Analyzing the Earth Using Remote Sensing

Instructors:

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Course Description

Remote Sensing: The remote sensing portion of the course will explore how satellites observe the environment in both the visible and thermal spectrum. The main project will be to devise an algorithm that will detect clouds both in day and night, and will classify the remaining surface into vegetated, urban, and water. MATLAB programming will be used to read, analyze and display the satellite data.

MATLAB: MATLAB is a powerful and intuitive programming environment that provides students with the tools needed for numerical computations, data analysis of experiments and sensor measurements, graphical displays of spatial and temporal data. The material covered in this portion of the course will be blended with the concepts of remote sensing, introducing students to the matlab programming techniques needed to read, display and analyze satellite data.

Python: Over the course of the Python module, students will explore introductory time-series analysis and mapping using the NumPy, SciPy, and Matplotlib Python libraries. The class will be analyzing a temperature record throughout: reading in the data, filtering it as appropriate, calculating statistics such as correlation on it, using it to predict future temperatures using regression, and visualizing the data and analysis of the data.

GIS: Geographic Information Systems (GIS) is a computer-based tool that uses spatial data to analyze and solve real-world problems. This course is designed to introduce the student to the basic principles and techniques of GIS with as objective to develop an understanding of geographic space and how maps represent geographic space. A student will be able to read maps, as well as write about and discuss information gleaned from maps. By the end of the GIS module, students will be creating maps from sources both graphical and tabular data using ArcMap. Students will be able to use GIS to build maps using data they collected during program. Students will present and discuss their mapping work based on data collected from different sources using PowerPoint presentation.

Section 1: Remote Sensing & Matlab (Dr. Brian Vant-Hull)

Scoring: Quizzes and classwork will occur on alternating days, worth 5 pts each. Each week long section will be accompanied by a computer project done in class and worth 10 pts each.

Quizzes*:* 5pts/twice weekly
Classwork: 5pts/twice weekly
Project: 10pts/one per section

July 6 – Introduction to Remote Sensing
- Reflection, transmission, absorption and optical depth
- Collimation and images
- Satellites and other sensors
- Using MatLab in Interactive mode

CWK: radiation physics, orbits

July 7 – Making images using visible light

- Images and arrays
- Reflectivity and Color
- Reading a text file in MatLab
- Arrange into groups

Quiz: radiation physics, orbits

July 9 – Detecting clouds using visible light

- Making an image in MatLab
- Writing functions in MatLab: reading a file, displaying an image
- Loops: the while loop

CWK: modify our image function to iteratively adjust contrast

July 10 – Thermal radiation and clouds

- Thermal Radiation
- Creating a thermal radiation function
- Thermal cloud mask

Quiz: thermal radiation

July 13 – Decision structures

- Decision structures in MatLab
- Output array based on criterion
- helpful function: histograms.
- Using a cloud mask to filter data

Project: write a function that classifies a scene into water, vegetation, urban and cloud.

July 14 – Matlab project day 1

- *Work as a group to come up with the best classification schemes*
- *Work on the presentation.*

Section 2: Python for Climate Analysis (Hannah Aizenman)

For all classwork, you may submit an IPython Notebook containing any required graphs and text. You must submit through blackboard unless otherwise instructed.

July 16 – **Temperature Analysis**

- Measuring Temperature
- Python as a calculator (Temperature Conversions)

Time series data (Temperature for the past year)

- Storing data (strings, lists, dictionaries, arrays)
- Using Python libraries
- Reading in temperature data from files (pandas)

CWK: Read in monthly 2015 precipitation values for New York, Philadelphia, Newark, and Boston data. Compare the temperature and precipitation values between cities. Submit a paragraph describing any patterns you find. You must support all conclusions with specific details (numbers, differences between two quantities, etc.)

July 17 – Filtering and Visualization

- Standalone Python scripts (.py files)
- Filtering global monthly data
- Numpy smart indexing
- Control Structures: (for loops, ifs)
- Line and scatter plots using Matplotlib

CWK: Plot the temperature and precipitation for New York, Philadelphia, Newark and Boston from 1948-2014. You should create the following graphs:

- *temperature line plot, with a labeled line for each city*
- *precipitation line plot, with a labeled line for each city*
- *temperate vs. scatter plot*
- *pick 2 months from different seasons (for example December and April) and redo 1-3 for just those months*

Submit these graphs and a paragraph describing whether the patterns discussed in the first assignment still appear in the longer time record, and if those patterns still appear when the data is sampled by month , with references back to the graphs to support your assertions.

July 20 – Statistical Analysis & Spatial Characteristics

- Mean, standard deviation, median, mode
- Error bar plots
- Histograms

Compute the mean, median, mode and standard deviation for each city for temperature and precipitation. Plot the temperature and precipitation plots with error bars and the the histograms for both variables for all 4 cities. Submit these graphs and a paragraph discussing whether the mean, median, and standard deviation are accurate representations of the variability in the data given the histogram.

July 21 - Spatial Characteristics

- Reading in netcdf global temperature files
- Heatmap of day/mean/median
- Overlaying a map
- Plotting cities

CWK: Plot New York, Philadelphia, Newark and Boston on a map and color the points based on the average temperature and precipitation of the city (2 plots). Plot the mean global temperature and precipitation and the standard deviation. Submit these graphs and a paragraph comparing the city's average temperature and precipitation (and the variability in it) to the regional pattern.

July 23 - Correlation

- Linear regression
- Correlation & Correlation Matrix
- Heatmaps

Compute and plot the correlation matrices for temperature and precipitation (two separate matrices) between New York, Philadelphia, Newark and Boston using a longer time record and then visualize them. Then compute the correlation between temperature and precipitation for each city and plot temperature vs. precipitation with the best fit line for the cities with the highest correlation between them. Submit these graphs and a paragraph discussing whether the timeseries and regional patterns support these correlations, with references back to the graphs and previous work to support your assertions.

July 24 - Python project day
For the Python portion of the project, you will analyze a dataset of your choosing. It **must** be related to your earth science theme, have a temporal component (though it can be hourly, daily, monthly, ...etc) and lend itself to correlational analysis. You will analyze the statistical characteristics of your data (plot, mean/standard deviation, correlation) and explain how that supports your hypothesis about your chosen Earth Science topic. All datasets must be approved by the instructor, who will gladly help you find an appropriate dataset.

Section 3: Geographic Information Systems (GIS) (Dr. Tarendra Lakhankar)

Grading:
Group Project: 60%
Quiz: 25%
Class Participation: 15%

Assignment:
Students will be given assignments based on activities performed during the class. The examples of assignments includes: (1) importing data with latitude and longitude coordinates in GIS and creating maps, (2) Import excel or other data formats data in GIS and joining it Global or Local maps to create new maps using imported datasets. Students need to submit the assignment in 2 days of time. Since, these assignments are about creating maps, students will have 3 attempts to improve their maps and submit on the blackboard.

Group GIS Project:
Students are divided in several groups with 3-4 students in each group. In the GIS project, students are free to choose Earth System Science related topic, in consultation with the instructor. The project should have rich GIS elements. Students will be downloading data from various government website sources including: Census bureau, NOAA, NASA, USGS, DOL, World Bank, UN, and educational institutes, etc. The grading in GIS project is based quality of GIS maps produced, presentation skills, effort in data processing and preparation, and analysis of data. Students are encouraged to ask questions after presentations.

Mode of Presentation:
The PowerPoint slides will be used to class material on projector. Also, the computer and projector is used to show how to use ArcGIS software and their functionalities.

Communication:
Blackboard will be used for official communication outside the classroom. Students are expected to check their Blackboard account at least once a day.

July 27 – Introduction to GIS
- An overview of GIS
- Concept of Vector and Raster
- Feature model and example of features
- How GIS data are captured, stored, retrieved, analyzed & displayed

July 28 – Introduction to ArcMap
- How to use ArcMap

- Introduction to shapefiles
- Importing remote sensing data/images

July 30 – Data analysis and mapping
- Importing and processing tabular data for GIS
- Editing data layers
- Analyzing GIS data
- Mapping the GIS data

July 31 –Remote Sensing data and GIS
- Downloading the remote sensing (Glovis, NASA)
- Importing remote sensing data in ArcMap
- Supervised Classification of Remote Sensing (LandSat) data in GIS

Quiz: GIS Data type, data analysis

August 3 – GIS project
- Selection of group GIS project
- Searching GIS data for project
- Creating/importing data
- Data plotting and analysis

August 6 – GIS project
- Analysis/plotting of GIS data
- Presentation of GIS Project

Project: students will independent project based on their area of interest. Instructor will help student in acquiring and processing data that will be imported in GIS framework.

August 7 – Project work day

August 10 – Project presentation day