Land Remote Sensing
Lab 5: Thermal Infrared and Microwave Remote Sensing

Assigned: October 30, 2017
Due: November 10, 2017

In this lab, you will generate several figures. Please sensibly name these figures, save them as .png or similar, collect them into a single .zip file named `xxxxxx_lab05.zip` where xxxxxx is your last name, and e-mail them to `gleggers@gatech.edu` with the subject line of "`[EAS 8803] Lab 05 Products`."

Any files you need are at: http://wray.eas.gatech.edu/remotesensing2017/RS_lab05_files.zip.

1 Thermal Infrared

Both the albedo and surface temperature of planetary bodies affect their reflected and emitted radiation, which together contribute to the radiance on sensor (L_{sat}) for an observing satellite. In thermal infrared spectroscopy, these factors influence the detectability of certain minerals. This is particularly true in the thermal crossover region—the range of wavelengths where both reflectance and emission are non-negligible.

The following questions explore this thermal crossover region for several planetary bodies. The file `E490_solarSpec_extended.txt` contains the reference spectrum E-490, which gives the Sun's spectral irradiance at 1 AU as a function of wavelength. Planetary parameters are provided in the following table.

	Daytime Surface Temp. (K)	Distane from Sun (AU)
Moon	380	1
Mars	250	1.52
Europa	110	5.2

1. Using what you know of radiative transfer and neglecting atmosphere, compute and plot a modeled L_{sat} vs. wavelength for the Moon, Mars, and Europa from 0 to 50 µm using the provided solar spectrum and planetary parameters. Assume that albedo is 0.2 and constant with wavelength. Discuss $L_{\mathrm{sat}}(\lambda)$ and variation by planetary body. E-mail your plot.

2. Make a plot of the percent of radiance on sensor that is reflected light. At approximately what wavelength is the "crossover wavelength" for each planetary surface, i.e. at what point is more radiance on sensor from thermal emission rather than reflected sunlight. E-mail your plot.

Using the same model, explore the more natural case in which the reflectance and emissivity of the surface vary as a function of wavelength. Specifically, consider the crossover region where thermal emission can start to influence the depth of absorption features. A synthetic surface spectrum is provided in the file `simSpec_30pct_extended.txt` to use. This spectrum has absorption bands of 30% strength at 2.5 µm, 3.0 µm, 3.5 µm, 4.0 µm, and 4.5 µm, which are locations of major vibrational absorption features in reflectance spectra of hydrated minerals and salts such as sulfates and carbonates.

3. Using the synthetic spectrum, make plots of I/F (not radiance) vs. wavelength over the 2–5 µm range for the Moon and Mars surface cases with four different albedos for the continuum: 0.05 (a dark, organic-rich surface), 0.2 (a typical basalt), 0.5 (mixed ice and rock), and 0.8 (pure ice). What happens to the band strengths and why? How does the surface temperature influence band strength? How does this change as a function of albedo? E-mail your plots.

4. Sythesize these findings into some comments about mineral detectability in different wavelength regions for different planetary surfaces. Consider, for example, what are the prospects for the detection of the 4.5 µm feature in sulfates on Mars?

2 RADAR

RADAR remote sensing uses microwaves and radio waves to image surfaces and detect surface properties like roughness. Radar instruments are active source, meaning they emit the waves that they then detect, and radar is among the most prevalent techniques used to observe Earth and other planetary bodies.

The file `sar.img` contains synthetic aperture radar data over Düsseldorf, Germany. The data was taken by RADARSAT-1 in the C-band (5.6 cmwavelength) with a nominal spatial resolution of 8 m. The following exercises will introduce how to work with radar data in ENVI.

5. Write a basic image description and indicate which parts of the image you think corner, specular, or diffuse reflectors, etc.

The default Linear 2% stretch is usually not the best choice for displaying radar images. From the image display window toolbar, select *Enhance* → *Interactive Stretching*. From the toolbar in the new dialog, select *Stretch_ Type* to view the various stretching options.

6. Ignoring the last two options in the menu, which of the stretch types are best for displaying radar data? Why did you conclude this?

Next, we'll investigate some spatial filtering. These are image operations by which individual pixel values are changed by a function of the intensities of neighboring pixels. From the image display window toolbar, select *Enhance* → *Filter* to view ENVI's basic filtering options.

7. Try applying each of the basic filters. What is the effect of spatial filtering, and why would one filter data? In your opinion, which of the basic filters provides the most useful result and why?

ENVI also has filters to specifically improve radar images by removing speckle, which is high-frequency noise. These filters are found by selecting *Radar* → *Adaptive Filters* from the main ENVI Classic toolbar.

8. Among the specialty radar filters, try the *Frost* filter, and comment on the results. How does changing the *Damping Factor* affect the results?

Density slicing is a process of assigning colors to ranges of pixel values in a single band image, such as a radar scene. It is a process akin to classification, though a bit simpler.

9. Density slice the original radar image using the ranges already provided in the file `dslice.dsr`. Do the colored slices correspond to real features? If so, what are those features? E-mail your image.

Now, consider a real application of radar imagery. Spudis et al. (2013) and Fa & Cai (2013) are two recently published papers that both use circular polarization of radar data from the Mini-RF instrument aboard the Lunar Reconnaissance Orbiter to determine whether polar impact craters on Moon contain H_2O ice. However, they reach opposite conclusions.

10. Read about the two studies, and consider the following:

(a) Summarize the respective arguments made by Spudis et al. and Fa & Cai.

(a) Describe the evidence from other remote sensing instruments for or against water on the Moon.

(a) Which side of the debate do you favor and why?