow cover is formed as a consequence of snow fall. Due to its special importance, the snow cover stands out as a special climatic element, especially for the middle and high latitudes and higher altitudes at the lower latitudes.

A number of different global and local conditions can affect the height and weight of snow observed at a given measuring point. Globally, snow loads may depend on the climatic conditions and geographical features of the region. Local factors of meso-scale (for example: lakes, large rivers, forests, large urban areas, etc.) affect the height of the snow cover.

In temperate coastal regions, the highest snow loads are usually the result of a single snow event caused by a cyclonic weather system. In a short time the snow usually melts completely, so that each subsequent event can be considered statistically independent of the previous one. Accumulated layers of snow are usually observed in regions with continental climate and / or mountainous regions, especially at higher altitudes. The highest snow load is usually registered after a series of snowfalls which all contribute to the maximum snow load.

In meteorology, a snowy day is a day in which snow, snowdrifts, granular snow and / or ice needles are observed at the meteorological station. The height of the snow cover deposited on the earth's surface is measured at a place in the meteorological circle that is not exposed to direct sunlight and is not inclined, and is determined by measuring the thickness of the

snow cover on a flat surface using a snow gauge or snow gauge ruler. The instrument is set according to WMO standards, and measurements are performed every day during the climatic term at 07:00 (CET; UTC + 1). The unit of measure for the height of the snow cover is centimeters. Snow load (S_k) is the weight of the snow cover measured per unit area, and is calculated according to the following equation (1)

$$S_k \ [kN \ / \ m^2] = \rho_s \, h_s \, g \quad (1),$$

where usually the density of snow (ρ_s) is measured in g/cm^3, and the height of the snow cover (h_s) in cm. After conversion into units of the SI system kg/m^3 and m, we express the snow load in kN/m^2 which is approximately equal to 100 kg/m^2.

At present, no mathematical model is known to explain the development of total snow depending on time, nor is there any additional action recorded to initiate such a calculation at all. However, for interpolation of daily values of water content in a snow column for longer periods observed, physical models give reliable results.

The characteristic value of the snow load should be determined in accordance with EN 1990: 2002, 4.1.2 (7) P, the definition of characteristic snow load on the ground is a load having an annual probability of exceeding 0.02, not taking into account the exceptional snow load.[1] When determining the characteristic values of the snow load on the ground, not all uncertainties associated with the statistical calculation and / or the applied calculation model can be avoided. The uncertainties of the statistical calculation are caused by the technique of measurements and the location of the measuring station, and the uncertainties of the model are caused by the way of converting the height of the snow cover into a load, selection of appropriate distribution and probabilistic model, appropriate return period and division of regions according to load.

In 1983 the World Meteorological Organization provided guidance on the instruments, manner and methods to be used for meteorological measurements.[2] By using empirical expressions, and by measuring the height of the snow cover and the density of the snow, snow load be calculated. Furthermore, the annual maximum snow load on the ground is analyzed, which means that the maximum annual value of the observations is used to further calculate the distribution. The Gumbel distribution is applied, which allows calculating the characteristic value of the snow load on the ground.

In some regions, and especially in southern Europe, isolated cases with significantly higher snow loads have been observed. Depending on the length of time series of the data being analyzed, if these isolated cases are included, the statistical processing of regular snowfall may be disrupted. Therefore, exceptional values of snow load are defined. The criterion for defining an exceptional snow load according to European research is as follows: "If the ratio of the maximum value of the characteristic snow load is determined without including values

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[1] EN 1990: 2002, 4.1.2 (7) P; EN 1991-1-3, 1.6.1

[2] World Meteorological Organization (WMO) - Guide to meteorological instruments and methods of observation. WMON ° 8, Geneva, Switzerland, 1983.

greater than 2.0, then the maximum value of the load will be considered to be exceptional"[3]. Of course, this criterion is left to further elaboration with national annexes.

The snow load maps developed by the NHMS include data from the meteorological stations from Table 1 and Figure 1, with the exception of the meteorological station at Solunska Glava, for which we have no measured data on the height of the snow cover. The empirical expressions of the measured data on the height of the snow cover and the constant density of the snow are used to calculate the characteristic snow load. Each country uses different models to transform snow density into load. With fixed values for average snow density, calculations are made in Belgium, France, the Netherlands, Luxembourg and Greece. The Republic of North Macedonia also accepted the calculation method where the mean value of snow density is 300 kg/m^3. With Gumbel's distribution a return period of 50 years is presented. The impact of altitude on snow load is presented in Figure 4.

Given the low number of meteorological stations at higher altitude (above 1500m), all snow load requirements relating to regions at altitude higher than 1500m should be additionally processed.

Table 3 shows the characteristic values of snow load calculated for a return period of 50 years, with a probability of occurrence of 0.02.
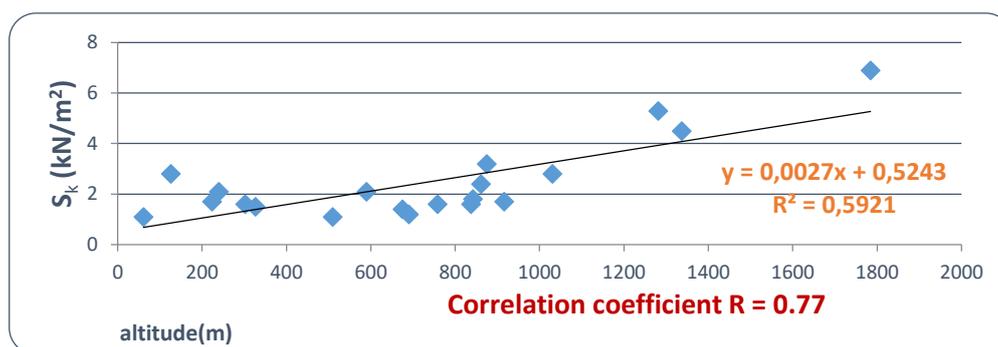
Graph 4: The dependence of the characteristic value of snow load and altitude

	Meteorological Station	S_k (kN / m^2)
1	Skopje	1.6
2	Aerodrom Skopje	2.1
3	Bitola	2.1
4	Shtip	1.5
5	Ohrid	1.6
6	Prilep	1.4
7	Demir Kapija	2.8
8	Gevgelija	1.1
9	Kriva Palanka	1.2

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[3] EN 1991-1-3; paragraph 4.3

10	Strumica	1.7
11	Berovo	1.6
12	Lazaropole	4.5
13	Pretor	1.7
14	Pozhar	2.8
15	Vinica	1.1
16	Topolchani	1.8
17	Mavrovo	5.3
18	Polog	3.2
19	Popova Shapka	6.9
20	Gjurishte	2.4

Table 3: Characteristic values of snow load with probability of occurrence 0.02

The spatial distribution of the calculated characteristic values of snow load in the Republic of North Macedonia, using geo-statistical kriging method of interpolation by super-positioning the weight field of the snow cover with a probability of exceeding 0.02 and the altitude where it occurred is presented in Figure 4.
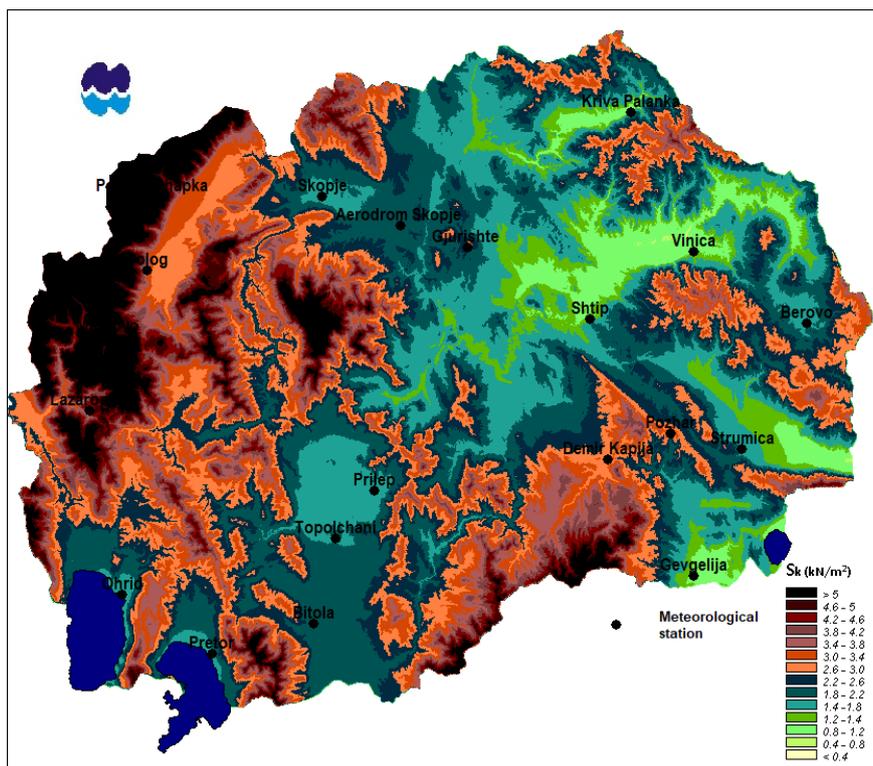

Figure 4: Characteristic value of snow load (Sk) with snow density of 300kg/m³ and probability of occurrence 0.02% (kN/m²)

SNOW LOAD WITH DIFFERENT SNOW DENSITY (100, 150, 200 AND 250KG/M³)

The values for snow load calculated with the data on the height of the snow cover and the different mean density of snow measured on the meteorological stations are given in Table 4. The spatial distribution of the characteristic values of snow load in the Republic of North Macedonia, using geostatistical kriging method of interpolation by super-positioning the weight field of the snow cover with a probability of exceeding 0.02 and the altitude of snow with density of 100, 150, 200 and 250 kg/m³ is presented in Figures 5, 6, 7 and 8.

(kg / m³) density of snow Meteorological station	100	150	200	250
Gevgelija	0.4	0.6	0.8	0.9
Lazaropole	1.5	2.2	3.0	3.7
Ohrid	0.5	0.8	1.0	1.3
Pretor	0.6	0.9	1.2	1.4
Bitola	0.7	1.1	1.4	1.8
Demir Kapija	0.9	1.4	1.9	2.3
Pozhar	0.9	1.4	1.9	2.4
Strumica	0.6	0.9	1.1	1.4
Topolchani	0.6	0.9	1.2	1.5
Mavrovo	1.8	2.6	3.5	4.4
Polog	1.1	1.6	2.2	2.7
Popova Shapka	2.3	3.5	4.6	5.8
Gjurishte	0.8	1.2	1.6	2.0
Prilep	0.5	0.7	0.9	1.2
Skopje	0.5	0.8	1.1	1.3
Aerodrom Skopje	0.7	1.0	1.4	1.7
Shtip	0.5	0.7	1.0	1.2
Berovo	0.5	0.8	1.1	1.3
Vinica	0.4	0.6	0.7	0.9
Kriva Palanka	0.4	0.6	0.8	1.0

Table 4: Characteristic values of snow load with different average snow density and probability of occurrence of 0.02
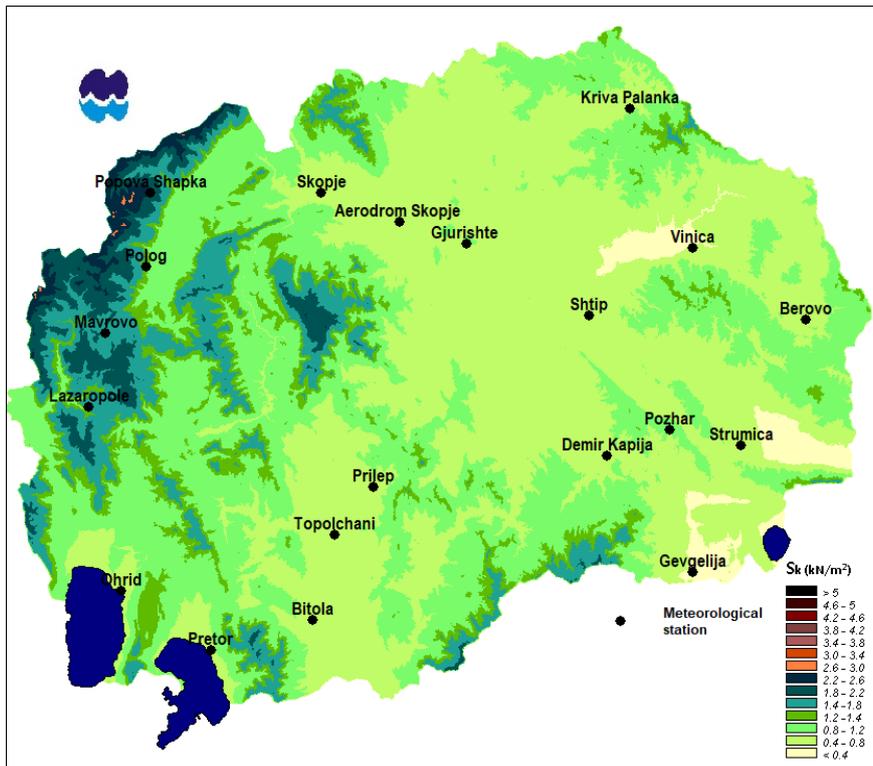
Figure 5: Characteristic value of snow load (Sk) with snow density of 100kg/m³ and probability of occurrence 0.02% (kN/m²)

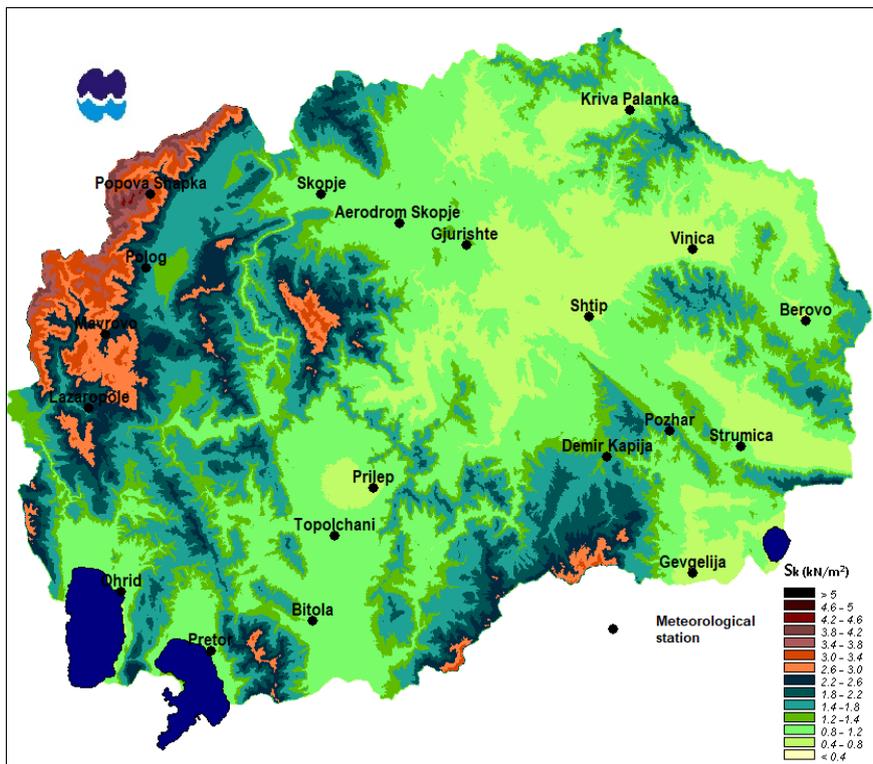*Figure 6: Characteristic value of snow load (Sk) with snow density of 150kg/m³ and probability of occurrence 0.02% (kN/m²)*
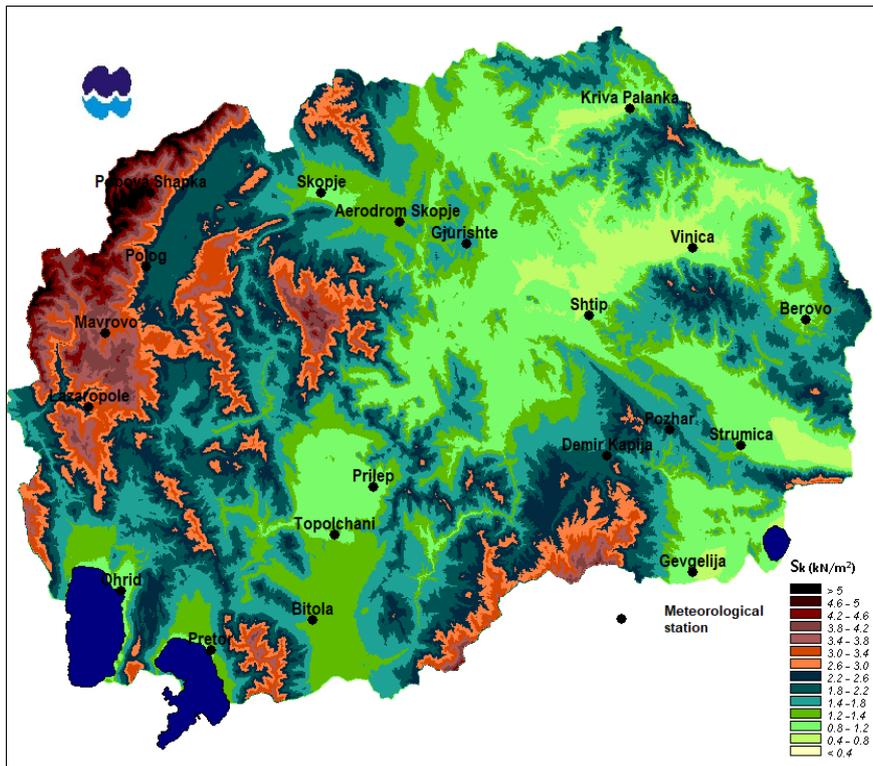
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Figure 7: Characteristic value of snow load (Sk) with snow density of 200kg/m³ and probability of occurrence 0.02% (kN/m²)

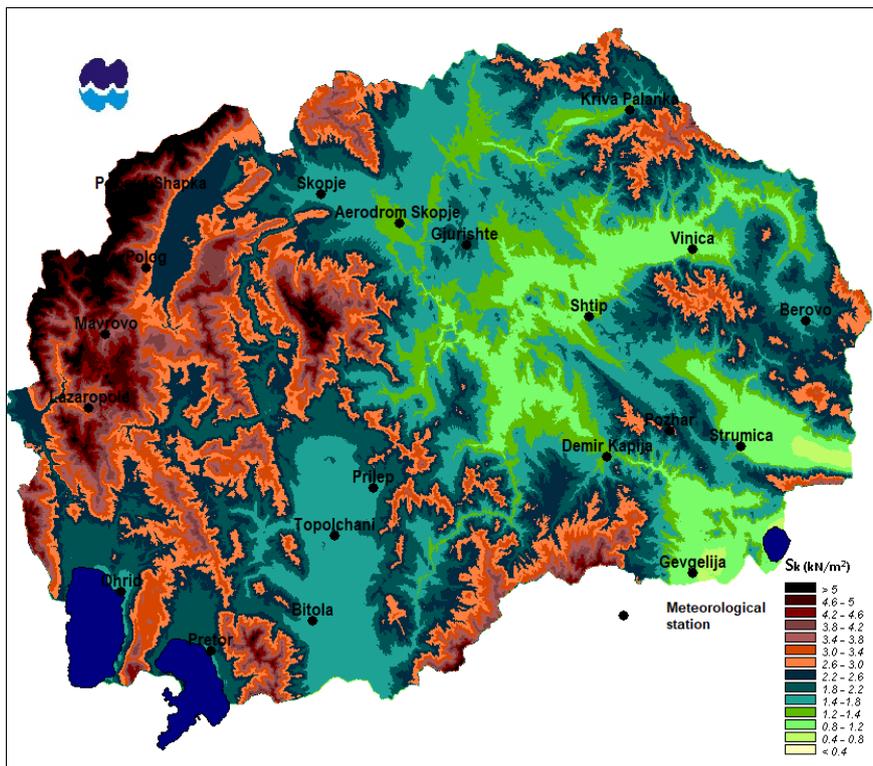*Figure 8: Characteristic value of snow load (Sk) with snow density of 250kg/m³ and probability of occurrence 0.02% (kN/m²)*

WIND ACTIONS

Due to the uneven distribution of energy over the Earth's surface the air in the atmosphere is in constant motion. The different distribution of energy that is manifested through the different air temperature of the Earth's surface creates differences in air pressure. As a result of the air pressure difference, a horizontal flow of air is created which is known as wind. Taking into account the importance of wind data, its action at different altitudes is carefully studied and the results are most often used during the design, construction and maintenance of buildings and structures.

The changes in wind speed and direction on the Earth's surface is mainly influenced by the complex relief, i.e. by the physical and geographical conditions. Daily wind changes depend on the state of the atmosphere, i.e. on the weather conditions. In the ground layer of the atmosphere, the change of wind with height is due to the friction force. These changes are more pronounced in the lowest layers of the atmosphere, up to 50m from the Earth's surface. In this layer the wind speed changes abruptly with altitude. The change in wind speed and direction depends on the Earth's surface, the state of the atmosphere and the value of the wind speed. Less smooth the surface, the greater is the force of external friction, and thus the greater is the change in speed and direction with height.

The aforementioned European standard for wind actions, recommends that the characteristic value of "10 minutes mean wind speed with a probability of exceeding 0.02, regardless of the direction, measured at a height of 10m" is used in calculations.

Data from 9 meteorological stations shown in Figure 10 were used for this analysis, for the period 1991-2017. Geographical characteristics of the stations are shown in Table 1. The instrument that records the 10 minute wind speed on anemographic tapes is an anemograph. This fundamental value of the basic wind speed is measured in m/s. The registered 10 minutes mean speed which passed the wind path was analyzed.
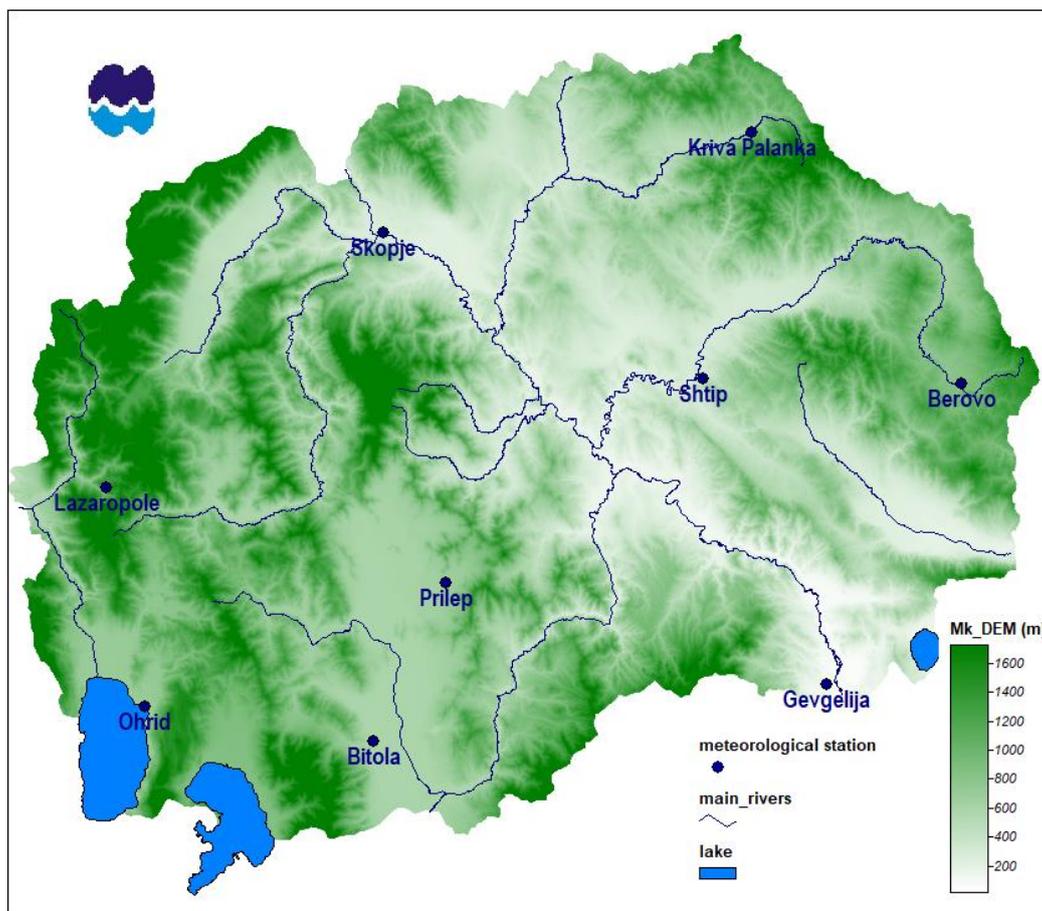
*Figure 10: Network of meteorological stations used to make a climate map for
the fundamental value of the basic wind speed*

The maximum annual 10 minute value was further used for statistical processing. The elaboration of the data was done according to the previously explained procedure. Due to the specificity of the variable and its further use, different statistical approaches for distribution were considered. The programming language "R" for research, statistical analysis, calculations and visualization was used to determine the wind return periods. Depending on the best statistical adaptation for calculating the 50-year return period, the program used a Gumbel, Weibull, or Frechet distribution. For Ohrid, Lazaropole and Berovo statistically the most important was the Frechet distribution, while for the other stations the Weibull distribution.

Table 5 shows the characteristic values of the fundamental value of the basic wind speed calculated for a return period of 50 years.

	Meteorological Station	V_{50pp} (m/s)
1	Skopje	24.3
2	Bitola	18.7
3	Prilep	21.3
4	Shtip	28.3
5	Gevgelija	21.6
6	Kriva Palanka	20.1
7	Lazaropole	23.8

8	Berovo	14.7
9	Ohrid	29.3

Table 5: Characteristic values of the fundamental value of the basic wind speed
with probability of occurrence of 0.02

The spatial distribution of the calculated characteristic wind values in the Republic of North Macedonia, using geostatistical kriging method of interpolation with superposition of the field of the value of 10 minute wind speed with probability of exceeding 0.02 and the altitude is presented in Figure 11.

The parts of the territory of the Republic of North Macedonia which altitude exceeds 1000m need to be additionally reviewed and specially analyzed. This means that the meteorological station of Lazaropole is not fully representative. It is also said that at low stations (Gevgelija) there is a high probability of having winds with higher speeds than those statistically calculated due to the more pronounced changes in wind speed caused by local impact and pronounced friction force in the ground layer.

Lines connecting places with the same characteristic wind speed values calculated for a return period of 50 years are called isotachs. Their distribution at every 5m/s is shown in Figure 12.
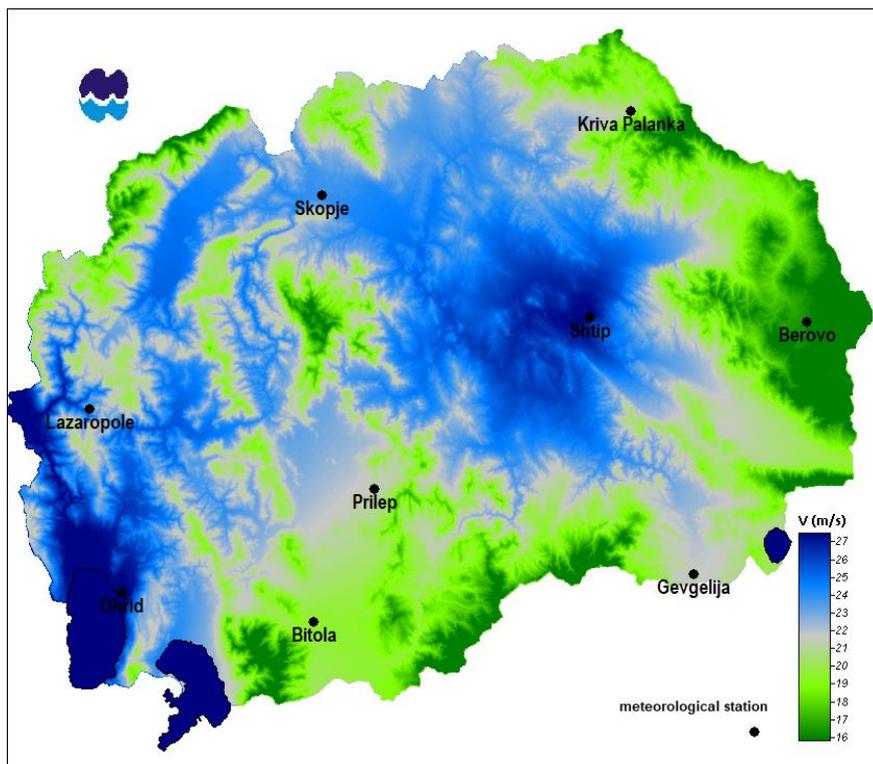

Figure 11: Characteristic value of wind speed (V) with probability of occurrence of 0.02 (m/s)
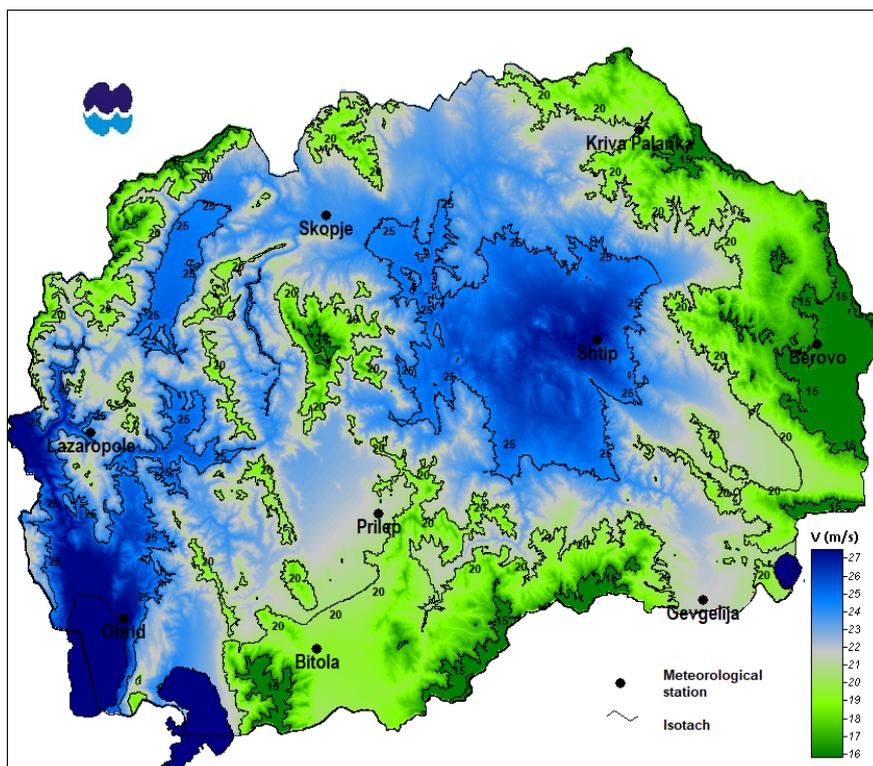
Figure 12: Isotachs of the characteristic value of wind speed (V) with probability of occurrence of 0.02 (m/s)

RECOMMENDATIONS AND CONCLUSIONS

The obtained results can be fully used as intended. The institutions that will further use these maps for the implementation of the Eurocodes should keep in mind in the next review that the following updates should be made:

o due to the urgent development of the climate maps, longer series of data were not included; nor a large number of meteorological stations;

o cooperation with neighboring countries for better harmonization and inclusion of data from border areas should certainly be one of the priorities, which would provide a more credible picture of the border regions;

o a longer timeframe for processing additional stations so that more accurate snow load data could be obtained, including measurements of actual snow density values (where available), will certainly provide a more reliable load analysis. This more detailed analysis will make it possible to define and determine the exceptional snow load, also.

It is recommended periodically to calculate the characteristic values of the variables (every 5-10 years) considering that automated measurements were introduced in the meteorological monitoring system throughout the country in the last decade, but also considering that third generation satellite data could be used as well as remote measurement data from European and other global organizations.

CLIMATE MAPS - CLIMATE CHANGE ACTIONS (IMPACTS)

The evidence of climate change is unequivocal and the consequences are increasingly being felt in Republic of North Macedonia and worldwide. The impact of climate change on man-made systems has a large component of uncertainty, given that the future climatic scenarios mainly depend on the evolution of the global CO_2 drivers.

The most likely pathways for drivers' concentrations depend on mitigation scenarios and deadlines for the implementation of policies to reduce greenhouse gas emissions, like the Kyoto Protocol. These scenarios, globally, show further warming and change in the water cycle, but locally, the trends can be very different and even opposite from the global average.

According to the results obtained, it is expected that the climate in North Macedonia will be warmer and drier and the amplitude of change will be initially related to future concentrations of greenhouse gases (V. Djurdjevic).

Namely, the obtained results signal that extreme precipitation in future, in the upper limit, gives 60% probability for increase in the number of days with precipitation over 40mm/day and 20% increase of the maximum daily precipitation (V. Djurdjevic), which indicates that further analysis is needed because local daily changes may not condition a change in the return period of the characteristic values analyzed during the development of the climate maps.

Additional research on climate maps is needed through the so-called pilot study in which a procedure will be developed for combining the historically measured meteorological data and the future predicted values, obtained as output data from the projections in the climate scenarios (maximum and minimum air temperature and amount of precipitation).

The proposed methodology should ensure a comprehensive overview of the climate change impacts on the characteristic values that were analyzed during the preparation of climate maps, according to the different emission scenarios.

MAFWE   Ministry of Agriculture, Forestry and Water Economy

WMO   World Meteorological Organization

NHMS   National Hydrometeorological Service

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SET   Central European Time (SEA)

HOMER   HOMogenizaton softwarE in R

UTC   Coordinated Universal Time