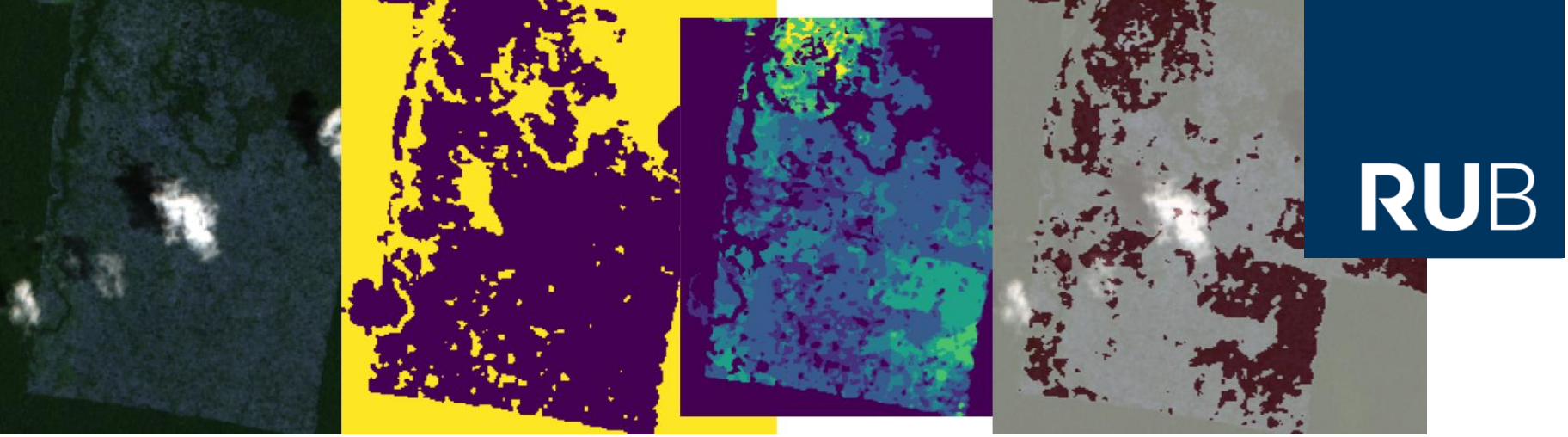


RUHR-UNIVERSITÄT BOCHUM

Comparative Analysis of Deep Learning Architectures for Deforestation Detection in the Amazon Rainforest Using Sentinel-2 Multispectral Imagery

Julian Bröcker, Rodrigo López Murguía, Piotr Oleksy

Deforestation in the Brazilian Rainforest

Why this subject?

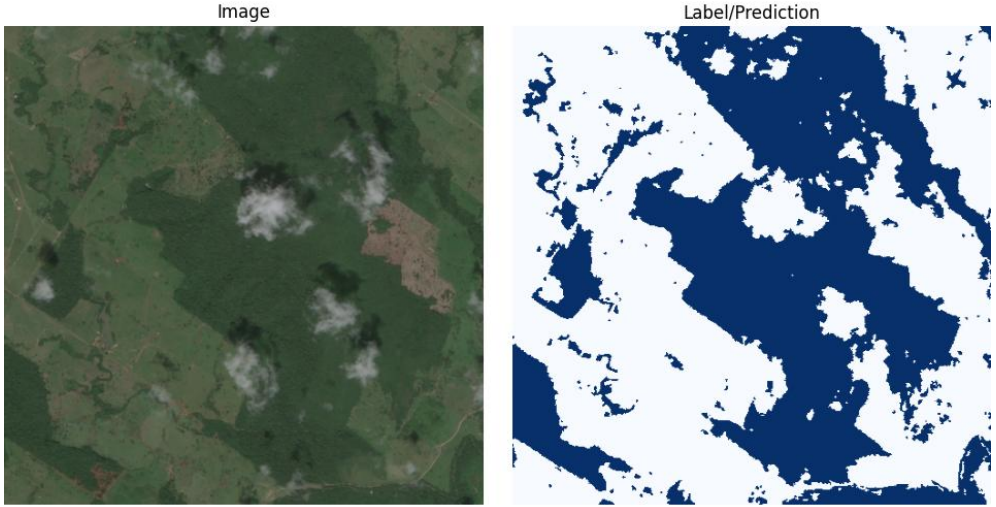
- A home for 30 million people, over 30,000 species and 400 billion trees
- A huge problem: 550,000 km^2 lost in 2001-2020, possible 240,000 km^2 from 2021 to 2025
- Over 90% of deforestation in the Brazilian Rainforest is illegal

Figure 1.

Dataset

Sentinel-2 4 Band Data (R,G,B,NIR)

- Dataset of satellite imagery with corresponding masks
- 499 training, 100 validation and 20 GeoTIFF images



U-Net

- Contracting using repeated convolutions to extract high-level features
- Expansinging by upsampling features to reconstruct the image and generate the segmentation map
- Skip connections linking encoder and decoder

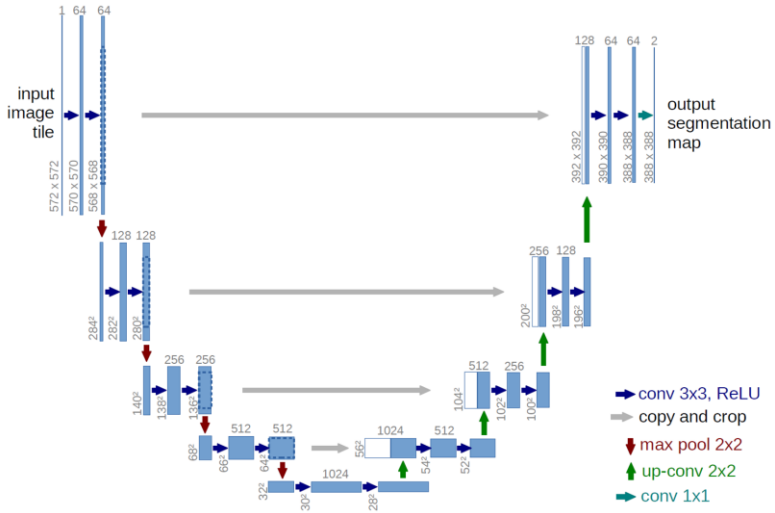


Figure 2.

U-Net++

- Base: U-Net
- Nested Skip Connections, a network of Skip Connections
- Deep Supervision by additional loss functions or predictions

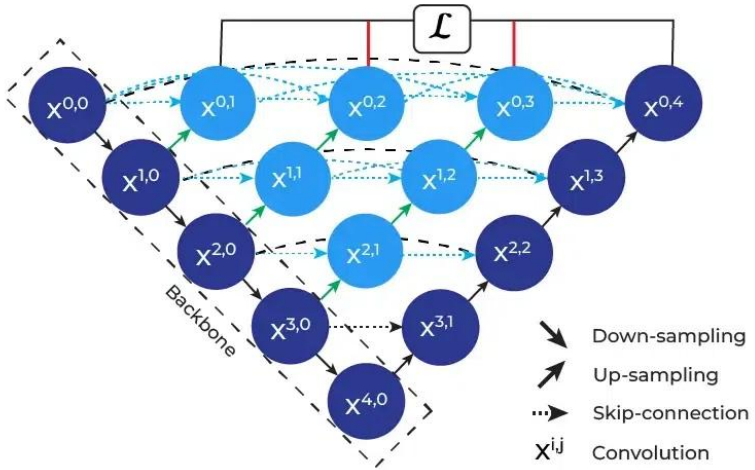


Figure 3.

Pyramid Attention Network (PAN)

- Multi-Scale context
- Global Average Pooling for extraction of low-level features
- Global context using 1x1 and 3x3 convolutions

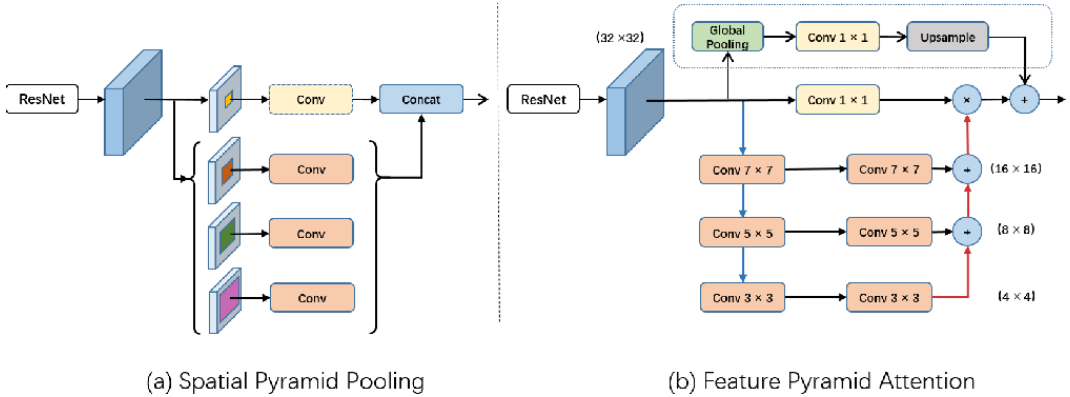


Figure 4.

Feature Pyramid Network (FPN)

- Bottom-Up pathway for feature extraction
- Top-Down pathway for reconstruction
- Lateral Connections merging high-level and low-level

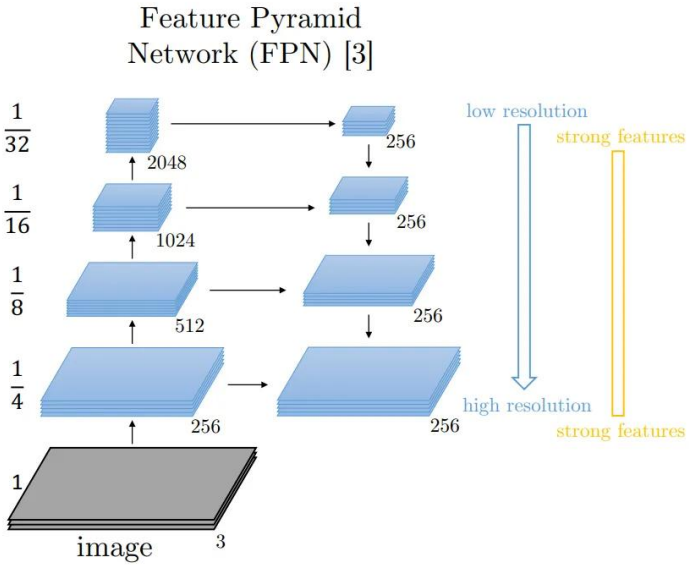


Figure 5.

DeepLab V3+

- Atrous Convolutions with “dilated” kernels
- Atrous Spatial Pyramid Pooling applying sets of Atrous Convolutions with different rates

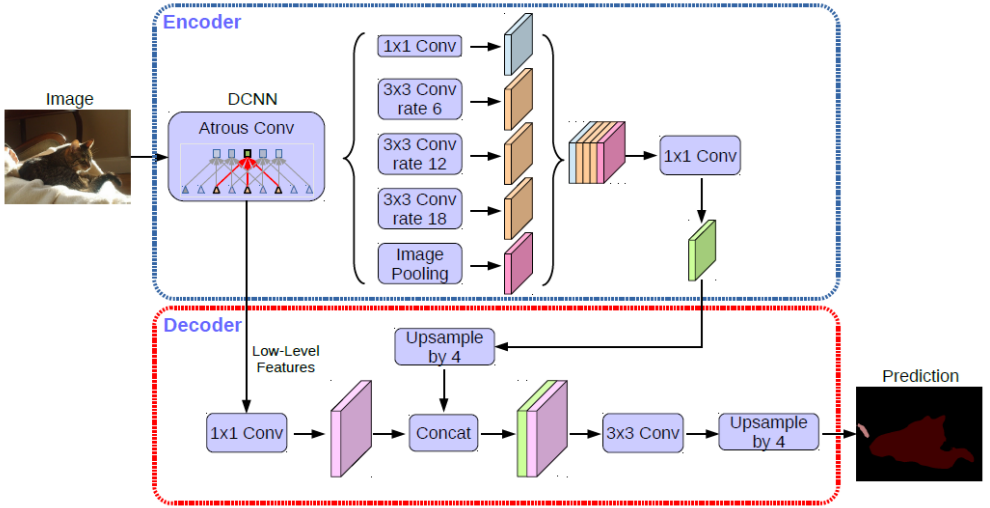


Figure 6.

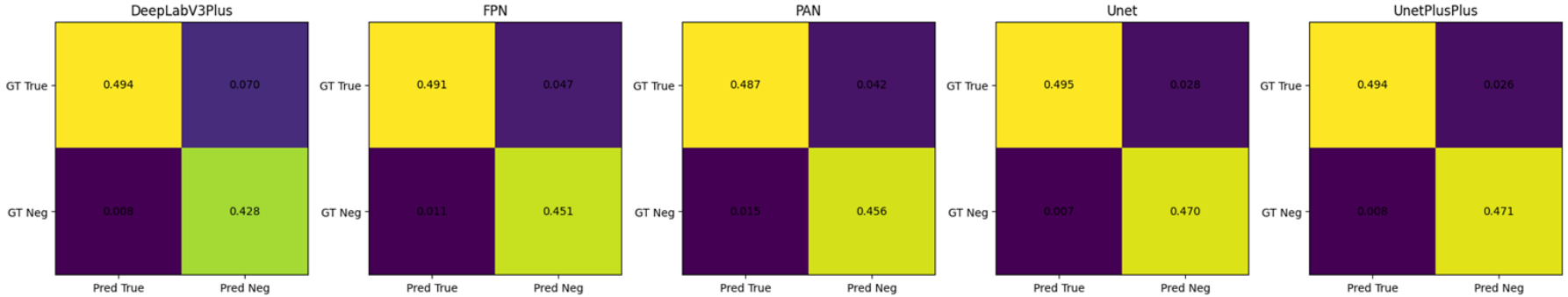
Comparison of the Models

Metrics of the models

	U-Net++	U-Net	PAN	FPN	DeepLab V3+
IoU	87.2%	87.4%	82.2%	82.2%	80.1%
Dice	90.1%	91.0%	87.8%	87.9%	86.7%
Accuracy	96.6%	96.5%	94.3%	94.2%	92.2%
Precision	89.1%	89.3%	85.4%	84.4%	81.8%
Recall	92.8%	92.8%	90.4%	91.8%	92.3%

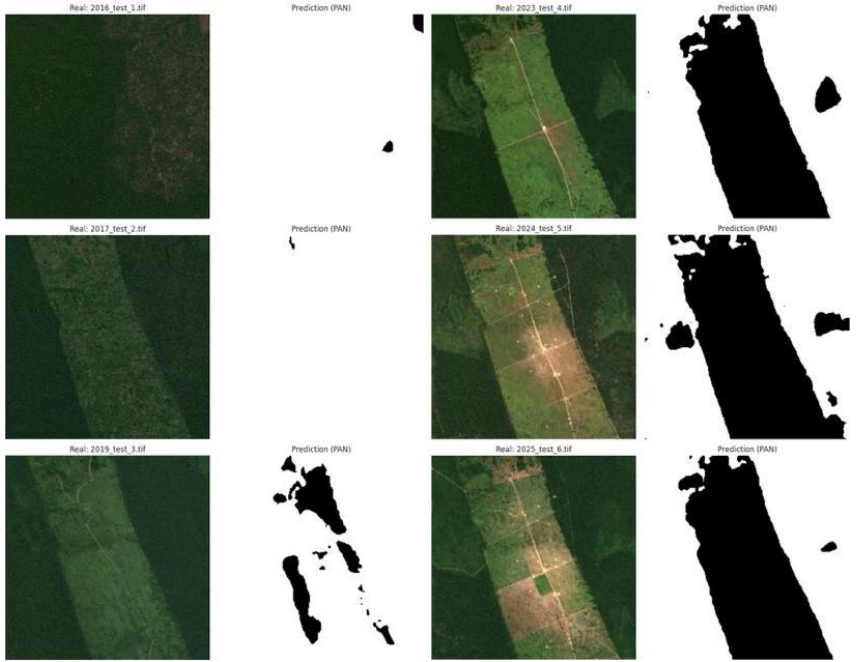
Comparison of the Models

Confusion Matrices



Deforestation detection

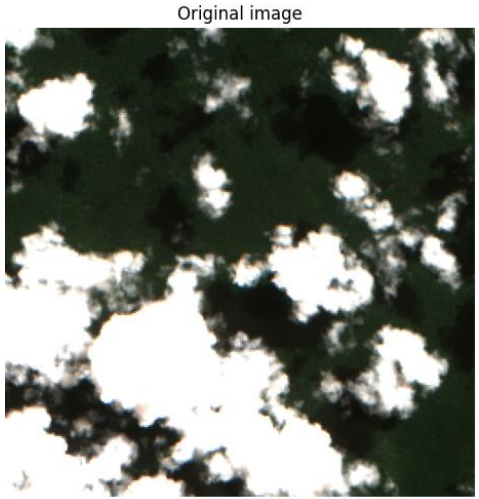
- Segmenting a satellite image into forest and non-forest classes
- Analyzing chronological images with the same extent to find changes in the classification
- Change from forest class into non-forest -> deforestation

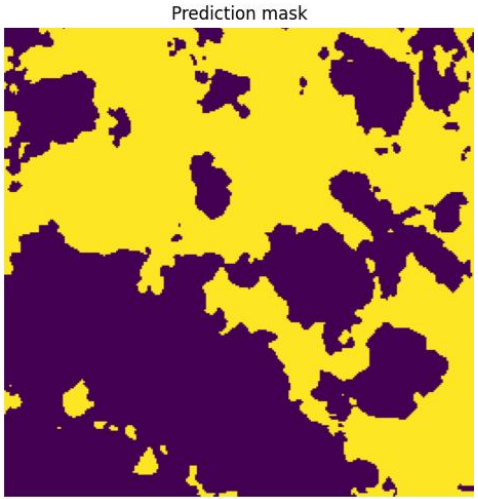


Deforestation detection

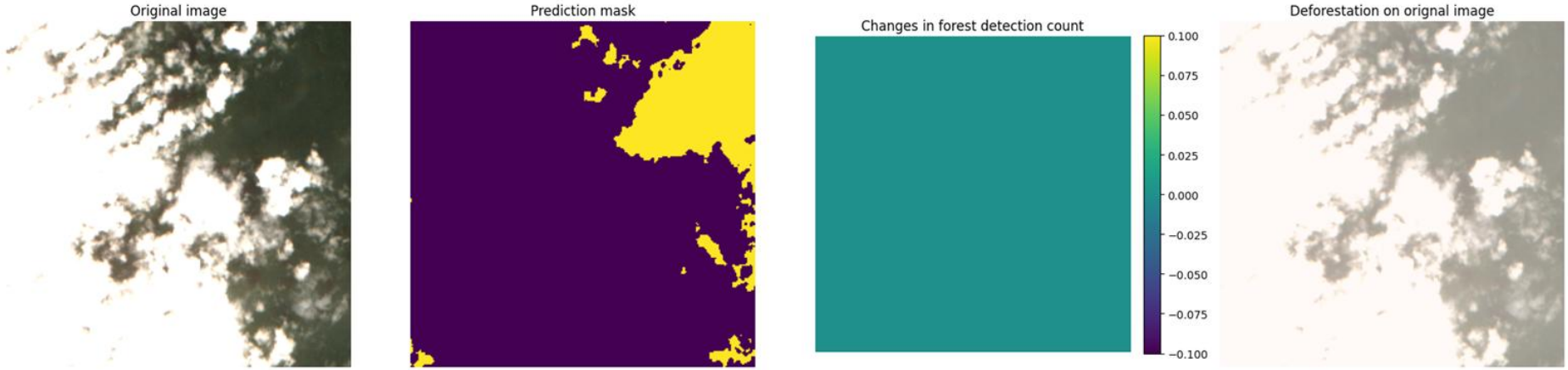
Main problem: Clouds

- Clouds classified as non-forest
- Mask solution: thresholding on Blue and NIR channel and automatic-generated masks from Copernicus
- Non-immediate deforestation alert
- Possible room for improvement: usage of Sentinel-1 radar data



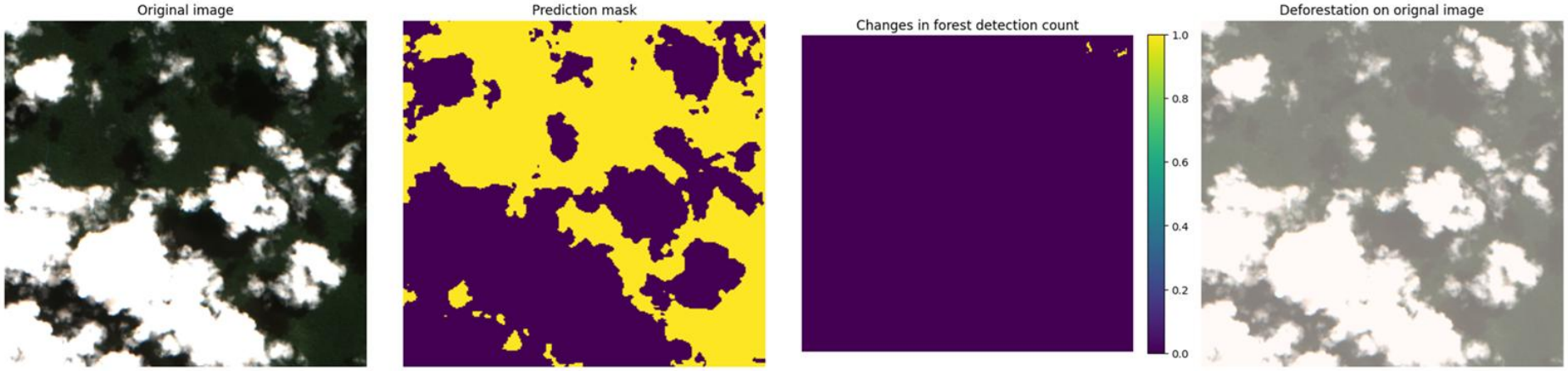


Deforestation detection step-by-step



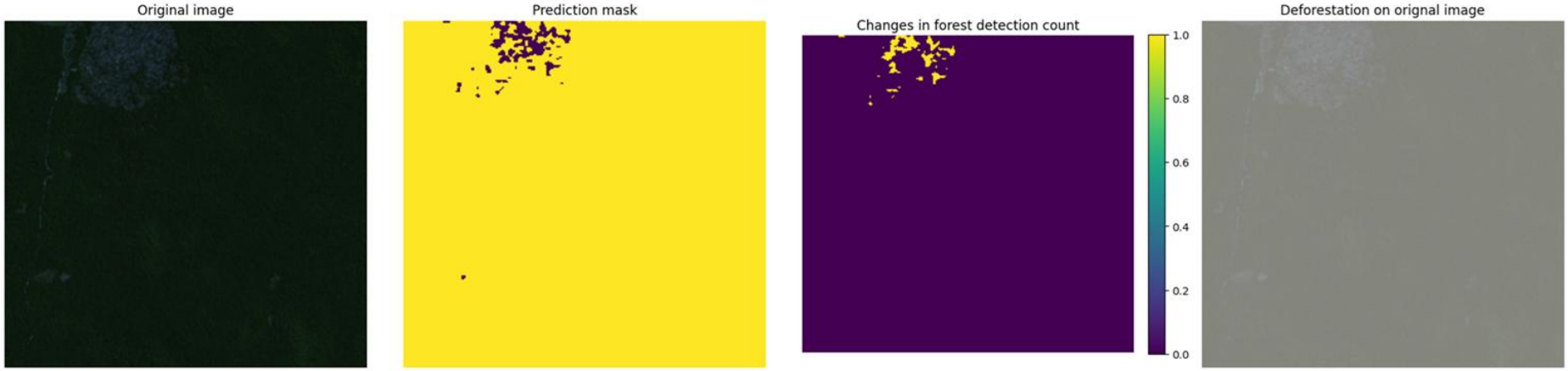
Step 1

Deforestation detection step-by-step



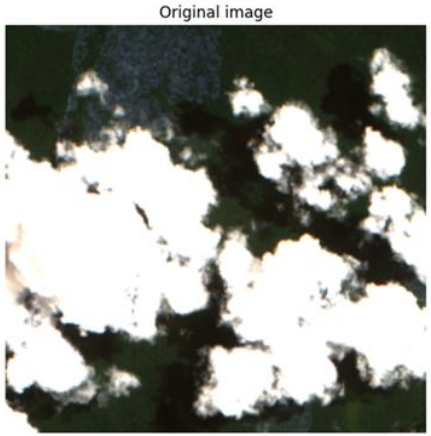
Step 2

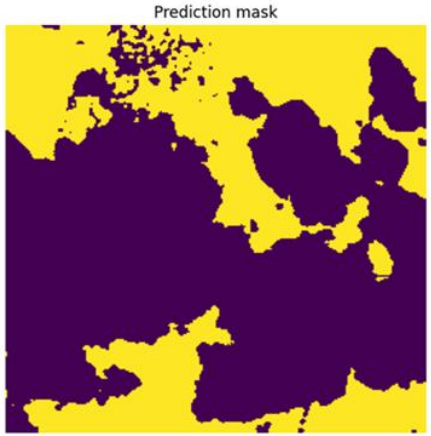
Deforestation detection step-by-step

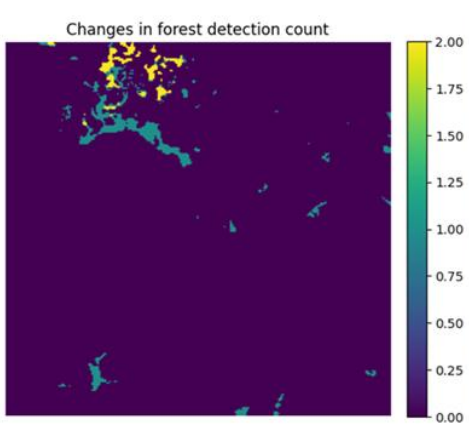


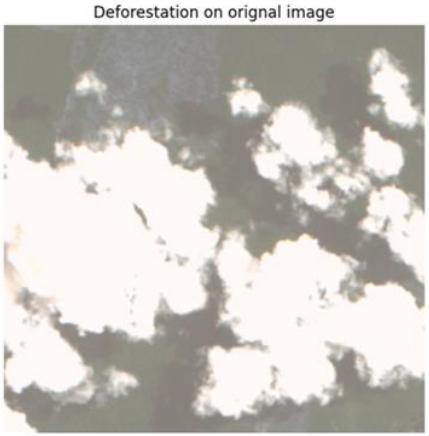
Step 3

Deforestation detection step-by-step



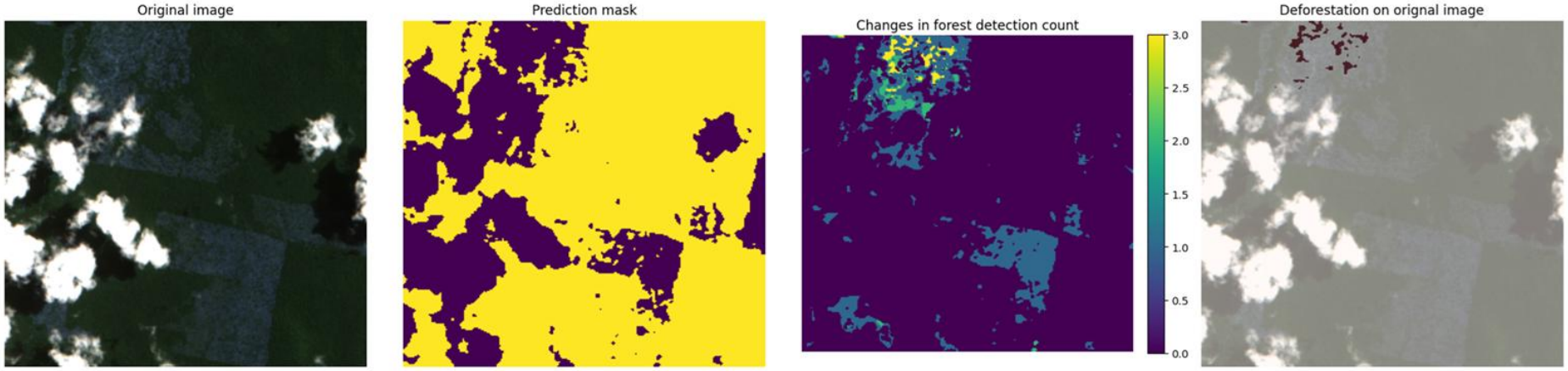






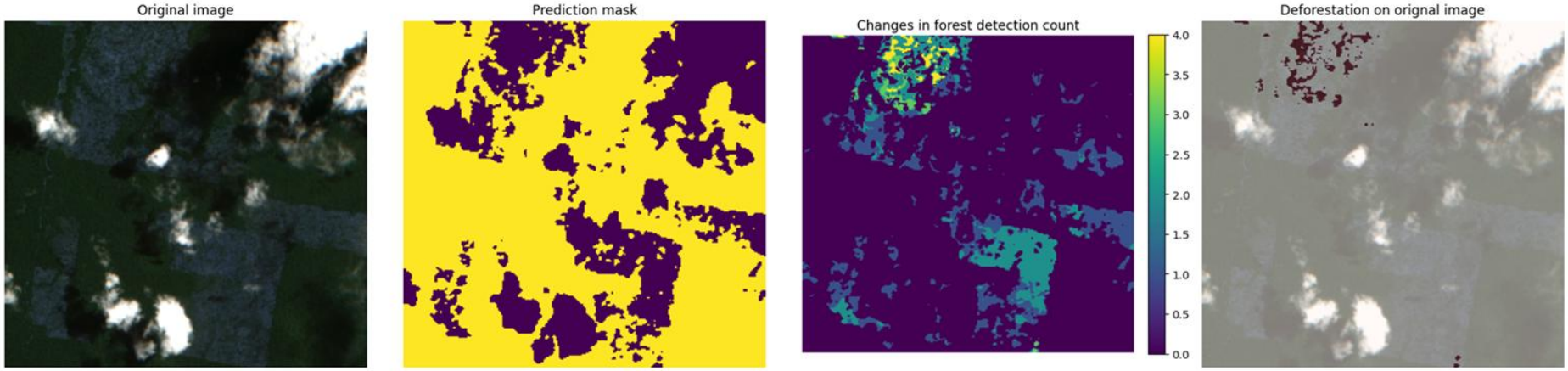
Step 4

Deforestation detection step-by-step



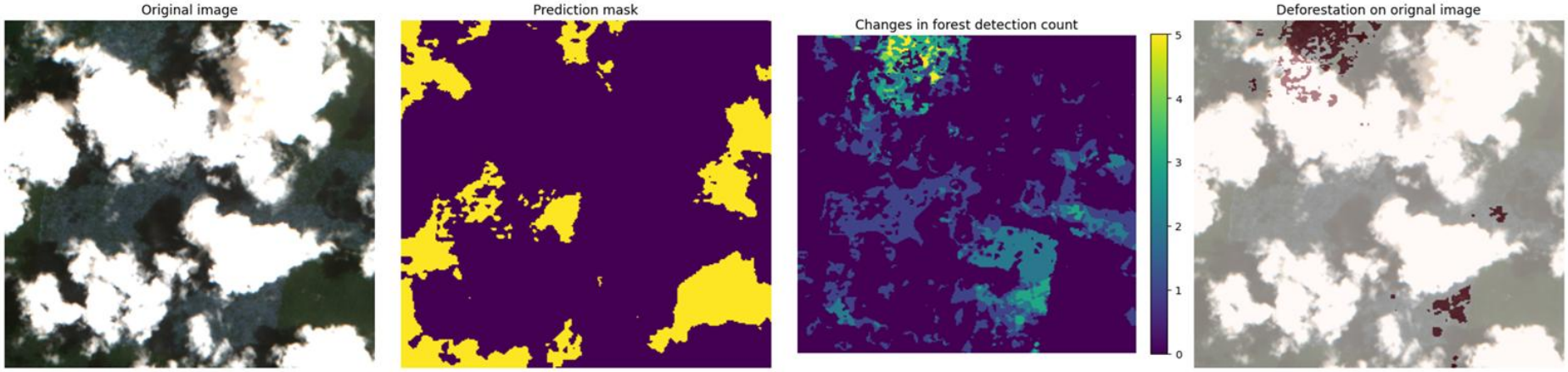
Step 5

Deforestation detection step-by-step



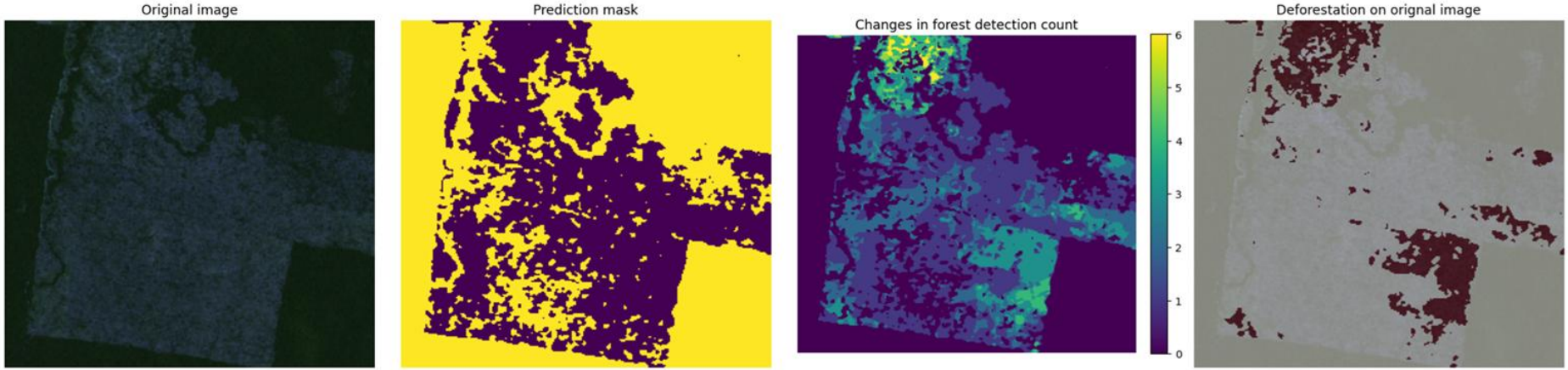
Step 6

Deforestation detection step-by-step



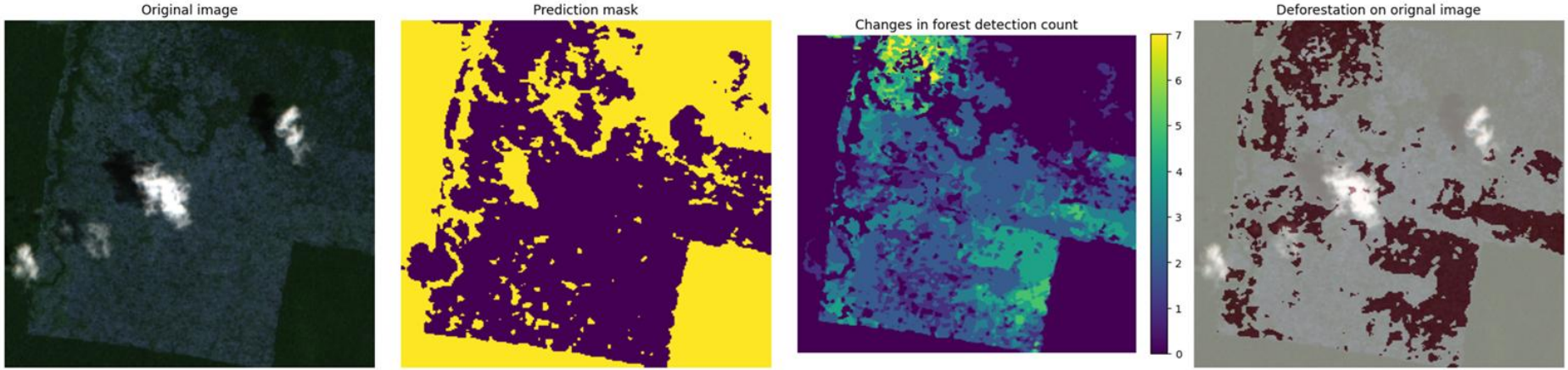
Step 7

Deforestation detection step-by-step



Step 8

Deforestation detection step-by-step



Step 9

List of figures