1   Instructions

This lab is principally about image classification. This is a complicated lab, so all steps of the lab have been demonstrated in `lab6demo.m` on a simple three-band RGB image, `demo.jpg`. (These two files are in the following directory: `http://topex.ucsd.edu/rs/labs2019/lab6/demo/`.) You should start by downloading these demo files and running this script to help you understand the steps of the lab. Please save your code for the lab exercises as an m-file or Jupyter Notebook file and email the file to me (at `m3becker@ucsd.edu`).

1.1   Background Information

Image classification generally has three steps:

1) create a *training set* of pixels you identify as belonging to a certain group;

2) classify all the pixels of an image into groups based on your training set; and

3) assess how well each pixel fits into a group, and identify pixels that do not fit well into any group.

For an overview of classification, review Section 11.3 in the textbook *Physical Principles of Remote Sensing* by Rees.

2   Exercises: MODIS

This section uses a composite image of Wilkins Sound in the Antarctic Peninsula made from the first seven spectral bands of data collected by the Moderate Resolution Imaging Spectroradiometer (MODIS). The data for these bands are available at `http://topex.ucsd.edu/rs/labs2019/lab6/modis/`, with the nth MODIS band having the file name `modisn.dat` (e.g., calibrated radiances from MODIS band 1 are stored in `modis1.dat`). The files in this folder have been saved in ASCII format and are a subset of a MODIS swath acquired on March 6, 2008, from the Terra satellite at 14:05 UTC. The nominal resolution is 500 m per image pixel. For further information about MODIS satellite data, you may read more at `https://modis.gsfc.nasa.gov/data/dataprod/`.

The seven MODIS bands provided for this assignment correspond to the following spectral ranges and applications:

Band #	Min. λ (μm)	Center λ (μm)	Color	Applications
1	0.620	0.670	Red	Absolute land cover transformation, vegetation
2	0.841	0.876	Near-IR	Cloud amount, vegetation land cover transformation
3	0.459	0.479	Blue	Soil/vegetation differences
4	0.545	0.565	Green	Green vegetation
5	1.230	1.250	Mid-IR	Leaf/canopy differences
6	1.628	1.652	Mid-IR	Snow/cloud differences
7	2.105	2.155	Mid-IR	Cloud properties, land properties

Table 2.1: MODIS spectral bands

Download all of the files for the individual bands and save them in the same directory as your m-file or Jupyter notebook file. There is also a file in the Lab 6 directory, `lab6start_modis.m`, which provides some skeleton code that will help you to complete the exercises.

This particular image was chosen because it depicts an episode of the disintegration of Wilkins Ice Shelf in March 2008. A team led by researchers at the National Snow and Ice Data Center and the Scripps Institution of Oceanography wrote a journal article [1] detailing how this event was observed through remote sensing. You can access this article at `http://dx.doi.org/10.1016/j.epsl.2008.12.027`.
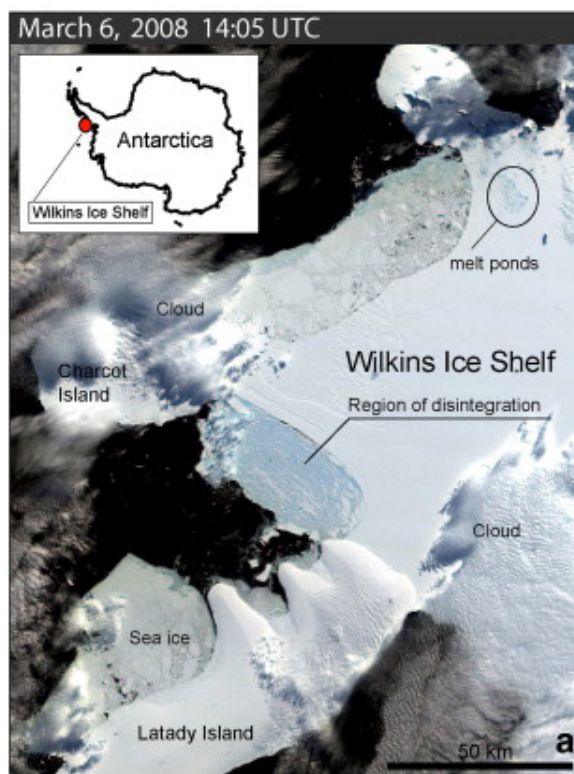
Figure 2.1: Classification of areas observed in the Wilkins Sound MODIS image (*Scambos et al.*, 2009)

2.1   Exercise 1

Start by reading in all seven bands of the Wilkins Sound MODIS image. Display all seven bands individually, and also display an RGB image. You will use this RGB image to identify pixels for your training set.

2.2   Exercise 2

Decide how many groups or classes, e.g., sea ice, open ocean, clouds, etc., into which you would like to sort your image. Create a three-column matrix, called `tpix`, containing the row, column, and group number of each training pixel. To do this, use the Data Cursor tool in your RGB image window. If you click a pixel in the image, a box should open and tell you the x-value (column); y-value (row); and R-, G-, and B-values of that pixel.

You will need to identify at least two training pixels per group. When you have identified the location of each training pixel, create a seven-column matrix, called `train`, that contains each of the seven band values for every pixel identified in `tpix`.

1) Before you can use MATLAB's `classify` function, the image data need to be reshaped into a vector with seven columns (the seven band values) and $nx*ny$ rows. For this MODIS image, $nx = ny = 400$, so the matrix of all pixels, `AllPix`, will have seven columns and 160,000 rows. Also, in order to use `classify`, `AllPix`, `train`, and `group` must be of data type `double`, not `uint8`, so you will need to convert them.

2) Classify the image using MATLAB's `classify` function. This step may take your computer a minute. The syntax for this command is:
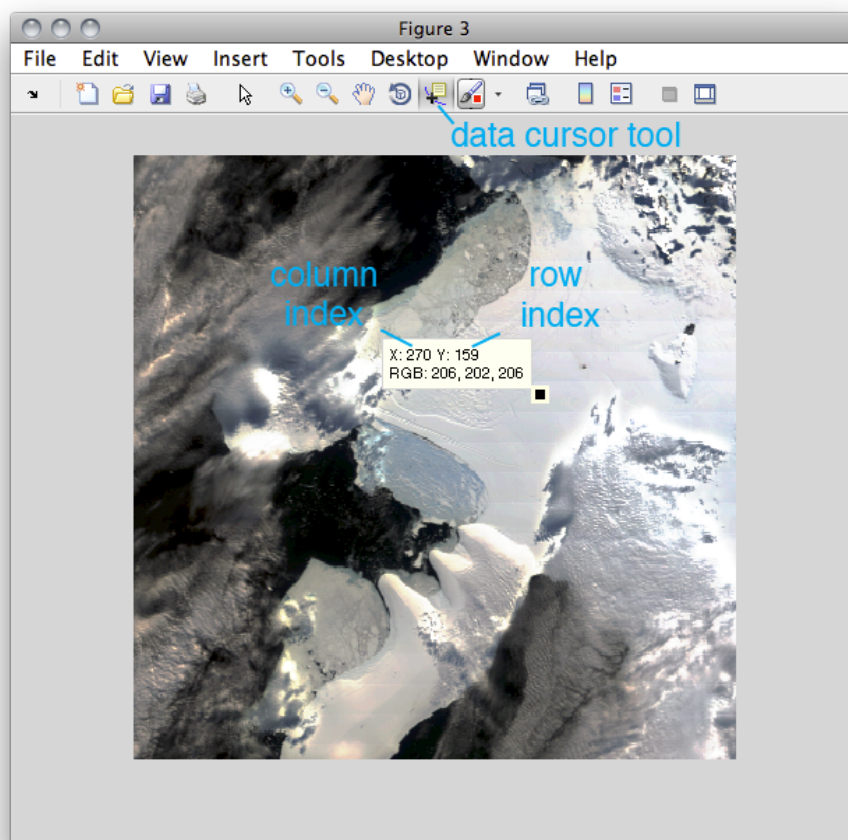
`[class, err, misfit] = classify(AllPix, train, group).`

Figure 2.2: An example of using the Data Cursor tool to select a training pixel—in this case, possibly for an "ice shelf" classification group.

As a reminder, `AllPix` is the matrix of seven band values for each pixel across the image, `train` is your training set, and `group` gives the groups to which each training pixel belongs. `class` is a vector that tells you to which group each pixel belongs, `err` is a dummy variable that you can ignore, and `misfit` is a matrix that tells you how well each pixel fits into each group (where 0 means no fit and 1 means a perfect fit).

3) To look at the classification and the misfit, you will need to reshape `class` and `misfit` back into $nx \times ny$ matrices. Then, you can look at the classification with `image` or `imagesc`. (You can use any colormap for this, or if you would like, you can create a colormap with a color for each group number that makes sense to you, e.g., white for clouds, blue for ocean, etc. See `lab6demo.m` for how to do this.) Does the classification make sense? Are all of the ocean pixels in one group? Are all of the cloud pixels in another?

2.3   Exercise 3: OPTIONAL

EXTRA CREDIT: Look at the misfit matrix for each group/class. Find the maximum group-misfit value for each pixel—this tells you which set of pixels fit well into one of the defined groups. Find the pixels with a maximum group-misfit value that is less than 0.9 (i.e., pixels that do not fit well into any of the groups), and change their class value to a new group number. Now look at the class matrix again with `image` or `imagesc`. Where are the pixels that did not fit well with any of your training set pixels?

2.4   Exercise 4: OPTIONAL

EXTRA CREDIT: Redo your classification with a different set of training pixels.

References

[1] Ted Scambos, Helen Amanda Fricker, Cheng-Chien Liu, Jennifer Bohlander, James Fastook, Aitbala Sargent, Robert Massom, An-Ming Wu, Ice shelf disintegration by plate bending and hydro-fracture: Satellite observations and model results of the 2008 Wilkins ice shelf break-ups, *Earth and Planetary Science Letters*, Volume 280, Issues 14, 15 April 2009, Pages 51-60, ISSN 0012-821X, `http://dx.doi.org/10.1016/j.epsl.2008.12.027`