UNIVERSITY OF TWENTE.

THERMAL INFRARED AIRBORNE HYPERSPECTRAL DATA FOR VEGETATION LANDCOVER CLASSIFICATION IN A MIXED TEMPERATE FOREST

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ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

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MOTIVATION

- Vegetation classification provides the baseline information on the ecosystem structure and composition.
- Land cover descriptions of vegetation is considered an Essential Climate variable (ECV) and a Remote Sensing-enabled Essential Biodiversity Variable (RS enabled EBV)
- Multi spectral and hyperspectral sensors have been widely used in vegetation classification.
- It is vital to explore feasibility of thermal Infrared region for vegetation

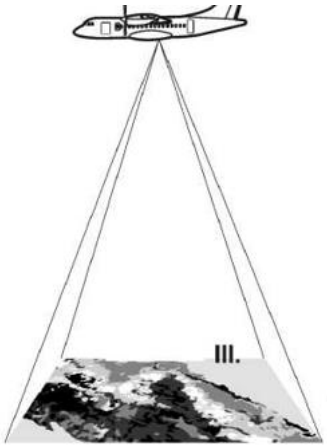
Type of sensor	Feasibility
Multispectral spaceborne medium resolution	✓
Very High Resolution spaceborne multispectral	✓
UAVs	✓
Hyperspectral	✓
Airborne hyperspectral	✓
Multispectral fusion with SAR	✓
Multispectral and hyperspectral fusion with lidar	✓

THERMAL INFRARED REMOTE SENSING

- Foliar spectral behaviour in the TIR region is species specific
- Translation from leaf level emissivity to canopy emissivity enables understanding of vegetation variability at the canopy level.
- Airborne TIR has been rarely used in vegetation studies

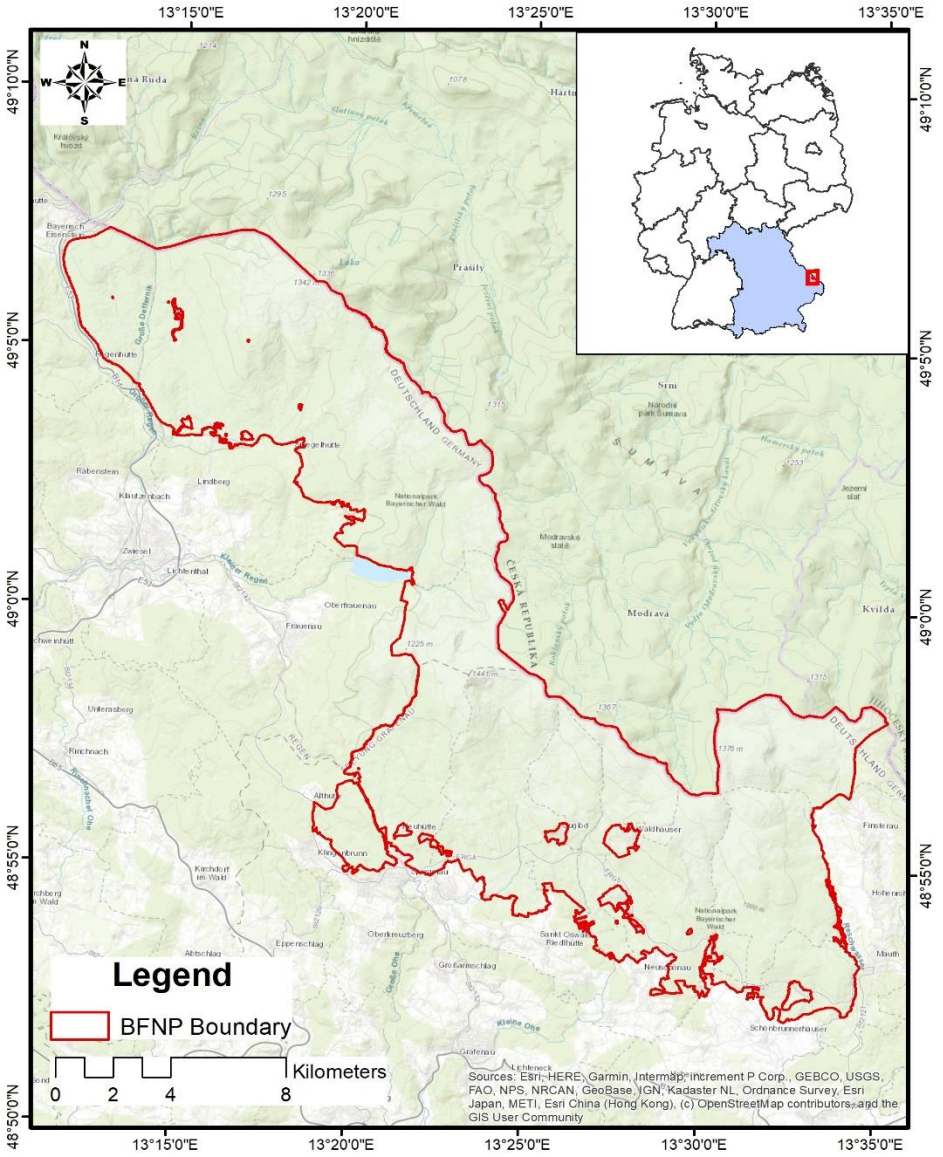
Research objective

➢ To classify the mixed forest using emissivity spectra derived from the airborne TIR hyperspectral data

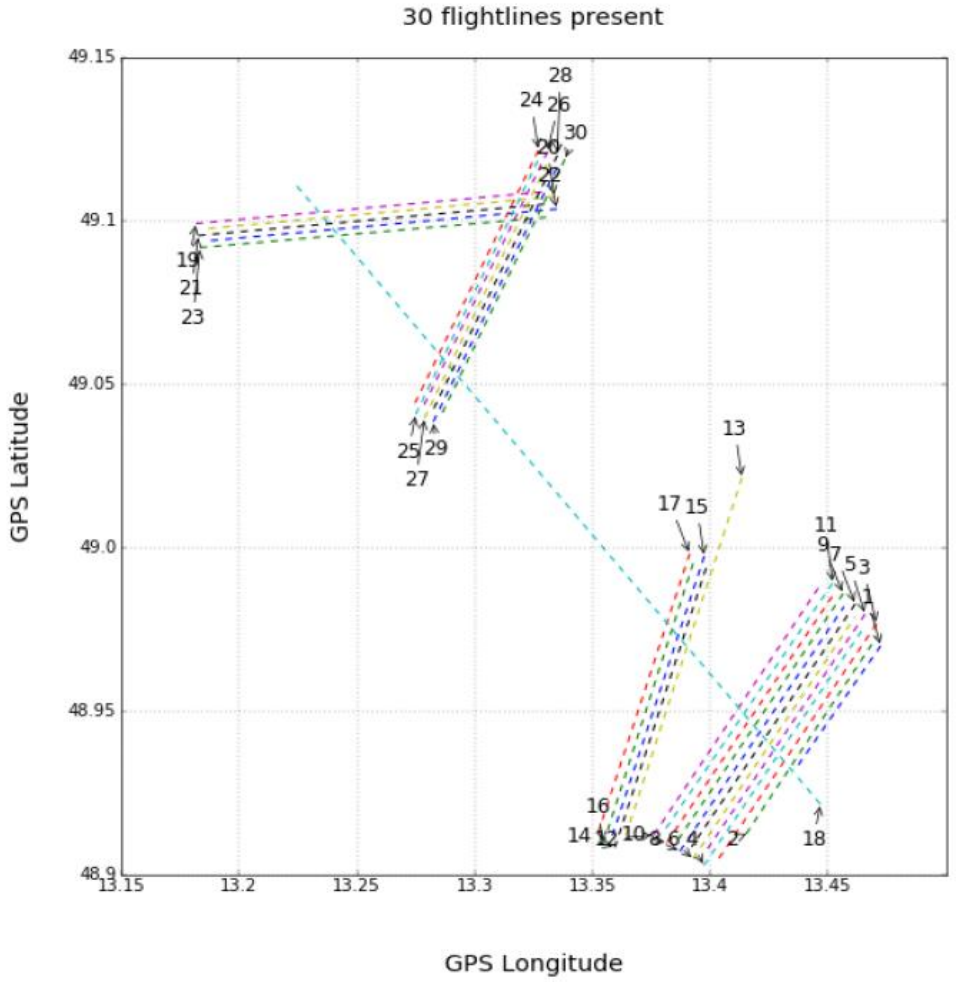


STUDY AREA: BAVARIAN FOREST NATIONAL PARK

- BFNP is one of the largest heterogenous continuous forests in Europe (2400 ha).
- The natural forest ecosystem of BNFP varies with altitude; on valleys are Norway spruce (*Picea abies*); on the hillsides and mountains, there is a mix of silver fir (*Abies alba*) and European beech (*Fagus sylvatica*).
- Major vegetation cover types are **conifer**, **broadleaf** and **mixed** stands



DATA ACQUISITION



Airborne thermal hyperspectral data acquired during EUFAR flight campaign on 6th June 2017 using Specim's AISA Owl sensor.

Data collected based on 30 flightlines over Northern and Southern BFNP using aircraft operated by NERC-ARF

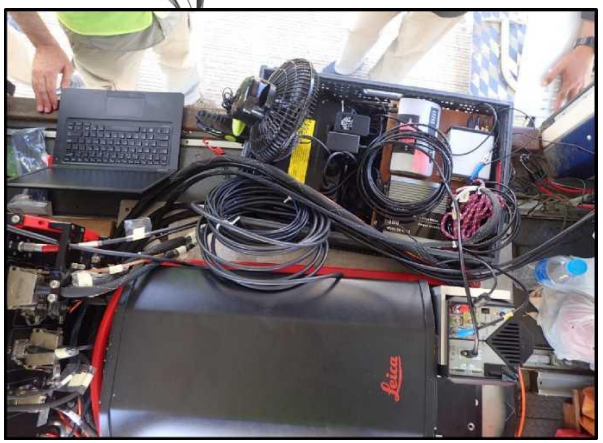
Specim's AISA Fenix and AISA Owl were mounted on the aircraft

A pair of internal blackbodies that were mechanically switched consecutively during the flight were used for calibration of the sensor

ITC UNIVERSITY OF TWENTE. NATIONALPARK Bayerischer Wald EUFAR European Facility for Airborne Research NERC SCIENCE OF THE ENVIRONMENT

AISA OWL THERMAL SENSOR CHARACTERISTICS

Inside Plane



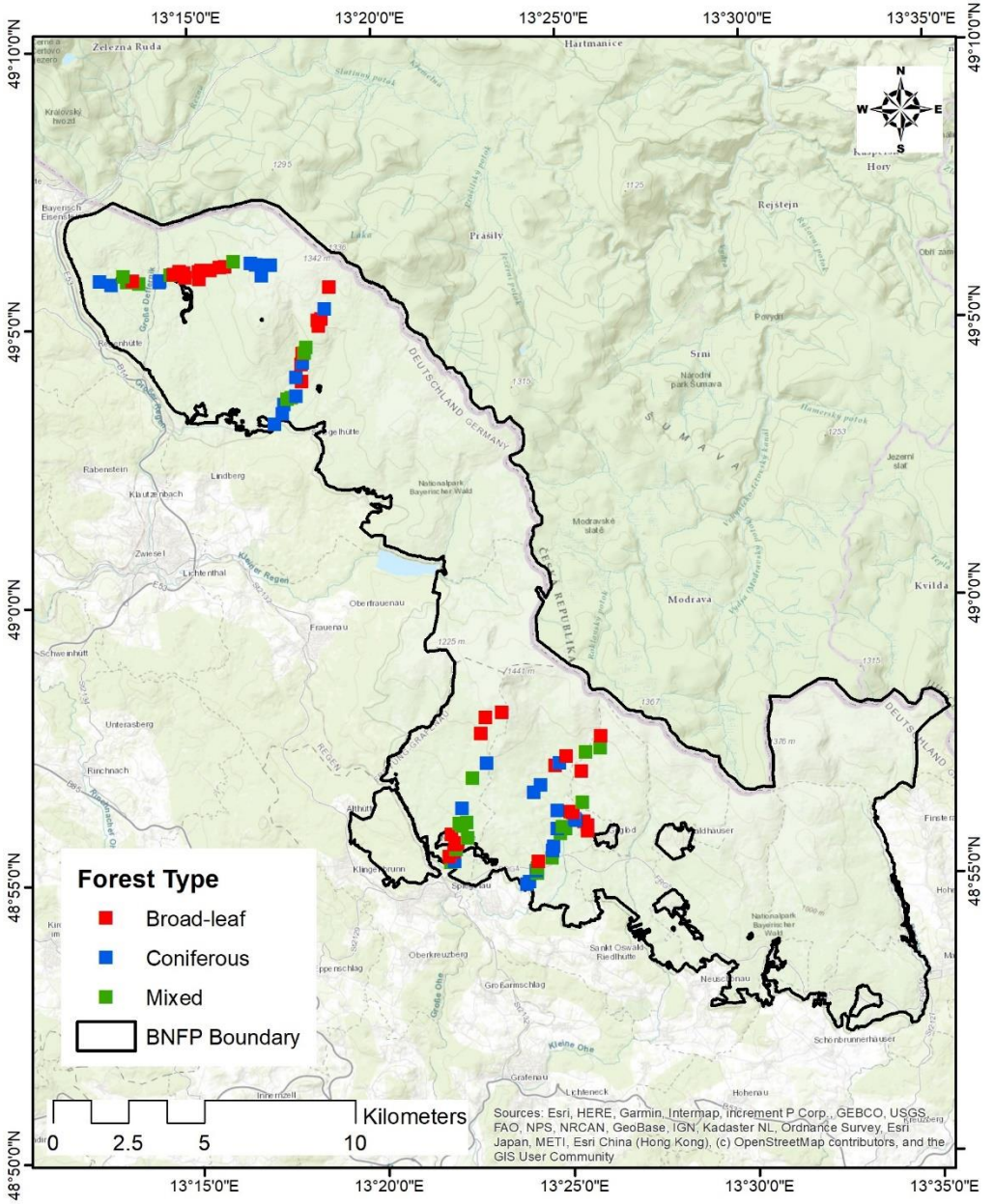
- AISA Owl sensor is a fast push-broom hyperspectral system.
- The spatial resolution is approximately 3m based on the flight height of 2083m

Parameter	Value		
Spectral range	7.6 - 12.5 µm		
Instantaneous field-of-view (IFOV)	1.10		
Max scan	24º		
Swath width (relative to nadir)	885 m		
Noise equivalent spectral radiance (NESR) ($mW/m^2sr^{-1}\mu m^{-1}$)	At 8 µm	At 10 µm	At 12 µm
	450	580	230
Signal to noise ratio (SNR) (300 K target)	21	18	40

Fieldwork data collection

- Field work during BIOSPACE project in 2021 and EUFAR flight campaign 2017.
- A total of 97 forest plots of 30m by 30m was collected.
- 92 forest plots used for analysis.

	EUFAR	BIOSPACE project	Overall
Coniferous	12	22	25
Broadleaf	13	24	37
Mixed	11	15	26
Total	**36**	**61**	**97**



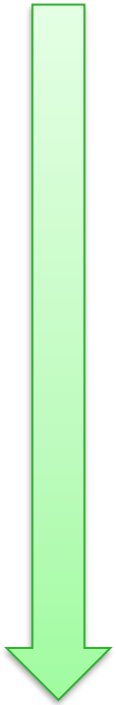
DATA PROCESSING

Radiometric correction and Radiance calibration

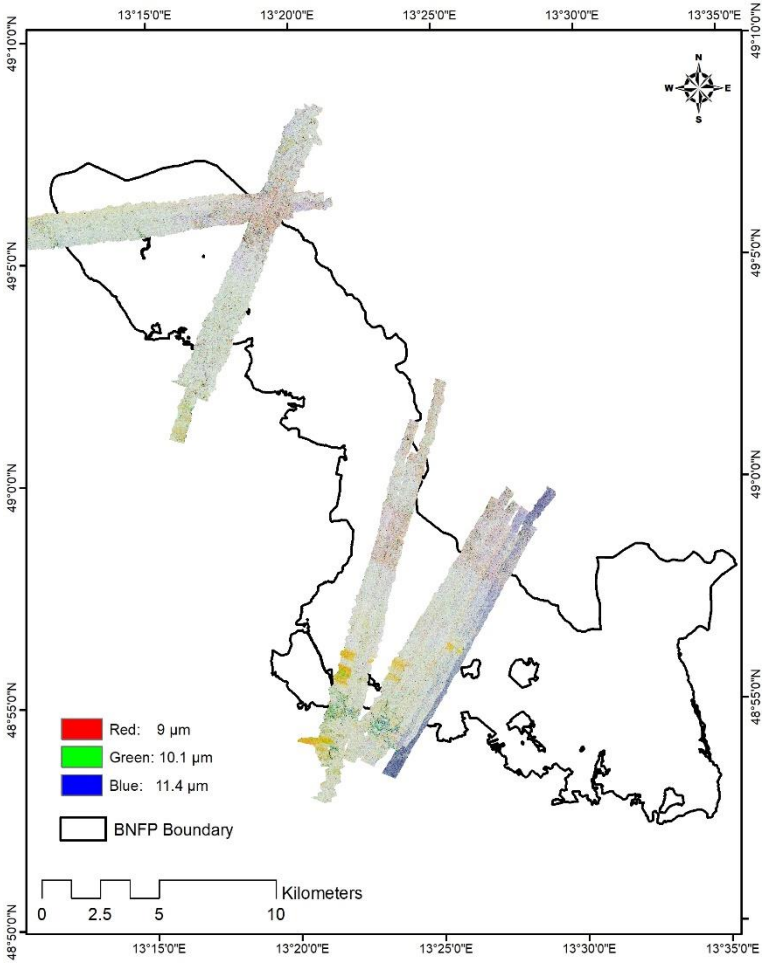
Data masking

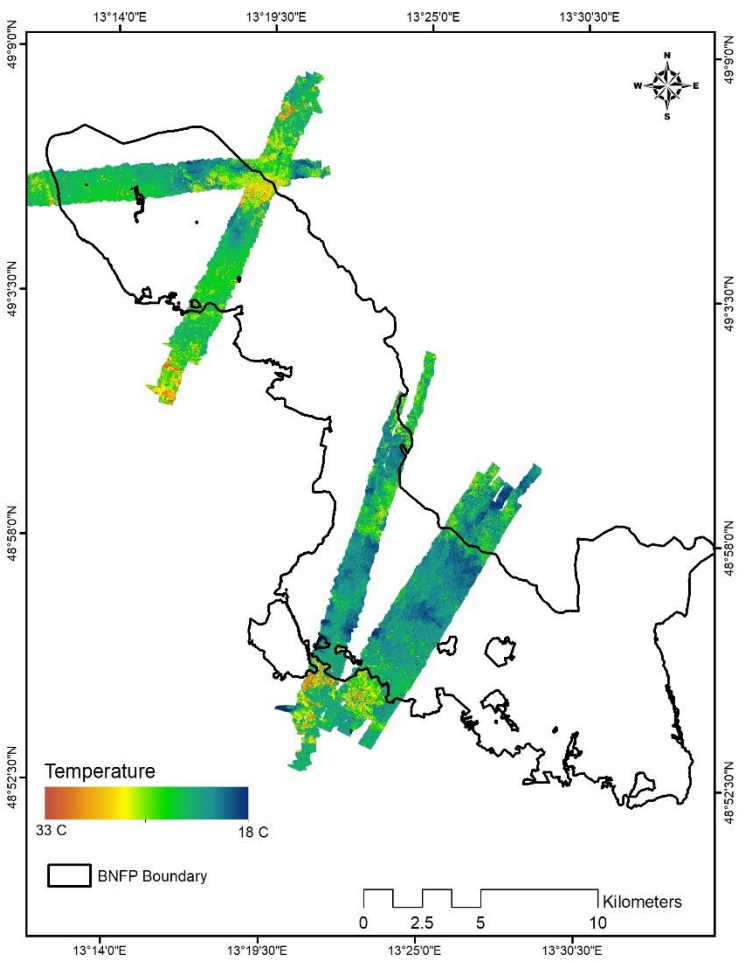
Geo-correction, Reprojection and Resampling

Temperature-emissivity separation

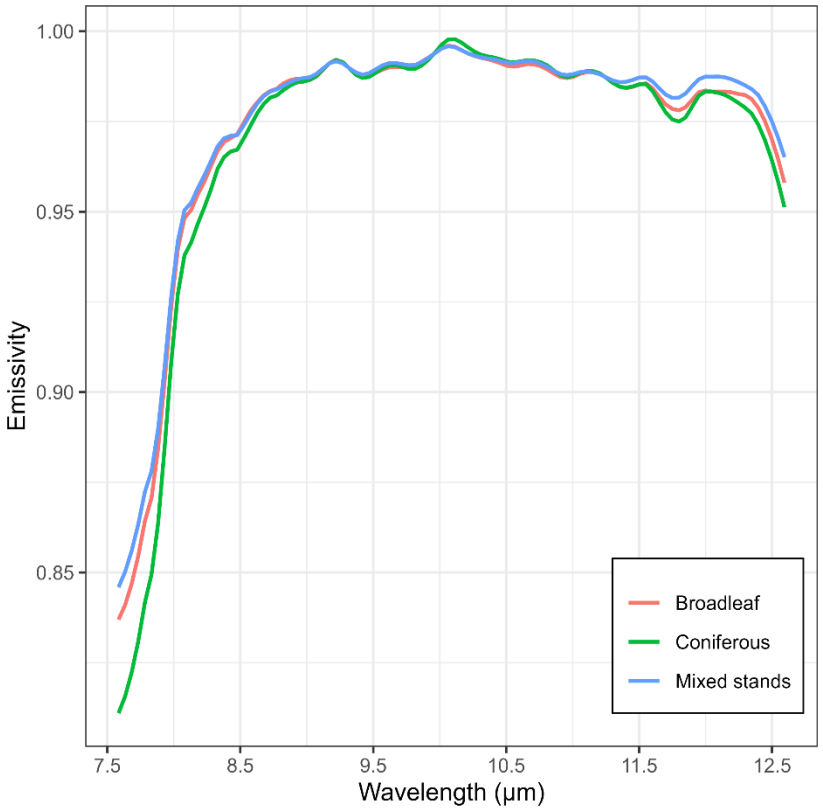


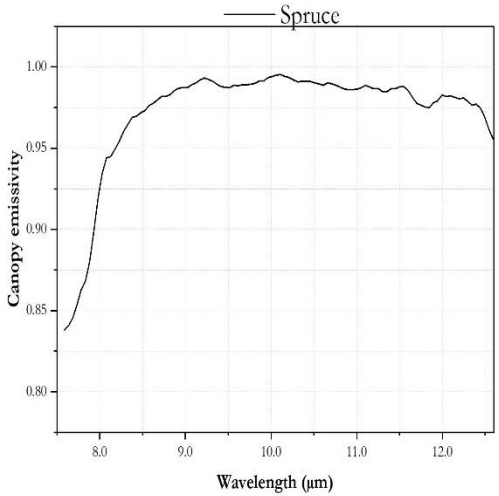
RESULTS

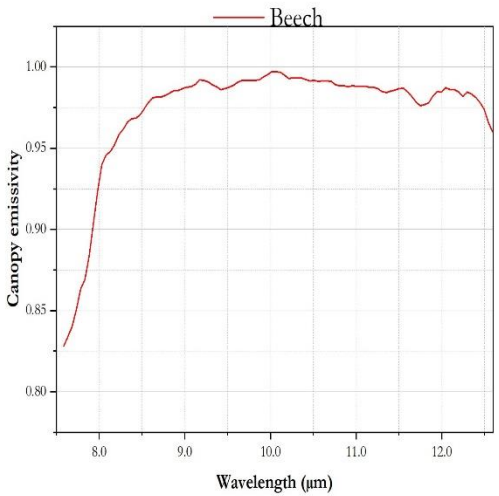

13°15'0"E
13°20'0"E
13°25'0"E
13°30'0"E
13°35'0"E
49°10'0"N
49°5'0"N
49°0'0"N
48°55'0"N
48°50'0"N
Red: 9 µm
Green: 10.1 µm
Blue: 11.4 µm
BNFP Boundary
Kilometers
0 2.5 5 10

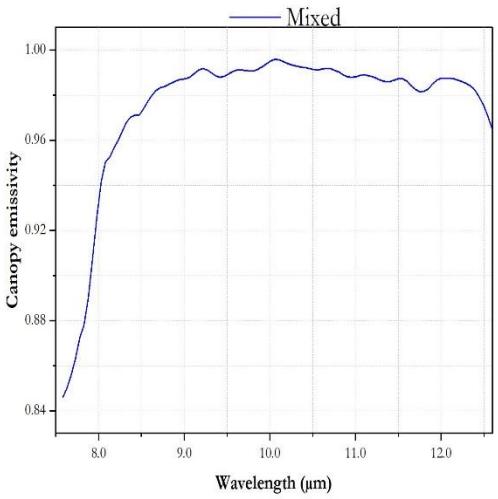

13°14'0"E
13°19'30"E
13°25'0"E
13°30'30"E
49°9'0"N
49°3'30"N
48°58'0"N
48°52'30"N
Temperature
33 C
18 C
BNFP Boundary
Kilometers
0 2.5 5 10

CANOPY EMISSIVITY



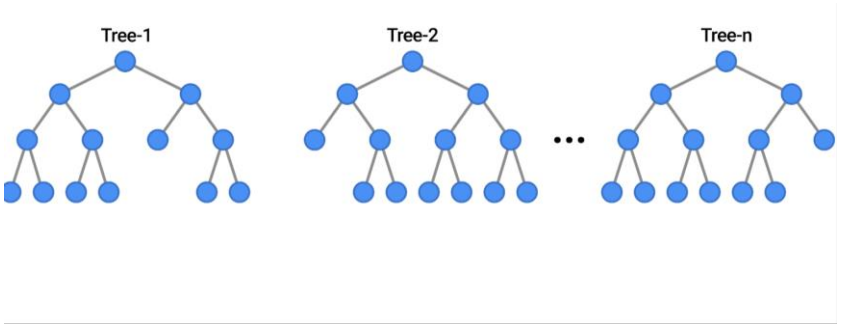






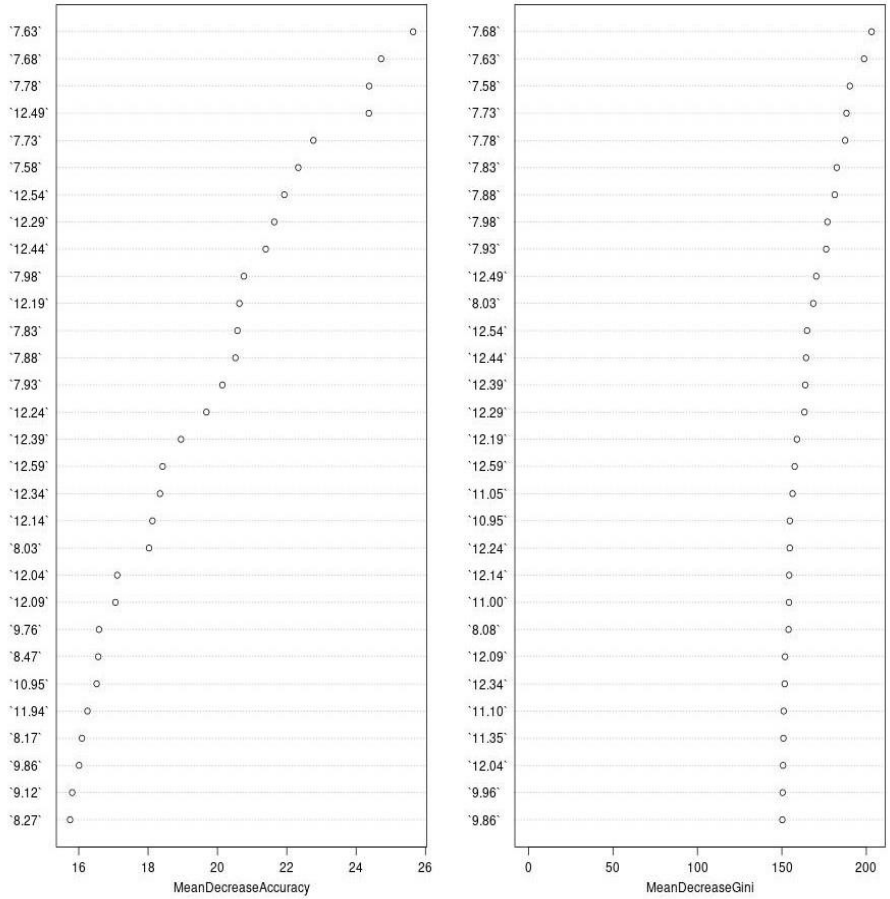
RANDOM FOREST CLASSIFICATION

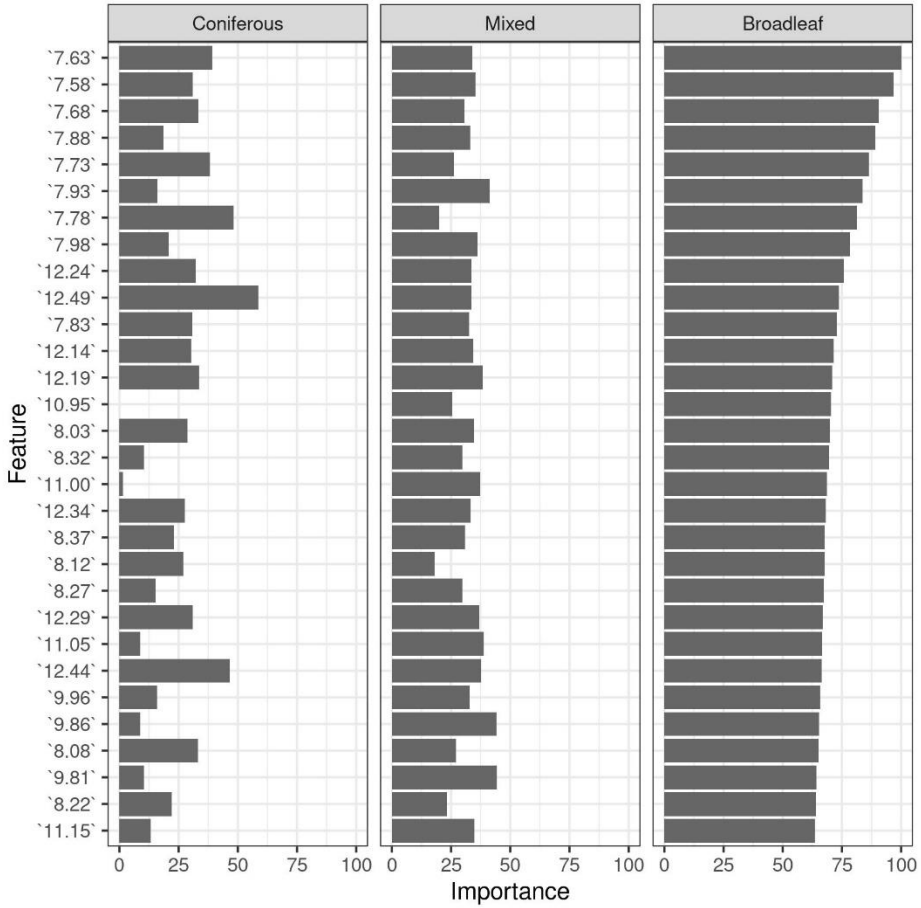
Forest type	Training data (70%)		Validation data (30%)	
	Number. of Plots	Number of Pixels	Number of Plots	Number of Pixels
Coniferous	22	7320	9	3136
Broadleaf	26	9078	10	3890
Mixed	18	6798	7	2913
Total	**66**	**23196**	**26**	**9939**



- 1500 trees and mtry (2) were used in the Random Forest
- Random forest was used in a first classification instance and important wavelengths from Random Forest was used in Feature selection

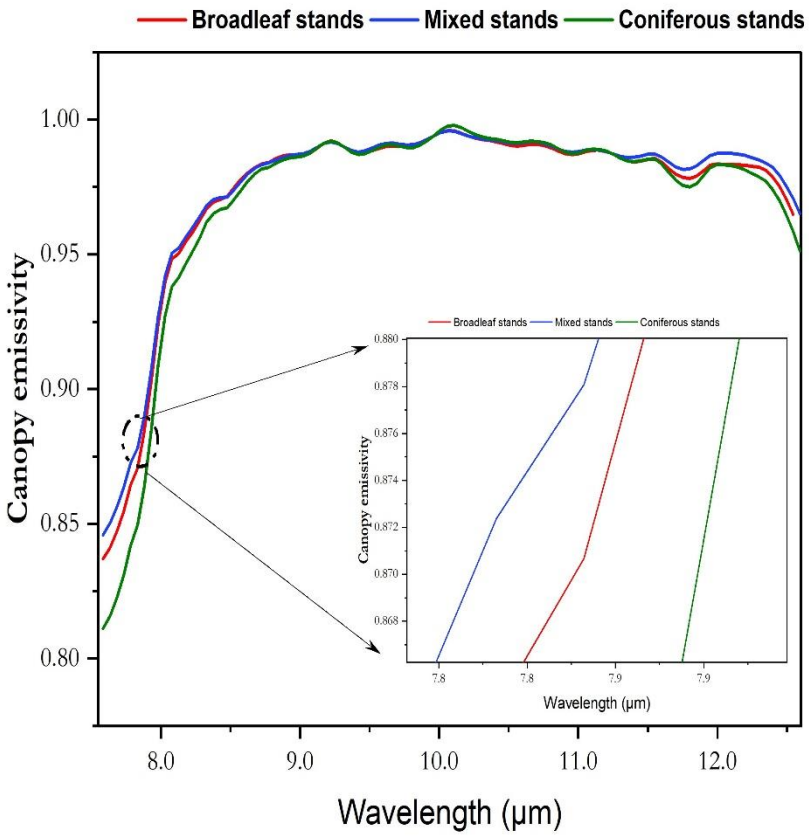
IMPORTANT WAVELENGTHS



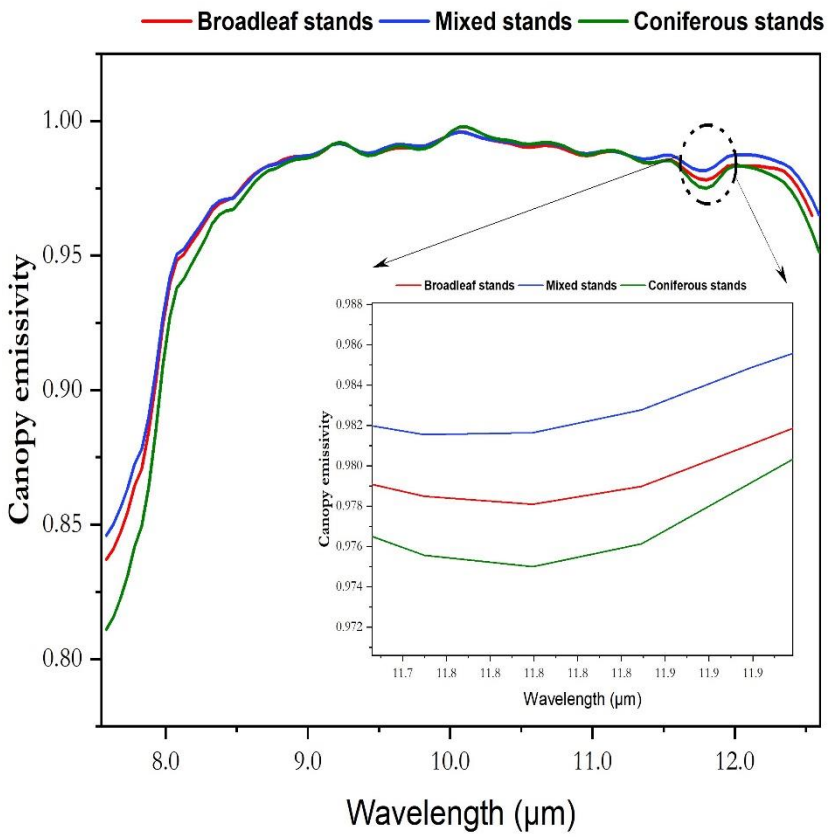


IMPORTANT WAVELENGTHS

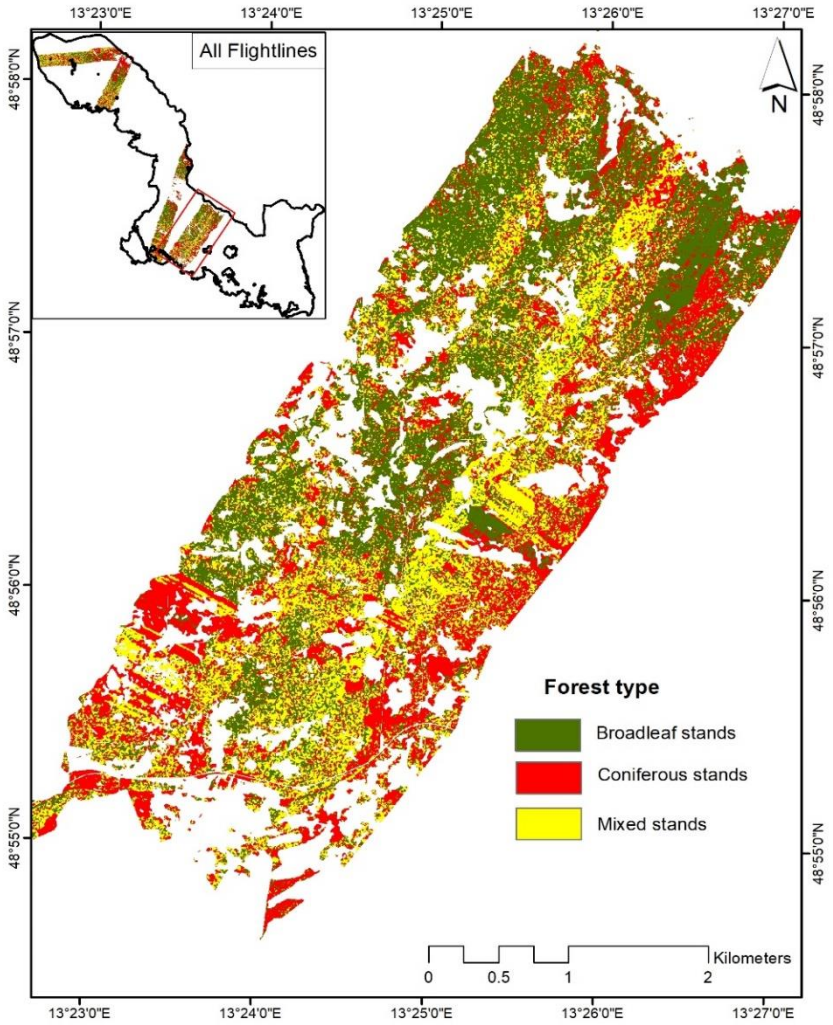
7.58 - 7.9 µm



11.5 - 12.5 µm



TIR CLASSIFIED MAP



COMPARISON: ACCURACY ASSESSMENT

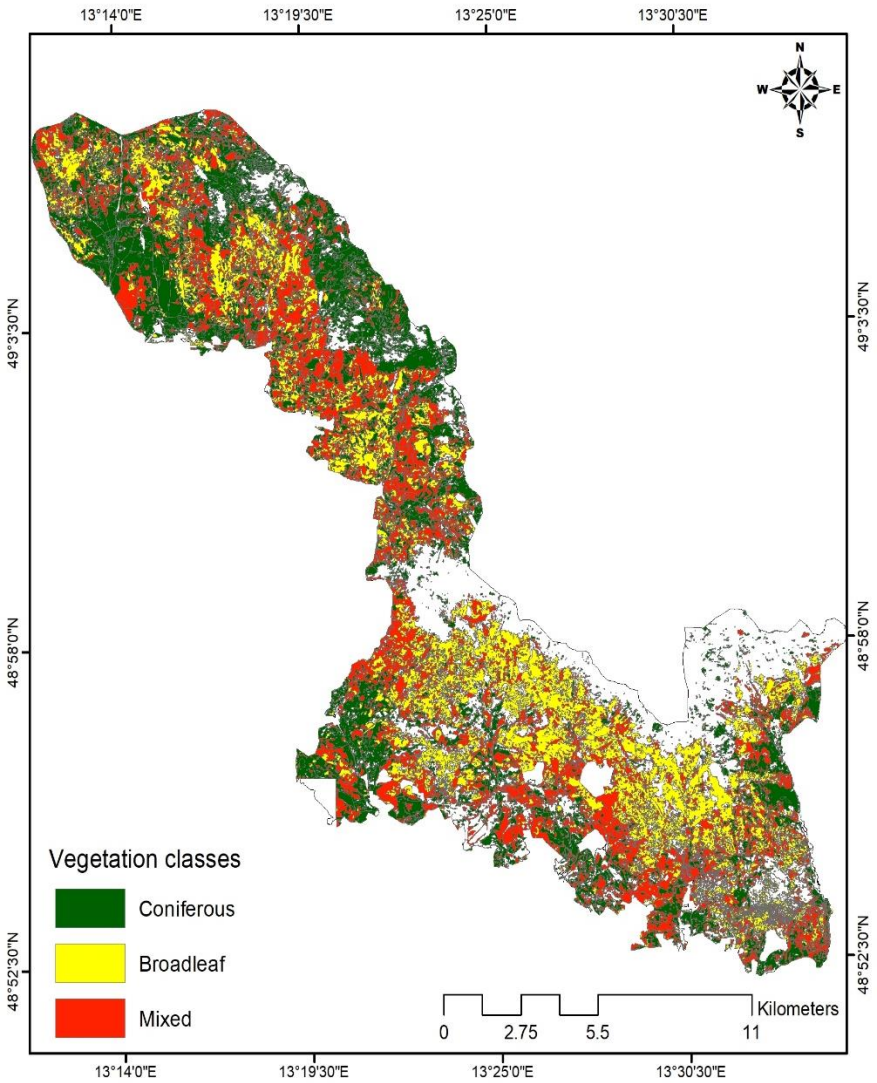
102 bands

	Coniferous	Broadleaf	Mixed	Total	UA (%)
Coniferous	1228	575	612	2412	50.91
Broadleaf	1093	2460	1039	4596	53.52
Mixed	865	854	1262	2981	42.33
Total	3186	3890	2913	4971	-
PA (%)	38.54	63.23	43.32	-	-
OA (%)	-	-	-	-	49.74
Kappa	0.35				

30 bands

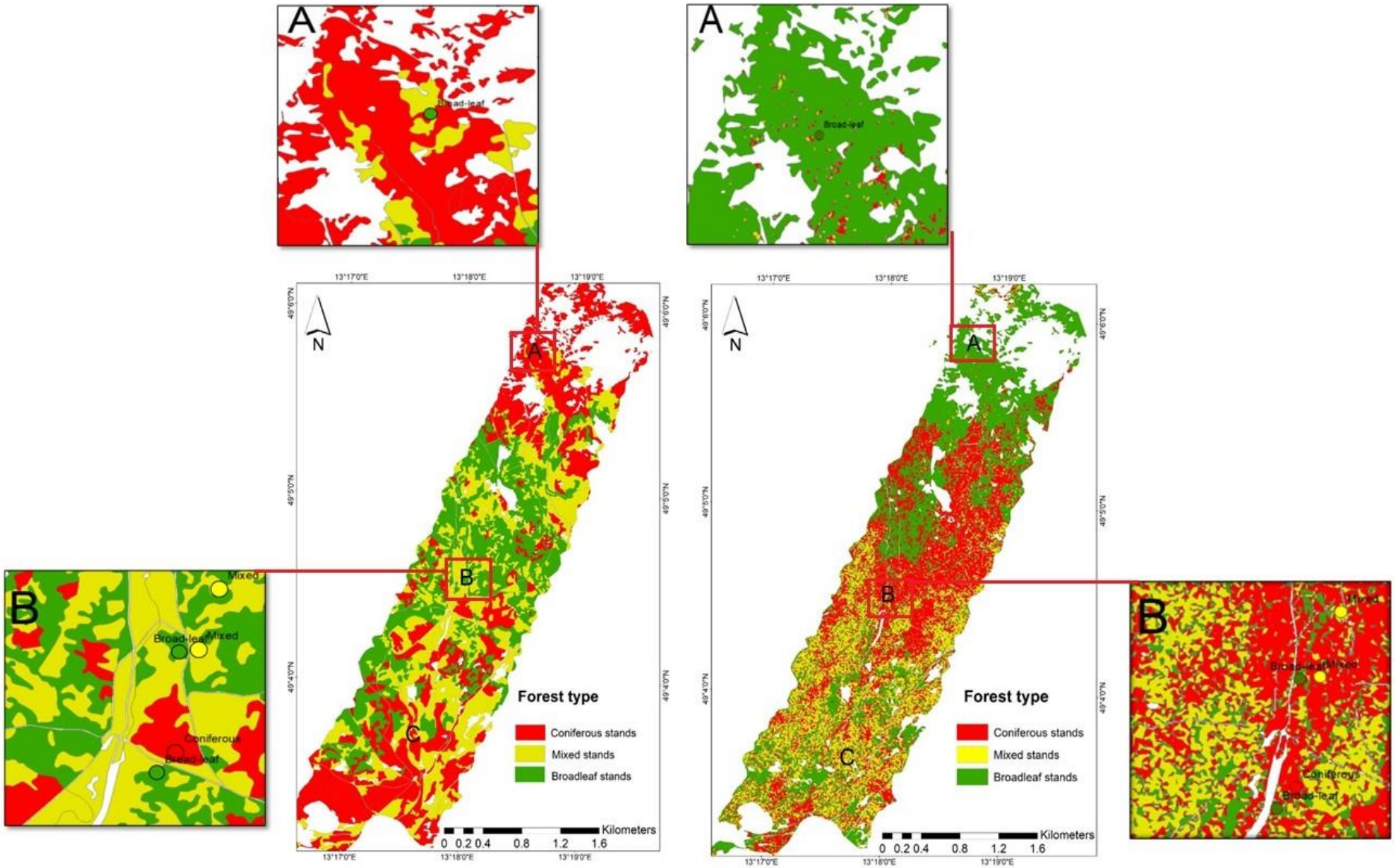
	Coniferous	Broadleaf	Mixed	Total	UA (%)
Coniferous	1230	575	607	2412	50.99
Broadleaf	1093	2469	1034	4596	53.72
Mixed	863	846	1272	2981	42.67
Total	3186	3890	2913	4971	-
PA (%)	39.22	63.47	43.67	-	-
OA (%)	-	-	-	-	50.02
Kappa	0.35				

COMPARISON OF TIR CLASSIFIED MAP AND REFERENCE MAP



- Field plot location and reference map used for comparison

Vegetation class	TIR classified map		Reference map	
	No. of plots	Proportion (%)	No. of plots	Proportion (%)
Coniferous stands	13/31	41	28/31	90
Broadleaf stands	22/36	61	30/36	83
Mixed stands	17/25	68	15/25	60
Total	**52/92**	**57**	**73/92**	**79**



Reference Map

TIR classified Map

LEVEL OF AGREEMENT BETWEEN THE MAPS

Cross tabulation analysis results in (km)

		Reference map			
		Coniferous	Broadleaf	Mixed	Total
TIR classified map	Coniferous	3.07	2.60	2.57	8.24
	Broadleaf	2.82	4.63	4.07	11.52
	Mixed	2.52	3.17	3.28	8.97
	Total	8.41	10.4	9.92	**28.73**

- The broadleaf vegetation class had the highest area of overlap between the two maps
- Coniferous vegetation class had the least area of overlap

CONCLUSION

- The preliminary vegetation land cover classification using airborne TIR from AISA Owl achieved low accuracy (50%)
- A slight positive effect was seen after feature selection was applied using the RF approach as a wrapper to select important wavebands.
- Pooled data for coniferous and mixed forest type affected accuracy.
- Airborne hyperspectral TIR classified map was less reliable than the reference map.

WHAT NEXT?

- To explore other classification and feature selection techniques.
- To explore the fusion of airborne TIR data with lidar.
- There is a need for spectral library at the canopy level for a forest ecosystem

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THANK YOU

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