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**ATLAS**  
**WEATHER HAZARDS in BELARUS**

Scientific Publication

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The Atlas contains maps with the most widespread weather hazards registered in Belarus from 1975 till 2015. The authors provide short description and quantitative criteria for each weather phenomenon which are defined according to the regulatory requirements of the Republic of Belarus. The main source for information in the Atlas is the data provided by the Center of Hydrometeorology, Radioactive Contamination Control and Environmental Monitoring of the Republic of Belarus which are published in climate reference-books, meteorological monthly bulletins, and analytical reviews.

The Atlas might be of interest for the scientists and experts in meteorology, climatology, geo-ecology, etc. who study climate fluctuations and their consequences. It can be used in curricula for international programs of academic mobility and student exchange or academic projects of double degrees at partner universities to train undergraduate students, Master Degree and Ph.D. students in different research areas.

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## Introduction

The Republic of Belarus lies in the western part of East European Plain in the catchment area of the Pripyat, the Neman, the Viliya, the West Dvina, and the Dnieper Rivers. It covers 207,600 km<sup>2</sup> and stretches for 650 km from west to east and 560 km from north to south. Its absolute elevation varies from 80 m in the Neman basin on the border with Lithuania to 345 m (Dzerzhinsk) on the Minsk Upland. The mean elevation is 160 m.

The territory of Belarus is a part of the Russian Plain. The terrain is predominately plain with flat and undulating flatlands. The northern territory is a Belarus lake district with elevation from 120–170 m to 250 m. The western and central parts of Belarus are uplands with 200–300 m elevation. These areas comprise a third of the country. In the south there are moraines and aqueoglacial plains and a flat swamped alluvial plain of Polessie.

Belarus is considered an area with sufficient humidity, its average annual precipitation being 600–700 millimetres. The highest annual precipitation is in Novogrudok Upland – 769 mm. Deviation from the norm could be 100–200 mm in particular years. Absolute maximum of precipitation was registered in the town of Vasilevichi in Rechitski district (1115 mm) while absolute minimum was in Bragin (298 mm).

70% of total annual precipitation coincides with the warm season (April – October) when there are a lot of showers. During a year most precipitation falls in July (75–95 mm), the least is in February (30–40 mm). Absolute maximum was registered in August (329 mm) in Pruzhany. Sometimes precipitation which is normal for a few months can fall in a few days. In particular years there is no precipitation for a month or longer.

There is a necessity to study weather hazards that may occur in Belarus. Hydro-meteorological hazards in Belarus involve meteorological, agro-meteorological, and hydrological phenomena which are intensive and prolonged

enough to cause quite a lot of damage to the national economy and even can threaten people's well-being or life. These include poor visibility, low cloud cover, strong wind, glaze and hard rime, snowstorm, shower with much precipitation in an hour, heavy rain, squall, whirlwind, thunderstorm, hail, freezing rain, upslope fog, etc. Strict definitions are provided for each meteorological hazard. They establish utmost limits for the intensity of each weather phenomenon. If a critical limit is reached or overreached, a weather station informs about a weather hazard.

According to, hydro-meteorological phenomena are the result of the processes taking place in the air, on the land surface and the objects over it, in the surface water (rain, snow, hail, glaze, hoar frost, fog, dew, snowstorm, dust storm, thunderstorm, squall, whirlwind, ground frost, drought, spring high water, flood, freshet, ice, river ice breakup, etc.).

The criteria characterizing meteorological hazards are defined in [1, 2, 7] as follows:

- Severe frost – decrease of minimal temperature up to  $-35^{\circ}\text{C}$  and below;
- Heat wave – increase of maximal temperature up to  $35^{\circ}\text{C}$  and above ;
- Heavy rainfall – falling of at least 50 mm precipitation in less than 12 hours;
- Heavy snowfall – precipitation that falls in the form of snow or sleet at more than 20 mm for less than 12 hours;
- Strong wind – a gust of wind of at least 25 m/s;
- Hazardous glaze ice and hard rime – glaze diameter on the wire of the ice accretion indicator is more than 20 mm, mixed type (glaze and hard rime or wet snow) is more than 35 mm;
- Thick fog – it lasts for at least 6 hours with visibility of less than 50 m;
- Severe snowstorm – a snowstorm with strong air gusts of at least 15 m/s that lasts for at least 12 hours;
- Dry wind (sukhovey) – air temperature is high for at least 3 days ( $25^{\circ}\text{C}$  or above in the day time) but relative humidity is low (less than 30% during the day)

with wind gusts up to 5 m/s or more (wind speed is calculated as mean within 2 or 10 min);

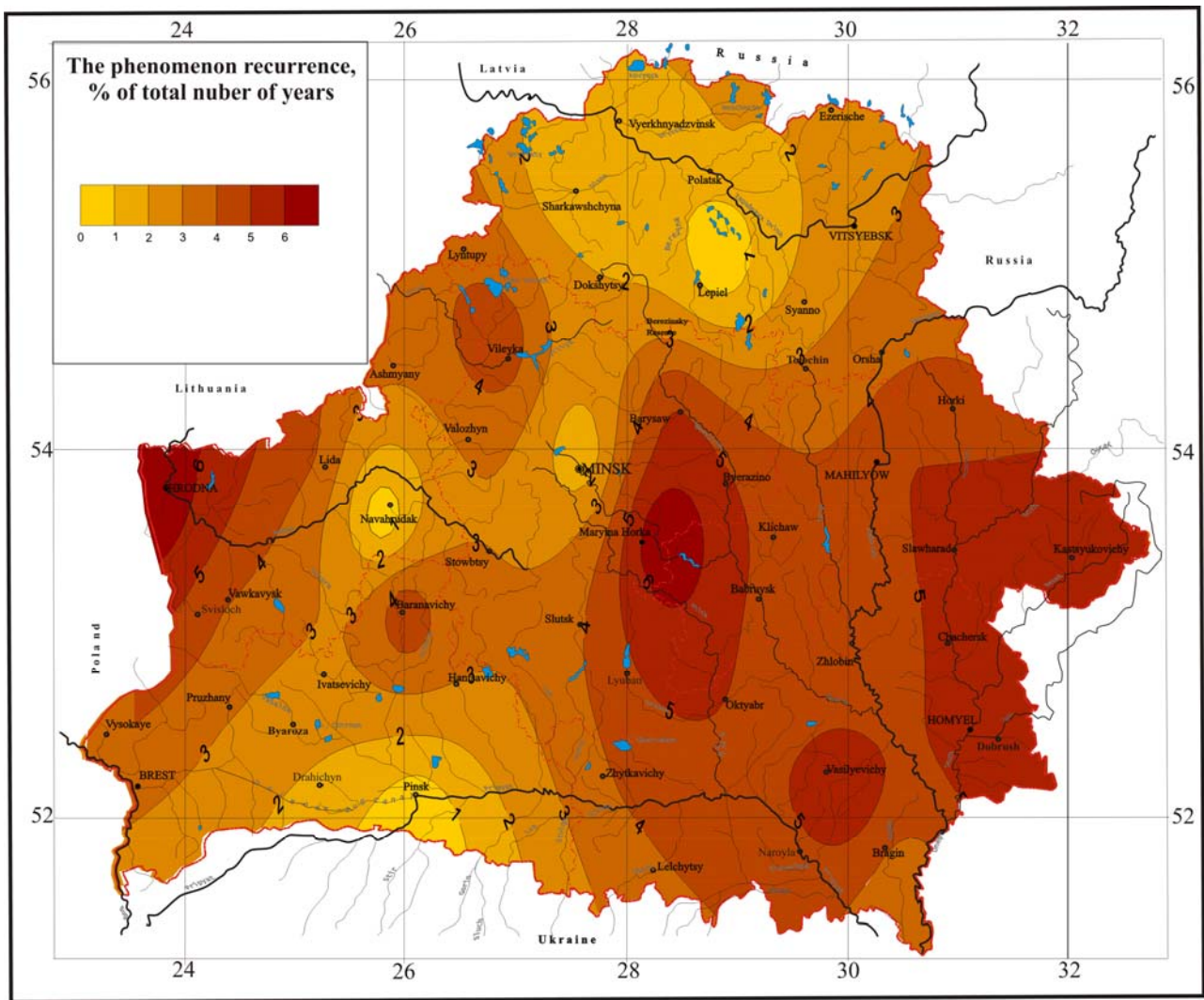
- Drought – precipitation is less than 5 mm per day for more than 30 days, with high air temperature (over 25 °C in the day time) during at least half of this period.

## Drought

Drought is a period of prolonged shortage of precipitation combined with high air temperature and low air humidity, which results in water balance disorders in plants and their further devastation. Droughts can be of atmospheric type, i.e. the air is short of precipitation but it has high temperature and low humidity; and of soil type, i.e. depletion of soil moisture that deprives plants of water supply.

Drought conditions are characterized by the lack of rainfall exceeding 5 mm per day for more than 30 days, with high air temperature (over 25 °C in the day time) during at least half of this period. A drought condition is a period when air temperature exceeds 25 °C with relative humidity less than 30 % for 5 consecutive days. Such conditions are recorded in Belarus almost annually. Droughts occur in Belarus any time from April to August.





Spatial distribution of droughts in Belarus, % years

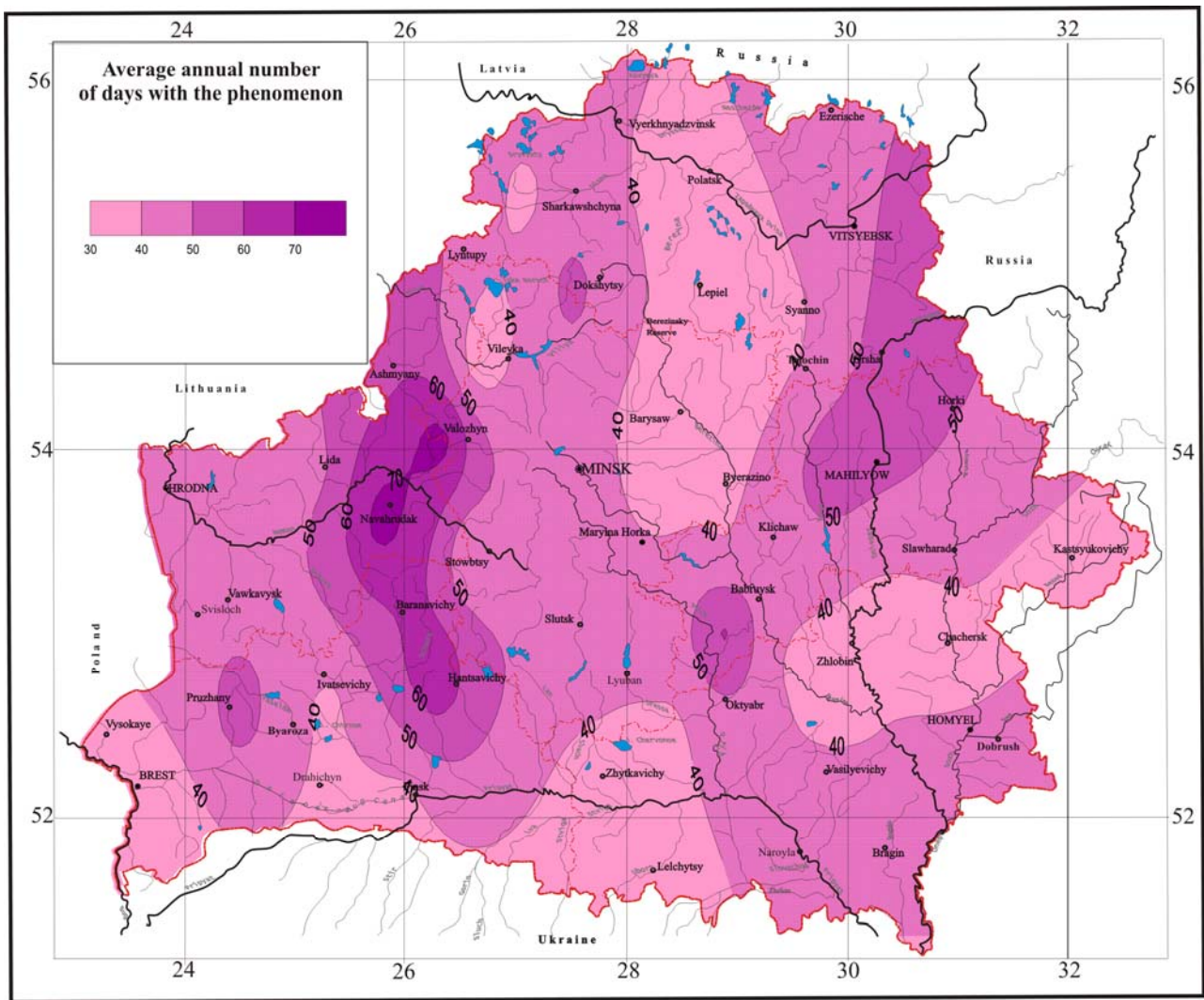




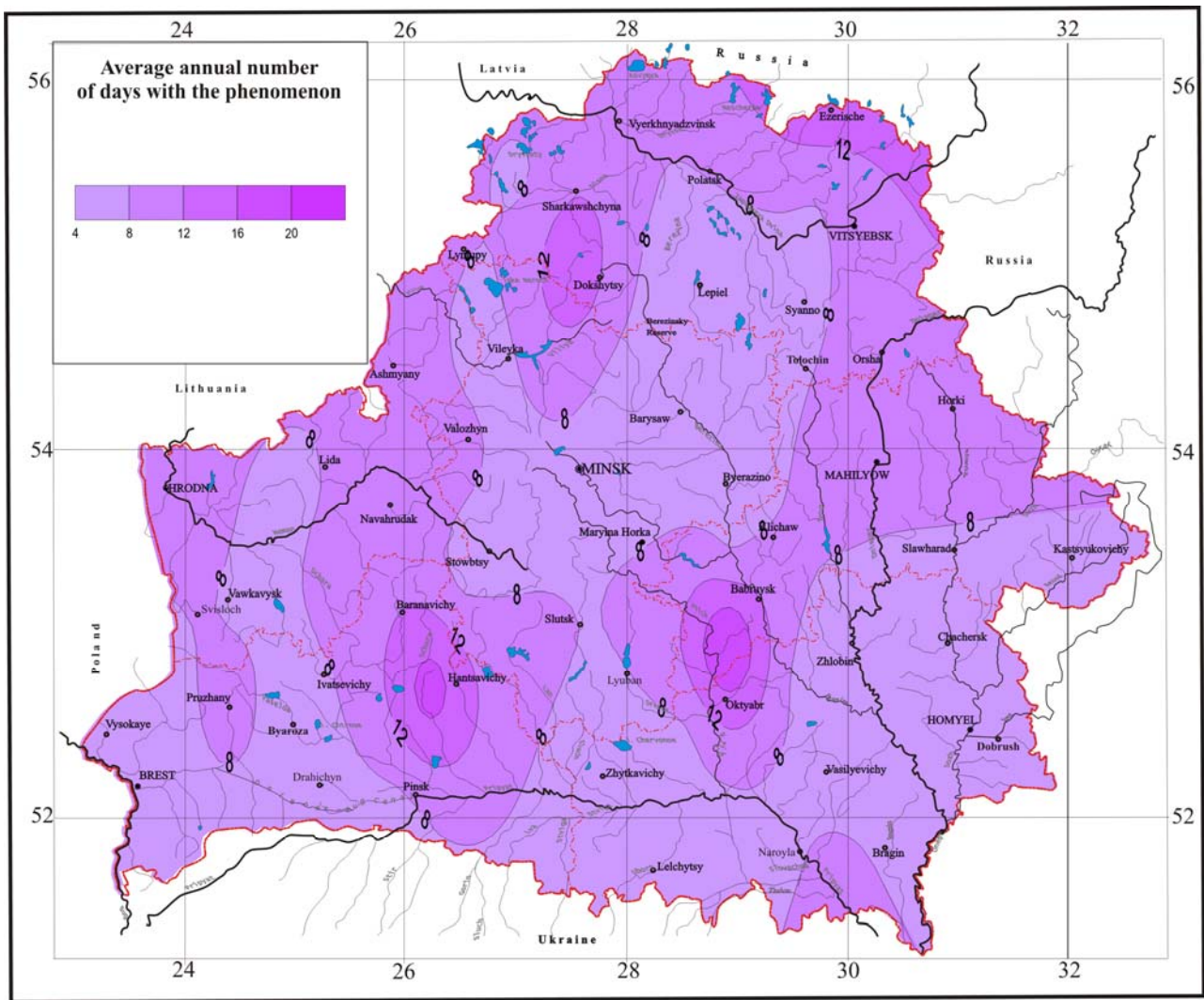
## Fog

Fog appears as a result of atmospheric condensation in the form of water droplets or ice crystals suspended in the air at or near the Earth's surface. It reduces visibility considerably. It can be classified as fog if horizontal visibility is less than 1 km, otherwise it is referred to as mist.

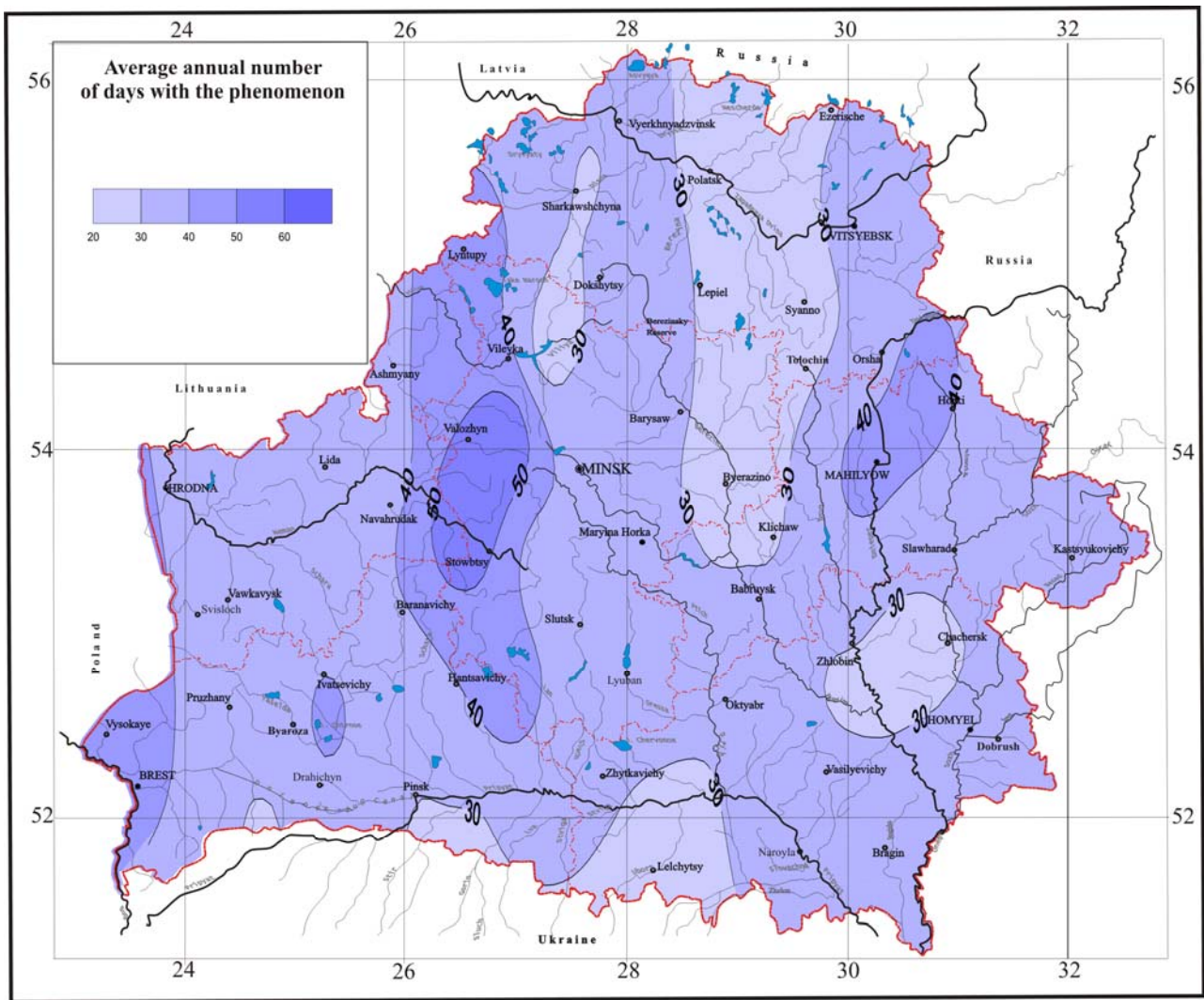




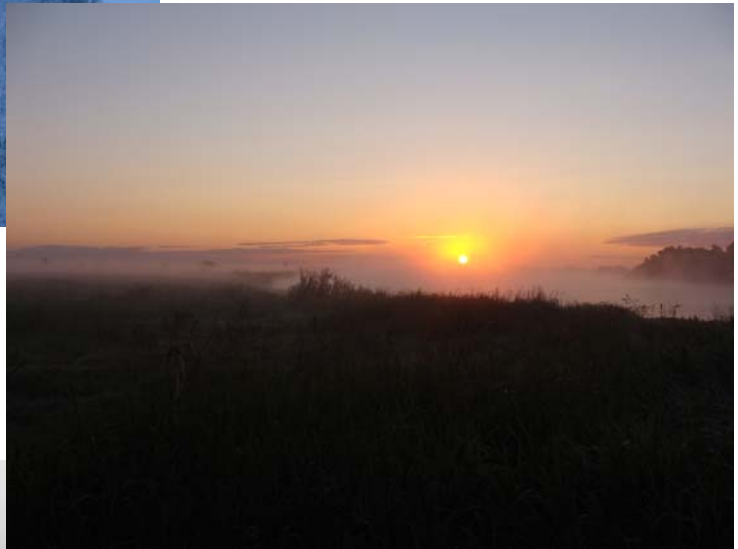
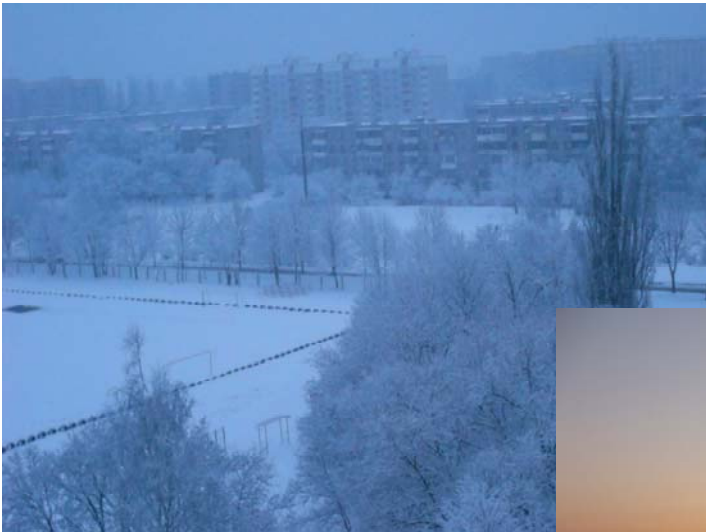
Spatial distribution of average annual number of days with fog in Belarus



Spatial distribution of average annual number of days with fog from May to August in Belarus



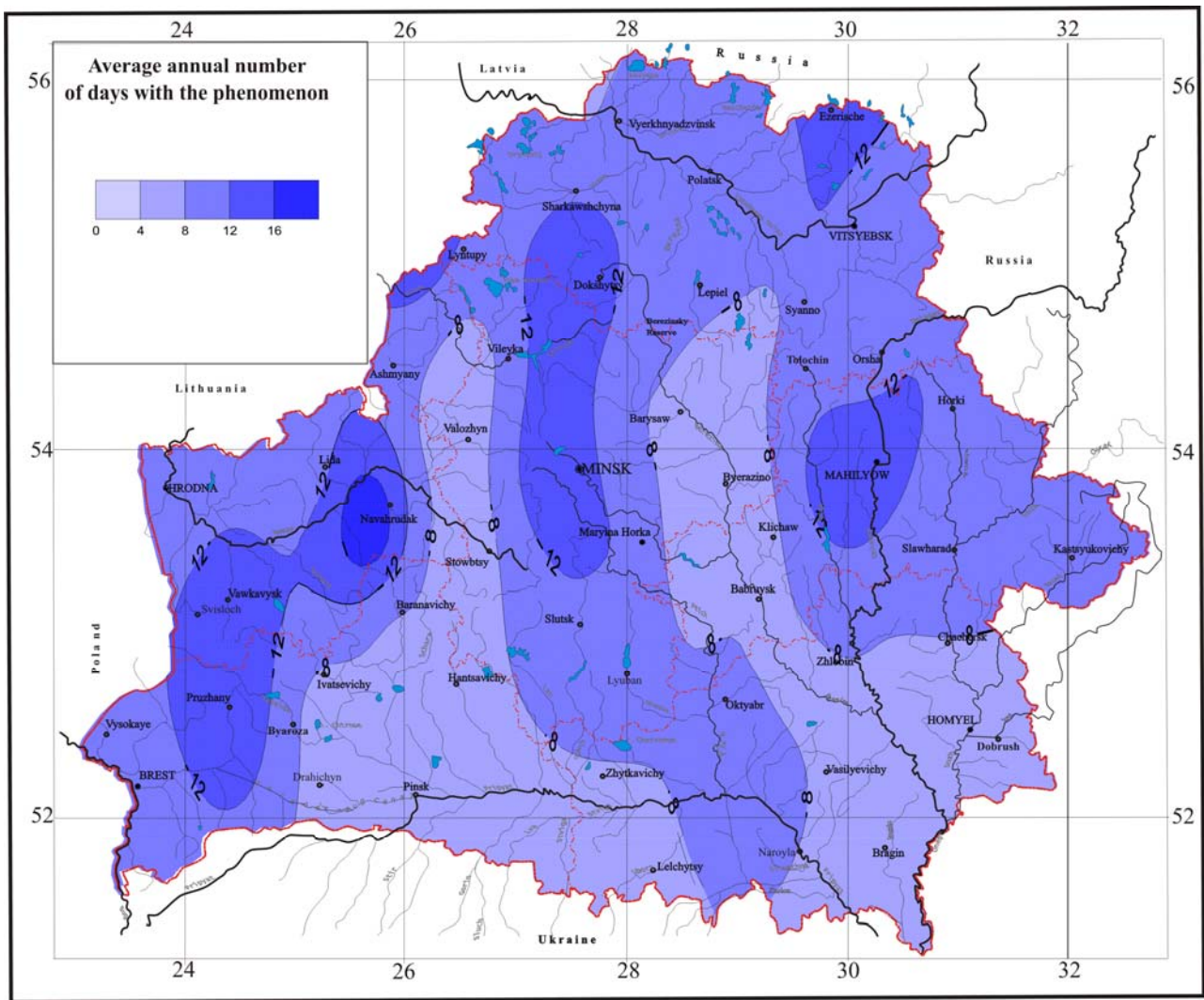
Spatial distribution of average annual number of days with fog from September to April in Belarus



## Glaze

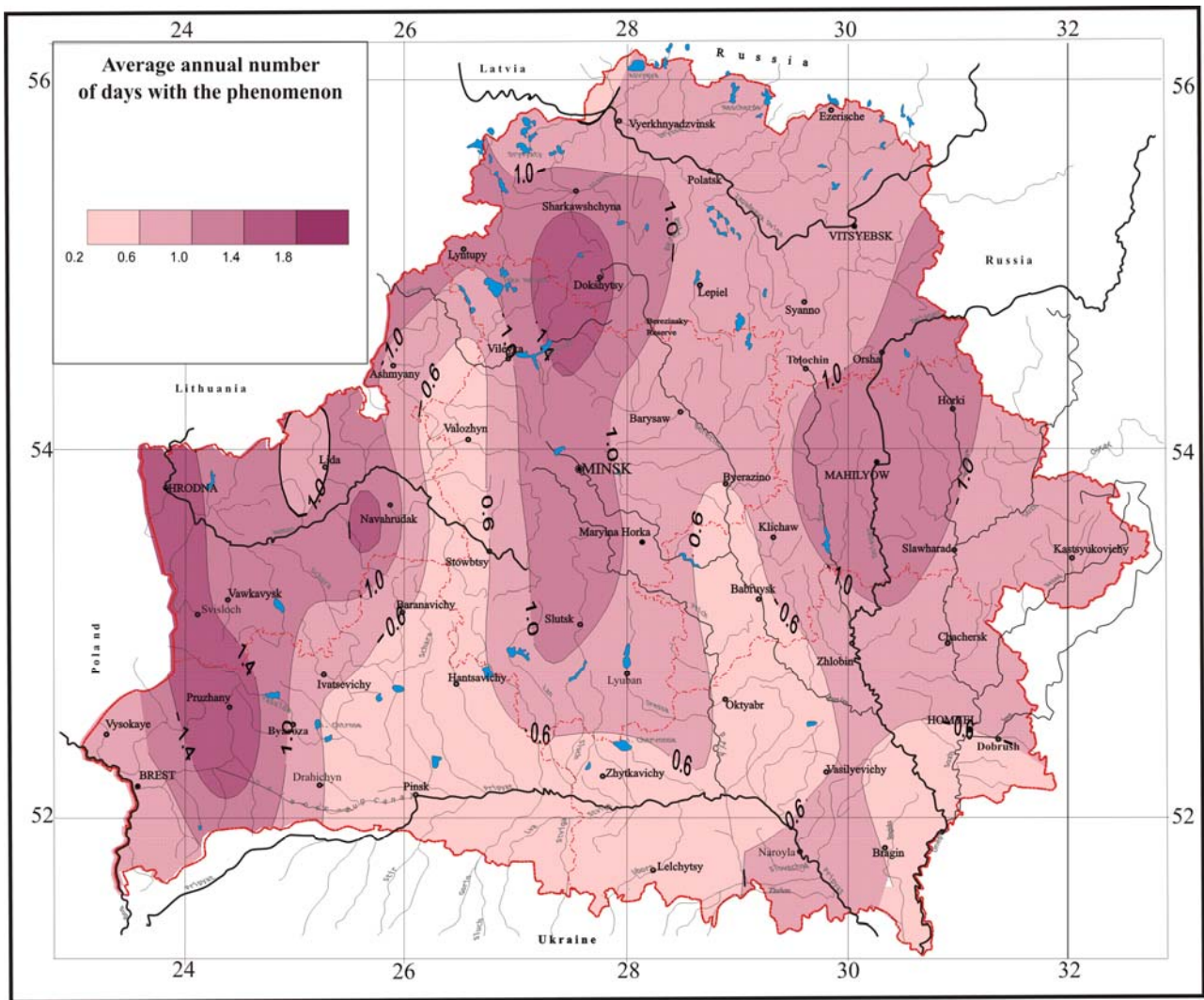
Glaze is a dense ice coating which forms from supercooled drizzle or fog droplets on the ground and on the surface of objects. Glaze appears as a result of warm and wet air advection. There are air-mass and frontal types of glaze. Air-mass glaze occurs when quite thick stratus clouds concentrate not only under inversion but also inside the inversion layer itself, with the temperature in the inversion being above 0 °C. Air-mass glaze forms at the temperatures of 0 to -10 °C, whereas frontal one is from 2 to -16 °C.



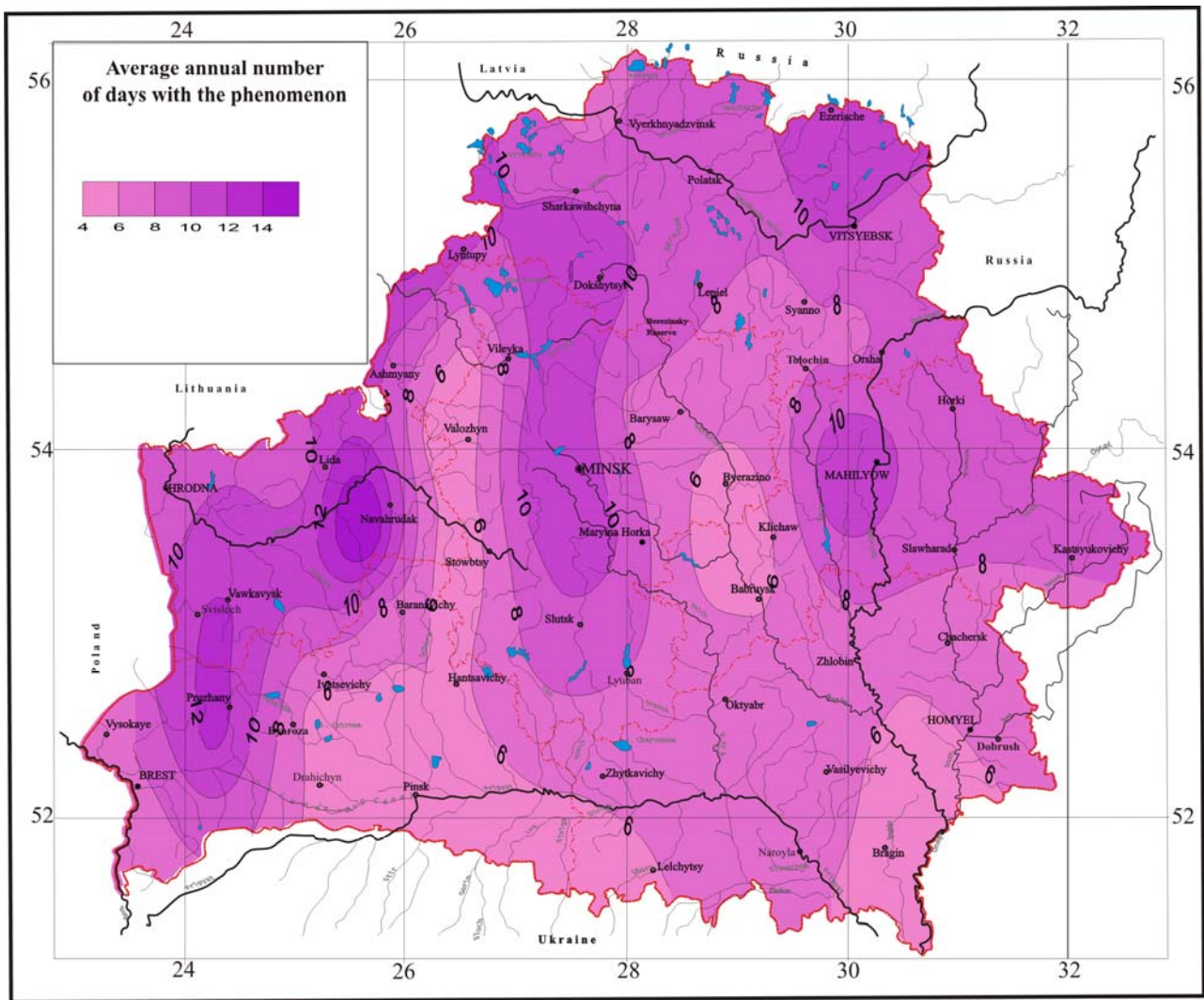


Spatial distribution of average annual number of days with glaze in Belarus





Spatial distribution of average annual number of days with glaze from March to October in Belarus



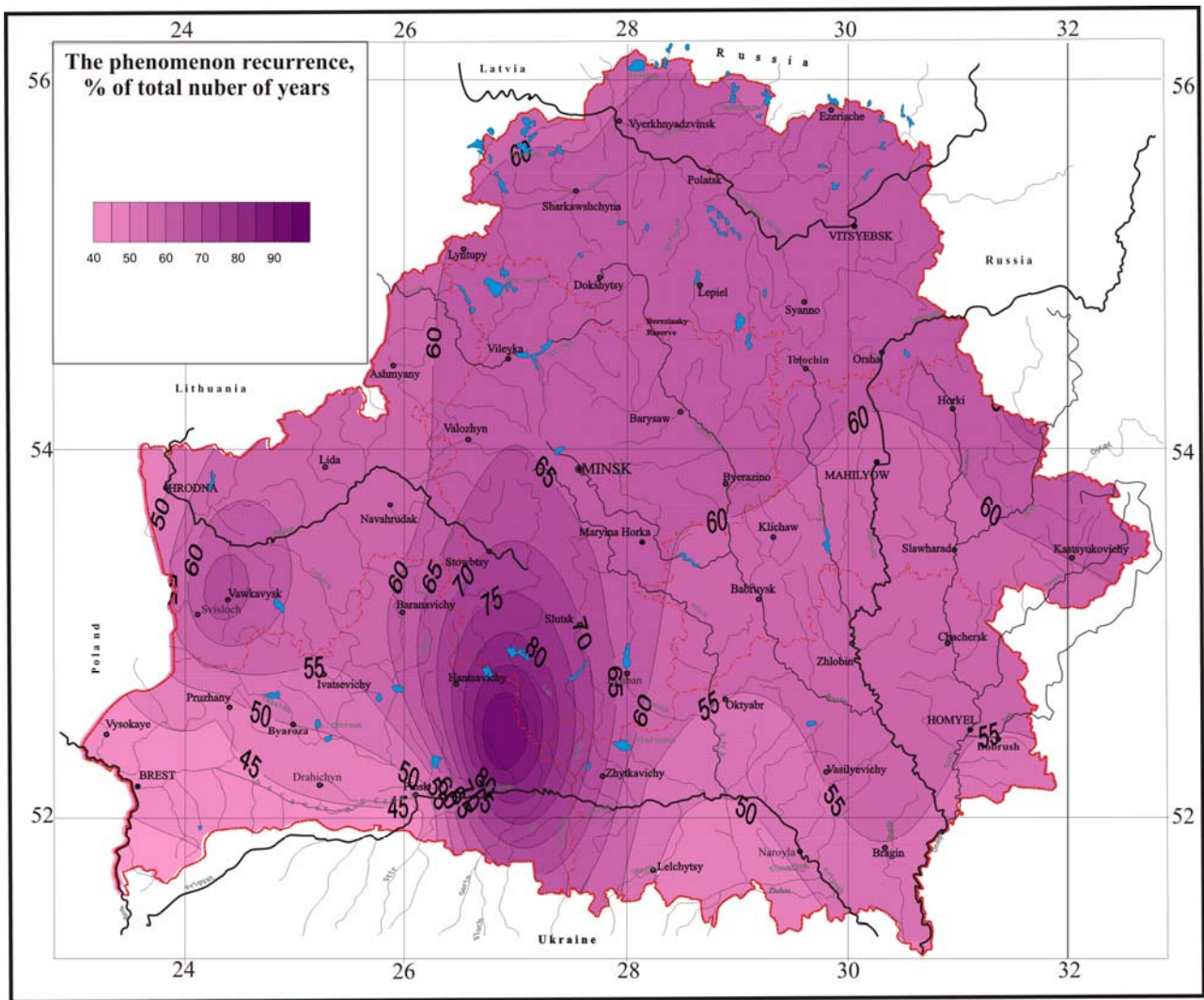
Spatial distribution of average annual number of days with glaze from November to February in Belarus



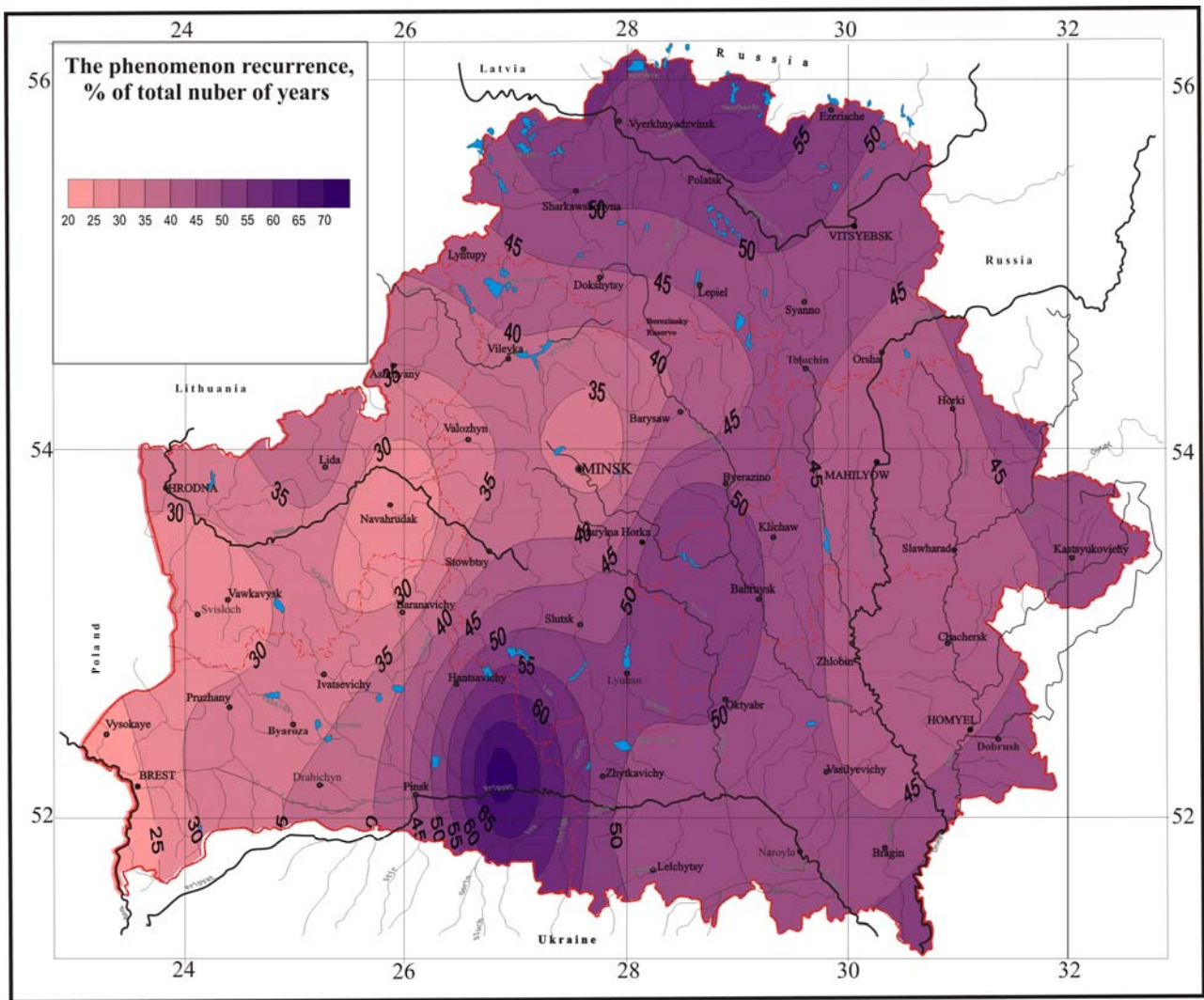
## Ground Frost

Ground frost refers to the condition when the temperature of air and/or ground surface decreases up to 0 °C and falls below 0 °C while average daily temperature remains positive. Ground frost is especially dangerous after average daily temperature has settled at 10 °C. Ground frost occurs in autumn and spring when average daily temperature is still or already above 0 °C.

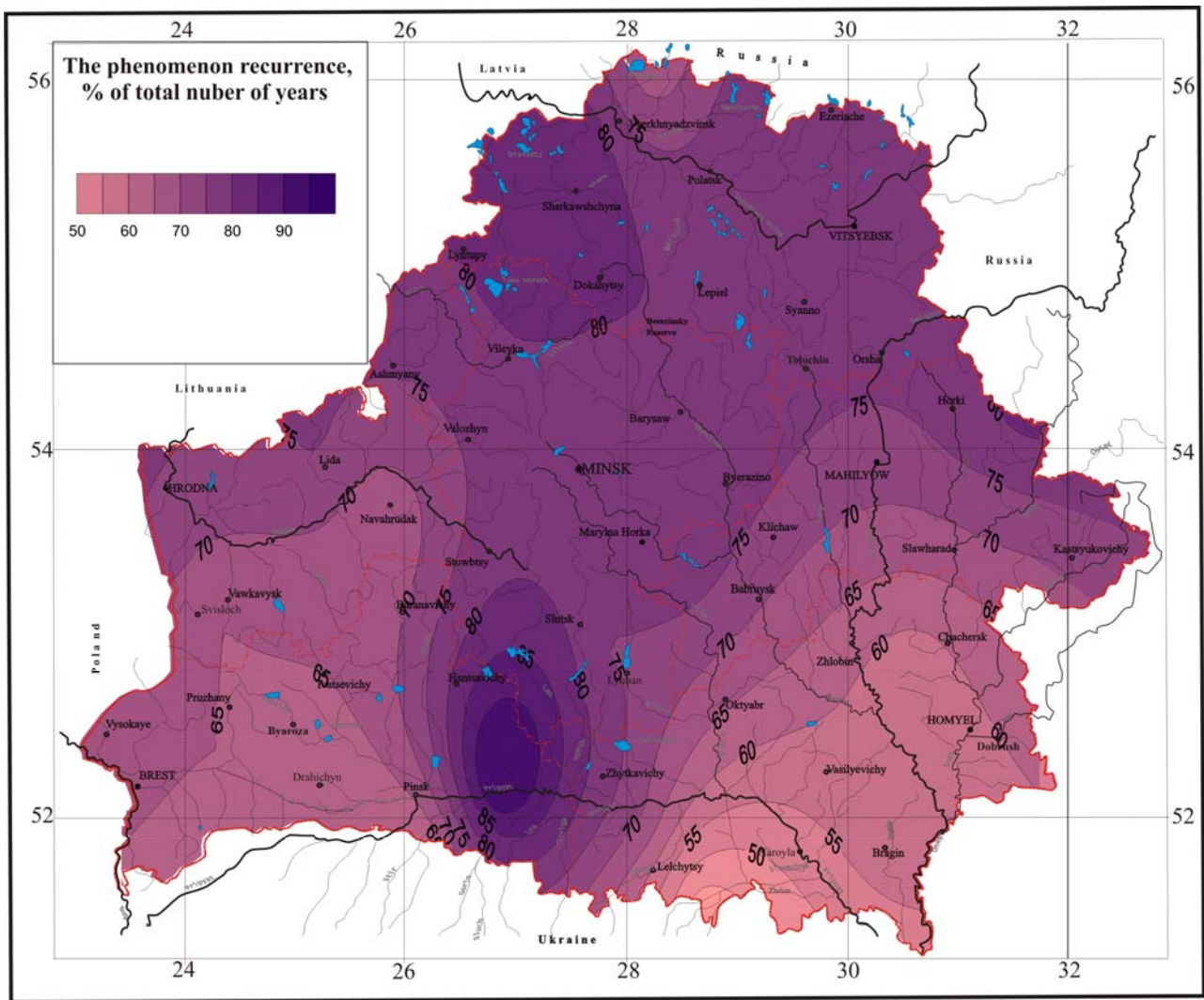




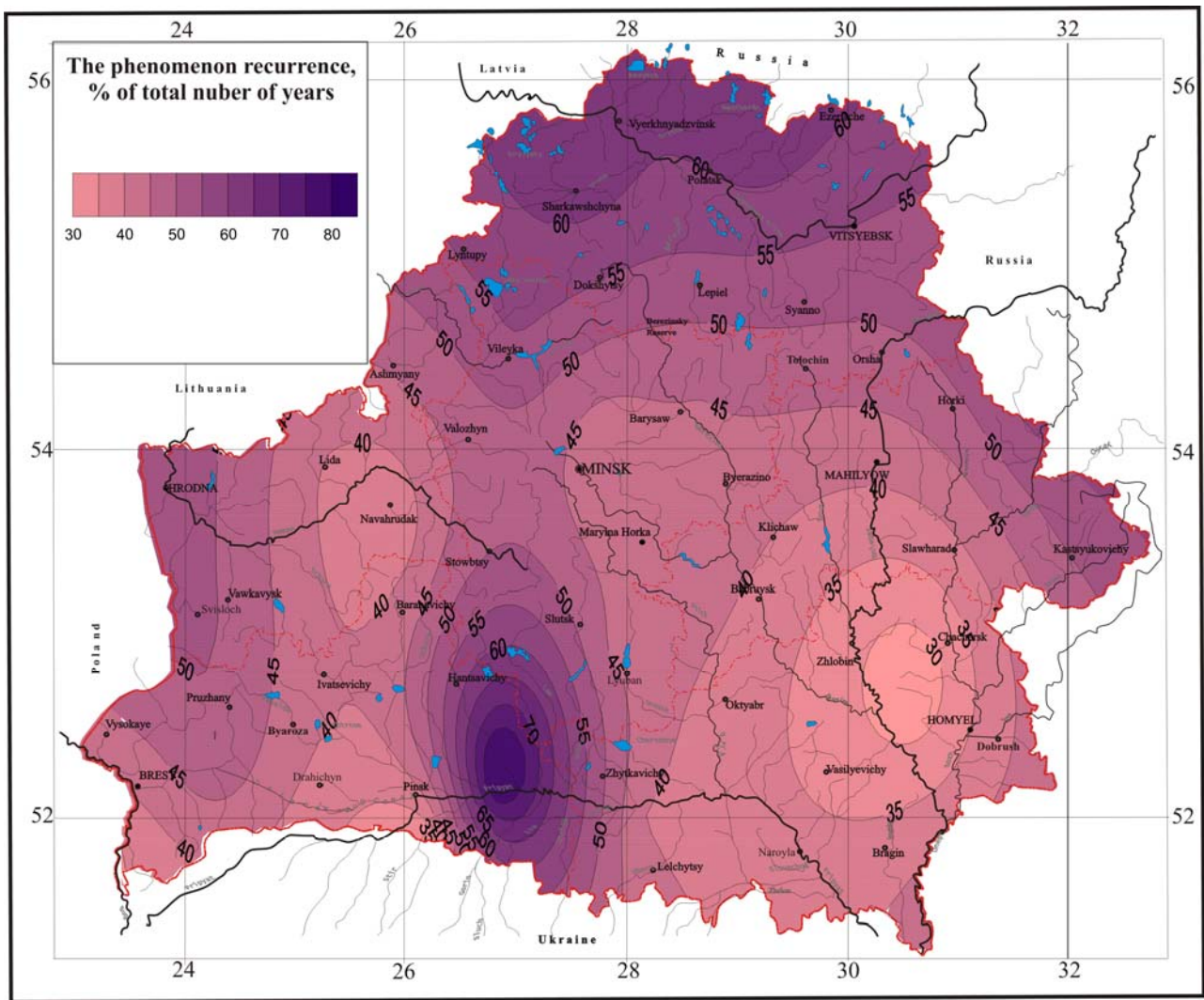
Spatial distribution of autumn frost before 30.09 at ground surface, % years



Spatial distribution of autumn frost after 30.09 at two-meter height, % years



Spatial distribution of spring frost after 30.04 at ground surface, % years



Spatial distribution of spring frost after 30.04 at two-meter height, % years

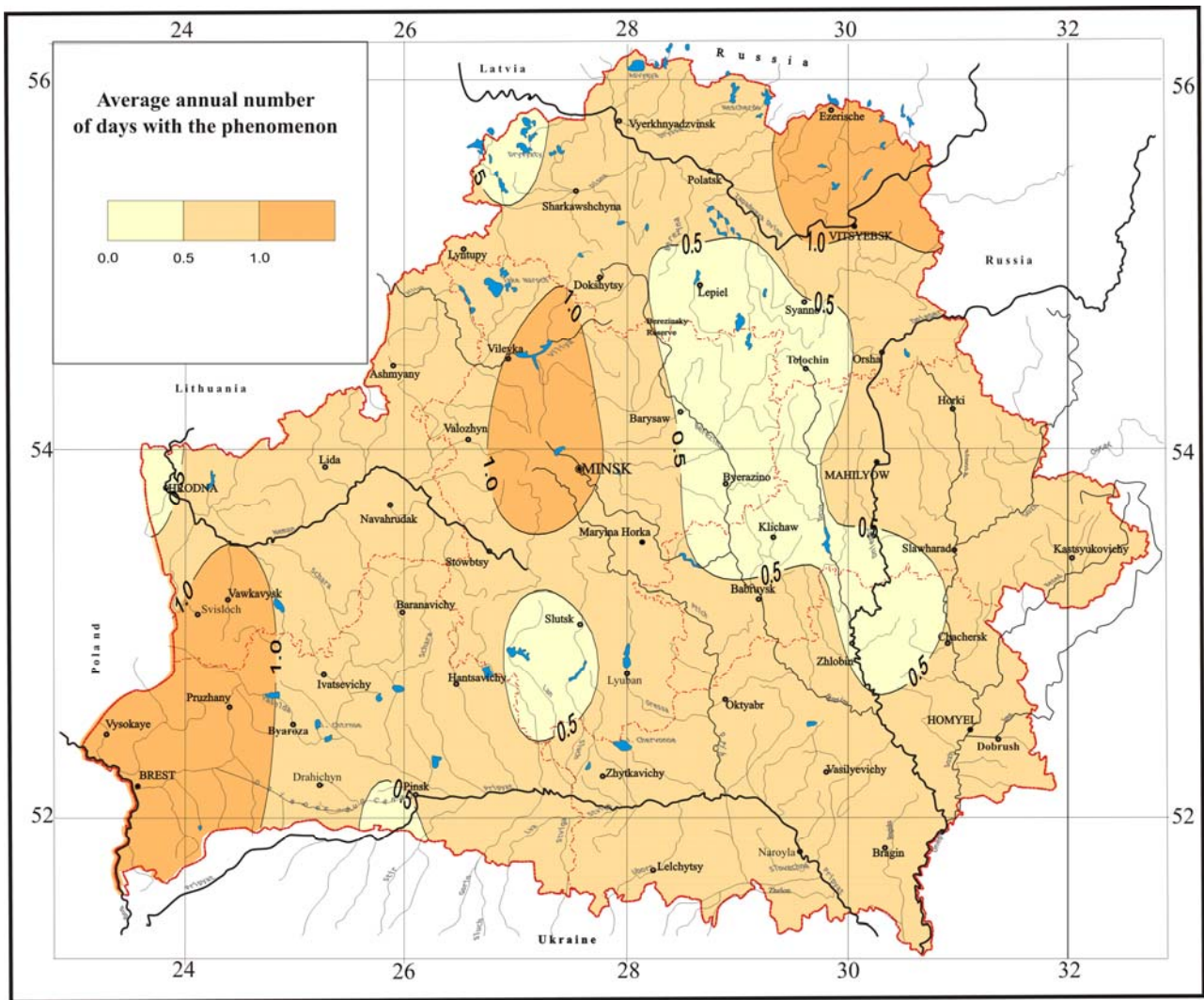




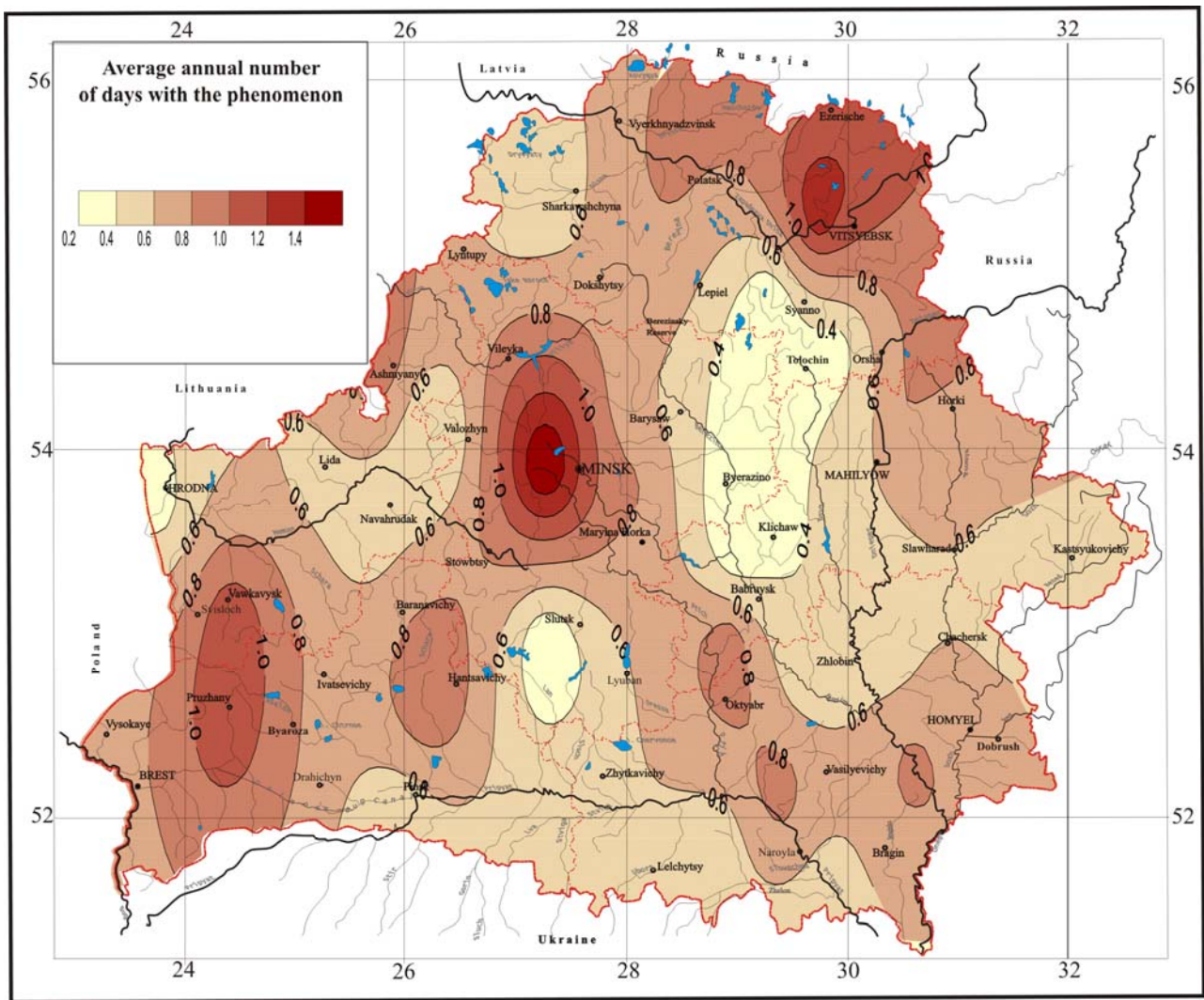
## Hail

Hail is a kind of precipitation in the form of dense ice balls or lumps measured between 5 mm and 15 cm in diameter. Hailstones usually fall with rainstorms in thunderstorms in a warm season. Sometimes hail can be so intense that the ground surface is covered with hailstone layer of 20–30 cm.

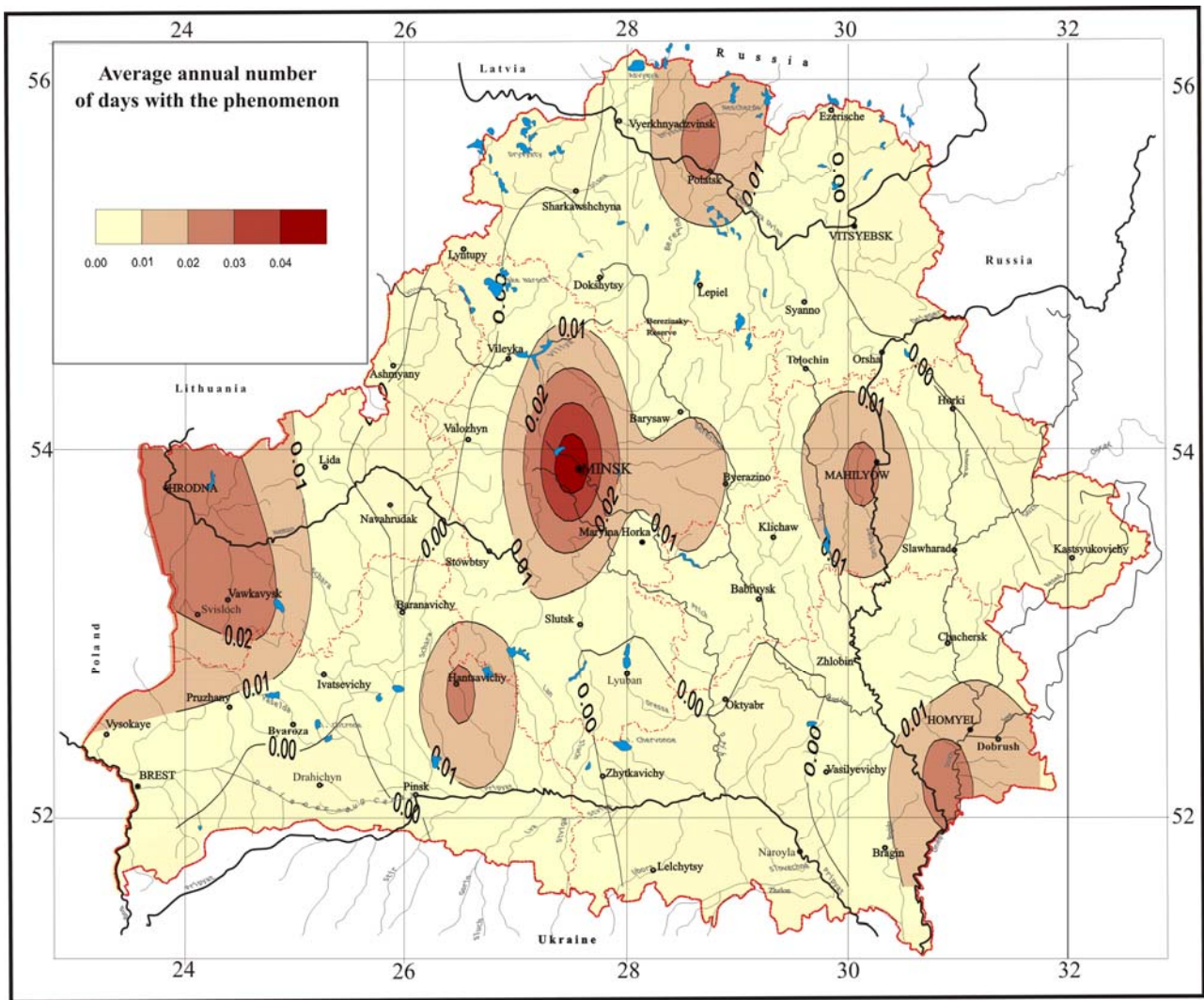




Spatial distribution of average annual number of days with hail in Belarus



Spatial distribution of average annual number of days with hail from March to October in Belarus

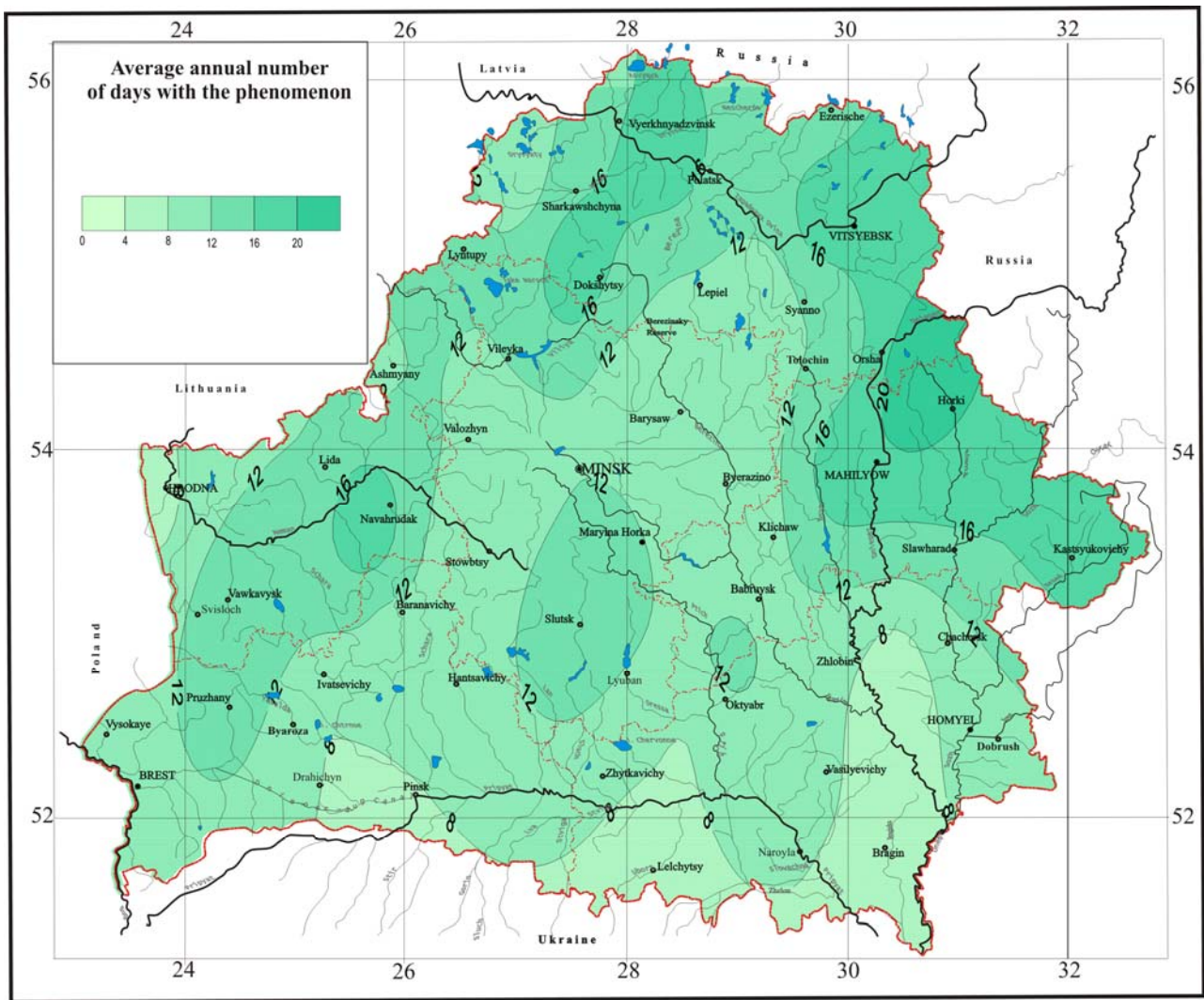


Spatial distribution of average annual number of days with hail from November to February in Belarus

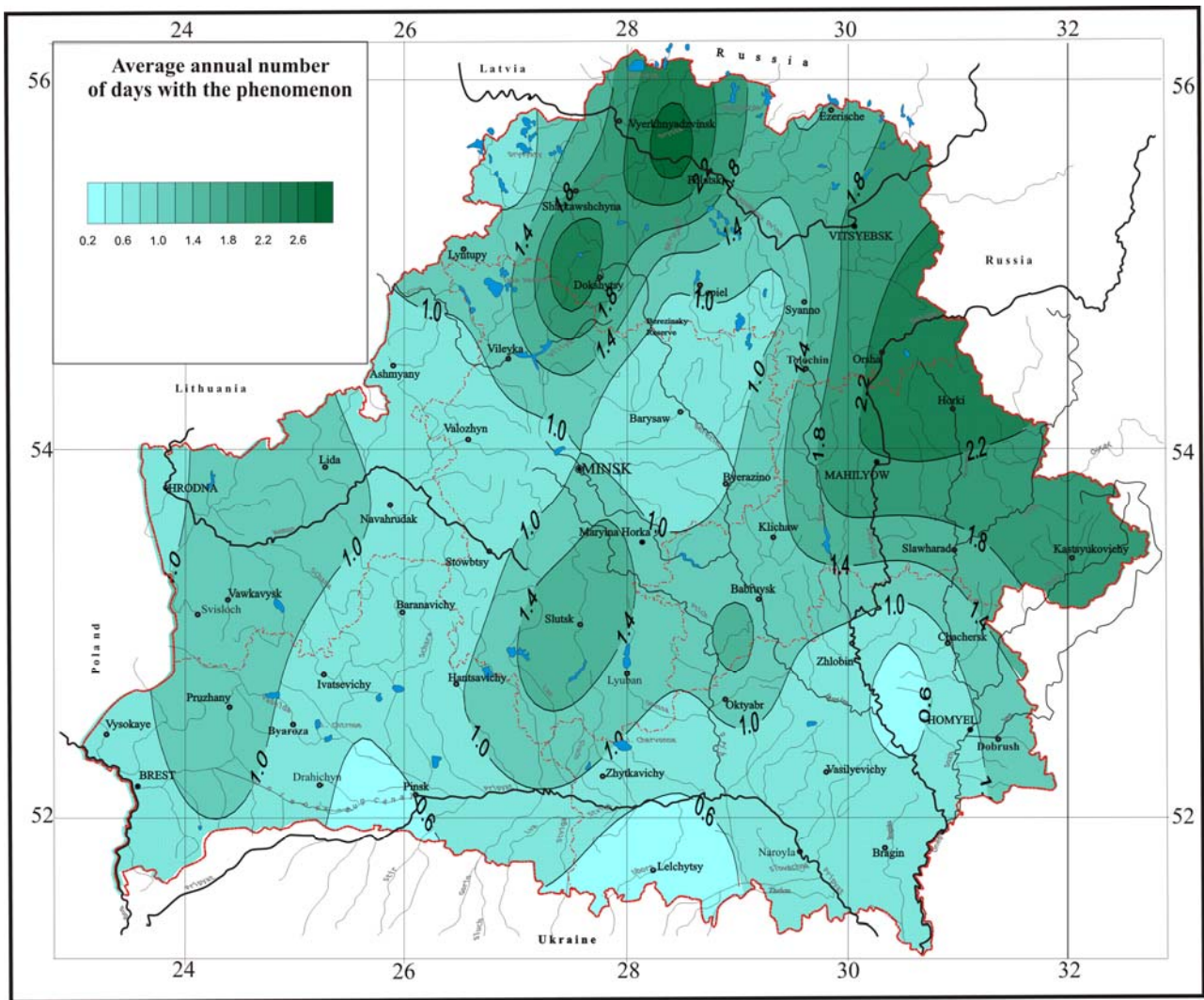
## Hard Rime

Rime is deposition of white ice that forms on trees, wires and other outer surfaces when the water droplets in light freezing fog or mist freeze, which is called soft rime. Hard rime results from super-cooled water liquid droplets of fog at air temperature of  $-15\text{ }^{\circ}\text{C}$ . Hard rime formations are difficult to shake off; they have a comb-like appearance, unlike soft rime, which looks feathery or spiky. Unlike glaze, rime mostly forms in anticyclones.



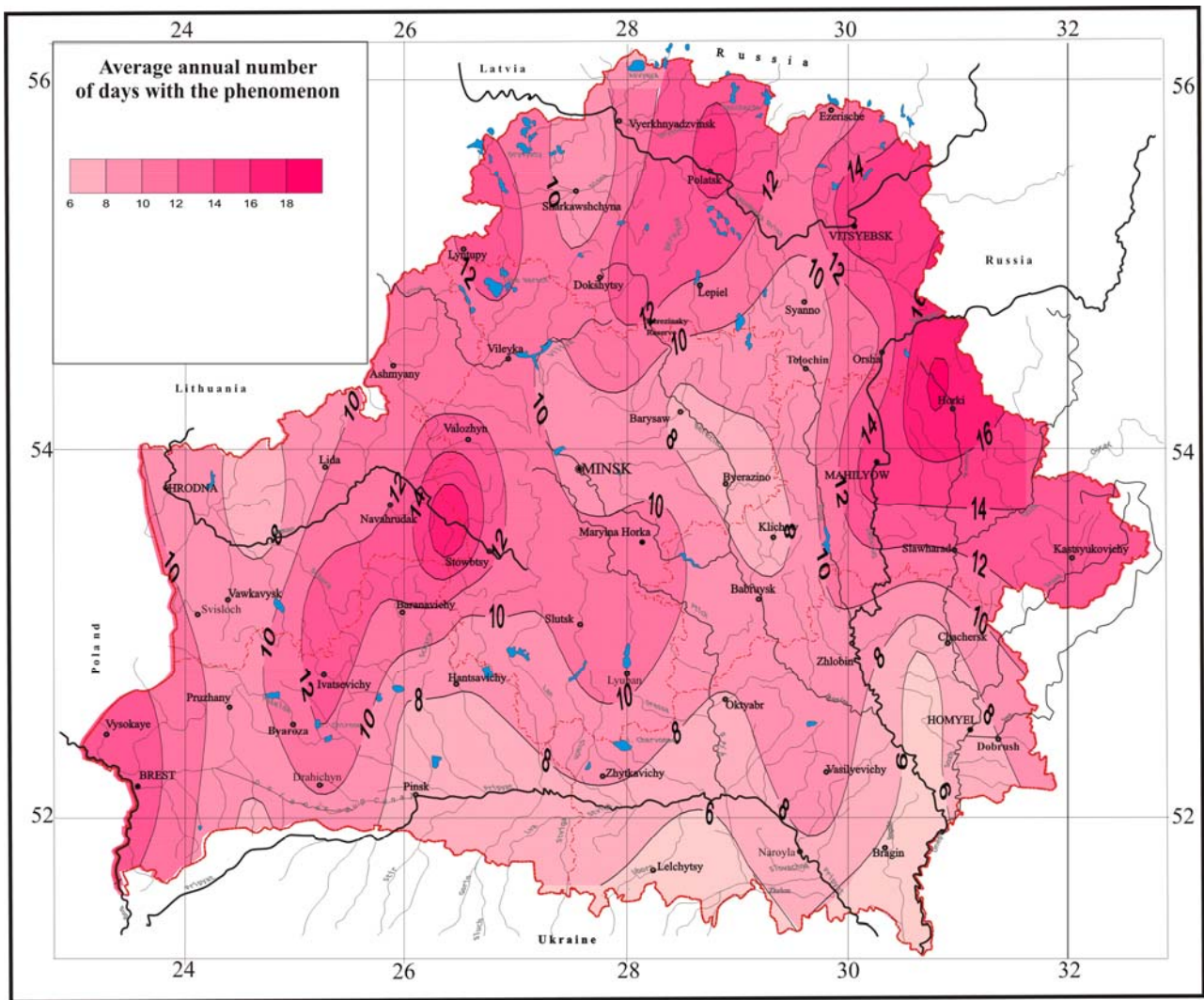


Spatial distribution of average number of days with hard rime in Belarus



Spatial distribution of average number of days with hard rime from March to October in Belarus



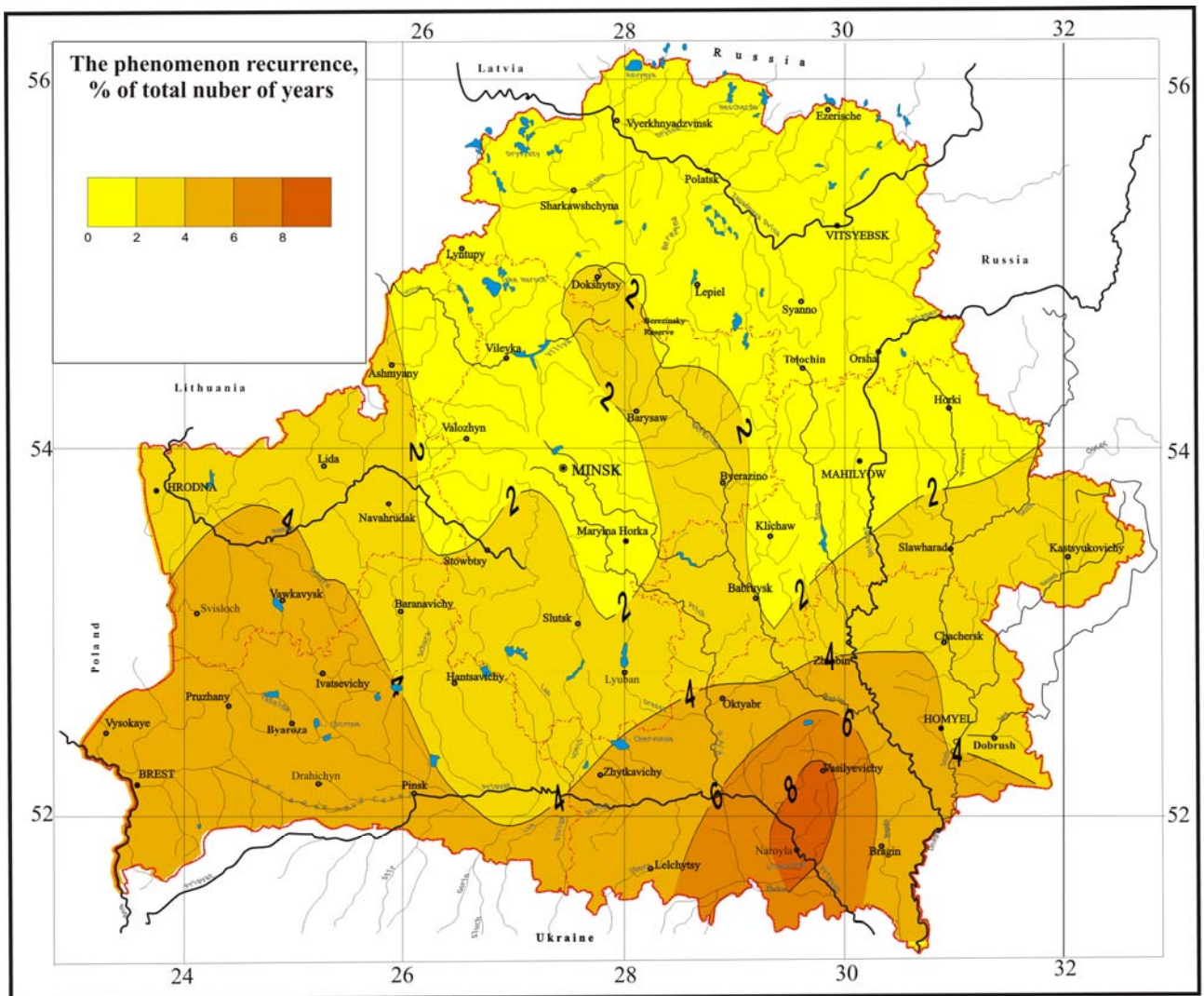


Spatial distribution of average number of days with hard rime from November to February in Belarus

## Heat Wave

A heat wave is an extreme rise in air temperature above 35 °C.





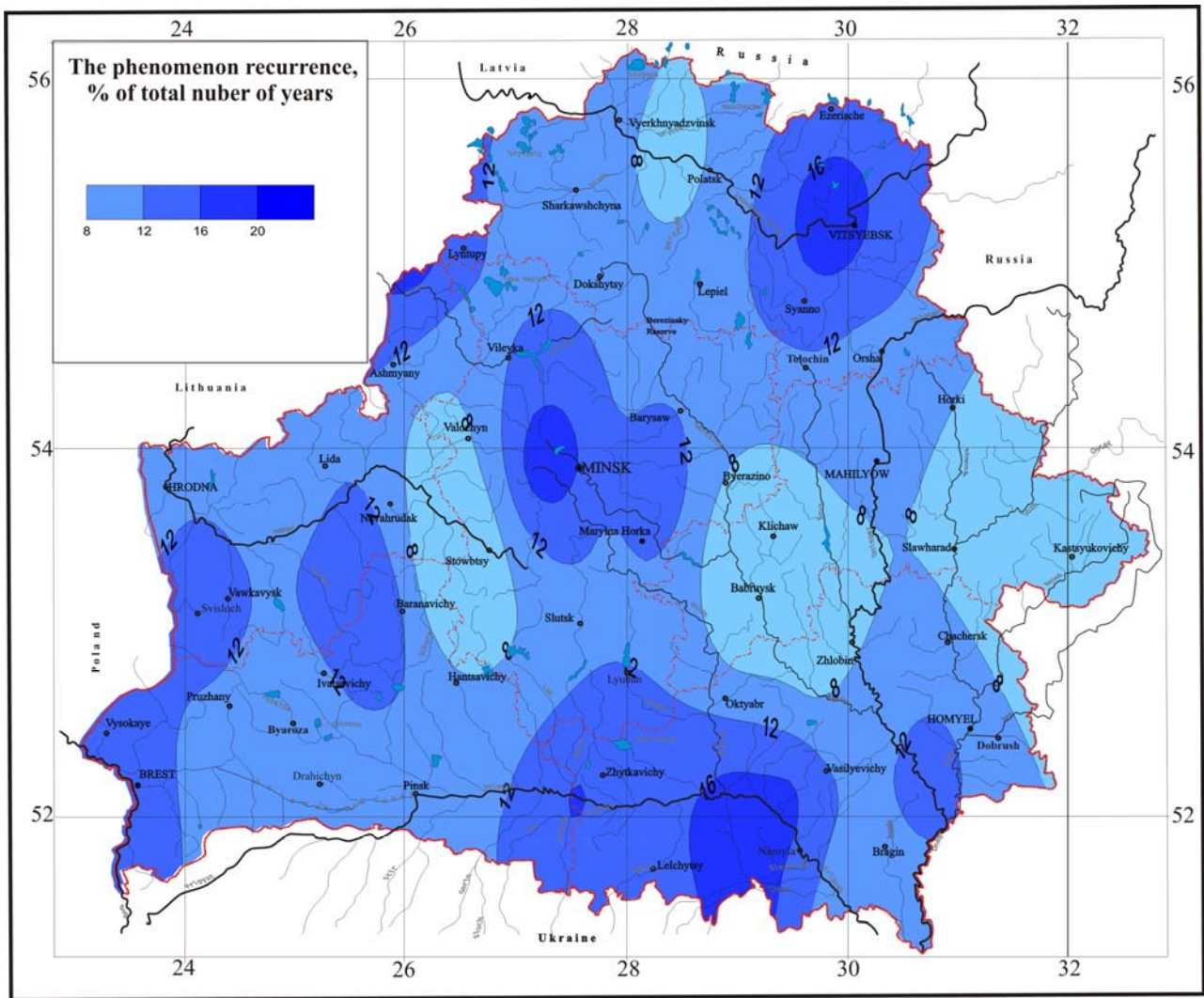
Spatial distribution of heat waves recurrence in Belarus, % years



## Heavy Rainfall

Heavy rainfall is a weather hazard which involves falling of at least 50 mm precipitation in less than 12 hours.





Spatial distribution of heavy rainfall recurrence in Belarus, % years

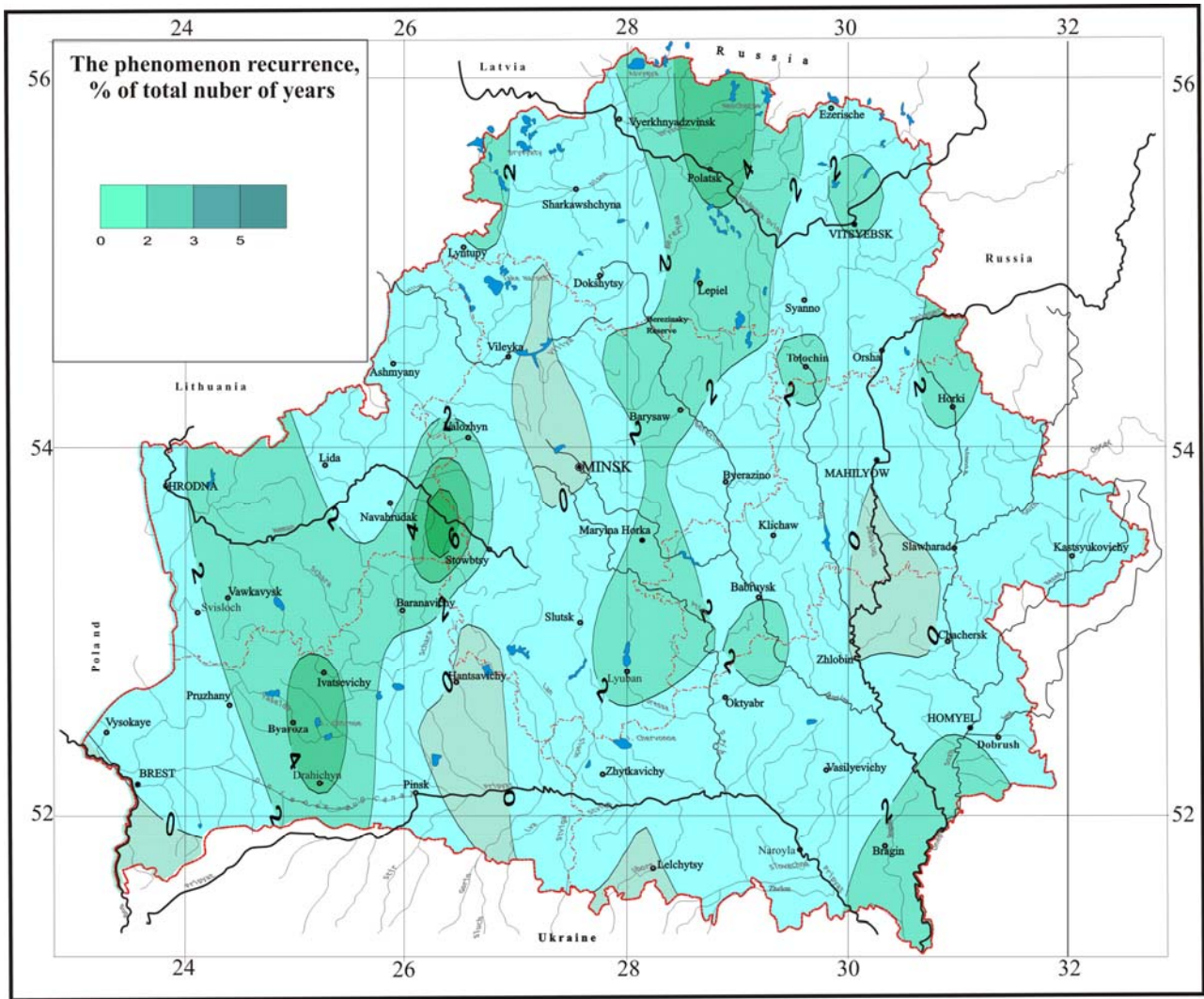


## Heavy Snowfall

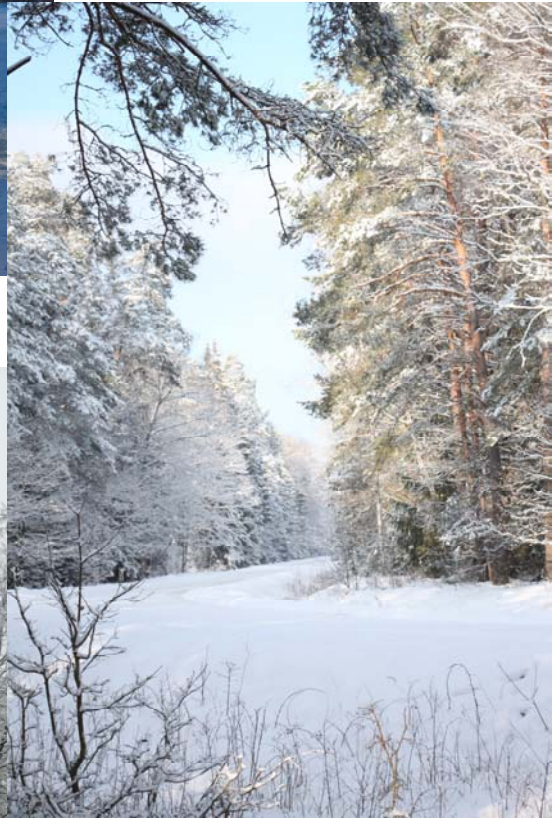
Heavy snowfall is a prolonged and heavy falling of snow from clouds that causes poor visibility and disturbs traffic on roads.







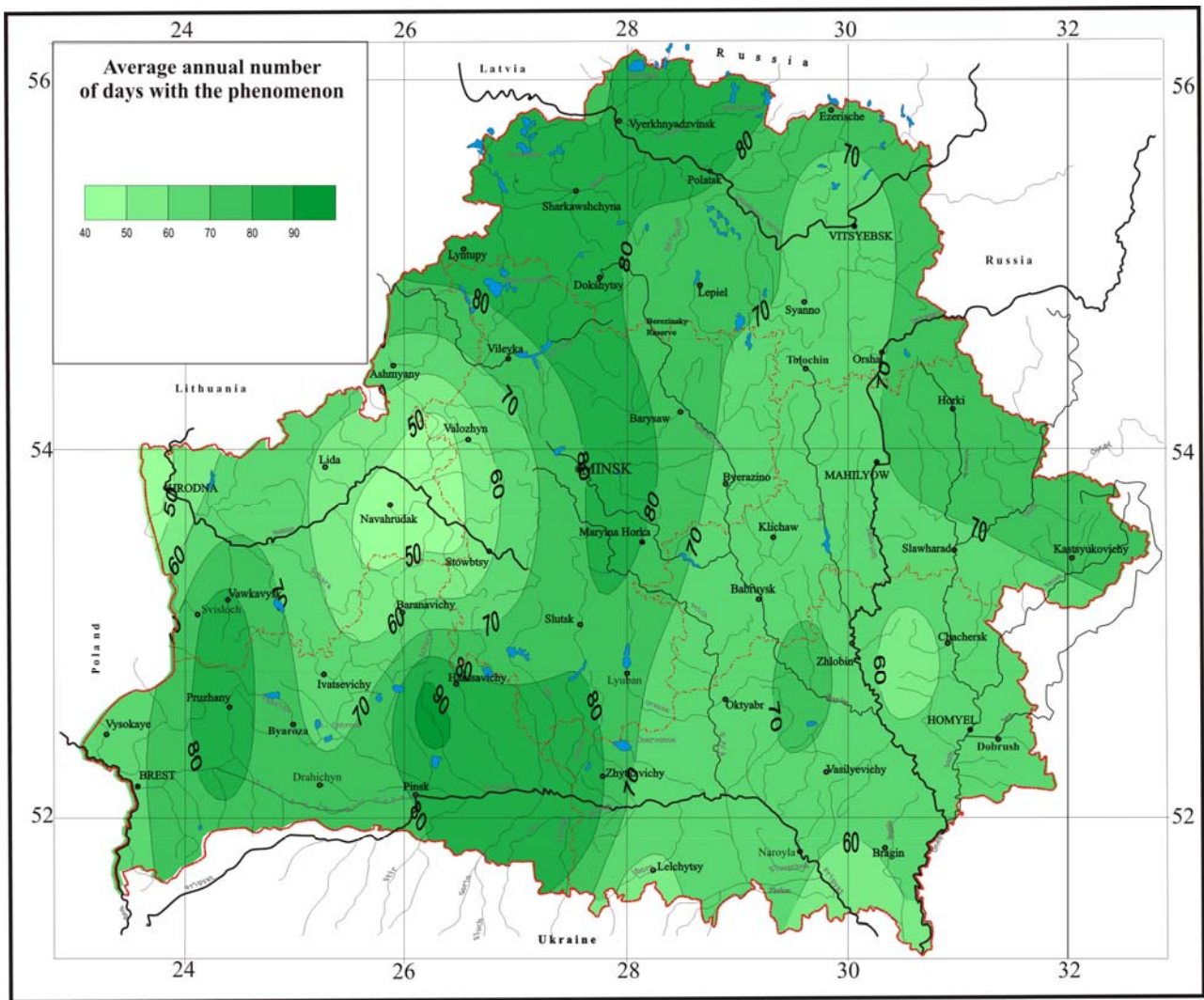
Spatial distribution of heavy snowfall recurrence in Belarus, % years



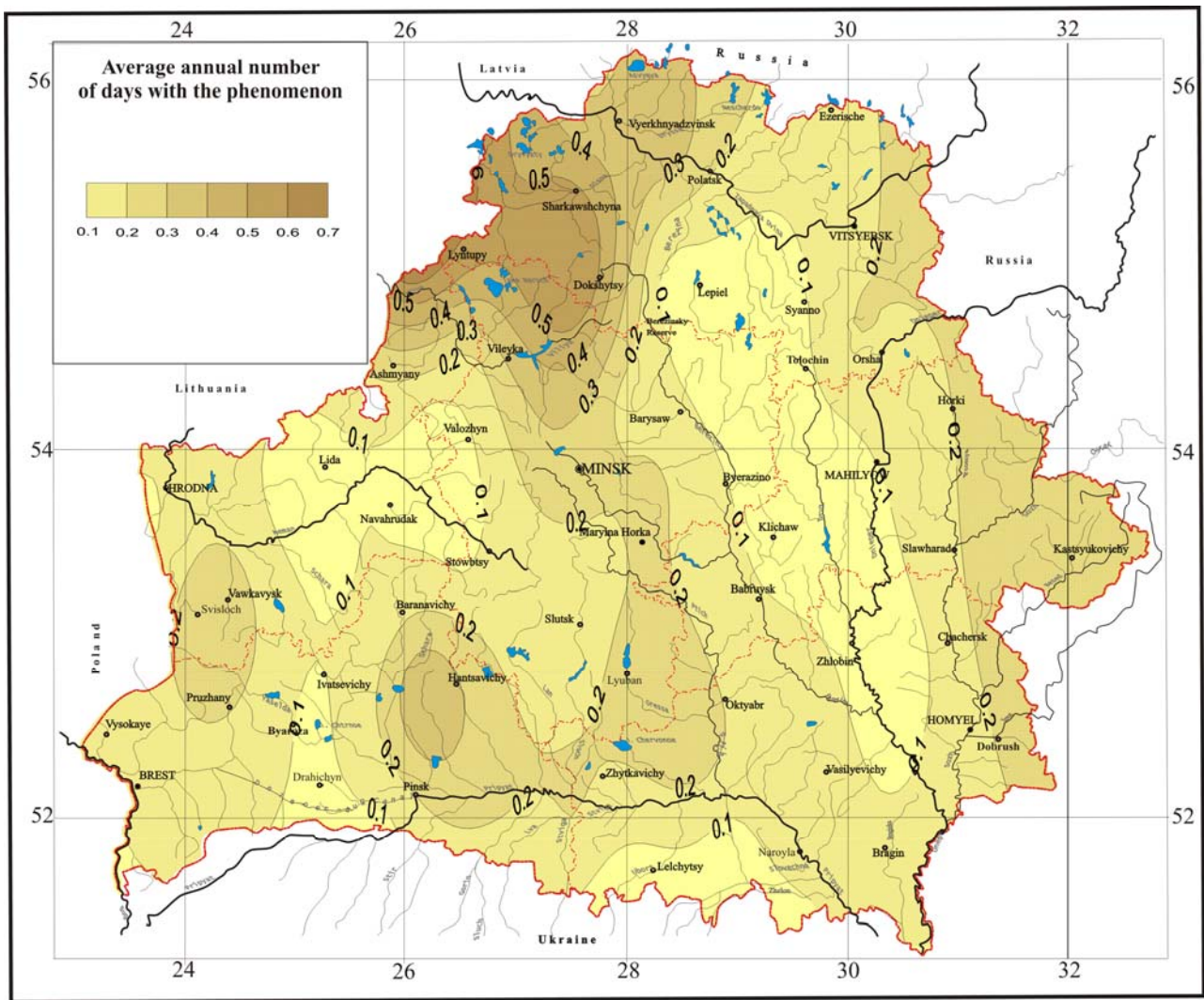
## Hoar Frost

Hoar frost is a thin uneven layer of ice crystals formed by water droplets in vapor and deposited on the ground or attached to exposed objects. It forms in the condition when radiation cooling of the objects becomes lower than the air temperature around.

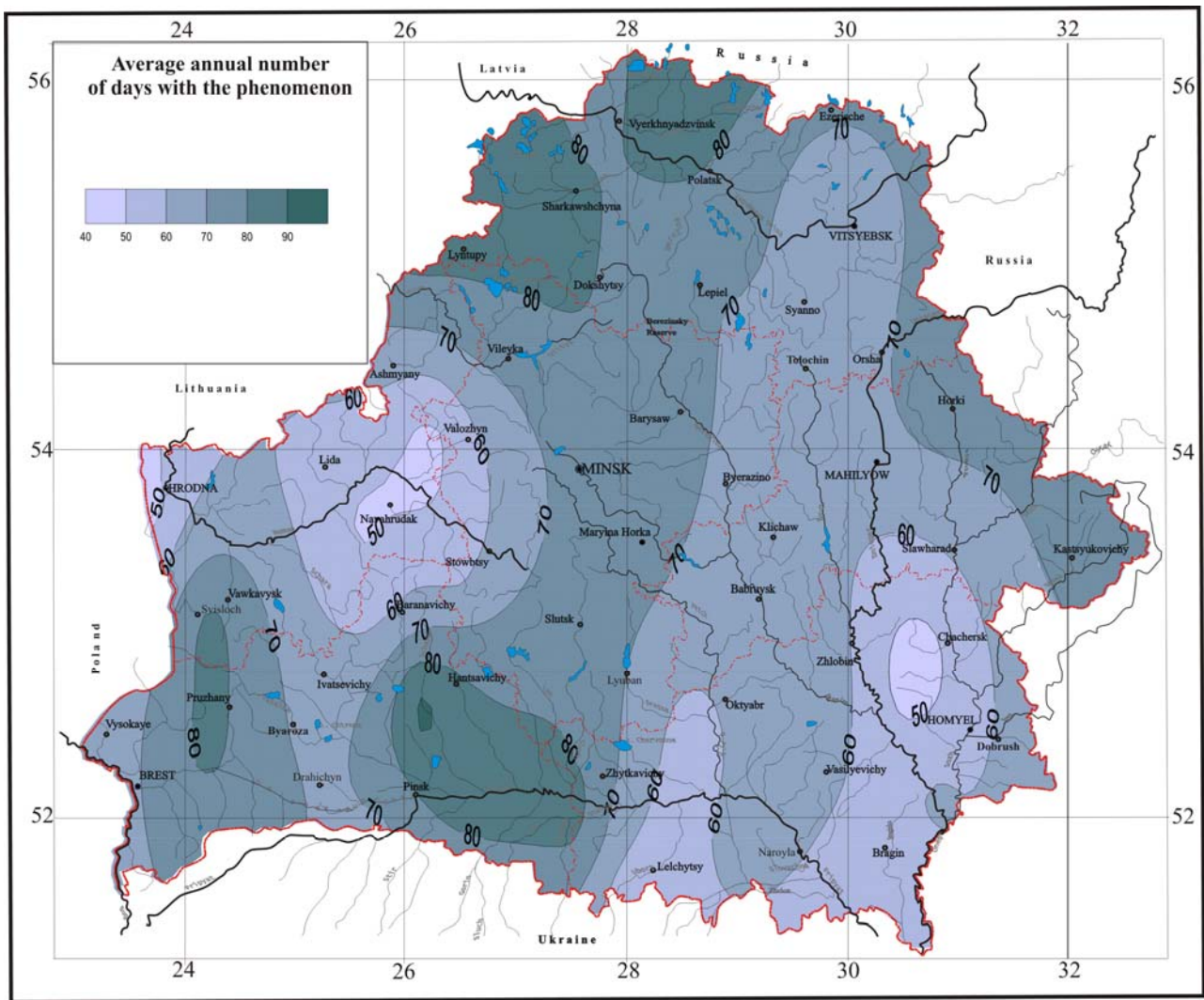




Spatial distribution of average annual number of days with hoar frost in Belarus



Spatial distribution of average annual number of days with hoar frost from June to August in Belarus



Spatial distribution of average annual number of days with hoar frost from September to May in Belarus

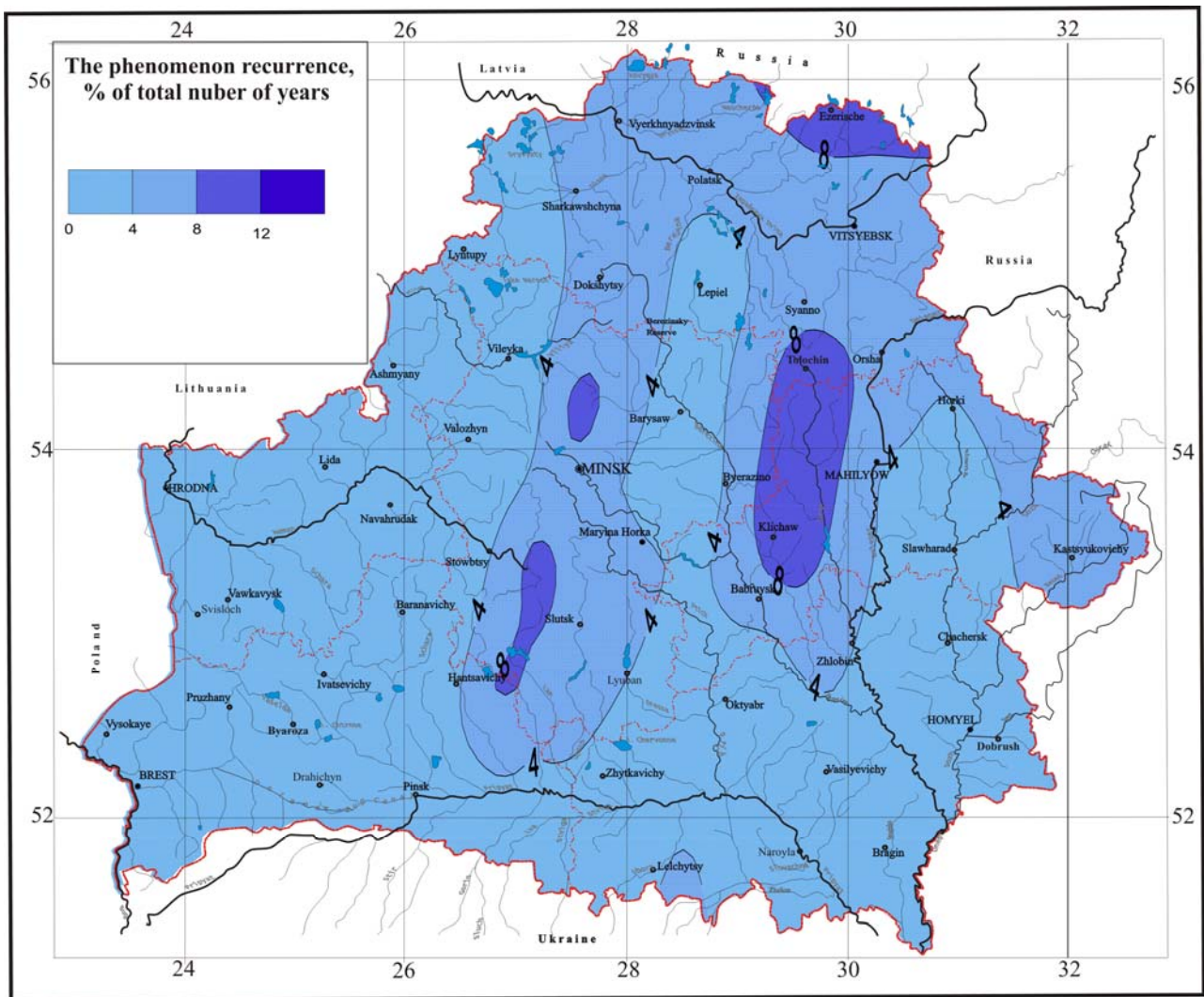


## Severe Frost

Severe frost is decrease of air temperature up to  $-35\text{ }^{\circ}\text{C}$  and below. As a meteorological hazard it is quite rare in Belarus.







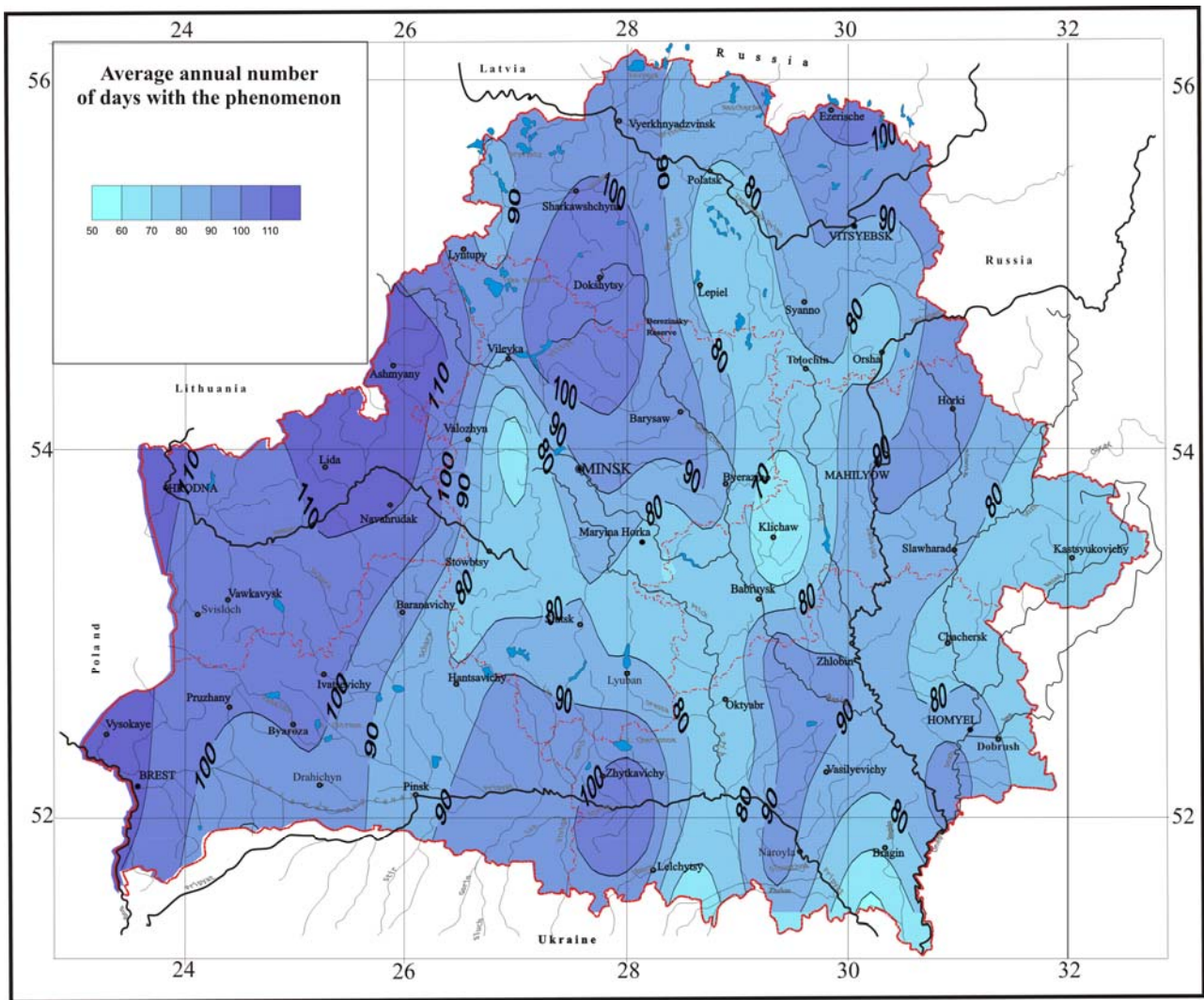
Spatial distribution of severe frost recurrence in Belarus, % years



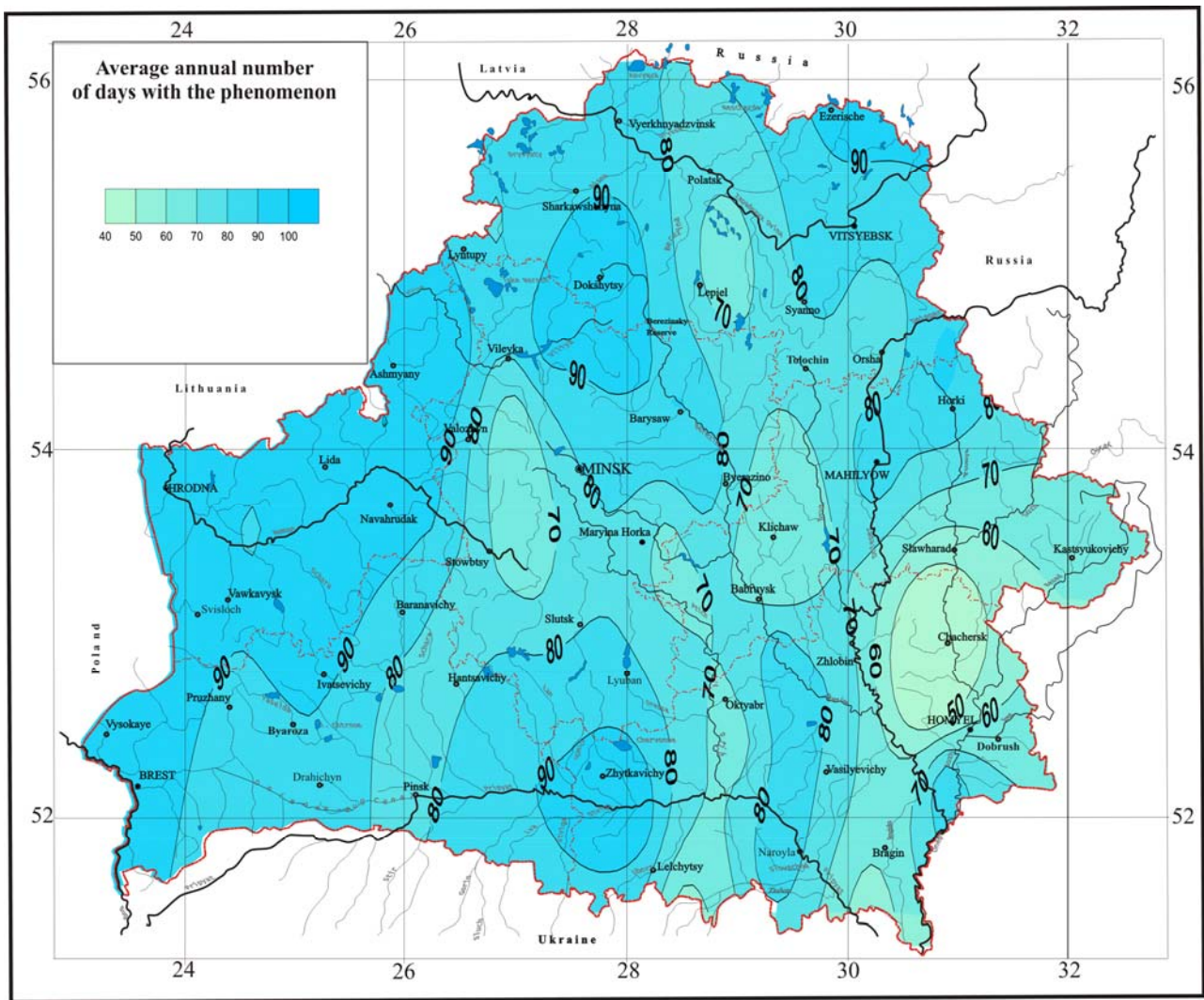
## Shower

Shower is short-term intensive precipitation usually in the form of rain or snow. Showers are often accompanied by thunderstorm, sleet and hail.

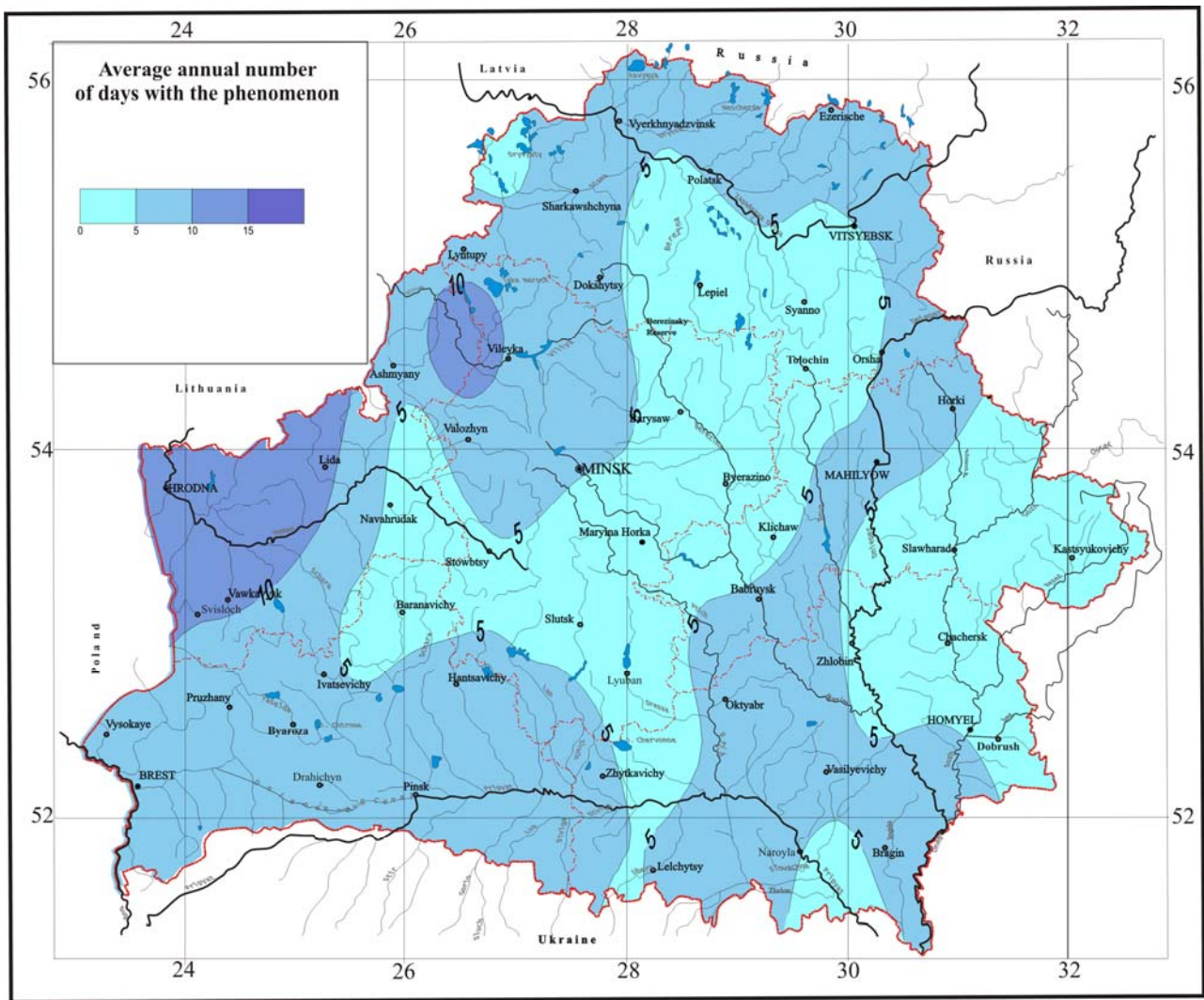




Spatial distribution of average annual number of days with showers in Belarus



Spatial distribution of average number of days with showers from March to October in Belarus



Spatial distribution of average number of days with showers from November to February in Belarus

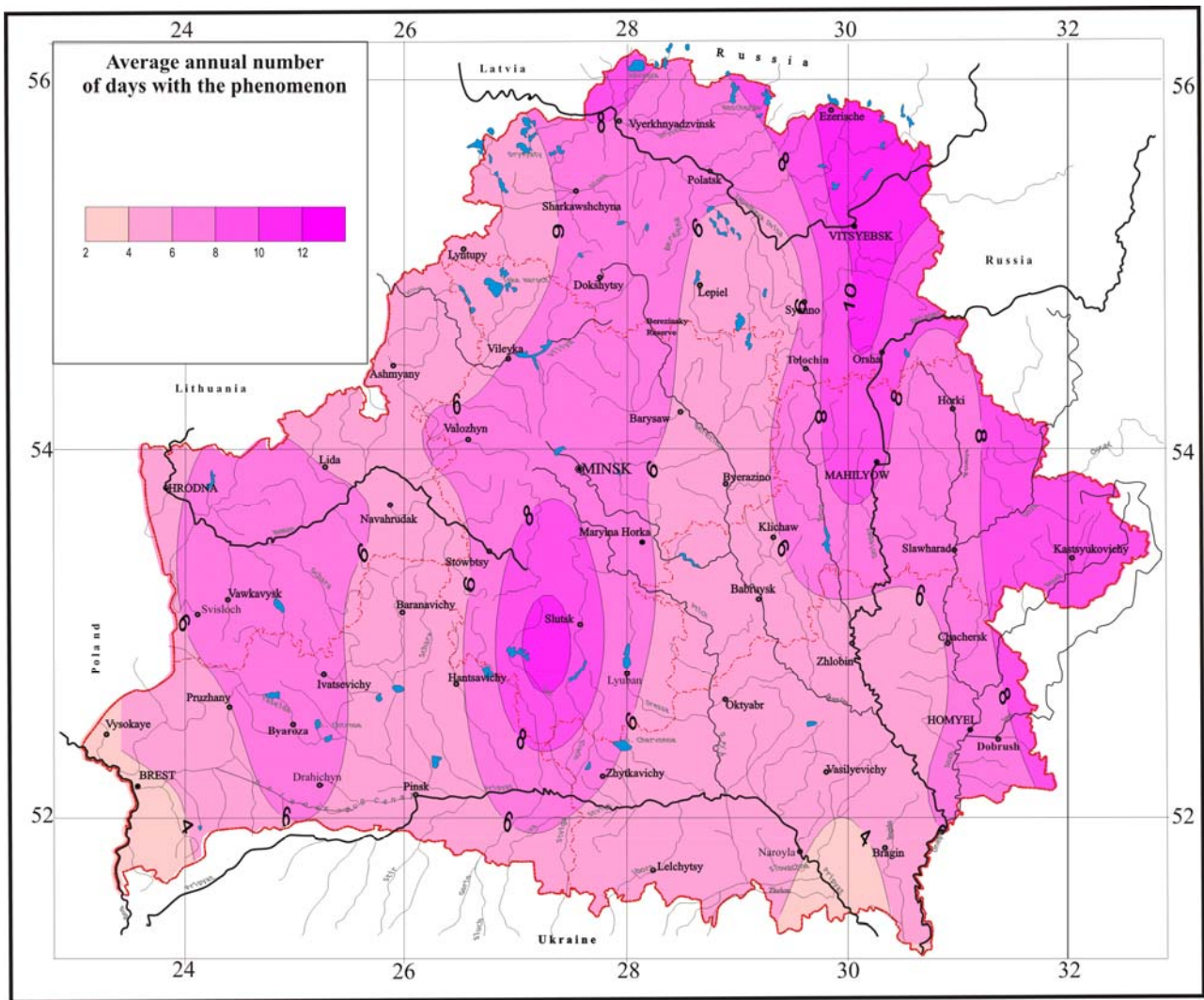


## Snowstorm

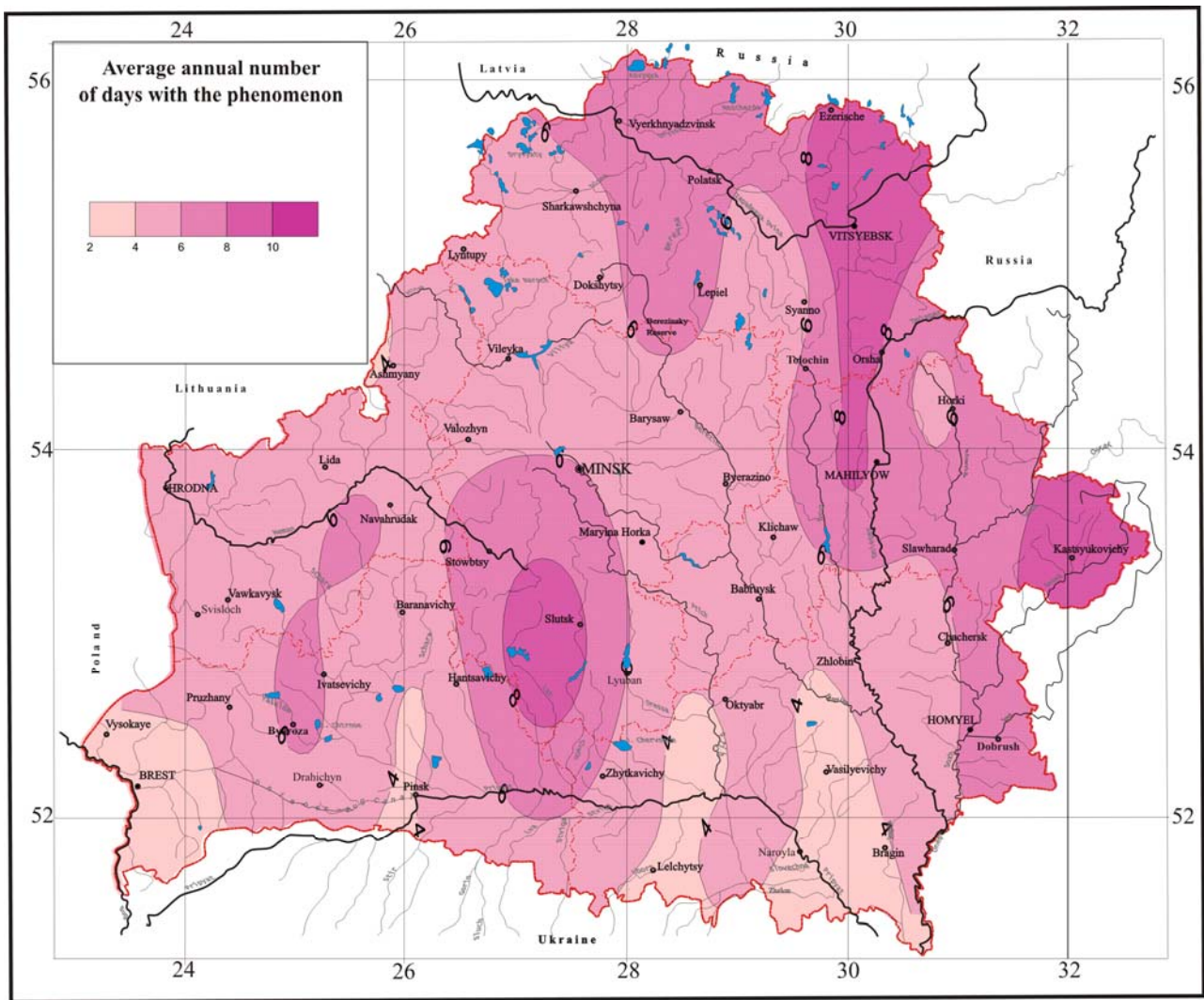
A snowstorm occurs when strong winds carry snow over the ground surface. A snowstorm becomes a meteorological hazard when the wind speed approaches more than 15 m/s and lasts for at least 12 hours.







Spatial distribution of average annual number of days with snowstorms in Belarus



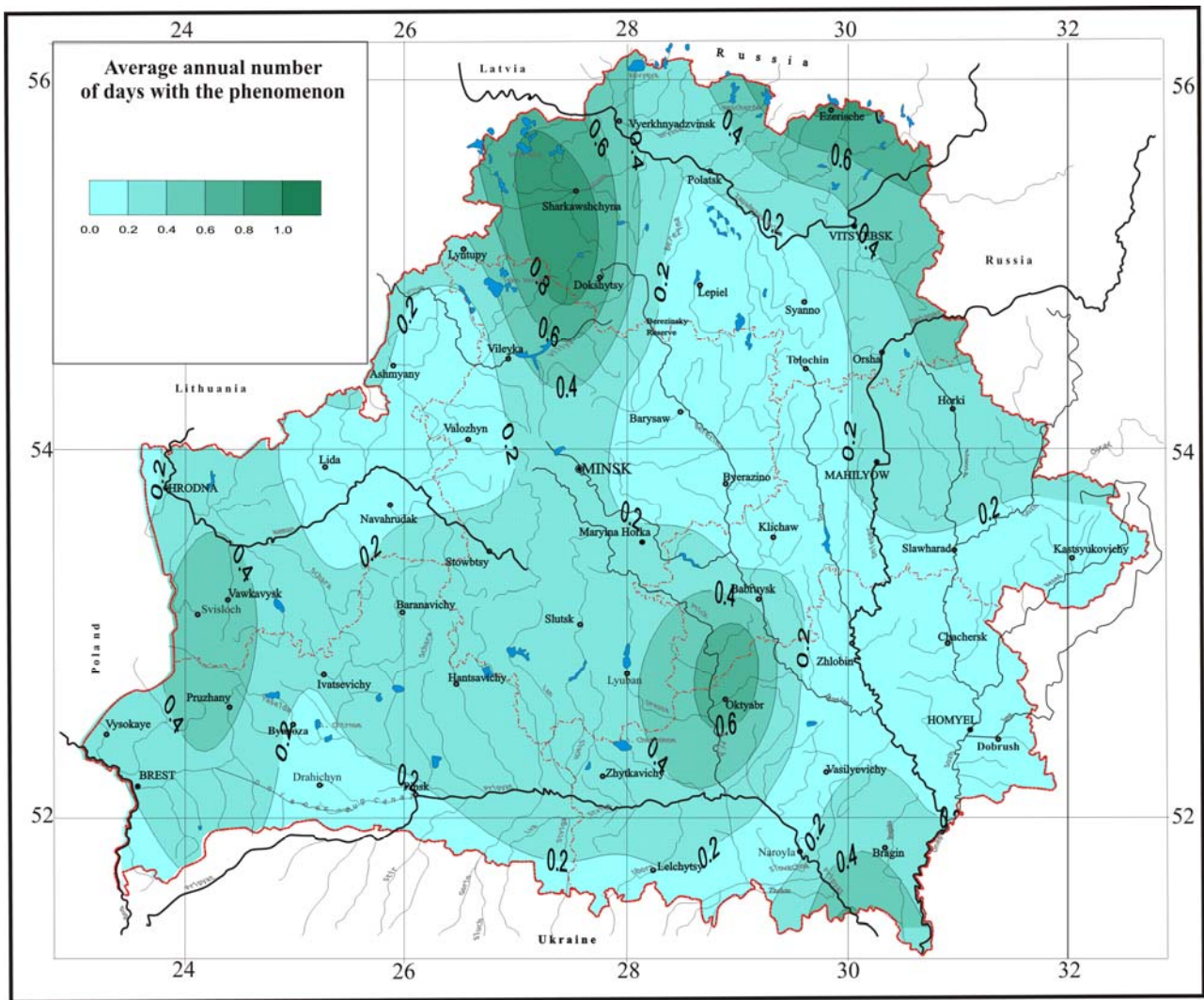
Spatial distribution of average annual number of days with snowstorms from December to February in Belarus



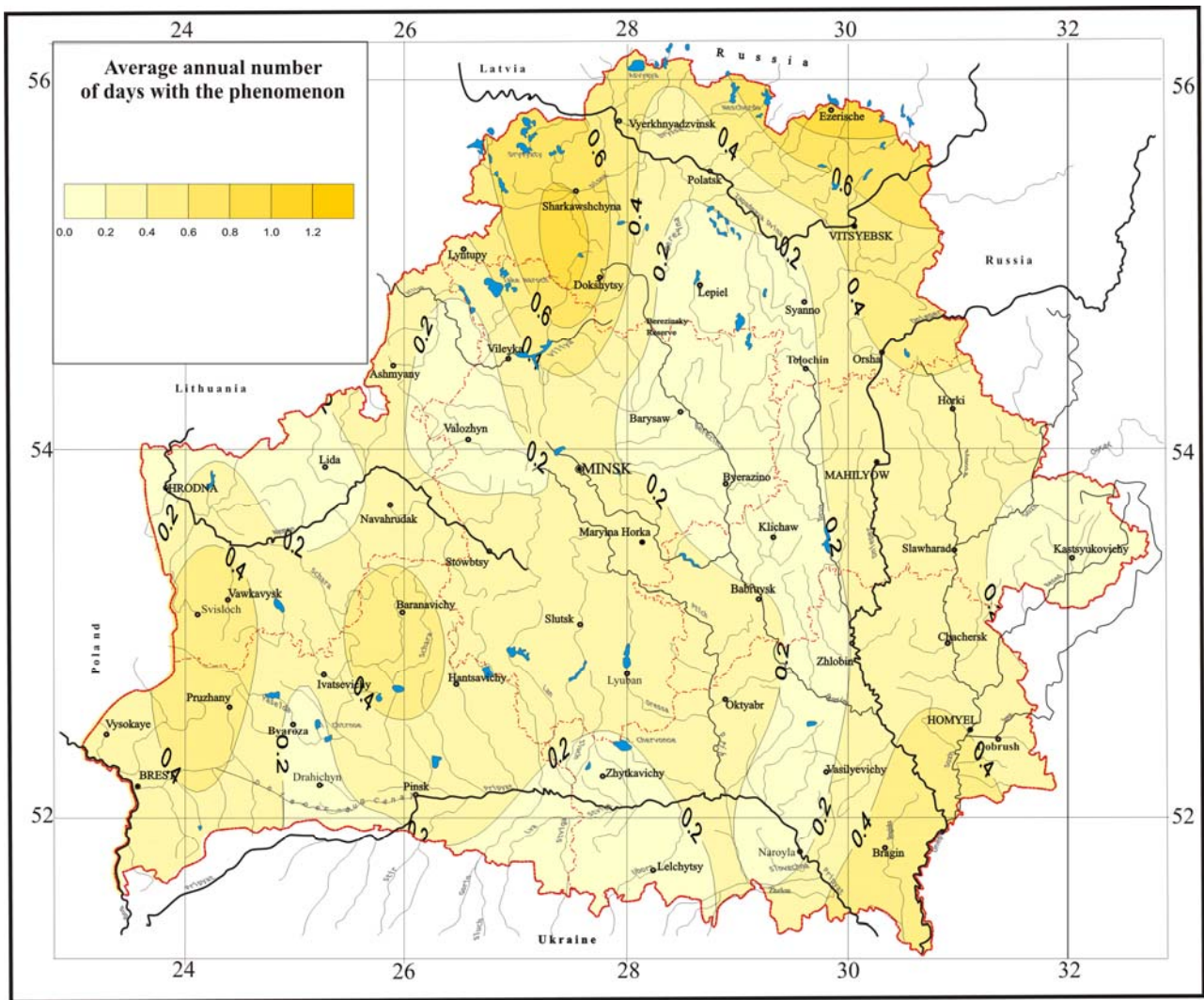
## Squall

A squall is a sudden, sharp increase in wind speed up to 20-30 m/s. The wind can change its direction due to convection. A squall lasts for a few minutes and it covers a relatively small area of a couple of hundred meters. Squalls result from dense cumulonimbus clouds. They are accompanied by thunders and showers, often with hail.

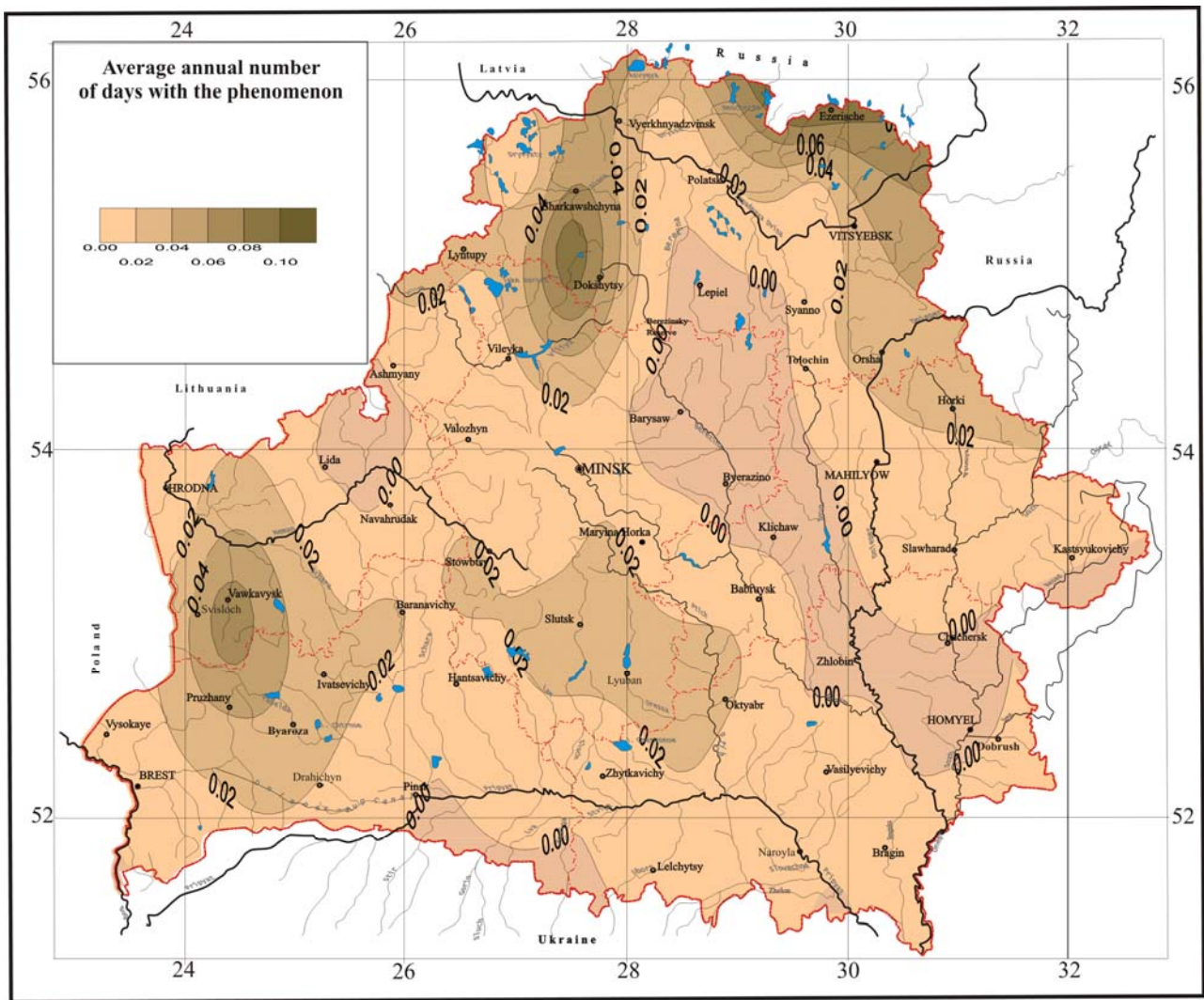




Spatial distribution of average annual number of days with squall in Belarus



Spatial distribution of average annual number of days with squall from March to September in Belarus



Spatial distribution of average annual number of days with squall from October to February in Belarus

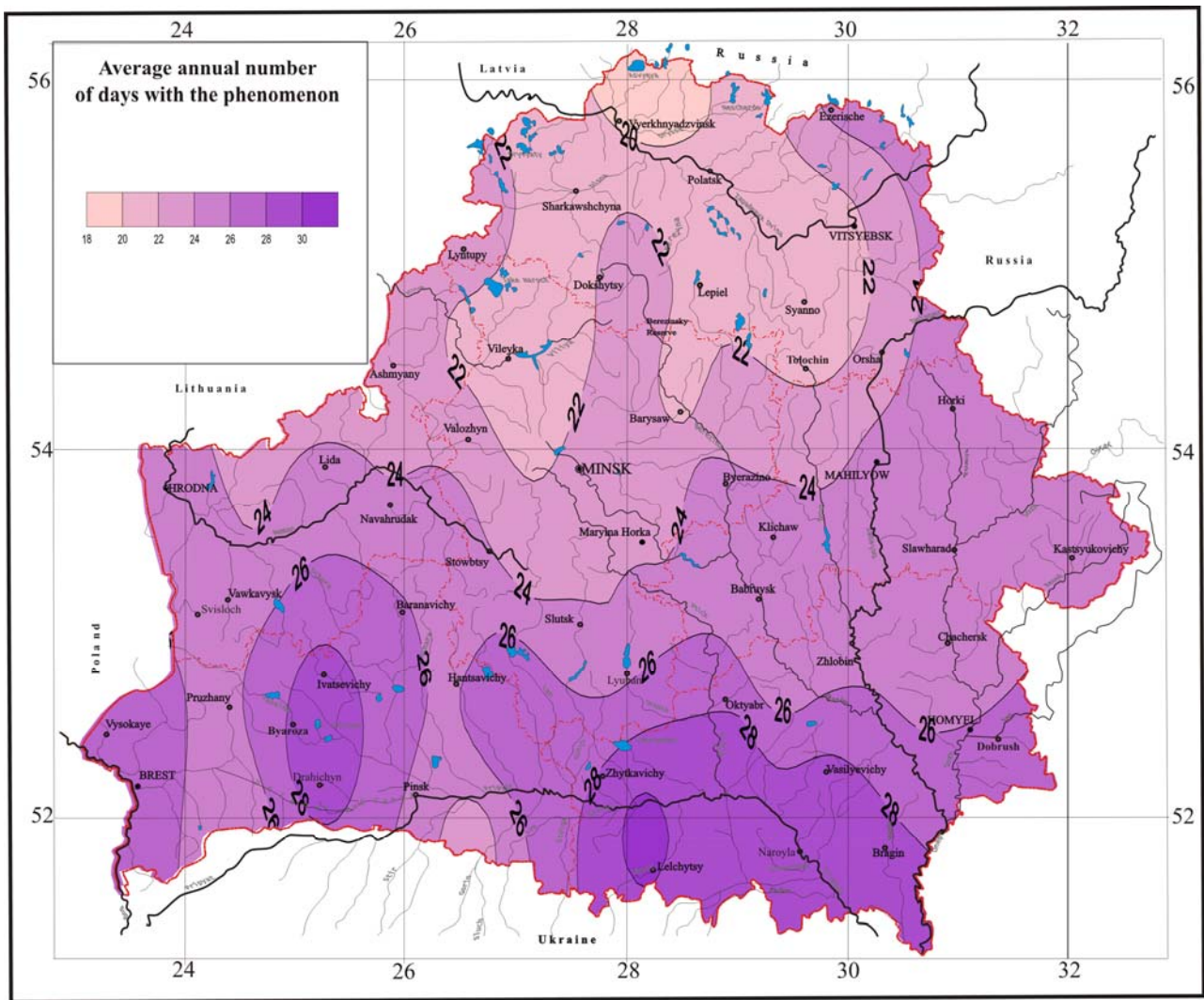




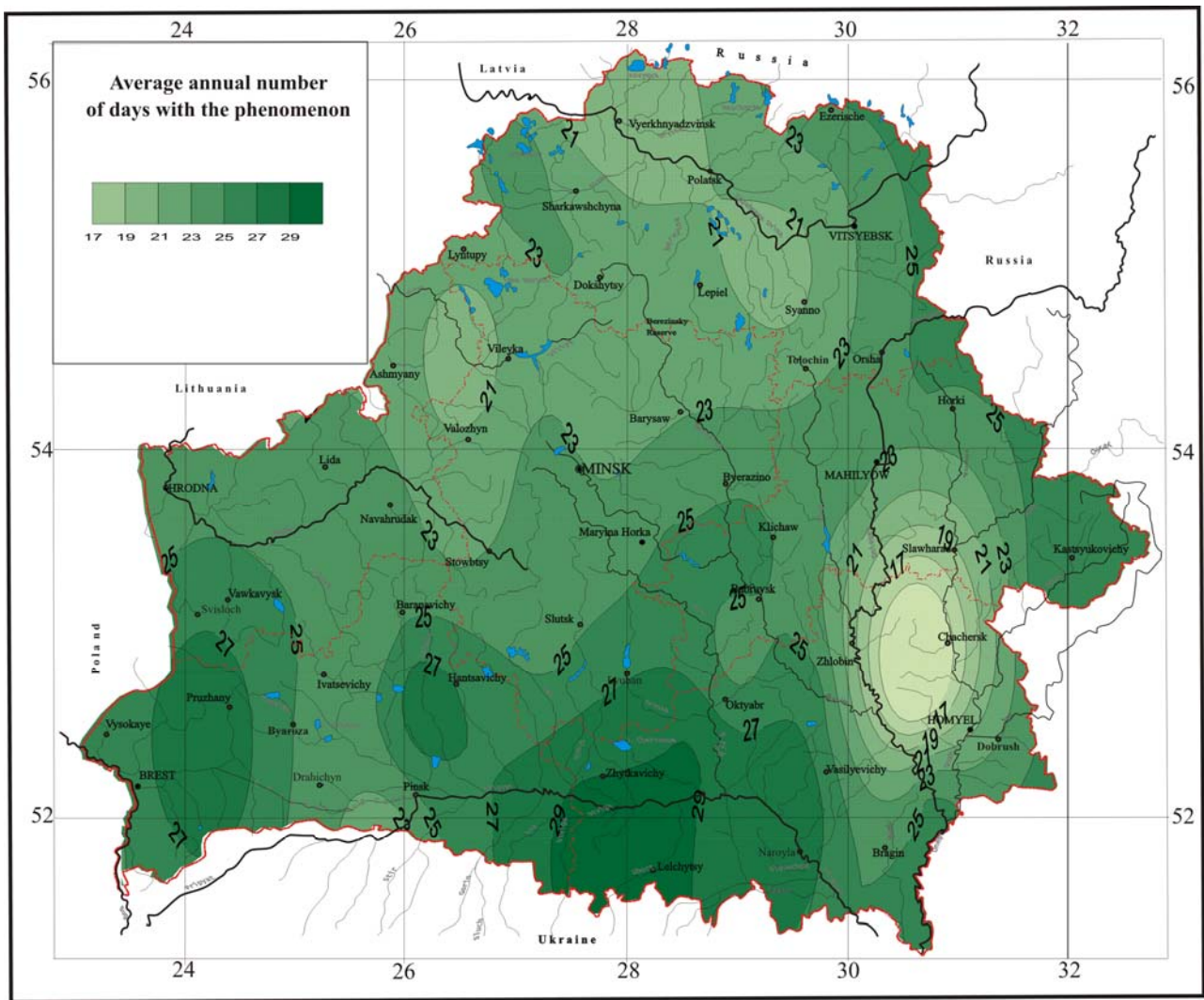
## Thunderstorm

Thunderstorm is an atmospheric phenomenon caused by dense cumulonimbus clouds accompanied by multiple electrical discharges between the clouds and the ground surface, acoustic effects, heavy rainfall, often with hail. As a rule thunderstorms are not prolonged. They rarely last for more than 2 hours.

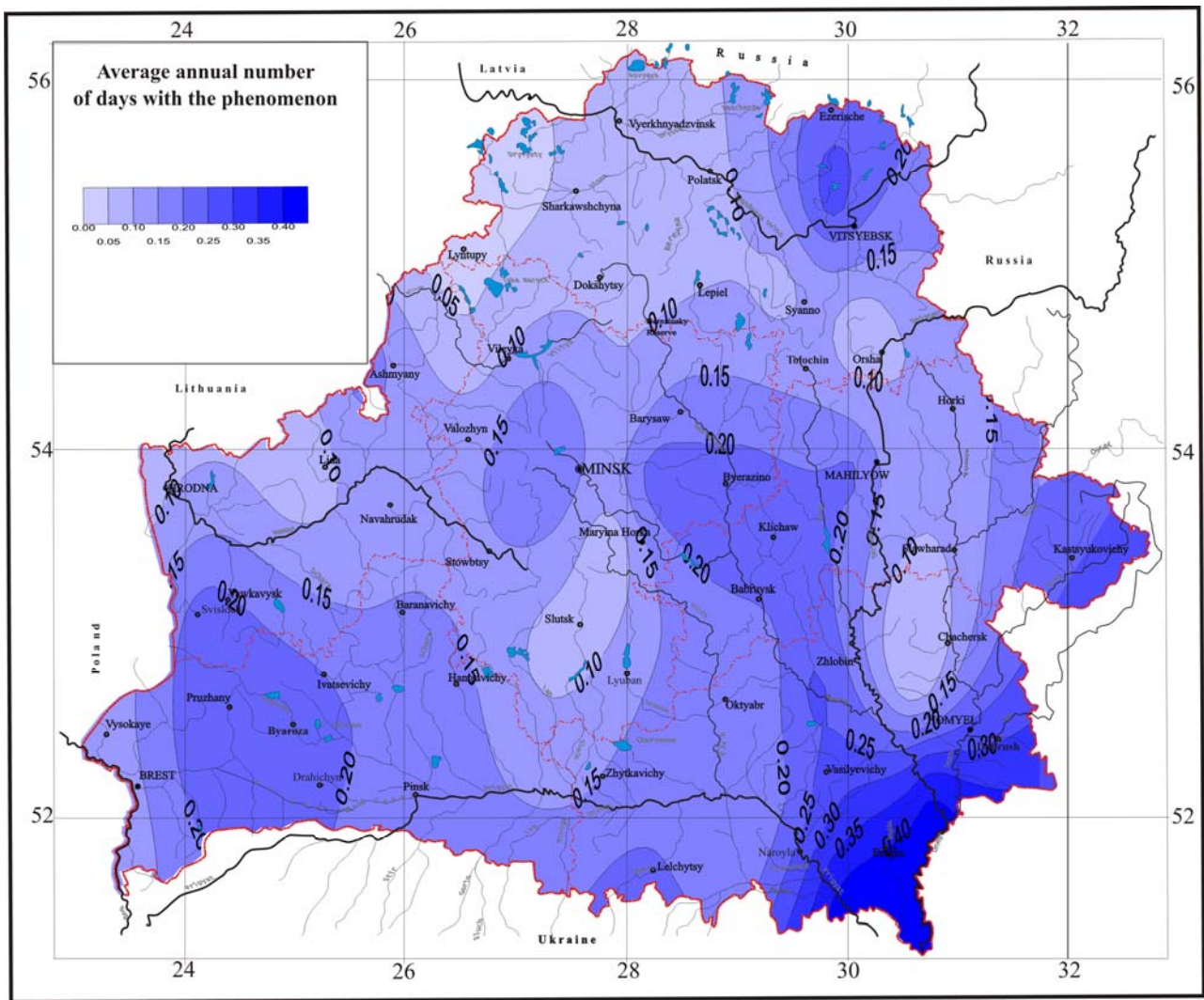




Spatial distribution of average annual number of days with thunderstorms in Belarus



Spatial distribution of average annual number of days with thunderstorms from March to October in Belarus



Spatial distribution of average annual number of days with thunderstorms from November to February in Belarus



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