Detection of oil spills in an inland lake using Multi-Spectral Satellite Images

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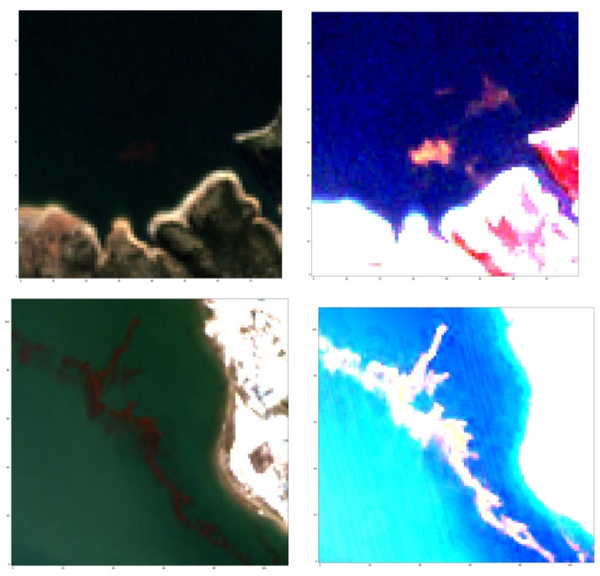
Challenge

- Detection of small extent oil spills in an inland lake, following local news [1-5]
- Very limited recordings of oil spill incidents in inland waters
- Use of satellite data for the area monitoring
- SAR images (traditionally used in oil spill detection) detect small amplitude wind induced surface waves and rely on the fact that under certain wind conditions oil spills dampen these waves
- SAR image do not show any dark spots that could be matched with oil spills
  - SAR images are of limited use in the case of inland waters
  - Use of multispectral images to overcome these challenges

[1] https://www.kozanilife.gr/2018/09/13/petrelaio-limni-polifitou-agogos-stratou/
[2] https://www.newsit.gr/topikes-eidhseis/nero-dilitirio-sti-thessaloniki-agogos-tou-stratou-molynei-me-petrelaio-ti-limni-polyfytou/2615077/
[3] https://www.protothema.gr/webtv/ellada/3476789/anisyxia-gia-to-nero-sti-thessaloniki-agwgos-toy-stratoy-molynei-me-petrelaio-ti-limni-polyfytoy/
[4] https://www.dikaiologitika.gr/eidhseis/koinonia/224175/anisyxia-gia-to-nero-sti-thessaloniki-agogos-tou-stratoy-molynei-me-petrelaio-ti-limni-polyfytou
[5] https://www.iefimerida.gr/news/443622/synagermos-stin-eyath-apo-agogo-toy-stratoy-i-rypansi-dexamenis-poy-trofodotei-me-posimo

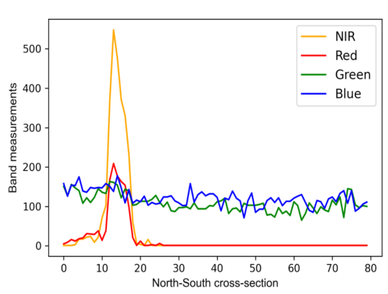
Data and Annotation

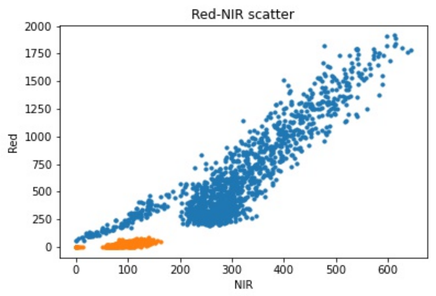
- Multispectral, HR **Sentinel-2** (10 m) and VHR **Planet images** (3 m)
- We implement three **VIS** and one **NIR** band.
- Oil spill and clear water pixels are annotated one-by-one via visual inspection of False Color Images (Green-Red-NIR).



Band Analysis

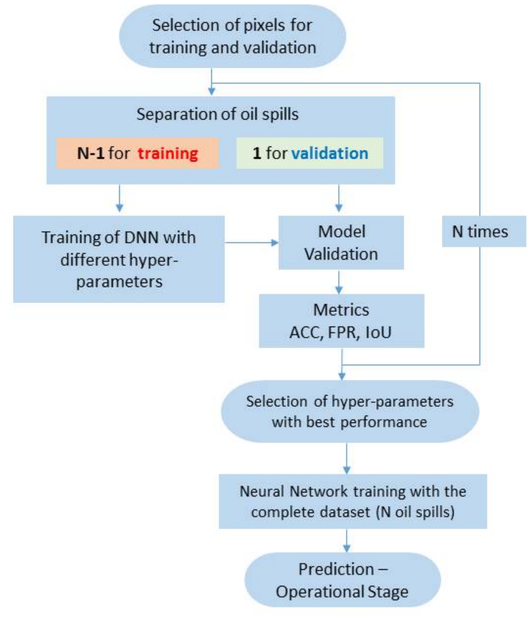
- Red and NIR bands have the largest sensitivity to oil spills.
- For areas with oil spills Red and NIR have a linear relationship, with NIR having a much stronger sensitivity than Red.





Deep Learning

- Training of a custom Deep Neural Network (DNN) to detect oil spills
- DNN has two hidden layers (12 and 8 units, each) and 1 output layer
- Input bands: Red and NIR bands due to the increased sensitivity
- Processing steps: cloud removal, masking of land and man-made constructions
- 5-fold validation is used for training and testing (i.e., 4 oil spills are used for training and 1 for testing).
- Experiments:
  - Testing of hyper-parameters: learning rate (LR) and optimizer.
  - Evaluation metrics: Intersection over Union (IoU), Accuracy (ACC), False Positive Rate (FPR)

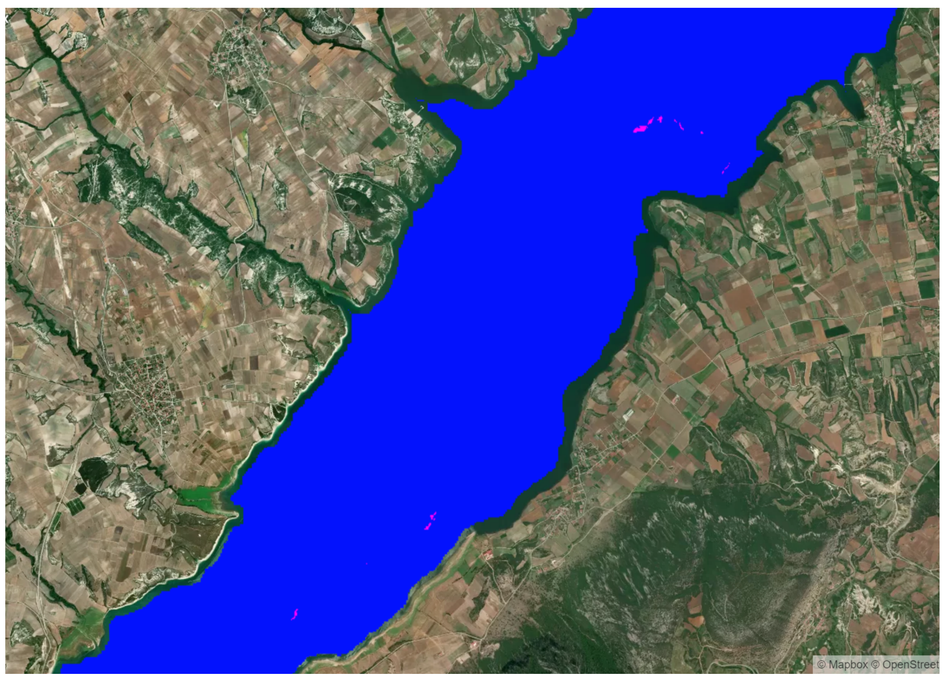


Results

- Experiments:

	4 Bands		Green-NIR		Red-NIR	
LR	**IoU**	**FPR**	**IoU**	**FPR**	**IoU**	**FPR**
0.1	7.48	30.5	7.41	28.03	1.48	32
0.05	12.7	30.43	15.83	30.13	18	18.26
0.01	43.08	1.79	54.64	0.74	54.37	0.82
0.005	46.84	1.8	62.94	0.63	58.15	0.93
0.001	60.43	0.93	69.82	0.42	63.09	0.8
0.0005	71.18	0.4	68.76	0.27	58.41	0.65
0.0001	33.78	0.05	40.88	0.05	31.09	0.21
0.00005	26.44	0.03	29.92	0.05	28.31	0.04

- Best achieved results: IoU=71.18%, FPR=0.4%, ACC=99.24% (parameters: LR=0.0005, Adam optimizer, 4 Bands as input).
- Ongoing work: improvement of the model by producing less false positives results



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