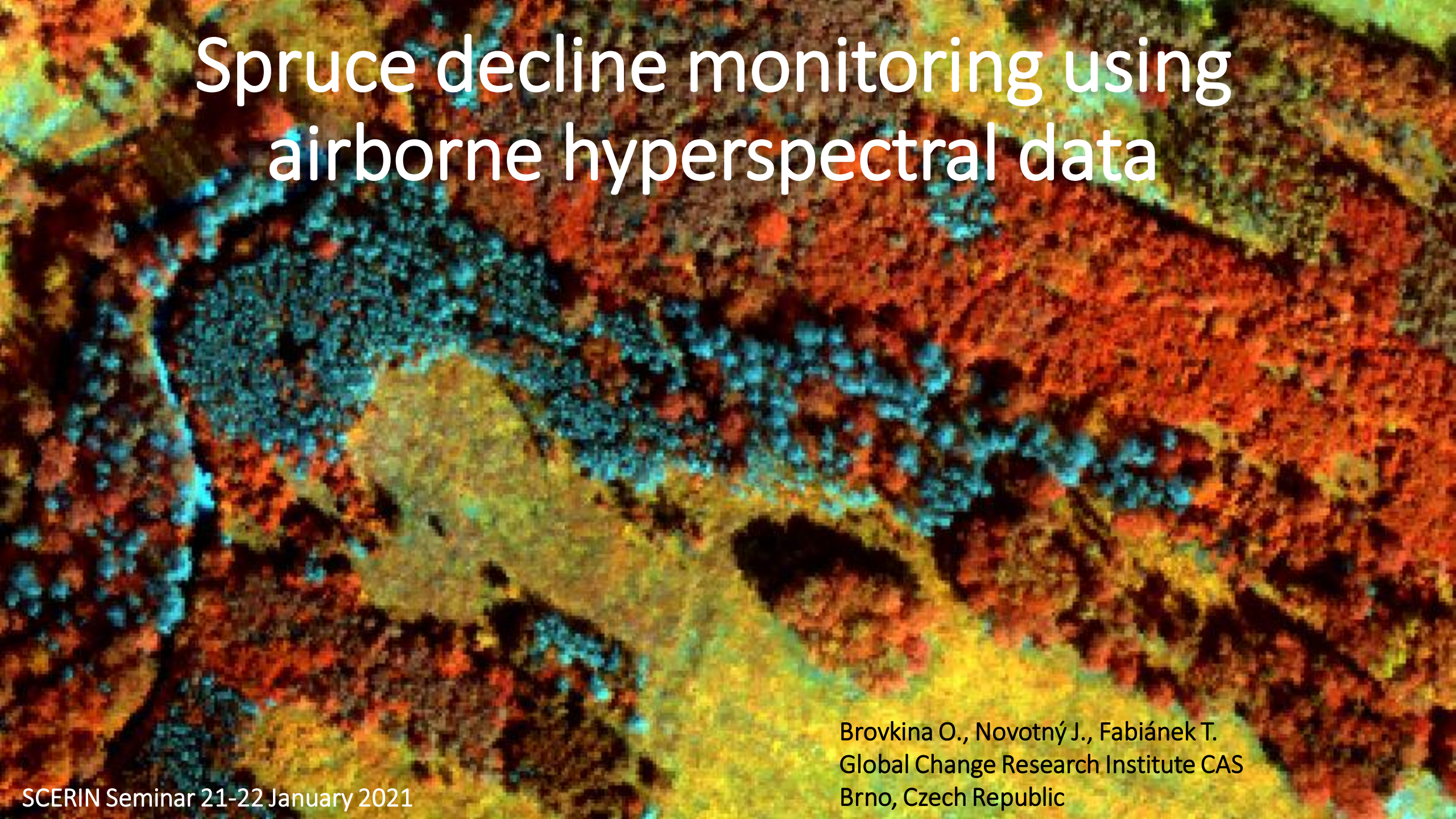
Spruce decline monitoring using airborne hyperspectral data



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SCERIN Seminar 21-22 January 2021

Two methods:

- Identification of spruce health decline from airborne hyperspectral data;

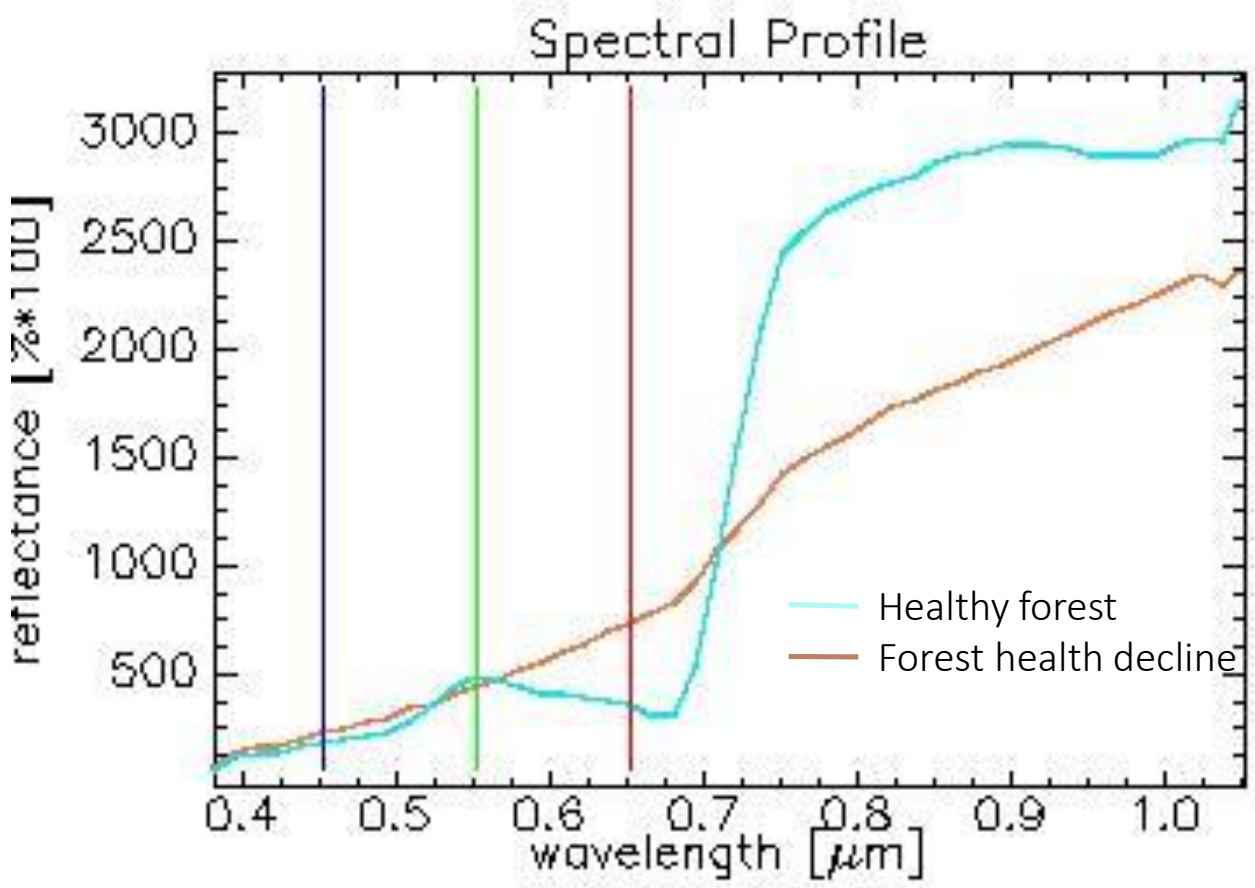
- Identification of spruce decline categories from airborne hyperspectral and field data.

Forest decline

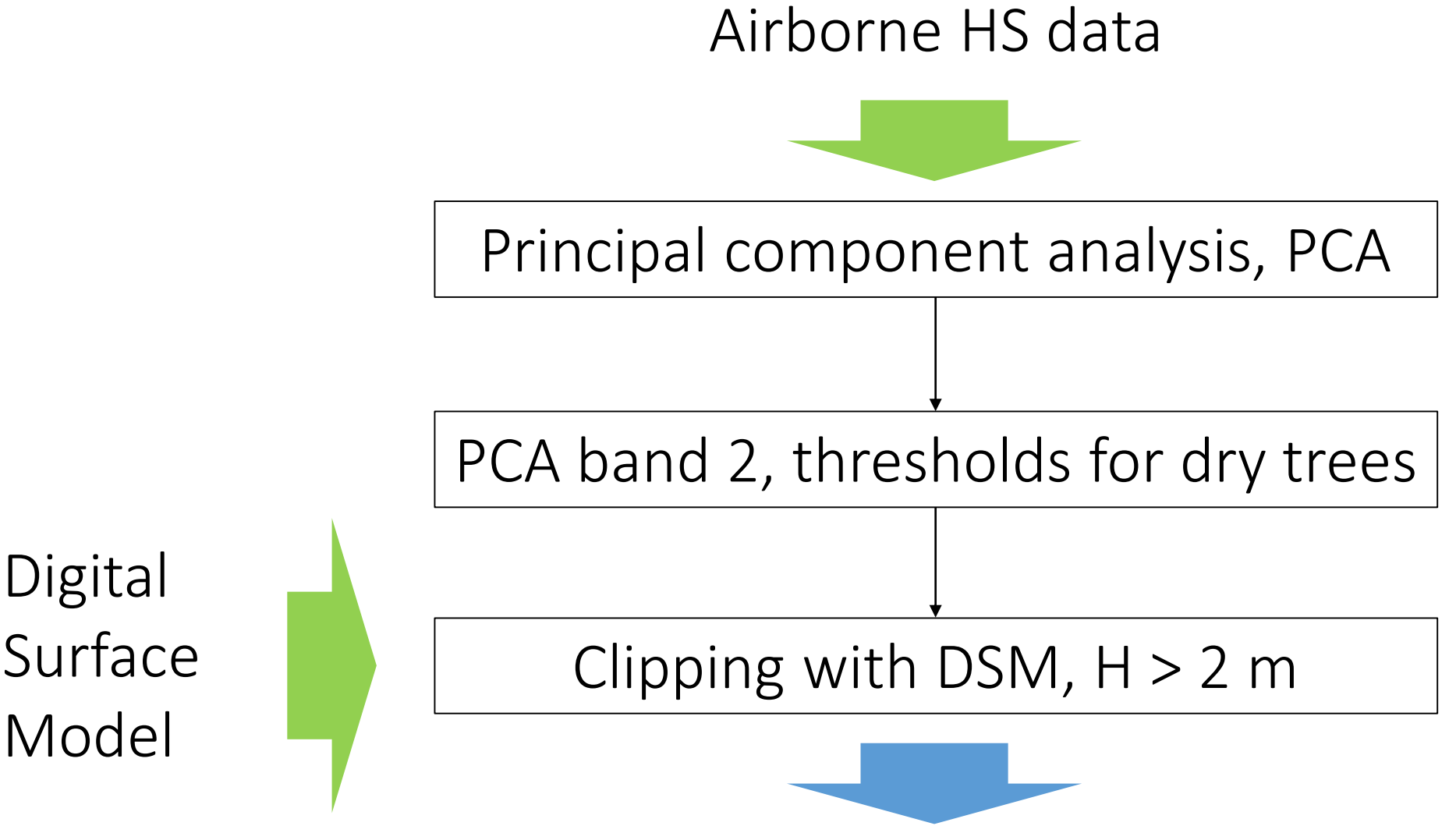
is a complex disorder involving abiotic and biotic stresses on a forest stand that results in a slow, progressive decrease in growth with loss of health and vigor.

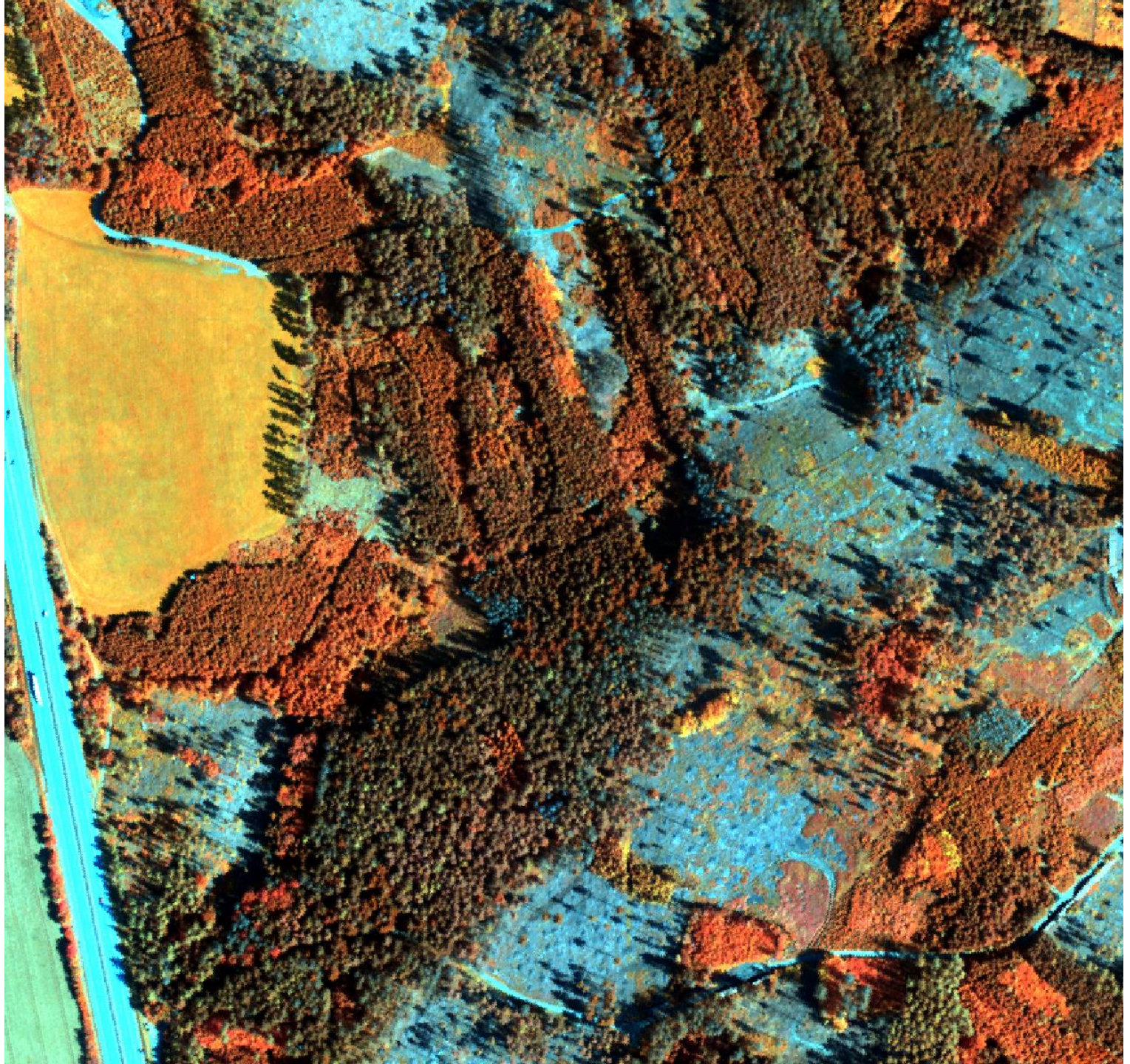
Kaennel & Schweingruber, 1995; NAL Glossary 2014

Identification of spruce health decline from airborne hyperspectral data



Method steps

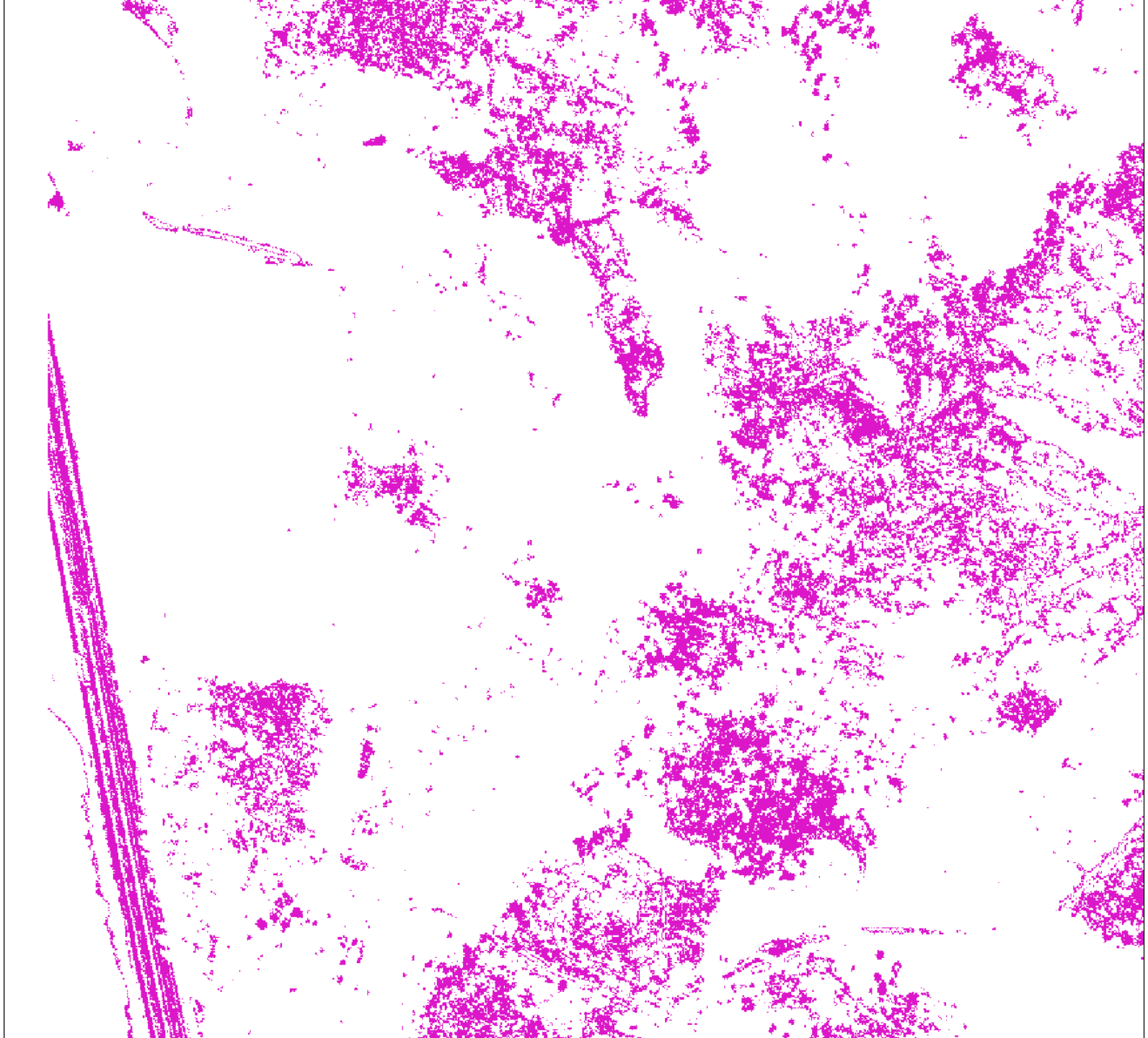




CzechGlobe

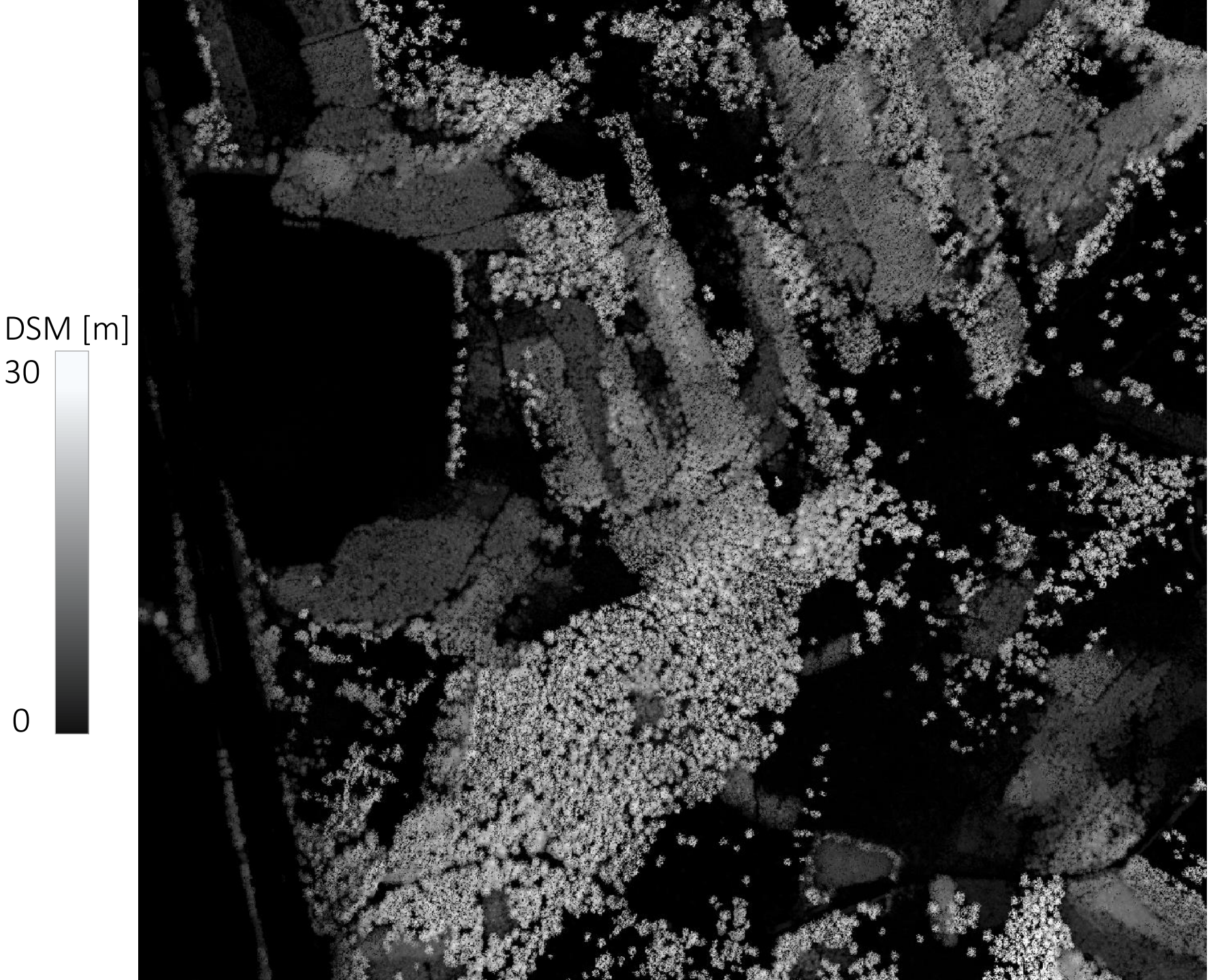
Airborne HS data

Composite
R 850 nm
G 550 nm
B 450 nm

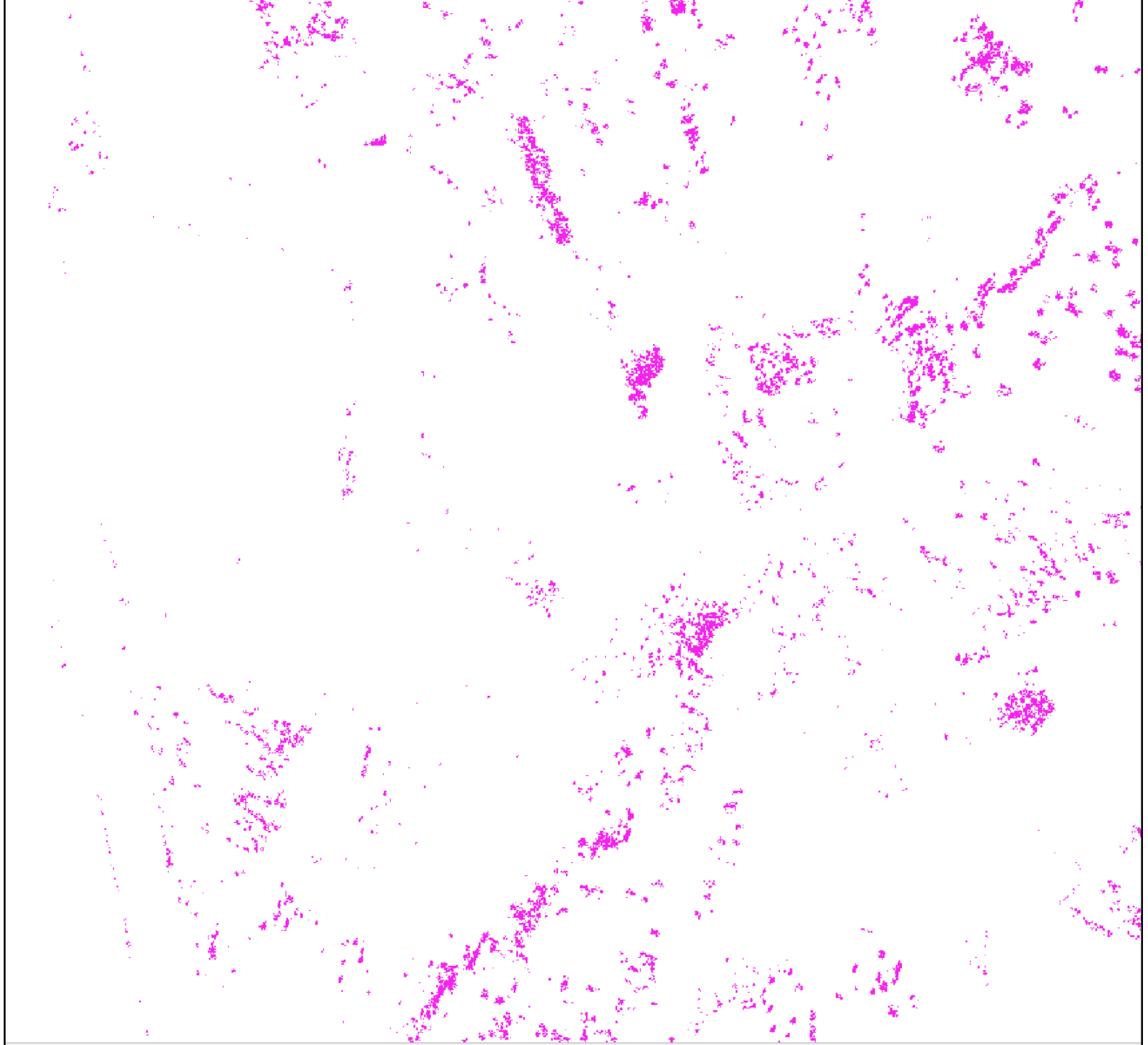


CzechGlobe

PCA band 2



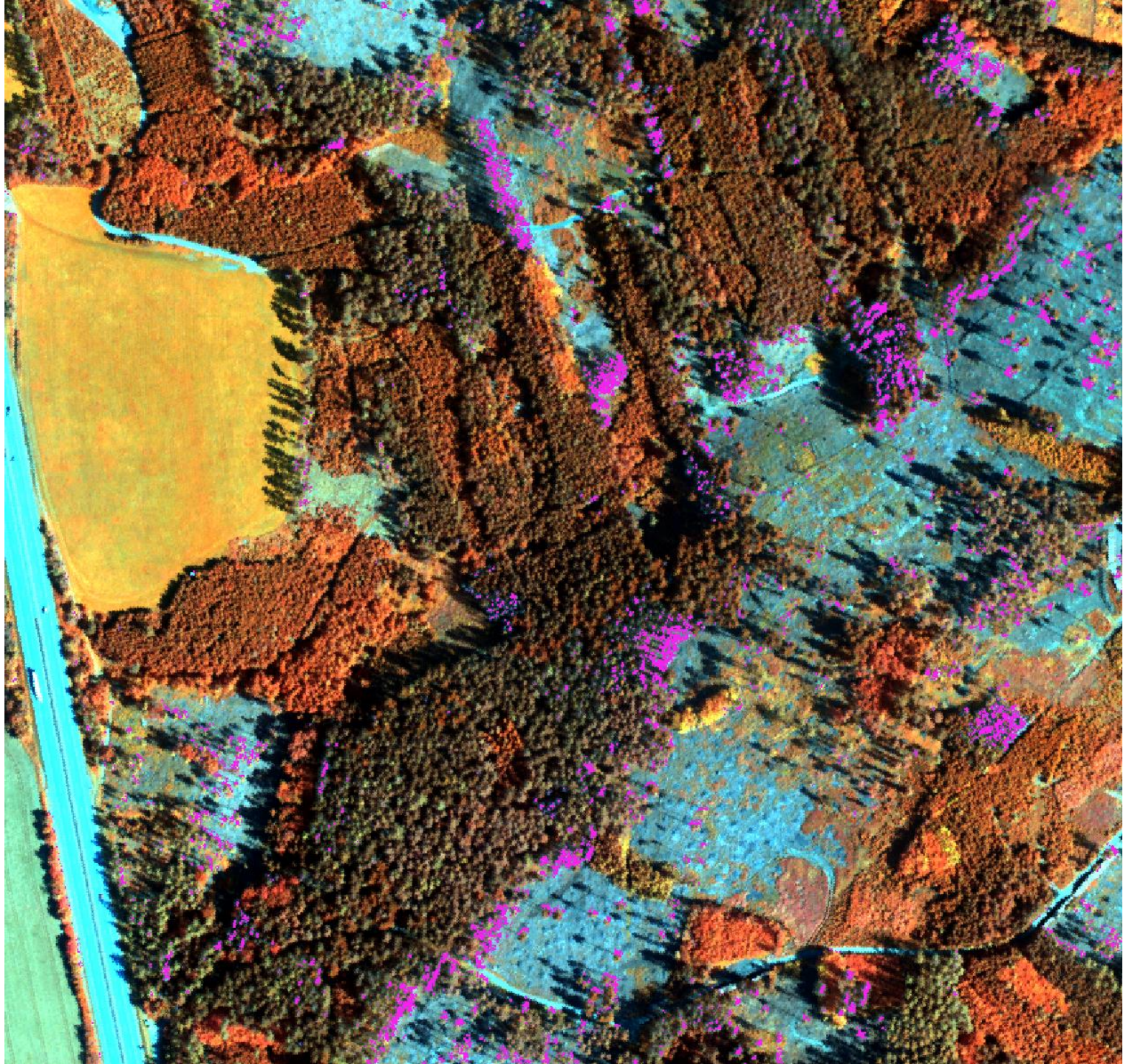
DSM from ALS data



CzechGlobe

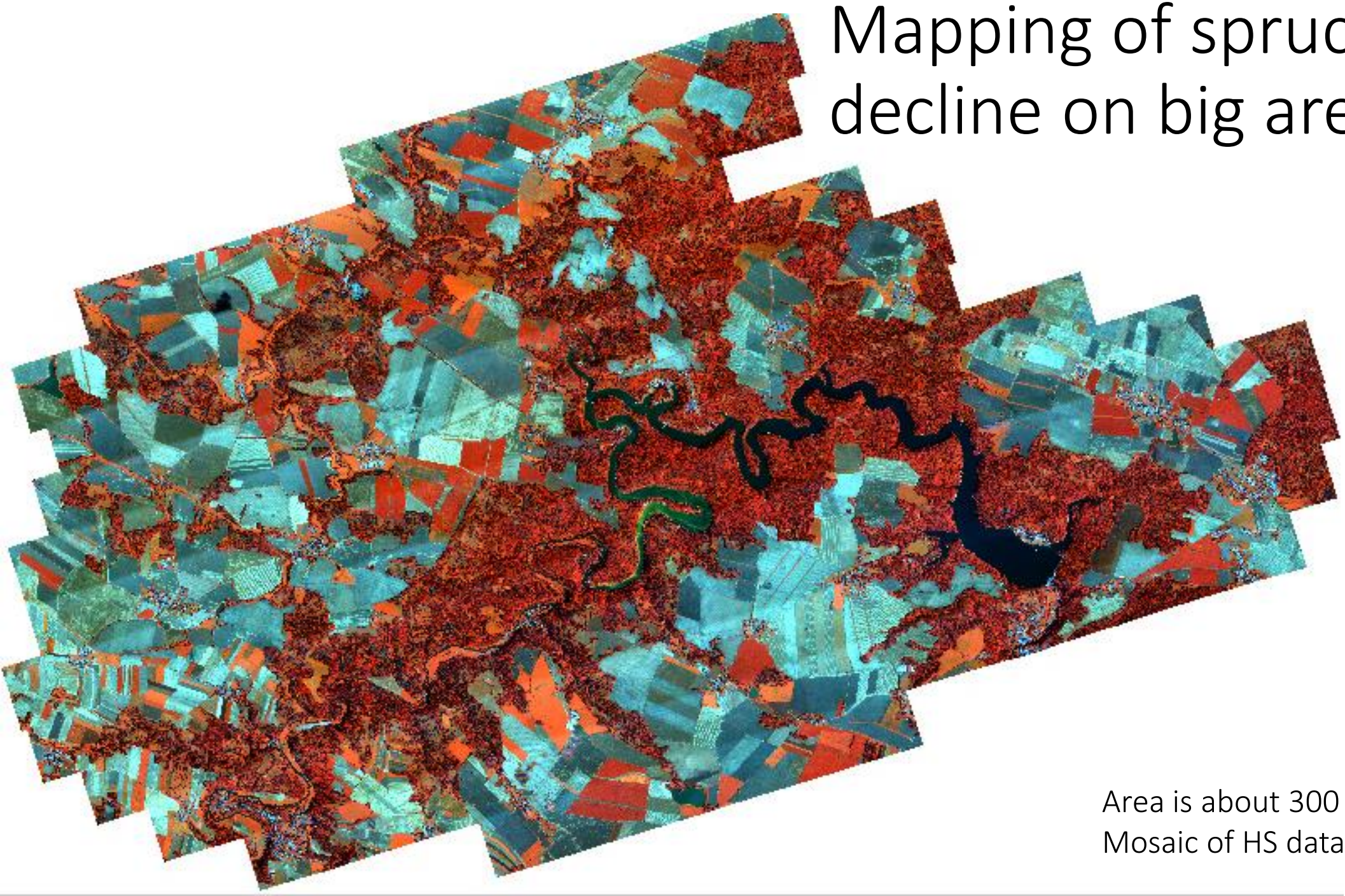
PCA band 2 after clipping with DSM

Condition of clipping:
Height > 2 m



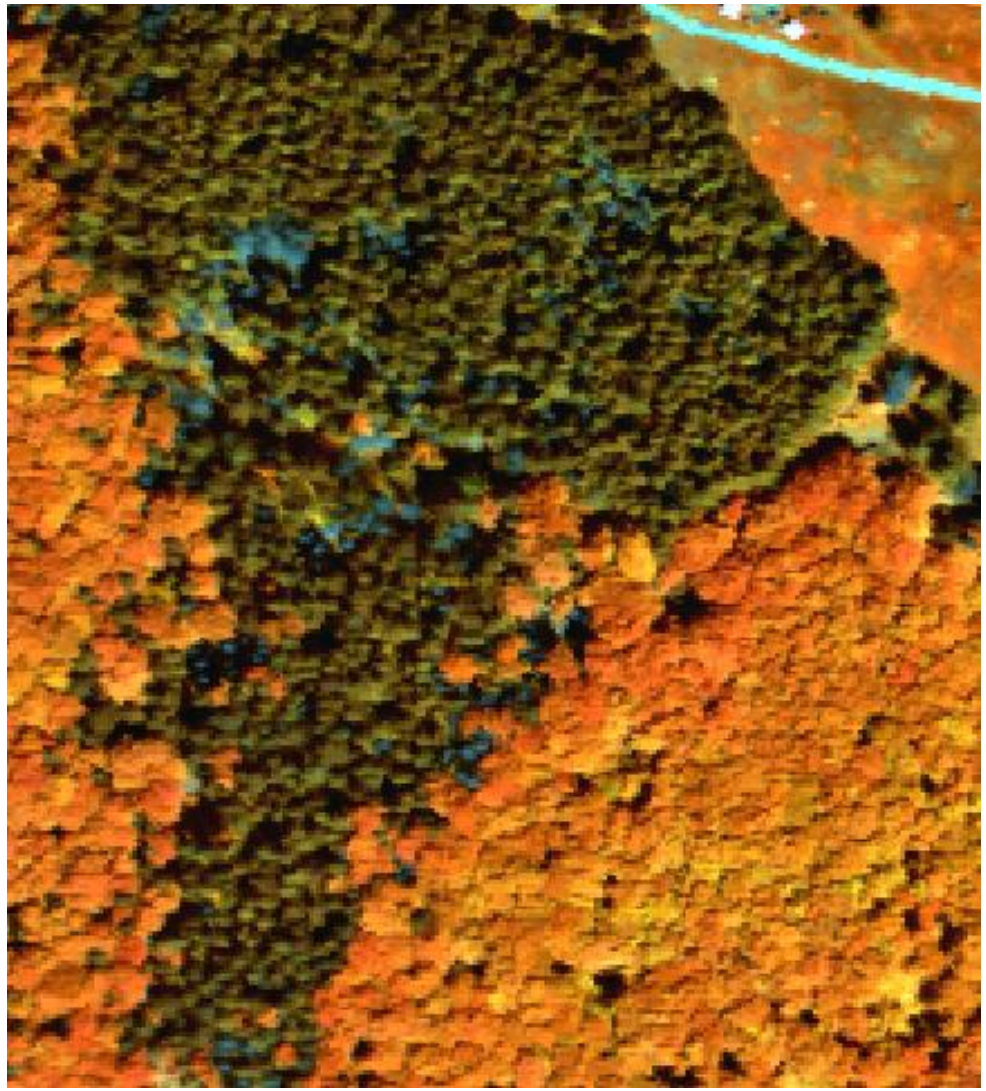
Map of spruce with health decline

Mapping of spruce health decline on big areas

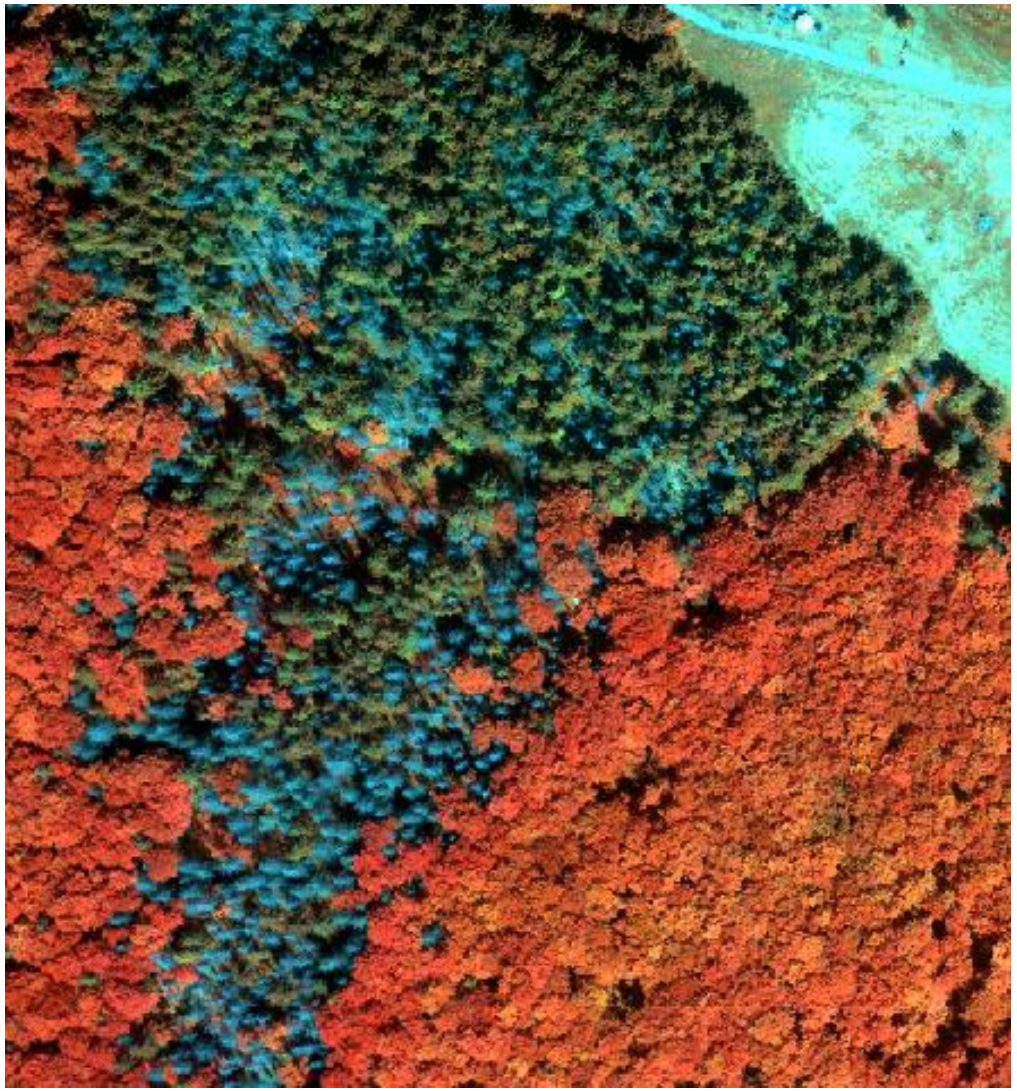


Area is about 300 km^2
Mosaic of HS data is about 110 Gb

Tracking the changes in spruce forest decline

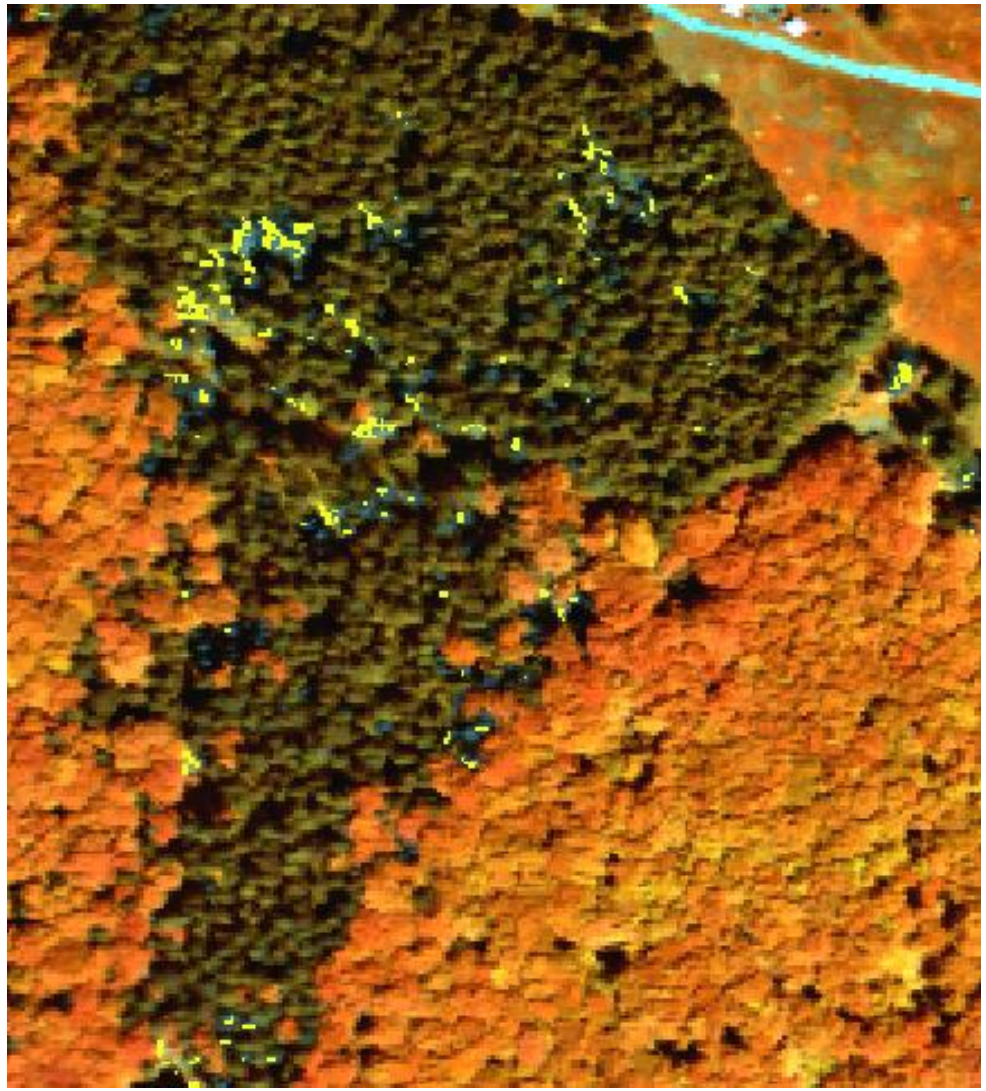


2015

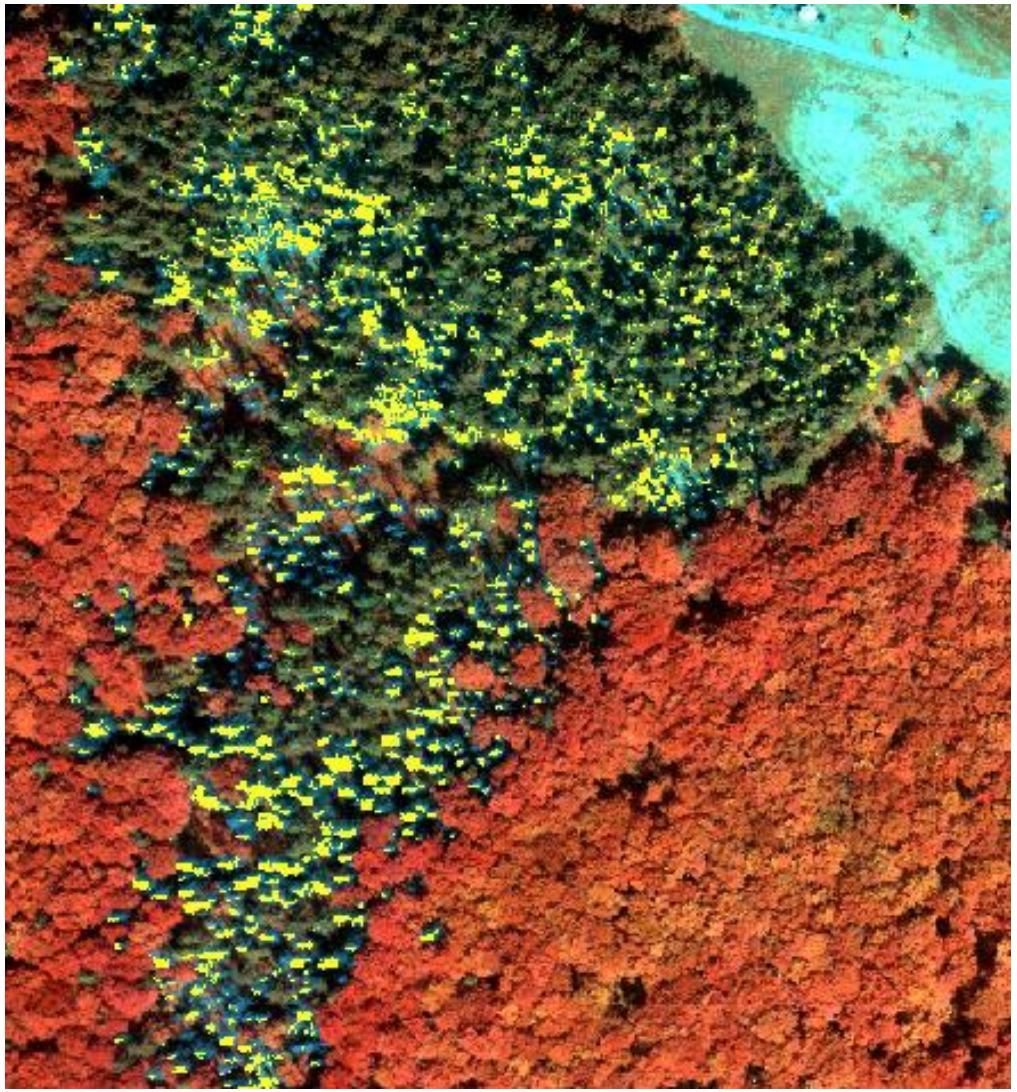


2019

Tracking the changes in spruce forest decline



Dry spruce



2015

2019

Method benefits

- Easy, almost automatic
- It works for big areas
- Does not require field measurements
- Can be used to track changes in spruce health decline

Identification of spruce **decline categories** from airborne hyperspectral and field data

- to determine the composite indicator of spruce health based on field data;

- to explore spectral properties of spruce stands from airborne HS data for categories of the composite indicator;

- to investigate the potential of VIs from airborne HS data to predict the development of the composite indicator.

Study area

Airborne HS data

10.8.2010	8.9.2013	5.6.2015
0.4 – 2.5 µm	0.4 – 1 µm	0.4 – 1 µm
5 m	2 m	2 m

Number of field sample plots

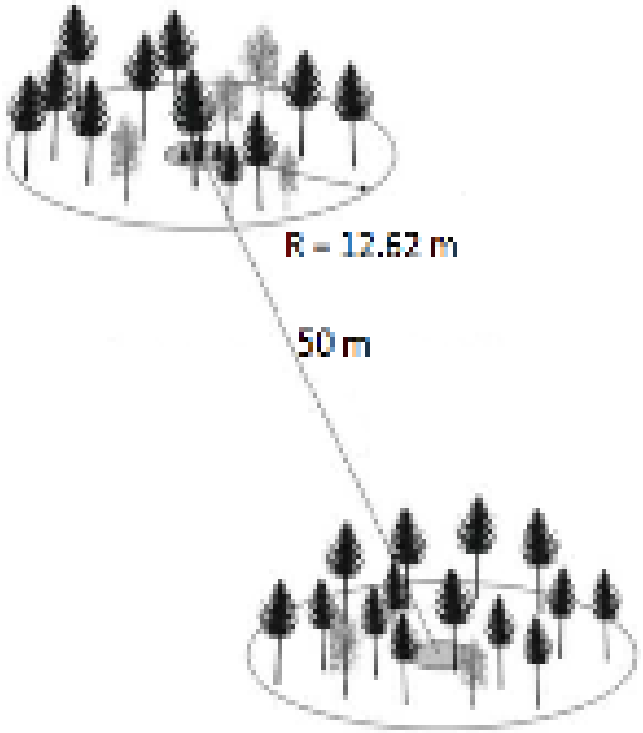
2010	2013	2015
62	78	27

Field plots

Field data

Indicator	Description	Range within study area, %					
		2010 (n =62)		2013 (n=78)		2015 (n=27)	
		Range	Mean	Range	Mean	Range	Mean
Dead trees	Fraction of dead trees	0..41	6	0..50	7	0..35	11
Broken trees	Trees with mechanical or wind break	0..43	8	0.44	9	0..35	8
Resin exudation	Trees with honey fungus resin exudation	0..18	5	0..44	8	0..21	6
Discoloration	Decreasing chlorophyll concentration causing color changes in foliage	0..33	10	0..33	7	0..23	5
Dry tree top	Fraction of trees with dry tree tops	0..40	10	0..33	10	0..18	9
Reduced increment	Reduced increment of top shoots	-	-	0..66	20	0..45	13
IUFRO vitality	Categorization based on visual classification of 10 trees per plot, distinguishing vital individuals, normal/average grown trees, and weak/suppressed trees	0..50	20	0..33	10	0..67	9

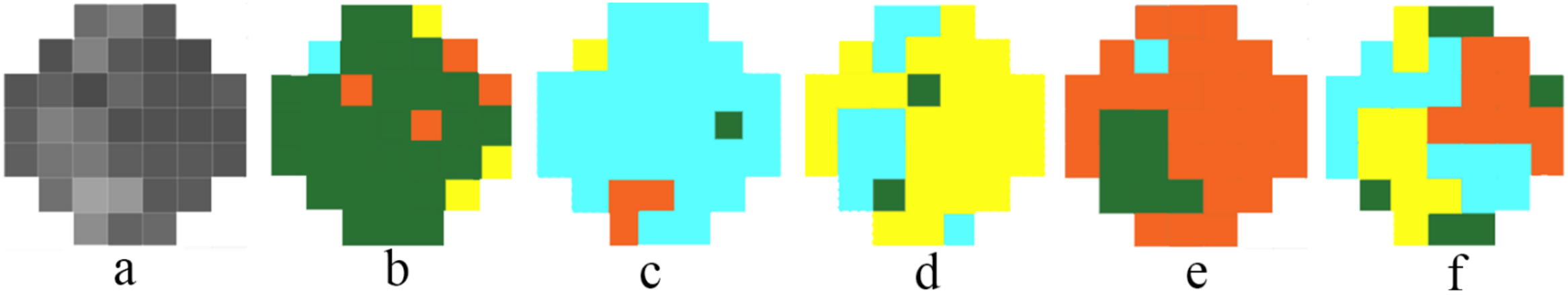
Field data were provided by IFER - Institute of Forest Ecosystem Research



Field plot

Airborne data, 2 m

Determination of composite indicator, CI



Distribution of spruce decline indicators through classes from unsupervised classification of airborne HS data

Indicator	Class 1		Class 2		Class 3		Class 4	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Dead trees	20 - 41	28	0 -15	6.8	0 -7	2.3	0 -15	6
Crown break	0 - 35	13.5	0 - 33	16	0 - 27	11	0 – 29	10
Resin exudation	0 - 14	7	0 - 16	3.5	0 - 23	7	4 – 17	9.3
Discoloration	3 - 6	3.1	0 - 42	17.2	0 - 7	2	0 -18	4
Dry tree top	0 - 11	3.7	0 - 33	13.3	0	-	0 -9	1
IUFRO vitality	0 - 15	5.5	0 - 50	20.3	0 - 10	9	0 - 20	9
CI4	23 - 47	31	6 - 20	15	0 - 5	2	8 - 16	11

Determination of composite indicator, CI

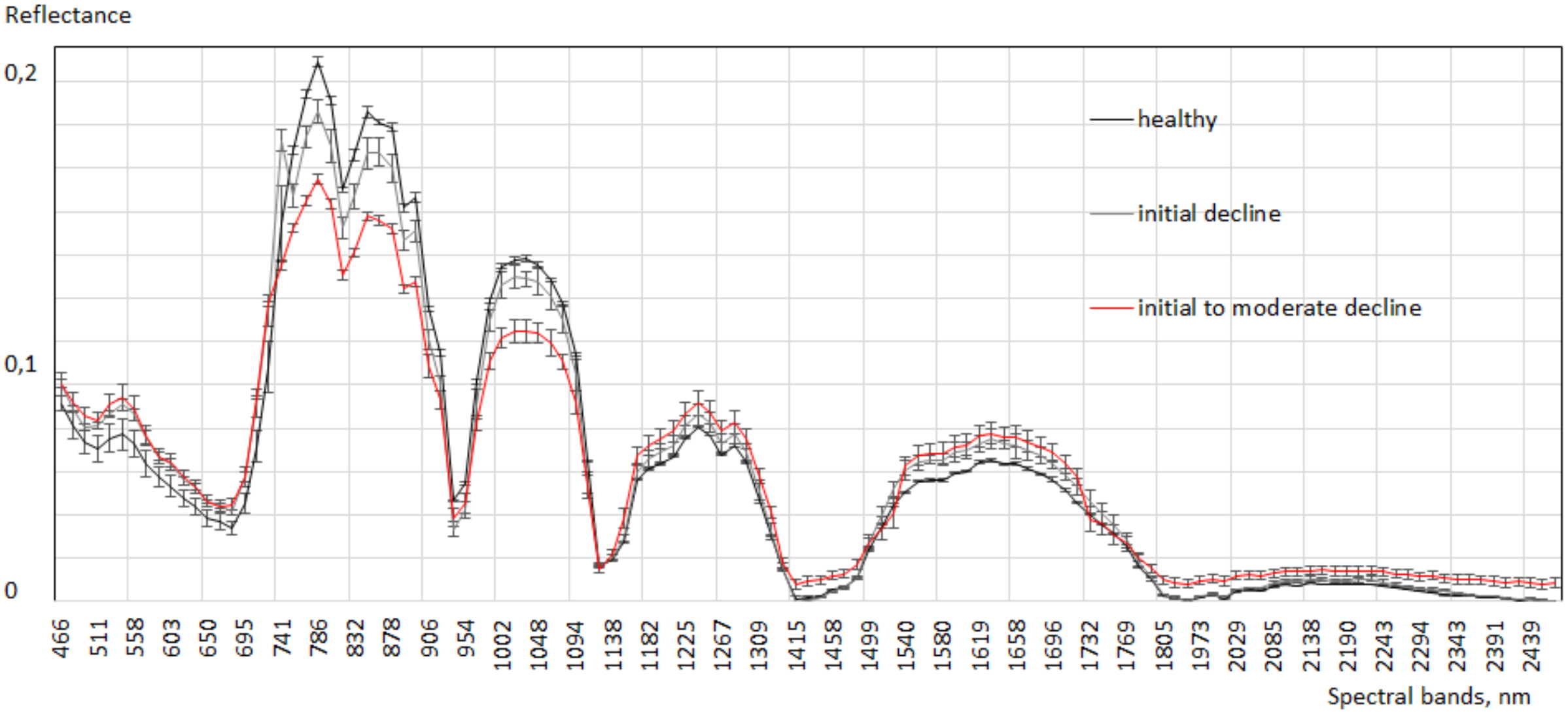
$$CI = \frac{Discoloration + DryTreeTop + IUFROvitality}{3} + DeadTrees$$

Indicator	Class 1		Class 2		Class 3		Class 4	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Dead trees	20 - 41	28	0 -15	6.8	0 -7	2.3	0 -15	6
Crown break	0 - 35	13.5	0 - 33	16	0 - 27	11	0 – 29	10
Resin exudation	0 - 14	7	0 - 16	3.5	0 - 23	7	4 – 17	9.3
Discoloration	3 - 6	3.1	0 - 42	17.2	0 - 7	2	0 -18	4
Dry tree top	0 - 11	3.7	0 - 33	13.3	0	-	0 -9	1
IUFRO vitality	0 - 15	5.5	0 - 50	20.3	0 - 10	9	0 - 20	9
CI	**23 - 47**	**31**	**6 - 20**	**15**	**0 - 5**	**2**	**8 - 16**	**11**

Categories of spruce health decline:

Healthy CI <5,
Initial decline 5< CI <20,
Initial to moderate decline CI >20

Categories of spruce health decline



VI	Equation	Data used	Referense	R^2
Vegetation structure				
$NDVI_{red\_edg}$	$(\rho_{750}-\rho_{705})/ (\rho_{750}+\rho_{705})$	HS	Gitelson and Merzlyak 1994	0.57
NDVI	$(\rho_{820}-\rho_{650})/ (\rho_{820}+\rho_{650})$	MS	Rous et al. 1974	0.39
SR	ρ_{820}/ρ_{650}	MS	Birth et al. 1968	0.21
GNDVI	$(\rho_{820}-\rho_{550})/ (\rho_{820}+\rho_{550})$	MS	Gitelson et al. 1998	0.09
GRVI	ρ_{820}/ρ_{550}	MS	Sripada et al. 2006	0.05
Biochemistry				
PSRI	$(\rho_{680}-\rho_{500})/ \rho_{750}$	MS	Merzlyak et al. 1999	0.71
WBI	ρ_{970}/ρ_{900}	HS	Penuelas et al. 1995	0.63
SIPI	$(\rho_{800}-\rho_{445})/ (\rho_{800}-\rho_{680})$	HS	Penuelas et al. 1995	0.02
MSI	ρ_{1620}/ρ_{820}	MS	Hunt et al. 1989	0.36
CARI	$(\rho_{700}-\rho_{670})-0.2*(\rho_{700}-\rho_{550})$	HS	Kim 1994	0.14
ARI_NIR	$\rho_{800} \times (1/\rho_{550} - 1/\rho_{700})$	MS	Gitelson et al. 2001	0.06
NDMI	$(\rho_{860} - (\rho_{1640}-\rho_{2130}))/ \rho_{860} + (\rho_{1640}-\rho_{2130})$	MS	Wang et al. 2007	0.34
NDWI	$(\rho_{857}-\rho_{1241}) / (\rho_{857}+ \rho_{1241})$	HS	Gao 1996	0.41
Phisiology/stress				
PRI	$(\rho_{531}-\rho_{570}) / (\rho_{531}+ \rho_{570})$	HS	Gamon et al. 1997	0.42
NDII	$(\rho_{819}-\rho_{1649})/ (\rho_{819}+\rho_{1649})$	MS	Hardisky et al. 1983	0.57
CRI_550	$(1/\rho_{515})-(1/\rho_{550})$	HS	Gitelson et al. 2003, 2006	0.18
CRI_700	$(1/\rho_{515})-(1/\rho_{700})$	HS		0.17

Method summary

- Field measurements are required;
- VIs (PRI, WBI, NDVI, PSRI, NDII) demonstrated a good potential to estimate Composite indicator;
- Decline categories of spruce health can be identified using Composite indicator;
- Can be used to track changes in spruce health decline.

O. Brovkina, E. Cienciala, F. Zemek, P. Lukeš , T. Fabianek & R. Russ (2017) Composite indicator for monitoring of Norway spruce stand decline, European Journal of Remote Sensing, 50:1, 550-563

Thank you for your attention!

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