DEPARTMENT OF LANDSCAPE
WATER CONSERVATION

Map digitalisation using multi-spatial resolution approach

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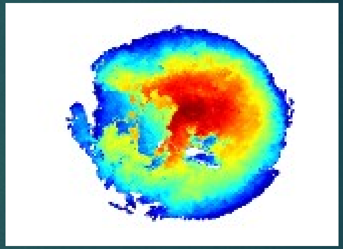


Motivation

- Tedious and slow process of manual identification of different map elements
- Training data will be created as a part of manual map digitalization
- Map fully digitalized and georeferenced
- Software and computing power are easily accessible

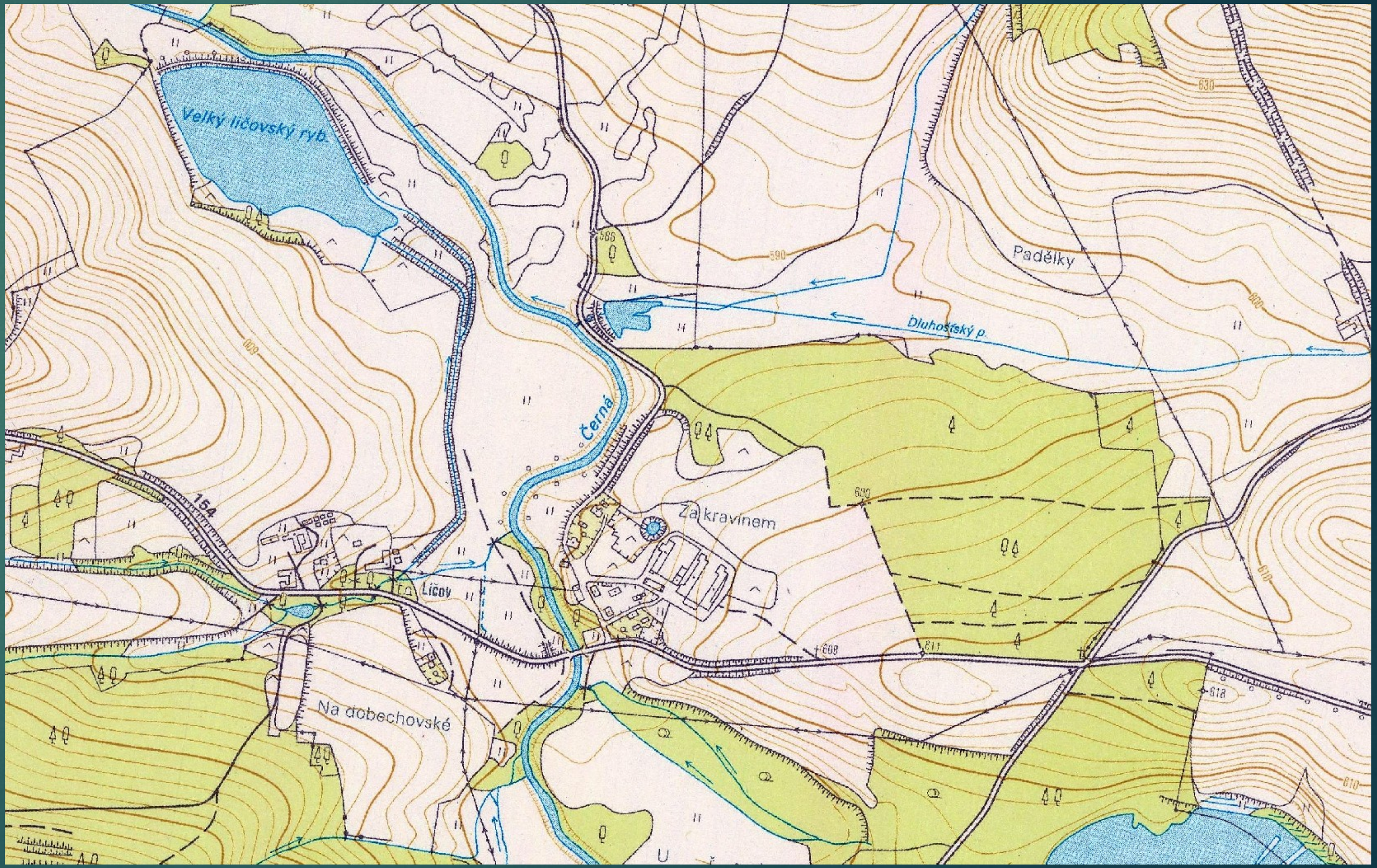
Goals

- Identify several classes of map symbology
  - Small Roads
  - Roads
  - Railway
  - Pasture
  - Dashed Roads
  - Wetland
  - Meadow
  - Rest
  - Boundaries
- Loading of classified raster back to ArcGIS
- Retrainable model

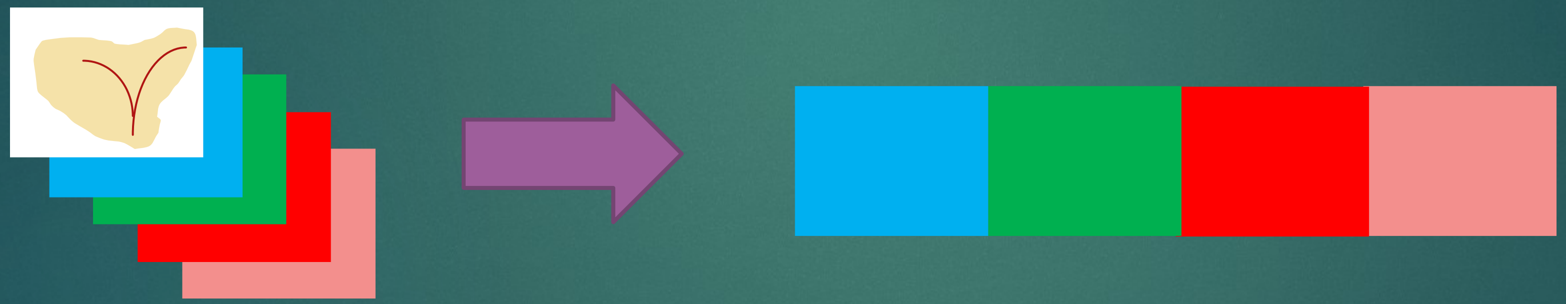
Methodology

- Manual creation of training data
- Creation of multiband composite

- Creation of mosaics from multiband composite segments and their export
- Training of the model
- Use of the model
- Import of the results back to GIS

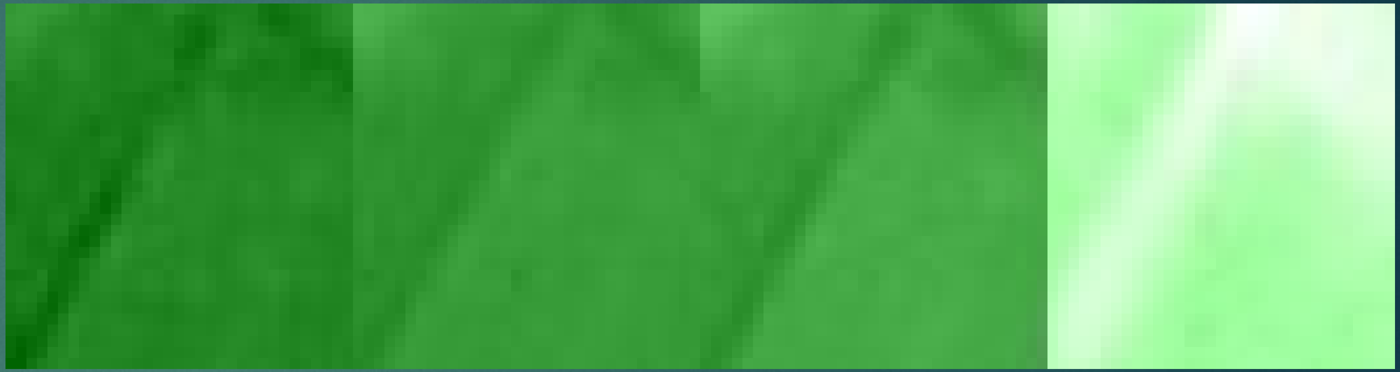


Creation of mosaics from multiband composite segments and their export



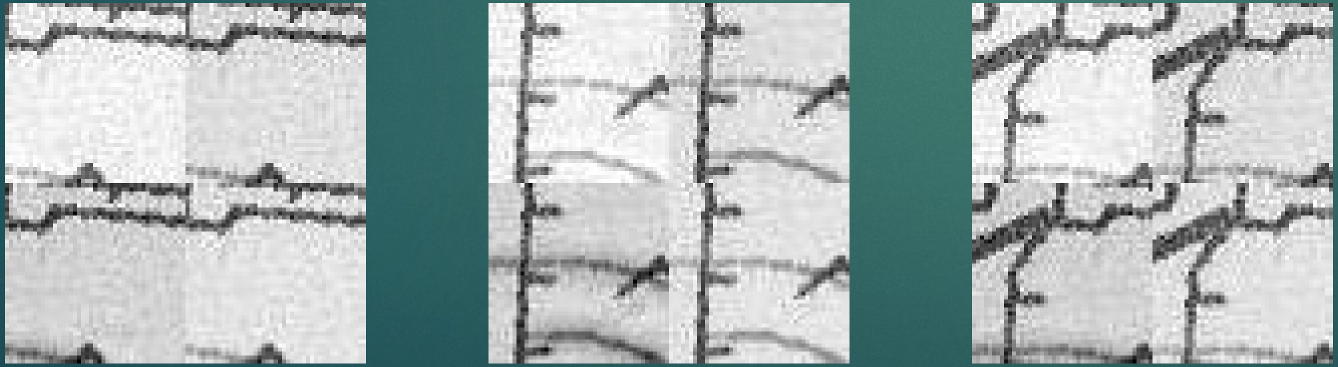
Mosaics from segments

- Variable size
- B, G, R
- Standardize [0, 1]
- Square shift
  - Right
  - Down
  - Down and right
- Saved as jpg format



Segment shift

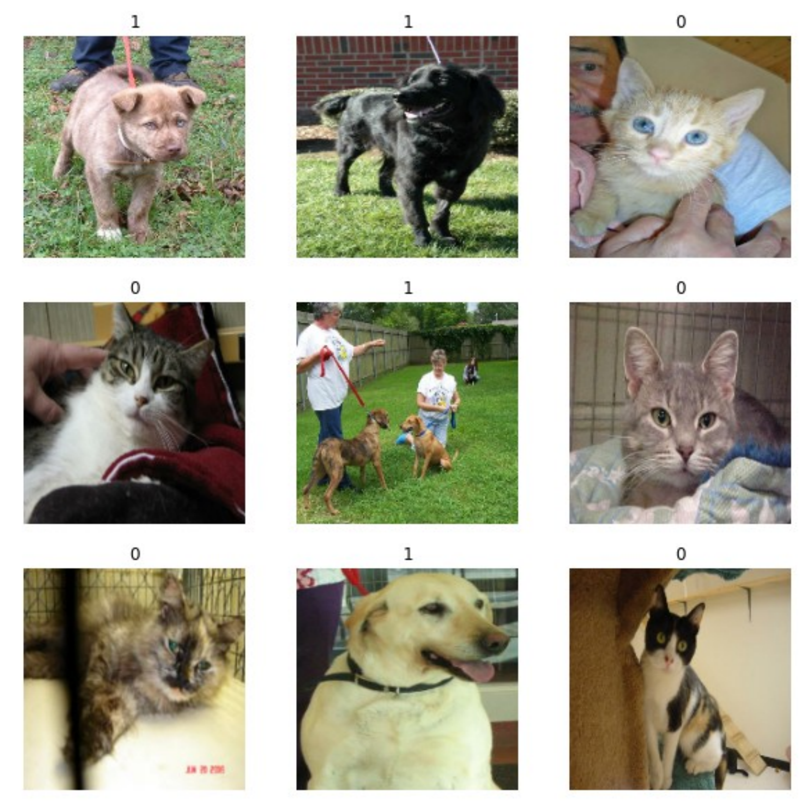
- 4 sets of mosaics are created from one scene
- Doubles the precision of the output
- Classification precision = Pixel size of segment



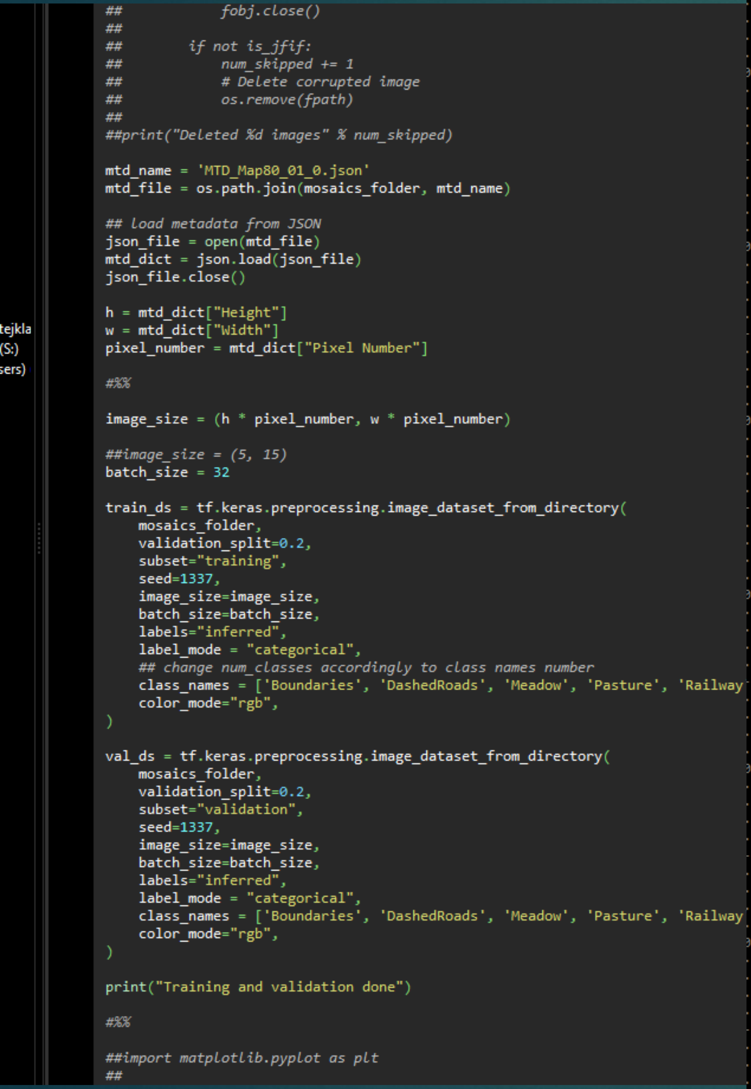
Model

- Python, Tensorflow, Keras
- Deep learning API
- Flexible, Simple workflow, Powerful
- Used by NASA, YouTube, Waymo (Chollet 2021)

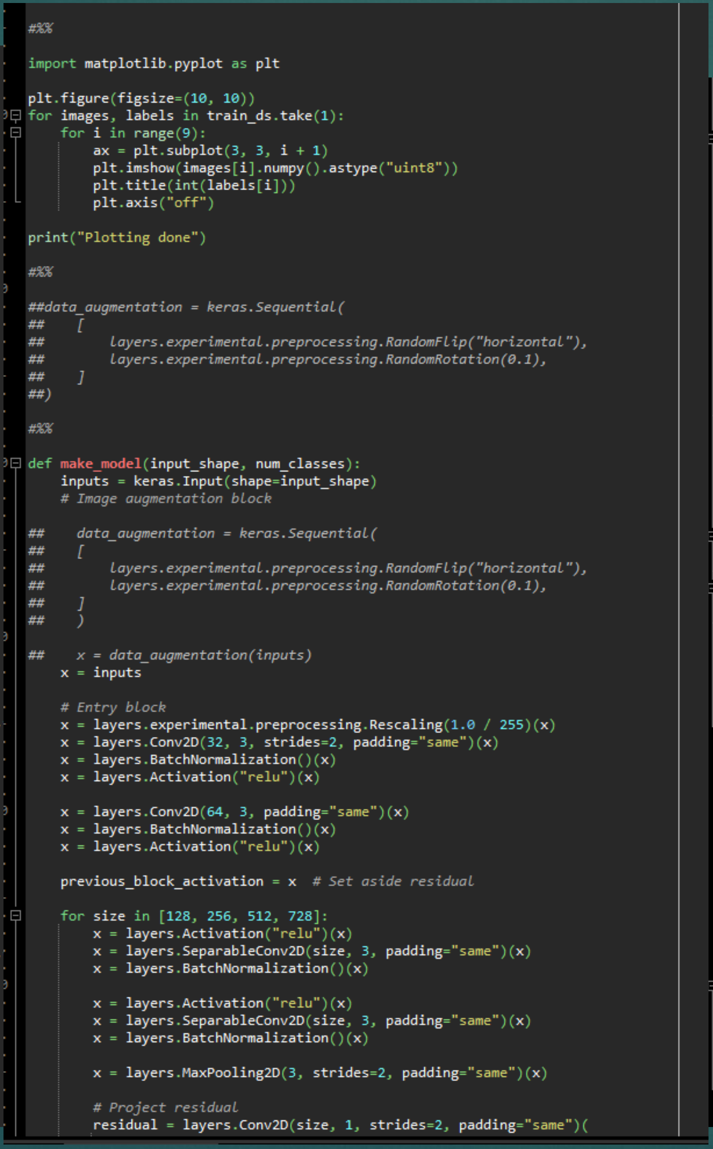
- Kaggle Cats vs Dogs used as a foundation
- 23 410 pictures of cats and dogs
- Binary classification



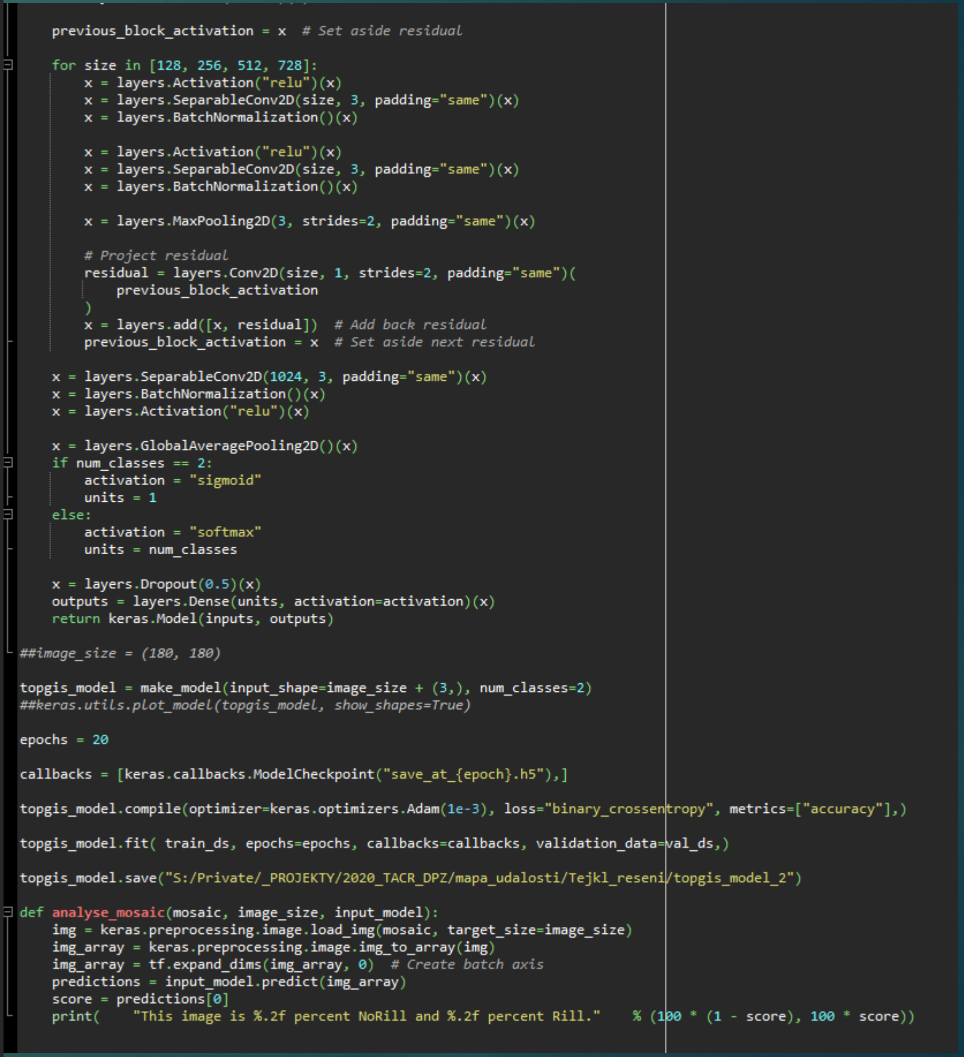
Model



```
##            fobj.close()
##
##        if not is_jfif:
##            num_skipped += 1
##            # Delete corrupted image
##            os.remove(fpath)
##
##print("Deleted %d images" % num_skipped)

mtd_name = 'MTD_Map80_01_0.json'
mtd_file = os.path.join(mosaics_folder, mtd_name)

## load metadata from JSON
json_file = open(mtd_file)
mtd_dict = json.load(json_file)
json_file.close()

h = mtd_dict["Height"]
w = mtd_dict["Width"]
pixel_number = mtd_dict["Pixel Number"]

#%%

image_size = (h * pixel_number, w * pixel_number)

##image_size = (5, 15)
batch_size = 32

train_ds = tf.keras.preprocessing.image_dataset_from_directory(
    mosaics_folder,
    validation_split=0.2,
    subset="training",
    seed=1337,
    image_size=image_size,
    batch_size=batch_size,
    labels="inferred",
    label_mode = "categorical",
    ## change num_classes accordingly to class names number
    class_names = ['Boundaries', 'DashedRoads', 'Meadow', 'Pasture', 'Railway
    color_mode="rgb",
)

val_ds = tf.keras.preprocessing.image_dataset_from_directory(
    mosaics_folder,
    validation_split=0.2,
    subset="validation",
    seed=1337,
    image_size=image_size,
    batch_size=batch_size,
    labels="inferred",
    label_mode = "categorical",
    class_names = ['Boundaries', 'DashedRoads', 'Meadow', 'Pasture', 'Railway
    color_mode="rgb",
)

print("Training and validation done")

#%%

##import matplotlib.pyplot as plt
##
```

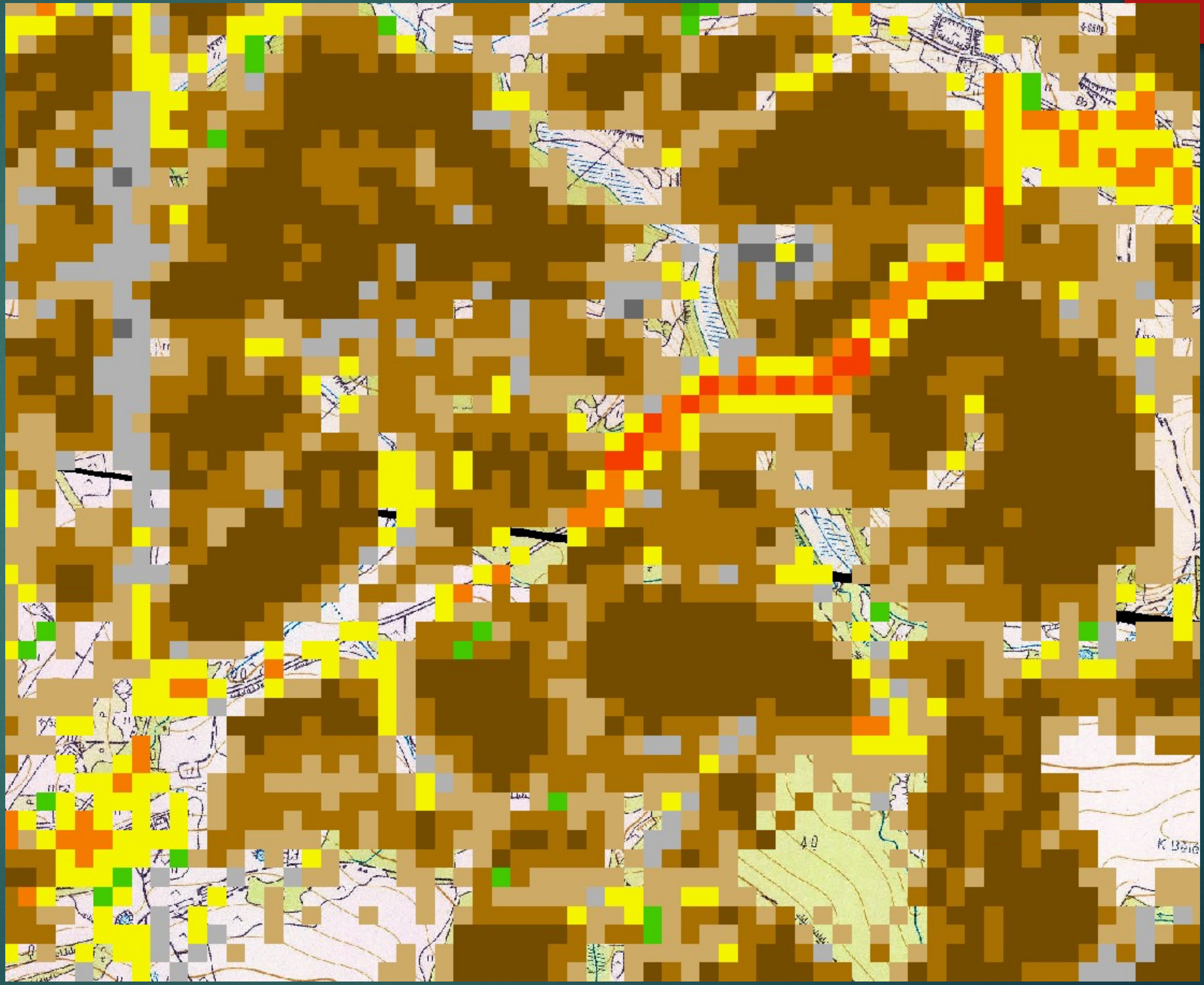


```
#%%

import matplotlib.pyplot as plt

plt.figure(figsize=(10, 10))
for images, labels in train_ds.take(1):
    for i in range(9):
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(images[i].numpy().astype("uint8"))
        plt.title(int(labels[i]))
        plt.axis("off")

print("Plotting done")

#%%

##data_augmentation = keras.Sequential(
##    [
##        layers.experimental.preprocessing.RandomFlip("horizontal"),
##        layers.experimental.preprocessing.RandomRotation(0.1),
##    ]
##)

#%%

def make_model(input_shape, num_classes):
    inputs = keras.Input(shape=input_shape)
    # Image augmentation block

##    data_augmentation = keras.Sequential(
##    [
##        layers.experimental.preprocessing.RandomFlip("horizontal"),
##        layers.experimental.preprocessing.RandomRotation(0.1),
##    ]
##    )

##    x = data_augmentation(inputs)
    x = inputs

    # Entry block
    x = layers.experimental.preprocessing.Rescaling(1.0 / 255)(x)
    x = layers.Conv2D(32, 3, strides=2, padding="same")(x)
    x = layers.BatchNormalization()(x)
    x = layers.Activation("relu")(x)

    x = layers.Conv2D(64, 3, padding="same")(x)
    x = layers.BatchNormalization()(x)
    x = layers.Activation("relu")(x)

    previous_block_activation = x  # Set aside residual

    for size in [128, 256, 512, 728]:
        x = layers.Activation("relu")(x)
        x = layers.SeparableConv2D(size, 3, padding="same")(x)
        x = layers.BatchNormalization()(x)

        x = layers.Activation("relu")(x)
        x = layers.SeparableConv2D(size, 3, padding="same")(x)
        x = layers.BatchNormalization()(x)

        x = layers.MaxPooling2D(3, strides=2, padding="same")(x)

        # Project residual
        residual = layers.Conv2D(size, 1, strides=2, padding="same")(
```



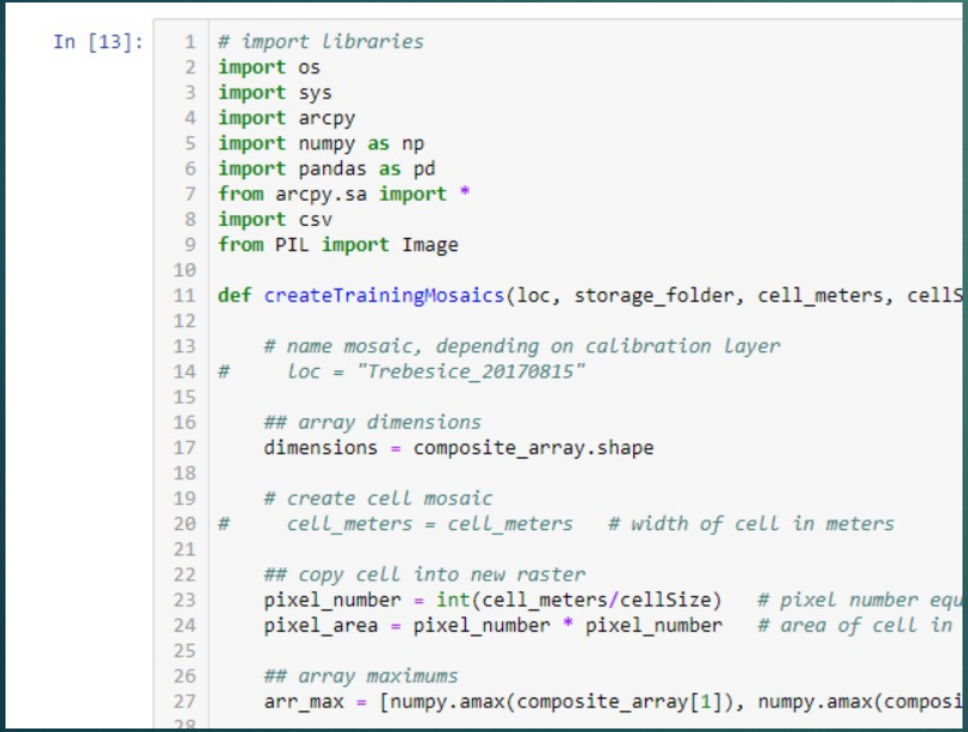
```
    previous_block_activation = x  # Set aside residual

    for size in [128, 256, 512, 728]:
        x = layers.Activation("relu")(x)
        x = layers.SeparableConv2D(size, 3, padding="same")(x)
        x = layers.BatchNormalization()(x)

        x = layers.Activation("relu")(x)
        x = layers.SeparableConv2D(size, 3, padding="same")(x)
        x = layers.BatchNormalization()(x)

        x = layers.MaxPooling2D(3, strides=2, padding="same")(x)

        # Project residual
        residual = layers.Conv2D(size, 1, strides=2, padding="same")(
            previous_block_activation
        )
        x = layers.add([x, residual])  # Add back residual
        previous_block_activation = x  # Set aside next residual

    x = layers.SeparableConv2D(1024, 3, padding="same")(x)
    x = layers.BatchNormalization()(x)
    x = layers.Activation("relu")(x)

    x = layers.GlobalAveragePooling2D()(x)
    if num_classes == 2:
        activation = "sigmoid"
        units = 1
    else:
        activation = "softmax"
        units = num_classes

    x = layers.Dropout(0.5)(x)
    outputs = layers.Dense(units, activation=activation)(x)
    return keras.Model(inputs, outputs)

##image_size = (180, 180)

topgis_model = make_model(input_shape=image_size + (3,), num_classes=2)
##keras.utils.plot_model(topgis_model, show_shapes=True)

epochs = 20

callbacks = [keras.callbacks.ModelCheckpoint("save_at_{epoch}.h5"),]

topgis_model.compile(optimizer=keras.optimizers.Adam(1e-3), loss="binary_crossentropy", metrics=["accuracy"],)

topgis_model.fit( train_ds, epochs=epochs, callbacks=callbacks, validation_data=val_ds,)

topgis_model.save("S:/Private/_PROJEKTY/2020_TACR_DPZ/mapa_udalosti/Tejkl_reseni/topgis_model_2")

def analyse_mosaic(mosaic, image_size, input_model):
    img = keras.preprocessing.image.load_img(mosaic, target_size=image_size)
    img_array = keras.preprocessing.image.img_to_array(img)
    img_array = tf.expand_dims(img_array, 0)  # Create batch axis
    predictions = input_model.predict(img_array)
    score = predictions[0]
    print(    "This image is %.2f percent NoRill and %.2f percent Rill."    % (100 * (1 - score), 100 * score))
```

Results



Evaluation

- Difficult and complex process



```
In [13]:
# import libraries
import os
import sys
import arcpy
import numpy as np
import pandas as pd
from arcpy.sa import *
import csv
from PIL import Image

def createTrainingMosaics(loc, storage_folder, cell_meters, cellS

    # name mosaic, depending on calibration layer
#     loc = "Trebesice_20170815"

    ## array dimensions
    dimensions = composite_array.shape

    # create cell mosaic
#     cell_meters = cell_meters    # width of cell in meters

    ## copy cell into new raster
    pixel_number = int(cell_meters/cellSize)    # pixel number equ
    pixel_area = pixel_number * pixel_number    # area of cell in

    ## array maximums
    arr_max = [numpy.amax(composite_array[1]), numpy.amax(composi
```

ArcGIS Python

Support

- Faculty
- Project No. SS01020366 “Using remote sensing to assess negative impacts of rainstorms“, supported by Technology Agency of the Czech Republic
- Project No. SS01020052 “Utility and risk of irrigation over the Czech Republic in changing climate“, supported by Technology Agency of the Czech Republic

Thanks for your attention

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