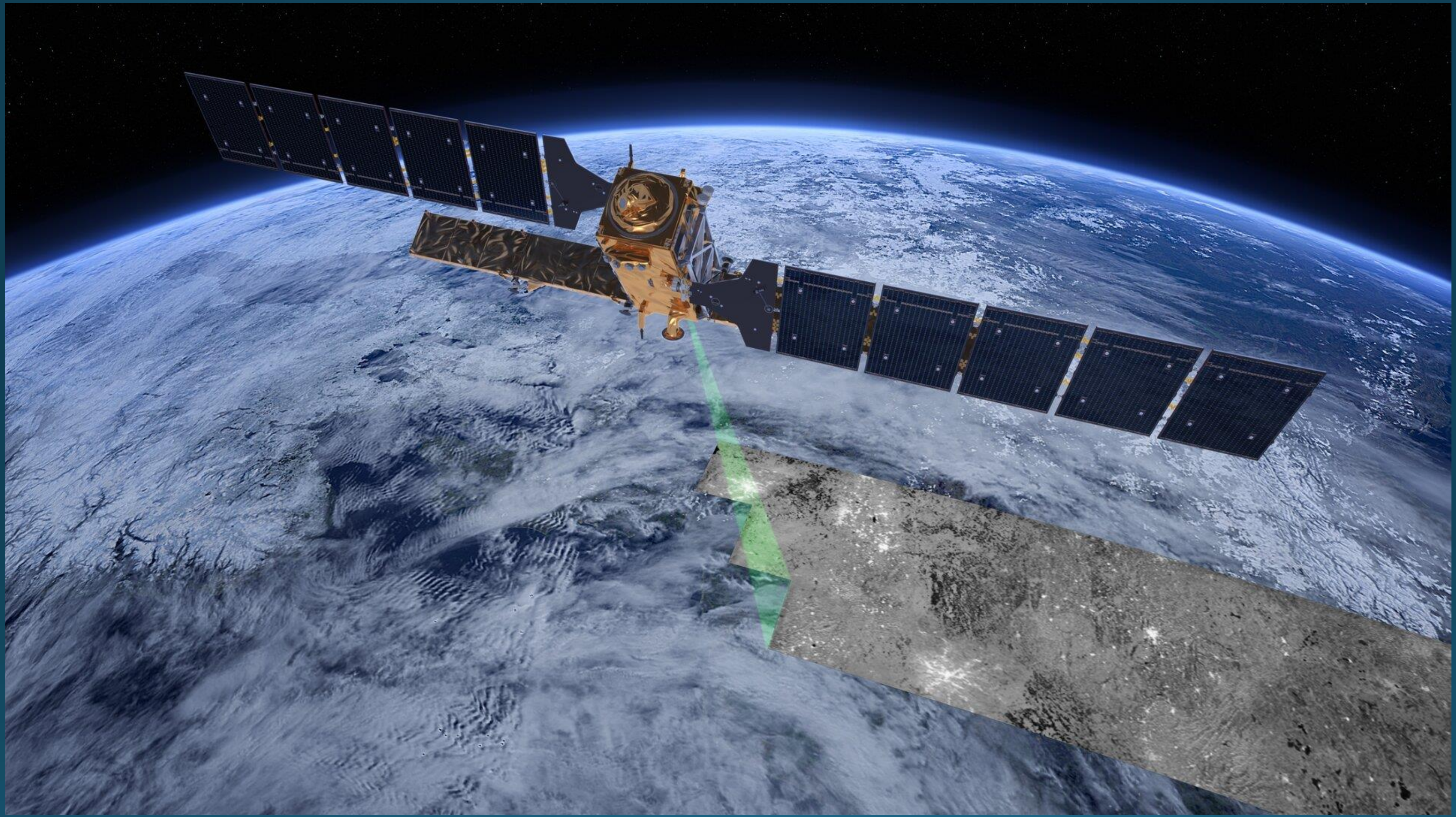
A Fully Convolutional Neural Net Identifying Ocean Phenomena from Sentinel-1 Satellite Images



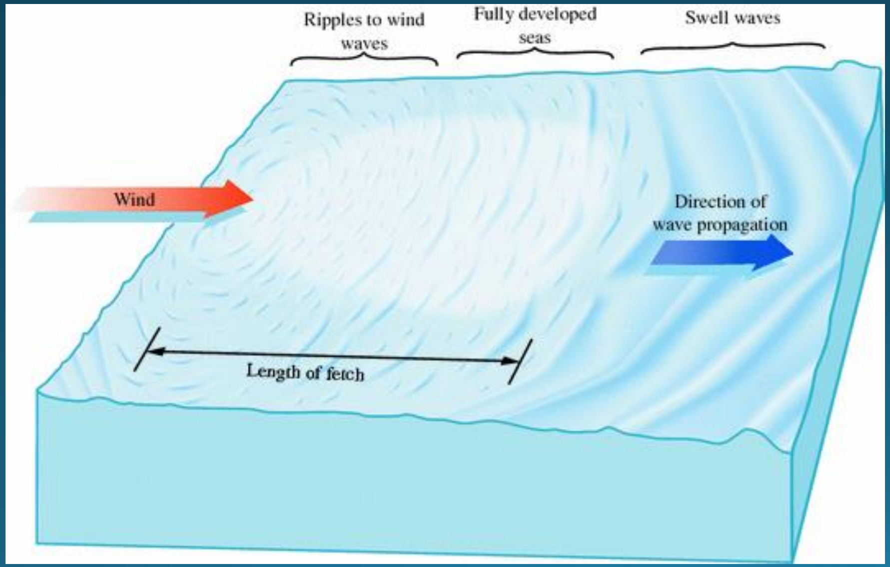
Presentation by: Matt LeGro
08/04/21

Presentation Outline

- Research motivation
- Discuss data source and relevant background
- Present model performance
- Discuss areas for improvement

Motivation for Algorithm Development

- Oceans cover 70% of the Earth's Surface, with air-sea interactions playing a crucial role in climate and weather projections
- Sentinel-1 and Sentinel-2 satellites launched in 2014 and 2016 take hundreds of thousands of images every month

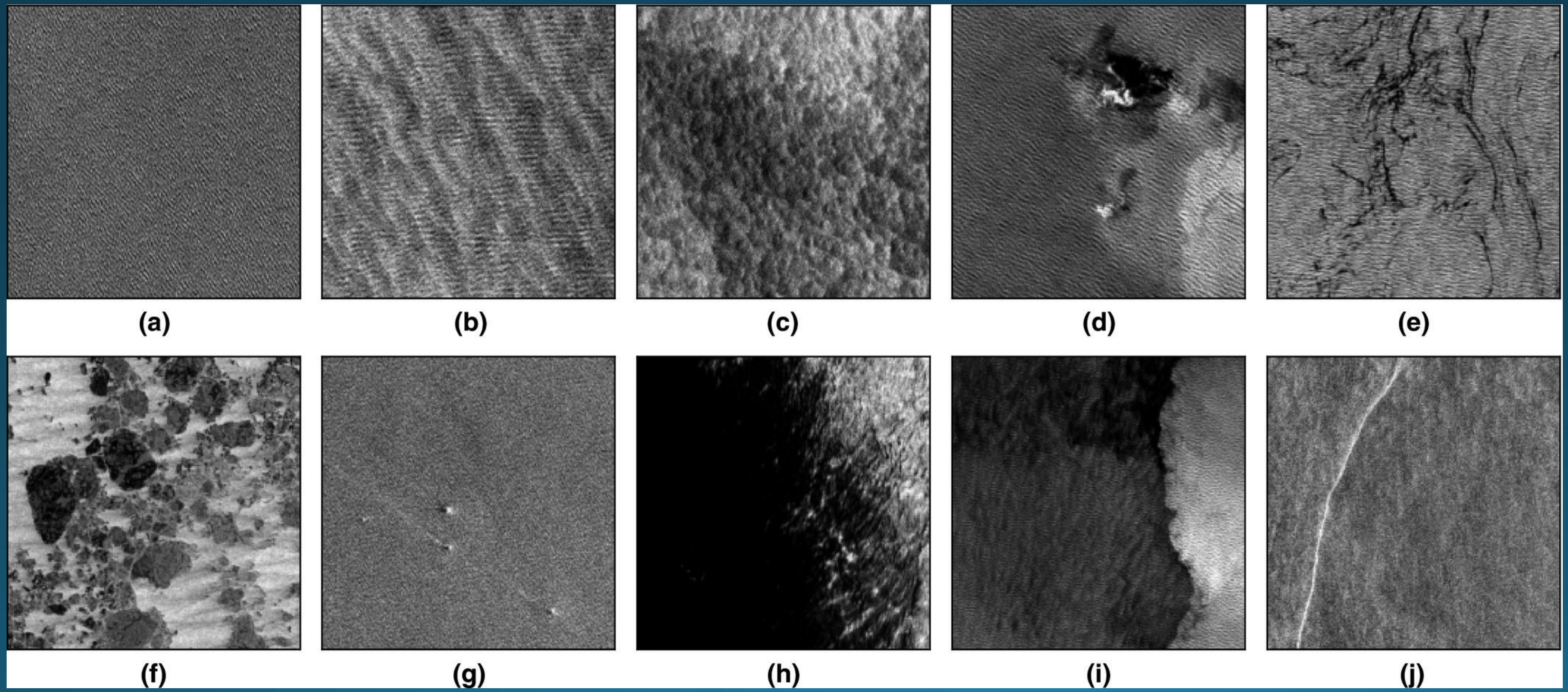


A Brief Literature Review

- Sentinel-1 collects 120,000 Synthetic Aperture Radar (SAR) images every month in 20x20km swaths with 5m resolution
- Images collected using visible light suffer from darkness and weather; radio waves do not
- With air-sea interactions being the root cause of waves and SARs sensitivity to sea surface roughness on a centimeter scale, these images are a valuable, practically untapped source of information
- CNNs such as ResNet and VGG19 have been trained effectively on common RGB images, but not SAR grayscale images

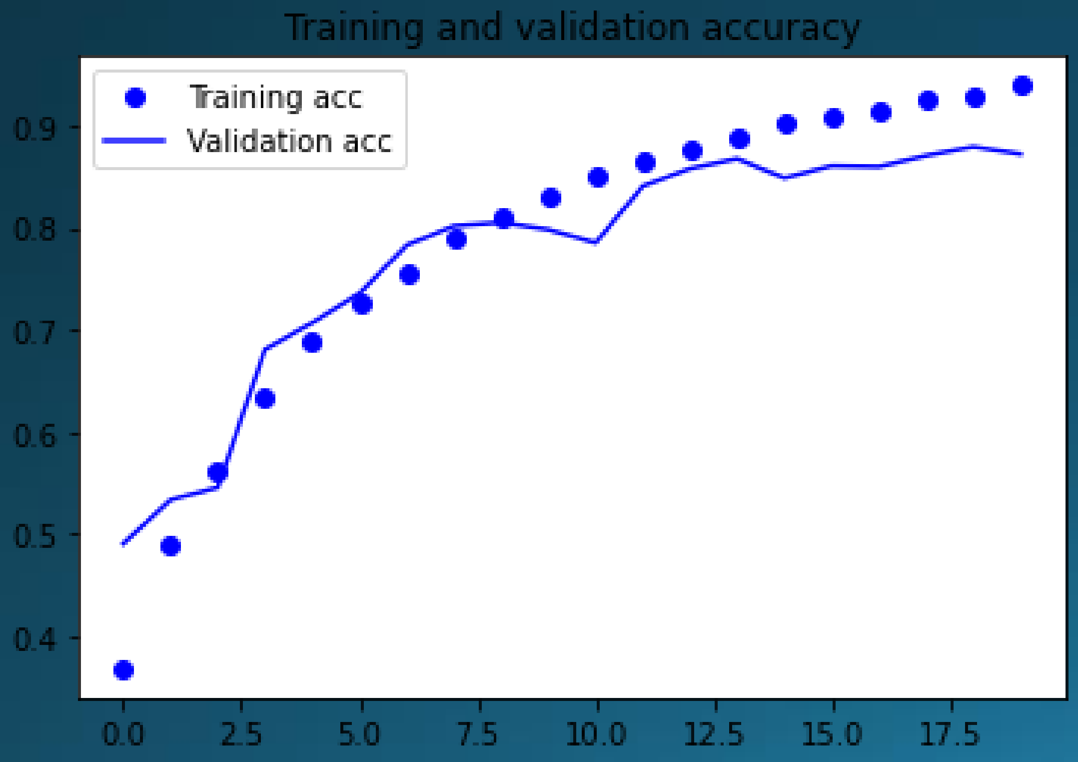
Image Examples

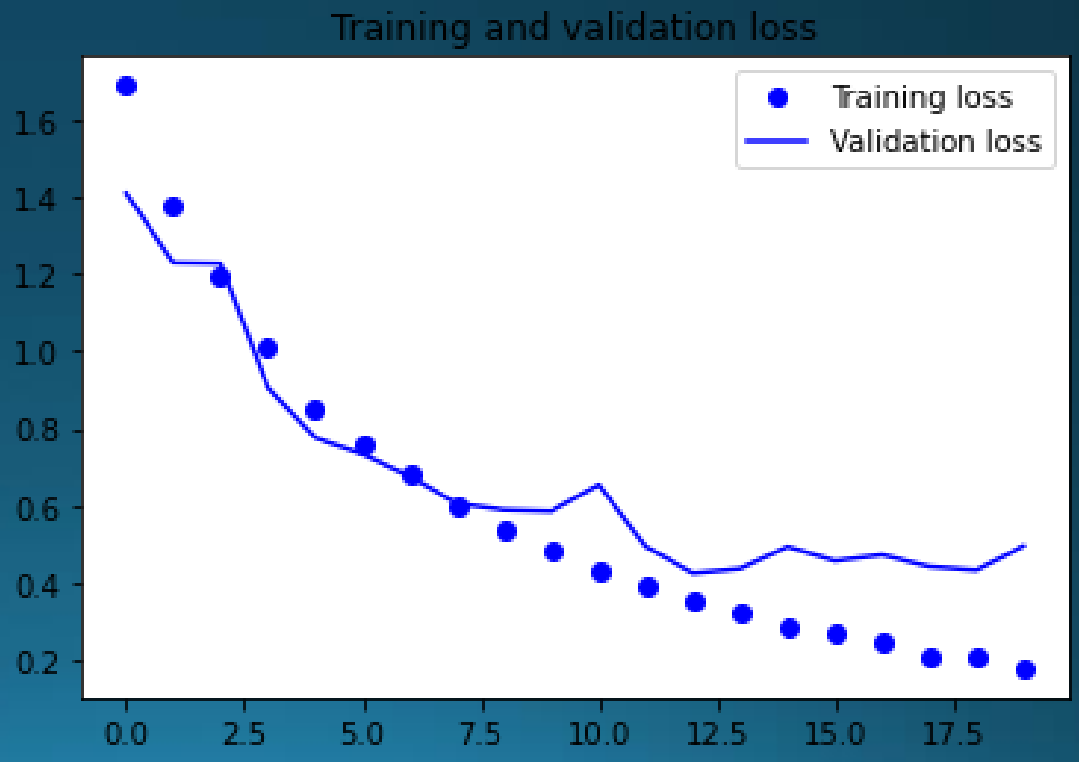
- This dataset was published by Wang et al. in 2019 for the express purpose of exploiting machine learning to benefit the remote sensing community
- 37000 open ocean SAR images were manually labeled with 10 ocean phenomena, reduced in resolution to 50m, and corrected for incidence angle
- The following phenomena, in order as seen below, are: Pure Ocean Waves, Wind Streaks, Micro Convective Cells, Rain Cells, Biological Slicks, Sea Ice, Icebergs, Low Wind Area, Atmospheric Front, and Oceanic Front



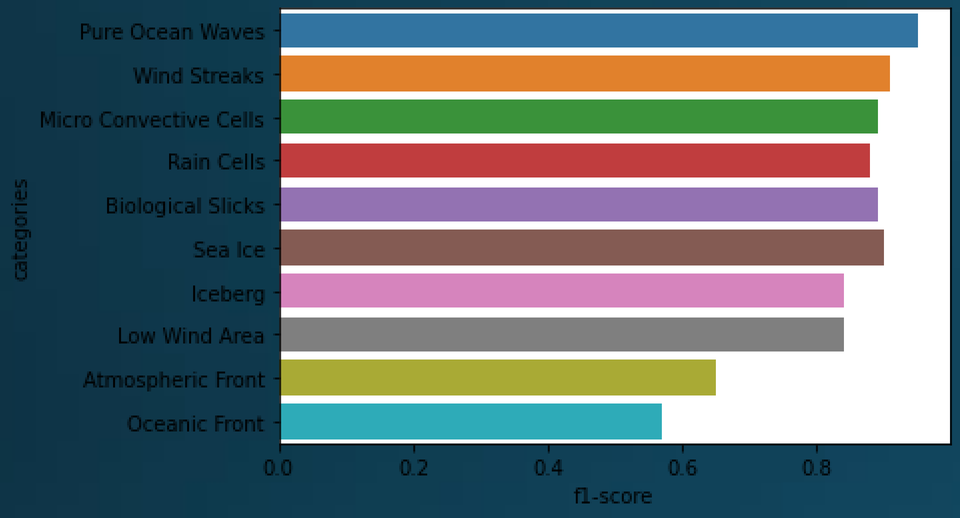
Model Architecture and Performance

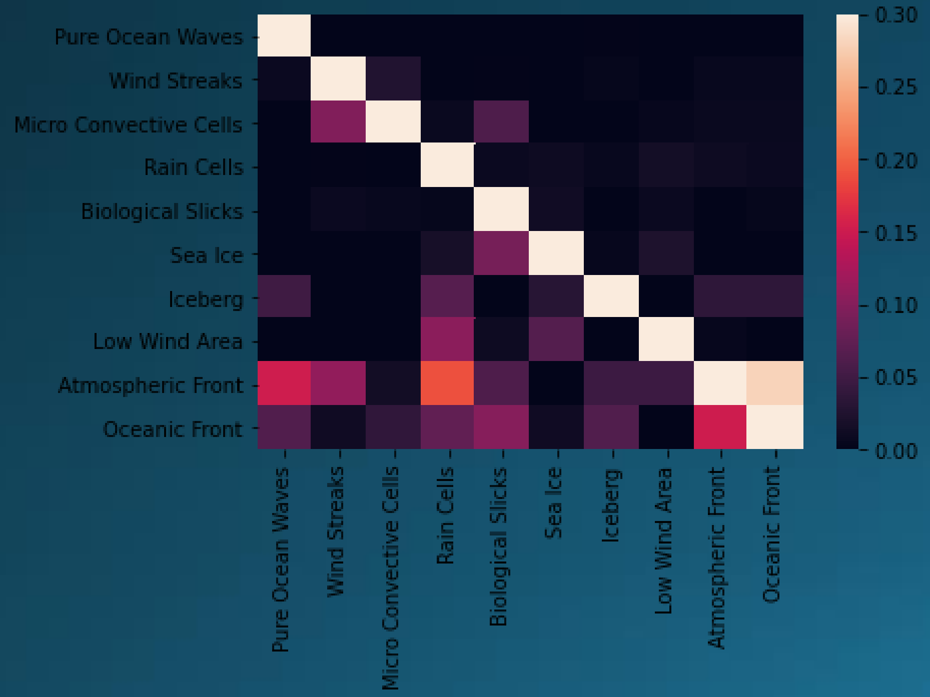
- The final architecture is a version of VGG19 with the densely connected layer sizes reduced so that they fit in my GPUs dedicated memory of 8GB
- Two independently trained models yielded test set accuracies of 84 and 86 %





Areas for Model Improvement





- Metrics plotted to the left are based on Model 2, but both models struggled in similar areas
- From the paper presenting this dataset, "Periodic signatures of ocean waves can coexist with [both] Ocean Front [and] Atmospheric Front."
- Not represented here, the Oceanic Front category is especially underrepresented in the dataset, having only a quarter of the images of other categories
- While the Iceberg and Low Wind Area categories also suffer from imbalance, data augmentation could be used in future iterations

Summary

- Two Fully Connected CNNs were trained and able to correctly classify with 84 and 86 % accuracy SAR images collected by the European Space Agency's Sentinel-1 Satellite
- Areas where the network suffers are in identifying Atmospheric and Oceanic Fronts, likely due to the presence of other phenomena in these images
- In the future, investigate data augmentation and the reduction of learning rate on accuracy or loss plateaus for further improving classification accuracy

Thank You!

- Questions?

Email: mlegro93@gmail.com

LinkedIn: https://www.linkedin.com/in/matthew-legro-8b60211b6/