Cartography M.Sc.

TECHNISCHE UNIVERSITÄT DRESDEN

Mapping the Vegetation of the Caucasian Ushba Region (Georgia, Russian Federation) as a contribution to an Alpine Club Map.

Michael Hallett

Overview

RESEARCH OBJECTIVES AND BACKGROUND

DATA ACQUISITION AND METHODOLOGY

RESULTS AND DISCUSSION

CONCLUSIONS

Overall Aim

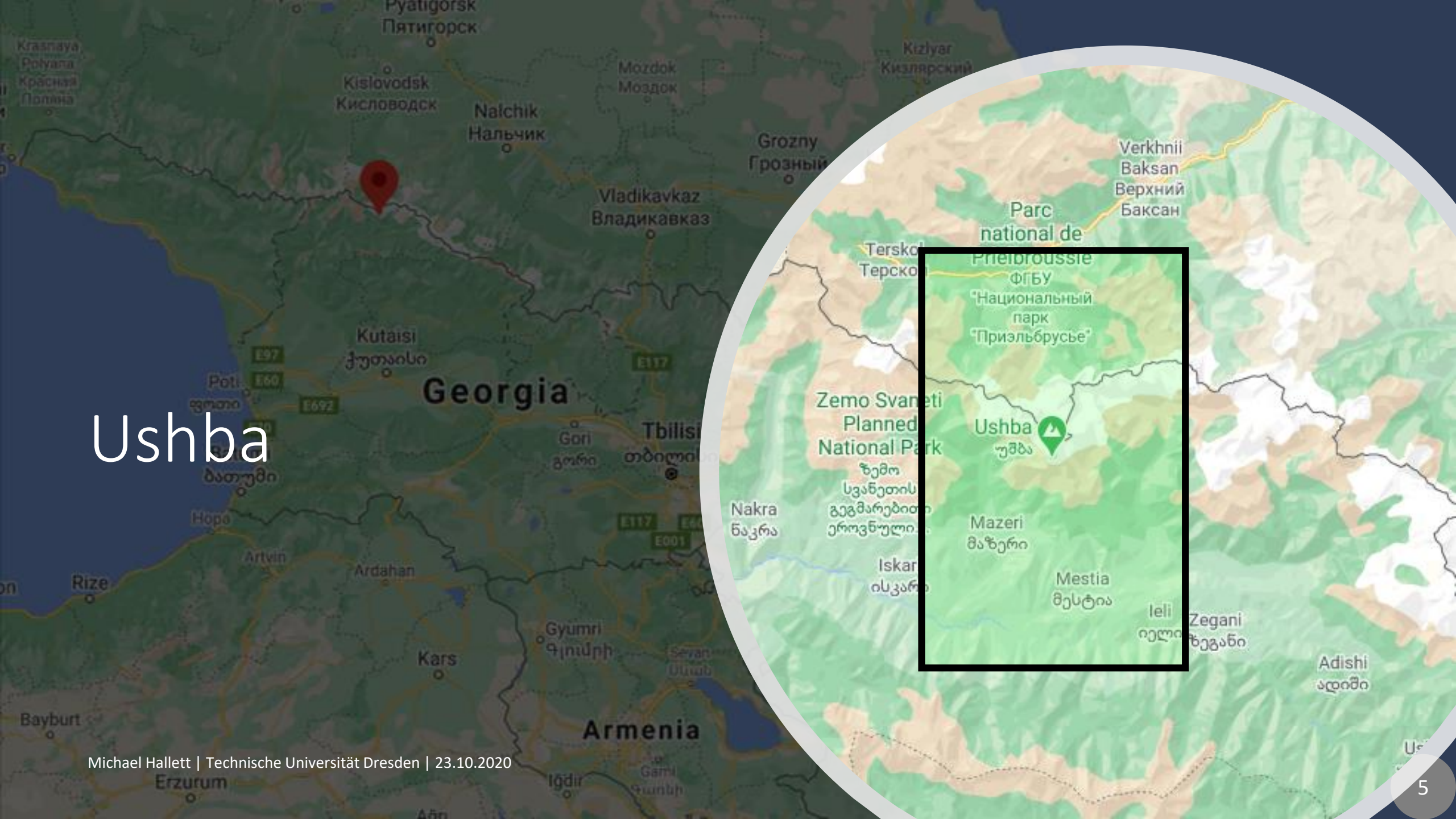
‘A symbolised layer of the actual vegetation cover shall be produced for a planned Alpine Club map of Ushba (Caucasus, Georgia/Russia). Information shall be extracted from existing maps, remotely sensed and field observations.’

- Remote sensed data sourced from: Landsat-8 and Sentinel-2 satellite missions.
- Aim to produce a vectorised vegetation layer that can be used on the suggested map sheet at a scale of 1:33,000.

Research Objectives

1. How is the vegetation of the Ushba region composed in terms of natural vegetation zones?
2. How are the different zones of vegetation related on the slopes of the Ushba mountain range?
3. How can these vegetation zones be classified using satellite data (Landsat-8, Sentinel-2)?
4. In what way can the vegetation zones be categorised/symbolised according to Alpine Club Map standards?
5. How is it possible to characterise the different transitions between vegetation zones (sudden boundary vs. gradual change etc.)?

Ushba


Pyatigorsk
Пятигорск
Kislovodsk
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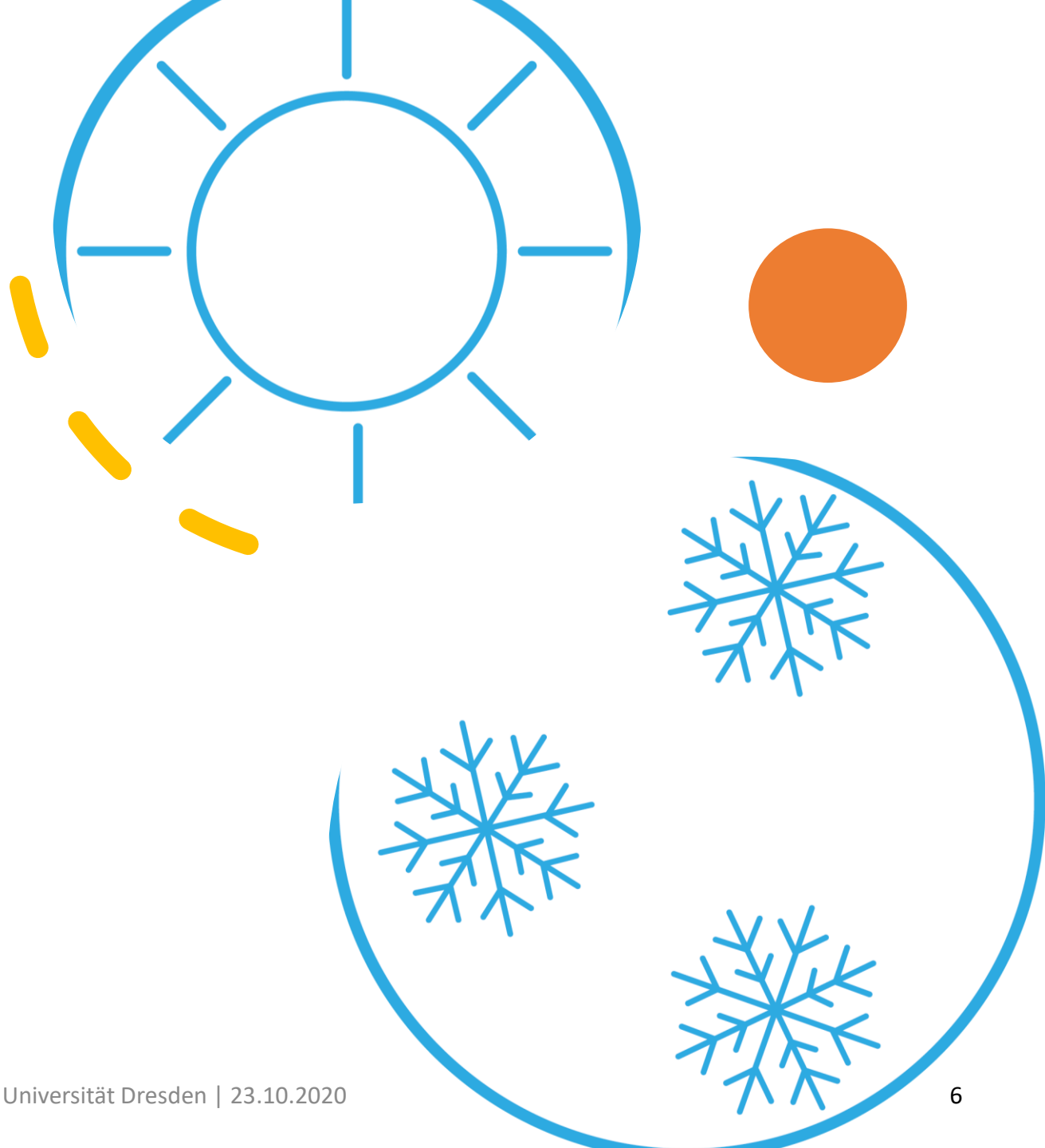
Nalchik
Нальчик
Mozdok
Моздок
Kizlyar
Кизлярский
Grozny
Грозный
Vladikavkaz
Владикавказ
Kutaisi
Georgia
Poti
Tbilisi
Gori
Batumi
Hopa
Artvin
Ardahan
Rize
Gyumri
Kars
Armenia
Bayburt
Erzurum
Igdir
Verkhnii
Baksan
Верхний
Баксан
Parc
national de
Prielbroussie
ФГБУ
"Национальный
парк
"Приэльбрусье"
Zemo Svaneti
Planned
National Park
Ushba
Nakra
Mazeri
Mestia
Ieli
Zegani
Adishi

Ushba

Climate:

- Relatively warm and humid
- 2200mm of rainfall per year [1]
- Warm influx from the black sea
- Protection from cold, winter air intrusions



Ushba

Vegetation Zones:

1) Mixed high forest stands
2) Krummholz
3) Alpine meadow

Alpine Club Maps

- Map series by the German and Austrian Alpine Club (Deutscher Alpenverein and Österreichischer Alpenverein).
- Characteristic large scale of mountain areas.
- Target audience of mountain hikers and climbers.

Vegetation Classification with Remote Sensing

Winter and summer scenes

Hyperspectral sensors

Machine Learning Algorithms (MLAs)

Supervised classification (ML)

Checking the accuracy of the classification

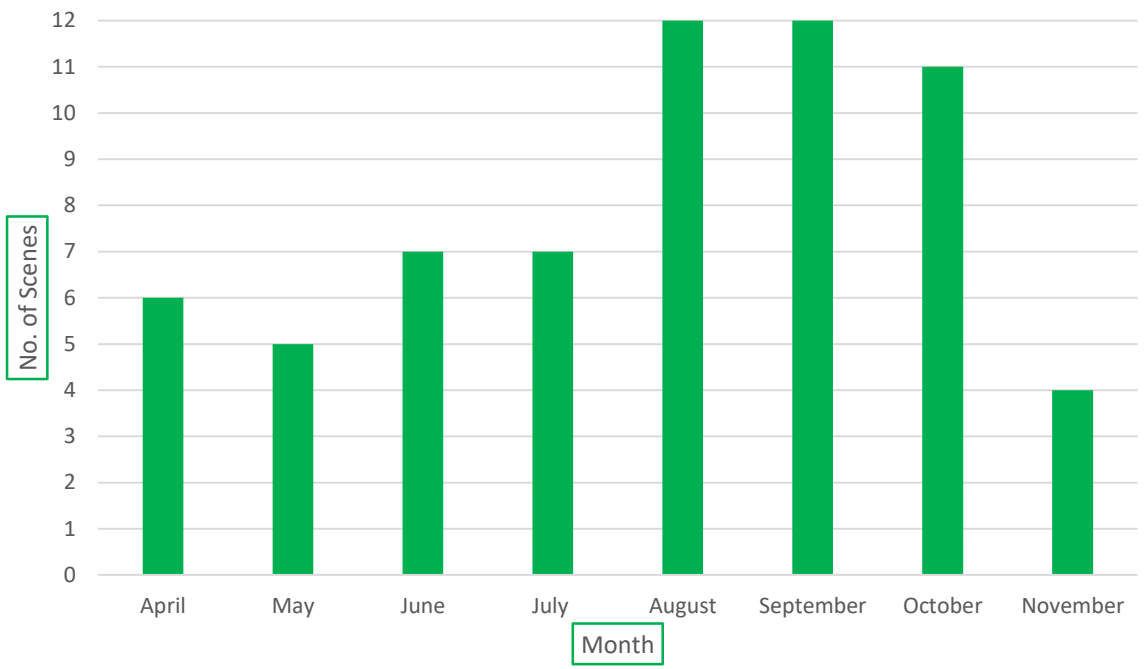
$$\kappa = \frac{p_o - p_e}{1 - p_e} = 1 - \frac{1 - p_o}{1 - p_e},$$

Data Acquisition

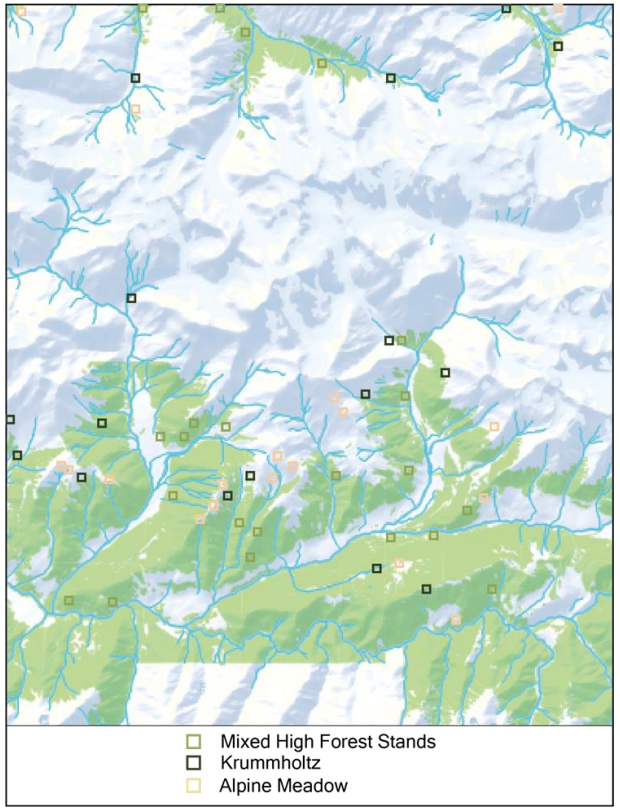
Satellite Image Scenes:

- Sentinel-2
- Landsat-8

- 64 cropped scenes in total



Satellite	No. of Bands	Spatial Resolution (metres)	Orbit Type	Temporal Resolution (days)	Product Type
Sentinel-2A	13	10 / 20 / 60	Polar	10	Level 1C and Level 2A
Landsat-8	11	30 / 15	Near-Polar	16	Level 1 - Terrain precision Correction



Reference Data

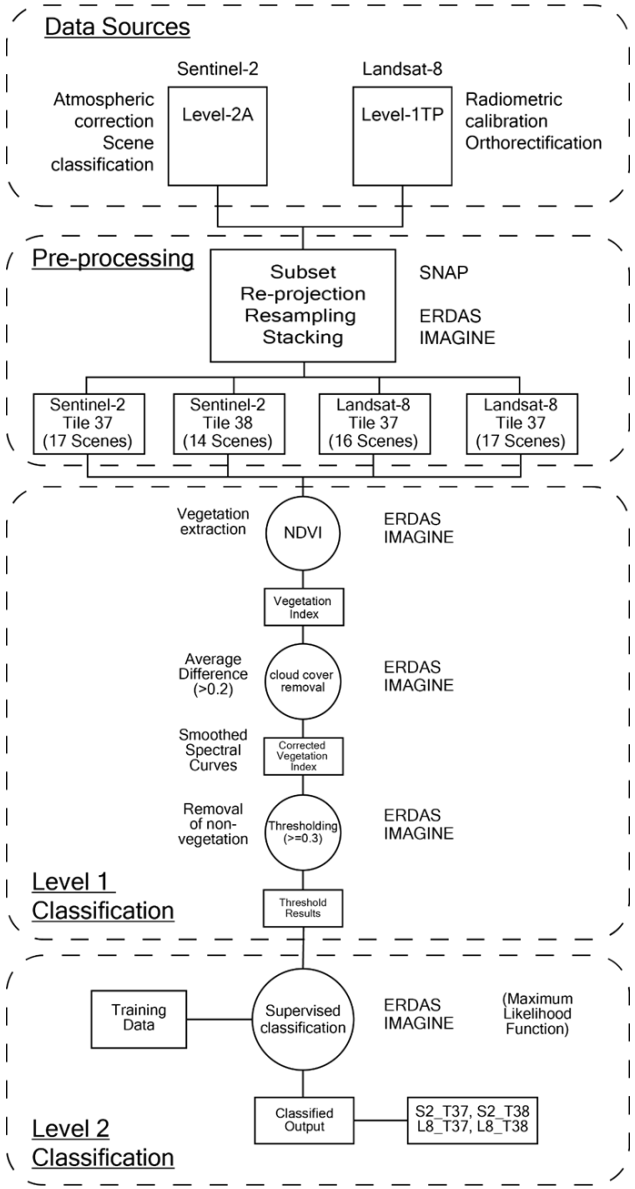
- No field trip
- No measurements from the field

- Georeferenced images
- High resolution satellite images

Method

Hierarchical classification

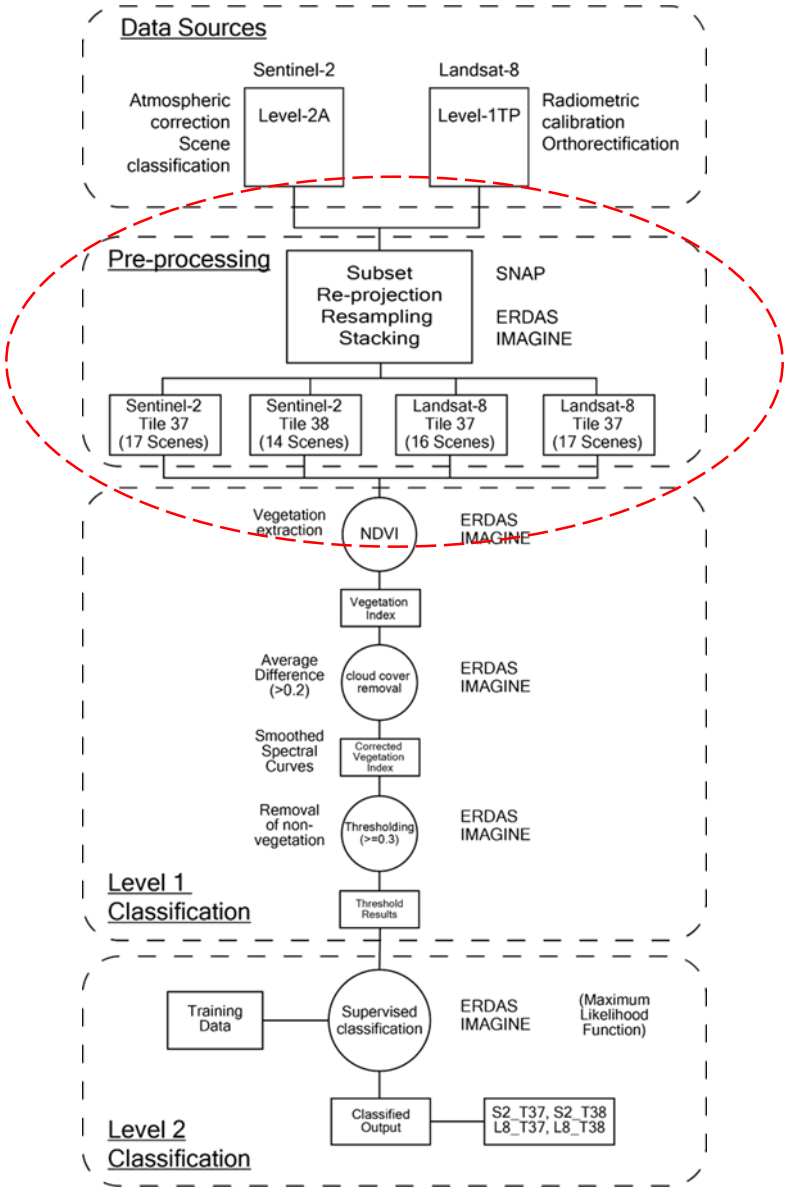
2 Levels of classification



Method

Pre-processing:

- Band stacks
- Subset
- Reprojection

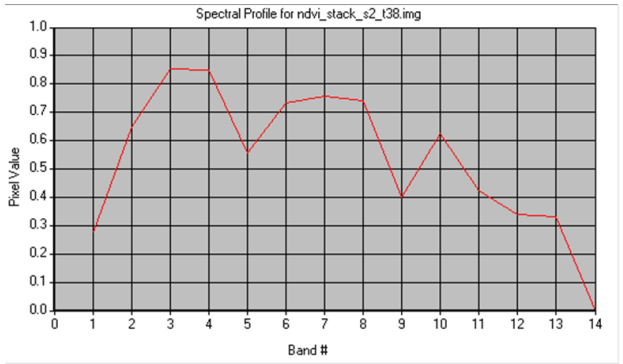


Method - Level 1 Classification

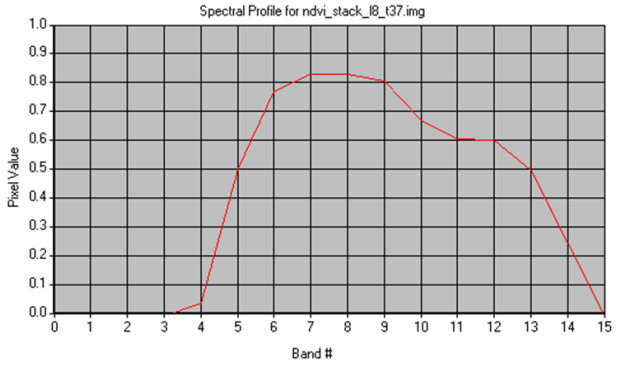
NDVI extraction

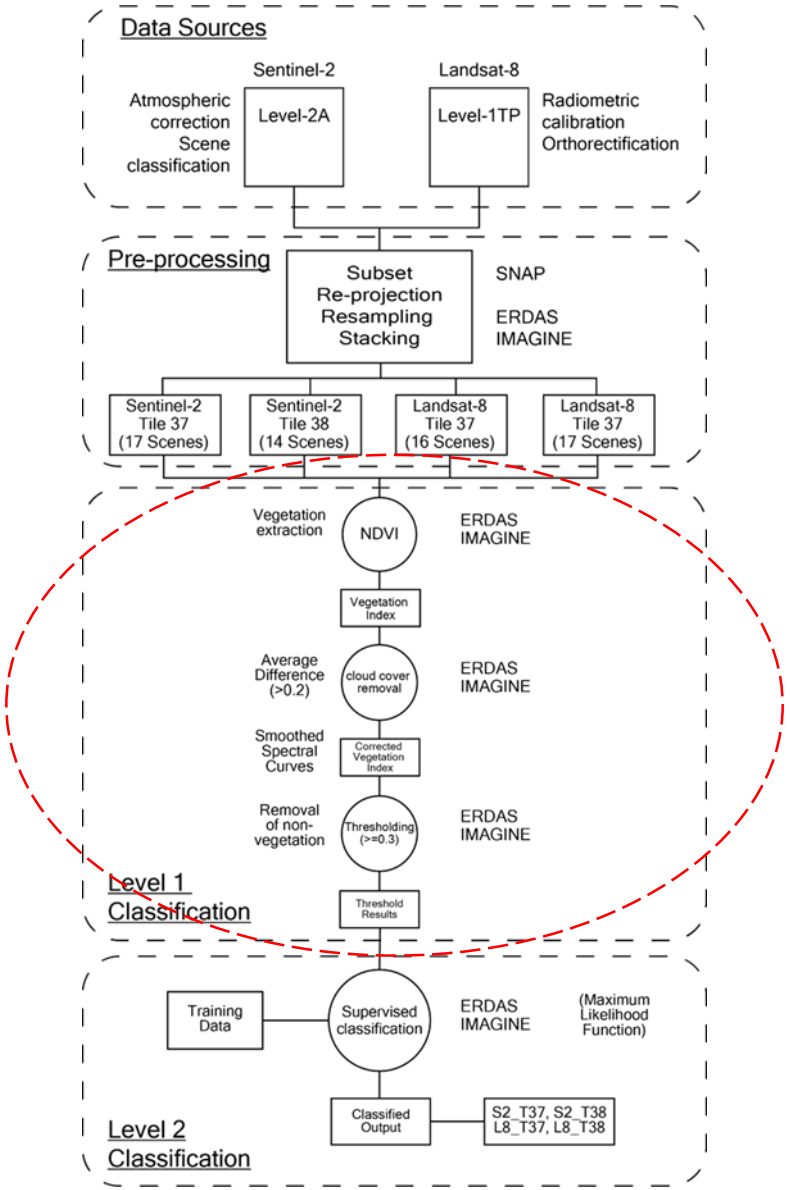
$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Cloud cover removal



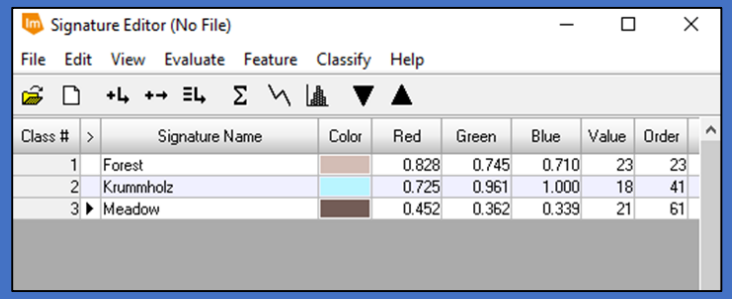
Thresholding





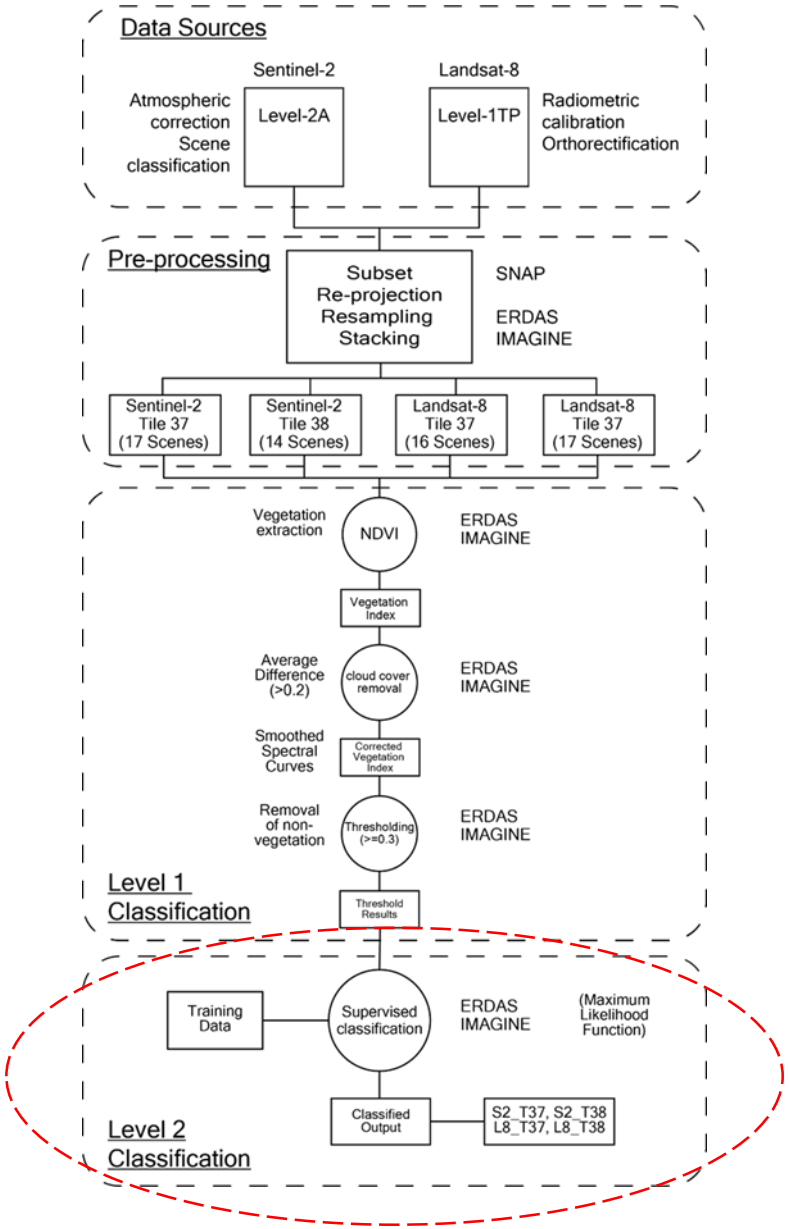
Method – Level 2 Classification

- Extraction of vegetation classes
- Supervised Classification



Class #	Signature Name	Color	Red	Green	Blue	Value	Order
1	Forest		0.828	0.745	0.710	23	23
2	Krummholz		0.725	0.961	1.000	18	41
3	Meadow		0.452	0.362	0.339	21	61

- Maximum Likelihood



Method – Post-processing

- Recoding
- Union

— ERDAS IMAGINE

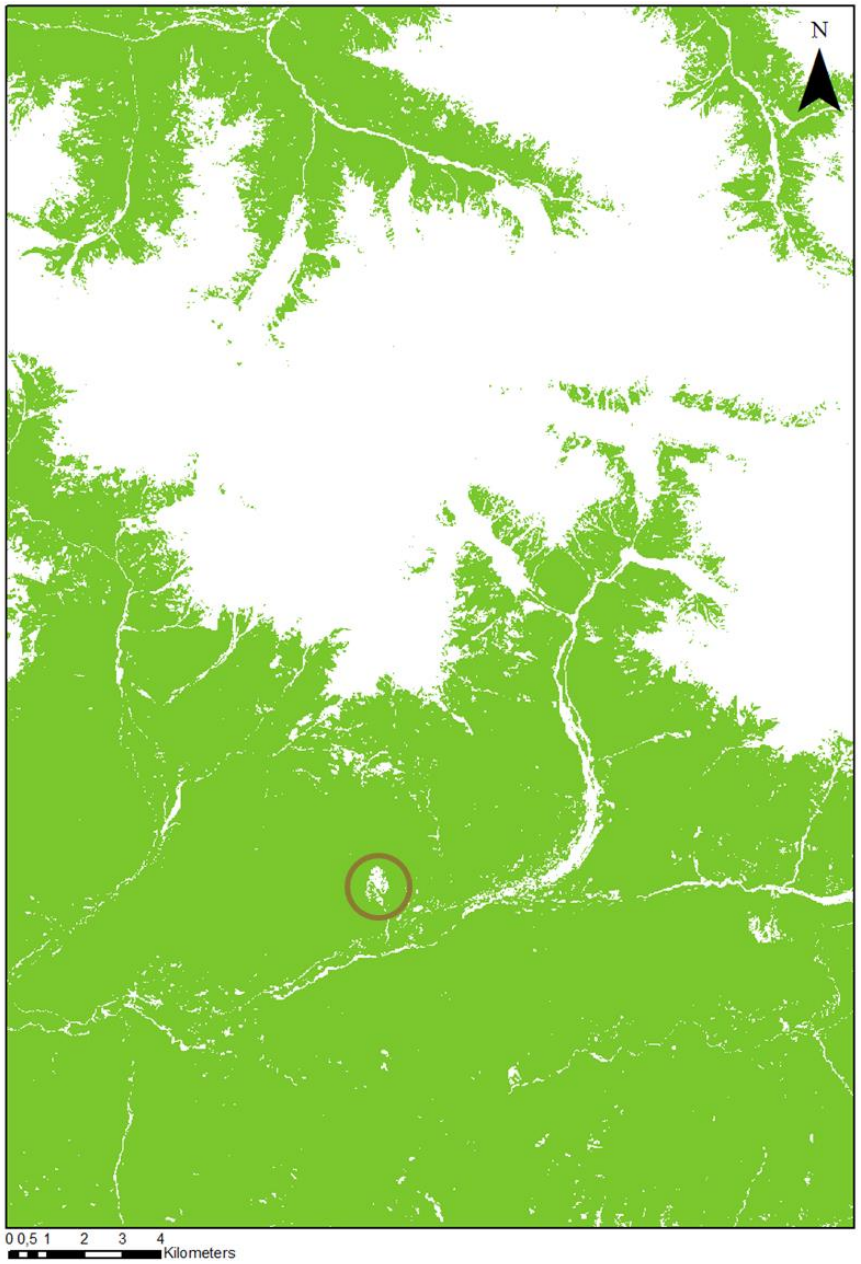
- Vectorisation — ArcMap

IMAGE	FEATURE NAME	DESCRIPTION
SENTINEL-2A (31 DATA SETS)	NDVI_STACK_S2_T37 (16 SCENES)	COMBINED CHRONOLOGICALLY ORDERED NDVI SCENES FOR TILE 37 OF THE SENTINEL-2A SENSOR
	NDVI_STACK_S2_T38 (14 SCENES)	COMBINED CHRONOLOGICALLY ORDERED NDVI SCENES FOR TILE 38 OF THE SENTINEL-2A SENSOR
	S37_T	CLASSIFICATION PRODUCT OF THE TILE 37 SCENES FOR THE SENTINEL-2A SENSOR
	S38_2	CLASSIFICATION PRODUCT OF THE TILE 38 SCENES FOR THE SENTINEL-2A SENSOR (FOREST AND MEADOW)
	S38_3	CLASSIFICATION PRODUCT OF THE TILE 37 SCENES FOR THE SENTINEL-2A SENSOR (KRUMMHOLZ AND MEADOW)
	S38_2C3	COMBINED CLASSIFICATIONS OF S38_2 AND S38_3 TO ARRIVE AT CLASSIFICATION WITH 3 CLASSES: FOREST, KRUMMHOLTZ AND MEADOW
LANDSAT-8 (33 DATA SETS)	NDVI_STACK_L8_T37 (15 SCENES)	COMBINED CHRONOLOGICALLY ORDERED NDVI SCENES FOR TILE 37 OF THE LANDSAT-8 SENSOR
	NDVI_STACK_L8_T38 (17 SCENES)	COMBINED CHRONOLOGICALLY ORDERED NDVI SCENES FOR TILE 38 OF THE LANDSAT-8 SENSOR
	L37_T	CLASSIFICATION PRODUCT OF THE TILE 37 SCENES FOR THE LANDSAT-8 SENSOR
	L38_T	CLASSIFICATION PRODUCT OF THE TILE 38 SCENES FOR THE LANDSAT-8 SENSOR

Results & Discussion

Vegetation Zone

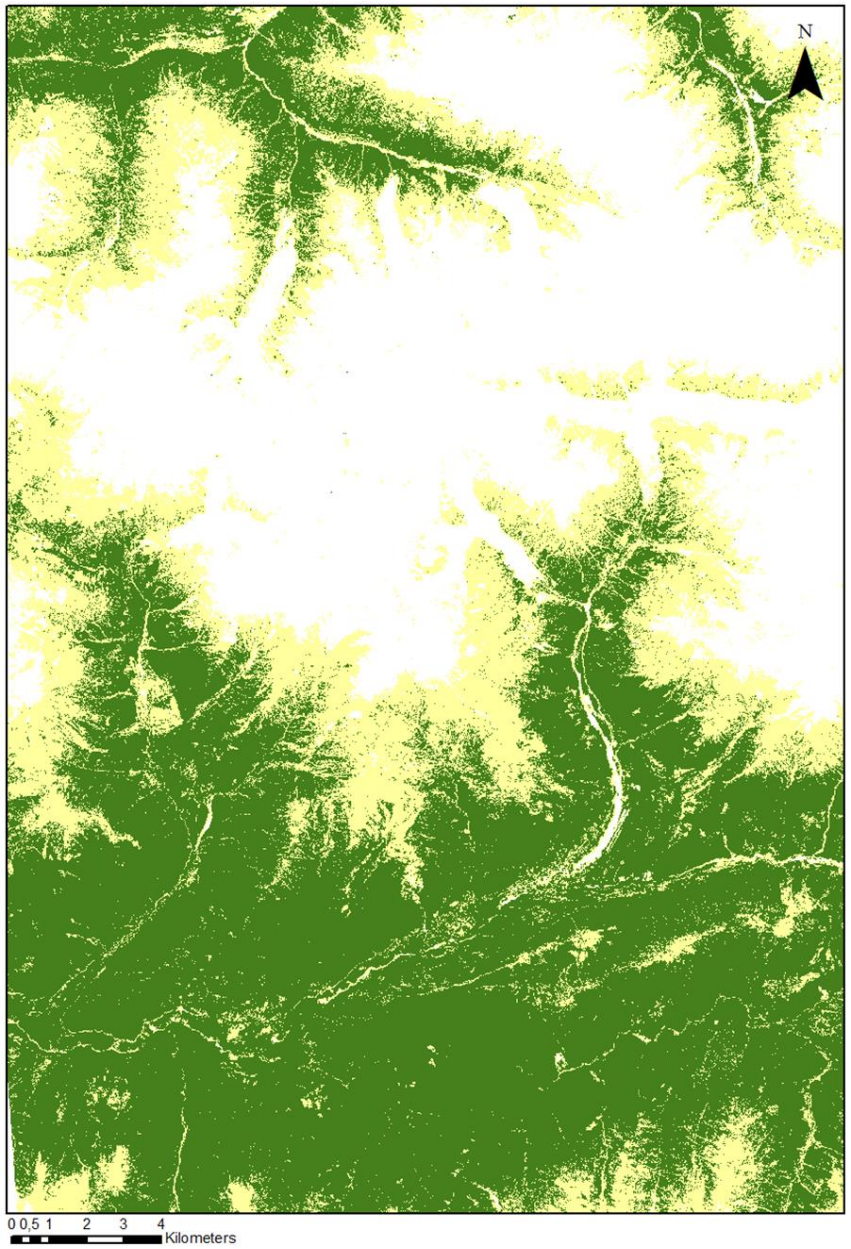
- Full cover within the valleys
- Non-vegetated areas along rivers and in towns



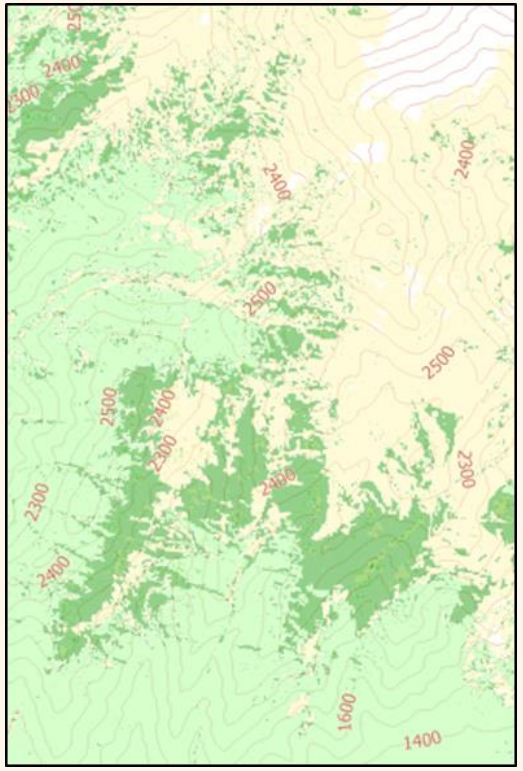
Results & Discussion

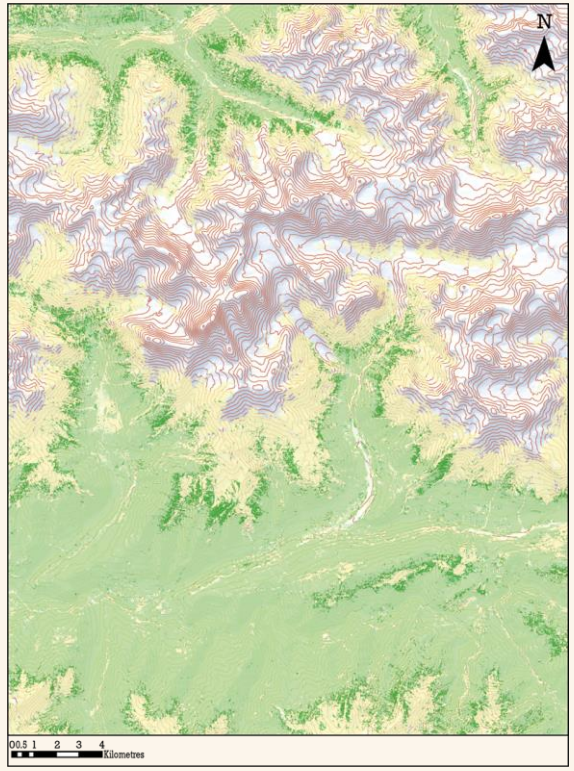
Forest and Meadow

- Areas of pasture / farming within the valleys
- Other cleared areas due to human management
- Clear tree line on hill tops



Results & Discussion





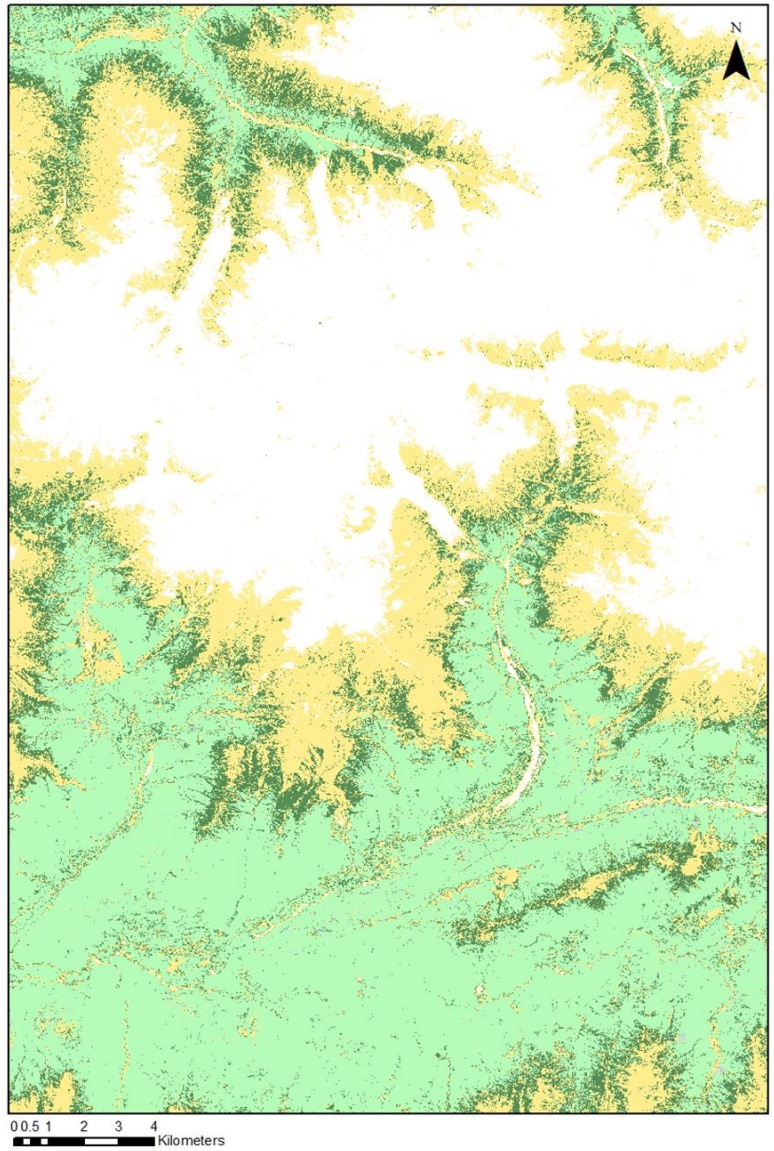
Checking agreement between vegetation boundaries on the map and known vegetation boundaries (from past research).

Results & Discussion

Final Classified Product

- Clear distinction between classes
- Representation based on existing Alpine Club maps and natural colouring
- Neutral colour scheme

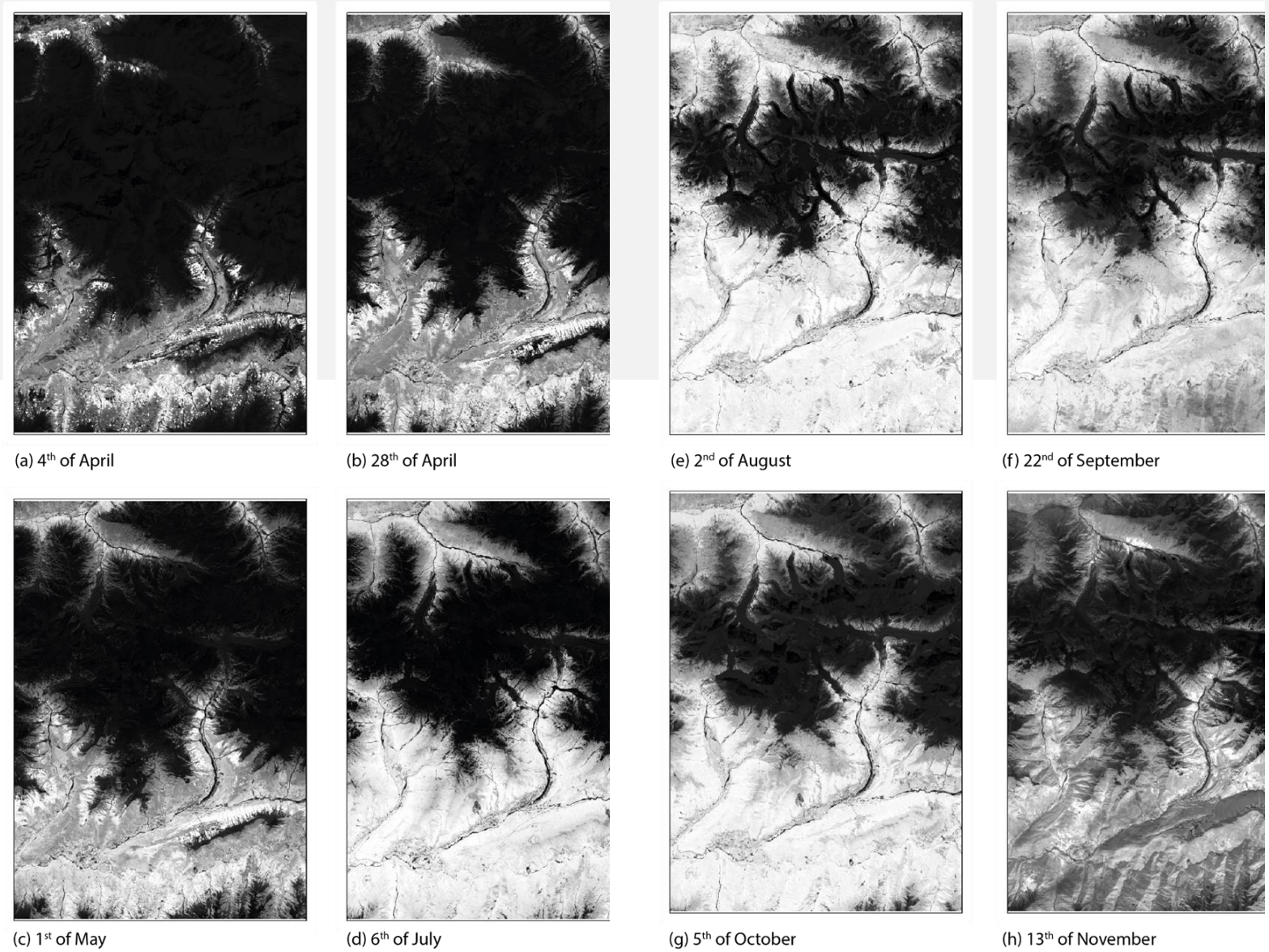
- Successful result



Results & Discussion

NDVI Annual Time Series

- Deciduous tree species and meadow plants start growing between May and July.
- Peak NDVI values in August.
- Still high NDVI values in early October.



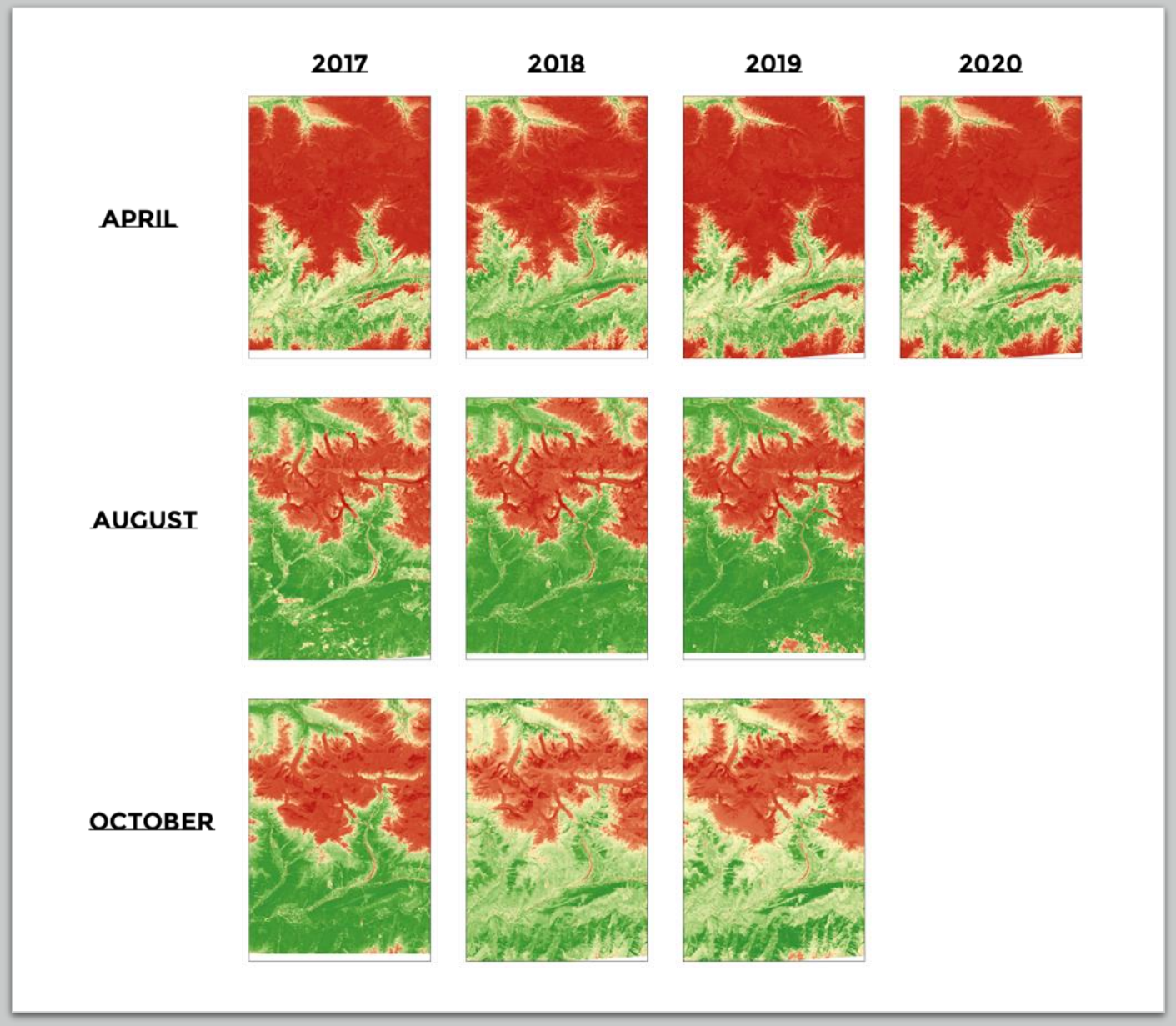
(a) 4th of April (b) 28th of April (e) 2nd of August (f) 22nd of September

(c) 1st of May (d) 6th of July (g) 5th of October (h) 13th of November

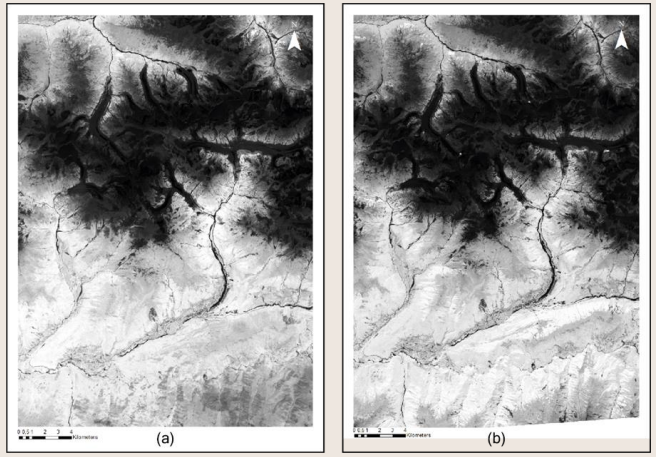
Results & Discussion

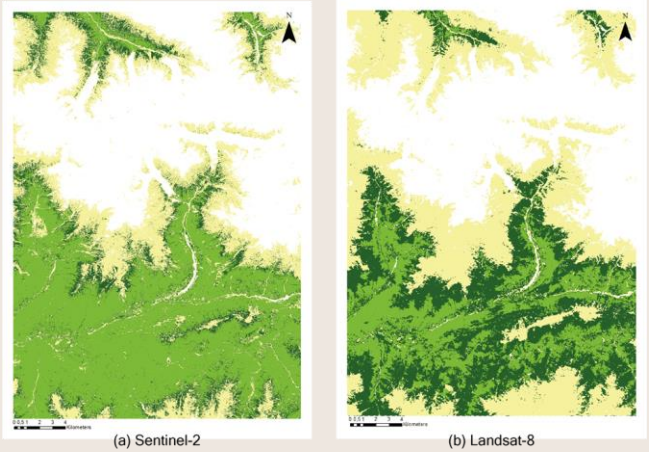
Yearly Comparisons

- Generally very similar NDVI for each year.
- Higher NDVI for April 2018.
- Lower NDVI for August 2017.
- Higher NDVI for October 2017.
- Supported by weather and temperature records.



Results & Discussion





Satellite Comparisons

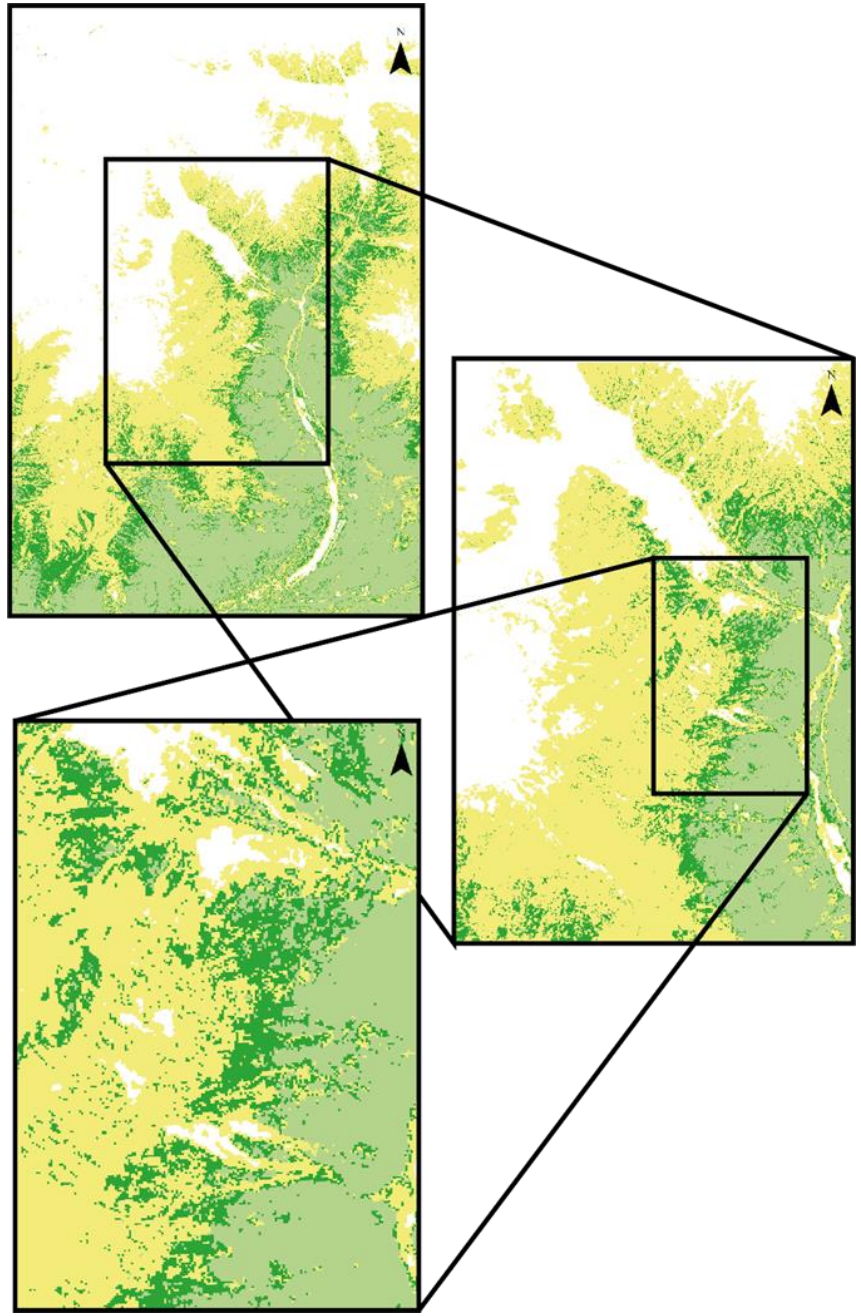
- Virtually identical NDVI classification results.
- Different classification results:
  - Timing of image scenes.
  - Differences in spatial resolution.

Results & Discussion

Vegetation Boundaries

- Solid boundaries
- Direct change from one class to another
- No gradation

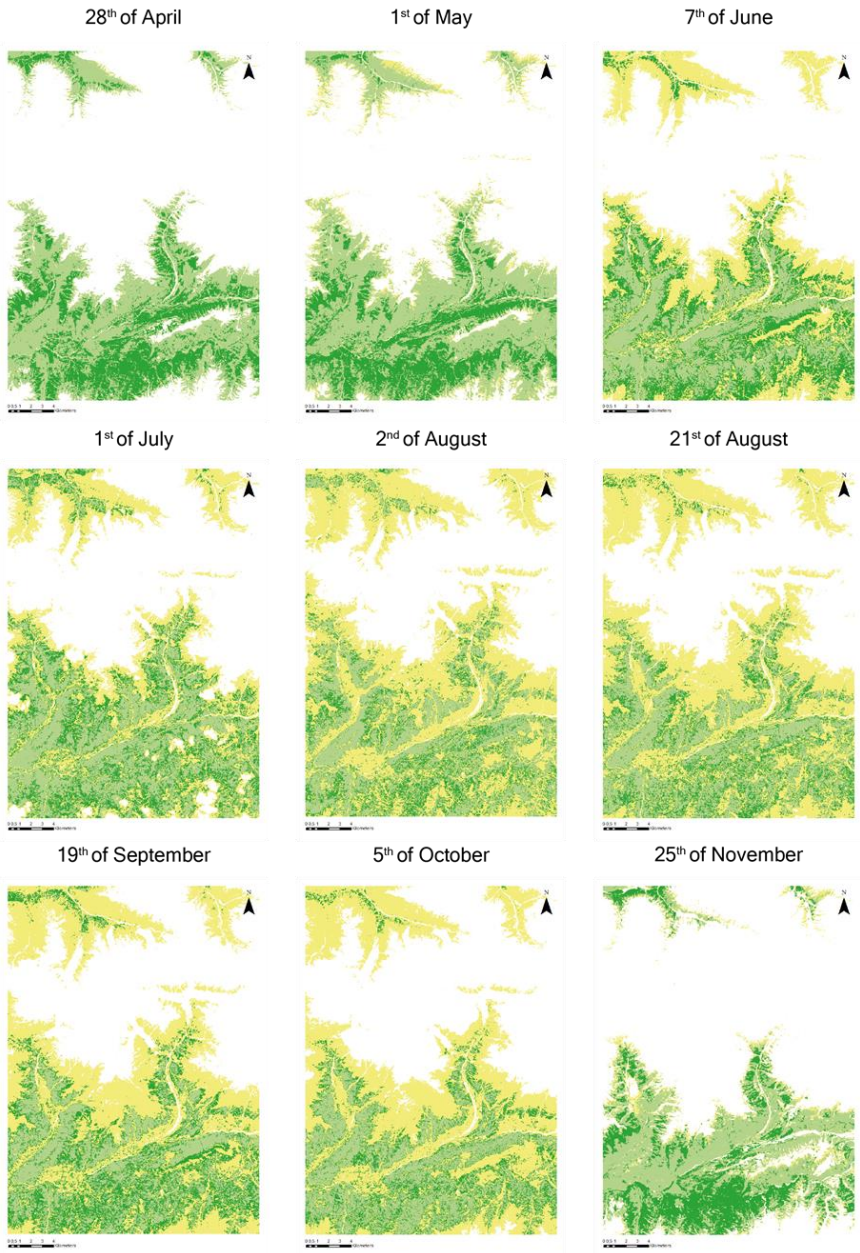
- Matched Alpine Club map style
- Considered more useful for map users



Results & Discussion

Timeline of Overall Classification

- Different vegetation classes dominate the visual spectrum at different points throughout the year:
  - Krummholz and Coniferous tree species early in the growing season.
  - Alpine Meadow dominates at the height of the growing period.
  - Krummholz and Coniferous forest again dominate towards the end of the growing season.
- Due to differences in the strength of the spectral signatures for each vegetation class.

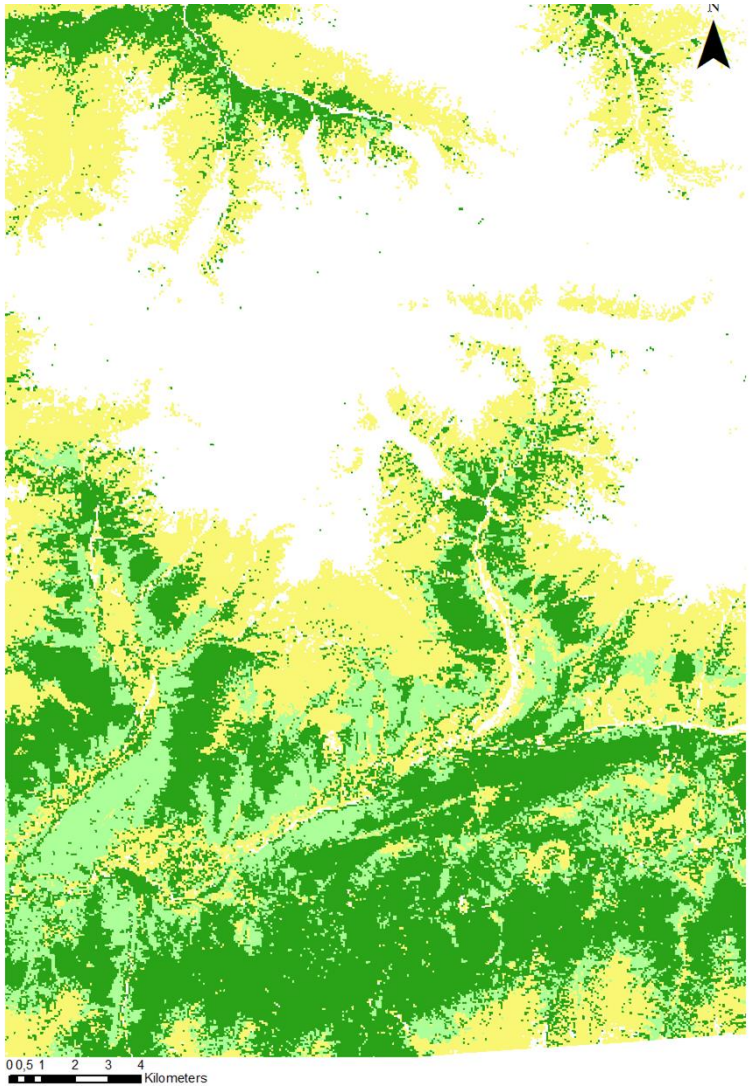


Results and Discussion

Forest-type classification

— Classification of deciduous and coniferous tree species.

- Coniferous species dominate overall.
- Deciduous species only exist within sheltered valley regions.



Results & Discussion

Accuracy Assessment – Confusion Matrix

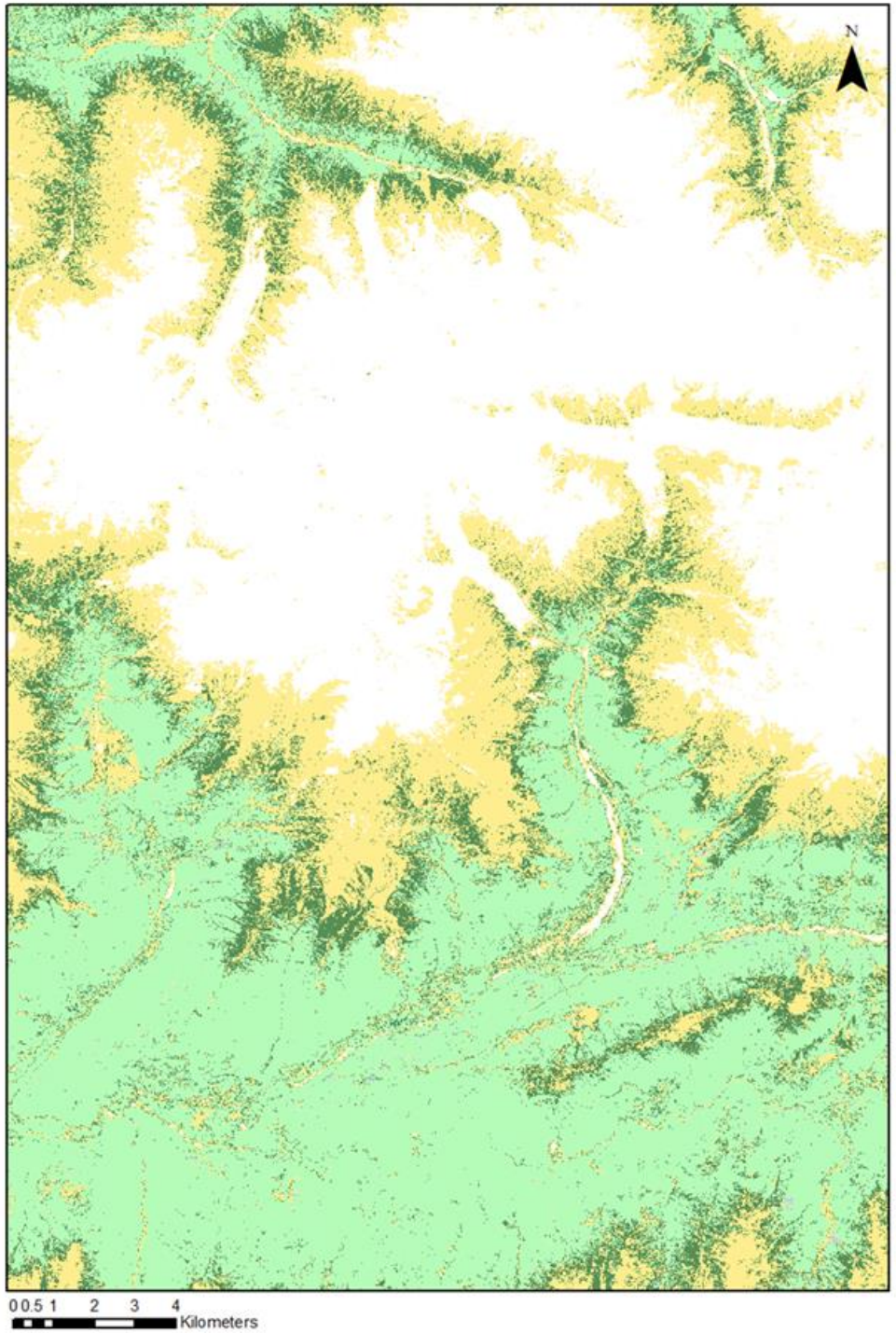
$$K = \frac{n \cdot \sum n_{ii} - \sum n_{i+} \cdot n_{+i}}{n^2 - \sum n_{i+} \cdot n_{+i}}$$

$$K = \frac{56 \cdot 48 - 1060}{56^2 - 1060}$$

	Mixed High Forest Stand	Krummholtz	Alpine Meadow	
Mixed High Forest Stand	20	1	1	22
Krummholtz	1	14	3	18
Alpine Meadow	1	1	14	16
	22	16	18	48

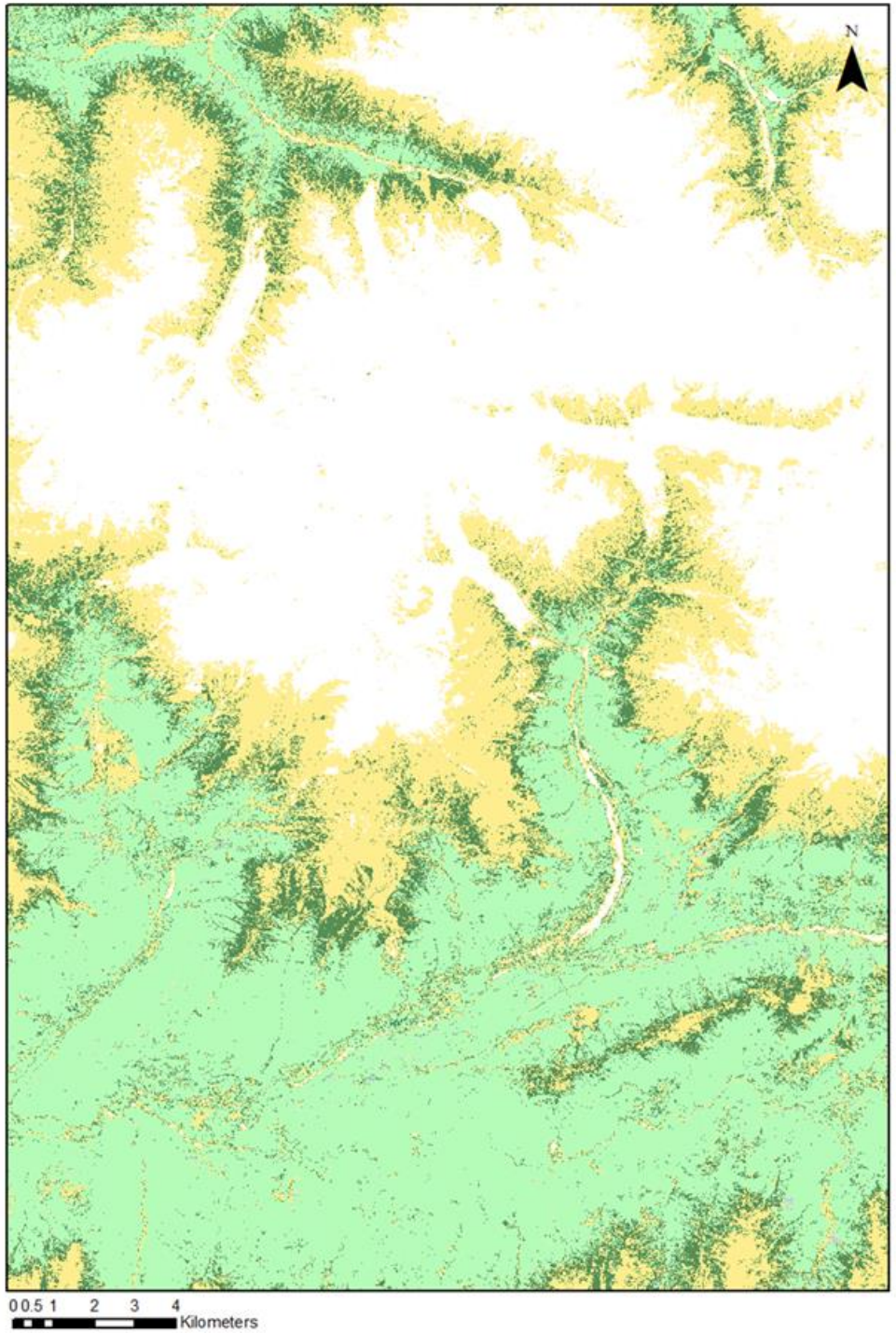
- Overall accuracy of 86%
- Kappa coefficient of 0.78

- Lowest User Accuracy for the Krummholz Class (78%).
- Highest error of omission for the Alpine Meadow Class (22%).



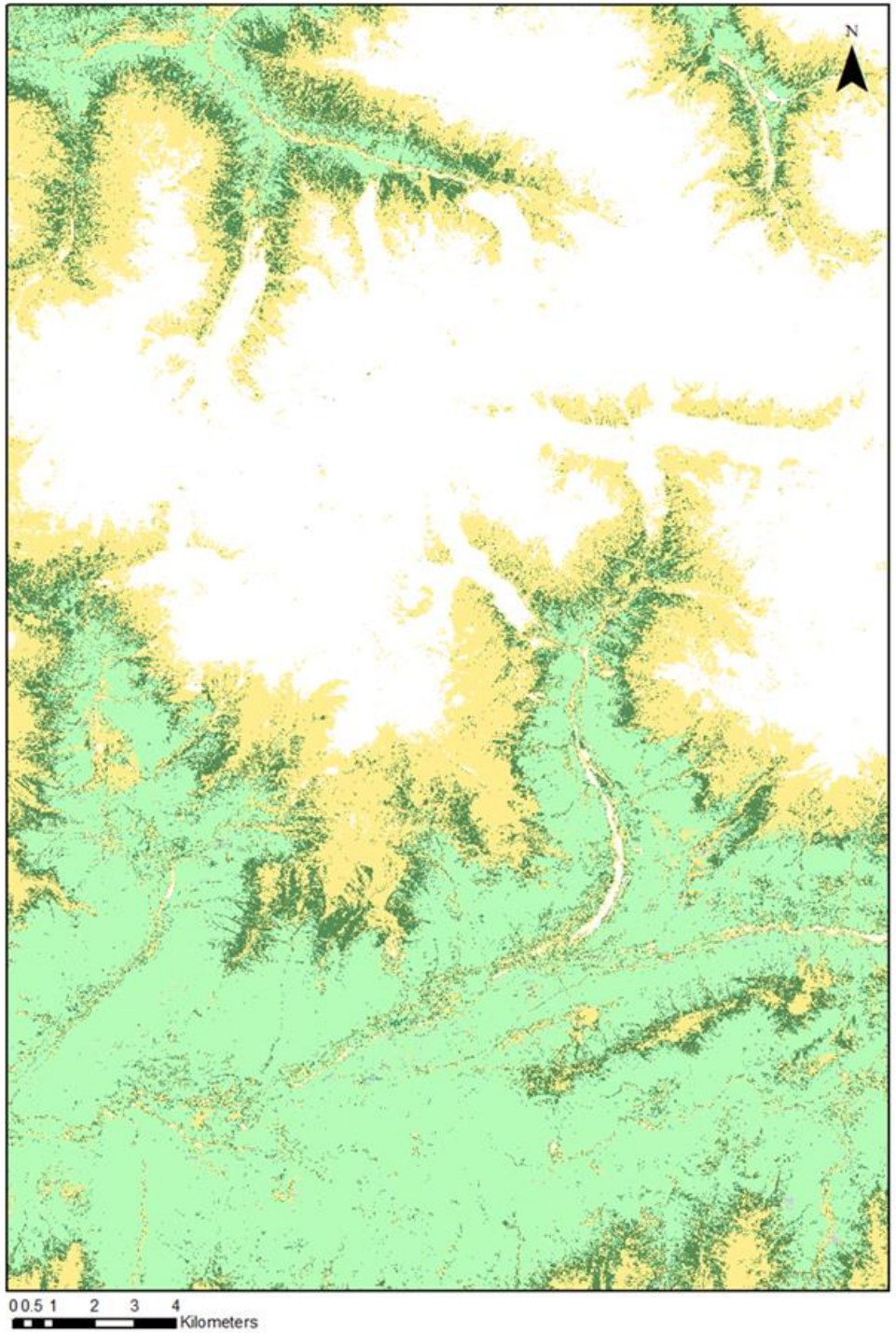
Conclusions

- Successfully created a classification output that matches the criteria for an Alpine Club map and can be used at the suggested map sheet scale of 1:33,000.
- Proves ability to use online reference data to make up for lack of ground truth data that would have been collected in the field.
- Accuracy assessment of the training areas proved high overall accuracy (86%).
- Clear representation of vegetation classes with colour scheme chosen to match with other Alpine Club maps and distinguish between vegetation zones.
- Distinctive borders chosen to clearly visualise class boundaries.



Conclusions

- Quality and validity of classification should be questioned due to a lack of field data.
- Classification of limited detail due to type and age of software used – ERDAS IMAGINE 2016.
- A valid quality assessment should be completed with actual field data in order to correctly analyse to accuracy of the classification result.



Conclusions – Future Research

- Next Ushba field trip planned for **July 2021**.
- Possibility of looking at using more developed classification software to distinguish between a greater number of vegetation classes.
- Look at using a greater number of satellite images including more from the winter period to increase reliability of classification result.

Acknowledgements to Nick and the rest of the Ushba team for assistance in the completion of this thesis.

Good luck with next year's field trip!