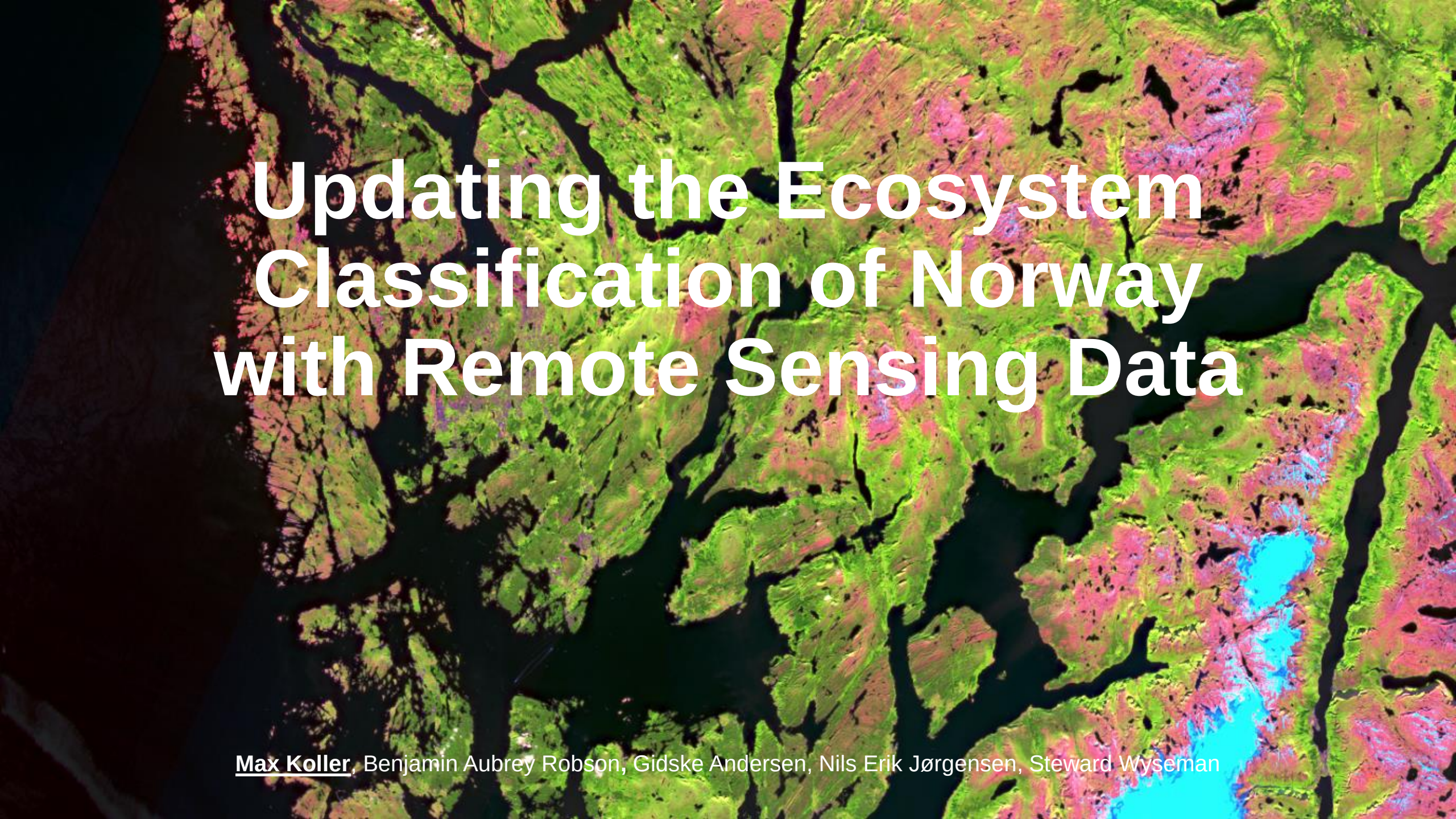
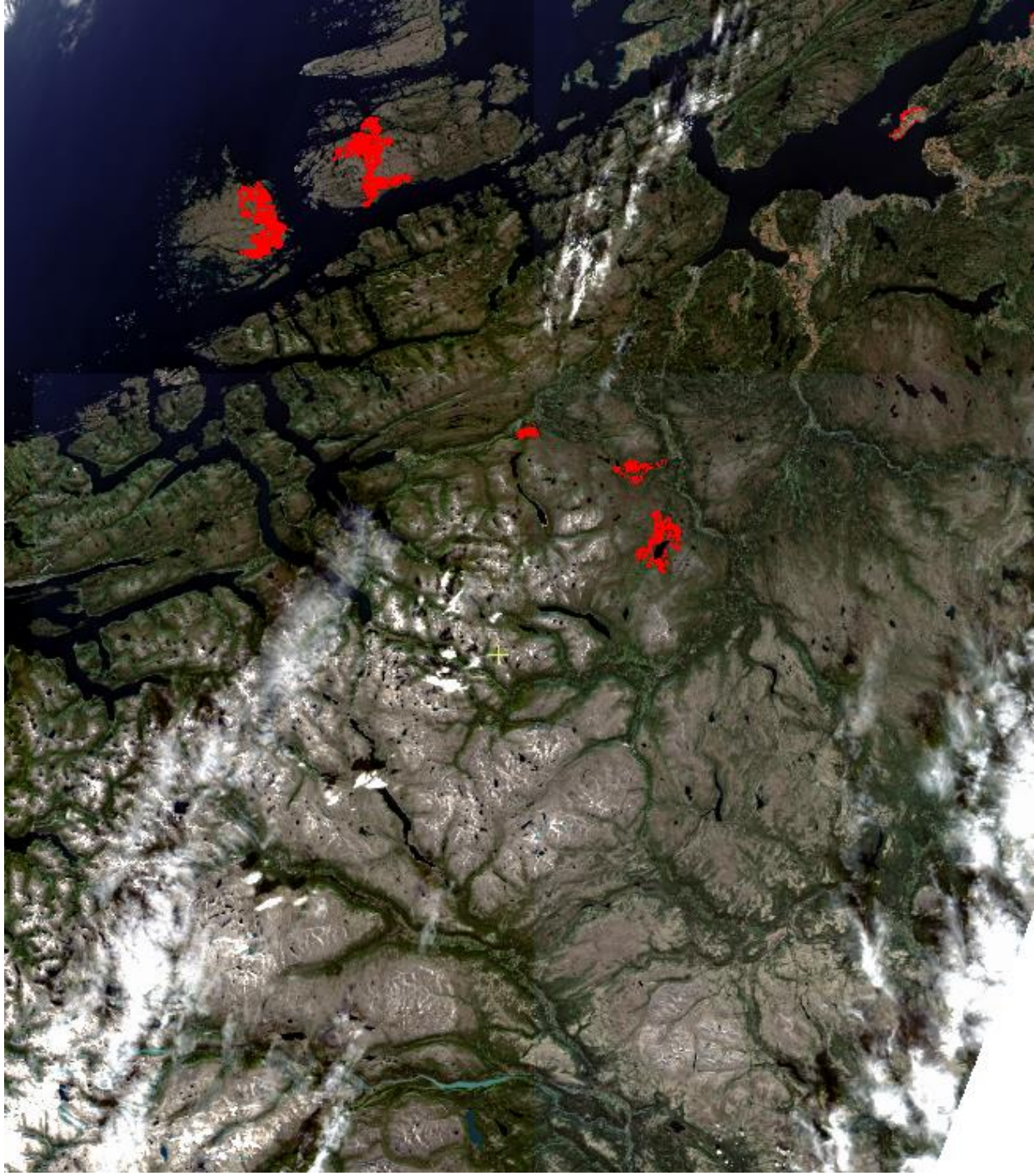


Updating the Ecosystem Classification of Norway with Remote Sensing Data

Max Koller, Benjamin Aubrey Robson, Gidske Andersen, Nils Erik Jørgensen, Steward Wyseman

Background

- Current “Natur i Norge” database very sporadic, inconsistent, and subjective
- System is not especially quantitative
- Huge potential to be updated with remote sensing and classified into the main eco-systems:
  - Vegetation
    - Meadows
    - Forest
      - Deciduous
      - Coniferous
  - Bogs
  - Bare rock
  - Open areas
  - Snow/Ice
  - Water
  - Urban
  - Semi-natural areas



Aims and challenges

- Develop an **automated** system to distinguish the main eco-systems from satellite imagery
- Routines for mass downloading and preparation of data for large areas
- Ability to repeat the analysis on-demand and assess changes
- **Challenges**:
  - Large amounts of data not always organised in a logical way.
  - Clouds, shadows
  - Some of the classes are difficult to distinguish solely with spectral information

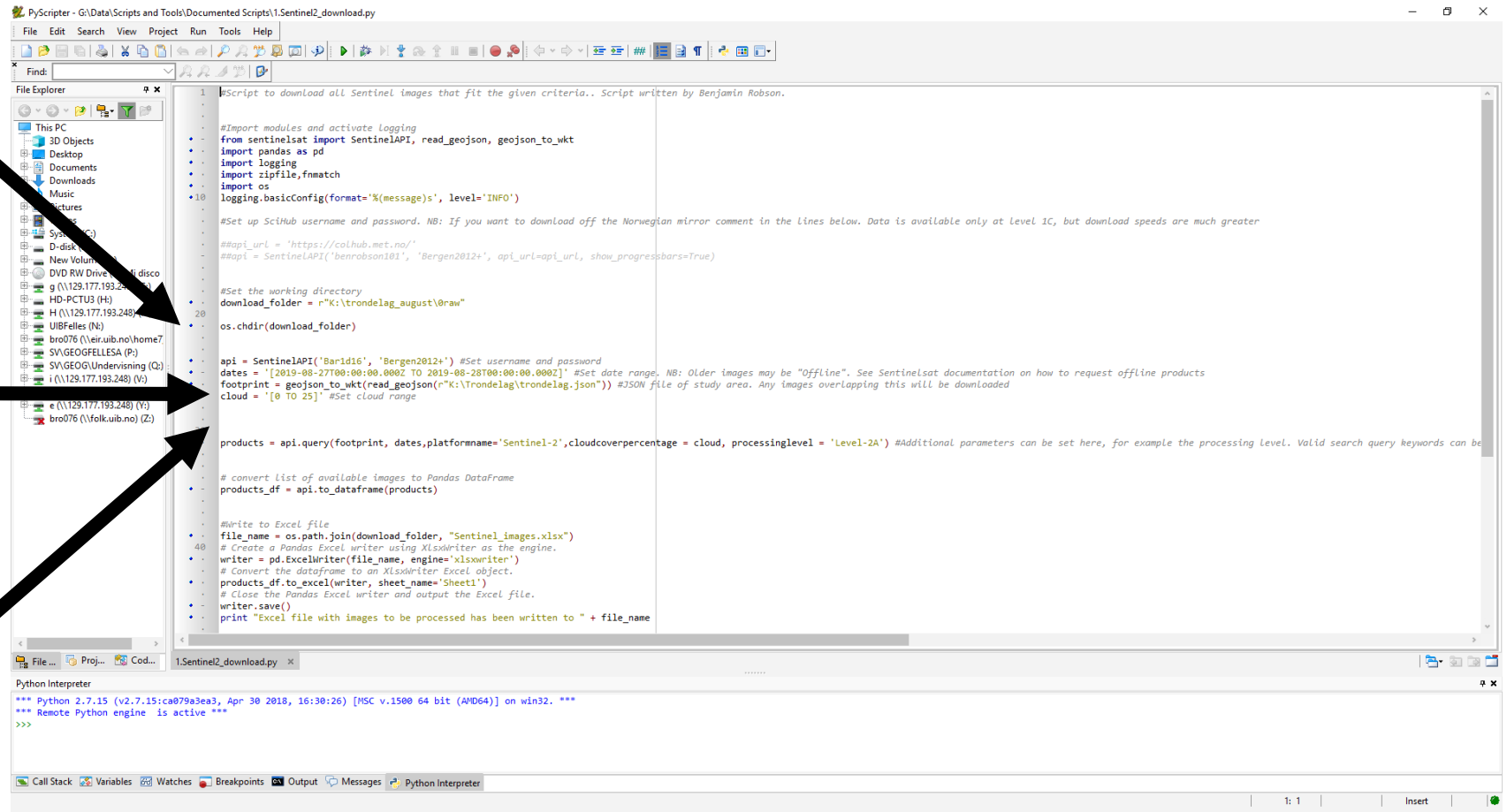
Step 1: Download lots and lots of satellite imagery

- Tiling of Sentinel 2 products…
- …and maximum two simultaneous downloads allowed
- Therefore use **Python** to download and catalogue necessary satellite imagery

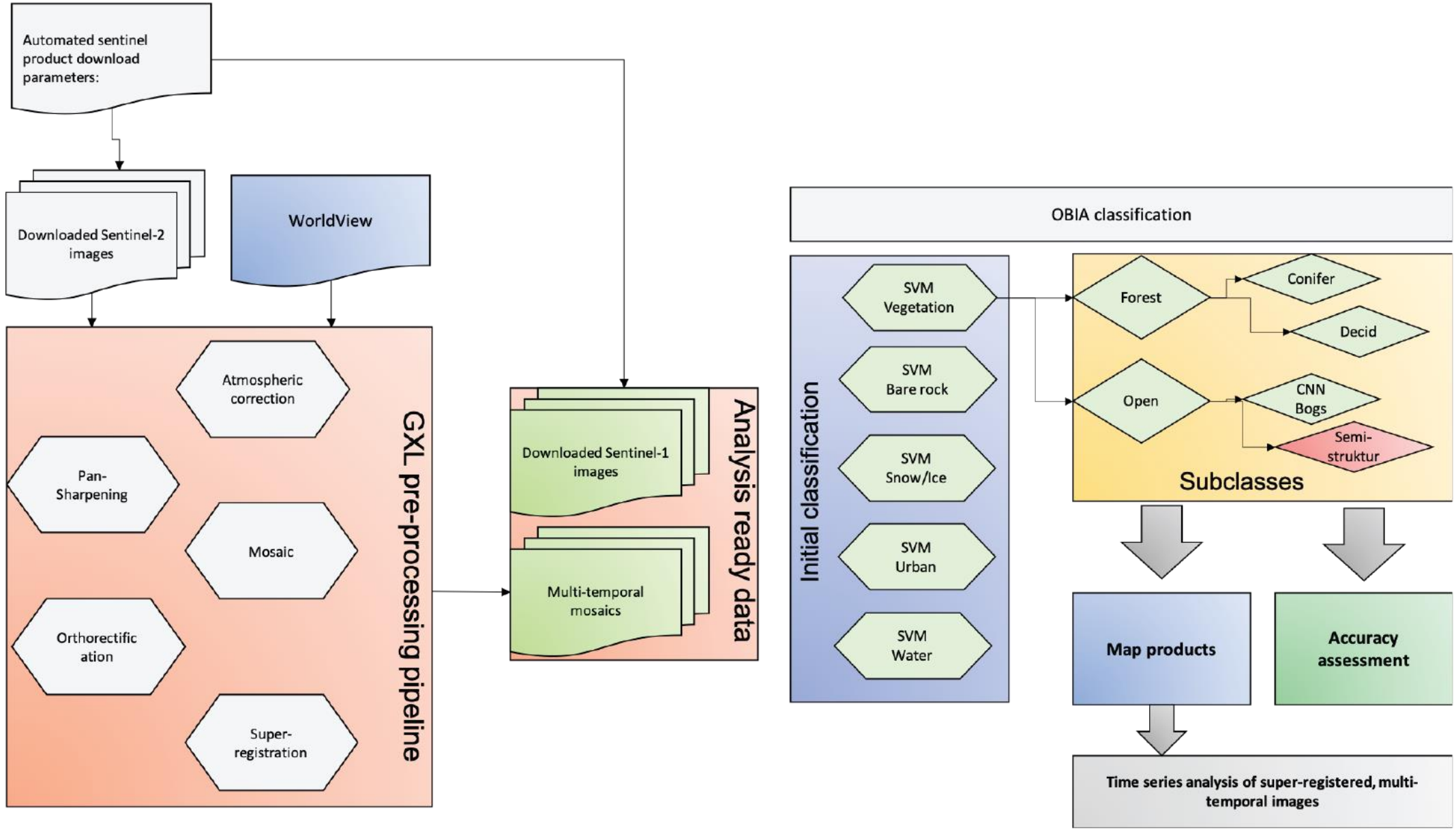
range of dates

Cloud cover

Area of interest



➔ **Each Sentinel image that meets the criteria downloaded and unzipped**


Automated sentinel product download parameters:
Downloaded Sentinel-2 images
WorldView
Atmospheric correction
Pan-Sharpening
Mosaic
Orthorectification
Super-registration
GXL pre-processing pipeline
Downloaded Sentinel-1 images
Multi-temporal mosaics
Analysis ready data
OBIA classification
Initial classification
SVM Vegetation
SVM Bare rock
SVM Snow/Ice
SVM Urban
SVM Water
Forest
Conifer
Decid
Open
CNN Bogs
Semi-struktur
Subclasses
Map products
Accuracy assessment
Time series analysis of super-registered, multi-temporal images

System overview

Ottawa

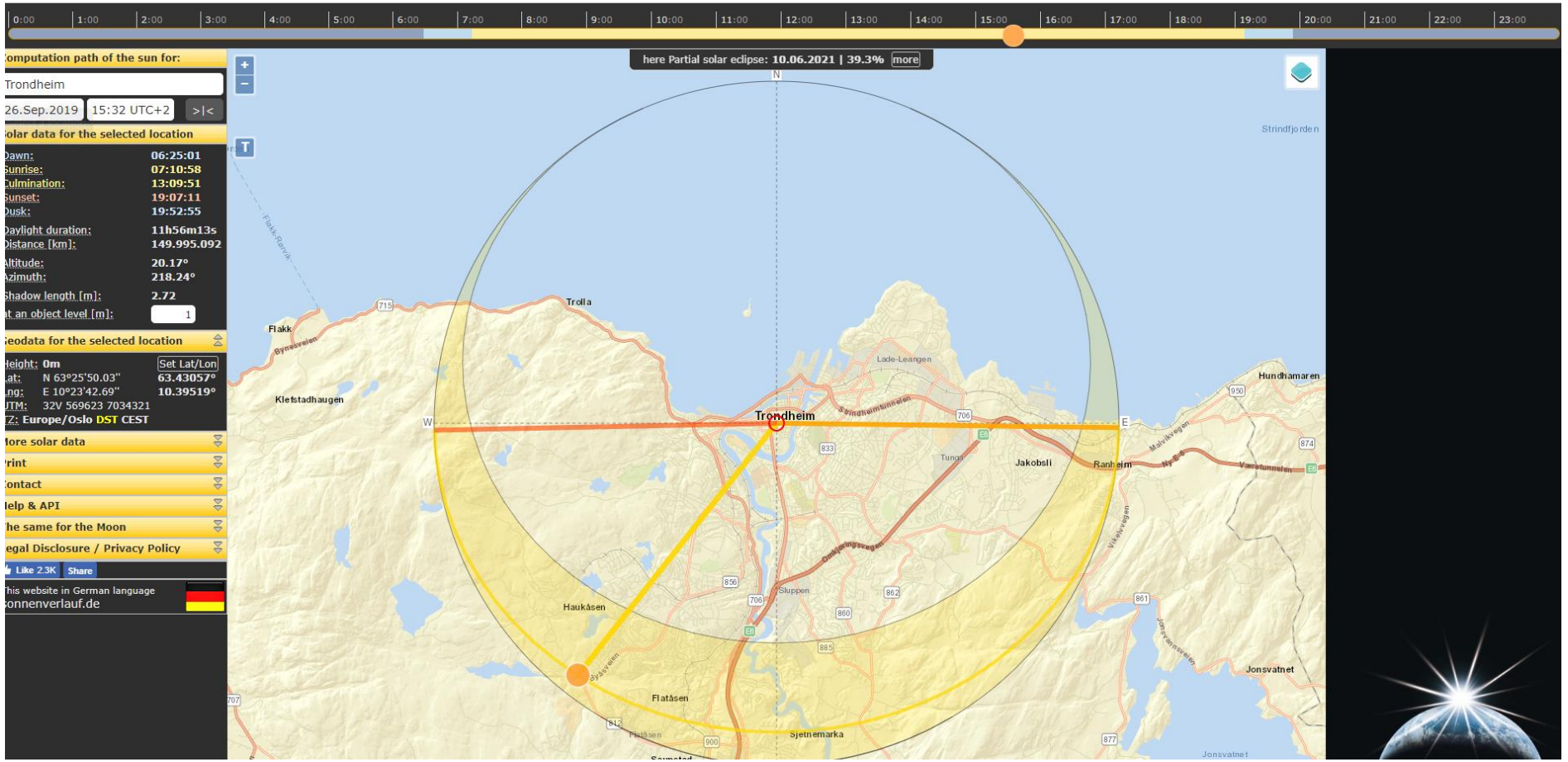
Oslo

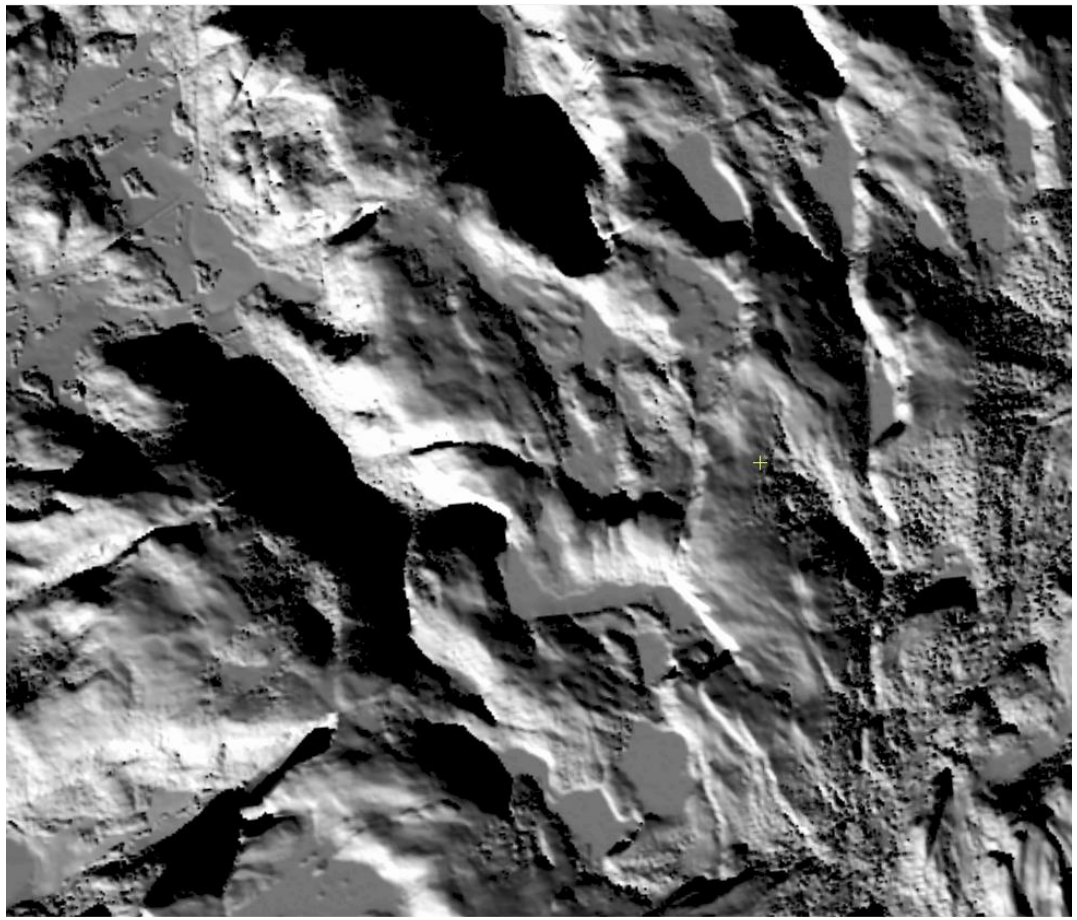
PCI GXL
eCognition
dev/server
(Bergen)

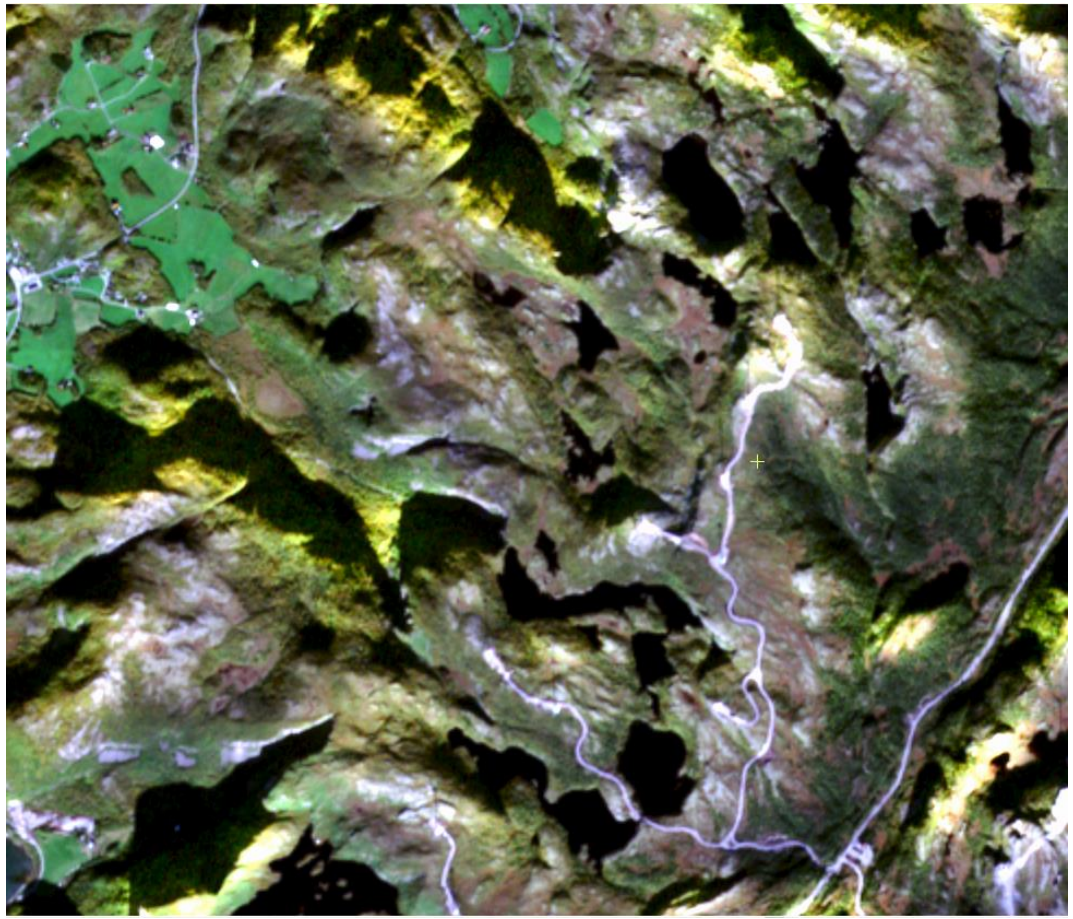
Bergen

Vancouver

Modelling shadows







Object image analysis: Image segmentation

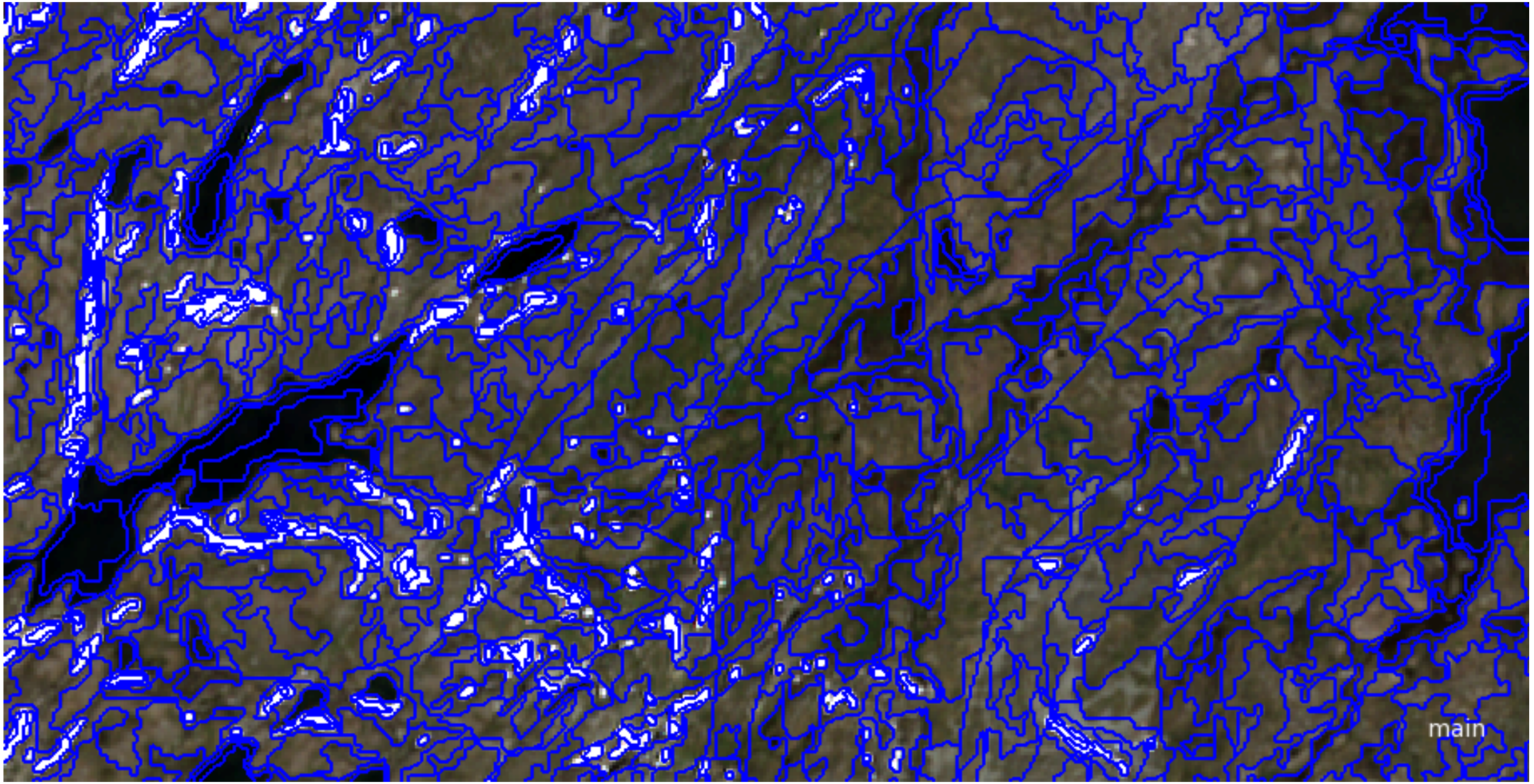
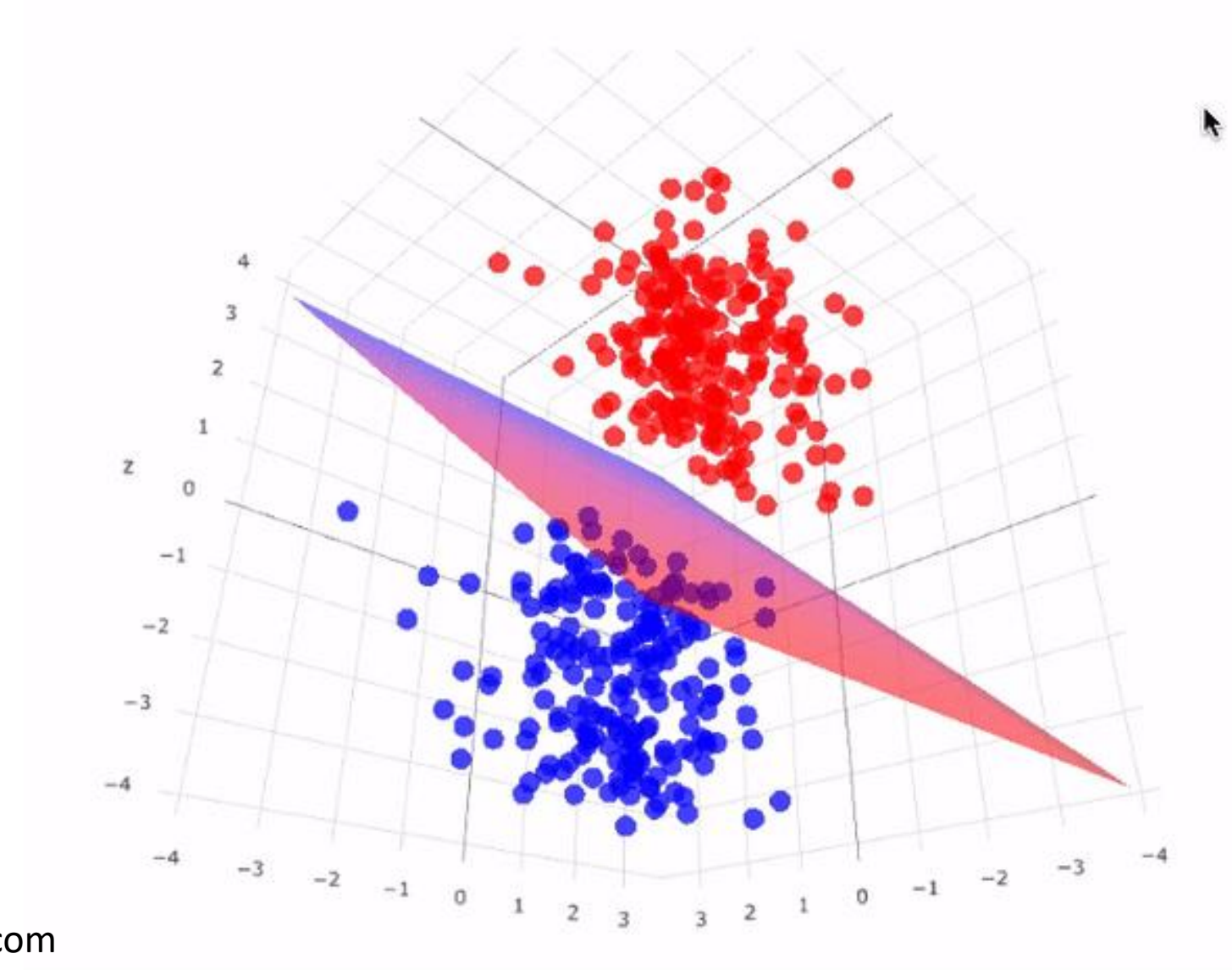
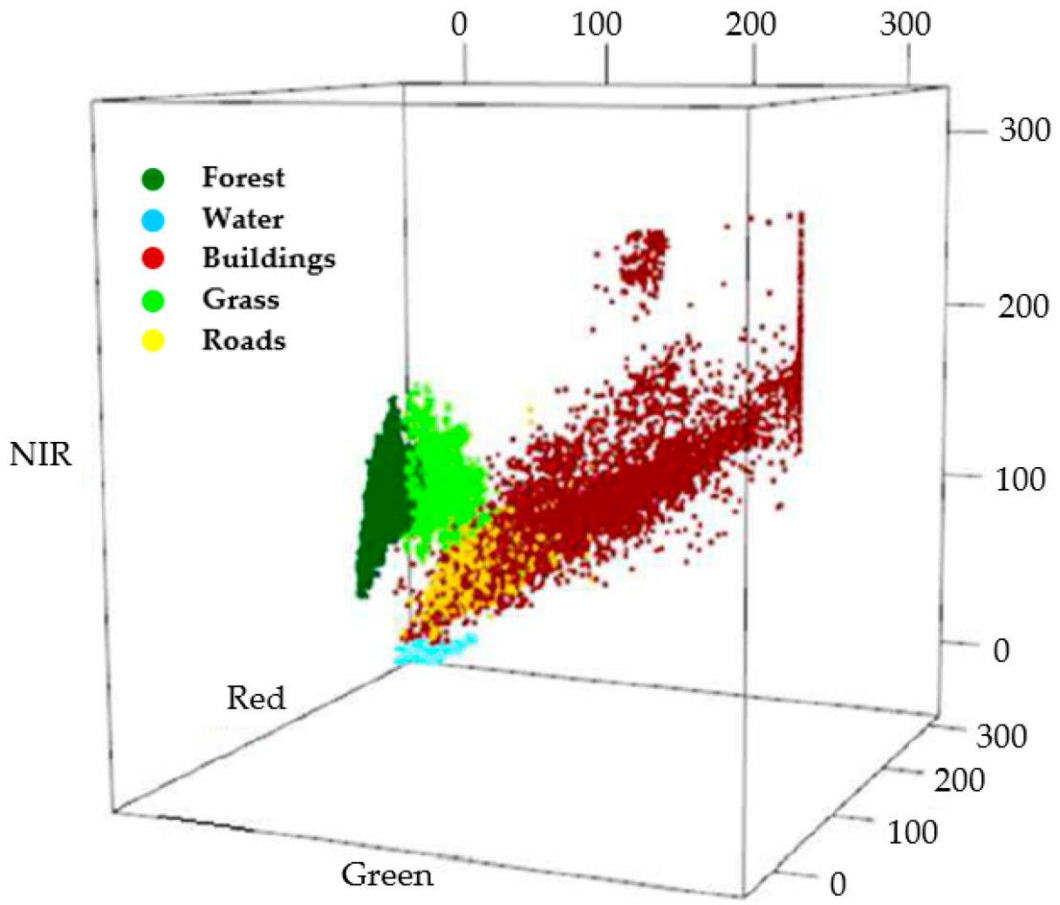


Image classification: SVM, Feature Space

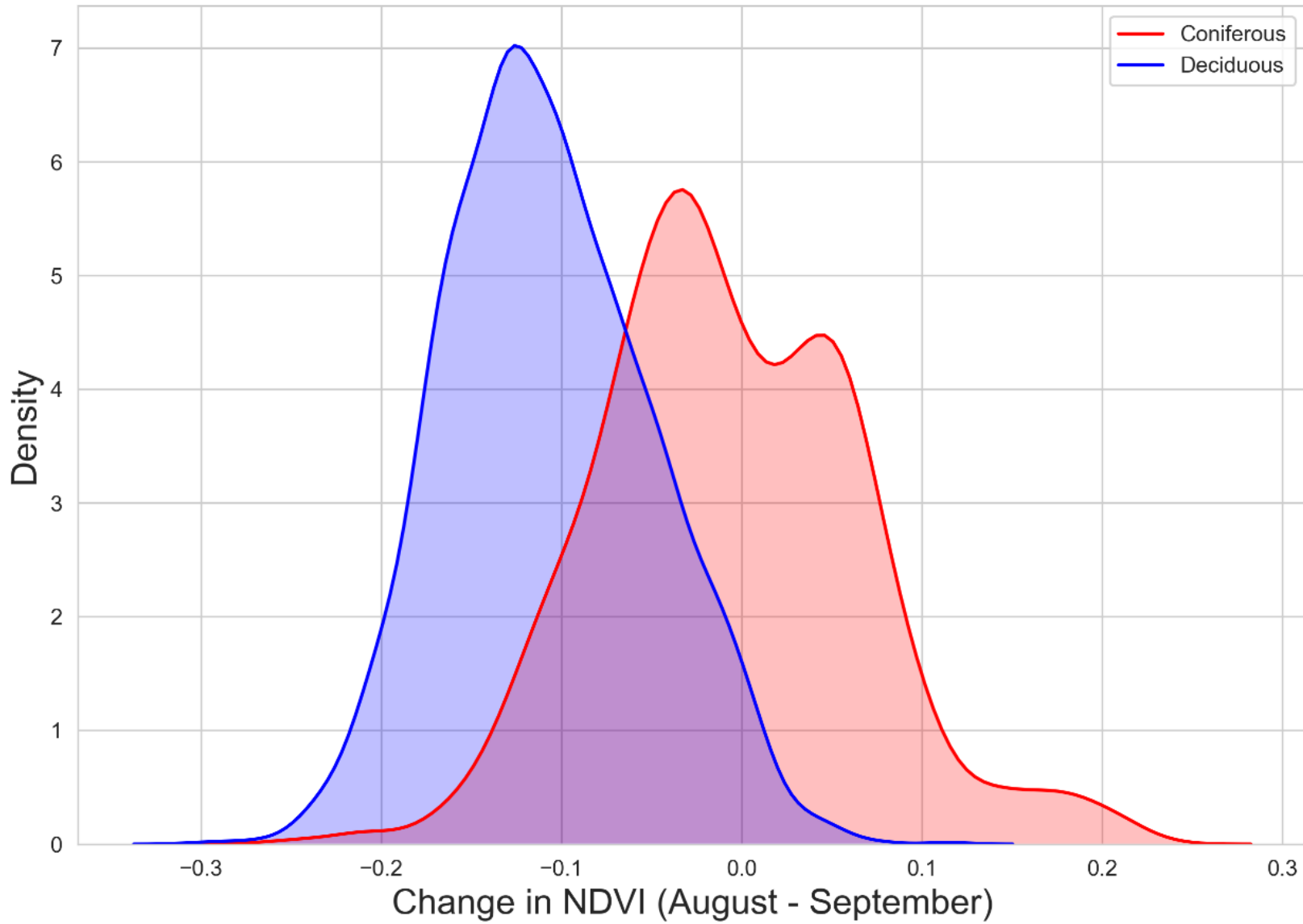


Towardsdatascience.com

Image classification: Feature Space

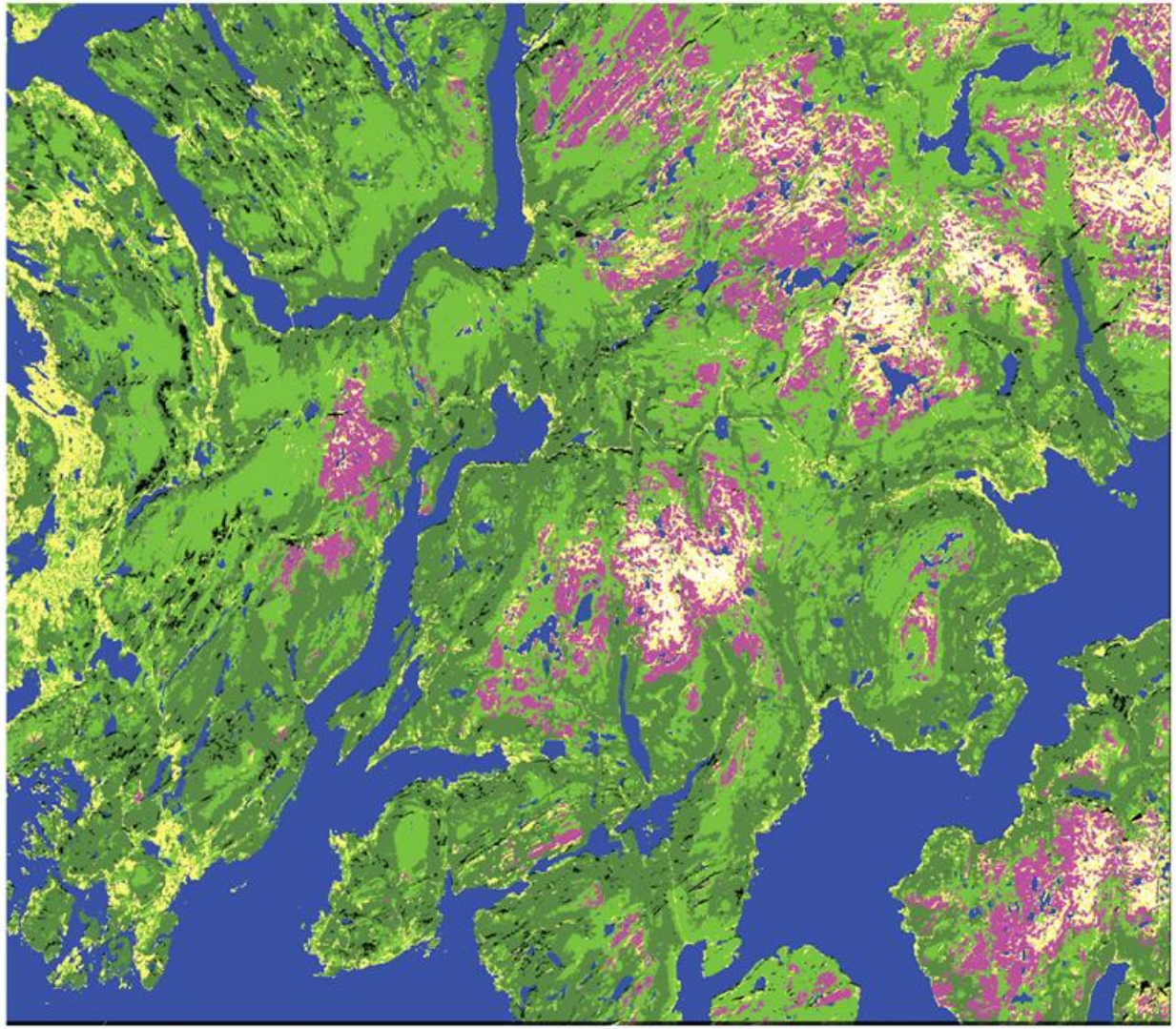


Deciduous forest vs coniferous forest


Coniferous
Deciduous
Density
0
1
2
3
4
5
6
7
−0.3
−0.2
−0.1
0.0
0.1
0.2
0.3
Change in NDVI (August - September)

Main classification - SVM

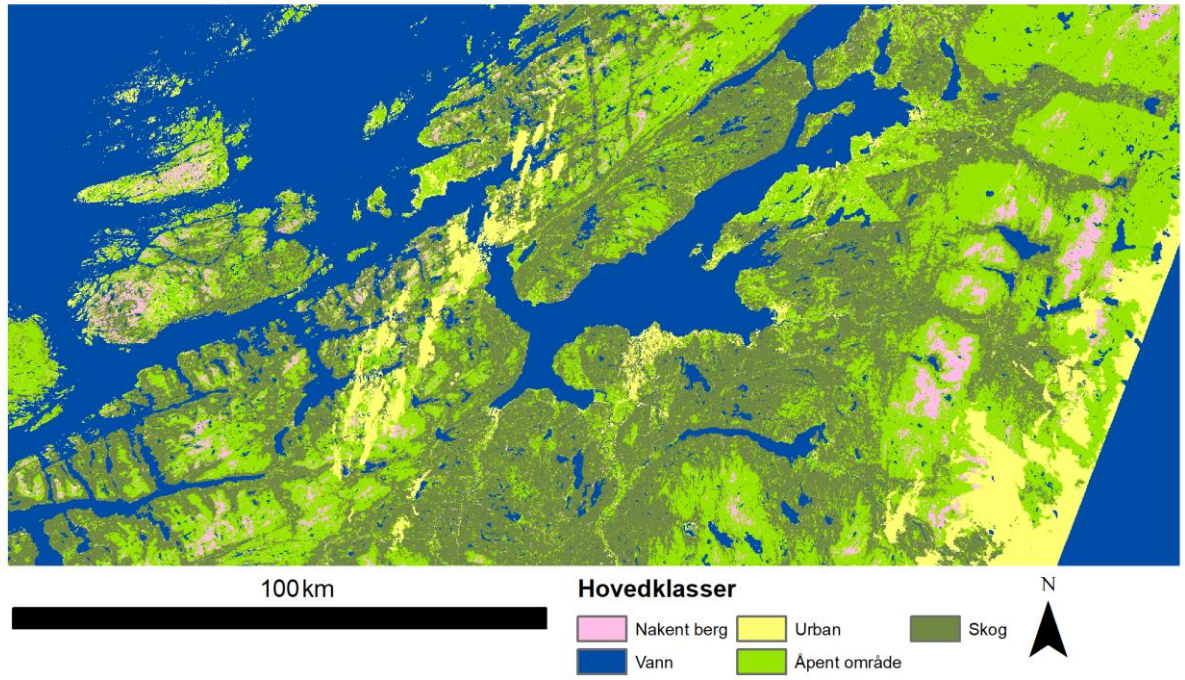
- Training data collected in eCognition based on AR5 data, NiN data and aerial images
- Verification data collected in ArcMap using same data, different locations
- Challenges related to geographic extent and data coverage
  - Trøndelag subset 10x larger than Hordaland subset
  - Elevation data coverage lacking in some areas

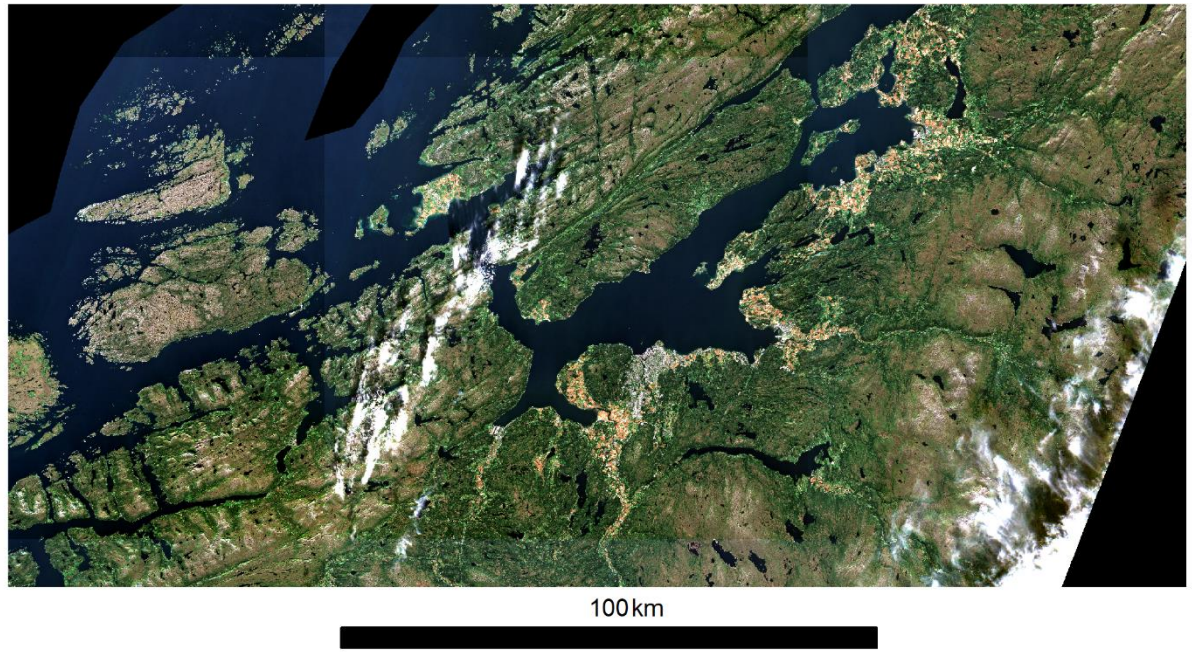


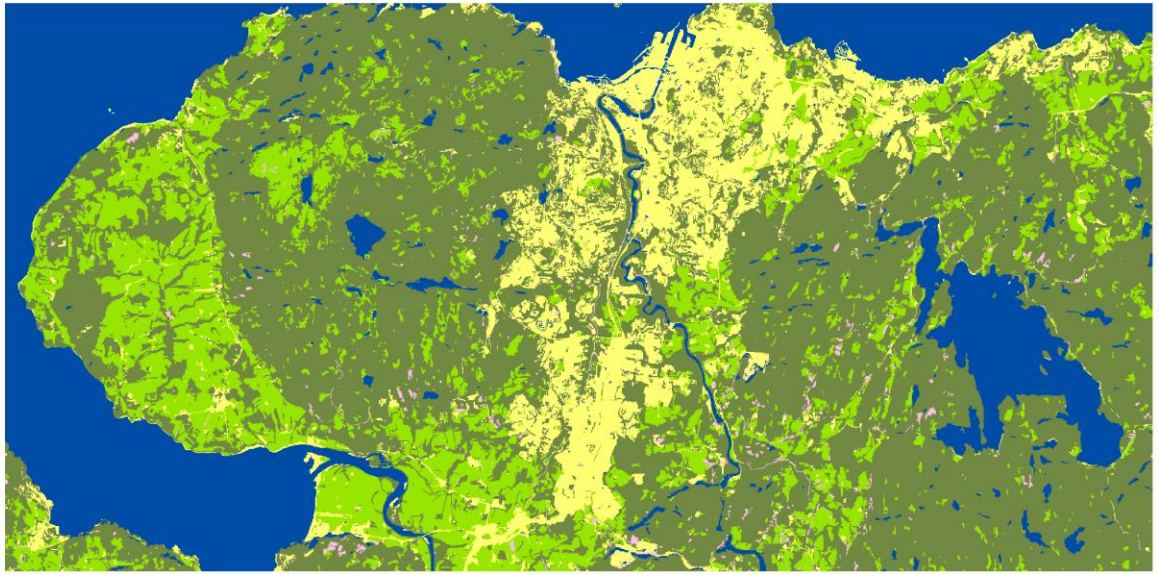
25 km

bart fjell
urban
skygge
skog
vann
snø og is
åpent område

25 km


100 km
Hovedklasser
Nakent berg
Urban
Skog
Vann
Åpent område
N


100 km

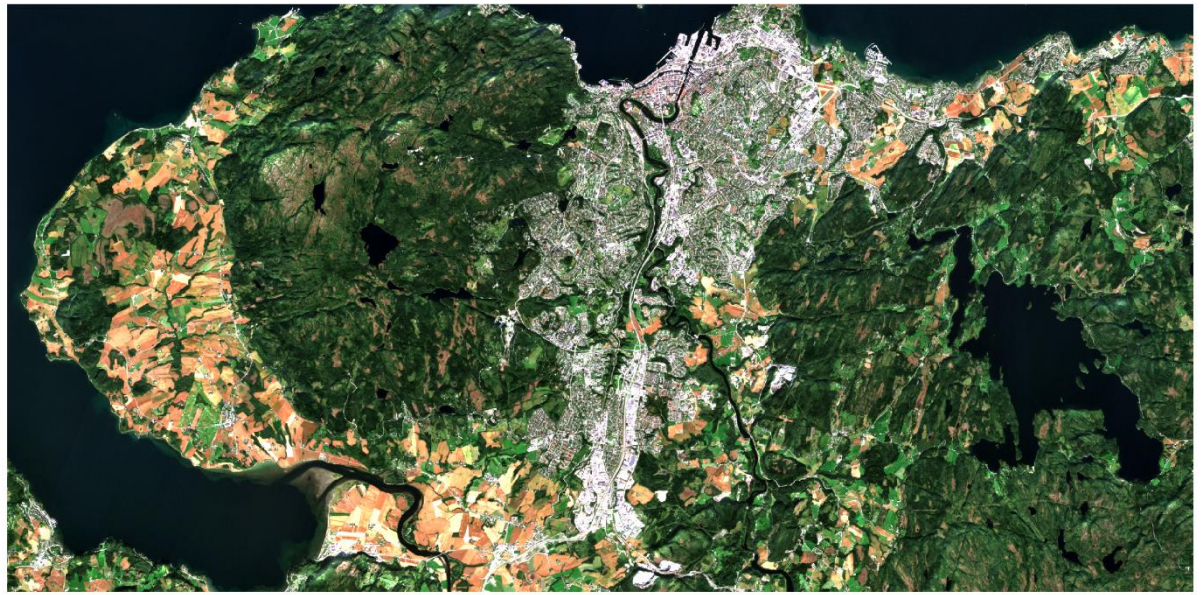


10 km

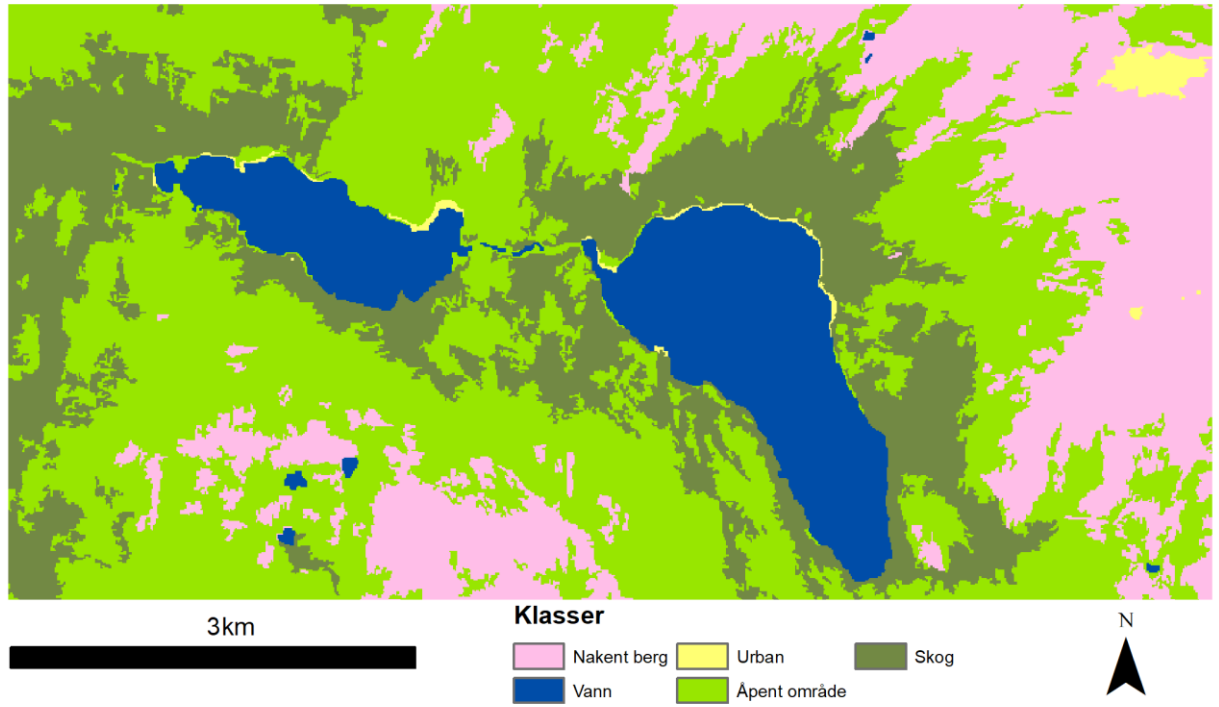
Hovedklasser

- Nakent berg
- Urban
- Skog
- Vann
- Åpent område

N



10 km


3km
Klasser
Nakent berg
Urban
Skog
Vann
Åpent område
N


3km

Confusion matrix

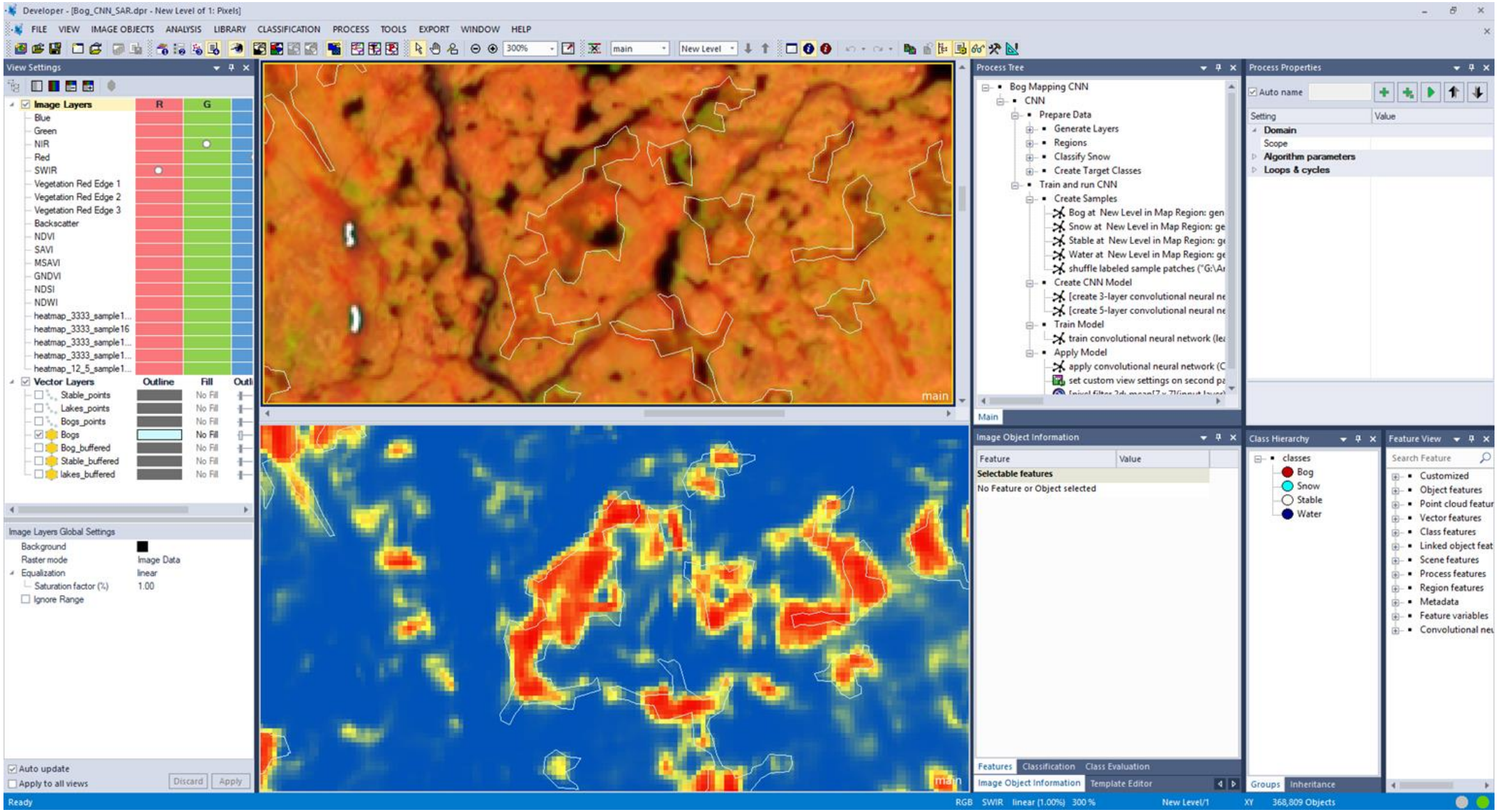
Klasse	Bart fjell	Vann	Urban	Snø	Åpent	Skog	Total	User
Bart fjell	26	0	0	1	1	0	28	0,93
Vann	0	158	0	0	0	1	159	0,99
Urban	5	0	68	0	3	1	77	0,88
Snø	0	0	0	15	0	0	15	1,00
Åpent	1	0	5	0	81	2	89	0,91
Skog	0	0	0	0	6	109	115	0,95
Total	32	158	73	16	91	130	500	0,00
Producer	0,81	1,00	0,93	0,94	0,89	0,84	0,00	0,91

Klasse	Nakent berg	Vann	Urban	Åpent område	Skog	Total	User
Nakent berg	281	0	7	1	2	291	0.97
Vann	0	2034	9	0	2	2045	0.99
Urban	37	91	751	1	0	880	0.85
Åpent område	19	3	25	81	2	130	0.62
Skog	0	1	73	10	170	254	0.67
Total	337	2129	865	93	176	3600	0
Producer	0.83	0.96	0.86	0.87	0.97	0	0.92

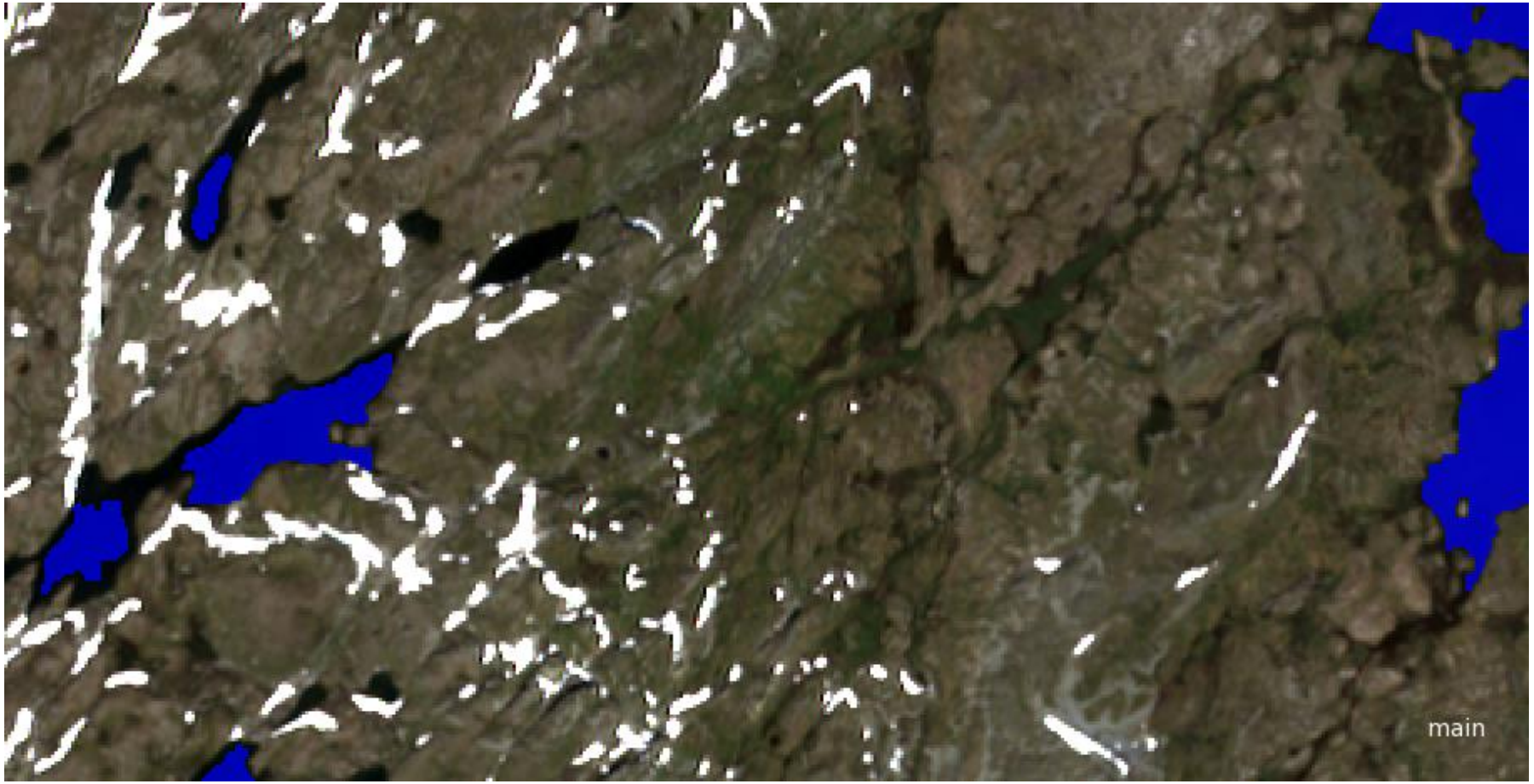
What about mapping bogs?

- Cannot be identified **spectrally**
- Rather by looking at **recurring patterns** in the spectral values
- Can use machine learning methods (i.e. deep learning)

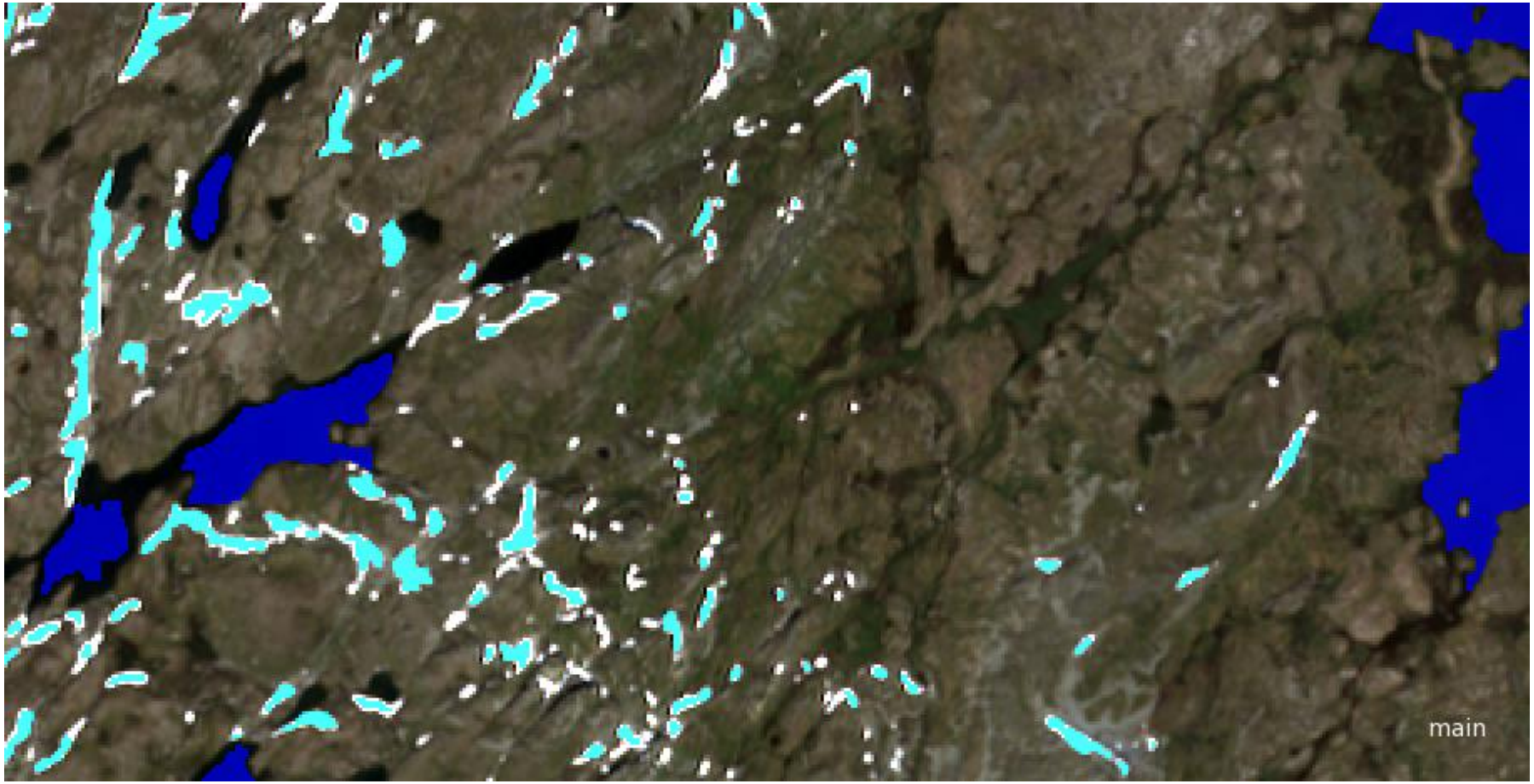
Heatmap


Developer - [Bog_CNN_SAR.dpr - New Level of 1: Pixels]
FILE VIEW IMAGE OBJECTS ANALYSIS LIBRARY CLASSIFICATION PROCESS TOOLS EXPORT WINDOW HELP
View Settings
Image Layers
Blue
Green
NIR
Red
SWIR
Vegetation Red Edge 1
Vegetation Red Edge 2
Vegetation Red Edge 3
Backscatter
NDVI
SAVI
MSAVI
GNDVI
NDSI
NDWI
Vector Layers
Stable_points
Lakes_points
Bogs_points
Bogs
Bog_buffered
Stable_buffered
lakes_buffered
Image Layers Global Settings
Process Tree
Bog Mapping CNN
CNN
Prepare Data
Generate Layers
Regions
Classify Snow
Create Target Classes
Train and run CNN
Create Samples
Create CNN Model
Train Model
Apply Model
Process Properties
Auto name
Setting
Value
Domain
Scope
Algorithm parameters
Loops & cycles
Image Object Information
Feature
Value
Selectable features
No Feature or Object selected
Class Hierarchy
classes
Bog
Snow
Stable
Water
Feature View
Search Feature
Customized
Object features
Point cloud featur
Vector features
Class features
Linked object feat
Scene features
Process features
Region features
Metadata
Feature variables
Convolutional ne
Auto update
Apply to all views
Discard
Apply
Ready
RGB SWIR linear (1.00%) 300 %
New Level/1
XY
368,809 Objects

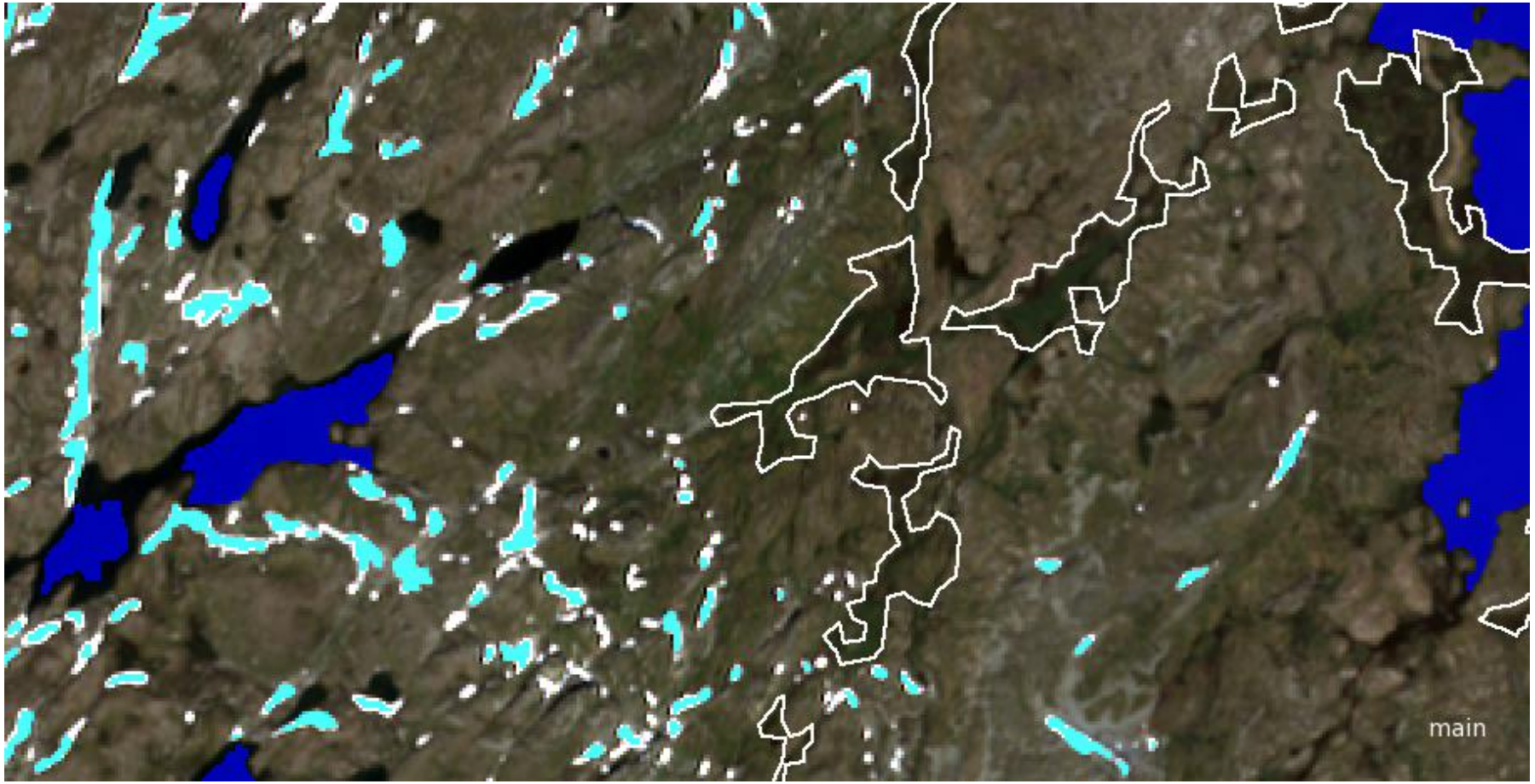
Classification of major water bodies



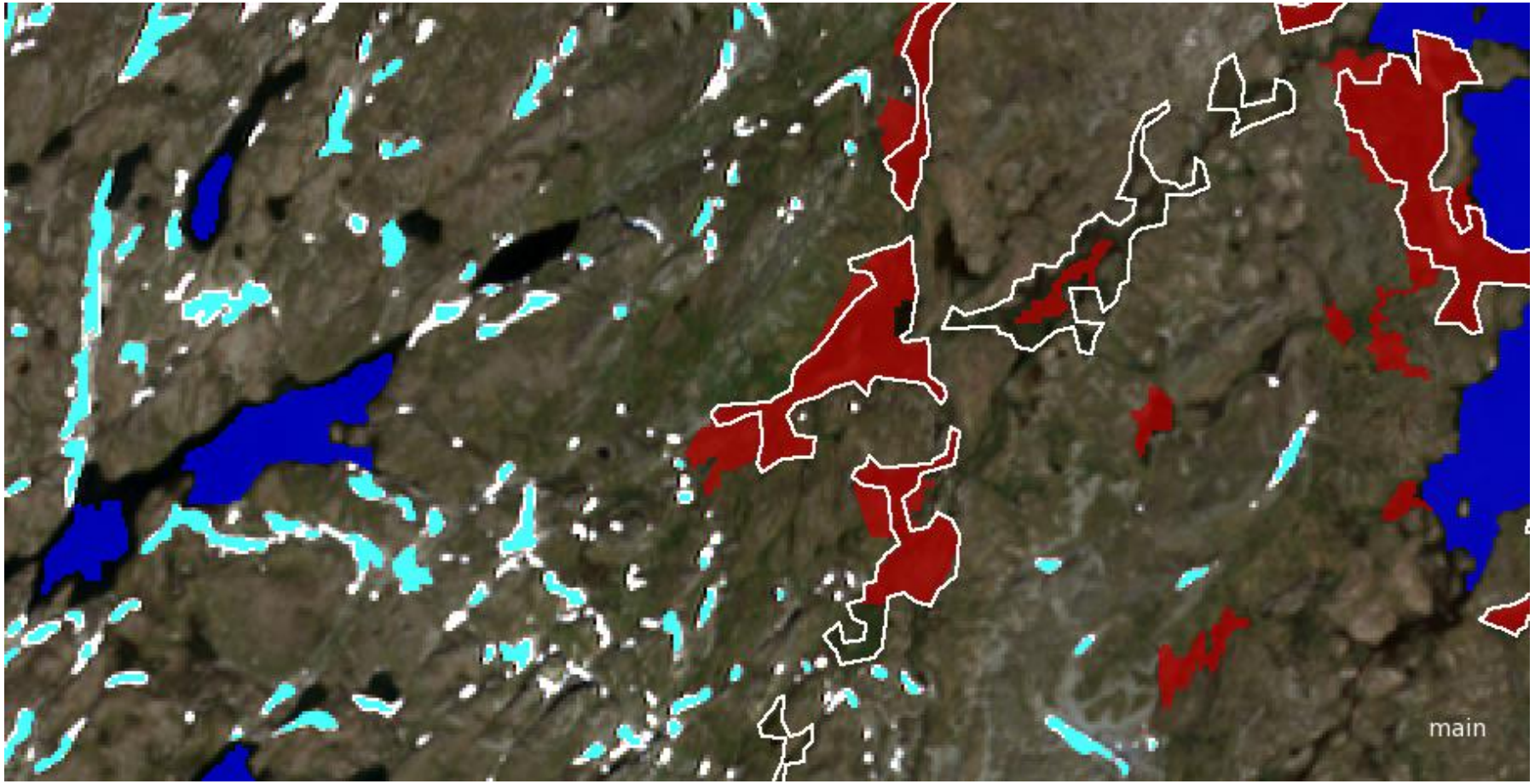
Classification of snow patches



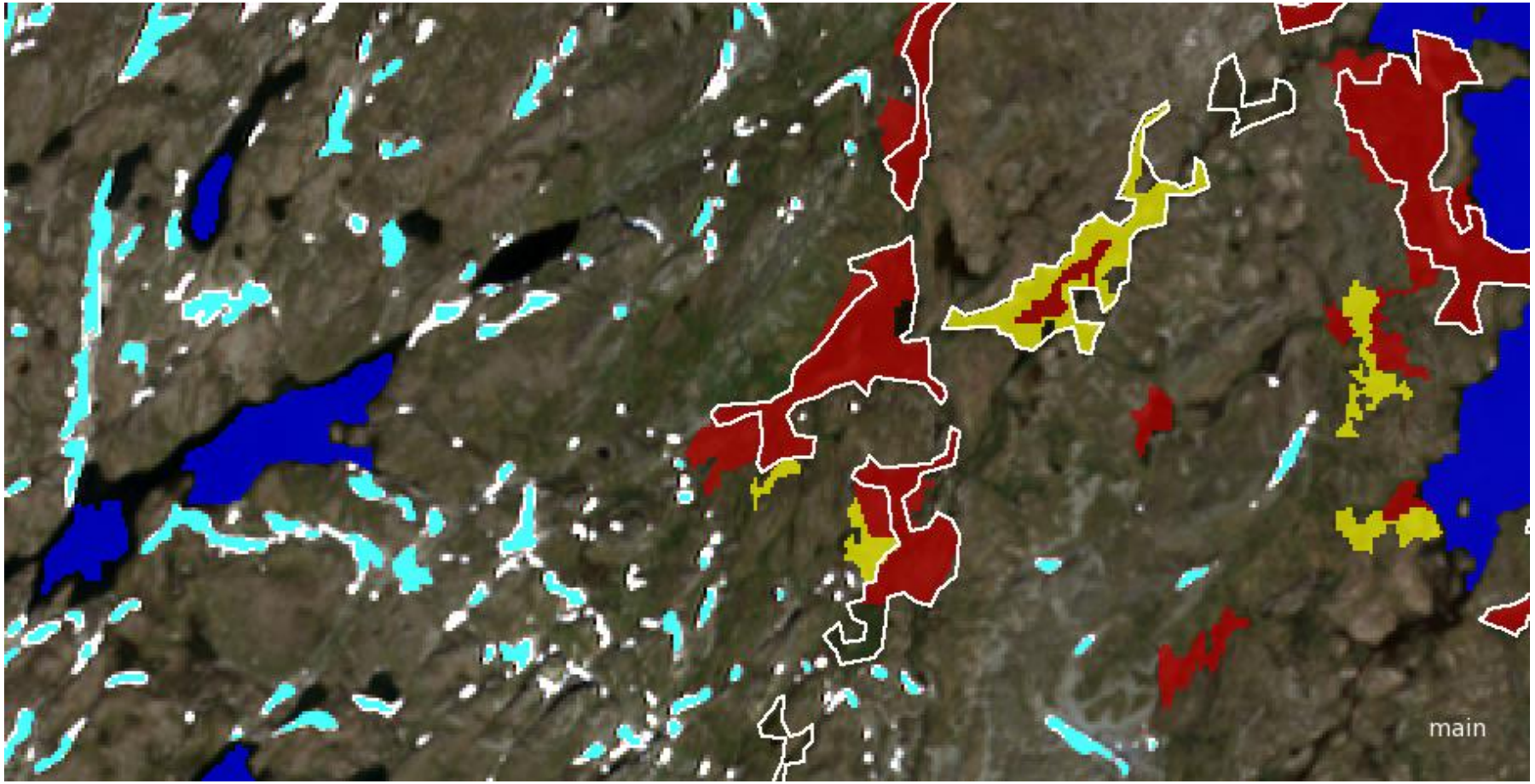
Objects > 0.25 heatmap OR > 0.4 median heatmap to bogs



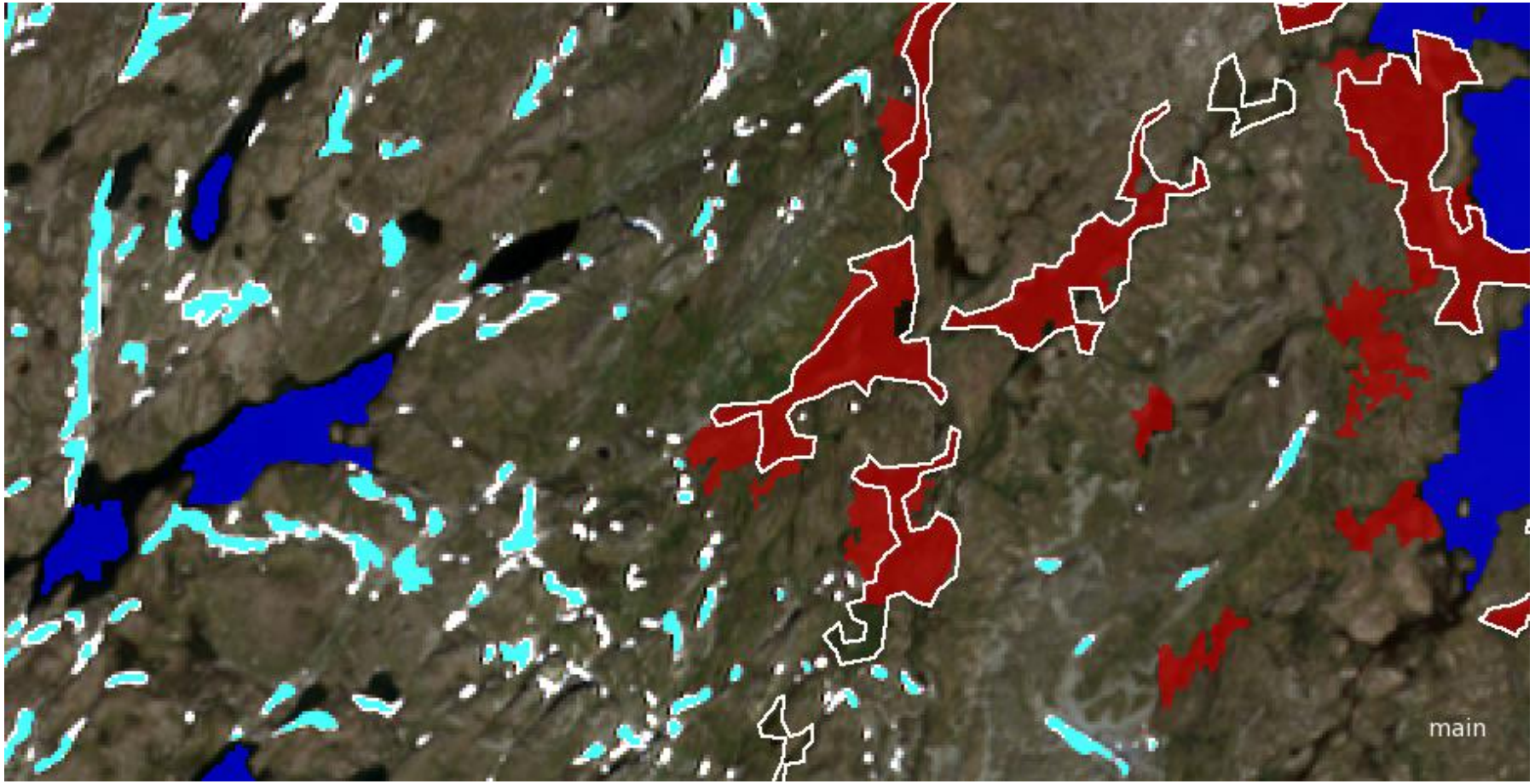
Objects > 0.25 heatmap OR > 0.4 median heatmap to bogs



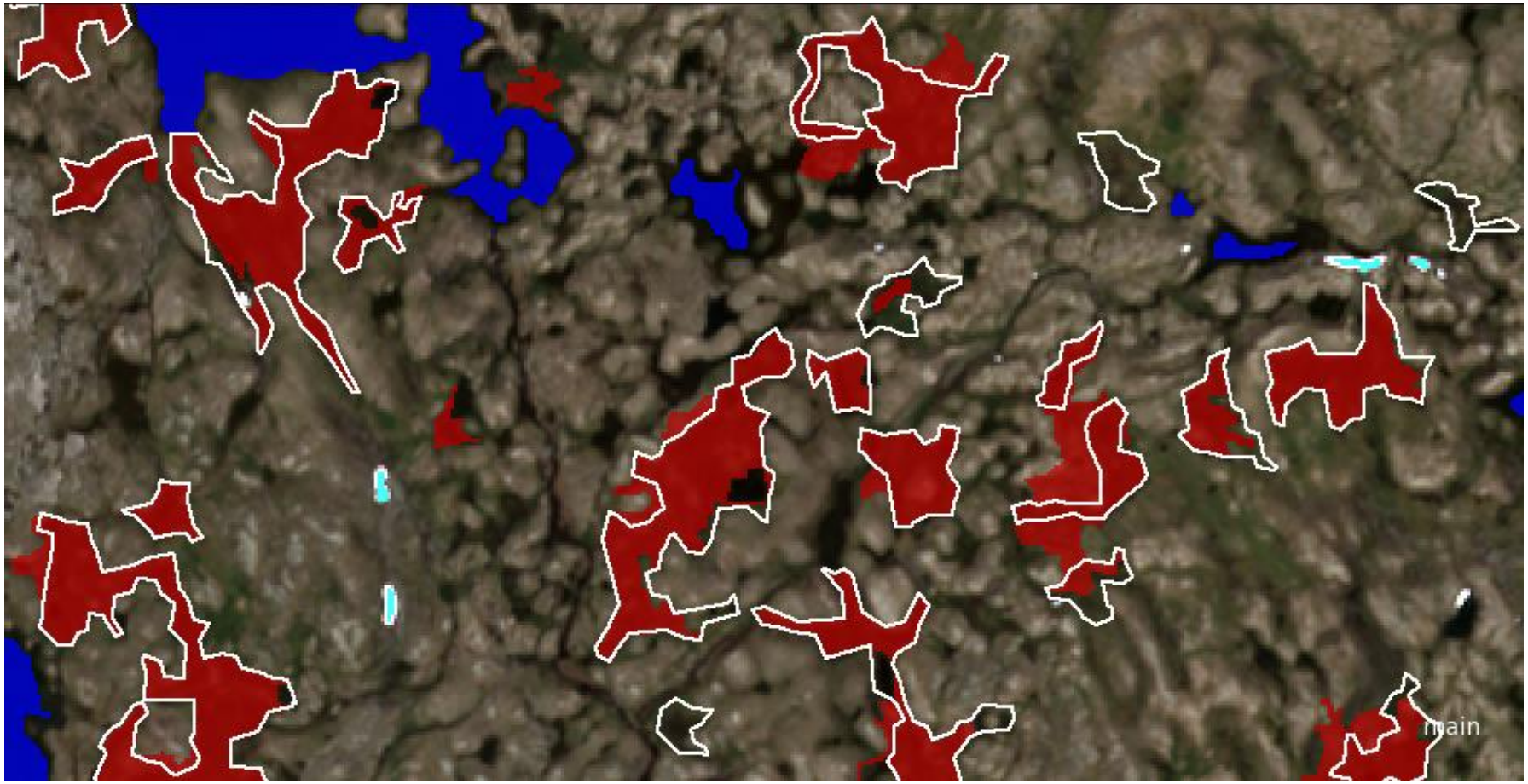
Expansion to nearby objects

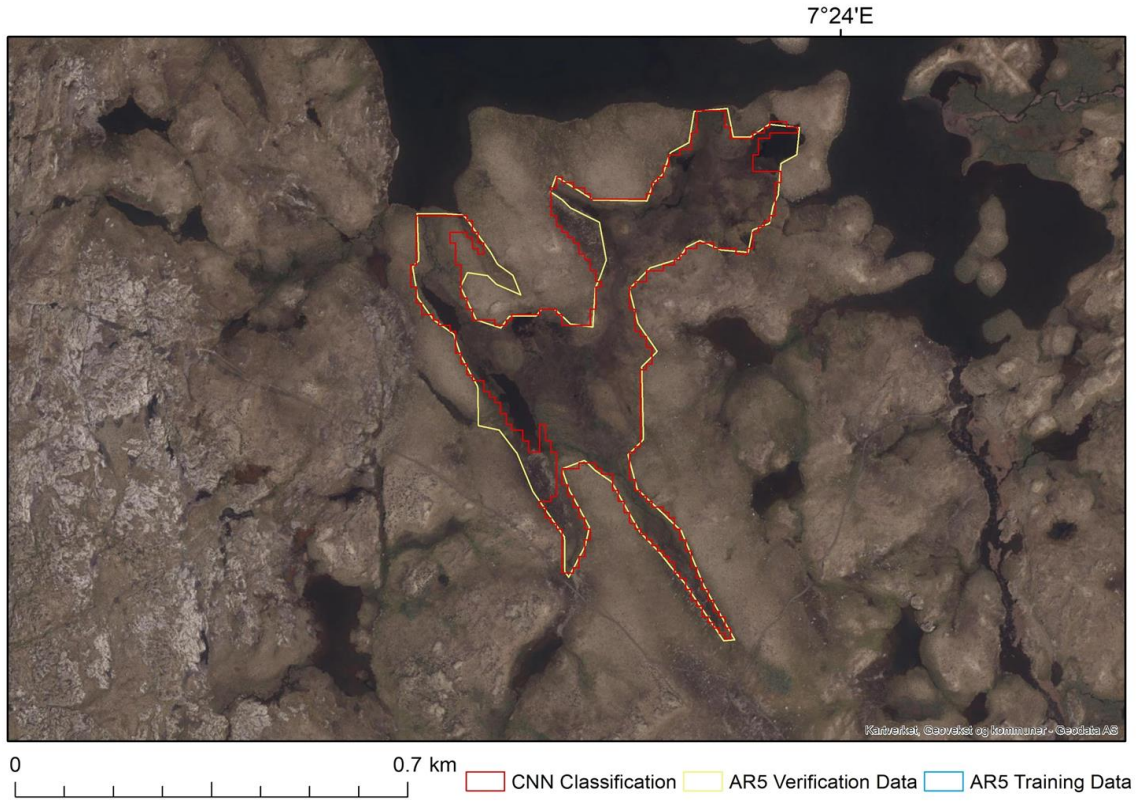


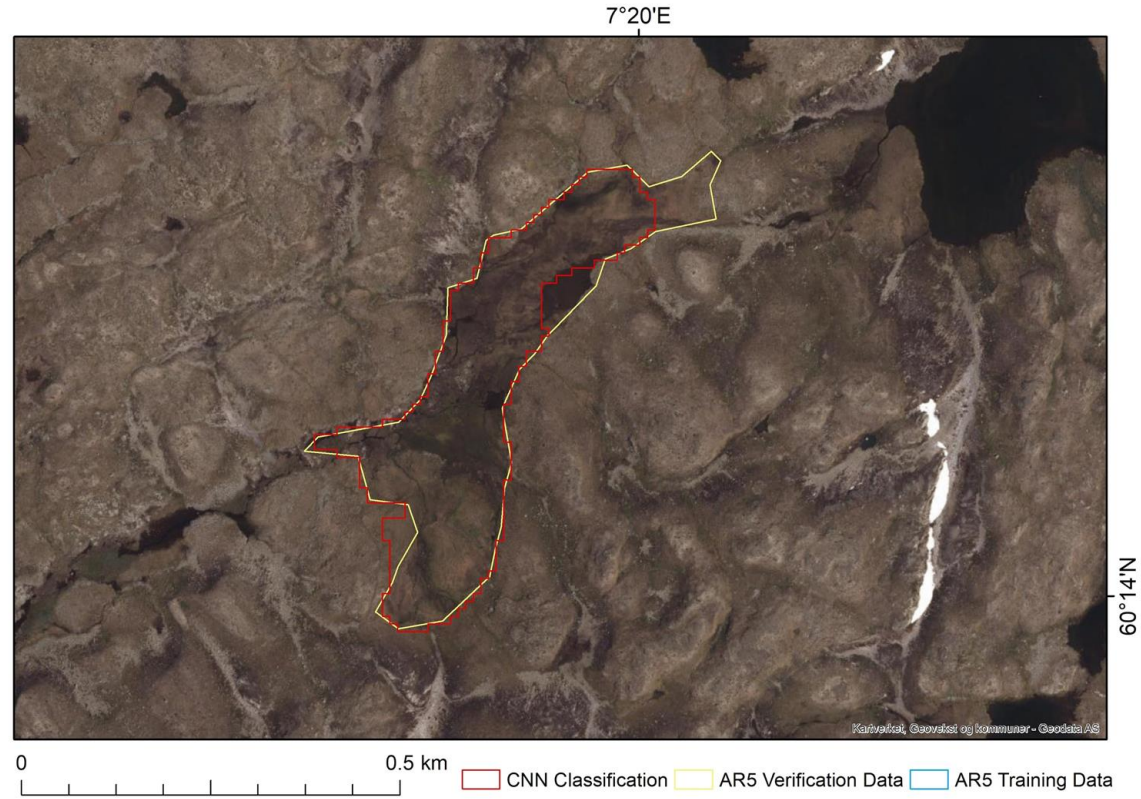
Merging of objects



Results

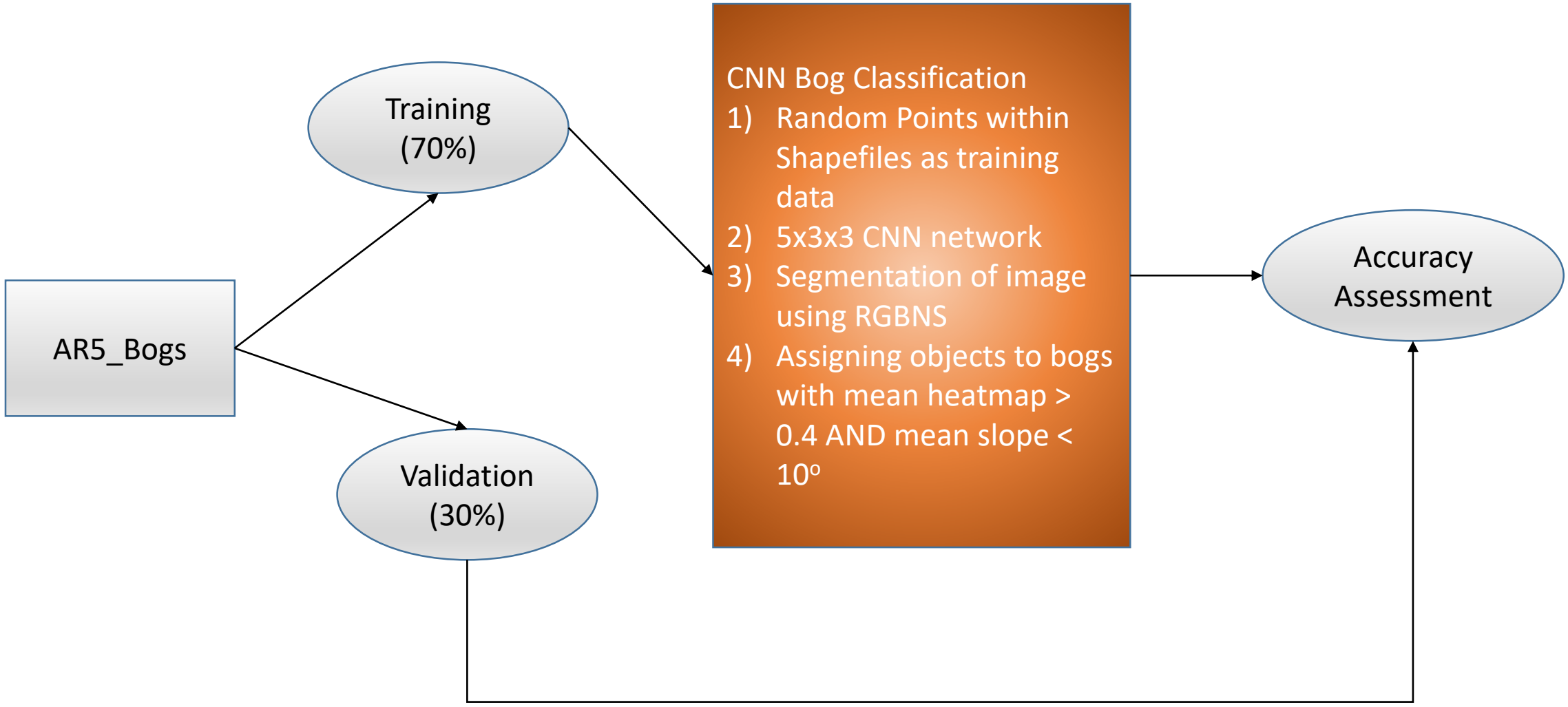




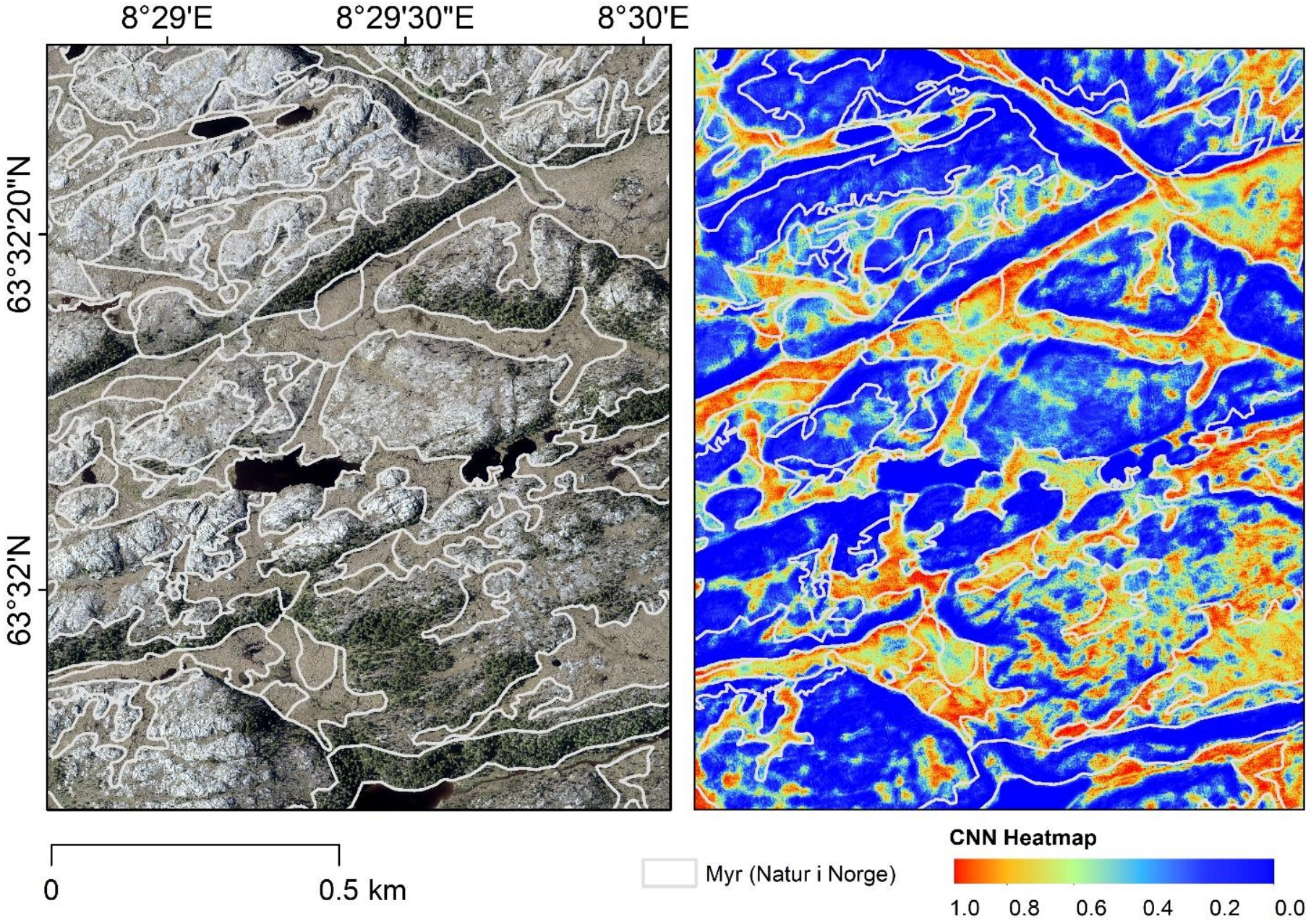


Producer Accuracy 74%

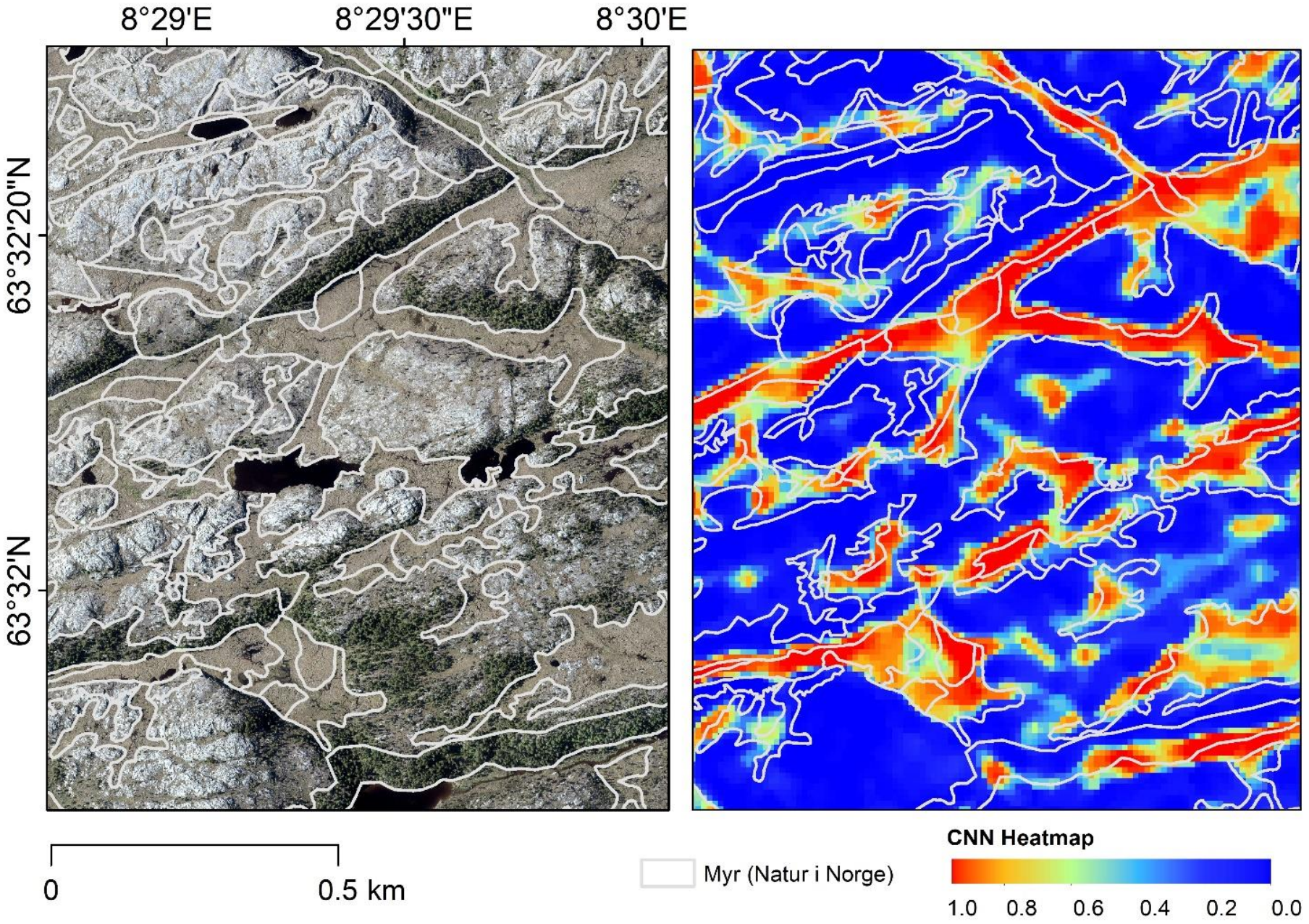
User Accuracy 73%


AR5_Bogs
Training (70%)
Validation (30%)
CNN Bog Classification
1) Random Points within Shapefiles as training data
2) 5x3x3 CNN network
3) Segmentation of image using RGBNS
4) Assigning objects to bogs with mean heatmap > 0.4 AND mean slope < 10°
Accuracy Assessment

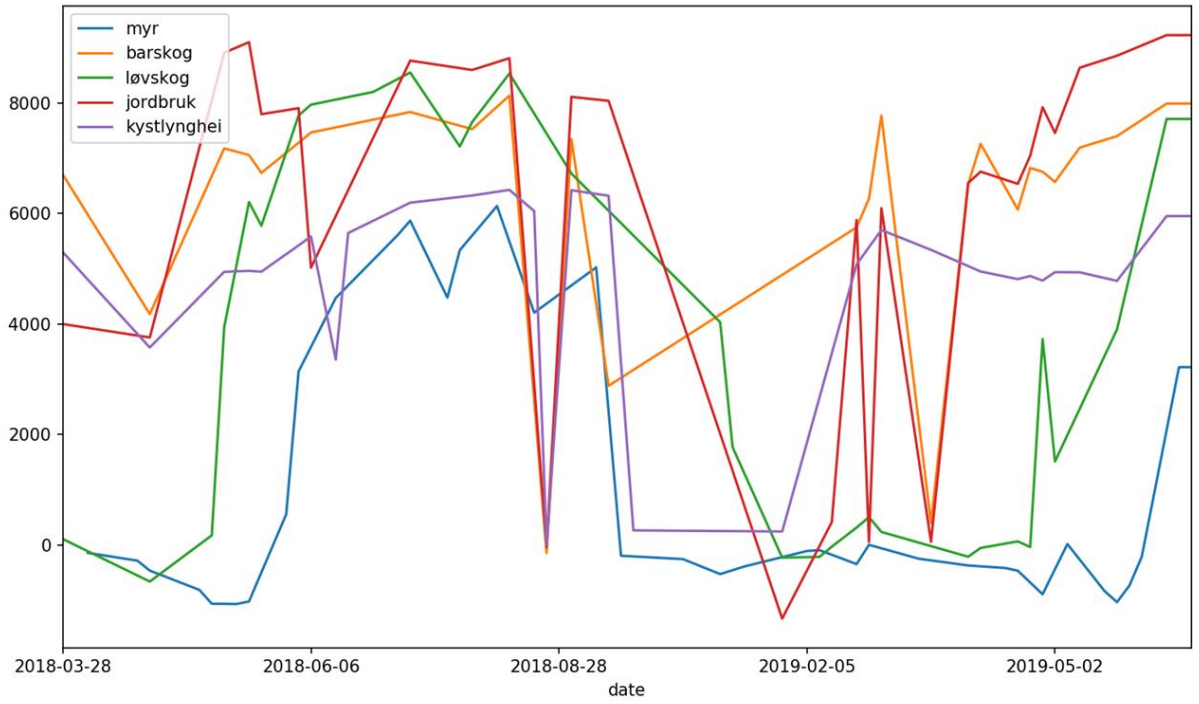
CNN heatmap based on 20 cm RGB aerial images

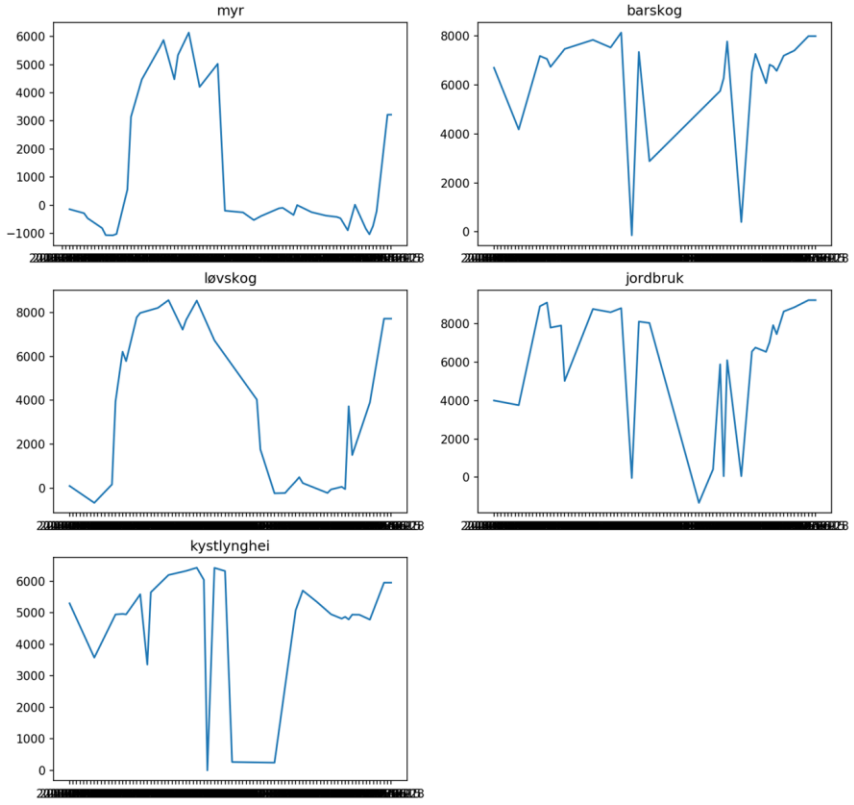


CNN heatmap based on Sentinel 1 + 2 (SAR, MS)

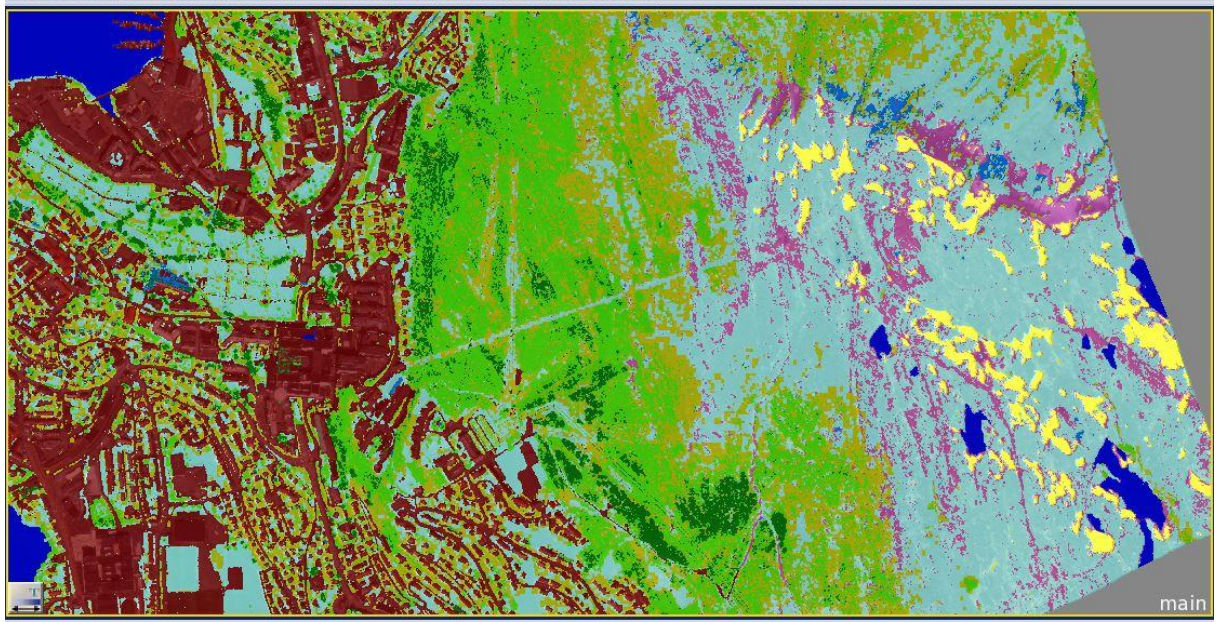


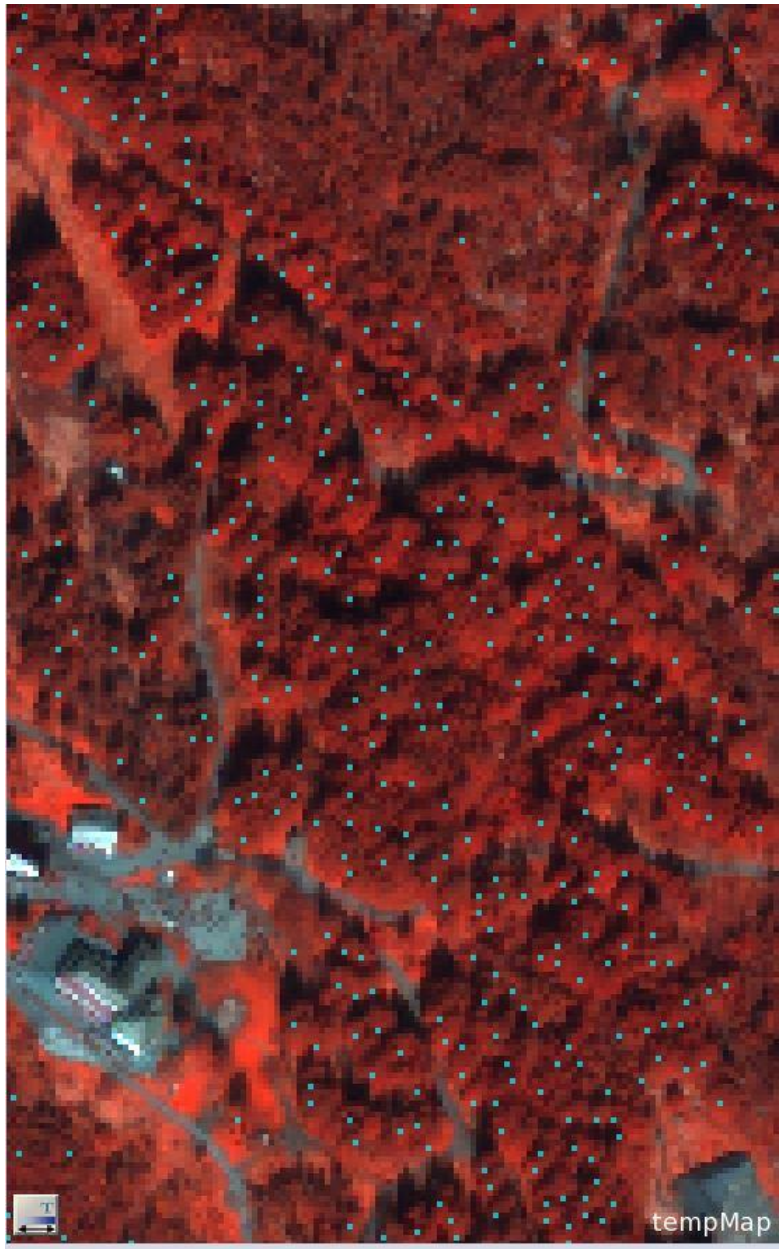
Future developments: Time series





Different sensors: WorldView 2 and LiDAR





Conclusions

- Remote Sensing has some key advantages when it comes to ecosystem mapping
- Some classes relatively easy to map…
- …Some are challenging
- Python is essential in working with such big datasets
- Difficulties in scaling up to all of Norway?
- Potential in the exploitation of time series