Forest and Vegetation Mapping using Multiple Datasources

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***Abstract*— Using multi temporal and multi resolution data-sources we can carry out a Quantitative Remote Sensing Model development for vegetation parameters like Forest Health Index (FHI) or tree mapping in urban areas. The paper uses the following data-sources to infer thematic maps with pixel based image classification techniques: World-View 2 images, hyper-spectral images, LIDAR data, Digital Terrain Models, ortho-photos and topographic maps. The classification is carried out with the built-in ENVI tools. As a result a series of thematic maps are produces like Vegetation Delineation Map, Forest Heath Map.**

***Keywords*— Remote Sensing, Urban Ecology, Image Classification**

I. Introduction

This recent research focuses on eco-environmental issues in Mátra Mountain (Fig. 1). To examine the eco-environmental condition a test area has been created considering the available datasets (space images and 3D models).

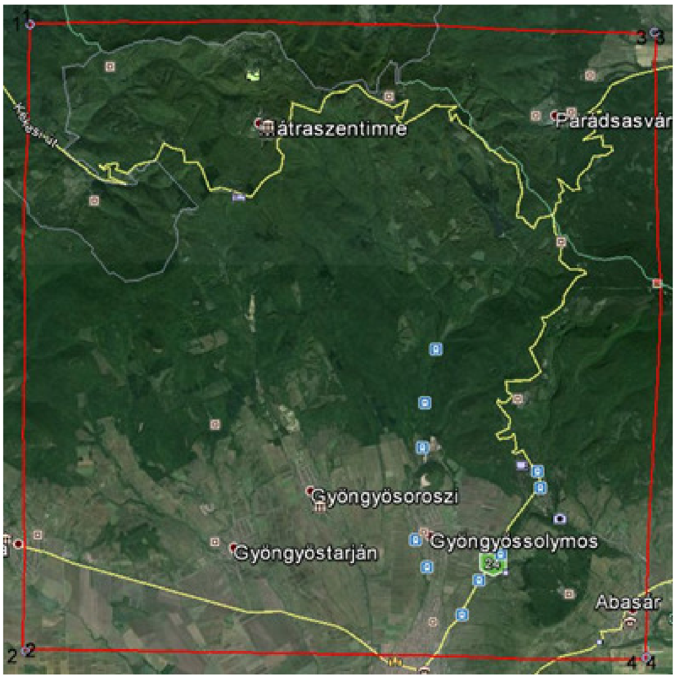

Fig. 1 Mátra Mountain near the city of Gyöngyös

Our recent research focuses on the vegetation mapping and on the derivation of different indices, which can be useful to monitor and judge the vegetation state and distribution. The research area is the northern mountain part of Hungary located in the Mátra Mountain. On this area the monitoring of the forest health has become an important issue [1], [2], [3].

II. Data Sources

We have the following data sources for the mountainous area above the city of Gyöngyös located in North-Hungary:

- WorldView-2 images of Szekesfehervar (8 channels, ground resolution is 2 m, Panchromatic channel with resolution of 0.5 m) in UTM-34N projection (Fig. 2).
- Digital Terrain model of Szekesfehervar in GRID format with ground step of 10 m.

Fig. 2 WV-2 image dated on 10 June, 2010

A. Pre-processing of DTM

This DTM has 10 m grid size and it was generated by interpolation of contour line points. The contour lines are part of the topographic maps in scale of 1: 10000. The maps have different age, and therefore the generated DTM has also some heterogeneity. In average the maps are 10 years old, although some maps are from 1987. The original data has text format, the ascii files contain the X, Y, Z coordinates with 10 m step. The final extent of the GRID is as follows (Table 1):

TABLE I
LIST OF CORNER COORDINATES OF THE TEST AREA

	UL Coordinates	LR Coordinates	Number of Nodes	Node distance
Value	408710, 5310605	423000, 5292165	1845x1845	10 m

This DTM was used to generate the ortho-photo from the ortho-ready WorldView-2 images. Figure 3 shows the resulting DTM:

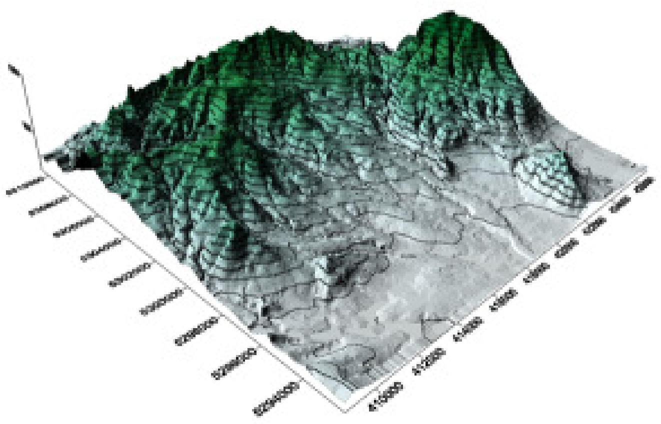

Fig. 3 DTM of 10 m grid

B. WorldView-2 images

We purchased WorldView2 images covering the target area. The date of the images is June 10, 2010 and July 7, 2013. We decided to buy ortho-ready images with radiometric corrections.

- WorldView-2 provides only 2 m high-resolution 8-band multispectral commercial satellite imagery available (Fig. 4). The panchromatic channel has 0.5m resolution. Along with the four typical multispectral bands: Blue (450-510), Green (510-580), Red (630-690) and NearIR (770-895), WorldView-2 is introducing the following new colour bands for enhanced multispectral analysis:
- Coastal Band (400 - 450 nm): This band supports vegetation identification and analysis, and supports bathymetric studies based upon its chlorophyll and water penetration characteristics. Also, this band is subject to atmospheric scattering and will be used to investigate atmospheric correction techniques.
- Yellow Band (585 - 625 nm): Used to identify "yellow-ness" characteristics of targets, important for vegetation applications. Also, this band assists in the development of "true-colour" hue correction for human vision representation. Red Edge Band (705 - 745 nm): Aids in the analysis of vegetative condition. It is directly related to plant health revealed through chlorophyll production.
- Near Infrared 2 Band (860 - 1040 nm): This band overlaps the NIR 1 band but is less affected by atmospheric influence. It supports vegetation analysis and biomass studies.

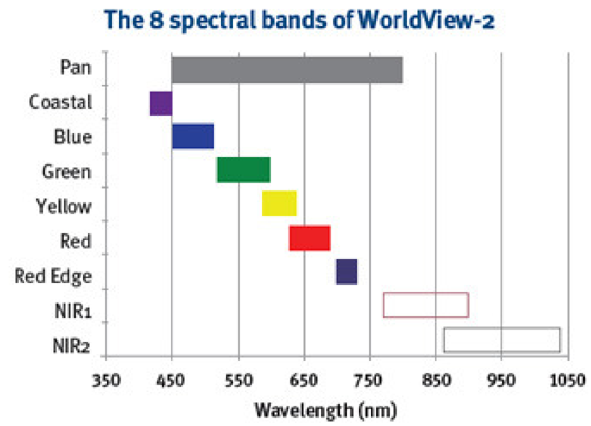

Fig. 4 Spectral bands of WordView-2

C. Ortho-photo resampling

The received images are in UTM projection (Datum: WGS84, Zone: 34N), but they are not ortho-rectified by an accurate DTM model. Therefore we used the existing DTM model to carry out the ortho-photo resampling. After that we corrected the resulted ortho-photo with nine control points.

After measuring 9 common points we could produce the image warping procedure and the pixels of resulting image are bound to UTM. On Fig. 5 you can see the chosen control points.

Fig. 5 Scheme of control points

III. Evaluation

VEGINDEX calculates green vegetation indices through a combination of the visible red and the near infrared bands of any earth observation satellite images. On Figure 32 you can see all the possible vegetation indices in IDRISI. Here we used only NDVI:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

By the NDVI image using the SPEAR TOOLS – Vegetation Delineation function in ENVI we can get the following maps for two different dates but for the same area (Fig. 6, Fig. 7):

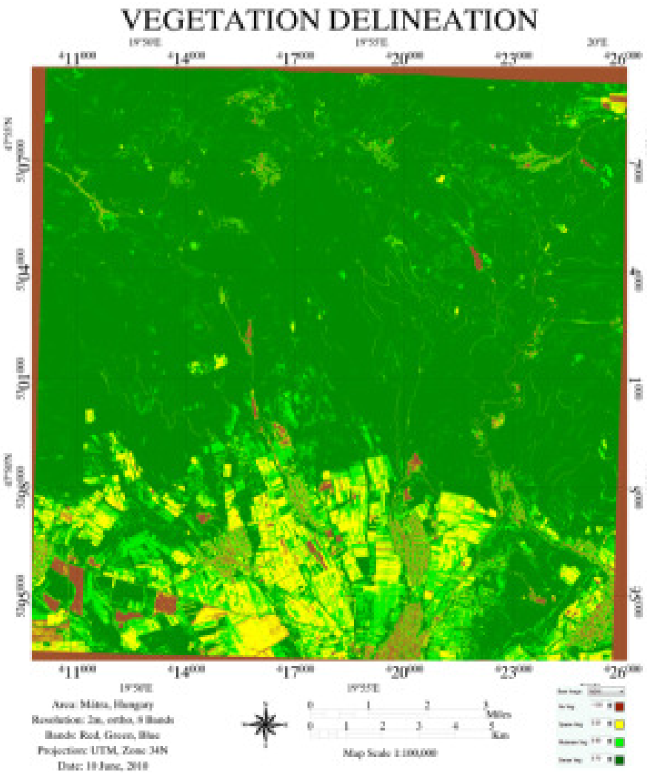

Fig. 6 Vegetation delineation map dated 2010, June 10

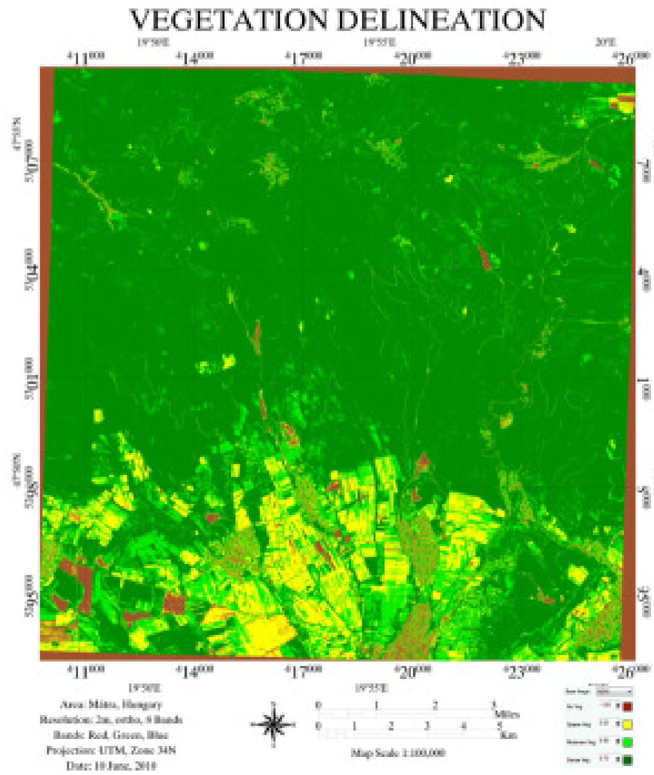

Fig. 7 Vegetation delineation map dated 2013, July 7

A. *Forest Heath investigation*

IN ENVI there is a tool for Forest Heath investigation. The menu item is “Spectral-Vegetation Analysis – Forest Health”. In order to run this tool first we need to generate a series of indices in four categories:

- Broadband and narrowband greenness, to show the distribution of green vegetation.
- Leaf pigments, to show the concentration of carotenoids and anthocyanin pigments for stress levels.
- Canopy water content, to show the concentration of water.
- Light use efficiency, to show forest growth rate.

In order to run the Forest Health tool we have to generate at least three different indices in three categories. Since the WorldView-2 images have 8 bands we can very well approximate the following indices:

In Broadband Category:

NDVI (Normalized Difference Vegetation Index) – Broadband. Value is between 1 and -1. Typically the vegetation is between 0.2-0.8.

$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}}$$

Which means at WV-2:

$$NDVI = \frac{NIR1 - RED}{NIR1 + RED}$$

SR1 (Simple ratio Index) - Broadband

$$SR = \frac{\rho_{NIR}}{\rho_{RED}}$$ Which means at WV-2: $$SR1 = \frac{NIR1}{RED}$$

In Leaf Pigments category:

ARI1 (Anthocyanin Reflectance Index 1) – Leaf pigments. Sensitive to anthocynanin. Higher value means new vegetation, which refers to the death of vegetation.

$$ARI1 = \left(\frac{1}{\rho_{550}}\right) - \left(\frac{1}{\rho_{700}}\right)$$ Which means at WV-2: $$ARI1 = \left(\frac{1}{GREEN}\right) - \left(\frac{1}{RED}\right)$$

CRI1 (Carotenoid Reflectance Index 1) – Leaf pigments. Carotenoid pigments in the foliage can be expressed by:

$$CRI1 = \left(\frac{1}{\rho_{510}}\right) - \left(\frac{1}{\rho_{550}}\right)$$ Which means at WV-2: $$CRI1 = \left(\frac{1}{BLUE}\right) - \left(\frac{1}{GREEN}\right)$$

In Canopy Water Content category:

WBI (Water Band Index) – Canopy water content. Water content, can express the vegetation stress:

$$WBI = \frac{\rho_{900}}{\rho_{970}}$$ Which means at WV-2: $$WBI = \frac{NIR1}{NIR2}$$

Using the NDVI, ARI1 and WBI we can get the following Forest Healthy Map for two dates (Fig. 8, Fig. 9):

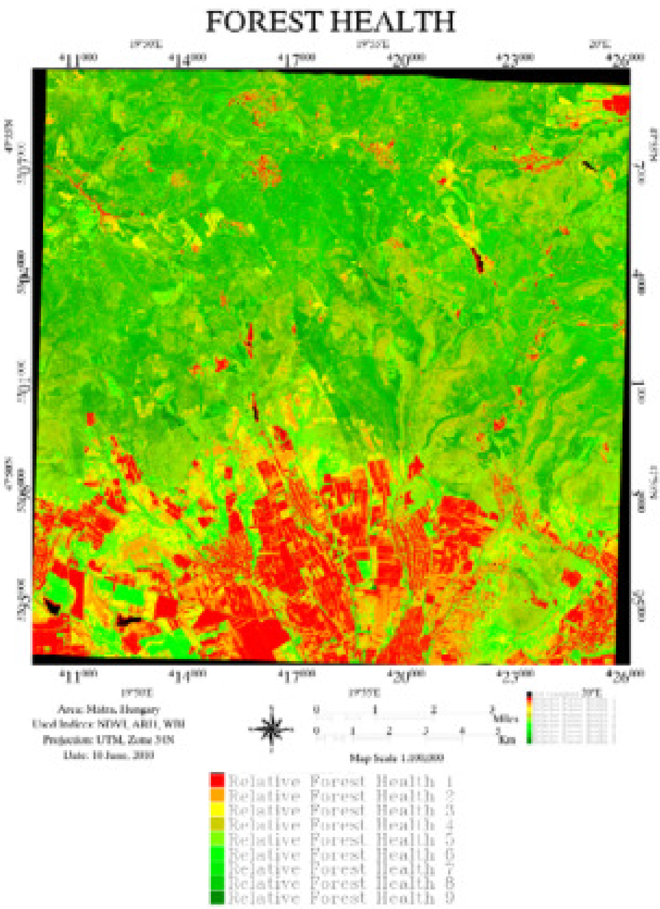

Fig. 8 Forest health map dated 2010, June 10

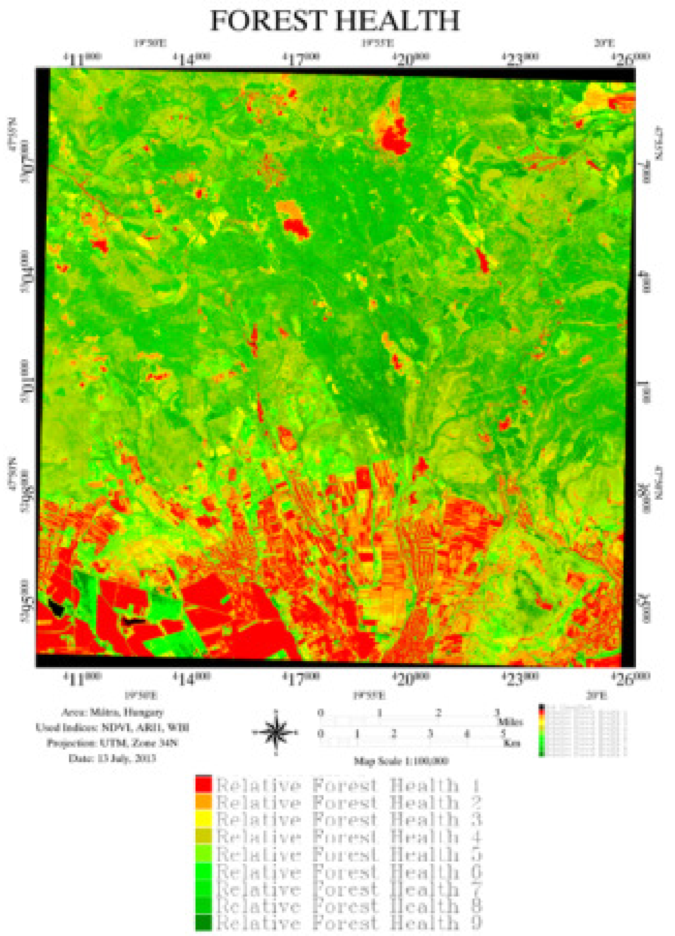

Fig. 9 Forest health map dated 2013, July 7

IV. Conclusions

Unfortunately these classifications are relative to the particular input scene only and cannot be generalized to other areas or other scenes. Field examination is essential to link the classes provided by the tool with the real-world conditions they represent. You cannot compare classes between scenes, as the vegetative variability between scenes could be significant, and the actual classification values may not match. For example, a classification color of green in one scene could represent the same field conditions as a classification color of orange in another.

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References

[1] J. Spruce, W. Hargrove, S. Norman, W. Christie, "Potential of Pest and Host Phenological Data in the Attribution of Regional Forest Disturbance Detection Maps According to Causal Agent", US-IALE International Association for Landscape Ecology Annual Symposium; 18-22 May 2014; Anchorage, AK; United States, Doc. Id: 20140002213

[2] M. Baumann, M. Ozdogan, P. T. Wolter, A. Krylov, N. Vladimirova, V. C. Radeloff, "Landsat remote sensing of forest windfall disturbance", Remote Sensing of Environment, Volume 143, 5 March 2014, Pages 171–179

[3] P. Chellamani, Ch. Prakash Singh, S. Panigrahy, "Assessment of the health status of Indian mangrove ecosystems using multi temporal remote sensing data", Tropical Ecology, Vol. 55(2), ISSN 0564-3295, 2014, pp. 245-253