

# Machine Learning for Snow Stratigraphy Classification

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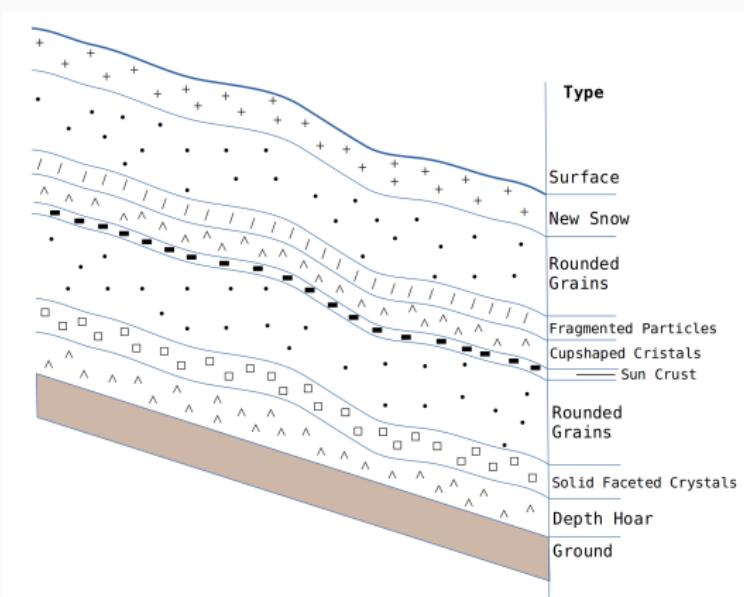
# Introduction and Motivation

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# Task Description

## Task: Snow Grain Classification and Snow Layer Segmentation

- Given a pack of snow, **automatically**:
- Segment it into different snow layers and
- Classify the snow grain type of each snow layer



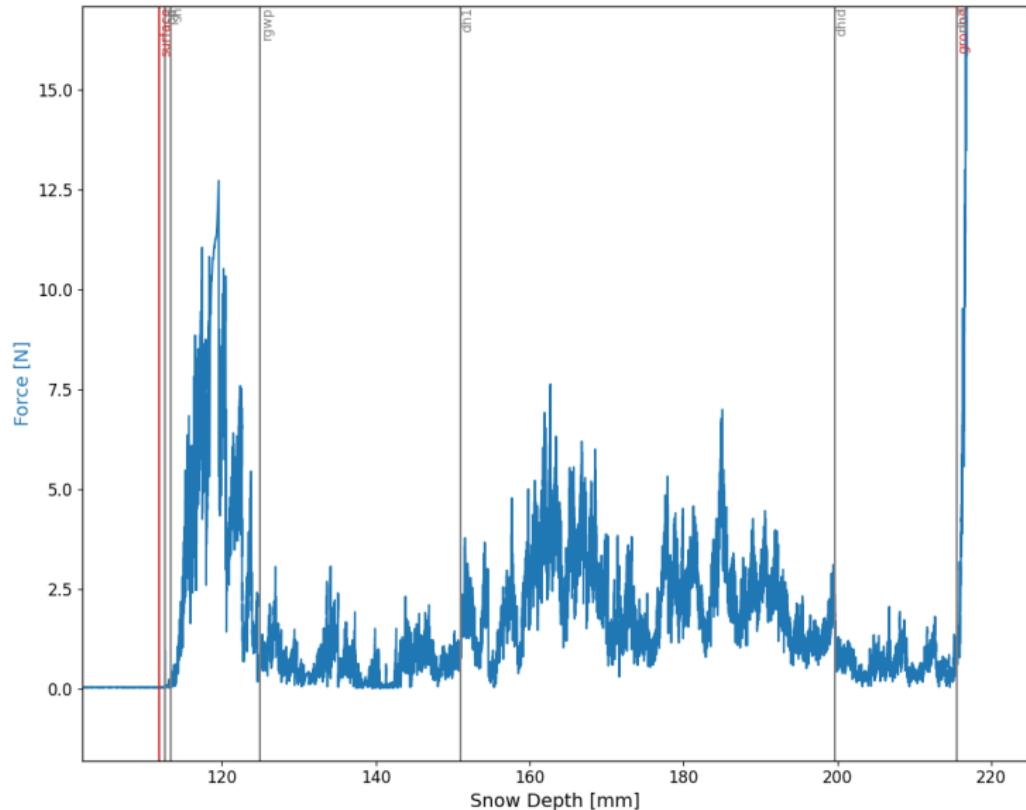
# Snow Micro Pen (SMP)

Fast, high-resolution, portable measuring device



[SLF, 2021] Snow Micro Pen

# SMP Profile Example: Manual Labelling



# Motivation

## Why automatic?

- Classify **large SMP datasets** (e.g. MOSAiC dataset)
- **Fast** analysis (e.g. avalanche prediction)
- **No human training** required (e.g. in remote sensing)

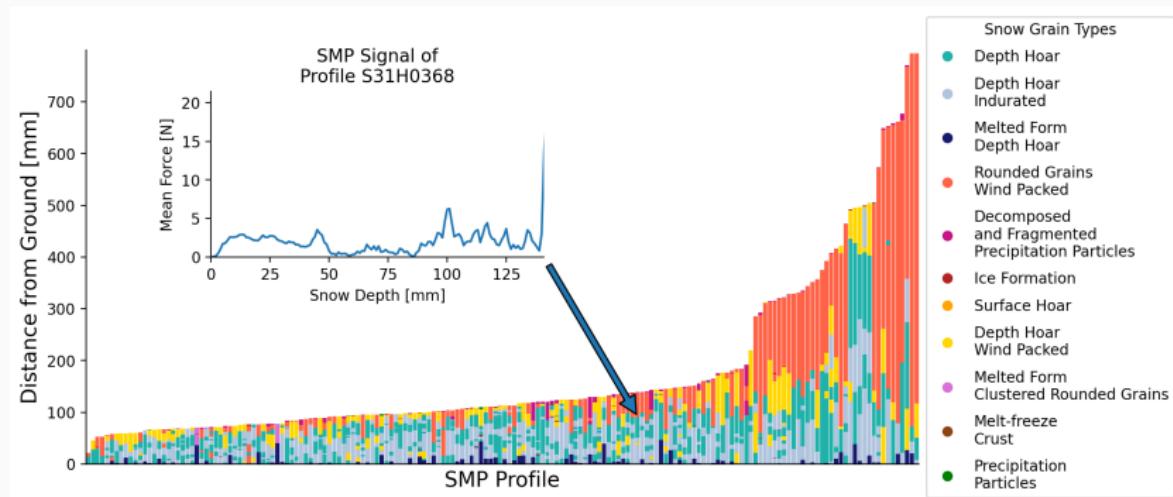
# Data

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# Labelled MOSAiC SMP dataset

MOSAiC [Shupe et al., 2020] SMP dataset:

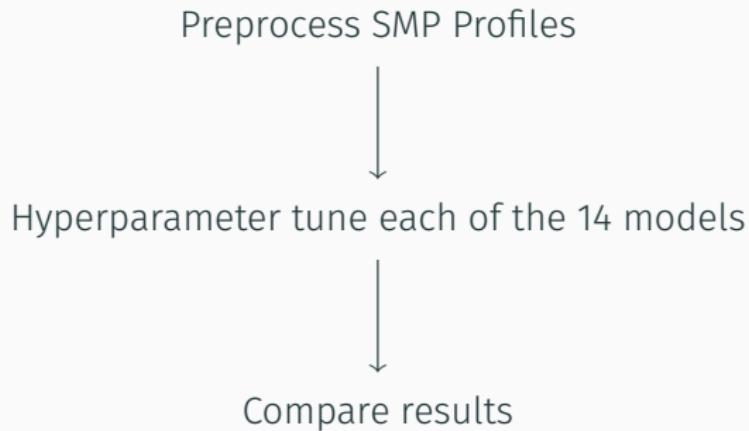
- Snow on arctic sea ice
- 160 / 3680 profiles are labelled



## Methods

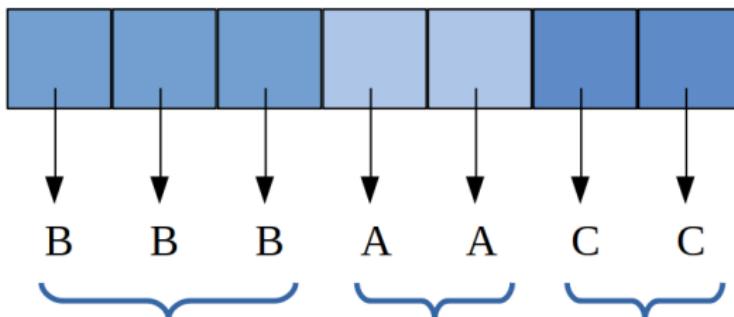
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# Framework



# Classification and Segmentation

*First classify, then segment*



**1. Classification**

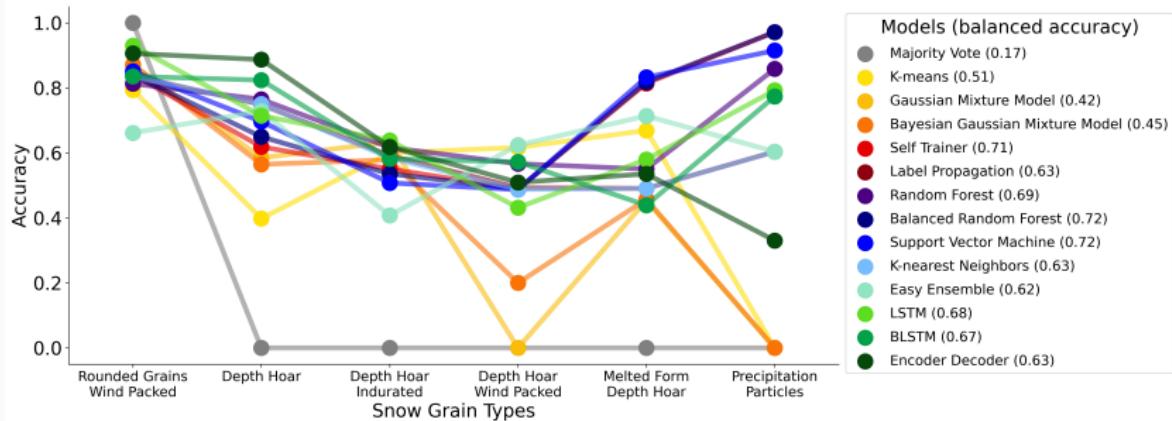


**2. Segmentation**

## Results and Discussion

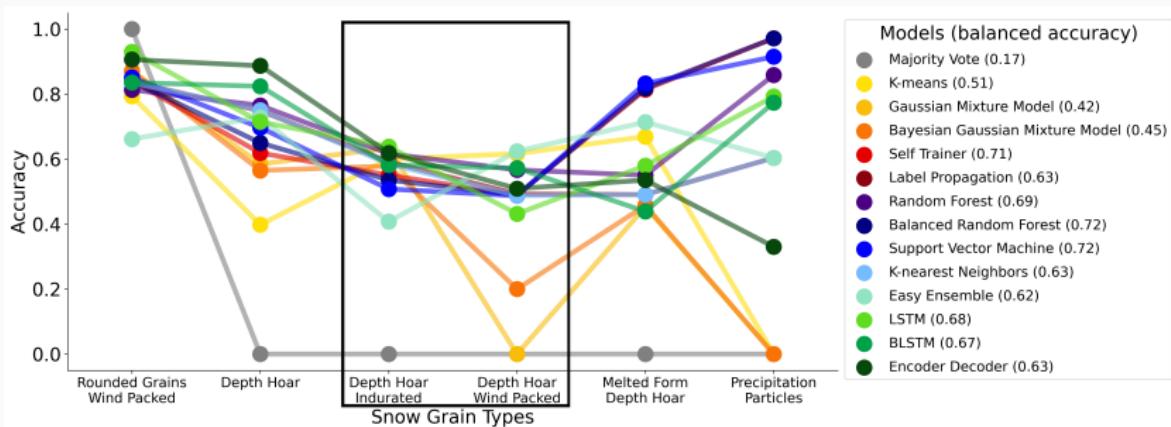
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# Results - Accuracy

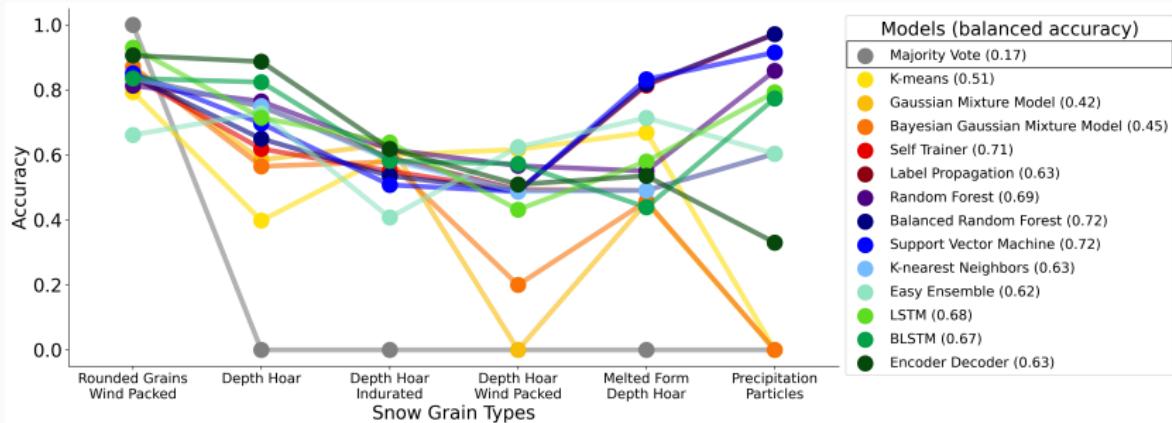


# Results - Accuracy

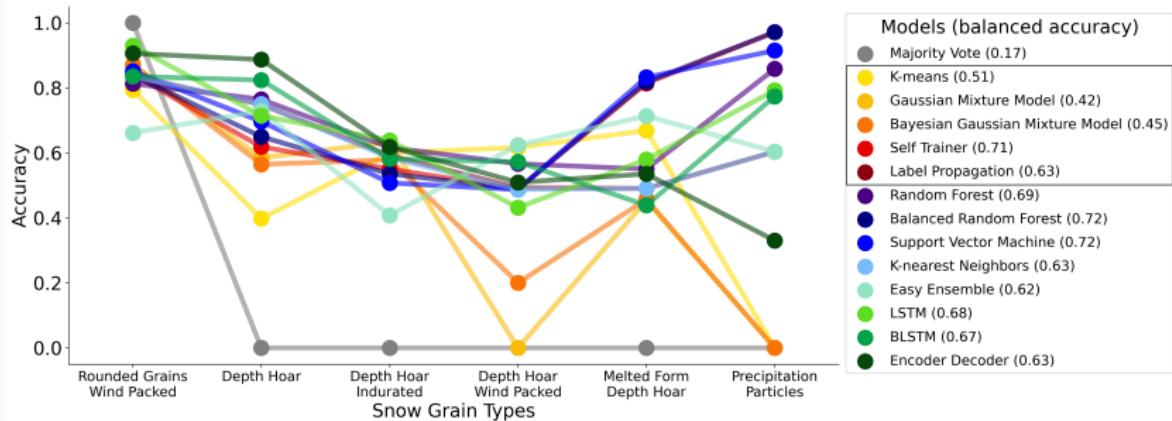
Some grain types are more difficult to classify than others



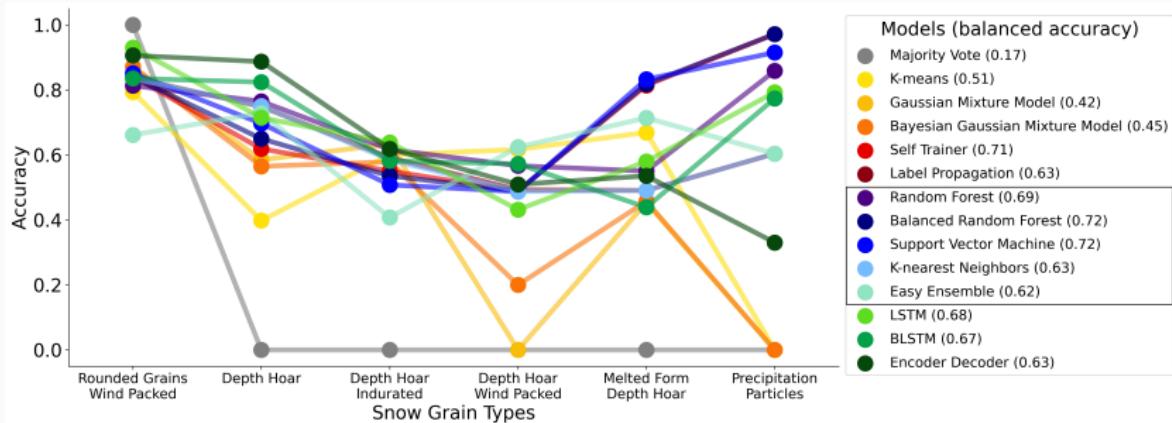
# Results - Accuracy



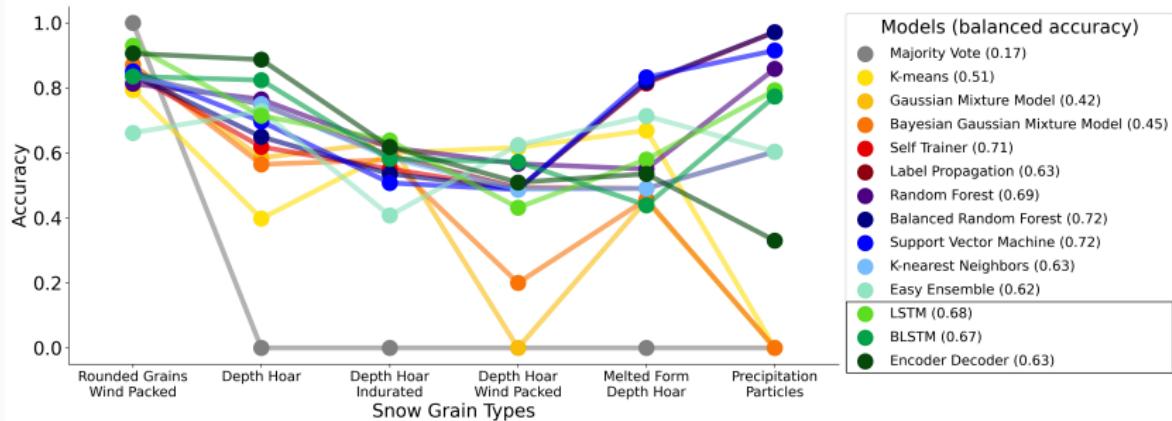
# Results - Accuracy



# Results - Accuracy



# Results - Accuracy



# Performance in Metrics

Model	Absolute Accuracy	Balanced Accuracy	Precision	F1 Score	ROC AUC	Log Loss	Fitting Time	Scoring Time
Majority Vote	0.39	0.14	0.15	0.22	nan	nan	< 1	$< 10^{-3}$
K-means	0.62	0.44	0.60	0.61	nan	nan	385	0.01
GMM	0.65	0.36	0.57	0.61	nan	nan	151	<u>0.008</u>
BGMM	0.65	0.38	0.63	0.63	nan	nan	225	0.009
Self trainer	0.69	0.67	0.74	0.71	0.92	0.84	19	0.29
Label propagation	0.71	0.54	0.72	0.71	0.92	1.5	10	3.35
Random Forest	0.73	0.60	0.73	0.73	0.93	0.70	72	0.97
Balanced RF	0.70	<b>0.67</b>	0.74	0.71	0.92	0.84	9.9	0.58
SVM	0.71	0.66	0.73	0.71	0.93	0.67	19	7.45
KNN	0.71	0.54	0.71	0.71	0.89	3.58	<u>≤ 1</u>	1.84
Easy Ensemble	0.62	0.59	0.70	0.64	0.88	1.66	46	42.5
LSTM	0.75	0.58	0.75	0.75	0.94	<b>0.63</b>	349	2.3
BLSTM	0.74	0.58	0.74	0.73	0.93	0.79	975	3.4
Encoder Decoder	<b>0.78</b>	0.54	<b>0.78</b>	<b>0.77</b>	0.94	0.64	2911	5.8

## Conclusion

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## Summary:

*First systematic comparison between ML models for the segmentation and classification of SMP profiles*

## Future Work:

Test generalization capabilities (e.g. on different seasons)

## Impact:

Makes knowledge behind cryospheric data accessible

→ Essential for understanding and mitigating climate change impacts

Thank you for your attention!

## Contact and Resources

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Please drop me a line if you have any questions:

*julia.kaltenborn@mail.mcgill.ca*

GitHub Repository:

*<https://github.com/liellnima/snowdragon>*

## References i

-  Shupe, M. D., Rex, M., Dethloff, K., Damm, E., Fong, A., Gradinger, R., Heuzé, C., Loose, B., Makarov, A., Maslowski, W., et al. (2020). Arctic report card 2020: The mosaic expedition: A year drifting with the arctic sea ice.
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