

# Segmentation of Dune Crestlines Using Convolutional Neural Networks

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Computer vision can learn to identify and outline Martian dune crestlines using few training images

## Why care about dunes?

- Dune crestlines can remotely tell us about environmental conditions (such as wind regime)

## The research goal!

- Take grayscale images of Martian dune fields and outline the dune crestline using computers
- Unique challenge using non-RGB [3, 5] nor elevation [2] to outline [3, 6] pixel-wide, linear features [1, 4]

## How did we do it?

- We digitized the crestlines of 5 Martian dune fields containing transverse dunes
- We trained on 4 dune fields and tested on 1
- To create a diverse dataset, we augmented images through preprocessing by rotating, scaling, and adjusting contrast and brightness
- Our loss function combined Dice and Focal Loss
- We used a U-net ("EfficientNet B3" backbone)

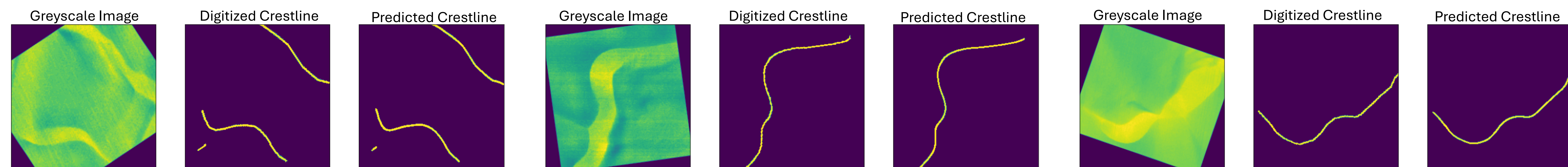
## Computers can (decently) see dunes!

- Model performs very well in training and validation sets, showing that there is good potential to identify dune crestlines automatically
- In the testing set, the CNN struggles with unfamiliar optical features related to lighting and shadows pointing towards the top right
- The CNN is actually picking up secondary dunes related to an additional wind regime
- Using a different performance metric may more adequately represent qualitative measures of success

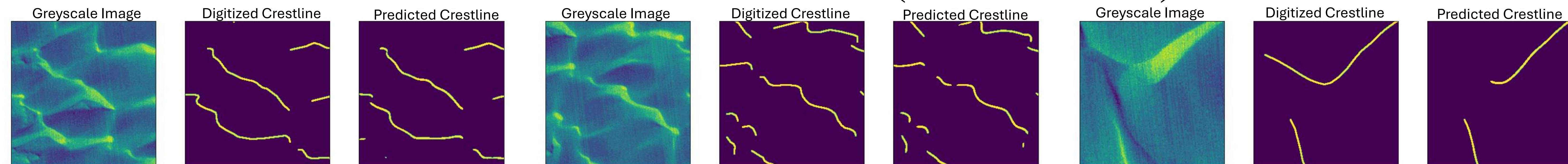
### References:

1. M. Azzaoui et al, 2020. International Journal of Advanced Computer Science and Applications.
2. J. Daynac et al, 2024. Geomorphology.
3. A. Lu et al, 2024. Proceedings of the AAAI Conference on Artificial Intelligence.
4. I. Rubanenko et al, 2021. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.
5. S. Shumack et al, 2020. Earth Surface Processes and Landforms.
6. Y. Tang et al, 2023. International Journal of Applied Earth Observation and Geoinformation.

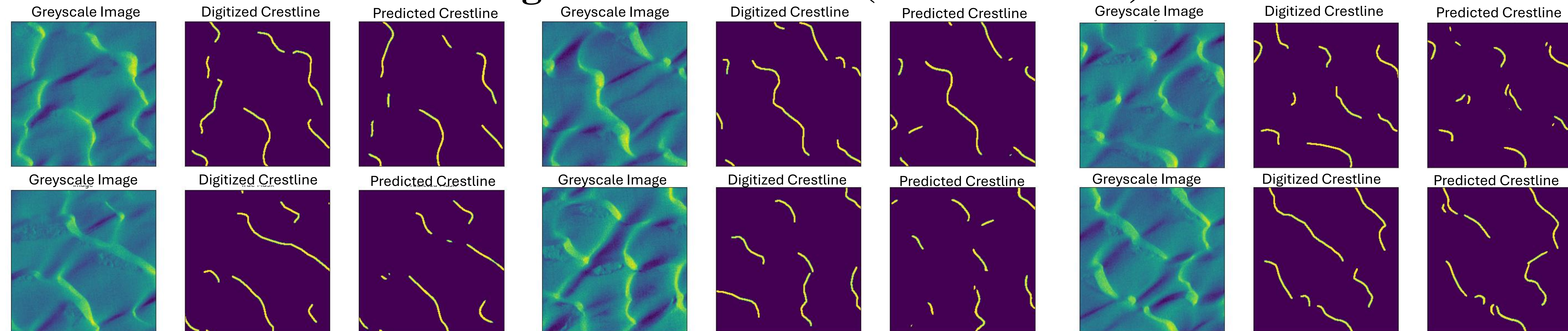
## Training Set Performance (F1-Score 0.88)



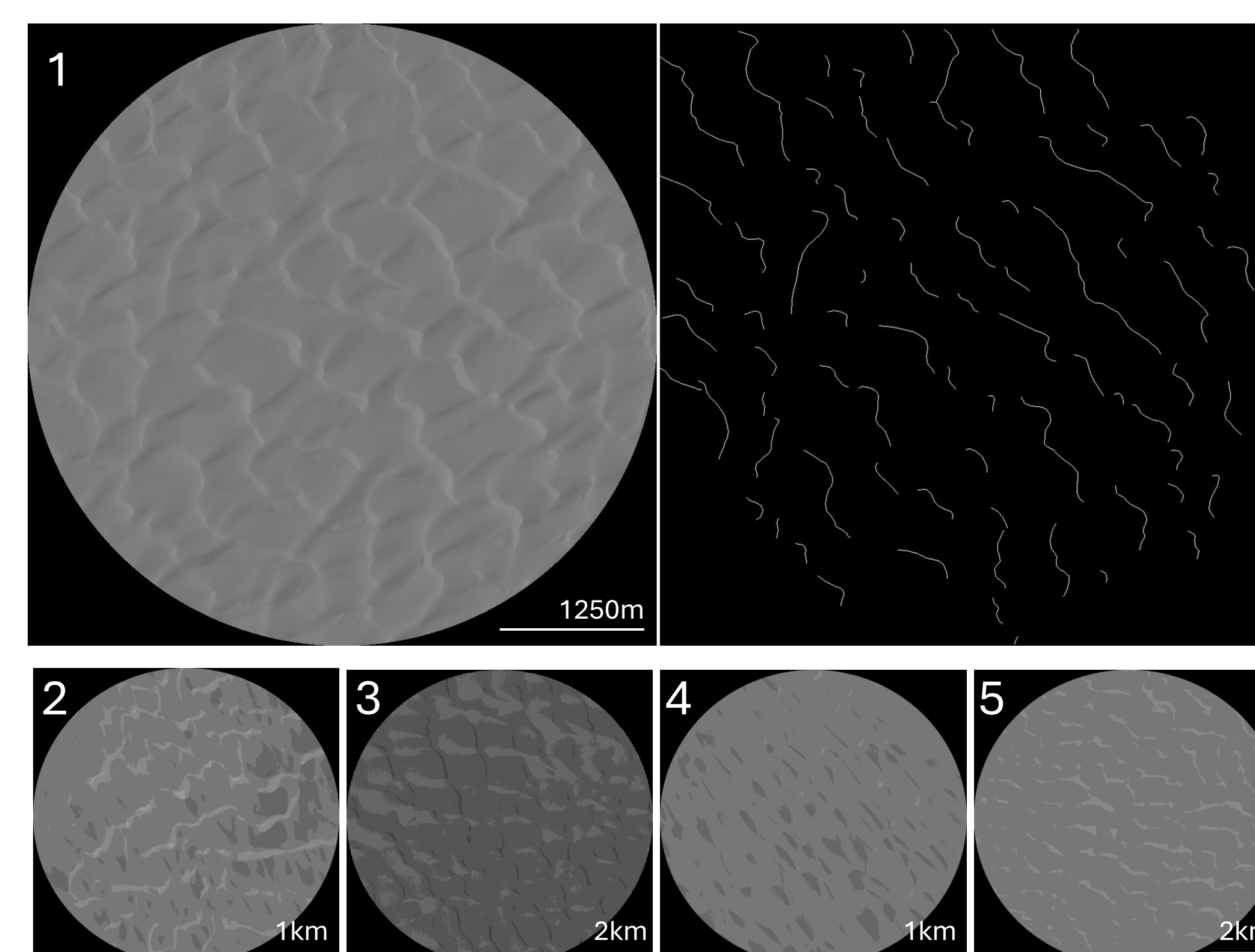
## Validation Set Performance (F1-Score 0.82)



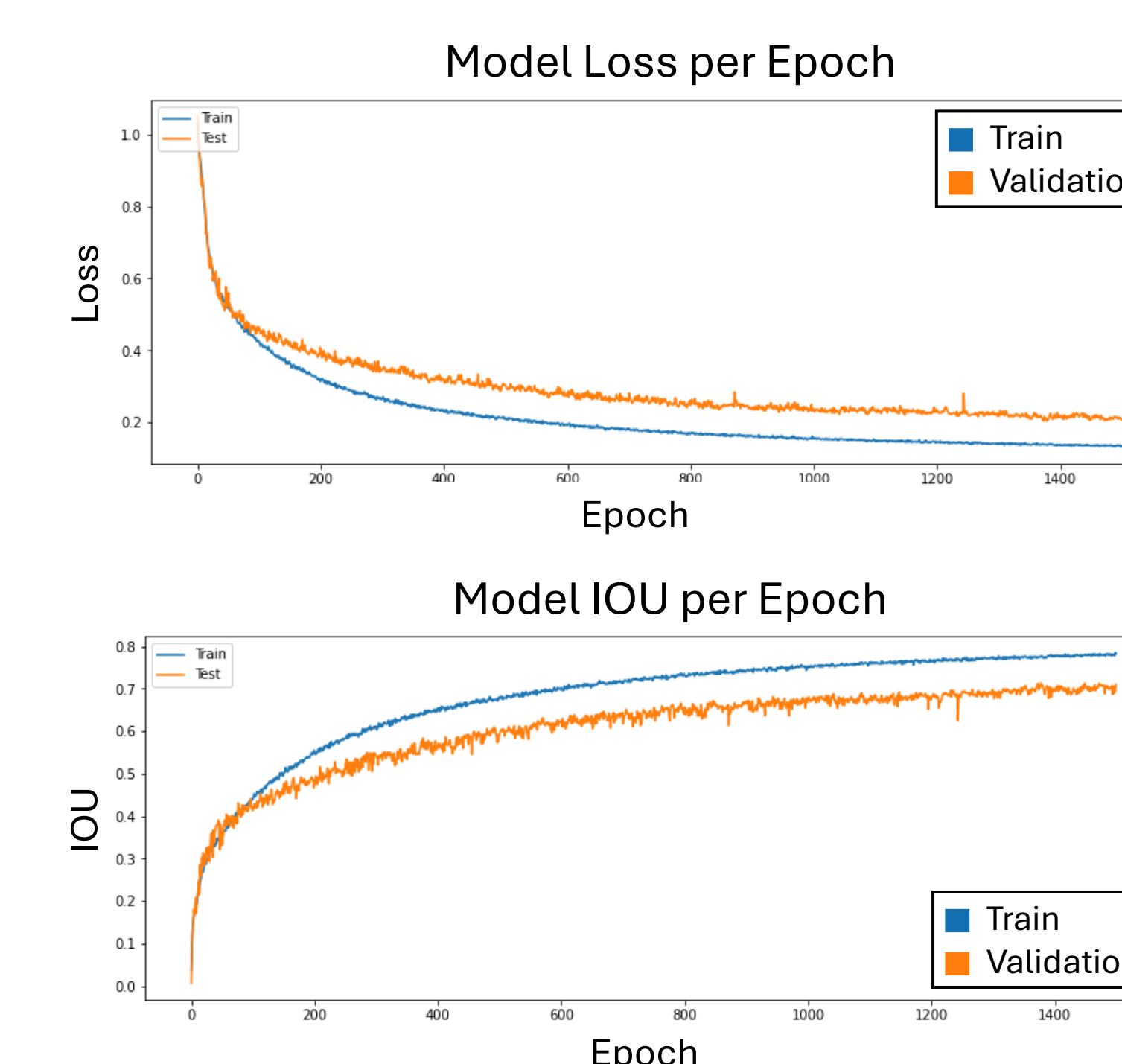
## Testing Set Performance (F1-Score 0.61)



## Dune Field + Crestlines



## Performance Curves



## Looping Each Dune Field

