Undergraduate Course Module

Title: Using Satellite Data in the Social Sciences
Target Audience: Undergraduate Students (can be expanded to grad students easily)

Pedagogical approach

Ideally the class will have a lab attached to it, so there is 1 class for the actual content learning and the lab for practicing the skills and doing the weekly exercises. Having a dedicated lab time increases the likelihood that students will do the exercises and gives them structured time to interact with the professor and ask questions in the hands-on portion. During the content portion of the class, it will be a mixture of lecture and discussion with possible small group breakouts. Technology will be involved for demonstrations in both content and lab portions of the class.

Course Goals

By the end of this course, students should be able to: (1) work with satellite imagery and understand the process by which different types of satellite data are produced; (2) understand how to collect and analyze satellite data in a way that is replicable and reliable; and (3) apply satellite data and imagery to the social sciences.

Topic Areas:

- What are Satellites and the Types of Data they Produce
    - Overview of the satellite, maybe some history of their use
    - Different types of data (environmental, "imagery", etc.)
    - The processing phases that data go through (Level 0 – Level 4)
- Applications for Satellite Data in the Social Sciences
    - From the perspective of the types of questions that can be answered
        - Humanitarian questions – verification of mass atrocities and violations
        - Oversight of international agreements (e.g., denuclearization)
        - Rapid Response to disasters or crises
            - Both environmental and cultural heritage
        - Intelligence information
        - Social processes – human movement over time, migrations, historical or current
            - Includes refugee movements and displacements during conflict
        - Archaeological – finding archaeological sites, remote sensing, looking at the evolution of landscapes, etc.
        - Global processes – environmental change, climate change, etc.
- Principles of Data Collection (both referring to the acquisition of satellite imagery/data and the extraction or collection of data from preexisting imagery/data resources)
    - The research "process" and how data collection fits in
    - Primary and secondary data collection and times in which the process differs
        - Including finding access to data to collect
    - The importance of documentation (metadata and contextual metadata)

    - Understanding the limits of your data
- Principles of Data Analysis
    - Types of data analysis you can do with satellite data
        - Focus on imagery because its easier, but can do a quick tutorial on other kinds – extracting data, etc.
    - Using GIS tools for analysis
    - Implications of data limitations for analysis
- Replicability and Reliability in Collection and Analysis

Assessments
Semester long course, weekly (ish) exercises in lab, 1 midterm exam
A semester/course long project that involves them conducting an actual analysis and writing a report on it. At the start of the course, the instructor will introduce the students to two or three sample datasets from satellites (imagery, environmental, etc.) that will be available to the students so they don't have to worry about finding access to data for this project and instead can focus on the hands-on element. The datasets will intentionally not be perfect, so they have to address limitations and so that the instructor knows what limitations to look for. As the course progresses, students will turn in segments of their project for feedback and a grade. Each segment is not worth a lot of points (5-10?) so that the student can focus more on learning than "getting it right" on the first try.

Proposed segments of project:
- Research question and brief paragraph proposal for project, including the identification of the dataset they want to use
- Basic descriptives of their data and a sample of how they plan to document their collection
- A draft of their analysis and findings
- The final project with all sections put together and comments addressed

Other assessments will include exercises every week or two depending on the schedule and 1 exam:
- Exercises
    - How to come up with a research question
    - How to use GIS
        - Loading in data to GIS (whichever tool the class uses)
        - Extracting information from satellite data
        - Creating a documentation protocol
        - Conducting basic analysis / getting descriptive information
        - Conducting more advanced analysis (whatever that means)
- Exam
    - Midterm I think, focused on the readings side of things – likely multiple choice with some short answer.

Proposed Readings by Topic Area

The readings here are suggestions and include more so that the syllabus could be adapted to whatever level the course is (undergraduate vs. graduate). It is recommended that the suggested readings be complemented with news stories of current events to maintain the relevancy for the course over the long-term. There are also options presented that can act as supplements or replacements to the suggested core texts depending on the technological requirements of the institution/department.

Core Texts:

- Borra, S., Thanki, R., and Dey, N. 2019. *Satellite image Analysis: Clustering and Classification* (first edition). Springer. https://www.amazon.com/Satellite-Image-Analysis-Classification-SpringerBriefs/dp/9811364230/ref=tmm_pap_swatch_0?_encoding=UTF8&qid=&sr=
    - Focuses on satellite images more specifically, providing a solid foundation in the different types of images available and the types of errors or possible distortions. It breaks out manual enhancement and analysis from more automated methods of analysis (classification and clustering). It has a robust set of applied examples.
- Chuvieco, E and Huete, A. 2020. *Fundamentals of Satellite Remote Sensing: An Environmental Approach* (Third Edition). CRC Press. https://www.routledge.com/Fundamentals-of-Satellite-Remote-Sensing-An-Environmental-Approach-Third/Chuvieco/p/book/9781138583832
    - Provides a solid foundation in history of satellite data and international space law as well as the principles of remote sensing. It breaks out how to interpret different types of satellite data, how to enhance or correct data, and how to assess the accuracy of data (often skipped over).

What are Satellites and the Types of Data they Produce

- Borra et al. (2019) – Chapter 1
- Chuvieco & Huete (2020) – Chapters 1 – 3
    - Optional – Chapters 6 & 7

Applications for Satellite Data in the Social Sciences

- Archaeology/Cultural Heritage
    - Lasaponara & Masini (2012) – Chapters 1,2, & 8
    - Contreras & Brodie (2010)
    - Borra et al. (2019) – Chapter 5.17
- Forensics/Intelligence
    - Allen et al. (2015)
- Natural Disasters/Emergency Relief

    - Román et al. (2019)
- General overview of many kinds (pick some, they're 1-page synopses of applications)
    - Borra et al. (2019) – Chapter 5

Principles of Data Collection (both referring to the acquisition of satellite imagery/data and the extraction or collection of data from preexisting imagery/data resources)

- Collecting your Own Data
    - Chuvieco & Huete (2020) – Chapter 4
    - Crowdsourcing
        - Rayne et al. 2017
- Using Pre-existing resources
    - Green et al. (2017) – Chapter 4
- SWGDE (2018) – Best Practices for Digital Evidence Collection

Principles of Data Analysis

- General / Research Process
    - Olson (1960)
- Forensic Analysis
    - Raymond et al. (2014)
    - SWGDE (2019) – Technical Overview for Forensic Image Comparison
- Visual Analysis
    - Chuvieco & Huete (2020) – Chapters 5
    - Green et al. (2017) – Chapter 8
    - SWGDE (2017) – Best Practices for Image Content Analysis
- Clustering
    - Borra et al. (2019) – Chapter 3
- Classification
    - Borrar et al. (2019) – Chapter 4
    - Green et al. (2017) – Chapter 10

Replicability and Reliability in Collection and Analysis

- Tullis, J.A. and B. Kar, 2019, "Where is the Provenance? Ethical Replicability and Reproducibility in GIScience and its Critical Applications"
- Chuvieco & Huete (2020) – Chapter 8
- Green et al. (2017) – Chapter 6, 12
- Tapete & Cigna (2019)
- Sadr (2016)
- SWGDE (2018) – Establishing Confidence…

Options for Different Technological Requirements

This course could be taught with ESRI /Open source GIS packages, or it could be taught through R or Python. If using ESRI/GIS, then consider using Green, Congalton, & Tukman (2017) as a

primary text. If using R, then consider Kamusoko (2019) as a primary text. If using Python, consider Canty (2019) as the primary text.

- Green, K., Congalton, R., and Tukman, M. 2017. *Imagery and GIS: Best Practices for Extracting Information from Imagery.* ESRI.
- Kamusoko, C. 2019. *Remote Sensing Image Classification in R (*First edition). Springer.
- Cany, M.J. 2019. *Image Analysis, Classification and Change Detection in Remote Sensing with Algorithms for Python* (fourth edition). CRC Press.

Full Bibliography

Allen, T., Case, S., Haggard, A., Higgins, E., van Huis, P., Kivimaki, V.-P., Ostanin, I., Patin, N., Romein, D., & Toler, A. 2015. *Forensic Analysis of Satellite Images Released by the Russian Ministry of Defense: A Bellingcat Investigation*. Bellingcat. https://www.bellingcat.com/wp-content/uploads/2015/05/Forensic_analysis_of_satellite_images_EN.pdf

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Raymond, N. Card, B., and Baker, I. 2014. A New Forensics: Developing Standard Remote Sensing Methodologies to Detect and Document Mass Atrocities. *Genocide Studies and Prevention: An International Journal* 8(3): 33-48. DOI: http://dx.doi.org/10.5038/1911-9933.8.3.4.

Rayne, L., Bradbury, J., Mattingly, D., Philip, G., Bewley, R., & Wilson, A. 2017. From Above and on the Ground: Geospatial Methods for Recording Endangered Archaeology in the Middle East and North Africa. *Geosciences*, 7(4). https://www.mdpi.com/2076-3263/7/4/100/html

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Sadr, K. 2016. The Impact of Coder Reliability on Reconstructing Archaeological Settlement Patterns from Satellite Imagery: A Case Study from South Africa. *Archaeological Prospection* 23: 45-54. Doi: 10.1002/arp.1515. https://onlinelibrary-wiley-com.proxy-um.researchport.umd.edu/doi/full/10.1002/arp.1515.

Scientific Working Group on Digital Evidence (SWGDE). 2017. *SWGDE Best Practices for Image Content Analysis*. SWGDE. https://www.swgde.org/documents/Current%20Documents/SWGDE%20Best%20Practices%20for%20Image%20Content%20Analysis

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