Classification of tundra vegetation in the Krkonoše Mts. National Park using APEX, AISA Dual and Sentinel-2A Data

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Starting points

- Tundra ecosystems (alpine treeless) belong to the most valuable natural phenomena worldwide.
- Biotopes above the treeline are very sensitive to various types of environmental factors
- Changes can be very fast in these areas and their monitoring is very important
- Earth observation potentially powerfull tool for the monitoring

Goals

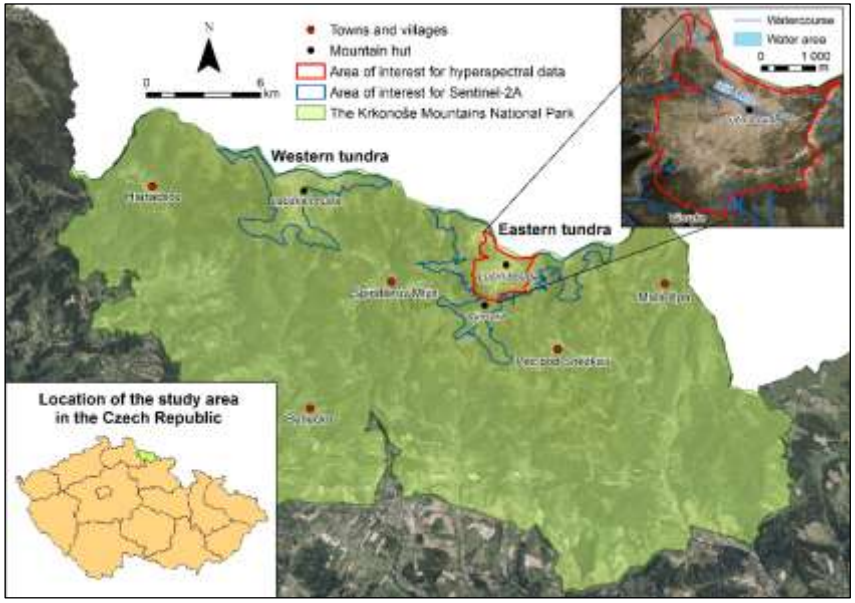
- To evaluate and compare suitability of aerial hyperspectral data (AISA Dual and APEX sensors) with freely available Sentinel-2A data for classification of tundra vegetation cover in the Krkonoše Mts. National Park.

- Different classification methods (pixel and object-based) were used to find out which classification algorithm for which type of data can bring the most accurate classification results.

- We expected that the best accuracy will be achieved using hyperspectral data with higher spatial and spectral resolution (AISA Dual).

- Further assumption was that in the case of Sentinel-2A data with its limited spatial and spectral resolutions some vegetation (especially grassland) categories will not be distinguishable.

Study area



The highest parts of the Krkonoše Mts. National above the treeline (1,300 m a. s. l.)

A unique ecosystem, southernmost relict area of the arctic-alpine tundra in Europe

Area of 47 km^2 - 7.4% of the total Krkonoše Mts. Area (Czech and Polish sides). Two parts: Western and Eastern.

As a result of palaeogeographical history the Krkonoše Mountains represent a "biodiversity crossroads" where Nordic and alpine flora and fauna coexist

Besides the mosses, lichens, and alpine heathlands, the prevailing vegetation types are: closed alpine grasslands dominated by *Nardus stricta*, subalpine tall grasslands, and *Pinus mugo* scrub

Over the years affected by human impacts

From the 9th century till the beginning of the 19th century expanding due to local agricultural practices that included deforestation and grazing

Since early 20th century this human impact has been reduced and the area became strictly protected as a nature reserve.

Data and classification legend

Sensor	Number of used bands	Wavelength range	Spatial ground resolution	Acquisition date
APEX	288	400 nm - 2,500 nm	2 to 5 m	09/10/2012
AISA Dual	494	400 nm - 2,500 nm	1 to 3 m	06/19/2013
Sentinel-2A	10	400 nm - 2,300 nm	10 and 20 m	08/30/2015

Detailed legend

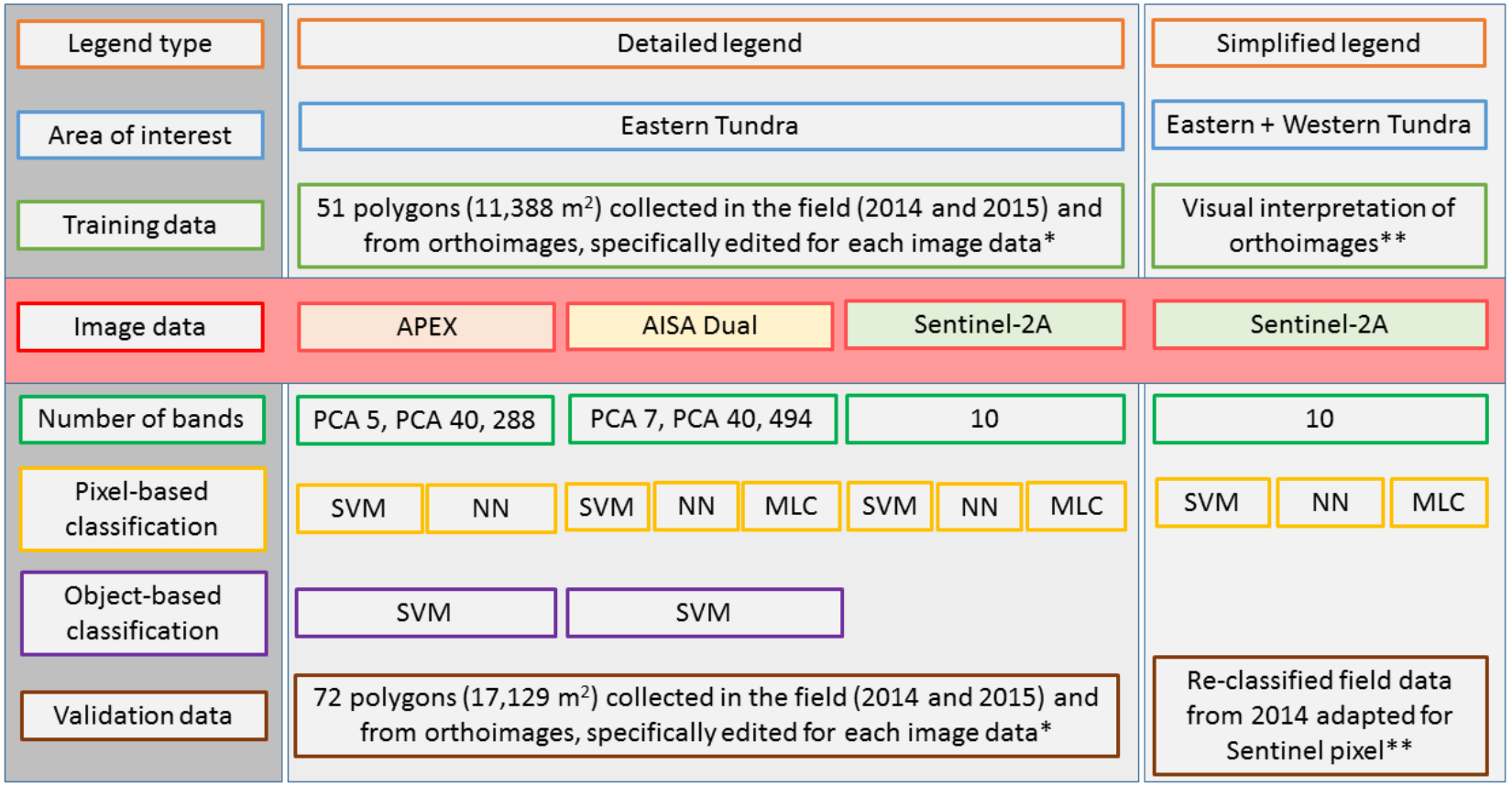
1. Block fields and anthropogenic areas
2. *Pinus mugo* scrub (Mountain pine)
3. Subalpine *Vaccinium* vegetation (Blueberries, cranberries and bog bilberries)
4. Closed alpine grasslands*
4a. *Nardus stricta* stands (Matgrass)
4b. Species-rich vegetation with high cover of forbs
5. Subalpine tall grasslands*
5a. *Calamagrostis villosa* stands (Hairy reed grass)
5b. *Molinia caeruela* stands (Purple moor grass)
5c. *Deschampsia cespitosa* stands (Tufted hair grass)
6. Alpine heathlands
7. Wetlands and peat bogs
8. Water areas (not for Sentinel-2A)

Simplified legend

1. Block fields and anthropogenic areas
2. *Picea abies* stands (Norway spruce)
3a. *Pinus mugo* scrub dense (more than 80 % of total cover)
3b. *Pinus mugo* scrub sparse (30 – 80 % of total cover)
4. Closed alpine grasslands dominated by *Nardus stricta*
5. Grasses (except *Nardus stricta*) and subalpine *Vaccinium* vegetation
6. Alpine heathlands
7. Wetlands and peat bogs

Classification legend

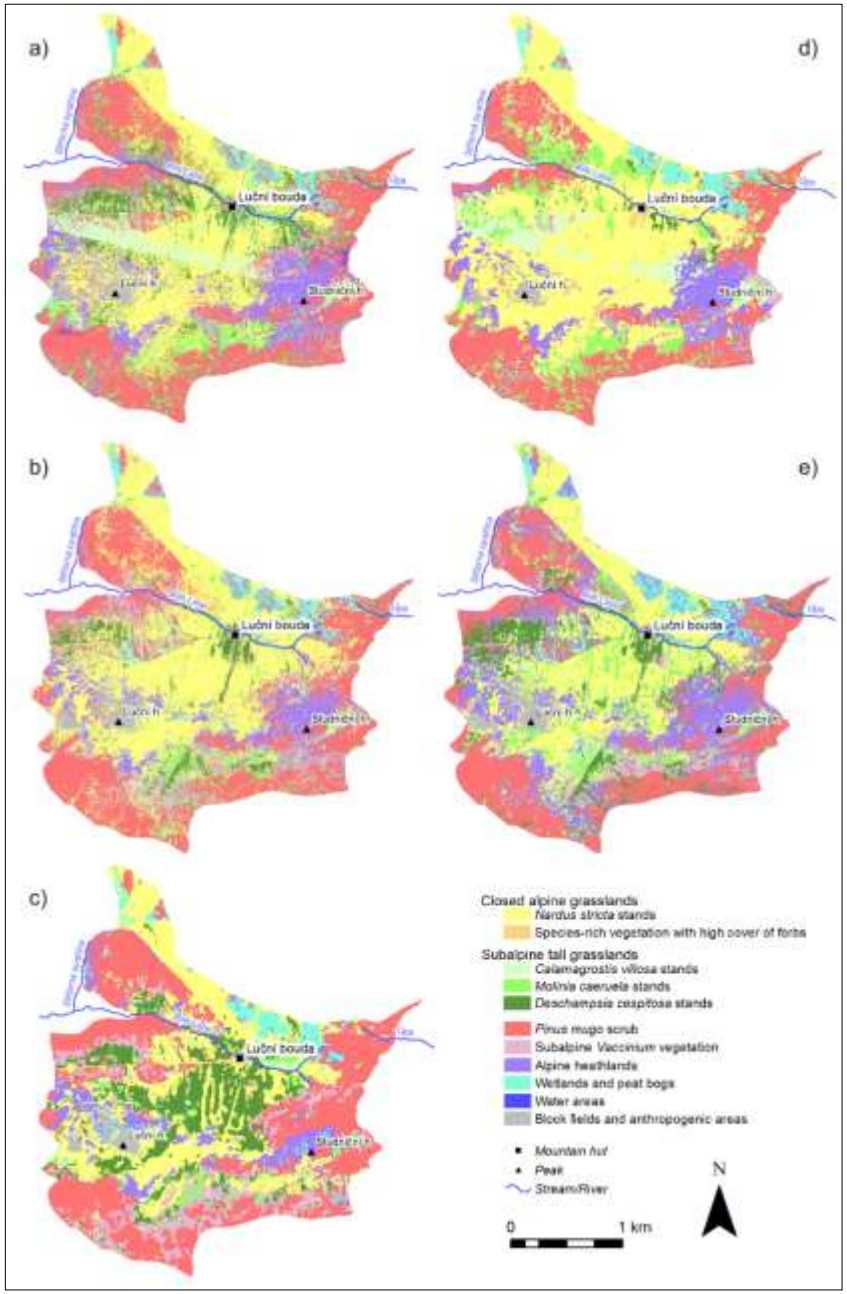
Workflow



* Edited based on the pixel-size; for Sentinel-2A class „water areas" was not assessed.

** Dataset originally created for Landsat 8 classification in Suchá et al. (2016) edited for Sentinel-2A pixel size.

Results for detailed legend (Eastern tundra, all data)



Land cover in the Eastern Tundra of the Krkonoše Mts. for the best classification results of per-pixel and object-based approaches:

a) per-pixel classification: APEX data, SVM classifier, 40 PCA bands;

b) per-pixel classification: AISA Dual data, SVM classifier, 40 PCA bands

c) per-pixel classification: Sentinel-2A data, NN classifier (user defined);

d) object-based classification: APEX data, SVM classifier, 40 PCA bands;

e) object-based classification: AISA Dual data, SVM classifier, 7 PCA bands.

Results for detailed legend (Eastern tundra, all data)

APEX

Classification method	Overall accuracy (%)	Kappa coefficient
PCA - 40 bands		
SVM	82.59	0.79

AISA

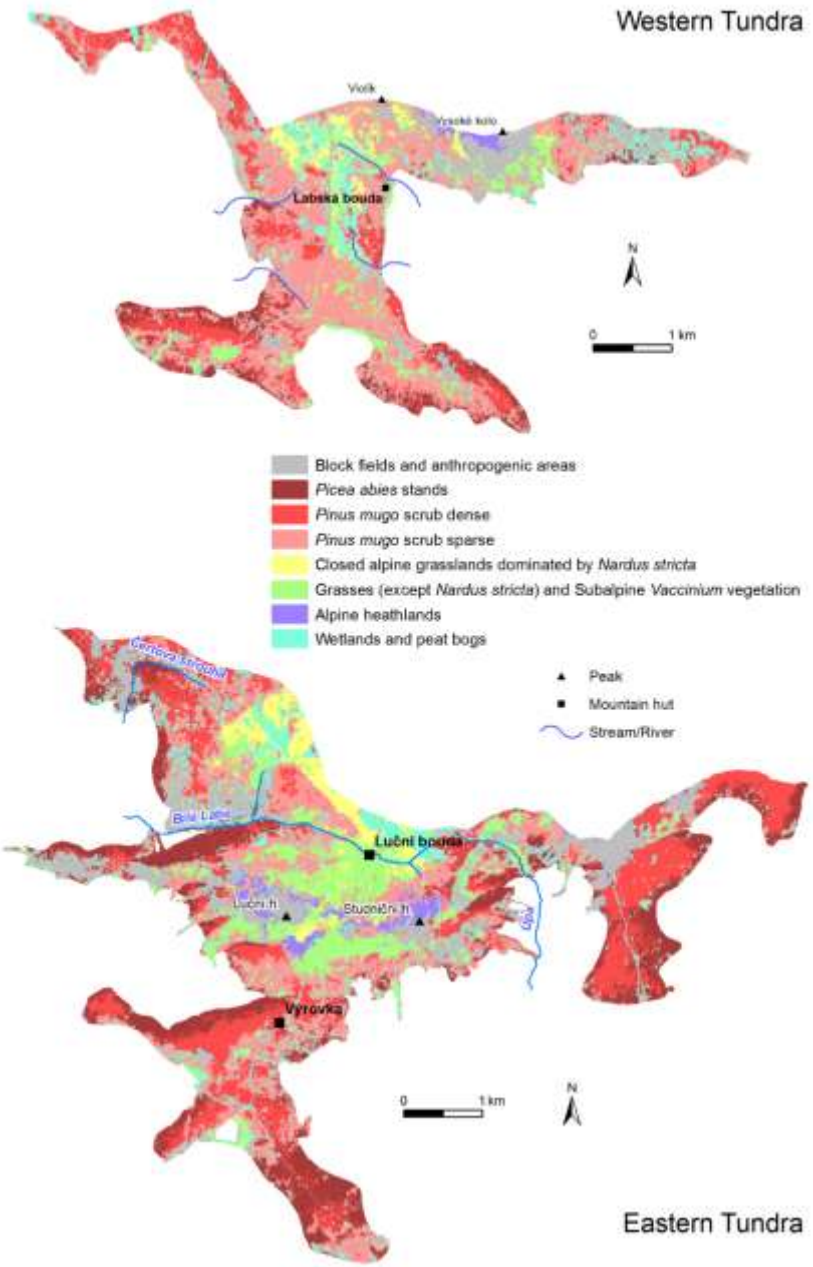
Classification method	Overall accuracy (%)	Kappa coefficient
PCA - 40 bands		
SVM	84.31	0.81
OBIA SMV RBF	80.66	0.77

Sentinel-2A

Classification method	Overall accuracy (%)	Kappa coefficient
All bands 10 and 20 m		
NN user defined	58.27	0.52

Data and classification method	pixel-based classification						OBIA	
	APEX (SVM 40 PCA bands)		AISA (SVM 40 PCA bands)		Sentinel-2A (NN)		AISA (SVM 7 PCA bands)	
Class	PA (%)	UA (%)	PA (%)	UA (%)	PA (%)	UA (%)	PA (%)	UA (%)
1. Block fields and anthropogenic areas	98.60	100.00	99.25	98.58	92.68	95.00	99.93	95.11
2. Pinus mugo scrub	99.86	94.78	99.96	98.45	100.00	88.51	100.00	99.36
3. Subalpine Vaccinium vegetation	8.54	100.00	63.90	50.19	65.38	45.95	53.15	87.66
4a. Nardus stricta stands	73.44	86.01	83.73	71.38	46.02	54.17	79.24	73.27
4b. Species-rich vegetation with high cover of forbs	86.84	44.59	55.32	60.00	50.00	35.29	81.22	33.06
5a. Calamagrostis villosa stands	63.95	49.74	55.03	87.29	31.82	43.75	76.20	82.62
5b. Molinia caeruela stands	64.54	59.87	66.78	75.22	15.00	60.00	79.15	44.94
5c. Deschampsia cespitosa stands	87.31	68.25	85.10	85.81	57.50	26.44	63.49	89.76
6. Alpine heathlands	90.36	82.14	81.60	83.80	37.78	42.50	66.11	73.13
7. Wetlands and peat bogs	58.56	80.30	63.46	86.74	56.76	91.30	40.24	85.07
8. Water areas	100.00	100.00	98.80	100.00	x	x	100.00	100.00

Results for simplified legend – Sentinel-2A



Classification method	Overall accuracy (%)	Kappa coefficient
all bands 10 a 20 m simplified legend		
MLC	77.73	0.74
SVM	70.99	0.67
NN (default)	76.21	0.73

Conclusions

- Best classification results for the hyperspectral data with the highest spectral and spatial resolution, i.e. AISA Dual data, comparable for APEX data
- Best results - both types of hyperspectral data: SVM classifier
- Best results - Sentinel-2A data in the case of simplified legend, NN and MLC methods achieved better results than SVM.
- Important - definition of legend categories – different for different spatial resolutions
- We have to improve classification accuracy of grassland categories
- Results for Sentinel-2A promissing, especially for Sentinel-2A in tandem with Sentinel-2B in time series
- Next improvement – UAV with hyperspectral sensor – high spectral and time resolution, biophysical parameters (chlorophyll, fAPAR, biomass, LAI etc.), upscaling to Sentinel
- Earth observation powerful tool for tundra ecosystem monitoring, management and presevation

THANK YOU
FOR YOUR ATTENTION!

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