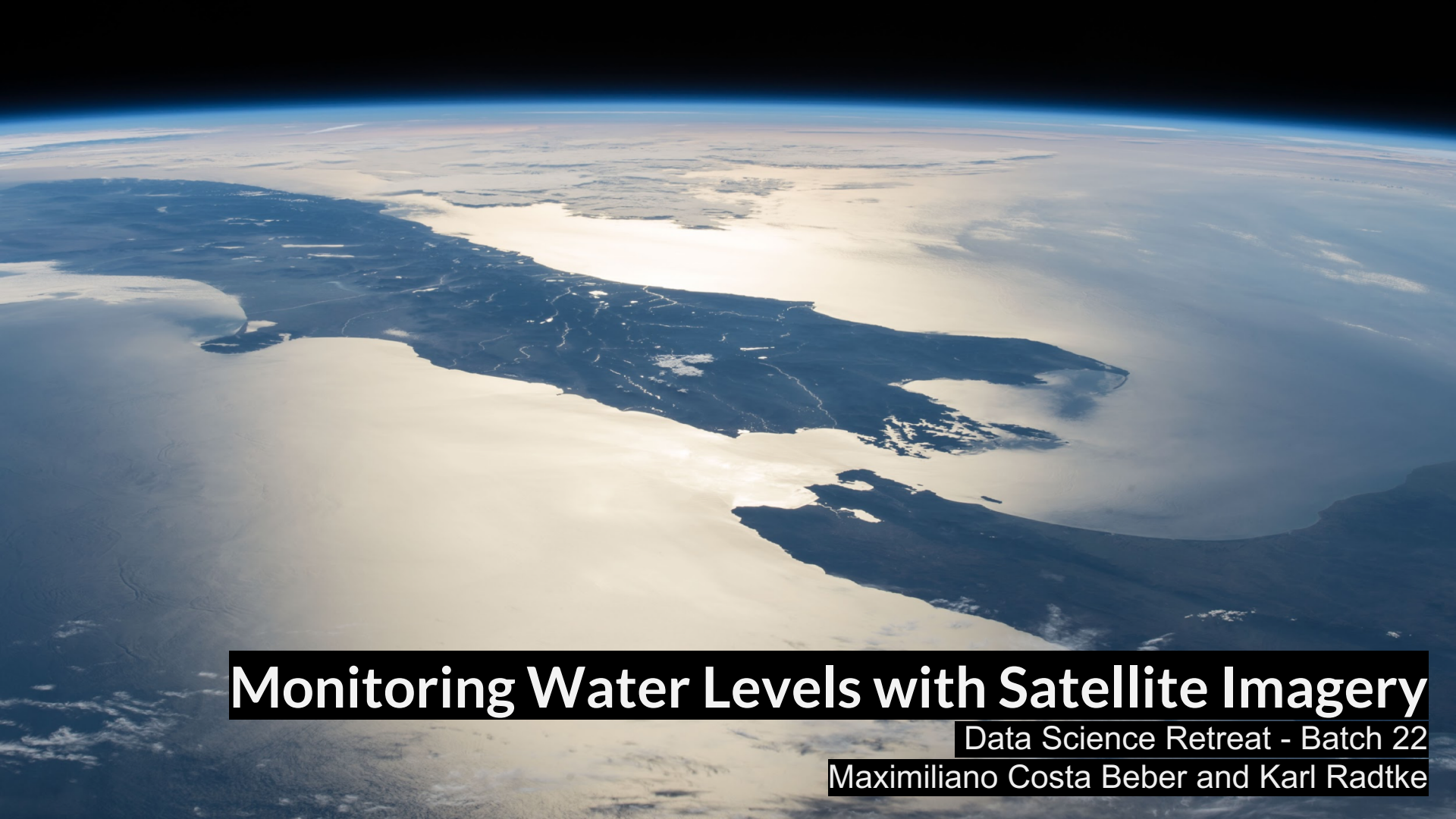


Monitoring Water Levels with Satellite Imagery

Data Science Retreat - Batch 22

Maximiliano Costa Beber and Karl Radtke

Agenda

- Motivation
- Data collection
- Labeling workflow
- Metrics
- Model exploration
- Model refinement
- Evaluation and testing
- Demo
- Question and Answers

https://www.nationalgeographic.com/magazine/2018/03/drying-lakes-climate-change-global-warming-drought/

Water bodies of interest

- Lake Poopo, Bolivia
- Lake Urmia, Iran
- Lake Mojave, USA
- Aral sea, Kazahkstan
- Lake Copais, Greece
- Lake Ramganga, India
- Lake Qinghai, China
- Salton sea, USA
- Elephant Butte Reservoir, USA
- Salton sea, USA
- Lake Faguibine, Mali
- Lake Mono, USA
- Lake Walker, USA
- Lake Balaton, Hungary
- Lake Koroneia, Greece
- Lake Salda, Turkey
- Lake Burdur, Turkey
- Lake Mendocino, USA

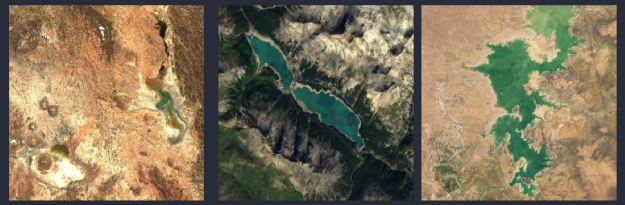
Data

1059 images

700 Resisc45

Train set

182 Sentinel-2 hub service



177 courtesy from Olga

Test set

U-NET

Encoding Path

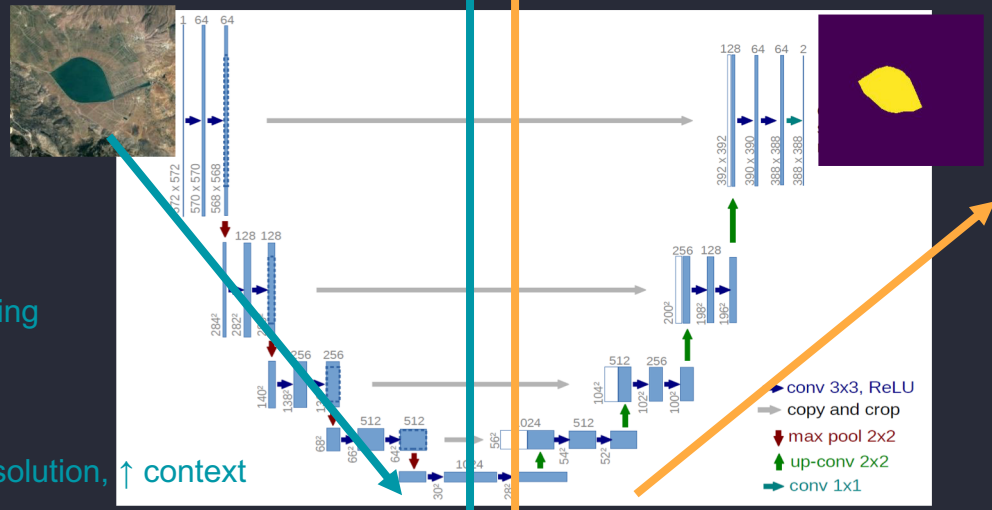
convolution + max pooling operations

Filters + cropping

↓ resolution, ↑ context

Higher level features

LAKES!



Decoding Path

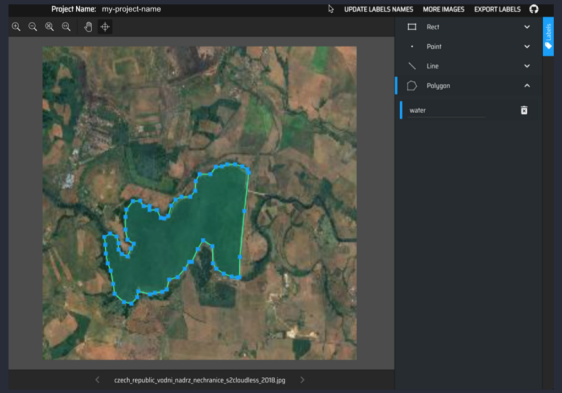
upsampling

LAKES!

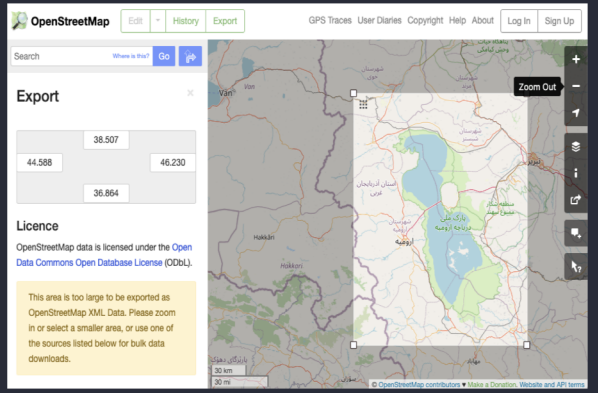
Labeling

Training set

Make Sense Tool

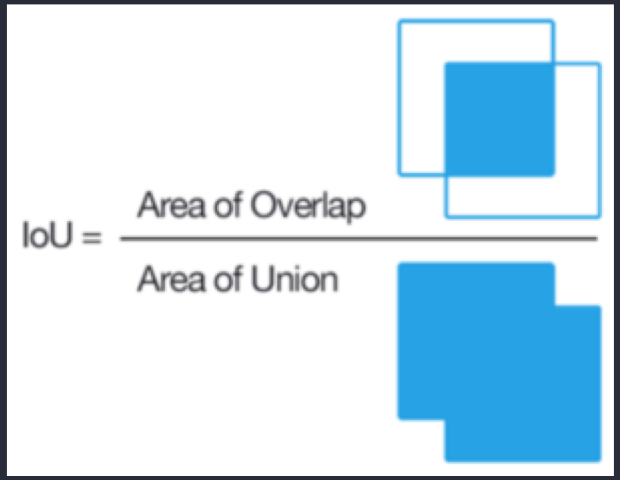


Test set

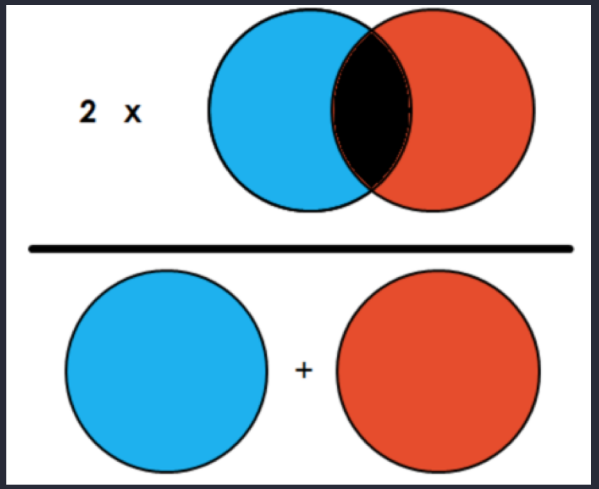


Metrics

Jaccard Index (IoU)

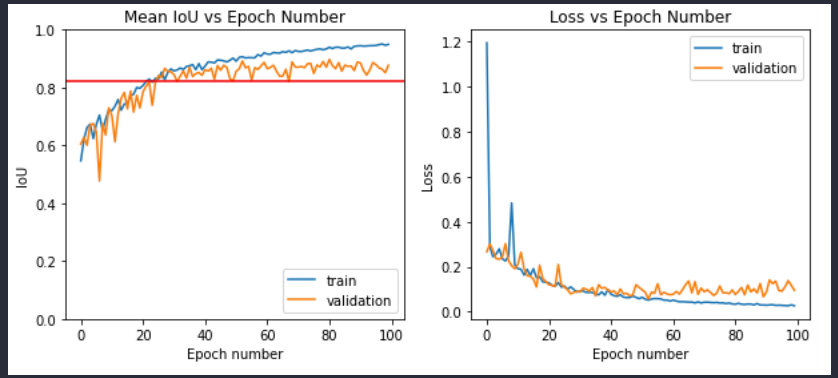


Dice Coefficient (F1 Score)



Source: https://towardsdatascience.com/metrics-to-evaluate-your-semantic-segmentation-model-6bcb99639aa2

Model training without image augmentation



Training : 489
Validation: 140
Test : 71

Loss: 0.09
IoU : 0.89

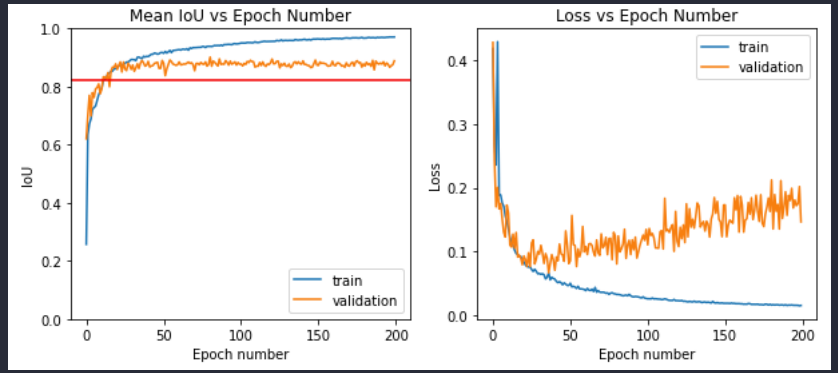
Loss function: binary cross entropy.

Image Augmentation

The following techniques have been applied during training:

- Height shift up to 30%
- Horizontal flip
- Rotation up to 45 degrees
- No shear
- Vertical flip
- Width shift up to 30%
- Zoom between 75% and 125%

Model training with image augmentation



Training : 979
Validation: 280
Test : 141

Loss: 0.18
IoU : 0.86

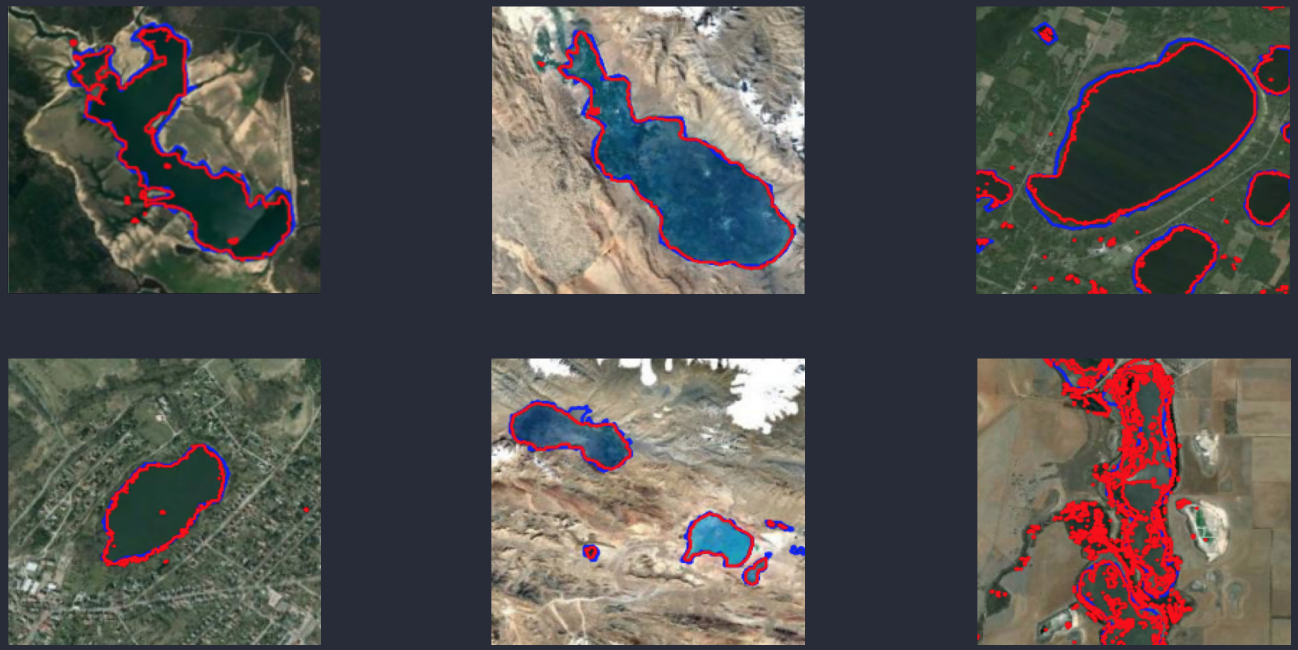
Loss function: binary cross entropy.

Model Refinement

The following strategies have been studied:

1. Dropout, early stopping and adaptive learning rates
2. Use a bigger rocket
3. Batch regularization
4. Residual connections
5. Dealing with imbalanced classes using Dice score
6. Different optimization algorithms
7. Refining labels using Conditional Random Fields
8. Ensemble predictions

Conditional Random Fields



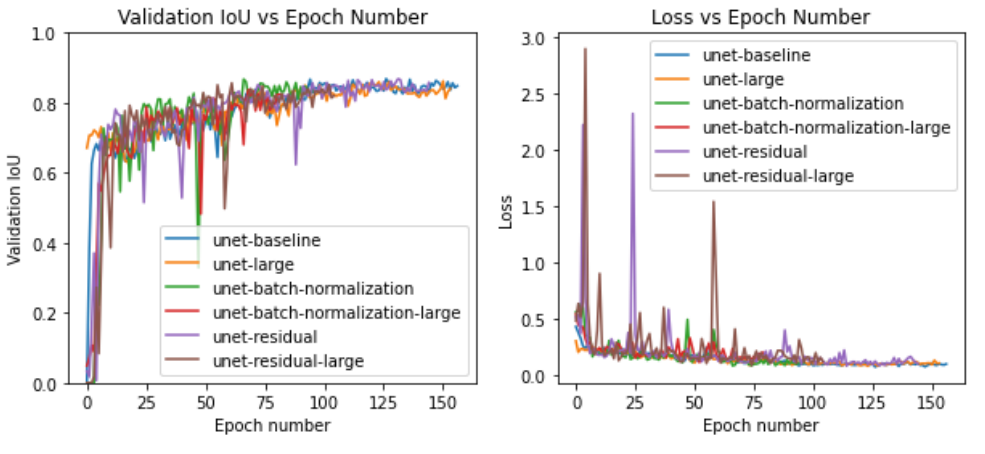
Models performance I

	Validation results				
	Loss	Jaccard index	Jaccard loss	Dice coefficient	Dice loss
unet-baseline	0.09	0.87	0.13	0.90	0.10
unet-large	0.08	0.89	0.11	0.91	0.09
unet-bn	0.15	0.83	0.17	0.88	0.11
unet-bn-large	0.11	0.85	0.15	0.90	0.10
unet-residual	0.22	0.80	0.20	0.86	0.14
unet-residual-large	0.12	0.85	0.15	0.89	0.11

Models performance II

	Test results				
	Loss	Jaccard index	Jaccard loss	Dice coefficient	Dice loss
unet-baseline	0.29	0.63	0.37	0.73	0.27
unet-large	0.82	0.55	0.45	0.69	0.31
unet-bn	0.27	0.65	0.35	0.75	0.25
unet-bn-large	0.28	0.63	0.37	0.73	0.27
unet-residual	0.54	0.50	0.50	0.64	0.36
unet-residual-large	0.29	0.60	0.40	0.72	0.28

Models performance III

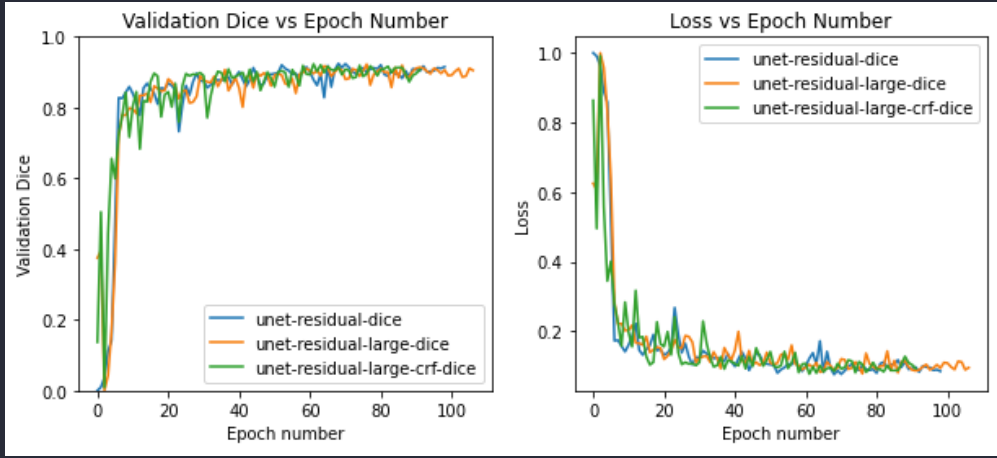


Loss function: binary cross entropy.

Models performance IV

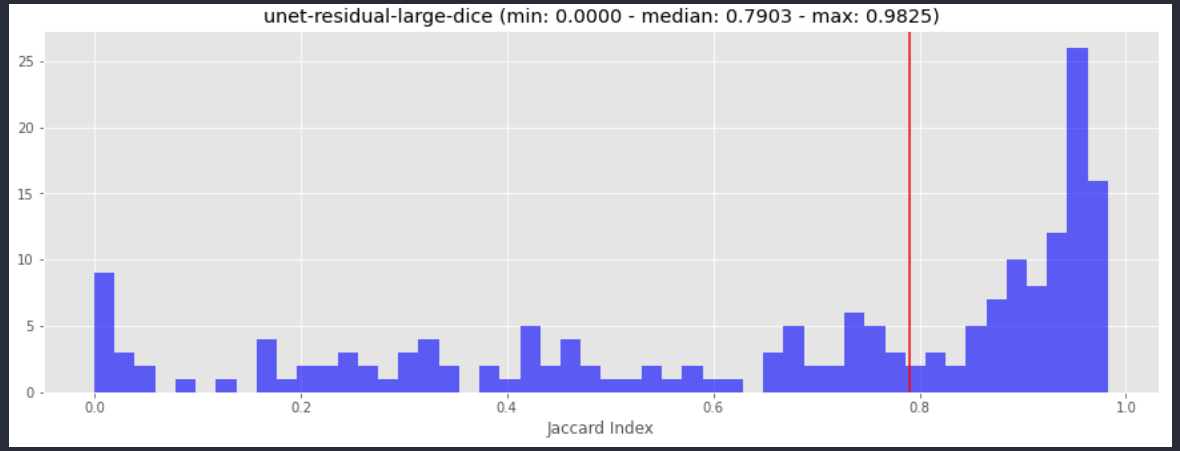
	Validation results		Test results	
	Dice coefficient	Dice loss	Dice coefficient	Dice loss
unet-residual-dice	0.92	0.08	0.73	0.27
unet-residual-large-dice	0.90	0.10	0.67	0.33
unet-residual-large-crf-dice	0.91	0.09	0.79	0.21

Models performance V



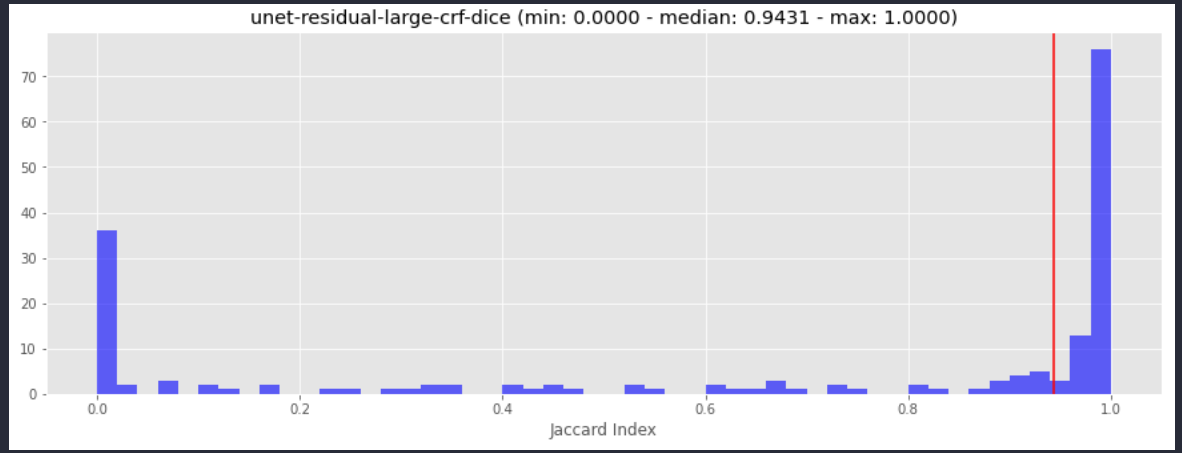
Loss function: dice coefficient loss.

Test results I - U-net residual large model



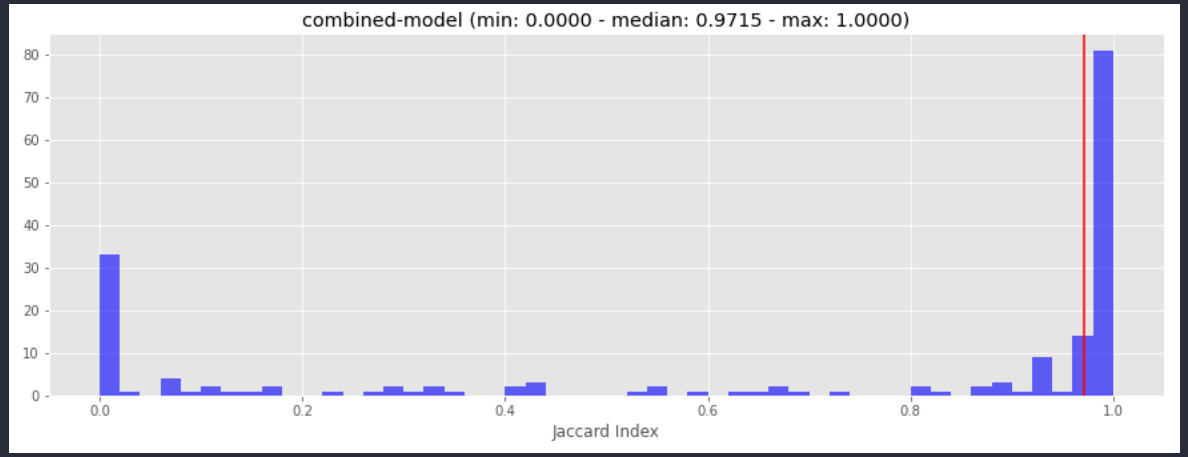
Test set contains 182 images from Sentinel-2 cloudless map service.

Test results II - U-net residual large with CRF model



Test set contains 182 images from Sentinel-2 cloudless map service.

Test results III – Ensemble model



Test set contains 182 images from Sentinel-2 cloudless map service.

DEEP WATER DASHBOARD

Next Steps

- Post-processing techniques like defrosting;
- Work with images with clouds;
- Use a pre-trained network to extract features;
- Collect more data from Sentinel-2 API;
- Calculate the volume of a given lake.

Repository

https://github.com/maxbeber/deep-water

Special thank you for our mentor Marcus Jones
for the guidance, support and kindness.

Dependencies:

- Cython
- Dash
- Matplotlib
- NumPy
- Pillow
- Pydensecrf
- Rasterio
- Requests
- Tensorflow 2.4