

# Machine Learning for Snow Stratigraphy Classification

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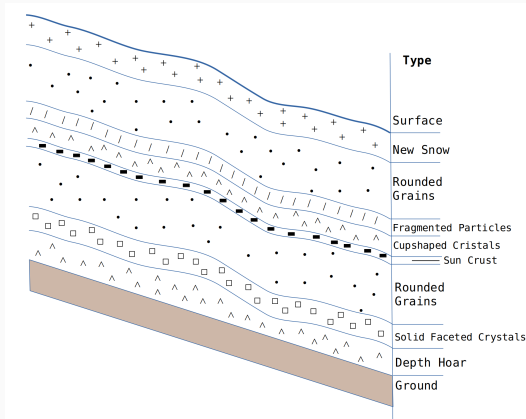
# Introduction and Motivation

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# Task Description

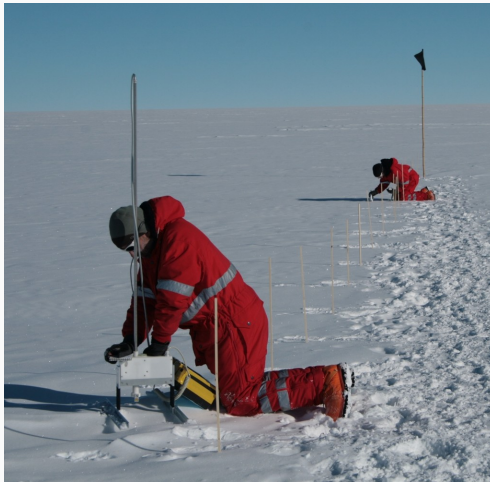
## Task: Snow Grain Classification and Snow Layer Segmentation

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



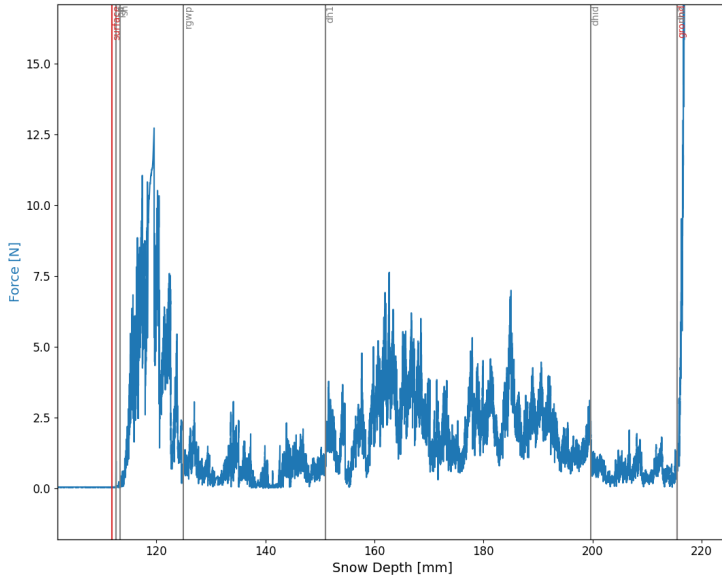
# Snow Micro Pen (SMP)

Fast, high-resolution, portable measuring device



[SLF, 2021] *Snow Micro Pen*

# SMP Profile Example: Manual Labelling



## 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)

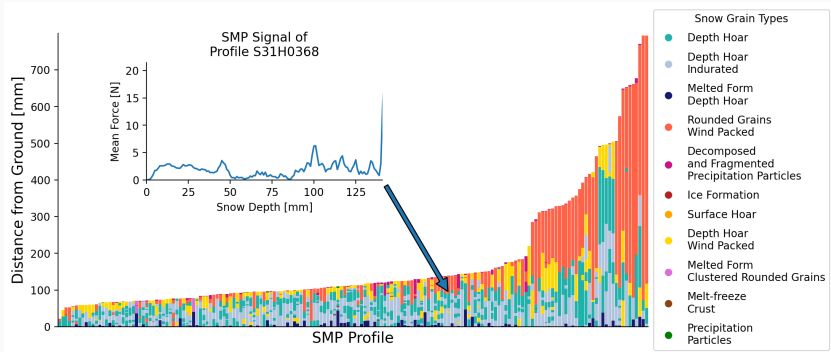
# Data

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# Labelled MOSAiC SMP dataset

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

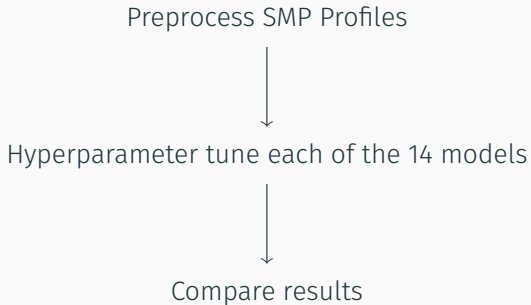
- Snow on arctic sea ice
- 160 / 3680 profiles are labelled





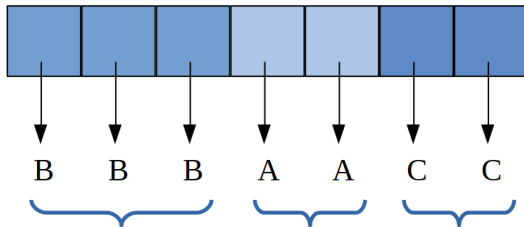
## Methods

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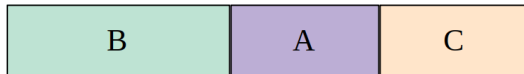


# Classification and Segmentation

*First classify, then segment*



**1. Classification**

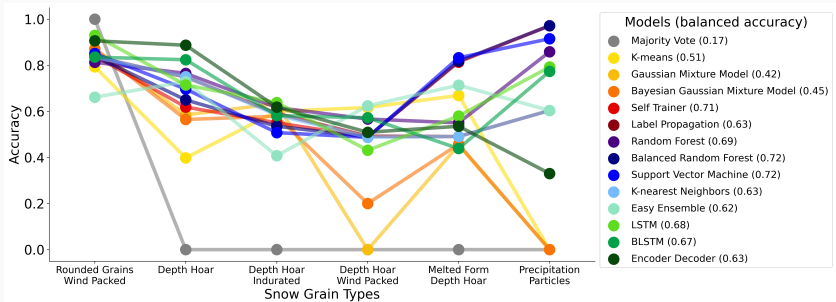


**2. Segmentation**

## Results and Discussion

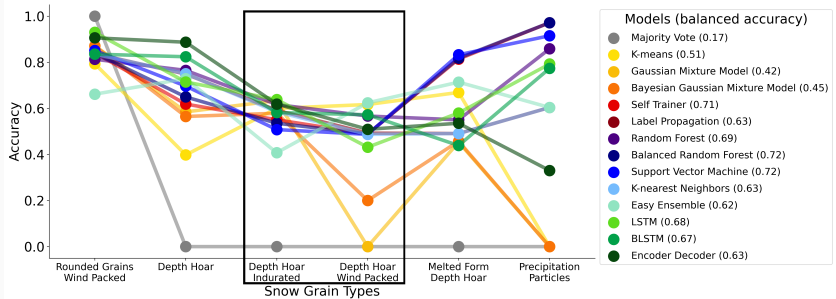
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# Results - Accuracy

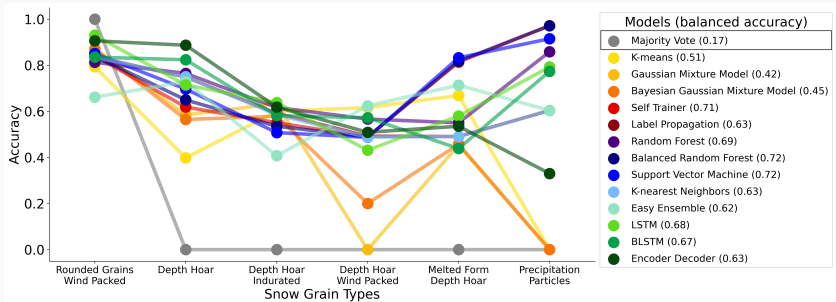


# Results - Accuracy

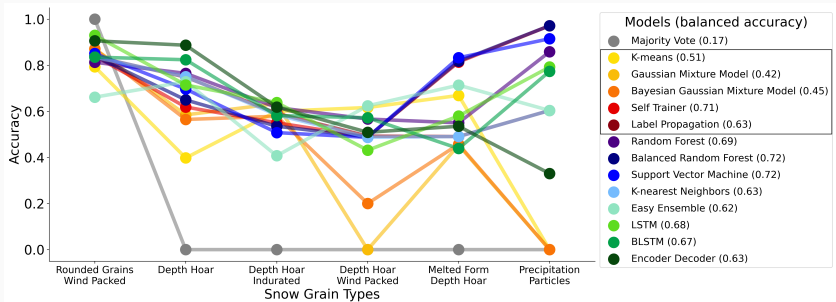
Some grain types are more difficult to classify than others



# Results - Accuracy

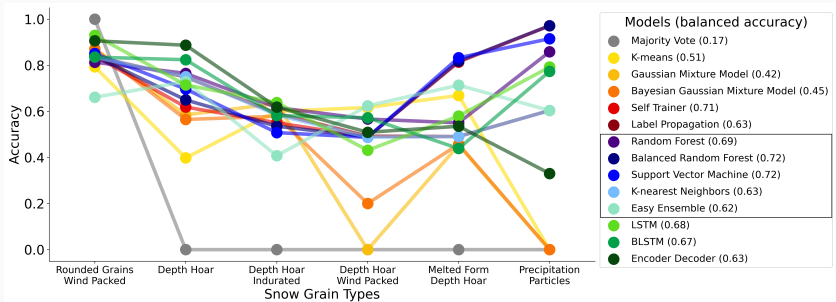


# Results - Accuracy

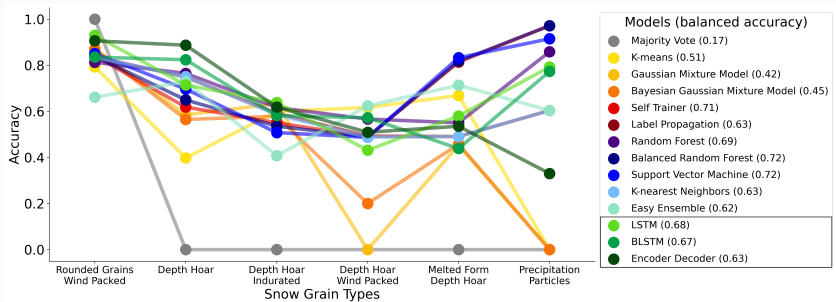




# Results - Accuracy



# 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 <sup>-3</sup>
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	<u>0.71</u>	0.54	0.72	<u>0.71</u>	0.92	1.5	<u>10</u>	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>	<u>0.74</u>	0.71	0.92	0.84	9.9	0.58
SVM	0.71	0.66	0.73	0.71	<u>0.93</u>	<u>0.67</u>	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	<u>0.75</u>	0.58	<u>0.75</u>	<u>0.75</u>	<b>0.94</b>	<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>	<u>0.94</u>	<u>0.64</u>	2911	5.8

## Conclusion

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# Conclusion

## 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!

Please drop me a line if you have any questions:

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GitHub Repository:

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

-  Shupe, M. D., Rex, M., Dethloff, K., Damm, E., Fong, A., Gradinger, R., Heuzé, C., Loose, B., Makarov, A., Maslowski, W., et al. (2020).  
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-  SLF, W. (2021).  
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<https://www.slf.ch/de/ueber-das-slf/versuchsanlagen-und-labors/kaeltelabor/snowmicropenr.html>.  
accessed: 2021-01-27.