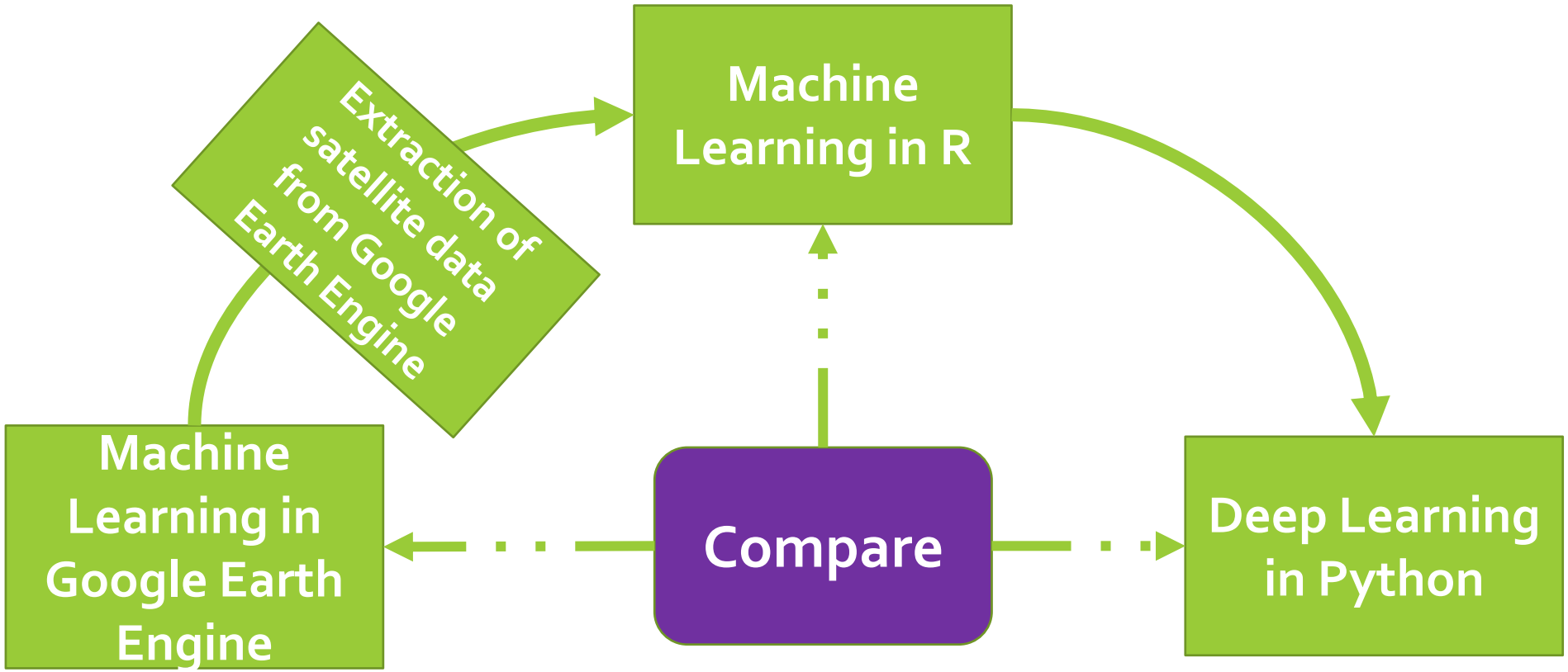
ILR
Institute for
Food and
Resource Economics

UNIVERSITÄT BONN

SATELLITE DATA IN AGRICULTURAL AND ENVIRONMENTAL ECONOMICS

DAVID WUEPPER, LISA BIBER-FREUDENBERGER, HADI, WYCLIFE AGUMBA OLUOCH

SESSION STRUCTURE



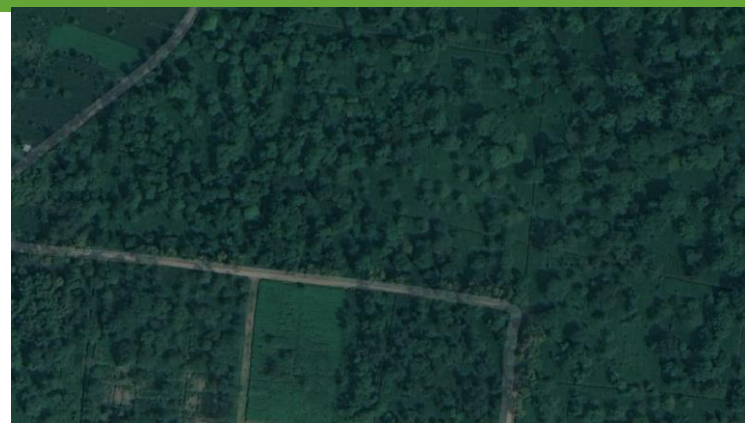
DEEP LEARNING IN AGRICULTURE

https://tinyurl.com/4brjfb6m

CROPLAND MAPPING – DIVERSITY

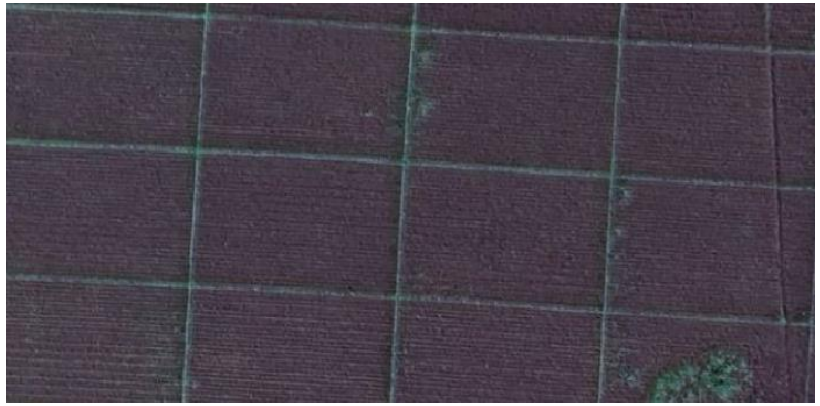
Kenya

Japan

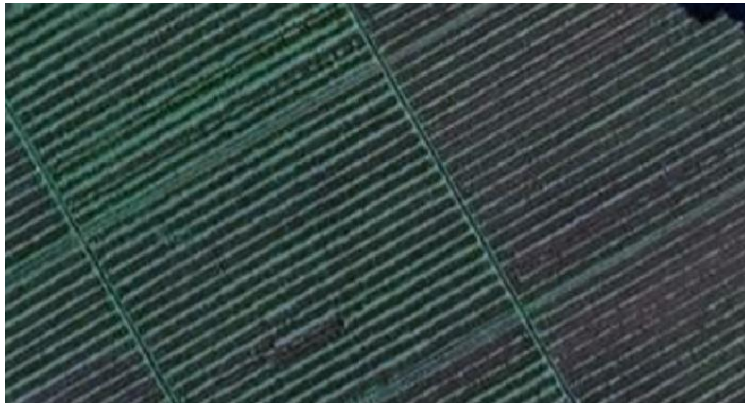


India

Rwanda



Kenya (cut-across prunning)



Kenya (lung-prunning)

DEEP LEARNING IN AGRICULTURE - GEE

- Select the most relevant sensor for the DL task at hand and extract the data
- Can save to disk or mount drive directly to colab and run from there

```
var s2: ImageCollection "Sentinel-2 MSI: MultiSpectral Instrument, Level-2A"
var geometry: Polygon, 4 vertices
// Obtaining Satellite data for deep learning tutorial

s2 = s2.select("B2", "B3", "B4", "B5", "B6", "B7", "B8", "B8A", "B11", "B12") // Selecting the bands to use
  .filterDate("2024-01-01", "2024-11-25") // Selecting the dates
  .filterBounds(geometry) // Filtering for the study area extent
  .filterMetadata("CLOUDY_PIXEL_PERCENTAGE", "less_than", 10) // Leaving out very cloudy images
  .median() // Picking the median pixels values to avoid extremes
  .multiply(0.0001) // Scaling factor for the bands
  .clip(geometry); // Clipping for the boundary of the study area

// Visualizing the image
Map.centerObject(geometry);

// Create a dictionary for the visualizing
var vis = {
  bands: ['B4', 'B3', 'B2'],
  min: 0.0062203901174822315,
  max: 0.0694065392749644,
  gamma: 0.5
};

Map.addLayer(s2, vis, "s2_rgb");

// Export to google drive
Export.image.toDrive({
    image: s2,
    description: 'image',
    folder: 'sat_course_dl',
    fileNamePrefix: 'sentinel',
    scale: 10, // Ensuring that the image is exported in the right scale
    region: geometry,  // Region is the polygon itself
    maxPixels: 1e13,  // Max pixels allowed in the export
    crs: "EPSG:3857" // This is the crs of out gpkg
  });
```

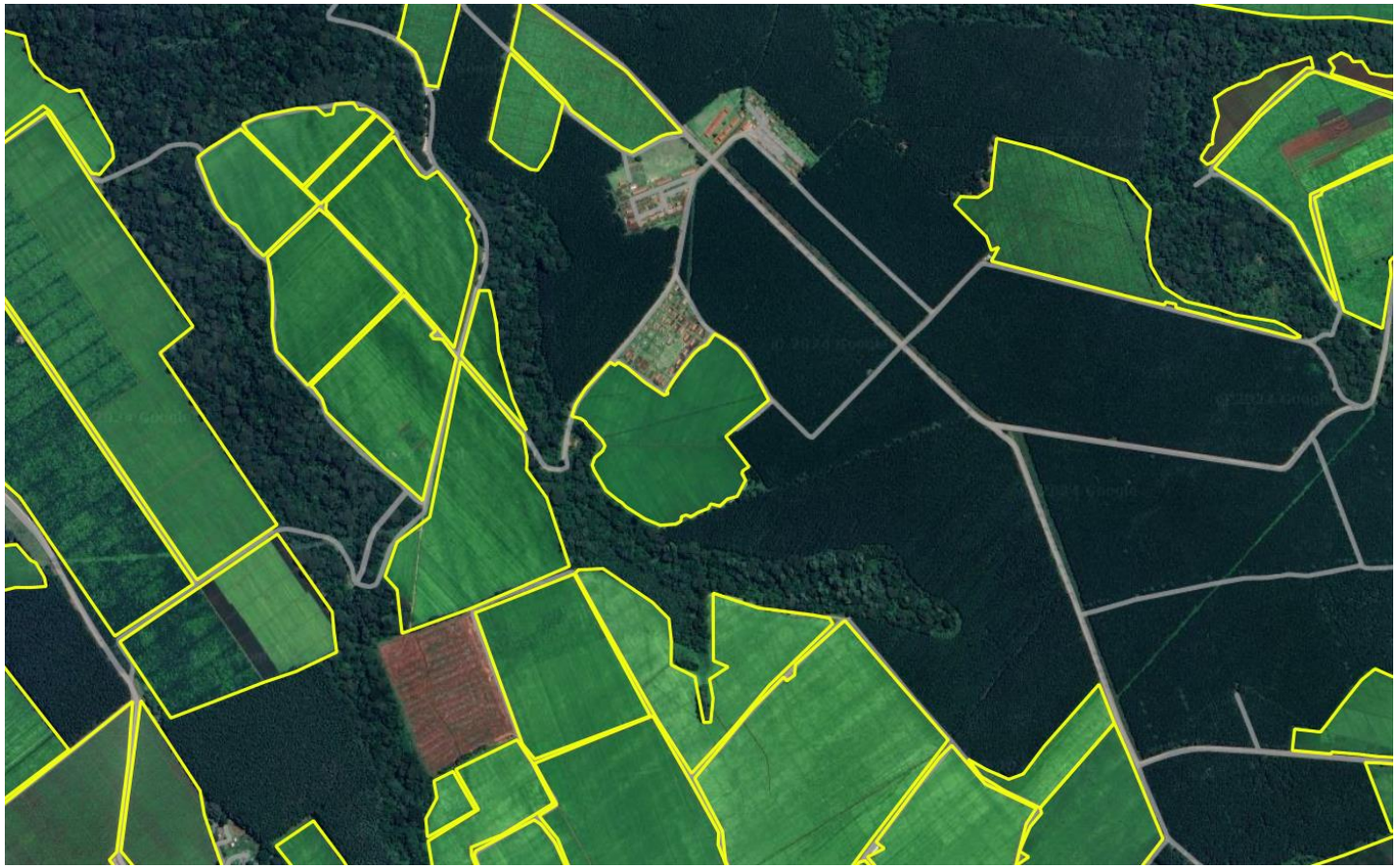
DEEP LEARNING IN AGRICULTURE – IMAGE SEGMENTATION

Image segmentation is the process of partitioning satellite imagery into specific classes/region based on pixel characteristics. This is the process normally used to:

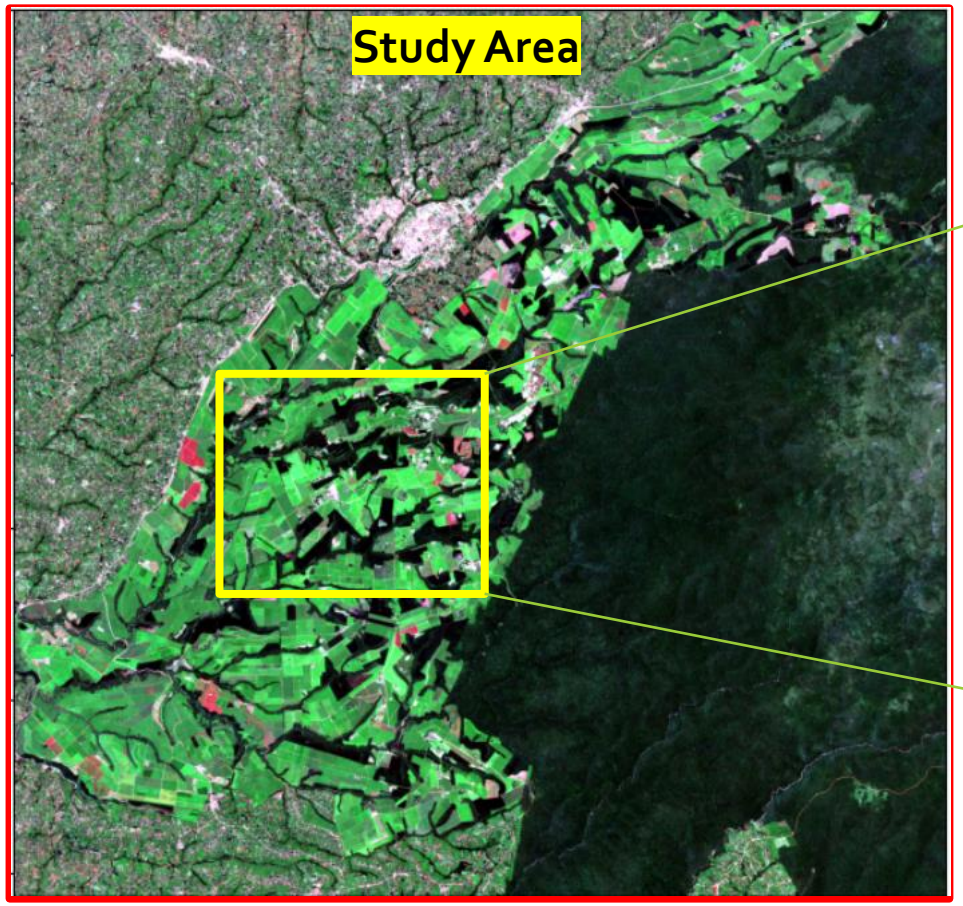
- Classify land cover classes.
- Classify crop types
- Delineate of urban areas
- Extract water bodies from images
- Detect crop disease or stress, among others

DEEP LEARNING IN AGRICULTURE - LABEL

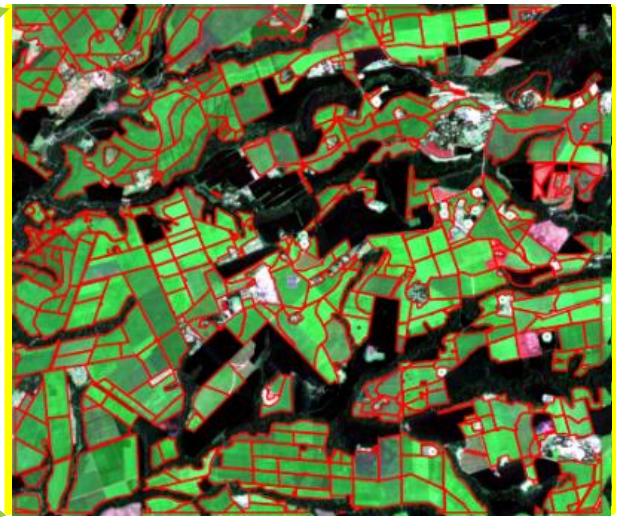
Getting a **well labeled data** is arguably the most challenging part of the whole deep learning process



CROPLAND MAPPING



Sampling area



Generated mask

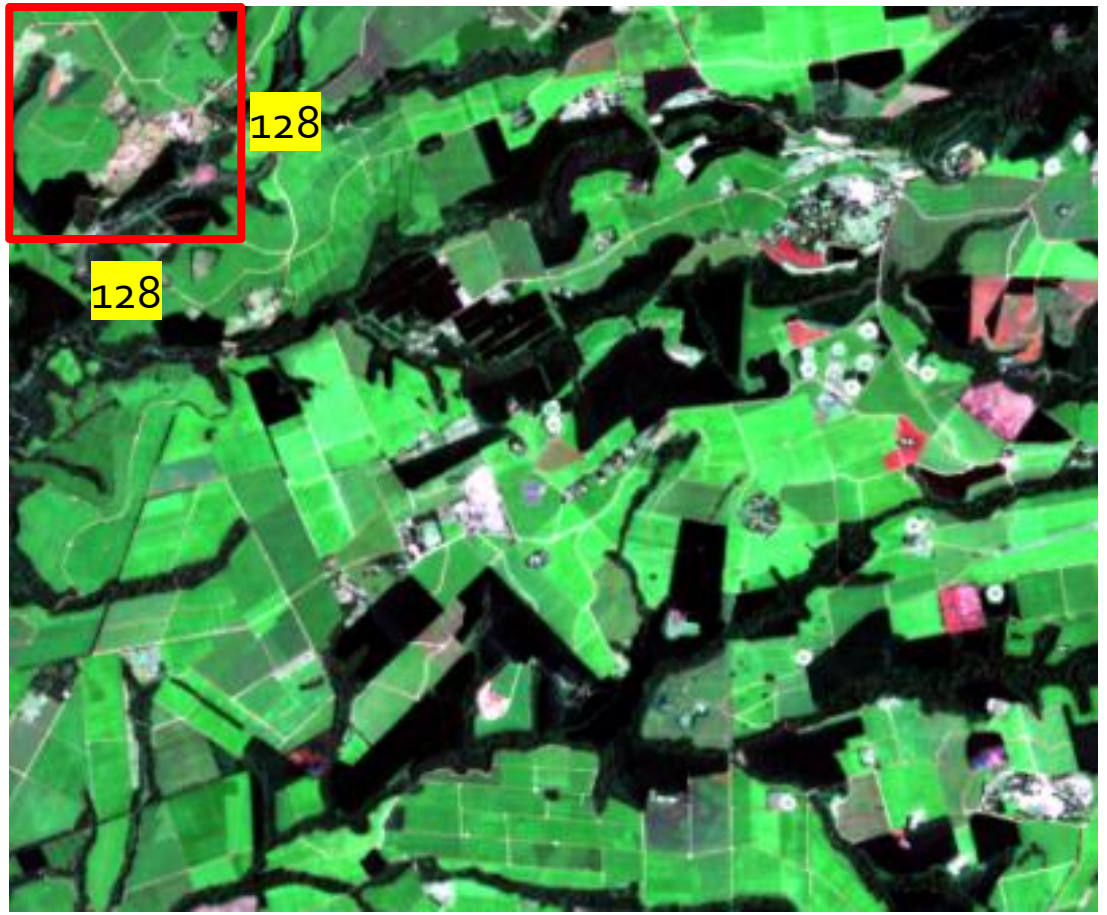
UNIVERSITÄT BONN

ILR Institute for Food and Resource Economics

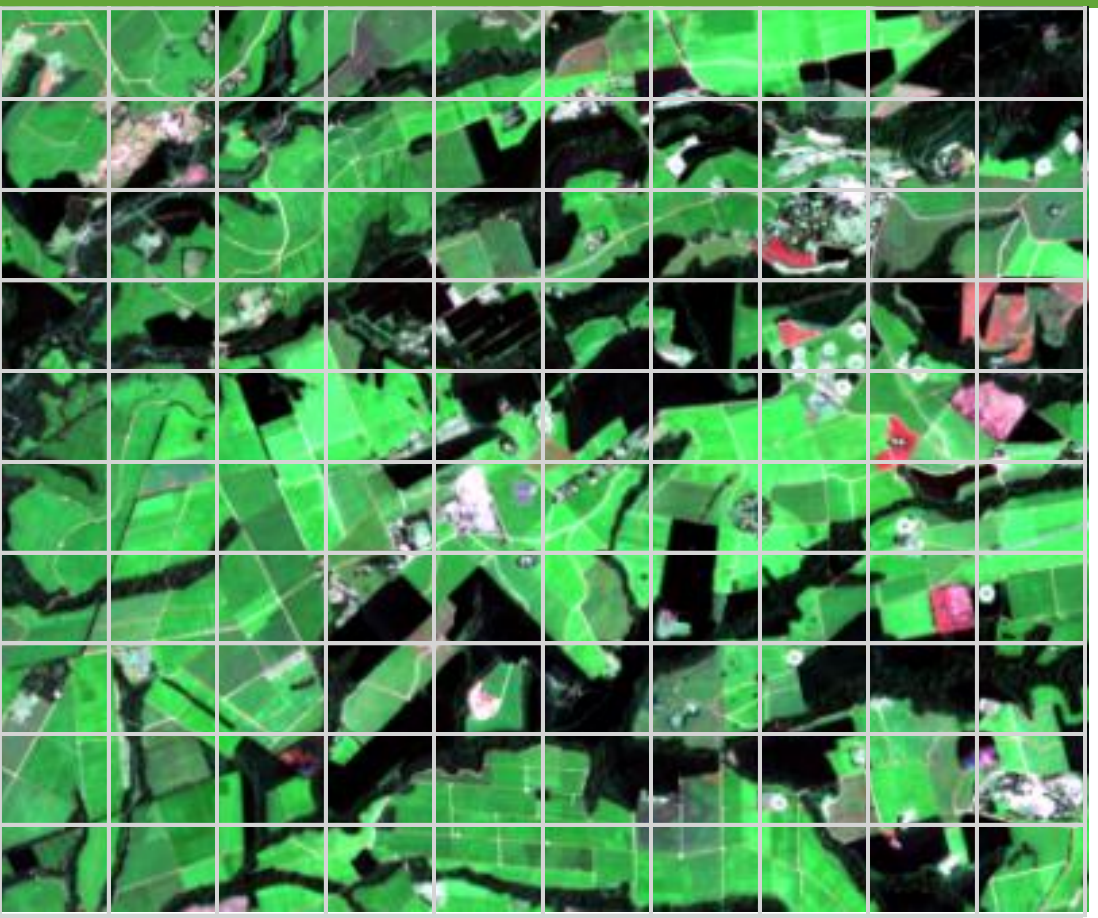
Land Economics Group

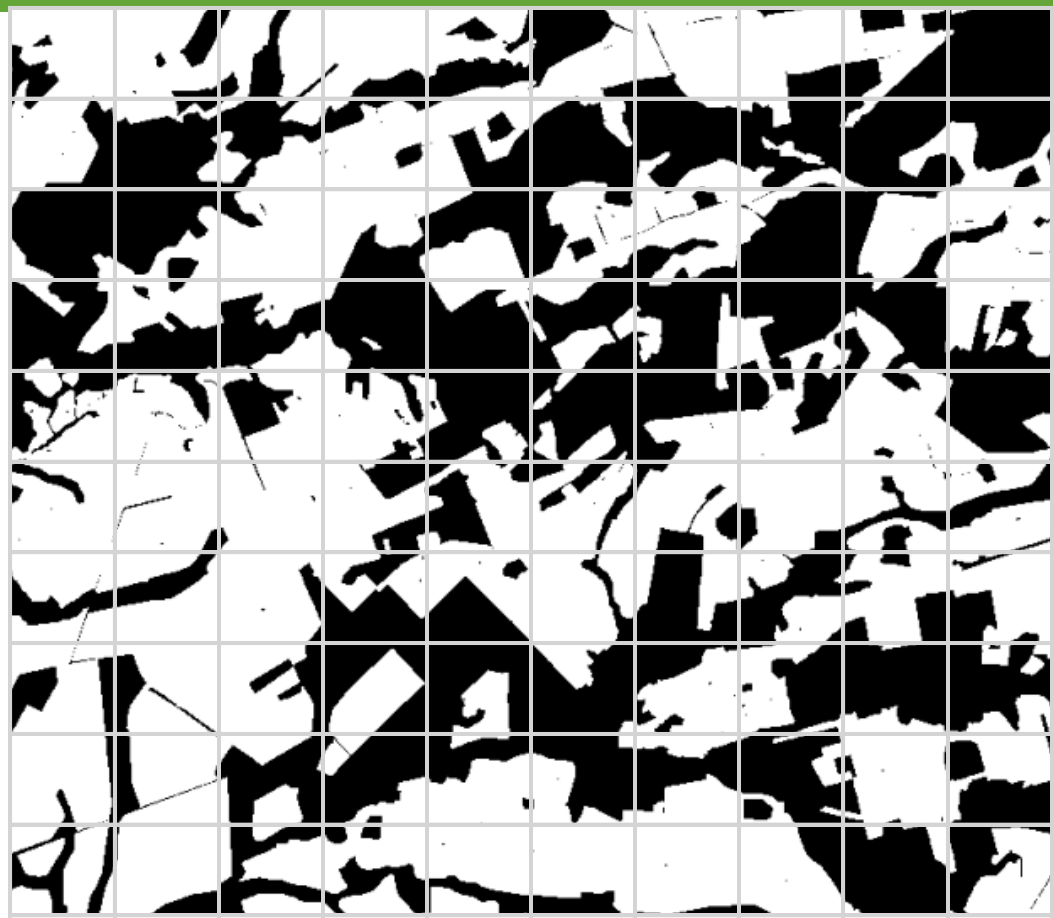
CROPLAND MAPPING - CREATING PATCHES

- Determine the patch size – Normally 2^x
- Consider the dimension of the image and its divisibility by your patch size
- Pad the image if necessary, or crop it

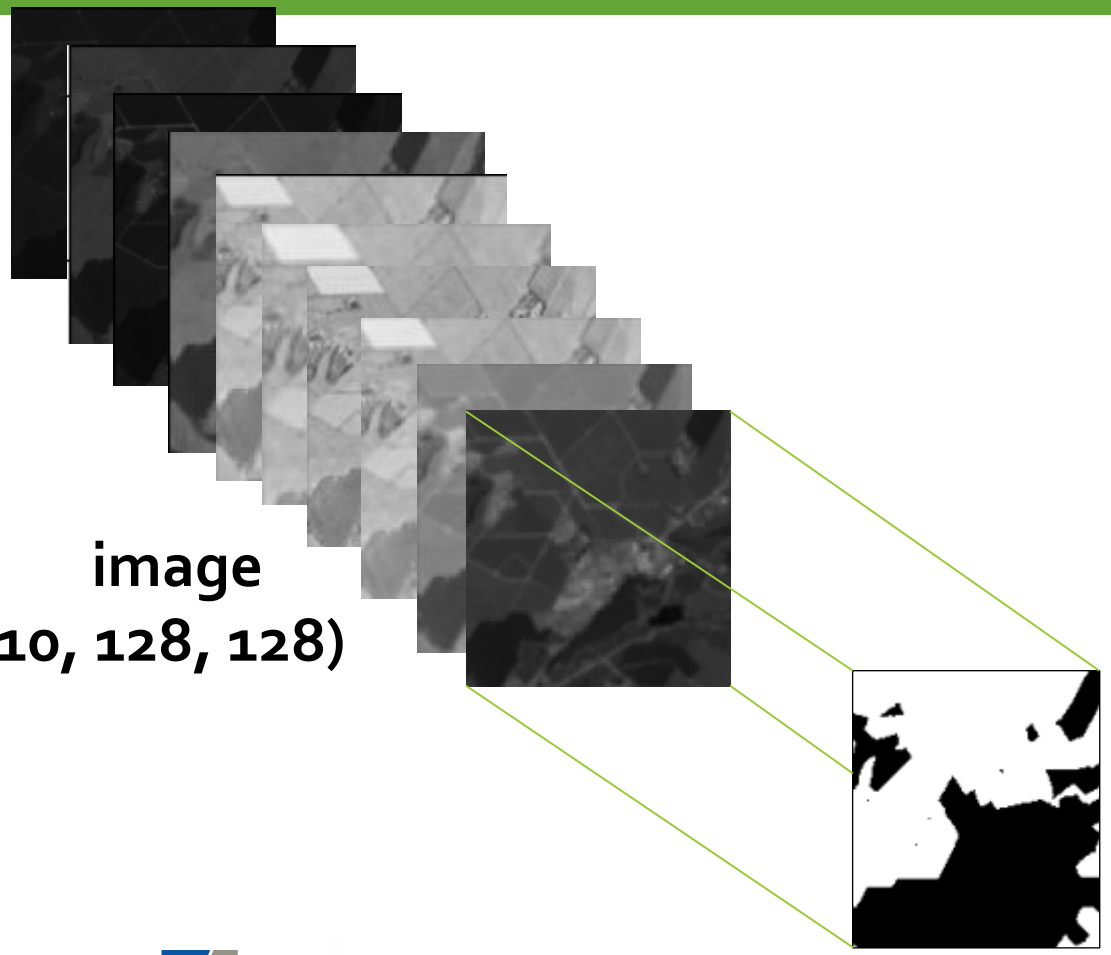


CROPLAND MAPPING - CREATING PATCHES





CROPLAND MAPPING – IMAGE & LABELS



The matrix and labels

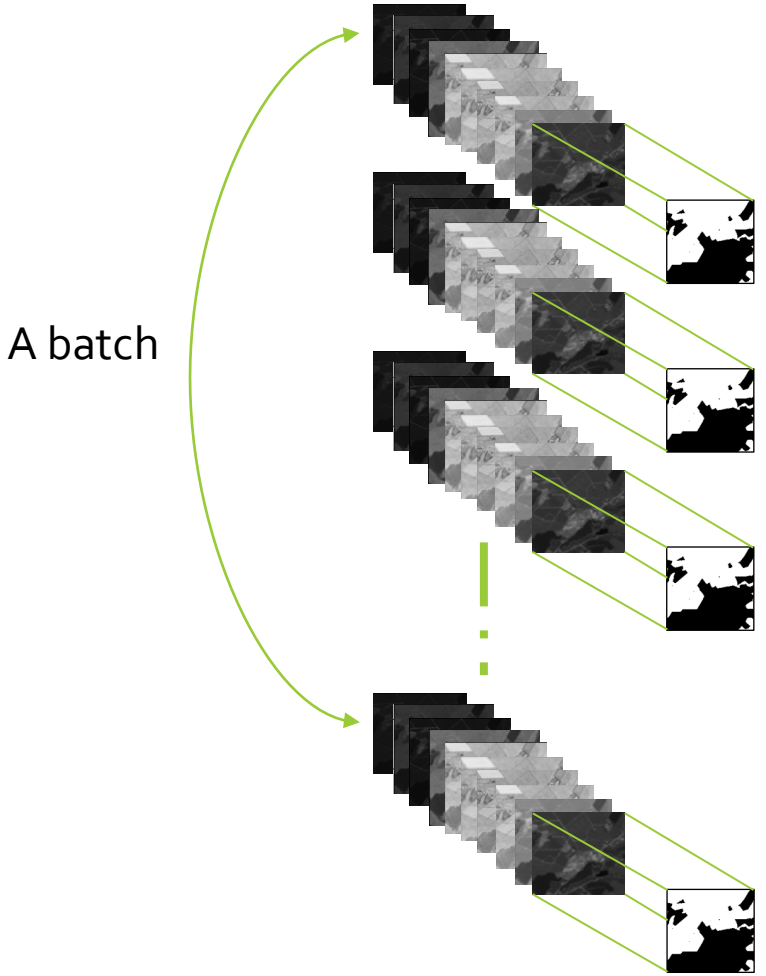
B2	B3	B4	B5	B6	B7	B8	B8A	B11	B12	Mask
0.050503	0.055595	0.0661	0.070009	0.074429	0.077546	0.089708	0.085558	0.161825	0.219849	0
0.047247	0.056389	0.066608	0.070088	0.073963	0.078977	0.084274	0.086059	0.161069	0.226217	0
0.047515	0.057162	0.065378	0.070666	0.074371	0.079291	0.086929	0.087294	0.160616	0.217802	1
0.051134	0.055476	0.067922	0.070737	0.074288	0.078877	0.080241	0.086171	0.157074	0.219841	0
0.046165	0.05529	0.067675	0.070001	0.073689	0.078164	0.080921	0.08618	0.161556	0.214059	1
0.046502	0.055556	0.065229	0.070134	0.073474	0.078107	0.078883	0.086654	0.160116	0.211296	1
0.049212	0.055296	0.067052	0.069823	0.073832	0.07771	0.082601	0.085742	0.162982	0.227283	1
0.047988	0.057581	0.067353	0.070999	0.073906	0.078857	0.078786	0.087444	0.157796	0.211337	1
0.049595	0.056136	0.065684	0.070346	0.073367	0.078104	0.085845	0.085742	0.164296	0.217406	0

CROPLAND MAPPING – BATCHSIZE

After creating patches, consisting of both images and labels/masks, the next step is to decide on **batch-size**

This is the **number of images** that are used for training **per single run** (both forward and backward passes)

Should normally be a **power of 2** (just like shape of image) for computational efficiency in modern hardware



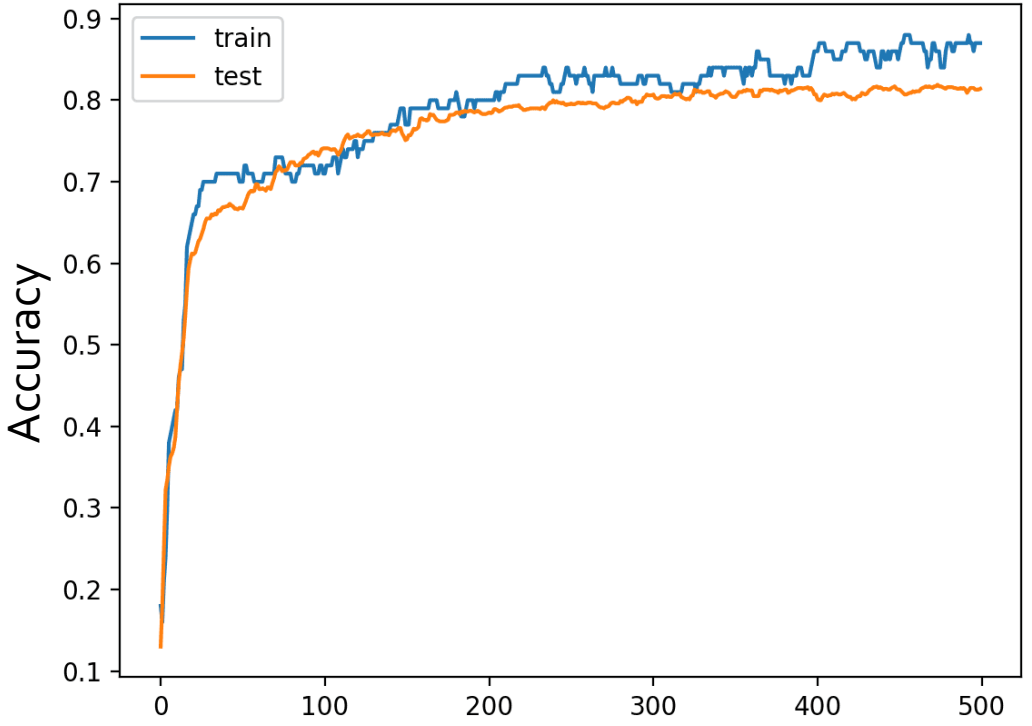
CROPLAND MAPPING - EPOCH

Epoch is a complete **pass through the entire training dataset** during the training process

Should always be set to **more than 1**

After each epoch, the model **updates it's weights** for better learning

One can **save best model** at best epoch based on evaluation metrics



https://shorturl.at/AMpVp

CROPLAND MAPPING - AUGMENTATION

- This involves artificial increase in **diversity of training dataset** by applying transformations to the data while preserving its labels.
- It is helpful to improve better performance and generalization especially when data is limited.

CROPLAND MAPPING - AUGMENTATION

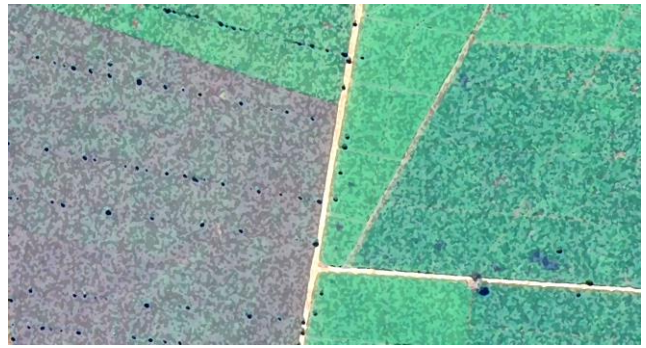
Original

RandomRain

RandomSizedCrop

VerticalFlip

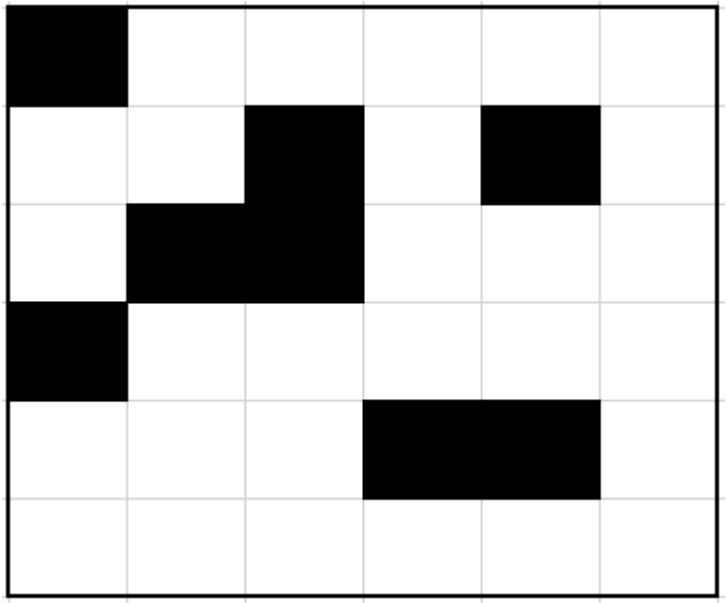
ColorJitter



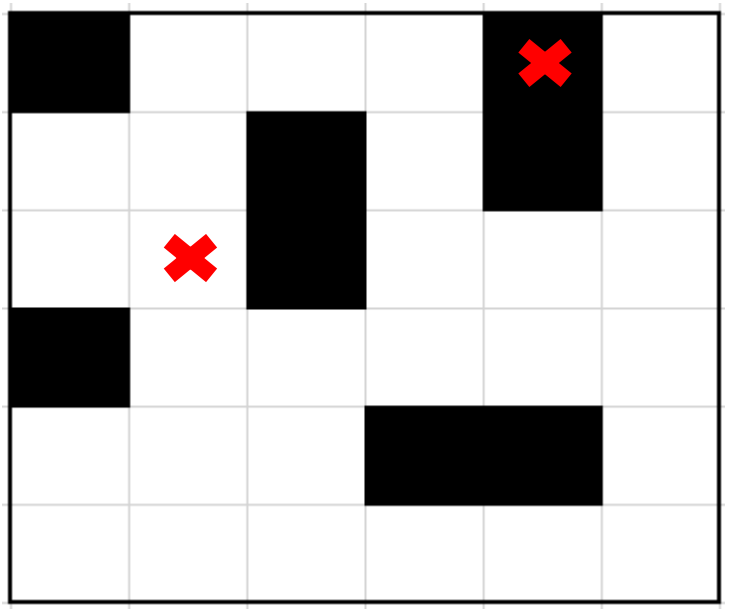
Several combined

MODEL EVALUATION - IOU

Intersection over Union – IoU (Area of overlap over area of union)



Ground truth / Mask / Label



Prediction

$$= \frac{34}{36} = 0.944$$

HANDLING INPUT VARIABLES – SIMPLIFIED

https://torchgeo.readthedocs.io/en/latest/

INPUT VARIABLES – HETEROGENEITY AGNOSTIC

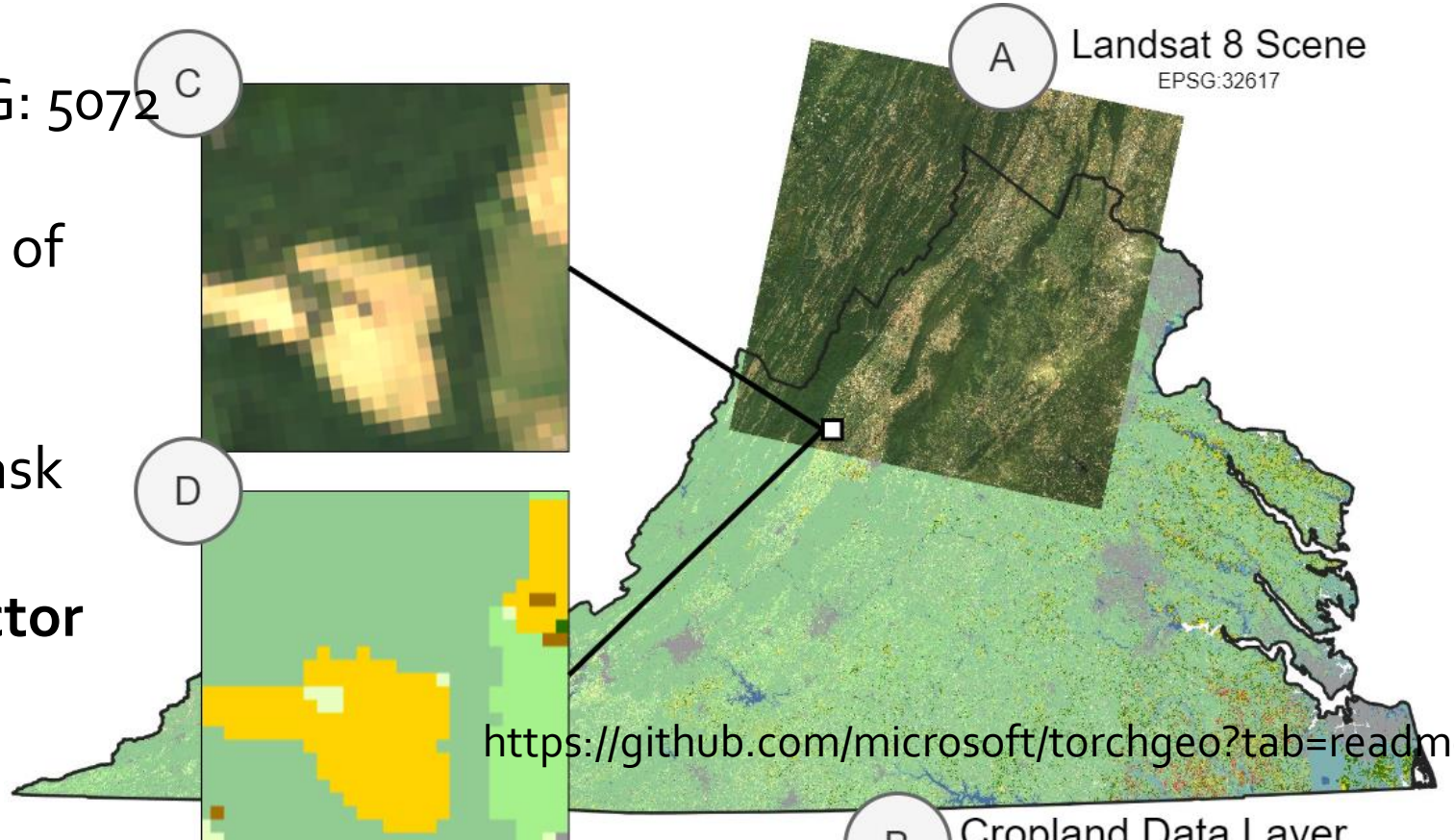
A: Landsat 8 scene at EPSG:32617

B: Cropland Data Layer at EPSG: 5072

C: Sampled chip at intersection of landsat and cropland.

D: Corresponding croplands mask

Note: The cropland can be vector



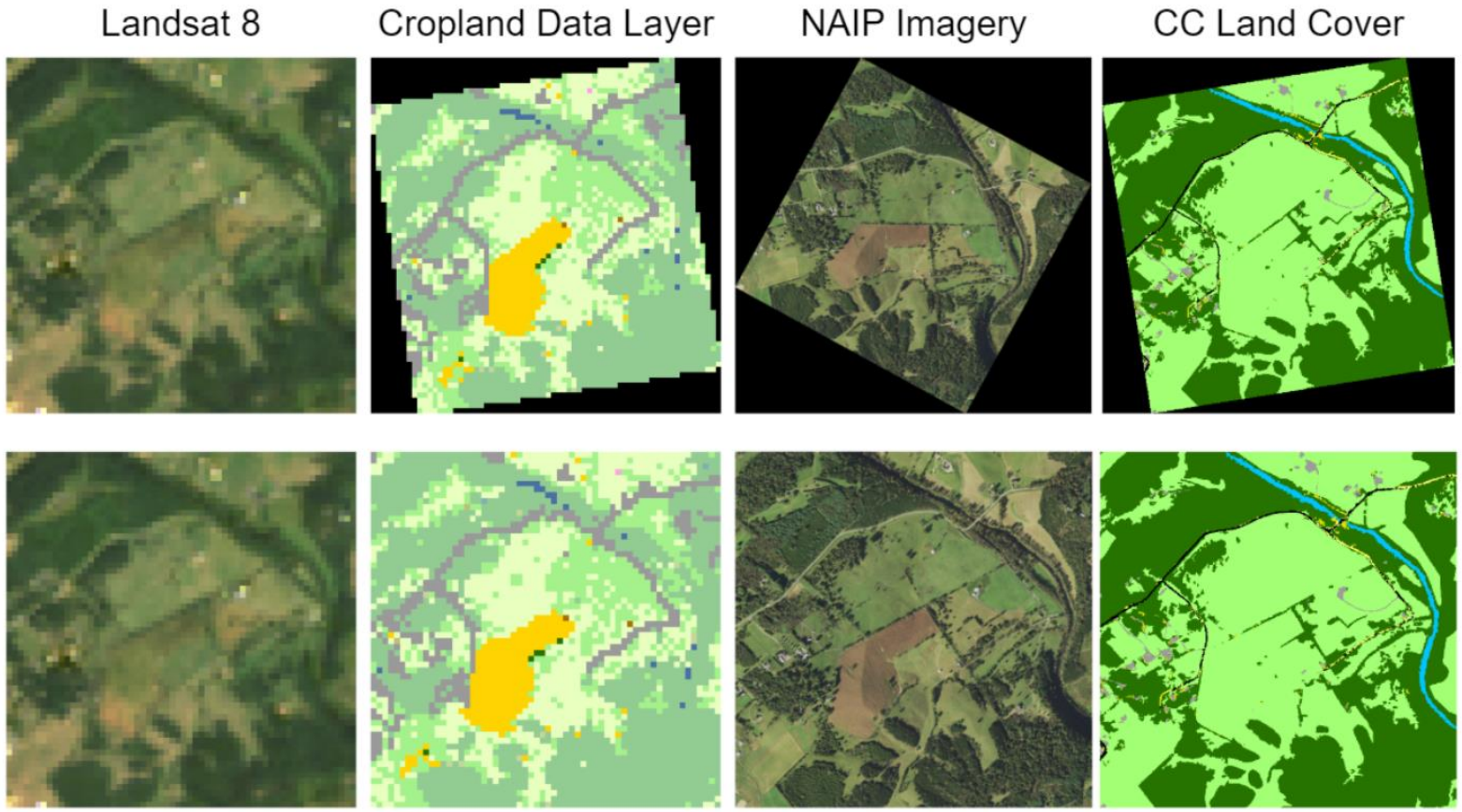
https://github.com/microsoft/torchgeo?tab=readme-ov-file

UNIVERSITÄT BONN

ILR Institute for Food and Resource Economics

Land Economics Group

INPUT VARIABLES – HETEROGENEITY AGNOSTIC



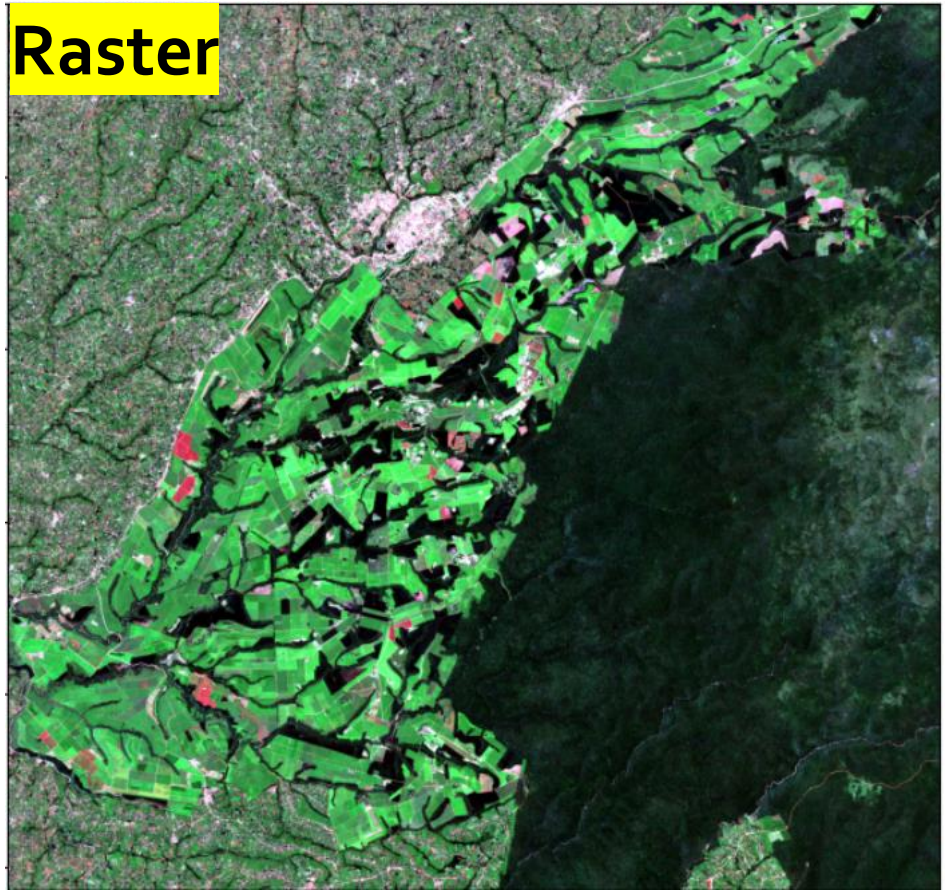
Different projections and spatial resolution

Reprojected and resampled

https://pytorch.org/blog/geospatial-deep-learning-with-torchgeo/

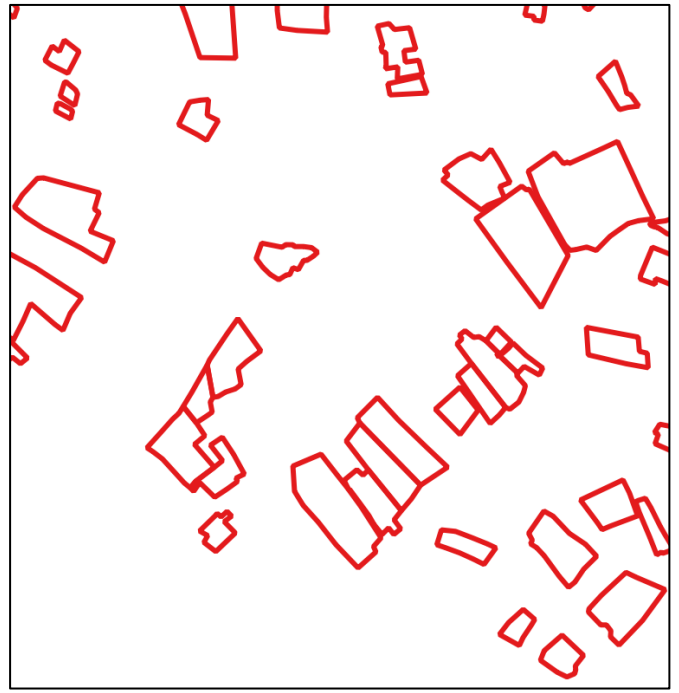
CROPLAND MAPPING – SIMPLIFIED

Raster



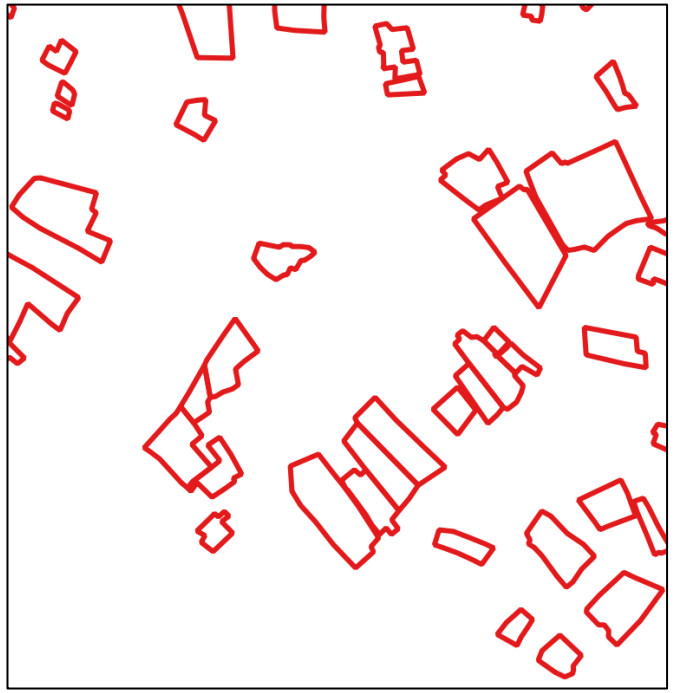
&

Vector



CROPLAND MAPPING – SIMPLIFIED

Vector



```
> v
class       : SpatVector
geometry    : polygons
dimensions  : 23, 1  (geometries, attributes)
extent      : 36.69581, 36.73747, -1.1138, -1.045927  (xmin, xmax, ymin, ymax)
source      : tea_no_tea.gpkg
coord. ref. : lon/lat WGS 84 (EPSG:4326)
names       : tea_no_tea
type        :      <int>
values      :          1
                       1
                       1
```

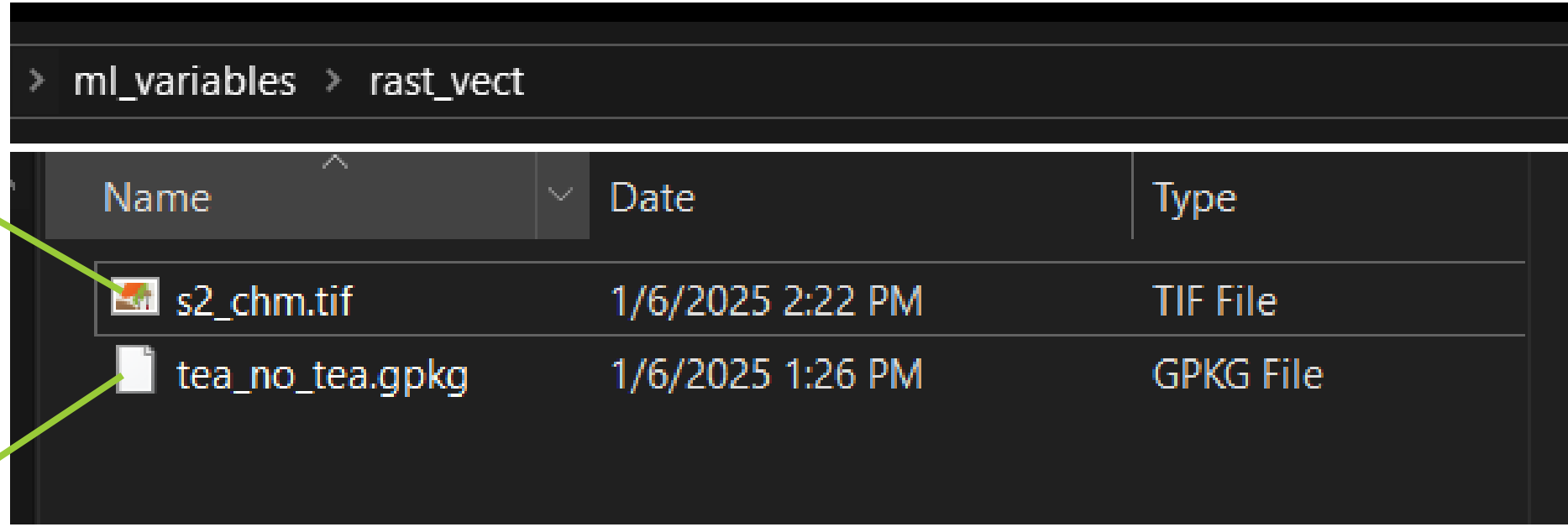
Column for label creation with values 1 for tea fields and 0 for non tea fields. Can be multiclass

CROPLAND MAPPING – SIMPLIFIED

Both in the same folder

raster

vector



DEEP LEARNING IN AGRICULTURE

WHY DEEP LEARNING	WHY NOT DEEP LEARNING
Better accuracy	Computationally expensive
Automation	A lot of labelled data
Scalability with large data	Black box in interpretation/how decisions are made
Unstructured + structured data (image,text,audio,video)	Poor generalization (tea in small vs large scale)
Higher adaptability	Expertise dependency

ILR
Institute for
Food and
Resource Economics

UNIVERSITÄT BONN

TUTORIAL

https://tinyurl.com/38s2arkc

Land Economics Group

ILR
Institute for
Food and
Resource Economics

UNIVERSITÄT BONN

THANK YOU

Land Economics Group