GNR 618 Course Project

PERMAFROST AREA MONITORING USING POLSAR

Submitted By:

Karan Chittora (180040050)
Ritvik Sharma (180040083)
Sahil Singh (180040087)
Sumit Suresh Shere (180040108)

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INTRODUCTION

INTRODUCTION

Permafrost is any type of ground frozen continuously for more than two years.

- It extends down beneath earth's surface from few feet to more than a mile.
- Water trapped in sediments, soils, and cracks and pores of rocks freezes and turns to ice when temperature drop below $0^{o}C$.
- If the ground freezes and thaws every year, it is called as seasonally frozen.

INTRODUCTION

PolSARPro & SNAP

PolSARPro:

- Polarimetric SAR Data Processing and Education Toolbox
- Supports the scientific exploitation of polarimetric SAR data
- Specialized in the analysis of fully-polarimetric data (HH, HV, VH, VV)

SNAP:

- Can load SAR data, pre-process it, calibrate it, filter it, terrain correct it, and so on

INTRODUCTION

Unsupervised Classification - K-means Clustering

Unsupervised Classification

- Unsupervised classification helps in identifying and aggregating pixels with similar features.
- it automatically determines what classes exist in the data and how best each pixel can be grouped.

K-means Clustering

- K-Means is a clustering algorithm divides observations into k clusters.

- it can be easily used in a classification where we divide data into clusters that can be equal to or more than the number of classes

INTRODUCTION

Supervised Classification -
Maximum Likelihood Classifier

Supervised Classification

- Supervised image classification is a procedure for identifying spectrally similar areas on an image.
- It requires training data that are typical and homogeneous and the application of a set of methods, or decision rules

Maximum Likelihood Classifier

- Maximum likelihood classification assumes that the statistics for each class in each band are normally distributed
- It calculates the probability that a given pixel belongs to a specific class.

METHODOLOGY

METHODOLOGY

Radiometric Calibration

- For quantitative use of SAR data, it is essential that the data should first be calibrated.
- Calibration radiometrically corrects a SAR image so that the pixel values truly represent the radar backscatter of the reflecting surface.

Polarimetric Processing

- Whenever electromagnetic radiation is reflected from a surface, it becomes polarised to a degree, dependent upon the surface structure
- With Polarimetric Processing, it is possible to reveal a detail about the surface that cannot be obtained by any other imaging technique

METHODOLOGY

Polarimetric Matrix Generation

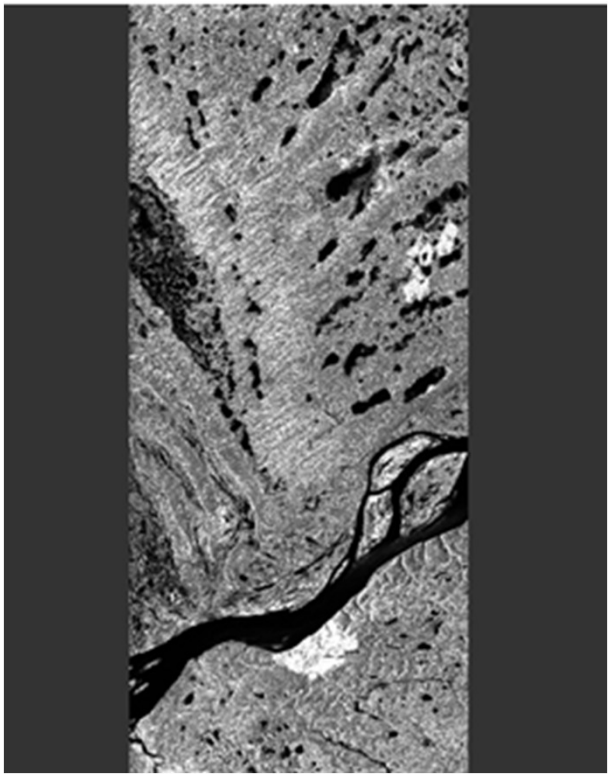
- A radar wave of a specific polarization, when interacts with the target surface, experiences change in its polarization state
- The wave reradiated from the target surface after this interaction will have response not only in horizontal polarization but also in vertical polarization as well
- In terms of SAR polarimetry, these responses from the backscattered wave in each polarization channel are stored in the form of 2 x 2 scattering matrix

$$[S] = \begin{bmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{bmatrix}$$

- The scattering matrix describes the information of the pure target exhibiting a particular scattering mechanism.

T11 Band after Matrix Generation

Before Multilooking

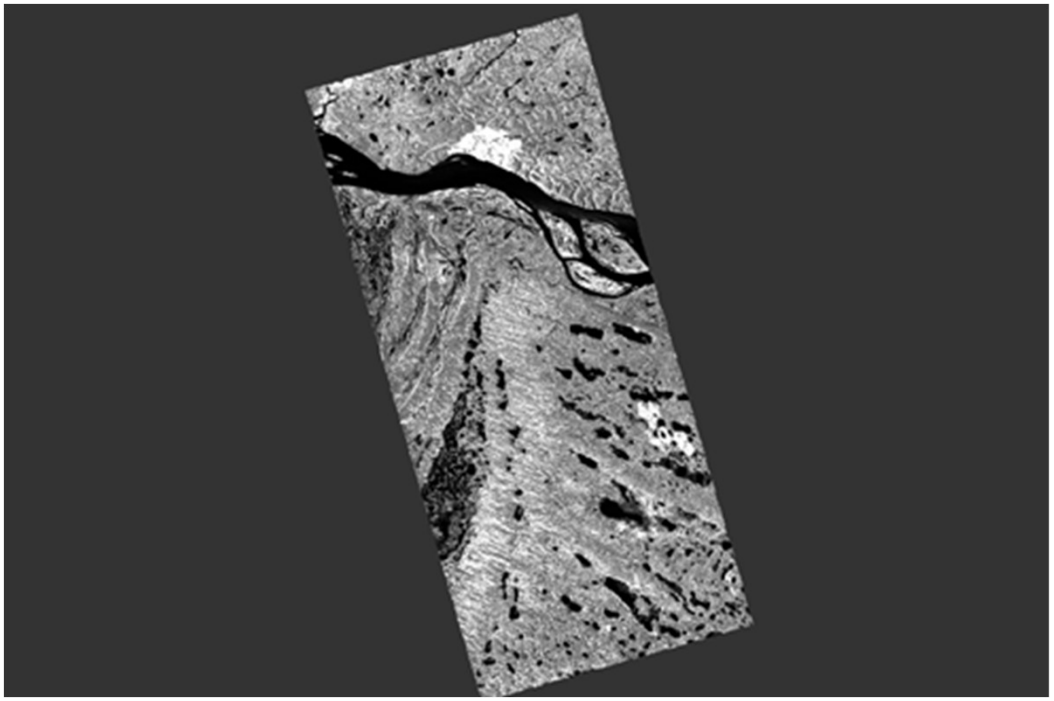


After Multilooking

METHODOLOGY

Terrain Correction

- Terrain Correction geocodes the image by correcting SAR geometric distortions using a digital elevation model (DEM) and producing a map projected product
- Geocoding converts an image from slant range or ground range geometry into a map coordinate system



T11 Band After Terrain Correction

METHODOLOGY

Polarimetric Decomposition

- Polarimetric decompositions allow the separation of different scattering contributions and can be used to extract information about the scattering process
- The objective of the decompositions is to express the measured scattering matrix by the radar as the combination of the scattering responses of simpler objects

$$[S] = \Sigma\ C_i[S]_i$$

- For PolSAR images including urban areas, the reflection symmetry condition does not hold. Thus, the well-established four-component Yamaguchi model is used

Images after Decomposition

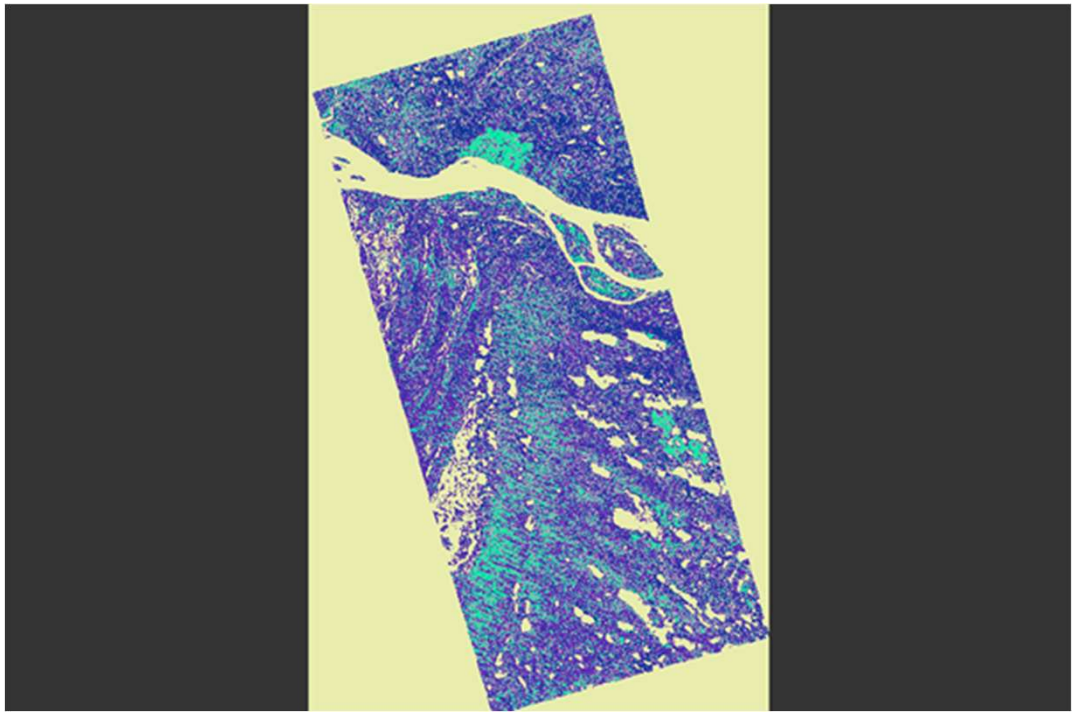
Yamaguchi Decomposition

Singh i6SD Decomposition

METHODOLOGY

K-Means Cluster Analysis

- The objective of K-means is to group similar data points together and discover underlying patterns.
- The K-means algorithm in data mining starts with a first group of randomly selected centroids, which are used as the beginning points for every cluster, and then performs iterative (repetitive) calculations to optimize the positions of the centroids.



T33 class indices image after k-means clustering

METHODOLOGY

K-means Cluster Analysis

- The classifier undertakes various iterations with random cluster centers of the multidimensional feature space to find pixels of similar properties.
- The output is a product with a single band, where each pixel is assigned to one of the classes (clusters)

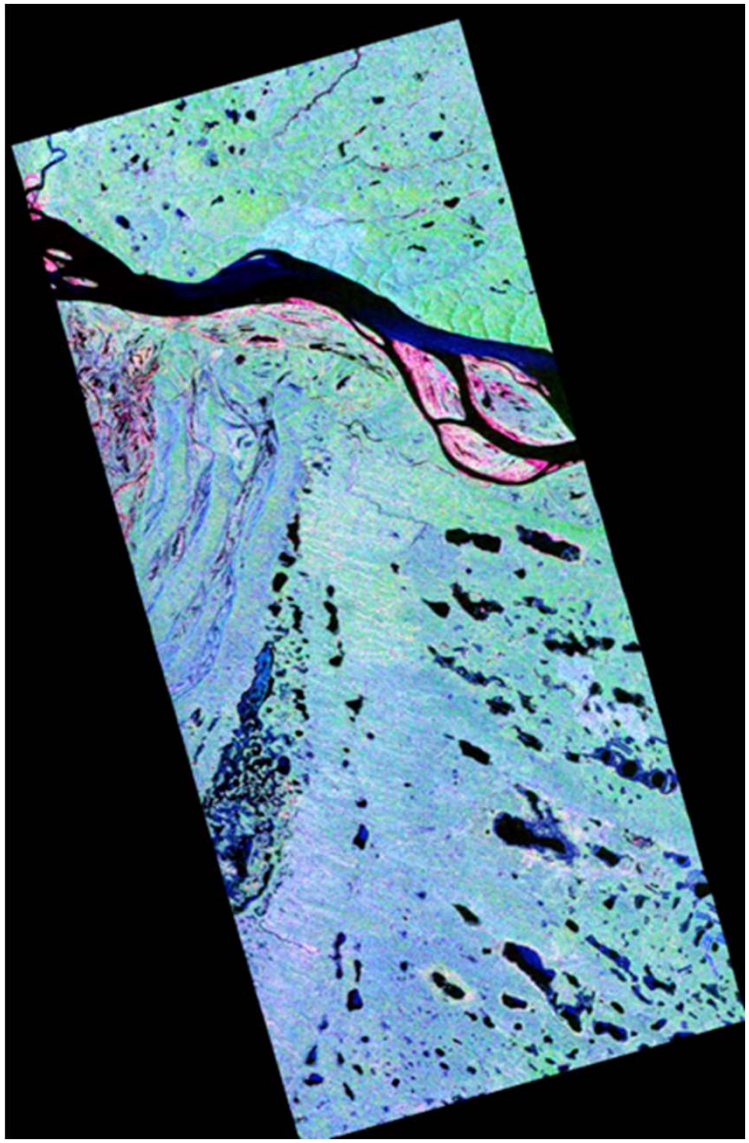
Maximum Likelihood Classifier

- Maximum Likelihood is a supervised classification method derived from the Bayes theorem
- calculates the probability that a given pixel belongs to a specific class
- Each pixel is assigned to the class that has the highest probability (that is, the maximum likelihood)

RESULTS

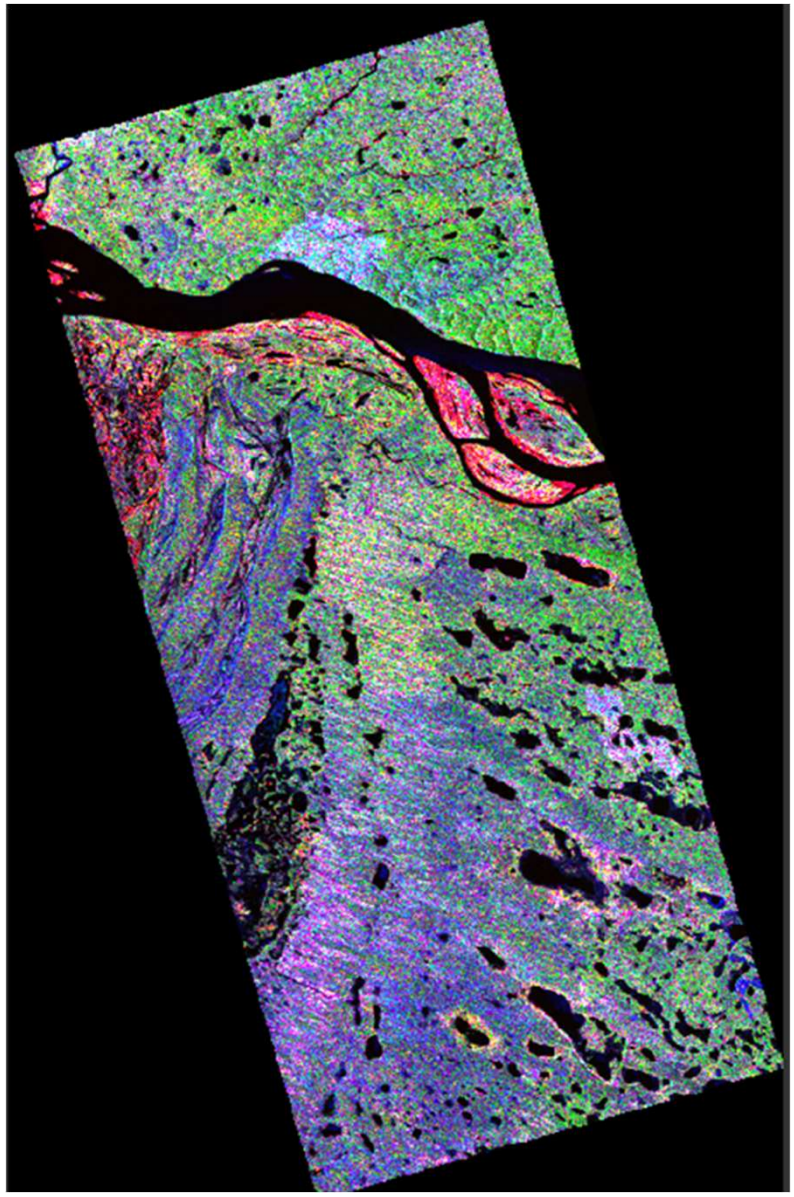
RESULTS

The image obtained after the Range-Doppler Terrain Correction needed to be decomposed before classification. We performed Yamaguchi Decomposition in SNAP, but for better output Singh i6SD decomposition was performed in the PolSARPro software. The output obtained after creating a RGB image with Blue, Green and Red input as Odd, Vol and Dbl layers respectively of i6SD decomposed image is shown



RESULTS

The final image obtained from the T33 Matrix with clear differentiation of various landscape features



DISCUSSION

DISCUSSION

- The SAR data provided consisted of four polarizations – HH, HV, VH, VV
- The processing was done using SNAP software to make the image easier to analyze using operations like Multi-looking, Terrain Correction, decomposition, etc.
- In the final image obtained, we can clearly classify various landscape features of the Permafrost.
- There is a large water body passing in the middle.
- Shrubs, vegetation, ponds, wet snow, etc. in small regions above the water body.
- The reddish colored layer comprises of the land surface or rocks.
- Below the large water body, the major part is snow covered area along with vegetation and small water bodies like lakes, ponds etc.

CONCLUSION

CONCLUSION

- Permafrost is a permanently frozen layer on or under Earth's surface consisting of soil, gravel, and sand, usually bound together by ice.
- Permafrost covers approximately 22.8 million square kilometers (about 8.8 million square miles) in Earth's Northern Hemisphere.
- The Sentinel Application Platform (SNAP) basic function includes: opening a product, exploring the product components such as bands, masks, and tie point grids.
- The PolSARpro software is controlled through a user-friendly, intuitive graphical interface, which enables the user to select a function, set its parameters, and then run it.
- Experimental results on real PolSAR dataset demonstrate the proposed methods are significantly effective.
- The Clustering classification model could achieve impressive classification performance compared to the comparison algorithm.
- The results might be further improved by researching the deep networking order to extract more valid PolSAR classification features.

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THANK YOU