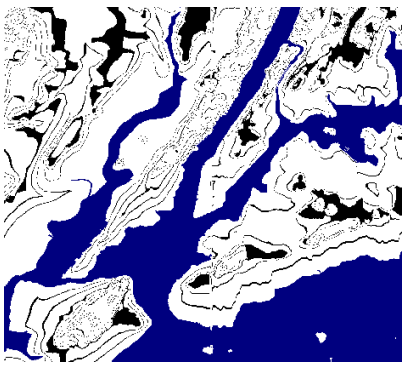
MfA: Python in the City

Katherine St. John
City University of New York
American Museum of Natural History

Outline



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- Workshop Overview
- Design Challenge: Flood Maps
  - Data: Elevations from NOAA
  - Packages: `numpy` and `pyplot`
  - Concepts: Colors and Arrays
  - Putting It Altogether
- Break
- Variations on the Theme
- Design a Challenge
- Wrap Up

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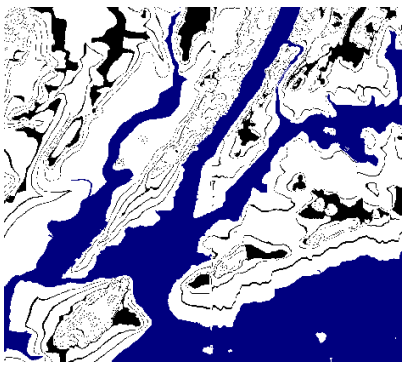

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Welcome and Introductions

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- Postdoctoral Work at University of Texas and University of Pennsylvania
- PhD, UCLA
- MA, Johns Hopkins University
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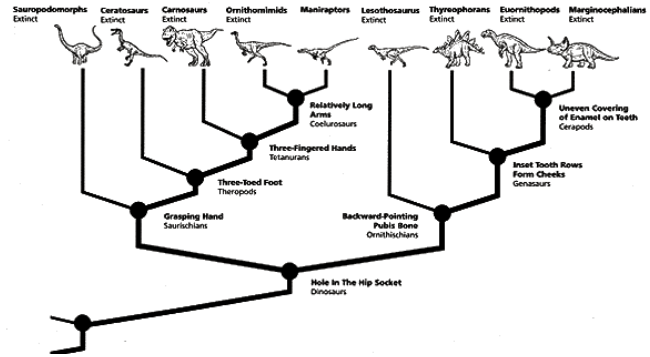

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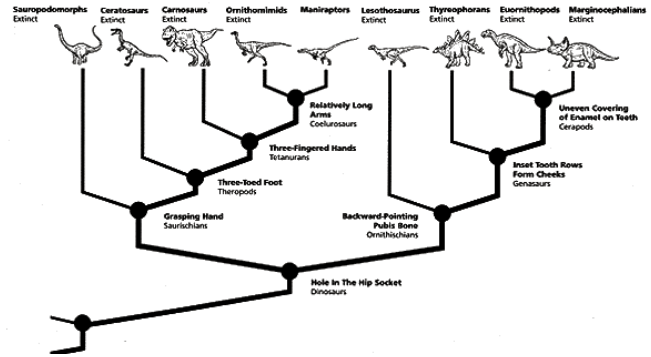

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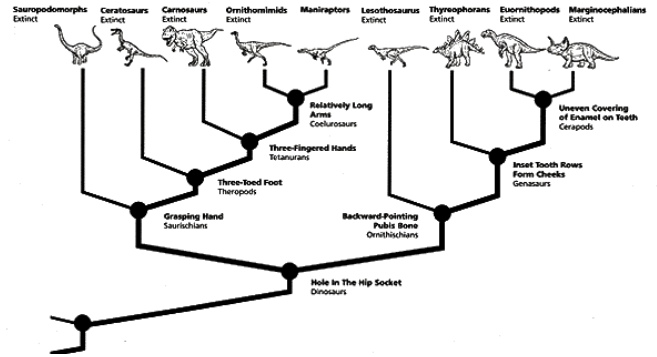

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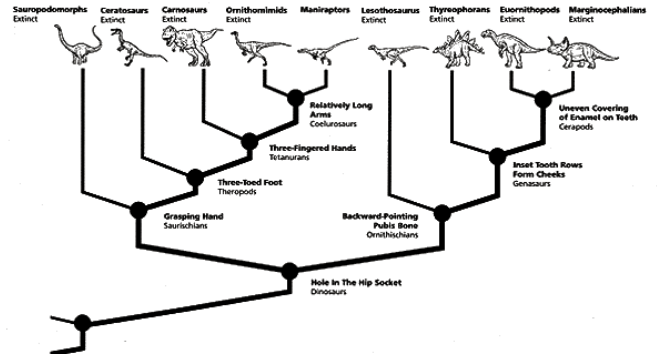

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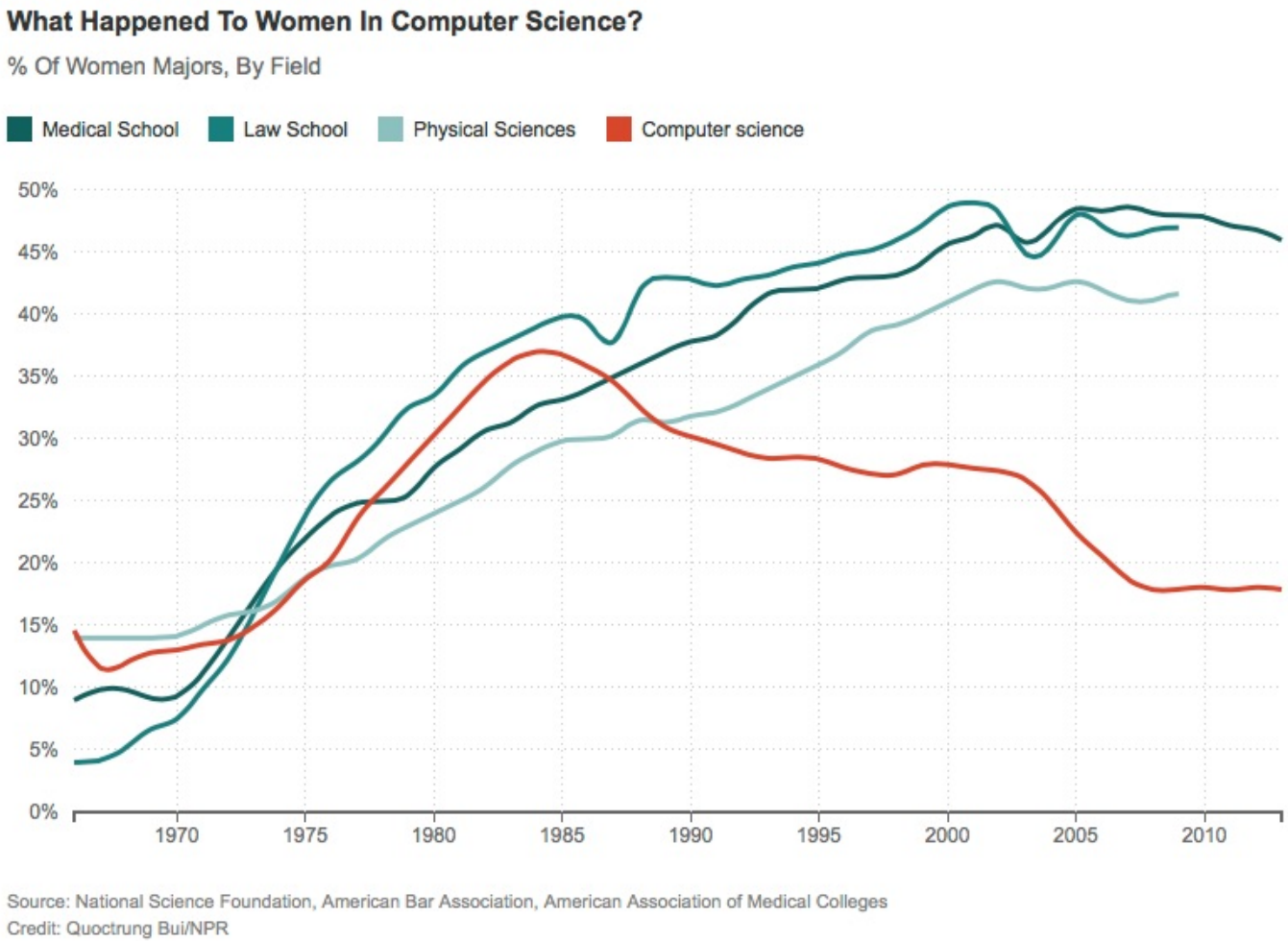
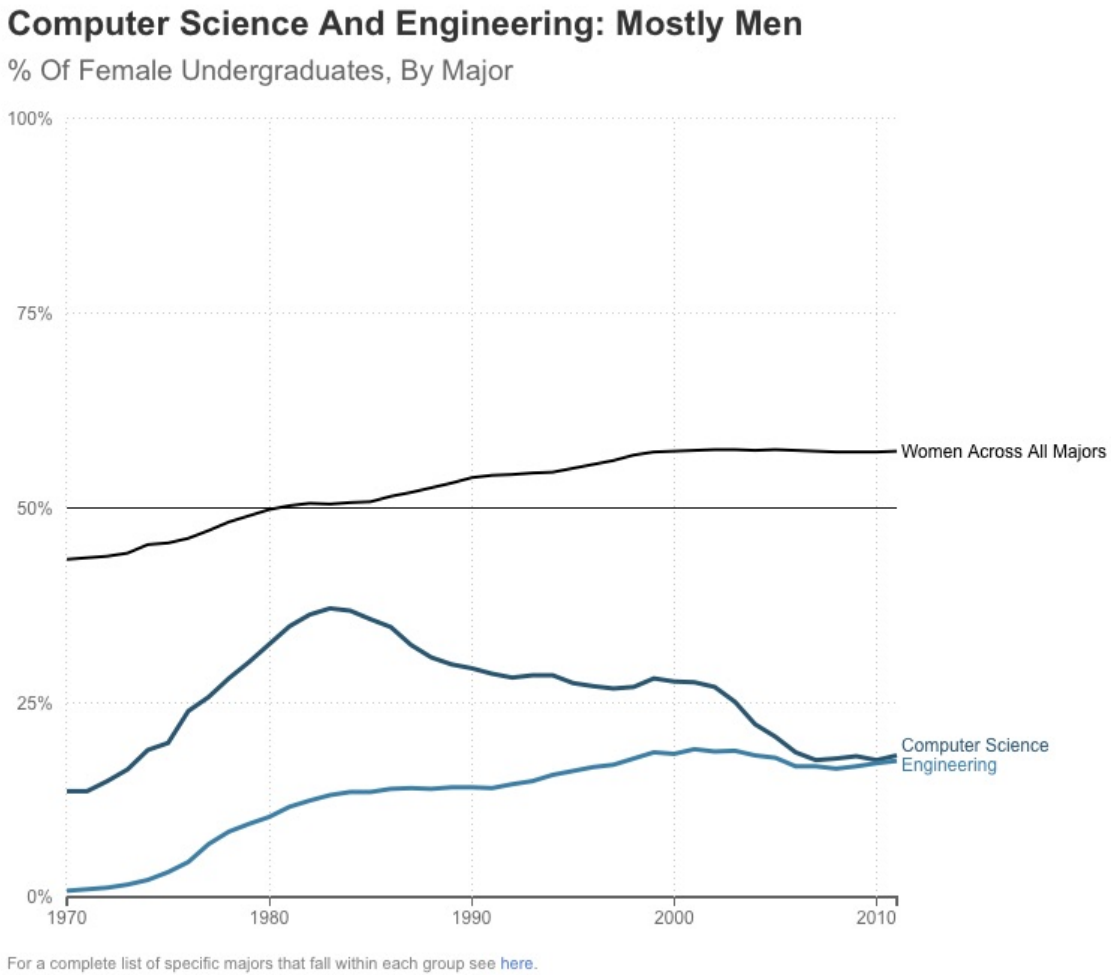
Why: Historical Trends: Women Majors



NPR Planet Money, October 2014

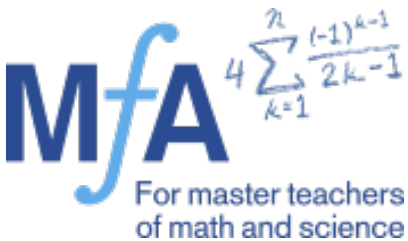
Why: Historical Trends: Computer Science & Engineering



NPR Planet Money, October 2014

Introductions

Your name, what you teach, and something you're passionate about...



Adam	Bradley	Brandon	Brian
Christa	Conor	Daisy	David
Derek	George	Izagma	Joshua
Julia	Katie	Laura	Luis
Marisa	Matthew	Michael	Paul
Peter	Tom	Thomas	Topher

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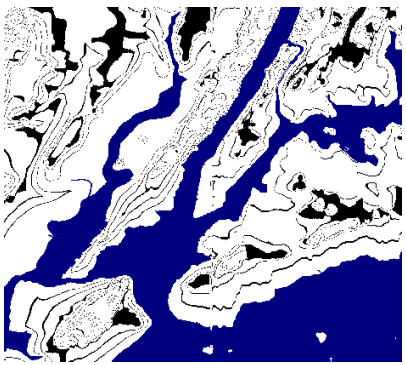

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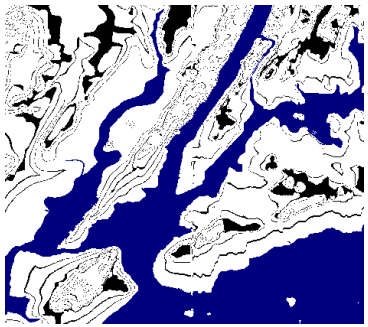

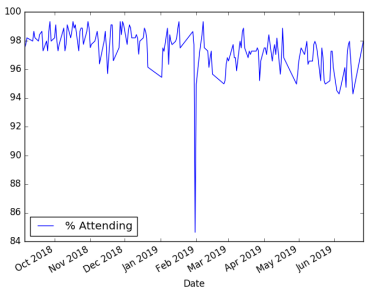

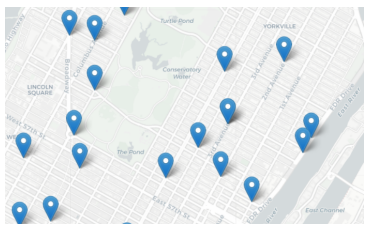

Three sessions:

1. Flood Maps (arrays & images)
2. Noisiest Street (structured data, file I/O)
3. Mapping Collisions (using objects, mapping coordinates)

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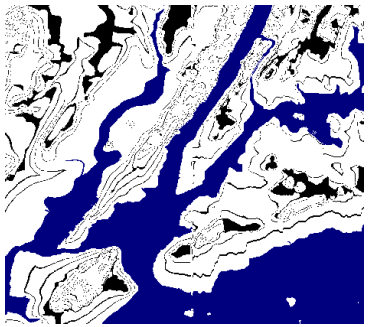

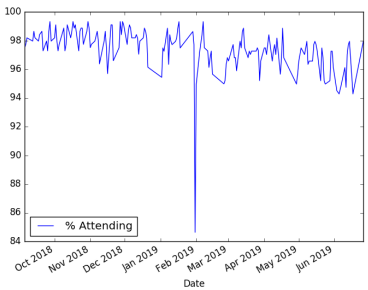

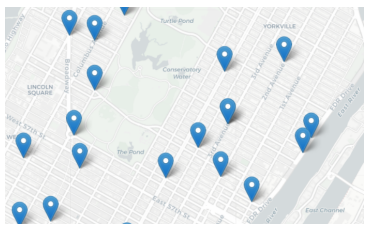

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1. Flood Maps (arrays & images)
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Each session:

- Design Challenge
  - Analyze a publicly available dataset
  - Introduce computing concepts & packages
  - Write a program to solve the problem
- Variations on the theme
- Design a Challenge

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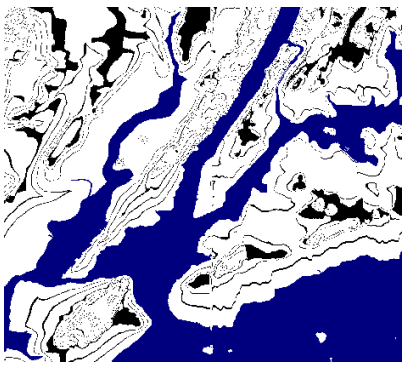

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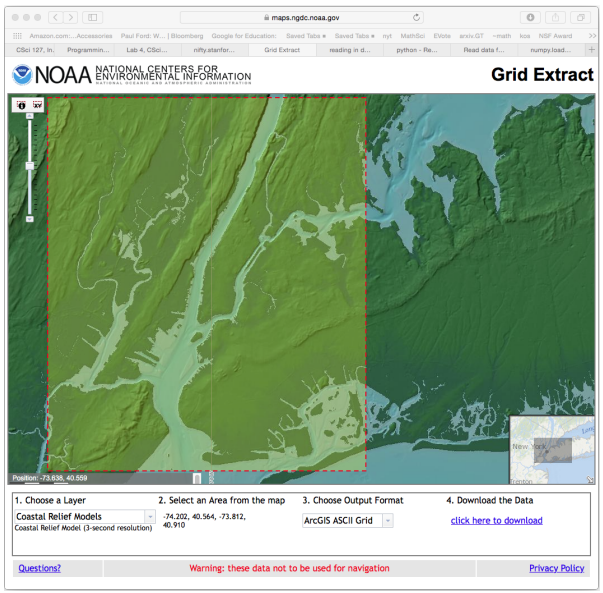

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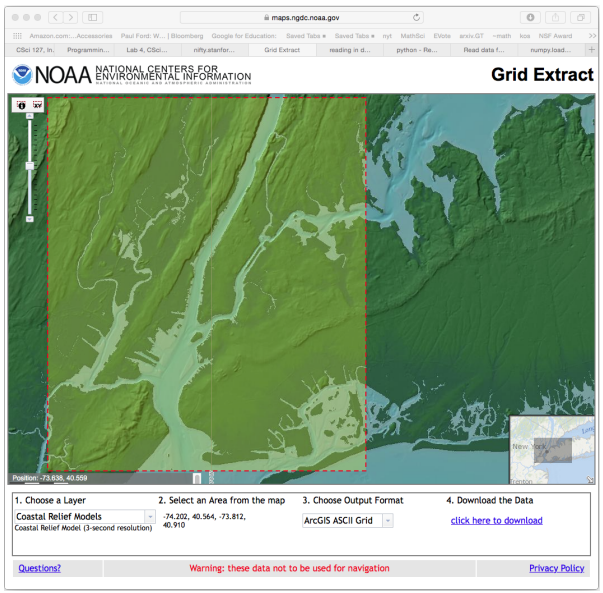
How much of New York City (and surrounds) will be flooded in the next big storm?

Design Challenge: Flood Maps



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> *How much of New York City (and surrounds) will be flooded in the next big storm?*

Some questions to discuss with your group to get started:

- What is the input? What data would you need to determine flooding?
- What is the output? How can you best present your results?

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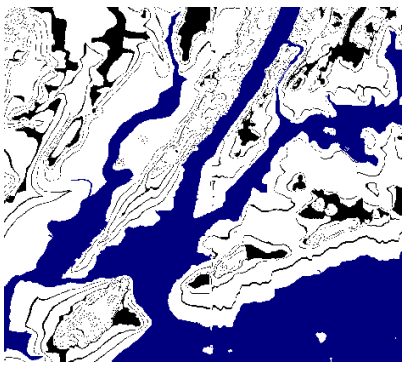

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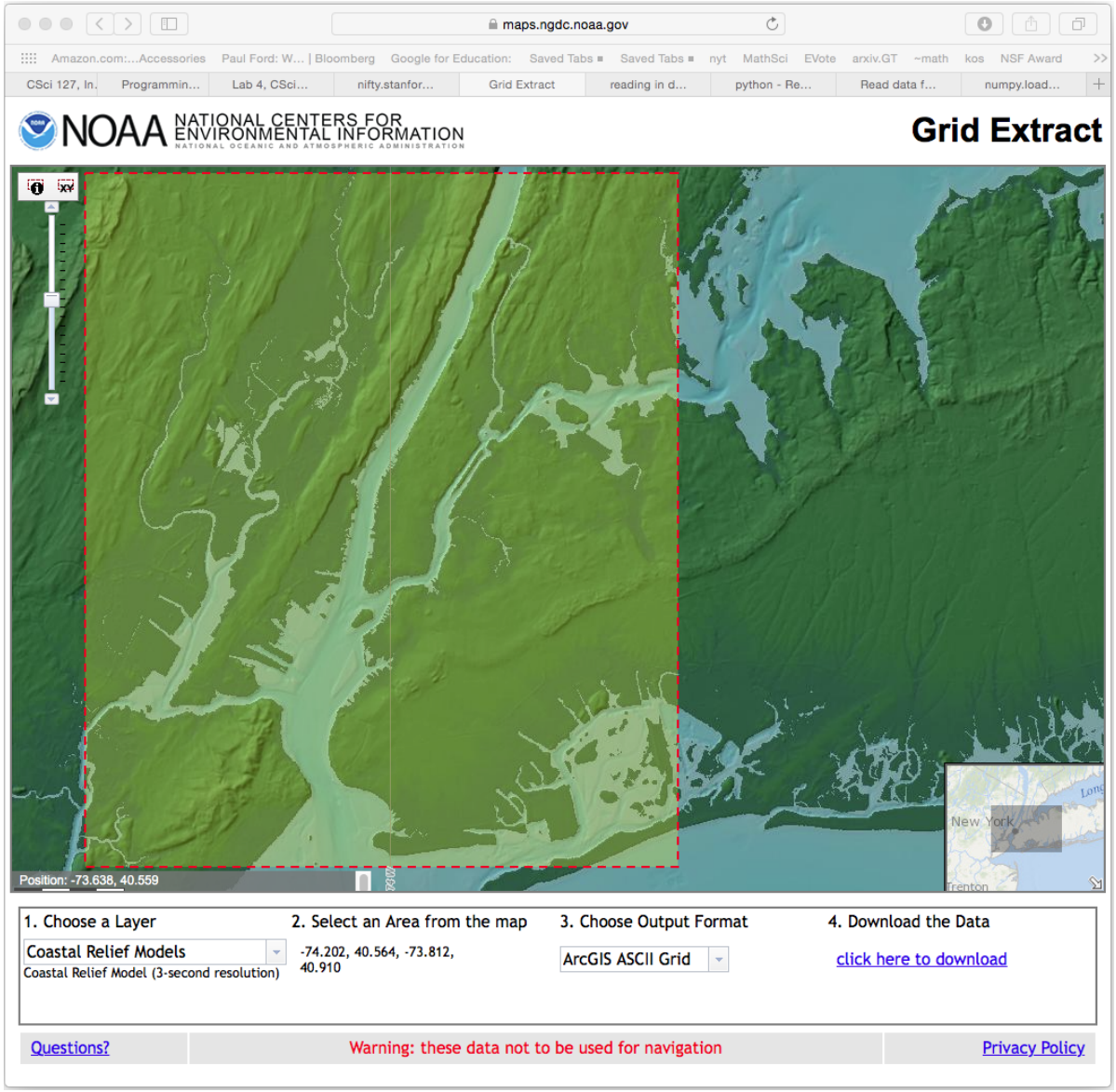

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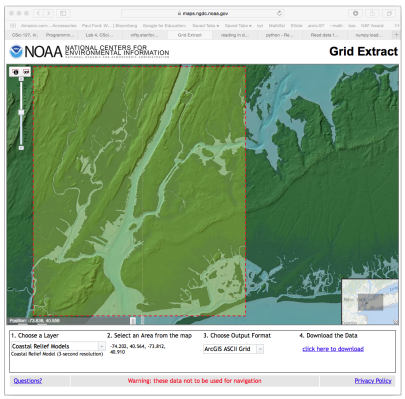

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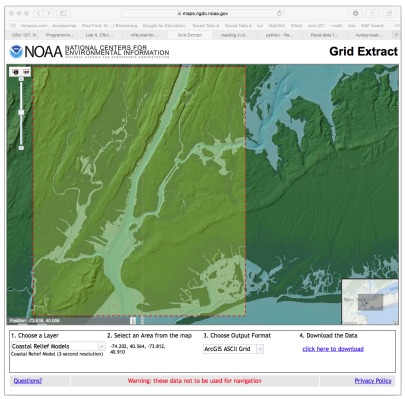

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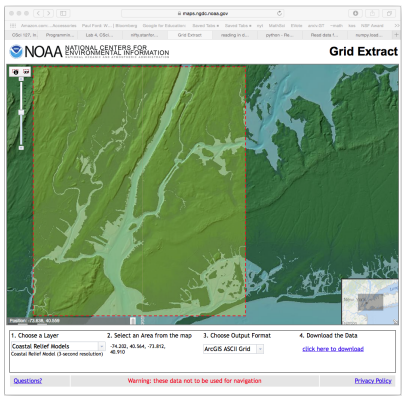

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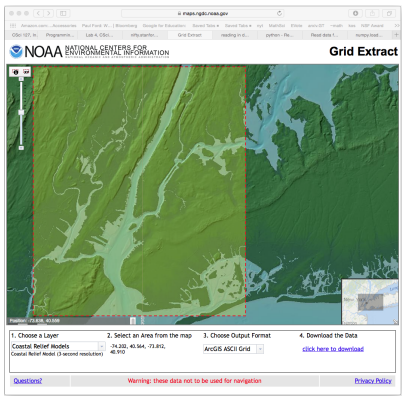

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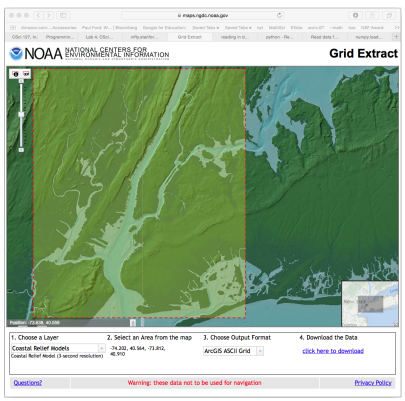

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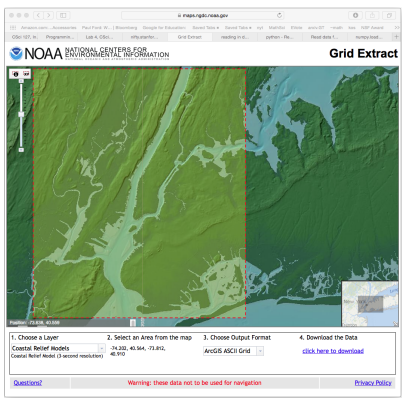

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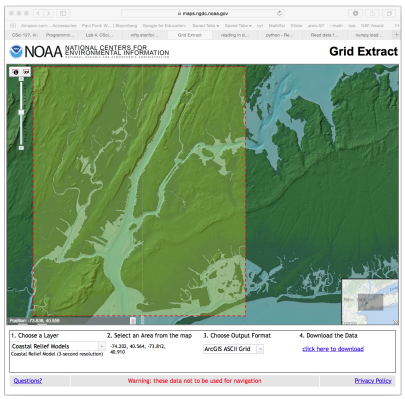

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- Open in text editor and delete metadata (5 lines: # of rows and Columns, lat, lon) and rename as a text file, `elevationsNYC.txt`.

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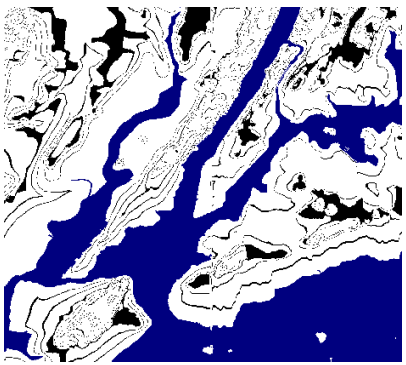

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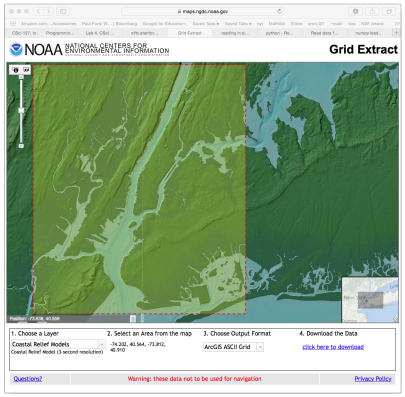

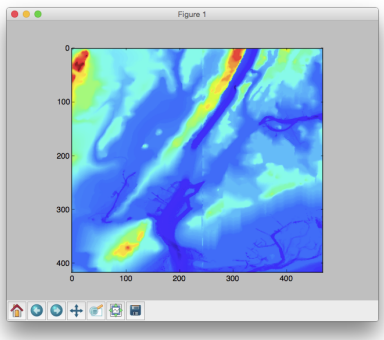

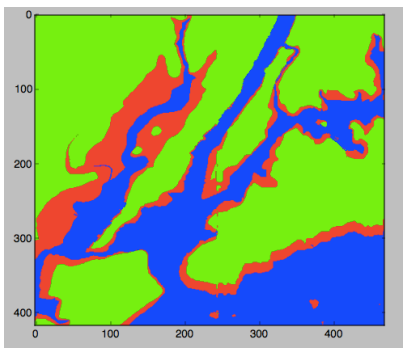

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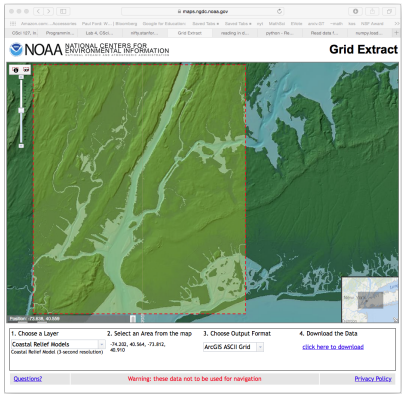

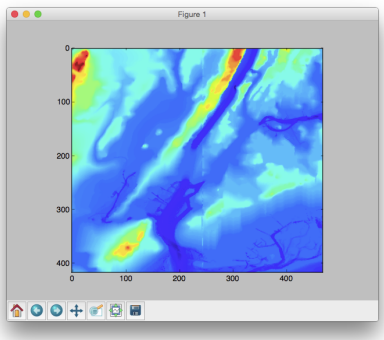

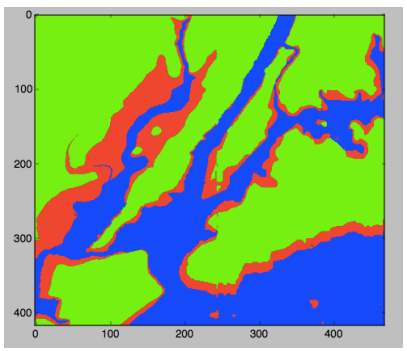

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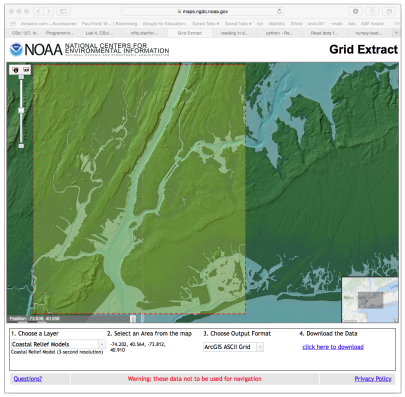
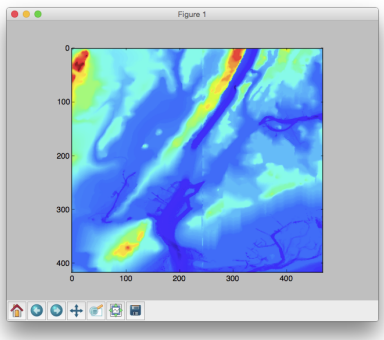
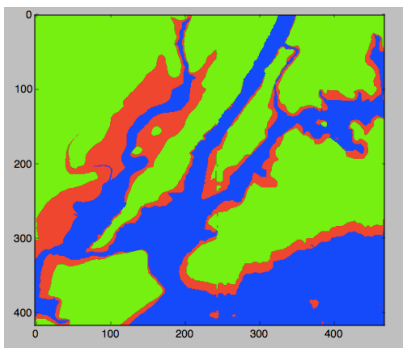
- `numpy`: numerical analysis package

Useful Packages: `numpy` and `pyplot`







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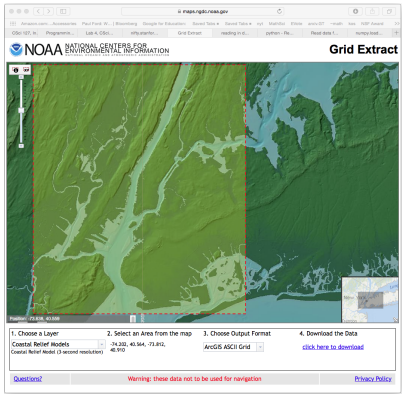
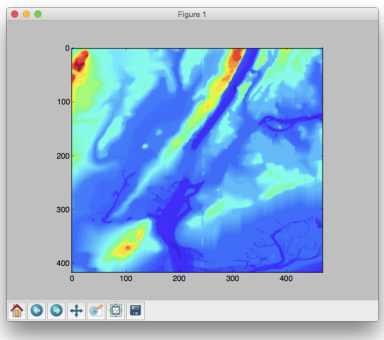
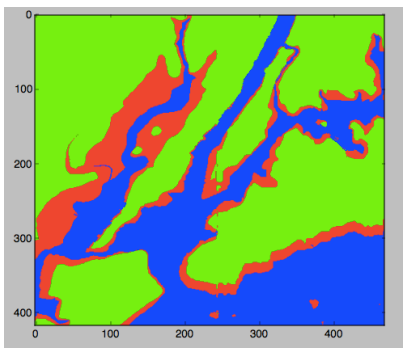
- Standard abbreviation: `np`

Useful Packages: `numpy` and `pyplot`







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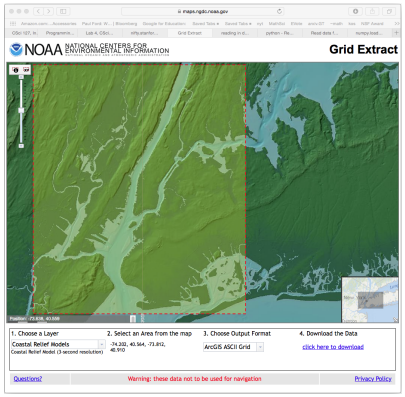
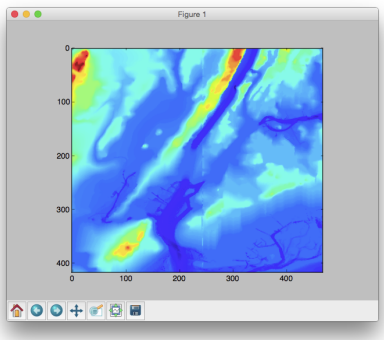
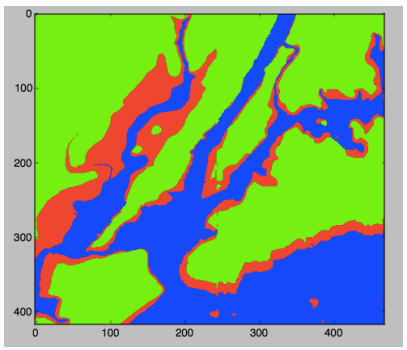
Useful Packages: `numpy` and `pyplot`







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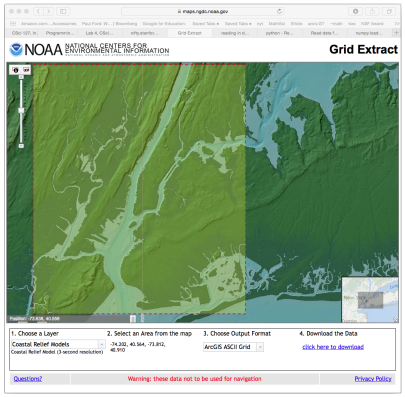
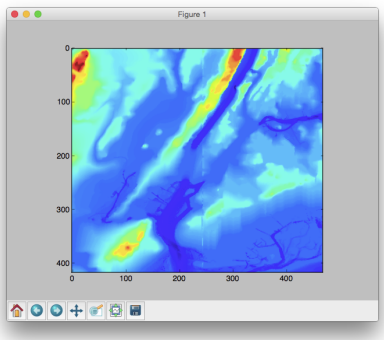
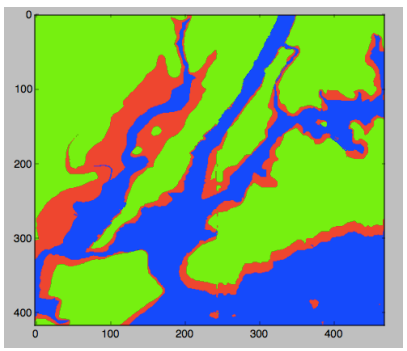
- `pyplot`: part of `matplotlib` for making graphs and plots

Useful Packages: `numpy` and `pyplot`







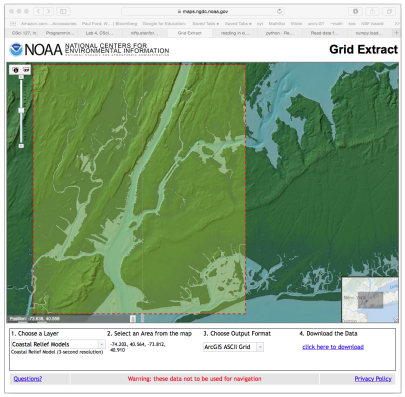
We will use two popular packages:

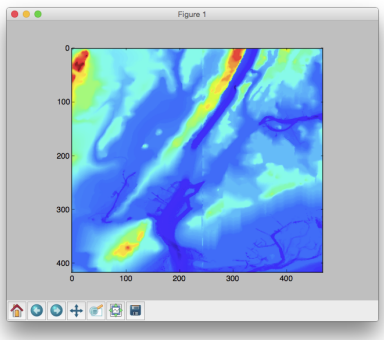
- `numpy`: numerical analysis package
- Standard abbreviation: `np`

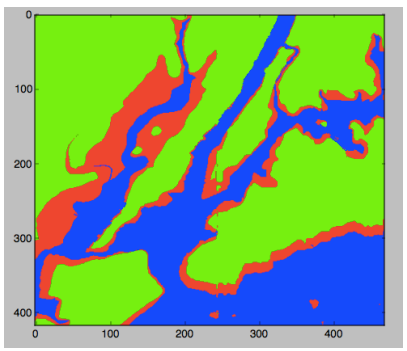
```
import numpy as np
```

- `pyplot`: part of `matplotlib` for making graphs and plots
- Standard abbreviation: `plt`

Useful Packages: `numpy` and `pyplot`







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```
import numpy as np
```

- `pyplot`: part of `matplotlib` for making graphs and plots
- Standard abbreviation: `plt`

```
import matplotlib.pyplot as plt
```

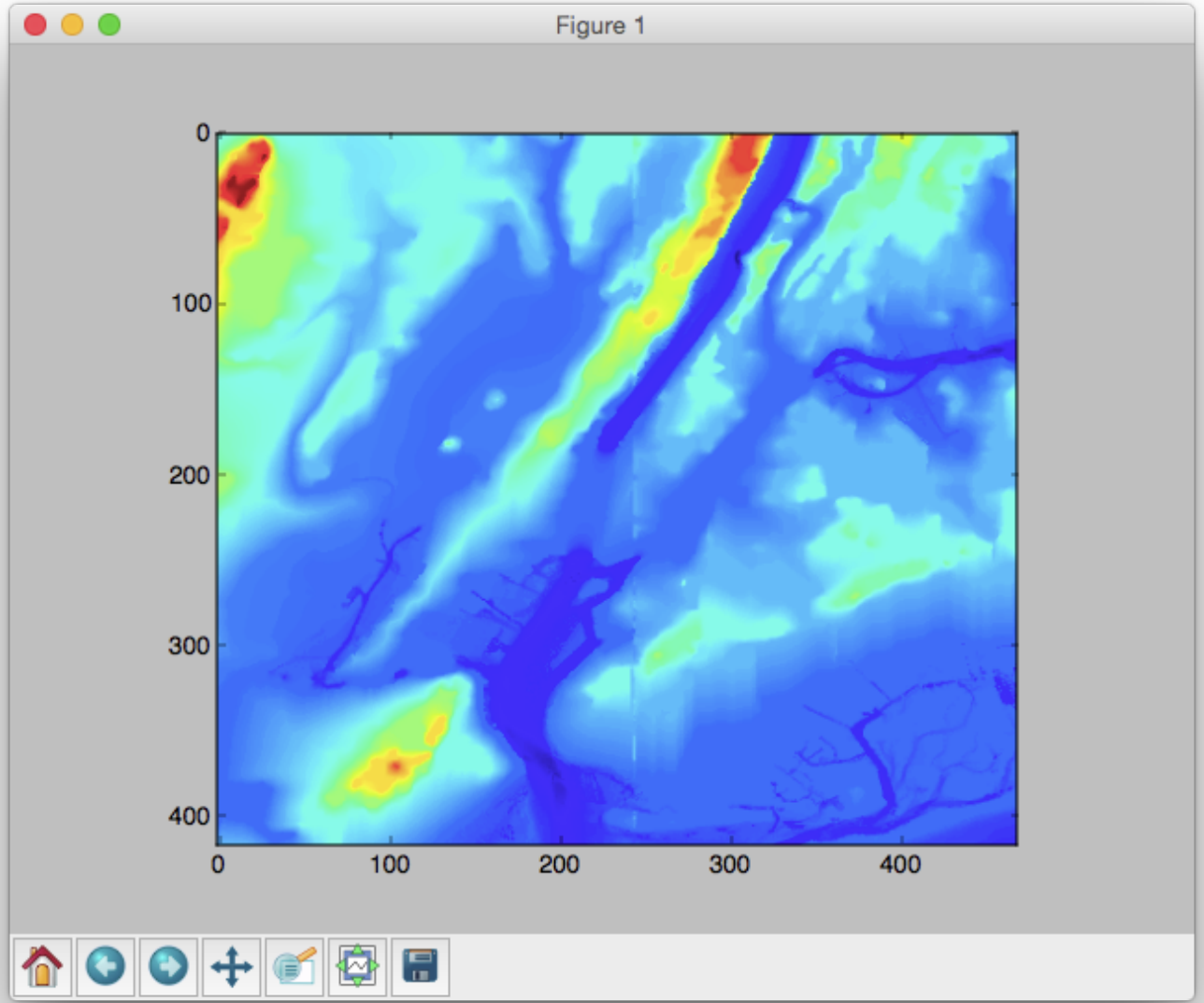
Your Turn: Using `plt`

Open IDLE (or favorite editor), and create the following short program:

```
#Import the libraries for arrays and displaying images:
import numpy as np
import matplotlib.pyplot as plt

#Read in the data to an array, called elevations:
elevations = np.loadtxt('elevationsNYC.txt')

#Load the array into matplotlib.pyplot:
plt.imshow(elevations)

#Display the plot:
plt.show()
```

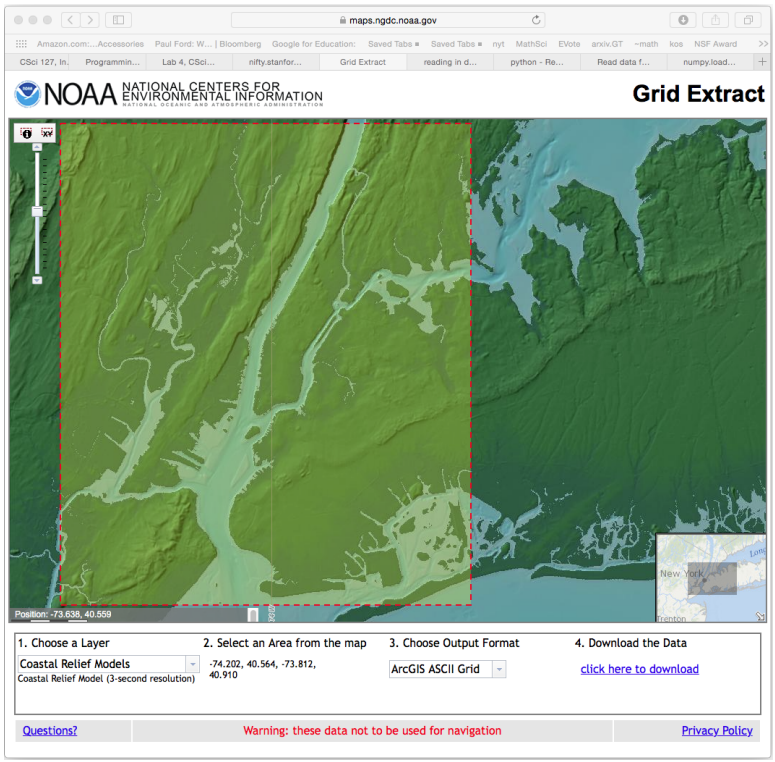
Your Turn: Using `plt`

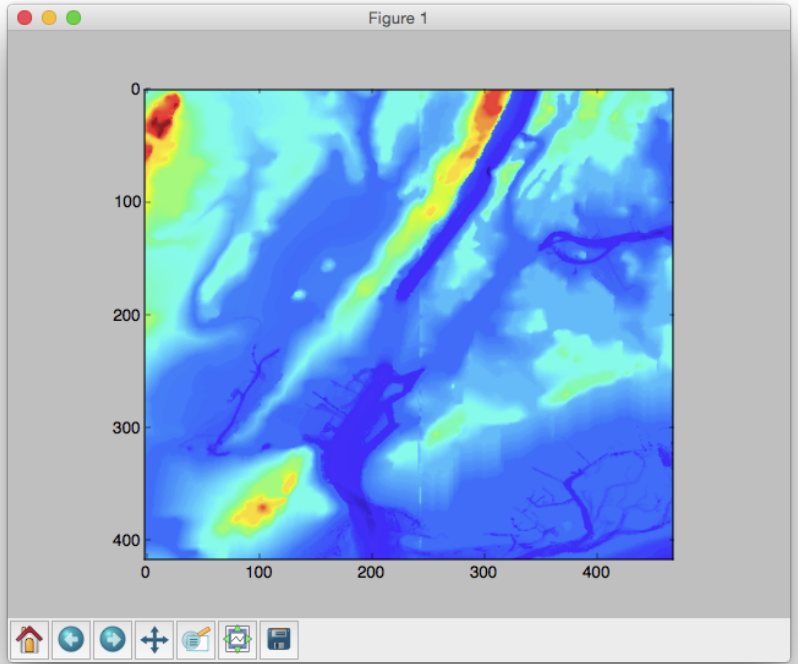
Run your program:



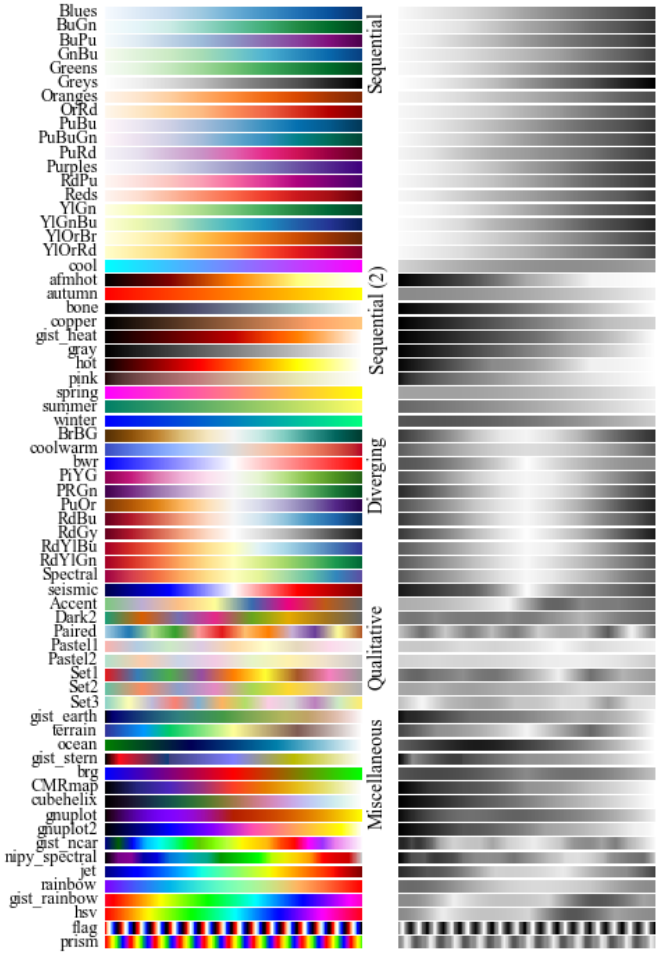
Color Maps

Comparing the NOAA image with the one you created:





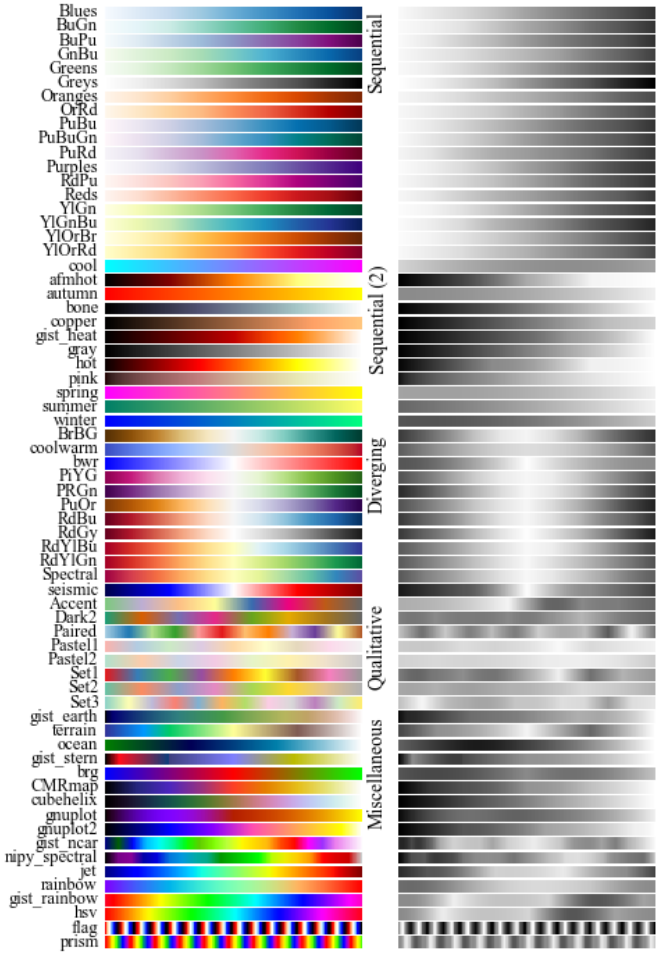
Color Maps



astrodsg blog

- The default ('jet') for displaying arrays is a color map that assigns:

Color Maps



astrodsg blog

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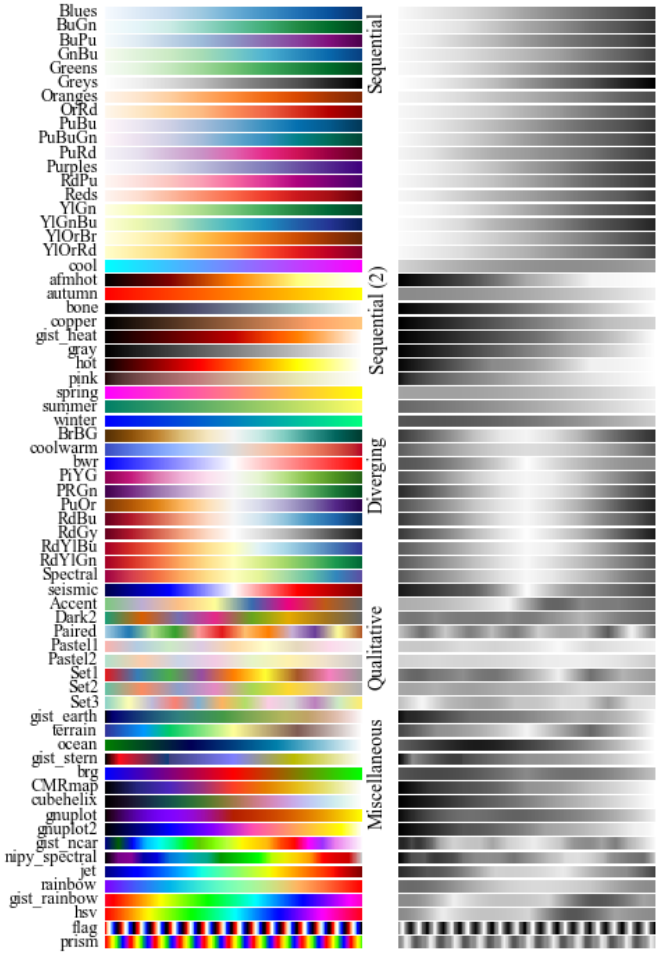
Color Maps



astrodsg blog

- The default ('jet') for displaying arrays is a color map that assigns:
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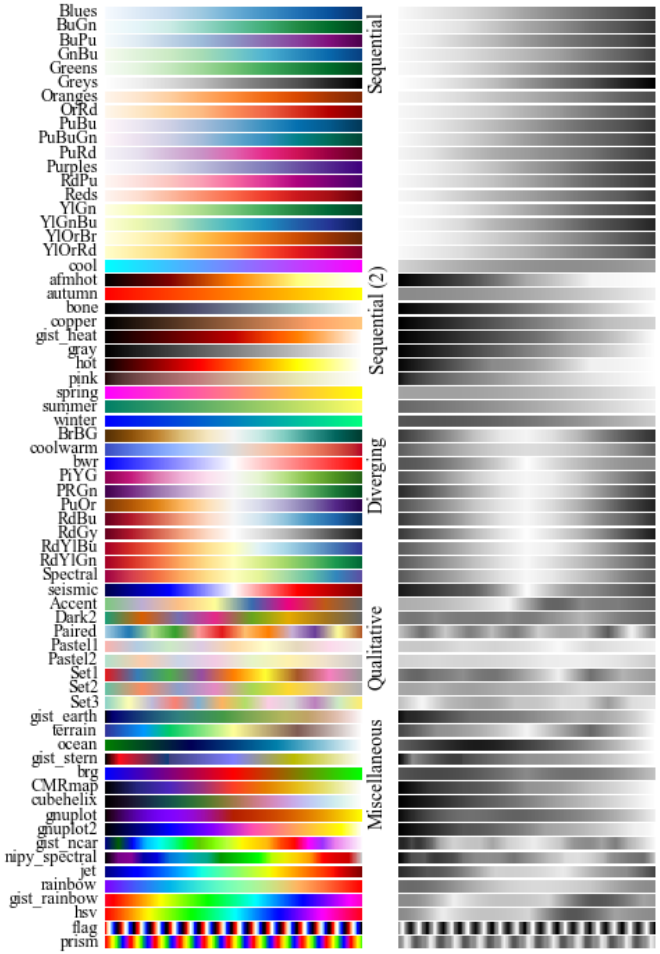
  - the highest values are red, and

Color Maps



astrodsg blog

- The default ('jet') for displaying arrays is a color map that assigns:
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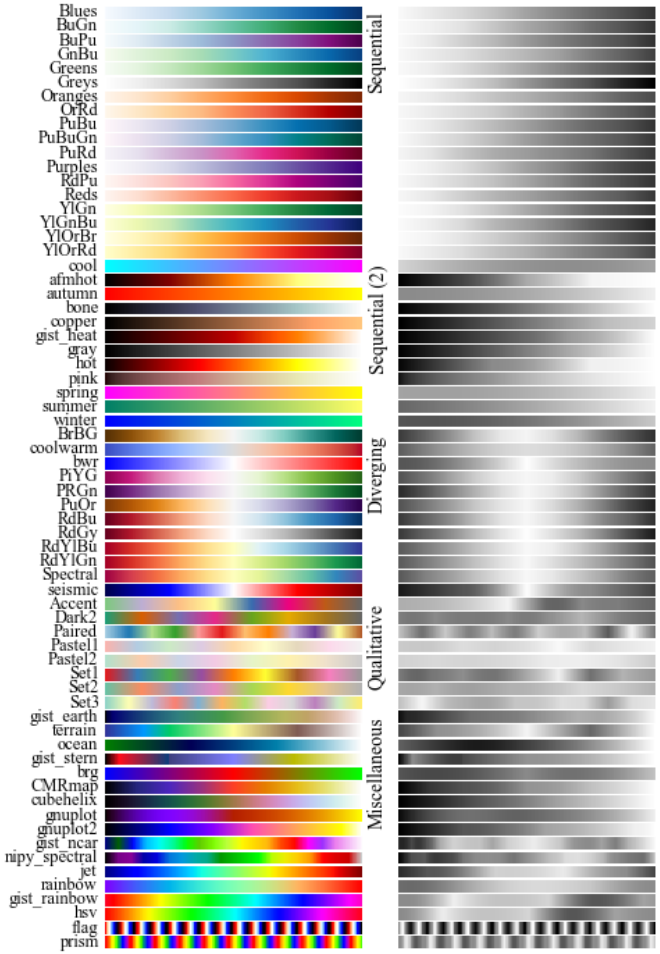
  - smoothly map the values in between.

Color Maps



astrodsg blog

- The default ('jet') for displaying arrays is a color map that assigns:
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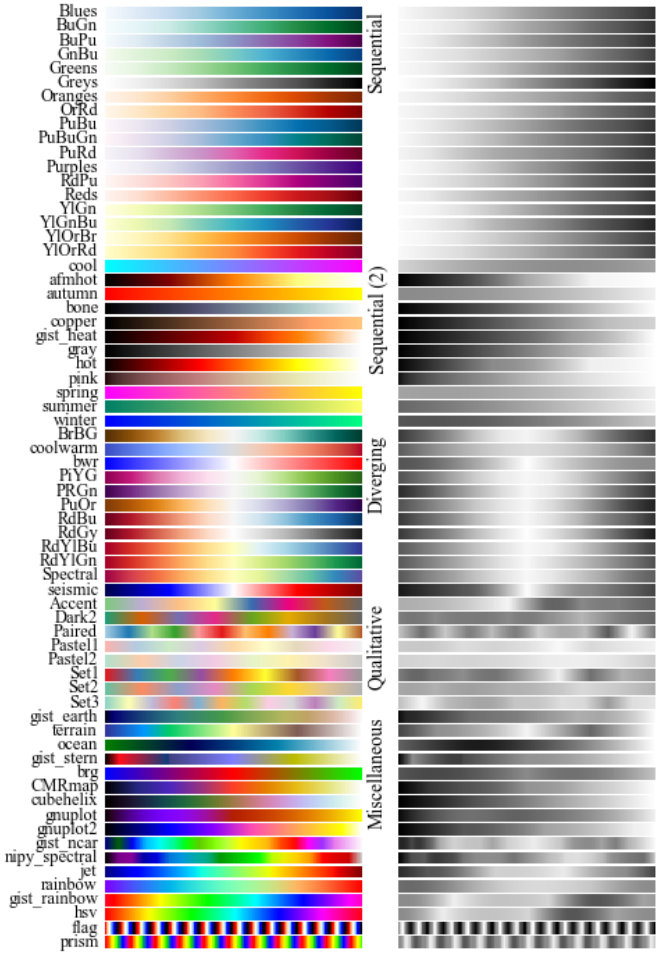
- Many other color maps available.

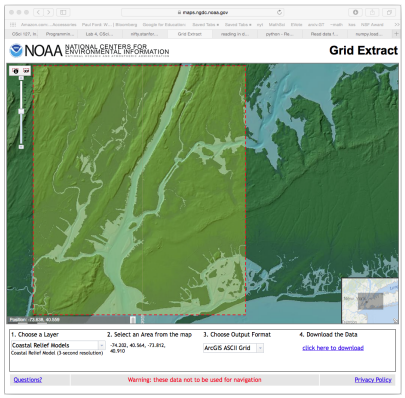
Color Maps

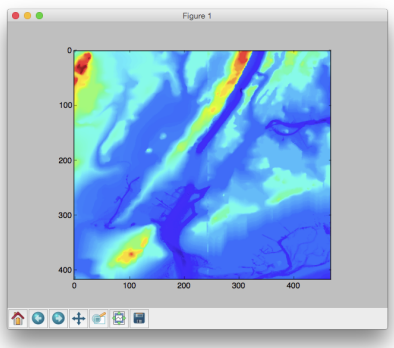


astrodsg blog

- The default ('jet') for displaying arrays is a color map that assigns:
  - the lowest values are blue,
  - the highest values are red, and
  - smoothly map the values in between.
- Many other color maps available.
- Equally space the coloring & do not treat 0 ("sea level") as a special value.

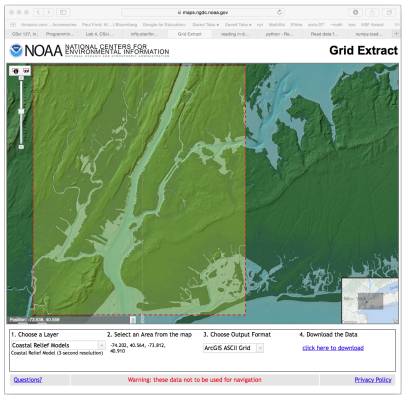
Refining our Coloring

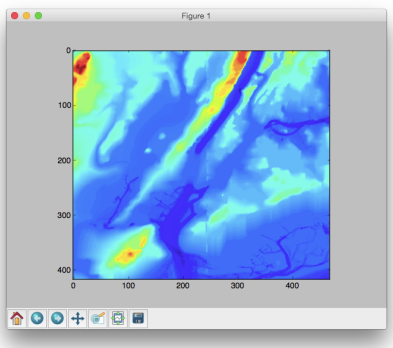




Using the storm surge of Hurricane Sandy in 2012:

Refining our Coloring

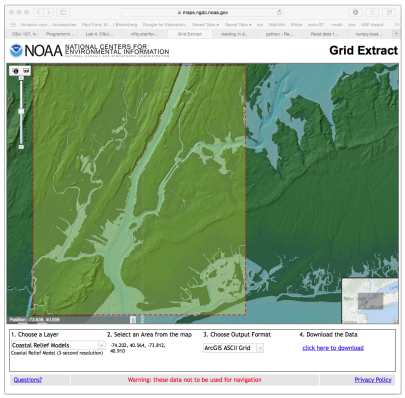


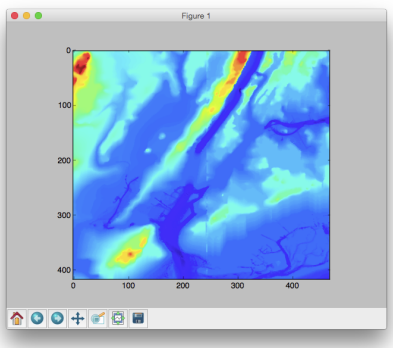


Using the storm surge of Hurricane Sandy in 2012:

- If the elevation is less than or equal to 0:

Refining our Coloring

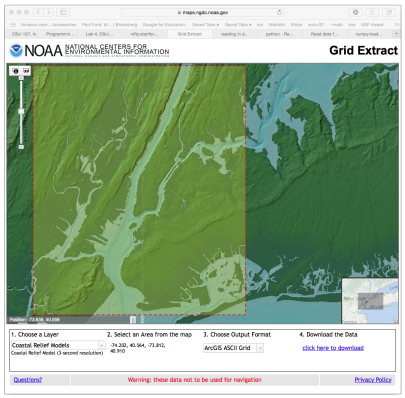


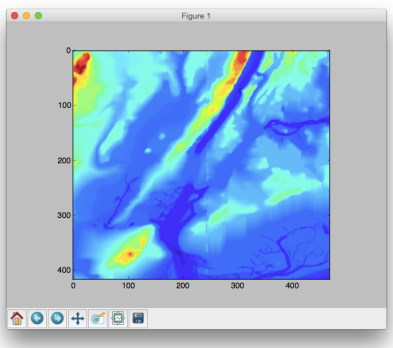


Using the storm surge of Hurricane Sandy in 2012:

- If the elevation is less than or equal to 0:
  - Below sea level,
  - Color the pixel blue

Refining our Coloring





Using the storm surge of Hurricane Sandy in 2012:

- If the elevation is less than or equal to 0:
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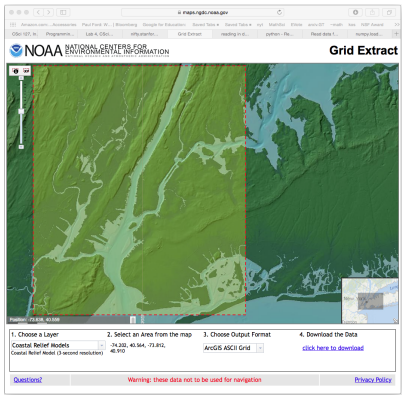
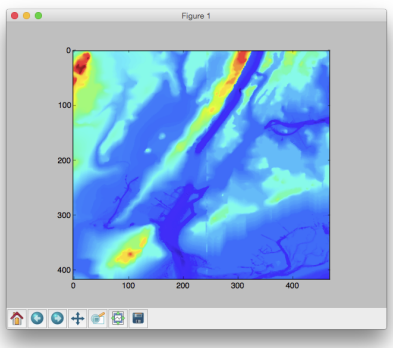
- Else if the elevation is less than or equal to 6:

Refining our Coloring





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- If the elevation is less than or equal to 0:
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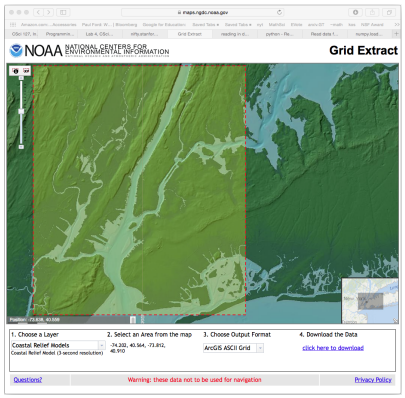

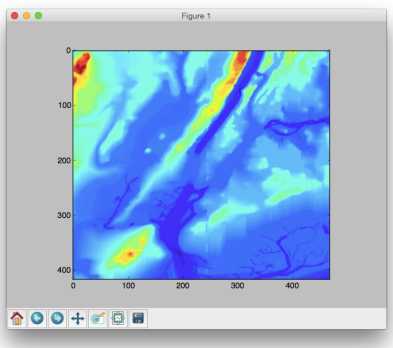

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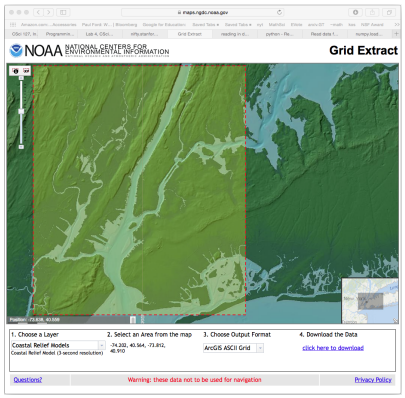

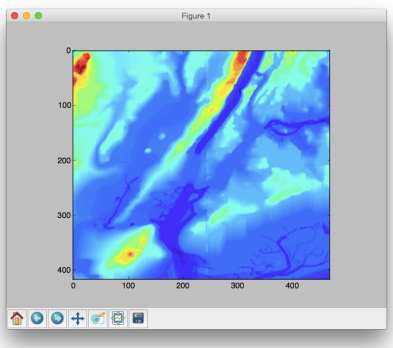

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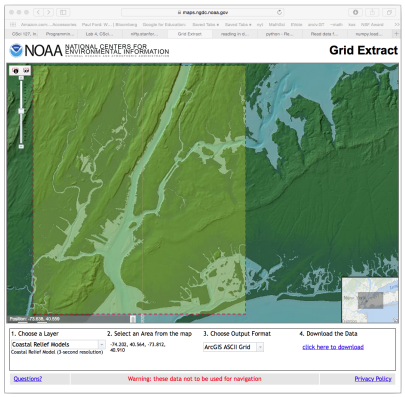

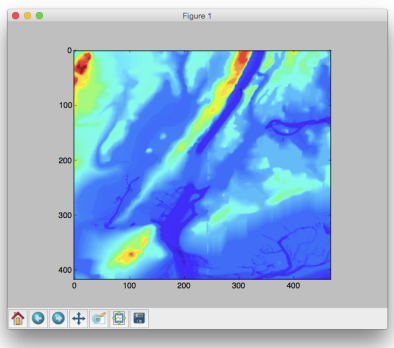

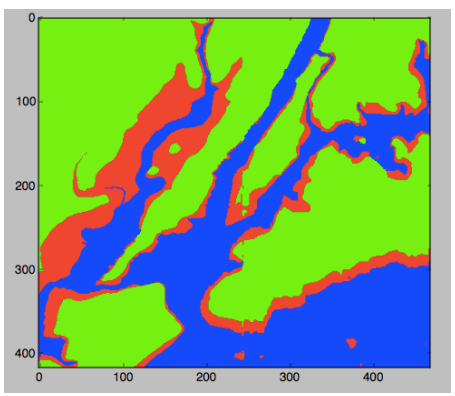

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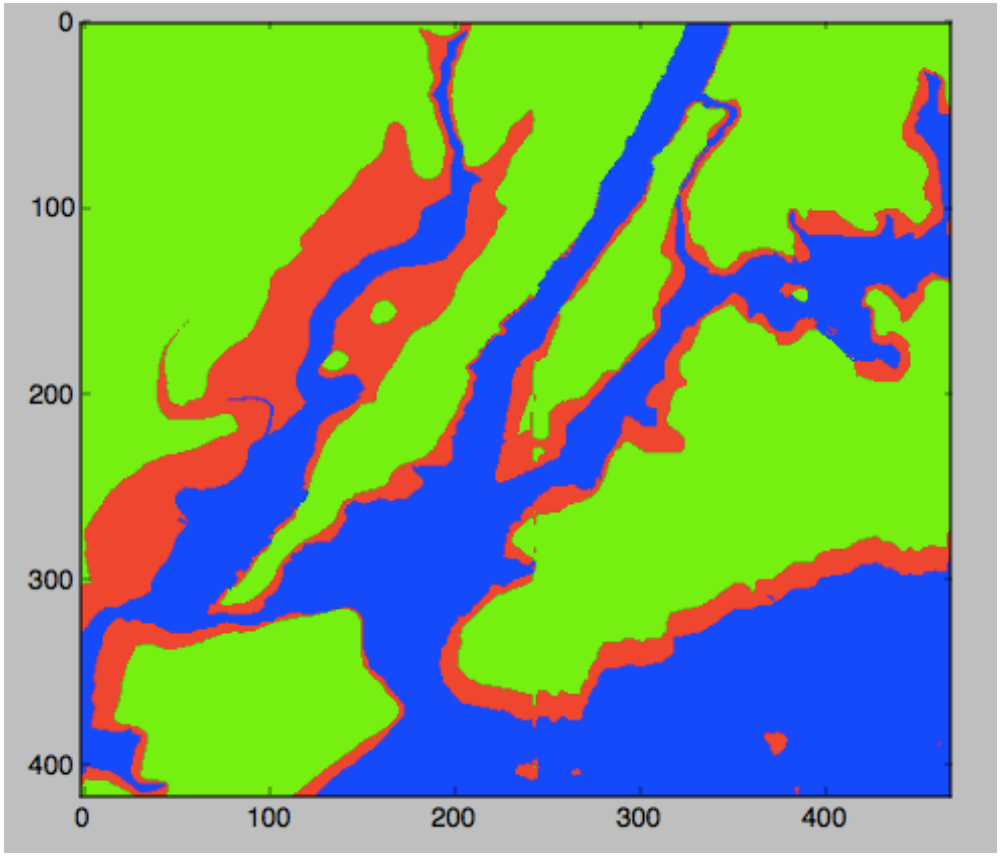

Need to explain:

- Color

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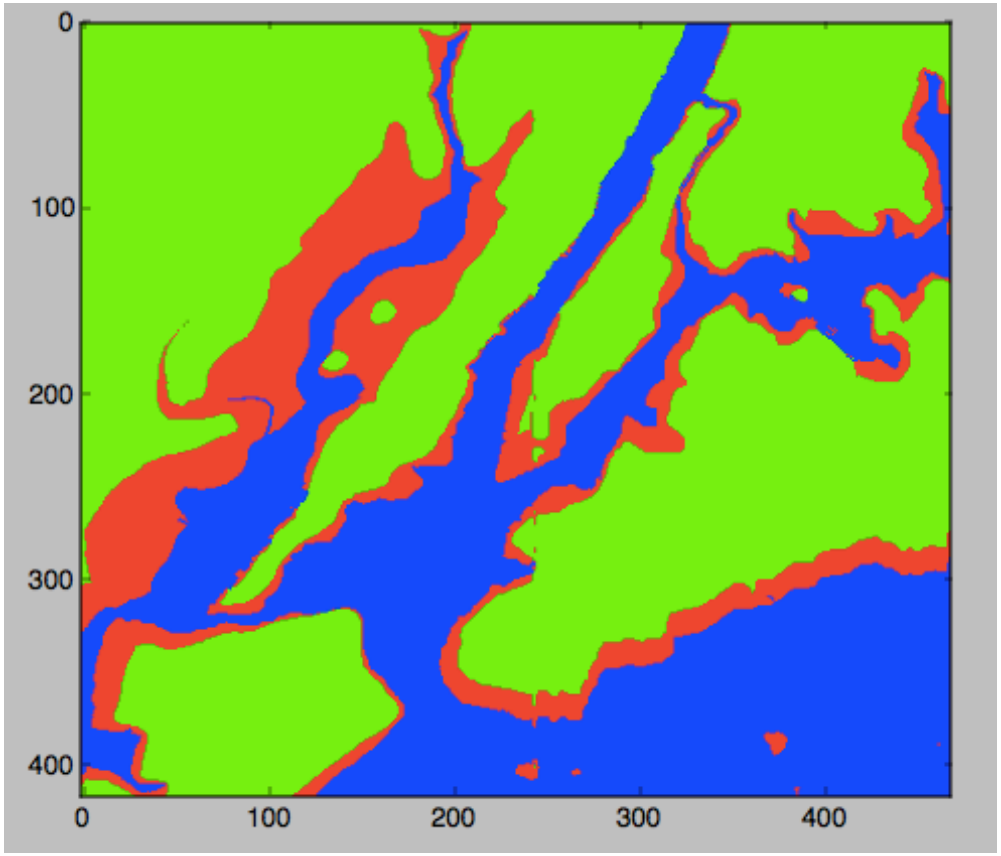

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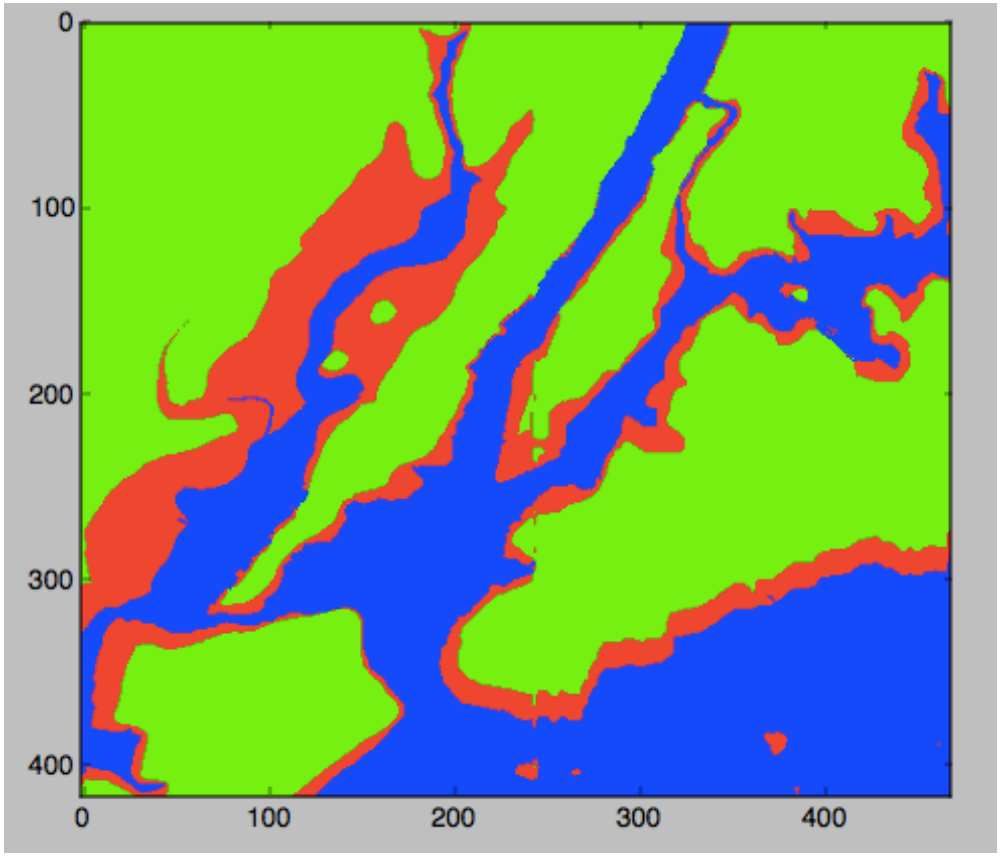

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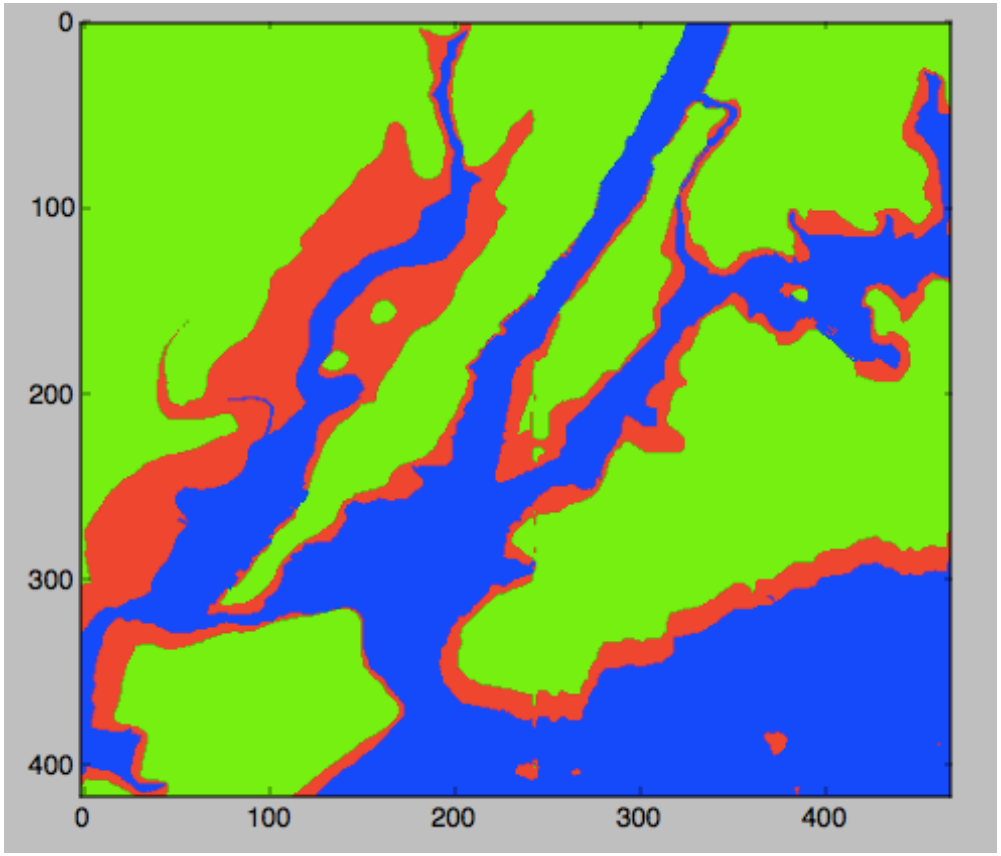
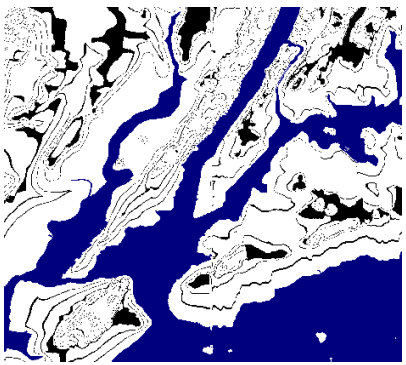


Need to explain:

- Color (usually done week before with turtles) and
- Arrays (two stage approach: bare minimum, then more details later).

Outline



- Welcome and Introductions
- Workshop Overview
- Design Challenge: Flood Maps
  - Data: Elevations from NOAA
  - Packages: `numpy` and `pyplot`
  - Concepts: Colors and Arrays
  - Putting It Altogether
- Break
- Variations on the Theme
- Design a Challenge
- Wrap Up

Colors

Color Name	HEX	Color
Black	#000000	
Navy	#000080	
DarkBlue	#00008B	
MediumBlue	#0000CD	
Blue	#0000FF	

- Can specify by name.

Colors

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  - Adding light, not paint:

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    - ★ Black: 0% red, 0% green, 0% blue

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    - ★ Black: 0% red, 0% green, 0% blue
    - ★ White: 100% red, 100% green, 100% blue

Colors

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    e.g. `(1.0, 0, 0)` is 100% red, no green, and no blue.

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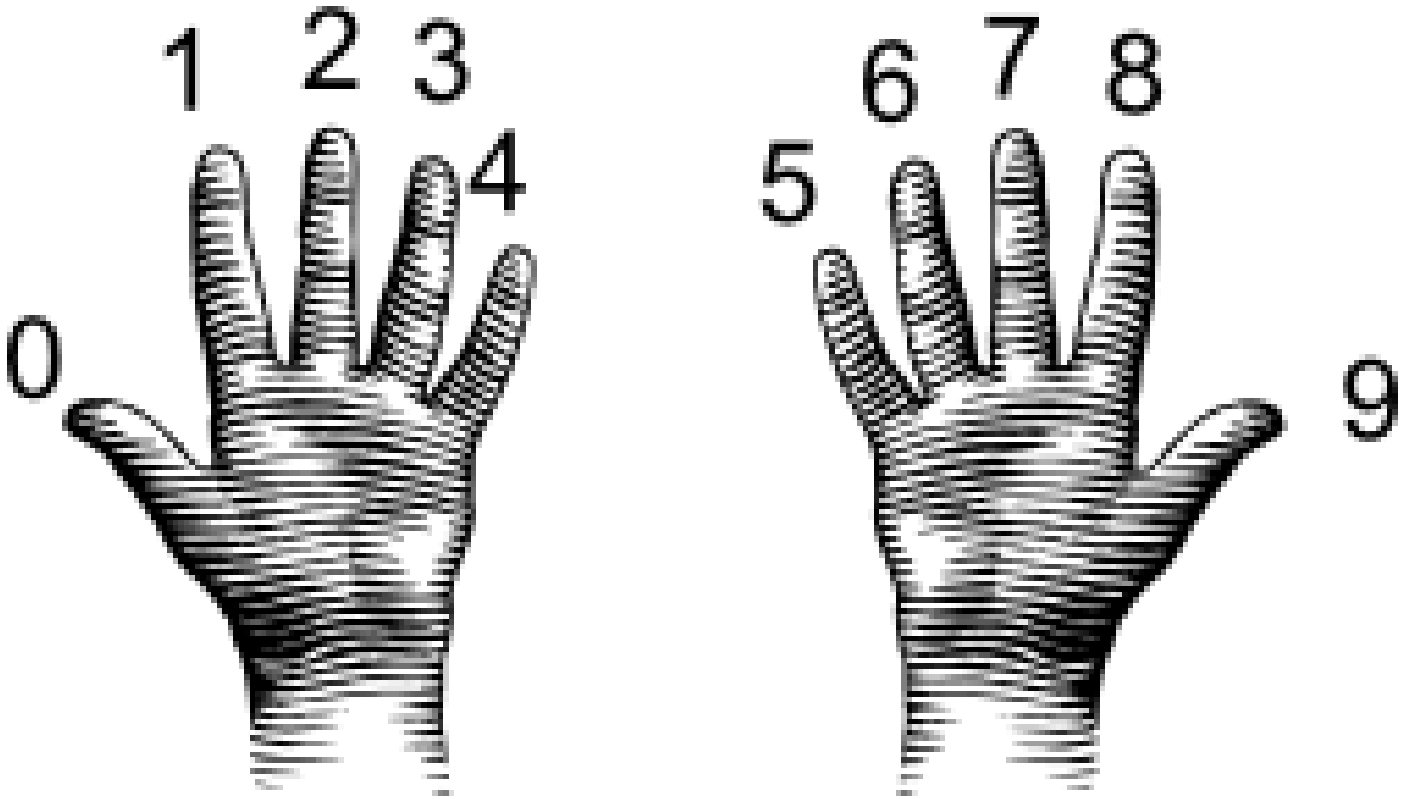
    e.g. `(0, 255, 0)` is no red, 100% green, and no blue.
  - Hexcodes (base-16 numbers)...

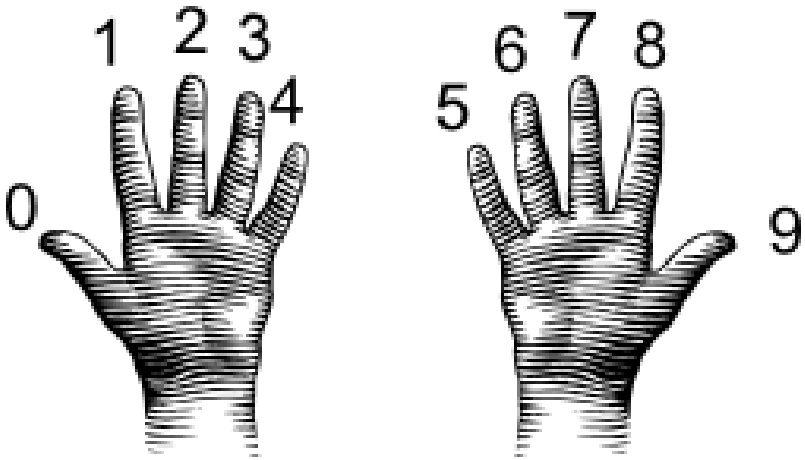
Decimal & Hexadecimal Numbers

Counting with 10 digits:



(from i-programmer.info)

Decimal



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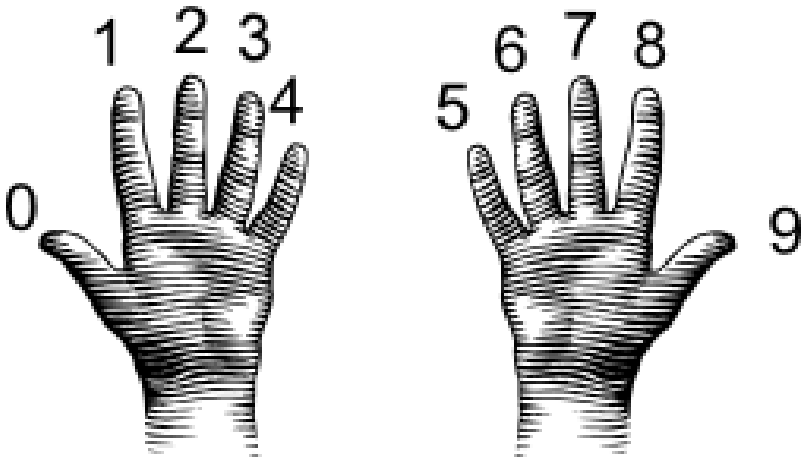
Decimal

00 01 02 03 04 05 06 07 08 09



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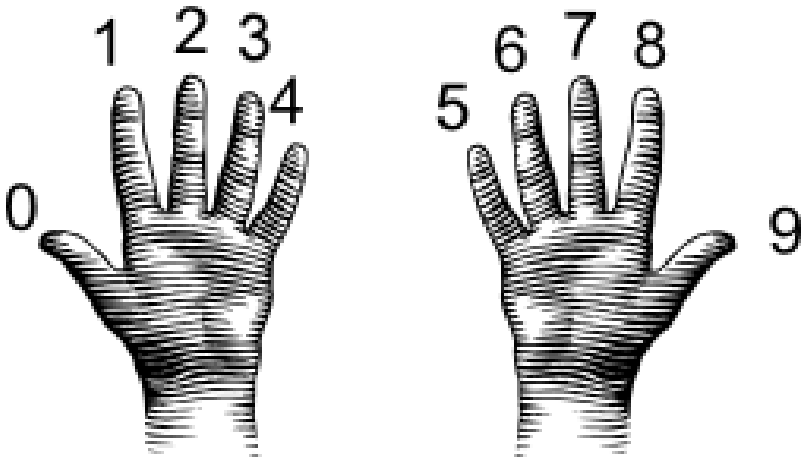
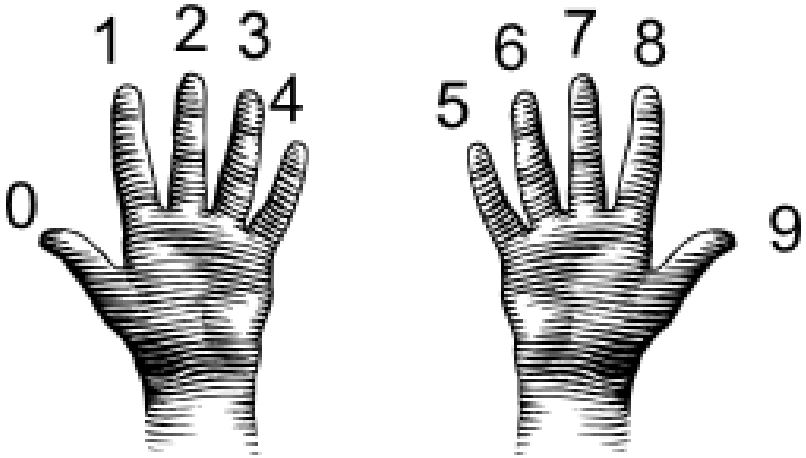
Decimal

00 01 02 03 04 05 06 07 08 09
10 11 12 13 14 15 16 17 18 19



(from i-programmer.info)

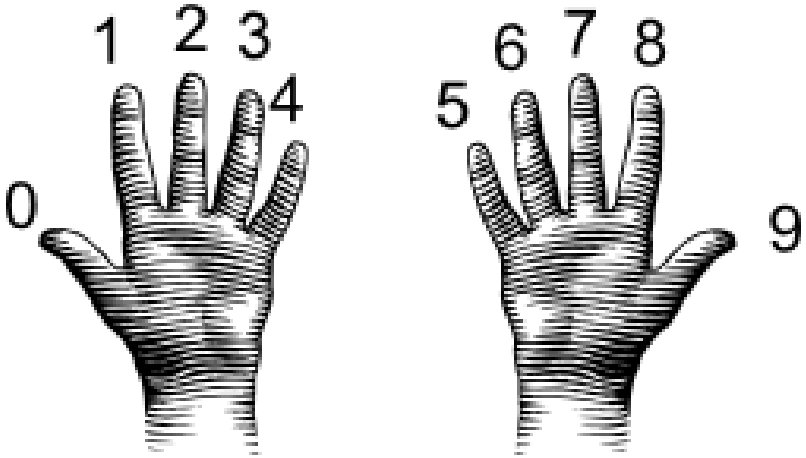
Decimal



(from i-programmer.info)

00 01 02 03 04 05 06 07 08 09
10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26 27 28 29

Decimal



(from i-programmer.info)

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10 11 12 13 14 15 16 17 18 19
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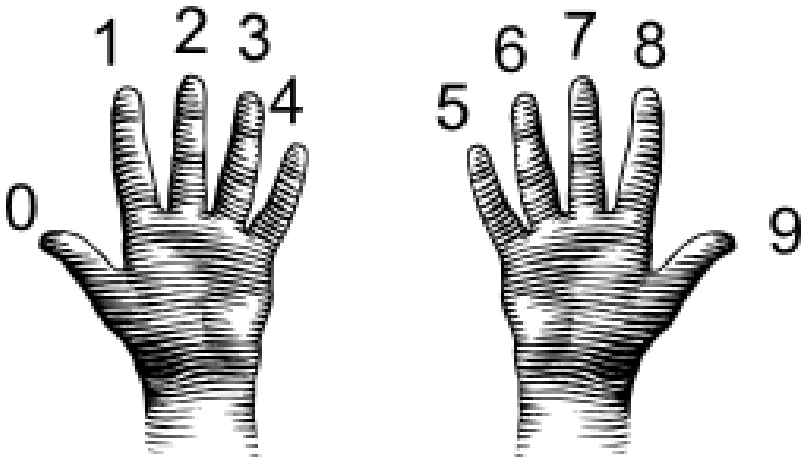

(from i-programmer.info)

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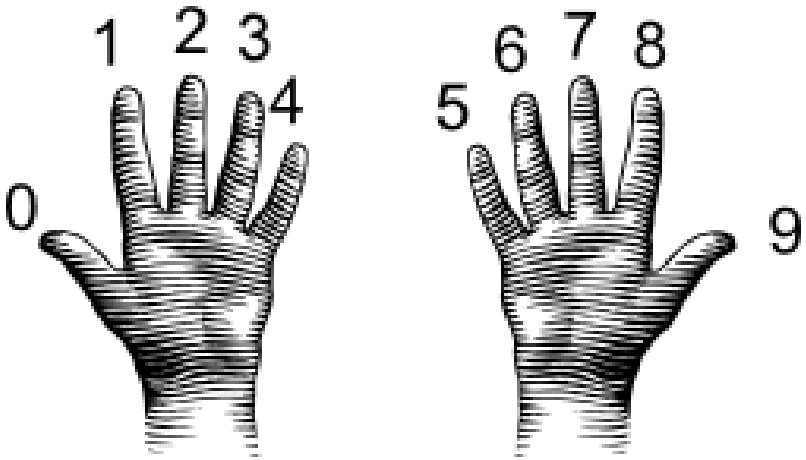
40 41 42 43 44 45 46 47 48 49

Decimal



(from i-programmer.info)

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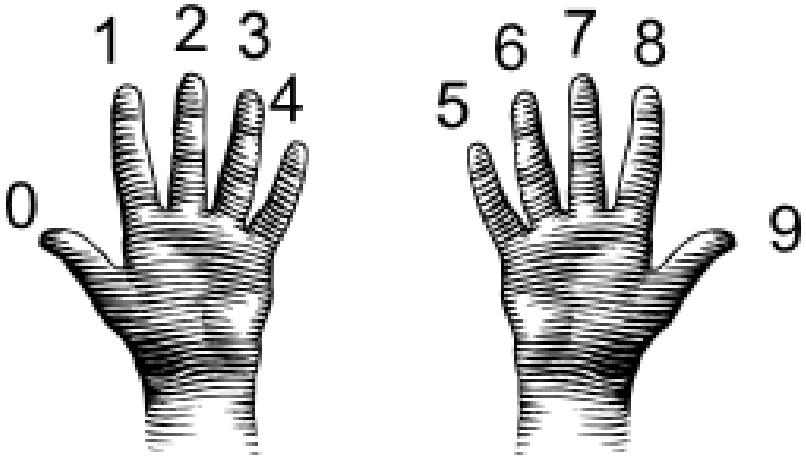
30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59

Decimal



(from i-programmer.info)

00	01	02	03	04	05	06	07	08	09
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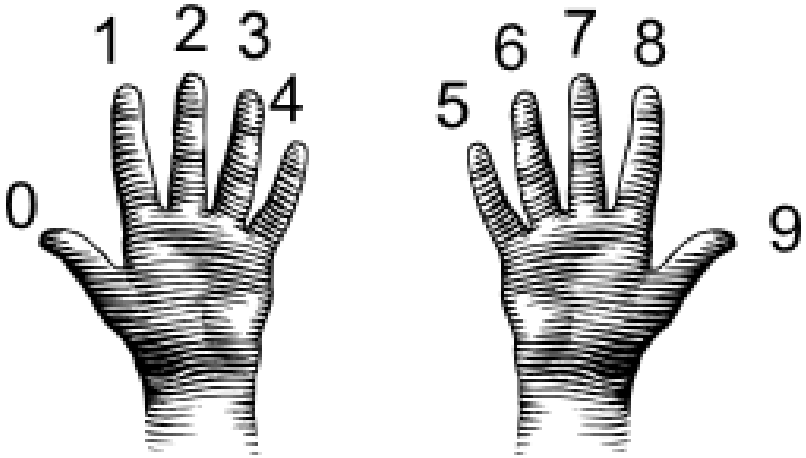
30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69

Decimal



(from i-programmer.info)

00	01	02	03	04	05	06	07	08	09
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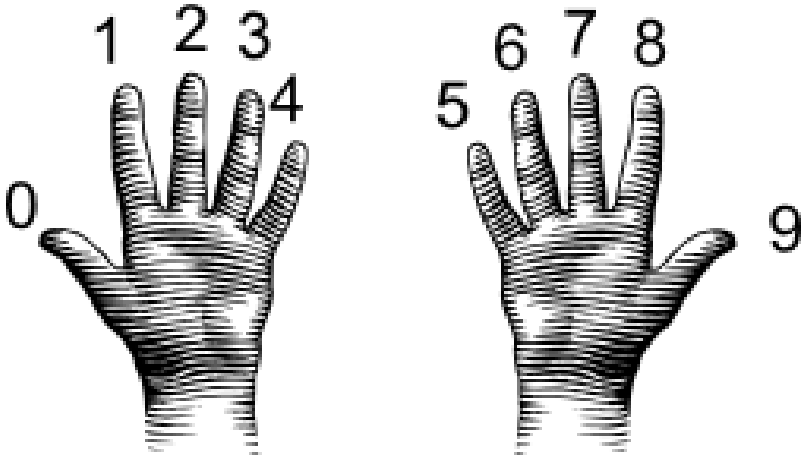
30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79

Decimal



(from i-programmer.info)

00	01	02	03	04	05	06	07	08	09
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50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69
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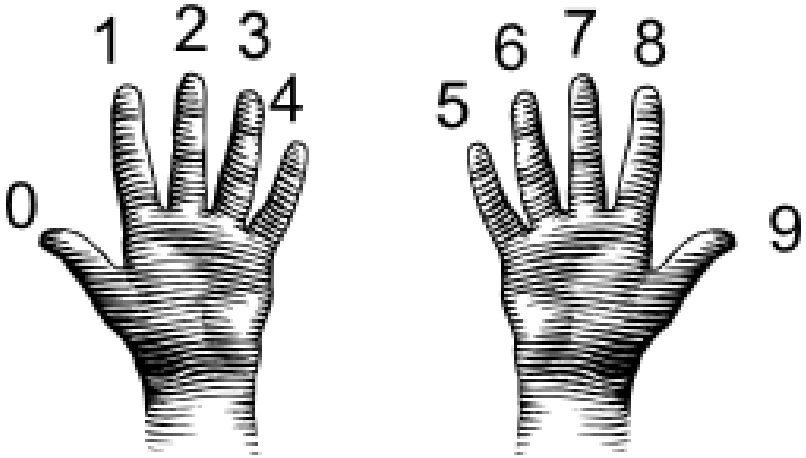
80	81	82	83	84	85	86	87	88	89

Decimal



(from i-programmer.info)

00	01	02	03	04	05	06	07	08	09
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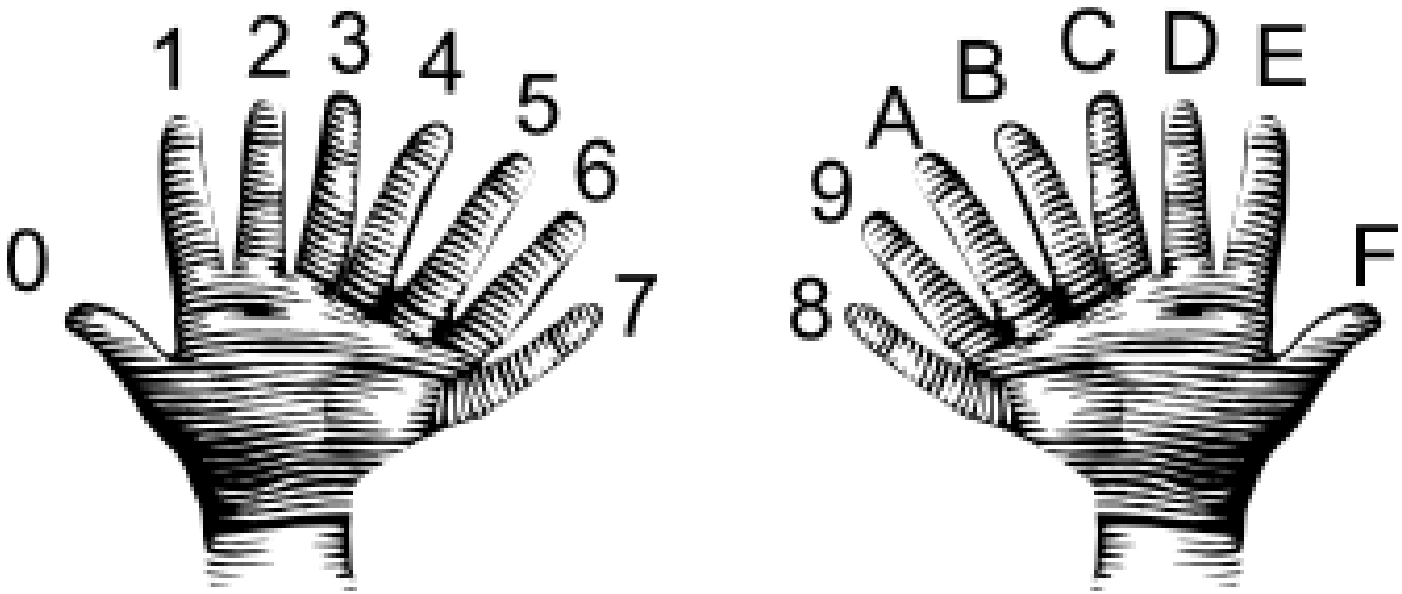
50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89
90	91	92	93	94	95	96	97	98	99

Decimal & Hexadecimal Numbers

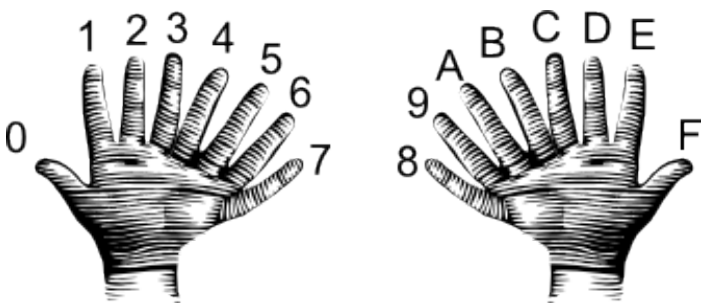
Counting with 16 digits:



(from i-programmer.info)

Hexadecimal

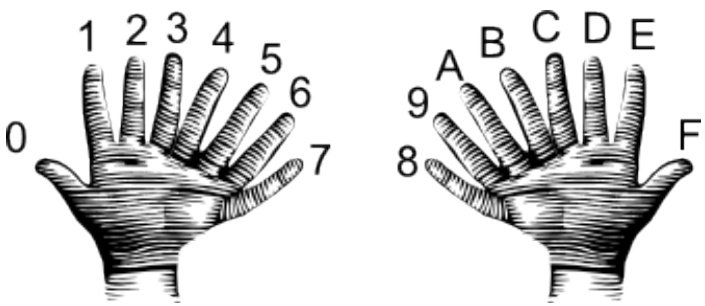
```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
```



(from i-programmer.info)

Hexadecimal

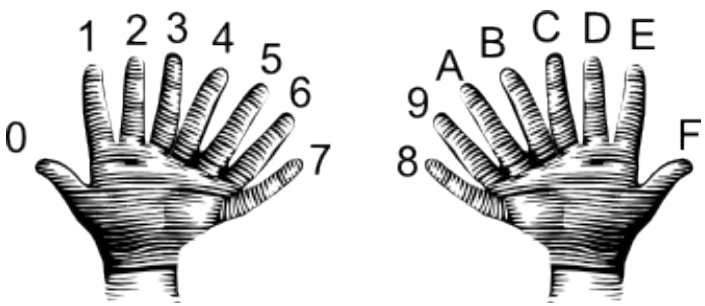
```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
```



(from i-programmer.info)

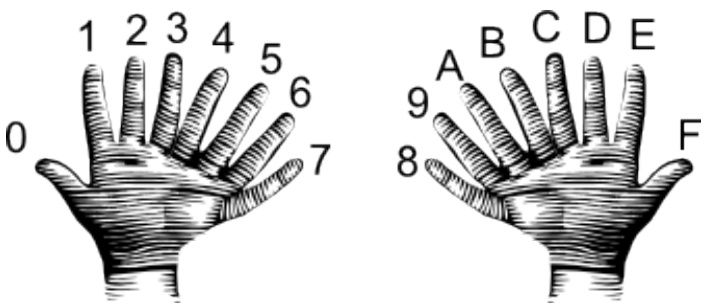
Hexadecimal

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
```



(from i-programmer.info)

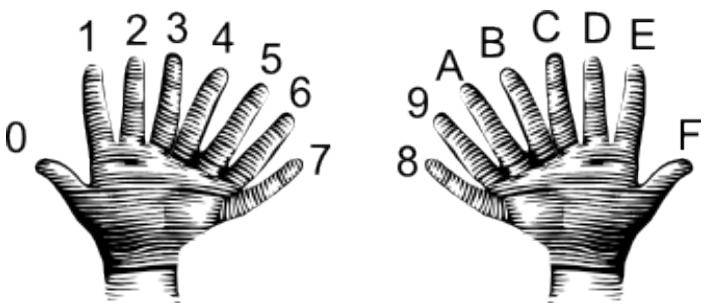
Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
```

Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
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20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
```
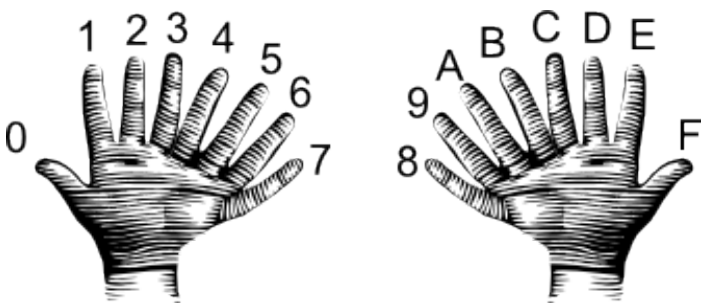

Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
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30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
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50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
```
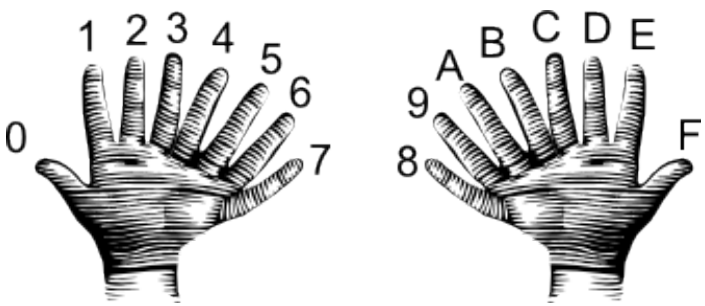

Hexadecimal



(from i-programmer.info)

```
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10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
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60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
```
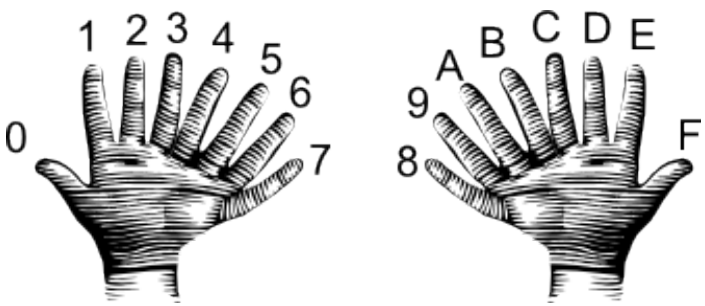
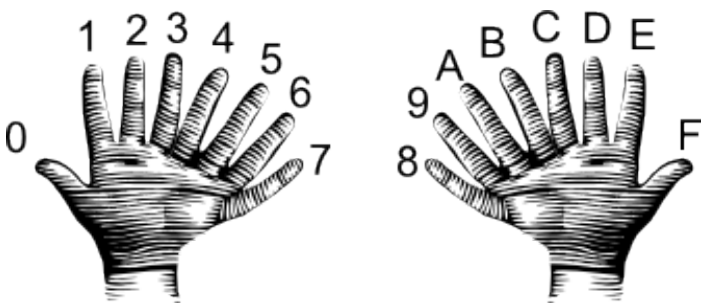

Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
```

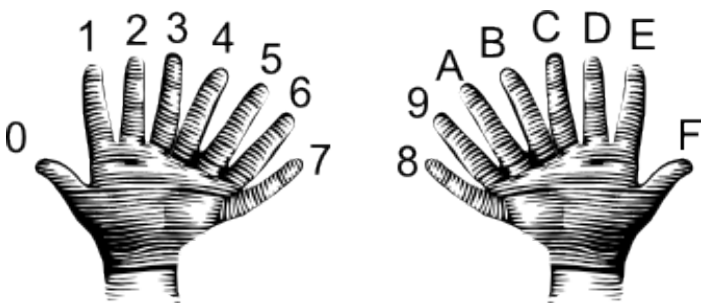
Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
```

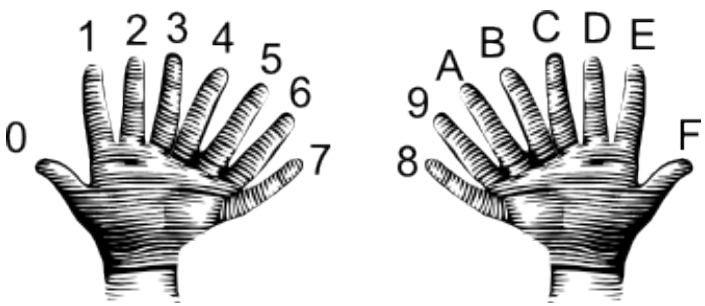
Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
```

Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
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30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
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70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
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A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF
```
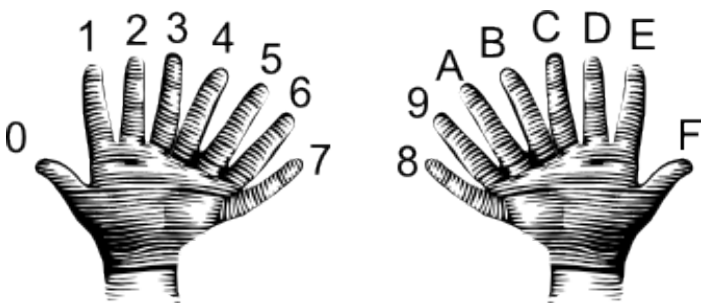

Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
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60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF
B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
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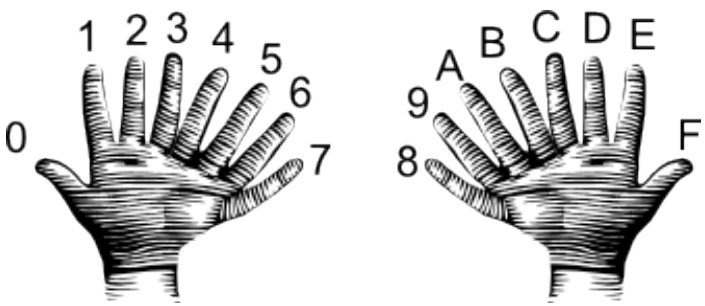
Hexadecimal



(from i-programmer.info)

```
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10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
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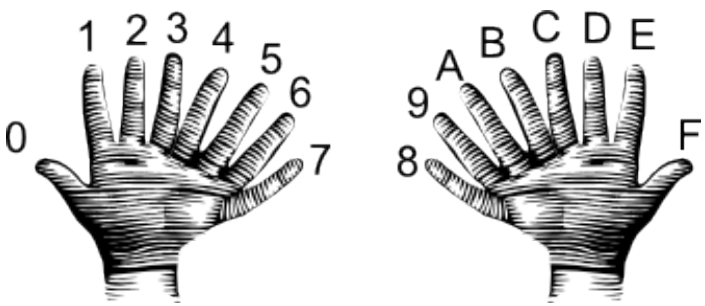
60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF
B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF
```

Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
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20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
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70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
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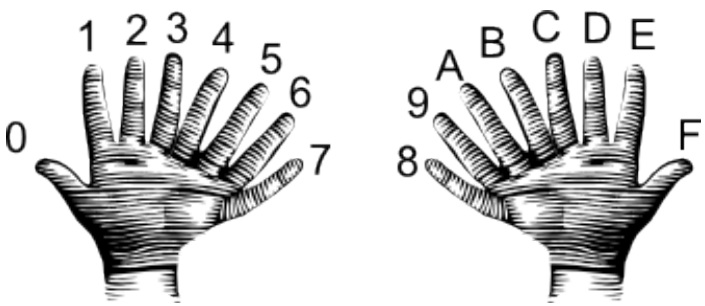
B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF
D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE DF
```

Hexadecimal



(from i-programmer.info)

```
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30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
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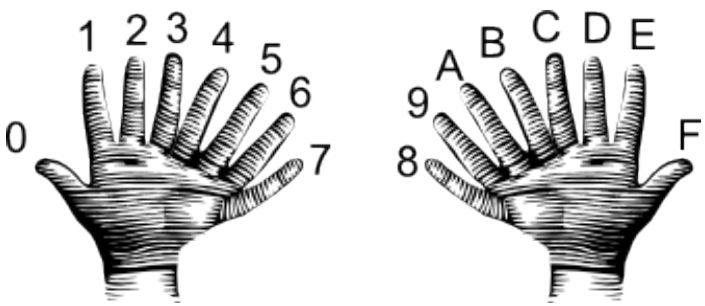
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF
B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF
D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE DF
E0 E1 E2 E3 E4 E5 E6 E7 E8 E9 EA EB EC ED EE EF
```

Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
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60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF
B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF
D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE DF
E0 E1 E2 E3 E4 E5 E6 E7 E8 E9 EA EB EC ED EE EF
F0 F1 F2 F3 F4 F5 F6 F7 F8 F9 FA FB FC FD FE FF
```

Colors

Color Name	HEX	Color
Black	#000000	
Navy	#000080	
DarkBlue	#00008B	
MediumBlue	#0000CD	
Blue	#0000FF	

- Can specify by numbers (RGB):
  - Fractions of each:
    e.g. `(1.0, 0, 0)` is 100% red, no green, and no blue.
  - 8-bit colors: numbers from 0 to 255:
    e.g. `(0, 255, 0)` is no red, 100% green, and no blue.
  - Hexcodes (base-16 numbers):

Colors

Color Name	HEX	Color
Black	#000000	
Navy	#000080	
DarkBlue	#00008B	
MediumBlue	#0000CD	
Blue	#0000FF	

- Can specify by numbers (RGB):
  - Fractions of each:
    e.g. `(1.0, 0, 0)` is 100% red, no green, and no blue.
  - 8-bit colors: numbers from 0 to 255:
    e.g. `(0, 255, 0)` is no red, 100% green, and no blue.
  - Hexcodes (base-16 numbers):
    e.g. `#0000FF` is no red, no green, and 100% blue.

Images

- For each picture element ('pixel'), we store the amount of red, the amount of blue, and the amount of green.

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- Can access the color component of each pixel: e.g. `img[row,col,0]` for red portion of `(row,col)`.

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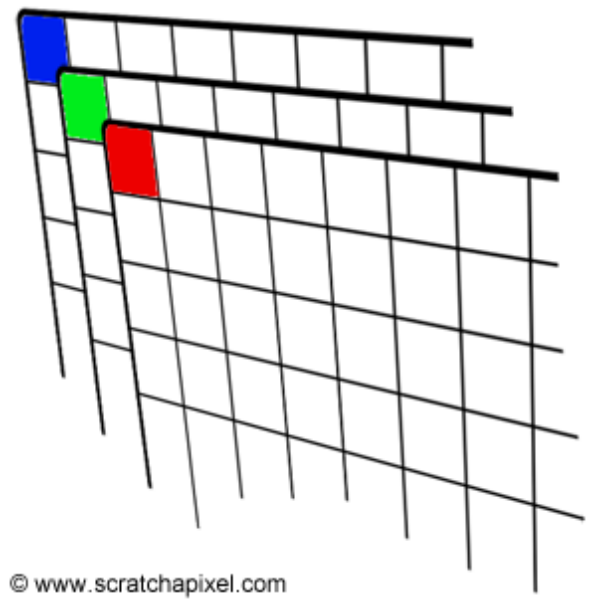

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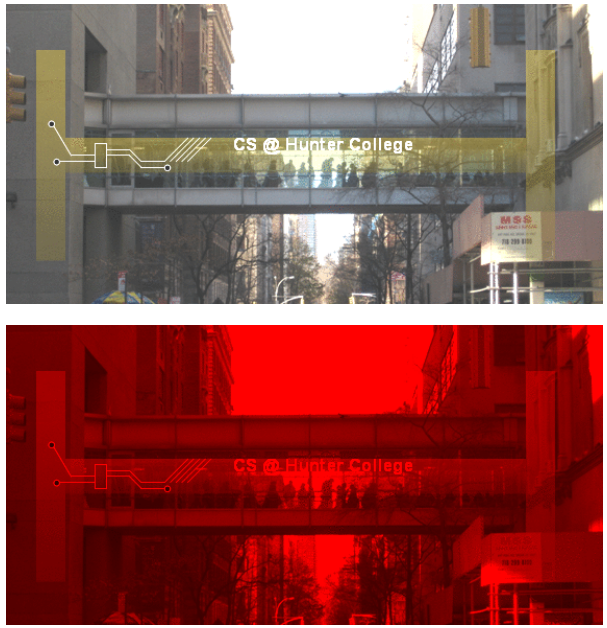

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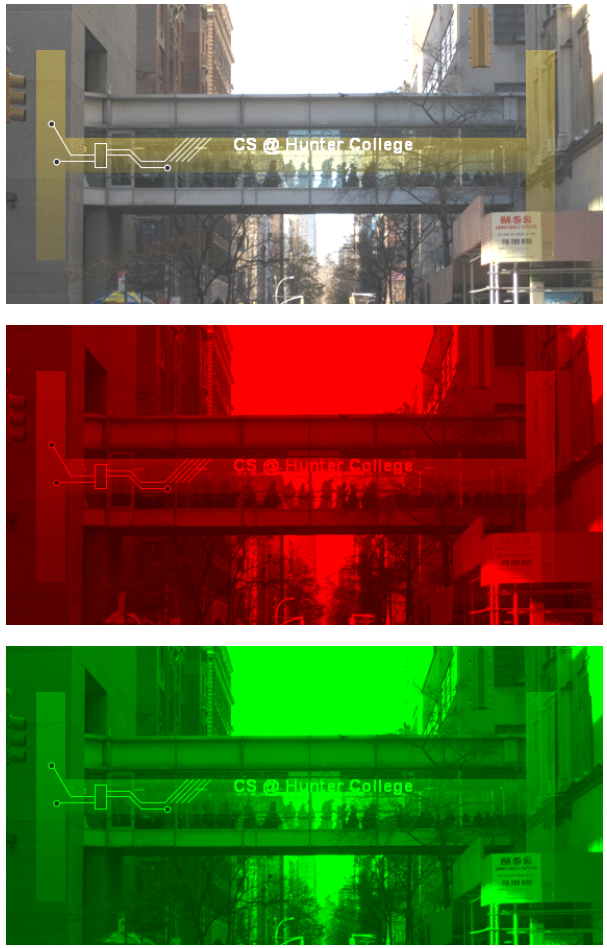

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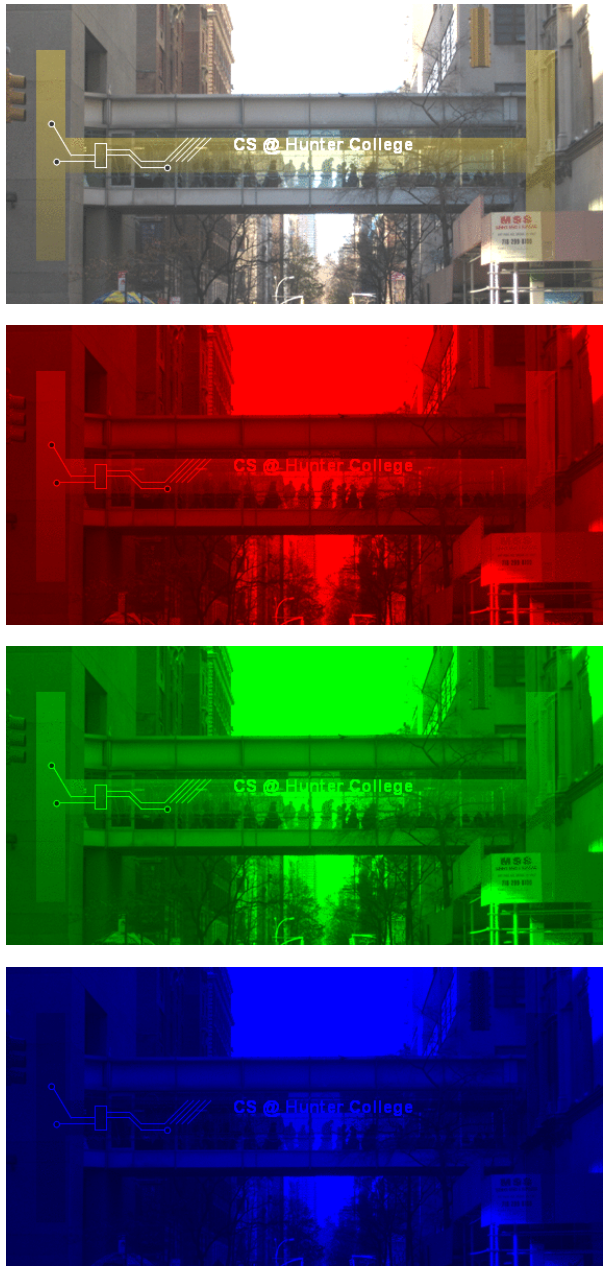
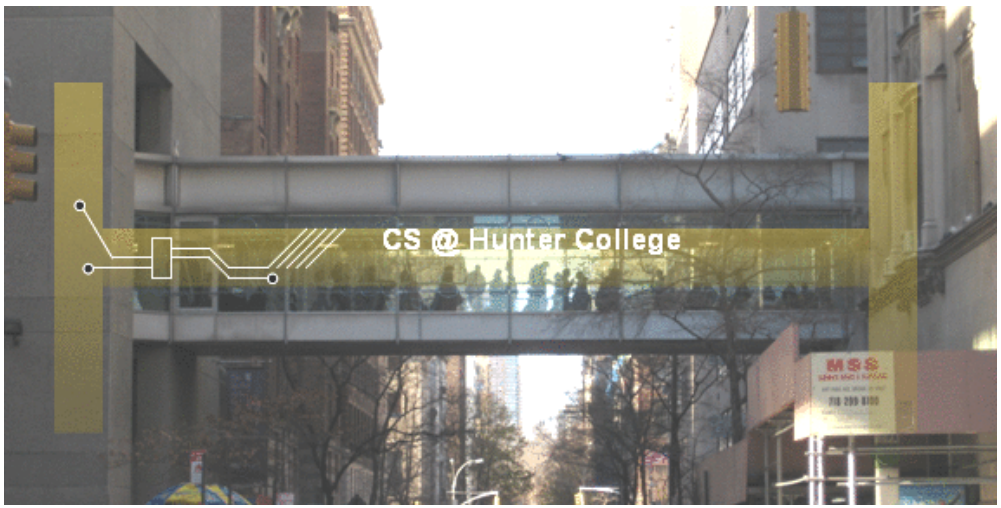
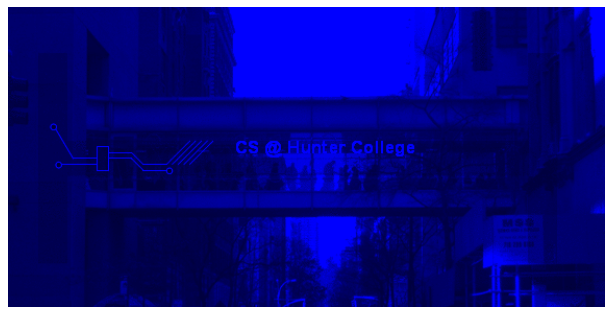


Images

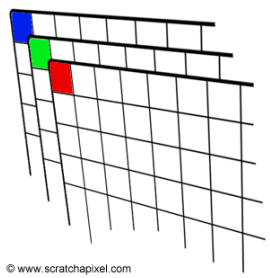




This image has 287 rows, 573 columns, and 4 color channels (for red, green, blue, and a 4th for how transparent).

Creating Images

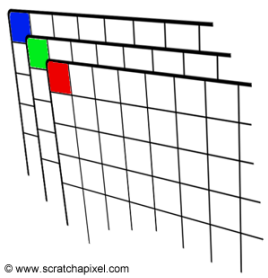
To create an image from scratch:



Creating Images

To create an image from scratch:

1. Import the libraries.



Creating Images

To create an image from scratch:

1. Import the libraries.

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import matplotlib.pyplot as plt
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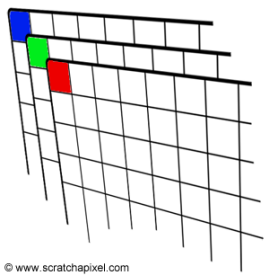

Creating Images

To create an image from scratch:

1. Import the libraries.

```
import matplotlib.pyplot as plt
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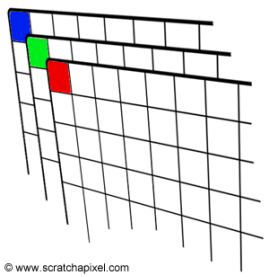
```

2. Create the image– easy to set all color



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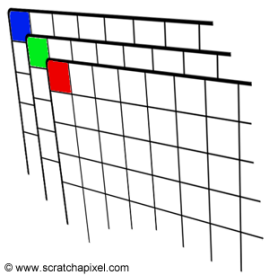
    1. to 0% (black):



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import matplotlib.pyplot as plt
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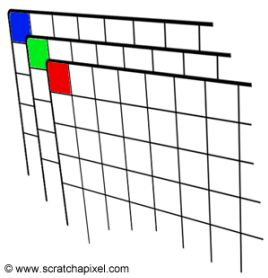
```
img = np.zeros( (num,num,3) )
```



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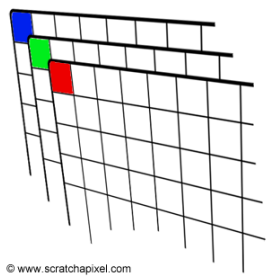

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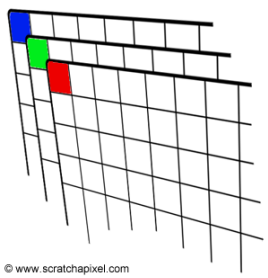

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      ```
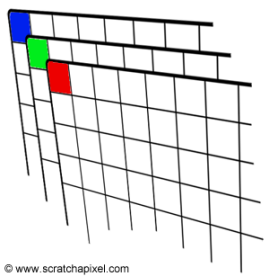
3. *Do stuff to the pixels to make your image*



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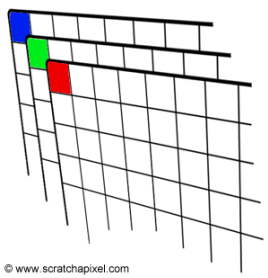

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```
plt.imshow(img)
plt.show()
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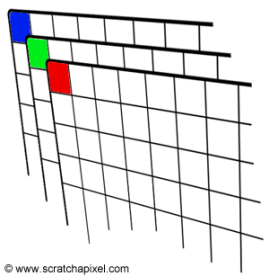

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```
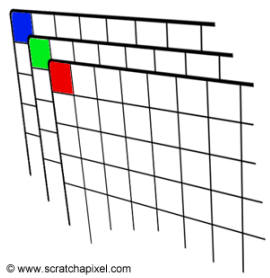

5. And save your image:



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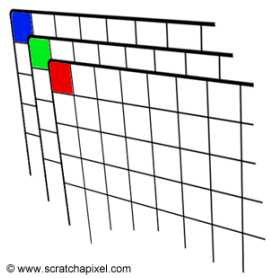
3. *Do stuff to the pixels to make your image*
4. You can display your image:

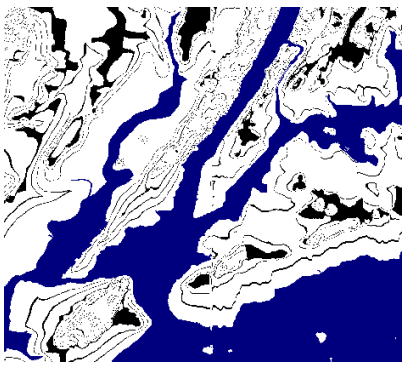
```
plt.imshow(img)
plt.show()
```

5. And save your image:

```
plt.imsave('myImage.png', img)
```



Outline



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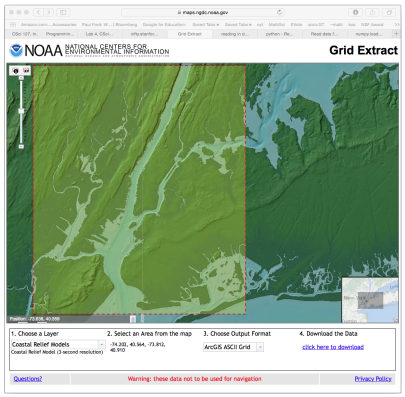
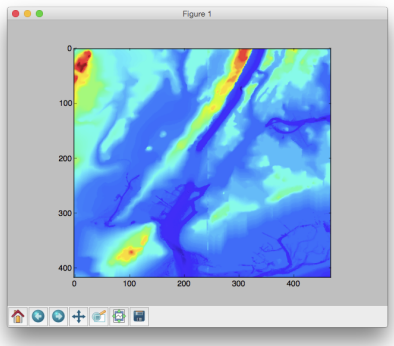
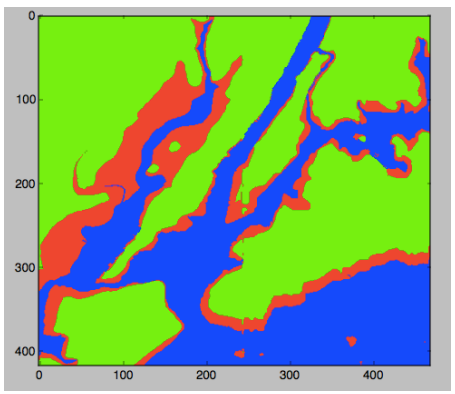
  - Concepts: Colors and Arrays
  - Putting It Altogether
- Break
- Variations on the Theme
- Design a Challenge
- Wrap Up

Putting It Altogether: Design







Using the storm surge of Hurricane Sandy in 2012:

- If the elevation is less than or equal to 0:
  - Below sea level,
  - Color the pixel blue
- Else if the elevation is less than or equal to 6:
  - In storm surge (flooding likely)
  - Color the pixel red
- Else:
  - Above the 6 foot storm surge
  - Color the pixel green

Setting up the Image

```
#Import the libraries for arrays and displaying images:
import numpy as np
import matplotlib.pyplot as plt

#Read in the data to an array, called elevations:
elevations = np.loadtxt('elevationsNYC.txt')

#Take the shape (dimensions) of the elevations
#  and add another dimension to hold the 3 color channels:
mapShape = elevations.shape + (3,)

#Create a blank image that's all zeros:
floodMap = np.zeros(mapShape)
```

Looping through Elevations

```
for row in range(mapShape[0]):
    for col in range(mapShape[1]):
        if elevations[row,col] <= 0:
            #Below sea level
           floodMap[row,col,2] = 1.0     #Set the blue channel to 100%
        elif elevations[row,col] <= 6:
            #Below the storm surge of Hurricane Sandy (flooding likely)
           floodMap[row,col,0] = 1.0     #Set the red channel to 100%
        else:
            #Above the 6 foot storm surge and didn't flood
            floodMap[row,col,1] = 1.0   #Set the green channel to 100%
```

Putting it Altogether

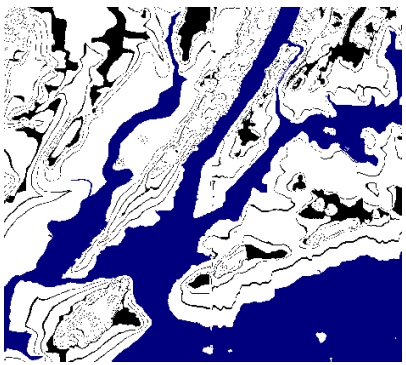
```
#Import the libraries for arrays and displaying images:
import numpy as np
import matplotlib.pyplot as plt
#Read in the data to an array, called elevations:
elevations = np.loadtxt('elevationsNYC.txt')
#Take the shape (dimensions) of the elevations
#  and add another dimension to hold the 3 color channels:
mapShape = elevations.shape + (3,)

#Create a blank image that's all zeros:
floodMap = np.zeros(mapShape)

for row in range(mapShape[0]):
    for col in range(mapShape[1]):
        if elevations[row,col] <= 0:
            #Below sea level
            floodMap[row,col,2] = 1.0     #Set the blue channel to 100%
        elif elevations[row,col] <= 6:
            #Below the storm surge of Hurricane Sandy (flooding likely)
            floodMap[row,col,0] = 1.0     #Set the red channel to 100%
        else:
            #Above the 6 foot storm surge and didn't flood
            floodMap[row,col,1] = 1.0   #Set the green channel to 100%

#Load the flood map image into matplotlib.pyplot:
plt.imshow(floodMap)
#Display the plot:
plt.show()
#Save the image:
plt.imsave('floodMap.png', floodMap)
```

Outline



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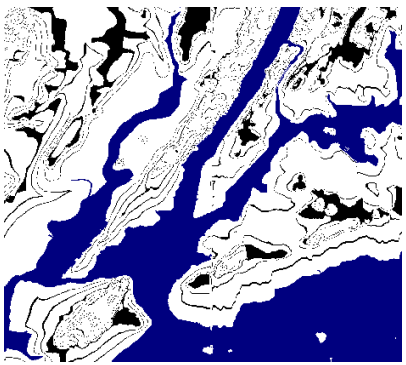
Break

Outline



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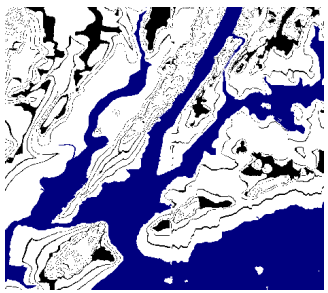
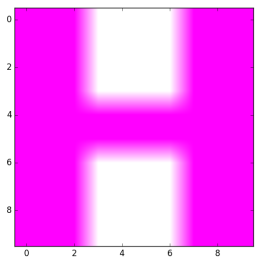
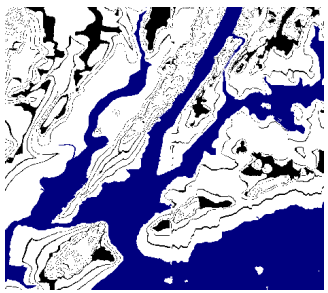
Variations on the Theme

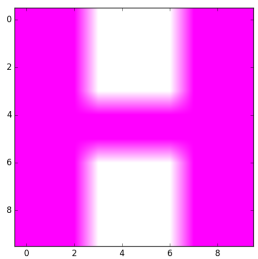




- Coastline Map
- Topographic Map
- School Logo

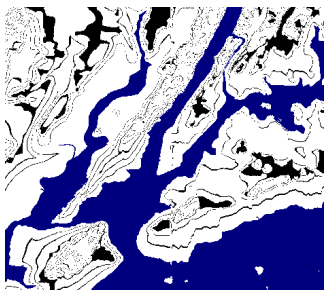
Variations on the Theme

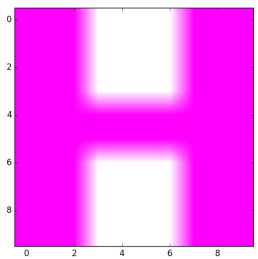




- Coastline Map: Modify your program:
  - If the elevation ≤ 0, color the pixel blue.
  - If the elevation $== 1$, color the pixel light gray.
  - Else, the pixel should be colored dark gray.

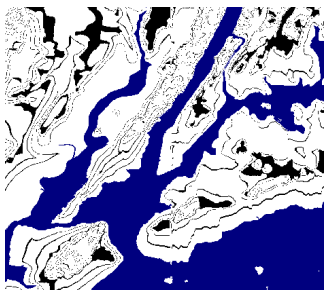
Variations on the Theme

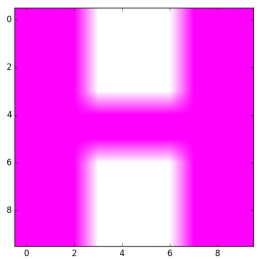




- Coastline Map: Modify your program:
  - If the elevation ≤ 0, color the pixel blue.
  - If the elevation $== 1$, color the pixel light gray.
  - Else, the pixel should be colored dark gray.
- Topographic Map: Modify your program:
  - If the elevation ≤ 0, color the pixel blue.
  - If the elevation is divisible by 10, color the pixel black.
  - Else, the pixel should be colored light gray.

Variations on the Theme





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- Topographic Map: Modify your program:
  - If the elevation ≤ 0, color the pixel blue.
  - If the elevation is divisible by 10, color the pixel black.
  - Else, the pixel should be colored light gray.
- School Logo: Design a 10x10 grid with your school logo (use only white and one other color).

Variations on the Theme: Coastline Map

- Coastline Map: Modify your program:
  - If the elevation ≤ 0, color the pixel blue.
  - If the elevation $== 1$, color the pixel light gray.
  - Else, the pixel should be colored dark gray.

Variations on the Theme: Coastline Map

```
for row in range(mapShape[0]):
    for col in range(mapShape[1]):
        if elevations[row,col] <= 0:
            #Below sea level
            floodMap[row,col,2] = 0.5
        elif elevations[row,col] == 1:
            floodMap[row,col,0] = 0.75
            floodMap[row,col,1] = 0.75
            floodMap[row,col,2] = 0.75
        else:
            floodMap[row,col,0] = 0.5
            floodMap[row,col,1] = 0.5
            floodMap[row,col,2] = 0.5
```

Variations on the Theme: Topographic Map

- Topographic Map: Modify your program:
  - If the elevation ≤ 0, color the pixel blue.
  - If the elevation is divisible by 10, color the pixel black.
  - Else, the pixel should be colored light gray.

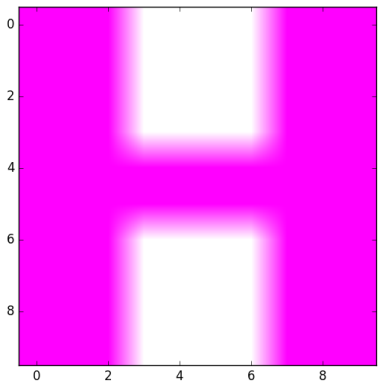
Variations on the Theme: Topographic Map

- Topographic Map: Modify your program:
  - If the elevation ≤ 0, color the pixel blue.
  - If the elevation is divisible by 10, color the pixel black.
  - Else, the pixel should be colored light gray.

Variations on the Theme: Topographic Map

```
for row in range(mapShape[0]):
    for col in range(mapShape[1]):
        if elevations[row,col] <= 0:
            #Below sea level
            floodMap[row,col,2] = blue
        elif elevations[row,col] %10 == 0:
            floodMap[row,col,0] = 0.0
            floodMap[row,col,1] = 0.0
            floodMap[row,col,2] = 0.0
        else:
            floodMap[row,col,0] = 1.0
            floodMap[row,col,1] = 1.0
            floodMap[row,col,2] = 1.0
```

Variations on the Theme



- School Logo: Design a 10x10 grid with your school logo (use only white and one other color).

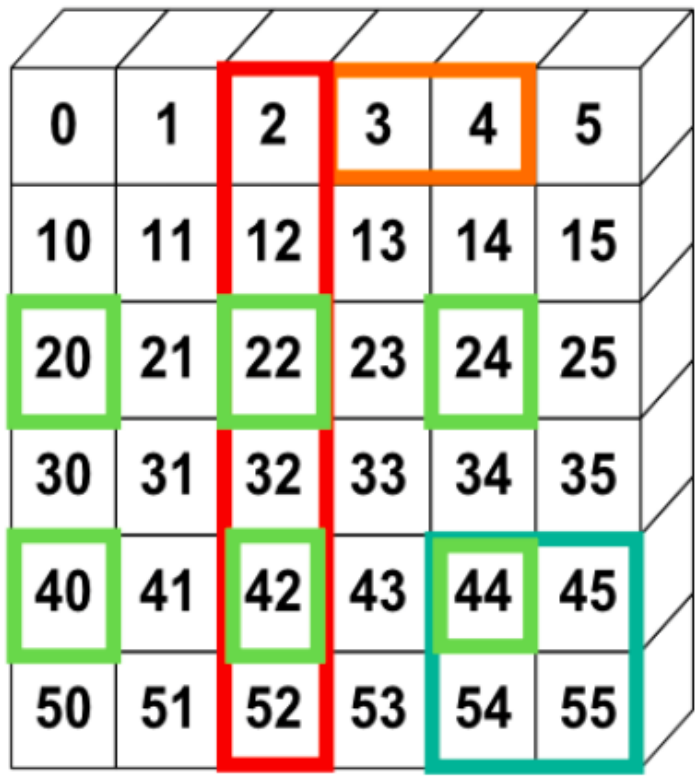
More on numpy arrays

```
>>> a[0,3:5]
array([3,4])

>>> a[4:,4:]
array([[44, 45],
       [54, 55]])

>>> a[:,2]
array([2,12,22,32,42,52])

>>> a[2::2,::2]
array([[20,22,24]
       [40,42,44]])
```



numpy tutorial

Slicing & Image Examples

- Basic pattern: *img[rows, columns, channels]* with: *start:stop:step*.

Slicing & Image Examples

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- Assuming the libraries are imported, what do the following code fragments produce:
  - ```
    img = np.zeros( (10,10,3) )
    img[0:10,0:5,0:1] = 1
    ```
    ```

Slicing & Image Examples

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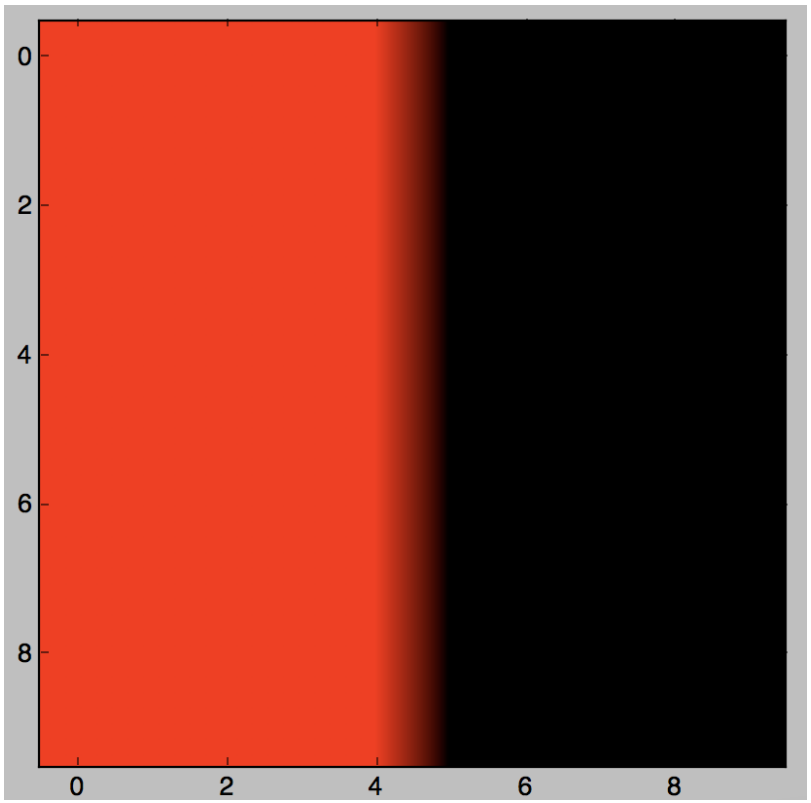
    ```

Slicing & Image Examples

- Basic pattern: *img[rows, columns, channels]* with: *start:stop:step*.
- Assuming the libraries are imported, what do the following code fragments produce:
  - ```
    num = 10
    img = np.zeros( (num,num,3) )
    img[0:2,:,2:3] = 1.0
    ```
    ```

Slicing & Image Examples

- Basic pattern: *img[rows, columns, channels]* with: *start:stop:step*.
- Assuming the libraries are imported, what do the following code fragments produce:
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    img[0:2,:,2:3] = 1.0
    ```

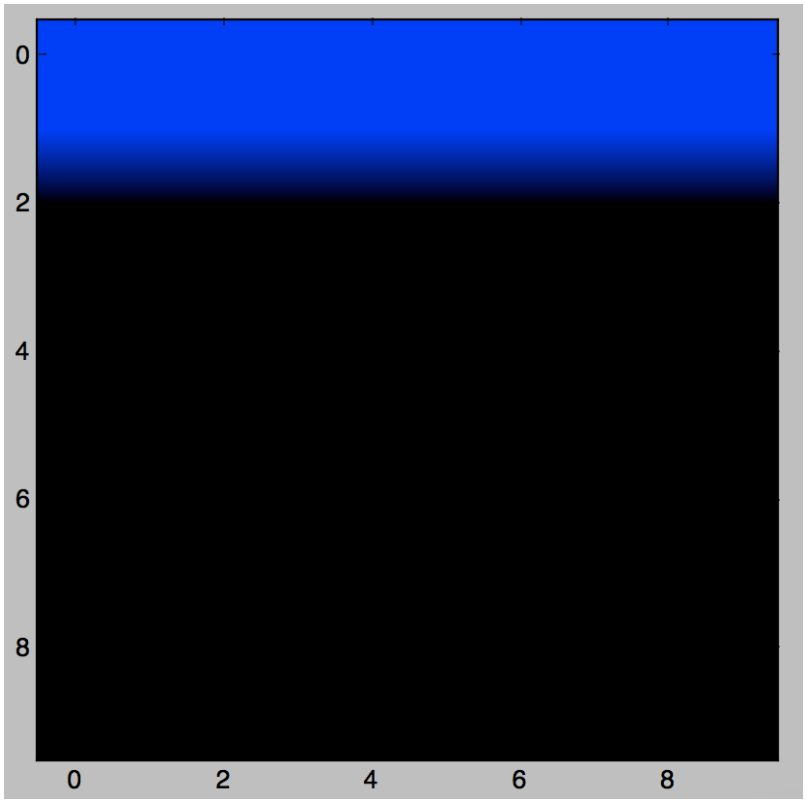
    ```

Slicing & Image Examples

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    num = int(input('Enter size'))
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    img[:,::2,1] = 1.0
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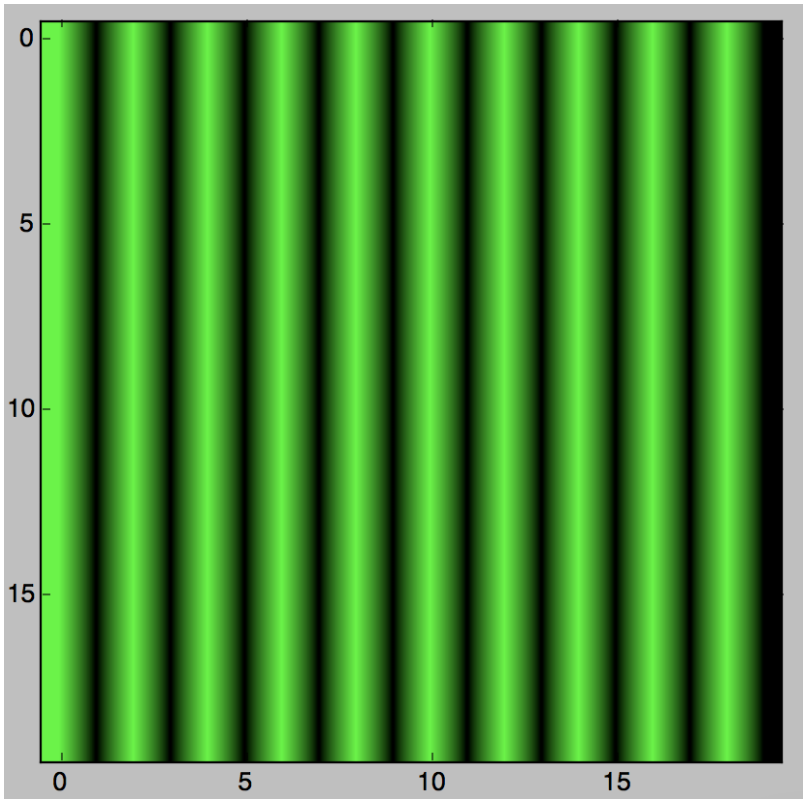
    ```

In Pairs or Triples

- Basic pattern: *img[rows, columns, channels]* with: *start:stop:step*.
- Assuming the libraries are imported, what do the following code fragments produce:

  - ```
    img = np.ones( (10,10,3) )
    img[0:10,0:5,0:2] = 0
    ```
    ```

In Pairs or Triples

- Basic pattern: *img[rows, columns, channels]* with: *start:stop:step*.
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    num = int(input('Enter size '))
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  - ```
    num = int(input('Enter size '))
    img = np.ones( (num,num,3) )
    img[::2,:,1:]  = 0
    ```

  - ```
    img = np.zeros( (8,8,3) )
    img[::2,::2,0] = 1
    ```
    ```

In Pairs or Triples

- Basic pattern: *img[rows, columns, channels]* with: *start:stop:step*.
- Assuming the libraries are imported, what do the following code fragments produce:

  - ```
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    img[0:10,0:5,0:2] = 0
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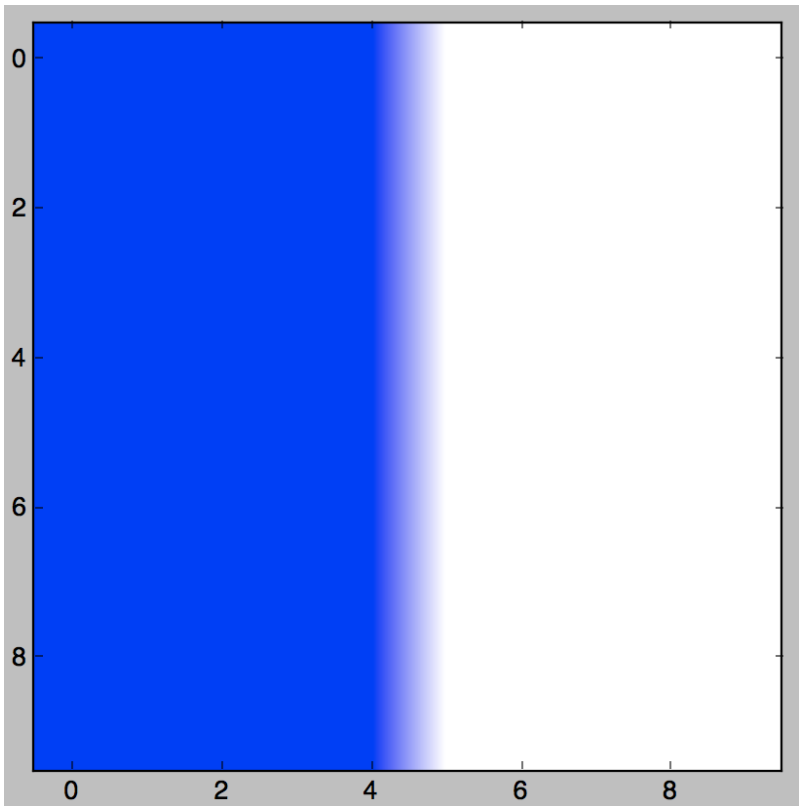
    ```

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  - ```
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    img = np.ones( (num,num,3) )
    img[::2,:,1:]  = 0
    ```
    ```

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    ```

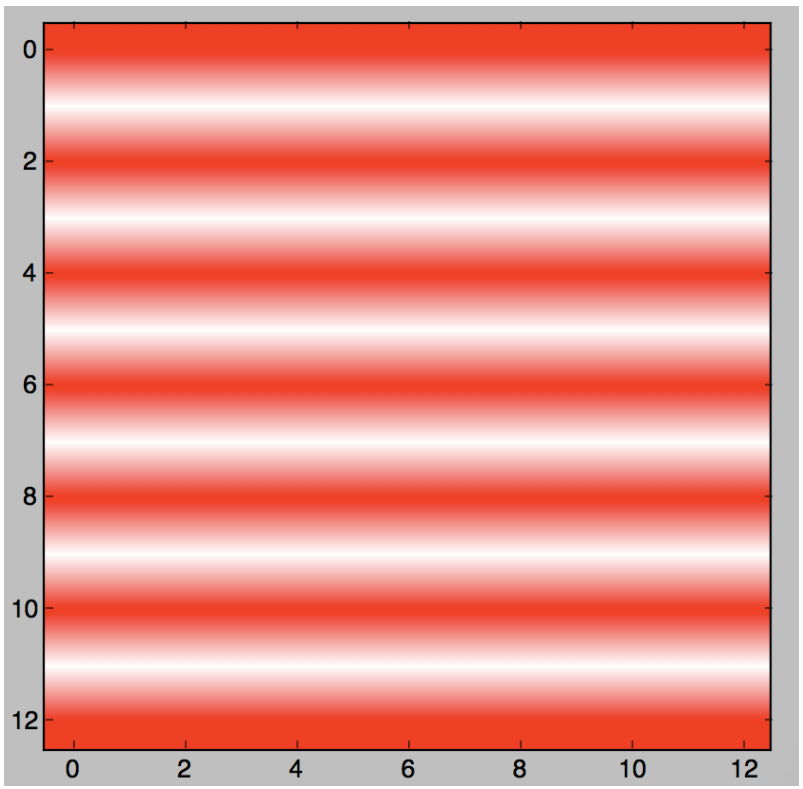
    ```

In Pairs or Triples

- Basic pattern: *img[rows, columns, channels]* with: *start:stop:step*.
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    img[::2,1::2,0] = 1
    ```
    ```

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    ```
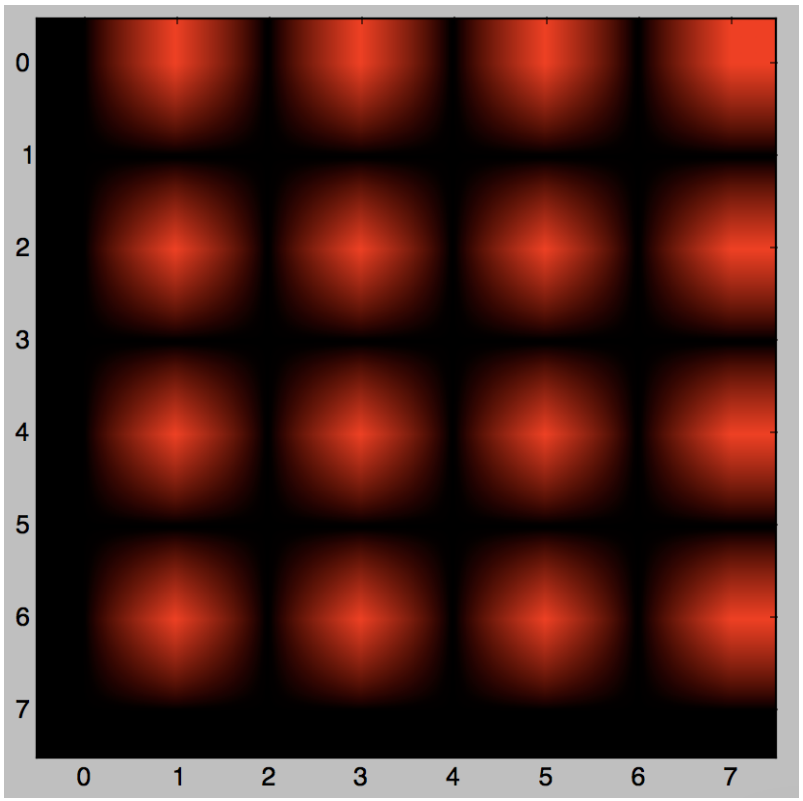
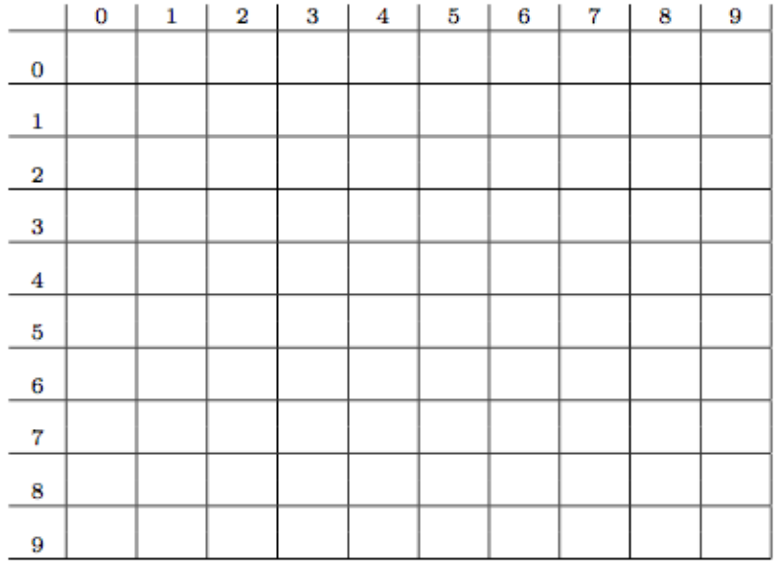
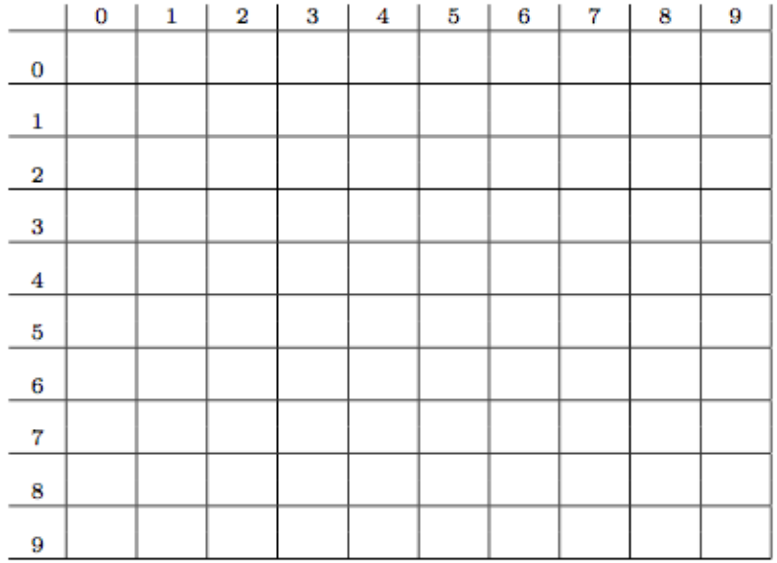
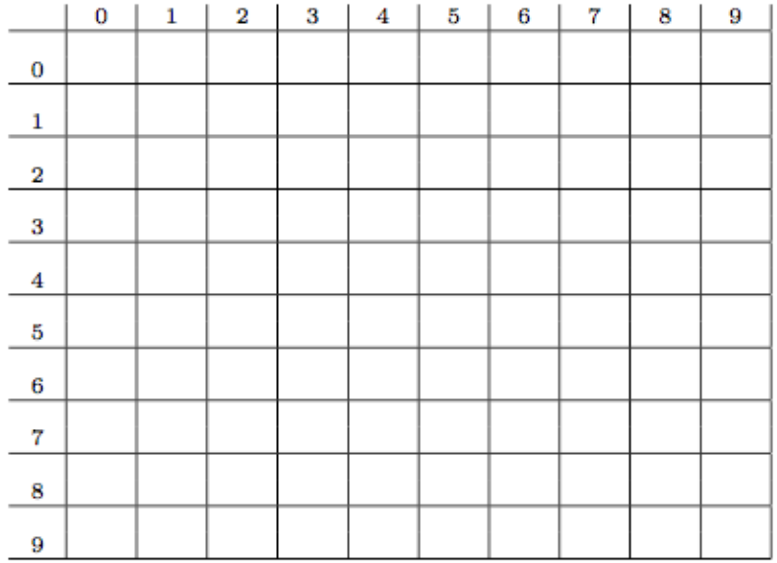
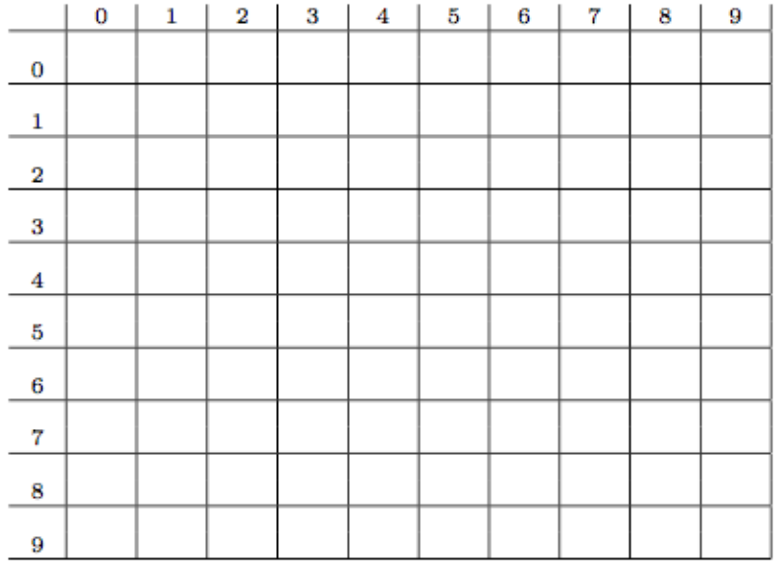
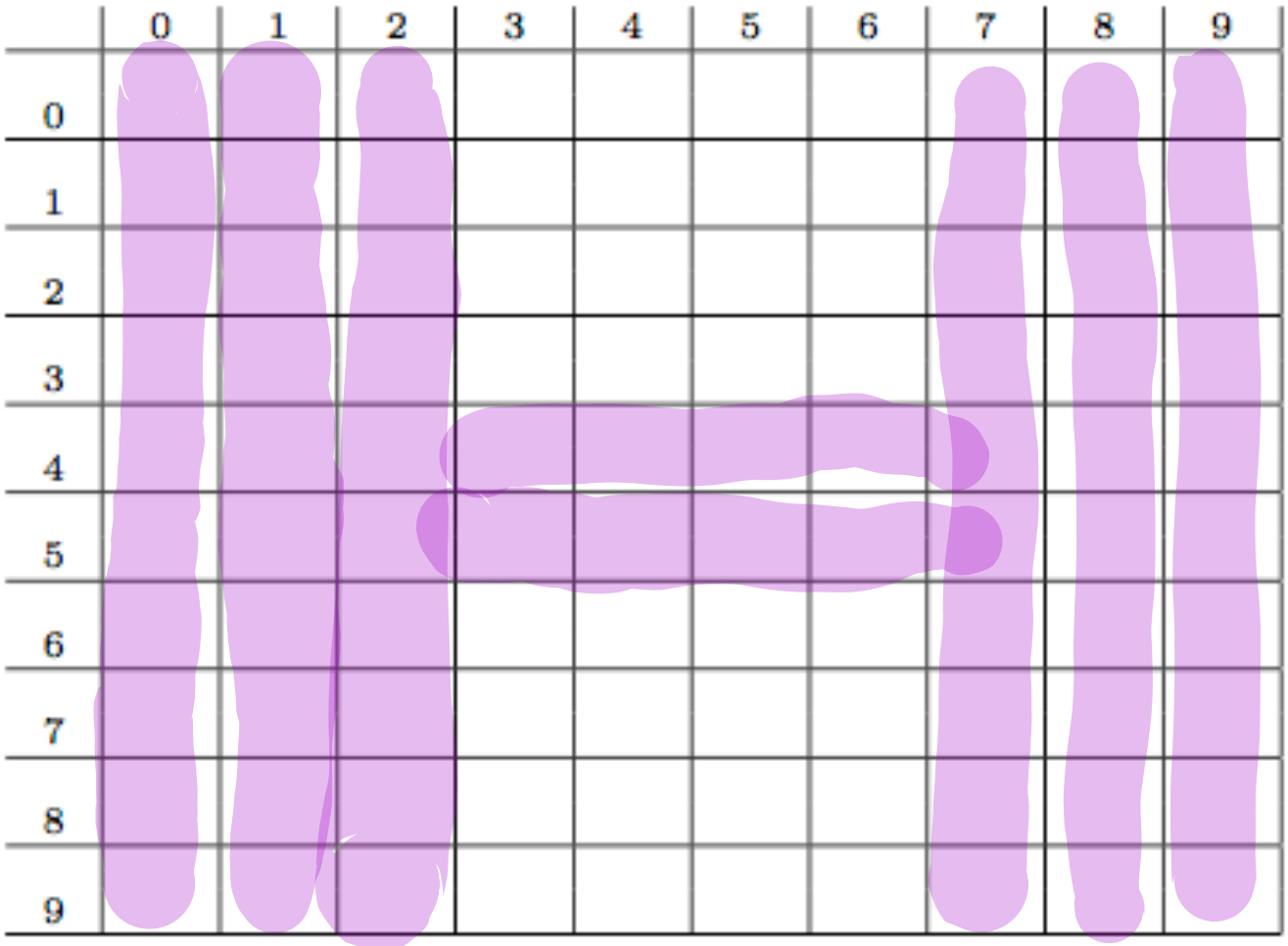
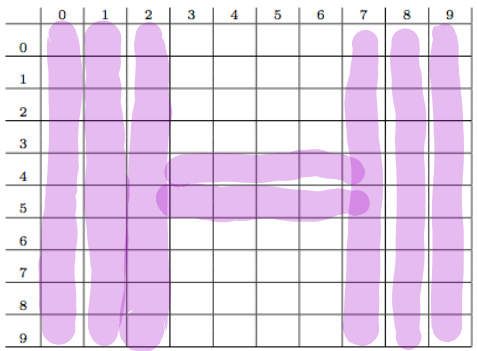
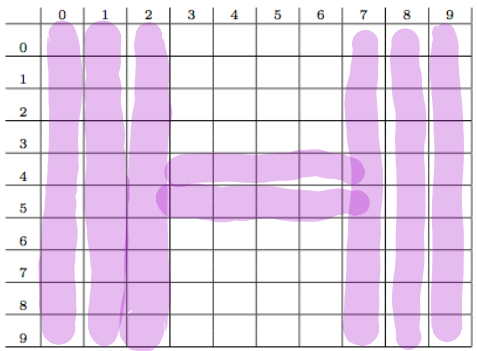
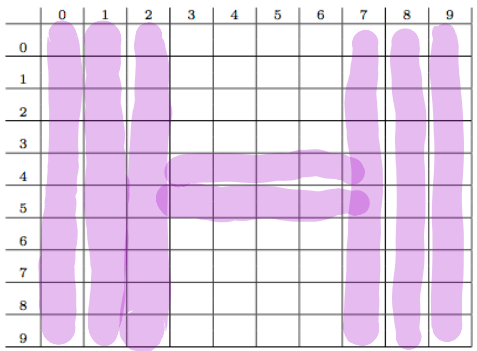
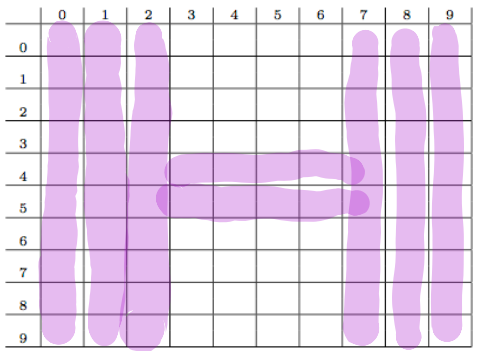


    ```

Side Challenge: School Logo



	0	1	2	3	4	5	6	7	8	9
0										
1										
2										
3										
4										
5										
6										
7										
8										
9										

1. Design a 10 by 10 logo for Hunter College that contains a purple 'H'.

Side Challenge: School Logo



1. Design a 10 by 10 logo for Hunter College that contains a purple 'H'.
2. Your logo should only contain the colors purple and white.

Side Challenge: School Logo



1. Design a 10 by 10 logo for Hunter College that contains a purple 'H'.
2. Your logo should only contain the colors purple and white.
3. How can you make Python draw the logo?
   Write down a "To Do" list of things you need to do.

Side Challenge: School Logo



1. Design a 10 by 10 logo for Hunter College that contains a purple 'H'.
2. Your logo should only contain the colors purple and white.
3. How can you make Python draw the logo?
   Write down a "To Do" list of things you need to do.
4. If time, refine your steps above into a Python program.

Design a Hunter Logo

One possible solution:



Design a Hunter Logo



1. Create a 10 by 10 array, `logo`, that starts out as all white pixels.

Design a Hunter Logo



1. Create a 10 by 10 array, `logo`, that starts out as all white pixels.
2. Set the 3 left columns to be purple.

Design a Hunter Logo



1. Create a 10 by 10 array, `logo`, that starts out as all white pixels.
2. Set the 3 left columns to be purple.
3. Set the 3 right columns to be purple.

Design a Hunter Logo



1. Create a 10 by 10 array, `logo`, that starts out as all white pixels.
2. Set the 3 left columns to be purple.
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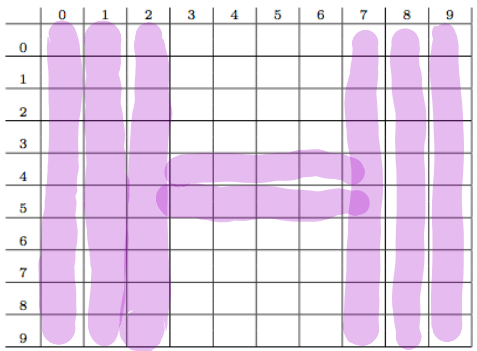
4. Set the middle 2 rows to be purple.

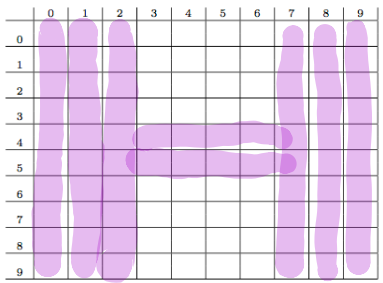
Design a Hunter Logo



1. Create a 10 by 10 array, `logo`, that starts out as all white pixels.
2. Set the 3 left columns to be purple.
3. Set the 3 right columns to be purple.
4. Set the middle 2 rows to be purple.
5. Save `logo` array to a file.

Translating the Design to Code

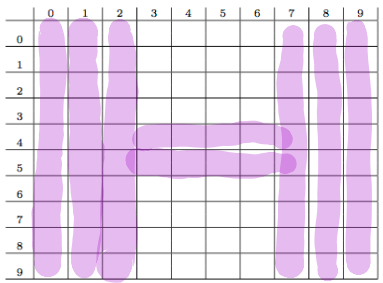
1. Create a 10 by 10 array, `logo`, that starts out as all white pixels.



Translating the Design to Code

1. Create a 10 by 10 array, `logo`, that starts out as all white pixels.

```
import matplotlib.pyplot as plt #import libraries for plotting
import numpy as np              #and for arrays (to hold images)
logoImg = np.ones((10,10,3))    #10x10 array with 3 sheets of 1's
```



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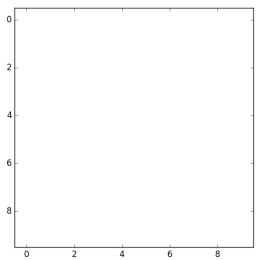

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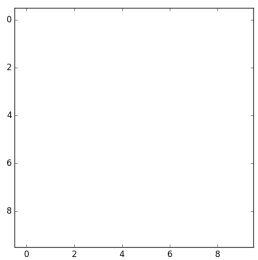
2. Set the 3 left columns to be purple.



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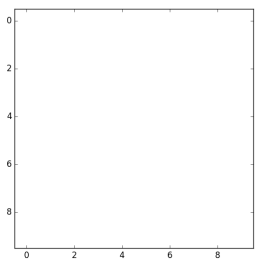
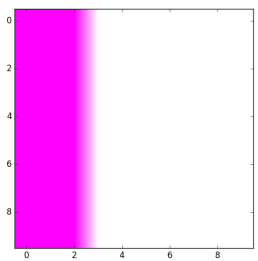
2. Set the 3 left columns to be purple.

```
#To make purple, we'll keep red and blue at 100% and turn green to 0%
logoImg[:,:3,1] = 0 #Turn the green to 0 for first 3 columns
```



Translating the Design to Code



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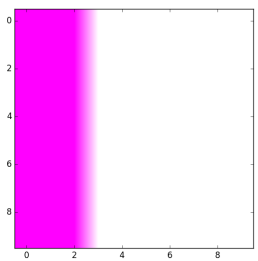
Translating the Design to Code



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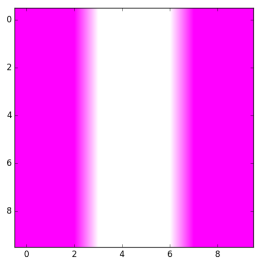
```
#To make purple, we'll keep red and blue at 100% and turn green to 0%
logoImg[:,:3,1] = 0 #Turn the green to 0 for first 3 columns
```

3. Set the 3 right columns to be purple.

```
logoImg[:,-3:,1] = 0 #Turn the green to 0 for last 3 columns
```

Translating the Design to Code



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logoImg[:,:3,1] = 0 #Turn the green to 0 for first 3 columns
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logoImg[:,-3:,1] = 0 #Turn the green to 0 for last 3 columns
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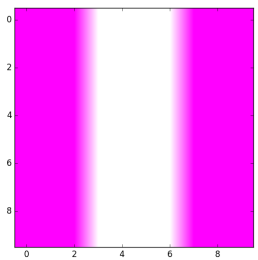
Translating the Design to Code



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```
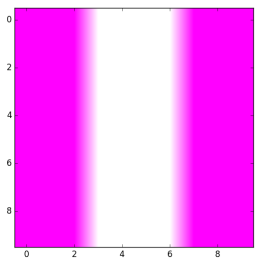

3. Set the 3 right columns to be purple.

```
logoImg[:,-3:,1] = 0 #Turn the green to 0 for last 3 columns
```

4. Set the middle 2 rows to be purple.

Translating the Design to Code



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```
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logoImg[:,:3,1] = 0 #Turn the green to 0 for first 3 columns
```

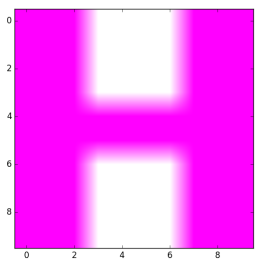
3. Set the 3 right columns to be purple.

```
logoImg[:,-3:,1] = 0 #Turn the green to 0 for last 3 columns
```

4. Set the middle 2 rows to be purple.

```
logoImg[4:6,:,1] = 0 #Turn the green to 0 for middle rows
```

Translating the Design to Code



1. Create a 10 by 10 array, `logo`, that starts out as all white pixels.

```
import matplotlib.pyplot as plt #import libraries for plotting
import numpy as np              #and for arrays (to hold images)
logoImg = np.ones((10,10,3))    #10x10 array with 3 sheets of 1's
```

2. Set the 3 left columns to be purple.

```
#To make purple, we'll keep red and blue at 100% and turn green to 0%
logoImg[:,:3,1] = 0 #Turn the green to 0 for first 3 columns
```

3. Set the 3 right columns to be purple.

```
logoImg[:,-3:,1] = 0 #Turn the green to 0 for last 3 columns
```

4. Set the middle 2 rows to be purple.

```
logoImg[4:6,:,1] = 0 #Turn the green to 0 for middle rows
```

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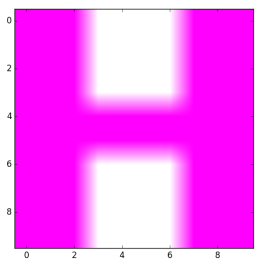

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5. Save logo array to file.

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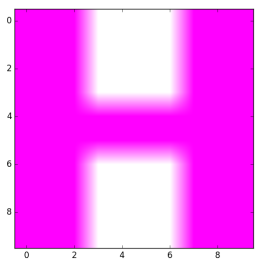

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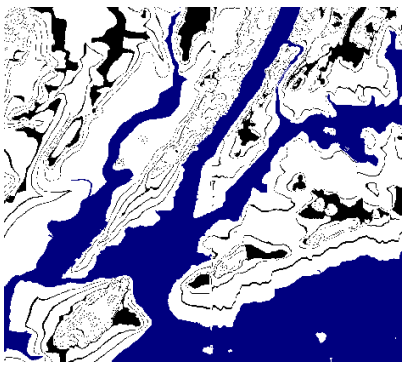
```
plt.imsave("logo.png", logoImg) #Save the image to logo.png
```

Outline



- Welcome and Introductions
- Workshop Overview
- Design Challenge: Flood Maps
  - Data: Elevations from NOAA
  - Packages: `numpy` and `pyplot`
  - Concepts: Colors and Arrays
  - Putting It Altogether
- Break
- Variations on the Theme
- Design a Challenge
- Wrap Up

Design a Challenge

With your group, brainstorm about a design challenge that:

- Creates an image with 2 or more colors.
- Can be based on a data file or implement a student design.

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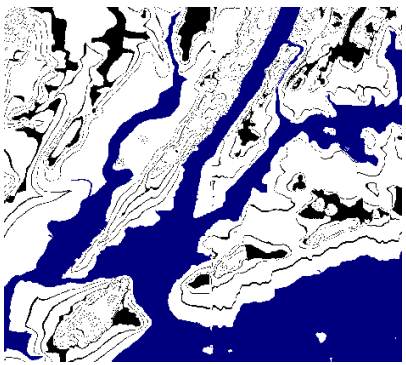

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- See you in two weeks!