The Use of Radar Data Mining for Forecasting of Convective Precipitation

D. Šaur, R. Žák, and J. Švejda

Abstract— This article is focused on the use of radar data mining for the prediction of convective precipitation on the the Zlín Region. The first chapter describes the principle of radar precipitation measurements implemented through a network CZRAD. The next chapter describes the program on mining radar data from the network CZRAD, including schematics software algorithm and its use for processing statistics of historical weather events. Subsequently, an example of selected meteorological situation is shown in terms of practical use of software tool intended for radar data mining. The last chapter presented a proposal of a prediction system of convective precipitation, the outputs of which are validated with real measured data. The aim of this chapter was to demonstrate the effectiveness of the use of radar data mining on the selected weather situation for forecast of the locations of convective precipitation in the Zlin region.

Keywords— data mining, radar precipitation measurement, flash floods, numerical weather prediction model

I. Introduction

GLOBAL warming significantly affects not only the climate of our planet, but also the development of the weather for the last 50 years. Some of the major effects of global warming is an increase of air temperature and relative humidity in the troposphere. Consequently, we can expect a higher number of extreme atmospheric phenomena inducing flash floods, such as strong thunderstorms accompanied by torrential rainfall, hail, strong wind gusts, electrical lightning discharges and tornadoes. Four flash floods occurred in the Czech Republic (Zlin Region) in 2009-2012, which caused considerable loss of life and material damage.

The current issue of crisis management of the Zlín Region are flash floods with rainfall of 10-80 mm which arise over the territory of a small size (approximately several square kilometers) and take short time interval (approximately 30-60 minutes) [1].

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The essence of the problem lies in the insufficient quality and accuracy of forecasts distributed by the Czech Hydrometeorological Institute, which provides information only about the probability of storm occurrences instead of their specific locations and time of occurrences; therefore, the main objective of our research is to propose a forecasting system in the form of a software application intended to the prediction of local intense precipitation in the Zlin region and to ensure the preparedness of units of the Integrated Rescue System for 24 hours in advance. This prediction system will be part of Information, Notification and Warning System, which is an information support for crisis management in the Zlín Region.

Forecasting system will be connected to both servers on which an application with the radar, satellite and station precipitation measurement runs and outputs from aerological soundings and numerical weather prediction models. These applications provide data in only graphical formats. Consequently, part of the forecast system must be other software tools that convert data from graphical into tabular form suitable for subsequent analysis and evaluation. Subsequently, the data will be compared with selected characteristics and statistics of historical meteorological situations in order to find the characters of similarity.

Radar precipitation measurement gives us data on the current distribution and the development of precipitation over our territory. These data will have major importance in the statistics of historical meteorological situations that describe the chronological development of the thunderstorm cloud with the occurrence of the maximum values of radar reflectivity of precipitation fields.

The Czech Hydrometeorological Institute provides radar data through the interactive application JSRadView. The data is displayed in the PNG format as measurement results. However, meteorologists work only with binary form of the original measured data only, which are not publicly available. Binary form of measured data contains values of radar reflectivity of precipitation fields that are used in other calculations such as meteorological radar estimates combined with rain gauge measurement. The data in binary form are paid; therefore it was necessary to create a software tool intended to radar data mining from publicly available JSRadView.

The values of radar reflectivity of precipitation fields will be used for both statistical processing of meteorological situations and creation of prediction of torrential rainfall in the Zlin Region in the last chapter.

II. Radar Precipitation Measurement

Radar precipitation measurement is operated by the Czech radar network of CZRAD in the Czech Republic, which consists of two meteorological radars.

Meteorological radar detects strong precipitation cloudiness (eg. thunderstorm to 250 km). Functional principle of radar is based on backscatter of microwaves (centimetres-waves) on water droplets and ice crystals in precipitation and cloud cover. The transmitter generates short high-energy pulses of electromagnetic waves which the antenna radiates in the form of a narrow beam into the atmosphere. Some of the energy is backscattered from meteorological targets (precipitation) or other targets (terrain, aircraft). Target position is determined according to the antenna position (azimuth, elevation) and the time between sending and receiving pulse. The amount of reflected energy is proportional to the intensity of precipitation (radar reflectivity) [2], [3], [10], [11], [12]:

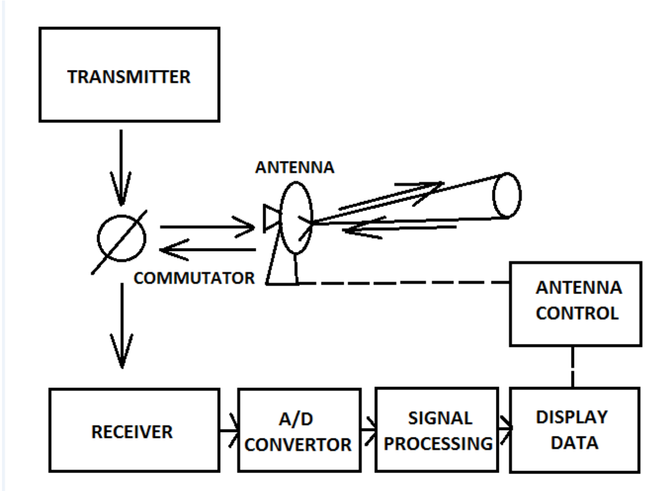

Fig. 1 scheme of meteorological radar [5]

A. Radar Precipitation Estimates

The fundamental quantity of radar precipitation measurement is radar reflectivity. This quantity is part of radar reflectivity scale shown in the bottom right of the radar picture. Radar reflectivity Z is defined as

$$Z = \sum_{i\in IV} D_i^6 = \int_0^\infty N(D)D^6 dD, \tag{1}$$

where N (D) is a spectrum of particle size and D_i is diameter of droplet. Radar reflectivity Z is proportional to the sum of the sixth power of the particle diameters in a unitary volume (Z=SUM (D^6)). This condition applies for smaller particles than the wavelength of the radar. The unit of radar reflectivity Z is 1 mm^6/m^3 or logarithmic unit dBz, where Z [dBZ] = 10log (Z[mm^6/m^3]), thus 0 dBZ corresponds to Z=1mm^6 /m^3 [5], [6]. The measured radar reflectivity Z has a direct relation to instantaneous intensity of precipitation in a given location. Rainfall intensity I, depended on the radar reflectivity Z, is determined by Marshall-Palmer relation in the form:

$$Z = aI^b, \tag{2}$$

where a and b are experimentally determined constants (a=200, b=1,6) for area of temperate latitudes [5], [6].

The rainfall intensity I is calculated by Marshall of Palm-relation (2) in a simplified form:

$$I = 10^{\frac{[Z-10\log(a)]}{10b}}. \tag{3}$$

As can be seen in Table I, the radar reflectivity Z increases exponentially depending on the rainfall intensity I [4], [8], [10], [11], [12]:

Table I colour scale of radar reflectivity with the recalculated rainfall intensity [9]

Colour spectrum of radar reflectivity	Z [dBz]	I [mm/h]
	4	0,1
	8	0,1
	12	0,2
	16	0,4
	20	0,6
	24	1,2
	28	2,1
	32	3,6
	36	6,5
	40	11,5
	44	20,5
	48	36,5
	52	64,8
	56	115,3
	60	205,0

The colour spectrum is used for recalculation radar reflectivity to rainfall intensity and data processing.

III. Radar Data Mining Software

The main purpose of this software tool is to simplify the process of collecting radar data from the CZRAD network for subsequent processing, analysis and evaluation of selected meteorological situation.

The program includes the following supporting applications:

- Meteo.exe - user interface.
- Data.csv - MS Office Excel file with the extension * csv intended to the selection and location updates.

- DataOutput.csv - MS Office Excel file with the extension * csv intended to storing the read data in the values of radar reflectivity converted from the RGB spectrum.

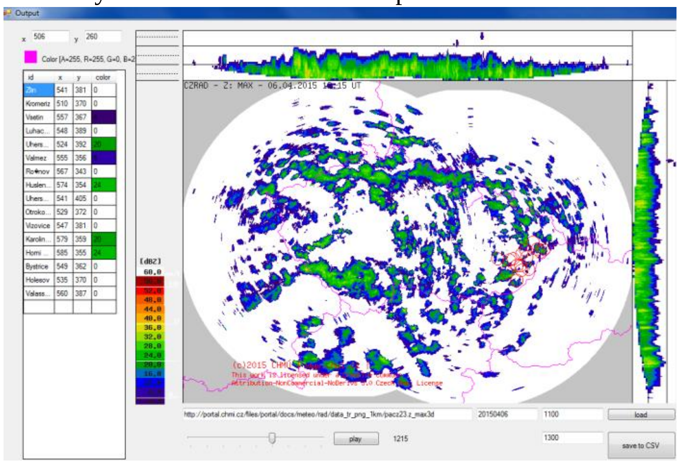

Fig. 2 the main panel of the Meteo program

The user interface of the program Meteo consists of the following parts:

- The radar picture that is loaded by pressing "load" button from JSRadView application, which runs on the server of Czech Hydrometeorological Institute (CHMI) portal.

Area under the radar images contains following parts of the program:

- Web address of CHMI portal.
- Date and time interval to retrieve the radar picture.
- Time scale for uploading radar images (the Web address).
- The "save to CSV" button intended to save the downloaded radar images to MS Office Excel.

Left of the radar output, there is a table containing these values:

a) ID - the name of the selected locality,

b) Coordinates of X and Y describing the location

c) Colour spectrum - the colour expression of the appropriate values of radar reflectivity.

```
private int color2value(int x, int y)
{
    if (loadImg)
    {
        Bitmap bitmap = (Bitmap)pictureBox1.Image;
        Color color = bitmap.GetPixel(x, y);
        int output = 0;
        if (color.R == 252 && color.G == 252 && color.B == 252) output = 60;
        if (color.R == 160 && color.G == 0 && color.B == 0) output = 56;
        if (color.R == 252 && color.G == 0 && color.B == 0) output = 52;
        if (color.R == 252 && color.G == 88 && color.B == 0) output = 48;
        if (color.R == 252 && color.G == 132 && color.B == 0) output = 44;
        if (color.R == 252 && color.G == 176 && color.B == 0) output = 40;
        if (color.R == 224 && color.G == 220 && color.B == 0) output = 36;
        if (color.R == 156 && color.G == 220 && color.B == 0) output = 32;
        if (color.R == 52 && color.G == 216 && color.B == 0) output = 28;
        if (color.R == 0 && color.G == 188 && color.B == 0) output = 24;
        if (color.R == 0 && color.G == 160 && color.B == 0) output = 20;
        if (color.R == 0 && color.G == 108 && color.B == 192) output = 16;
        if (color.R == 0 && color.G == 0 && color.B == 252) output = 12;
        if (color.R == 48 && color.G == 0 && color.B == 168) output = 8;
        if (color.R == 56 && color.G == 0 && color.B == 112) output = 4;
```

Fig. 3 sample of source code - conversion of RGB values to the radar reflectivity Z

A. *Scheme of the Program*

Initially, the user got familiar with the program, its visualization and features.

The user should follow these steps:

1) Firstly, radar data has to be loaded from the server of the Czech Hydrometeorological Institute (JSRadView application). The radar data is stored in bitmap file in the form of spectrum colour of radar reflectivity.

2) Secondly, the user sets point and the input file (name_point – name; X; Y - coordinates of the location).

3) The third step is the analysis and processing of data array.

4) Subsequently, coordinates are loaded from the file and the value from the spectrum colour of radar reflectivity is determined.

5) Further, values are converted into numerical data of the spectrum colour of radar reflectivity.

6) Finally, data is saved into output file in MS Excel.

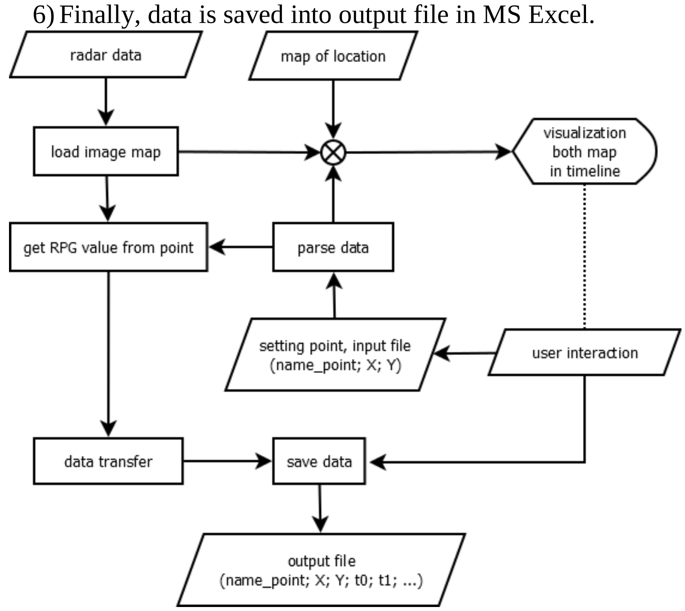

Fig. 4 scheme of the radar data mining

Controlling of the Meteo program is easy and intuitive. Firstly, the user chooses a date and a time interval for recording radar images of CZRAD network. Moreover, JSRadView the application provides a history of images for the last 87 hours. The user loads the selected radar images using the "load" button and then they can be stored using the "save to CSV" button. Selection of locations can be updated by clicking the mouse on the map radar picture, where coordinates X and Y are displayed. These coordinates are copied to a file Data.csv.

The file DataOutput.csv contains coordinates of selected locations and values of radar reflectivity loaded from radar images according to the selected time interval. The values of radar reflectivity can be calculated by formula (3) to the values of rainfall intensity for subsequent analysis and data evaluation.

IV. Analysis of Case Study on 21.7.2014

Use of the radar data mining program is demonstrated on the analysis of the situation on July 21, 2014, when the most intense rainfall occurred in the Zlín Region in 2014. This situation showed typical features of a trough (in meteorology) passing through central Europe. Initially, the anticyclone influenced us above western Europe, which moved very quickly through central Europe to the east. Subsequently, trough influenced us from the west. Warm stable air mass was transformed into unstable air mass due to intensive warming of the Earth's surface and an increase the moisture in the atmosphere. The formation of very strong thunderstorms was significantly supported by orography terrain, especially on the windward side of the local hills and mountains [7].

Table II indexes convection calculated from aerological station Prostějov on 21.7.2014

Date	Time release radiosonde	CAPE (J/kg)	CIN (J/kg)	LI	KI	SI	SWEAT	TT index	FAUST	SHEAR (m/s)
21.7	12:00	2 077	-13	-3	36	-3	222	50	2	5

Indices of convection characterize the degree of atmosphere instability (atmospheric condition for the formation of storms). Very high value of CAPE (Convective Avalaible Potential Energy) was the main feature of the formation of very strong thunderstorms exceeding 2000 J/kg in combination with wind shear in the level of 0-6 km. The value of wind shear of 5 m/s is characteristic for the formation of convective cells and weak multicell storms, but the main parameter was the wind blowing from the southeast of the surface layer (10-100 m above the terrain) and northwest in the direction of precipitation movement (700 hPa geopotential level - 3 km above the terrain). The opposite direction of air flow in the surface and height levels of the atmosphere led to the formation of stationary convective storms, when a large amount of rainfall fell in a small area [7].

Table III shows three basic data array:

- Location - selected locations in the Zlín Region.
- Coordinates X and Y - describe the location of the selected sites.
- Time interval 2:30 p.m. to 3:15 p.m. for radar rainfall measurements.

Table III radar measurement of atmospheric precipitation on July 21, 2014-Data Output.csv

lokace	x	y	1430	1445	1500	1515
Zlin	541	381	0	0	40	36
Kromeriz	510	370	48	56	52	40
Vsetin	557	367	40	28	32	36
Hostalkova	545	365	48	56	56	52
Luhacovice	548	389	0	0	52	48
Uherske Hradiste	524	392	0	0	0	0
Valmez	555	356	40	24	8	32
Roznov	567	343	16	28	28	28
Huslenky	574	354	36	32	28	28
Uhersky Brod	541	405	0	0	0	52
Otrokovice	529	372	0	0	4	4
Vizovice	547	381	0	0	16	4
Karolinka	579	359	32	28	24	36
Horni Becva	585	355	32	28	32	32
Bystrice	549	362	20	24	24	28
Holesov	535	370	32	16	40	24
Valasske Klobouky	560	387	0	0	12	24

The result was the measured values of radar reflectivity of the most intense rainfall that occurred in the time between 14:30 and 15:15 in the Zlín Region. Maximum values of radar reflectivity were recalculated to rainfall intensity according to the formula (3) and incorporated into the statistics of the meteorological situations.

Average values of radar reflectivity *Z* was achieved for the locations Kroměříž (Z=48 dBz => I=37 mm/ hr) and Hošťálková (Z=52 dBz => I = 65 mm/hr).

The objective of radar data mining was to obtain the data of the maximum radar reflectivity intended to the processing of statistics of precipitation and locations for selected meteorological situation.

Result of the analysis of the meteorological situation on July 21, 2014 is the statistic of precipitation and locations listed in Table IV:

Table IV the statistic of precipitation and locations for meteorological situation on July 21, 2014

Locations	Mountains	Time of occurence	Z (dBz)	I (mm/hr)	Rainfall (mm/24h)	Station
Vsetín	**Hostýn-Vsetín Higland**	**5x 14-17; 2x 18-21**	**56**	**115**	**74**	**Maruška**
Luhačovice	Vizovice Highland	3x 14-17; 3x 18-21	56	115	49	Horní Lhota
Uh. Hradiště	Chřiby	3x 14-17; 3x 18-21	52	65	41	Staré Hutě
Rožnov p. Radhoštěm	Vizovice Highland	3x 14-17; 2x 18-21	56	115	35	Horní Bečva
Kroměříž	Litenčice Highland	3x 14-17; 2x 18-21	52	65	24	Kroměříž

Table IV expresses the relation between radar (Z of dBz) recalculated to rainfall intensity *I* of mm/hr and station measurements (Totals – 24 mm / hr + station). The most intense rainfall fell on the windward side of the Hostýn-Vsetín highlands due to wind shear, which prolonged the duration of the precipitation. The station Hošťálková measured the total precipitation of 65 mm/hour (between 15 and 16 hrs.), which is classified by Integrated Warning Service System of CHMI as "Very strong thunderstorms". 24-hour total precipitation was even greater (74 mm). Torrential rainfall caused considerable material damage including extensive soil erosion in the affected area [7].

V. THE USE OF RADAR DATA MINING FOR FORECASTING OF CONVECTIVE PRECIPITATION

Use of the program on radar data mining will be shown in the same example mentioned in the previous chapter. Forecast will be recalculated aditionally for historical weather situation on July 21, 2014.

A. FORECASTING OF CONVECTIVE PRECIPITATION

Convective precipitation together with other accompanying atmospheric phenomena (eg. hail, strong wind gusts, tornadoes and electrical atmospheric discharges) are the result of the mature stage convective storms. The cause of convective storms and rainfall is atmospheric process known as convection. Convection occurs an uneven heating of the earth's surface where there is release of warmer air particles compared to the surroundings. This warm air is held up by upwardly to the atmosphere by the aerodynamic lift force. The projecting air is cooled in the process up until there is a condensation and the formation of a cloud. Water droplets collide and connect to exceed a certain weight, in which the updraft cannot hold. Consequently, there is downdraft formed dropout precipitation.

Elementary unit of convective storm is a convective cell. Each convective cell is generated by:

- Factors of trigger mechanisms of convection and
- Factors of air masses.

Factors of trigger mechanisms of convection are:

- Temperature contrasts of the earth's surface.
- Relative humidity at 2 meters above the ground.
- Wind speed and direction.
- Orography of terrain.

Factors of trigger mechanisms of convection influence the formation of convection between the surface (0-2 meters) to a Lift Condensation Level (1-2 km). Temperature contrasts of the earth's surface, the relative humidity at 2 meters above the ground and the wind direction and speed influencing formation of convective cells approximately near the earth's surface. If there are large differences in the the earth's surface temperature (2-3 ° C) of the characteristic radiation of the earth's surface, the relative humidity above 40% and a wind direction in the direction of valley speeds above 5 m / s, the ideal conditions for the formation of convection. Orography of terrain, respectively windward and leeward effects of the surrounding hills and mountains can amplify and support the forced output of of hot unsaturated air.

Factors of air mass influence the development of convection over the lift condensation level to the upper limit of the troposphere (12-14 km). These factors determine the degree of instability of the environment (a favorable environment for the development of convective cells). These factors are indexes of convection such. CAPE (Convective avalaible Potential Energy), CIN (Convective Inhibition), LI (Lifted Index), SI (Showalter Index), KI (K-Index), TT (Totals totals index), FAUST, SHEAR (0-6 km) and the SWEAT index.

Interaction of factors and trigger mechanisms of convection of air masses are formed very appropriate conditions for the emergence of the strongest convective storms. Each factor will have set limits that are differentiated depending on the rainfall intensity. The aim of prediction is finding the intersection of all of these factors with the highest values.

B. ALGORITHM OF FORECASTING OF CONVECTIVE PRECIPITATION

Convective precipitation prediction algorithm consists of eight steps in the calculation of sub predictions with the main goal to create the resulting prediction of temporal and spatial occurrence of convective precipitation:

- Forecast for 6 to 24 hours in advance.
- Forecast three-hour time interval.
- Forecast place of occurrence (from individual sites to areas with a large area, eg. municipalities with extended powers of the Zlín region).

Selecting expanses of territory has a significant importance for the success of predictions. Forecasts for larger areas will have a higher success rate compared to forecasts for individual locations.

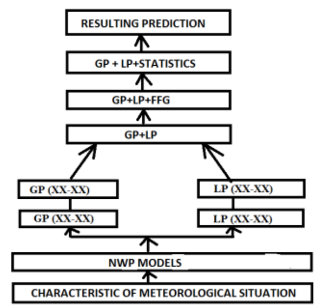

Fig. 5 algorithm of convective precipitation forecasts

Individual steps of partial predictions are:

1) **General characteristics of the weather situation** - a summary of the basic knowledge for the purpose of finding statistics of historical weather situation (flow direction of movement of rainfall, type of convection - the frontal, orographic or combined convection).
2) **NWP models** - to determine the time of occurrence of precipitation (especially outputs of ALADIN, GFS, EURO4, GEM and UKMET).
3) **GP (Global prediction)** for a certain period of time (eg. 12-15; 15-18) - calculation of the instability of the atmosphere (according to general characteristics determine the frontal or orographic convection of and assigning appropriate parameters and indices convection).
4) **LP (local prediction)** for a specified period of time (eg. 12-15; 15-18) - the overall calculation for:
   • individual meteorological elements for municipalities with extended powers and their sub-region (data source: INTERNET - meteograms ALADIN)
   • outputs morphometric analysis of relief for the direction of flow for three trigger mechanisms convection (orography of terrain, heat the Earth's surface contrasts of and convergence of flow) - Data source:

i. INTERNET - ČÚZK - Analysis of the ground - fine DMR - of slope, orientation, and aperture of relief, or
ii. ArcGIS version 10 and higher,
iii. USGG - IR image - thermal radiation Relief (IR image)
• FFG (Flash Flood Guidance) - degree of saturation of soils to determine the risk of flash floods - Data source: INTERNET - HYDRO.CHMI.CZ

5) **GP+LP** - Summary of outputs of global and local forecast
6) **GP + LP + FFG** - a summary of the of outputs of global, local characteristics and degrees of saturation of soil (from application Flash Flood Gouidance).
7) **GP + LP + FFG + STATISTICS** - summary of outputs of global, local characteristics, the degree of saturation of soils and outputs found historical weather situation (based on the direction of flow and comparing synoptic forecasts from GFS model for all of Europe).
8) **The resulting prediction** - comprehensive summary of the overall prediction of place and time of occurrence of convective precipitation for the area selected territorial unit.

C. *FORECASTING SYSTEM OF CONVECTIVE PRECIPITATION*

Forecast of convective precipitation will be implemented in three phases:

I. The issued a warning information from the System of Integrated Warning Service of Czech Hydrometeorological Institute next 24 hours.
II. Calculation of convective precipitation forecasts to 6-24 hours in advance.
III. Nowcasting prediction through the CZRAD network and mobile meteorological radar MMR50 for 30-60 minutes in advance.

The main end-user of the regional emergency management authorities, together with municipalities with extended powers and other entities (eg. legal and physical persons).

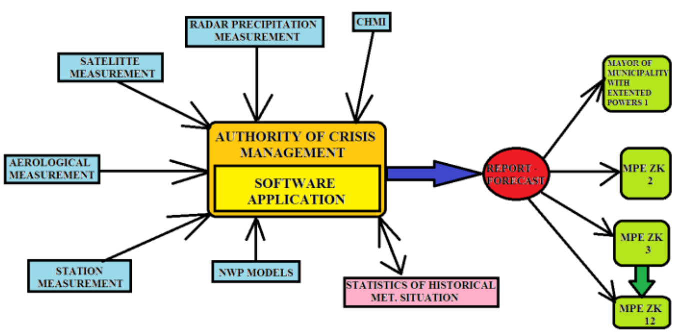

Fig. 6 scheme of prediction of convective precipitation

The input data is data from meteorological radars, satellites, aerological soundings, land-based meteorological stations and numerical weather prediction models (NWP models). Data from NWP models will be the main source for calculating forecasts and other data will be used for monitoring the current rainfall situation. Calculation of NWP models will be compared and supplemented with output statistics of historical weather events from 2007 to 2015.

The main objective will be to create regional prediction based on warning issued information from Integrated Warning Service of Czech Hydrometeorological Institute to distribute timely and accurate information for preventive measures against probable occurrence of flash floods. The essence of this tool is to minimize loss of human life and material damage caused by flash floods.

D. CALCULATION OF PROBABILITY PLACE OF OCCURRENCE CONVECTIVE PRECIPITATION AND THEIR RAINFALL INTENSITY

Calculation of the resulting predictions locations of rainfall established for 13 municipalities with extended powers Zlin region. The main objective is to find the values of merging meteorological parameters (e.g. indices convection), respectively meteorological parameters. The output is likely in the value of 13% for individual municipalities with extended powers by the equation:

$$P = (\sum n / \sum m \times 4) \times 100\ (\%), \qquad (4)$$

Where n is the sum of the partial prediction coefficients (e.g. prediction of instability of the atmosphere which consists of 10 indices convection) and m is the total number of predicted parameters multiplied by four coefficients probability place of occurence and rainfall intensity:

0. Coefficient of probability of location of 0-25%, while the intensity of weak storms 0-30 mm / h.
1. Coefficient of probability locations of 25-50%, while the intensity of strong thunderstorms 30-50 mm / hr.
2. Coefficient of probability locations of 50-75%, while the intensity of very strong thunderstorms 50-90 mm / hr.
3. Coefficient of probability locations of 75-100%, while the intensity of extremely strong thunderstorms over 90 mm / hr.

E. APPLICATION OF RADAR DATA MINING FOR THE CREATION OF CONVECTIVE PRECIPITATION FORECASTS

Outputs from radar data mining are applicable especially in statistical historical weather events. Each statistics are compared outputs from the radar precipitation measurement network CZRAD and station networks for the selected region (in this case for Zlin region). Meteorological station network in the Zlin region includes 16 ground-based weather stations.
In processing statistics follow these steps:

- Radar reflectivity values assigned to 3 hour intervals.
- Radar reflectivity values of coefficients to convert rainfall intensity.

TABLE 5 converting of radar reflectivity of convective precipitation to coefficients of rainfall intensity

Radar reflectivity	Coefficients
<48 dBz (<37 mm/hour)	0
52 dBz (65 mm/hour)	1
56 dBz (115 mm/hour)	2
>=60 dBz (>=200 mm/hour)	3

The values of radar reflectivity were assigned to three hour time intervals and converted into coefficients of convective precipitation intensity.

The aim of radar data mining was to gain maximum radar reflectivity data processing and statistics precipitation of locations for the selected meteorological situation.

Table 6 statistics of radar and station precipitation measurement on 21.7.2014

					Station	Results
lokace	x	y	12 to 15	15 to 18	12 to 18	12 to 18
Zlin	541	381	0	0	0	0
Kromeriz	510	370	1	0	0	0
Vsetin	557	367	0	0	0	0
Hostalkova	545	365	1	2	2	2
Luhacovice	548	389	0	1	1	1
Uherske Hradiste	524	392	0	0	1	1
Valmez	555	356	0	0	0	0
Roznov	567	343	0	0	0	0
Huslenky	574	354	0	0	0	0
Uhersky Brod	541	405	0	1	0	0
Otrokovice	529	372	0	0	0	0
Vizovice	547	381	0	0	0	0
Karolinka	579	359	0	0	0	0
Horni Becva	585	355	0	0	1	1
Bystrice	549	362	0	0	0	0
Holesov	535	370	0	0	0	0
Valasske Klobouky	560	387	0	0	0	0

The value of rainfall intensity was determined by unification of outputs from radar and station measurements.

In the penultimate stage, the resulting predictions were compared weather situations from 21.07.2014 with other historical weather events. Comparison and assignment of historical weather events was based on a comparison of the forecasting synoptic maps of Europe. The weather situation on 21 July 2014 was the most similar to these historical weather situations:

- 20.6.2011
- 27.7.2011

June 20, 2011, there were few weak thunderstorms, especially in Luhačovice and Uherský Brod. The intensity of the of precipitation in these areas has reached 52 DBZ (65 mm / h), but the stations were measured very low rainfall. Therefore, of precipitation statistics and locations were not included in the resulting prediction.

Situation on July 27, 2011 was the occurrence of convective of precipitation a more favorable than the previous situation. The most intense rainfall were observed at stations Luhačovice Kladná-Žilín and Bystřice pod Hostýnem. Occurrence of severe convective of precipitation was almost identical with the occurrence of rainfall per 07.21.2014.

Table 7 statistics place and time of occurrence of convective of precipitation in the Zlin region dated July 27, 2011

27.7.2011			Radar	Station	Results
lokace	x	y	15 to 18	15 to 18	15 to 18
Zlin	541	381	0	0	0
Kromeriz	510	370	1	0	1
Vsetin	557	367	0	0	0
Hostalkova	545	365	0	0	0
Luhacovice	548	389	1	1	1
Uherske Hradiste	524	392	0	0	0
Valmez	555	356	0	0	0
Roznov	567	343	1	0	1
Huslenky	574	354	0	0	0
Uhersky Brod	541	405	1	0	1
Otrokovice	529	372	0	0	0
Vizovice	547	381	0	0	0
Karolinka	579	359	0	0	0
Horni Becva	585	355	0	0	0
Bystrice	549	362	0	1	1
Holesov	535	370	0	0	0
Valasske Klobouky	560	387	0	0	0

Subsequently, outputs o precipitation and locations were analyzed and compared with predictions generated by the predictive system of convective of precipitation in his previous seven steps on the basis of the proposed algorithm on 20.6 and 27.7.2011. In the final, the eighth step table was created with the outputs of forecasting and statistics, historical weather situations. The aim was to create a resulting forecast of locations of precipitation for the different locations, which are part of the 13 municipalities with extended powers Zlin region.

Table 8 the resulting forecast of locations and precipitation in the Zlin Region for 21.07.2014

21.7.2014			Forecast	Statistics	Results	Real state
lokace	x	y	15 to 18	15 to 18	15 to 18	15 to 18
Zlin	541	381	0	0	0	0
Kromeriz	510	370	1	0	1	0
Vsetin	557	367	2	0	0	0
Hostalkova	545	365	2	0	0	1 (X)
Luhacovice	548	389	2	1	1	1
Uherske Hradiste	524	392	0	0	0	1 (X)
Valmez	555	356	0	0	0	0
Roznov	567	343	1	0	1	1
Huslenky	574	354	1	0	0	0
Uhersky Brod	541	405	1	0	1	0
Otrokovice	529	372	0	0	0	0
Vizovice	547	381	0	0	0	0
Karolinka	579	359	0	0	0	0
Horni Becva	585	355	0	0	0	1 (X)
Bystrice	549	362	1	1	1	0
Holesov	535	370	0	0	0	0
Valasske Klobouky	560	387	0	0	0	0

As shown in Table 8, the item "Results" presents the resulting prediction locations of convective of precipitation in the Zlin region. Results are compared with the real state of the measured of precipitation. Crosses in real conditions illustrate the failure predict when rainfall was measured at the station, but were predicted for the area. Success rate of forecasts of locations of precipitation is 82%. However, the success of predictions precipitation intensity is slightly lower, around 65%. Nevertheless, the success of forecasting of convective of precipitation is considerably higher than the predictions of numerical weather prediction models which reached 10-40% for year 2014.

Figure 7 indicate that success rate prediction of locations of convective of precipitation by the NWP model has reached 10 to 40% for 2014. The success rate of the prediction system was higher than 50%, therefore it can consider this system to be operative for regional prediction. The main purpose of the radar data mining for forecasting system of convective precipitation was demonstrated in the analysis and re-calculated prediction actual weather events. In this situation, there was very intense rainfall, which caused considerable material damage in the affected areas Hostýn-Vsetín Highlands.

VI. Conclusion

The aim of this article was to provide information on new approach of radar data mining from publicly available application JSRadView of the Czech Hydrometeorological Institute (CHMI). Radar Department of CHMI currently works only with the original measured data in binary form, but these data is not publicly available yet; therefore the Meteo program was created for quick and easy radar data obtaining.

The program's output of radar data mining was presented in the analysis of the situation on July 21, 2014, when most precipitation fell in the Zlín Region in 2014 (station Hošťálková-Maruška - 74 mm / 24 hours). The results are the values of radar reflectivity of precipitation fields detected by meteorological radars of the CZRAD network obtained in tabular form. These values can also be used to calculate the rainfall intensity for the purpose of comparison with the station measured data.

The main usage consists in getting of radar data for weather forecasting system of local intense rainfall, which will be part of the Information, Notification and Warning System of the Zlín Region.

Practical use of radar data mining has been proven to retrospectively the calculated predictions for the weather situation of 21.07.2014, when there was a very intensive heavy rainfall. This chapter was a description of the algorithm of a prediction of convective precipitation, including a detailed description of the creation of statistics of precipitation and locations in which it operates with radar data obtained through the program Meteo. In conclusion, a comparison of the resulting prediction with measured station data, including evaluation of the success rate of prediction. In addition, the success rate was compared with the success rate of the individual NWP models, which had fallen far short of success rate of the prediction system of convective precipitation.

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