Remote Sensing 4113 Spring 2018
Final Exam Review Outline
Exam: Friday May 11 1:15-3:15 ESB 1038

The following is a general outline of topics from the second half of the semester, which may be covered on the final exam.

I haven't repeated all the topics listed in the midterm review sheet (which covered up through Chapter 5, and part of 8), but the final exam is comprehensive, so you should study those midterm topics as well. The final will tend to emphasize material from the second part of the course, for the most part "applications" of remote sensing. However you still need to know the basic principles and techniques from the first half, to understand those applications.

This is a list of the topics, not the material itself. For that material you'll need to review the text by Sabins, your lecture notes, and the PowerPoint lecture handouts.

While you do need to know facts, the emphasis will be not be on memorizing facts but rather on applying general principles. For example don't try to memorize the fact that urban areas are bright in radar images, – remember that "corner cubes" reflect the radar signal back to the source, and urban landscapes contain lots of "corner cubes". Similarly, remember that multiple reflections depolarize radar signals. Then you can apply those principle to many situations.

Besides material from the lecture, material covered in the labs may also appear on the final exam. I haven't listed that material explicitly in this outline. Review your lab reports.

We'll spend much of Friday May 4 reviewing the material. Come with questions.

The exam will be open book (Sabins only) and open notes. You should bring a calculator. I'll provide a list of equations and constants, but you will need to know how to use them.

Chapter 6 – Radar Technology and Terrain interactions

- General construction of radar systems
    - What determines Range Resolution
    - What determines Azimuthal Resolution for
        - a) Real apertures, b) Synthetic Apertures
- Geometry of radar beam
    - Depression angles, look direction, cardinal effects
- Radar reflectivity of different surfaces
    - Effects of roughness, dielectric properties, water content, right angle reflectors, specular reflection from smooth surfaces
    - Backscatter coefficient
- Distortions in Radar systems
    - Shadows, Foreshortening, image layover
- Polarization: HH, HV, VV, VH
- Interferometry

Chapter 7 – Interpretation of radar images

Don't try to know all the different radar systems mentioned in this chapter – just know how to apply the Chapter 6 principles to interpretation of a few basic types of surfaces we discussed, in particular vegetation (such as the Mahantango Mountain area of Pennsylvania shown in Fig. 7-15) , and rough (aa) vs. smooth (pahoehoe) volcanic terrain in Hawaii, and the, and the Magellan observations of Venus and Cassini radar observations of Titan.

Chapter 8 – Digital image processing

- Three "divisions" of image processing
    - Image restoration
        - Photometric corrections: de-striping, correcting for atmospheric scattering, filtering to reduce random noise.
          Also, calibration of digital data (<u>from lecture, not in book</u>)
        - Geometric corrections: restoring line offsets, replacing bad lines or pixels, and correcting for camera or scan distortions
    - Image enhancement
        - Contrast enhancement, density slicing, edge enhancement, various color transformations.
        - Merging data in various ways, such as producing mosaics, merging color, and creating artificial stereo.
        - Understand the basics of digital filters including smoothing and edge detection, using various "kernels"
    - Information extraction
        - Image ratios to extract composition information
        - Temperature measurement from IR data
        - Change detection
        - Principal-component analysis

- Multispectral classification
    - Supervised vs. Unsupervised
    - Cluster analysis, such as K-Means
  - More sophisticated mathematical indexes
    - such as NDVI and others – covered later under specific applications
- Map projections – <u>in more detail than shown in book</u> (see lecture)
  - Basic principles of projecting spherical surface to flat plane.
  - Why certain projections are best for certain applications, because they minimize the most objectionable distortions, or they minimize them over the area of interest.
  - Orthographic projection
  - Regular Cylindrical Projections
    - Choice of different types of distortions:
      - Plate Carrée (Equirectangular) vs. Mercator vs. Miller
  - Transverse Cylindrical Projections
    - Small distortion along a given meridian
    - Basis for UTM projections and coordinates, and USGS 7.5' topos
  - Oblique Cylindrical Projections
    - Space Oblique Projections (for Landsat)
  - Misc. Other projections
- Differences between raster (pixel) and vector data
- Color transformations

(Note: Classification methods and spectral unmixing covered primarily in the labs is also fair game to be on the exam, as are detailed indices such as band depth ratios.)

Chapter 9 – Meteorological, Oceanographic, and Environmental Applications

- Ozone Mapping (TOMS)
  - Nature and causes of Antarctic ozone hole, seasonal effects
  - TOMS use of UV backscatter to measure ozone
  - Units to measure atmosphere abundance:
    - cm-atmospheres (and Dobson units)
    - (I don't expect you to remember how many cm-atm per Dobson units, but you should understand what a cm-atm is.)
- Rainfall (Precipitation) mapping
  - Importance of measurement
  - Difficulties in measuring this remotely
  - "Proxy" measurements related to rainfall
    - Radar measurements of raindrops (not cloud particles)
    - IR measurements of coldest (tropical) clouds
    - Passive microwave observations
    - Emission observations
    - Use of polarization (scattering)
- Snowcover
  - Snow cover area estimates in visible

        - Distinguishing clouds from snow using spectral differences
        - Use of Snotel (ground truth) to calibrate remote observations
        - Gamma ray observations
    - Sea Ice and Glaciers <u>(more detailed than book – from lectures)</u>
        - Importance of radar
            - Can see through clouds, characterize roughness, measure small movements through interferometry
            - Applications of Canada's Radarsat 1&2 (<u>from lecture</u>)
                - Advantages of multiple polarizations for characterizing sea and land ice
        - Laser Altimetry (IceSat) for measuring ice thickness
        - Differences between ice shelves and ice sheets
        - Recent changes in Antarctica – global climate change
    - Ocean Floor topography
        - Indirect radar measurements of "large-scale" topography
            - from ocean surface height
        - Side-scan sonar and similarities to synthetic aperture radar
    - Gravity Measurements
        - GRACE and GRAIL (dual) satellite techniques

Vegetation (<u>Chapter 11 from Jensen – or from lecture</u>)

- Typical Leaf Spectra
    - pigments
    - changes with season
    - reflection and transmission
    - changes with water content
    - differences between types of vegetation
- Vegetation Indices
    - SR and NDVI
    - Tasseled Cap and use of scatter plots
- Evergreen vs. deciduous spectra
- Angular effects (BDRF's)
- Difficulties in distinguishing vegetation types with single observations
- Phenology (seasonal cycles)
- Landscape ecology metrics

Chapter 10 – Oil exploration

5 stages as detailed on pg. 339:

1) Regional remote sensing reconnaissance
2) Reconnaissance geophysical surveys
3) Detailed remote sensing interpretation
4) Seismic surveys
5) Drilling

Two examples covered in more detail:

Sudan

Recognition of sedimentary basins

General landform/landcover mapping to aid on-the-ground logistics

Central Arabian Arch

Regional geologic mapping of unexplored areas

Recognition of subtle anticlines in this type of terrain

Chapter 11 – Mineral exploration

Rather than covering all the examples in this chapter we concentrated on general principles plus the specific examples from Goldfield, NV and from the Hewson *et al.* 2005 paper

Lineaments and their relationship to mineralization

General principles related to ore bodies (<u>from the lecture more than the text</u>)

Specific patterns of minerals at Goldfield, NV, as related to the above.

Expected spectra of minerals which can be detected

Use of certain minerals as proxies for others

Alteration products – clays and iron minerals

Difficulties in directly detecting quartz (or precious metals)

Detection of above minerals using Landsat TM data

Classification based on band ratios

Unsupervised classification results

Resulting Geologic Maps

Use of hyperspectral data to identify specific minerals (band ratios, band depth ratios)

Unmixing techniques and mineral abundance images

Chapter 12 – Land use and land cover

The Multilevel Classification System

The <u>three (or more) levels</u> of classification

Reasons to use a <u>multilevel</u> system

Different types of data needed to classify at the three different levels

The general types of classification performed at the different levels

(Again – don't try to memorize the numbers of the multiple classes, but understand how they are used and why.)

You are not responsible for the second part of the chapter, on GIS systems.

Chapter 13 – Natural hazards

This chapter mostly serves as a summary and application of techniques discussed in earlier chapters.

Recognition of faults, earthquake hazards, landside hazards
Volcanic plumes

Chapter 14 – Comparing Image Types: Summary)

Again, this chapter serves as a summary of the multiple techniques discussed earlier, all applied to one particular region (Death Valley). Don't memorize details about the Death Valley results, but be prepared to know the advantages of applying multiple techniques to a given region.

Other topics, not from text

Review the more detailed discussion of mineral spectra and the mineral mixture -- abundance estimating techniques, discussed above under the Chapter 11 Goldfield results.

Also review the more quantitative analysis performed in the various labs. I don't expect you to remember the details of the individual sites, but do want you to know how to apply the various techniques discussed.

Lunar geology and remote analysis of lunar minerals

- Very general geological history of the moon
  - Magma ocean and anorthosite crust
  - Declining impact cratering
  - Later eruption of mare basalts
- "Simplicity" of lunar remote sensing
  - Relatively simple geologic history
  - Simple or absent "weathering" processes
  - Mechanically "simple" regolith generation
  - Lack of vegetation
- Albedo differences between highlands and mare
- Recognition of general mineral types based on spectra
- Use of wavelength shifts in bands to determine composition
  - Again – don't memorize names of minerals, but understand how the techniques work. For example, if presented with reference spectra, and one of "unknown" composition, you should be able to determine its type and composition.
- Fe and Ti abundance techniques
  - Again – don't memorize formulae – but if presented with graphs or data and formulae, you should know how to use them.