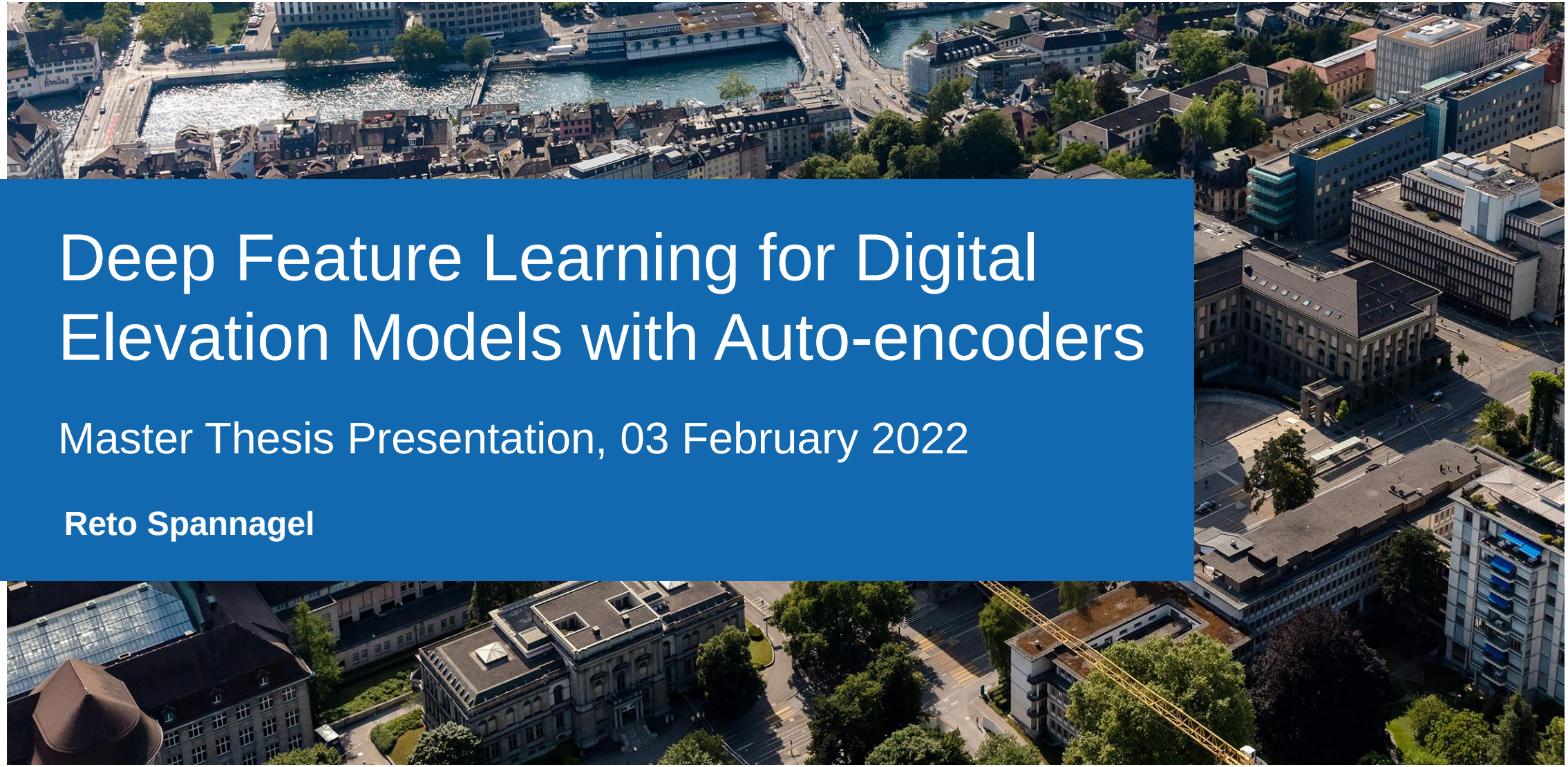
ETH zürich



Deep Feature Learning for Digital Elevation Models with Auto-encoders

Master Thesis Presentation, 03 February 2022

Reto Spannagel

Table of contents

Introduction

- Subdivision of a digital elevation model (DEM of Switzerland) into different landscape classes
- Learning and identifying meaningful features from a DEM for clustering
- Investigation of feasible auto-encoder architectures for deep feature learning

- Landscape Typology of Switzerland (ARE, BAFU, BFS)

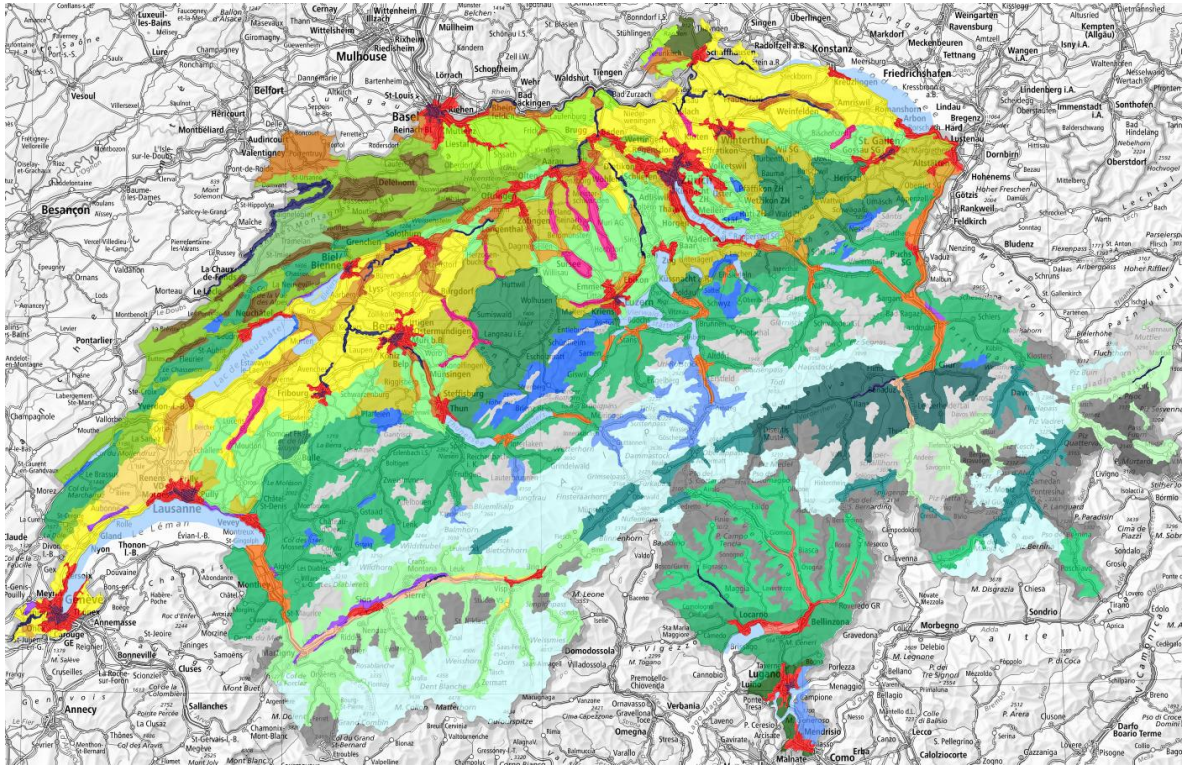
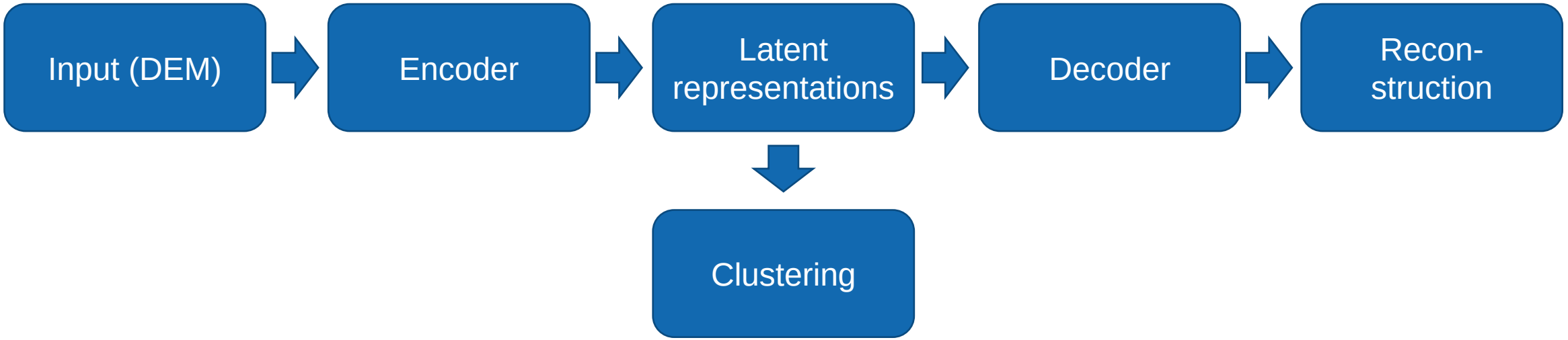


Figure: Baumann (2016)

Introduction

- Auto-encoder model

$$\min_{\phi,\theta} L_{rec} = \min \frac{1}{n} \sum_{i=1}^{n} ||x_i - x_n||^2$$



Auto-encoder architecture

- Auto-encoder model: SegNet architecture

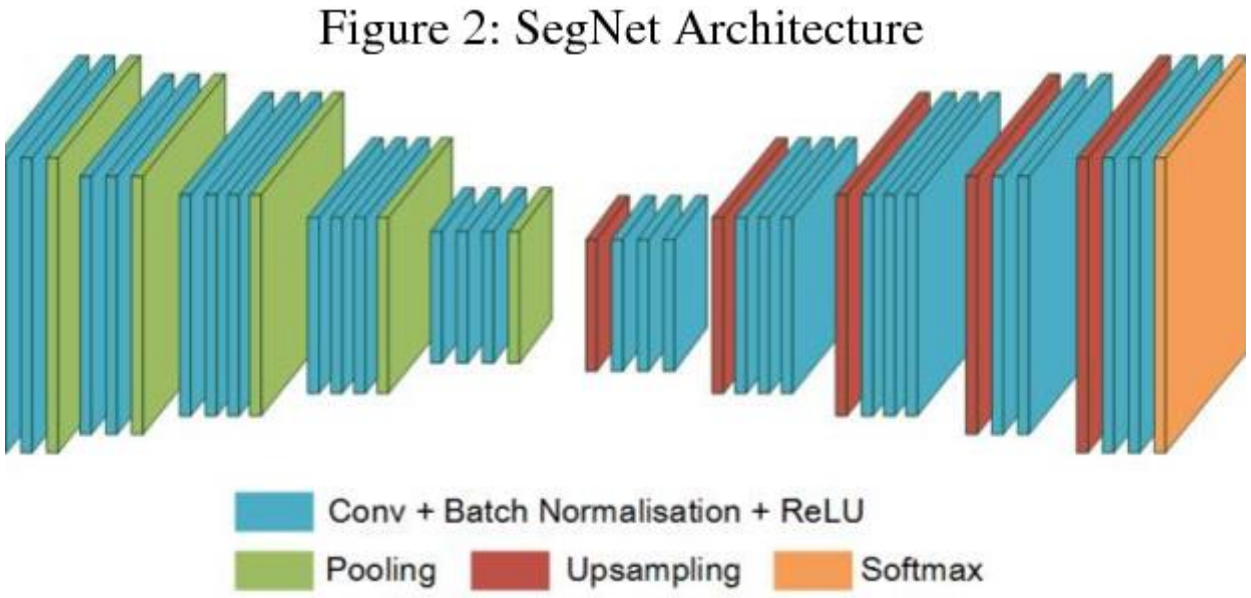


Figure: Du et al. (2018)

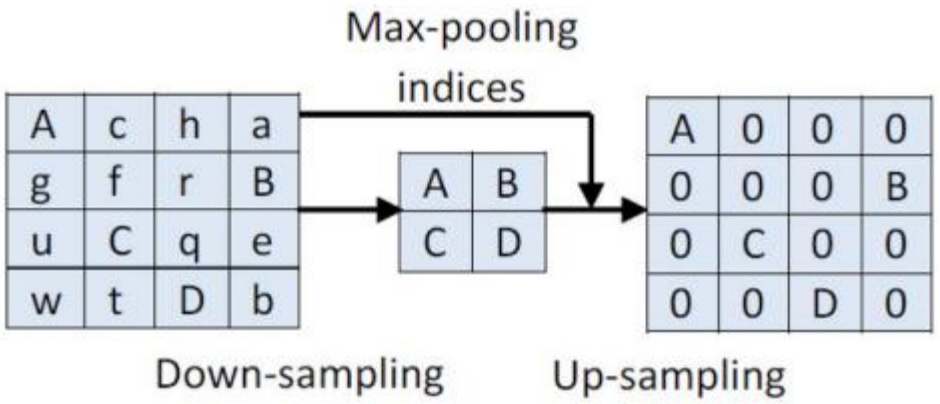
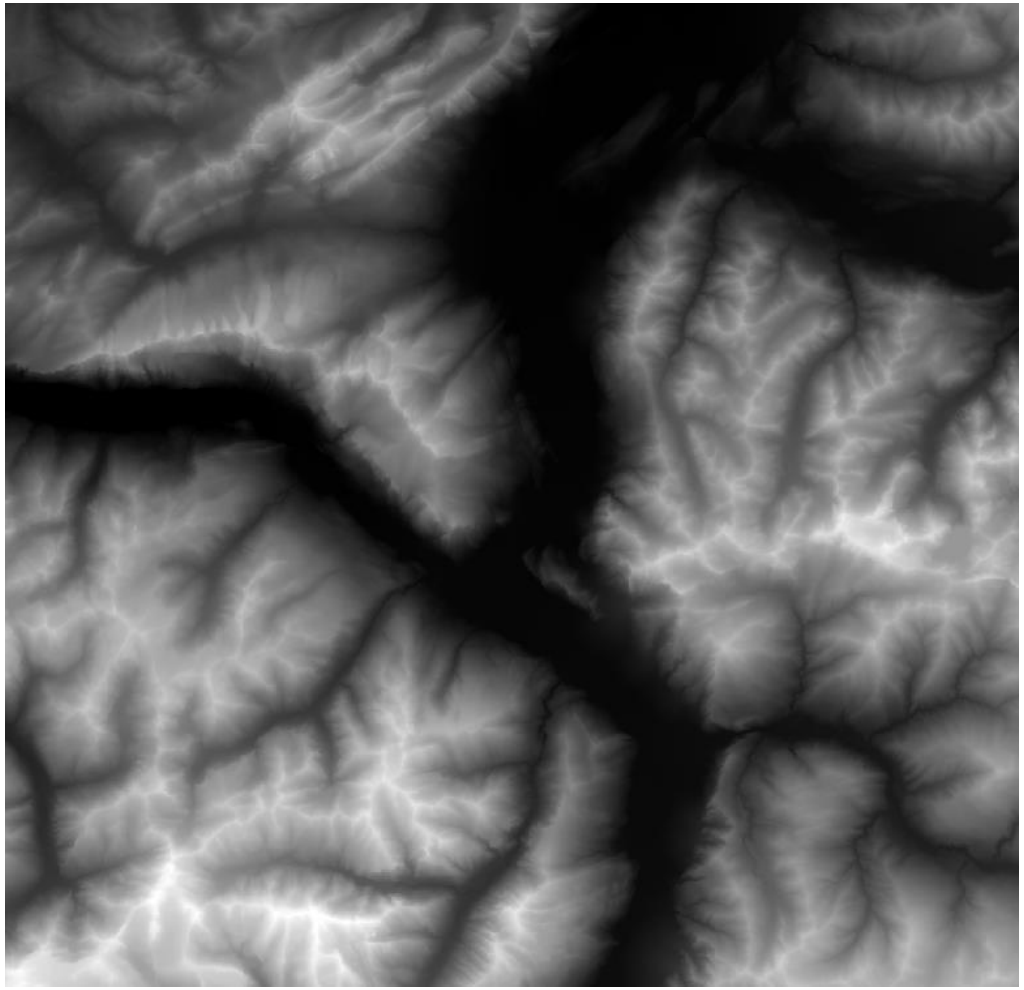


Figure: Badrinarayanan et al. (2015)

Model training

- Input samples: 128 x 128 px
- Kernel size: 3 x 3
- Batch size: 16
- 128 training samples, 32 validation samples (fixed selection)
- 1000 epochs
- Learning rate: 0.001

Study area



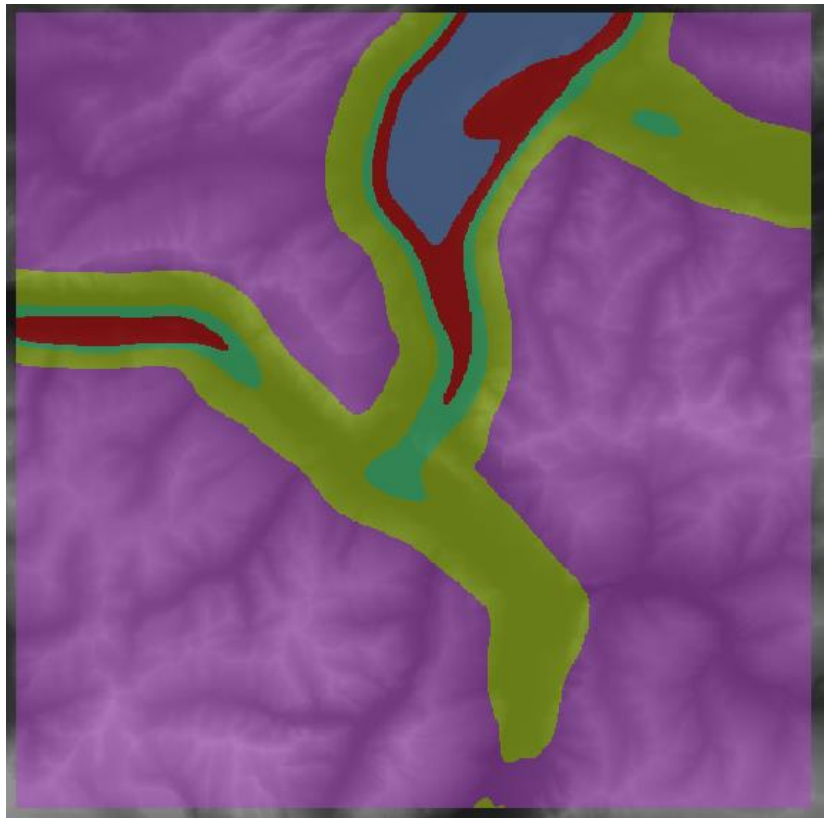
Model A

Input sample 128 x 128	
2x conv. + pooling 2 x 2	Feature 128 x 128 x 8
2x conv. + pooling 2 x 2	Feature 64 x 64 x 16
3x conv. + pooling 2 x 2	Feature 32 x 32 x 32
3x conv. + pooling 2 x 2	Feature 16 x 16 x 64
3x conv. + pooling 2 x 2	Feature 8 x 8 x 64
3x conv. + pooling 2 x 2	Feature 4 x 4 x 64
3x conv. + pooling 2 x 2	Feature 2 x 2 x 64
3x conv. + pooling 2 x 2	Feature 64

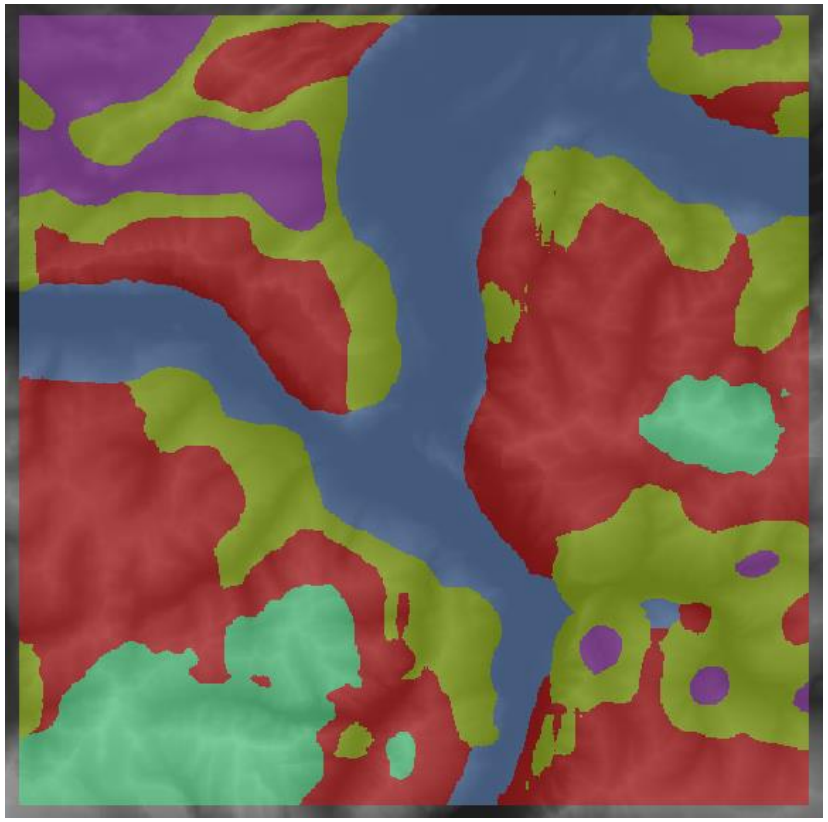
Model B

Input sample 128 x 128	
2x conv. + pooling 2 x 2	Feature 128 x 128 x 8
2x conv. + pooling 2 x 2	Feature 64 x 64 x 16
3x conv. + pooling 2 x 2	Feature 32 x 32 x 32
3x conv. + pooling 2 x 2	Feature 16 x 16 x 64
3x conv. + pooling 2 x 2	Feature 8 x 8 x 64
2x pooling 2 x 2	Feature 2 x 2 x 64
Flatten	Feature 256

Model A



Model B



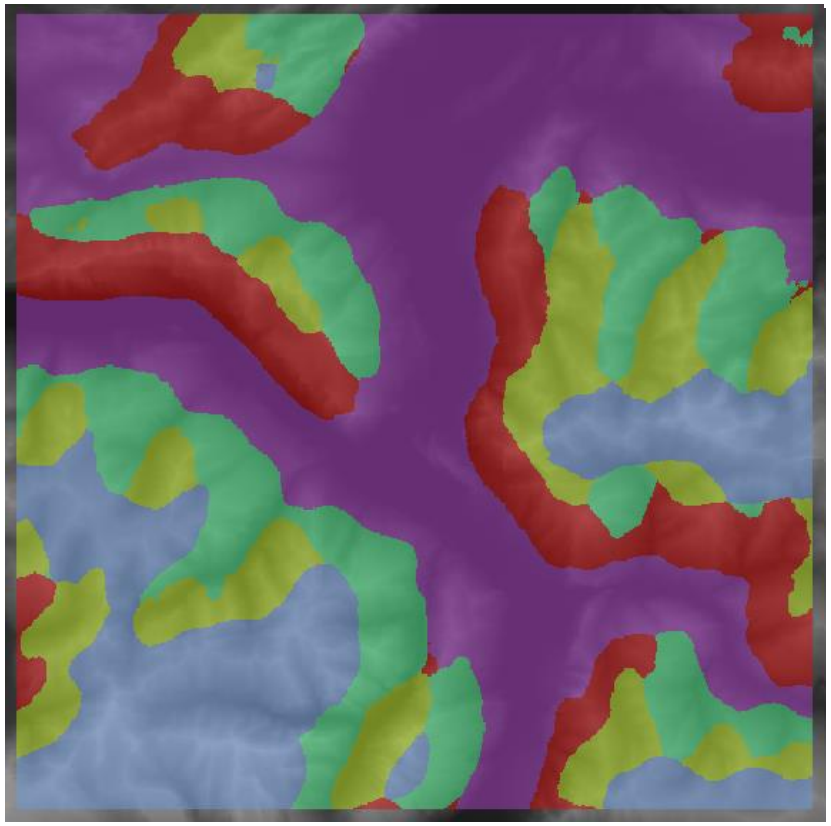
Model C

Input sample 128 x 128	
2x conv. + pooling 2 x 2	Feature 128 x 128 x 8
2x conv. + pooling 2 x 2	Feature 64 x 64 x 16
3x conv. + pooling 2 x 2	Feature 32 x 32 x 32
3x conv. + pooling 2 x 2	Feature 16 x 16 x 64
3x conv. + pooling 2 x 2	Feature 8 x 8 x 64
2x pooling 2 x 2	Feature 2 x 2 x 64
Flatten	Feature 256

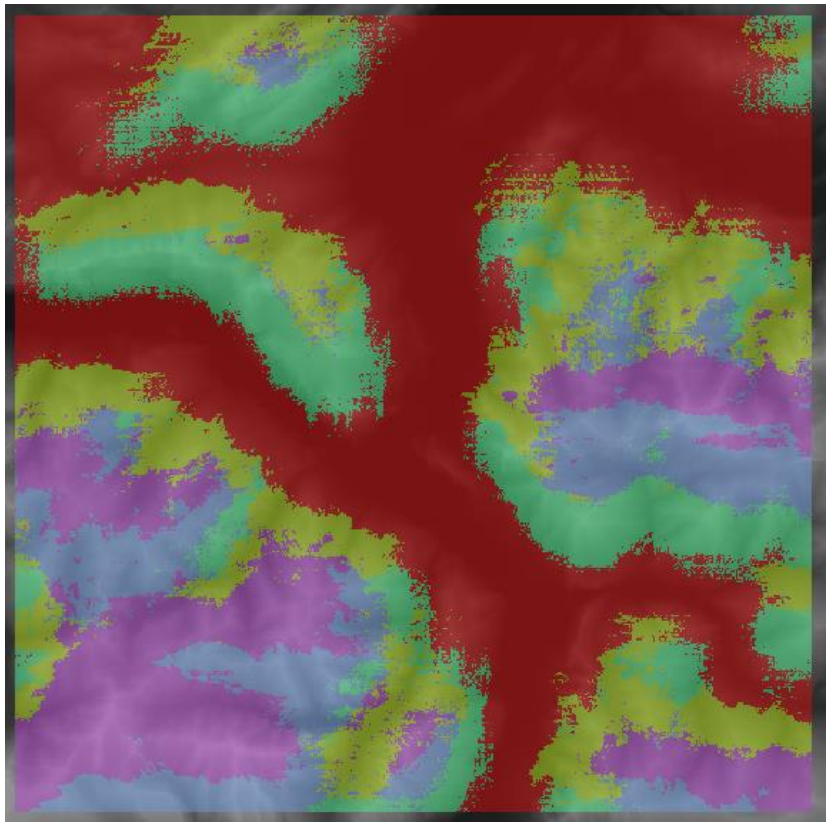
Model D

Input sample 128 x 128	
2x conv. + pooling 2 x 2	Feature 128 x 128 x 2
2x conv. + pooling 2 x 2	Feature 64 x 64 x 2
3x conv. + pooling 2 x 2	Feature 32 x 32 x 4
3x conv. + pooling 2 x 2	Feature 16 x 16 x 4
3x conv. + pooling 2 x 2	Feature 8 x 8 x 4
2x pooling 2 x 2	Feature 2 x 2 x 4
Flatten	Feature 16

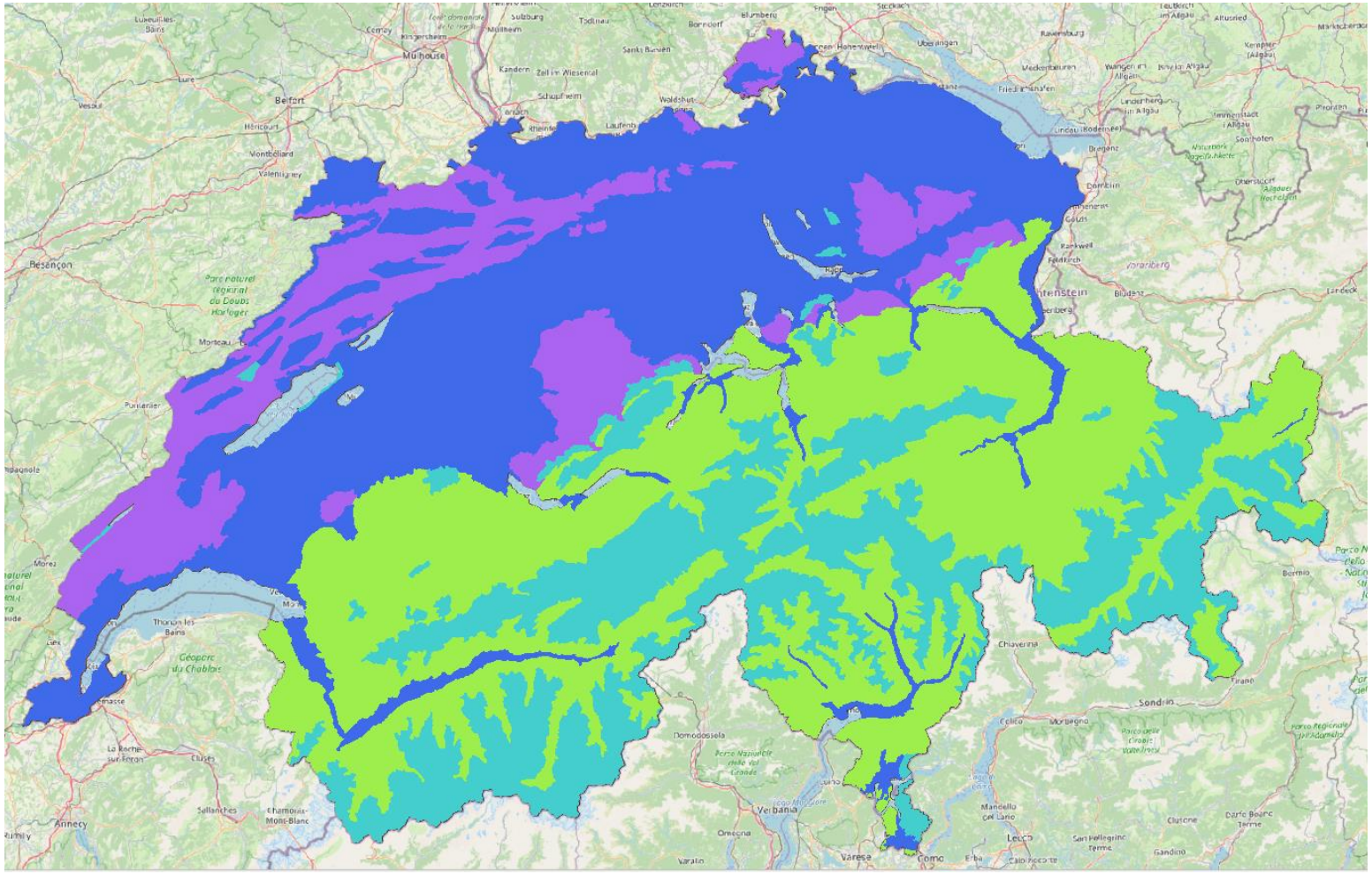
Model C



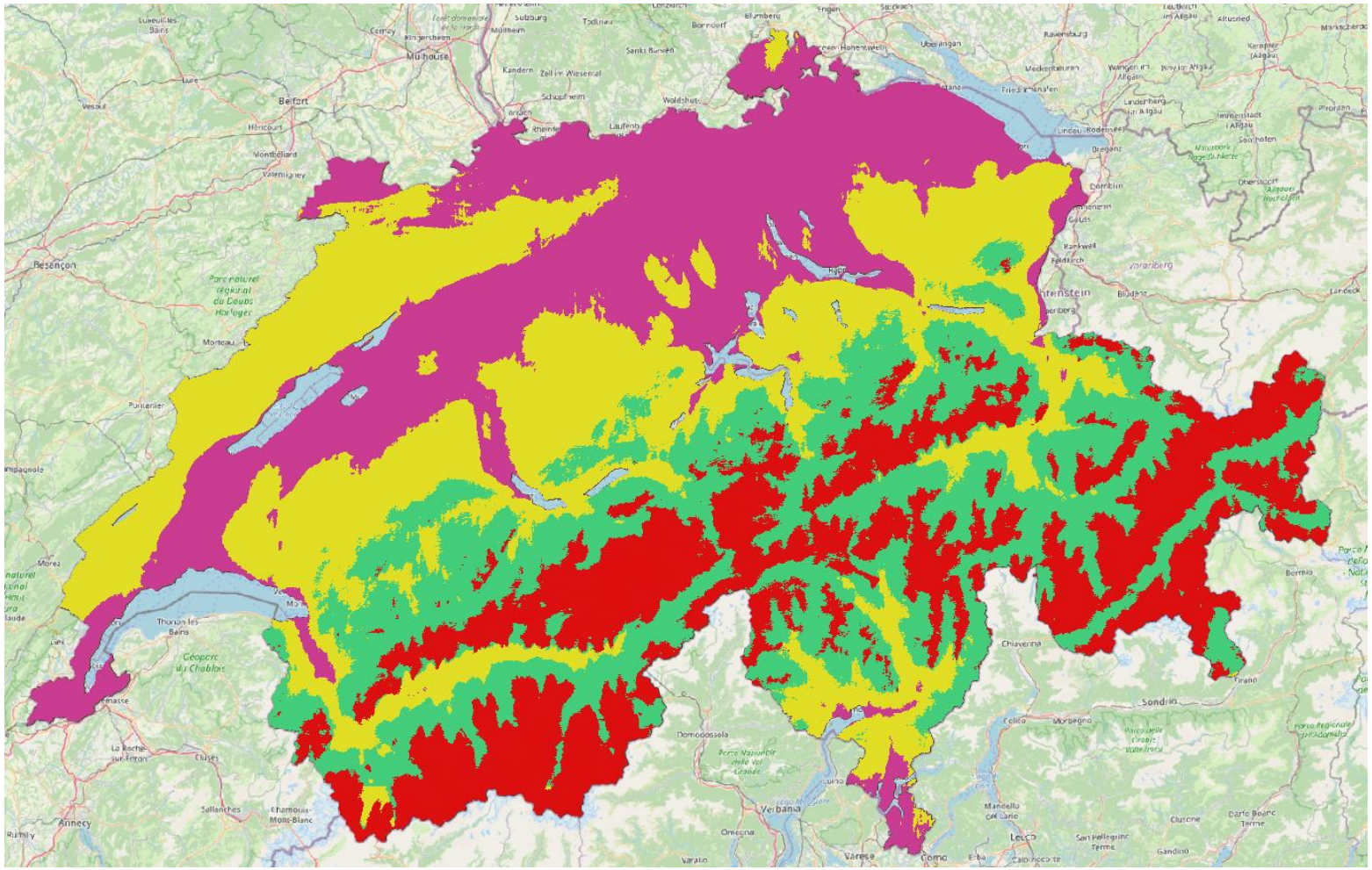
Model D



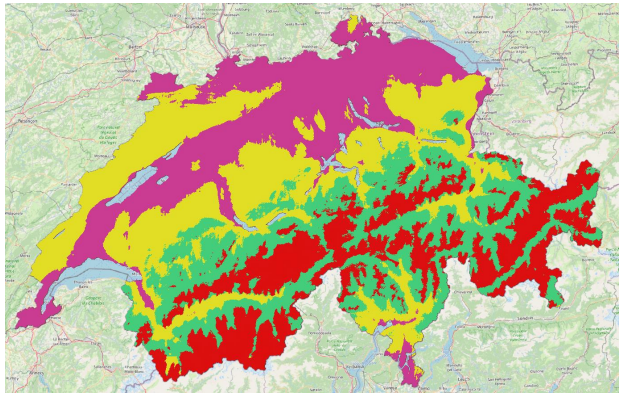
Reduced refeference model



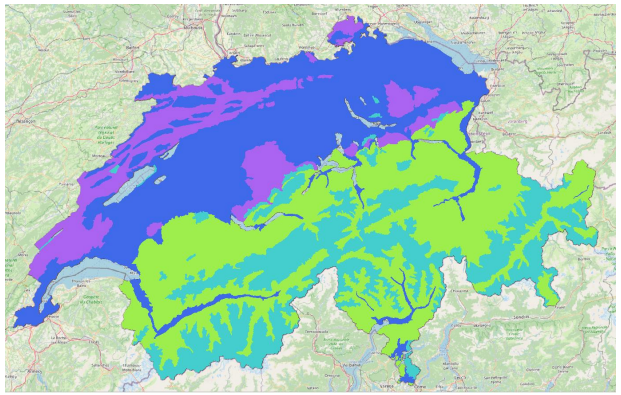
Results


Mulhouse
Belfort
Besançon
Annecy
Chiavenna
Sondrio
Domodossola
Verbania
Varese
Como
Bormio

Results

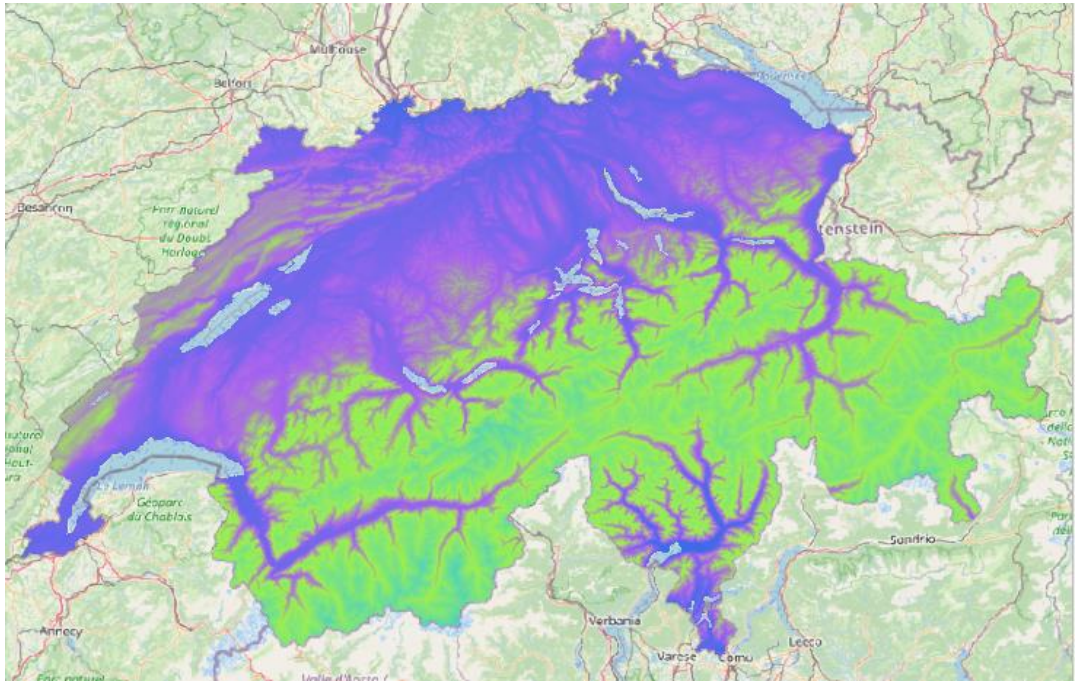


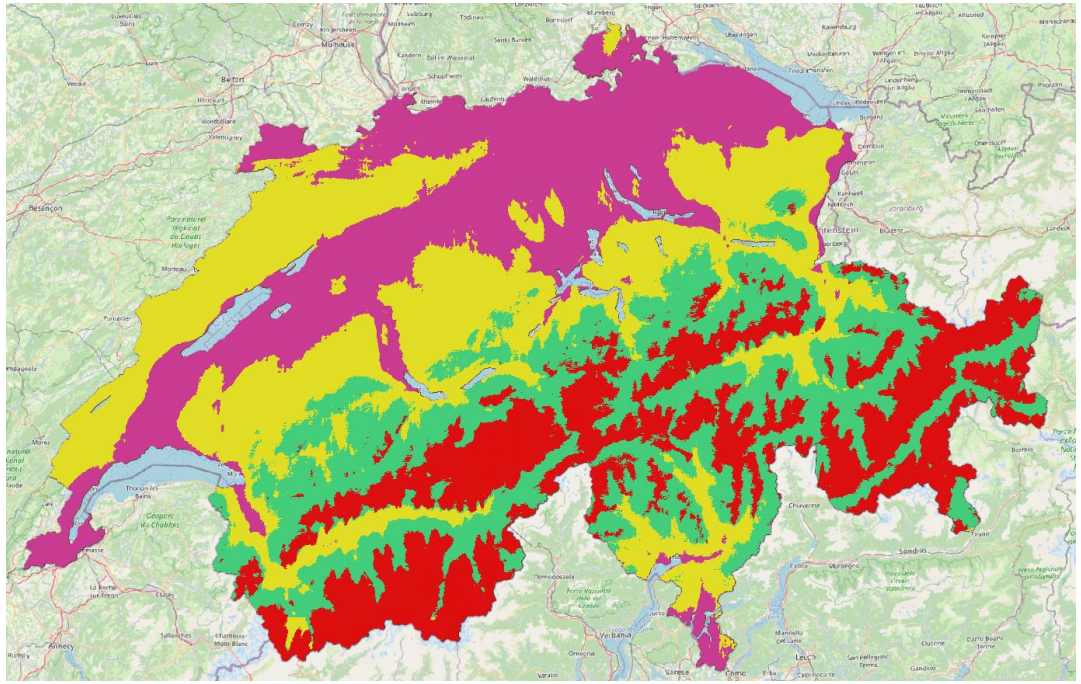
Class	Class A	Class B	Class C	Class D
Class 1	89.1 %	8.5 %	1.4 %	1.0 %
Class 2	33.7 %	32.6 %	30.3 %	3.4 %
Class 3	0.2 %	0.3 %	75.3 %	24.2 %
Class 4	0.0 %	10.0 %	31.3 %	68.7 %



Class	Class 1	Class 2	Class 3	Class 4
Class A	67.8 %	32.1 %	0.1 %	0.0 %
Class B	17.2 %	82.2 %	0.6 %	0.0 %
Class C	1.0 %	26.8 %	53.4 %	18.8 %
Class D	1.1 %	4.8 %	27.6 %	66.4 %

Results


Mulhouse
Belfort
Besançon
Parc Naturel Régional du Doubs Horloger
Géoparc du Chablais
Sondrio
Annecy
Verbania
Varese
Como
Lecco


Mulhouse
Belfort
Besançon
Géoparc du Chablais
Annecy
Verbania
Varese
Como
Lecco

Conclusions

- Creating reasonable classes is possible
- Less complex classes compared to reference model
- Classes mostly characterized by altitude and slope
- Trade-off between strength of model and amount of data

Thank you for your attention !

Questions?