Poster ID: 12

Taisei Shibakura, 2nd Year Master Student.
Satellite Data Utilization Cluster, The University of Aizu.

# Automatic Production of the Geologic Classification Map of the Moon Based on the Kaguya/SP Data

## Introduction

- A lunar geological map is important for understanding the Moon.
- VIS-NIR reflectance spectra of the Moon contains key information about distributed minerals.
- Global lunar classification map of absorption spectra originally proposed by Hareyama et al. (2019).
- Fuzzy C-means were applied to MARIA and SPA (South Pole Aitken) of the lunar spectral data sets (Shibakura et al. 2023., JpGU).
- Classification results were compared to existing geologic maps.
  Good agreement with distribution of Anorthosite in SPA.
  **Examine the spectra of the two regions in this report.**

## Purpose and Goal

**Confirmation of:**

What detailed spectra are included for each class.
Areas with potential anorthosite distribution.

**Contribution by updating the dataset:**

Apply clustering to the datasets of MARIA and SPA.
Contribute to the generation of lunar geological classification maps based on data.

## Data and method

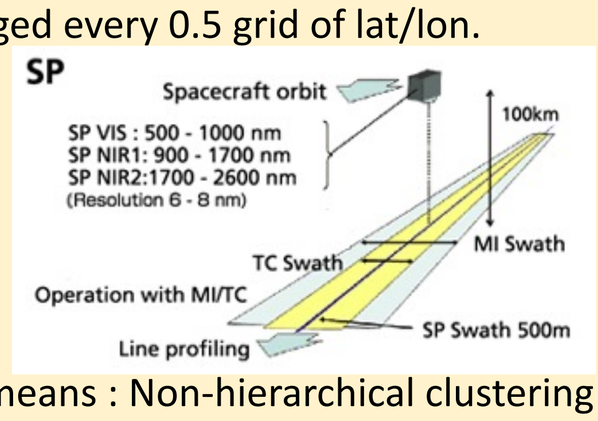
**Kaguya/SP data:**

SP data collected by Spectral Profiler onboard lunar orbiter Kaguya.

- 296 bands of reflectance spectra

Data used in the study:

The same 160-band SP data as Hareyama et al. (2019), averaged every 0.5 grid of lat/lon.



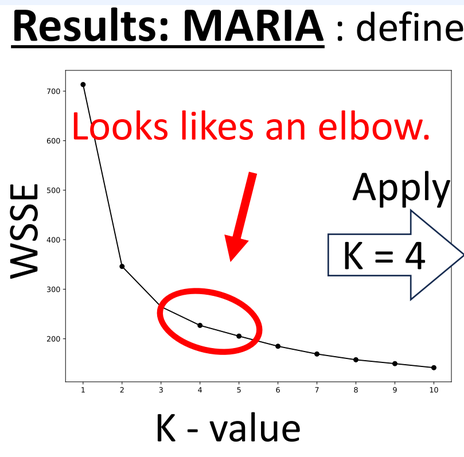

Spectral profiler image: https://www.selene.jaxa.jp/en/equipment/tc_e.htm#

**Clustering:**

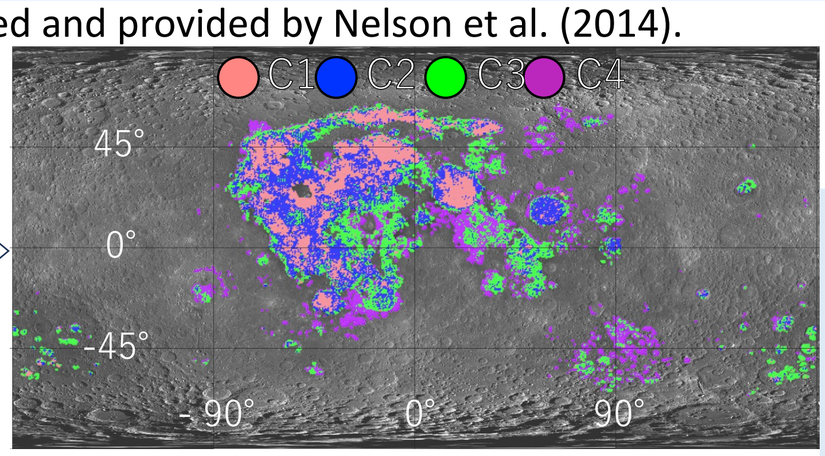
Fuzzy C-means : Non-hierarchical clustering

- Determine the number of classes in advance.
- The advantage of Fuzzy C-means over K-means is flexible and allows an object to belong to more than one cluster.
- The optimal K value is determined based on the result of the elbow K-means, which plots WSSE (Within-cluster Sum-of-Squared Error) values in relation with clustering number (e.g., Syakur et al., 2018).
- Clustering algorithms applied using RasterMiner clustering tool (Rage, 2021., ICDAR).

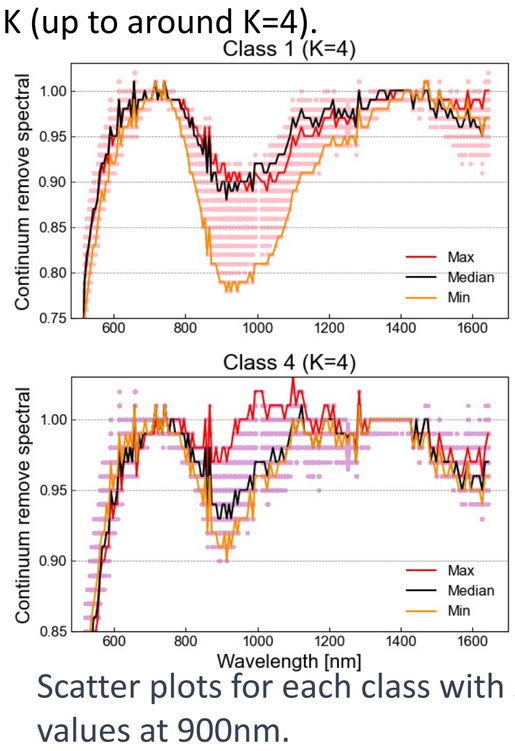
## Results: MARIA : defined and provided by Nelson et al. (2014).

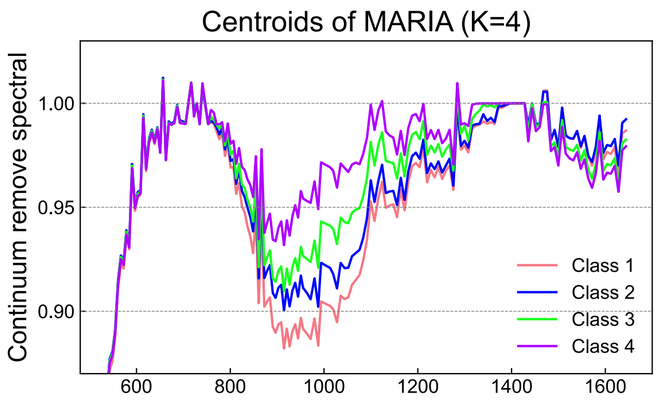



Applying elbow K-means to lunar reflectance spectra by using RasterMiner.
The WSSE values decrease significantly with the increase of K (up to around K=4).




Example of applying Fuzzy C-means (K=4) to lunar reflectance spectra in the global MARIA.
The colors in the spectral classification map correspond to the spectra indicated below.



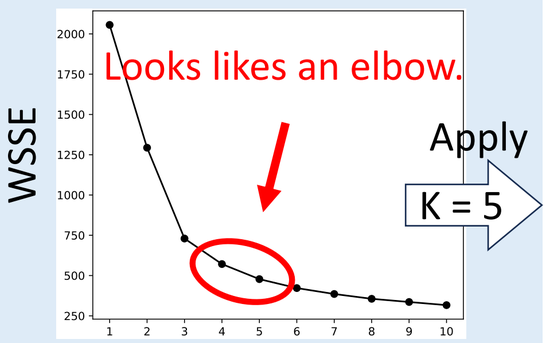

Continuum-removed spectra representing each class (K=4) in MARIA.

- Central wavelengths of the absorption are ~ 900, ~ 1000 or ~ 1050 nm.
- C1 to C4 are ascending order of reflectance value around 950 nm for clarification.

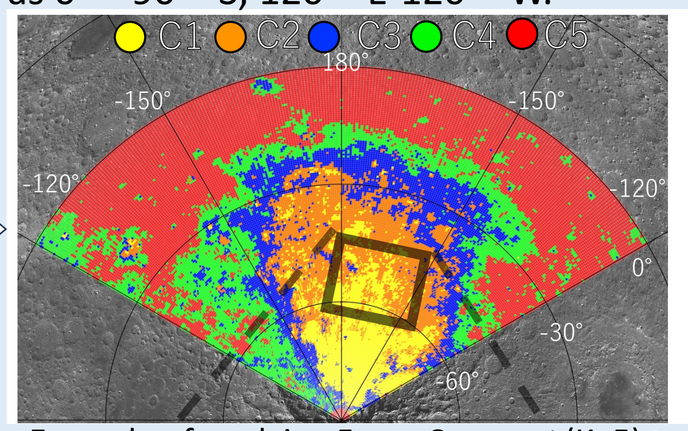
Scatter plots for each class with spectra of Maximum, Median, and Minimum values at 900nm.

- In classes 1, the waveforms of maximum and median values exhibit similarities. Class 1 distinctly shows a lower minimum label.
- As can be seen in Class 4, Max and Min are classified as the same class, although they have different waveforms.

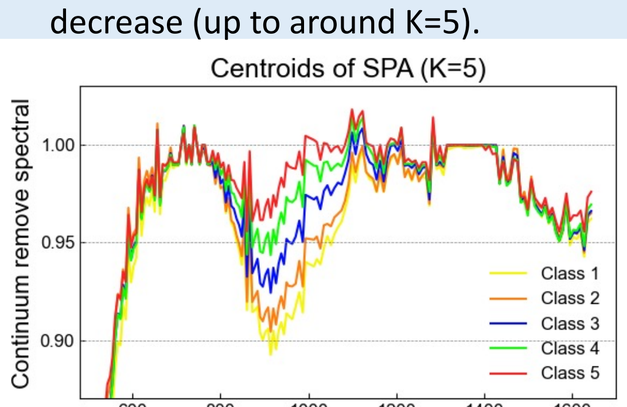
## Results: SPA region : defined as 0° -90° S, 120° E-120° W.




Applying elbow K-means to lunar reflectance spectra by using RasterMiner. The WSSE values decrease (up to around K=5).

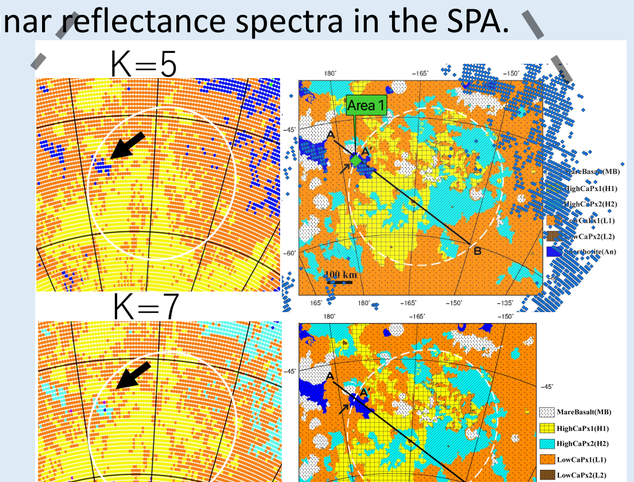



Example of applying Fuzzy C-means (K=5) to lunar reflectance spectra in the SPA.



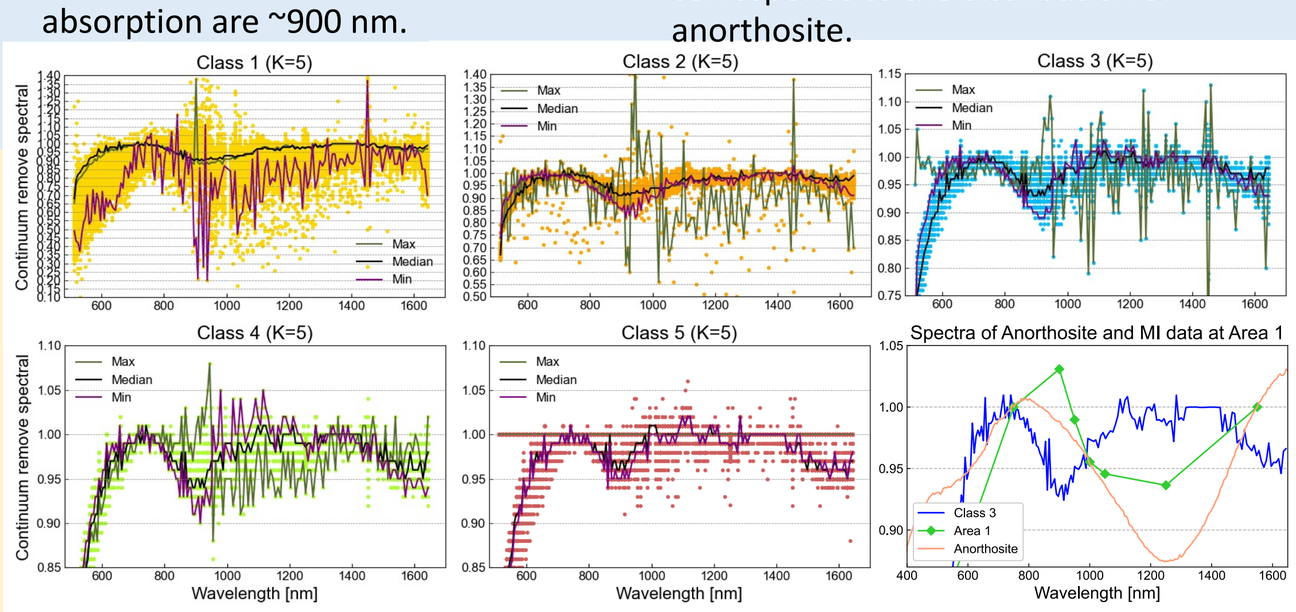

Continuum-removed spectra representing each class (K=5) in the SPA.

- 1-μm band absorption is clearly observed.
- Central wavelengths of the absorption are ~900 nm.




Left: Classification results for K=5 K=7).
Right: Each results overlaid on the lithology map from Uemoto et al. (2017).

- Classification results (black arrows) corresponds to the distribution of anorthosite.




Scatter plots for each class with spectra of Maximum, Median, and Minimum values at 900nm, and lower right is laboratory observed anorthosite data and Kaguya/MI data for Areas 1 (9 bands).

- Spectra with distorted waveforms were displayed. All of them were spectra observed in high-latitude regions.
- Area 1 is included in Class 3 and exhibits absorption bands similar to anorthosite.

## Discussion

- In MARIA , C1 and C4 exhibit a widespread distribution compared to C2 and C3, resulting in scattered scatter plots.
- Spectra that appear differently to human judgment are classified into the same class in the data space.
- The SPA contains a significant number of spectra with inappropriate waveforms. This is due to the inclusion of data from high-latitude regions.
- The classification results seemed to represent the distribution of anorthosite at Area 1 as shown in Uemoto et al. (2017). However, the absorption of the average spectrum was different from the absorption bands of anorthosite.

## Conclusion

- Elbow K-means and Fuzzy C-means are applied to averaged Kaguya/SP data sets in MARIA and SPA regions of the Moon.
- Classification results confirmed spectra of each class and found future issues to be improved.
- The SPA data set including high latitude areas was found to contain noisy waveform data.
- Future work includes detailed discussion and screening of additional good quality data sets toward updating the global lunar geologic map.