

POLITECNICO
MILANO 1863

Rutor glacier

Temporal classification using
Random Forest and MLP

Earth Observation - Advanced
Edoardo Pessina

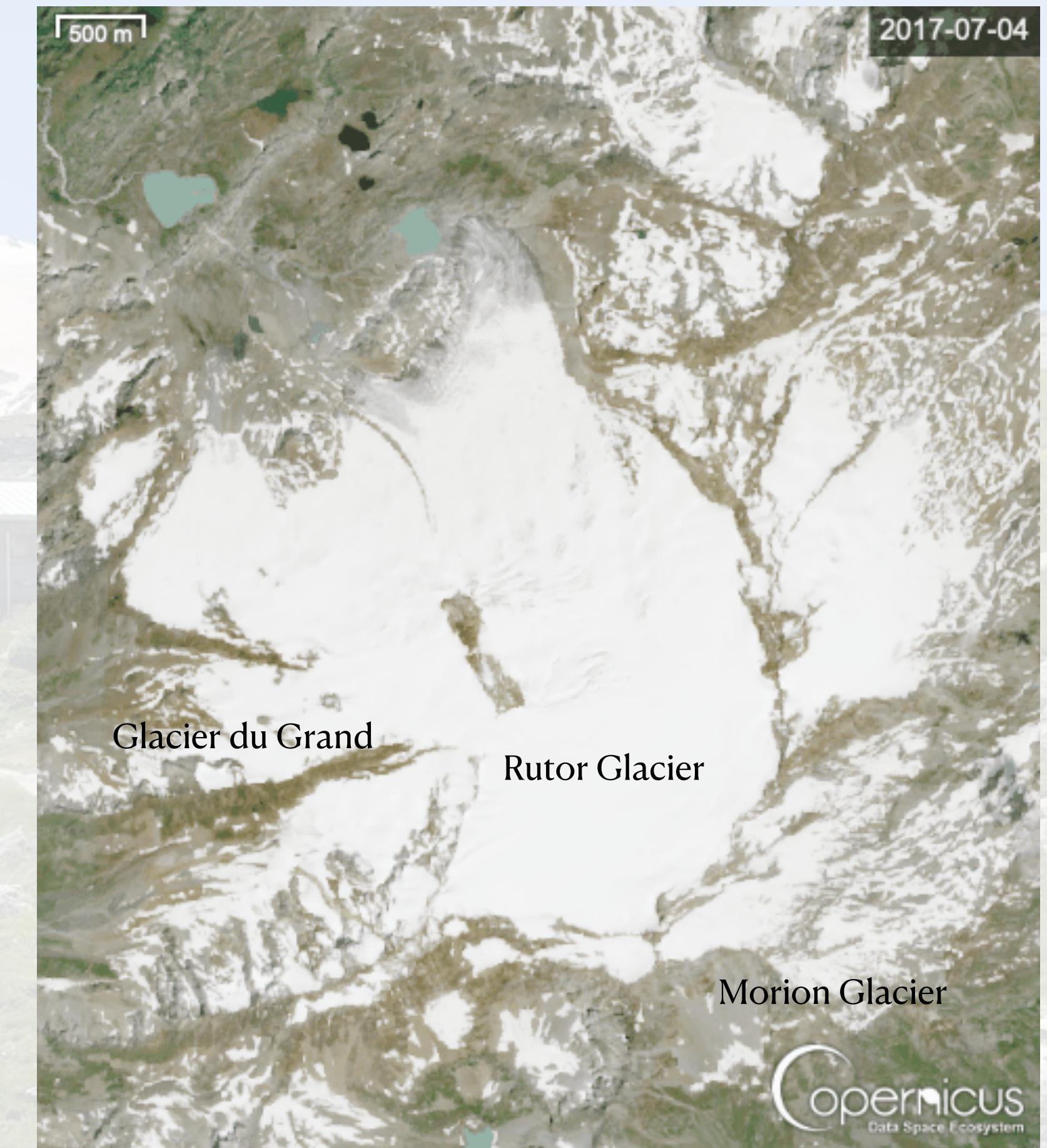
Study area: Rutor Glacier

Technical specifications

- Time range: August 1984 - September 2024
- 5 years time period
- Elevation 2500m - 3500m

Data characteristics

- Landsat 5 and Landsat 8
- Temporal resolution: 16 days
- Spatial resolution: 30m*
- Bands: {SR_1, SR_2, SR_3, SR_4, SR_5, SR_7, ST_B6}



Rutor Glacier temporal evolution [2017-2025]

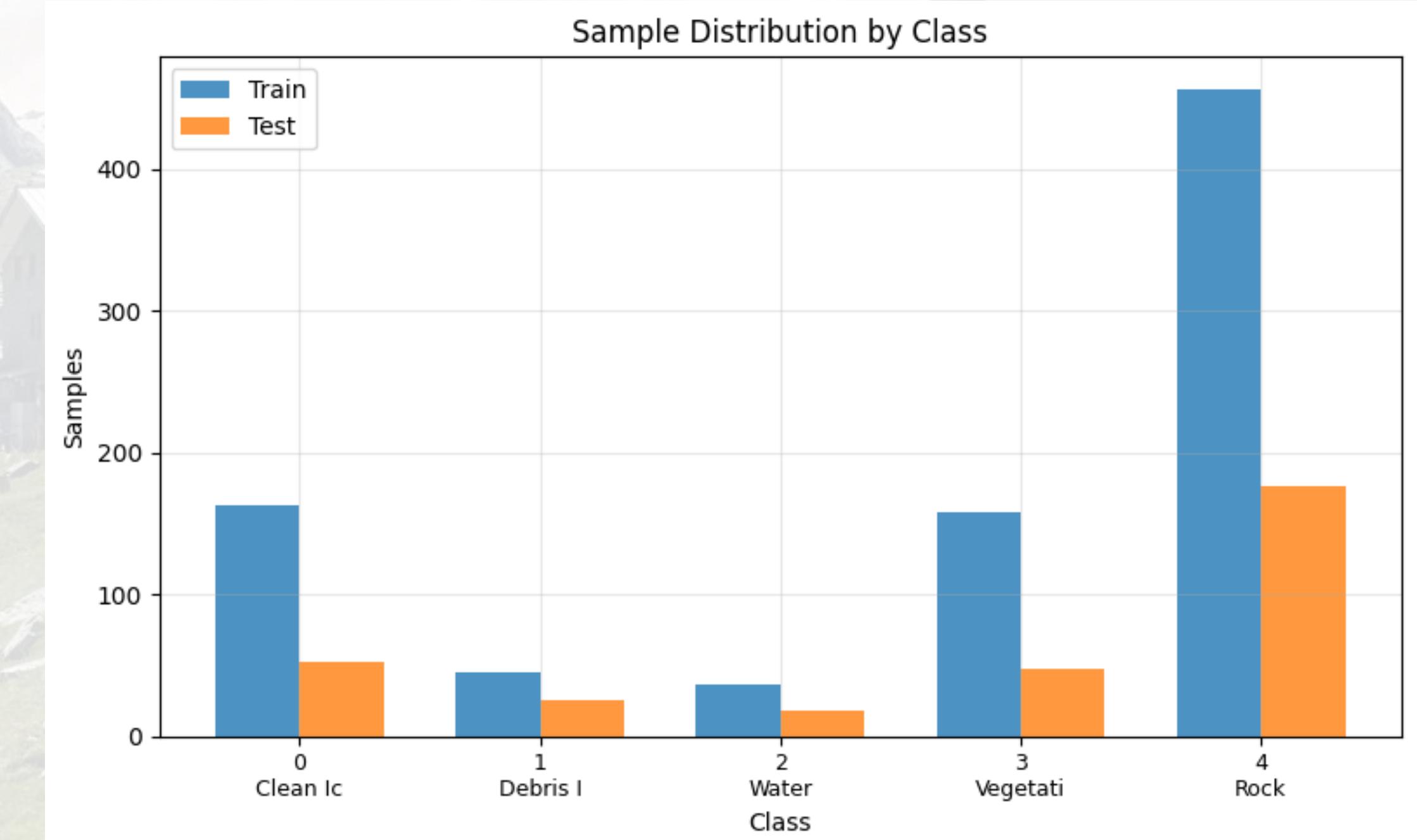
Methodology

Workflow

- **Data collection** [Landsat 5-8]
- **Preprocessing** [cloud masking, 3 spectral indices]
- **Training samples** [manual creation of polygons]
- **Training models** [RF vs MLP architecture]
- **Temporal classification** [8 time periods]
- **Validation**

Classes

- (0) - Clean ice
- (1) - Debris-covered ice
- (2) - Water
- (3) - Vegetation
- (4) - Rock



Machine learning approaches - RF

Random Forest implementation

Input

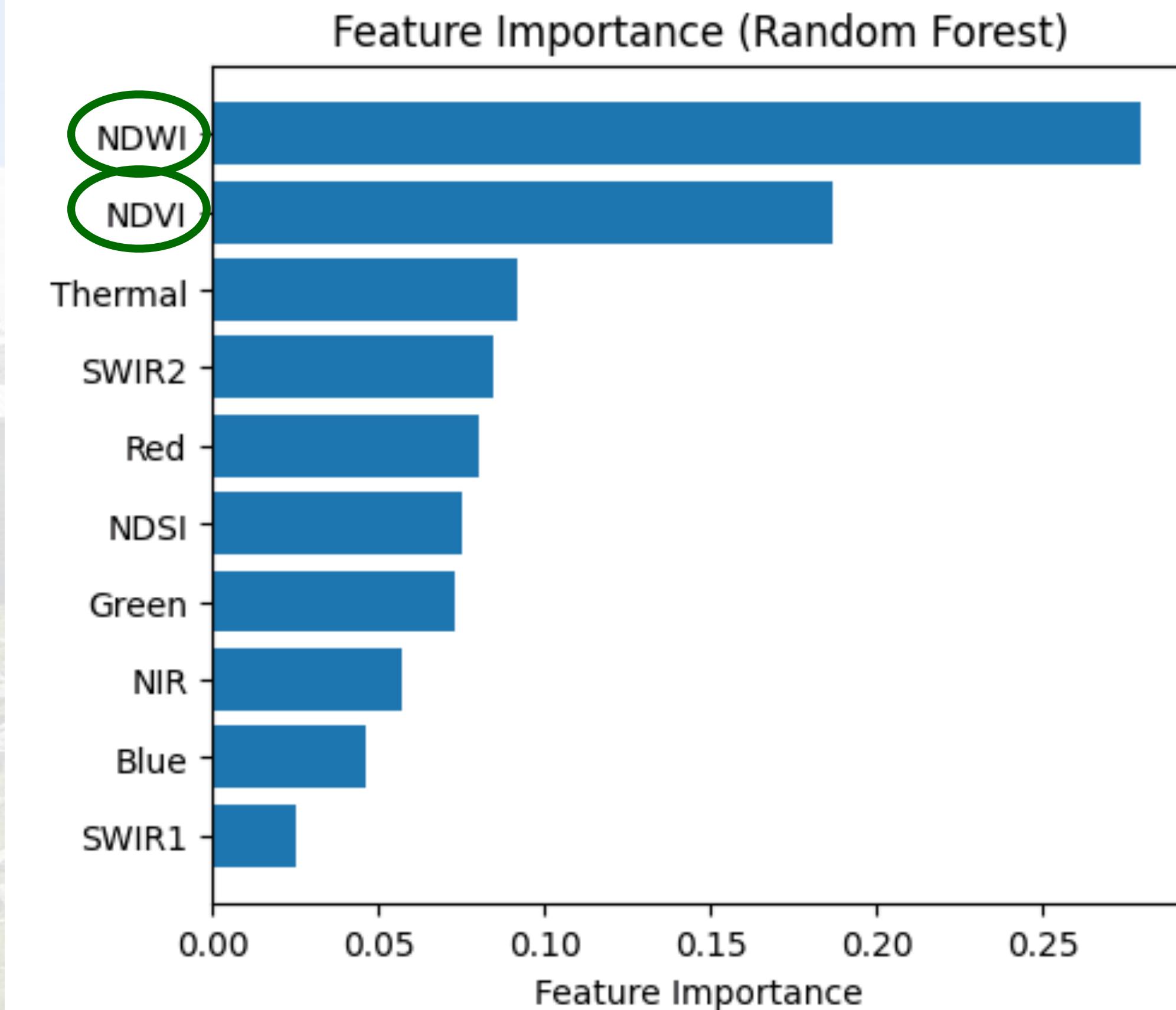
- 1178 samples
 - (75 %) - 858 training samples
 - (25 %) - 320 testing samples

RF Model

- *ee.Classifier.smileRandomForest()*
- DT = 110
- Seed = 42

RF training performance

- Overall accuracy: 100%
- Overfitting: 0.9 %



Machine learning approaches - MLP

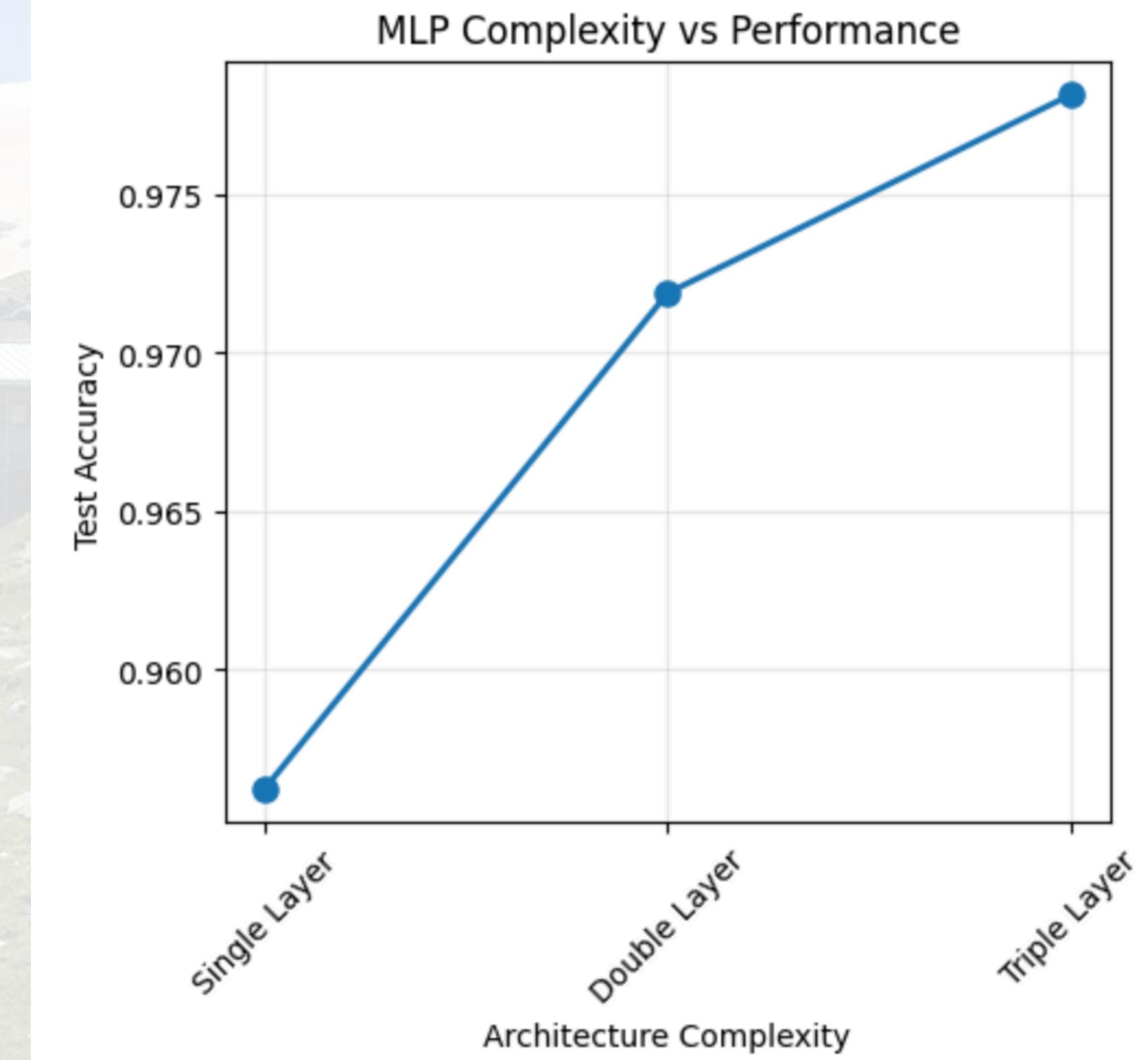
Multi-layer Perceptron implementation

MLP architecture

- Hidden layers: 128 | 128-64 | 128-64-32
- Learning rate: 0.001

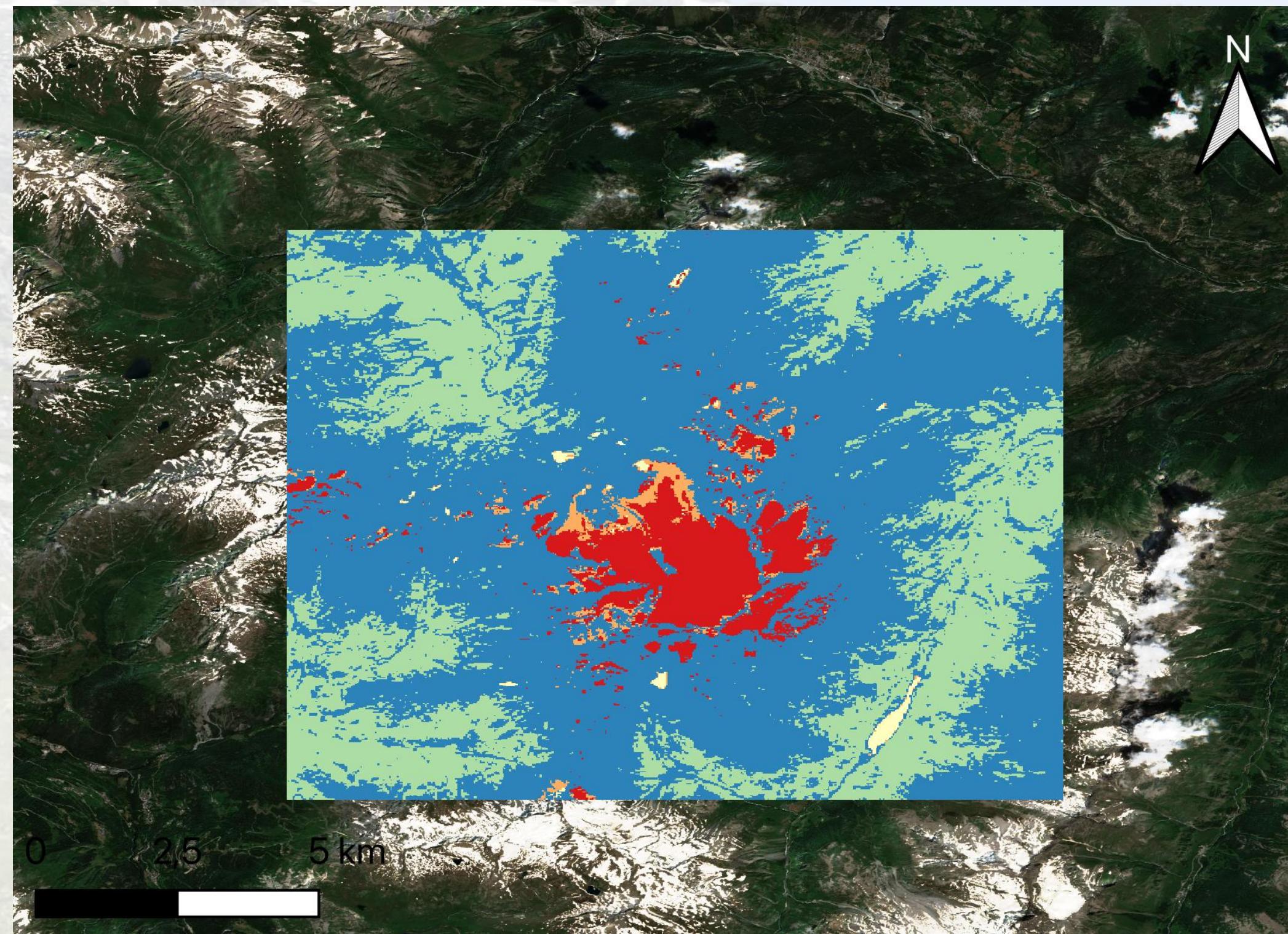
MLP Model

- *MLPClassifier()*
 - `hidden_layer_size()`
 - Activation = ‘relu’
 - Loss function: ‘cross-entropy’
 - Low learning rate: 0.001



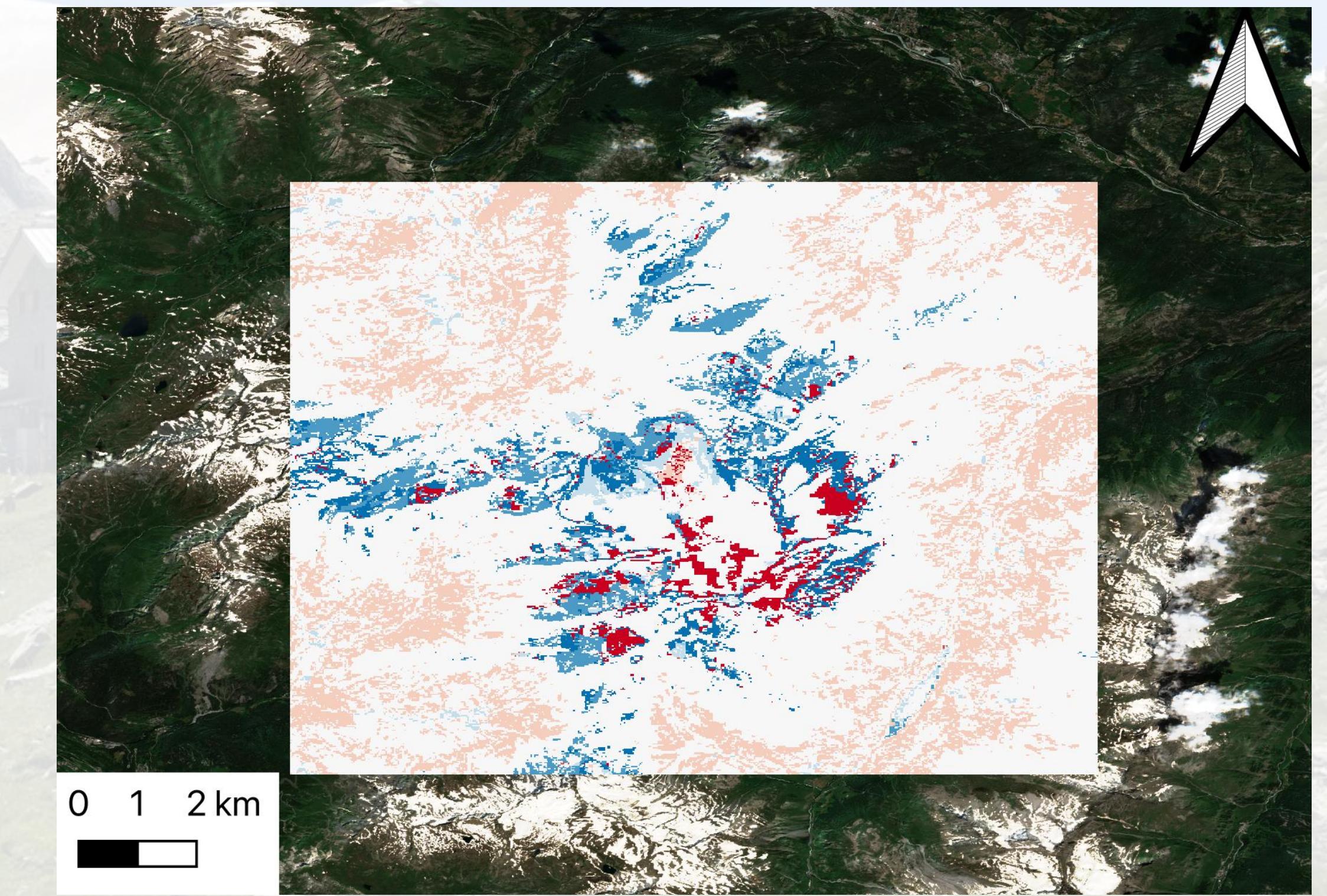
Results RF

Random Forest classification



RF 2020-2024 classification map

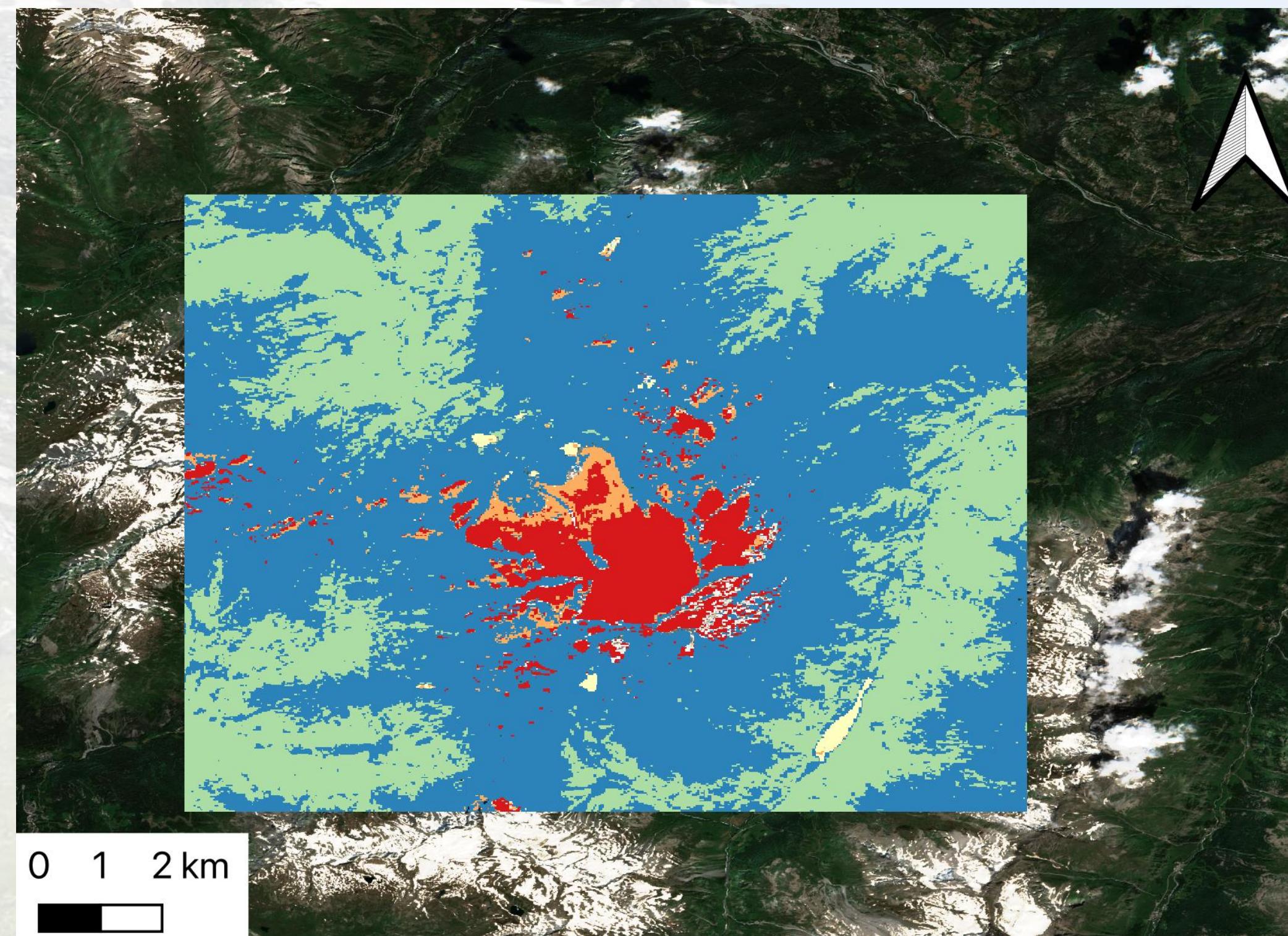
RF difference = 2024 - 1984



RF 2024 - 1984 difference in classification map

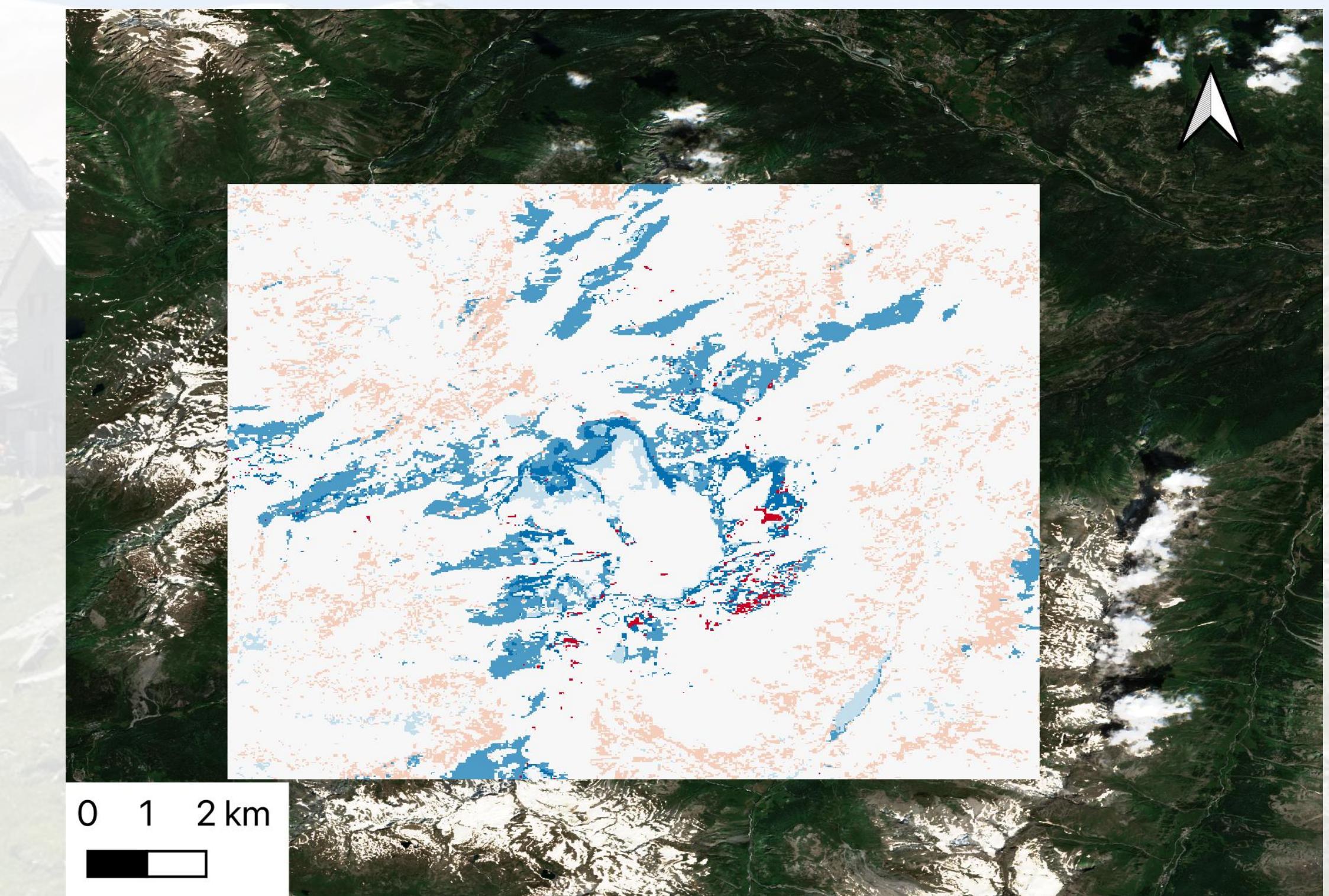
Results MLP

MLP classification 2024



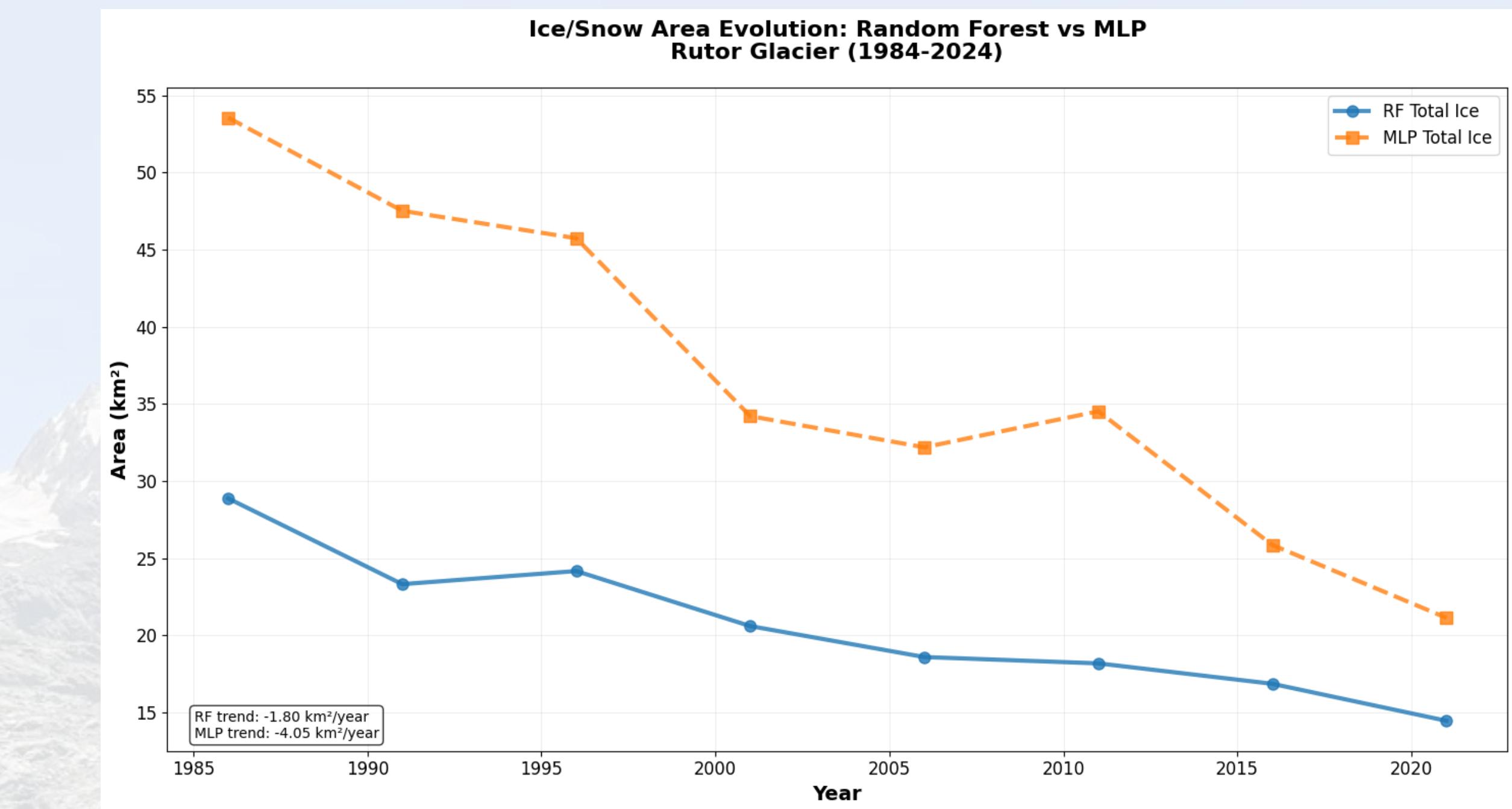
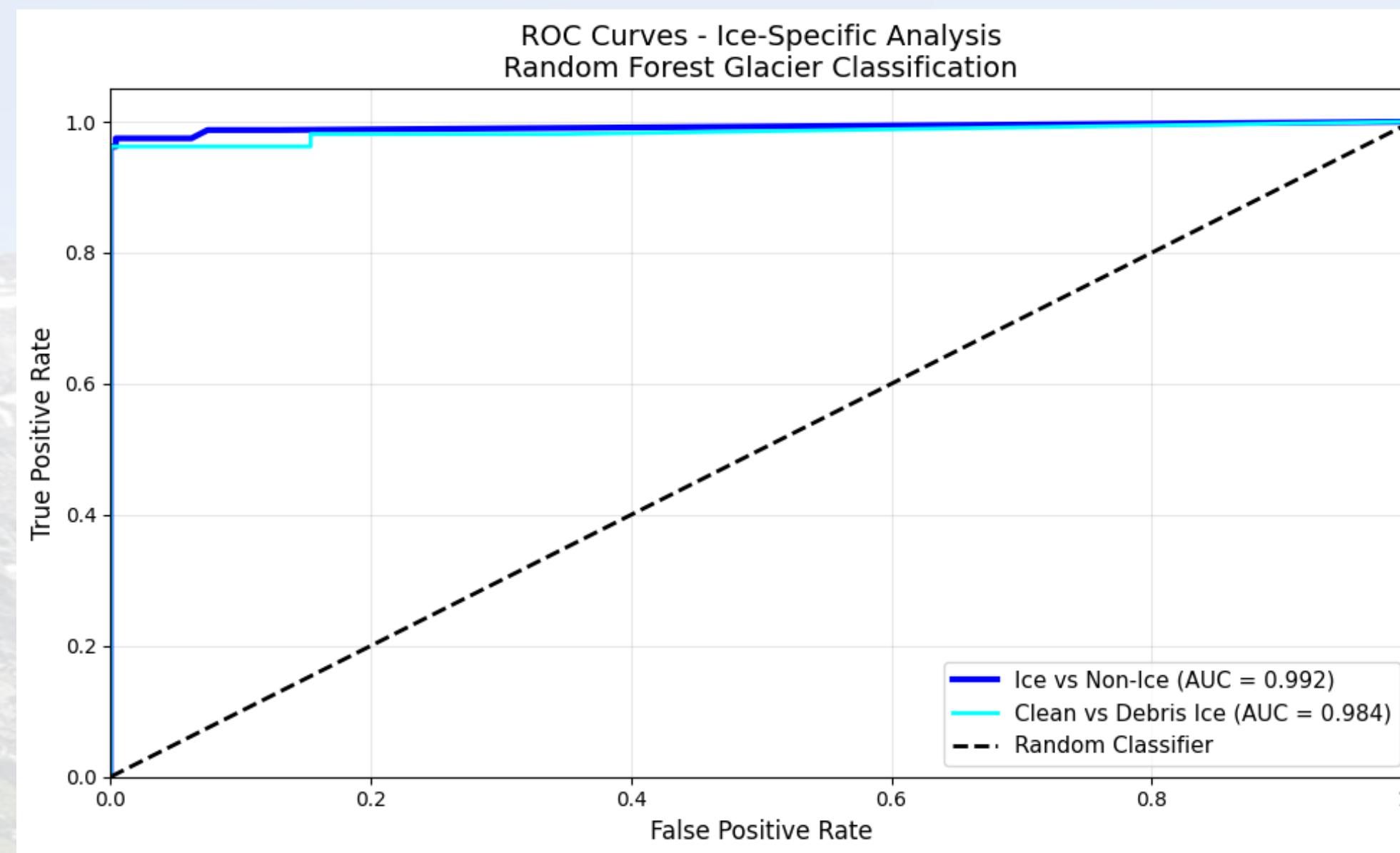
MLP 2020-2024 classification map

MLP difference = 2024 - 1984



MLP 2024 - 1984 difference

RF vs MLP



== DETAILED ANALYSIS: Random Forest ==

Classification Report:

	precision	recall	f1-score	support
Clean Ice	1.00	0.96	0.98	53
Debris Ice	1.00	0.96	0.98	26
Water	1.00	1.00	1.00	18
Vegetation	1.00	1.00	1.00	47
Rock	0.98	1.00	0.99	176
accuracy			0.99	320
macro avg	1.00	0.98	0.99	320
weighted avg	0.99	0.99	0.99	320

Confusion Matrix:

```
[[ 51  0  0  0  2]
 [ 0 25  0  0  1]
 [ 0  0 18  0  0]
 [ 0  0  0 47  0]
 [ 0  0  0  0 176]]
```

RF Performance evaluation

== DETAILED ANALYSIS: MLP Triple Layer ==

Classification Report:

	precision	recall	f1-score	support
Clean Ice	1.00	0.92	0.96	53
Debris Ice	0.89	0.96	0.93	26
Water	1.00	0.94	0.97	18
Vegetation	0.98	1.00	0.99	47
Rock	0.98	0.99	0.99	176
accuracy			0.98	320
macro avg	0.97	0.96	0.97	320
weighted avg	0.98	0.98	0.98	320

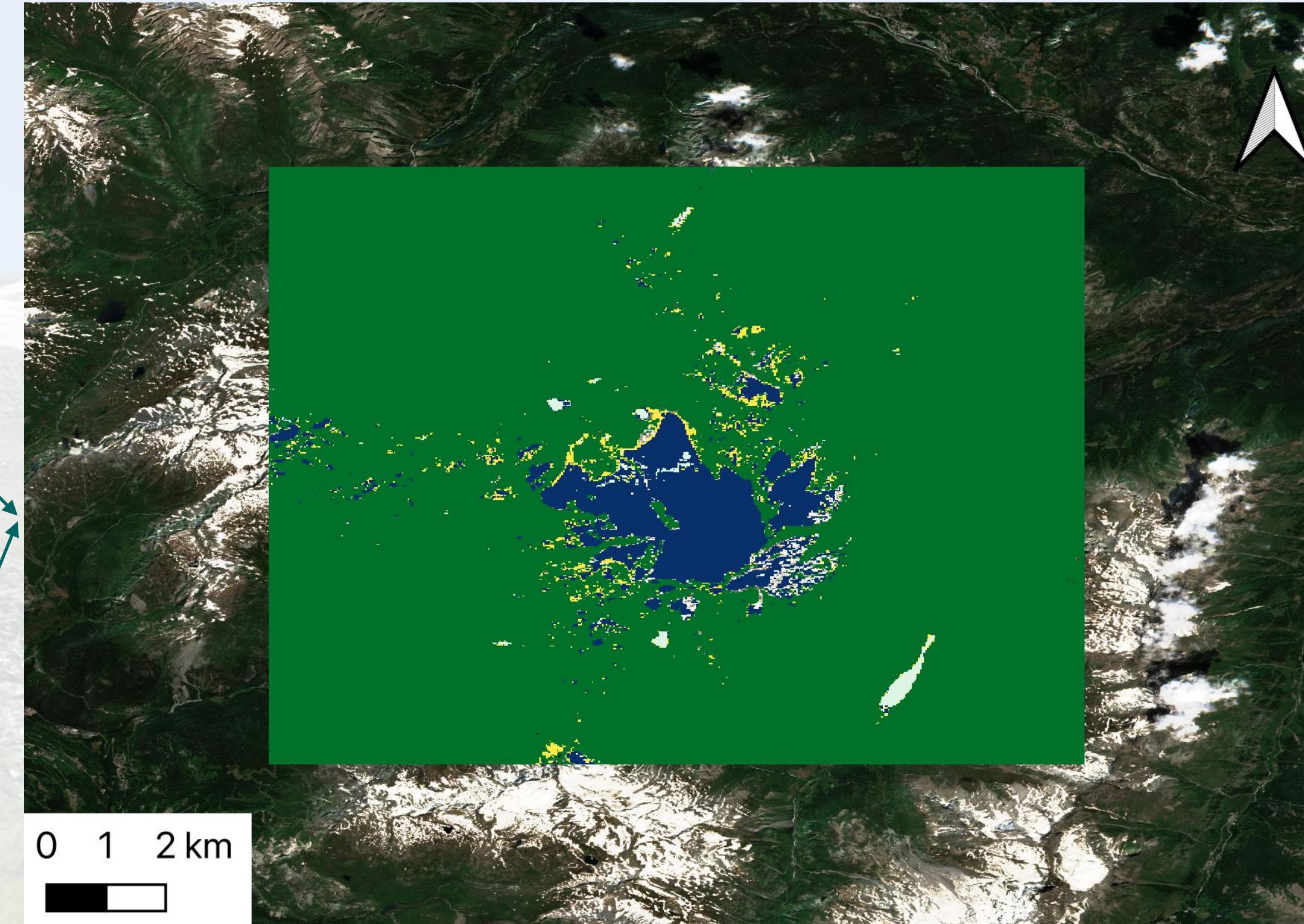
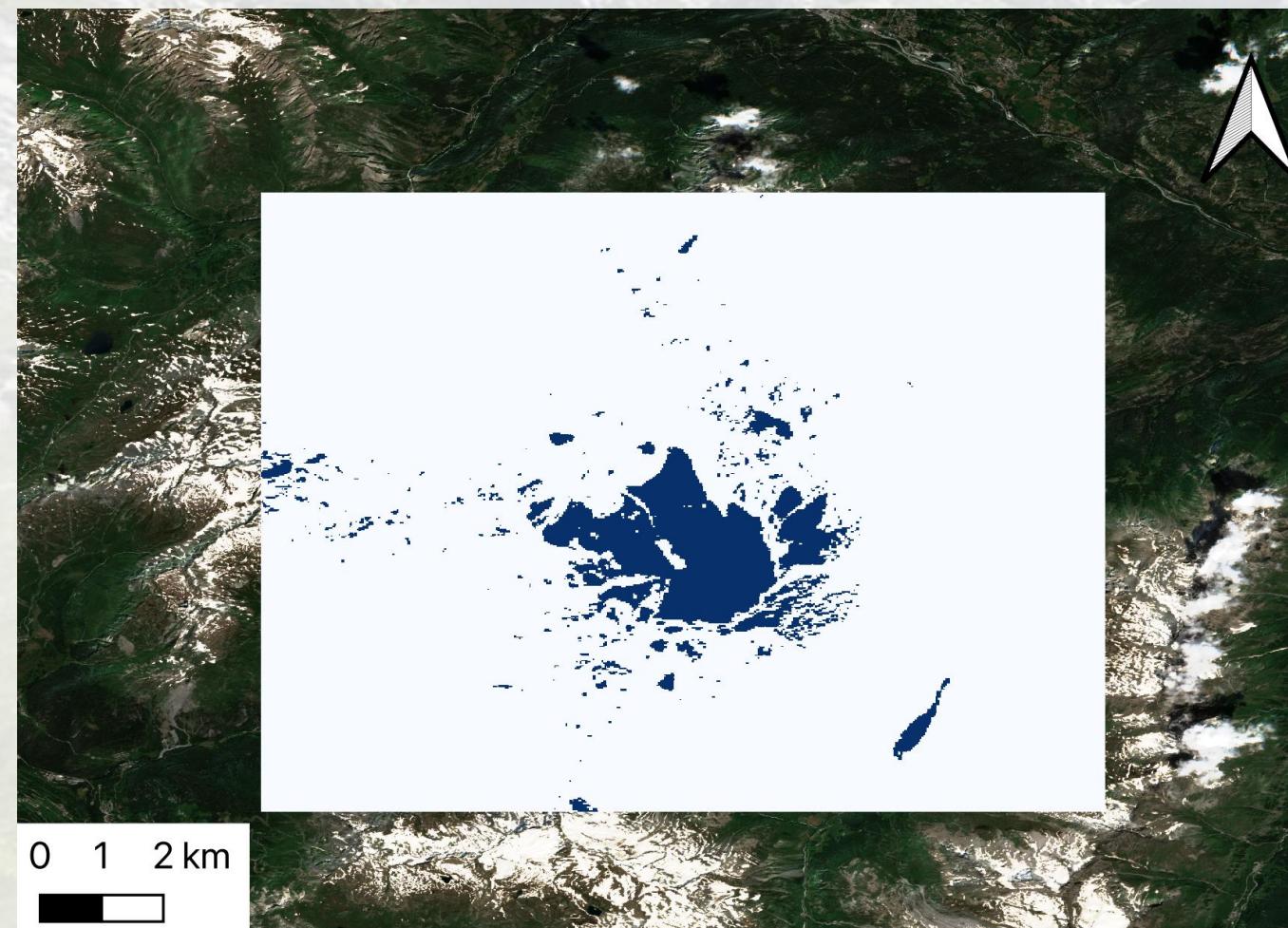
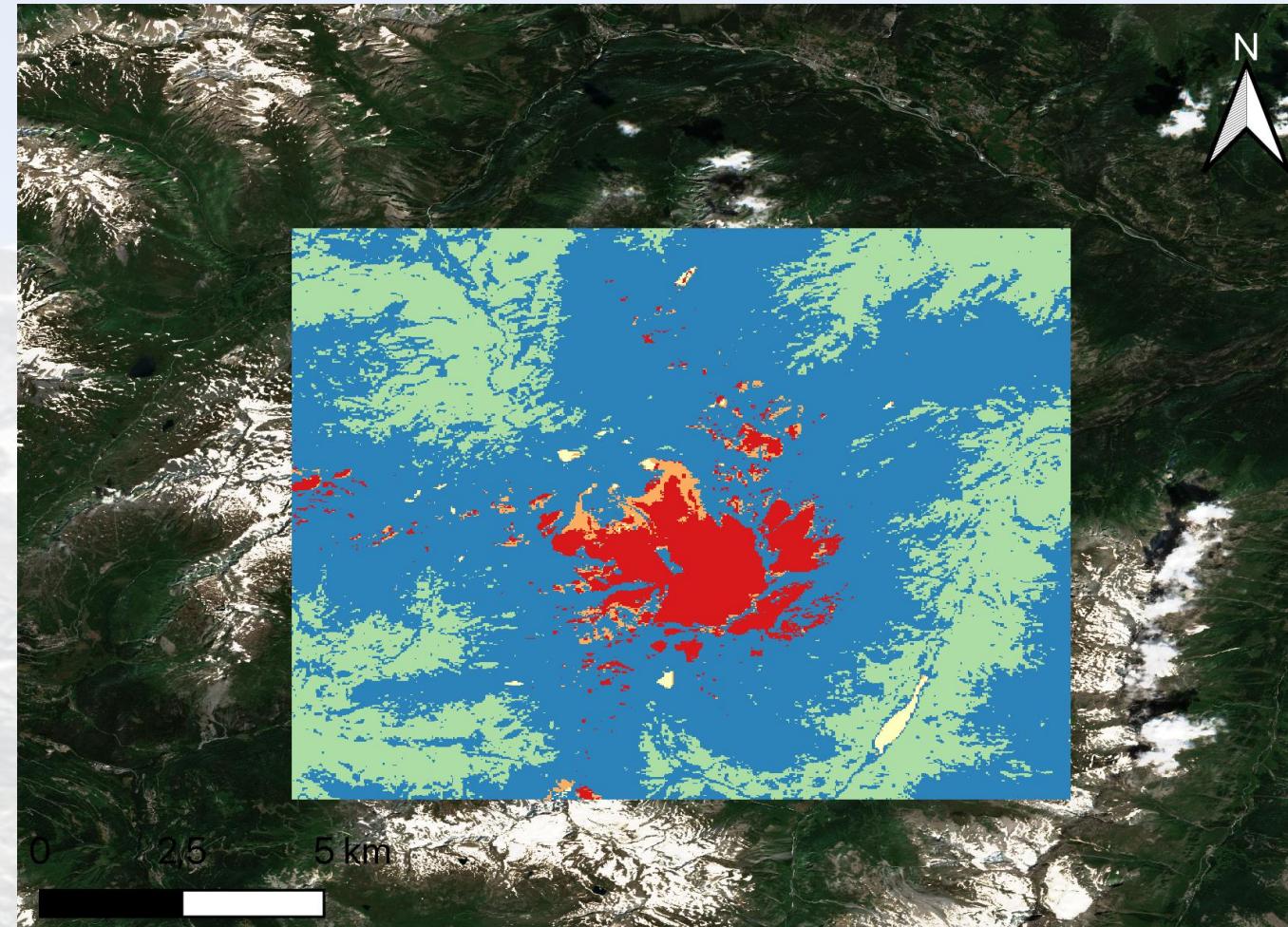
Confusion Matrix:

```
[[ 49  2  0  0  2]
 [ 0 25  0  0  1]
 [ 0  1 17  0  0]
 [ 0  0  0 47  0]
 [ 0  0  0  0 175]]
```

MLP performance evaluation

Indices

How ML model compares against NDSI



Legend

- RF, NDSI
- RF no, NDSI
- RF, NDSI no
- RF no, NDSI no

Agreement

- Overall agreement : 97, 71%
- Clean ice agreement: 95, 9%
- Debris ice agreement: 42, 2%

Testing

How RF compare with other glacier testing

Lys glacier

- 2250 samples
 - 755
 - 65
 - 36
 - 35
 - 1359
- Overall accuracy: 96, 9 %

$$\begin{bmatrix} 755 & 0 & 0 & 0 & 0 \\ 7 & 27 & 0 & 0 & 31 \\ 1 & 0 & 34 & 0 & 1 \\ 0 & 0 & 0 & 30 & 5 \\ 1 & 1 & 0 & 23 & 1334 \end{bmatrix}$$

Géant Glacier

- 2369 samples
 - 1209
 - 458
 - 2
 - 111
 - 589
- Overall accuracy: 78, 4 %

$$\begin{bmatrix} 1172 & 13 & 0 & 0 & 24 \\ 160 & 19 & 0 & 0 & 279 \\ 0 & 2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 86 & 25 \\ 8 & 3 & 0 & 0 & 578 \end{bmatrix}$$

Conclusion

Data

- Not uniform samples
- Gap in the first images
- Gap between the two satellites missions

Methodology

- NDSI -> 97,71 % agreement
- NDWI and NDVI most important features
- Vegetation and water area are increasing
- RF outperformed MLP with minimal overfitting

Climat change

- Glacier is melting!
- Vegetation and water area are increasing

Thanks for the attention

