RADARSAT-2* Synthetic-Aperture Radar Land Cover Segmentation using Deep Convolutional Neural Networks

Mirmohammad Saadati, Marco Pedersoli, Patrick Cardinal, Peter Oliver

Laboratoire d'imagerie, de vision et d'intelligence artificielle (LIVIA)

ÉTS
Le génie pour l'industrie

ÉCOLE DE TECHNOLOGIE SUPÉRIEURE

Université du Québec

Outline

- Introduction
- Synthetic Aperture Radar (SAR)
- Proposed Method
- Dataset
- Sampling
- Experimental Results
- Conclusion
- Showcase

Introduction

GOAL

- Evaluate the performance of Deep Learning on land cover pixel-wise classification using Synthetic Aperture Rader (SAR) imagery

MOTIVATION

- Unavailability of large public annotated SAR data
- Noisy SAR images due to different wavelengths and incident angles
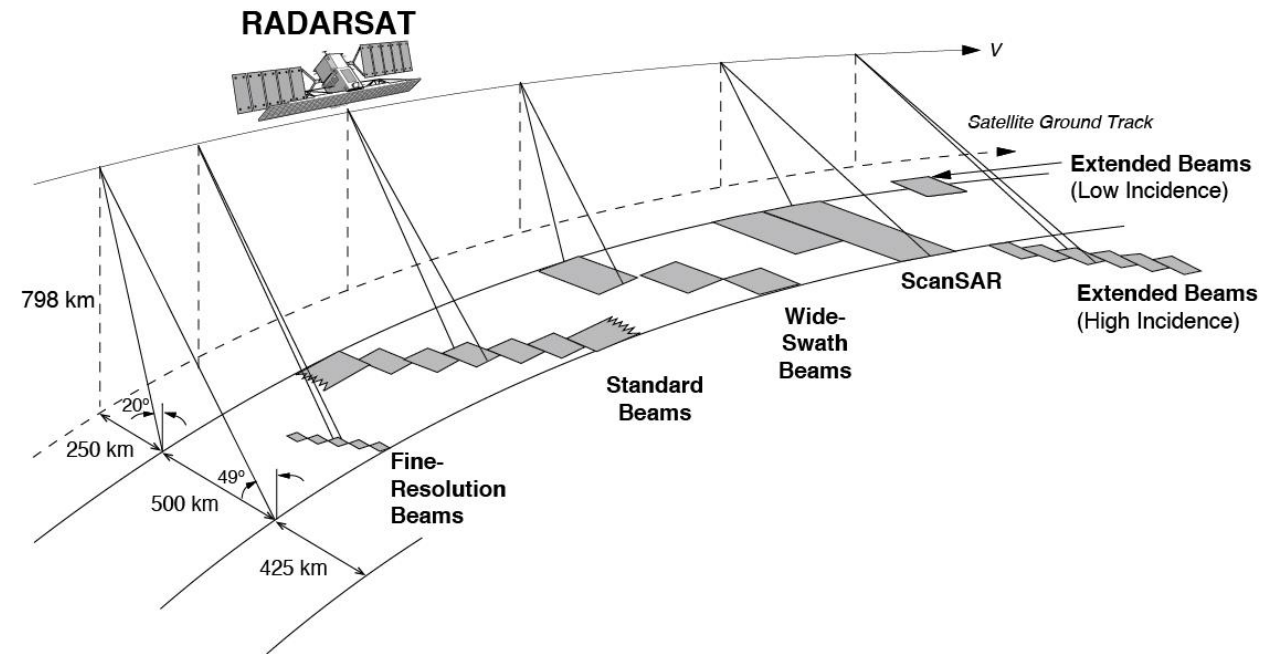- Imbalanced land cover categories

Synthetic Aperture Radar (SAR)

MECHANISM

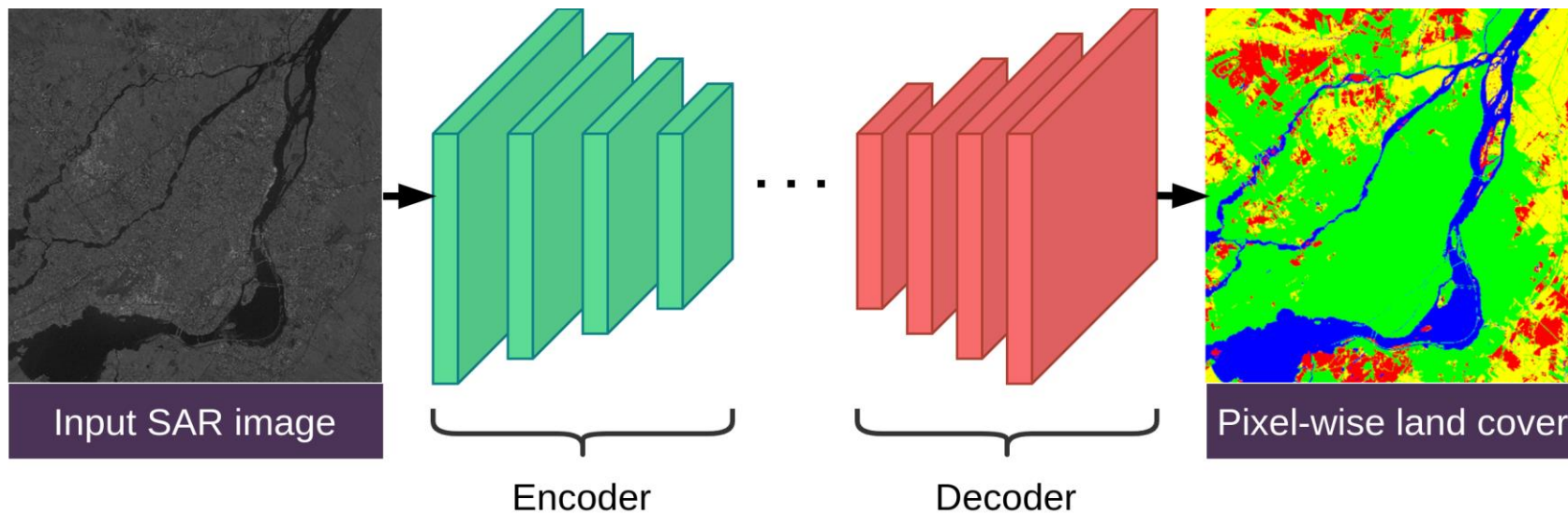- Sequential electromagnetic waves

- Backscattered signal

PROPERTIES

- High spatial resolution

- Continuous (in different weather and lighting conditions)

- Noisy
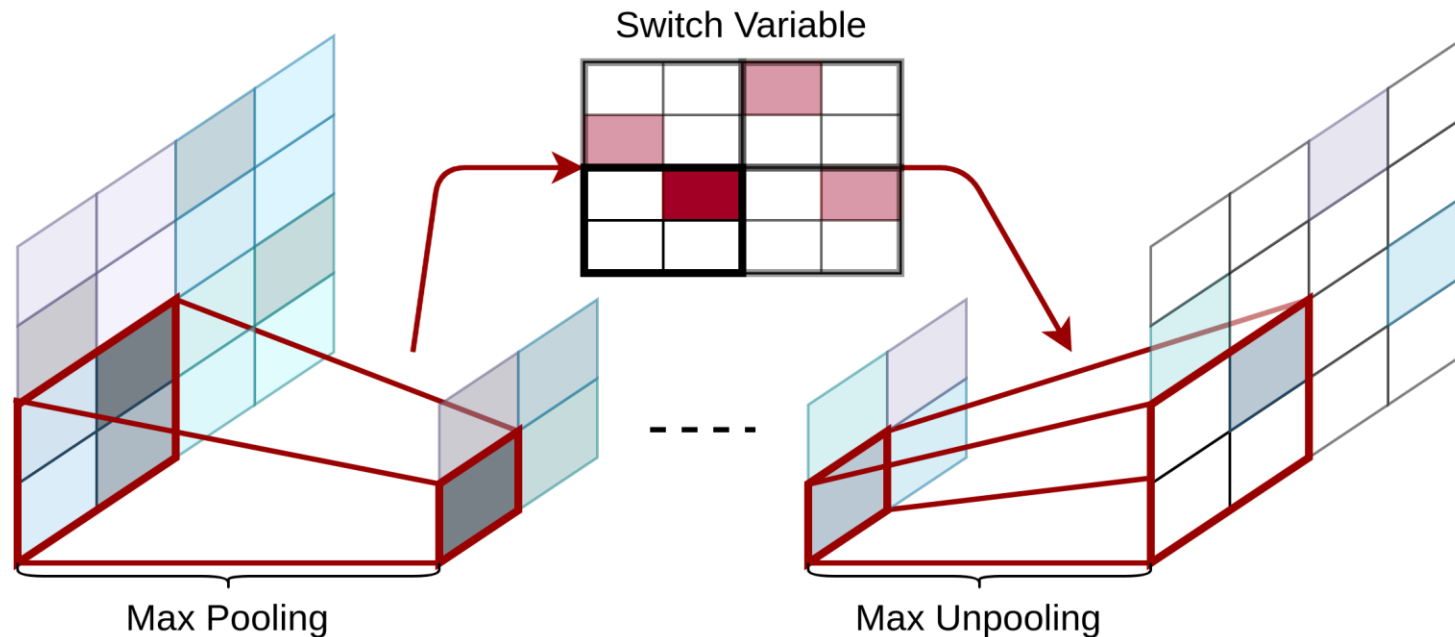
Method

- Semantic segmentation using Deep Convolutional Neural Networks
    - **Encoder-Decoder:** DeconvNet and SegNet
    - **Pyramid Pooling:** PSPNet

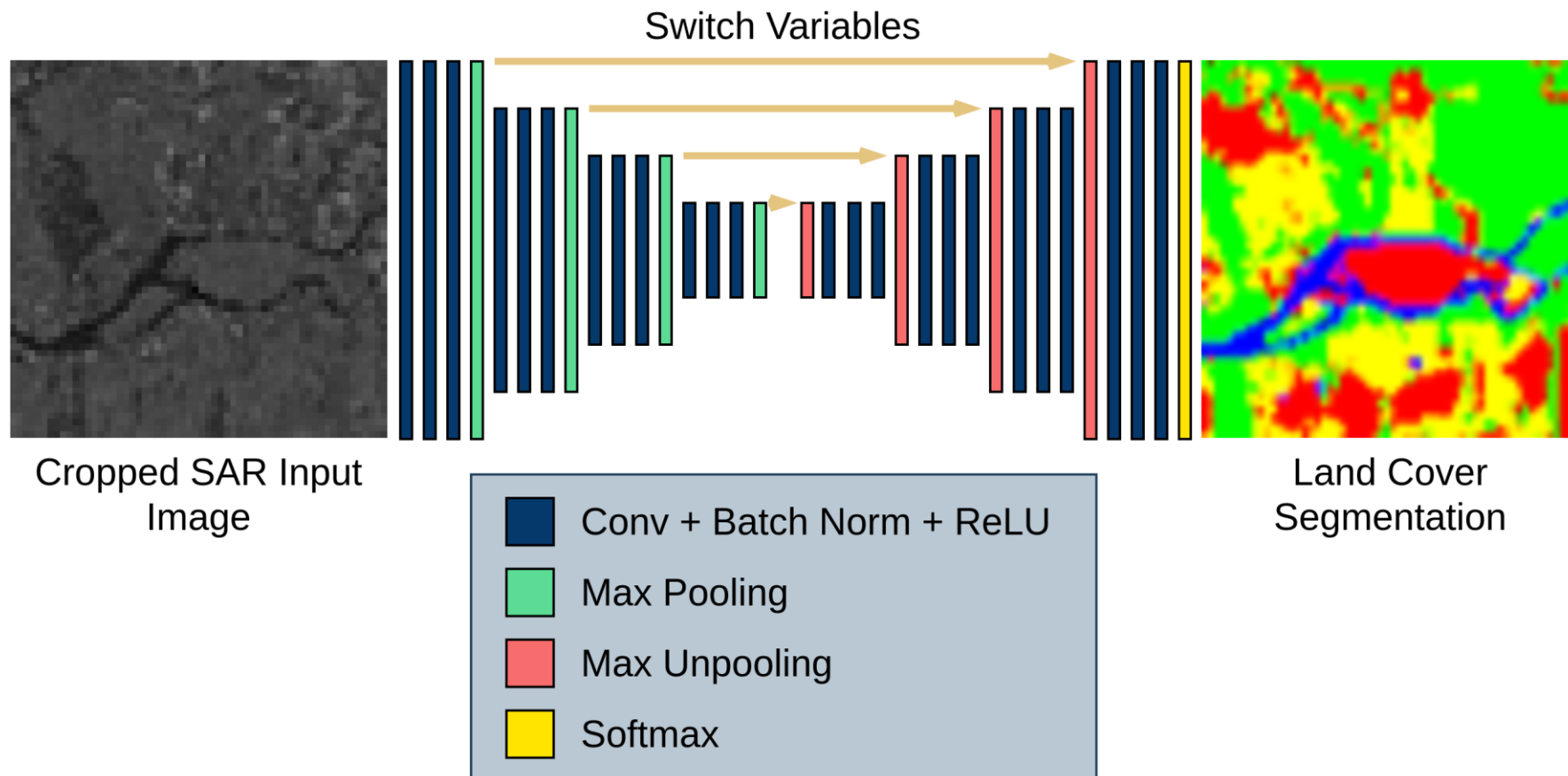Input SAR image   Encoder   Decoder   Pixel-wise land cover

DeconvNet

- Unpooling used to reconstruct the spatial structure of input image
- Deconvolution used to associate the sparse enlarged activations to a dense activation map using multiple learned filters
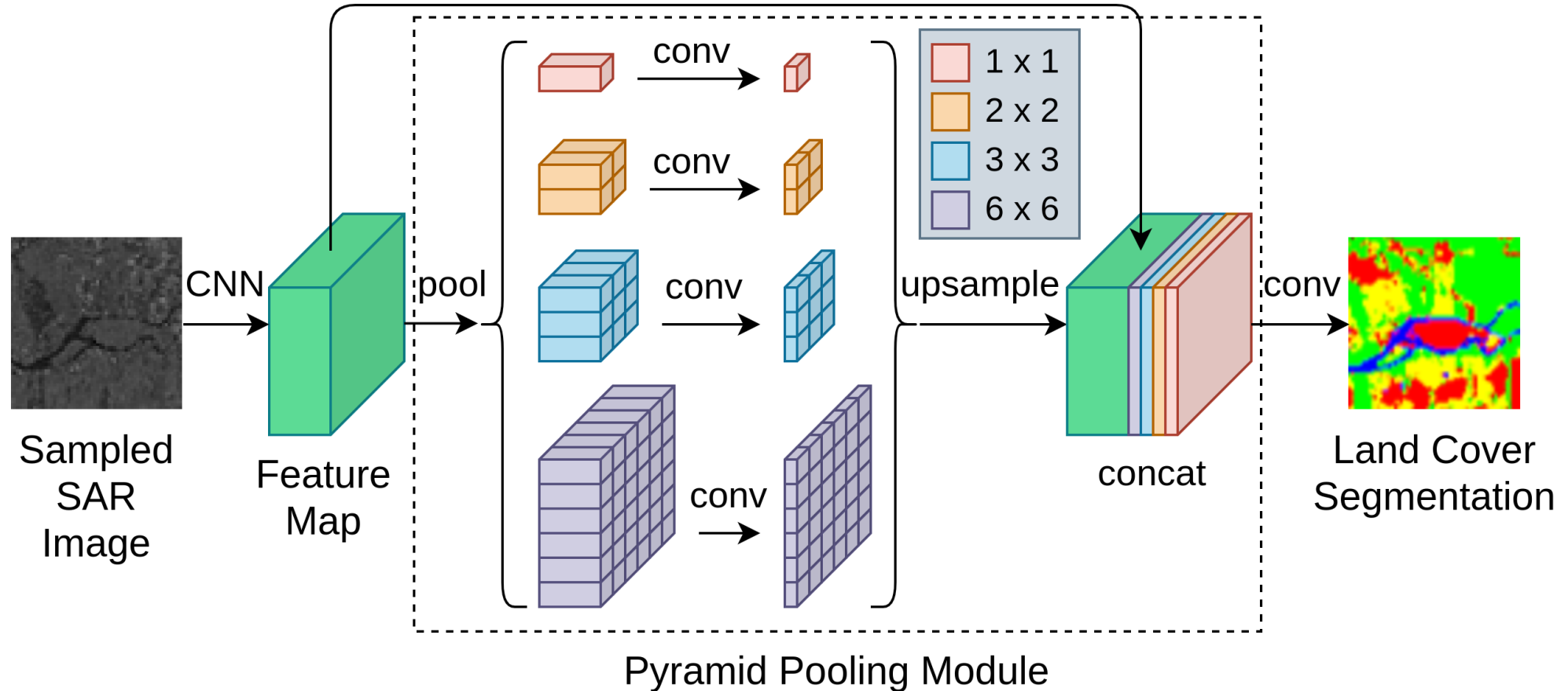
SegNet

- Almost identical to DeconvNet; eliminating fully-connected layers

Switch Variables

Cropped SAR Input Image

Land Cover Segmentation

Conv + Batch Norm + ReLU

Max Pooling

Max Unpooling

Softmax

Pyramid scene parsing network (PSPNet)

- Pooling at four different resolutions

Dataset

- **RADATSAT-2** satellite SAR images on six Canadian cities
  - Montreal – Ottawa – Quebec – Saskatoon – Toronto – Vancouver

- Four category labeled at 30-meter resolution
  - Urban – Water – Vegetation – Farm

- 116 SAR images in total obtained 24 days apart
  - Images from same regions are stacked to reduce noise

Color	ID	Class
Green	21	Urban
Blue	31	Water
Red	41	Vegetation
Yellow	51	Farm
Black	-999	Unknown
White	0	Empty

Dataset – details of stacked SAR images

Region	Beam Mode	Dimension (in pixels)	Size (in MB)
Montreal	Multi-Look	(20,669 × 21,470)	1,775
Ottawa	Multi-Look	(20,325 × 19,888)	1,617
Quebec	Ultra-Fine	(13,271 × 13,210)	701
Saskatoon	Ultra-Fine	(11,255 × 11,166)	502
Toronto	Multi-Look-Fine	(20,882 × 21,683)	1,811
Vancouver	Fine	(10,085 × 10,389)	419

Sampling

- Limited available GPU memory
- Overlapped square crops

Mode	Kernel	Stride	Overlap
Large		112	112
Medium	224	152	72
<u>Small</u>		192	32
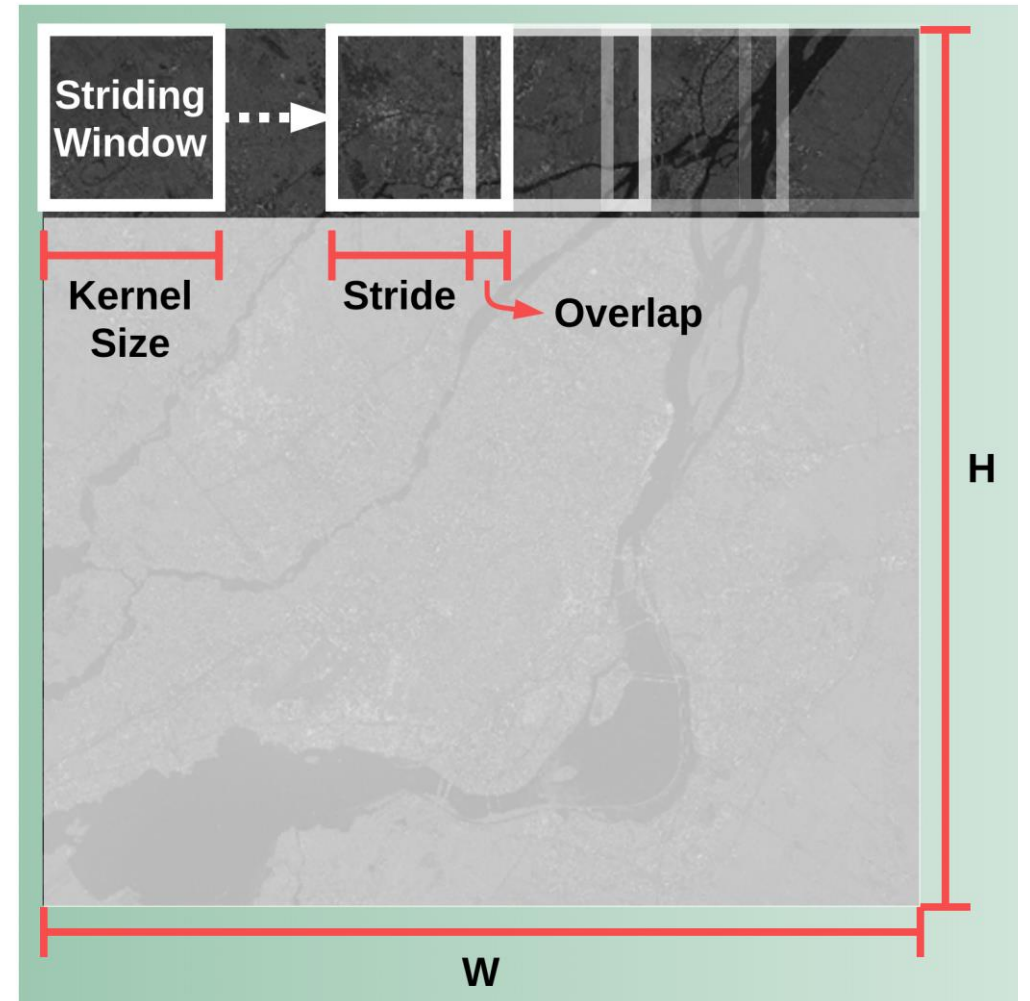
Sampling – class distribution

Number of pixels (in millions) per class using the <u>Small</u> sampling mode

Region	Urban (21)	Water (31)	Vegetation (41)	Farm (51)
[T] Montreal	185	51	55	109
[V] Ottawa	77	24	151	57
[T] Quebec	77	16	27	20
[T] Saskatoon	28	4	12	56
[V] Toronto	231	70	27	96
[T] Vancouver	19	28	28	1
Total	619	196	302	341
[T]raining Set	310	101	124	187
[V]alidation Set	308	94	178	153

Experimental Results

Validation performance of different sampling modes using SegNet model

Sampling mode	Urban (21)	Water (31)	Vegetation (41)	Farm (51)	Average
Large	90.4	**94.1**	**82.0**	87.7	**88.3**
Medium	90.3	93.4	80.8	**87.8**	87.8
Small	**90.6**	91.5	78.7	**87.8**	87.2

Validation performance of trained deep segmentation models (small sampling)

Model	Urban (21)	Water (31)	Vegetation (41)	Farm (51)	Average
DeconvNet	89.4	84.0	72.4	75.5	82.4
SegNet	**90.6**	91.5	78.7	**87.8**	87.2
PSPNet	90.2	**93.3**	**82.3**	86.8	**88.9**

Conclusion

- Achieved very high evaluation accuracy (near 90%) with implemented deep convnets on land cover segmentation using SAR imagery

  - Averaging stacked SAR images to reduce noise and retain finer details

  - Applied sampling to train deep models using very large SAR images with limited GPU memory
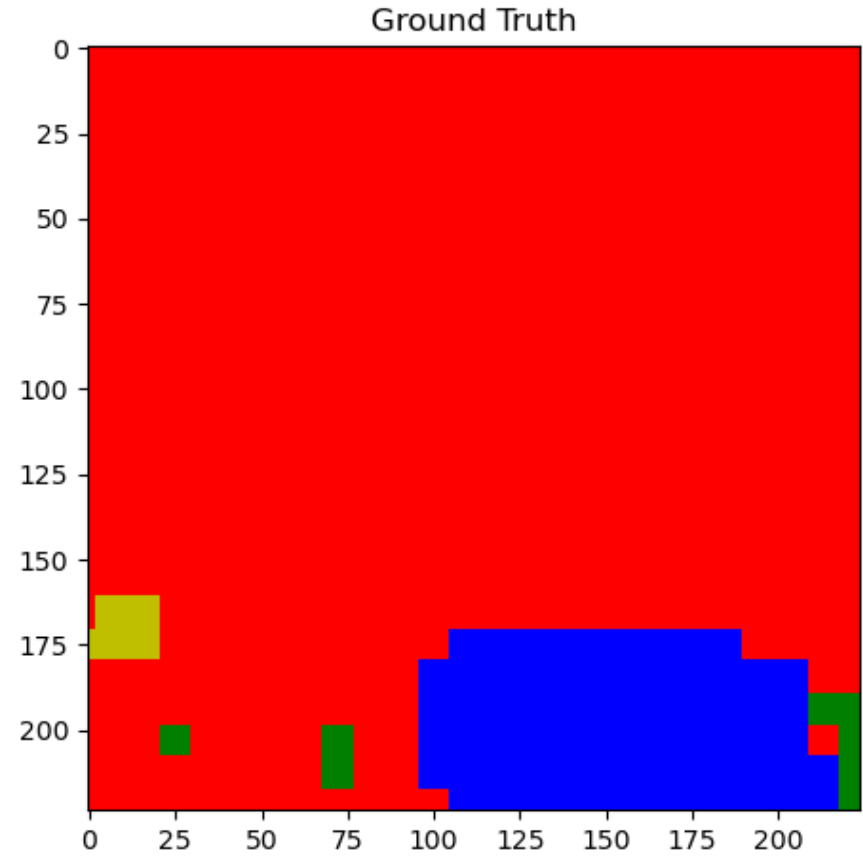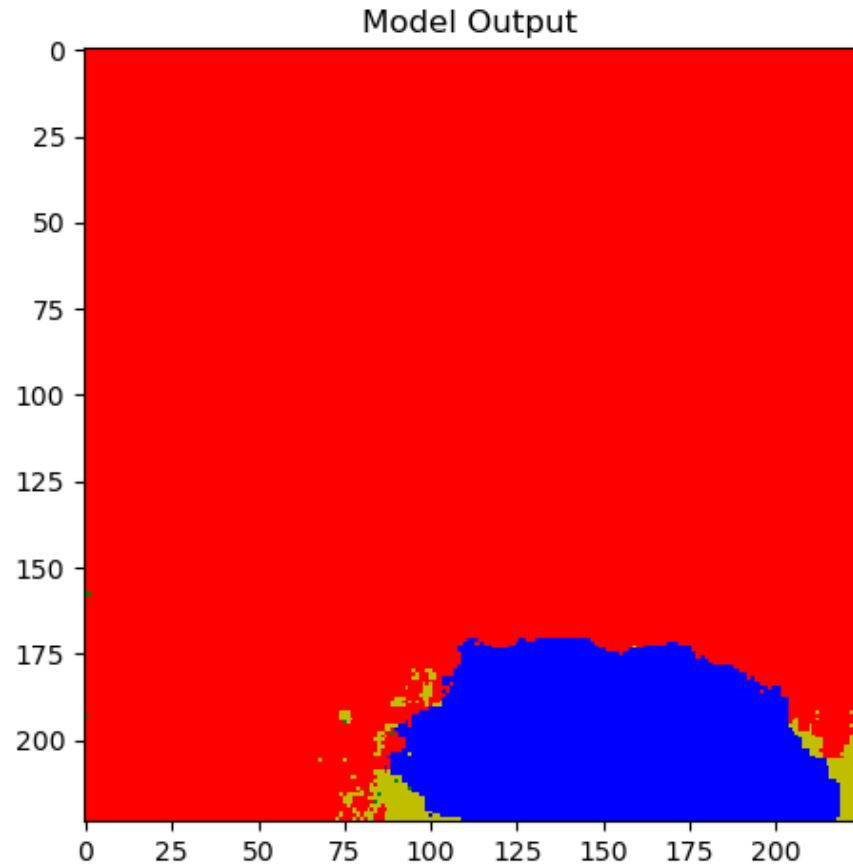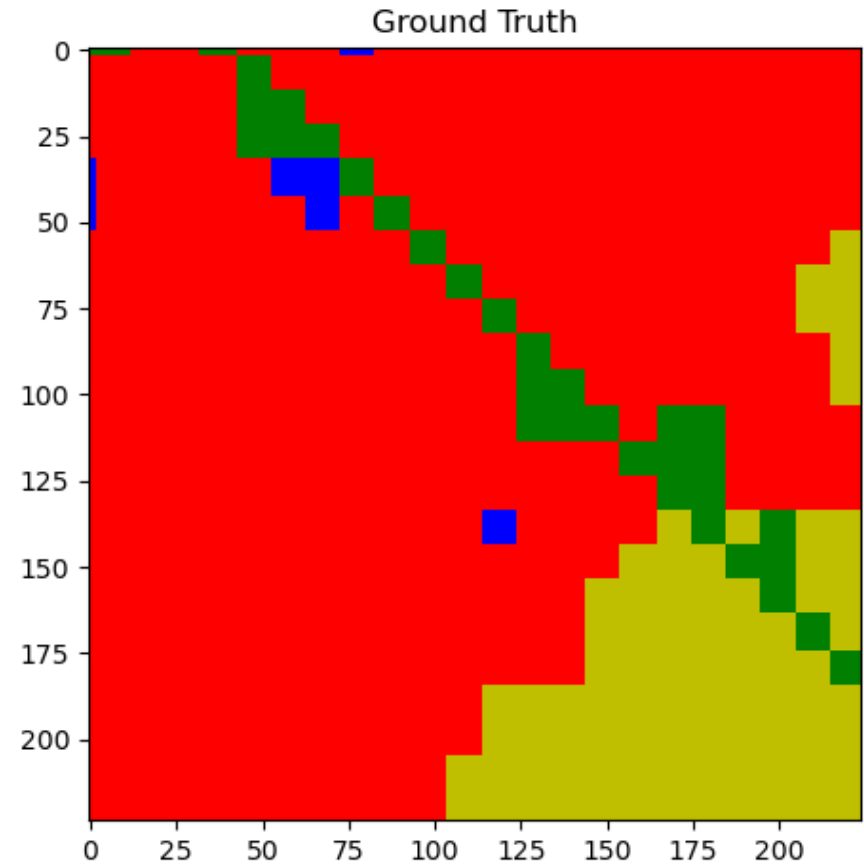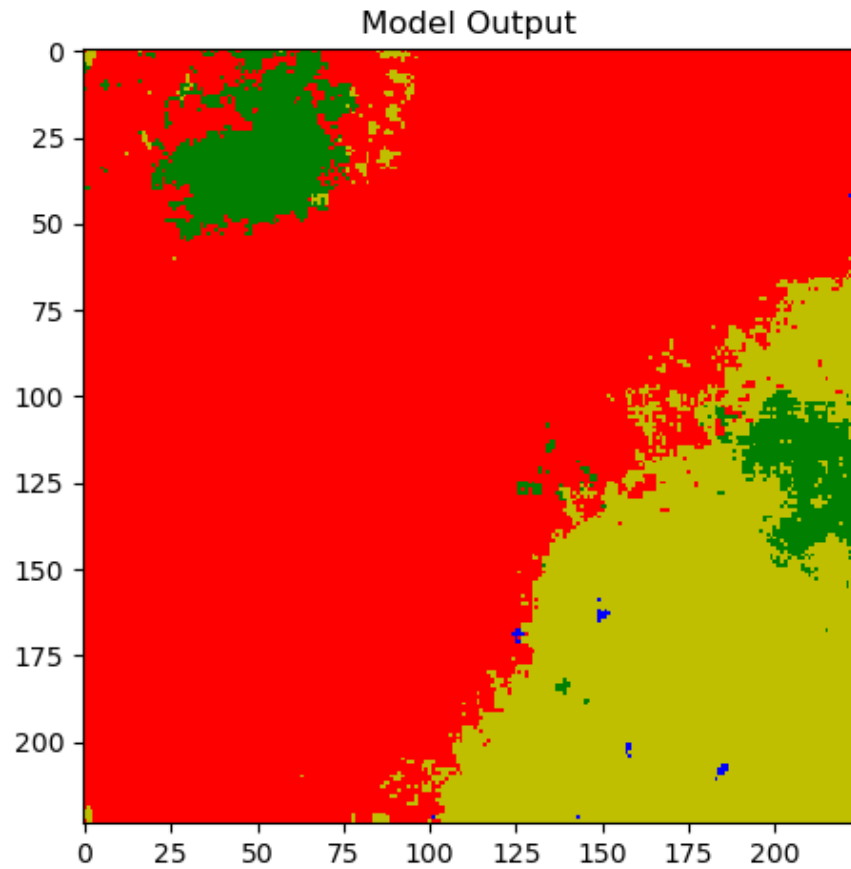
Showcase – Ottawa

Model Output
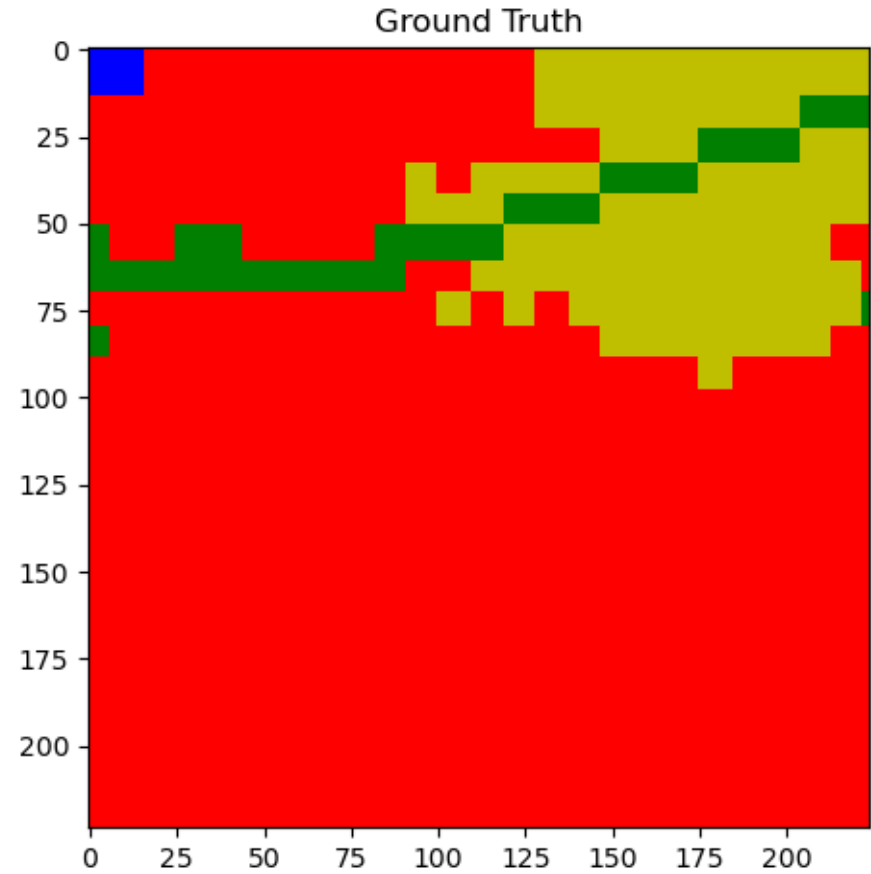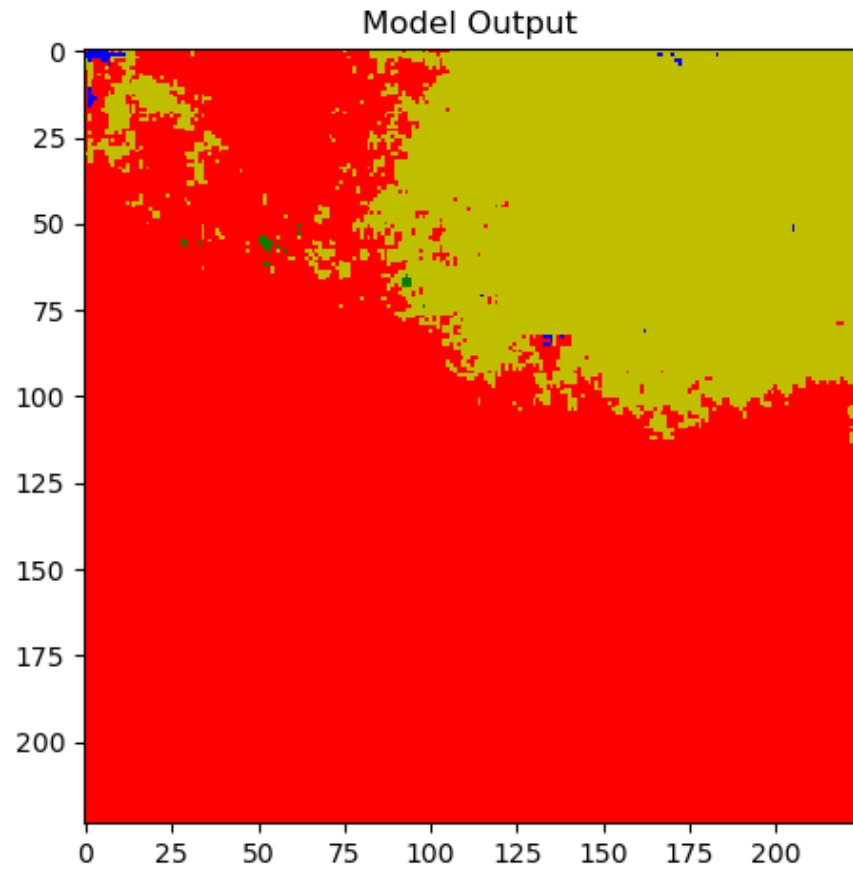
Ground Truth

Showcase – Ottawa
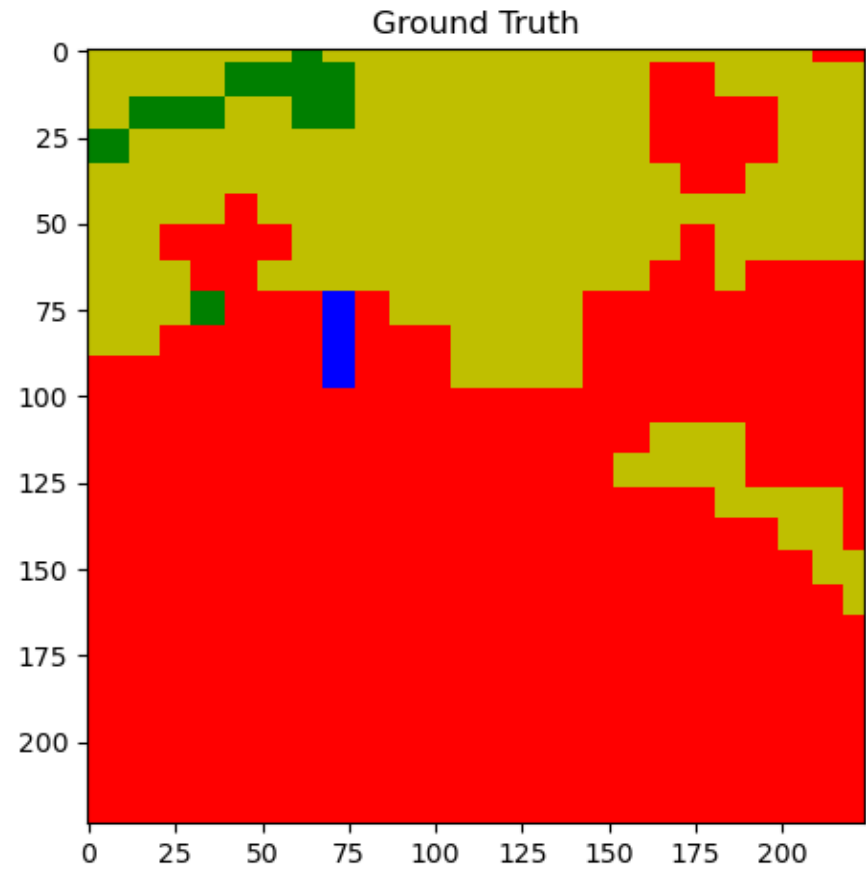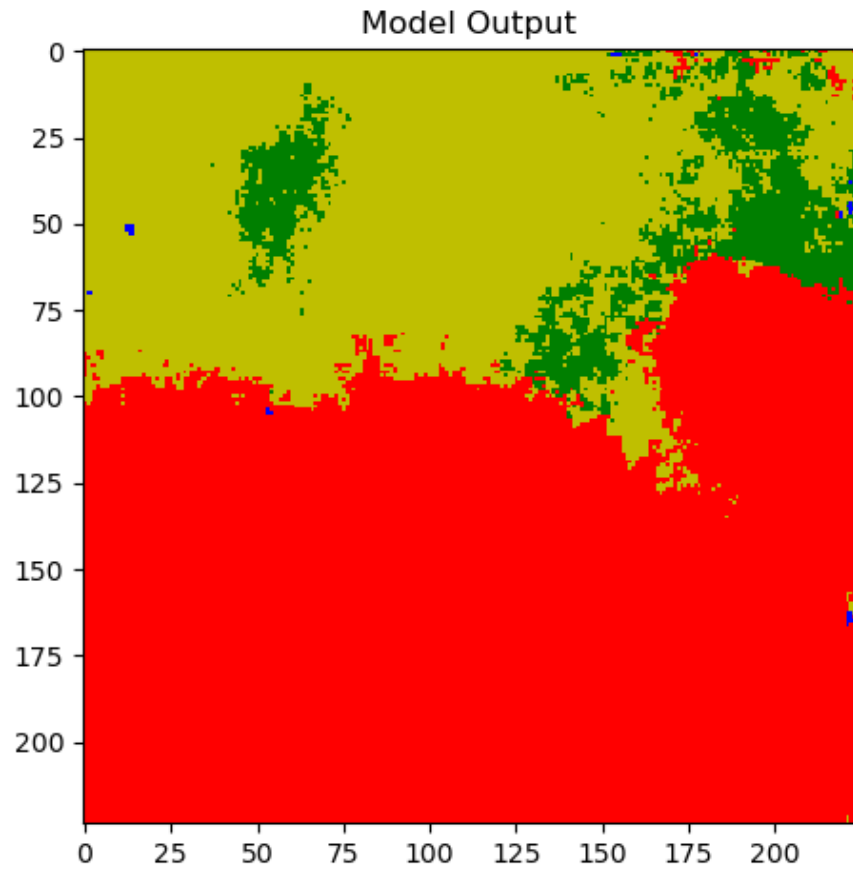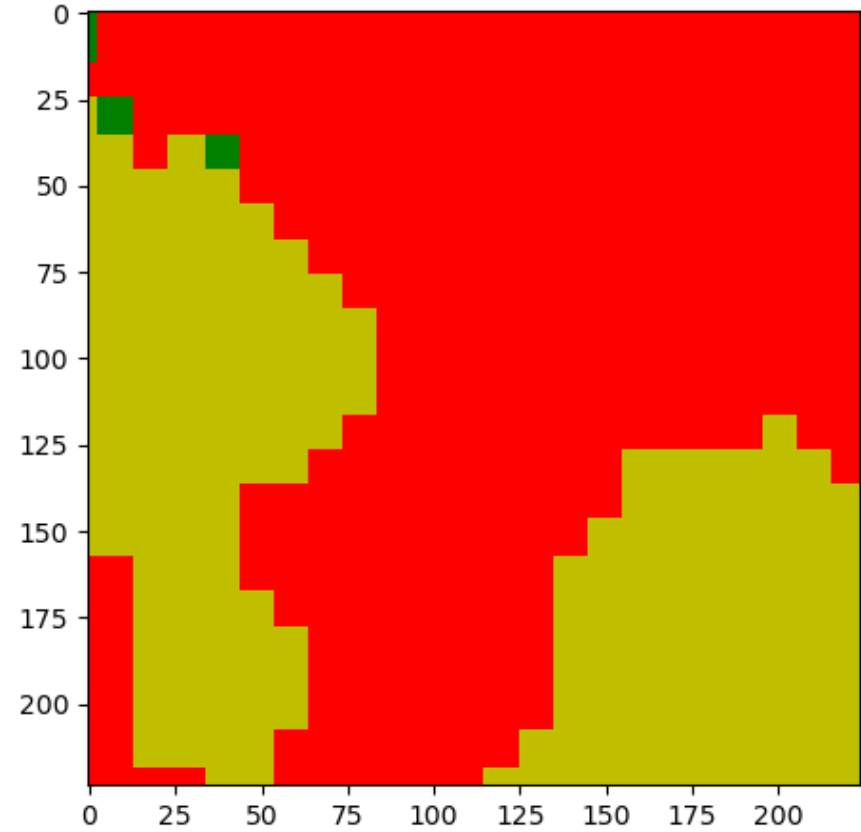
Showcase – Ottawa

Showcase –Toronto

Model Output

Ground Truth

Showcase –Toronto

Showcase –Toronto

End

THANK YOU

Questions?