University of Architecture, Civil Engineering and Geodesy – Bulgaria

QGIS as a supporting tool for spatial distribution of drought

Milan Gocić

Slaviša Trajković

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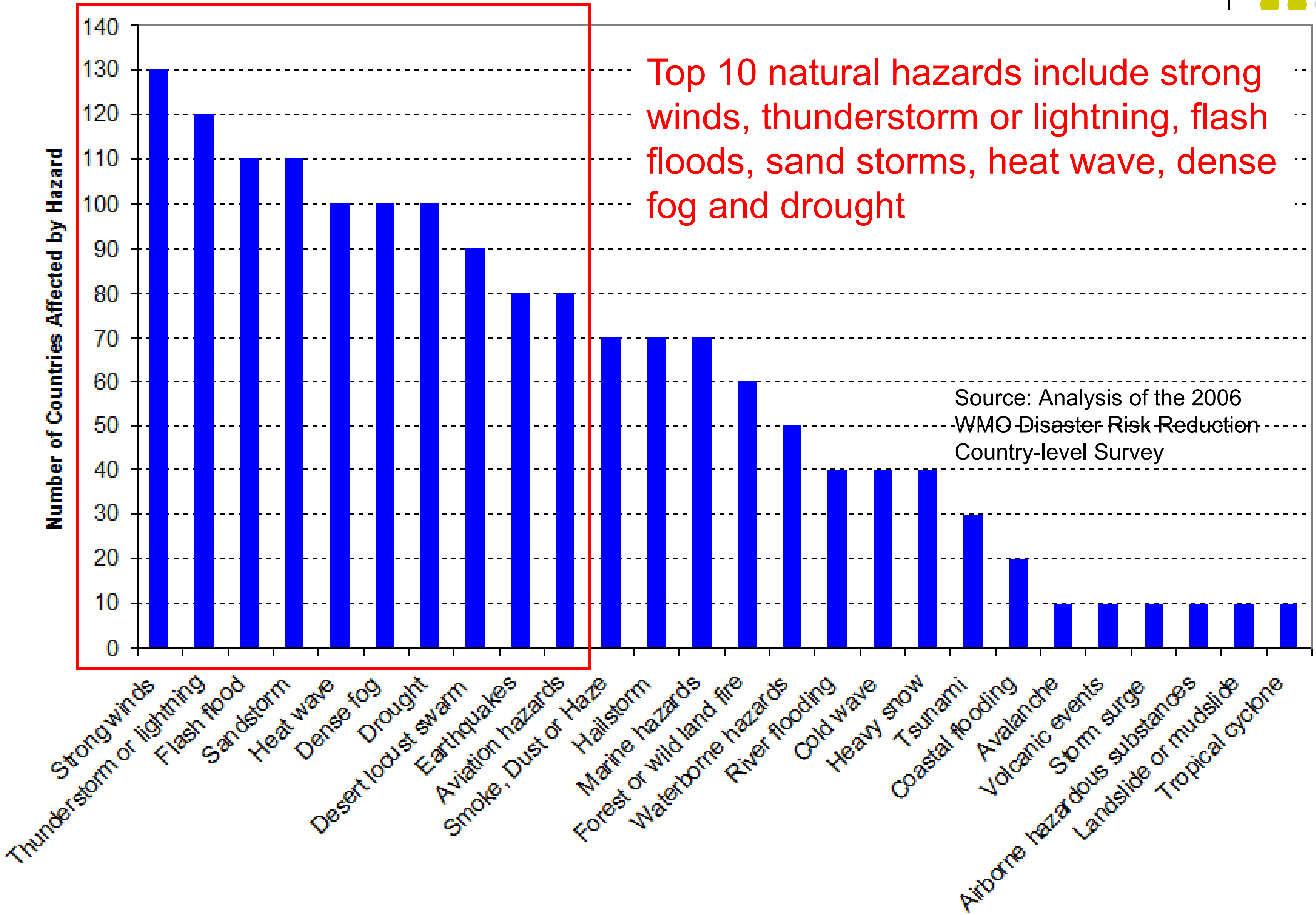
Risks associated with climate change

Conclusions from 4th IPCC Assessment Report

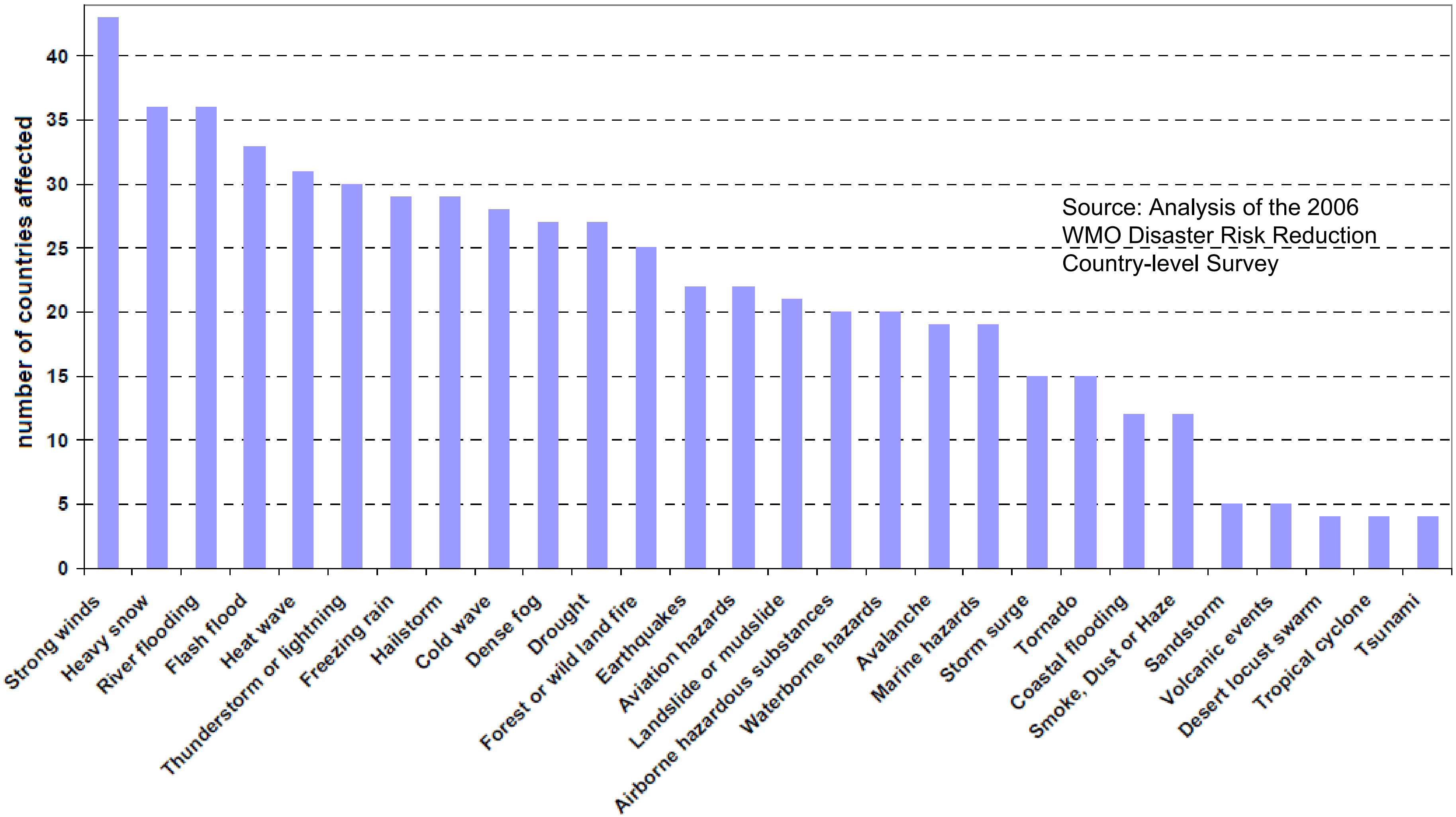
IPCC - Intergovernmental Panel on Climate Change

Phenomenon	Major projected impacts
Increased frequency of **heat waves**	Increased risk of heat-related mortality, health
Increased frequency of **heavy precipitation** events	Increased loss of life and property due to flooding
Area affected by **drought** increases	Increased risk of food and water shortage
Intense **tropical cyclone** activity increases	Increased risk of deaths, injuries, potential for population migrations, loss of property
Increased incidence of extreme **sea level rise**	Disruption of coastal echo systems, fisheries, infrastructure, water resources, migration of populations

Number of responding countries (139) that identified themselves as being affected by specific hazards



Number of responding countries in Europe that identified themselves as being affected by specified hazards



Erasmus+ project NatRisk

- Development of master curricula for natural disasters risk management in Western Balkan countries (NatRisk)
- http://www.natrisk.ni.ac.rs/

NatRisk

Co-funded by the Erasmus+ Programme of the European Union

Hydrological hazard

- **Hydrological hazard** is a hazard caused by the occurrence, movement, and distribution of surface and subsurface freshwater and saltwater.

- Hydrological hazards and their impacts are associated with climate variability, demographic trends, land cover change, and other causative factors and could be exasperated by global climate change.

- We cannot avoid hydrological hazards, but we can prevent them from becoming disasters.

Hydrological hazards


Obrenovac, Serbia, 2014

Floods


North West Province, South Africa, 2015


India, 2015


California, USA, 2015

Droughts


USA, 2015

Drought

Because drought cannot be viewed solely as a physical phenomenon, it is usually defined both conceptually and operationally.

- **Conceptual definition:** Drought is defined as a water caused by deficiency of rainfall.

It is important in establishing drought policy.

- **Operational definition**: Operational definitions of drought, meaning the degree of precipitation reduction that constitutes a drought, vary by locality, climate and environmental sector.

Types of droughts

According to Wilhite and Glantz (1985) there are four types of droughts:

- **Meteorological drought** is defined usually on the basis of the degree of dryness, expresses as a departure of actual precipation from an expected average or normal amount based on monthly, seasonal or annual time scales.

- **Hydrological drought** is related to the effects of precipitation shortfalls on streamflows and reservoir, lake and groundwater levels.

Wilhite, D.A.; and M.H. Glantz. 1985. Understanding the Drought Phenomenon: The Role of Definitions. *Water International* 10(3):111–120.

Types of droughts

- **Agricultural drought** is defined principally in terms of soil moisture deficiencies relative to water demands of plant life, usually crops.

- **Socioeconomic drought** associates the supply and demand of economic goods or services with elements of meteorological, hydrological and agricultural drought.

Impacts of drought

- Economic impacts include losses in the timber, agricultural, and fisheries communities, resulting in the form of higher commodity pricing.
- Social impacts include increased chance of conflict over commodities, fertile land, and water resources or abandonment of cultural traditions, loss of homelands, changes in lifestyle, and increased chance of health risks due to poverty and hygiene issues.
- Environmental impacts of drought include loss in species biodiversity, migration changes, reduced air quality, and increased soil erosion.

Drought index

Drought index value is typically a single number useful for decision making.

Dorught index

- provides a historical perspective that can be used in planning and design applications

- gives quantitative assessment of climate conditions

Standardized Precipitation Index

Standardized Precipitation Index (SPI) (McKee et al., 1993, 1995) focuses on the cumulative probability of precipitation occurring at the selected post and calculated as given below:

$$G(x) = \frac{1}{\beta_{pro}^{\alpha_{pro}} \Gamma(\alpha_{pro})} \int_0^x x^{\alpha_{pro}-1} e^{-\frac{x}{\beta_{pro}}} dx \quad \text{where } \alpha_{pro} = \frac{1}{4A}\left(1+\sqrt{1+\frac{4A}{3}}\right), A = \ln(x_{sr}) - \frac{\sum_{i=1}^{n} \ln(x_i)}{n}, \ \beta_{pro} = \frac{x_{sr}}{\alpha_{pro}},$$

and x_{sr} is the mean estimate of precipitation amount; n is the precipitation estimation number; x_i is the amount of precipitation in a sequence of data.

If x is equal to 0, then the cumulative probability is given as

$$H(x) = q + (1-q)G(x),$$

where q is equal to the probability for zero precipitation.

McKee, T.B., Doesken, N.J., Kleist, J., 1993. The relationship of drought frequency and duration to time scales. In 8th Conference on Applied Climatology, 17–22 January, Anaheim, California, 179–184.

McKee, T.B., Doesken, N.J., Kleist, J., 1995. Drought monitoring with multiple time scales. In 9th Conference on Applied Climatology, American Meteorological Society, Boston, 233–236.

Standardized Precipitation Index

The SPI can be calculated as:

$$SPI = \begin{cases} -\left(t - \dfrac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right), & 0 < H(x) \le 0.5 \\ +\left(t - \dfrac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right), & 0.5 < H(x) \le 1.0 \end{cases}$$

where *t* is determined as

$$t = \begin{cases} \sqrt{\ln \dfrac{1}{(H(x))^2}}, & 0 < H(x) \le 0.5 \\ \sqrt{\ln \dfrac{1}{(1 - H(x))^2}}, & 0.5 < H(x) \le 1.0 \end{cases}$$

The values for coefficients c_0, c_1, c_2, d_1, d_2 and d_3 are 2.515517, 0.802853, 0.010328, 1.432788, 0.189269, and 0.001308, respectively.

Standardized Precipitation Index - characteristics

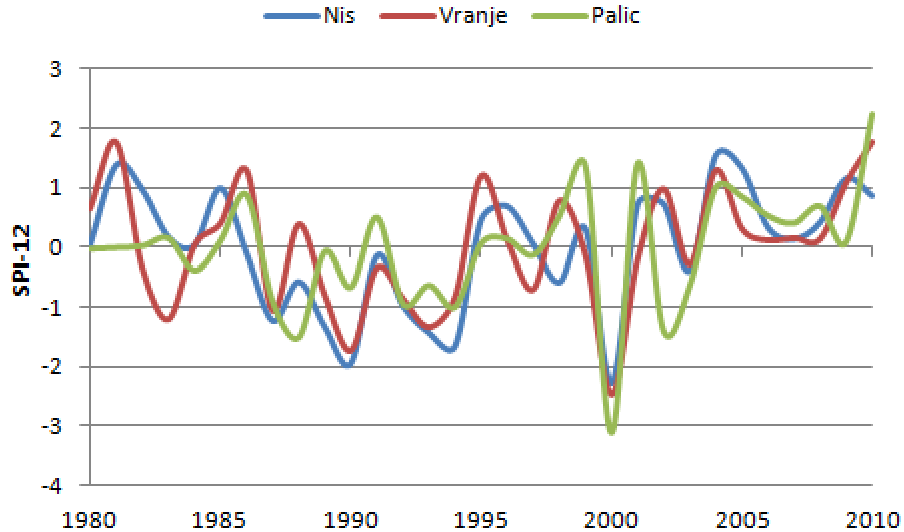
- SPI is recommended as a probabilistic drought index, which is **simple** and **spatially consistent in its interpretation**.

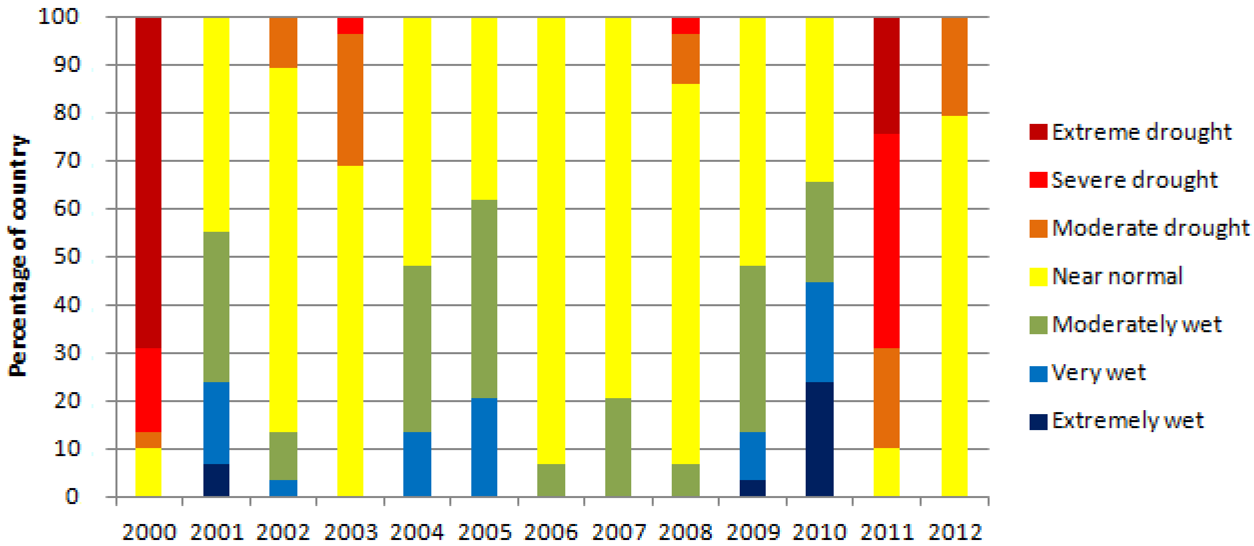
- SPI is estimated **only** on the basis of monthly **precipitation data**.

- SPI quantifies the precipitation deficit for **multiple time scales** (1, 3, 6, 12, 24, 48 months).

Drought classification of SPI

Drought class	SPI value
Extremely wet	SPI ≥ 2.0
Very wet	1.5 ≤ SPI < 2.0
Moderately wet	1.0 ≤ SPI < 1.5
Near normal	-1.0 ≤ SPI < 1.0
Moderate drought	-1.5 ≤ SPI < -1.0
Severe drought	-2.0 ≤ SPI < -1.5
Extreme drought	SPI < -2.0



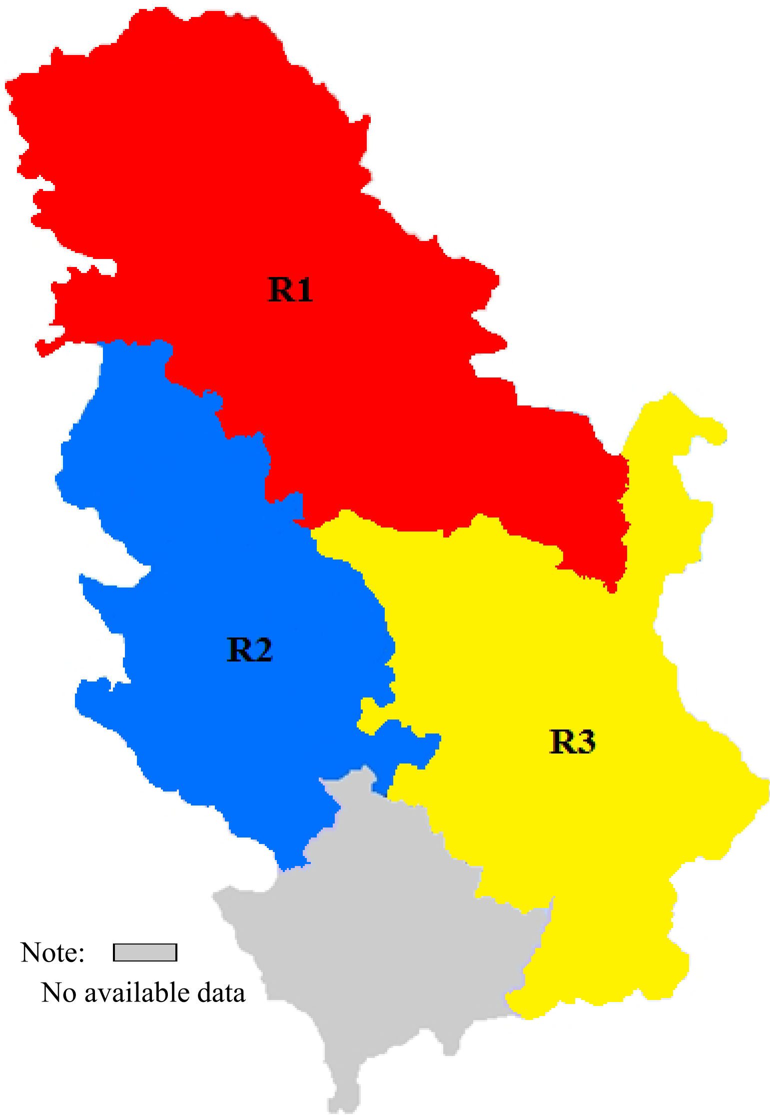


Percentage of Serbia affected by drought, 2000–2012

Gocic, M., Trajkovic, S., 2014. Spatiotemporal characteristics of drought in Serbia. *Journal of Hydrology* 510, 110–123.

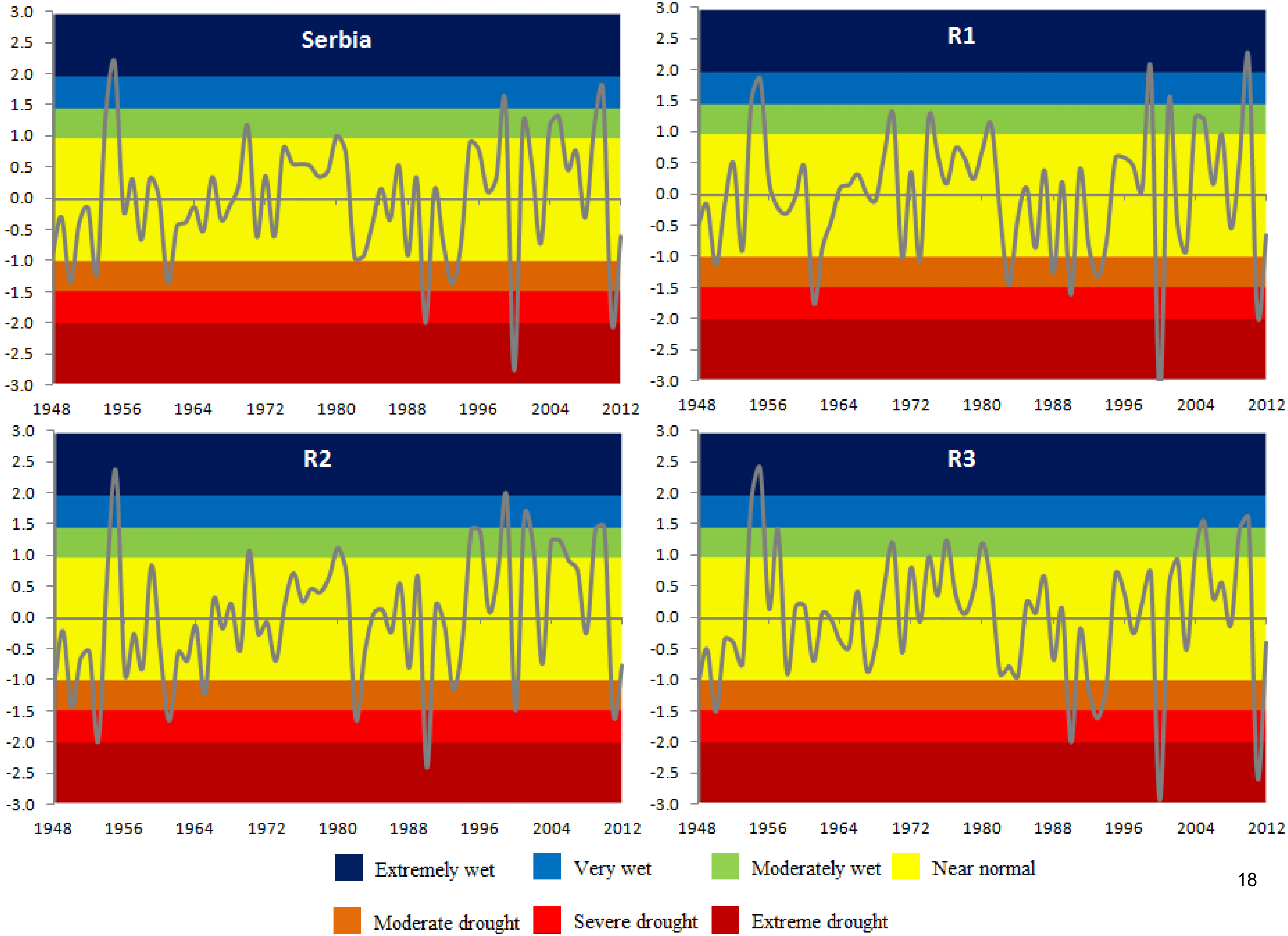
Drought–based regionalization in Serbia

- The Standardized Precipitation Index (SPI) and S–mode principal component analysis (PCA) were used to capture the drought patterns.
- Agglomerative hierarchical cluster analysis was applied to identify three different drought sub–regions: (1) region R1 includes the north and the northeast part of Serbia; (2) region R2 includes the western part of Central Serbia and southwestern part of Serbia; and (3) region R3 includes central, east, south and southeast part of Serbia.

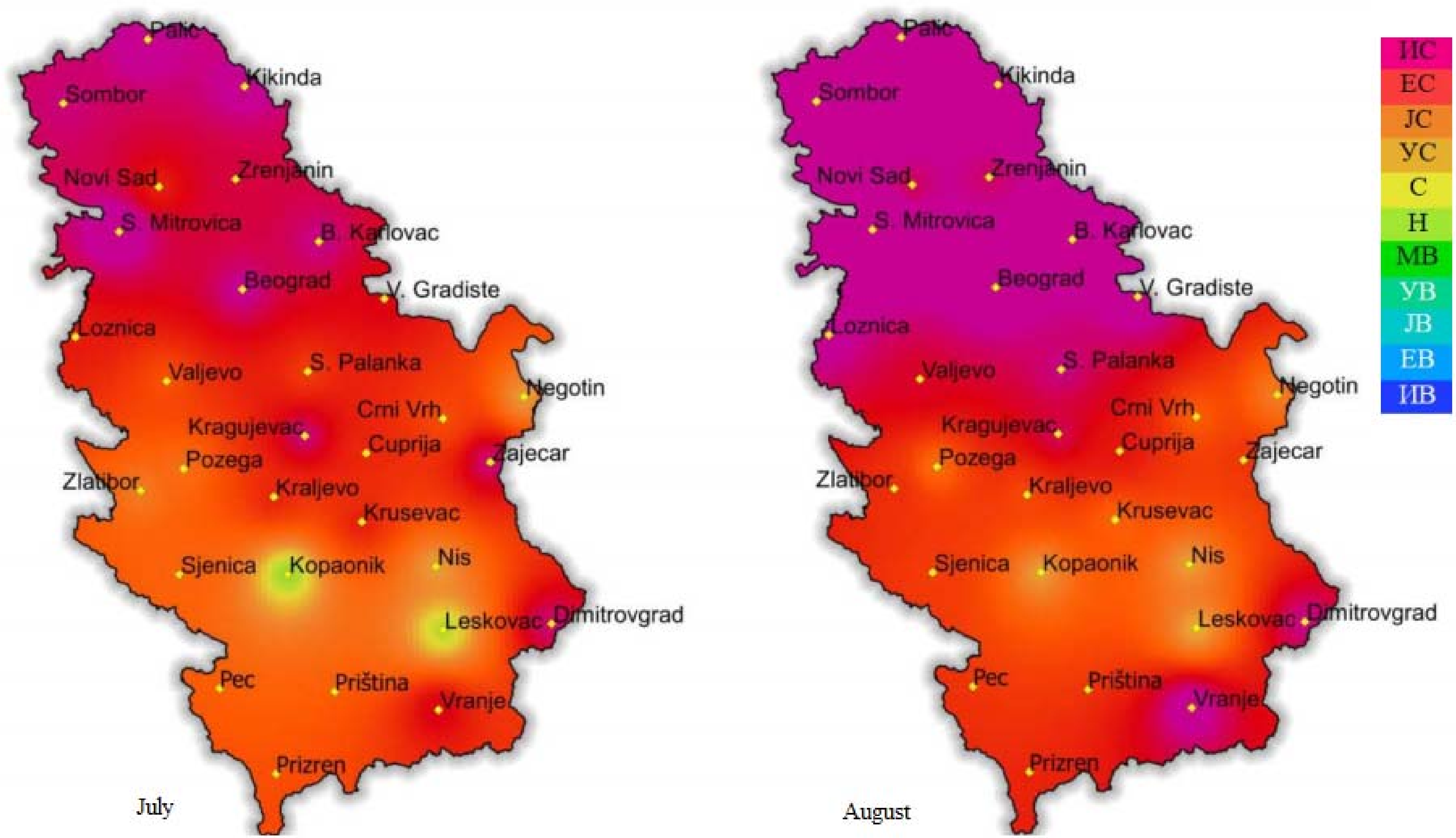


Gocic, M., Trajkovic, S., 2014. Spatiotemporal characteristics of drought in Serbia. *Journal of Hydrology* 510, 110–123.

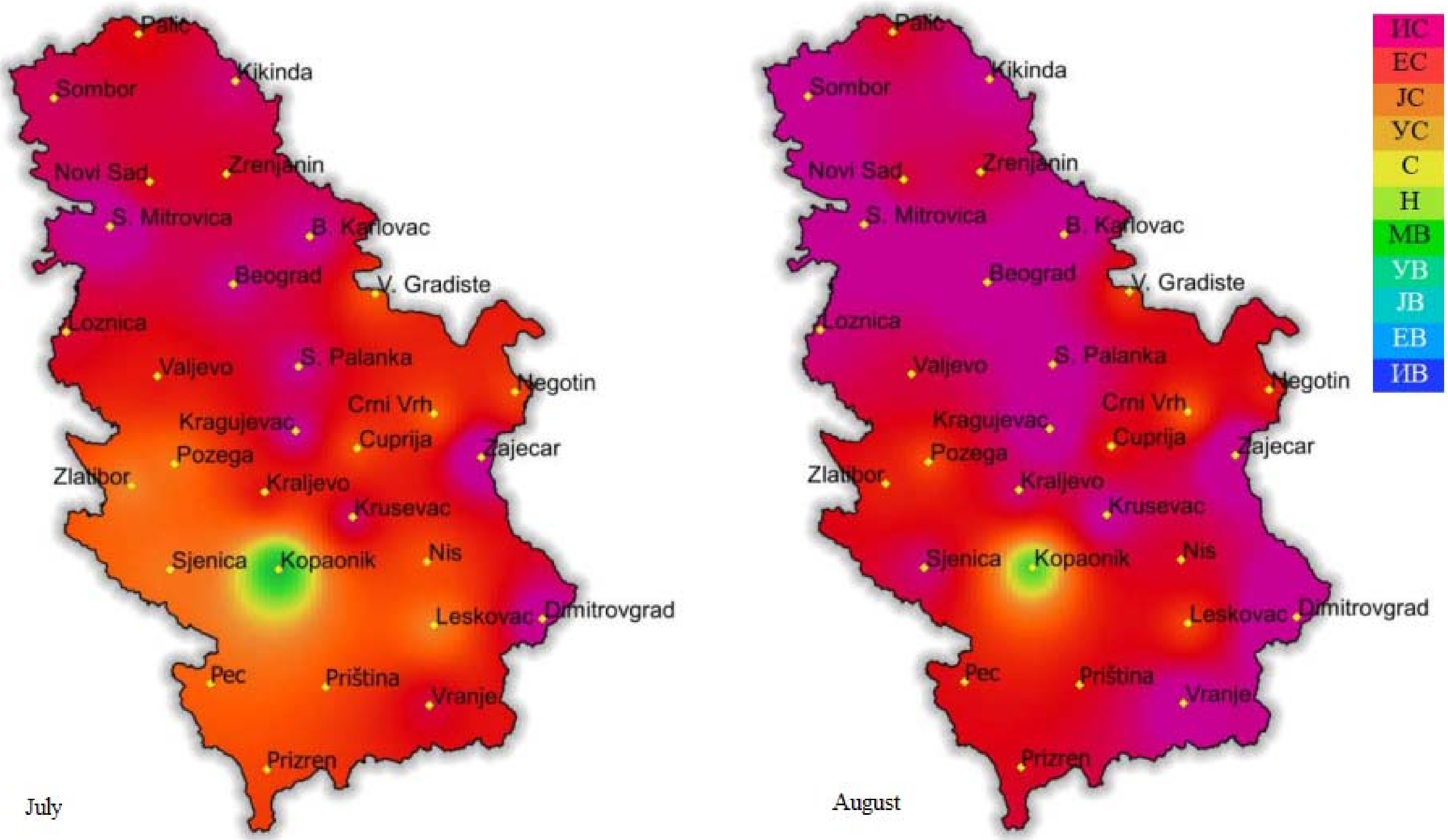
Time series of SPI–12 for Serbia and three sub–regions



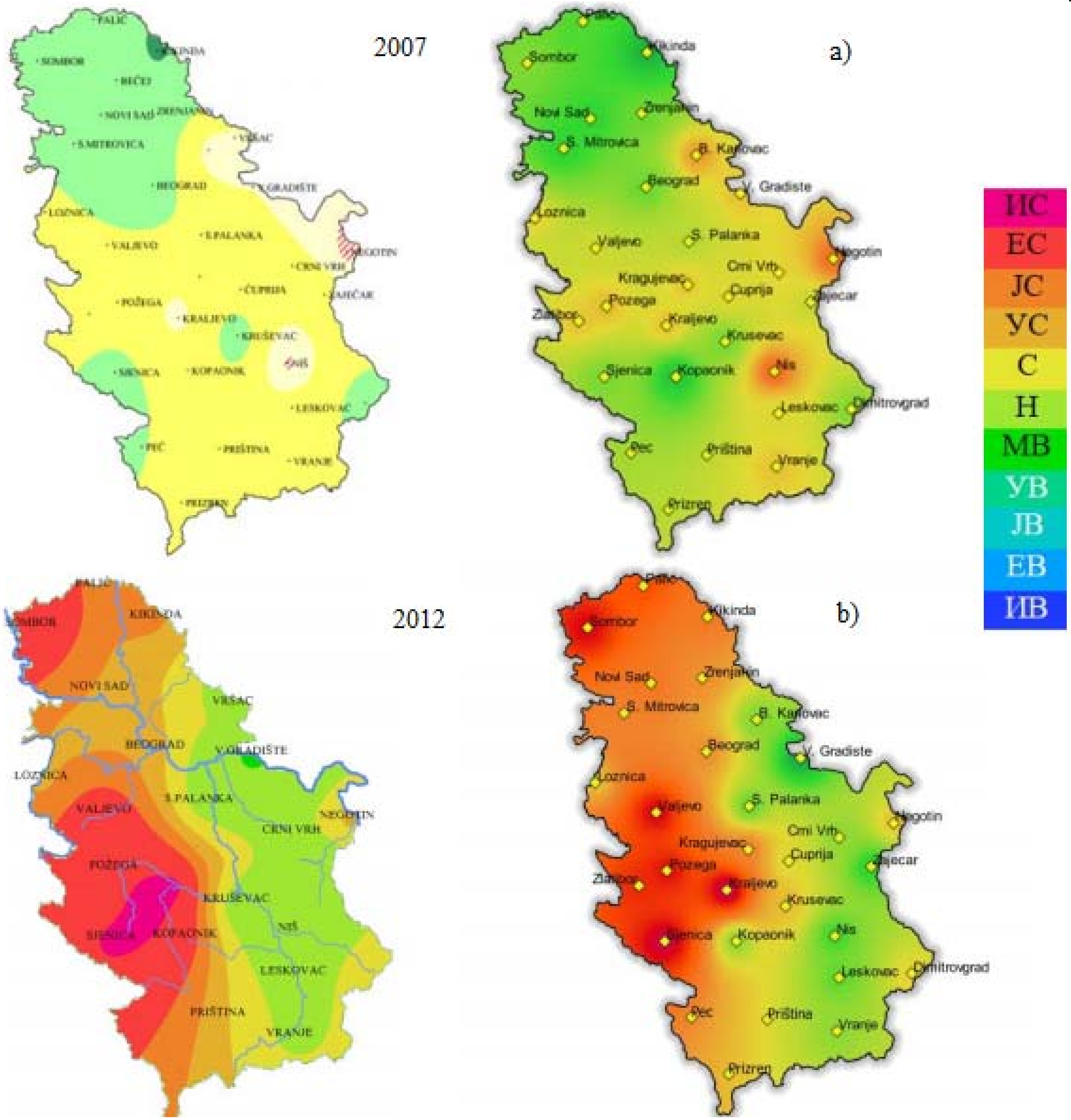
Spatial distribution of SPI–3 for Serbia



Spatial distribution of SPI–6 for Serbia



Spatial distribution of SPI–6



Conclusions

- Because of immense impacts of hydrological hazards on society and its economies, it is important to consider novel approaches, techniques, or methods for the prediction, prevention, and mitigation of hydrological hazards.

- It is critical to utilize the recent technological developments and scientific knowledge to improve our understanding of hydrological hazards and our ability to cope with droughts and floods.

Questions?