

# COMPARING FIRN DENSIFICATION LAYERS SIMULATED THROUGH REGIONAL CLIMATE MODELS AND THOSE TRACKED THROUGH RADARGRAMS

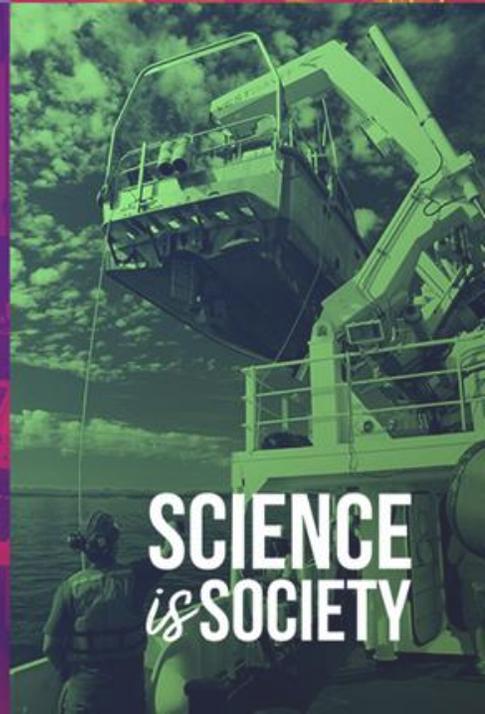
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**AGU** FALL  
MEETING

15<sup>th</sup> December 2021



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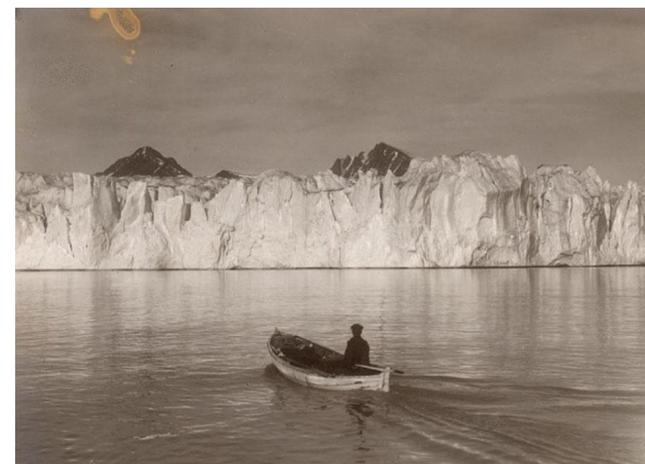
# OVERVIEW

- Introduction and Background
- Background on climate models and radar observations
- Comparing firn layer profiles from climate models and radar
- Layer tracking from radargrams
- Integration and future scope



## INTRODUCTION

- Global warming is rapidly reducing the polar ice caps and contributing to sea level rise
- Simulating the ice melt accurately is necessary to project global natural disasters



Greenland 100 years ago (top) and now (bottom)



# BACKGROUND

- State-of-the-art climate models make accurate predictions of firn layer characteristics at very-low resolution, whereas radar sensors can make high resolution observations which are somewhat noisy
- Intern firn layers simulated through climate models need to be validated with actual observations made through airborne sensors



# CLIMATE MODEL: ISSM-GEMB

- The Glacier Energy and Mass Balance (GEMB) module of the Ice-Sheet and Sea-Level System Model (ISSM) can simulate the temporal evolution of the icesheet snow pack.
- GEMB is a column model (1-D) which simulates parameterized snow grain growth, depth-dependent albedo based on grain-size, thermal diffusion, depth-dependent calculation of temperature, melt, meltwater percolation and refreeze etc.
- It takes a 3-hourly input of ambient variables such as air temperature, wind speed, downward radiation flux, surface pressure etc.
- Gives a daily estimate of density, temperature, depth, grain size, water content etc. of each snowpack layer



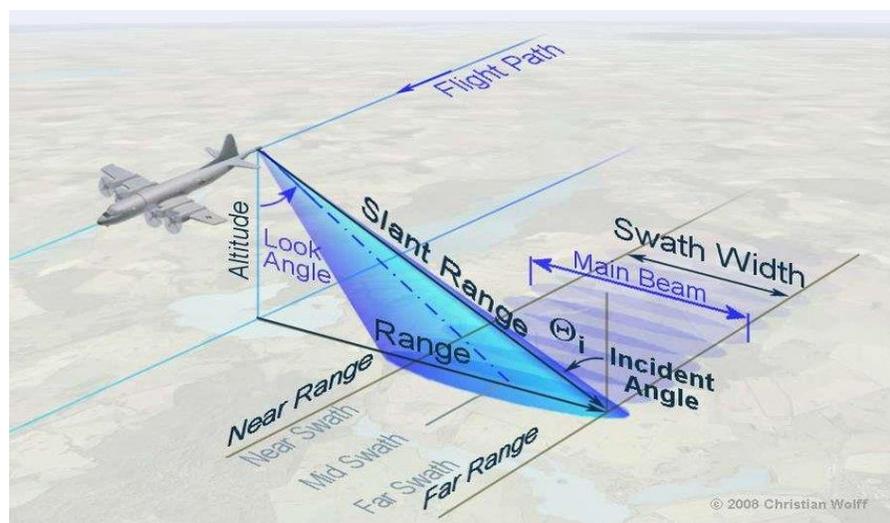
# CLIMATE MODEL: ISSM-GEMB



Model can make daily predictions for a given coordinate



# OBSERVATIONS: AIRBORNE SNOW RADAR



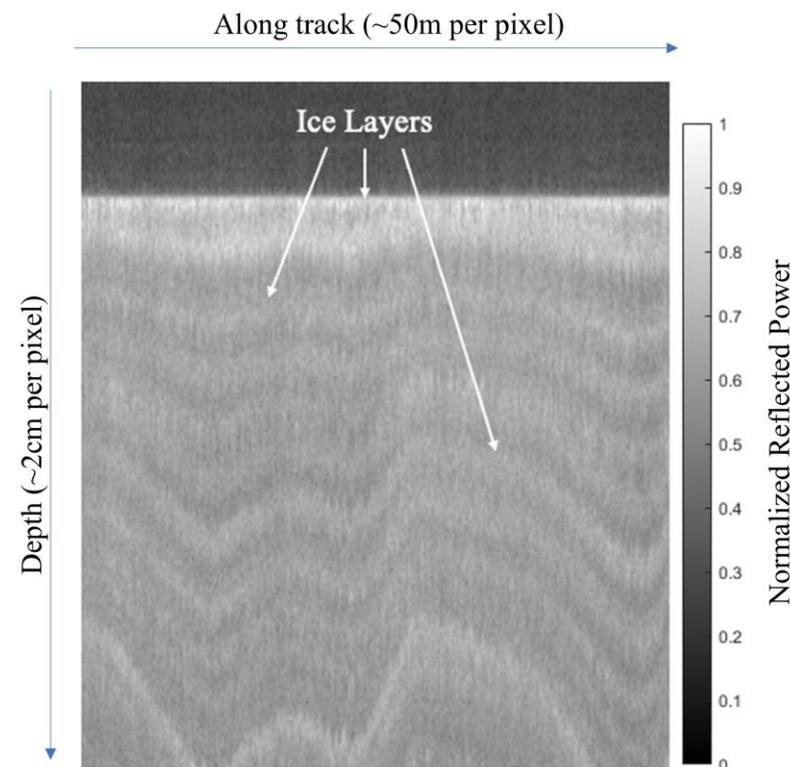
## Dataset Details

**Campaign:** NASA Operation IceBridge 2009-2012

**Sensor:** Ultra wide-band (2-6.5GHz) Airborne Snow Radar sensor

**Timespan:** 2009-2012

**Resolution:** ~2cm per pixel in the vertical direction

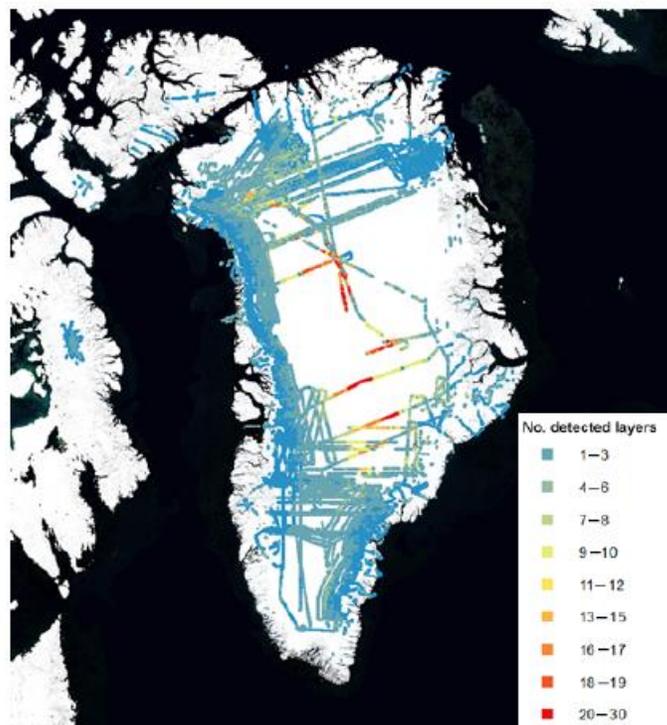


A Snow Radar echogram showing multiple internal layers. [1]



# OBSERVATIONS: AIRBORNE SNOW RADAR

Flight map of Snow Radar

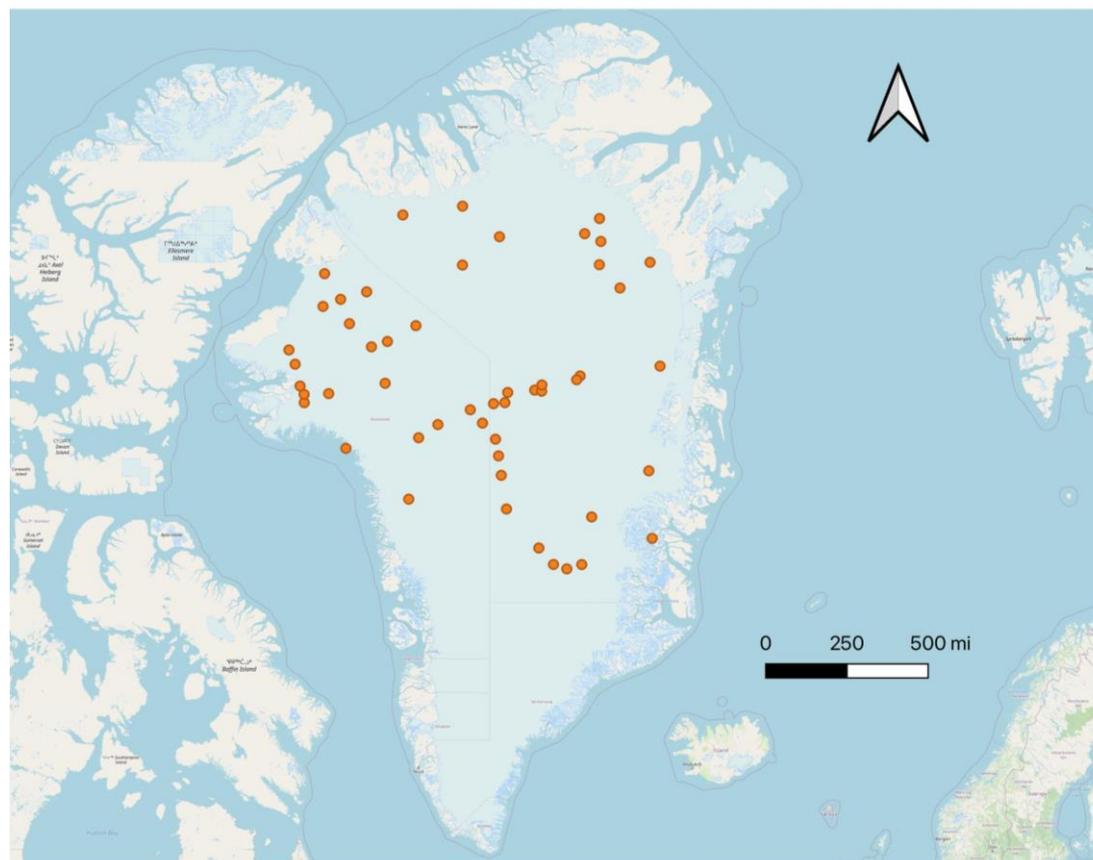


Number of detected annual layers from 2009 through 2012 across the Greenland Ice Sheet [1]



# STUDY LOCATIONS

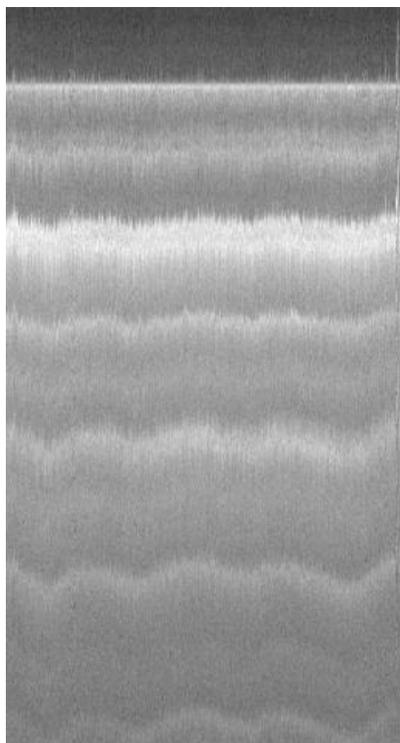
Locations where both radar observations and model simulations are taken into consideration



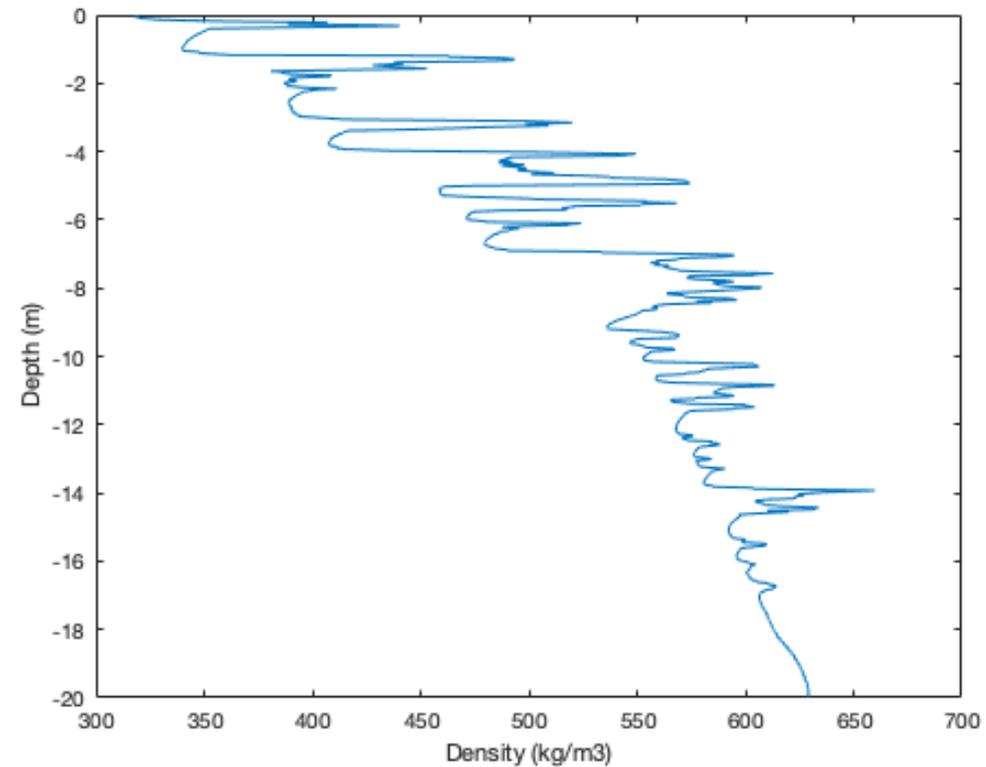
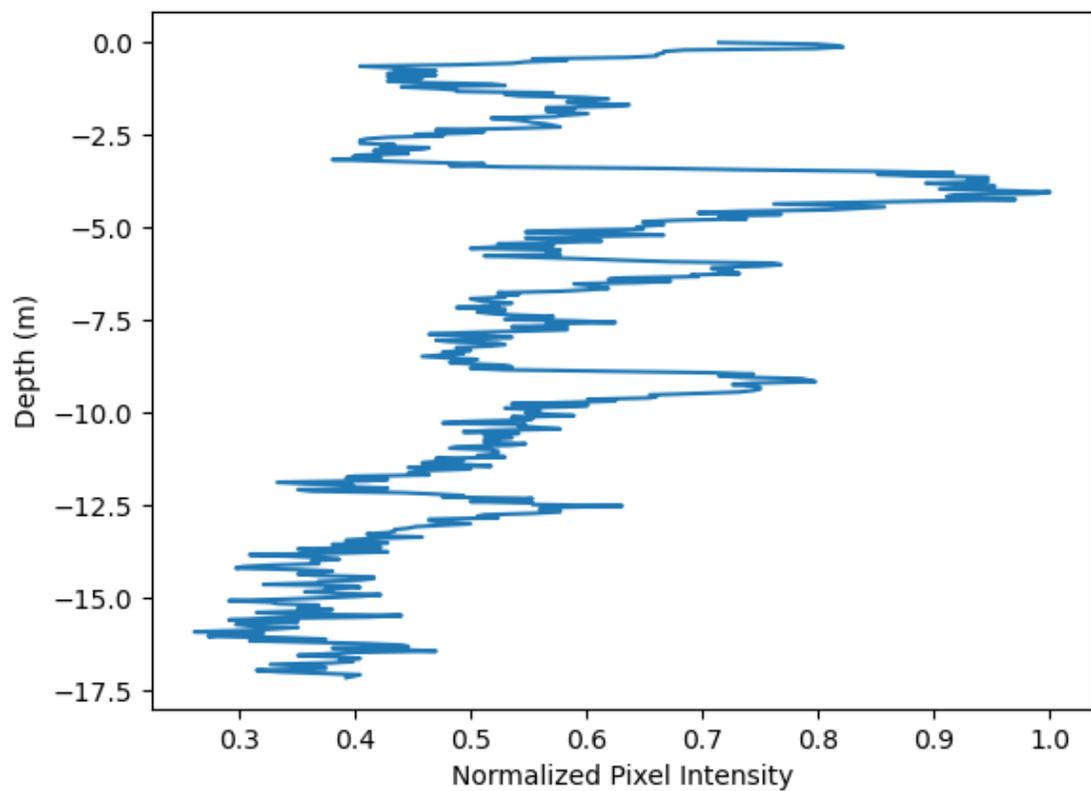
~50 coordinates randomly chosen across Greenland



## ANALYSIS

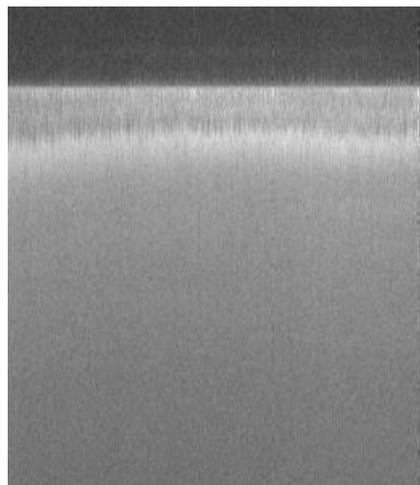


Radargram

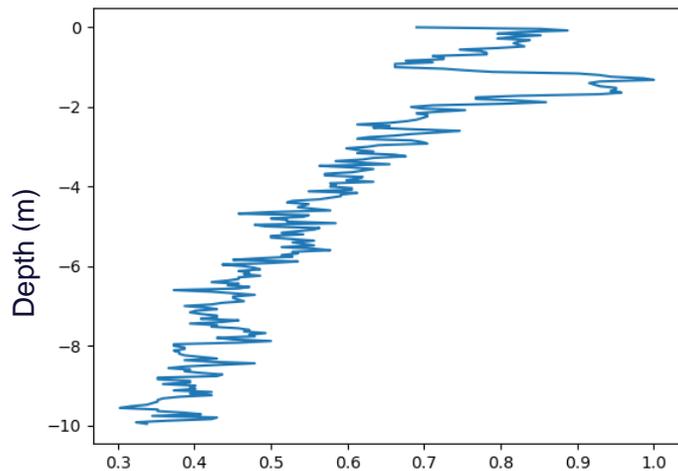




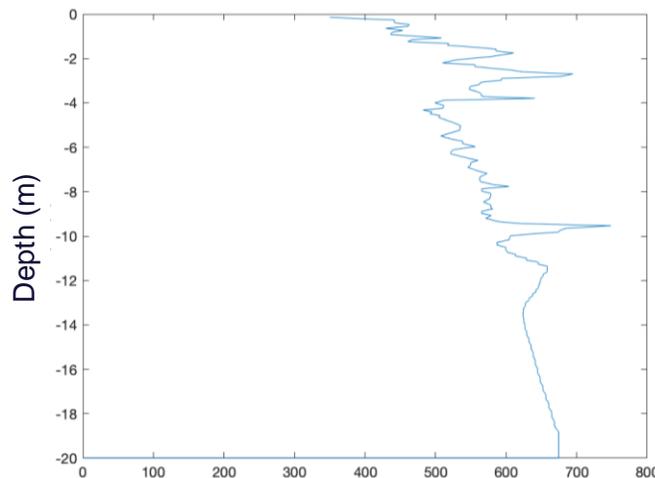
## ANALYSIS



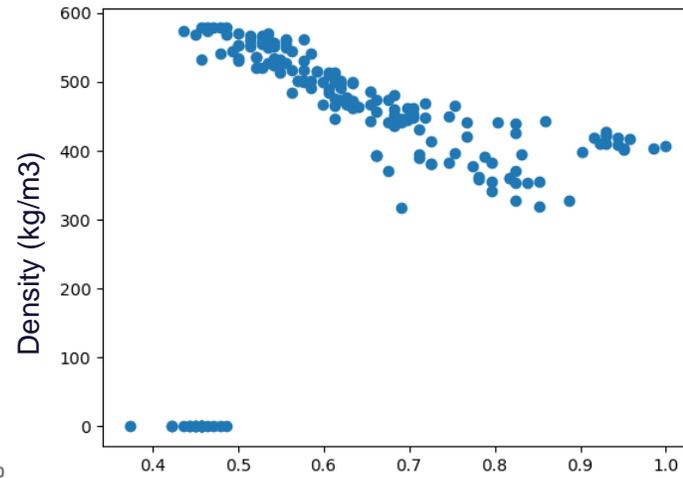
Radargram



Normalized Pixel Intensity of Radargram



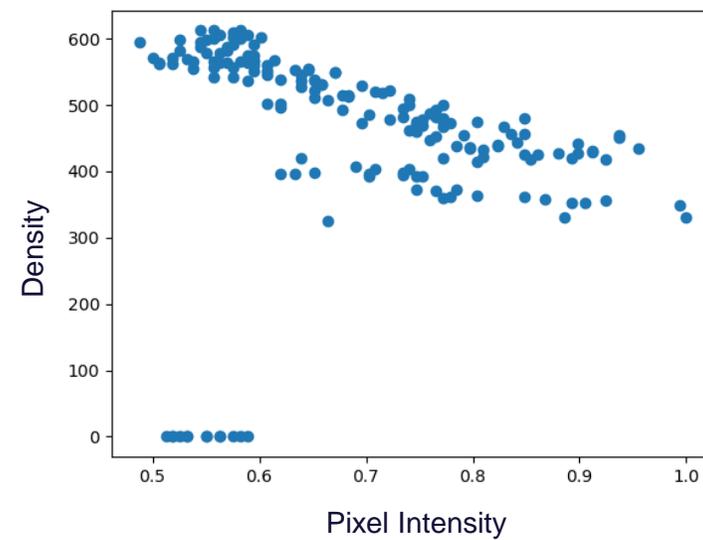
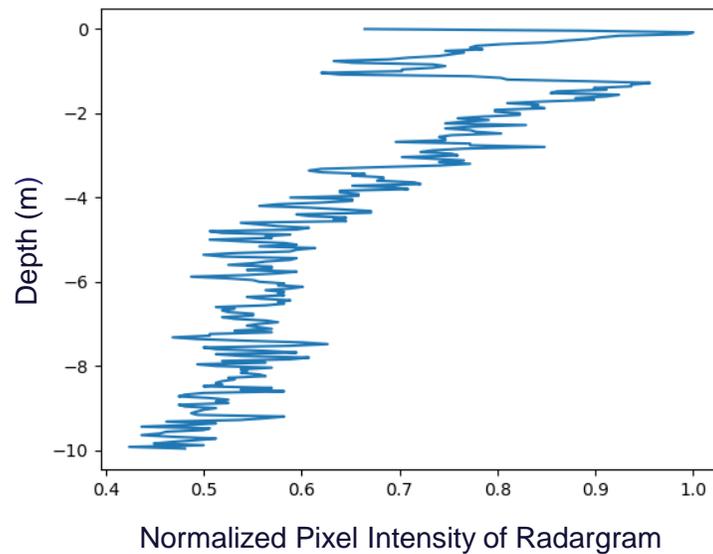
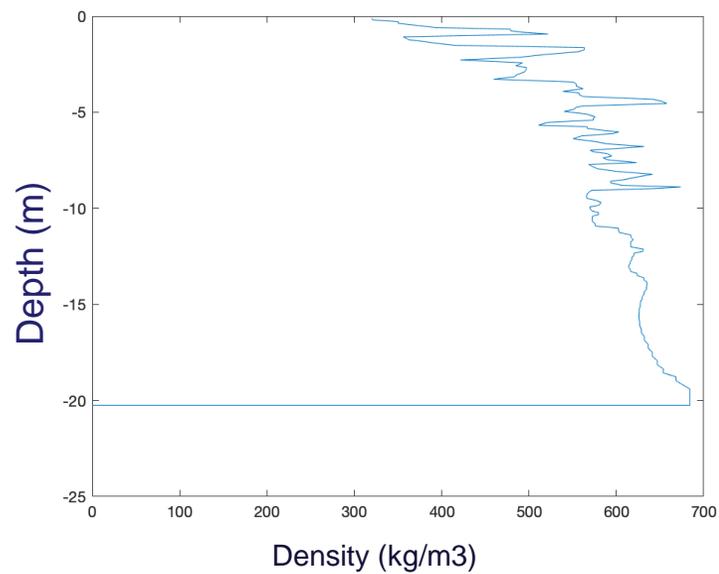
Density (kg/m3)



Pixel Intensity

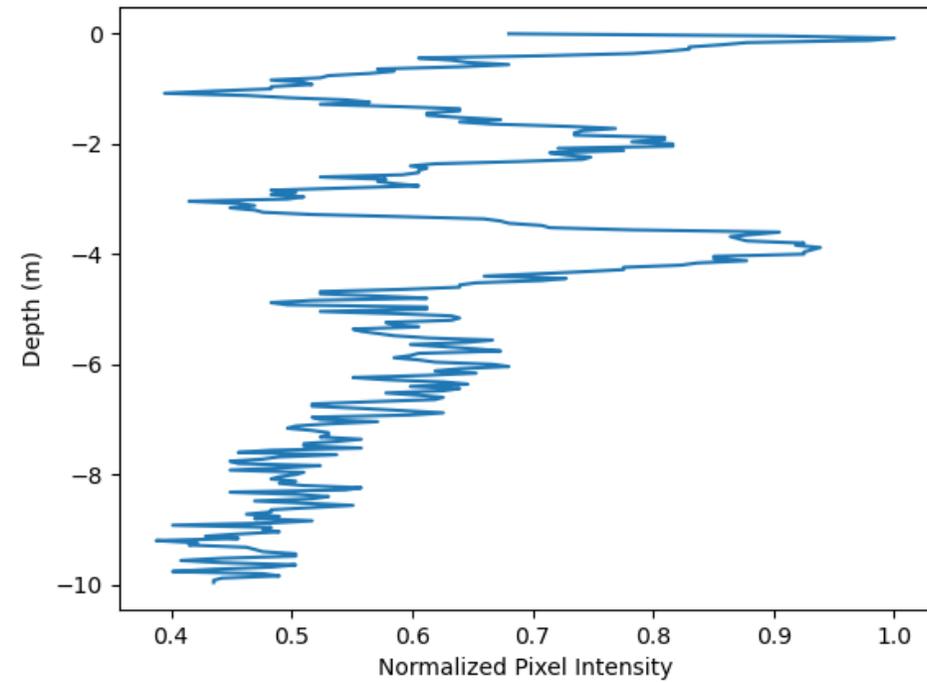
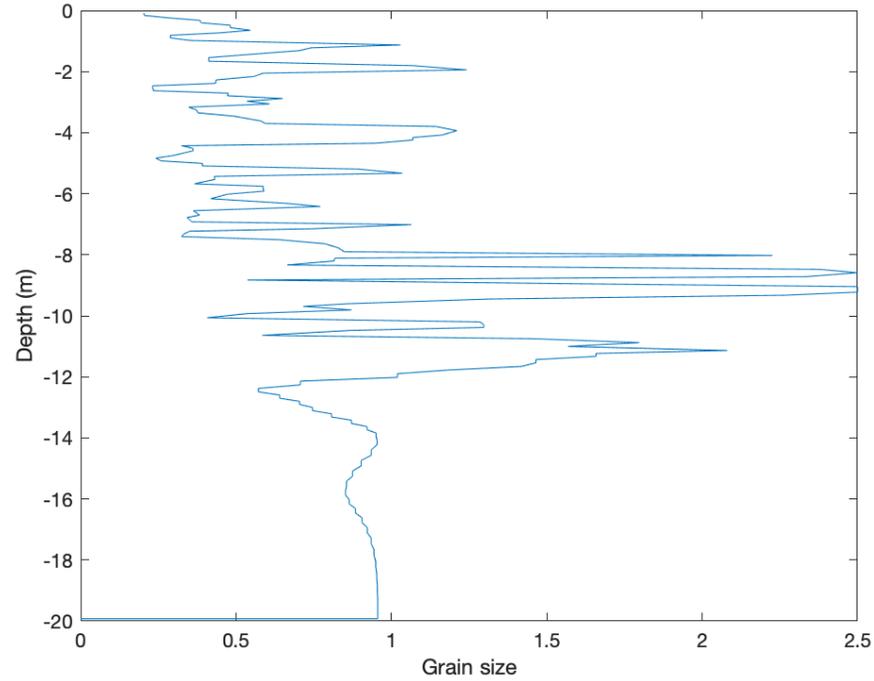


## ANALYSIS



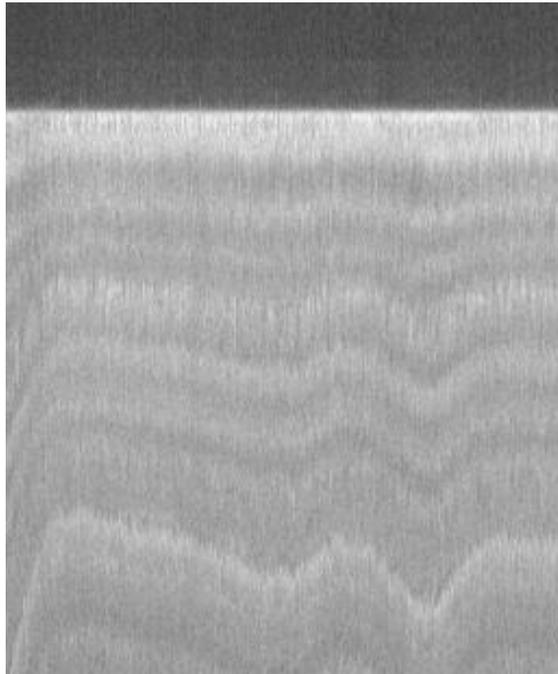


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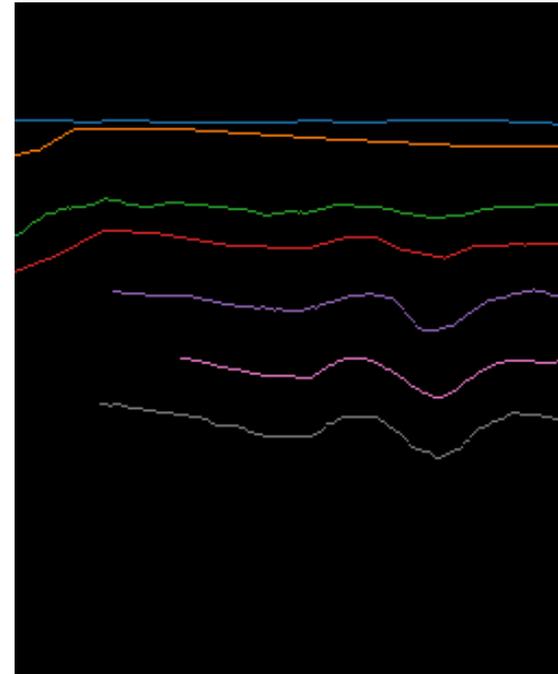




# ICE LAYER TRACKING THROUGH FCN



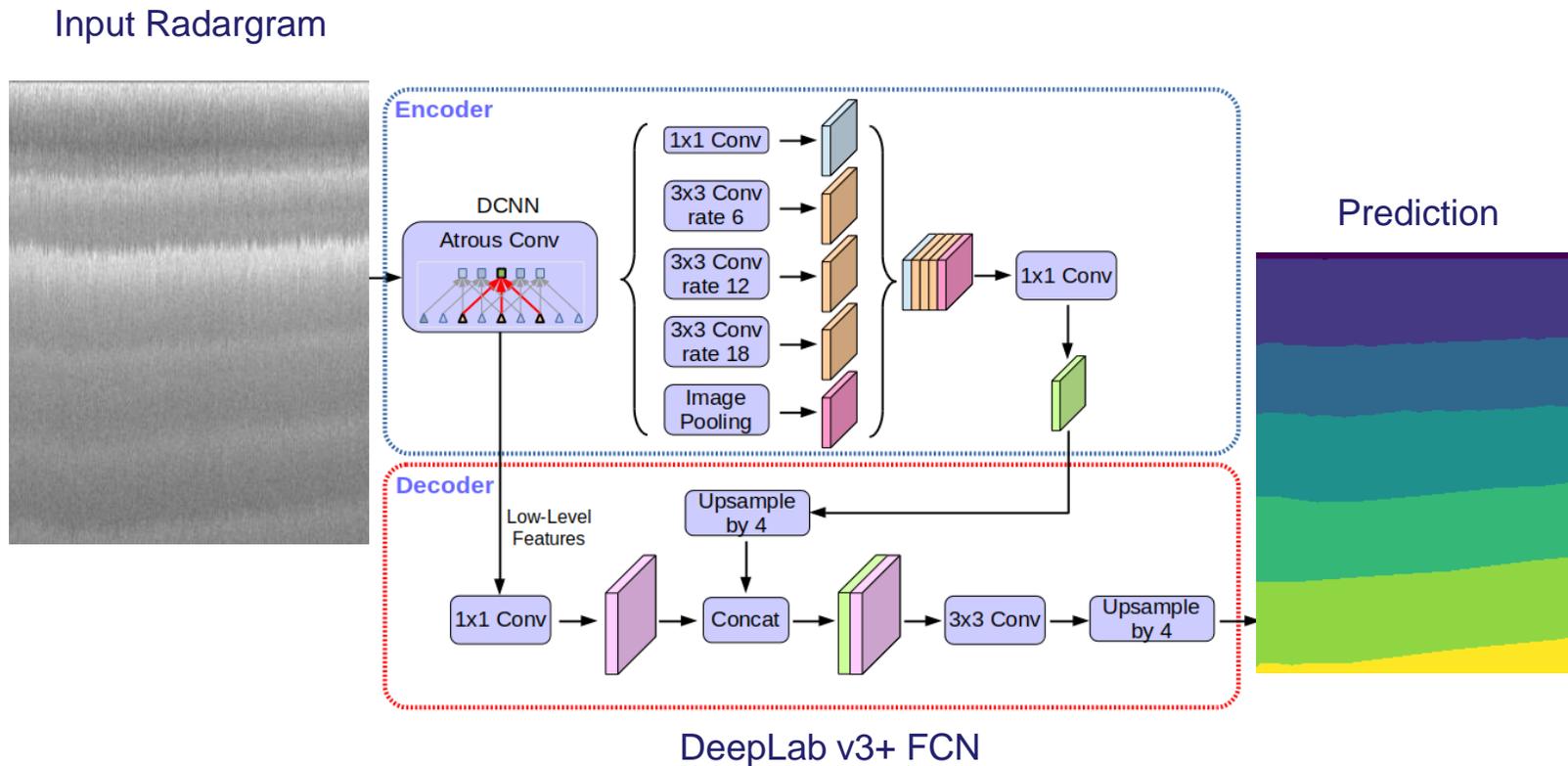
Radargram



Manual annotations  
(Ground Truth)

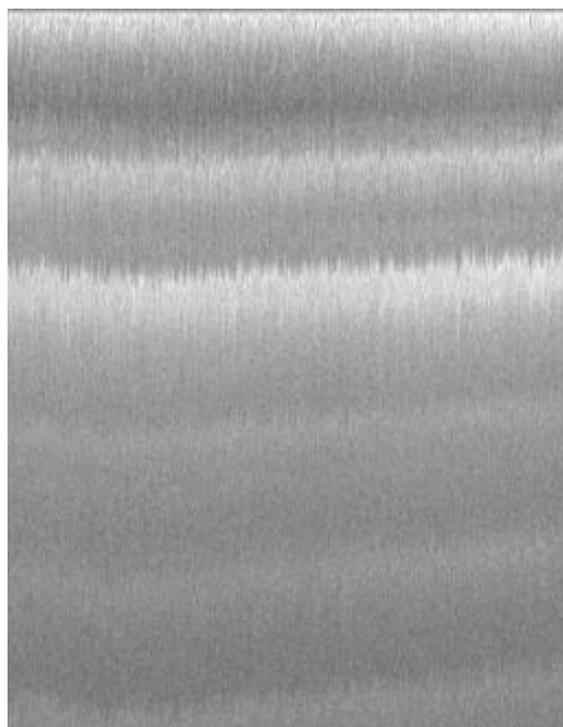


# ICE LAYER TRACKING THROUGH FCN





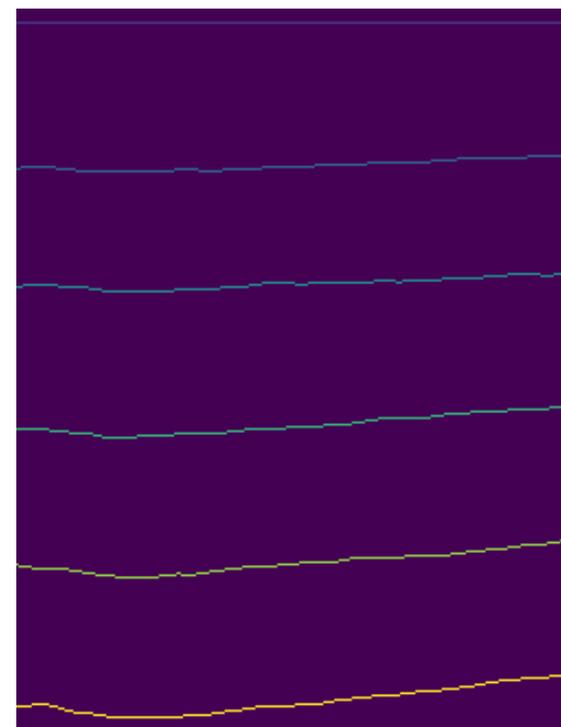
# ICE LAYER TRACKING THROUGH FCN



Test Radargram



Prediction



Converted to Layers



## CONCLUSION AND FUTURE SCOPE

- Density variation vs depth for both radar observations and GEMB simulations are *similar* for most sample points.
- Layers detected in high resolution radar observations can be used to re-parameterize surface mass balance models with the help of machine learning.
- This would improve the models' prediction of ice melt and subsequent sea level rise.

# THANK YOU

For queries, please reach out to [dvarshney@umbc.edu](mailto:dvarshney@umbc.edu)



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