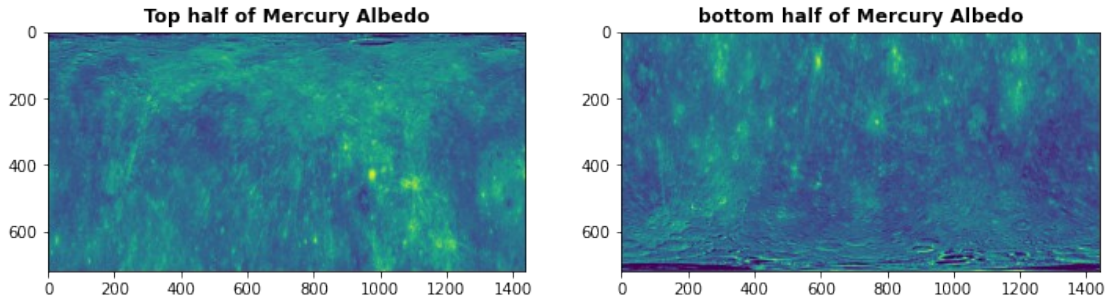
```
import pandas as pd
import numpy as np
from sklearn.metrics import mean_squared_error

alsi = pd.read_csv("Dataset/Mercury/alsimap_smooth_032015.png.csv",
header = None)
casi = pd.read_csv("Dataset/Mercury/casimap_smooth_032015.png.csv",
header = None)
fesi = pd.read_csv("Dataset/Mercury/fesimap_smooth_032015.png.csv",
header = None)
mgsi = pd.read_csv("Dataset/Mercury/mgsimap_smooth_032015.png.csv",
header = None)
ssi = pd.read_csv("Dataset/Mercury/ssimap_smooth_032015.png.csv",
header = None)
top = pd.read_csv("Dataset/Mercury/mercury-albedo-top-half.png.csv",
header = None)
bottom = pd.read_csv("Dataset/Mercury/mercury-albedo-resized-bottom-
half.png.csv", header = None)

%matplotlib inline
import matplotlib.pyplot as plt

plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(top)
plt.title('Top half of Mercury Albedo', fontweight="bold")

plt.subplot(1, 2, 2)
plt.imshow(bottom)
plt.title('bottom half of Mercury Albedo', fontweight="bold")
```

```
Text(0.5, 1.0, 'bottom half of Mercury Albedo')
```

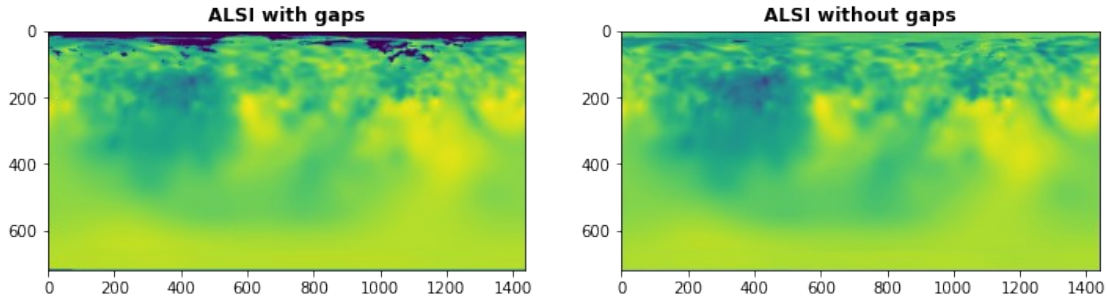


Filling gaps

```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(alsi)
plt.title('ALSI with gaps', fontweight="bold")

alsi_mean = alsi.replace(0E+00, alsi.mean())
```

```
plt.subplot(1, 2, 2)
plt.imshow(alsi_mean)
plt.title('ALSI without gaps', fontweight="bold")
```

```
Text(0.5, 1.0, 'ALSI without gaps')
```

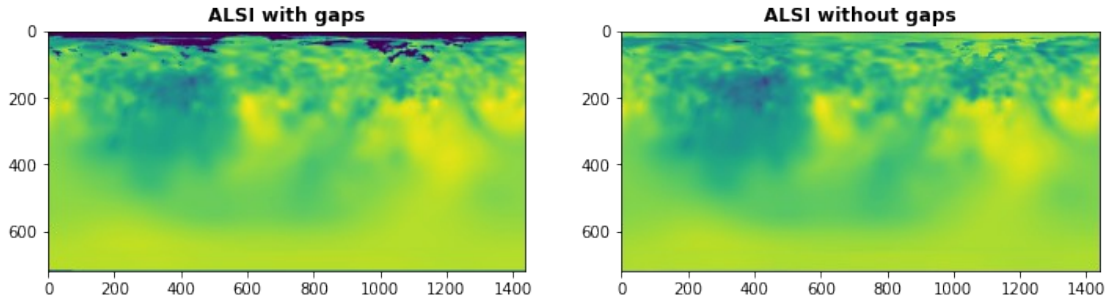



```
alsi_mean.std().sum()
```

```
122.94801210708867
```

```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(alsi)
plt.title('ALSI with gaps', fontweight="bold")

alsi_median = alsi.replace(0E+00, alsi.median())

plt.subplot(1, 2, 2)
plt.imshow(alsi_median)
plt.title('ALSI without gaps', fontweight="bold")
```

```
Text(0.5, 1.0, 'ALSI without gaps')
```




```
alsi_median.std().sum()
```

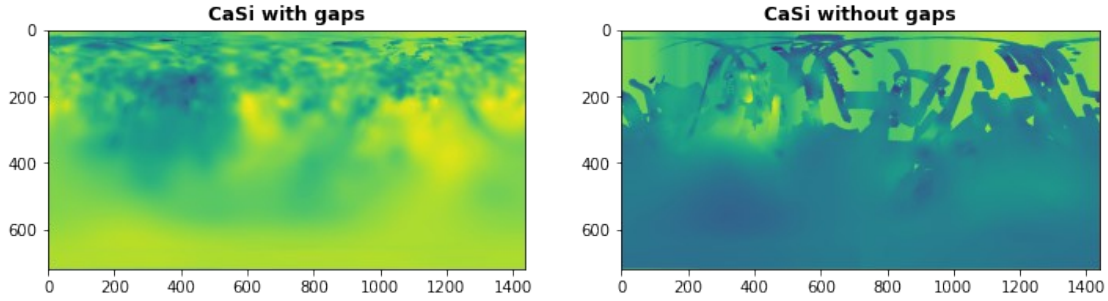
```
122.29112638414719
```

On comparing the standard deviations of both data, imputing gaps with median is giving better results.

```
alsi = alsi_median
```

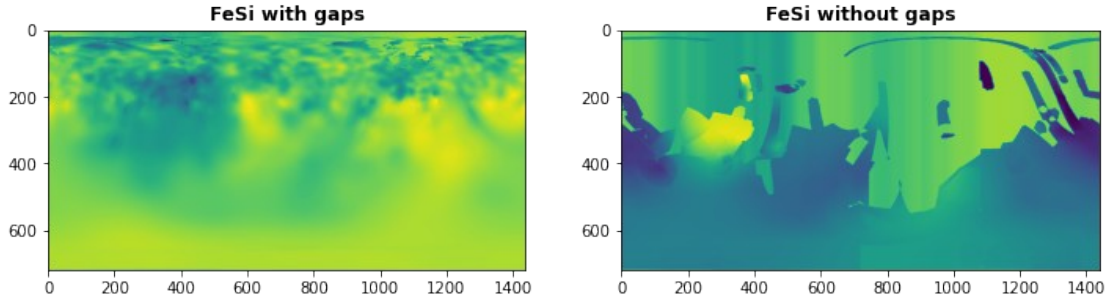
```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(alsi)
plt.title('CaSi with gaps', fontweight="bold")

casi = casi.replace(0E+00, alsi.median())

plt.subplot(1, 2, 2)
plt.imshow(casi)
plt.title('CaSi without gaps', fontweight="bold")
```

```
Text(0.5, 1.0, 'CaSi without gaps')
```



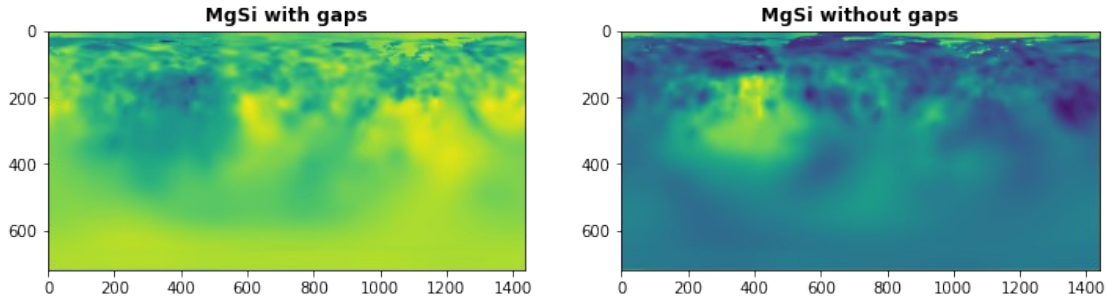

```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(alsi)
plt.title('FeSi with gaps', fontweight="bold")

fesi = fesi.replace(0E+00, alsi.median())

plt.subplot(1, 2, 2)
plt.imshow(fesi)
plt.title('FeSi without gaps', fontweight="bold")
```

```
Text(0.5, 1.0, 'FeSi without gaps')
```

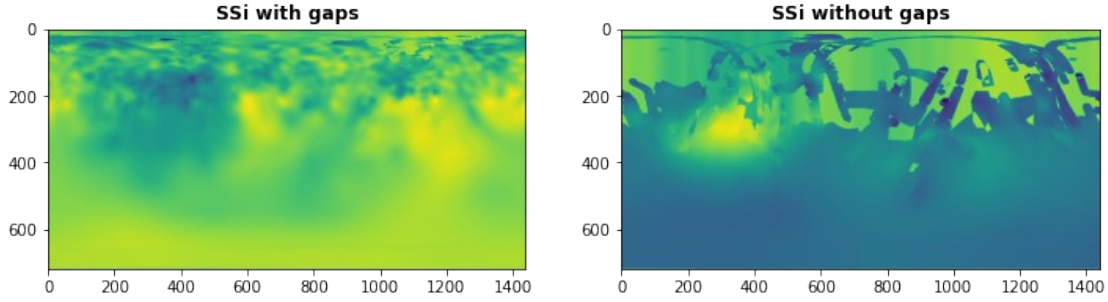



```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(alsi)
plt.title('MgSi with gaps', fontweight="bold")
```

```
mgsi = mgsi.replace(0E+00, alsi.median())

plt.subplot(1, 2, 2)
plt.imshow(mgsi)
plt.title('MgSi without gaps', fontweight="bold")

Text(0.5, 1.0, 'MgSi without gaps')
```




```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(alsi)
plt.title('SSi with gaps', fontweight="bold")

ssi = ssi.replace(0E+00, alsi.median())

plt.subplot(1, 2, 2)
plt.imshow(ssi)
plt.title('SSi without gaps', fontweight="bold")

Text(0.5, 1.0, 'SSi without gaps')
```



ALSI

Data split

```
x_train = top
y_train = alsi
x_test = bottom
y_test = alsi
```

We are not using XGBRegressor for this problem because size of dataset is large and computation time of XGBRegressor is very long.

```
from numpy import asarray
from sklearn.datasets import make_regression
from keras.models import Sequential
from keras.layers import Dense
```

```
model = Sequential()
model.add(Dense(100, input_dim=x_train.shape[1], activation="relu"))
model.add(Dense(32, activation="relu"))
model.add(Dense(y_train.shape[1]))
model.compile(loss="mse", optimizer="adam")
model.summary()
```

```
Model: "sequential_12"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_36 (Dense)            (None, 100)               144100

 dense_37 (Dense)            (None, 32)                3232

 dense_38 (Dense)            (None, 1440)              47520

=================================================================
Total params: 194,852
Trainable params: 194,852
Non-trainable params: 0
_________________________________________________________________
```

```
model.fit(x_train, y_train, epochs=1000, batch_size=12, verbose=0)
ypred = model.predict(x_test)
```

```
from sklearn.metrics import mean_squared_error
mean_squared_error(y_test,ypred)
```

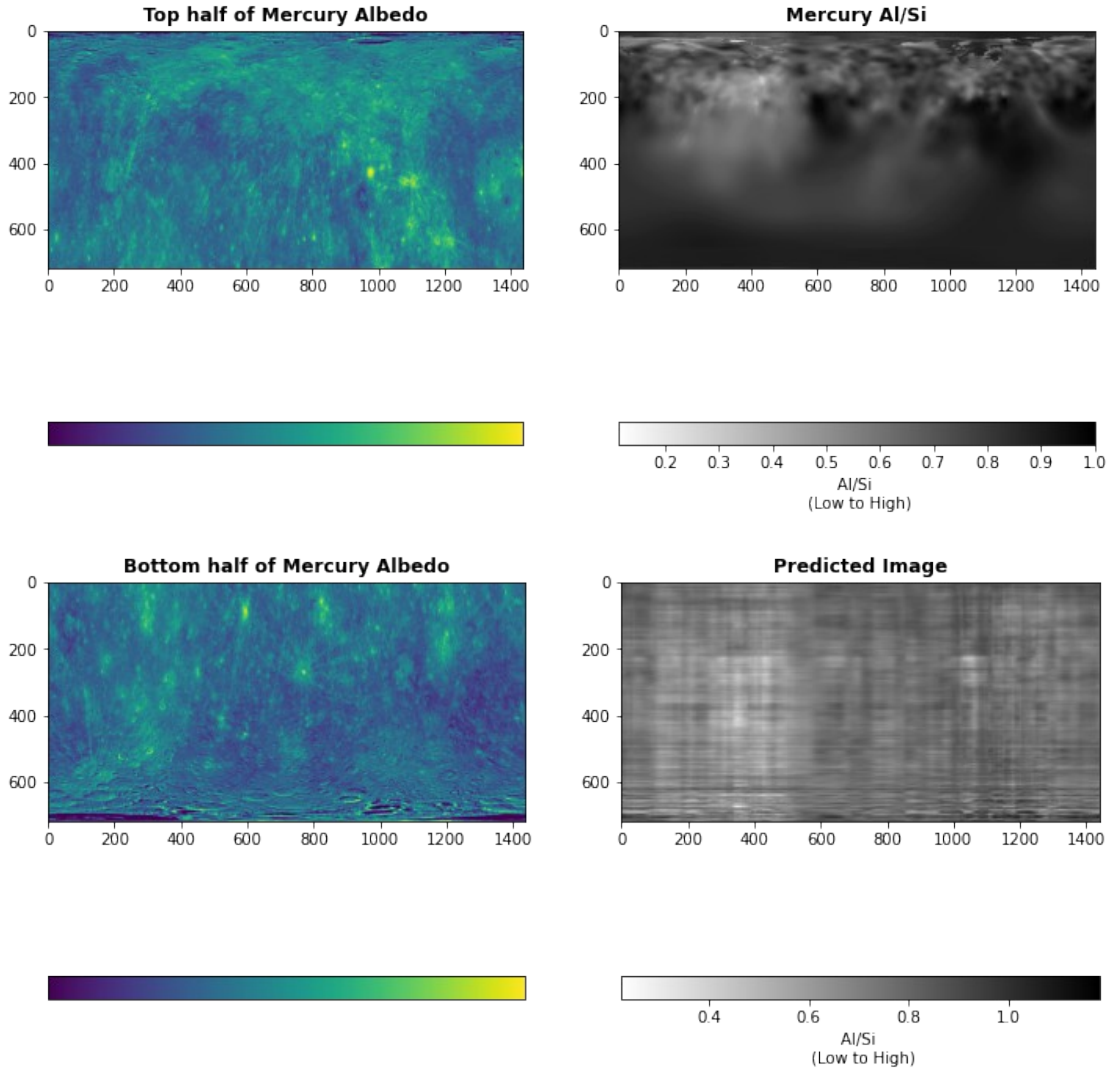
```
0.01585633437039213
```

For these outputs greyscale images are easy to analyze

```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(top)
plt.title('Top half of Mercury Albedo', fontweight="bold")
plt.colorbar(orientation='horizontal', ticks=[])

plt.subplot(1, 2, 2)
plt.imshow(alsi, cmap = 'binary')
plt.title('Mercury Al/Si', fontweight="bold")
plt.colorbar(orientation='horizontal', label= 'Al/Si \n (Low to
High)')

plt.figure(figsize =(12,12))
```

```
plt.subplot(1, 2, 1)
plt.imshow(bottom)
plt.colorbar(orientation='horizontal', ticks=[])
plt.title('Bottom half of Mercury Albedo', fontweight="bold")

plt.subplot(1, 2, 2)
plt.imshow(ypred, cmap = 'binary')
plt.colorbar(orientation='horizontal', label= 'Al/Si \n (Low to
High)')
plt.title('Predicted Image', fontweight="bold")
```

```
Text(0.5, 1.0, 'Predicted Image')
```



CASI

```
x_train = top
y_train = casi
x_test = bottom
y_test = casi
```

We are not using XGBRegressor for this problem because size of dataset is large and computation time of XGBRegressor is very long.

```
model = Sequential()
model.add(Dense(100, input_dim=x_train.shape[1], activation="relu"))
model.add(Dense(32, activation="relu"))
model.add(Dense(y_train.shape[1]))
model.compile(loss="mse", optimizer="adam")
model.summary()
```

```
Model: "sequential_13"
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 dense_39 (Dense)             (None, 100)               144100

 dense_40 (Dense)             (None, 32)                3232

 dense_41 (Dense)             (None, 1440)              47520

=================================================================
Total params: 194,852
Trainable params: 194,852
Non-trainable params: 0
_________________________________________________________________
```

```
model.fit(x_train, y_train, epochs=1000, batch_size=12, verbose=0)
ypred = model.predict(x_test)
```

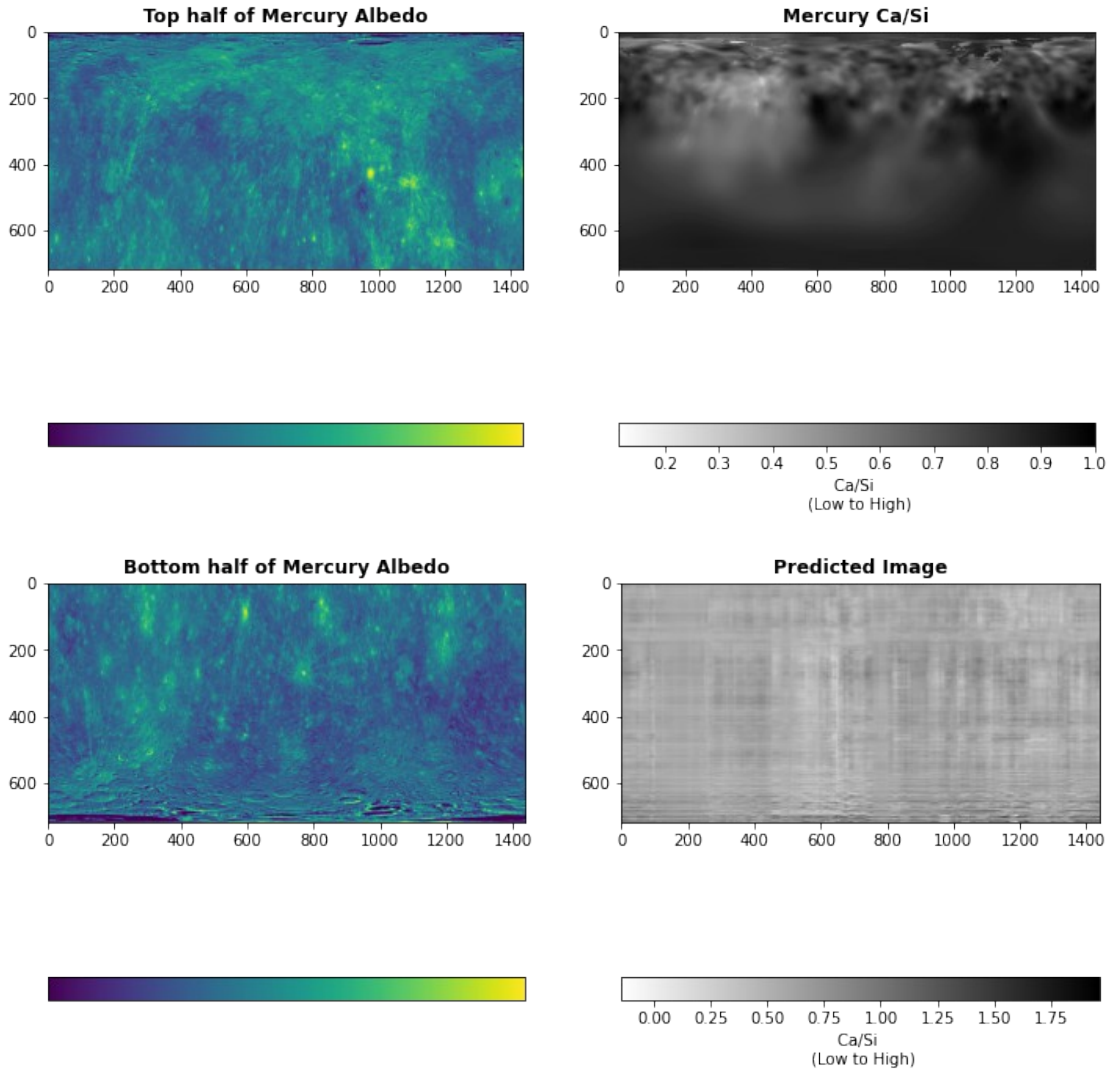
```
mean_squared_error(y_test,ypred)
```

```
0.02935314307516593
```

```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(top)
plt.title('Top half of Mercury Albedo', fontweight="bold")
plt.colorbar(orientation='horizontal', ticks=[])

plt.subplot(1, 2, 2)
plt.imshow(alsi, cmap = 'binary')
plt.title('Mercury Ca/Si', fontweight="bold")
plt.colorbar(orientation='horizontal', label= 'Ca/Si \n (Low to
High)')

plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(bottom)
plt.colorbar(orientation='horizontal', ticks=[])
plt.title('Bottom half of Mercury Albedo', fontweight="bold")
```

```
plt.subplot(1, 2, 2)
plt.imshow(ypred, cmap = 'binary')
plt.colorbar(orientation='horizontal', label= 'Ca/Si \n (Low to
High)')
plt.title('Predicted Image', fontweight="bold")
```

```
Text(0.5, 1.0, 'Predicted Image')
```



FESI

```
x_train = top
y_train = fesi
x_test = bottom
y_test = fesi
```

We are not using XGBRegressor for this problem because size of dataset is large and computation time of XGBRegressor is very long.

```
model = Sequential()
model.add(Dense(100, input_dim=x_train.shape[1], activation="relu"))
model.add(Dense(32, activation="relu"))
model.add(Dense(y_train.shape[1]))
model.compile(loss="mse", optimizer="adam")
model.summary()
```

```
Model: "sequential_14"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_42 (Dense)            (None, 100)               144100

 dense_43 (Dense)            (None, 32)                3232

 dense_44 (Dense)            (None, 1440)              47520

=================================================================
Total params: 194,852
Trainable params: 194,852
Non-trainable params: 0
_________________________________________________________________
```

```
model.fit(x_train, y_train, epochs=1000, batch_size=12, verbose=0)
ypred = model.predict(x_test)
```

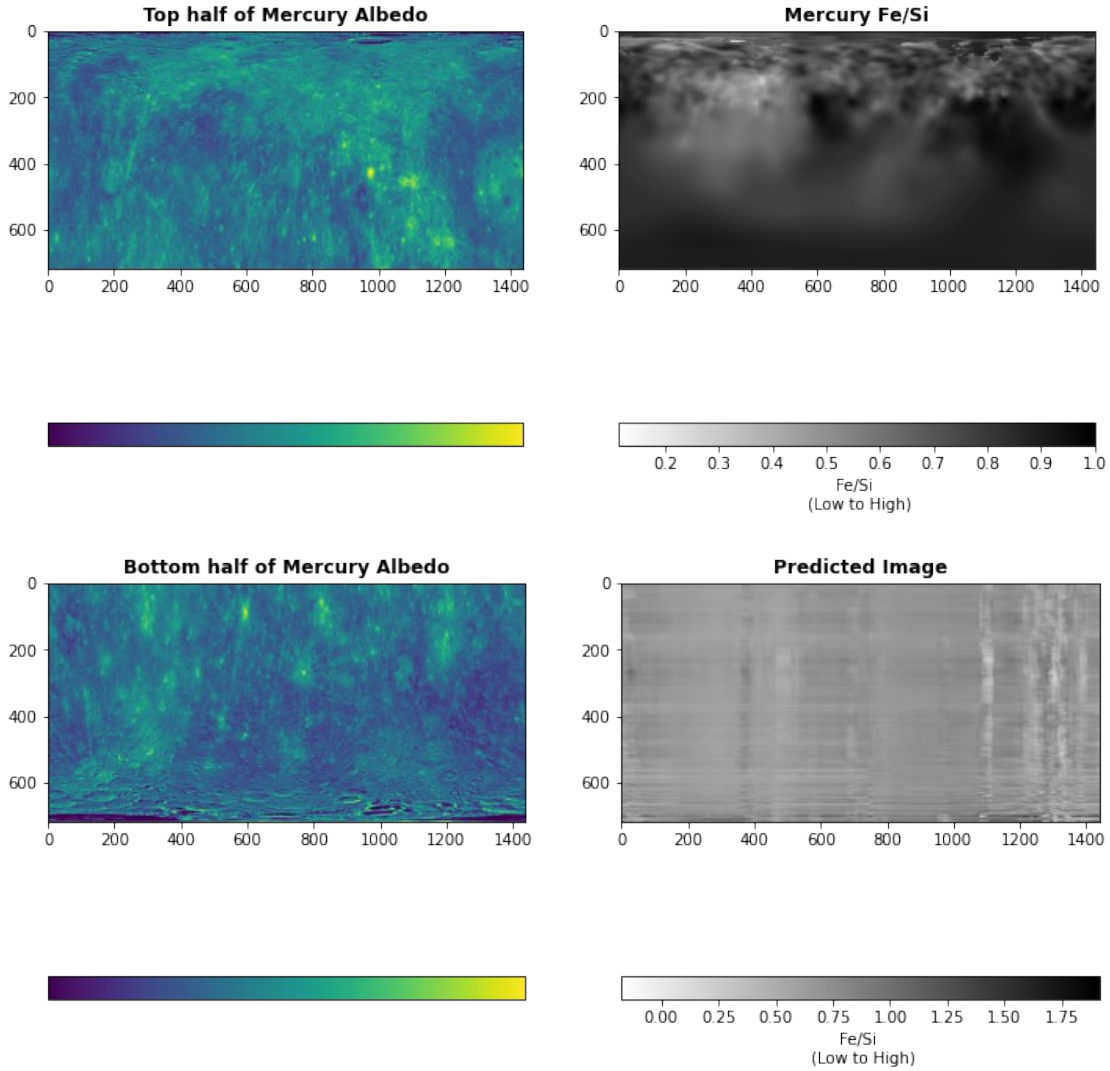
```
mean_squared_error(y_test,ypred)
```

```
0.028232106945608133
```

```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(top)
plt.title('Top half of Mercury Albedo', fontweight="bold")
plt.colorbar(orientation='horizontal', ticks=[])

plt.subplot(1, 2, 2)
plt.imshow(alsi, cmap = 'binary')
plt.title('Mercury Fe/Si', fontweight="bold")
plt.colorbar(orientation='horizontal', label= 'Fe/Si \n (Low to
High)')

plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(bottom)
plt.colorbar(orientation='horizontal', ticks=[])
plt.title('Bottom half of Mercury Albedo', fontweight="bold")

plt.subplot(1, 2, 2)
plt.imshow(ypred, cmap = 'binary')
plt.colorbar(orientation='horizontal', label= 'Fe/Si \n (Low to
```

```
High)')
plt.title('Predicted Image', fontweight="bold")
```

```
Text(0.5, 1.0, 'Predicted Image')
```



MGSI

```
x_train = top
y_train = mgsi
x_test = bottom
y_test = mgsi
```

We are not using XGBRegressor for this problem because size of dataset is large and computation time of XGBRegressor is very long.

```
model = Sequential()
model.add(Dense(100, input_dim=x_train.shape[1], activation="relu"))
model.add(Dense(32, activation="relu"))
model.add(Dense(y_train.shape[1]))
```

```
model.compile(loss="mse", optimizer="adam")
model.summary()
```

```
Model: "sequential_15"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_45 (Dense)            (None, 100)               144100

 dense_46 (Dense)            (None, 32)                3232

 dense_47 (Dense)            (None, 1440)              47520

=================================================================
Total params: 194,852
Trainable params: 194,852
Non-trainable params: 0
_________________________________________________________________
```

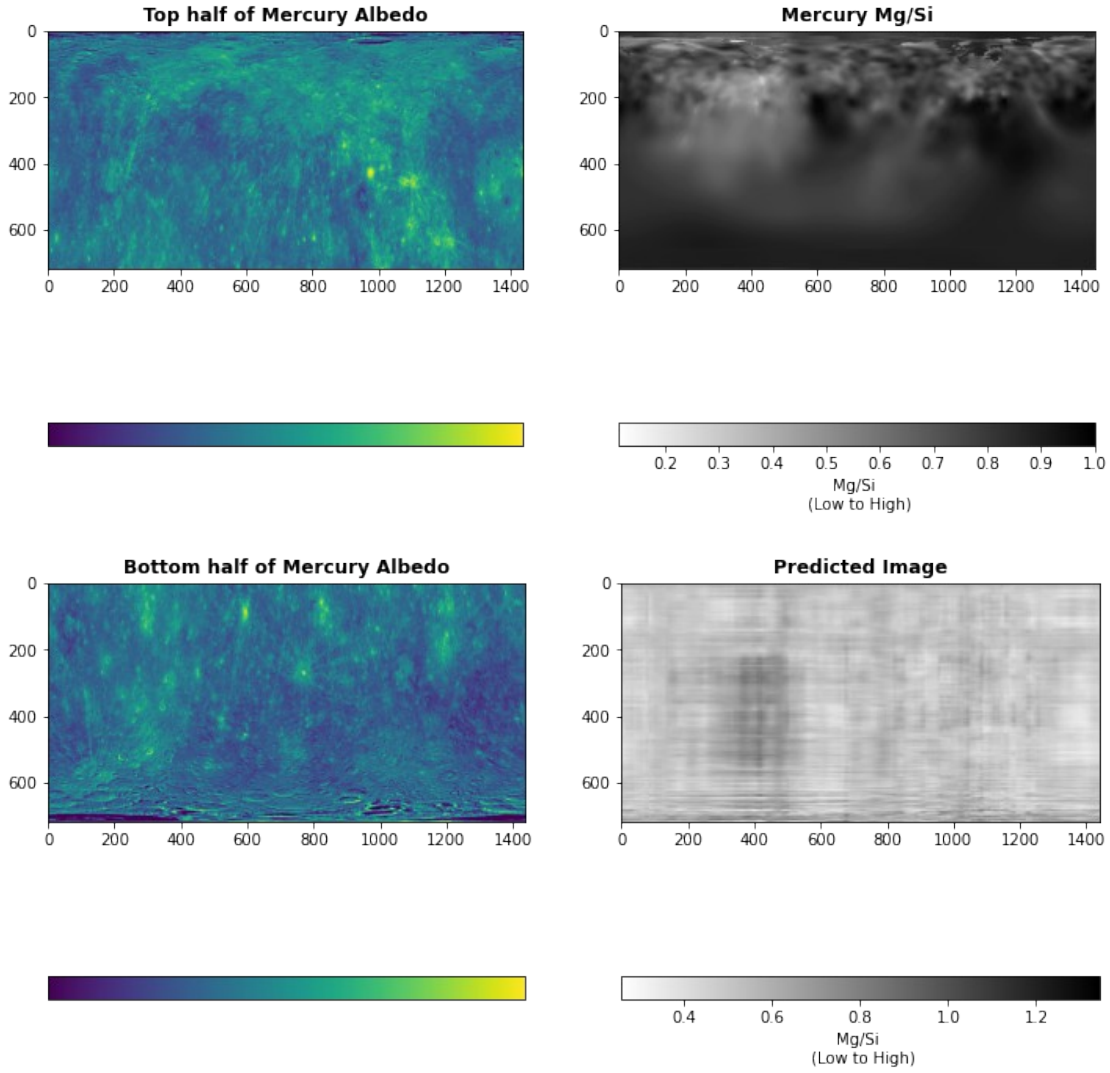
```
model.fit(x_train, y_train, epochs=1000, batch_size=12, verbose=0)
ypred = model.predict(x_test)
```

```
mean_squared_error(y_test,ypred)
```

```
0.012962058376719043
```

```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(top)
plt.title('Top half of Mercury Albedo', fontweight="bold")
plt.colorbar(orientation='horizontal', ticks=[])

plt.subplot(1, 2, 2)
plt.imshow(alsi, cmap = 'binary')
plt.title('Mercury Mg/Si', fontweight="bold")
plt.colorbar(orientation='horizontal', label= 'Mg/Si \n (Low to
High)')

plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(bottom)
plt.colorbar(orientation='horizontal', ticks=[])
plt.title('Bottom half of Mercury Albedo', fontweight="bold")

plt.subplot(1, 2, 2)
plt.imshow(ypred, cmap = 'binary')
plt.colorbar(orientation='horizontal', label= 'Mg/Si \n (Low to
High)')
plt.title('Predicted Image', fontweight="bold")
```

```
Text(0.5, 1.0, 'Predicted Image')
```



SSI

```
x_train = top
y_train = ssi
x_test = bottom
y_test = ssi
```

We are not using XGBRegressor for this problem because size of dataset is large and computation time of XGBRegressor is very long.

```
model = Sequential()
model.add(Dense(100, input_dim=x_train.shape[1], activation="relu"))
model.add(Dense(32, activation="relu"))
model.add(Dense(y_train.shape[1]))
model.compile(loss="mse", optimizer="adam")
model.summary()
```

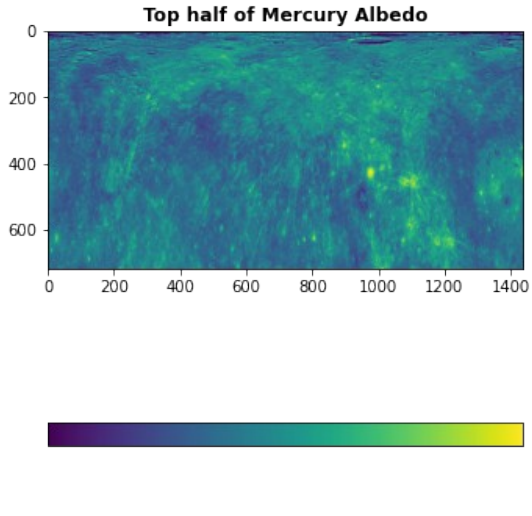
```
Model: "sequential_16"
_________________________________________________________________
```

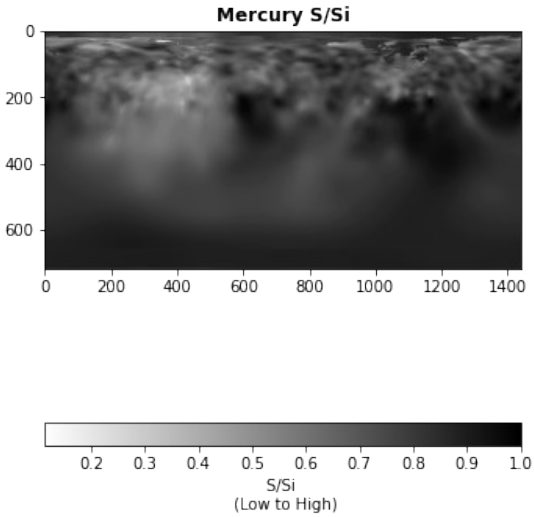
```
 Layer (type)                 Output Shape              Param #
=================================================================
 dense_48 (Dense)             (None, 100)               144100

 dense_49 (Dense)             (None, 32)                3232

 dense_50 (Dense)             (None, 1440)              47520

=================================================================
Total params: 194,852
Trainable params: 194,852
Non-trainable params: 0
_________________________________________________________________
```

```
model.fit(x_train, y_train, epochs=1000, batch_size=12, verbose=0)
ypred = model.predict(x_test)

mean_squared_error(y_test,ypred)
```

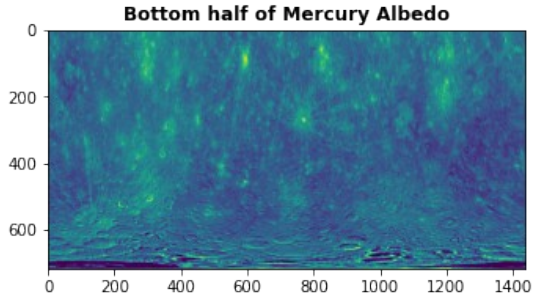
```
0.040603376142447495
```

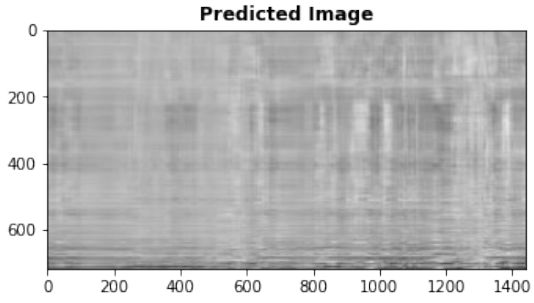
```
plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(top)
plt.title('Top half of Mercury Albedo', fontweight="bold")
plt.colorbar(orientation='horizontal', ticks=[])

plt.subplot(1, 2, 2)
plt.imshow(alsi, cmap = 'binary')
plt.title('Mercury S/Si', fontweight="bold")
plt.colorbar(orientation='horizontal', label= 'S/Si \n (Low to High)')

plt.figure(figsize =(12,12))
plt.subplot(1, 2, 1)
plt.imshow(bottom)
plt.colorbar(orientation='horizontal', ticks=[])
plt.title('Bottom half of Mercury Albedo', fontweight="bold")

plt.subplot(1, 2, 2)
plt.imshow(ypred, cmap = 'binary')
plt.colorbar(orientation='horizontal', label= 'S/Si \n (Low to High)')
plt.title('Predicted Image', fontweight="bold")

Text(0.5, 1.0, 'Predicted Image')
```

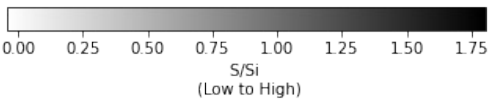

Top half of Mercury Albedo
0
200
400
600
0
200
400
600
800
1000
1200
1400


Mercury S/Si
0
200
400
600
0
200
400
600
800
1000
1200
1400

0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
S/Si
(Low to High)


Bottom half of Mercury Albedo
0
200
400
600
0
200
400
600
800
1000
1200
1400


Predicted Image
0
200
400
600
0
200
400
600
800
1000
1200
1400


0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
S/Si
(Low to High)