

Exercise #5C

Image Classification

(Evaluating Signatures)



Objective

- Examine the signatures of different land cover
 - Learn how to evaluate these.
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Once signatures have been defined and saved in a signature file they can be evaluated, deleted, renamed and merged with signatures from other files. You can use signatures defined from one image to classify a different image. You can merge parametric and non-parametric signatures, and signatures that are defined from supervised and unsupervised training sites.

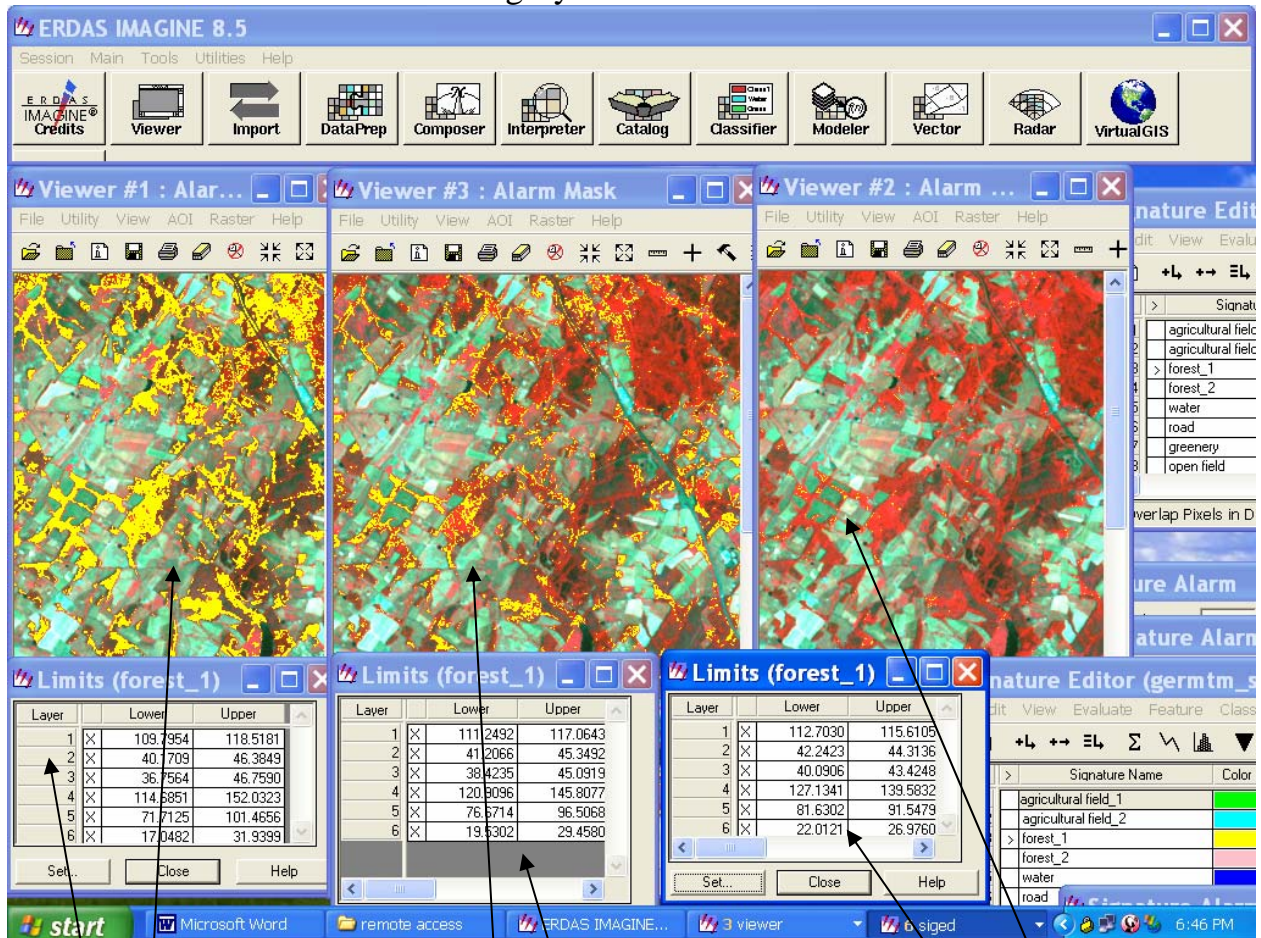
In this set of exercise you will learn the tools for looking in detail at the spectral signatures you have defined, and for evaluating the signatures. The steps we will go through allow you to look at the statistics of the signatures and the areas in the image which fall within the signature definitions – but **they do not do** the actual classification. This will require us to choose the decision rules to apply in allocating pixels to classes, and will be done later.

1. Alarm

Alarm gives you quick look at which pixels in the image fall within your signature definitions using the parallelepiped rule (i.e. those pixels in the image which have intensity values in each band between the minimum and maximum values, or the mean \pm some number of standard deviations, used in the signature definition for that class).

Open the image (los_angeles_subset.img or <yourfile_subset>.img) in the Viewer. Open the Signature Editor. Open one of your signature files for this image (eg. los_angeles_subset_aoi.sig or <yourfile_subset_aoi>.sig). Select one of the signatures (eg. grass). Select View -> Image Alarm from the Signature Editor menu bar. Select Set Parallelepiped Limits. You can change the boundaries of the spectral defining box to the maximum and minimum used in the training sample, or some # of standard deviations from the mean value. Close this dialog. Click OK. The alarmed pixels will be highlighted in yellow (or other signature color). Now investigate how the highlighted areas change when you change the definition of the parallelepiped.

In the screen dump below, 3 alarm masks are shown using 3 different definitions of the parallelepiped. If you increase its size, more pixels fall into the definition for that signature. The aim is to define the signature and decision rule so that exactly the right amount of land falls into this category.



Parallelepiped limits are set to the minimum and maximum values.

Parallelepiped limits are set to 2 standard deviations within the mean.

Parallelepiped limits are set to 1 standard deviation within the mean.

1.1 Turn in a screen dump similar to the one displayed above, showing part of your image with three different settings for the limits on one of the land covers. (The example above shows the limits for forest_1.) (Set your limits to max and min, 1 standard deviation, and 2 standard deviations as above). Label each appropriately. Explain your observations – which definition puts most pixels into the class you have chosen (and why)?

2. View signatures in feature space (ellipses)

Draw ellipses showing the signature mean \pm some number of standard deviations, or the minimum and maximum limits, in feature space. This will show which signatures have a lot of overlap and which are well separated. It is also useful for gauging the number of standard deviations which should be applied in the classification decision. (You want the signatures to cover as much of the feature space as possible, without overlapping.)

Open the image (los_angeles_subset.img or <yourfile_subset>.img) in Viewer1, and one of the feature spaces, e.g. bands 2 and 4 (los_angeles_subset_2_4.fsp.img), in Viewer2. Open your signature file. In the Signature Editor menu bar choose Feature -> Objects. Enter 2 for the Viewer number (corresponding to Viewer used for the Feature Space image). Enter the number of standard deviations from the mean you wish the ellipses to encompass. Label the ellipses. Select all the signatures in the Signature Editor. Click OK in the Objects dialog. Experiment with different numbers of standard deviations and see how the sizes and shapes of the ellipses change. View the ellipses in other feature spaces (i.e. using other band combinations). You should be able to see which signatures are well-separated, which are not very well differentiated, and which bands differentiate the signatures best.

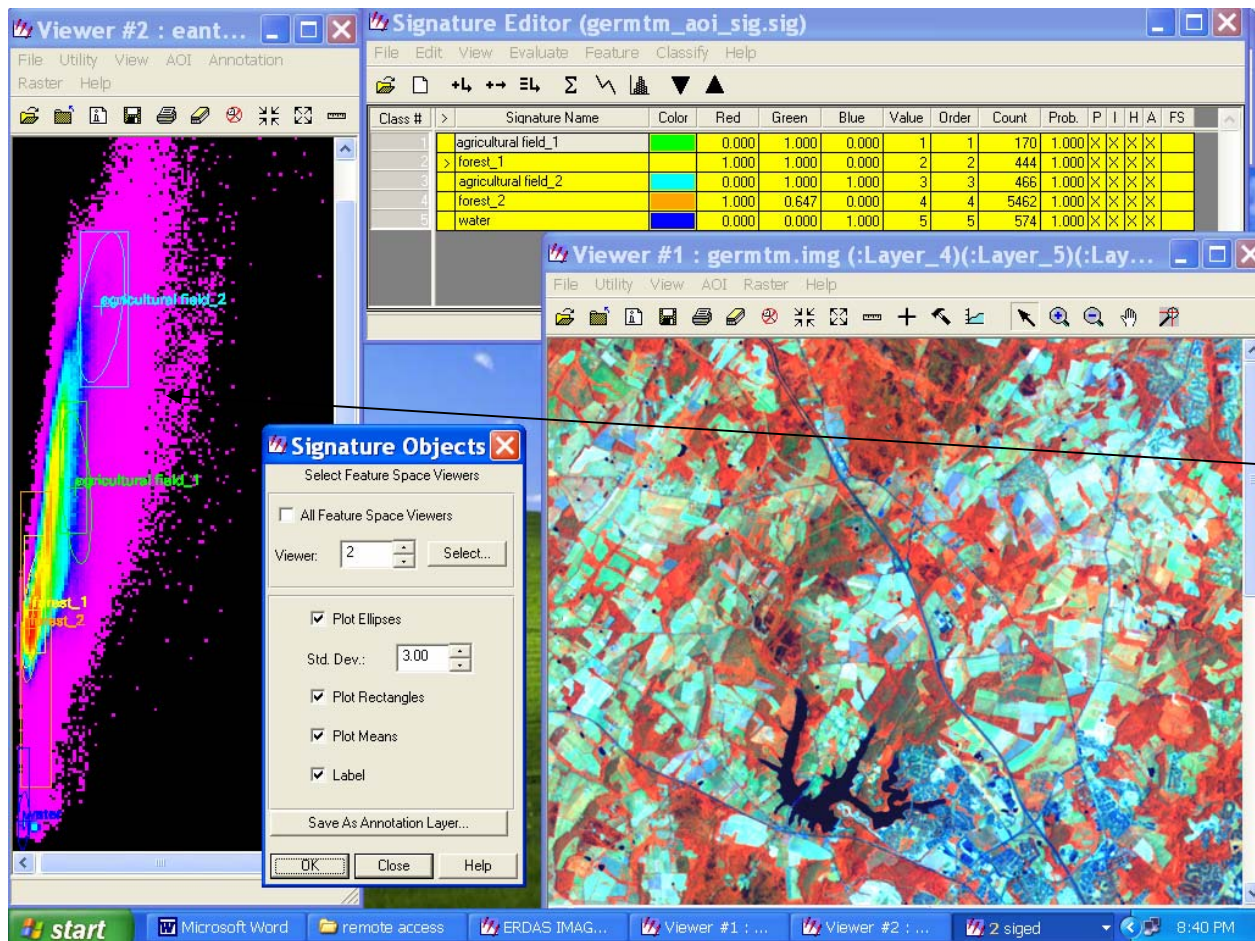
Turn in a screen dump similar to the one displayed below, showing the same part of your image with a setting of 1 standard deviation for the signature limits, and showing the ellipses drawn in feature space for all of the signatures. Use feature space for bands 2 and 4.

2.1. Which of the land covers show a large amount of overlap?

2.2. Which are well-separated?

2.3. Would you expect this to be the case in different spectral bands?

2.4. How do your ellipses change when you increase the signature definition to include 3 standard deviations?



Feature and 5.

3. Contingency matrix

Use a contingency matrix to find out how many of the pixels used in the training sample for each class will end up being classified into that class according to the decision rule that you choose. If the spectral signatures of two different classes are quite similar then outlying pixels in the training sample used to define one signature class may actually be closer (spectrally) to the mean of a different class. Then if the minimum distance decision rule was used to put pixels into classes these outliers might wind up being classified differently. The contingency matrix tests this.

Open the image (los_angeles_subset.img or <yourfile_subset>.img) in Viewer1. Open the signature file. In the Signature Editor select all the signatures. In the menu bar select Evaluate -> Contingency. Choose the minimum distance or maximum likelihood rule and click OK. Print out or save the report.

	Reference Data					
Classified Data	agricultural field 1	forest_1	agricultural field 2	forest_2	water	Row Total
agricultural field 1	170	0	0	6	0	176
forest_1	0	414	0	405	0	819
agricultural field 2	0	0	466	0	0	466
forest_2	0	30	0	5050	0	5080
water	0	0	0	1	574	575
Column Total	170	444	466	5462	574	7116

The contingency matrix above shows that of 176 pixels classified by the chosen decision rule to be agricultural field_1, 170 were from the original training sample used for this class, and 6 were from the training sample used for forest_2.

All the training sample for water was classified as water, but so was one other pixel that came from the forest_2 training sample.

3.1 In the table shown above, how many pixels were classified as water?

3.2 How many of these came from the original AOI used to define the water signature?

3.3 How many came from some other signature definition? Which signature was this?

3.4 What two classifications are most confused?

3.5 Why do you think this is?

Now print out and turn in your own table. Choosing water (if it is defined for your image) or some other class (if water is not defined), answer the same questions posed above.

4. Separability

This is a measure of the spectral distance between two signatures, and helps you to decide how different the signatures are. There are several ways of defining “distance”. The simplest is the Euclidean distance, which is the square root of the sum of the squares of the distances between each pair of band mean values. (Note this

is the same way that we find the distance between 2 points on a graph in 2- dimensions, or between 2 points in space in 3-dimensions. In this case we are just extending that definition to the n -dimensions of n bands, and are using spectral space rather than spatial space.) Some of the other definitions of distance which can be used incorporate the covariances of the signatures as well as their means. (These formulas include — Divergence, Transformed Divergence and Jeffries-Matusita Distance.)

Open the signature file. In the Signature Editor, select all the signatures. Then choose Evaluate -> Separability from the menu bar. In the dialog pick Euclidean distance. Leave Layers per Combination at 6. Choose a Summary Report and click OK. Print out and/or Save the Report.

Signature Separability Listing									
File: c:/documents/helen/remote sensing images/imagene_examples/germtm_aoi_sig.sig									
Distance measure: Euclidean Distance									
Using bands: 1 2 3 4 5 6									
Taken 6 at a time									
Class									
1	agricultural field_1								
2	forest_1								
3	agricultural field_2								
4	forest_2								
5	water								
Best Minimum Separability									
Bands		AVE	MIN	Class Pairs:					
				1: 2	1: 3	1: 4	1: 5	2: 3	2: 4
2: 5	3: 4	3: 5	4: 5						
1	2	3	4	5	6	115	21	79	74
133	144	220	112					76	149
								140	21
Best Average Separability									
Bands		AVE	MIN	Class Pairs:					
				1: 2	1: 3	1: 4	1: 5	2: 3	2: 4
2: 5	3: 4	3: 5	4: 5						
1	2	3	4	5	6	115	21	79	74
133	144	220	112					76	149
								140	21

This report shows that the average Euclidean distance between the signatures (using all 6 bands in the signature definition) is 115. The minimum distance between any

two signatures is 21. This is between classes 2 and 4. In the signature file used here, these classes correspond to forest_1 and forest_2.

4.1 Which two classes are most distinct?

4.2 What units are used for these distances? (Think carefully about how these distances are defined.)

4.3 Turn in the separability report for your signatures. In your report, which two of your classes are most distinct?

Perform a new separability using only 3 Layers per Combination. This means that only 3 bands at a time will be used in the signature definitions. Now instead of calculating the Euclidean distance over 6-dimensional space, it will be calculated over 3-dimensions. The computer performs the computation using every possible set of three bands. It prints a report on the three bands giving the Best Minimum Separability and the Best Average Separability. This will help you make a decision about displaying and classifying an image if you only want to use three bands and want to do the best job of distinguishing between all the land cover types.

Signature Separability Listing

File: c:/documents/helen/remote sensing
images/imagene_examples/germtm_aoi_sig.sig

Distance measure: Euclidean Distance

Using bands: 1 2 3 4 5 6

Taken 3 at a time

Class

- 1 agricultural field_1
- 2 forest_1
- 3 agricultural field_2
- 4 forest_2
- 5 water

Best Minimum Separability

Bands			AVE	MIN	Class Pairs:						
3: 4	3: 5	4: 5			1: 2	1: 3	1: 4	1: 5	2: 3	2: 4	2: 5
4 5 6	105	21	63	70	58	140	121	21	132		
124	207	112									

Best Average Separability

Bands			AVE	MIN	Class Pairs:						
3: 4	3: 5	4: 5			1: 2	1: 3	1: 4	1: 5	2: 3	2: 4	2: 5
3	4	5	105	21	70	65	66	140	121	21	131
124	202	111									

When considering only three bands in the classification, the report above shows that for the signatures used in this classification we could choose either bands 4, 5 and 6 — which produce the best (i.e. largest) minimum separation between signatures, or bands 3, 4 and 5 — which produce the best average over all the signatures. You can see in the report above that there is very little difference between the separation of the signatures whichever of these two sets of bands we choose.

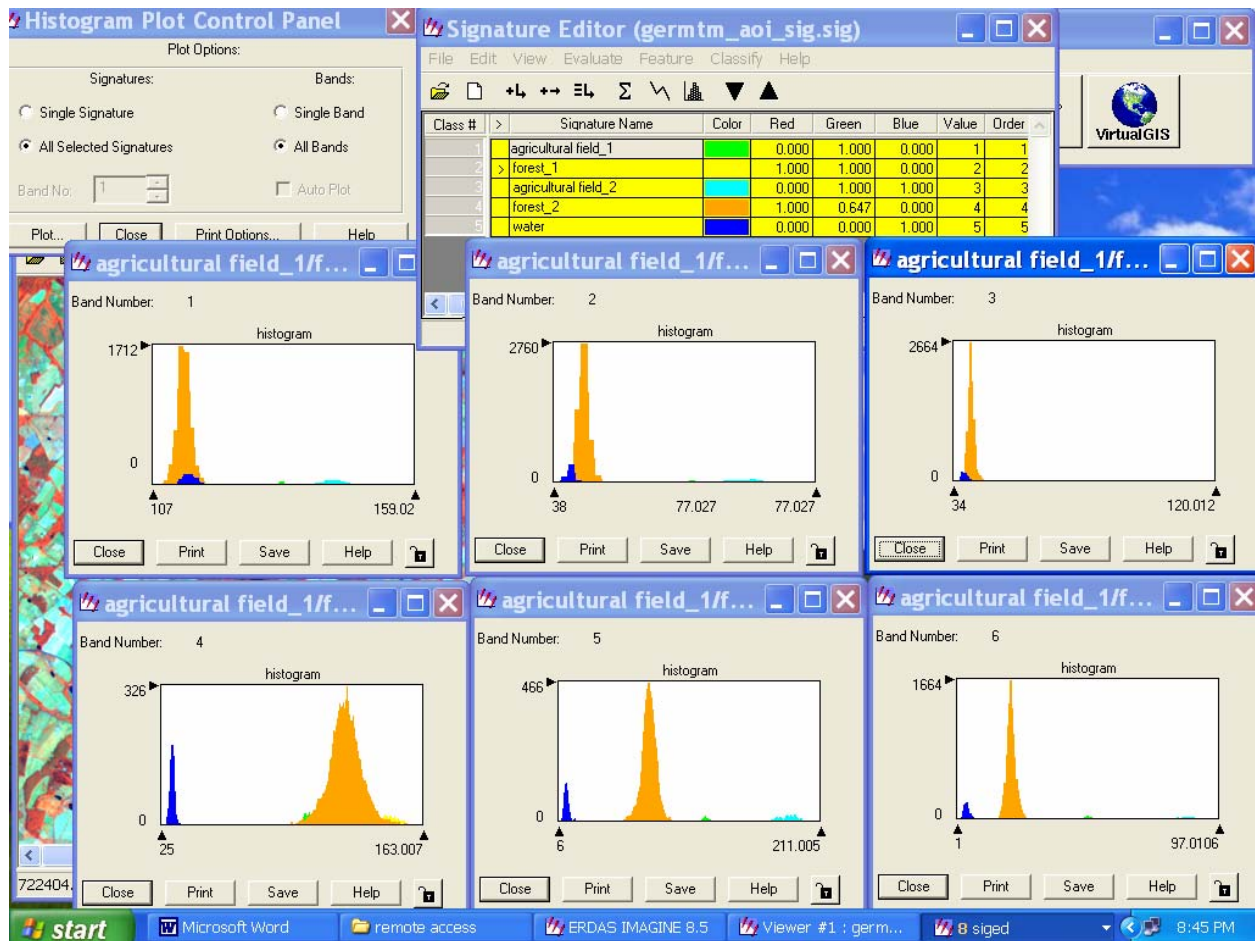
4.4 Print out and turn in a separability report for your signatures based on three bands. Which three bands produce the best minimum separation between signatures, and which produce the best average separation?

4.5 Print out and turn in a separability report for your signatures based on two bands. Which two bands produce the best minimum separation between signatures, and which produce the best average separation?

5. Histograms

You can also check on the difference between the signature definitions (or the spectral signatures of the pixels that were used to defined the signatures in the file) by viewing their histograms. Each histogram shows the number of pixels of a given brightness (intensity) in some band. You can choose to look at one signature at a time, or view them all together.

In the Signature Editor select all the signatures. In the menu bar select View -> Histograms. In the dialog box, select All Selected Signatures (to plot the histograms of all the signatures together). Select a single band, or all bands. Click on Plot.



This screen dump shows the histograms for all the bands.

- 5.1 Turn in a screen dump for your signature histograms similar to that shown above.
- 5.2 In the one shown above, in which band are water and forest_2 most difficult to distinguish?
- 5.3 In which band are they most distinguishable?
- 5.4 What parts of the spectrum do these bands correspond to?
- 5.5 In your signature definitions, which bands do the best job of separating water from other land covers?
- 5.6 Which bands are the worst for this?

6. Statistics

A parametric signature is based on the statistics of the pixels which went into its definition — i.e. the mean and standard deviations of the intensity values in each band for each pixel used. The signature file stores these statistics:

- the number of bands in the input image

- the minimum and maximum value in each band for each cluster used in the definition
- the mean intensity in each band for the pixels in the cluster
- the covariance matrix for each cluster
- the number of pixels in each cluster

You can view these statistics to make judgments about the signatures and their differences.

In the Signature Editor choose View -> Statistics. You will see the statistics for the signature selected.

Or you can print a statistics report. Choose File -> Report -> Check the Statistics box and the All Signatures box. The report will appear on the screen. Print it from the File menu.

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Number of layers: 6

Signature: agricultural field_1
Number of pixels: 170

                Statistics
Layer  Mimimum   Maximum   Mean      Sigma
  1    124.000   137.000  131.382   2.146
  2     52.000    61.000   57.365    1.746
  3     67.000    88.000   81.324    4.299
  4     93.000   115.000  101.459   3.067
  5    108.000   152.000  123.306   8.464
  6     41.000    62.000   48.953    3.581

                Covariance
Layer      1      2      3      4      5      6
  1      4.604   2.576   6.568  -1.526  -5.212  -1.834
  2      2.576   3.050   6.503  -1.222  -5.053  -1.829
  3      6.568   6.503  18.481  -3.777  -12.058  -4.807
  4     -1.526  -1.222  -3.777   9.410  11.492   3.608
  5     -5.212  -5.053 -12.058  11.492  71.634  27.926
  6     -1.834  -1.829  -4.807   3.608  27.926  12.826

Signature: forest_1
Number of pixels: 444

                Statistics
Layer  Mimimum   Maximum   Mean      Sigma
  1    108.000   119.000  112.926   1.381
  2     40.000    47.000   43.045    1.263
  3     37.000    45.000   40.047    1.486
  4    122.000   158.000  141.108   6.963
  5     68.000   107.000  82.423    6.519
  6     17.000    32.000   21.615    2.641

                Covariance
Layer      1      2      3      4      5      6

```

1	1.906	0.565	0.656	0.245	3.311	1.154
2	0.565	1.596	1.226	-1.499	5.024	1.963
3	0.656	1.226	2.208	-0.962	6.490	2.603
4	0.245	-1.499	-0.962	48.489	8.647	0.437
5	3.311	5.024	6.490	8.647	42.493	15.407
6	1.154	1.963	2.603	0.437	15.407	6.973

Signature: agricultural field_2

Number of pixels: 466

Statistics				
Layer	Mimumum	Maximum	Mean	Sigma
1	135.000	157.000	142.418	3.268
2	59.000	75.000	65.948	2.633
3	86.000	118.000	100.818	5.550
4	103.000	130.000	115.453	5.315
5	157.000	209.000	183.792	8.405
6	68.000	95.000	81.693	5.513

Covariance						
Layer	1	2	3	4	5	6
1	10.678	7.348	15.657	11.651	10.397	3.247
2	7.348	6.931	13.513	10.539	9.680	3.083
3	15.657	13.513	30.799	23.399	21.945	5.907
4	11.651	10.539	23.399	28.244	12.869	-3.912
5	10.397	9.680	21.945	12.869	70.651	37.824
6	3.247	3.083	5.907	-3.912	37.824	30.398

Signature: forest_2

Number of pixels: 5462

Statistics				
Layer	Mimumum	Maximum	Mean	Sigma
1	107.000	121.000	112.531	1.384
2	39.000	49.000	41.909	0.888
3	35.000	58.000	39.237	1.253
4	47.000	161.000	121.109	9.257
5	23.000	122.000	76.291	6.067
6	6.000	62.000	20.248	2.069

Covariance						
Layer	1	2	3	4	5	6
1	1.915	0.316	0.514	0.892	1.007	0.628
2	0.316	0.789	0.504	0.874	1.750	0.763
3	0.514	0.504	1.571	-1.120	2.136	1.311
4	0.892	0.874	-1.120	85.694	34.176	4.738
5	1.007	1.750	2.136	34.176	36.804	9.174
6	0.628	0.763	1.311	4.738	9.174	4.283

Signature: water

Number of pixels: 574

Statistics				
Layer	Mimumum	Maximum	Mean	Sigma

