THE UNIVERSITY OF ARIZONA

BE/BAT 485/585

Remote Sensing Data and Methods

Lab - 4

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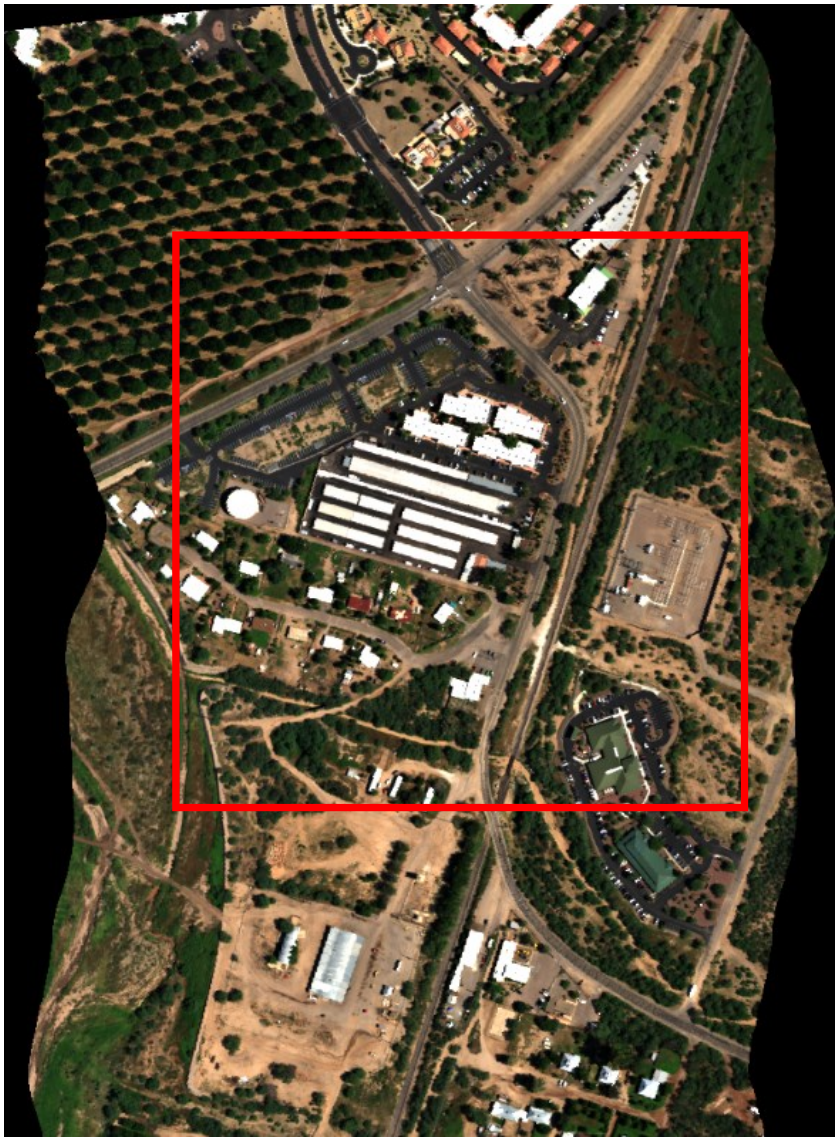
NEON



NEON AOP single path flight file

A NEON Airborne Observation Platform (AOP) is an array of instruments installed into a light aircraft to collect high resolution remote sensing data at low altitude.

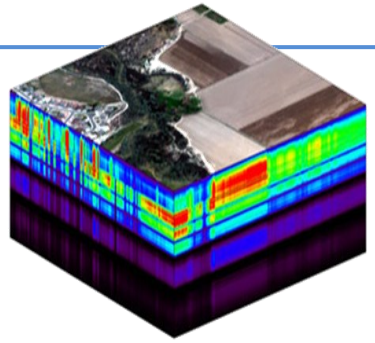
Hyperspectral NEON Data: Narrow spectral bands extending from 380 to 2500 nm with a spectral sampling of five nm. Approximately one meter, at 1000 meters above ground level (AGL).

What happens if the plane flies at a lower altitude (AGL)?

Why is the image to the left wavy?

neon Data http://data.neonscience.org

Data and Specs



NEON_GreenValley.bsq
NumRows : 500
NumCols : 500
NumBands : 426
DataType : INT16 (16 bits)
NEON_wave.txt
What is the number of data levels?

Blue
Green
Red
NIR
SWIR1

Index	Wavelength
0	381.27301
1	386.281097
2	391.289215
3	396.297302
4	401.305511
5	406.313599
6	411.321686
7	416.329895
8	421.338013
9	426.3461
10	431.354309
11	436.362396
12	441.370514
13	446.378601
14	451.38681
15	456.394897
16	461.403015
17	466.411194
18	471.419312
19	476.427399
20	481.435486
21	486.443695
22	491.451813
23	496.4599
24	501.468109
25	506.476196
26	511.484314
27	516.492493
28	521.50061
29	526.508728
30	531.516785
31	536.525024
32	541.533081
33	546.541199
34	551.549377
35	556.557495
36	561.565613
37	566.573792
38	571.581909
39	576.590027
40	581.598083
41	586.606323
42	591.61438
43	596.622498
44	601.630676
45	606.638794
46	611.646912
47	616.65509
48	621.663208
49	626.671326
50	631.679382
51	636.687622
52	641.695679
53	646.703796
54	651.711975
55	656.720093
56	661.72821
57	666.736328
58	671.744507
59	676.752625
60	681.760681
61	686.768921
62	691.776978
63	696.785095
64	701.793274
65	706.801392
66	711.809509
67	716.817627
68	721.825806
69	726.833923
70	731.84198
71	736.85022
72	741.858276
73	746.866394
74	751.874573
75	756.88269
76	761.890808
77	766.898926
78	771.907104
79	776.915222
80	781.923279
81	786.931519
82	791.939575
83	796.947693
84	801.955872
85	806.963989
86	811.972107
87	816.980225
88	821.988403
89	826.996521
90	832.004578
91	837.012817
92	842.020874
93	847.028992
94	852.03717
95	857.045288
96	862.053406
97	867.061523
98	872.069702
99	877.07782
100	882.085876
101	887.094116
102	892.102173
103	897.110291
104	902.118408
105	907.126587
106	912.134705
107	917.142822
108	922.151001
109	927.159119
110	932.167175
111	937.175415
112	942.183472
113	947.191589
114	952.199707
115	957.207886
116	962.216003
117	967.224121
118	972.2323
119	977.240417
120	982.248474
121	987.256714
122	992.264771
123	997.272888
124	1002.281006
125	1007.289185
126	1012.297302
127	1017.30542
128	1022.313599
129	1027.321655
130	1032.329834
131	1037.338013
132	1042.346069
133	1047.354248
134	1052.362305
135	1057.370483
136	1062.37854
137	1067.386719
138	1072.394897
139	1077.402954
140	1082.411133
141	1087.419312
142	1092.427368
143	1097.435547
144	1102.443604
145	1107.451782
146	1112.459961
147	1117.468018
148	1122.476196
149	1127.484253
150	1132.492432
151	1137.500488
152	1142.508667
153	1147.516846
154	1152.524902
155	1157.533081
156	1162.54126
157	1167.549316
158	1172.557495
159	1177.565552
160	1182.57373
161	1187.581787
162	1192.589966
163	1197.598145
164	1202.606201
165	1207.61438
166	1212.622559
167	1217.630615
168	1222.638794
169	1227.646851
170	1232.655029
171	1237.663086
172	1242.671265
173	1247.679443
174	1252.6875
175	1257.695679
176	1262.703857
177	1267.711914
178	1272.720093
179	1277.728149
180	1282.736328
181	1287.744385
182	1292.752563
183	1297.760742
184	1302.768799
185	1307.776978
186	1312.785156
187	1317.793213
188	1322.80127
189	1327.809448
190	1332.817627
191	1337.825684
192	1342.833862
193	1347.842041
194	1352.850098
195	1357.858276
196	1362.866455
197	1367.874512
198	1372.882568
199	1377.890747
200	1382.898926
201	1387.906982
202	1392.915161
203	1397.92334
204	1402.931396
205	1407.939575
206	1412.947754
207	1417.955811
208	1422.963867
209	1427.972046
210	1432.980225
211	1437.988281
212	1442.99646
213	1448.004639
214	1453.012695
215	1458.020874
216	1463.029053
217	1468.037109
218	1473.045166
219	1478.053345
220	1483.061523
221	1488.06958
222	1493.077759
223	1498.085938
224	1503.093994
225	1508.102173
226	1513.110352
227	1518.118408
228	1523.126465
229	1528.134644
230	1533.142822
231	1538.150879
232	1543.159058
233	1548.167236
234	1553.175293
235	1558.18335
236	1563.19165
237	1568.199707
238	1573.207764
239	1578.215942
240	1583.224121
241	1588.232178
242	1593.240356
243	1598.248535
244	1603.256592
245	1608.264648
246	1613.272949
247	1618.281006
248	1623.289063
249	1628.297241
250	1633.30542

Color Combinations

- Colors are at the heart of images and images are at the heart of remote sensing
- There are many ways to create a color image
  - A natural image is made up of Red-Green-Blue combinations that maps the image data to R-G-B computer colors
  - Natural (True Color Image) are the most common
    - Basically, you assign the Red to Red, Green to Green, and Blue to Blue (need some stretching at times)
  - But there are other interesting band combinations that could be displayed using other bands instead of the natural RGB. These are called **False Color Composite** (False to say they are not natural)

Landsat 8

Purpose	Band Combinations
Natural Color	R-G-B
False Color (Urban)	SWIR2-SWIR1-R
Color Infrared (Vegetation)	N-R-G
Agriculture	SWIR1-N-B
Atmospheric penetration	SWIR2-SWIR1-5
Healthy Vegetation	N-SWIR1-B
Land/Water	N-SWIR1-R
Natural With Atmospheric Removal	SWIR2-N-G
Shortwave Infrared	SWIR2-N-R
Vegetation Analysis	SWIR1-N-R

Landsat 8/9		
Band Name	Bandwidth (µm)	Resolution (m)
Band 1 Coastal	0.43 – 0.45	30
Band 2 Blue	0.45 – 0.51	30
Band 3 Green	0.53 – 0.59	30
Band 4 Red	0.64 – 0.67	30
Band 5 NIR	0.85 – 0.88	30
Band 6 SWIR 1	1.57 – 1.65	30
Band 7 SWIR 2	2.11 – 2.29	30
Band 8 Pan	0.50 – 0.68	15
Band 9 Cirrus	1.36 – 1.38	30
Band 10 TIRS 1	10.6 – 11.19	100
Band 11 TIRS 2	11.5 – 12.51	100

Landsat 8/9		
Band Name	Bandwidth (µm)	Resolution (m)
Band 1 Coastal	0.43 - 0.45	30
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Band 4 Red	0.64 - 0.67	30
Band 5 NIR	0.85 - 0.88	30
Band 6 SWIR-1	1.57 - 1.65	30
Band 7 SWIR-2	2.11 - 2.29	30
Band 8 Pan	0.50 - 0.68	15
Band 9 Cirrus	1.36 - 1.38	30
Band 10 TIRS-1	10.6 - 11.19	100
Band 11 TIRS2	11.5 - 12.51	100

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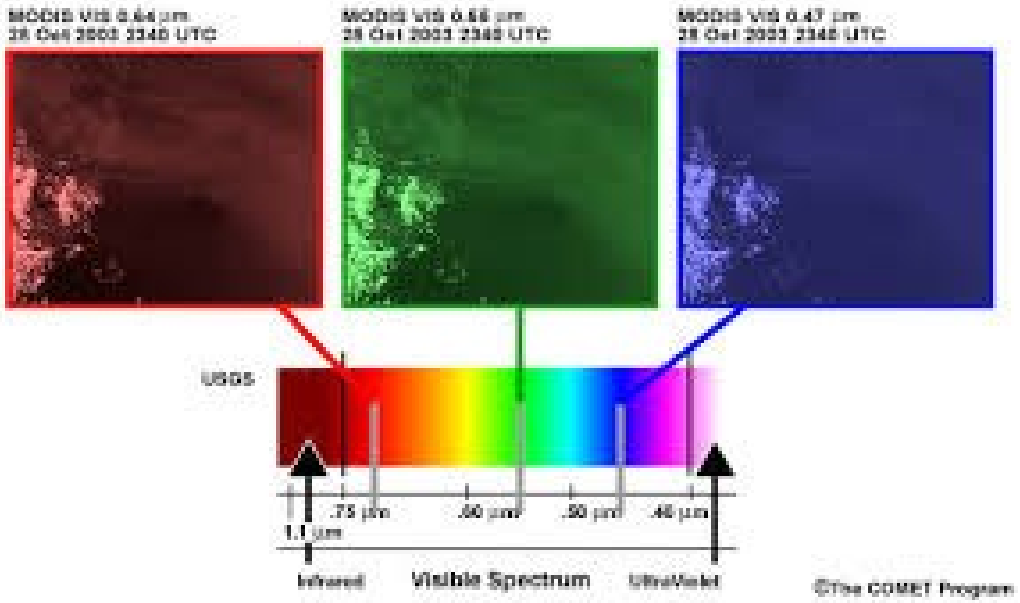
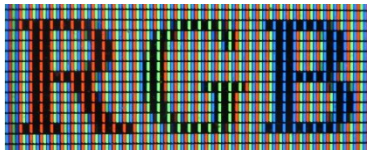




There are two Images

- Green Valley, AZ

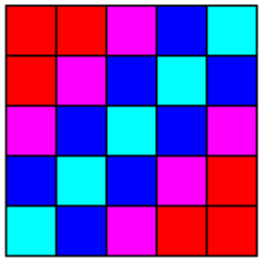
- Harvard Forest

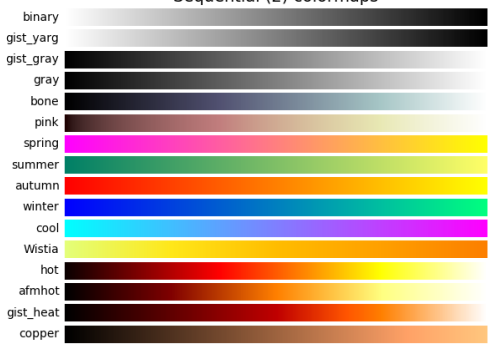
Color Assignment or Indexing ≠ FCC

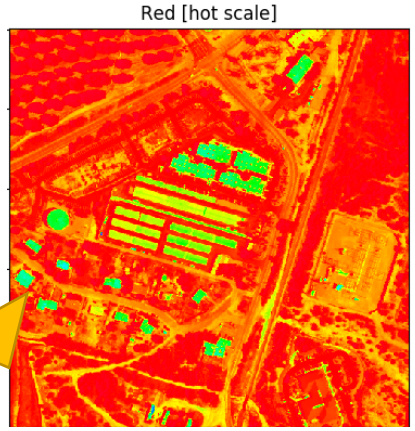
- The color of each **pixel** is represented by a number; each number (the *index*) corresponds to a color in the color table (the ***palette***).

0	0	1	2	3
0	1	2	3	2
1	2	3	2	1
2	3	2	1	0
3	2	1	0	0

0 =
1 =
2 =
3 =

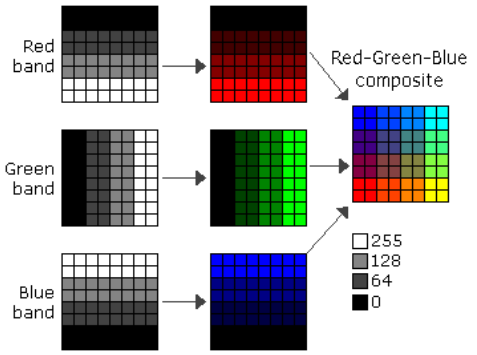






Exercise #1: Color Images

- Read Hyperspectral data
  - Read bands from a BSQ file
    - We will learn what a BSQ file is later
    - BSQ stands for Band Sequential (meaning all pixels for one band are stored first, then next band, etc.)
- Create some images from this data
  - Gray scale Image which is the norm (grey level depict signal strength or sensed energy by the sensor)
  - Colored greyscale images (assigning a color ramp to the grey levels) to make it easier to interpret
    - This is indexed Color Images
  - True color composite (RGB)
    - A true-color image resemble natural colors
  - False color composite (any combination of bands assigned to RGB)
    - A false-color is a way to emphasize a particular object or land features



- **Homework**:
  - Can you add/display a **color legend** next to the image? – Search the web for help
  - Try different band combinations and explain what is happening (see the previous slide)
    - Recall how green vegetation reflects in the NIR region, try to assign the NIR to one of the RGB colors (Ex: Red), and see what the image will look like?

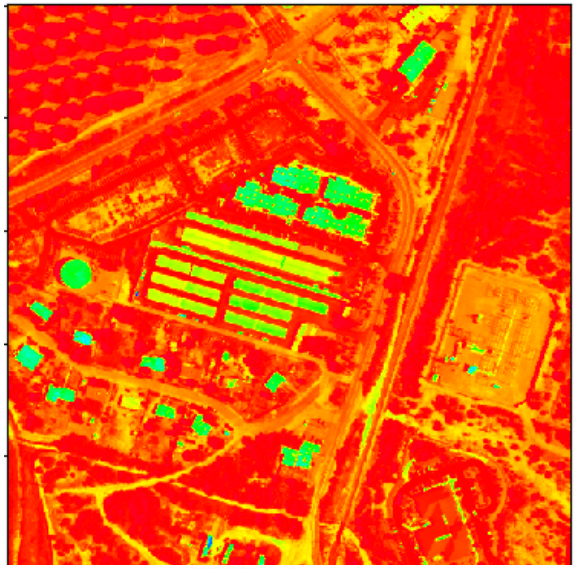
Instructions:

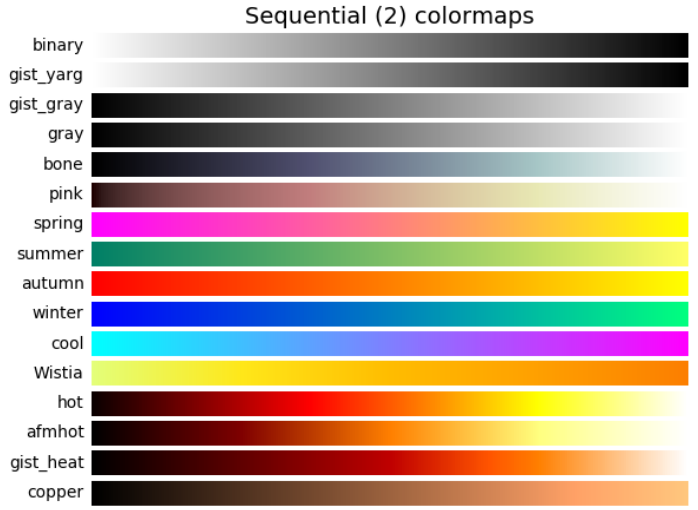
- From D2L download these files:
  - GreenValley.jpg or HarvardForest.jpg
  - NEON_GreenValley.bsq or NEON_HarvardForest.bsq [NEON Sensor Data]
  - BE484-585-Lab4-Ex1.ipynb [Notebook that you will work with and modify]

Color Ramp/Scale for Grey Level Images

Red [gray scale]

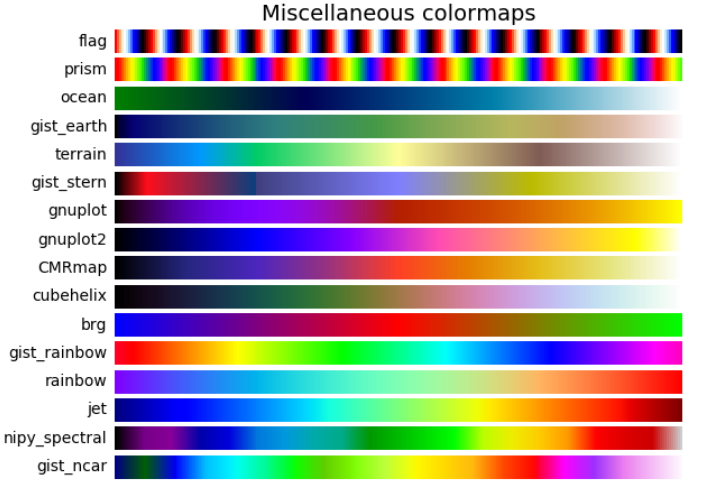
Red [hot scale]





RGB True color

MNR False color



https://matplotlib.org/tutorials/colors/colormaps.html

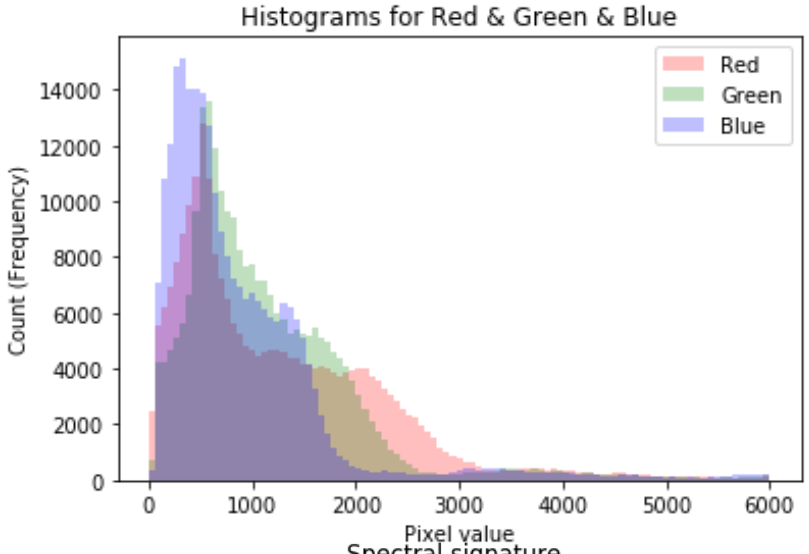
Exercise #2 : Exploring & Plotting Your Image & Data

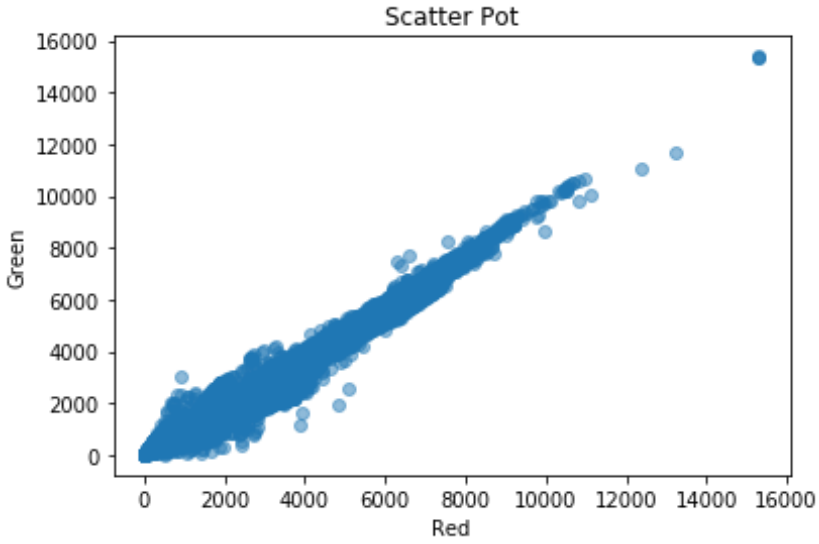
- **Data Input**
  - Read a BSQ file(s) (file Ex1)
  - Read a text file (provides information about the bands and their wavelengths) so you can use as labels
- **Plots**
  - **Histograms** (how the data is distributed)
    - What is the most common data/value for example
  - **Scatter Plots**
    - Capture how data and bands correlate with each other (this is useful to understand covariance and redundancy)
    - Linear regression with a Machine Learning algorithm (Sklearn library)
    - Generate the prediction model form this linear regression
  - **Spectral signature plots**
    - We've looked at this in class and this is one of the main basis for Remote Sensing
      - So be creative and explore different locations (pixel locations) in the image
    - Each object has a specific signature (a curve that illustrates how it interacts with radiation/energy)
- **Homework**
  - What kind of information these plots capture? Explain?
  - Create a scatter plot of RED vs NIR band (or any other combination)
  - Create a semi-simulated image from predicted spectral bands
  - Create spectral signature plots for:
    - A Vegetated pixel, Asphalt, Soil, Roof, Water, etc . (you will need the Row x Column location)

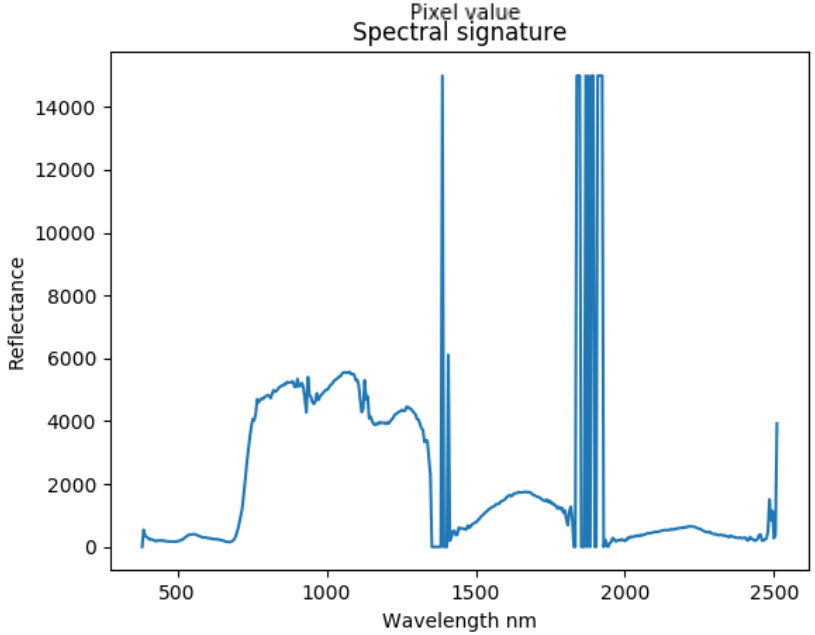
Instructions:

- Download from D2L files:
  - NEON_GreenValley.bsq or NEON_HarvardForest.bsq [NEON Sensor Data]
  - NEON_wavelength_values.txt
  - BE484-585-Lab4-Ex2.ipynb

Exercise #2 : Example outputs



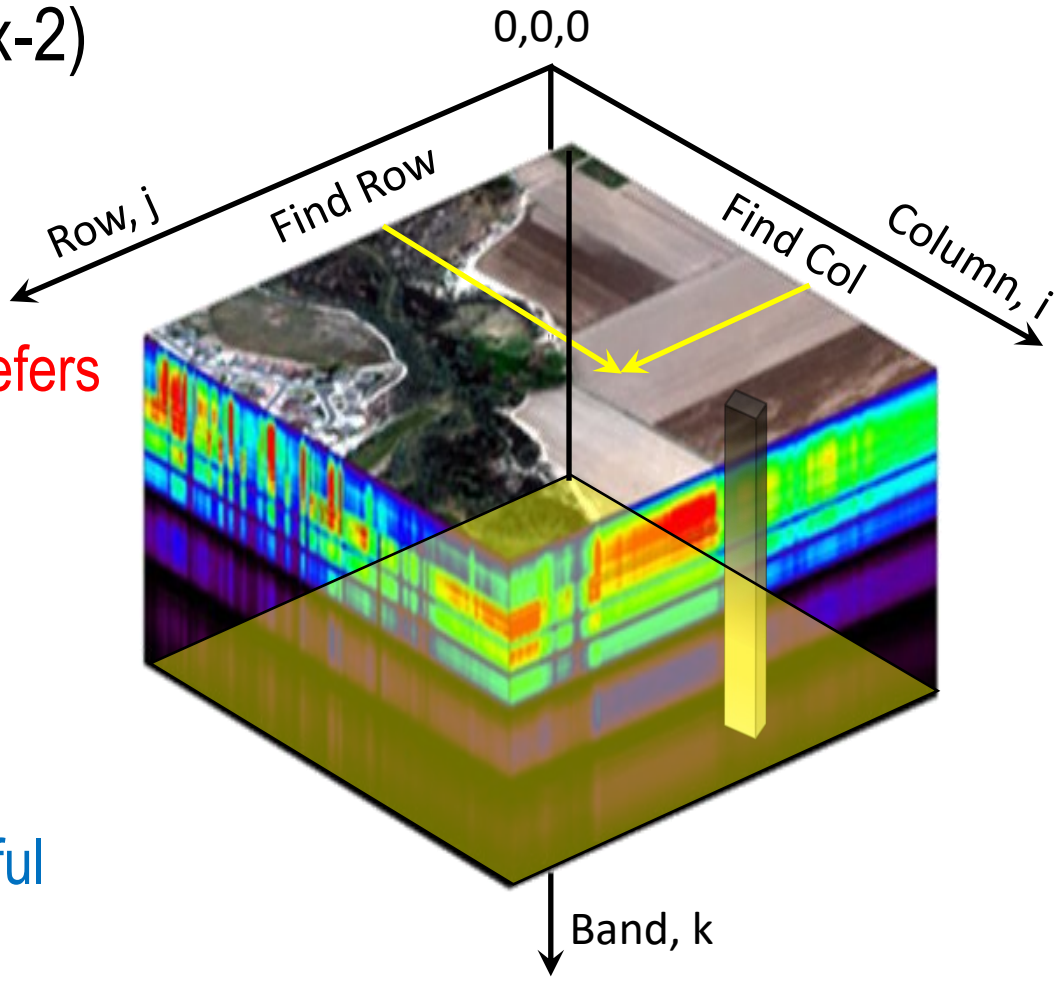




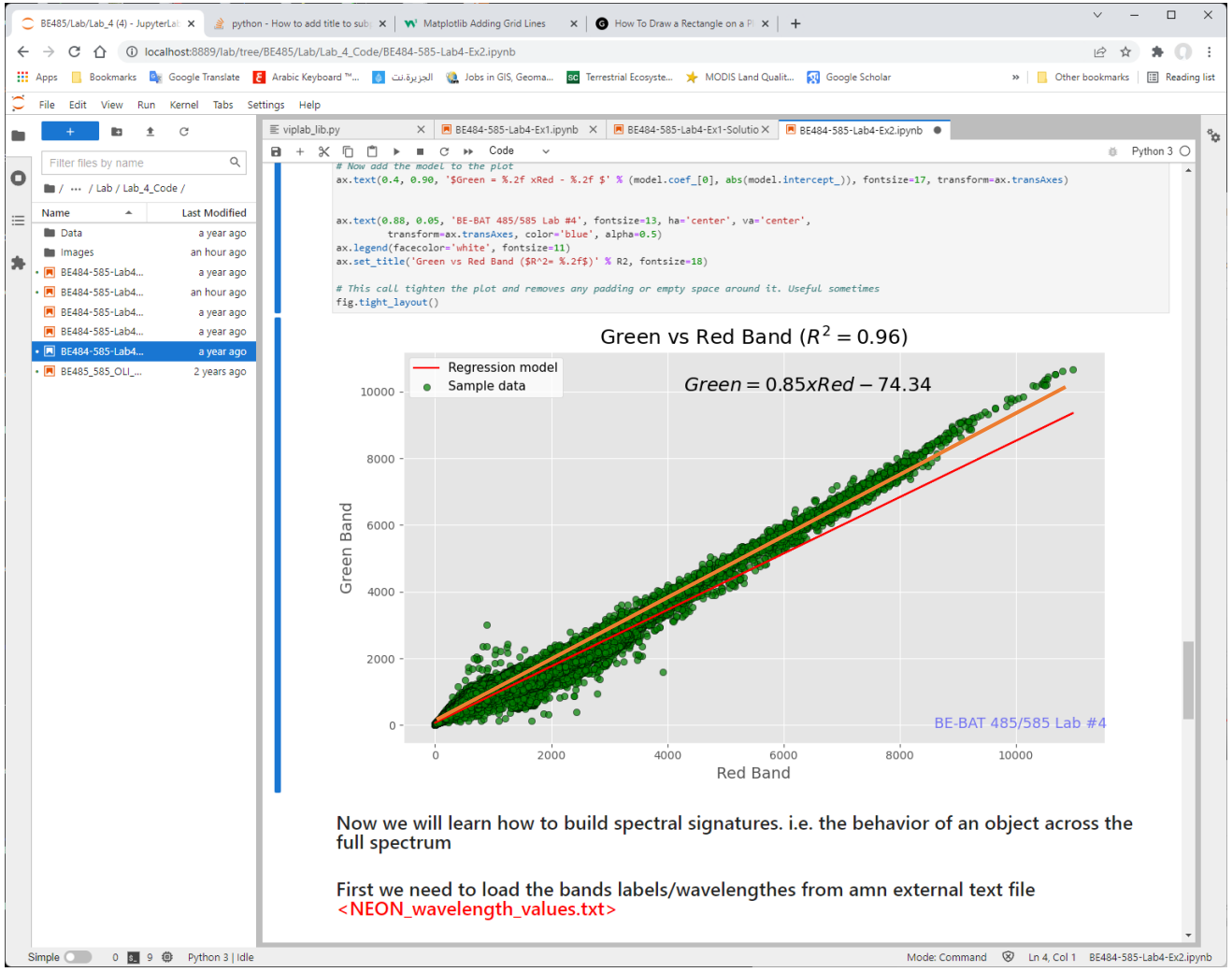
Be creative and label your figures and plots properly and use colors.

You Should Notice

- The (spectral signature, Ex-2) code has the following
  - DataAll [35,78,:]
  - DataAll [205,67,:]
  - Can you guess what this refers to?



- This is called array slicing
  - Please read about it (see reference material on D2L)
  - It is very useful and powerful


BE485/Lab/Lab_4 (4) - JupyterLab
python - How to add title to sub
Matplotlib Adding Grid Lines
How To Draw a Rectangle on a P
localhost:8889/lab/tree/BE485/Lab/Lab_4_Code/BE484-585-Lab4-Ex2.ipynb
File Edit View Run Kernel Tabs Settings Help
Filter files by name
/ Lab / Lab_4_Code /
Name
Last Modified
Data a year ago
Images an hour ago
BE484-585-Lab4... a year ago
BE484-585-Lab4... an hour ago
BE484-585-Lab4... a year ago
BE484-585-Lab4... a year ago
BE484-585-Lab4... a year ago
BE485_585_OLI_... 2 years ago
viplab_lib.py
BE484-585-Lab4-Ex1.ipynb
BE484-585-Lab4-Ex1-Solutio
BE484-585-Lab4-Ex2.ipynb
Code
Python 3
# Now add the model to the plot
ax.text(0.4, 0.90, '$Green = %.2f xRed - %.2f $' % (model.coef_[0], abs(model.intercept_)), fontsize=17, transform=ax.transAxes)
ax.text(0.88, 0.05, 'BE-BAT 485/585 Lab #4', fontsize=13, ha='center', va='center',
transform=ax.transAxes, color='blue', alpha=0.5)
ax.legend(facecolor='white', fontsize=11)
ax.set_title('Green vs Red Band ($R^2= %.2f$)' % R2, fontsize=18)
# This call tighten the plot and removes any padding or empty space around it. Useful sometimes
fig.tight_layout()
Green vs Red Band ($R^2 = 0.96$)
Regression model
Sample data
$Green = 0.85xRed - 74.34$
Green Band
Red Band
BE-BAT 485/585 Lab #4
Now we will learn how to build spectral signatures. i.e. the behavior of an object across the full spectrum
First we need to load the bands labels/wavelengthes from amn external text file
<NEON_wavelength_values.txt>
Simple
Python 3 | Idle
Mode: Command
Ln 4, Col 1
BE484-585-Lab4-Ex2.ipynb