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Improving ECOCLIMAP Physiography Map using Machine Learning Techniques and Satellite Image data

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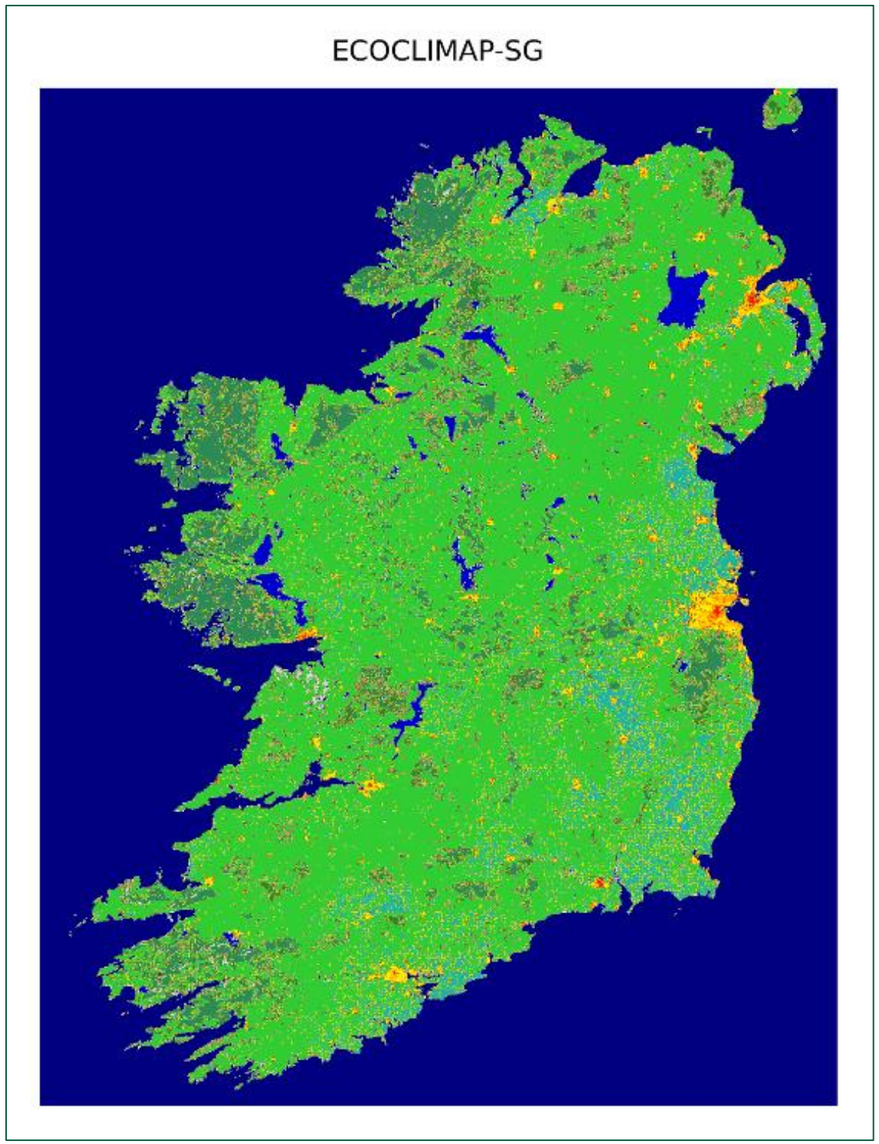
UNIVERSITY OF LIMERICK OLLSCOIL LUIMNIGH | Bernal Institute

Project Motivation

- HARMONIE-AROME requires physiographic input – ECOCLIMAP (Météo-France).
- ECOCLIMAP can be improved– Icelandic Meteorological Office.
- Need for a universal mode of improvement.
- Need for method that can offer improved resolution.

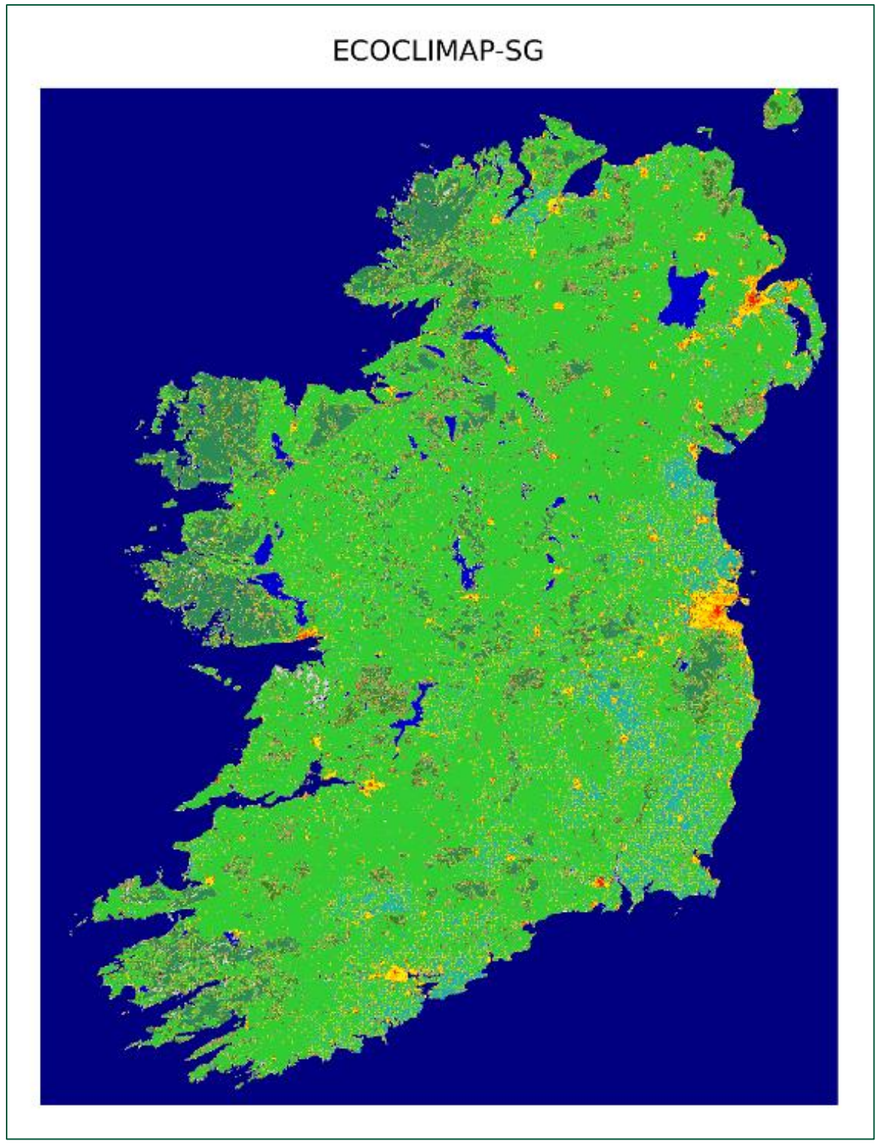


Project Motivation

1. Accuracy.

2. Resolution.

3. Universality.



Project Goals:

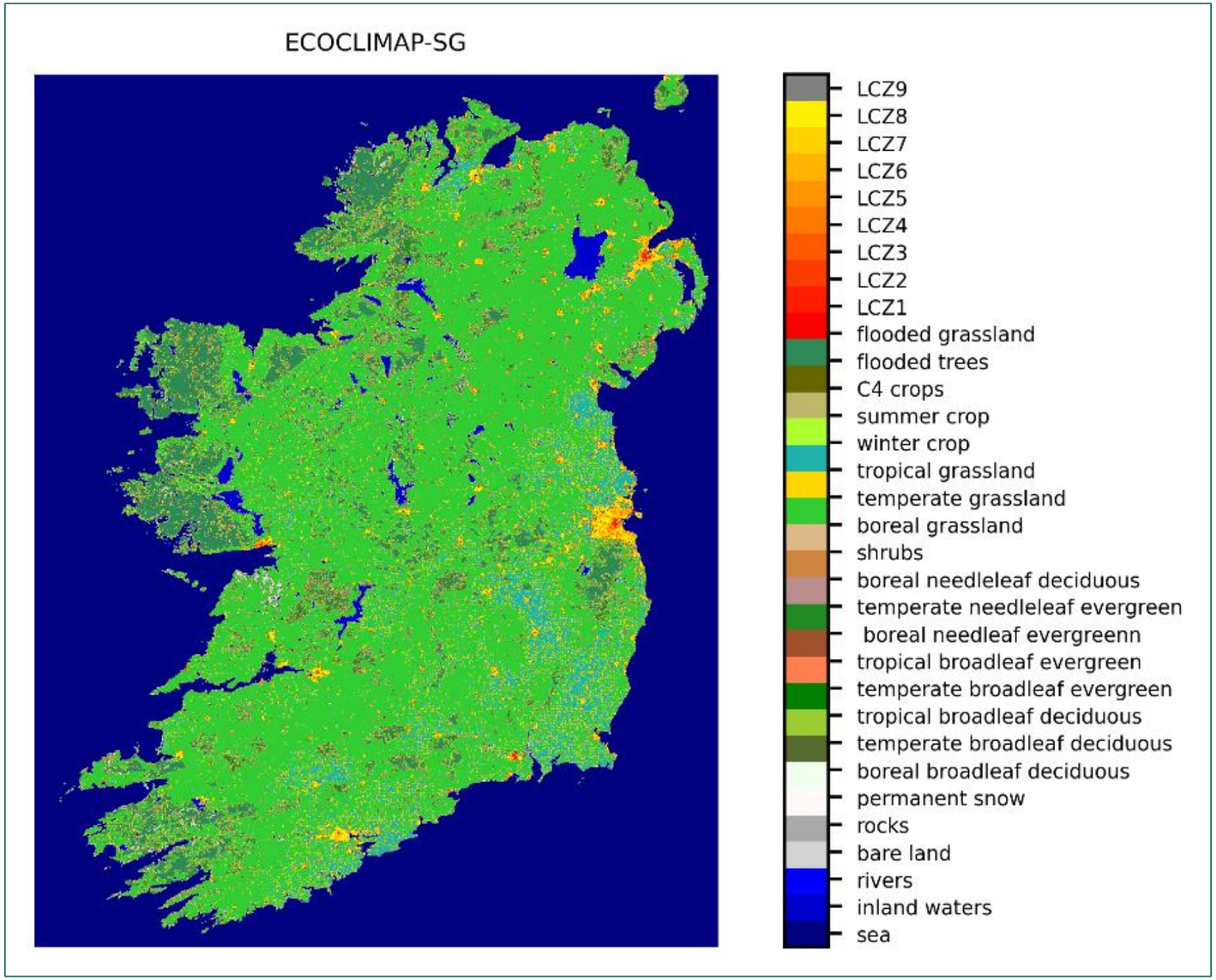
- Can ground-based image data and/or Satellite data be used:
    1. To increase the accuracy.
    2. To improve the resolution.
    3. For universal improvement.

Resources:

- Google Streetview API.
- CORINE Land Cover Map. (European Environmental Agency)
- Copernicus Open Access Hub for Sentinel-2 Data. (European Space Agency)

ECOCLIMAP-SG

- Global Landcover database, 1km resolution for 1st generation.
- ECOCLIMAP-SG has resolution of 300m.
- 33 landcover types in SG, 23 of which are present in Ireland.



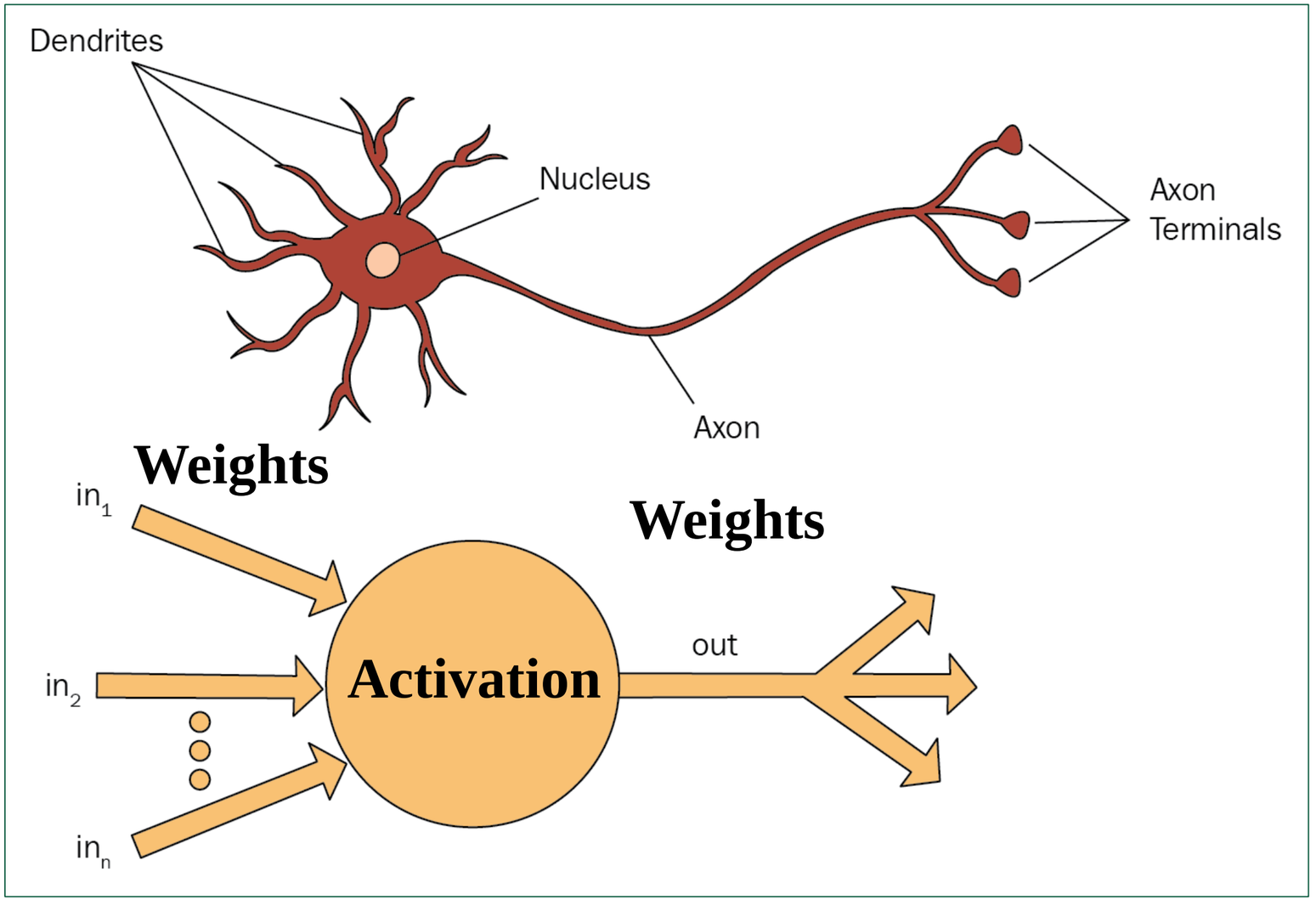
ECOCLIMAP-SG webpage:
https://opensource.umr-cnrm.fr/projects/ecoclimap-sg/

Machine Learning

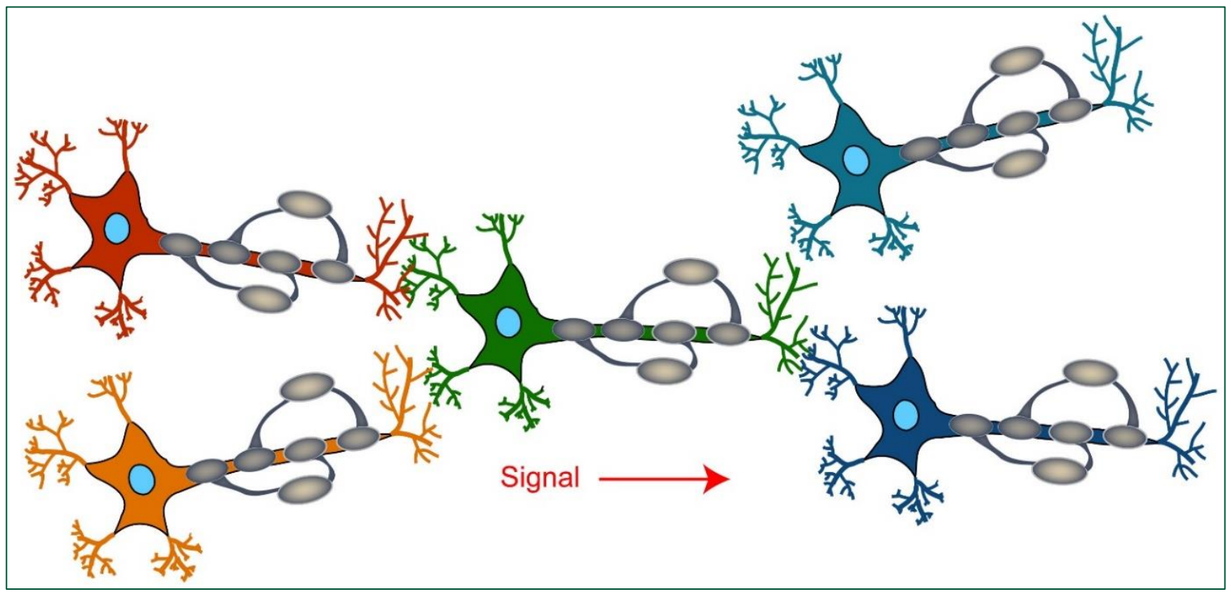
‘Machine Learning is the study of computer algorithms that improve automatically through experience’

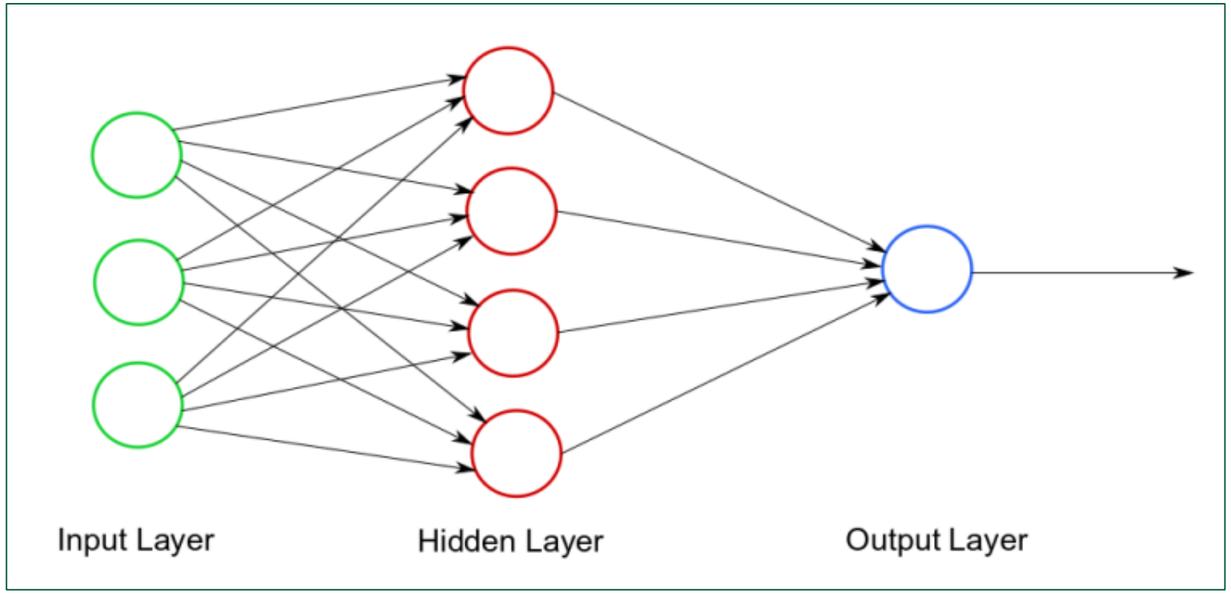
- Tom Mitchell, Machine Learning (1997).

Neural Networks



Neural Networks





Convolutional Neural Networks (CNNs)

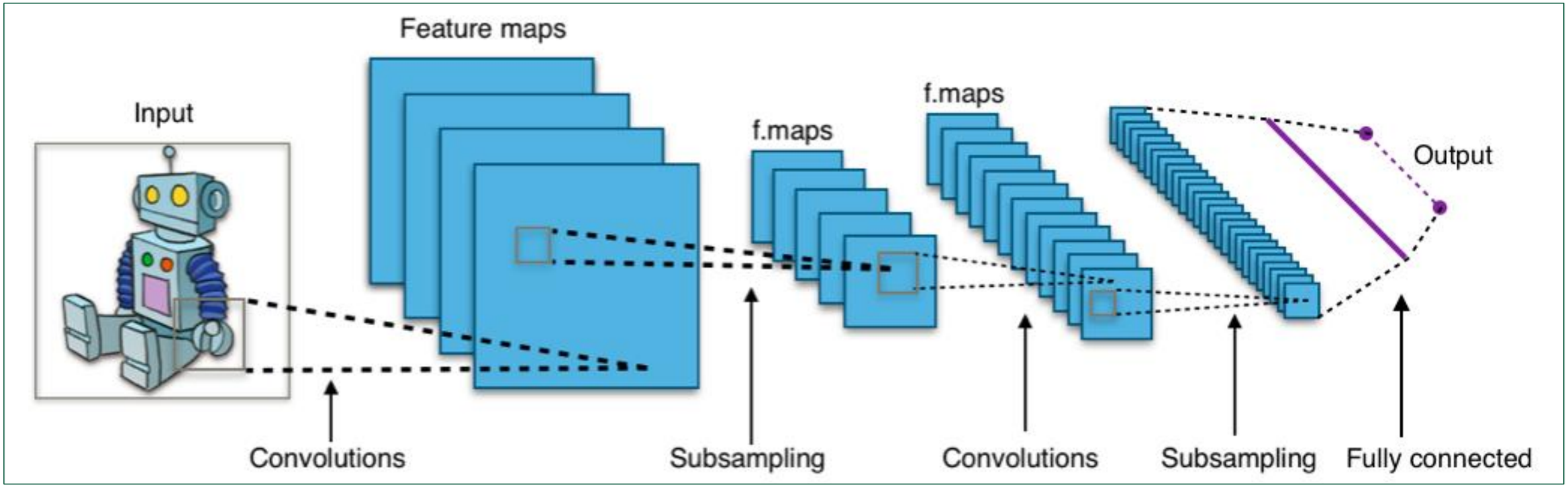


Image Source: https://medium.com/@himadrisankarchatterjee/a-basic-introduction-to-convolutional-neural-network-8e39019b27c4

CNN for Image Classification

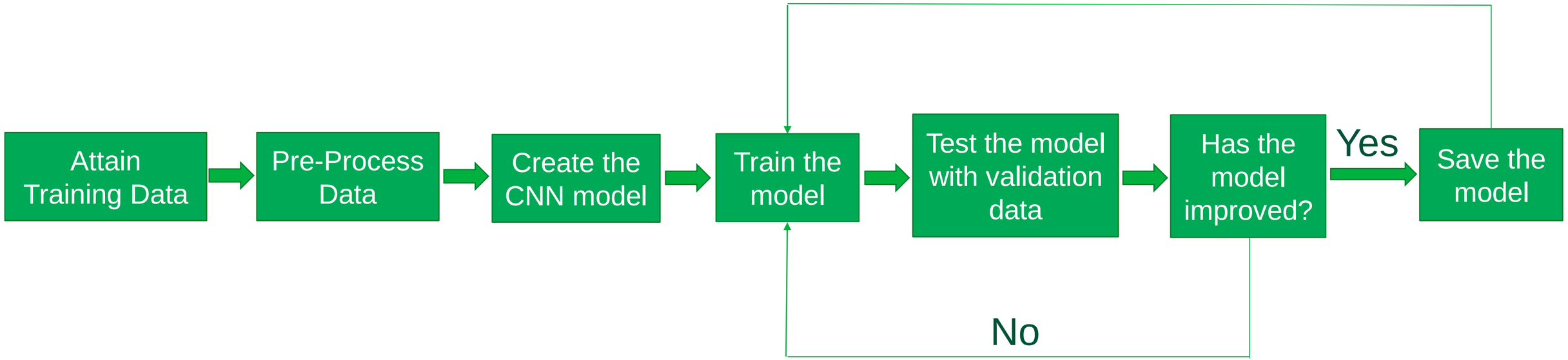




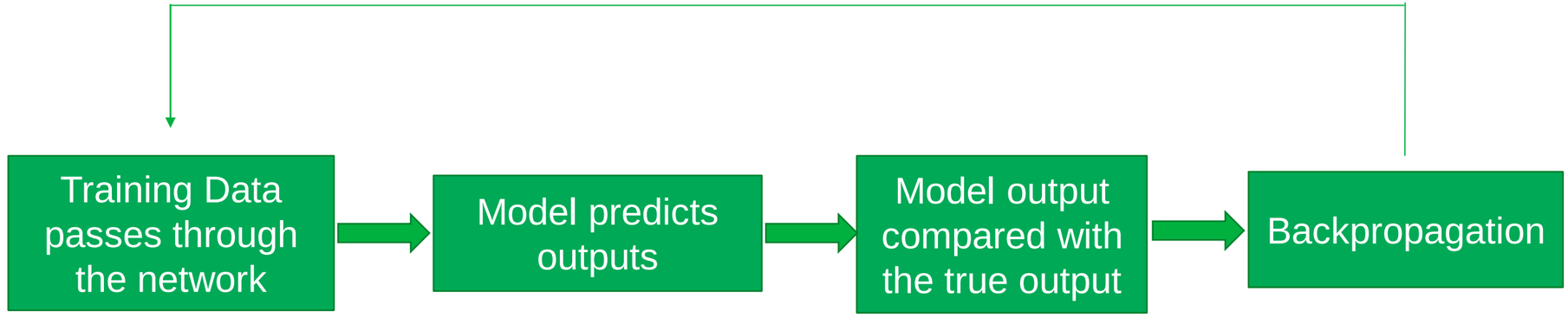


The process of a machine learning

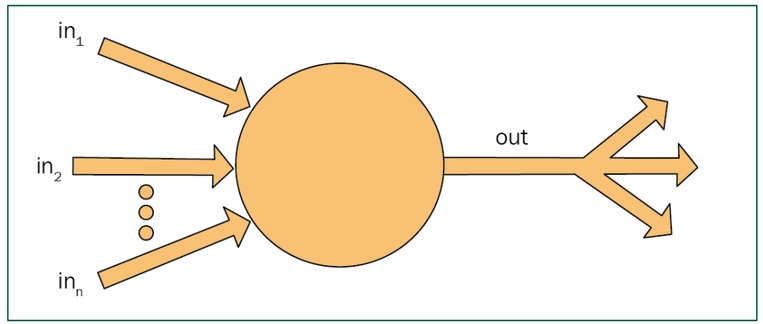
- Training Data – input data and corresponding correct output.
- Validation Data – Unseen Data to test the trained model.
- Epoch – One iteration of all of the training + validation data through the model.



How does a model ‘learn’?



- Backpropagation:
  - The activations and weights of the network get adjusted appropriately, so as to reduce the error value.



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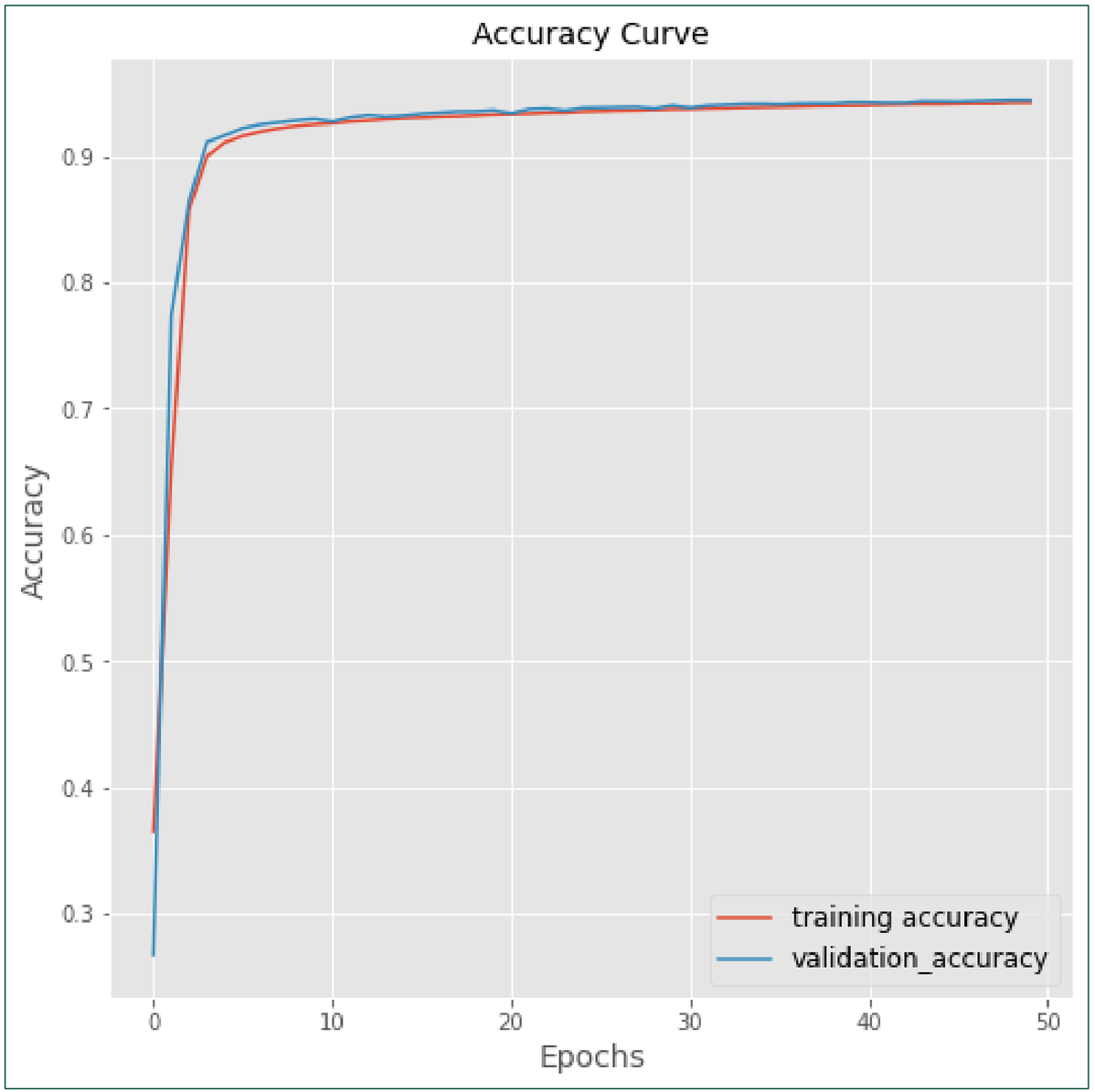


CNN for Image Segmentation

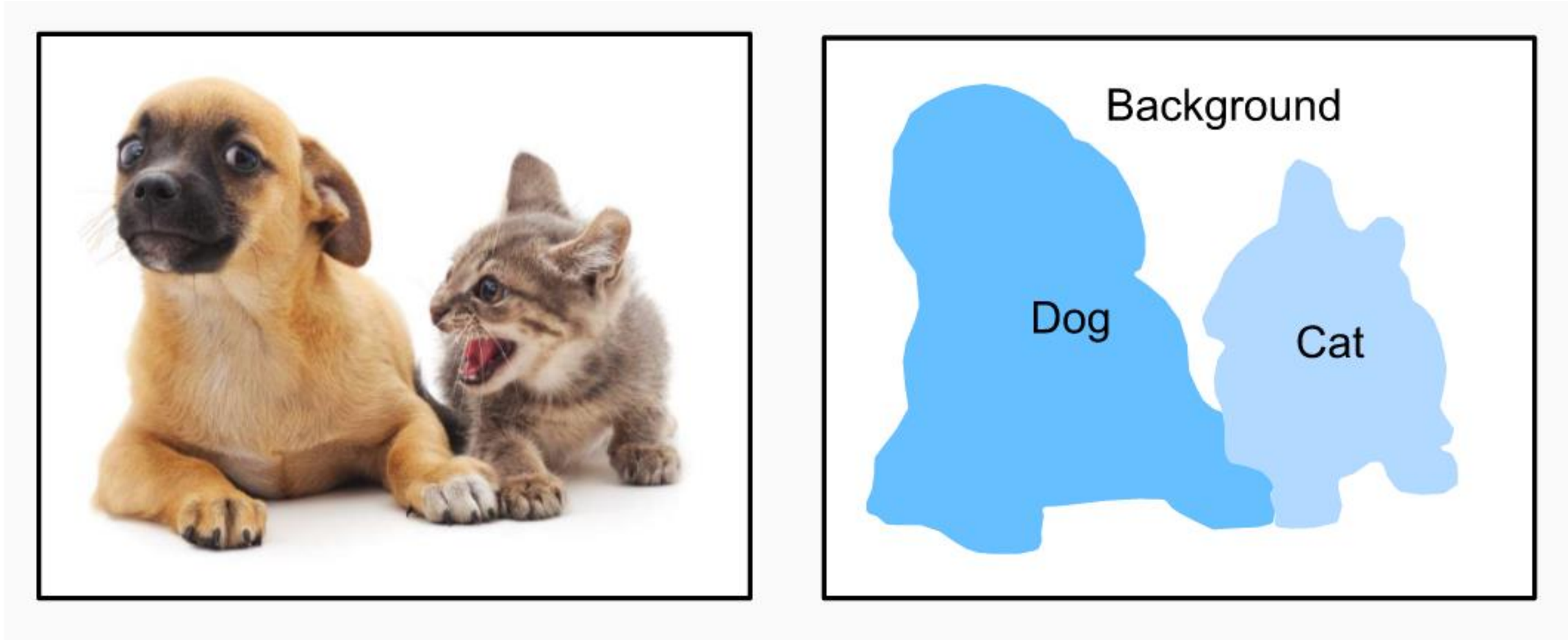


Image Source: https://d2l.ai/chapter_computer-vision/semantic-segmentation-and-dataset.html

Transfer Learning 1

- A model trained for one task is re-purposed for use on a second related task.
- Re-purposing a CNN Classifier.





Transfer Learning 2

- A model trained for one task is re-purposed for use on a second related task.
- Re-purposing CNN Classifier as a segmentation model.

Horse

Images Source: https://www.learnopencv.com/pytorch-for-beginners-semantic-segmentation-using-torchvision/

Transfer Learning 2

- A model trained for one task is re-purposed for use on a second related task.
- Re-purposing CNN Classifier as a segmentation model.

Images Source: https://www.learnopencv.com/pytorch-for-beginners-semantic-segmentation-using-torchvision/

12 Week Synopsis

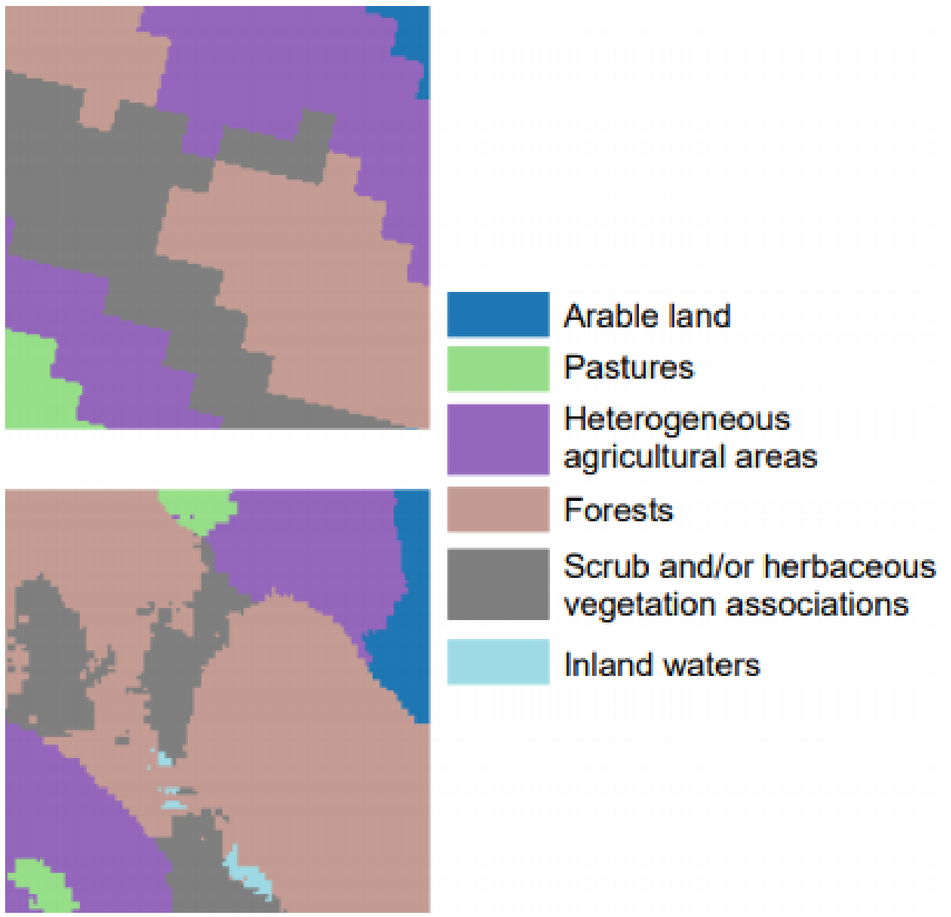
- First 4 weeks:
  - ➢ Inv
  - ➢ Go
  - ➢ CN d no bui

12 Week Synopsis

12 week Synopsis

- Remaining 8 weeks:
  - ➢Investigation using Satellite Imagery.
  - ➢Sentinel-2 Images plus Corine Landcover Images.
    - ➢2 Segmentation algorithms.
      - ➢5 label algorithm.
      - ➢15 label algorithm.

Improving CORINE Land Cover map in Estonia



The segmentation model shows a high 91.4% pixel-level accuracy on the first classification level with 75.8% and 59.7% on the second and third levels (Table 3). An example of segmentation model results and comparison to validation data can be seen on Figures 3 and 4.

Source:

Ulmas, Priit; Liiv, Innar; “Segmentation of Satellite Imagery using U-Net Models for Land Cover Classification”, March 2020.

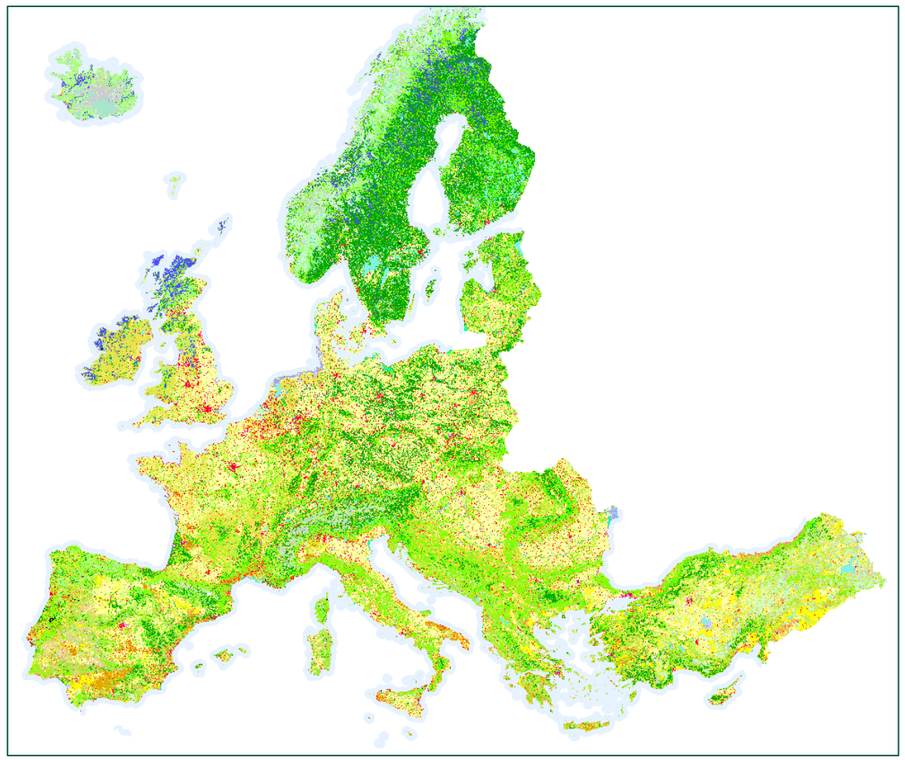
Datasets Used

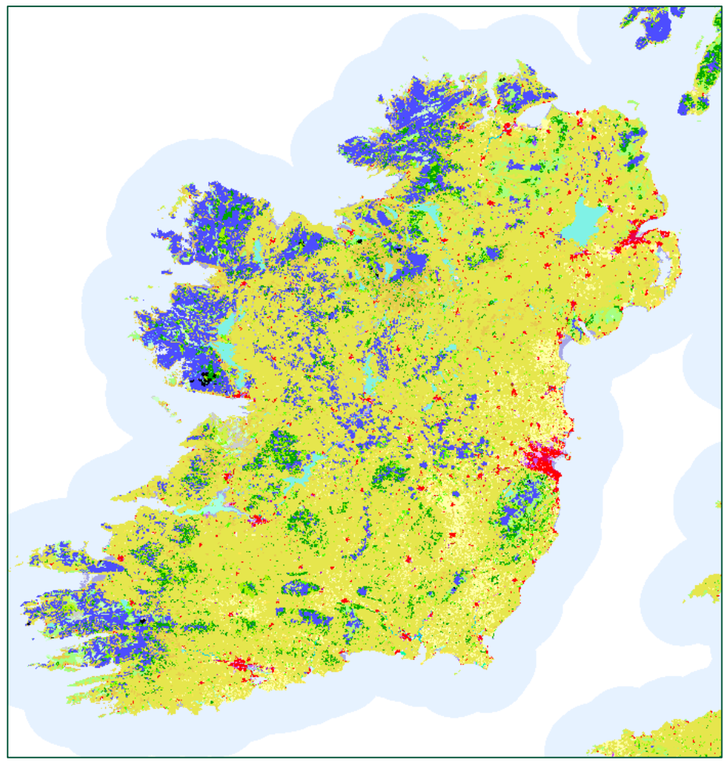
- BigEarthNet
  - ➢ ~ 600,000 sentinel segments ($1.2km^2$ each), appended with cover labels.

Website: bigearth.net

Datasets Used

- Corine Land Cover Map.
  - ➢ Split into Primary, Secondary and Tertiary Labels (5, 15 and 44 labels).
  - ➢100 metre resolution





Website: https://land.copernicus.eu/pan-european/corine-land-cover

Datasets Used

- Sentinel-2 Satellite Images.
  - ➢Obtained from Copernicus Open Access Hub.
  - ➢10 metre resolution.

Donegal

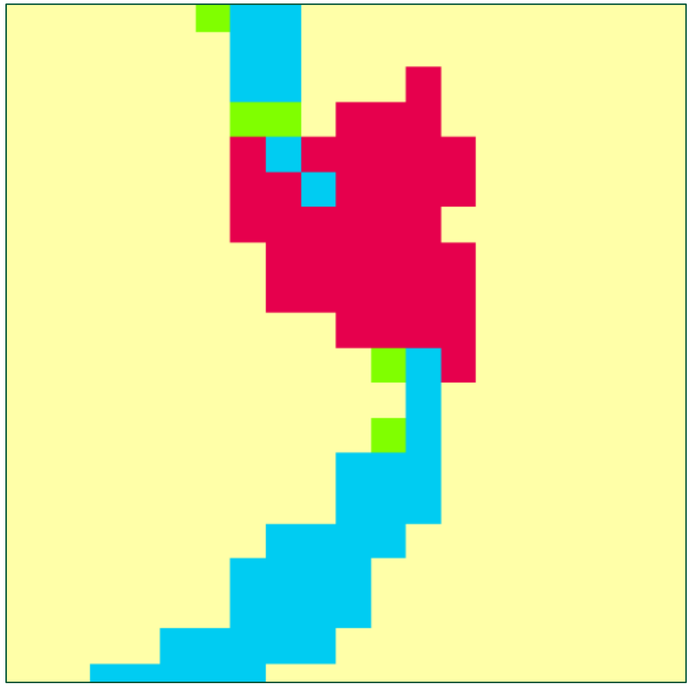
Dublin

Website: https://scihub.copernicus.eu/dhus/#/home

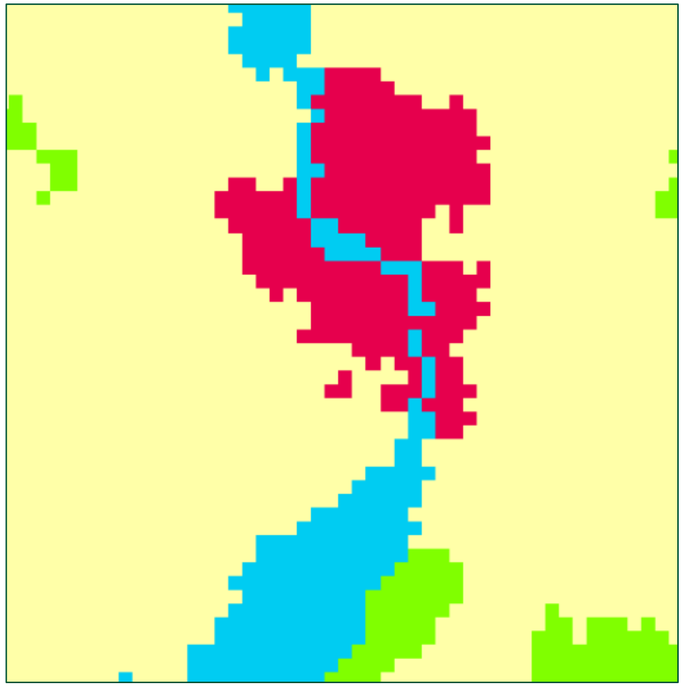
Why use Corine as training output?

- Corine (100m) has a better resolution than ECOCLIMAP-SG (300m)
- Corine considered to be 85% accurate. [1]

Sentinel-2



ECOCLIMAP-SG

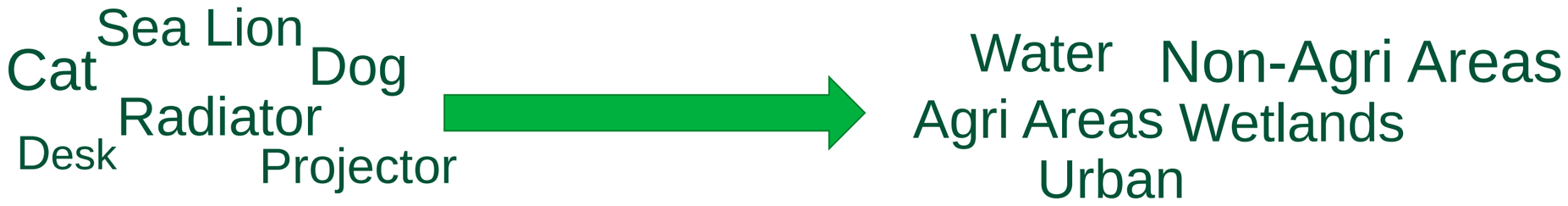


CORINE

[1] CORINE LAND COVER 2012 FINAL VALIDATION REPORT
Link: https://land.copernicus.eu/user-corner/technical-library/clc-2012-validation-report-1

The Model

- ‘Resnet-50’, pre-trained on the ImageNet dataset.
- Transfer Learning..



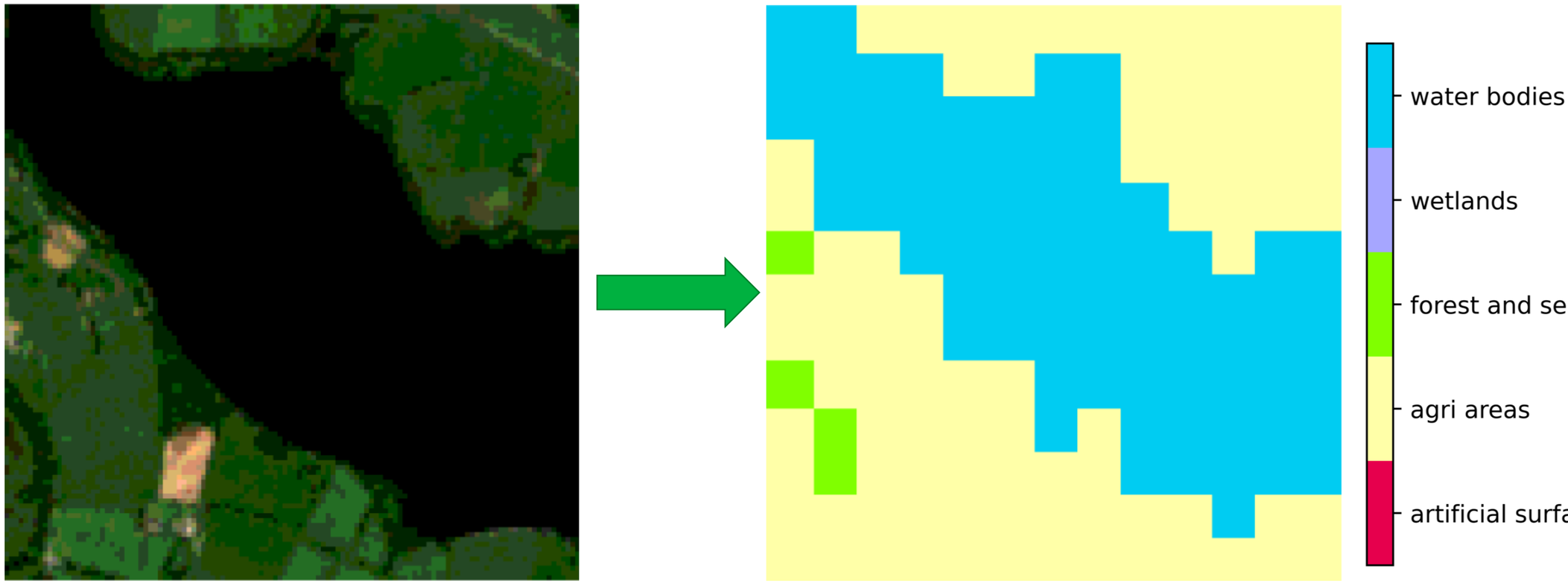
The Model

- Classifier Model re-purposed as a segmentation algorithm.

waters, agri-areas.

The Model

- Classifier Model re-purposed as a segmentation algorithm.



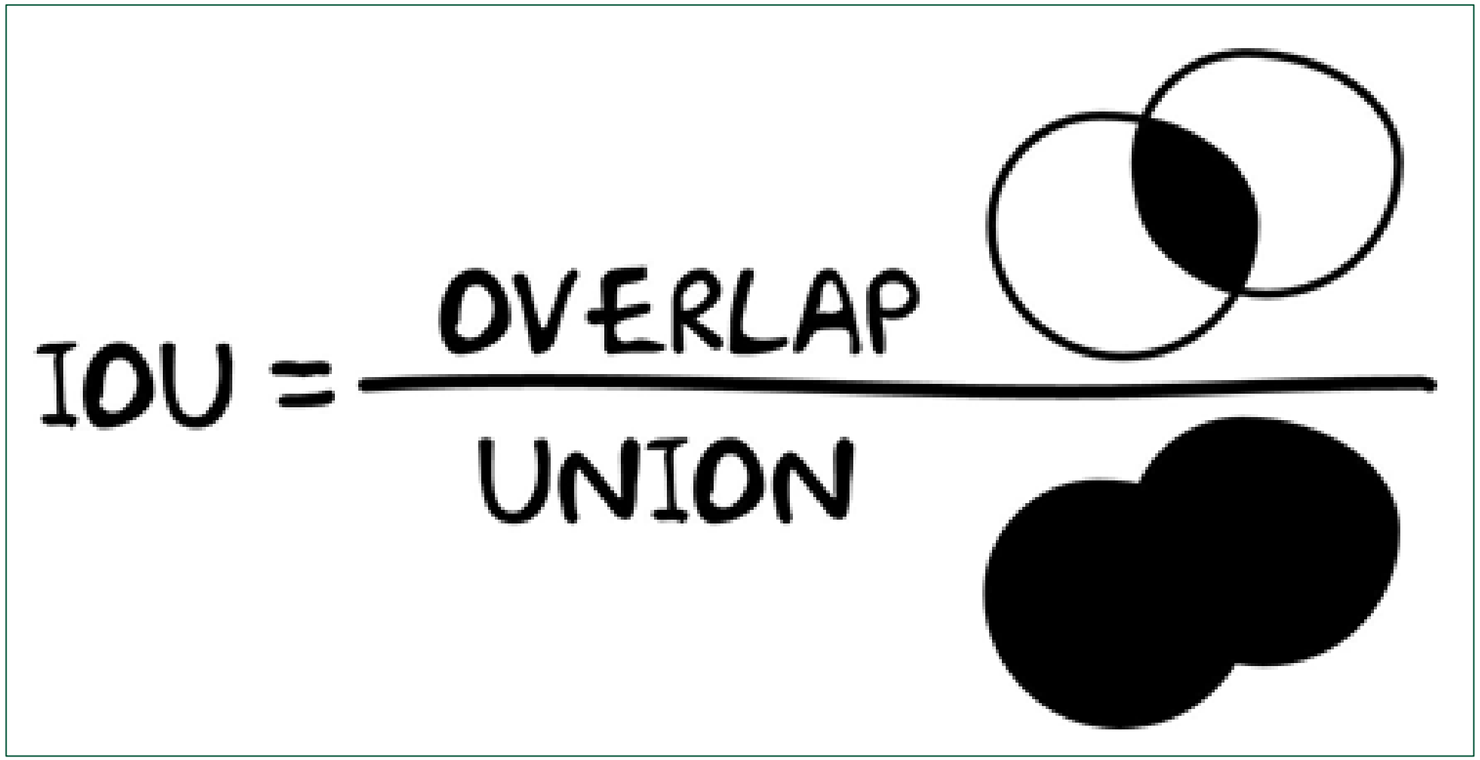
Analysing Model results

- Compare ECOCLIMAP and Model Prediction with best map we have – CORINE.

- Intersection over Union to compare accuracy of categories.

- Visual Inspection to demonstrate better accuracy.

Intersection Over Union (IOU)



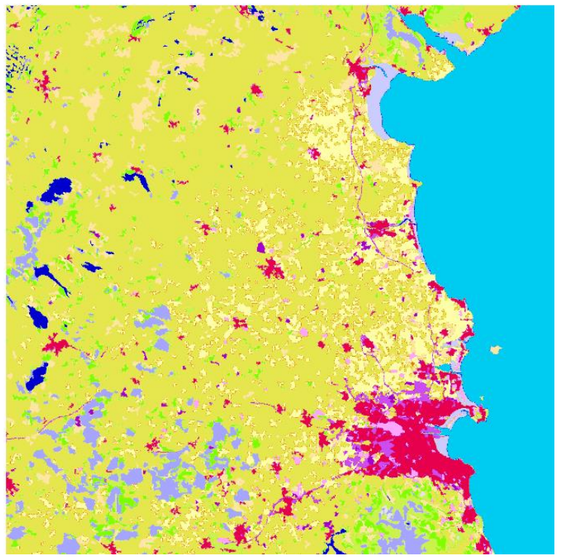
- IOU of 1 – prediction completely correct.
- IOU of 0 – prediction completely incorrect.

Primary Training Data

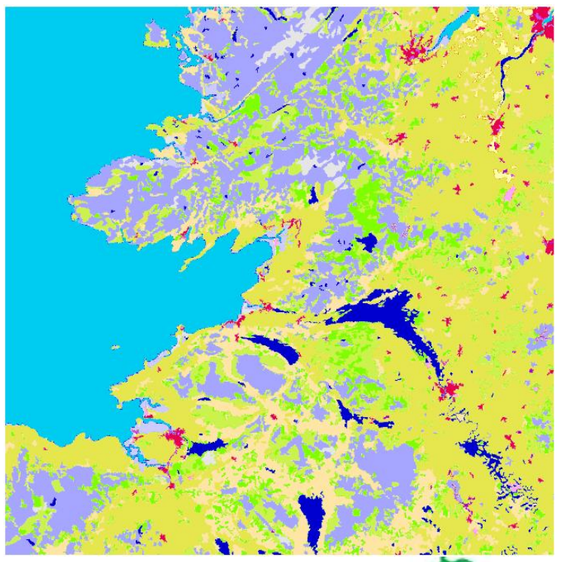
Sentinel-2 Segments

CORINE Segments

Dublin

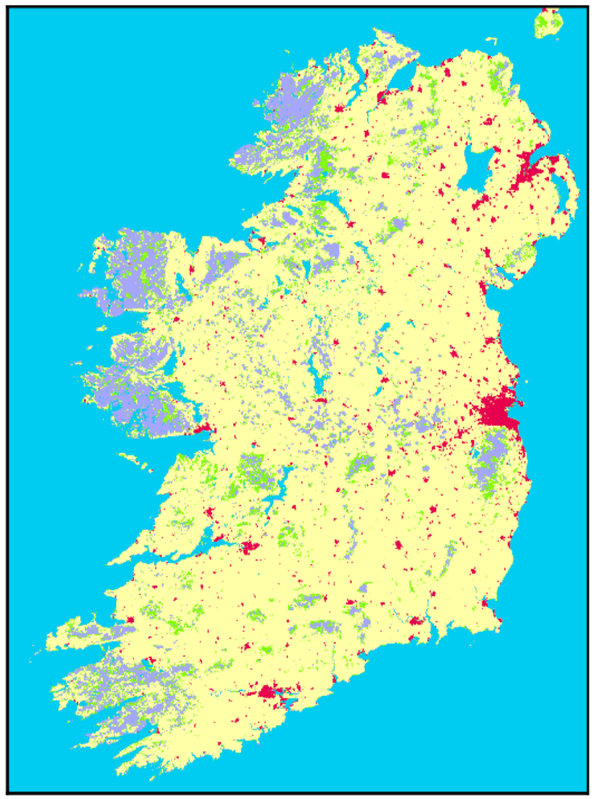


Donegal



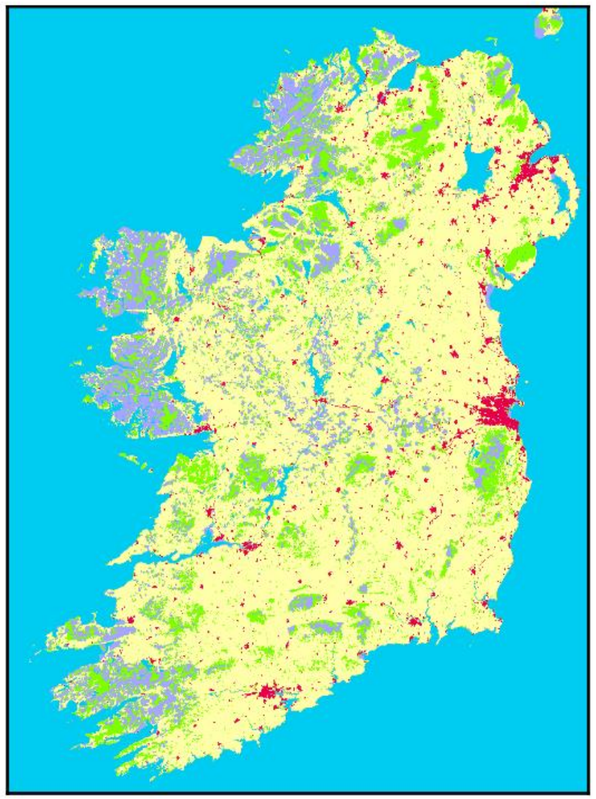
Primary Results

ECOCLIMAP

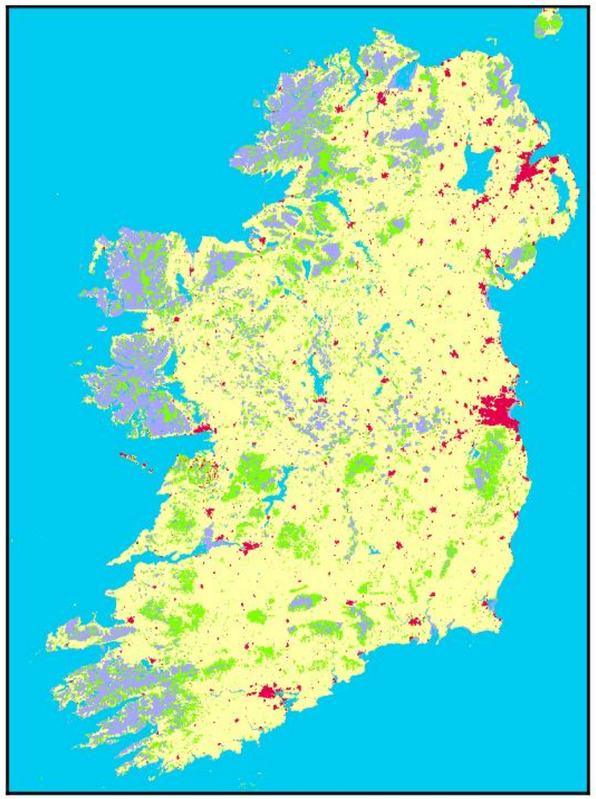


89.8%

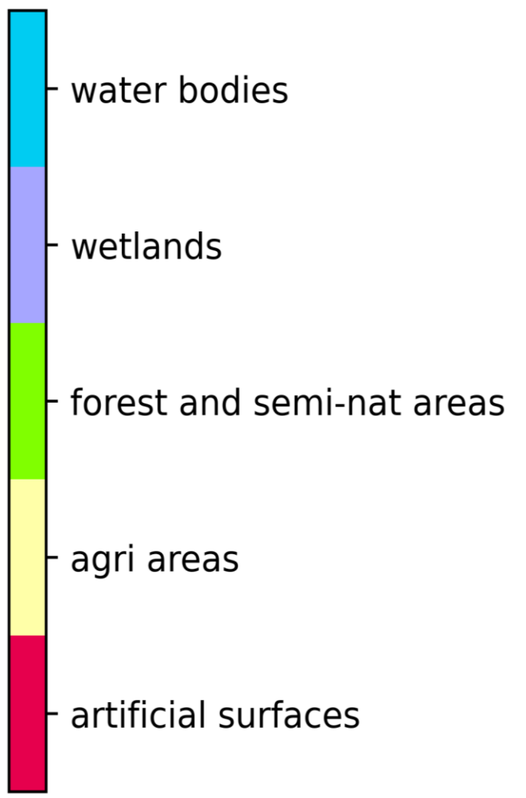
CORINE



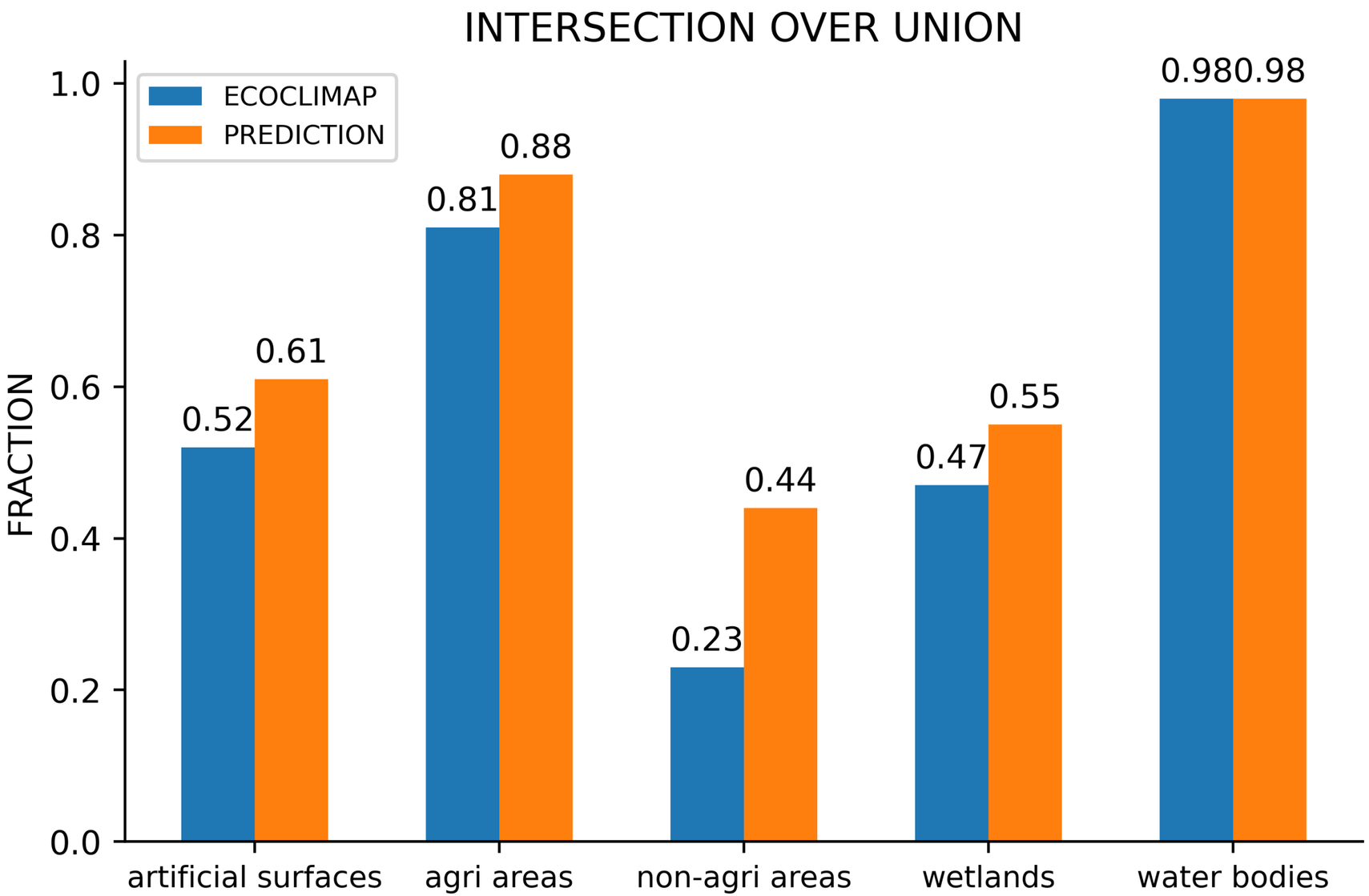
MODEL PREDICTION



92.6%

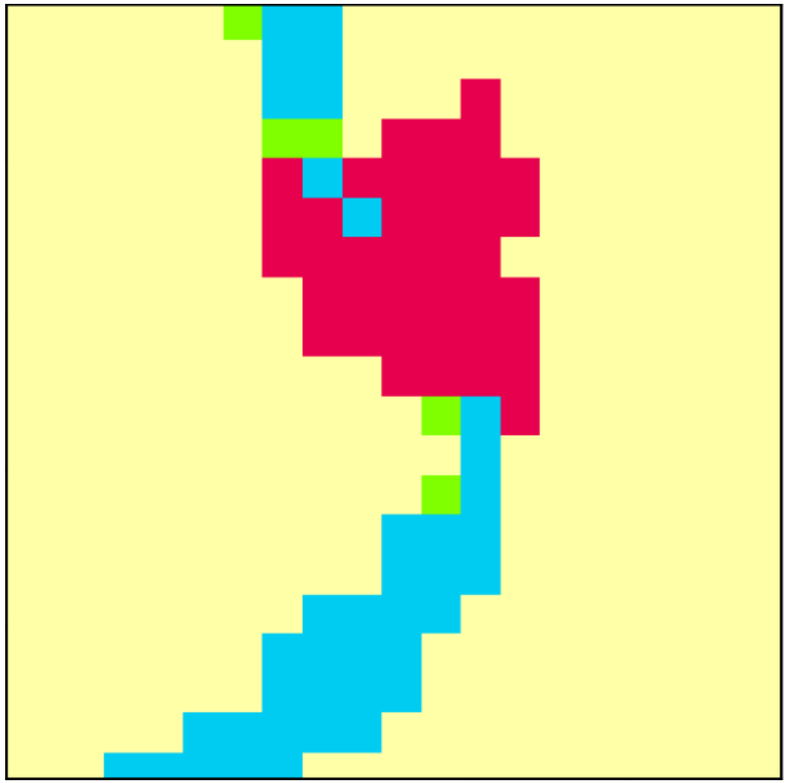


Primary Results - Accuracy

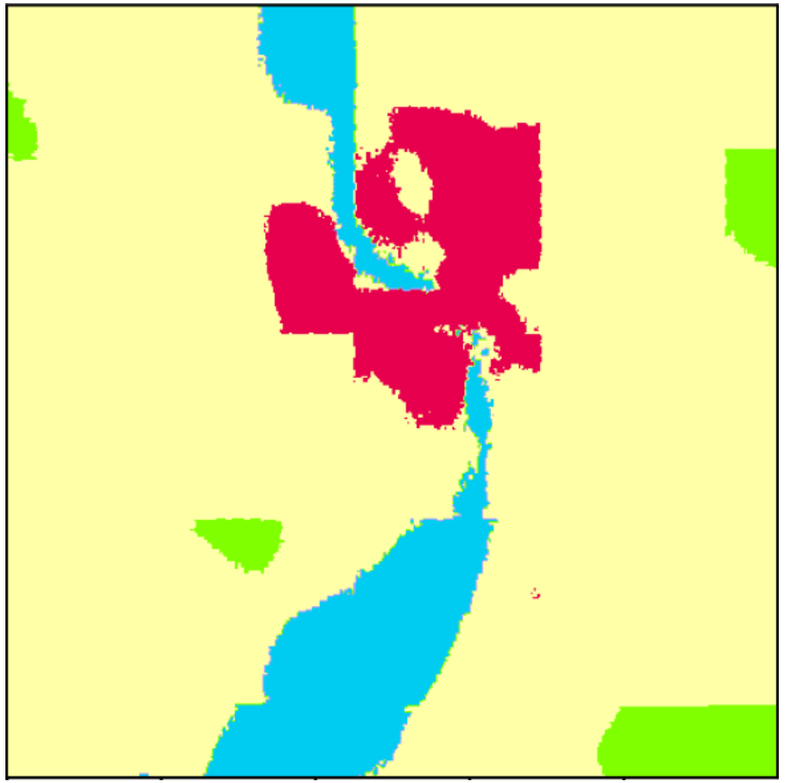


Primary Results - Resolution

Sentinel-2

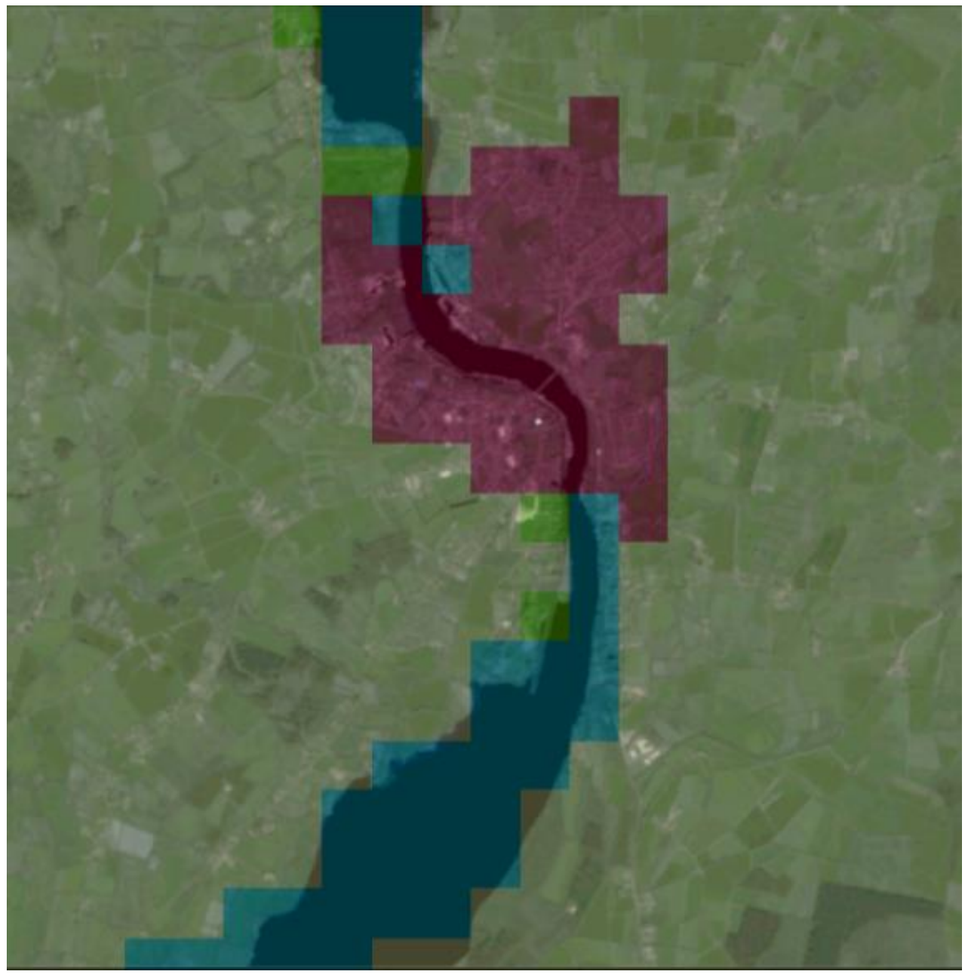


ECOCLIMAP-SG



Model Prediction

Primary Results - Resolution



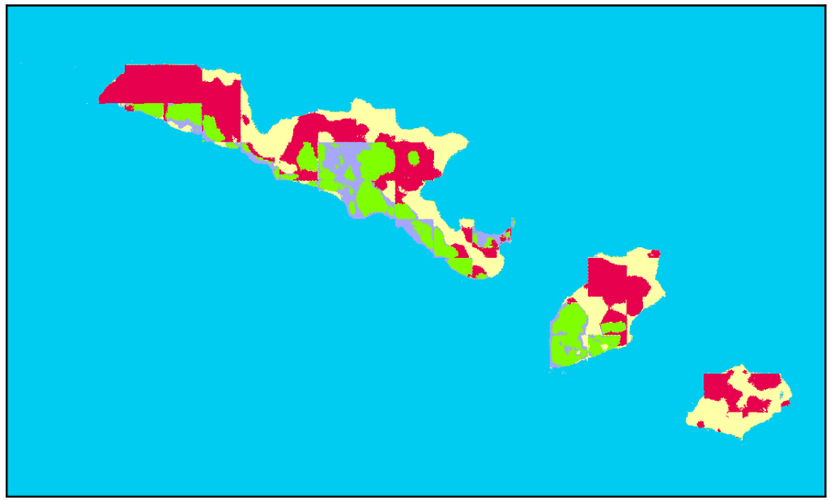
ECOCLIMAP-SG

Model Prediction

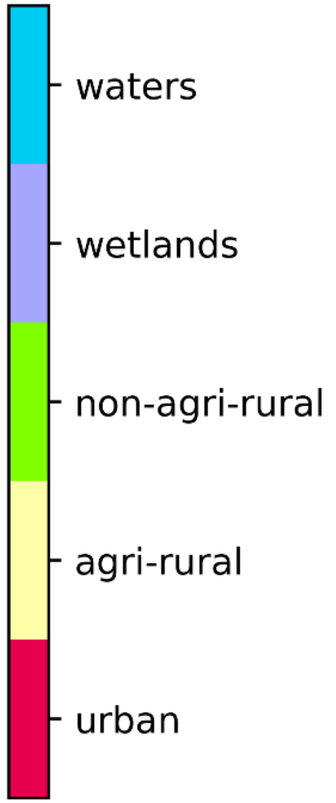
Interesting Observations

Aran Islands

MODEL PREDICTION



CORINE



Secondary Training Data

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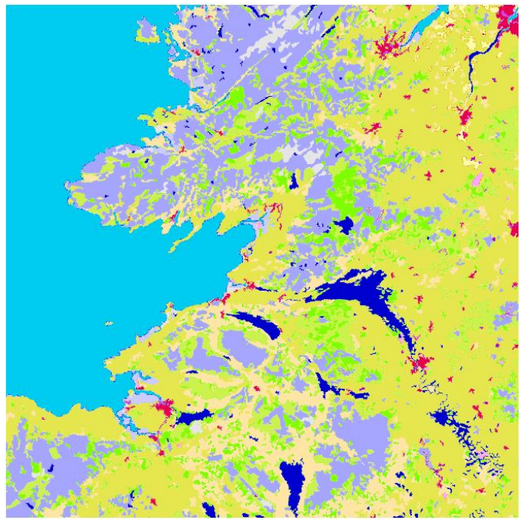
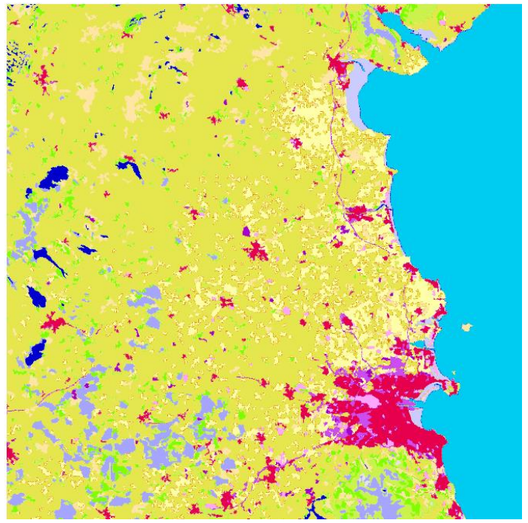
CORINE Segments

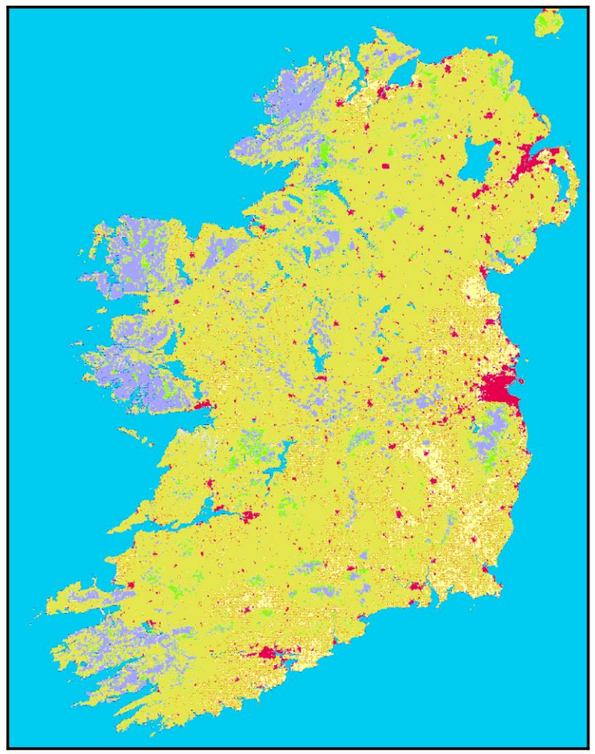




Sentinel-2 Segments

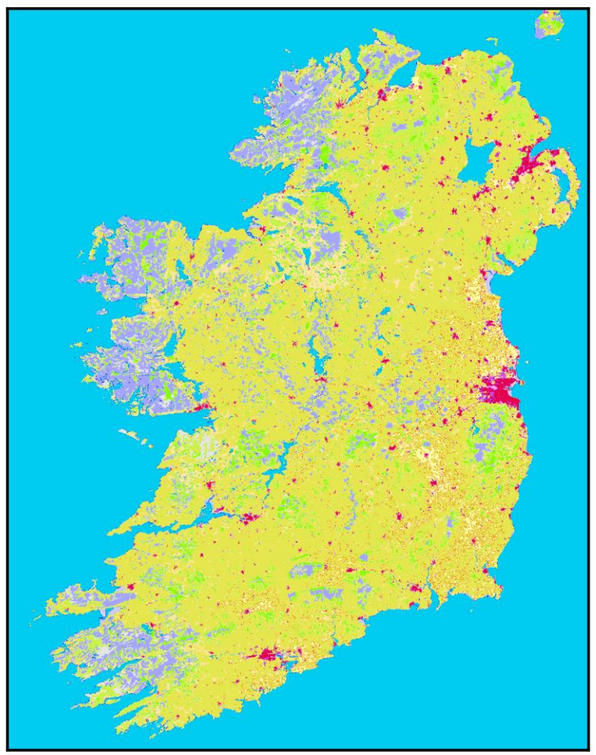
Secondary Results

ECOCLIMAP

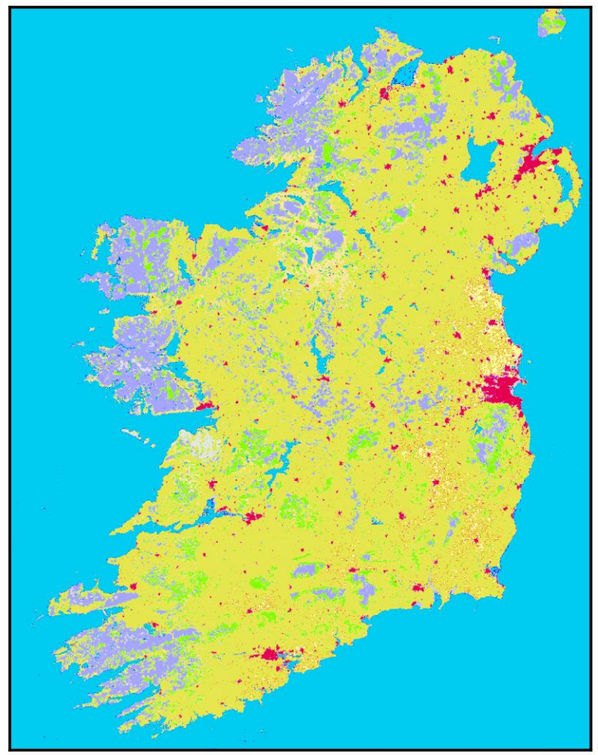


82.4%

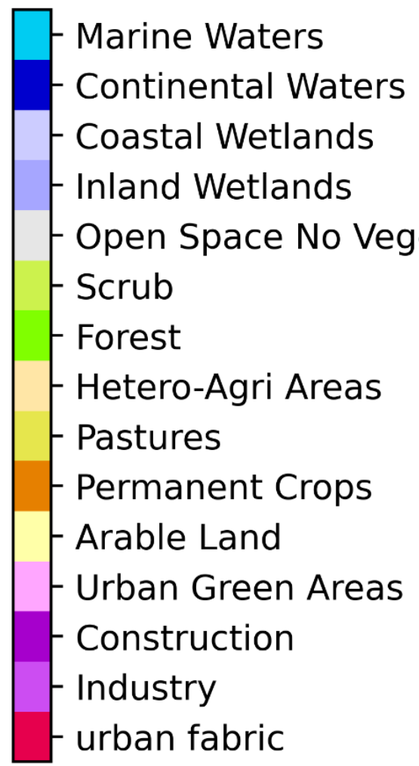
CORINE



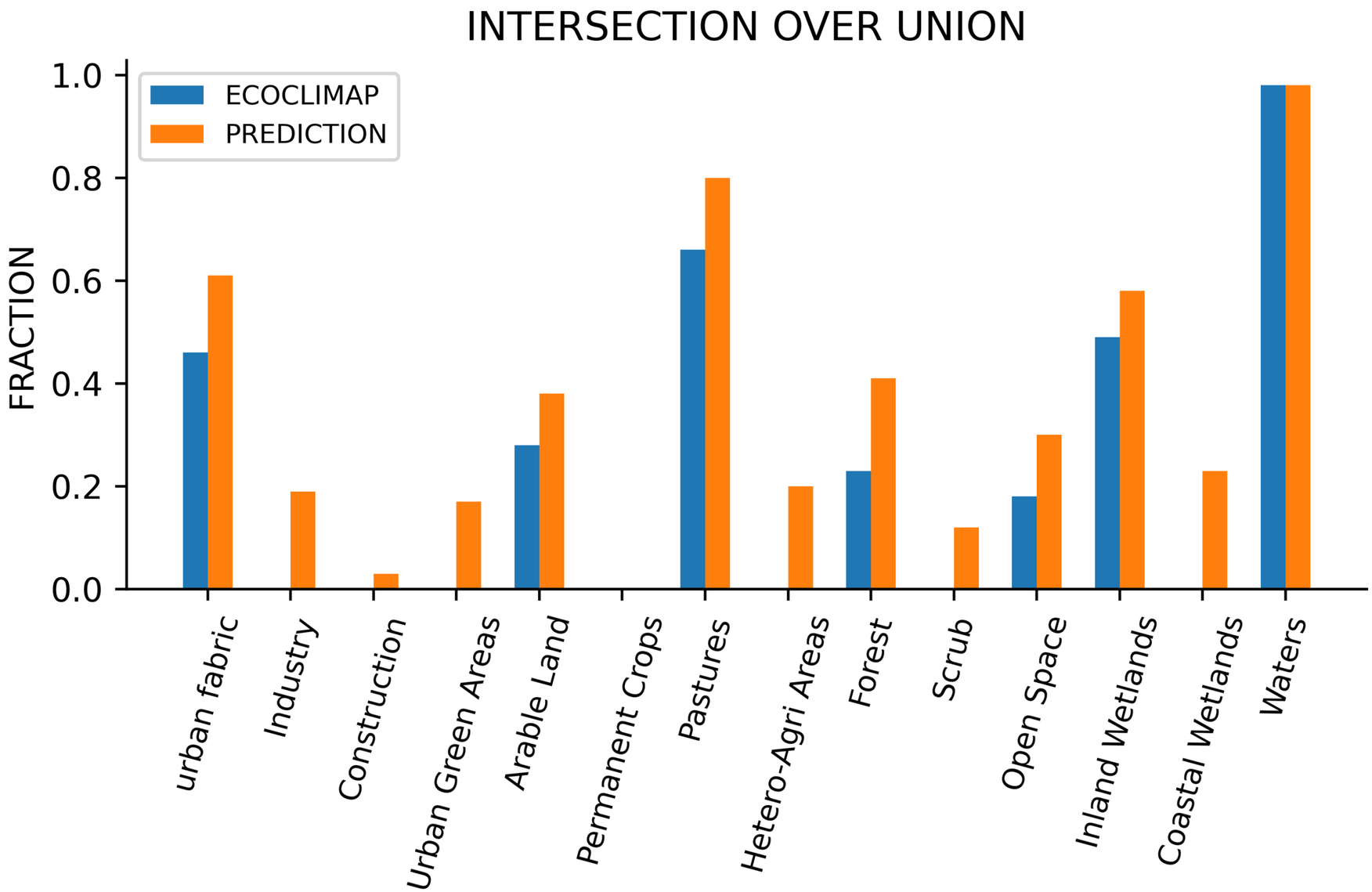
MODEL PREDICTION



87.3%



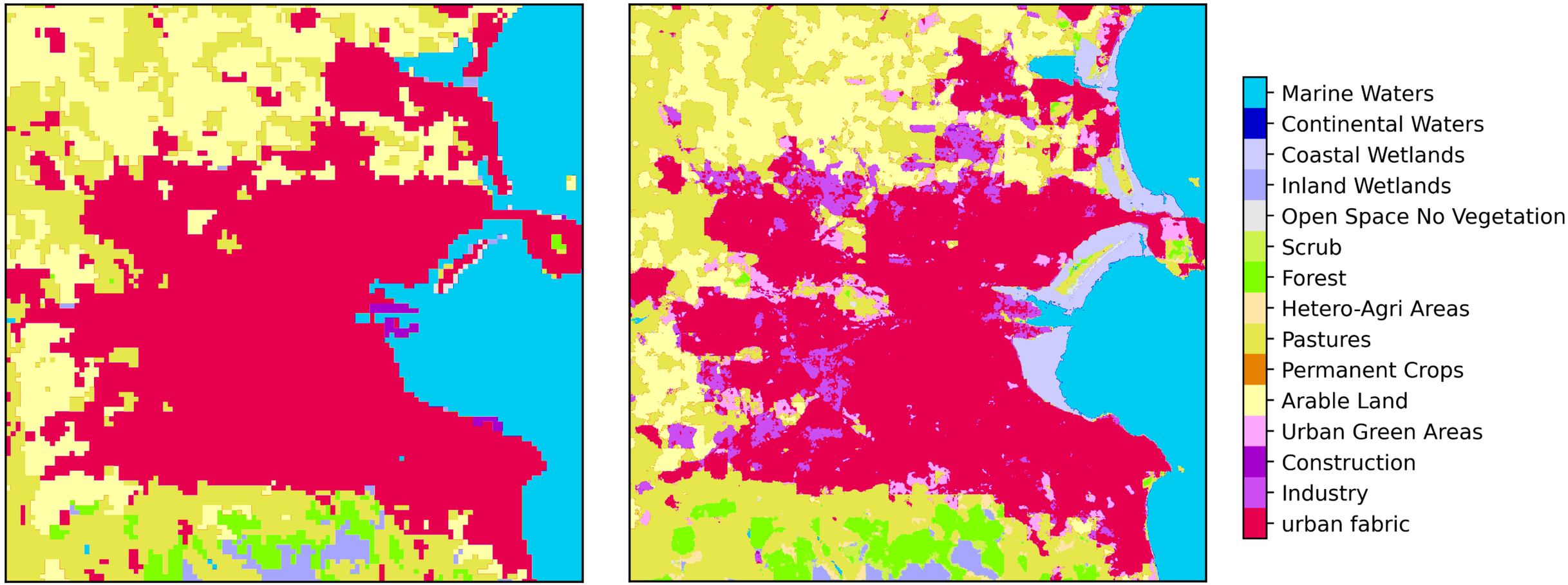
Secondary Results



Dublin

ECOCLIMAP

Model Prediction



Further Work

- Custom labels.
- More nuanced training data selection.
- Attempt a model trained across multiple jurisdictions.

Conclusions

- Machine Learning model shows an improved accuracy on ECOCLIMAP-SG.
- Machine Learning model offers a universal method of improving the map.
- Machine Learning shows a viable way of improving the resolution of the map.