# Glacier Facies Classification using SAR –Backscatter and Glacier Velocity Mapping of Pine Island Glacier.


Supervisor

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Submitted by

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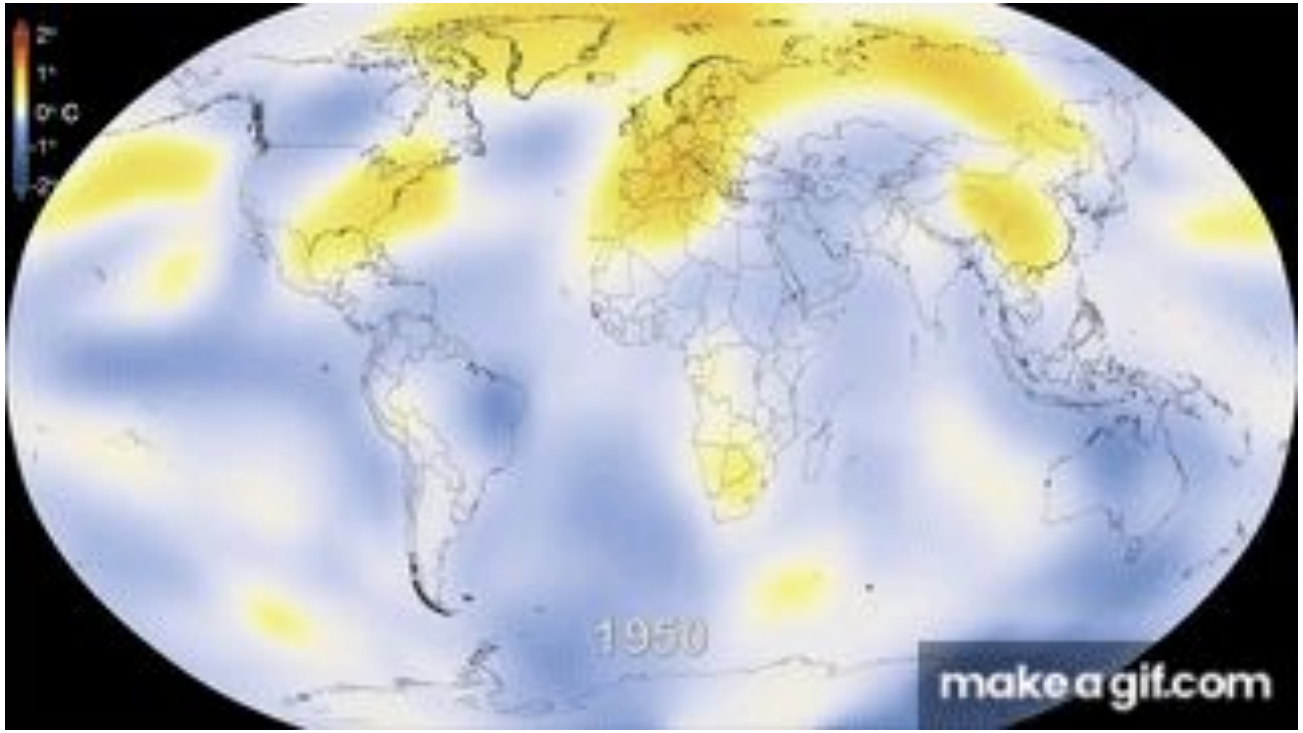
IIRS2021021511761

# BACKGROUND



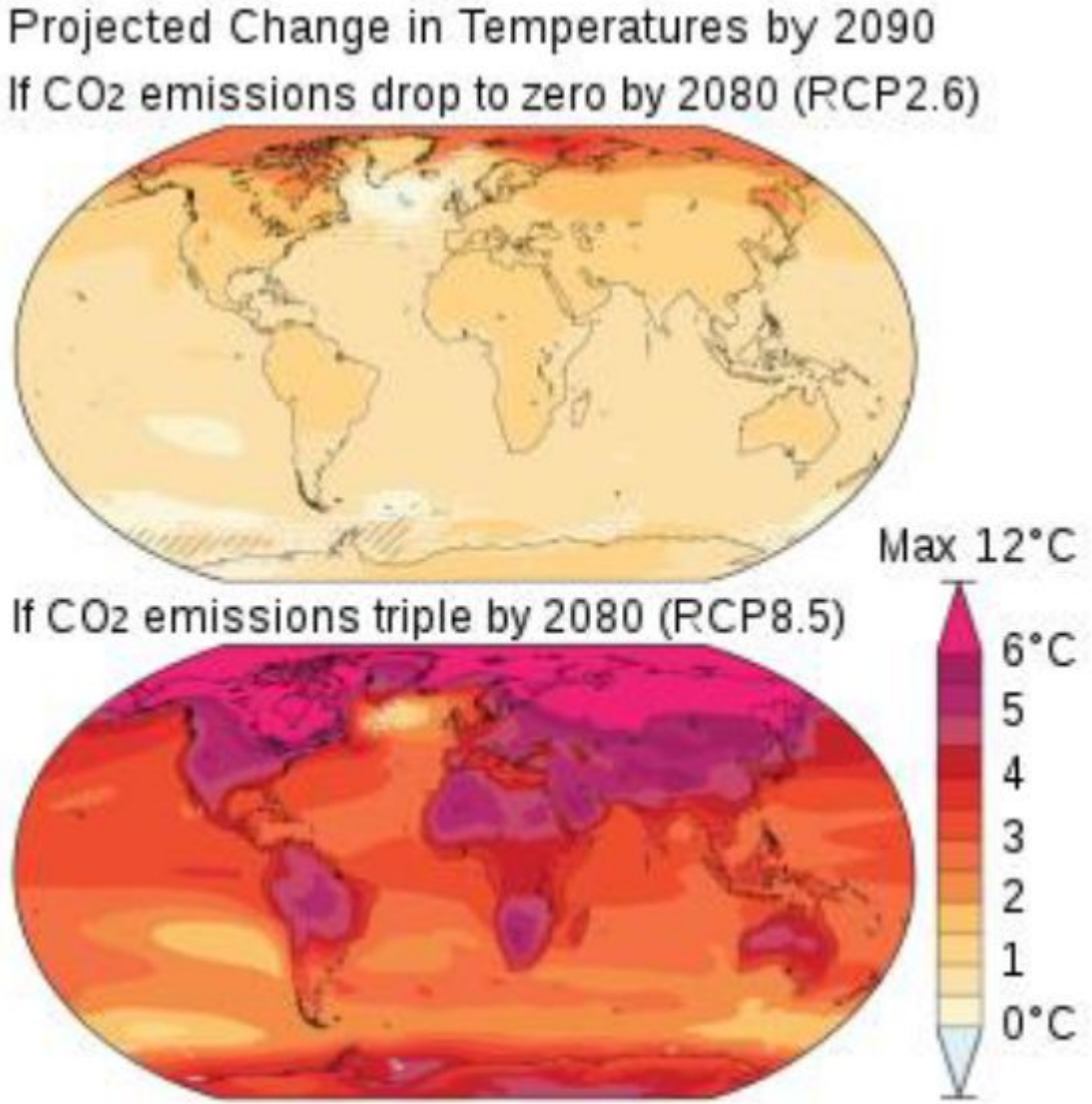

GHG CONCENTRATIONS

RISING TEMPERATURE

EXTREME WEATHER

GLACIER RETREAT

SEA-LEVEL RISE



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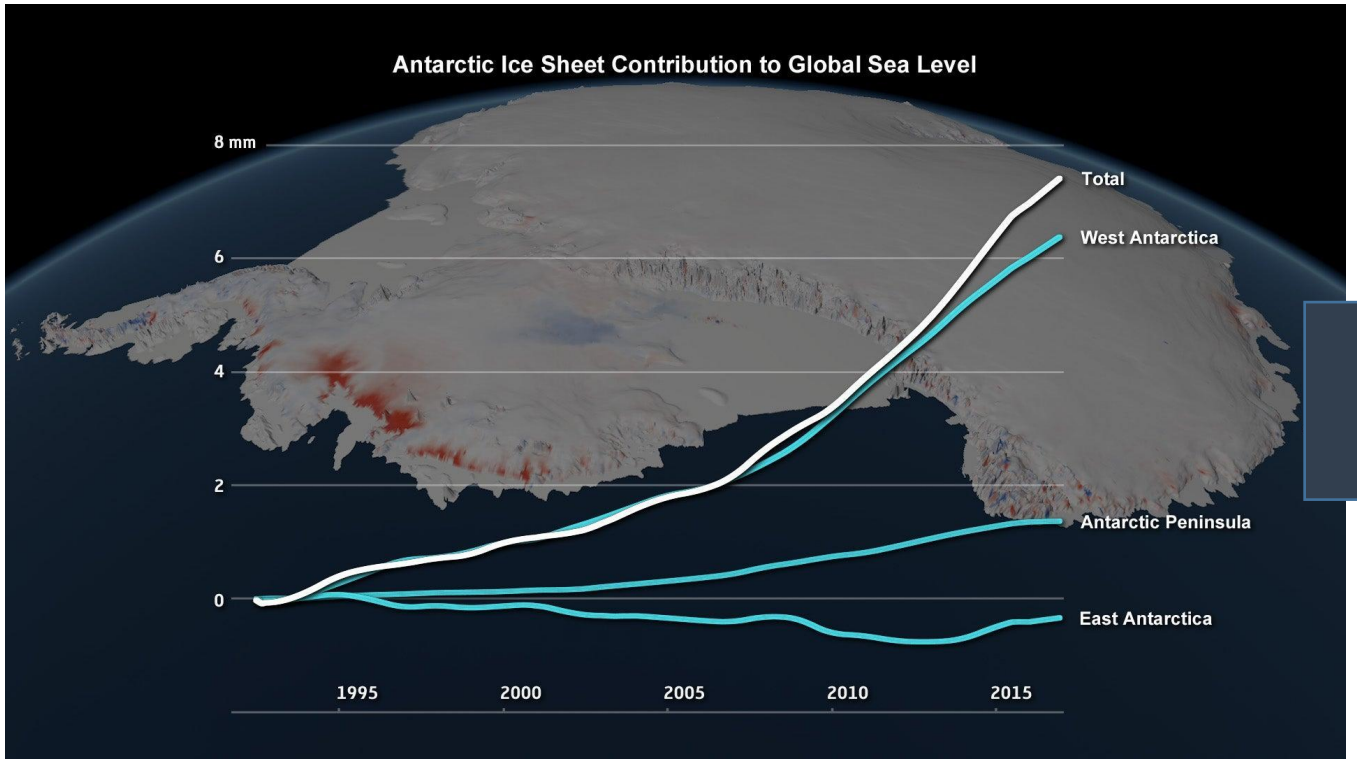



MORE HEAT IS TRAPPED

LOSS OF HIGH SURFACE REFLECTANCE

MORE MELT- OFF

Source - Antarctic Melt Rate Has Tripled in the Last 25 Years - Scientific American

# OBJECTIVE – RESEARCH QUESTION

**Research Objective:**

- To classify different zones of glacier using SAR backscatter seasonal analysis.
- To do a temporal study of glaciers velocity.

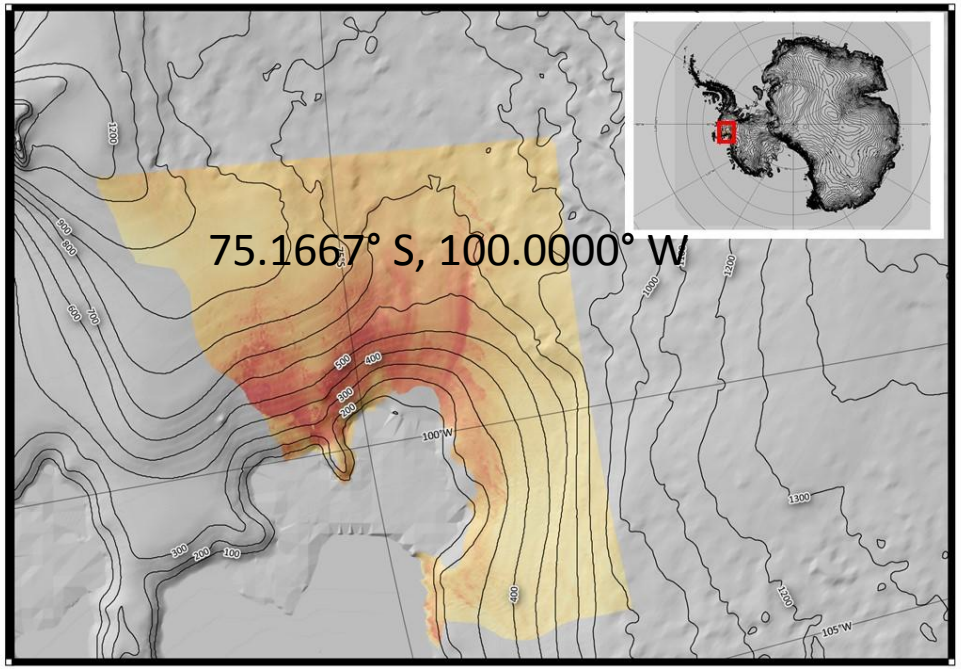
**Sub objectives:**

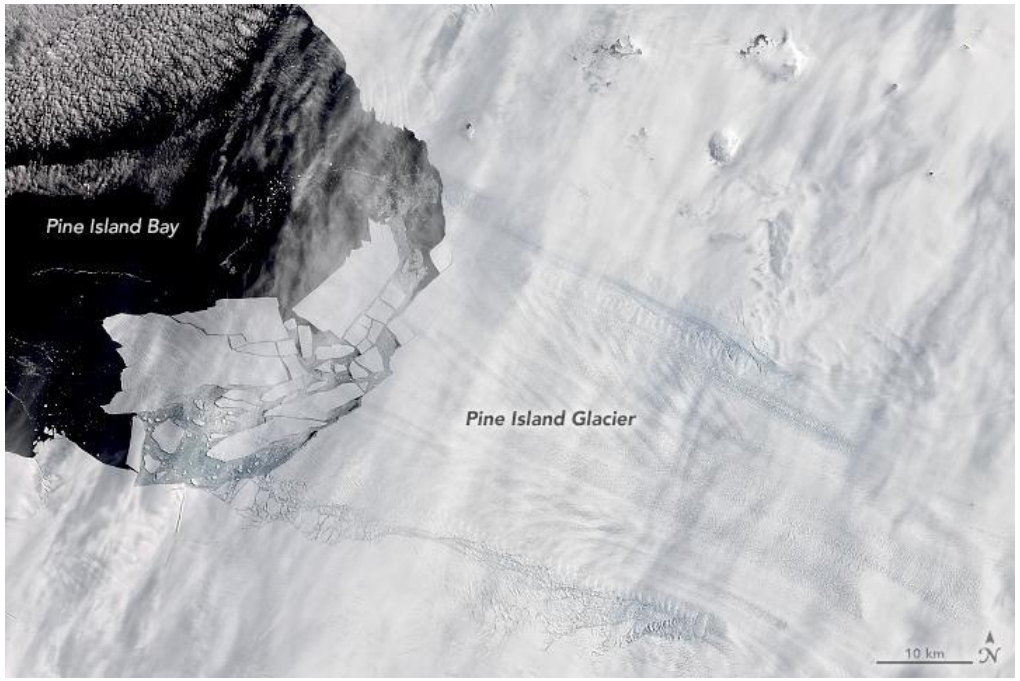
- Map Radar Glacier Zones (RGZ), using random forest classifier.
- To plot  and do an inferential study of pine glacier's velocity.

**Research Question:**

- How useful is Synthetic Aperture Radar in identifying and mapping glacier facies?
- What is the accuracy of Random Forest classifier?
- How has the glacier velocity changed over the year?

# STUDY AREA




LARGEST ICE STREAM 175,000 $km^2$

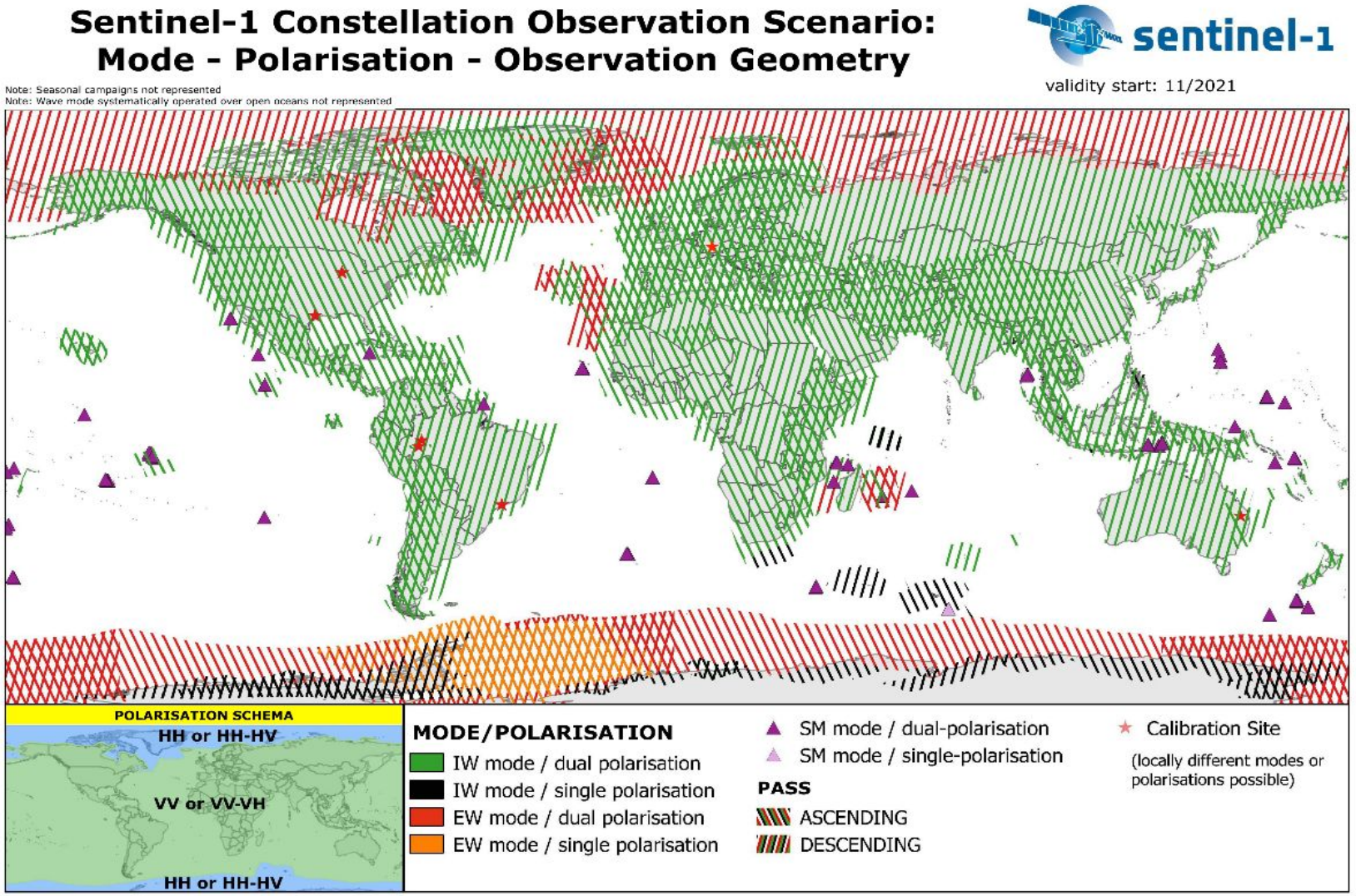
+10 °C to −40 °C (Coastal) ; −30 °C to −80 °C (High Altitude)

SUMMERS – OCTOBER to MARCH

WINTERS – MARCH to OCTOBER

# DATA-SET

- Sentinel -1
- C-BAND - 5.405GHz
- 10 Meter Resolution
- IW - 250 km Swath width
- HH - Polarization
- DESCENDING PASS



# SOFTWARES - TOOLS

Sentinel -1 SAR GRD Data

Image Pre-processing
(Orbital Corrections, Radiometric Calibration)

Terrain Correction
DEM

Geometric Correction
Convert Intensity to dB

GOOGLE EARTH ENGINE GRD – Level 1 DATA

Refined Lee Speckle Filtering

RGB Composite
Red Band : Transition
Green Band : Summer
Blue Band : Winter

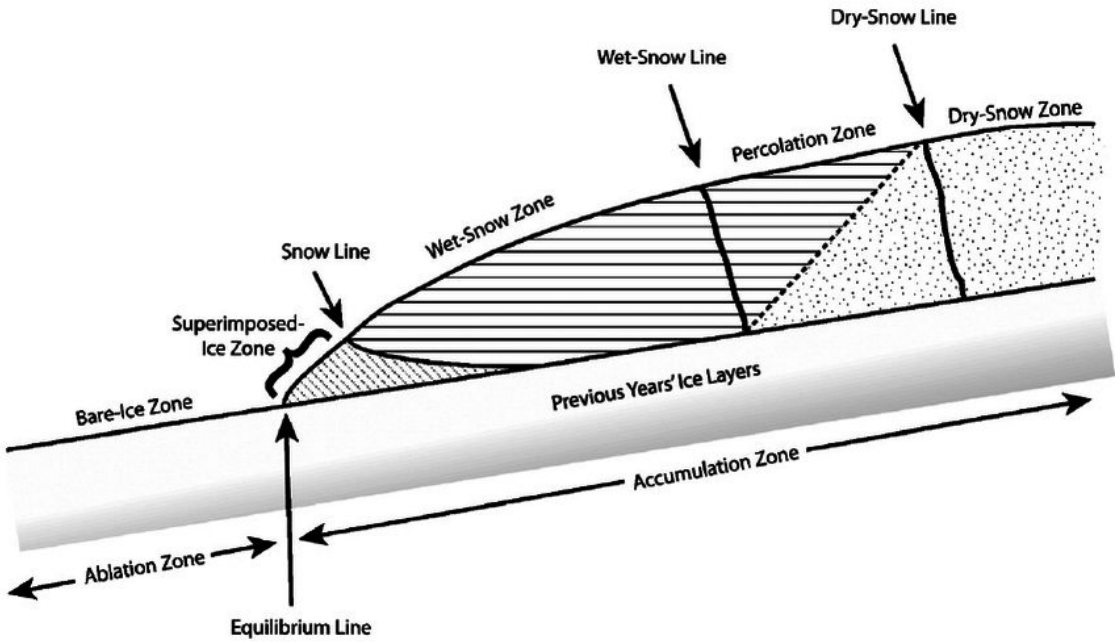
Supervised Classification

Glacier Radar Zones

# GOOGLE – EARTH ENGINE Sentinel – 1 Level 1 GRD DATA

- Orbital corrections - Updates orbit metadata with a restituted orbit file (or a precise orbit file if the restituted one is not available).
- GRD border noise removal - Removes low intensity noise and invalid data on scene edges. (As of January 12, 2018)
- Thermal noise removal - Removes additive noise in sub-swaths to help reduce discontinuities between sub-swaths for scenes in multi-swath acquisition modes. (This operation cannot be applied to images produced before July 2015)
- Radiometric calibration - Computes backscatter intensity using sensor calibration parameters in the GRD metadata
- Terrain correction (orthorectification) - Converts data from ground range geometry, which does not take terrain into account, to σ° using the SRTM 30 meter DEM or the ASTER DEM for high latitudes (greater than 60° or less than -60°).

# GLACIER RADAR ZONES




DRY ZONE - VOLUME SCATTERING

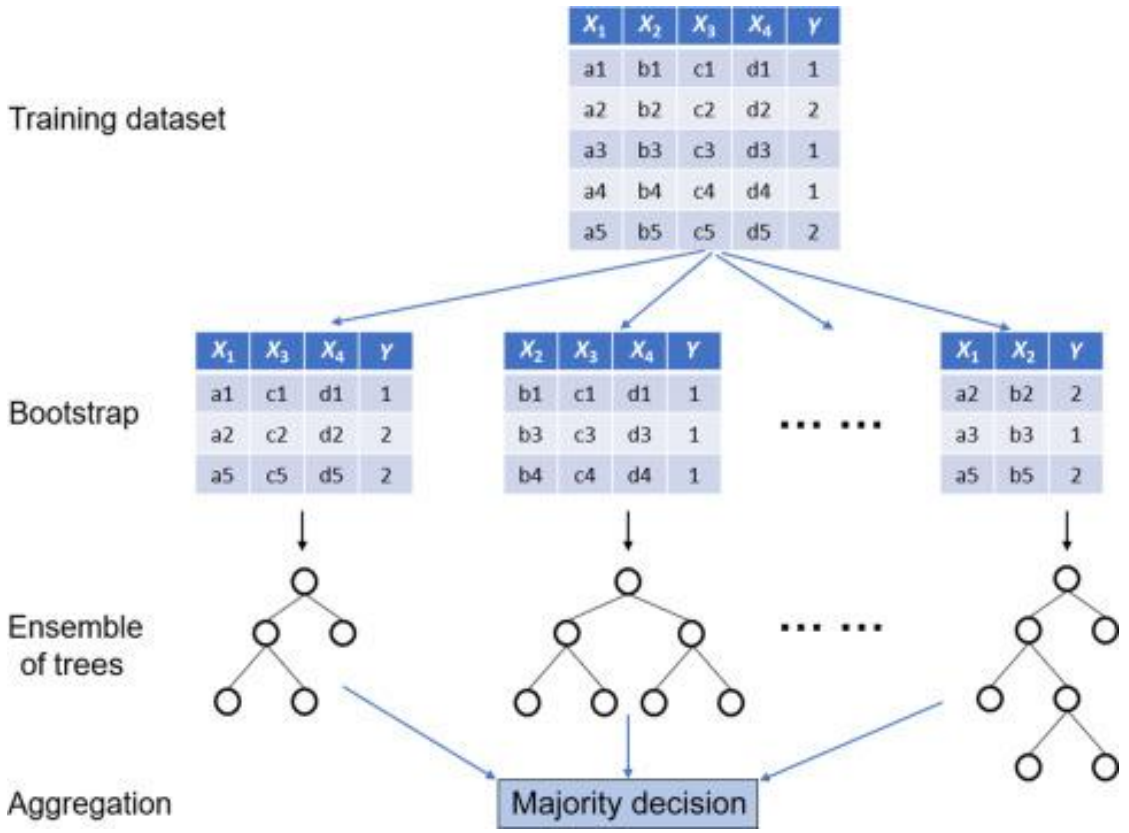
PERCOLATION ZONE – HIGH VALUE OF BACKSCATTER IN WINTER LOW IN SUMMER

WET ZONE – LOW BACKSCATTER

SUPERIMPOSSED - HIGH BACKSCATTER

# RANDOM – FOREST CLASSIFICATION

Ensemble – of Decision Trees
(Many Weak Learners Come to a Strong Decision)




| $X_1$ | $X_2$ | $X_3$ | $X_4$ | $Y$ |
|---|---|---|---|---|
| a1 | b1 | c1 | d1 | 1 |
| a2 | b2 | c2 | d2 | 2 |
| a3 | b3 | c3 | d3 | 1 |
| a4 | b4 | c4 | d4 | 1 |
| a5 | b5 | c5 | d5 | 2 |

| $X_1$ | $X_3$ | $X_4$ | $Y$ |
|---|---|---|---|
| a1 | c1 | d1 | 1 |
| a2 | c2 | d2 | 2 |
| a5 | c5 | d5 | 2 |

| $X_2$ | $X_3$ | $X_4$ | $Y$ |
|---|---|---|---|
| b1 | c1 | d1 | 1 |
| b3 | c3 | d3 | 1 |
| b4 | c4 | d4 | 1 |

| $X_1$ | $X_2$ | $Y$ |
|---|---|---|
| a2 | b2 | 2 |
| a3 | b3 | 1 |
| a5 | b5 | 2 |

Training Samples are collected

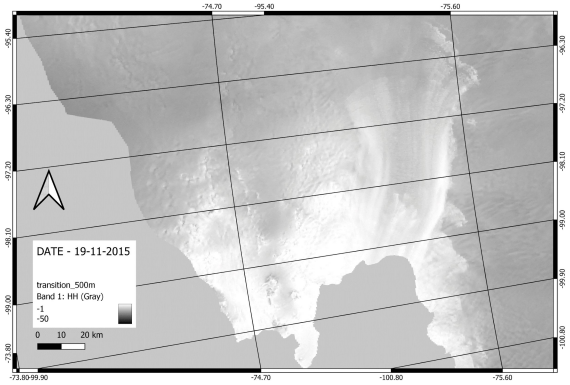
Bagging – Random Sampling with replacement

Random feature selection – To Split in child nodes

Predicts the class label for a given data point through the majority vote of all individual trees (RF regression often uses the mean of the values

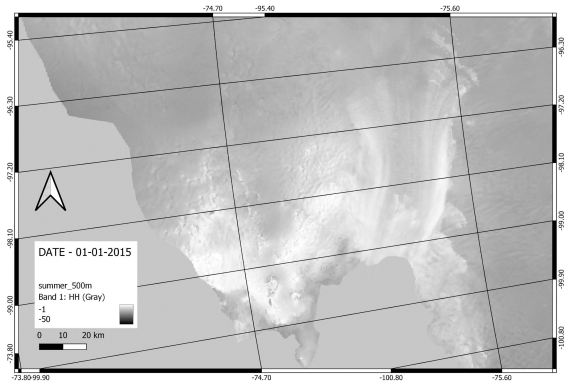
# RESULTS

19-11-15



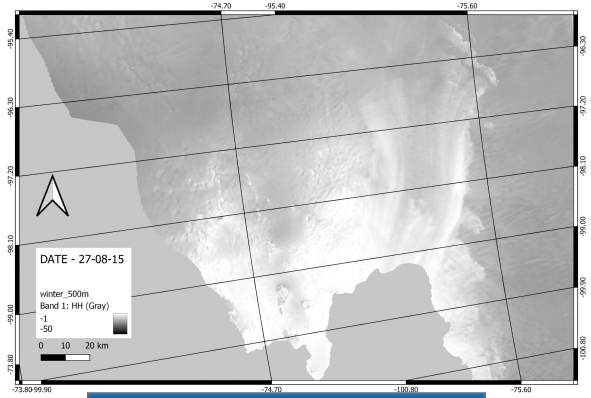

TRANSITION

1-1-15

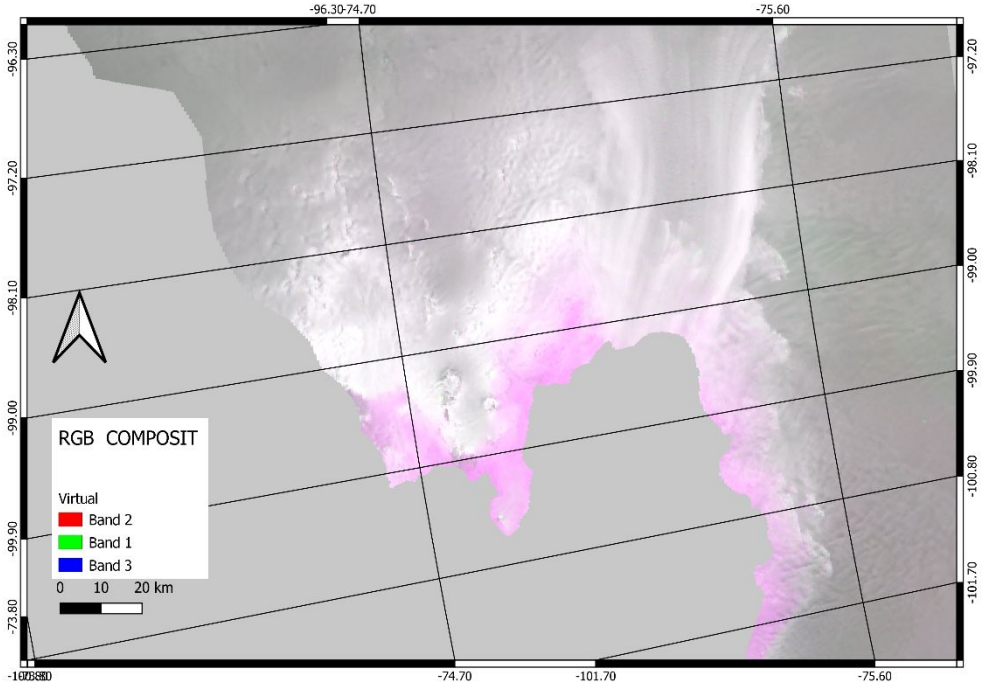



SUMMER

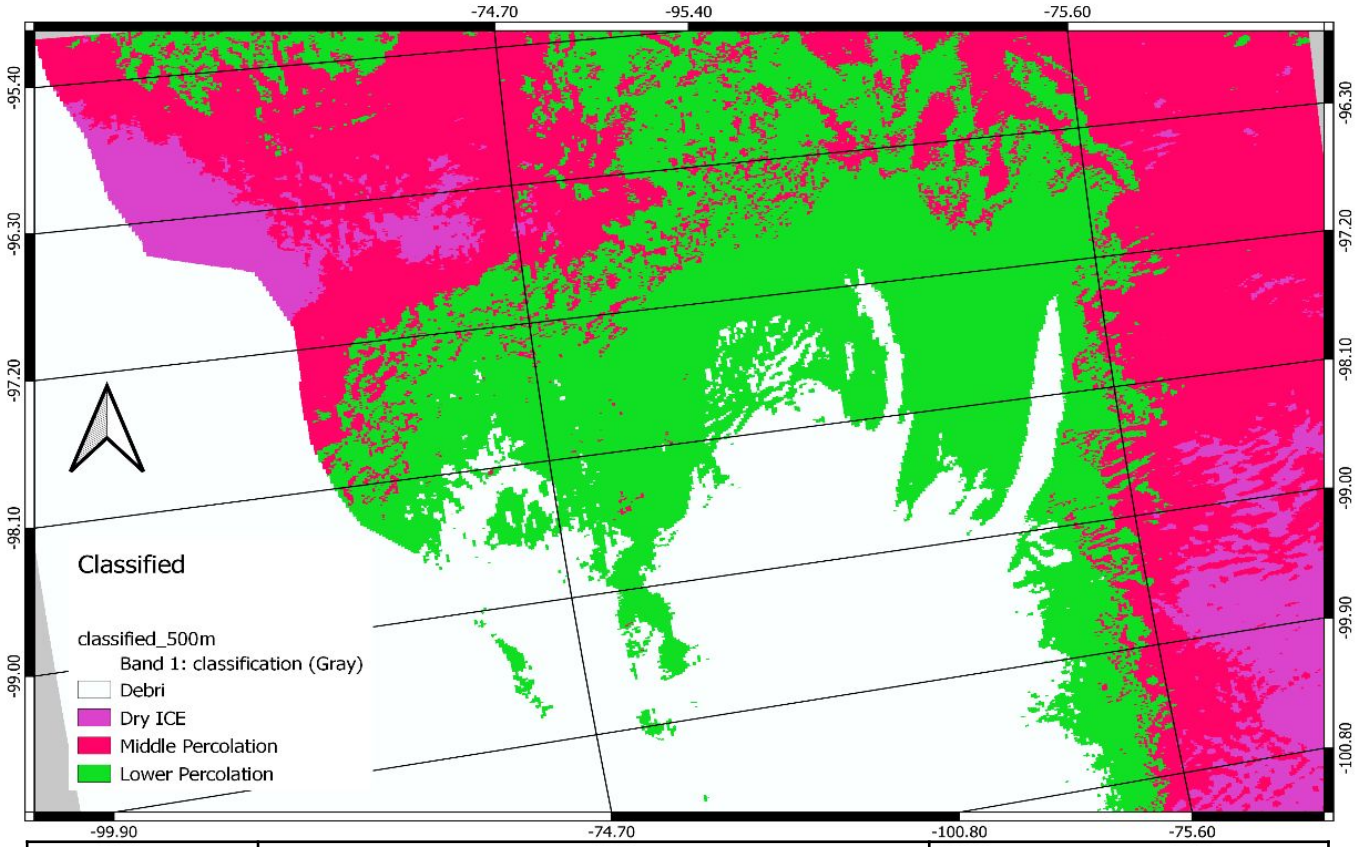
27-08-15




WINTER



# RESULTS




| | | |
|---|---|---|
| **Class 0** | **Debris** | |
| **Class 1** | **Dry ICE** | |
| **Class 2** | **Middle Percolation** | |
| **Class 3** | **Lower Percolation** | |

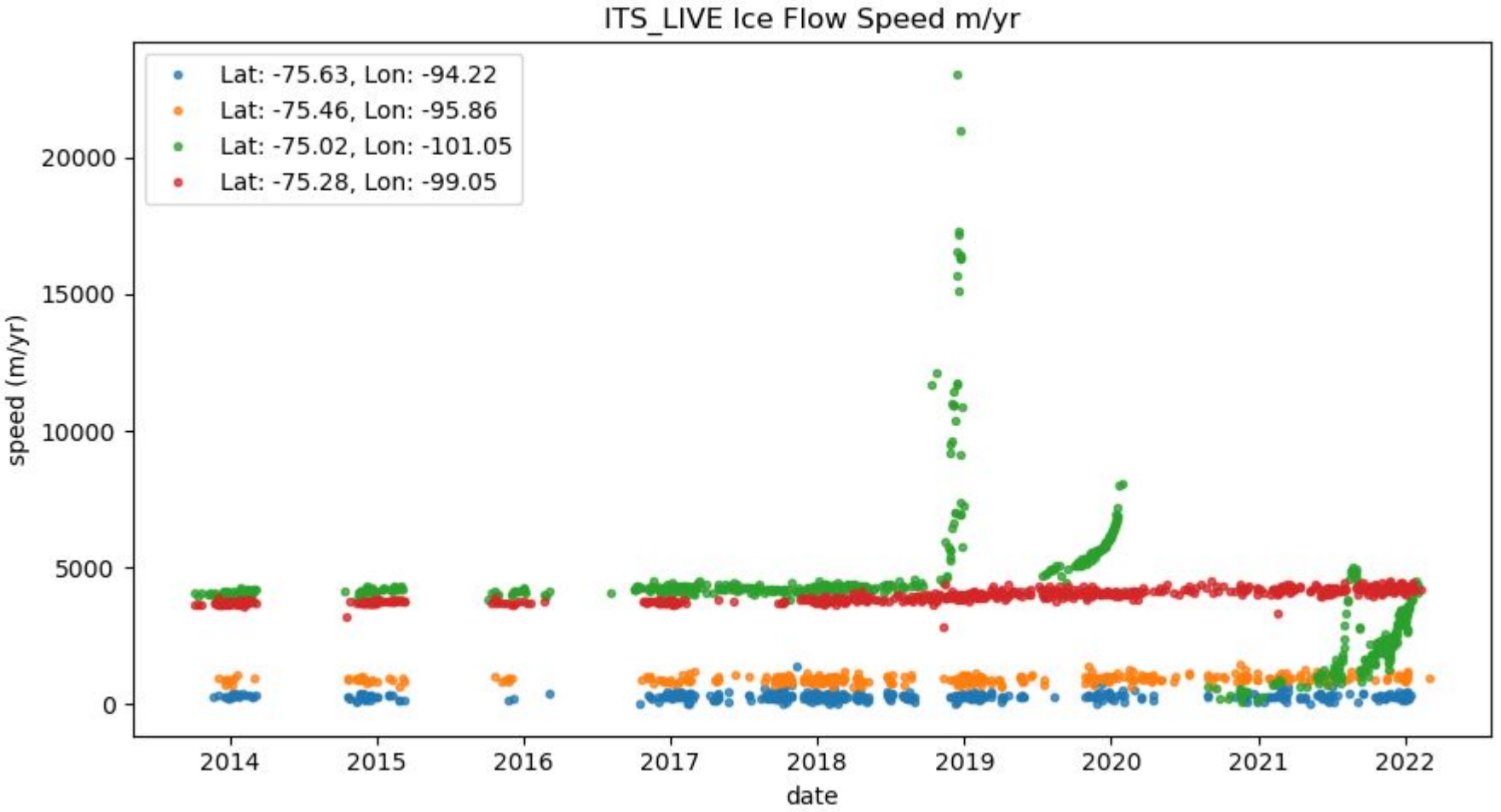
| | | Classification (Prediction) | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | |
| Ground Truth (Actual) | **0** | 5 | 0 | 0 | 0 | **1** |
| | **1** | 0 | 5 | 1 | 0 | **0.83** |
| | **2** | 0 | 0 | 3 | 0 | **1** |
| | **3** | 0 | 0 | 1 | 1 | **0.5** |
| | | **1** | **1** | **0.6** | **1** | **0.87** |
| | | Consumer's Accuracy | | | | |

Producer's Accuracy

**OVERALL – ACCURACY : 87%**

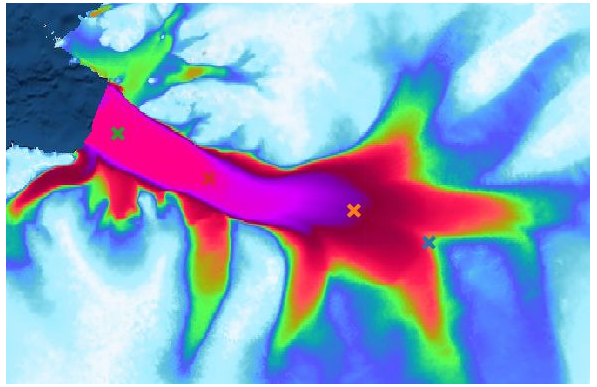
**KAPPA – STATISTICS : 82**

# RESULTS




ITS_LIVE

a NASA MEaSUREs project



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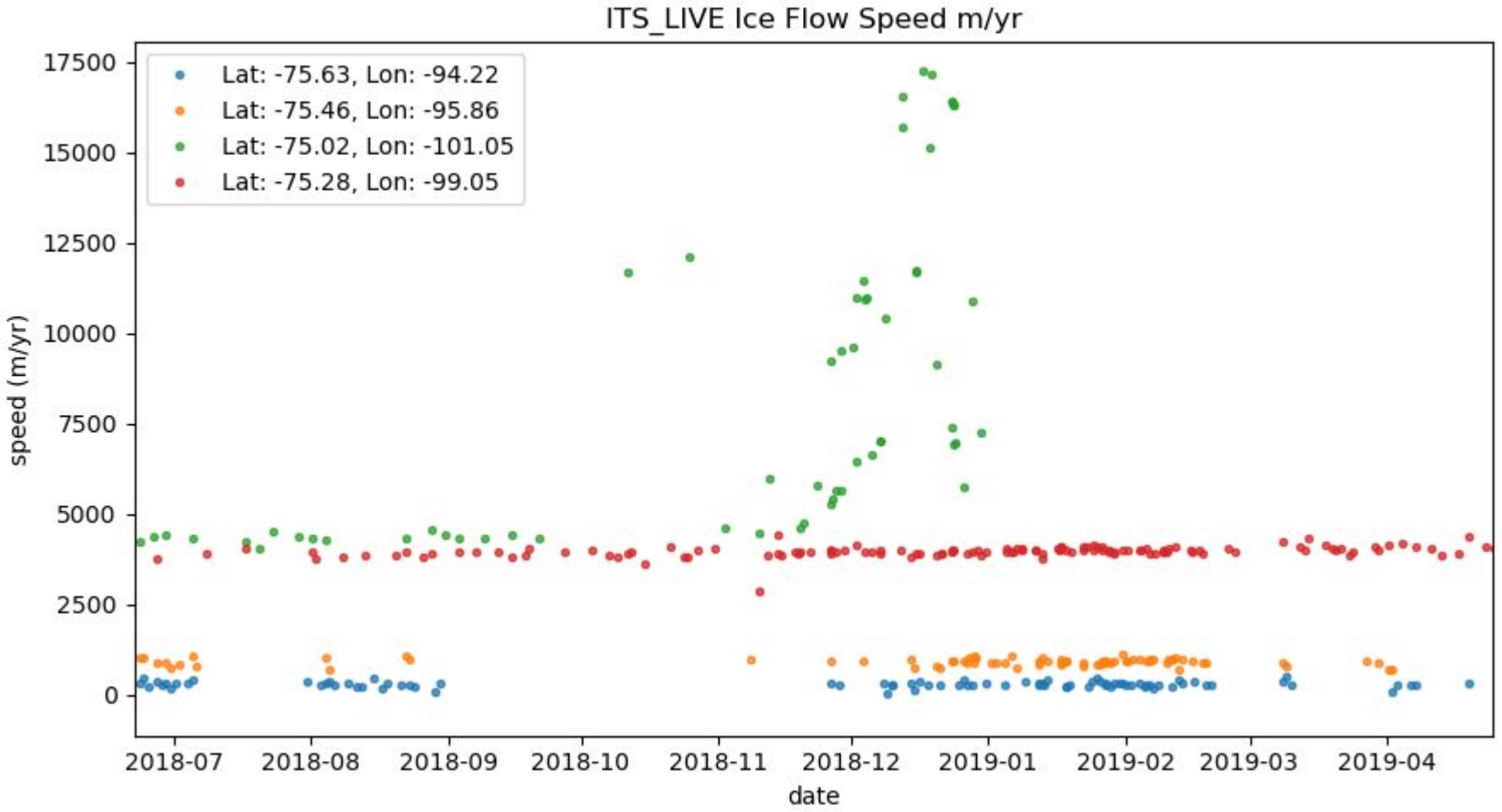


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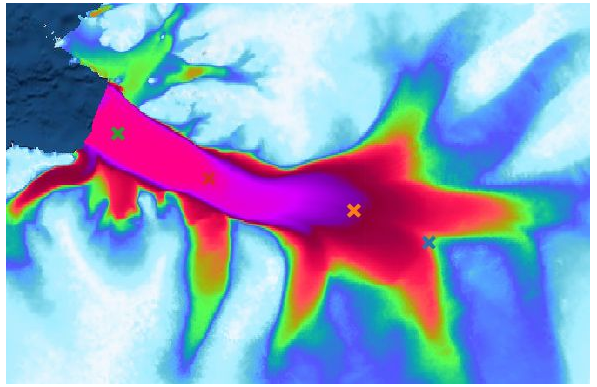

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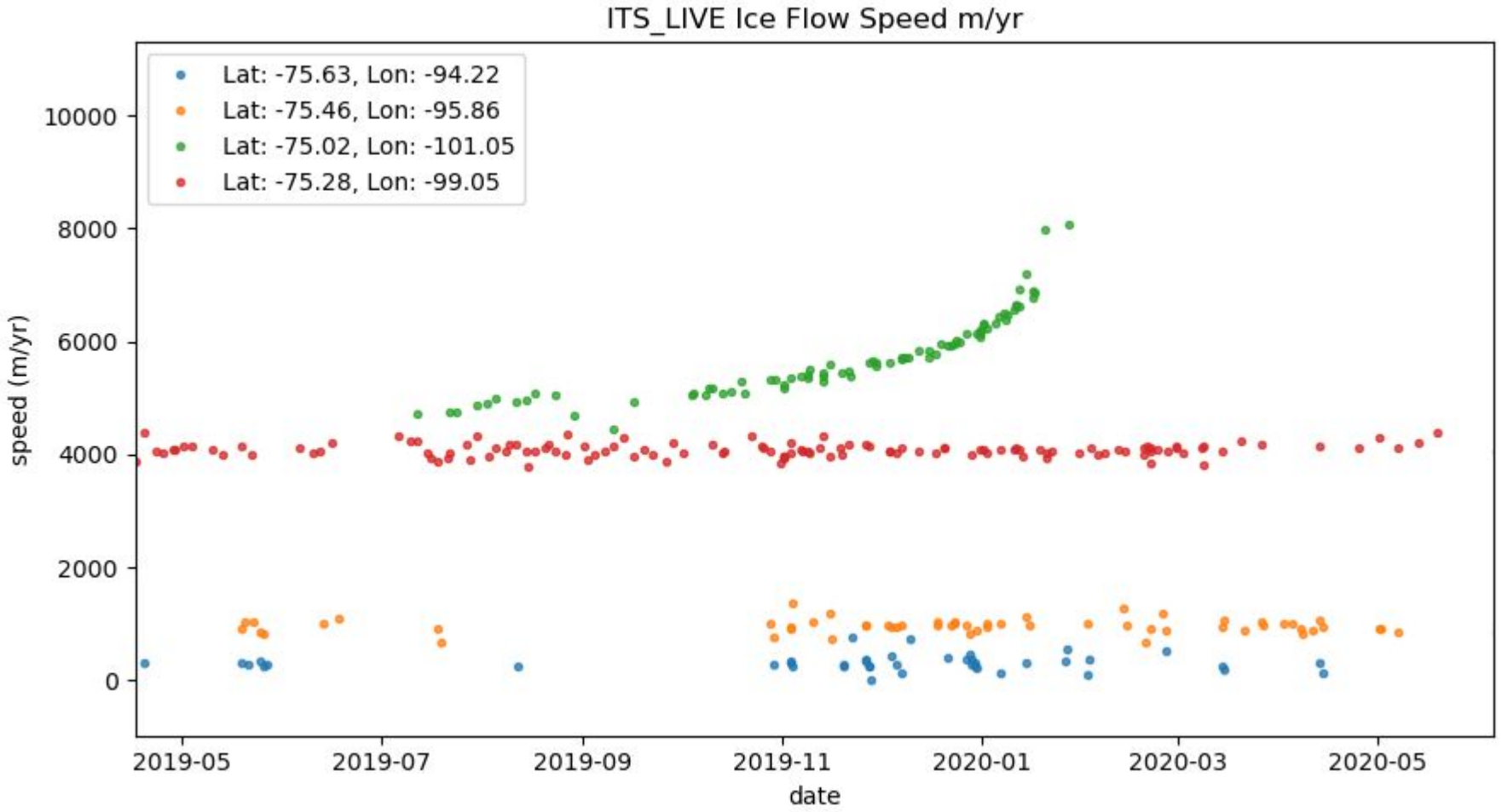


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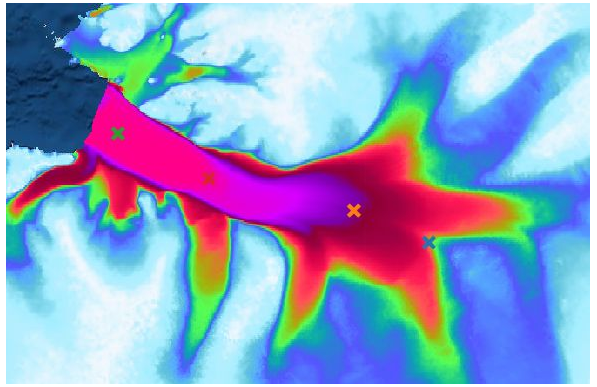

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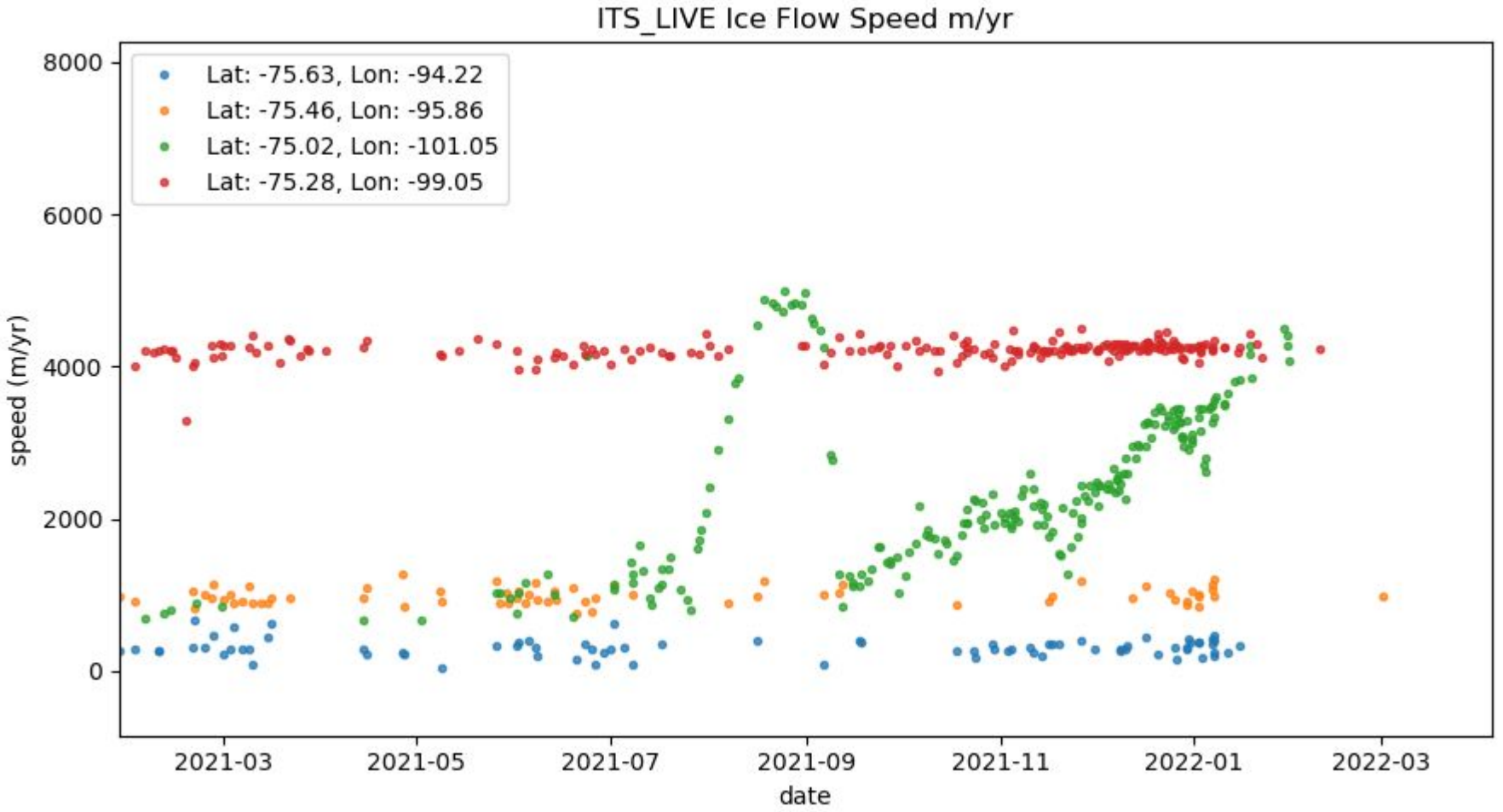


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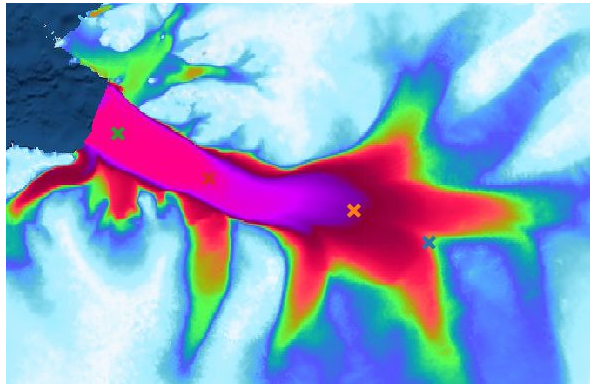

# CONCLUSION

- As the liquid water content of a glacier changes due to season, the glacier surface features would reflect different tonal variations using an RGB composite we can classify Radar Glacier Zones.

- Random Forest classifier has a fairly good accuracy of 87 percent.

- Glacier velocity has remained fairly stable, except in 2018, 2019, 2021 Summer season.

# FUTURE - WORK - SCOPE

- Exploration of other machine learning algorithms to classify RGZ, and for the year 2015-2021
- Random Forest classifier has a fairly good accuracy of 87 percent.
- Deeper analysis of Ice velocity in 2018, 2019, 2021.

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# THANK YOU