Machine Learning Model for the Planetary Albedo

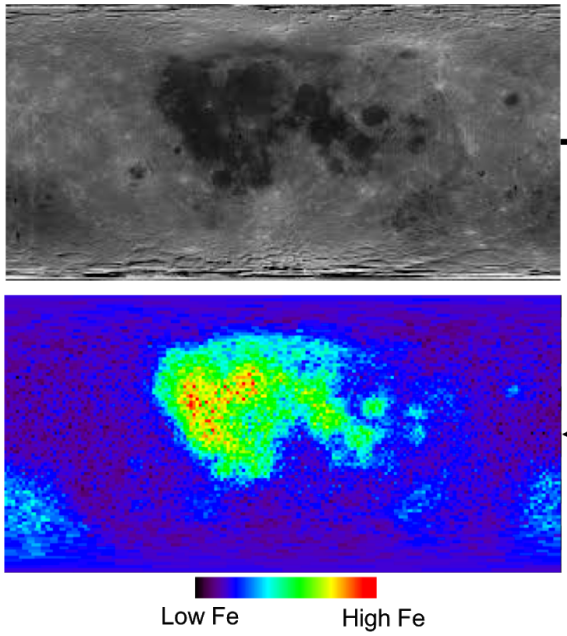
For the exercises, please work in a Python (Jupyter) notebook and submit the notebook as part of your solution together with a converted version to pdf that shows all the outputs.

Task 1. Predicting the Lunar Albedo based on Chemical Composition

Moon as seen in the night sky.

Cylindrical Projection of the Lunar Albedo, including the “Far Side”, never visible from Earth.

The chemical composition of lunar rocks determines how light or dark the surface is. Note the relationship between high iron (Fe) and dark regions on the Moon in the above maps.



The chemical composition of Lunar rocks, as measured by the Lunar Prospector spacecraft from orbit around the Moon.

Your goal is to build a predictive model for the Lunar albedo based on the chemical composition data from the Lunar Prospector. The task is to build a regression model (using a machine learning algorithm of your choice) to predict the brightness of each pixel. To do this, we suggest that you divide the data into two halves (left and right side of the Albedo), train on one side (left) and predict the other. Please show the resulting prediction and plot the residuals (difference from the true image) as a 2-D image and a 1-D histogram

Here is the link to the dataset that contains the albedo map and chemical composition maps link:
https://github.com/ML4SCI/ML4SCI_GSoC/tree/main/Messenger/Moon

The albedo map, LPFe (iron map), LPK (potassium map), LPTh (thorium map), and LPTi (titanium) map should be used for this study. The maps are csv files with data that represents the element concentration at each location. Make sure you can reproduce the maps above to verify you are reading the data correctly.

Task 1 Details - Using the data found in ML4SCI_GSoC/Messenger/Moon/, select a subset of the Moons surface to train your model to identify relationship between albedo and composition. Then, make a prediction about the albedo of the untrained portion of the map using just the chemical data.

Compare your albedo prediction to the albedo map. How did your algorithm perform? Choose a metric to quantify your performance.

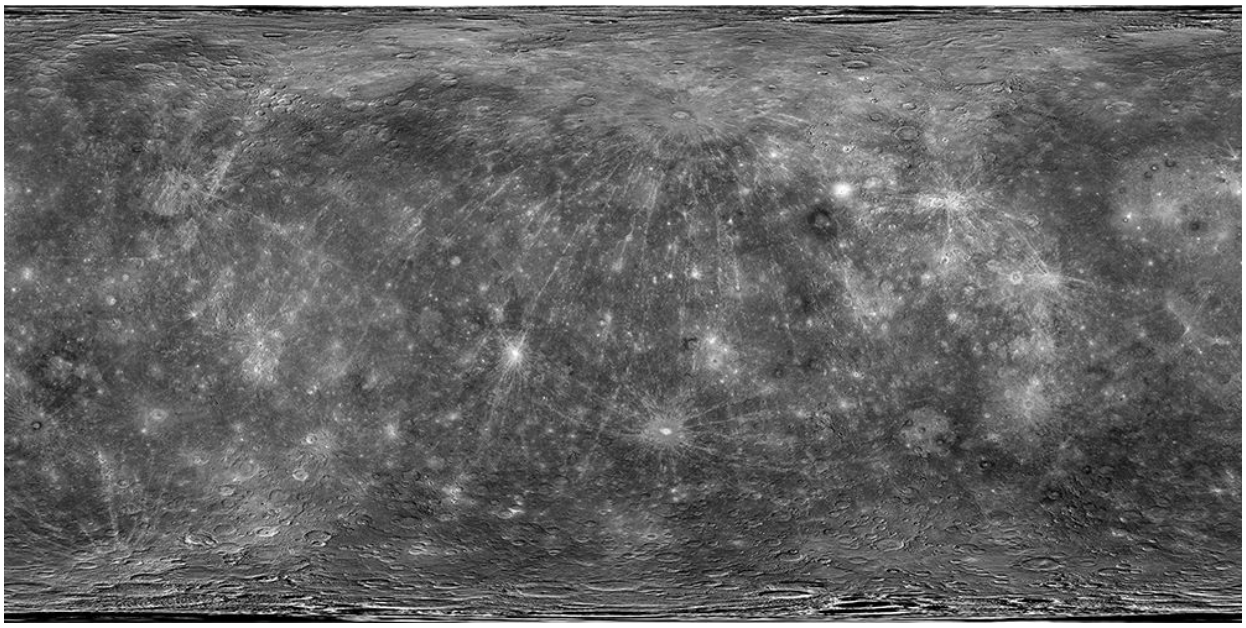
Task 2 Predicting Mercury's elemental composition from Albedo with MESSENGER Data

You may have found that albedo and elemental composition are highly correlated on the Moon. Is this also true for Mercury? The MESSENGER spacecraft mapped Mercury's surface from 2011 to 2015, including making full-surface albedo maps and partial element maps.
Using the Mercury chemical data located at:

https://github.com/ML4SCI/ML4SCI_GSoC/tree/main/Messenger/Mercury

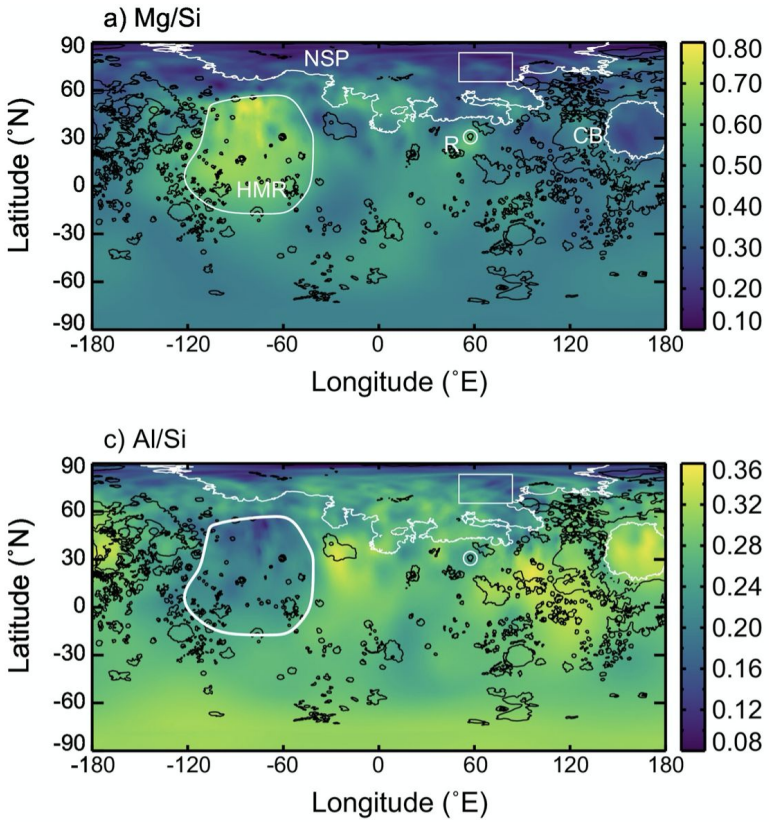
attempt to build a predictive model of albedo versus composition. It is harder on Mercury, in large part because the elemental maps have coverage gaps.

Mercury Albedo:



From:
https://messenger.jhuapl.edu/Explore/images/MESSENGER_Mosaics/low_incidence/MDIS_LowIncidence_20170512_PDS16_64ppd_equirectangular.png

Example Mercury Element Maps:



From: https://www.sciencedirect.com/science/article/pii/S001910352030107X

Attempt to predict the element composition data within these gaps by applying ML techniques to derive relationships between albedo and composition data relationships in regions that had full coverage for all quantities of interest. Can you make predictions of elemental composition in locations without measurements?

Here is the link to the dataset that contains the albedo map and chemical composition maps link:
https://github.com/ML4SCI/ML4SCI_GSoC/tree/main/Messenger/Mercury

For Mercury the albedo map is split into the top and bottom of the planet (mercury-albedo-top-half.png.csv and mercury-albedo_resized_botton-half.png.csv). Train your model on the top half. Training should attempt to identify relationships between albedo and chemistry. Chemical maps are:
alsimap_smooth (Al to Si element ratio),
casimap_smooth (Ca to Si element ratio),
fesimap_smooth (Fe to Si element ratio),
mgsimap_smooth (Mg to Si element ratio),
ssimap_smooth (S to Si element ratio),

The maps are csv files with data that represents the element concentration at each location. Make sure you can reproduce the maps above to verify you are reading the data correctly.

Task 2 Details - Using the data found in ML4SCI_GSoC/Messenger/Mercury/, use a model to train your algorith to find relationships between albedo and chemical composition in the top of the planet. Then, make a prediction about chemical composition for the bottom half of the planet using the albedo

Compare your albedo prediction to the albedo map. How did your algorithm perform? Choose a metric to quantify your performance.

Submission Instructions: Please send your completed work (Jupyter notebook, pdf of Jupyter notebook with output) to ml4-sci@cern.ch with Evaluation Test: MLMAPPER in the title.