Implementing Curriculum Updates in a Geoscience/Environmental Science Program: An Example from the University of Texas at El Paso

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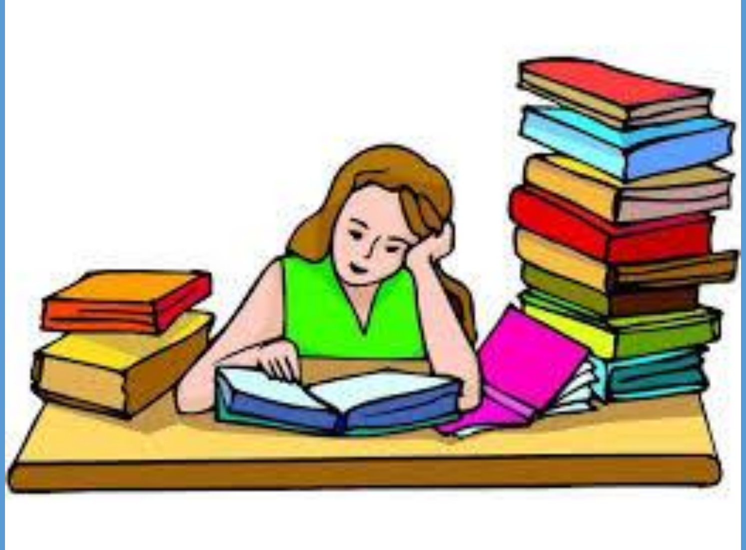
Department of Earth, Environmental & Resource Sciences

AGU Heads & Chairs Meeting

March 25, 2021

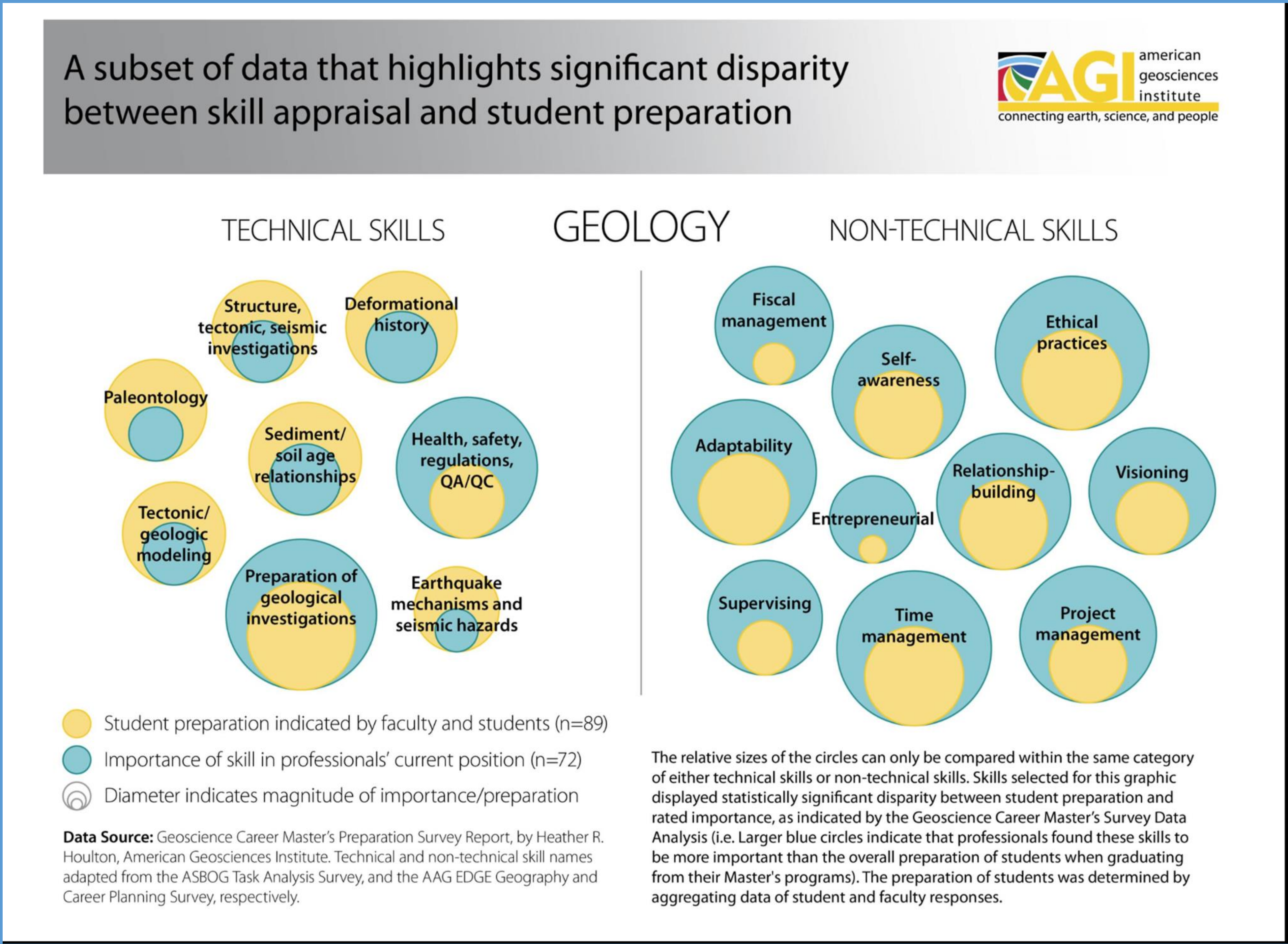
Serving Society - Educating Students



- Are we educating students about today's career opportunities?
- Are we giving students the skills they need to obtain a position & thrive in it?

- Have students networked sufficiently to feel confident entering the job market?
- Are graduating students versatile enough to adapt to evolving markets?

National surveys provided data to convince any skeptics that change is needed.



Future of Undergraduate Geoscience Education

- National conversation on shape and content of future Bachelors-level geoscience curriculum & programs (supported by NSF-Geosciences)
- Objectives:
  - Identify consensus on essential skills, concepts & competencies (and additional objectives – pedagogy, diversity, etc.)
  - Facilitate curricular transformation in geoscience programs nationwide

Developing a high-level community vision for the geosciences – over 1000 total participants

- **2014 Summit -- broad spectrum of undergraduate geoscience education community**
  - 180 educators (2YC to R1); ~20 employers
  - *Surprising collective agreement*
- **Nationwide survey of geoscience faculty and professionals – further agreement**
  - 360 academics; 105 employers; 85% non-Summit participants
- **2015 Geoscience Employers Workshop – agreement – added granularity**
  - 46 participants – Geology & Geophysics
  - Energy, hydro/engineering/environmental, mining, govt. agency, prof. societies, academics
- *2018- started new initiative for Graduate Geoscience Education – Earth, Oceans, Atmospheric Sciences*
  - *2018 Geoscience Employers Workshop; 2019 Heads/Chairs Summit*

http://www.jsg.utexas.edu/events/future-of-geoscience-undergraduate-education/

Implementing Community vision

- **2016 Heads and Chairs Summit - focused on how to implement**
  - 114 department heads/chair (2YC to R1)
- **2015, 2017, 2019 Earth Educator Rendezvous workshops - focused on how to implement**

91 individual departmental action plans for implementation
53 progress reports (58% return), - after 1.5 years to 3 years
11 2nd progress report – after 3 years

Vision and Change for Undergraduate Geoscience Education: A Call to Action (working title)

Faculty retreat to determine what we were already doing, identify gaps, and make curriculum more cohesive.

UTEPEDGE Talented Students. Enriching Experiences. Lifelong Success.

The Edge Advantages

Experience Type	*BBA Program Classification*	*Enriching Experiences*	*Leadership*	*Problem Solving*	*Communication*	*Entrepreneurship*	*Confidence*	*Global Awareness*	*Teamwork*	*Critical Thinking*	*Social Responsibility*
A	F	GEOL 1103 research based project written report	■	■	■		■		■	■	
A	F	GEOL 1104 research based project and oral report	■	■	■		■		■	■	
A	Fr-Sn	SCI 1301- speed dating: interpersonal awareness and reflection	■		■		■				
A	Fr-Sn	SCI 1301- bring your dirt: individual observation vs. group report	■	■	■		■	■	■	■	■
A	F	GEOL 1306 Intro Physical Geography active learning with data and models		■				■	■	■	■
A	S	ESCI 2105, mentoring students at all levels of undergrad research		■	■		■		■	■	
A	S	ESCI 2204, mentoring students in this research course		■	■		■		■	■	
A	Sr	ESCI 2301, Field methods for ESCI research		■	■		■		■	■	■
PD	J	ESCI 3192, professional development class for ESCI majors	■		■		■		■		
A	J	GEOL 3215, Scientific observations in the field		■	■		■		■	■	
A	J	GEOL 3215, Scientific writing and collaboration	■	■	■		■		■	■	
A	Jn	GEOG 3306, Weather and Climate						■		■	
A	S-Sn	ESCI 3308 Arid Lands	■	■	■		■	■	■	■	■
A	J-Sn	GEOG 3308, Climate Science						■		■	■
A,E	F-S-J	GEOL 3312/3112 (Geoscience Processes): field geology assignments	■	■	■		■		■	■	
A	J	GEOL 3321 for civil engineers, team work, project	■	■	■		■	■	■	■	■
E	Sr	GEOL 3323, reading scientific literature			■		■			■	
A	Jr-Sn	GEOL 3326 Sedimentology and Stratigraphy		■	■		■		■	■	
E	F-Sr	RSCR 4033, mentoring students at all levels of undergrad research		■	■		■		■	■	
PD	J-Sr	GEOL 4166 professional development class for geoscientists	■	■	■		■		■		
A	Sn	GEOG 4307, Arid Lands						■	■	■	
A	Jr-Sn	GEOL 4315-002 Written Summary Reports		■	■		■	■		■	■
A	Sn	GEOL 4316- systems analysis of bathtub		■			■		■	■	
A	Sn	GEOL 4316- build your own waste dump: synthesis report		■	■	■		■		■	■
A	Sn	ESCI 4320 Monitoring regional sustainability	■	■	■		■	■	■	■	
E	Jr-Sr	GEOL 4375 Field Geology 1	■	■	■		■		■	■	

BBA Program Classification | *F- Freshman S- Sophomore J- Junior Sn- Senior*

Activity Type | *PP- Passport Program Activity PD- Professional Development A- Academic E- Experiential Learning*

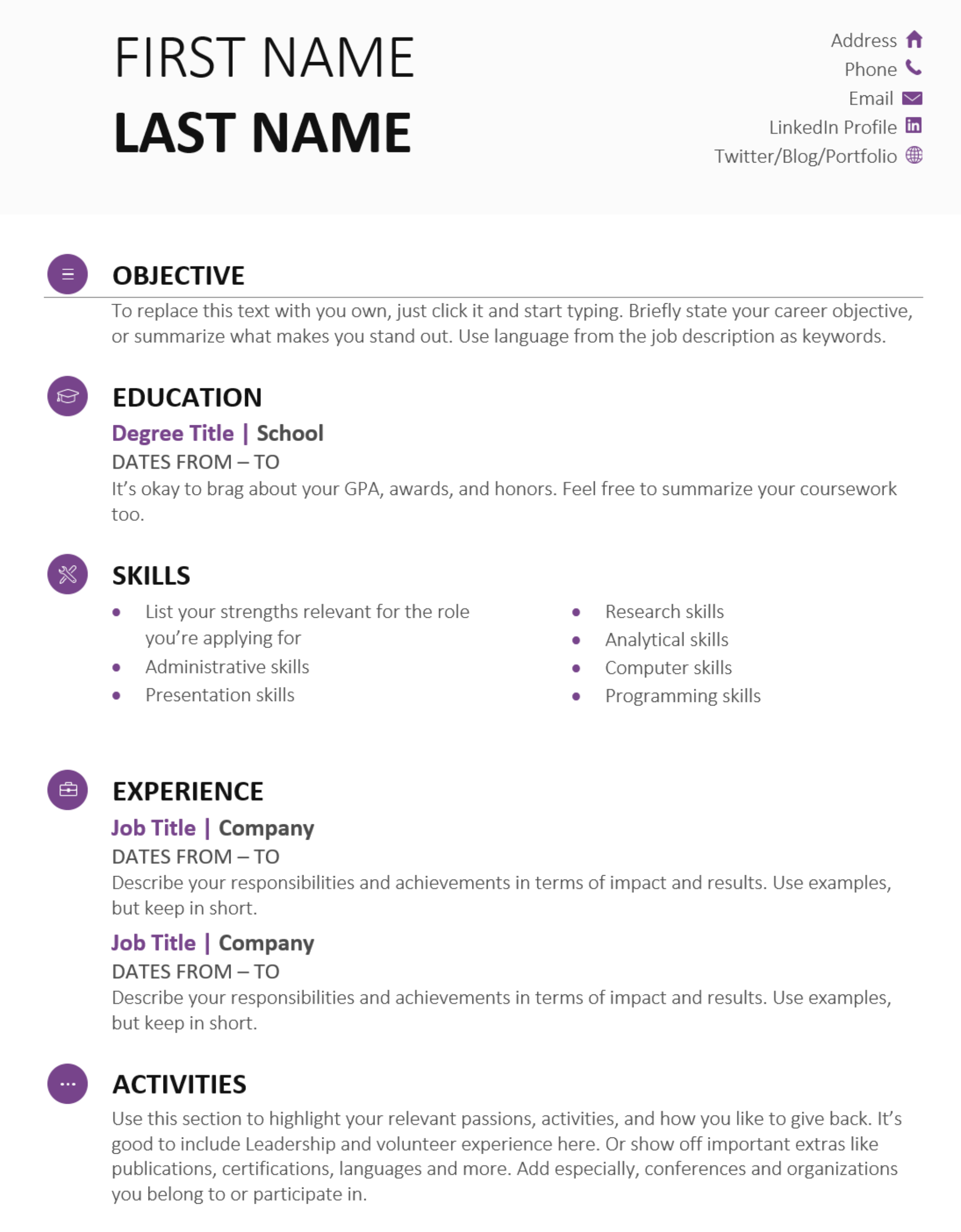
Educating Students - Preparing for a career

"The world is changing and future scientists must be well prepared to work with a broad range of scales, cross-disciplinary problems, and diverse settings."

What skills and knowledge do we want students to obtain before graduation?

- Observation & Data Collection
- Quantitative Data Analysis
- Computer Literacy
- Broad Fundamentals & In-depth Specialization
- Critical & Integrative Thinking
- Research Design

- *Provide students with resume templates at the earliest possible stages to guide them through skills development as well as degree program.*
- *Full-time undergraduate advisor meets with each student every semester with career mentoring provided by faculty.*



FIRST NAME
LAST NAME

Address
Phone
Email
LinkedIn Profile
Twitter/Blog/Portfolio

OBJECTIVE

To replace this text with you own, just click it and start typing. Briefly state your career objective, or summarize what makes you stand out. Use language from the job description as keywords.

EDUCATION

Degree Title | School

DATES FROM – TO

It's okay to brag about your GPA, awards, and honors. Feel free to summarize your coursework too.

SKILLS

- List your strengths relevant for the role you're applying for
- Administrative skills
- Presentation skills
- Research skills
- Analytical skills
- Computer skills
- Programming skills

EXPERIENCE

Job Title | Company

DATES FROM – TO

Describe your responsibilities and achievements in terms of impact and results. Use examples, but keep in short.

Job Title | Company

DATES FROM – TO

Describe your responsibilities and achievements in terms of impact and results. Use examples, but keep in short.

ACTIVITIES

Use this section to highlight your relevant passions, activities, and how you like to give back. It's good to include Leadership and volunteer experience here. Or show off important extras like publications, certifications, languages and more. Add especially, conferences and organizations you belong to or participate in.

By pairing and block scheduling our sophomore, junior and senior classes, we take students in the field on a regular basis. This field-oriented, experiential curriculum is rare for a commuter school and allows students to complete our major in 3 years, making possible timely completion by transfer students. We integrate experiences and problem-solving into courses, preparing students for careers in science.

Start with team-based research projects in Introduction to Physical Geology labs for majors.

Research Opportunities for Community College Students (ROCCS) - Diane Doser and Rob Rohrbaugh (EPCC)

Created faculty profile slides to incorporate into courses.

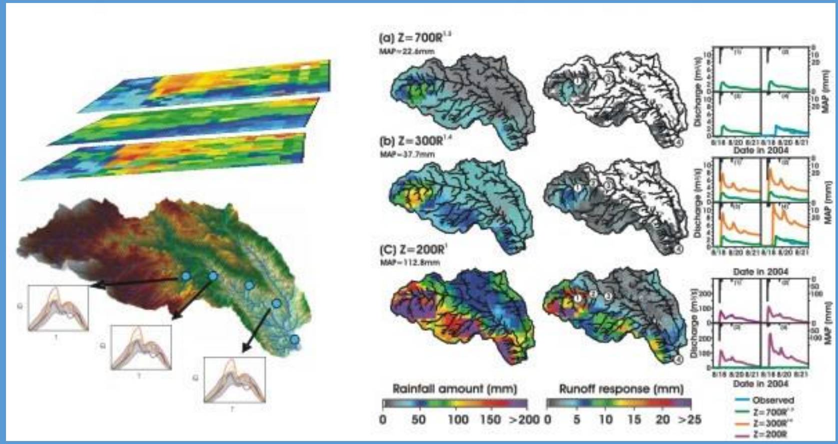
Dr. Hernan Moreno

- Latino born in Colombia.
- First scientist and Ph.D. in my family.
- Piano player (Salsa, Cumbia, Merengue, etc).
- My former students work in geology and engineering companies and academia.

I study water, its storage, circulation and distribution in natural and urban systems. I also help understanding and predicting natural hazards like flooding, landslides and droughts through observations and modeling.

Satellite, ground radars and drone-based remote sensing

Geographic Information System-based models

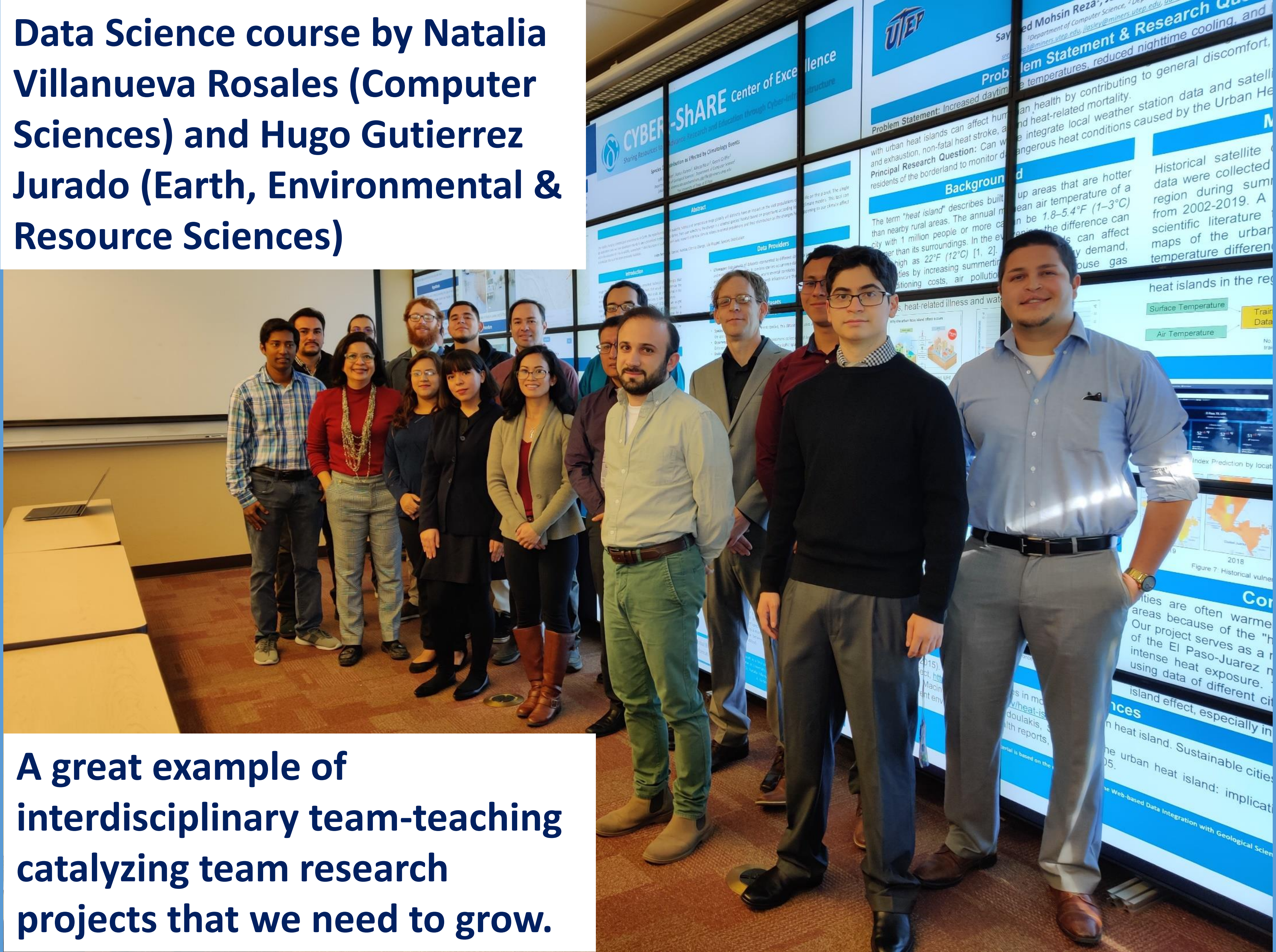


We help our students find internships and start careers with companies and government agencies around the country.

Example: Angela Trejo

I was accepted to participate in the Woods Hole Partnership in Education Program (PEP) as a 2019 summer intern. I worked at the Marine Biological Laboratory in Woods Hole, MA, and gained experience in environmental research. One of the opportunities offered is the PEP research cruise. We boarded a research vessel, called the SSV Corwith Cramer, for five days to experience what it is like to be part of the crew. It was extremely hard, rewarding work!

Data Science course by Natalia Villanueva Rosales (Computer Sciences) and Hugo Gutierrez Jurado (Earth, Environmental & Resource Sciences)



A great example of interdisciplinary team-teaching catalyzing team research projects that we need to grow.

Transdisciplinary course where both Undergraduate and Graduate Computer Science and Geoscience students worked collaboratively throughout the semester to develop informatic and web-based applications for solving environmental problems with potential societal impacts.

Students worked in teams and learned to communicate and transform small research projects integrating computer science and earth science knowledge and tools.

Team-based experiential learning in the Geosciences: lessons from an Ecohydrology course with a diverse student group

Earth Educators' Rendezvous
Online, July 13-17, 2020

*El Palmar Ecohydrological Monitoring Station, Yucatan, Mexico**

Course Design - Required skills recommended

Technical Skills

- Data analysis of real data
- 3D/4D problem solving with non-unique answers
- Quantitative skills – higher level math competency
- Statistics, probability, uncertainty analysis
- Computer programming and modeling
- Field skills

Non-Technical Skills

- Team work, project management
- Communication skills
- Interpersonal skills
- Leadership, professionalism
- Ethics, societal relevance
- Global perspective

Based on notes from the report on Outcomes and Next steps Geoscience Workforce & the Future of Undergraduate Geoscience Education.

Source: www.jsg.utexas.edu/events/future-of-geoscience-undergraduate-education/

The research project - Considerations

Class is performance and grade are mostly based on a Project students develop throughout the semester

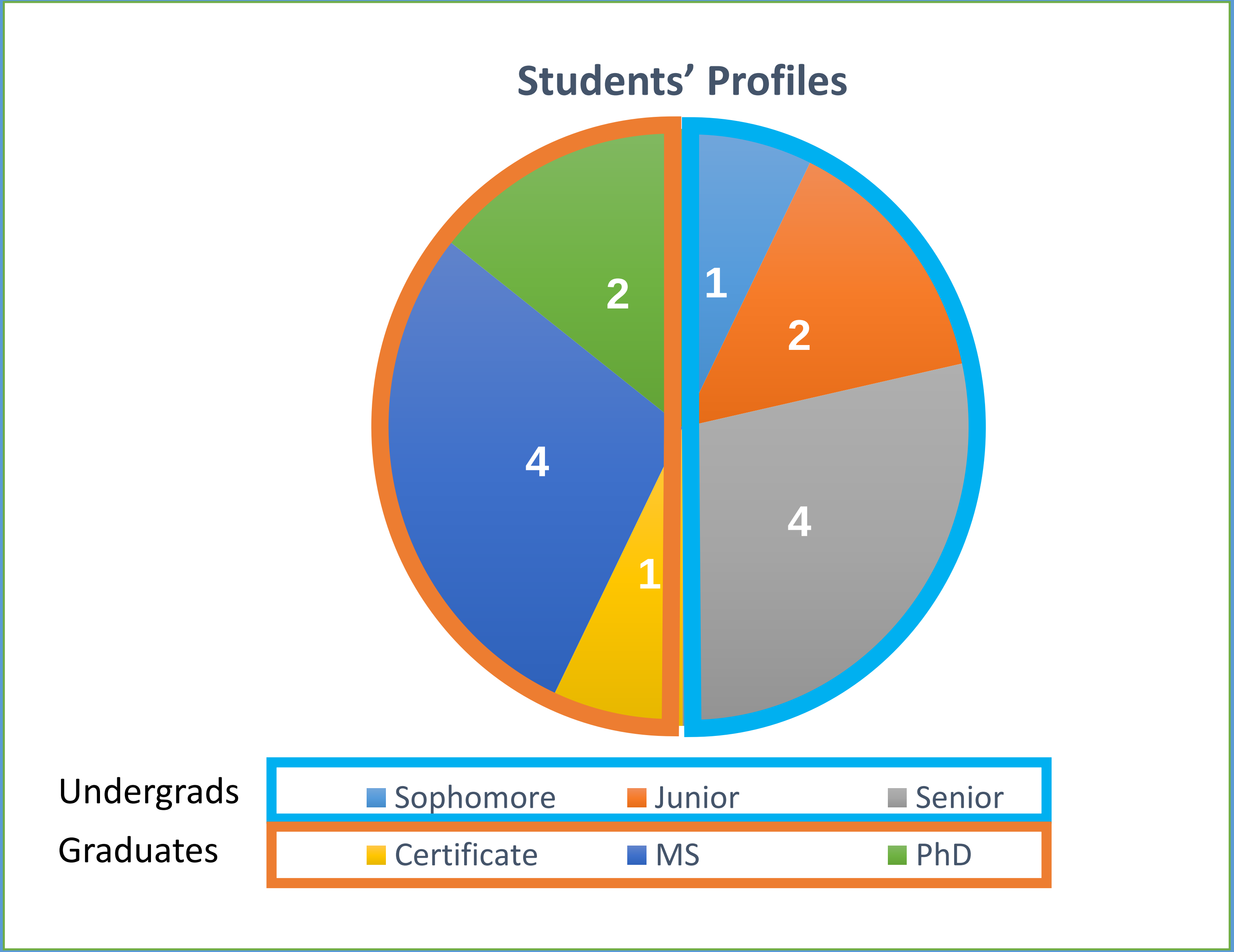
- **Class projects discussed and chosen between teams of 2 and the instructor.**
- **For each project, a data collection, data processing, data analysis, interpretation and conclusion was required**
- **A full report on the project was handed by teams.**
- **The format of the report followed that of a professional publication, with the following sections:**
  - **1) Introduction,**
  - **2) Materials and Methods,**
  - **3) Results,**
  - **4) Discussion,**
  - **5) Conclusions or Final Remarks and Future work,**
  - **6) References.**
- **The format will be written with 1.5 line spacing, Times New Roman font 11, should have a minimum of 6 pages of text, not including figures, tables and references. References should be properly cited throughout the text, and Figures and Tables should have appropriate captions.**

Group Diversity

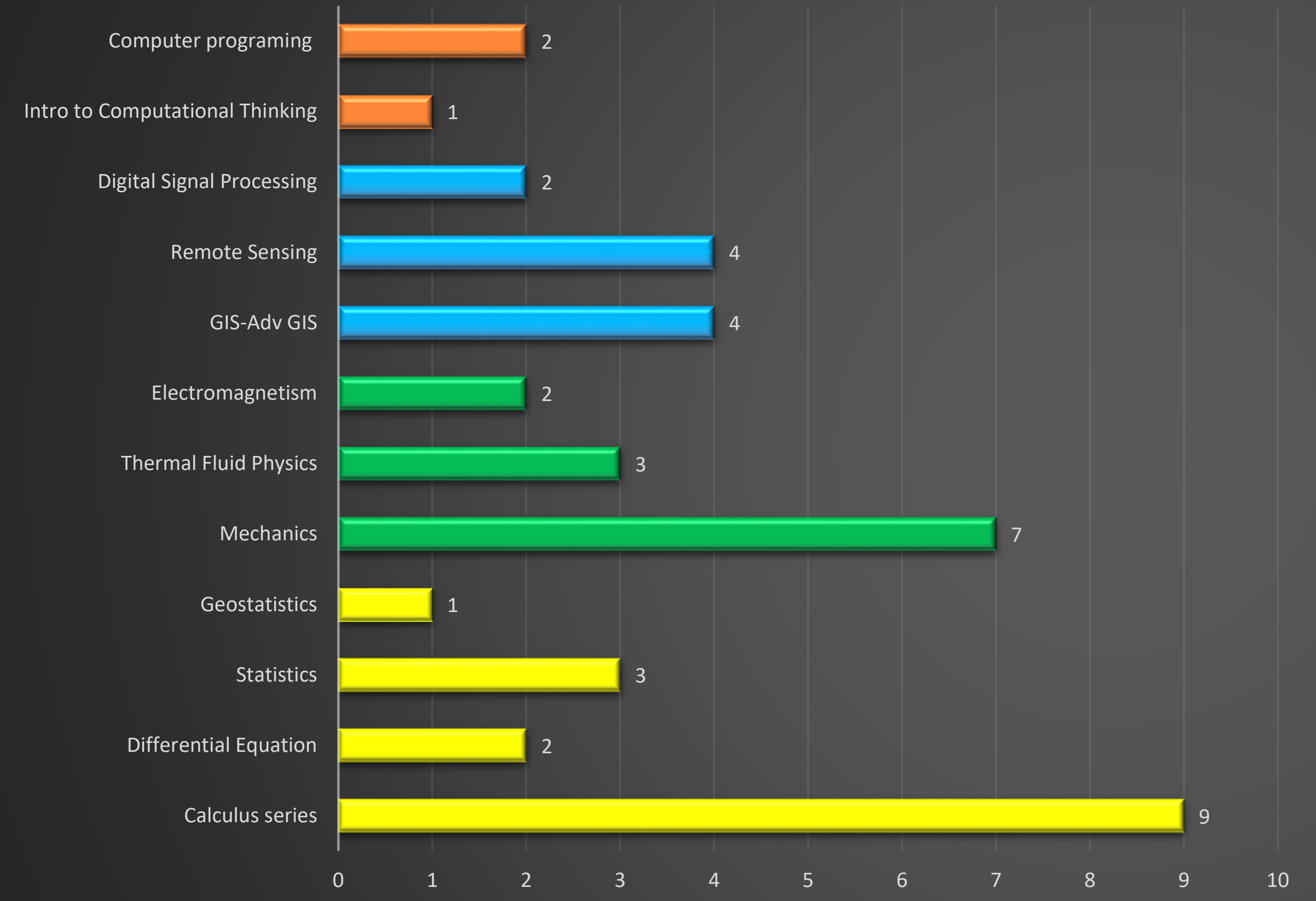
- **Cross listed class between Undergrads and Graduate Students**

Profile of students:

- **7 Undergraduates**
- **7 Graduates**



Student Profile – Possible skills attained



Systems and logical thinking
Advanced conceptualization of algorithms

Data handling - Processing and presentation
Application of mathematical expressions for intensive data analysis
Familiarity with Raster-based data analyses
Familiarity with Vectorized data
Exposure to spatial and temporal thinking

Logical thinking
Applied mathematics
Conceptualization of physical processes
Abstraction of physical processes into mathematical expressions
Development of process-based thinking

Development of mathematical skills
Familiarization with equations and principles of algorithms

Computing and Data Analysis Literacy – Barriers

- **Difficulties digesting the concept of algorithm**
- **Difficulties learning a new language (Syntaxis, coding environment), translating simple commands into comp. code**
- **Paralysis in front of coding environment**
- **Unfamiliarity with matrix operations**
- **Difficulties conceptualizing matrix(raster)-based analysis**
- **Difficulties relating the concepts of Spatial and Temporal analyses**

Course schedule

Week	Topic
01/23	Syllabus, Overview, Course Objectives, Introduction, Water Cycle and project example
01/28-30	Water cycle components
02/04-06	Conservation of energy (exchange, heterogeneity and scale)
02/11-13	Plant water relations (project selection due)
02/18-20	Soil Plant Atmosphere Continuum & Hydraulic Architecture
02/25-27	Watershed hydrology
03/04-06	Evapotranspiration processes
03/11-13	Techniques in Ecohydrology
03/18-20	Techniques in Ecohydrology
03/25-27	(Mid-term project review presentations)
04/01-03	Techniques in Ecohydrology
04/08-10	Techniques in Ecohydrology
04/15-17	Groundwater dependent ecosystems
04/22-24	Climate-Ecohydrologic interactions
4/29-5/01	Student Presentations
Final week	Project report due (5:30pm hardcopy, or 11:59pm electronically)

Conceptual-Based Portion of the class (Building the foundations)

- Introduction to main ideas and theoretical background of the main topics in the class
- Exploration of research ideas by students
- Hypothesis building
- Students' interactions

Participative Lecturing

Quantitative Portion of the class (Building skills)

- Data exploration, fetching and quality control (intro to basic statistical concepts)
- Programming (algorithm development and implementation)
- Spatial and temporal analysis of large Raster (Matrices) datasets

Hands-on (Practical)

Course schedule

Week	Topic
01/23	Syllabus, Overview, Course Objectives, Introduction, Water Cycle and project example
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Introduction to the coding language and its environment (MATLAB)

Practical lessons (drills) on math operations in MATLAB, exercising syntaxis, definition of variables objects and data classes (Vectors vs Matrices)

Introduction to Matrices and Matrix operations, placing an emphasis on building of 3D Matrices for 4D analyses (2 spatial dimensions + time + variable of interest)

Introduction to data sources, quality control considerations (basic statistics), downloading, pre-processing (geographic and format transformations [i.e. NetCDF, GeoTiff, ASCII])

Changing Gears – Now students are in charge!

Week	Topic
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03/18-20	Techniques in Ecohydrology
03/25-27	(Mid-term project review presentations)
04/01-03	Progress – In Class Presentations
04/08-10	Progress – In Class Presentations
04/15-17	Progress – In Class Presentations
04/22-24	Progress – In Class Presentations
4/29-5/01	Student Presentations
Final week	Project report due (5:30pm hardcopy, or 11:59pm electronically)

Student-driven portion of the Class

Class time devoted to assess progress

Each class 3 or 4 teams would present their progress highlighting:

- new findings,
- methods,
- challenges

Completely interactive – Real time feedback of instructor and peers

Enhanced student attention during class and lively discussions

Discussions driven by student challenges and findings

Increased attendance to office hours seeking help

Students' Research Projects – Teams of 2

1. **Analysis of vegetation indices in Peru:** using elevation and precipitation to better understand variation of vegetation activity across steep elevation and latitudinal gradients
2. **Ecohydrology of the Chihuahuan Desert:** hydroclimatic drivers of ecosystem dynamics
3. **Ecohydrology of Cape York Peninsula:** Productivity dynamics of the southernmost rainforest
4. **Climate Change and its effects on the Arctic Tundra of the Yukon:** are increasing temperatures accelerating hydrologic changes?
5. **Effects of drought on the Amazon rainforests:** Analyzing the 2005 and 2010 Amazon Rainforest Drought Events
6. **Extreme hydroclimatic impacts on tropical ecosystems of a densely populated Island:** Analysis of Puerto Rico's Ecosystems Pre and Post Hurricane Maria
7. **The Role of Neotropical Dry-forests in the Dynamics of the Water Cycle In The Yucatán Peninsula, México**

Geographic Distribution and approximate spatial extent of Students Projects

Results – from Professor perspective

- **70 % of the class received an “A”**
- **30 % received a “B”**
- **The final projects varied in level of quality but all except one exceeded instructor expectations**
- **Most final project reports attained ”Thesis Chapter” quality both in terms of format completeness and the quality of the research and new information generated.**
- **All project reports included an appendix with the code scripts generated during the work - The average length of script was 700 lines (all varied in complexity) and one student provided scripts in both MATLAB and Google Earth Engine**

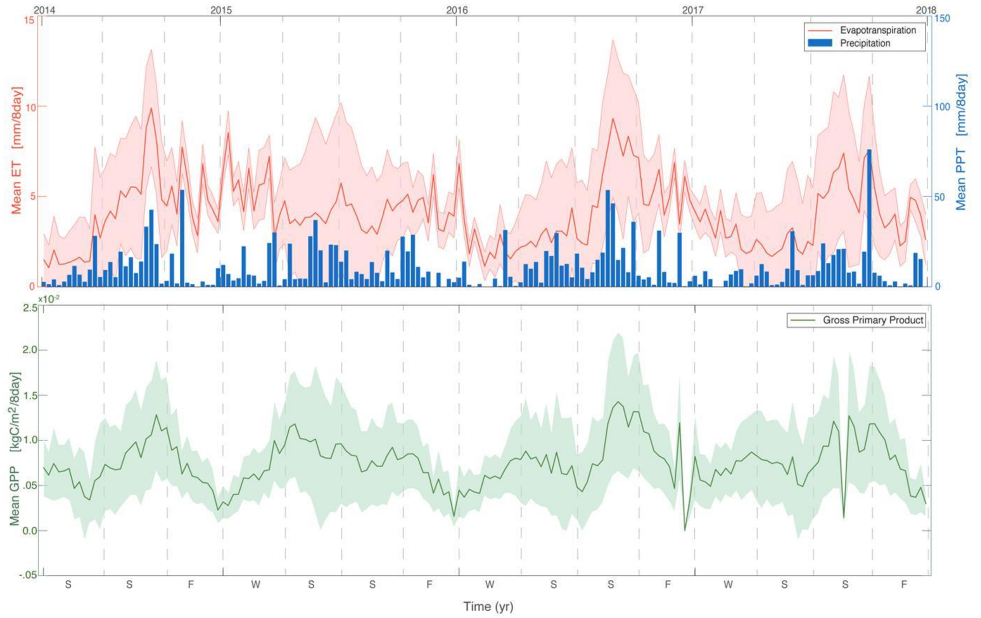


Figure 3: Time series of PPT (blue bars), ET (red line), and GPP (green line). Shaded areas represent +/- one standard deviation. The intervals in the time series are in 8 days. PPT: precipitation; ET: evapotranspiration; GPP: Gross Primary Productivity.

Seasonal Variability and Relationships Between PPT, ET, and GPP

The seasonal variability of PPT, ET, and GPP can be observed in the timeseries graph in Figure 3. Although all three variables show similar seasonal patterns, each of the variables has its own distinct trend and range of values. Precipitation (PPT) appears to be the most inconsistent of the three variables of interest. From March 2014 to December 2017, PPT values range from 0 to ~80 mm/8days with the highest values

Chihuahuan Desert Ecohydrology 6 Cisneros & Thompson

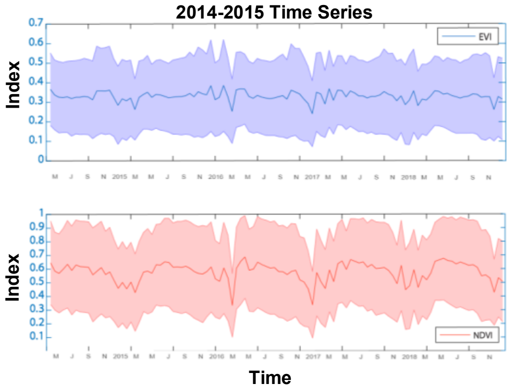
Sample from one of the final Reports

Student Reports Samples

Results

Seasonal Variability

The top image is from MATLAB using the ShadedErrorBar and below is the graph from Google Earth Engine. The seasonal variability of EVI and NDVI can be seen in this time series graph (Figure 4). This starts on April 7th due to 16-day intervals. We can see that there is a very clear seasonal dip in the indices. There are extreme dips on 12/19/2014, 02/08/2016, 01/01/2017. NDVI has values of 0.3, 0.3, and 0.302 respectively. EVI has values of 0.235, 0.252, and 0.239 respectively to the dates of the dips. The top time series is showing variation with the shaded area shows about equal variability for both



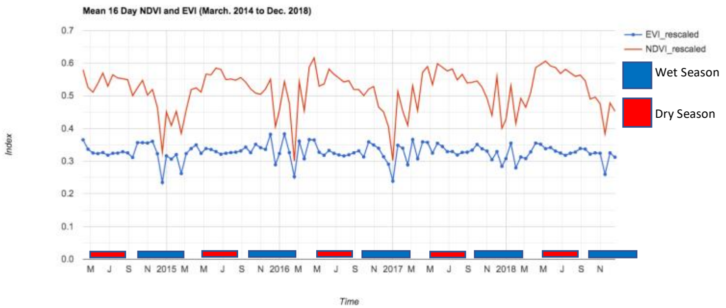


Figure 4: Top graph is showing EVI and NDVI mean with shaded standard deviation from April 7th, 2014 to December 31, 2018 from MATLAB, the bottom graph is the same data using Google Earth Engine. This map was annotated to show wet and dry seasons.

PPT Elevation Analysis for Cumulative Sum and Standard Deviation

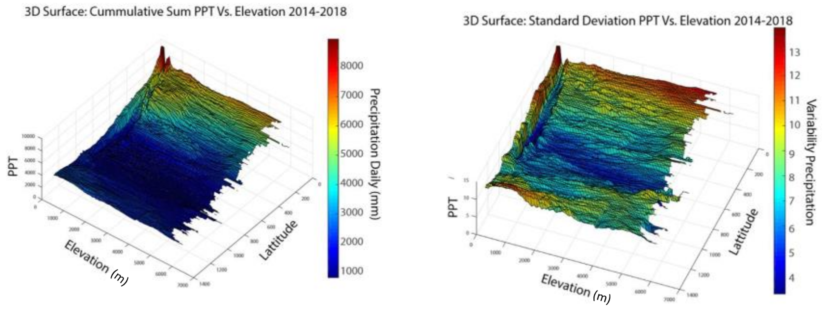


Figure 9: Left image: Cumulative sum of precipitation in relation to elevation and latitude. Right: Standard deviation of precipitation in relation to elevation and latitude.

The cumulative sum of precipitation seems to be higher closer to the north eastern corner of the study area. It was also very confined to elevations less than 2000 meters. The variation of the study area shows higher values of variability along the coastline, and low variability from 1000 meters to 5000 meters along -12 to -13 latitude. Even so overall variation is quite low unless at high elevation and at -9 latitude or along the coast.

Year	Component	Statistical Analysis	Range of Interest NDVI	Elevation (meters)	Statistical Analysis	Range of Interest Variability	Elevation (meters)
2014	Normalized Difference Vegetation Index (NDVI)	Mean	0.70 - 0.80	250 - 850	Standard Deviation	0.20 - 0.27	850 - 3700
2014	Enhanced Vegetation Index (EVI)	Mean	0.40 - 0.53	250 - 1750	Standard Deviation	0.10 - 0.14	800 - 3600
2015	Normalized Difference Vegetation Index (NDVI)	Mean	0.71 – 0.76	300 - 700	Standard Deviation	0.20 – 0.27	450 - 3700
2015	Enhanced Vegetation Index (EVI)	Mean	0.37 – 0.53	250 - 1650	Standard Deviation	0.09 – 0.15	400 - 3700

ANALYSIS AND FIGURES

Contents

Synopsis:

-This scrip loads Precipitation, Evapotranspiration and Gross Primary Production Matrices previously processed.
-The following calculations were made in order to analyze the data.
1)Spatial Mean of PPT ET and GPP.
2)Spatial Standard deviation of ET and GPP.
3)Temporal (yearly) Sum, Mean and Standard deviation of PPT and ET.
4)Probability density function (PDF) of Mean yearly.
5)Temporal (total) Sum, Mean and Standard deviation of PPT and ET.
-The following Figures are made with the previous calculations:
1)Time Series Plot with PPT, ET, GPP mean and ET std, GPP std.
2)Spatial Gradient of total Mean PPT and ET with PDF yearly.
3)Spatial Gradient of yearly Sum PPT and ET with PDF yearly.

```
close all; clear all;
```

Loading Matrices - PPT, ET, GPP

```
load('Chides_PPT.mat');
load('Chides_ET.mat');
load('Chides_GPP.mat');
% Get time size of the Matrices
[~,~,z] = size(PPT);
```

Spatial Mean [M] of PPT ET and GPP

```
% PPT Mean
   PPTm = [];
    for i = 1:z
        A = PPT(:,:,i);
        a = nanmean(A(:));
        PPTm = [PPTm;a];
    end
% ET Mean
    ETm = [];
```

Revisiting Class objectives for recommended skills

Through hands-on Project Activities

Technical Skills

- Data analysis of real data ✓
- 3D/4D problem solving with non-unique answers ✓
- Quantitative skills – higher level math competency ✓
- Statistics, probability, uncertainty analysis
- Computer programming and modeling ✓
- Field skills. X

Through Project Activities, Team-work and Class interactions

Non-Technical Skills

- Team work, project management ✓
- Communication skills ✓
- Interpersonal skills ✓
- Leadership, professionalism ✓
- Ethics, societal relevance ✓
- Global perspective ✓

Source: www.jsg.utexas.edu/events/future-of-geoscience-undergraduate-education/

Comments from Students

1. I enjoyed taking this course, I feel my software and technical skills improve. I also believe that I would have benefited if there were a lab involved with this class, as I feel that more time should've been given to explain ecohydrologic concepts, how they relate to one another and how to analyze them. For my final presentation I felt confident about the images I was able to produce through Matlab, but I felt weak in trying to explain them and understand them. I would recommend more time trying to explain the role of ecoghydrologic data sets and how they should be analyzed.

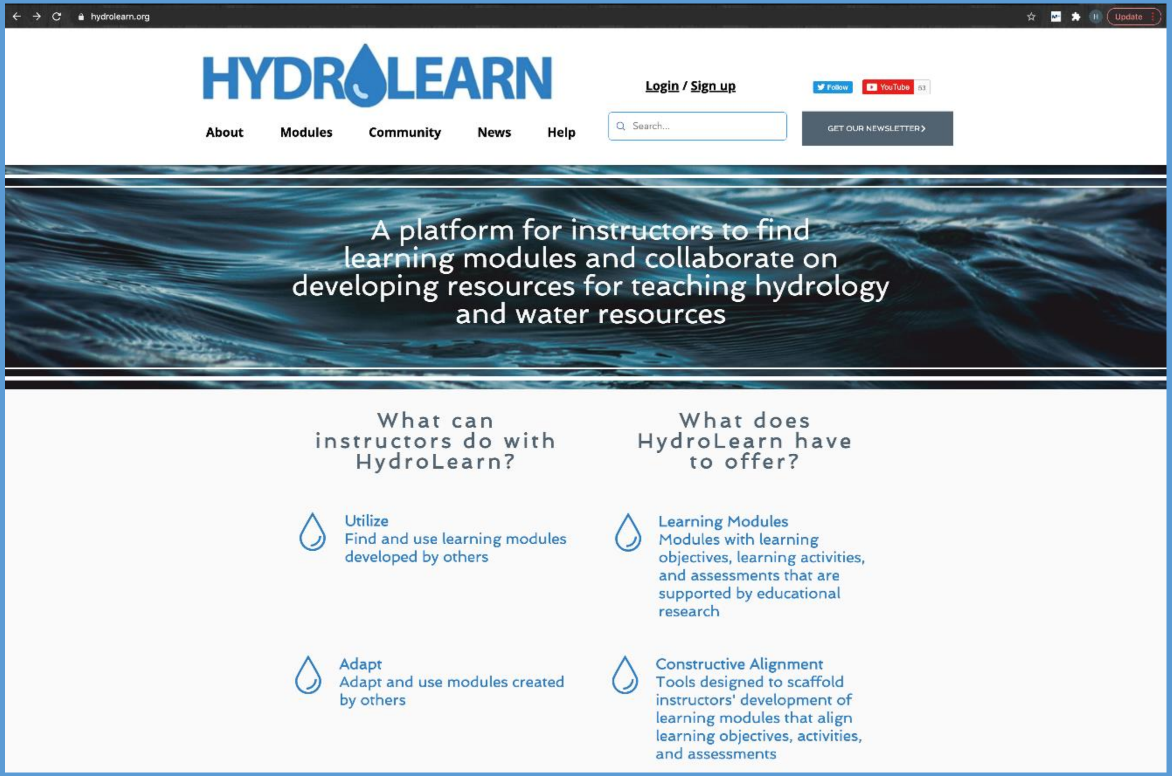
2. The idea of this class was really cool but it REALLY NEEDED a lab. This class was unnecessarily difficult just because of the lack of help.

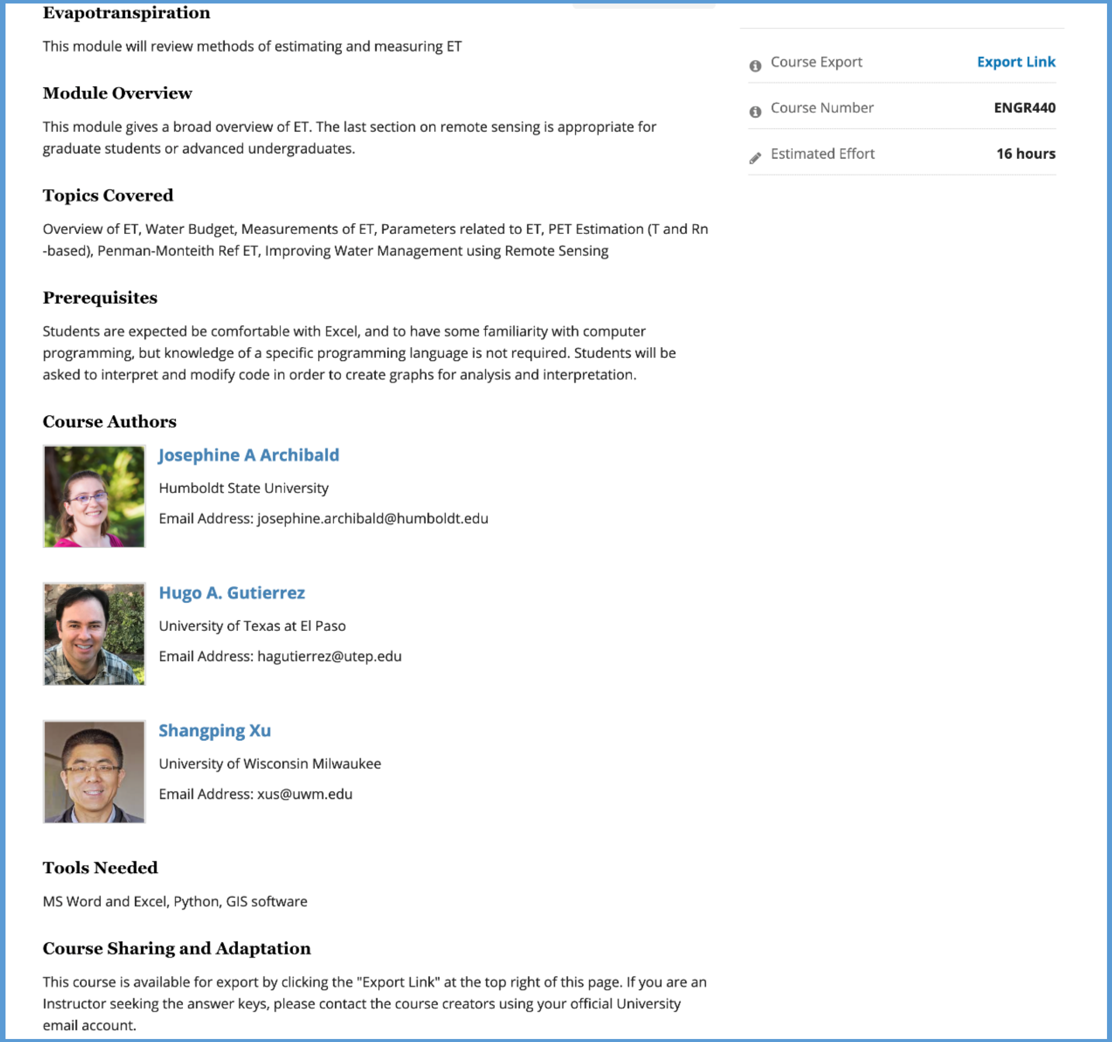
5. The instructor was available to students either electronically or in person.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Response
40%	40%	10%	10%	0%	0%

Bottomline – Apparently the class needs a lab?

New online tools for delivery of experiential based learning in the Hydroscience curriculum being implemented this Spring 2021





Evapotranspiration

This module will review methods of estimating and measuring ET

Course Export	Export Link
Course Number	ENGR440
Estimated Effort	16 hours

Module Overview

This module gives a broad overview of ET. The last section on remote sensing is appropriate for graduate students or advanced undergraduates.

Topics Covered

Overview of ET, Water Budget, Measurements of ET, Parameters related to ET, PET Estimation (T and Rn -based), Penman-Monteith Ref ET, Improving Water Management using Remote Sensing

Prerequisites

Students are expected be comfortable with Excel, and to have some familiarity with computer programming, but knowledge of a specific programming language is not required. Students will be asked to interpret and modify code in order to create graphs for analysis and interpretation.

Course Authors

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Tools Needed

MS Word and Excel, Python, GIS software

Course Sharing and Adaptation

This course is available for export by clicking the "Export Link" at the top right of this page. If you are an Instructor seeking the answer keys, please contact the course creators using your official University email account.

Students work on “real-life cases” with real data in open-ended problems challenging them to develop critical thinking and decision making while acquiring new tools

Learning Activity

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You are a consultant on water sustainability of agricultural areas from the "Sustainable Water Engineering Planning Technologies (SWEPT)" Company, an engineering firm dedicated to provide integral solutions for growers facing water scarcity/reliability/uncertainty issues. You have been hired by representatives of a corn growers association in Lake Bustillo's basin to help them reduce their crop's water footprint, save on production costs and help alleviate the urgent threat of groundwater exhaustion of the aquifer which they have observed is rapidly depleting. They specifically want to know when during their crop growing cycle can they save water, and how, without necessarily having to invest much money by converting their irrigation system. They have noted to you that someone in the association have recently upgraded their irrigation system from furrow (gravity fed water applied on top of the field) to drip (water provided under the soil at the base of the plant), and they are curious to see if that has lead to any significant improvements in water use reduction. So they have asked you to look at two parcels, each with one of these two irrigation systems (furrow and drip irrigation) and provide technical advice based on data from the two parcels during one growing cycle.

Figure 1. Furrow irrigation in Lake Bustillos Basin. (Photo by Hugo Gutierrez)

The corn growers association has given you a detailed account of their irrigation activities (time and amounts) during the 2017 growing cycle for the two parcels considered. They have also granted you access to meteorological data from a network of weather stations they operate and maintain across the Valley. You will assess the impact of the two different irrigation systems and the farmers' water management practices on the water balance of the cropland at the scale of the studied parcels. Using a combination of satellite-based ET data with local weather stations-based Evapotranspiration (ET) calculations, you will calculate and contrast the irrigation efficiencies of the two irrigation systems for the same crop after evaluating the partitioning of ET into unproductive (Evaporation) and productive (Transpiration) in the parcels. Using your gained knowledge you will present a detailed analysis showing the times when most unproductive water can be saved with recommendations of when and how much to irrigate. You will also discuss your observations on the efficiencies of both irrigation systems and recommend any suitable changes in water use practices for both systems providing detailed water balance analyses of each parcel. Your final product will be an improved irrigation plan for the growers association.

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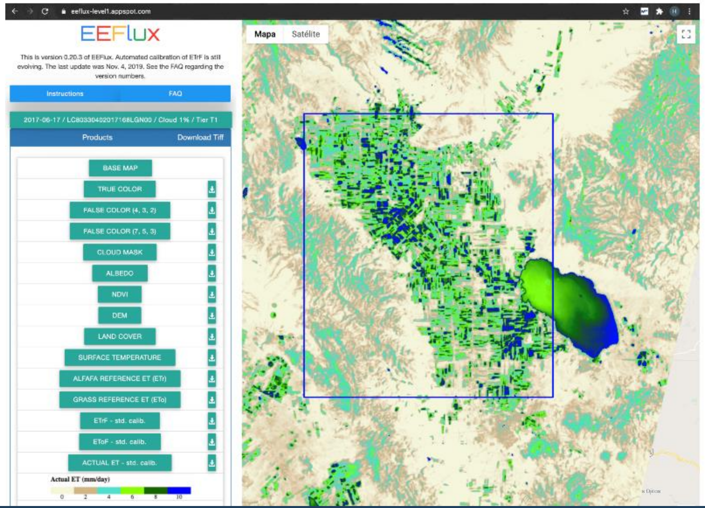
Partitioning Evapotranspiration fluxes at the Parcel scale using Remote Sensing and Meteorological Data

1. Landsat-derived Evapotranspiration

In this activity you will derive average evapotranspiration fluxes for each parcel from a set of images (raster files) where Evapotranspiration was calculated using the METRIC (Mapping Evapotranspiration at high Resolution with Internalized Calibration) algorithm available at the EEFlux (Earth Engine Evapotranspiration Flux) website (https://eeflux-level1.appspot.com/). EEFlux is a web application that operates on the Google Earth Engine system (https://earthengine.google.com/) for looking up and retrieving Evapotranspiration values together with a list of other important land cover and environmental variables such as surface temperature, vegetation indices, surface albedo and others. For this learning activity, you will not be required to fetch the ET data from EEFlux, but you are encouraged to look up the website and explore it on your own. A set of raster images for each day that Landsat have good quality data over the study area is provided in the resources list below. You will need to download the raster files for each parcel and process them with a python code in google colabs (https://colab.research.google.com/notebooks/intro.ipynb).



The results for this activity should include

- Time series plots of the Evapotranspiration (*ET*) and Transpiration (T_r) for 2 parcels with different irrigation systems (based on Landsat ET data) and Crop Coefficient derived Transpiration (from Sentinel-2 K_{cb})
- A report discussing the differences of productive water use (proportion of T_r vs *ET*) in the Parcels, addressing differences in irrigation management.

Resources

- Below there is a table with a list of resources needed during the course of this activity. The list includes links to files and websites to retrieve or navigate to those resources.

Resources	Location of files or programs
Weather Station data	/static/Micromet_January_to_December_201.xlsx
Shapefile zip for Furrow parcel	/static/Drip_Parcel.zip
Shapefile zip for Furrow parcel	/static/Furrow_Parcel.zip
Irrigation data from Drip parcel	/static/Drip_irrigation.xlsx
Irrigation data from Furrow parcel	/static/Furrow_irrigation.xlsx
Google Earth Engine	https://code.earthengine.google.com/
EEFlux ETa image collection	users/conquerboy/LB_Basin_ET
Google Colab Python notebook	https://colab.research.google.com/

Instructions

- *Retrieve two parcels (shapefiles) with two different irrigation systems.*
- *Run the Google Earth Engine (GEE) code to calculate the Kcb time series.*
- *Run a script to generate time series of ET from the EEFlux (Landsat) image collection provided.*
- *Retrieve EEFlux ET data for those parcels in Google Earth Engine - Only for the G-level module. For the U-level module the students will retrieve data in matrices (excel spreadsheets) with spatially distributed ET data.*
- *Using raster data files (G-level) or provided parcel average values (U-level) build a time series of Evapotranspiration from Landsat during the growing season.*
- *Run the Python notebook code in Colab to calculate Reference ET and Transpiration for each parcel and plot it together with the ET time series from EEFlux.*
- After plotting the ET data contrast and discuss differences or similarities between the resulting time series from the two parcels, and discuss the issue of temporal resolution on data quality and availability.

Note from this activity: Landsat AET data is only good at the beginning and end of the growing season due to low quality images from extensive cloud cover during the peak of the growing season (July-August). As a result, the students will be challenged to explain why their ET time series data will have data gaps.

1) How much progress have you made with your plan? If you modified your plan, in what way did it change and why?

We have had a retreat to discuss undergraduate and graduate curriculum revision. Faculty generally agreed on the overall goals, concepts and skills we need to emphasize throughout our curriculum. We did not need to add courses, but we agreed to make courses more consistently emphasize important concepts and skills as a student progresses.

2) What has been accomplished, whether it was in your original plan or not?

We have a more cohesive curriculum that stresses repeated exposure and expected mastery of key skills necessary for conducting research, reporting research (oral and written), analyzing data and designing research plans.

3) What are your future plans?

We are currently revising the way we do assessments to reflect the new curriculum & goals.

4) Which implementation strategies worked – i.e. what was successful, and what wasn't?

Pairing courses throughout the undergraduate trajectory is effective because students see the connections between courses and can spend more time as teams working on projects.

5) What were roadblocks to progress or where did problems occur? If you were able to overcome them, what did you do?

We are limited in the math and computer skills of many of our undergraduates, so introducing math and computation is difficult. We are working to include examples in every class to show how math and computational skills are important and applied in Geological Sciences.

6) What did you anticipate would be a problem that was not?

We started a team-based research laboratory for majors in Physical Geology, but recruiting students into this course consistently has been a problem.

7) Any advice to others who wish to make similar changes?

Utilize and undergraduate advisor to let students know what the overall goals of the obtaining a degree in Geological Sciences are. They need to see the big picture. Also, career advising and access to internships are key to opening up students' horizons.

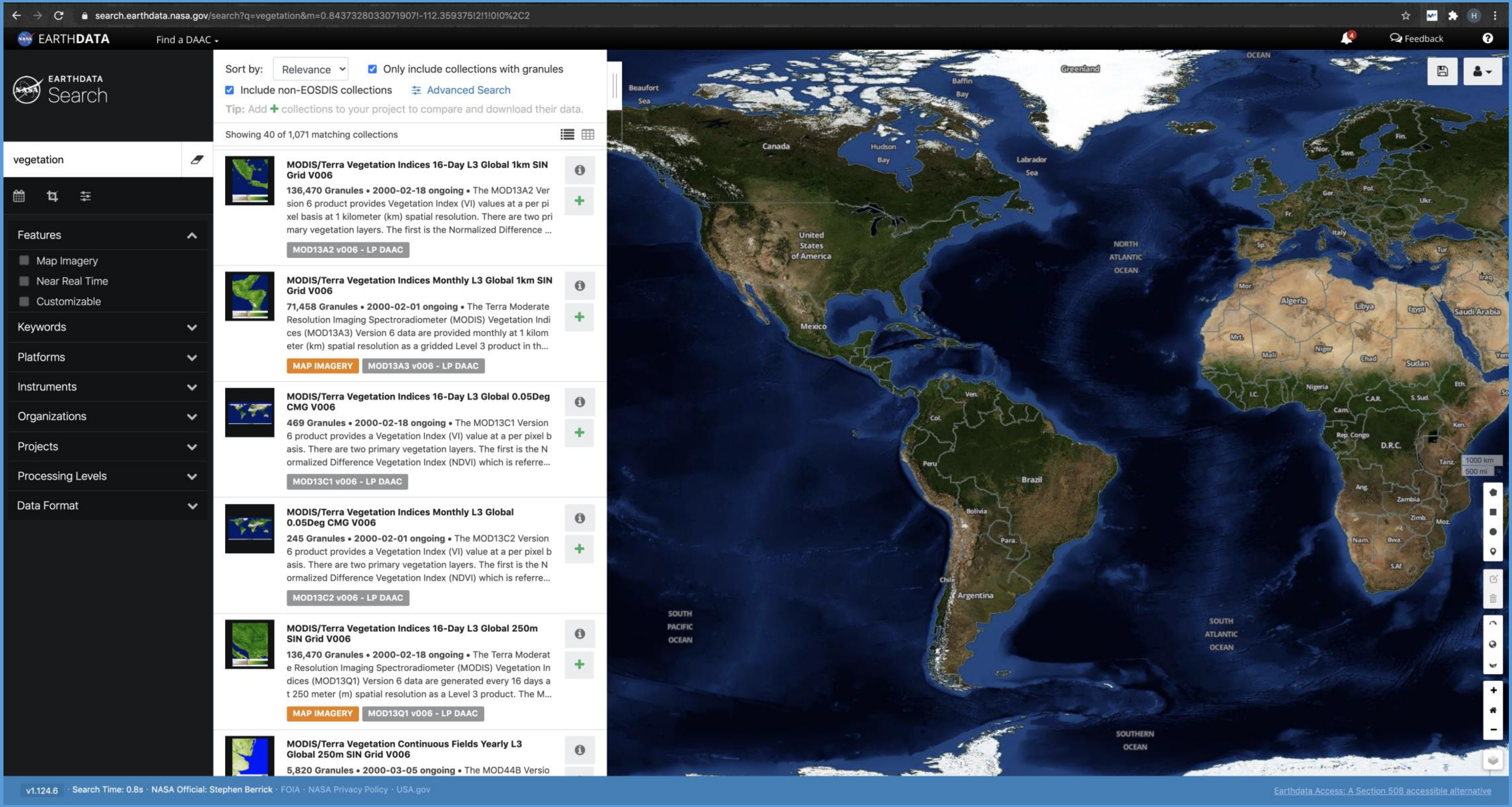
Assessment of Geology B.S. program at UTEP

- **Data collection through Field Camp I and II**
- **Learning outcomes:**
  1. **A general knowledge of physical and historical geology and of the interrelations between surface and interior earth processes. (Knowledge)**
  2. **The ability to solve geological problems, to propose multiple working hypotheses, to observe, and map surface geology, and deduce subsurface structure. (Knowledge and Skills)**
  3. **The ability to communicate geologic information in oral or written form. (Skill)**
  4. **The professional attitude required to conduct geological investigations as a graduate student or employees in industry or government. (Attitude)**

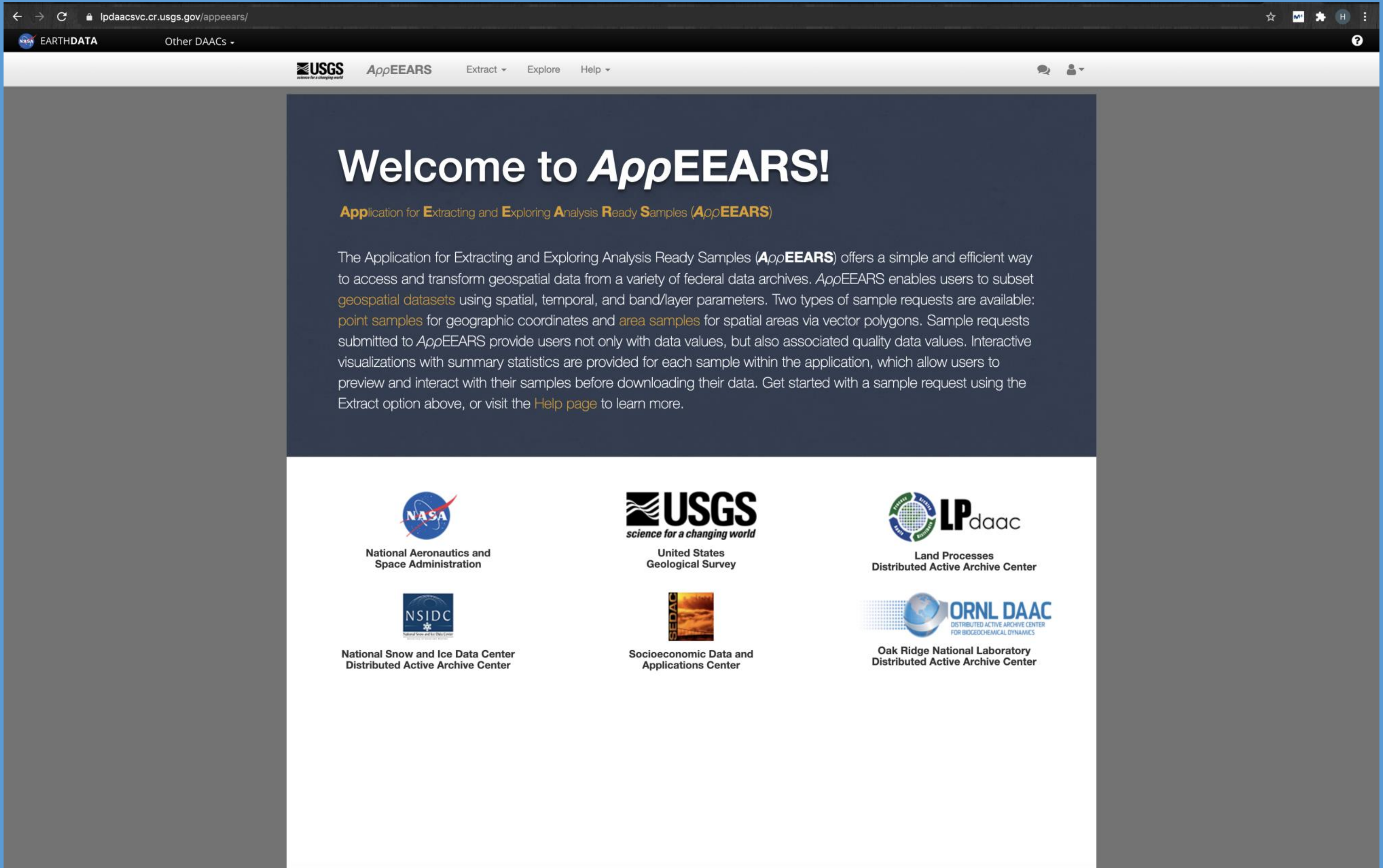
Thank you!

www.flickr.com/photos/rchiarello/8398790824

Data Exploration – NASA EARTHDATA Portal



Data Exploration using AppEEARS



Results – Evaluation from students

4. The instructor encouraged me to take an active role in my own learning.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Response	Index
70%	30%	0%	0%	0%	0%	4.7000

5. The instructor was available to students either electronically or in person.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Response	Index
40%	40%	10%	10%	0%	0%	4.1000

6. The instructor stimulated my interest in the subject:

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Response	Index
50%	10%	30%	10%	0%	0%	4.0000

Only 10 students provided evaluations

~ 70% of the Class

Hence, 10% = 1 student

Results

Section B

The following questions refer to this course.

7. Estimate how much you learned in this course:

Well Above Avg	Above Avg	Average	Below Avg	Well Below Avg	No Response	Index
30%	30%	20%	10%	10%	0%	N/A

8. Estimate how much this course challenged you intellectually:

Well Above Avg	Above Avg	Average	Below Avg	Well Below Avg	No Response	Index
90%	10%	0%	0%	0%	0%	N/A

Section C

Overall

9. Provide an overall rating of this course:

Excellent	Good	Satisfactory	Poor	Very Poor	No Response	Index
30%	40%	10%	20%	0%	0%	3.8000

10. Provide an overall rating of the instructor:

Excellent	Good	Satisfactory	Poor	Very Poor	No Response	Index
40%	30%	20%	10%	0%	0%	4.0000

Only 10 students provided evaluations

~ 70% of the Class

Hence, 10% = 1 student