ABSTRACT

The paper presents results of plant communities mapping of an alpine and subalpine zones of the Tatra National Park (southern part of the Polish Carpathian Mts.), located within a range of altitudes of 1500-2549 m a. s. l. Classification algorithm based on the hyperspectral DAIS 7915 imagery and the fuzzy ARTMAP (FAM) neural networks simulator of 2 key polygons (Biesnik and Uchrocie Kasprowe) using training sets of 40 original bands (after geometric and atmospheric correction) and 20 MNF bands (derived from 60 preselected DAIS 7915 channels).

The results of 37 plant communities were compared with the reference sets acquired from ground validation. The best overall accuracy (87%) for the test set was achieved using 40 original bands bands.

Index Terms — fuzzy ARTMAP, hyperspectral data, Tatra National Park, plant communities, ANN

1. INTRODUCTION

Mountain plants developed specific adaptations to survive at the fringe of life (pigment content, plant tissue structure etc.). These adaptations have direct impact on reflectance which can be quantified using hyperspectral imagery, which are characterised by a large number of closely spaced spectral channels. Application of remotely sensed techniques allows vegetation research and mapping in areas that are otherwise inaccessible. Due to low accessibility of terrain, very short vegetative season and unstable weather conditions, mapping vegetation and its condition is often constrained or even prevented using traditional, field mapping techniques. To protect a delicate balance in mountain environments, vegetation cover (a perfect indicator of all the other components of biosphere) should be well researched and mapped. This is of particular importance for the proper management since both anthropopression and local disturbances (avalanches, solifluction after extensive rainfalls) can significantly impact vegetation, leading to its stress, and eventually – disintegration of plant cover. It is anticipated, that vegetation mapping and condition analysis can be achieved using hyperspectral, high ground resolution imagery and digital and field remote sensing techniques.

Artificial nets algorithms use whole object characteristics (spectral and neighbourhood pattern properties, where the relationship between pixels are analysed). These relationships between image objects frequently appear over natural biotopes and covered plant communities, and traditional classification methods that use parametrical approaches does not show satisfying results. The implemented neural network is the fuzzy ARTMAP (FAM) simulator. For training the neural network, particular layers of the cover classes were used which were identified during field mapping using the aircraft. Land research turned out to be the reference material for estimating the precision of the classification. Hyperspectral data compression procedure was applied by using the Minimum Noise Fraction transformation (MNF). This method may be especially useful to separate and classify vegetation communities [1] or land cover units [2].

2. RESEARCH AREA AND DATA SOURCES

The High Tatras are located within the MAB Biosphere Reserve and encompasses alpine and subalpine zones of the Tatra National Park (TPN). The area extends within: 49° 10’ 30” - 49° 16’ 00” N and 19° 45’ 30” - 20° 07’ 30” E rectangle, encompassing approximately 110 km², but in this paper only Polish part of the Tatra Mountains (so called “High Tatras”) was analysed (Figure 1).

Vegetation in the area has been well researched (since the 1920’s), however most of the research has been carried out on transects and in polygons. Plant species have been well identified and described, however detailed maps of vegetation are available only for selected areas. The most of research area is covered by natural and seminatural key units: peaty and boggy communities, avalanche meadows, tall herb communities (Adenostylion), grassland communities after grazing, subalpine dwarf scrub communities, willow thicket (Chamaenerion angustifolium-Salix silesiaca community), mountain-pine scrub on silikat substrate (Pinetum mugho carpaticum silicicolum), mountain-pine scrub (Pinetum mugho carpaticum silicicolum) in a complex with epilitic lichen communities,
mountain-pine scrub on calcareus substrate (Pinetum mugho carpaticum calcicolium), montane spruce forest (Plagiothecio-Piceetum) and lakes. DAIS 7915 hyperspectral data classified in this study was acquired on 04 August 2002 by the German Space Agency (DLR) in the frame of the HySens PL02_05 project. This instrument is a 79-channel imaging spectrometer operating in the wavelength range 0.4-12.5 µm with 15 bit radiometric resolution. After preprocessing the resulting pixel size was 3 meters.

The accuracy was measured using ENVI software’s algorithms based on test and training sets (prepared from ground mapping).

4. RESULTS

The overall accuracy was measured pixel by pixel using the post classification and reference layer as a basis. The final results of the High Tatras polygon are shown in Table 1 and the post classification images presents Figure 3. Generally, the forty-band set of input data offered higher accuracy (1-2%) than the twenty-MNF-band set. In the first case, the overall accuracy achieved value of 86.96% (286175 pixels of 329088), and kappa coefficient was 0.8425.

In the case of 20 MNF bands, the overall accuracy was 85.50% (281352/329065), and kappa coefficient 0.8253.

5 of 42 plant communities weren’t classified properly: Salicetum herbaceae in a complex with Empetro-Vaccinietum (class# 6); Oreochloo distichae-Juncetum trifidi cetrarietosum (9); tall herb communities (Adenostyliion) (28); grassland communities after grazing in a complex with ruderal communities (32); montane spruce forest (Plagiothecio-Piceetum) (41). The worst classification results were achieved in the range of 18-28% for willow thicket (Chamaenerion angustifolium-Salix silesiaca community), and the best results 92-96% for mountain-pine scrub on silikat substrate (38), 84-94% for Caricetum fuscae subalpinum (21), Empetro-Vaccinietum in a complex with Pinetum mugho (34).

Figure 1. Data cube of the central part of the High Tatras

3. METHODS

The classification procedures began with a preparation of reference layers of 42 dominant plant communities (Figure 2). This stage based on terrain and Spectral Angle Mapping (SAM). SAM classification was used to verify classified maps performed in 2002 during the terrain mapping. Endmembers were obtained from DAIS data (corresponding to the key areas from the ground mapping).

Parallel to this procedure, an extraction from all 79 bands covering the VIS-TIR regions of the spectrum was made. The first step was a visual histogram analysis (inspection of bands with severe striping problems) and the reselection of 60 spectral bands. The second step was the reduction to 40 original and 20 MNF bands.

For classifying plant communities, a fuzzy ARTMAP simulator was applied. For classification were used 4900 and 10000 iterations. Each set contained DEM of analysed area Key polygons for teaching and validation of classification were created on the base of terrain mapping and the map of actual vegetation of this area [3].

![Figure 2. Legend and class codes of the analysed key units: 1 - cryptogamic plant communities on scree (initial phase); 2 - epilitic lichen communities (Rhizocarpetalia); 3 - scree](image)
communities (Androsace alpinae); 4 - Luzuletum alpino-pilosae; 5 - Salicetum herbaceae, Luzuletum spadiceae; 7 - subnivale swards (Oreochloo distichae-Juncetum trifidi subnivale form); 8 - Oreochloo distichae-Juncetum trifidi typicum; 10 - Oreochloo distichae-Juncetum trifidi (vegetation fragments on rocky shelves); 11 - Oreochloo distichae-Juncetum trifidi sphagnetosum; 12 - Oreochloo distichae-Juncetum trifidi salicetosum herbaceae; 13 - Oreochloo distichae-Juncetum trifidi salicetosum kitaibeliana; 14 - Oreochloo distichae-Juncetum trifidi scree form with Juncus trifidus; 15 - Oreochloo distichae-Juncetum trifidi subalpine anthropogenic form; 17 - Oreochloo distichae-Juncetum trifidi in a complex with Calamagrostietum villosae; 19 - Oreochloo distichae-Juncetum trifidi in a complex with Festuco versicoloris-Agrostietum; 20 - Festuca versicoloris-Agrostietum; 21 - Caricetum fuscae subalpinum; 22 - Sphagno-Nardetum, Polytricho-Nardetum; 23 - Sphagno-Nardetum, Polytricho-Nardetum in a complex with Carex laetia community; 24 - Calamagrostietum villosae taticrum; 25 - Calamagrostietum in a complex with Luzuletum alpino-pilosae pioneer form; 26 - Calamagrostietum in a complex with wet subalpine meadows; 27 - Calamagrostietum in a complex with Pinetum mugho and subalpine meadows; 29 - Festuca picta community in a complex with Luzuletum alpino-pilosae; 30 - Festuca picta community; 31 - Deschampsia longiseta community, Hieracio alpini-Nardetum; 33 - Empetrio-Vaccinietum; 34 - Empetrio-Vaccinietum in a complex with Pinetum mugho; 35 - Vaccinium myrtillus community in a complex with Pinetum mugho carpathicum silicicolum; 36 - Vaccinium myrtillus community in a complex with tall herb communities; 37 - willow thicket (Chamaenerion angustifolium-Salix silesiaca community); 38 - mountain-pine scrub on silikat substrate (Pinetum mugho carpathicum silicicolum); 39 - mountain-pine scrub (Pinetum mugho carpathicum silicicolum) in a complex with epilithic lichen communities; 40 - mountain-pine scrub on calcareous substrate (Pinetum mugho carpathicum calcicolum); 42 - lakes

Table 1. Total accuracy of classifications of 40 original and 20 MNF bands after 10000 iterations

<table>
<thead>
<tr>
<th>Class</th>
<th>Producer Acc. (%)</th>
<th>User Acc. (%)</th>
<th>Producer Acc. (%)</th>
<th>User Acc. (%)</th>
</tr>
</thead>
<tbody>
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<td>80.12</td>
<td>92.16</td>
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<tr>
<td>Class #2</td>
<td>79.01</td>
<td>81.64</td>
<td>81.62</td>
<td>82.49</td>
</tr>
</tbody>
</table>
5. CONCLUSIONS

The use of an artificial neural network is a proper method for plant communities mapping, but it should be a supporting tool for traditional vegetation mapping. The increasing number of classified bands (more than 40) does not offer a significantly better overall accuracy, but eliminates the worst results. Hyperspectral data showed significant potential for discriminating different vegetation types. A long training time is the most inconvenient aspect of this kind of classification.

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7. REFERENCES

