CLASSIFICATION OF TEMPORAL CHANGES IN SPOT DATA FOR RAINFALL-RUNOFF MODELS

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Abstrakt. Příspěvek přináší část výzkumu projektu České grantové agentury, který se týká aplikace geoinformačních technologií pro srážkoodtokové modely povodí. Jsou použita multitemporální SPOT data řeky Bělá před a po povodňové události. Jsou zkoumány změny mezi třídami pokrytí území určenými podle definice CORINE LC s použitím původních pásem a vypočtených kanálů metodami mapové algebry.

Klíčová slova: srážkoodtokový model, časová změna, data SPOT, mapová algebra

Abstract. The paper presents a part of the Czech Grant Agency project research concerning geoinformation technology application for rainfall-runoff models of water catchments. Multitemporal SPOT data of the Bělá River before and after flood events are utilized. Changes between land cover classes determined according to CORINE LC definition are studied using original bands and channels calculated by map algebra.

Keywords: rainfall-runoff model, temporal change, SPOT data, map algebra

1 Introduction

The project Application of Geoinformation Technologies for Improvement of Rainfall-Runoff Relationships is focused on preparation of a river catchment model allowing to process input data: precipitation forecast, instantaneous draining river discharge using the catchment boundary data – land cover, soil layer, and DEM. The model will be used for the final determination whether the given rainfall can cause a flood and the warning system must be activated.

Remote sensing data – optical and radar image data– can be applied not only for land cover updating, but also for the catchment state monitoring. The catchment state means the instantaneous vegetation occurrence and soil moisture level. Vegetation occurrence and density, and soil moisture are the most flexible data together with precipitation in the model.

However, optical data measured in visible and infrared bands are available only under good atmospheric situation. Therefore, to propose operational model more reliable, input data source is necessary. Radar imagery is the second information source measurable under any atmospheric situation.

2 SPOT and ERS data

SPOT data are optical data used very often for various types of land cover determination. The list of their spectral bands are in table 1. Their band width and wave length determine what kind of information can be derived from image data.

Satellite/**Sensor**	Band	Band width
SPOT – 4/**HRV**	XS1 = blue = B	0,5-0,59 µm
	XS2 = green = G	0,61-0,68 µm
	XS3 = near infra red = NIR	0,79-0,89 µm
SPOT -5/**HRVIR**	B1 = blue = B	0,5-0,59 µm
	B2 = green = G	0,61-0,68 µm
	B3 = near infra red = NIR	0,79-0,89 µm
	MIR = short wave infra red	1,58–1,75 µm

Table 1. Bands in SPOT data

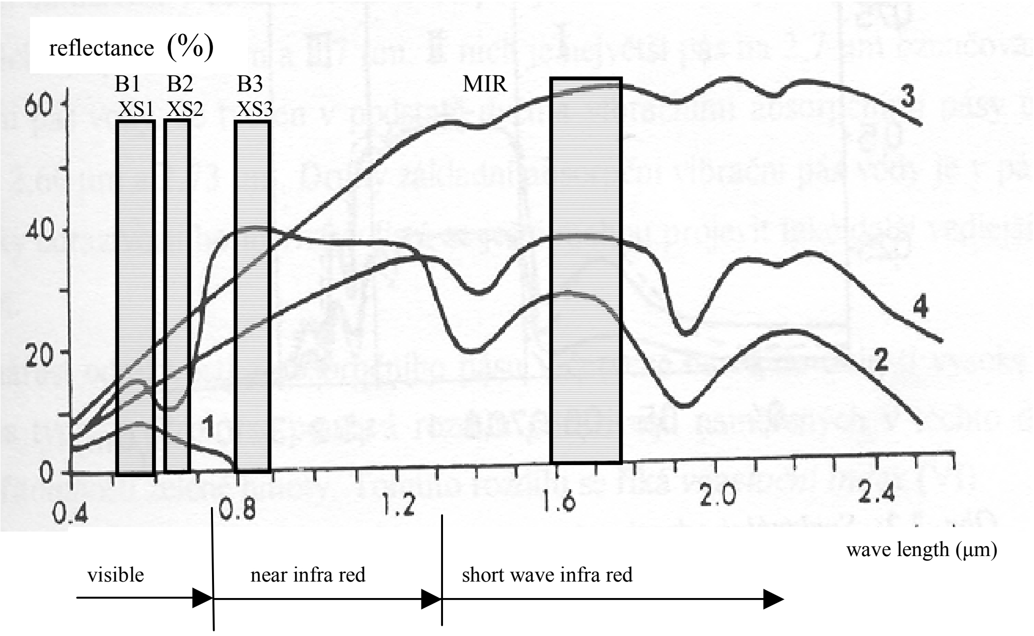

Figure 1. Curves of spectral reflectance of typical land cover types – water (1), green vegetation (2), dry soil (3), wet soil (4) and SPOT wave bands – HRV and HRVIR modes.
Adapted from Lillesand and Kiefer 1987

Figure 1 shows SPOT bands and spectral curves of reflectance. Their mutual position in measured spectral bands is decisive for distinguishing individual land cover types. The highest differences between spectral curves in each band represents more visible and measured difference between these land cover types in the band.
There are several flood events in two river catchments selected for the project.

Detailed search was performed in SPOT data archives using SIRIUS catalogue (2007)and in ERS catalogue (ESA 2007. Data with the same geometric conditions and time gap shorter than one month were selected. However, the flood event in 2004 was not imaged within a month period before and therefore only one SPOT data were selected and a pair of ERS data both after the event to detect a phase of drying.

Table 2 shows two precipitation events which caused flood situations in the Bělá River catchments and SPOT data and ERS 2 data measured before and after these events.

The flood in 2002 can be evaluated from imagery before and after the event both from SPOT, and ERS in the Bělá River catchment.

	Image data dates	
Flood event dates	SPOT data	ERS data
the Bělá River		
12/08/2002	**21.7., 21.8.**	**10.8., 14.9.**
25/04/2004	4.4.	1.5., 5.6.

Table 2. Dates of high precipitations in the Bělá River catchments and SPOT and ERS data of the flood corresponding periods. Bold dates represent pairs imaging the event before and after the event in less than one month time difference, the other covered the region after the flood situation

3 Land cover classes

Land cover classes were defined according to the CORINE LC definition (Hanzlová et al 2006). Table 3 comprises all classes in the catchment and detectable changes form remote sensing data – SPOT.

CORINE classes	**CORINE classes 2^{nd} and 3^{rd} level**	natural development	detection from bands	unexpected changes	detection from bands
1.FOREST AND SEMINATURAL AREAS	Forests				
	Coniferous forest	growth	NIR + R/**NI**	worse quality deforestation reforestation	NIR + R
	Broad-leaved forest	growth		worse quality deforestation reforestation	
	Mixed forest	growth		worse quality deforestation reforestation	
	Scrub and herbaceous vegetation associations				
	Transitorial woodland-shrub	growth higher density	NIR + R/**NI**	shrub removal different land cover	NIR + R
	Natural grasslands	improved quality worsened quality		changed land cover	
	Moors and heathland	difference in size	NIR	drying up	NIR
2. AGRICULTURAL AREAS	Pastures				
	Pastures	quality change		changed land cover	
	Permanent crops	different phenological state		changed land cover	

		different crop			
	Fruit trees and berry plantations	growth different phenological state different crop	NIR + R/**NI**	changed land cover	NIR + R
	Heterogeneous agricultural areas	different phenological state different crop		changed land cover	
	Land principally occupied by agriculture, with significant areas of natural vegetation	different phenological state different crop		changed land cover	
	Complex cultivation patterns	different phenological state different crop		changed land cover	
	Arable land				
	Non-irrigated arable land	different phenological state different crop		changed land cover	NIR + R
3. ARTIFICIAL SURFACES	Artificial, non-agricultural vegetated areas				
	Sport and leisure facilities	none	G, R, NIR	changed land cover	NIR + R
	Green urban areas	growth	NIR + R	changed land cover	NIR + R
	Mine, dump and construction sites				
	Mineral extraction sites	work progress	G, R, NIR	changed land cover	NIR + R
	Construction sites	work progress		changed land cover	
	Urban fabric:				
	Discontinuous urban fabric	none		changed land cover	NIR + R
	Continuous urban fabric	none		changed land cover	
	Industrial, commercial and transports units				
	Industrial or commercial units	none		changed land cover	NIR + R
	Road and rail networks and associated land	none		changed land cover	
4. WET LAN DS	Inland wetlands				
	Inland Marshes	none		changed land cover	NIR
	Peat Bogs	none		changed land cover	
5. WATER BODIES	Inland waters				
	Water bodies	none		changed land cover change of water surface quality	R, NIR

NIR is near infrared band, R is the red (visible) band, G je the green (visible) band, **NI** change not influencing rainfall-runoff models

Table 4. Potential changes in multitemporal image data in the third level CORINE classes form two groups – natural development of the land cover classes and changes caused by human activities. The fourth and sixth columns comprise the most suitable bands for land cover change determination. NIR + R means that both bands are demanded

The column "detection from bands" can comprise other bands for selected land cover changes. However, NIR (near infra red)+ R (red) band combination represents a general tool for complex change type combinations.

4 Methodology

4.1 Calculation of new bands

The bands from table 4 are used for calculation of vegetation indices. There are many vegetation indices and none of them can be reliably used for confirmation of vegetation state improvement, e.g. However, the vegetation indices and their changes seem to be the best source for information about land cover changes. Values of NDVI (normalised defferential vegetation index) characterize individual land cover types. Holben (1986) presented a table of NDVI examples for different land cover types.

COVER TYPE	RED band	NIR band	NDVI
Dense vegetation	0.1	0.5	0.7
Dry bare soil	0.269	0.283	0.025
Clouds	0.227	0.228	0.002
Snow and ice	0.375	0.342	-0.046
Water	0.022	0.013	-0.257

Table 4. Land cover types, their red and near infra red band reflectances and calculated NDVI

The other methods are band subtraction and calculation of principal components. Band differences do not respect real reflectance; they can be called “blind” in the sense of reflectance. Therefore the same change is determined from difference between dry and wet soil in red band as between wet soil and green vegetation (see figure 1). The band subtraction is a good prove of an existing change and unsuitable tool for determination what kind of change it can be.

Principle component channels – the first and second ones show temporal changes very expressively if they are used for band differences and vegetation index differences. However, the changes must be semantically described.

The exact choice of bands, calculation of new channels and change detections is still a matter of project research related to individual temporal changes.

4.2 Filtering and segmentation for SPOT data

Improved image data with newly calculated channels must be filtered to smooth local extremes caused by vegetation growth. If evaluated data covering studying area are from different years, changes in vegetation cover can be more significant in values, but in fact not for rainfall-runoff models.

Low pass filters are preferable – mean, median to produce homogenous areas. Segmentation process in Definiens software not only creates areas with homogenous values, it allows comparing many feature values of all segments, but also conditional classification using accurate definition of classes – special temporal changes. The filter size must be tested. small size does not smooth sufficiently non-important differences (caused by growth of vegetation, e.g.) large filter sizes can even smooth important information. Filtering can be used either in bands, or in calculated channels, or in both.

4.3 Filtering and segmentation for ERS data

Filtering is a very important step of ERS data processing (Halounová 2004). The filter should be processed repeatedly with various filter sizes. Small filter size produces channels still with pepper and salt appearance with more enhanced lines and edges than large filter size suspending unhomogeneity. Repeated filtering allows to compare calculated channels. Filter sizes and their repeated application will be tested both for filtering and segmentation .

5 Conclusion

The final evaluation of further steps will be performed during the last year of the GA ČR project. The SPOT data processing will comprise:

- the most suitable channels,
- filter size/sizes determination,
- the best change detection calculation.

The ERS data processing will be focused on following steps and subtraction of channels will be used after the filtering of original bands:

- filter choice
- filter sizes choice.

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