Mapping Mangrove Growth and Deforestation with Satellite Imagery

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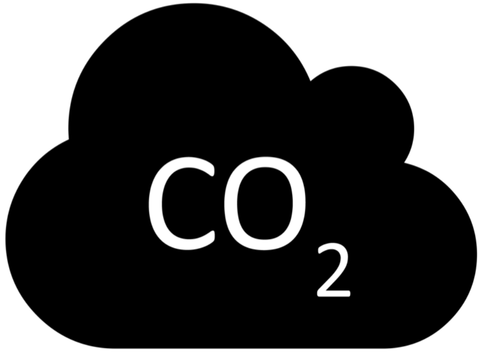
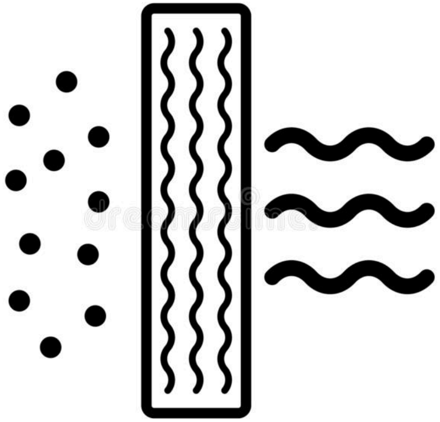
METIS Winter 2021 Cohort

Mangroves are salt tolerant trees that thrive along warm coastal waters

There are around 135,000 square kilometers of mangrove forested areas around the world

These mangrove provide a number of benefits:





Store 4-10x more carbon than ordinary forests	Protect shorelines against storm surges	Filter pollutants from ocean waters	Provide natural habitats for many species

Under Threat

- From both climate change and more immediate man-made causes
- Monitoring and tracking, these mangrove forests is a vital task for protecting our environment on a global and local scale

1% loss per year globally

according to the Global Mangrove Alliance

Satellites are a great tool for remote monitoring of mangrove forests worldwide

They can provide a constant stream of useful information for hard to reach places

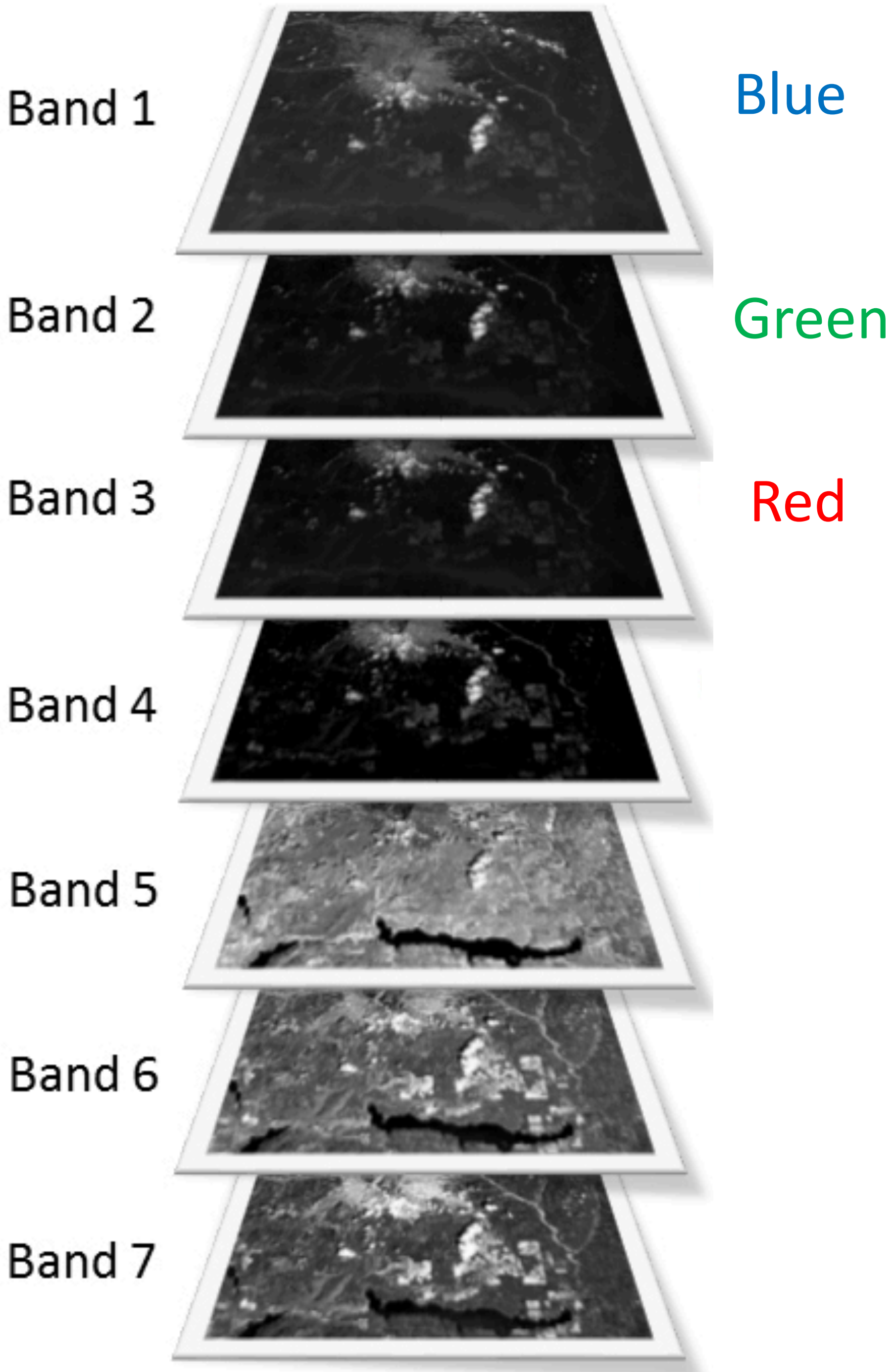
My Project

- I decided to take freely available satellite imagery from Google Earth Engine, and train a neural network classifier in order to map the extent of mangroves in the south of Florida
- Through GEE, I acquired a map of mangrove forests for the world in the year 2000, as well as images of my region of interest, allowing me to cross-reference the two

The Data

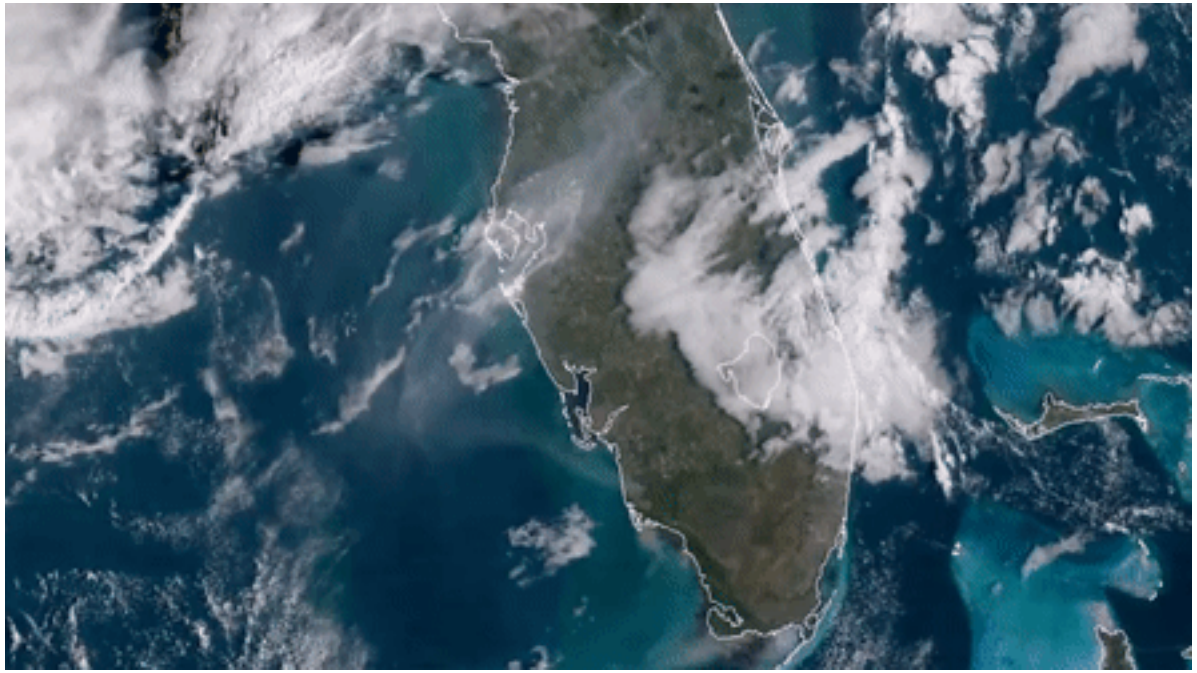
- Selected Landsat 7 satellite images for the years 2000 and 2020
- Each pixel in a satellite image has a resolution of 30 meters and contains information in different "bands"
  - RGB, infrared, thermal, etc.

- **Project: Develop a pixel-wise classification model with target classes of "mangrove" and "not-mangrove," using this band information as the features for the model**



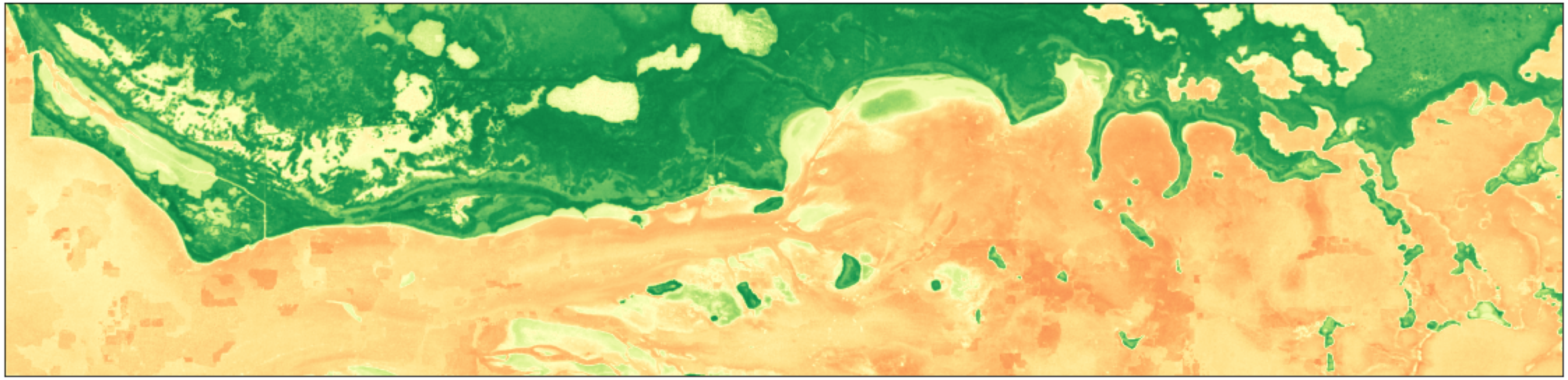
Satellite Image Compositing

- Problem: Each individual image contains clouds, cloud shadows, or potentially artifacts
- Solution: Create a composite image from many separate images – each pixel in a view can come from a different image
- I selected the pixels by maximizing the NDVI value per pixel - “Normalized Difference Vegetation Index,” which essentially measures the amount of green vegetation within a pixel



RGB

NDVI



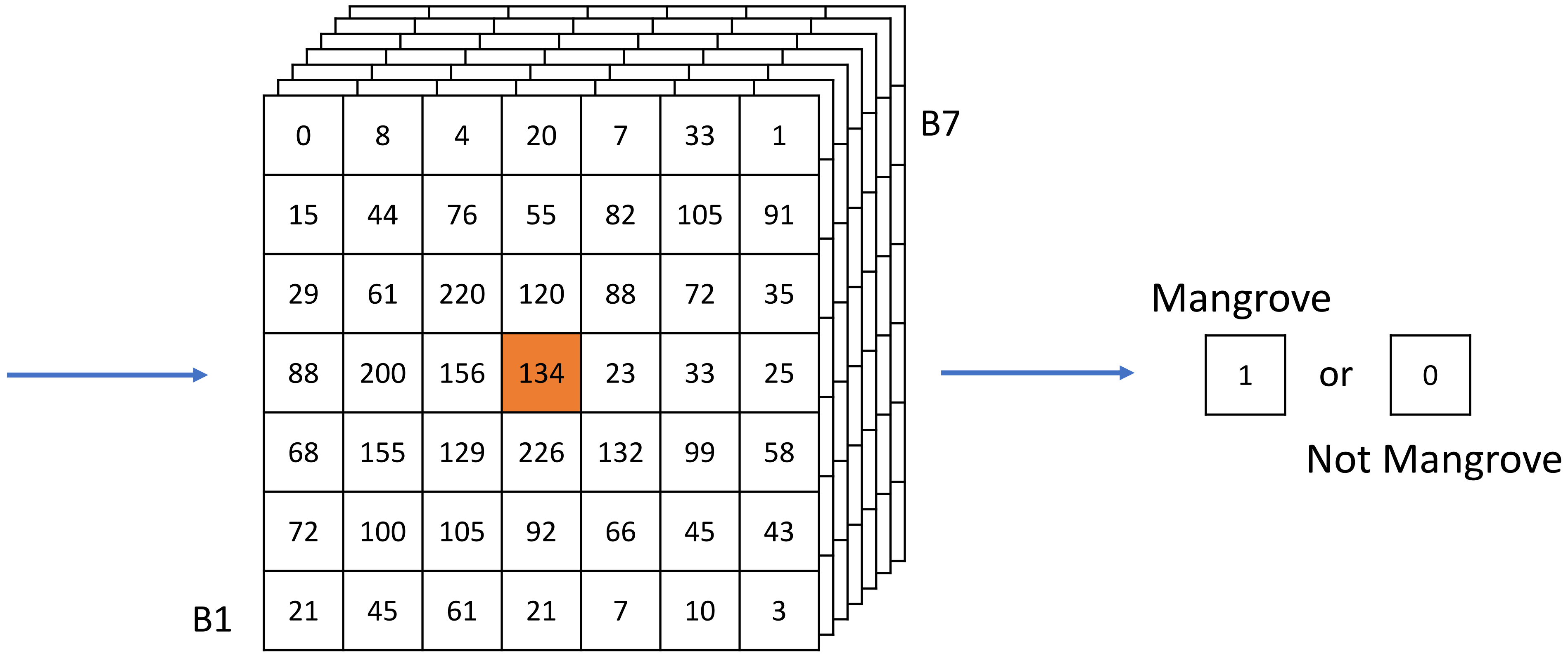
Mangrove Map

Have the data, now on to modeling…

Convolutional Neural Network Model

- Adapted model that I discovered online to my use case
- Input: Information from pixels in a 7x7 grid around the target pixel

Values of bands in pixels in a 7x7 grid around the target pixel

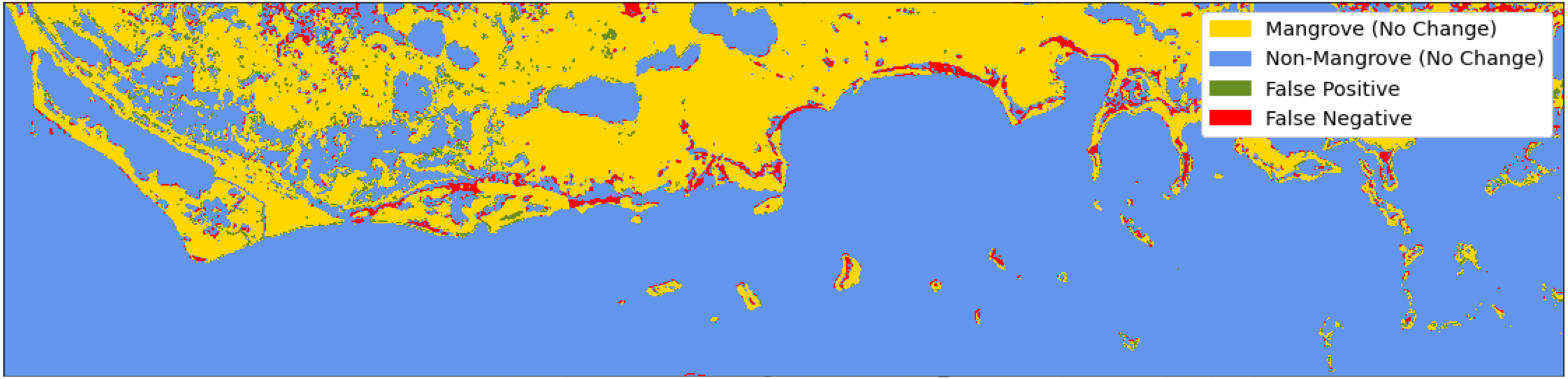


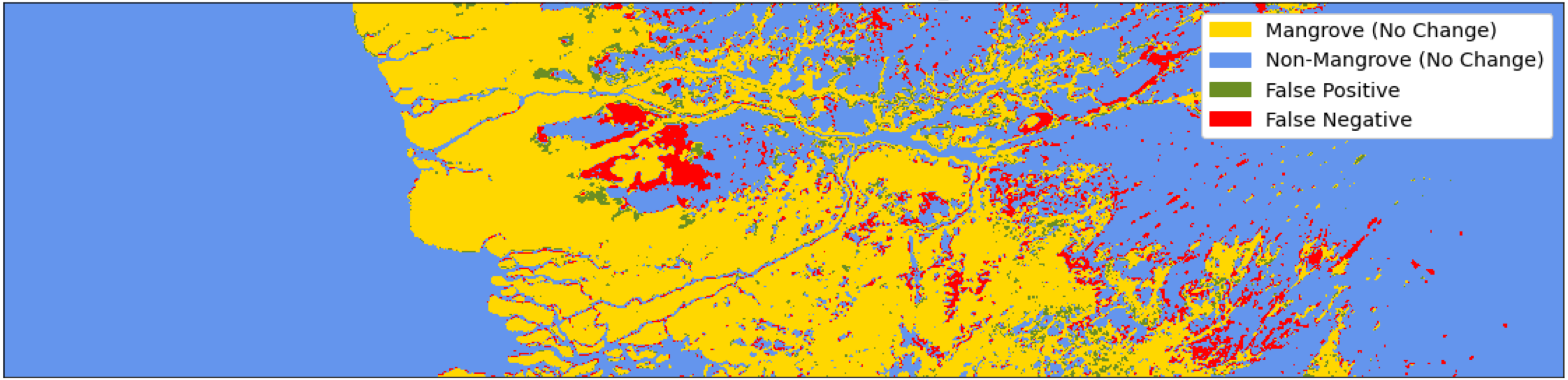
Training and Testing Data

- For training data, I passed in pixels from 4 separate wide-field images of the Florida coastline in the year 2000 to the model
- I then tested the model both on held-out pixels from the original images, as well as new images entirely

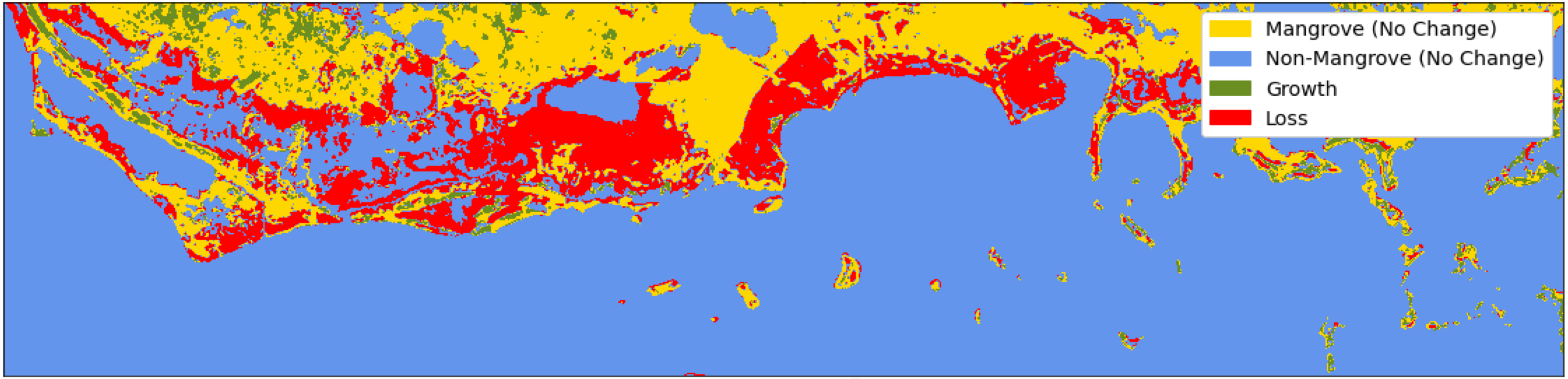
F1 Scores	CNN
Test Data	0.914
Separate Image 1	0.921
Separate Image 2	0.901

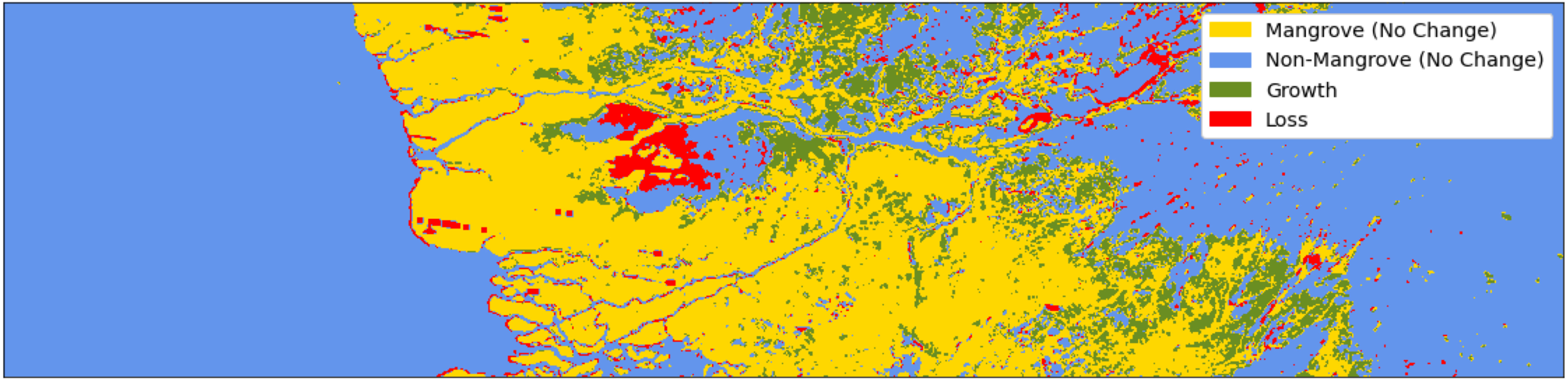
Results for 2000 Data





Applied Model to 2020 Data





Conclusions

- I've trained a convolutional neural network model on year 2000 satellite image data in order to classify pixels as belonging to mangrove forests or not
- I've applied it to 2020 data in order to track changes over time
- This approach be used to automate tracking of mangroves around the world, along with other similar applications using satellite imagery

Florida_1 RGB

Thank you!

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Appendix

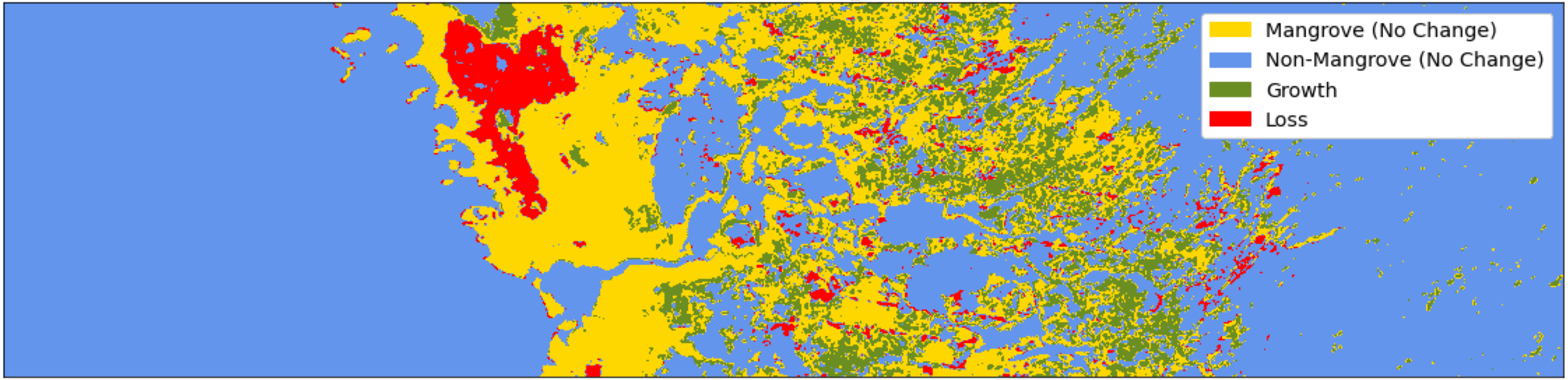
Future Work

- Include other features such as elevation or other satellite imagery for better classification
- Try out using a U-Net for better classification, using features beyond just those in a 7x7 grid around the target pixel
  - Might be able to pick up features such as being on or near the coastline
- Build a recurrent neural network from yearly data over the last 20 years in order to better predict the state of mangroves in the future

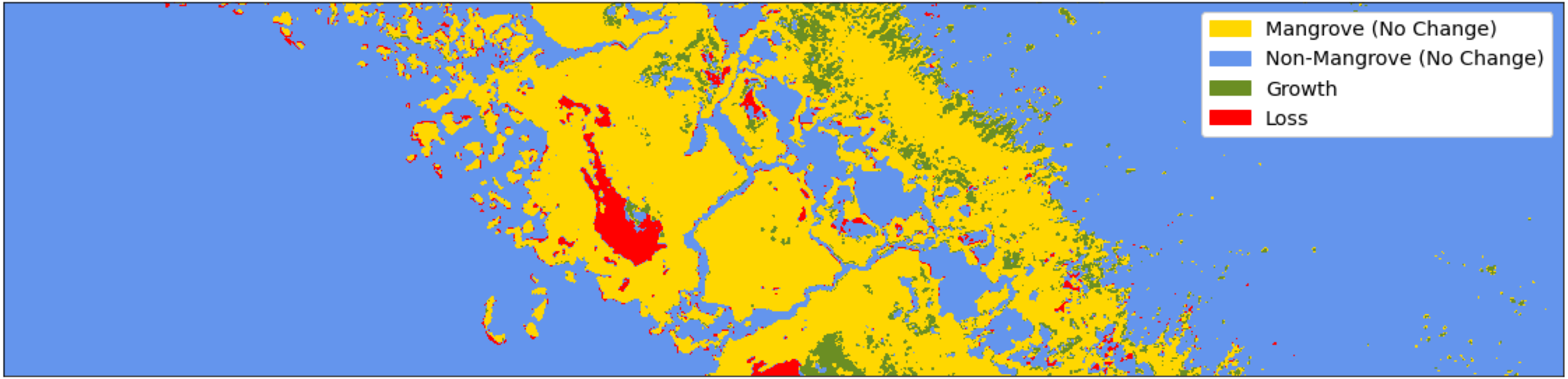
Florida_1 RGB

Florida_4 RGB

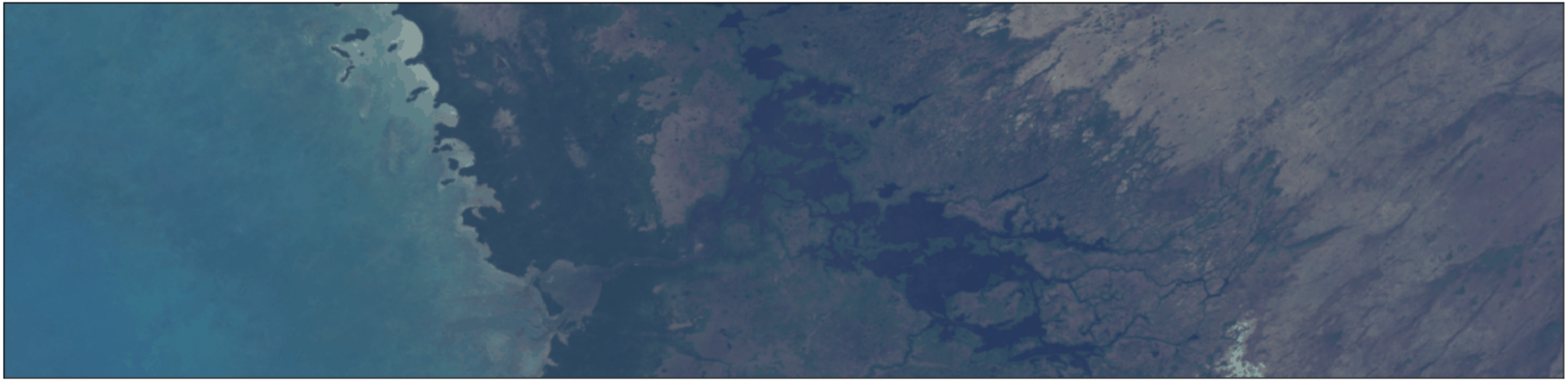
Change in Mangroves for Florida_5 in 2020 vs 2000



Change in Mangroves for Florida_6 in 2020 vs 2000



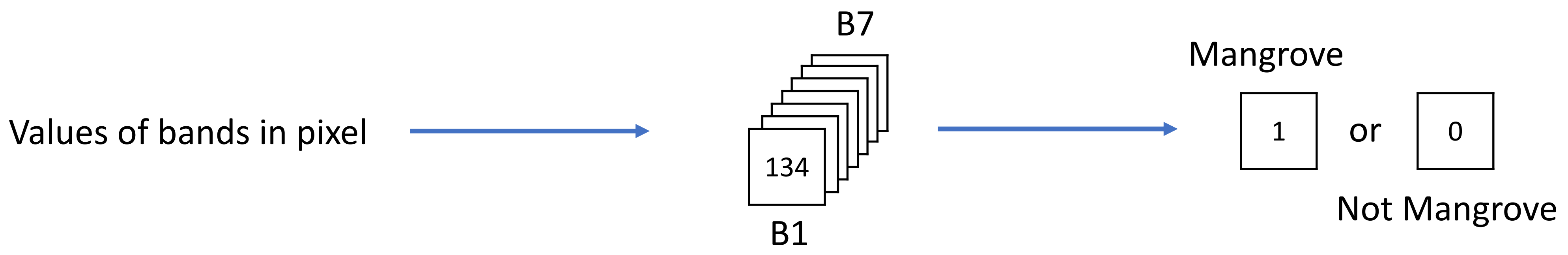
Florida_5 RGB



Florida_6 RGB

Basic Neural Net

- I tested out 2 different neural networks for my classification model
- The first model was a simple basic neural net model, containing just 2 dense layers of 14 nodes each
- Input: information from a single pixel



F1 Scores	Basic NN	CNN
Test Data	0.871	0.914
Separate Image 1	0.911	0.921
Separate Image 2	0.870	0.901