European Commission

Experience from the region in elaboration of maps for climatic actions: Bulgaria

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Elaborated maps for climatic actions in Bulgaria
EUROCODE 1: Actions on Structures

- EN 1991-1-3 Snow loads;
- EN 1991-1-4 Wind actions;
- EN 1991-1-5 Thermal actions.

EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

Main goals

The elaboration of the map for snow load in Bulgaria was focused on the following two tasks:

- estimation of the **characteristic value of the snow load on the ground** – s_k and
- estimation of the **exceptional snow loads on the ground**.

EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

According to EN 1991-1-3 the **characteristic value of the snow load on the ground** s_k is the "snow load on the ground based on an annual probability of exceedence of 0.02, excluding exceptional snow loads", which is equivalent to Mean Recurrence Interval (MRI) of 50 years

and the **exceptional snow loads on the ground** is the "load of the snow layer on the ground resulting from a snow fall which has an exceptionally infrequent likelihood of occurring" .

The criterion for identifying the last is "If the ratio of the largest load value to the characteristic load determined without the inclusion of that value is greater than 1.5 then the largest value should be treated as an exceptional value".

EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

Background research for snow maps in Bulgaria

- Till 2004 the national snow load standard was based on 2 years MRI, which corresponds to the mean values of the seasonal maxima of the snow cover;
- Maps with this requirement were elaborated in 1979 and 1989;
- In 2004 a new transient standard was adopted with MRI of 25 years;
- In 2009 ended the described research for elaboration of a new snow load map according to EN 1991-1-3;
- Since 2012 the EN 1991-1-3 has been in force.

EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

For the snow map of Bulgaria the following common methodology has been applied:

- ✓ statistical analysis of the seasonal maxima of the snow cover using four different cumulative distribution functions (Gumbel, Lognormal, Weibull and Freshe);
- ✓ LSM for determination of the best fitting regression curve;
- ✓ snow density estimations;
- ✓ snow load – altitude dependency;
- ✓ exclusion of the exceptional snow loads;
- ✓ checking for consistency at the national borders.

EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

Models for snow density used for transformation of a measured snow depth into a load according to EN 1991-1-3:

- Fixed value for the mean density of snow (Belgium, Eire, France, Greece, Luxembourg and Netherlands);
- Density as a function of snow depth (Germany);
- Density as a function of the place of observation (Sweden, Spain and Austria);
- Density as a function of time (Italy, Portugal, Spain, Norway and Switzerland).

EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

Data and examples from Bulgaria

- Data for the seasonal snow cover maxima from 126 meteorological stations was used;
- The main period is 1931–2006. Only few of the used stations have such long period, but for all of them it is longer than 50 years;
- Regular data for the snow density from 22 stations was added;
- Old archive field measurements of the snow density complemented the data base;
- New field campaigns in the mountain regions during this research were organized.

EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

The snow density model in Bulgaria

- fixed value (210 kg/m^3) up to 1000 m

Mean monthly snow density for the period 1984-2007

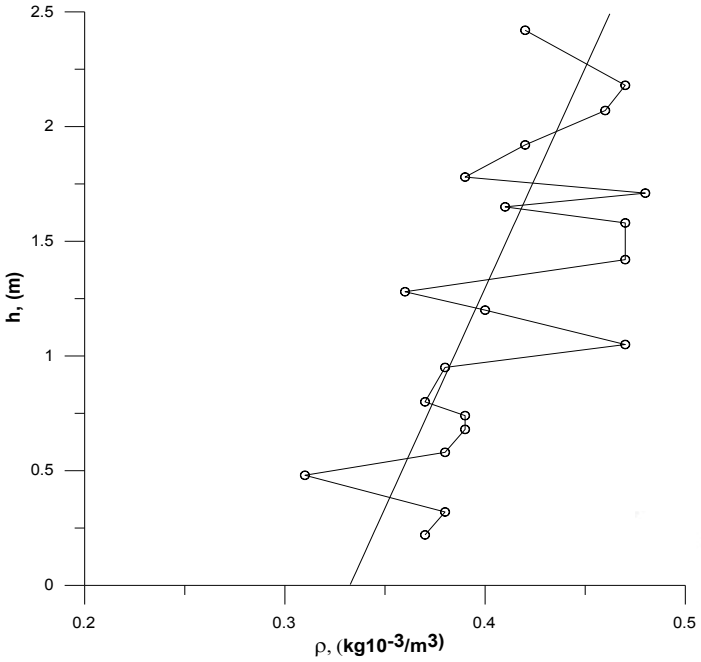
Station	I	II	III	XI	XII
Vidin	0,21	0,23	0,26	0,14	0,22
Kneja	0,26	0,28	0,23	0,22	0,25
Veliko Tarnovoo	0,19	0,16	0,16	0,15	0,14
Ivailo	0,16	0,16	0,16	0,16	0,15

EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

The snow density model in Bulgaria

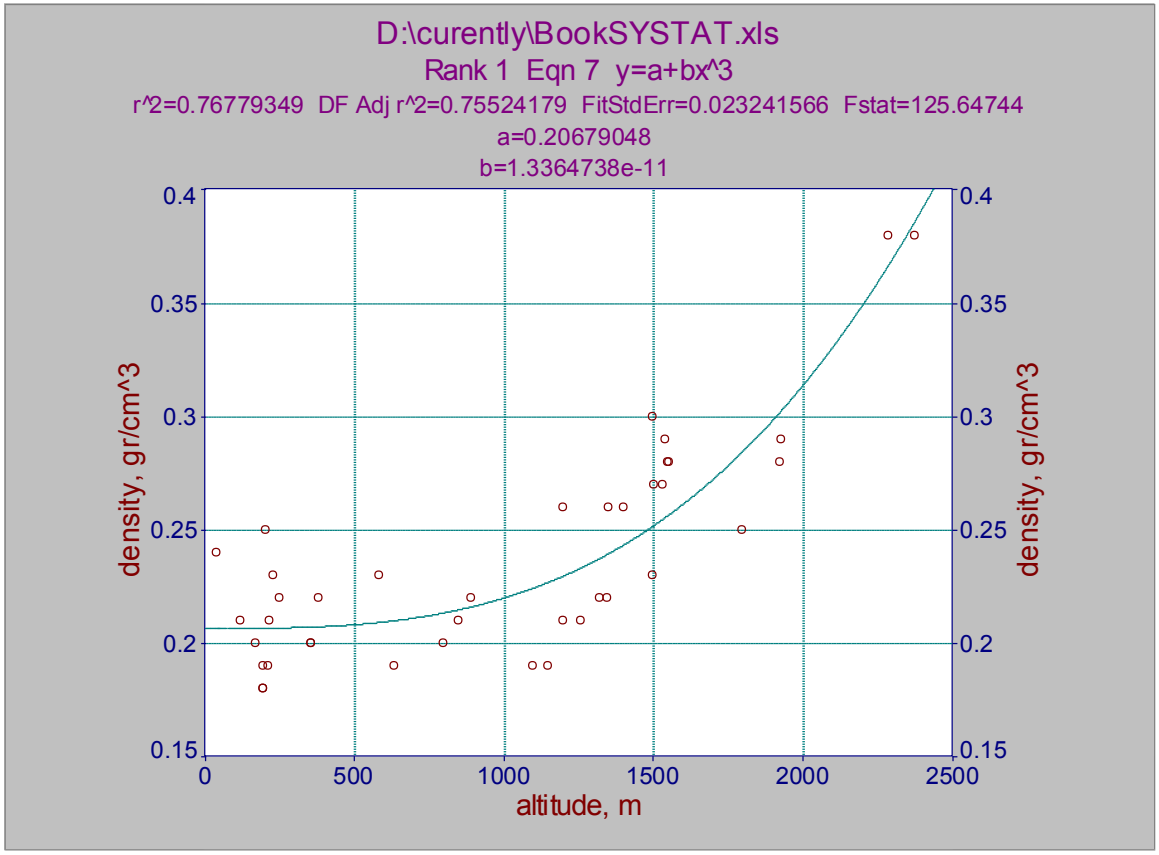
- above 1000 m – as function of the altitude, snow depth and the time of the year;

Dependency of the snow density from the snow depth for the regions above 1000-1200 m in Bulgaria for month April



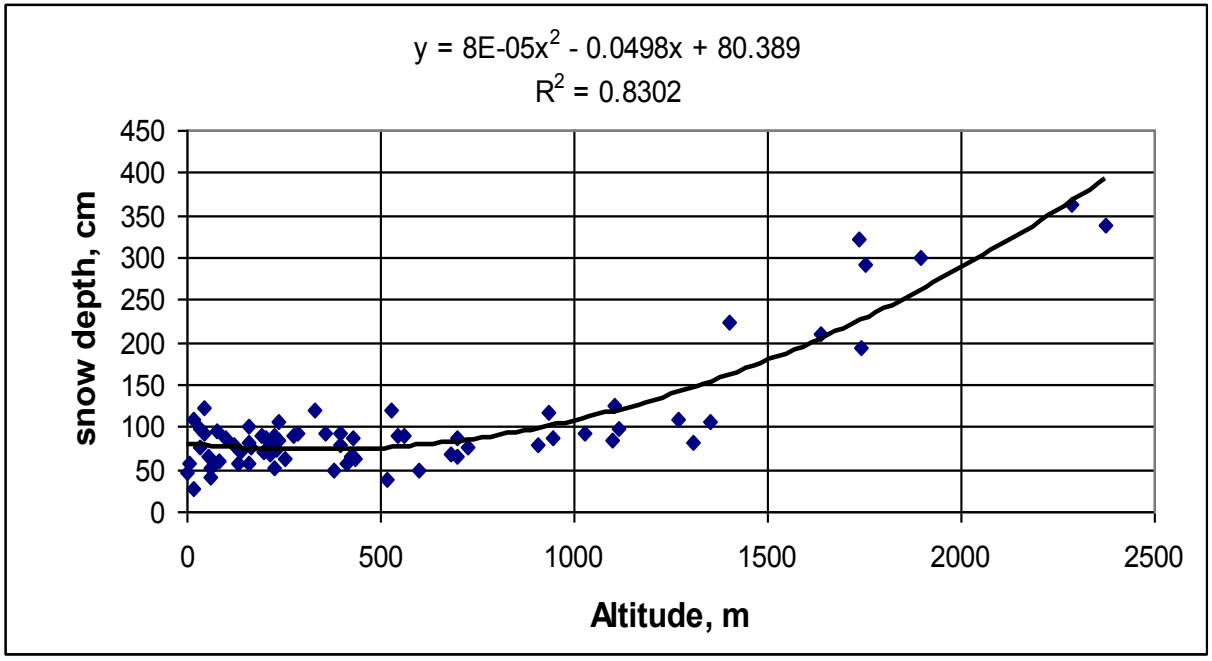
EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

The altitude dependency of the density in Bulgaria



EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

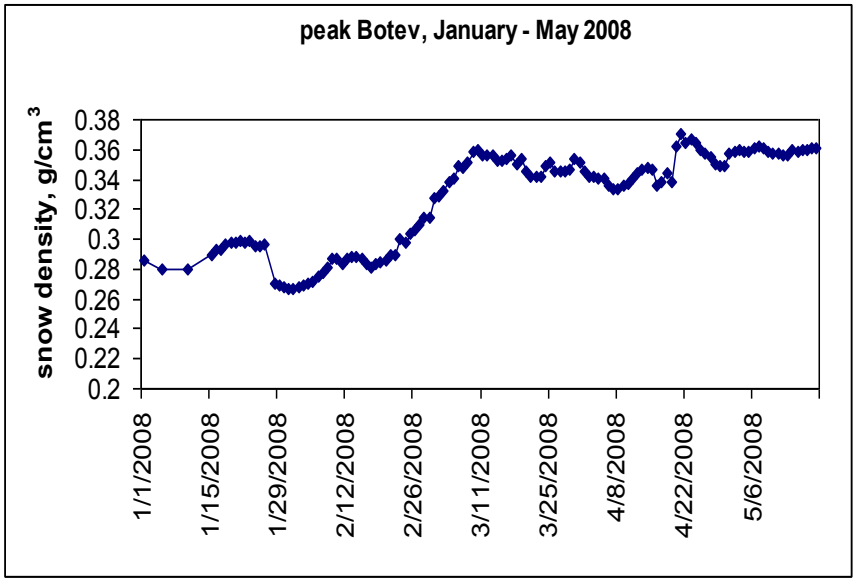
The altitude dependency of the snow depth in Bulgaria

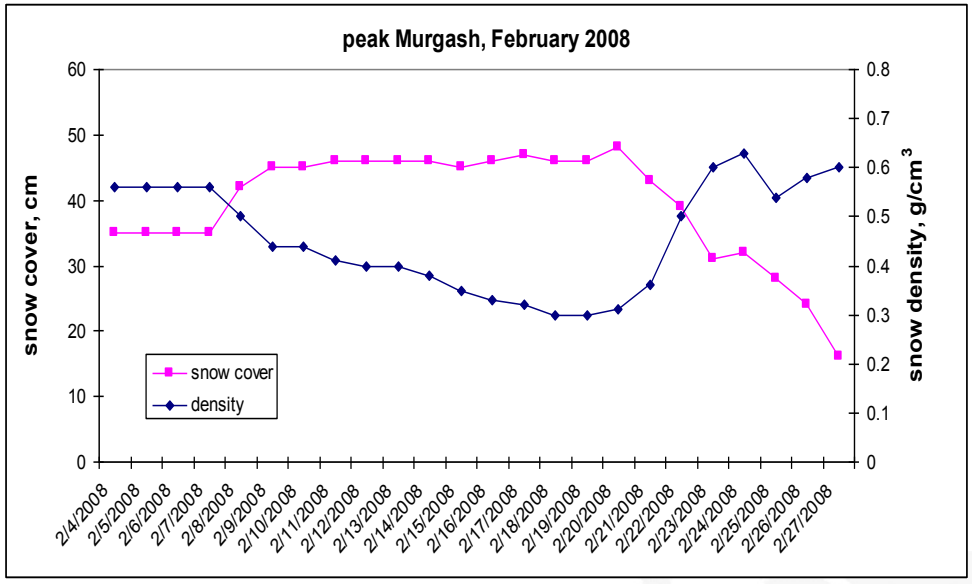


EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

Examples of the new density measurements in the mountain regions of Bulgaria:

a. at meteorological stations





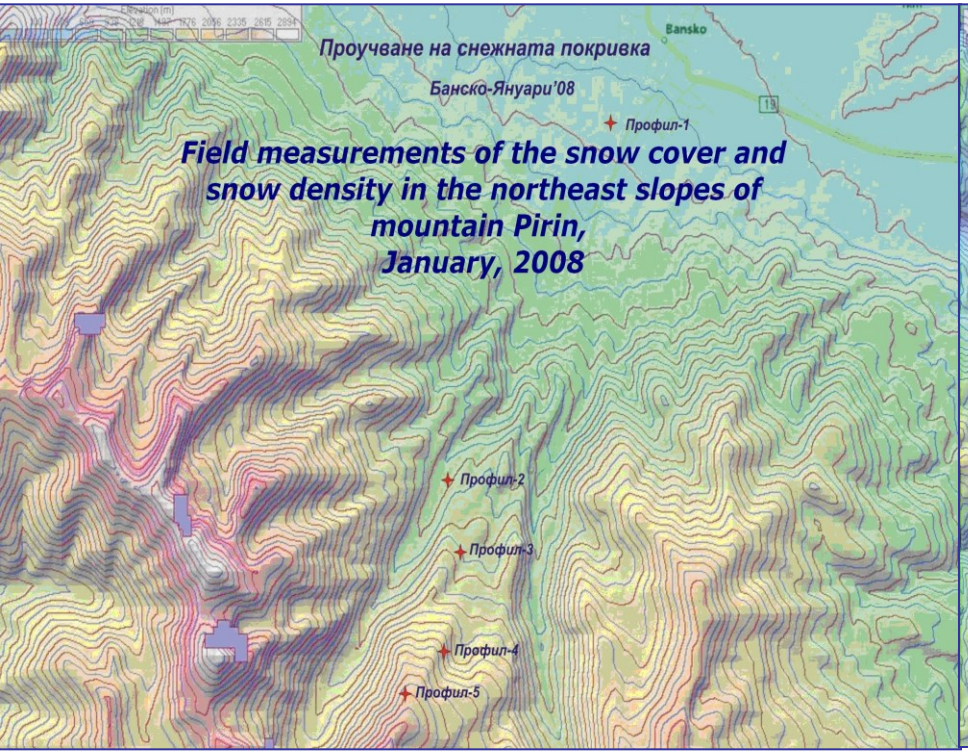
EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

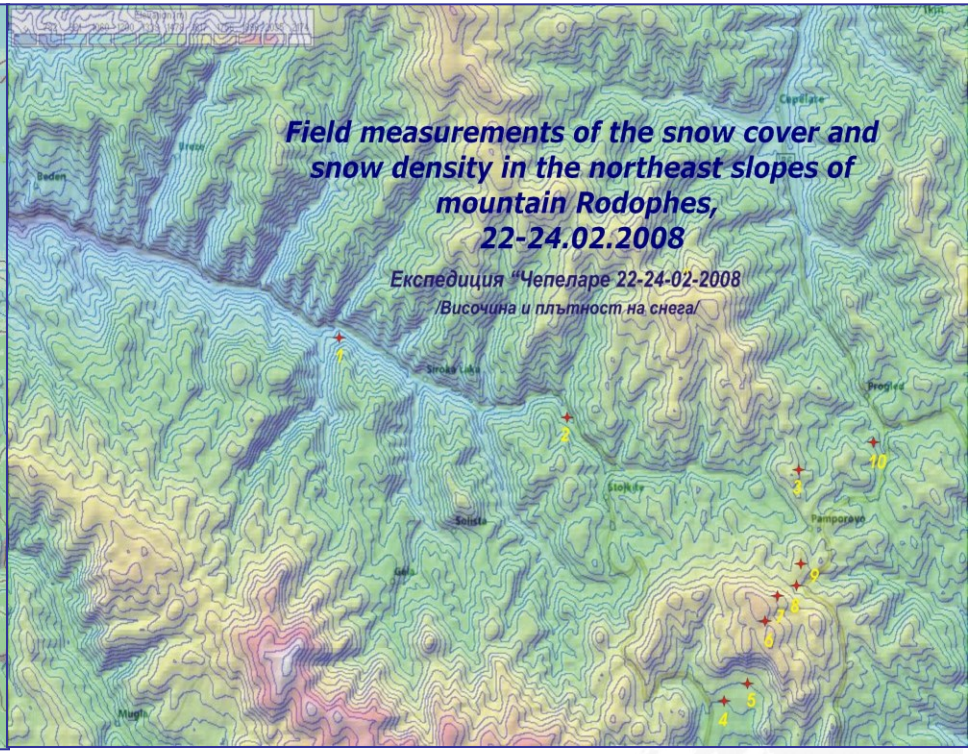
b. *and in field campaigns*

Points	Latitude	Longitude	Altitudde, m	snow cover, cm	Mean density, gr/cm^3	air temperature, ^{o}C
1	41 50 603	23 29 324	970	17	0,317	5.0
2	47 47 984	23 26 422	1635	62	0,255	0.0
3	41 46 436	23 26 489	1916	72	0,287	2.2
4	41 45 954	23 26 385	2226	140	0,276	0.0
5	41 45 440	23 26 082	2543	175	0,335	0.0

EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

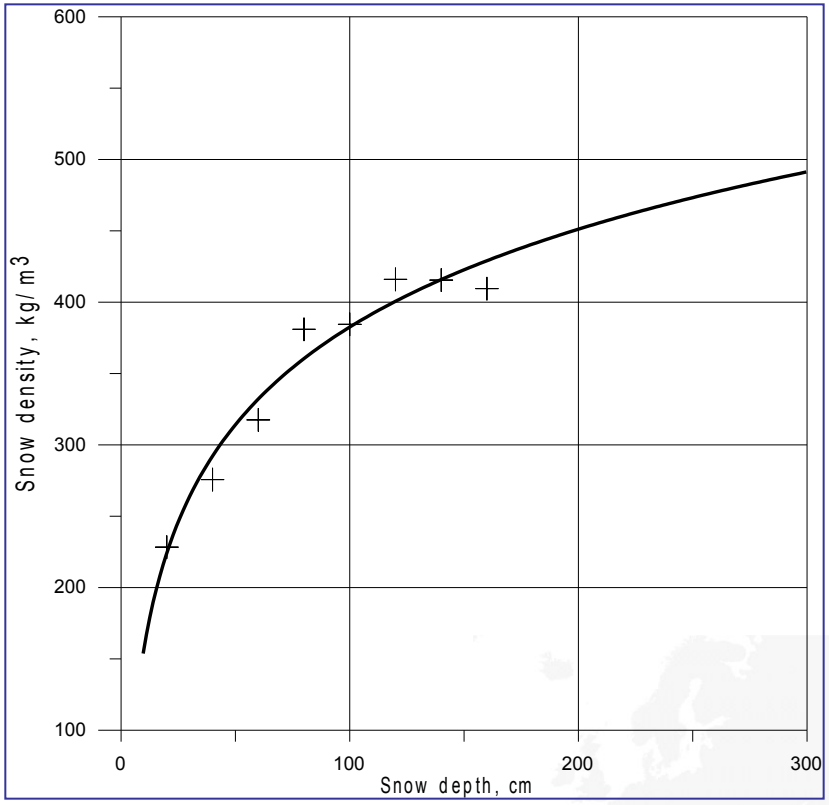
Further examples of the measurements from the field campaigns in the mountain regions of Bulgaria





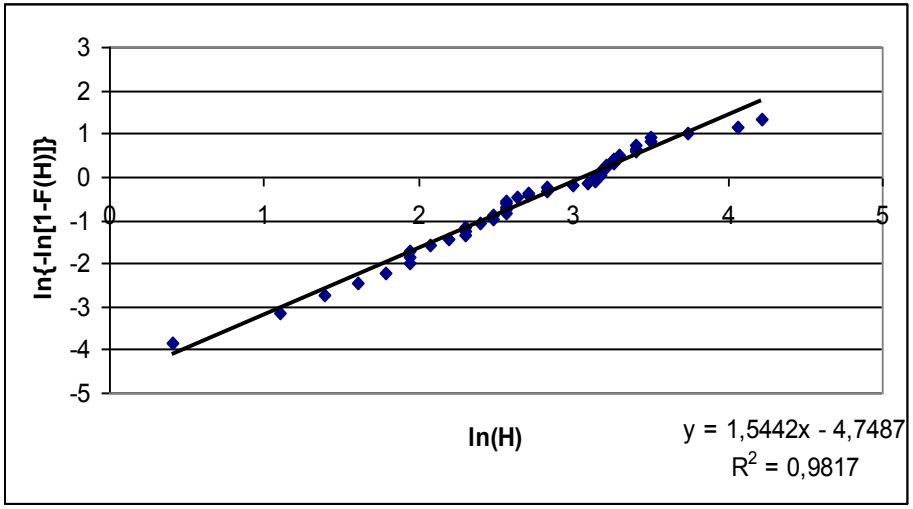
EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

Further examples of the measurements from the field campaigns in the mountain regions of Bulgaria

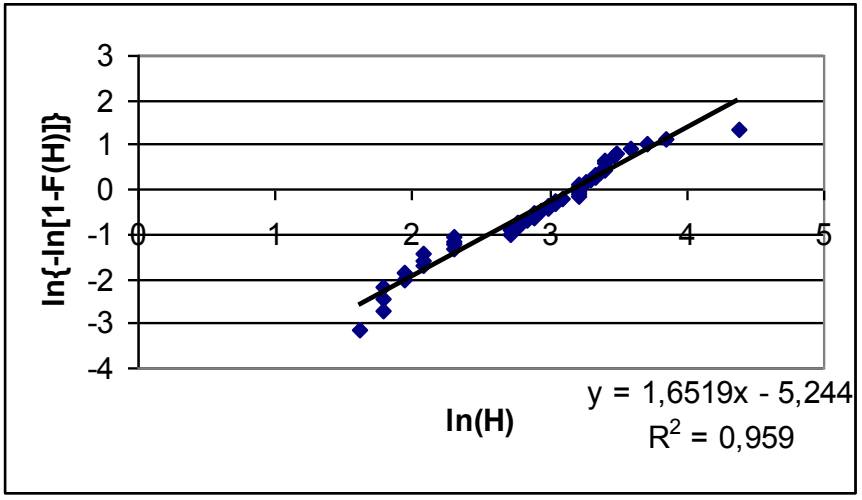


EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

Examples of the best fitting regression line



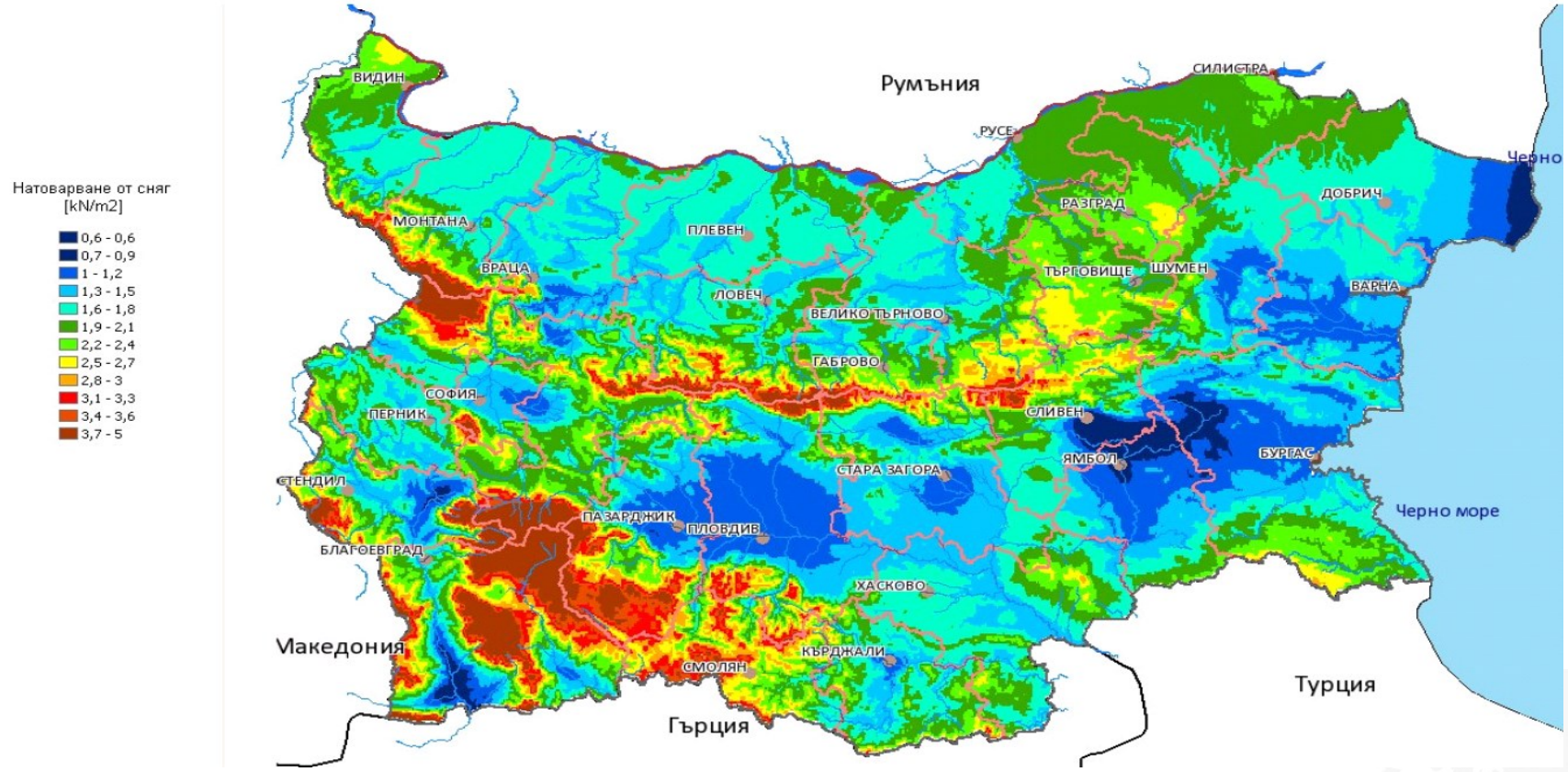
Station Gospodinci – Weibull best fit regression line



Station Goleshevo – Gumbel best fit regression line

EN 1991-1-3 Snow loads – elaboration of the snow load map for Bulgaria

The snow load map



EN 1991-1-4 Wind actions – elaboration of the wind load map for Bulgaria

Main goals

- to determine the characteristic values of the wind velocity $v_{b,0}$ and velocity pressure q_0 for Bulgaria;
- to estimate relations for estimation of other representative values (values with different MRI);
- to check for consistency at the national borders.

EN 1991-1-4 Wind actions – elaboration of the wind load map for Bulgaria

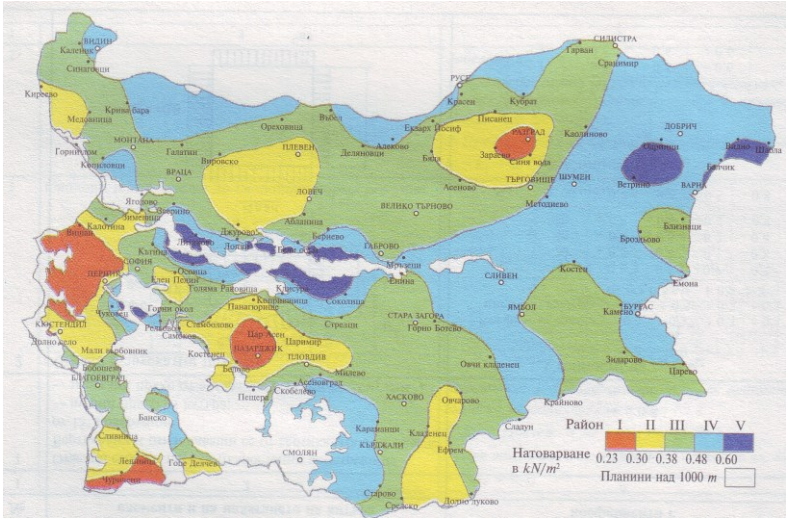
Definitions and methodology

- The definition of characteristic value is the same as for the snow.
- As well as the statistical methodology for estimation of these values

EN 1991-1-4 Wind actions – elaboration of the wind load map for Bulgaria

Background research for wind load maps in Bulgaria

- The first map for wind load was developed in 1978;
- In 2004 a new transient standard according to EN-1991-1-4 was adopted.



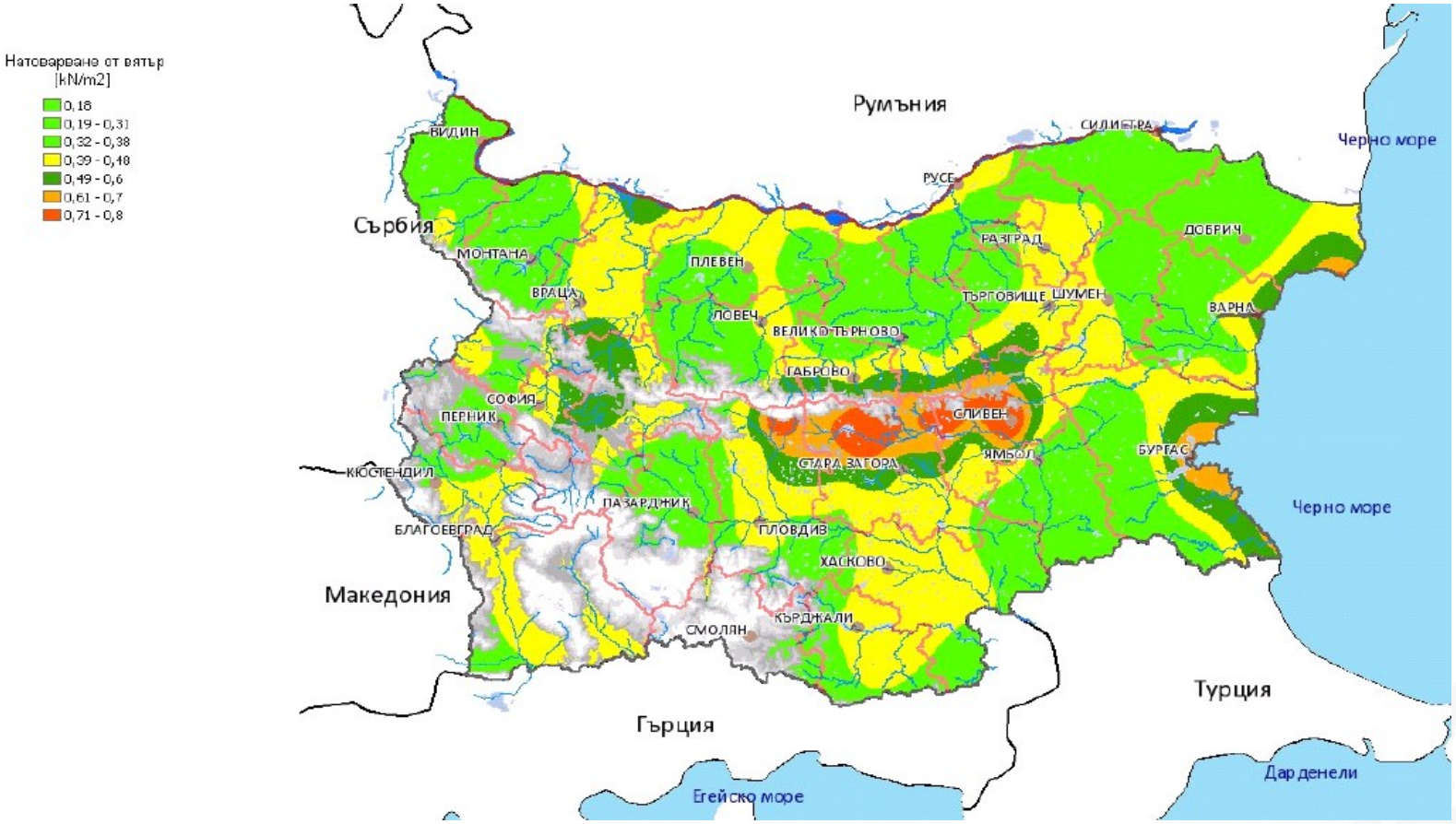
EN 1991-1-4 Wind actions – elaboration of the wind load map for Bulgaria

Data and period of investigation

- *Data from 150 meteorological stations for the wind speed at 10 m above ground;*
- *more than 50 years;*
- *accepted terrain category – II from the Table 4.1 of the EN 1991-1-4 Wind actions.*

EN 1991-1-4 Wind actions – elaboration of the wind load map for Bulgaria

Map of the characteristic wind load



EN 1991-1-5 Thermal actions – elaboration of the maps for Bulgaria

Main goals

- to determine the characteristic values of the extreme temperatures (maximum and minimum shade air temperature – Tmax and Tmin) for Bulgaria;
- to elaborate maps for these values for both temperatures;
- to recognize the regions with very low/high air temperatures;
- to conduct an experimental investigations for assessment of temperature changes in buildings.

EN 1991-1-5 Thermal actions – elaboration of the maps for Bulgaria

Definitions and methodology

- The definition of characteristic value is the same as for the snow and wind.
- As well as the statistical methodology for estimation of these values.

EN 1991-1-5 Thermal actions – elaboration of the maps for Bulgaria

Data and period of investigation

- The number of the used stations is 125 and the investigated period is 1950–2006.
- One averaged gradient for the change of the maximum shade air temperature with the altitude was used:

$$T_{max}^{50} = -0.0096H + 47.442;$$

- The averaged gradient for the change of the minimum shade air temperature with the altitude above 1000 m was estimated as:

$$T_{min}^{50} = -0.0053H - 18.77$$

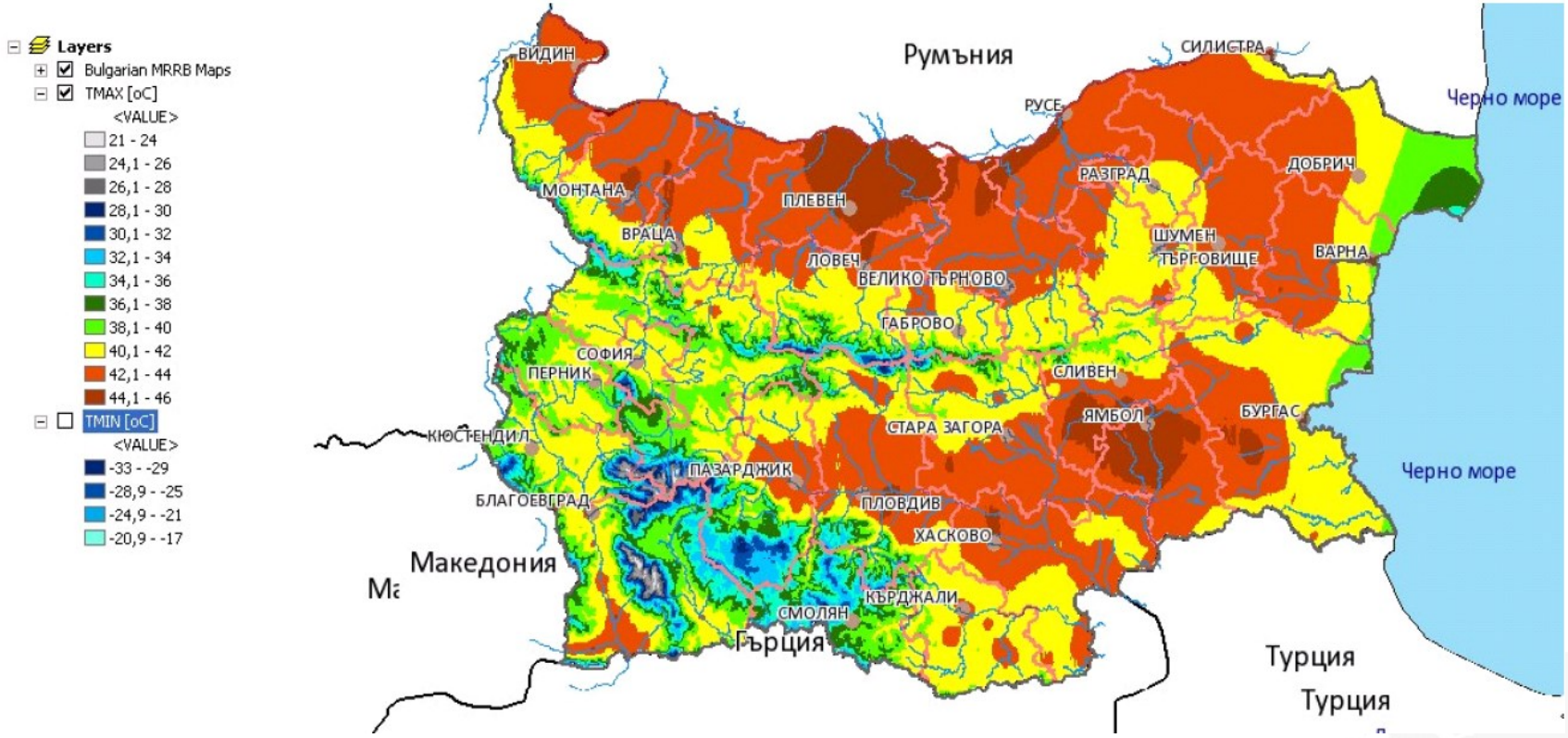
EN 1991-1-5 Thermal actions – elaboration of the maps for Bulgaria

Regression model for the dependency of the air temperature on the altitude

- Tmax_elev = -0.006*elev + 44.7 for 100<elev<1000 m, r_2=0.64;
- Tmax_elev = -0.010*elev + 47.9 for elev>1000 m; r^2=0.95
- Tmin_elev = -0.005*elev + 20.1 for elev > 800 m, r^2=0.82

EN 1991-1-5 Thermal actions – elaboration of the maps for Bulgaria

Map of the characteristic values for the yearly maximum shade air temperatures



EN 1991-1-5 Thermal actions – elaboration of the maps for Bulgaria

Map of the characteristic values for the yearly minimum shade air temperatures

Thank you for your attention