More Raster Processing

(or there is more than one way to skin a cat)

Open Source RS/GIS Python
Week 6

Projecting rasters

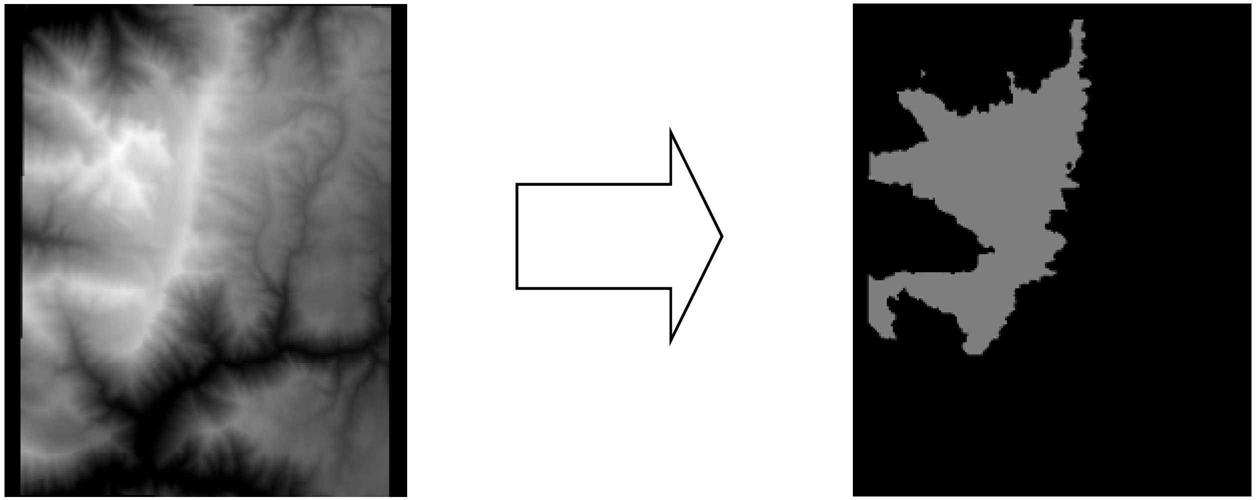
- Need Well Known Text (WKT) for input and output projections
- Can get it from the original Dataset (if it has a projection defined) with **`GetProjection()`**
- Can create output WKT using the SpatialReference objects we learned about earlier

- **`gdal.CreateAndReprojectImage(<source_dataset>, <output_filename>, src_wkt=<source_wkt>, dst_wkt=<output_wkt>, dst_driver=<Driver>, eResampleAlg=<GDALResampleAlg>)`**
- There are a few other options that I won't cover here
- Sets geotransform and projection but does not build pyramids

```
import gdal, osr
from gdalconst import *

inFn = 'd:/data/classes/python/data/aster.img'
outFn = 'd:/data/classes/python/data/aster_geo.img'

driver = gdal.GetDriverByName('HFA')
driver.Register()

# input WKT
inDs = gdal.Open(inFn)
inWkt = inDs.GetProjection()

# output WKT
outSr = osr.SpatialReference()
outSr.ImportFromEPSG(4326)
outWkt = outSr.ExportToWkt()

# reproject
gdal.CreateAndReprojectImage(inDs, outFn, src_wkt=inWkt,
  dst_wkt=outWkt, dst_driver=driver,
  eResampleAlg=GRA_Bilinear)

inDs = None
```

Method comparison

- Simple model using a DEM
  - elevation > 2500 = 1
  - elevation <= 2500 = 0
  - Small DEM (1051 X 1397)



Pixel by pixel processing

- Can loop through each pixel with Numeric

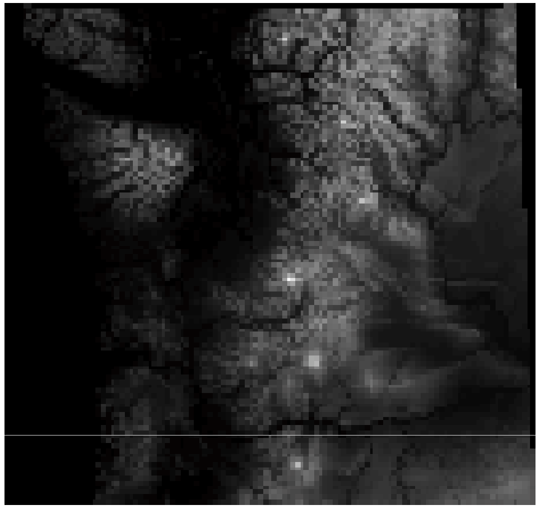
```
outData = Numeric.zeros((rows, cols))
for y in range(rows):
  for x in range(cols):
    if inData[y, x] > 2500:
      outData[y, x] = 1
    else:
      outData[y, x] = 0
```

Built-in function

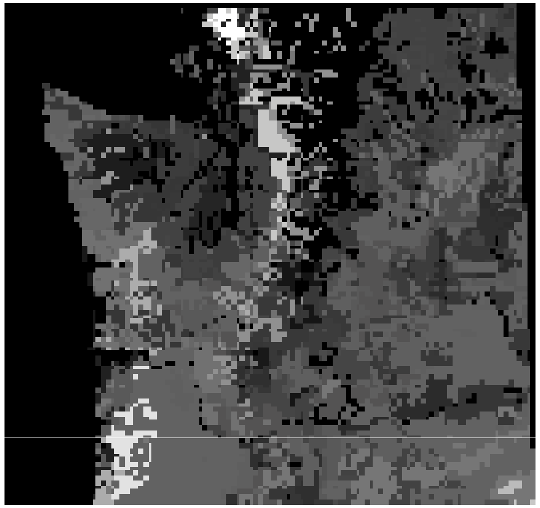
- Or can use a built-in Numeric (or numpy) function whenever possible

```
outData = numpy.greater(inData, 2500)
```

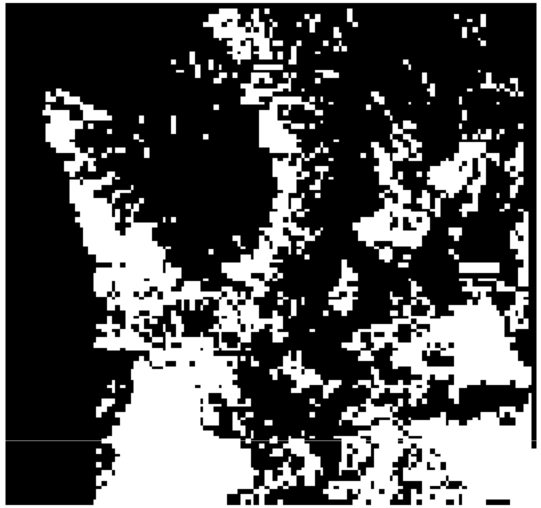
Another comparison



Elevation



Soil available water capacity (awch)



Output

```
if elevation > 2000:
    if awch > 0.15: output = 1
    else: output = 0
else:
    if awch > 0.2: output = 1
    else: output = 0
```

Pixel by pixel

```
outData = Numeric.zeros((rows, cols), Numeric.Int)
  for y in range(rows):
    for x in range(cols):
      if elev[y, x] > 2000:
        if awch[y, x] > 0.15:
          outData[y, x] = 1
        else:
          outData[y, x] = 0
      else:
        if awch[y, x] > 0.2:
          outData[y, x] = 1
        else:
          outData[y, x] = 0
```

Built-in functions

- Method 1

```
case1 = Numeric.where((elev > 2000) & (awch > 0.15), 1, 0)
case2 = Numeric.where((elev <= 2000) & (awch > 0.2), 1, 0)
outData = case1 + case2
```

- Method 2

```
case1 = Numeric.where(Numeric.greater(elev, 2000) &
  Numeric.greater(awch, 0.15), 1, 0)
case2 = Numeric.where(Numeric.less_equal(elev, 2000) &
  Numeric.greater(awch, 0.2), 1, 0)
outData = case1 + case2
```

- Method 3

```
outData = Numeric.where(Numeric.greater(elev, 2000),
  Numeric.where(Numeric.greater(awch, 0.15), 1, 0),
  Numeric.where(Numeric.greater(awch, 0.2), 1, 0))
```

Results

Method	My old PC (Numeric)	Numeric on Windows VM	Numpy on Windows VM	Numpy on Mac
DEM Pixel by pixel	28.4	6.5	7.5	12.9
DEM Built-in function	0.14	0.06	0.0	0.005
Tree Pixel by pixel	n/a	39.9	49.3	77.1
Tree Built-in function	n/a	1.5, 1.6, 1.3	0.7, 0.7, 0.7	0.4, 0.4, 0.4

Processing times in seconds

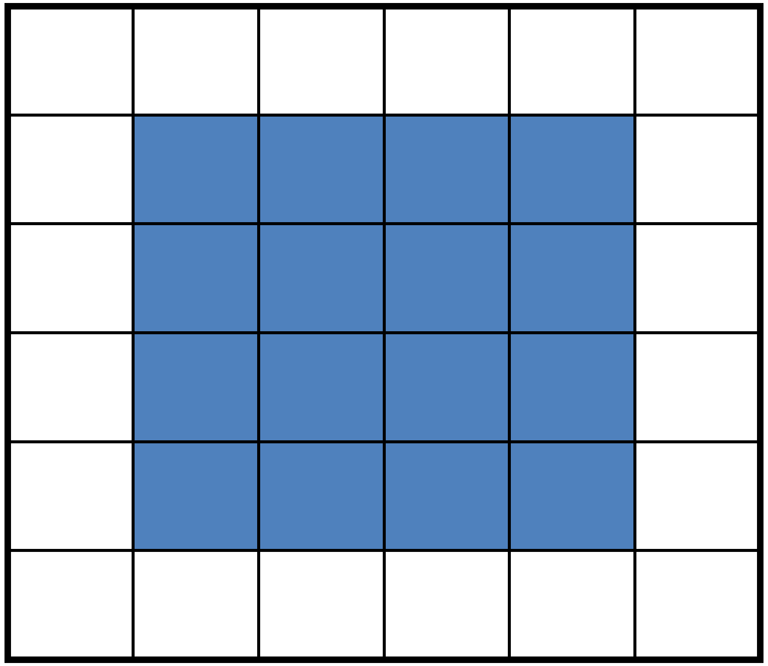
- Built-in functions are much faster than looping through pixels

Moving windows (neighborhoods)

- Neighborhood notation
- 3x3 average:
- J = (E + F + G + I + J + K + M + N + O) / 9
- out[i,j] = (in[i-1,j-1] + in[i-1,j] + in[i-1,j+1] + in[i,j-1] + in[i,j] + in[i,j+1] + in[i+1,j-1] + in[i+1,j] + in[i+1,j+1]) / 9

A i-2, j-1	B i-2, j	C i-2, j+1	D i-2, j+2
E i-1, j-1	F i-1, j	G i-1, j+1	H i-1, j+2
I i, j-1	J i, j	K i, j+1	L i, j+2
M i+1, j-1	N i+1, j	O i+1, j+1	P i+1, j+2

- For 3x3 window, the output is 2 columns and 2 rows smaller than input



3x3 average pixel by pixel

- Write output to a band of type Byte
- Truncating the average (86.7 -> 86)
- Average gets truncated to integer when put into outData, which is type Int

```
data = inBand.ReadAsArray(0, 0, cols, rows).astype(Numeric.Int)
outData = Numeric.zeros((rows, cols), Numeric.Int)
for i in range(1, rows-1): # skipping first & last
  for j in range(1, cols-1):
    outData[i,j] = (data[i-1,j-1] + data[i-1,j] + data[i-1,j+1] +
      data[i,j-1] + data[i,j] + data[i,j+1] +
      data[i+1,j-1] + data[i+1,j] + data[i+1,j+1]) / 9.0
```

- Explicitly rounding the average (86.7 -> 87)
- Average gets rounded before being put into outData

```
data = inBand.ReadAsArray(0, 0, cols, rows).astype(Numeric.Int)
outData = Numeric.zeros((rows, cols), Numeric.Int)
for i in range(1, rows-1): # skipping first & last
  for j in range(1, cols-1):
    outData[i,j] = round((data[i-1,j-1] + data[i-1,j] +
      data[i-1,j+1] + data[i,j-1] + data[i,j] + data[i,j+1] +
      data[i+1,j-1] + data[i+1,j] + data[i+1,j+1]) / 9.0)
```

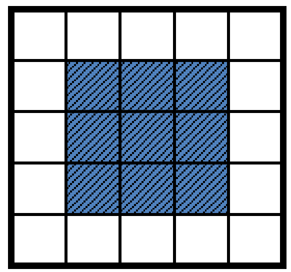
- Implicitly rounding the average (86.7 -> 87)
- Average stays a float when put into outData (type Float) but rounding to Byte when written to output band (type Byte)

```
data = inBand.ReadAsArray(0, 0, cols, rows).astype(Numeric.Int)
outData = Numeric.zeros((rows, cols), Numeric.Float)
for i in range(1, rows-1): # skipping first & last
  for j in range(1, cols-1):
    outData[i,j] = (data[i-1,j-1] + data[i-1,j] + data[i-1,j+1] +
      data[i,j-1] + data[i,j] + data[i,j+1] +
      data[i+1,j-1] + data[i+1,j] + data[i+1,j+1]) / 9.0
```

3x3 average with array slices

- Basically slicing and shifting arrays
- Perform calculations on entire arrays rather than individual pixels
- Output and all input array slices MUST be the same dimensions
- Output array cannot be a smaller data type than any of the input arrays

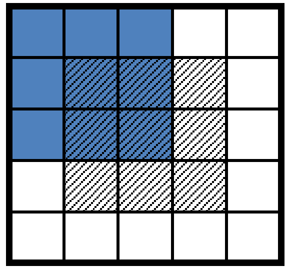
- Substitute a reference to an array slice for a specific pixel
- Hatched areas are the i,j pixels that will get output values
- Shaded areas are the slices that go into the calculation



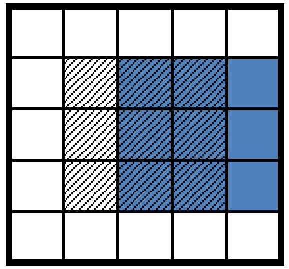
`Pixel notation: data[i,j]`

`Slice notation: data[1:rows-1,1:cols-1]`

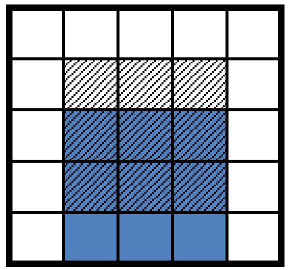
```
Pixel: data[i-1,j-1]
Slice: data[0:rows-2,0:cols-2]
```



```
Pixel: data[i, j+1]
Slice: data[1:rows-1,2:cols]
```



```
Pixel: data[i+1, j]
Slice: data[2:rows, 1:cols-1]
```



- Truncating the average (86.7 -> 86)
- Because outData is Int, must keep everything integer during calculations (divide by 9 instead of 9.0)

```
data = inBand.ReadAsArray(0, 0, cols, rows).astype(Numeric.Int)
outData = Numeric.zeros((rows, cols), Numeric.Int)
outData[1:rows-1,1:cols-1] = (data[0:rows-2, 0:cols-2] +
  data[0:rows-2,1:cols-1] + data[0:rows-2,2:cols] +
  data[1:rows-1, 0:cols-2] + data[1:rows-1,1:cols-1] +
  data[1:rows-1,2:cols] + data[2:rows,0:cols-2] +
  data[2:rows,1:cols-1] + data[2:rows,2:cols]) / 9
```

- Explicitly rounding the average (86.7 -> 87)
- Average gets rounded and then converted back to integer so it can be put into outData (type Int)

```
data = inBand.ReadAsArray(0, 0, cols, rows).astype(Numeric.Int)
outData = Numeric.zeros((rows, cols), Numeric.Int)
outData[1:rows-1,1:cols-1] = Numeric.around((
  data[0:rows-2, 0:cols-2] + data[0:rows-2,1:cols-1] +
  data[0:rows-2,2:cols] + data[1:rows-1, 0:cols-2] +
  data[1:rows-1,1:cols-1] + data[1:rows-1,2:cols] +
  data[2:rows,0:cols-2] + data[2:rows,1:cols-1] +
  data[2:rows,2:cols]) / 9.0).astype(Numeric.Int)
```

- Implicitly rounding the average (86.7 -> 87)
- Average stays a float when put into outData (type Float) but rounding to Byte when written to output band (type Byte)

```
data = inBand.ReadAsArray(0, 0, cols, rows).astype(Numeric.Int)
outData = Numeric.zeros((rows, cols), Numeric.Float)
outData[1:rows-1,1:cols-1] = (data[0:rows-2, 0:cols-2] +
  data[0:rows-2,1:cols-1] + data[0:rows-2,2:cols] +
  data[1:rows-1, 0:cols-2] + data[1:rows-1,1:cols-1] +
  data[1:rows-1,2:cols] + data[2:rows,0:cols-2] +
  data[2:rows,1:cols-1] + data[2:rows,2:cols]) / 9.0
```

Results

Method	My old PC (Numeric)	Numeric on Windows VM	Numpy on Windows VM	Numpy on Mac
Truncating pixel by pixel	44.3	13.5	34.7	44.2
Explicit round pixel by pixel	50.9	14.5	37.0	47.8
Implicit round pixel by pixel	47.4	13.1	22.5	23.7
Truncating slices	0.6	0.5	0.5	0.2
Explicit round slices	3.6	2.4	0.7	0.3
Implicit round slices	2.1	0.7	0.6	0.3

Processing times in seconds

Another way to get average

- To compute a 3x3 average we added 9 pixel values and divided by 9

```
(p1+p2+p3+p4+p5+p6+p7+p8+p9) / 9
```

- Since 1/9 = 0.111, this is the same as

```
(p1+p2+p3+p4+p5+p6+p7+p8+p9) * 0.111
```

- Which is the same as

```
0.111p1+0.111p2+0.111p3+0.111p4+
0.111p5+0.111p6+0.111p7+0.111p8+
0.111p9
```

Filters

- Low-pass filter
  - Used to smooth data
  - Every pixel is weighted the same – same as our 3x3 average

0.111	0.111	0.111
0.111	0.111	0.111
0.111	0.111	0.111

- High-pass filter
  - Used to enhance edges
  - Pixels have different weights

-0.7	-1.0	-0.7
-1.0	6.8	-1.0
-0.7	-1.0	-0.7

Assignment 6a

- Use a 3x3 high pass filter to detect edges in band 1 of smallaster.img
- The output data type will be Float
- Use pixel notation (that's why you're doing it on smallaster.img instead of aster.img)
- Turn in your code and a screenshot of the output

Assignment 6b

- Use a 3x3 high pass filter to detect edges in band 1 of aster.img (good idea to test on smallaster.img first)
- The output data type will be Float
- Use slice notation
- Turn in your code and a screenshot of the output

- Compare your output to output.img (it’s a subset of smallaster.img)
- **No class next week**