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Rainfall erosivity research on the territory of the Czech Republic

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Abstract

Water erosion is a main factor of degradation of soils used for agriculture in the Czech Republic. For landscape conservation purposes the soil erosion risk is defined here mostly by USLE method published by Wischmeier and Smith (1978). Within USLE the precipitation impact on erosion is a function of rainfall kinetic energy and intensity represented by R-factor. In the Czech Republic historically and recently several research teams have analyzed rainfall data to assess rainfall erosivity. The article is based on review of different approaches and results of recent rainfall erosivity studies. Those studies differ in both the data used for erosivity definition and the methodology applied. At the end the article presents results of the most recent study on rainfall erosivity spatial distribution over the Czech Republic performed by Research Institute for Amelioration and Soil Conservation (VUMOP), Czech Hydrometeorological Institute (CHMI) and Czech Technical University in Prague (CTU). The analysis was based on digital rain gauge data from automatic stations of the CHMI. The erosive rains were derived from continuous 1 minute step 10-year rainfall data (2003-2012) from 245 stations, all necessary quality checks and corrections were adopted. Based on the research recent annual R-factor values in the stations vary from 37 to 239 [$N.h^{-1}$] (values over 100 are located in mountain regions with minimum agricultural land). The raster based R-factor map used for erosivity definition in cross compliance soil erosion risk maps of Ministry of Agriculture adopted values varying from 37 to 110 [$N.h^{-1}$] over the Czech territory.

Key words: Erosion, R-factor, rainfall, comparison

Introduction

In the Czech Republic water erosion on agricultural lands is extremely important degradation process. Based on the historical evolution context – mainly collectivization of agriculture in the socialist period in 20th century – the soil loss on arable land reaches very high values (Van Rompaey et al. 2003). Arable land extent is continuously decreasing but proportion between arable/grassland is still unbalanced in hilly regions (database LUCC Czechia – Charles University in Prague). Land fragmentation was totally destroyed by collectivization and current process of land consolidation is unable to reconstruct the original landscape mosaic. Significant erosion vulnerability is also caused by insufficient protection of soil, growing unsuitable crops on sloping land and ultimately climate.

To evaluate the significance of climate for erosion is quite difficult. It is not the same as to assess the overall balance of precipitation and runoff or long-term precipitation coverage. The erosion process is episodic and in the Czech Republic it takes place almost exclusively in extreme precipitation events (summer thunderstorms and torrential rains). Procedure for the evaluation of erosion vulnerability of agricultural land in the Czech Republic and in the outside world is mostly based on the USLE method (Wischmeier and Smith, 1978). In the rainfall erosivity factor of the USLE the episodic nature of the erosion process is being considered.

USLE is a typical representative of empirical methods for calculating soil loss. It is a simple relationship with six parameters, the accuracy of which, however, contributes significantly to the results obtained. The basic shape of the universal soil loss equation is formed by multiplication:

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

A	is the average long term soil loss [t. $ha^{-1}.y^{-1}$];
R	is rainfall erosivity factor [N. $h^{-1}.y^{-1}$];
K	is soil erodibility factor [t.N^{-1}];
L	is slope length factor [-];
S	is slope steepness factor [-];
C	is crop management factor [-];
P	rates erosion control practices [-].

All factors were determined empirically by statistical evaluation of the soil loss on the unit plots (22 m length and 9% slope) and on different parcels compared with the unit plots. The first two factors determine the actual soil loss on unit plots for defined soils and rainfalls and can therefore be expressed in physical units. Other factors are dimensionless and represent the ratio between soil loss on a unit plot and other parameters of analyzed parcels.

In the Czech Republic in engineering practice USLE is commonly applied for several purposes:

- assessment of vulnerability of land in the design of protective measures (common facilities) within land consolidation;
- assessment of vulnerability of land and sediment transport in the basin revitalization projects and dredging of small water reservoirs;
- to identify endangered parcels under the application of EU cross compliance subsidy policy (part of the GAEC standards defined by the Ministry of Agriculture);
- as part of the calculation of sediment transport and silting reservoirs within the implementation of the Water Framework Directive (USLE here is part of a more complex model);
- other purposes (calculations of the importance of erosion for the eutrophication of reservoirs, computing infrastructure vulnerability for erosion, etc.).

The correct identification of soil loss rate by USLE is therefore a prerequisite of realistic implementation of measures against erosion in many fields of engineering.

From the above it is clear that the climate in the evaluation of erosion risk is most often expressed in terms of R-factor. Because the total soil loss defined by USLE is simply the multiplication of the individual factors the effect of R-factor on the overall result is in direct proportion (twice the value of R-factor results in twice the soil loss).

In the Czech Republic, R-factor research have been conducted at several sites continuously for the past decade and gradually brought refined results for the whole country and different regions, however the official engineering practice did not reflect the research.

In late eighties the official methodologies, defining the standards for engineering practice, recommended the use of constant R-factor of 20 [$N.h^{-1}.y^{-1}$] for the entire country. It have kept the constant recommended value for the last 30 years (Janeček et al. 1992-2012a) also at a time when research clearly demonstrated significantly higher rainfall erosivity in the last 50 years in the Czech Republic and in its neighborhood (Dostál et al. 2006). High quality data from measurements on automatic precipitation and climatological stations of the Czech Hydrometeorological Institute (CHMI) have currently allowed assembly of representative maps of rainfall erosivity in the Czech Republic over the last ten years. The density, coverage and quality of data output from automatic stations significantly exceed the outputs achieved by processing of paper ombrometer data or other previous solutions based on long-term precipitation totals (Rožnovský et al. 2013).

Materials and methods

According to measurements with the unit plots (Wischmeier and Smith, 1978) rain erosion efficiency is determined by its kinetic energy and intensity. The empirical relationship assumes that for the other factors constant, soil loss is directly proportional to the total kinetic energy of rain (Ed) multiplied by the maximum thirty-minute intensity (I_{30}).The annual value of the R-factor (based on continuous records of rainfall) is determined as the sum of erosivities of individual rains with amounts of more than 12.5 mm or of rains with maximum intensity exceeding 6 mm in 15 minutes. As an individual rainfall a rain-period separated from other rains by more than 6 hours is considered. Long-term average value of R-factor is then defined as the average annual value (annual totals) for the entire study period:

$$R = \frac{1}{n} \times \sum_{1}^{n} \sum_{1}^{k} (E_d \times I_{30})$$

R	average annual rain erosivity factor [N.h^{-1}.year^{-1}]
E_d	the total kinetic energy of a single rain [MJ.ha^{-1}]
I_{30}	maximum thirty-minute intensity of the rain [cm.h^{-1}]
n	number of years (seasons from April to October), for R-factor assessment
k	the number of erosive rainfalls in a particular year

The total kinetic energy of the rainfall according to the original manuals (after conversion to SI units) is then:

$$E_d = \sum_{1}^{s} \left[(0{,}119 + 0{,}0873 \log I_s) \times H_s \right]$$

E_d	the total kinetic energy of a single rain [MJ.ha^{-1}]
I_s	constant intensity of the uniform rain section [mm.h^{-1}]

H_s the sum of the rain section [mm]

s the number of sections of rain with constant intensity

In the publications of the last 20 years it is more often recommended to use the following updated and better calibrated equation for calculating kinetic energy (Brown and Foster, 1987).

$$E_d = \sum_{1}^{s}\left[0,29 \times \left(1 - 0,72\, e^{(-0.05 I_s)}\right) \times H_s\right]$$

This relationship is used in the Revised Universal equation (RUSLE - Renard et al. 1997) and it better defines the lower kinetic energy of light rains. For rain intensity exceeding 25 $mm.h^{-1}$ it is almost identical to the original relationship.

Van Dijk et al. (2002) conducted an extensive search and analysis of the relationships used to calculate the kinetic energy and recommended the equation, giving values approximately between the above two relations. Nevertheless the most commonly used procedure remains currently the equation of Brown and Foster.

Actual soil loss values of similar rainfall episodes show high variance (Wischmeier et al. 1959). Even though the dependence of soil loss on rainfall erosivity is relatively loose the long-term erosivity average is uniquely determined by this addiction. The original methodology for R-factor determination is still the world considered the most accurate way - as regards the empirical soil erosion models. More precisely, it is possible to determine the soil loss only by episodic physical models working directly with the hyetographs of individual rainfall events accounting for the distribution of rainfall and infiltration over time. That is not a solution for soil erosion risk assessment in large scales.

Alternative methods of deriving the R-factor are always applied in cases where no information is available about the actual characteristics of torrential rains for research locations. Since the acquisition of continuous rainfall data at high spatial resolution is problematic for many regions worldwide in the literature there is a number of ways how to approximate R-factor described. These methods are based on long-term measurements (daily, monthly, or yearly rainfall sums).Calibrations of these methods are usually not performed directly against the measured soil losses, but almost always against the values of R-factor calculated by the original Wischmeier's methodology for single stations. The procedures have three main benefits:

- data on long-term precipitation totals are much more accessible, cheaper and more available at higher spatial resolution;
- data are "robust", they may be better spatially interpolated, totals are correlated with altitude and better preserve the long-term trends;
- these data are contained in the current climate scenarios for future development and there are higher probabilities of achieving attached to them.

However, these methods have a fundamental disadvantage. Even at the higher level of correlation with EI_{30} R-factor in some studies the original direct translation between a given parameter and soil loss is missing. In other words, soil loss is mainly driven by torrential rains but the studies working only with rainfall totals do not include the share of torrential rains in the datasets.

In the world, Europe and the surrounding area of the Czech Republic the following procedures are used:

- R-factor depending on the total annual rainfall sums derived for Austria by Strauss et al. (1995) or analogous solutions for very remote regions - Hawaii, North Africa, some areas of China, etc. (Renard et al. 1994).
- Fournier index.
- Modified Fournier index and its conversion to the R-factor by Arnoldus (1977, 1980) or by Sauerborna et al. (1999).
- The relationship derived for Bavaria depending on summer totals (sums for May-October) according Rogler and Schwertmann (1981) and modified for use in the Pan-European R-factor Map (Van der Knijff et al. 2000).
- Adoption of Wischmeier's equation using the reduction of daily precipitation sums into torrential rains (reduction formulas are published by various authors for rainfall-runoff modelling purposes).
- Wischmeier's method of EI derivation applied to design rainfalls with 10 year periodicity (referred to as EI_{10}).

In Europe, it would be possible to find even more attempts to determine R-factor by long-term rainfall sums, but these are inaccurate procedures that in many countries are increasingly being replaced by new conversions utilizing the RUSLE methodology (combination of Wischmeier's and Brown and Foster equations) and correcting erosivity values on the basis of the torrential rains from continuous rainfall data (Meusburger et al. 2011; Klik et al. 2012 etc.).Applications adapting directly EI_{30}

methodology for the calculation of the monthly or daily totals also occur (Loureiro et al. 2001), but not for the climatic conditions corresponding to the Czech Republic. The aforementioned relationships are not described in detail because all the current detailed solutions for the CR are already based on accurate data by equations of Wischmeier's (1978) and Brown and Foster's (1987).

Recent computations and mapping R-factor in the CR

Already 40 years ago Pretl (Holý et al. 1975) derived Czech values of the R-factor according to the original methodology (Wischmeier and Smith, 1965). Based on data evaluation of long-term monitoring of precipitation at the erosion plots in Velke Zernoseky and in eight other stations in the northern and north-eastern Bohemia he found the range of annual R-factor of between 30 and 72 [$N.h^{-1}$]. On the basis of his own assessment of a correlation between the calculations and total annual precipitation amounts with regard to morphology he then compiled a map of R-factor isolines for the entire territory of the Czech Republic proposing the annual R-values in the range 30-100 [$N.h^{-1}$].

Precipitation measurements and calculations of the erosivity index continued in the following years, not only in Velke Zernoseky, but also in other stations. However, during the eighties and nineties, a simplified practice was adopted that minimized the rainfall erosivity contribution to the soil loss assessment. On the basis of experimental data from the stations in Prague - Klementinum, Tabor and Bila Tremesna the average R-factor value 20 [$N.h^{-1}$] was proposed by Research Institute of Amelioration and Soil Conservation (VUMOP). Based on a few erosion plot experiments this value has been derived by modified methodology, in which rainfall totals used to calculate kinetic energy were reduced by 12.5 mm rainfall as a base before invoking surface runoff (Janeček et al. 2007). Involved in this experimental research Toman in the nineties published the results of calculating the rain erosivity and erosion vulnerability based on the assessed ombrographs from Telc station (Toman, 1995) and for a number of stations in South Moravia (Toman et al. 1993). The resulting R-values are in the range from 17.6 to 25.7 [$N.h^{-1}$]. Based on experimentally verified assumption that the erosive effect of rainfall is subject to a minimum total rainfall of 10 mm, he again substracted 10 mm from the data before rainfall energy computation. This assumption corresponds to the empirically validated values at other locations and also to the Wischmeiers' observations. But according the USLE methodology (Wischmeier at al. 1978) the effective rainfalls have to be assessed in total. Methodology used in conservation planning in the Czech Republic then (and recently) conserved the underestimated R-factor value 20 (Janeček et al. 1992). In the handbook regional values for a number of stations in the Czech Republic were published but not recommended to use and the values differed only slightly from proposed constant of 20 [N.h^{-1}]. Also these values were reduced by reduction of input rainfalls. The methodology (Janeček et al. 1992) also proposed a modified threshold for erosive torrential rainfalls selection. According the plot experiments, only rainfalls meeting both criteria (exceeding both 12.5 mm amount and 6 mm/15 min intensity) caused runoff and soil loss. This way only intensive storms are selected while Wischmeier computes R-factor for all rains above 12.5 mm (and intensive smaller rains). The stricter criteria were used in most studies during following research in the Czech Republic.

In 2004 R-factor was computed for complete ombrometer data (ca 50-years) for 4 stations by Krása (2004) in Czech Technical University in Prague (CTU). Using the original Wischmeier's method for rainfall kinetic energy computation but only the rains matching both intensity and amount criteria he found the long term R-factor varying from 34-56 [N.h^{-1}.year^{-1}]. Using these data for calibration he then in cooperation with CHMI developed an R-factor map for the Czech Republic. The map was based on monthly precipitation sums for 87 stations for 1962-2001 (Dostál et al. 2006). This map brought already much more accurate spatial distribution of rainfall erosivities, yet it binds to a number of uncertainties, especially given very loose dependency between long-term (monthly) precipitation totals and torrential rainfall (see Fig. 1).

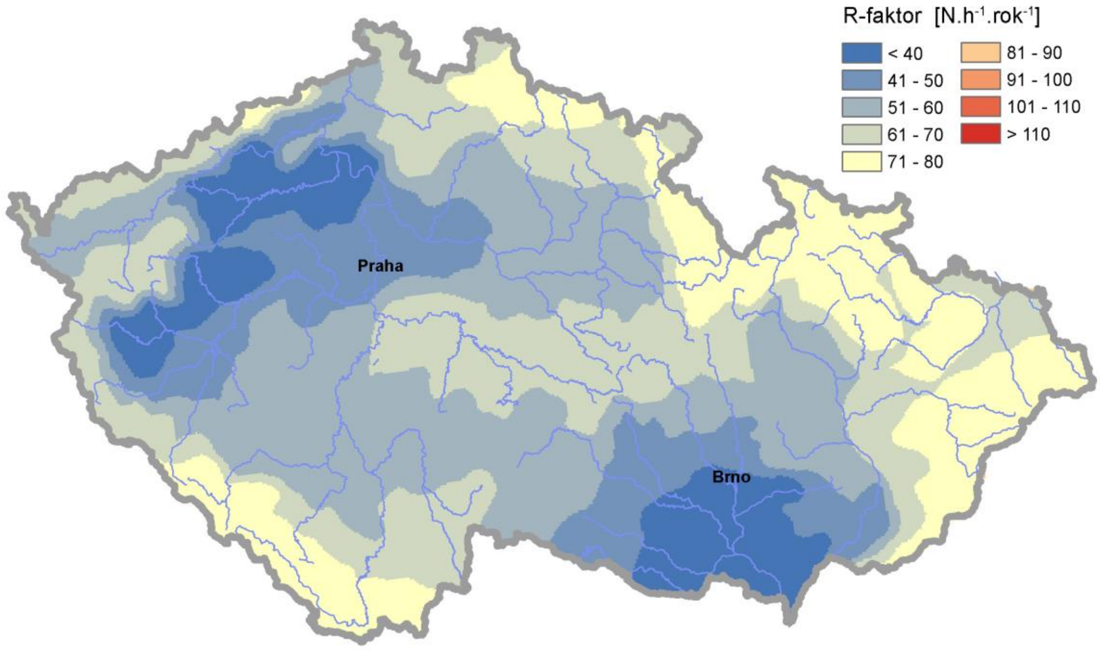

Fig. 1: R-factor map (Dostal et al., 2006) prepared by a modified methodology based on monthly totals of 87 stations (1962-2001).

At the end of 2005 (Dostál et al. 2006) in cooperation of CTU and CHMI, the R-factor was calculated by the original Wischmeier's methodology for data from minute rainfall records for 37 automatic stations. It was the first processing of digital records for this purpose in the Czech Republic and the processed data were only six seasons (2000-2005). Yet in the group 1372 torrential rainfalls were identified, representing an average of more than 6 erosive precipitation events in each station annually. On the basis of the derived digital map the average value of R-factor for the entire Czech Republic was 69 [$N.h^{-1}.year^{-1}$]. Given the short time period of processed data and the limited number of stations the regionalization in Bohemia is rather course and it is significantly affected by European extreme flood event in summer 2002 (see Fig. 2).

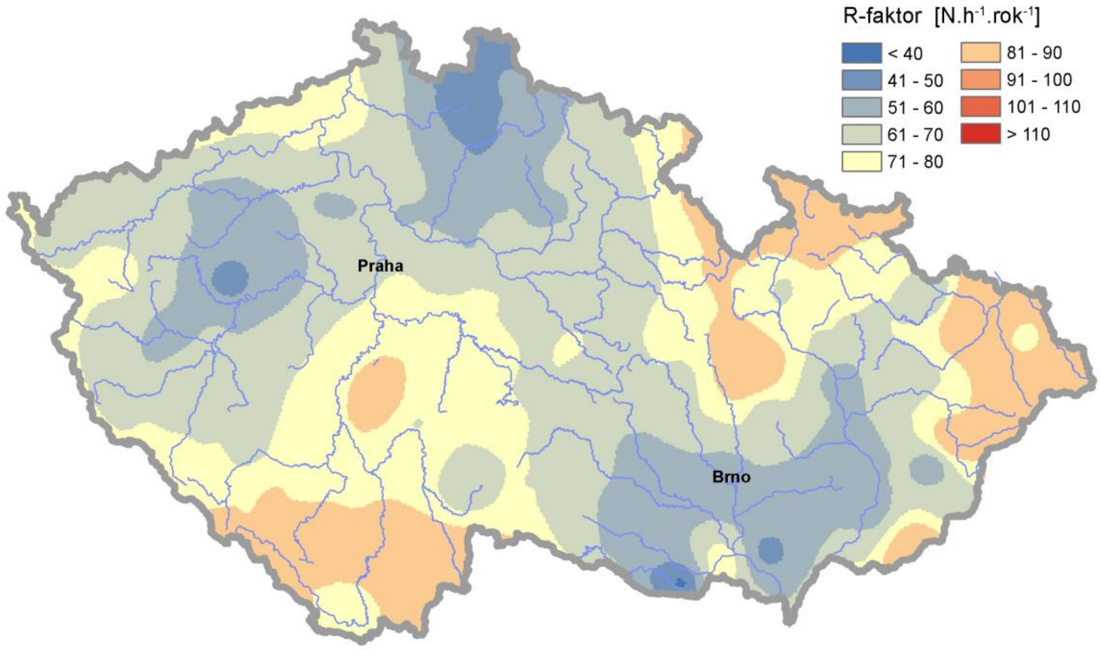

Fig. 2: R-factor map according the Wischmeier's method (Dostal et al., 2006), but only for 37 stations (2000-2005).

Bek (Charles University) tried to improve the regionalization of R-factor using weather radar data (Bek et al. 2010). Radar data show relatively high precision of localization of storm cores and storm precipitation. According the authors preparing actual R-factor maps based on radar data, however, still faces in particular following issues:

- The derivation of the actual rainfall intensity based on the reflectance is not always precise, in particular for certain types of precipitation (eg stake hail) and for extreme intensities the radar data may not be accurate (rather leads to underestimation than vice versa). It is therefore necessary to fit the data on the data from rain gauges, which, however, do not have the same time distribution. The methodology is developing rapidly and the future seems to bring much more accuracy.
- High spatial resolution of radar data is generally accurate, but there are also data errors (spatial noise) when the radar signal is damaged (eg disturbed by external phenomena), relating in particular to peripheral sites where only one of the opposing signal monitoring radars in our country is giving a close data. The error usually occurs in the form of stripes in the data only for a specific period of

observation. These errors cannot be completely eliminated in the future, but the methods of filtering the measured data would improve.

- The existing time series do not cover enough years of continuous monitoring, as it is a relatively new method. According to estimates of the authors it should be relevant to obtain a time series of observed radar data for approximately twenty years, to which we will have to wait. However, the combination of the radar and rain gauge data is promising, the correlation between the datasets justifies the use of combined data.

Prof. Janeček research group works now in Czech University of Life Sciences (CULS) and also continues assessing the rainfall data for erosivity. Kubátová et al. (2009) focuses on the distribution of erosive rainfall during the growing season. Data from her evaluated stations confirm previous trends, most erosion is caused by summer storms with a peak in June and July. In cooperation CULS–CHMI Janeček et al. (2012b) processed data from 31 ombrometric stations for the 1971 (1961) - 2000. The measured period at individual stations was variable (range 19-40 years). After separation of torrential precipitation (by the stricter criteria) file contained an average of two to three erosive rainfall at each station annually. The average value of R-factor based on the data from these stations was 48 [$N.h^{-1}.y^{-1}$], with fluctuations from 25.3 to 74.9 [$N.h^{-1}.y^{-1}$].Stations were underrepresented for regionalization in the Czech Republic, hence the data were subsequently combined with long-term daily totals of 257 CHMI rain gauge stations (1971-2000). For spatial interpolation also the altitudes of the stations were taken into account. The problem of the database is the interrupted time series used and a simplified interpretation of the calculated values. The paper presents a map created from the "clipped average" (omitted every two years with the highest and lowest values of R-factor). Statistically, it is a common practice, when we want to get closer to the median of the data set. However in the case of R-factor this procedure is irrelevant. R-factor has not an even probability distribution. The smallest rainfalls do not contribute and long term soil loss is caused mainly by extreme events, specifically those with the highest totals and intensities. To calculate the average R-factor these episodes cannot be omitted (see Fig. 3).

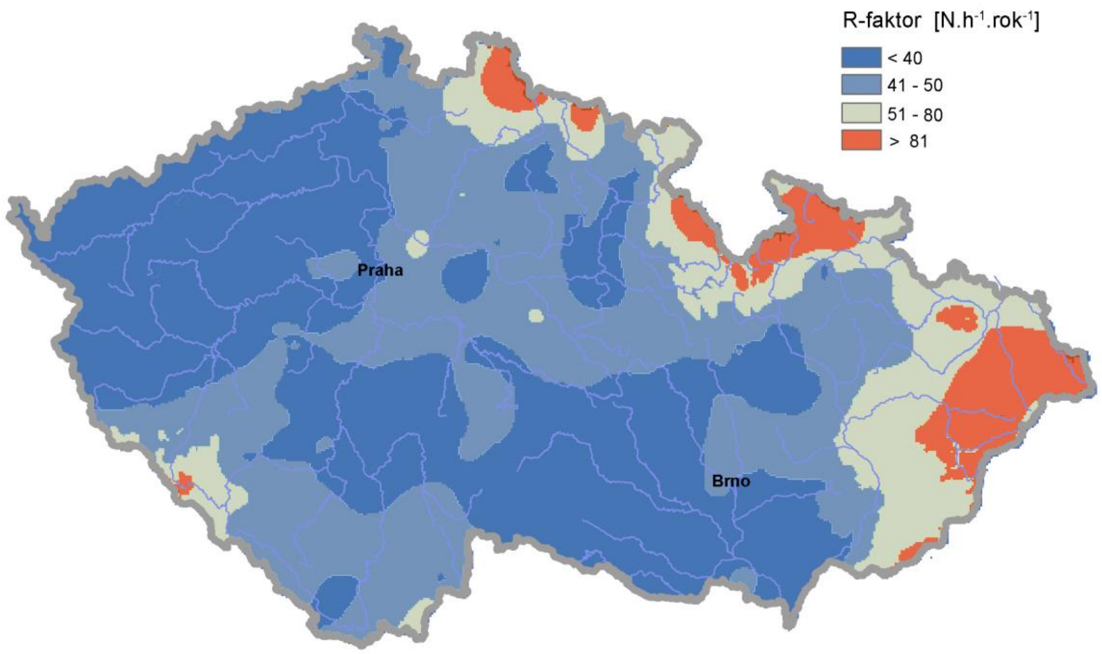

Fig. 3: R-factor map for the period 1971 - 2000 (Janeček et al., 2012b), compiled from continuous data and daily totals, based on the modified methodology with erased maximum and minimum years in considered stations.

Within a project focused on urban vulnerability for erosion risk in climate change Hanel (2013) at T. G. Masaryk Water Research Institute (WRI TGM) derived the R-factor map by original Wischmeier's methodology. He used the processed ombrometric records from 1989-2003 for 96 stations. The rainfalls exceeding 12.5 mm were selected together with torrential rains exceeding 6 mm in 10 minutes. The newer method for determining the kinetic energy of rain by Van Dijk et al. (2002) was used. The average value for the Czech Republic from the resulting digital map (see Fig. 4) is 64 [$N.h^{-1}.y^{-1}$].

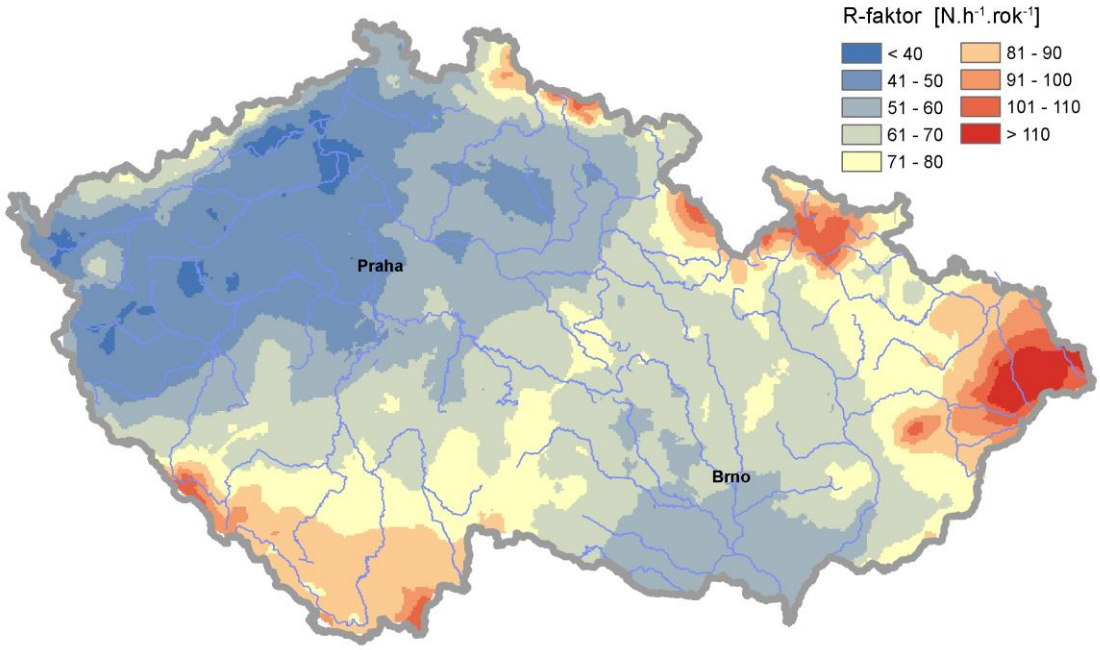

Fig. 4: R-factor map based on processed ombrometer data for 96 stations for 1989 – 2003 (Hanel, 2013).

Recent R-factor values for the Czech Republic

Finally, the most detailed and accurate current solution is based on an evaluation carried out by CHMI for the period 2003-2012. The analysis was performed in cooperation of VUMOP, CTU and CHMI and the network of 245 automatic stations was used, measuring precipitation parameters in 1 minute step. Processed rainfall intensities were available in the CLIDATA database in December 2012. After all checks outages and the initial data analyses for the direct calculation of the 10-year period R-factor 106 stations were used. Remaining stations were used for interpolating the missing values at selected stations in case of errors in the data in some years.

For its quantity and limited human resources at CHMI the 1-minute rainfalls are not systematically checked, hence in the CLIDATA database of the minute totals (precipitation intensity tables) errors can be expected. Therefore before the calculation the input data were subjected to quality control. The daily precipitation data at the stations served as the basis for the comparison and quality check. At CHMI these data pass quality control and revisions after the end of each month (control equations are applied, surface inspection is carried out in a GIS environment, missing data are substituted by neighborhood stations etc.).

In the first phase minute rainfalls greater than 10 mm were selected and subject to control (0.6% of the total number of over 11 million records per minute from 300 stations with automatic rain gauge - stations were taken without limitations regarding the minimum length range). These data were manually scanned and assessed together with other information (weather phenomena, other elements, etc.), and have been found to be faulty (in the sense of manifest error) they were excluded from further processing.

Basic control of rainfall intensities was based on a comparison of the revised (ie expired by CHMI on quality control) daily total precipitation with daily rainfall sums computed of minute totals (for the same station a day when the day is set from 07:00 CET the day to 07:00 the next day). The audit was based mainly on a comparison between the two datasets using the differences and ratios. A huge amount of data has undergone a control (about 400 thousand daily sums) and the actual process went in loop: setting up criteria for the selection of suspicious values; application of the criteria; selection of a sample of data; expertise, whether the application of the criteria did not result in leaving considerable number of errors in the database or on the contrary, the data have not been excluded that could be considered reliable; repeating the analysis. Finally, about 6 percent surveyed days were excluded from further processing. For these days, minute records were replaced by a code for missing values and they were not further processed. Missing values supplementing went up on the basis of the final results - the annual R-values, and only for stations showing the risk of undetected erosive rains (a significant daily precipitation sum recorded in the revised database). For the addition R-factor of appropriate surrounding stations the IDW interpolation was used (the reciprocal of the distance to the third power).

Result is a detailed map of the R-factor for the 2003-2012 period showing a relatively significant regional differences in the R-factor in the Czech Republic and corresponding surprisingly well with previous regionalization of other working teams (see Fig. 5). The values of the average R-factor in the stations range from 37 to 239 [N.h-1.y-1], but values above 100 are found exclusively in mountain stations (except the Radostín station near Zdarske Hills). The values in the map are therefore exposed in the range 37-110 [$N.h^{-1}.y^{-1}$].

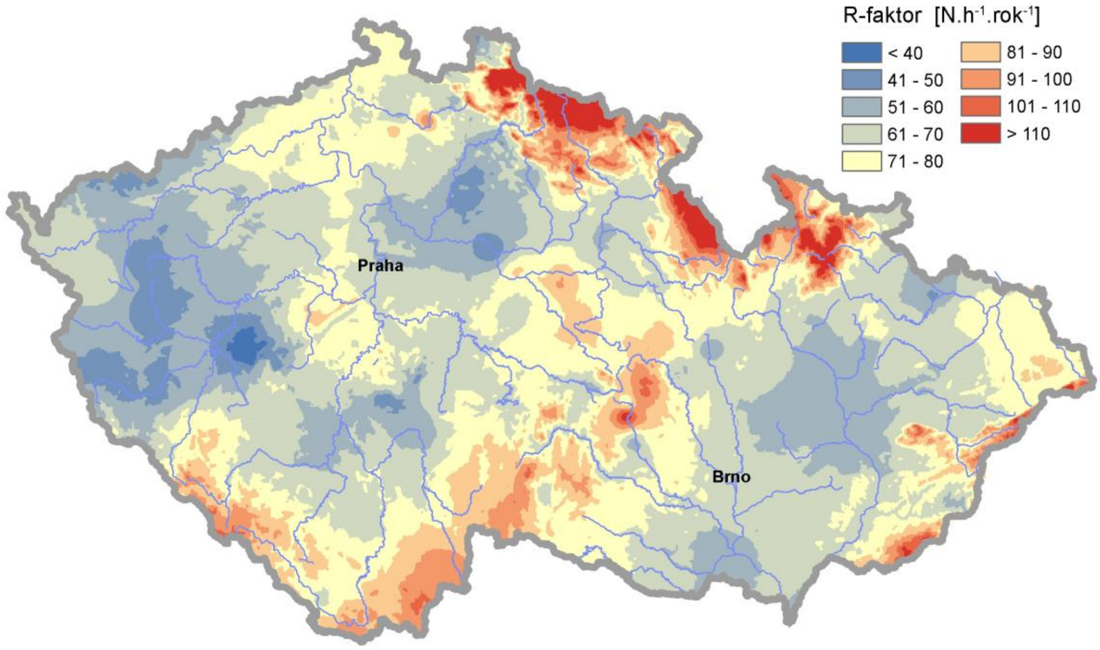

Fig. 5: Detailed map of the R-factor for the 2003-2012 period based on 106 (243) automatic rain gauge stations (Rožnovský et al. 2013).

Conclusion

Calculations of rainfall erosivity in the Czech Republic were implemented by numerous scientific teams repeatedly from the beginning of international publications of the USLE methodology in 60's of the last century. Yet since the beginning of the 80's the R-factor underestimating case study lead in to the preservation of constant value 20[$N.h^{-1}.y^{-1}$] used in the R-factor engineering practice, values significantly undervalued according to the latest calculations, and also when compared with neighboring countries (with the exception of Slovakia, which uses identical value since the time of Czechoslovakia). Table 1 summarizes recent results of nationwide R-factor calculations. The regionalization attempts made with a use of significant number of measurement stations are shown in Fig. (1-5).

Table 1: Overview of the results of nationwide R-factor calculations.

Publication	Data period	The number of stations *	min/max R in the map **	average R-factor of the Czech Republic ***
Holý et al. 1975	1965-1974	8	30/100	Not specified
Janeček et al. 1992	different lengths	3/102	5/34	20
Krása, 2004	1949-1990	4	34/56	Not specified
Dostál et al. 2006	1962-2001	4/87 month sums	35/80	57
Dostál et al. 2006	2000-2005	37	44/85	69
Janeček et al. 2012	(1961) 1971-2000	31/257 daily sums	25/75	48
Hanel, 2013	1989-2003	96	35/150	64
Rožnovský et al. 2013	2003-2012	106/245	37/110	69

Grey lines indicate solutions where regionalization did not proceed according to Wischmeier's methodology and was not based on continuous data.

** Number of stations listed after the slash indicates the stations used only for regionalization. To calculate the R-factor stations listed before the slash were used.*

*** Maximum values in the created maps are always arbitrary. Actual long-term maximum R-factors for some stations in the mountain regions always exceeded these maxima listed in maps (up to several times).*

**** Except Janeček et al. (1992, 2012) it is an average derived from raster maps, indeed relate to the whole territory of the Czech Republic, not the simple arithmetic average of the values at stations.*

Regarding the spatial variability of the R-factor in the Czech Republic, a few basic facts can be stated:

- In the regions with a large share of agricultural land long term rainfall erosivity ranges from about 35 to 90[$N.h^{-1}.y^{-1}$], with both values less than 50, so values greater than 70 occupying a significant area, always more than ¼ of the country.
- Extensive agricultural areas exist where rainfall erosivity is doubled (Czech-Moravian Highlands) compared to other regions (western Bohemia, southern and central Moravia).
- In mountainous areas in the periphery of the Czech Republic the R-factor is proven to be even higher.

- Defined regions with above-average and below-average precipitation erosive effect are permanent in nature (as demonstrated in solutions based on data since 1961) despite significant fluctuations in each period and generally high variability of R-factor in specific years.

Acknowledgement

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Summary

Vodní eroze je u nás hlavním degradačním faktorem zemědělských půd a riziko zvýšeného smyvu je pro účely ochrany půdy v ČR vyjadřováno především pomocí Univerzální rovnice ztráty půdy. Erozivita srážek je v této rovnici vyjádřena R-faktorem. V České republice výzkum R-faktoru probíhal na několika pracovištích od šedesátých let 20. století a postupně přinášel zpřesňující výsledky, nicméně oficiální praxe tento výzkum nereflektovala. V oficiálních metodikách byla dosud doporučována neměnná hodnota R-faktoru 20 [$N.h^{-1}.rok^{-1}$] pro celé území ČR. A to i v době, kdy výzkum jednoznačně prokazoval významně vyšší hodnoty erozní účinnosti srážek na území ČR i v jejím bezprostředním okolí. Kvalitní data z měření na automatických klimatologických a klimatologických srážkoměrných stanicích ČHMÚ již v současné době umožňují sestavení reprezentativní mapy erozní účinnosti srážek České republiky za období posledních deseti let. Svou hustotou pokrytí a kvalitou dat výstupy z automatických stanic výrazně převyšují výstupy dosažené zpracováním ombrogramů nebo jiná předchozí řešení postavená na dlouhodobých srážkových úhrnech. Nejpodrobnější a nejpřesnější dosavadní řešení vychází z vyhodnocení provedeného ČHMÚ za období 2003-2012. K analýze byla použita databáze Clidata ČHMÚ ze sítě 245 automatických stanic měřících parametry srážek v 1 minutovém kroku. Po všech kontrolách výpadků a analýze dat

bylo k přímému výpočtu R-faktoru využito 106 stanic, zbylé stanice byly využity pro interpolační doplnění chybějících hodnot u vybraných stanic v případě chyb v datech v některých letech.

Výsledkem je podrobná mapa R-faktoru ukazující na poměrně výrazné regionální rozdíly v R-faktoru na území ČR a korespondující překvapivě dobře s předchozími regionalizacemi ostatních řešitelských kolektivů. Hodnoty průměrného R-faktoru v řešených stanicích se pohybují v rozmezí 37 – 239 [$N.h^{-1}.rok^{-1}$], nicméně hodnoty přesahující 100 se vyskytují výhradně v horských stanicích. Hodnoty v mapě se proto pohybují v rozmezí 40 – 110 [$N.h^{-1}.rok^{-1}$].

Pokud se týká prostorové variability R-faktoru na území ČR, lze konstatovat několik základních faktů: Erozní účinnost srážek se dlouhodobě v jednotlivých regionech s významným zastoupením zemědělské půdy pohybuje v rozmezí cca 35 – 90, přičemž jak hodnoty menší než 50, tak hodnoty vyšší než 70 zabírají významnou rozlohu, vždy více než ¼ území ČR. Existují rozsáhlé zemědělské oblasti, kde je erozní účinnost srážek dvojnásobná (Českomoravská vrchovina) oproti regionům jiným (západní Čechy, jižní a střední Morava). V horských oblastech v okrajových partiích ČR je erozní účinnost srážek prokazatelně ještě vyšší. Vymezené regiony s nadprůměrnou a podprůměrnou erozní účinností srážek mají trvalý charakter (jak prokazují řešení postavená na datech od roku 1961) i přes výrazné výkyvy v jednotlivých obdobích a obecně vysokou variabilitu R-faktoru v konkrétních letech.

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