



**Urban & Environmental Geophysics Course Planning Workshop**  
University of South Florida, Tampa, Florida  
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- **Workshop motivation and goals**
  - Motivation
    - Engage a broader audience of students, particularly those from groups that are traditionally underrepresented in geosciences, in geophysics topics early
    - Generate excitement about geophysics-related careers
    - Learn about existing course materials and research/field experiences
  - Goals
    - Develop a list of potential learning goals and content topics for an introductory urban and environmental geophysics course that is designed to attract a more diverse group of students
    - Identify course questions and problems that can help engage underrepresented minority students throughout the course
    - Expand workshop participants' awareness of existing geophysics course(s) and course materials, and research/field experiences for students
    - understand the teaching needs/limitations that currently limit teaching effectiveness [particularly with respect to underrepresented minority students]
  
- **Course development goals** [*big-picture; from N GEO proposal*]
  - address the engagement and recruitment of underrepresented groups in the geosciences
  - attract and engage students from underrepresented groups to pursue a geoscience career
  - develop a new half-semester-long place- and/or problem-based course to engage freshman and sophomores in questions or problems in their communities that can be addressed with geophysical approaches
  - This course will be designed so it can be taught by geoscience or physics faculty from two-year colleges through research universities.
  - recruit a diverse student population to enroll
  - engage students in hands-on/minds-on learning of geoscience content and research skills, particularly an introduction to data-intensive computational techniques<sup>1</sup>
  - overcome the perception of a lack of societal relevance of a geoscience career
  
- **Workshop overview and structure summary**

The workshop was structured around 1.5 days of discussion-centered meetings between the 28 participants. Introductory and motivational materials were presented, including perspectives from workshop organizers and outside diversity/education experts (Sit & Carrick), followed by a set of 4 breakout groups and full-group discussions. Break-out discussions generally followed a logical linear trend covering teaching and learning styles, teaching diverse audiences, course content, and specific topics to develop course modules around. In between breakout group

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<sup>1</sup> We chose to deemphasize data-intensive computational techniques based on the pre-workshop survey and workshop consensus

discussions, workshop participants introduced themselves to the group through “Ignite” style mini-talks, and there was also an outdoor instrument demonstration with examples of equipment that may be available to use with course modules. Additional short presentations illustrated success with the NSF funded GeoPATHS program (Mount), recapped the pre-workshop survey (Parsekian) and introduced instrumentation facilities (Anderson).

- **Participants overview**

A total of 28 participants were involved in the workshop from a range of geographic areas (including one international) and different types of institutions: national lab, 2-year college, 4-year college, research center. Participants ranged in expertise from non-geoscientist, to experienced geophysicist. A potential weakness of the workshop was a lack of representation of HBCUs – and, indeed, a lack of ethnic/racial diversity in the attendees. However, we also recognize that the small number of minority researchers and educators in geoscience may be disproportionately engaged with diversity recruitment efforts already, causing an undue burden on their time. Therefore, we acknowledge the role of the majority in shouldering the burden for creating opportunities for minority groups.



- **Summary of "what U&E geophysics means to me" talks**

Each of the workshop academic liaison organizers was asked to give a short presentation on their perception of the field of Urban & Environmental Geophysics, examples of research foci, opportunities created for engaging broad audiences, teaching approaches, and potential benefits to society. Parsekian (UWyo) addressed flipped-classroom pedagogical strategies, how U&E geophysics can be compelling due to opportunities for students to connect to their surroundings, teaching ‘soft skills,’ and success with student engagement through involvement in research projects. Slater (RUN) described the highly diverse nature of Rutgers-Newark, the evolution of U&E research towards petrophysics, Newark’s historical industrially impacted environment, successes with paid internship programs, challenges with student perceptions of geosciences in the New York City regions and related family pressures to seek careers in medical/law/vocational fields. Kruse (USF) highlighted some of the unique and complex challenges that the urban environment presents, opportunities for targets and data collection that leverages the built environment and attempts to resolve software bottlenecks with open-source codes. Additional notes on these talks can be found in Appendix A and the full slideshow presentations are available on the workshop webpage hosted on the IRIS website.

- **Summary of Geoscience Outreach talks**

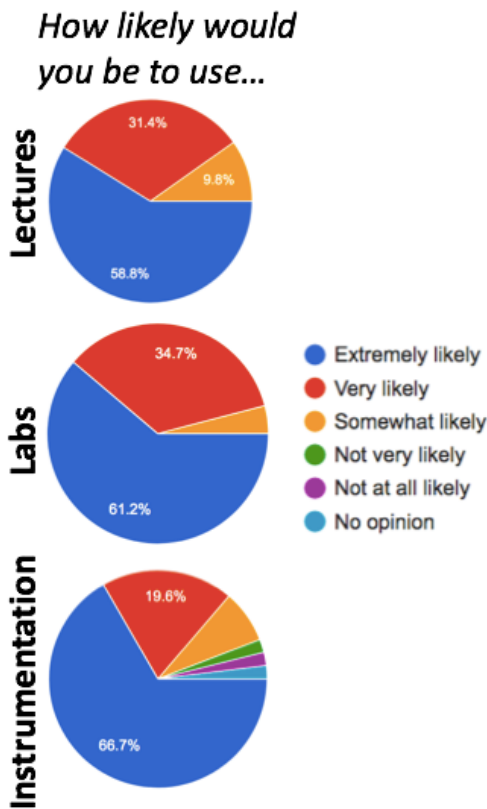
Two talks were presented by experts in geoscience diversity outreach and engagement. Stefany Sit delivered the first talk and discussed approaching gender parity with graduates, however racially diverse groups are still behind. She also highlighted the positive perception of place-based science, as well as authentic data collection experiences. Tina Carrick presented a talk focused on recruitment and retention. She reported on the importance of early engagement,

particularly focused on freshman and sophomores as well as some experiences aimed at pre-college students. Additional notes on these talks can be found in Appendix B and the full slideshow presentations are available on the workshop webpage hosted on the IRIS website.

- **Summary of pre-workshop survey**

A survey was administered in the early spring to: 1) gauge interest in participants for the workshop, 2) gather preliminary information, and 3) gather community-driven ideas from people who might not be able to participate in the workshop directly. The survey was circulated to a wide audience across at least eight email listservs, including the general geoscience community, seismology community, near surface (NS) geophysics community, and geoscience education community. A total of 51 responses were recorded by the start of the workshop.

The responses to questions that asked if instructors would use developed teaching materials for urban and environmental geophysics strongly indicated that people would value access to lessons, labs, and modules. ~95% of respondents had access to at least one instrument at their home institution that could be used for teaching, while 5% said they had no access whatsoever. Respondents were widely interested in using instruments, if made available, however there was no clear “most desirable” – generally the commonly available tools of the field were all viewed as useful.



When asked what topical focus for the course would be most likely to increase participation, the response was overwhelmingly to have an “environmental” theme. Hands-on field measurements were overwhelmingly viewed as the optimal course feature, and problem-based learning was also favorably viewed. Forward modeling exercises and using geophysics as a platform to develop mathematical skills was not favorably viewed.

Assessment methods were a mixed response and more thought should be placed into this topic. For example, “exams” and “course projects” were noted both as ‘most’ and ‘least’ effective.

- **Instrument demonstration**

The USF geoscience department offered a field demonstration of near-surface geophysical instrumentation to give workshop participants with less



exposure to the methods an opportunity to see what is involved with data acquisition. Three stations were set up including GPR for pipe detection (image at right, Tonian Robinson at pipe-detection station), a seismic streamer, and electrical resistivity tomography. The example of using a GPR instrument to scan for pipes was really relevant to what were considered ideal short modules for the course because the instrument is relatively transportable and robust, data acquisition is quick, and targets are readily available in most urban areas.

- **Summary of each breakout group**

Breakout #1: Teaching and Learning:

The questions posed to all teams for this breakout were as follows:

- What geophysics courses/modules do you teach or would you like to teach? At what level?
- What are your key learning goals and how does that relate to the group that you're teaching?
- What type of teaching approaches do you currently use (e.g., labs, individual or group assignments, in class or video lectures, classroom discussions)?
- What are the barriers to new course (or half-semester long course) implementation at your institution (e.g., department or institutional approval, timing, cost)?

The participants currently teach geophysical and earth science in a wide range of topics and formats. The most commonly taught course material was some form of seismology, environmental geophysics, or applied geophysics generally at an upper level. A few participants taught general geoscience or “dynamic planet” type courses at the lower level. Several participants also reported their primary teaching was at the level of “direct training” that was not formal classroom coursework. Programing and engineering topics courses were also reported.

A total of 15 learning goals were reported by the groups. Summarized examples of generalized learning goals are as follows:

- Develop relevant job skills and be able to answer practical questions
- Teach instrumentation, how to acquire and validate data
- Understand how geophysics can solve environmental problems or other non-energy exploration topics
- Teach how to approach a research problem & strengths and limitations of research

*ANALYSIS: The overall interpretation of all current learning goals is that instructors are focusing on two general categories of desired outcomes: ‘technical’ and ‘conceptual.’ Perhaps a third category spans the first two: ‘practical’ that mixes technical understanding with some conceptual problem-solving skills.*

Teaching approaches currently used with our workshop cohort include application examples, sample datasets, hands on experiential learning, case studies, group work, games, lab assignments, lectures, online tools, discussions, and demonstrations.

Generalized barriers to implementing a new course – considered in the context of a U&E course – included:

- Students don't have the math background
- May be overlap between existing course topics
- None (instructors have power to run any course they want)
- Impossible (adjuncts have no power to change anything at all)
- Equipment/instrumentation is not available at home institution

#### Breakout #2: Approaches to diversity

The questions posed to all teams for this breakout were as follows:

- What approaches have you used in the past to attract a more diverse group of students to your course and/or institution?
- What are the barriers to engaging a diverse audience in your courses and/or at your institution?
- At your institution and/or in your classroom, what are the strategies for student retention and success with geophysics?
- What would success look like for you or your institution?

Reports of tools used for recruitment ranged from passive (e.g., email blasts) to active (e.g., outreach events, “in-reach” in courses) to externally coordinated (e.g., bridge programs). There were nearly 30 different reported instruments highlighted specifically for use in increasing enrollment from underrepresented groups, a strong number that suggests the participants have put a lot of thought and effort into recruitment in the past. Use of direct (specifically aimed at increasing participation) and indirect (general programs that have been leveraged to increase participation) bridge programs emerged as a widely used and potentially effective method. For example, the direct bridge programs of LSAMP and McNair are carefully designed to specifically target underrepresented groups and these have apparently generated students who have gone on to have success in geoscience academics. The indirect programs, such as the IRIS intern program and SAGE are primarily focused on getting students involved in geophysics, but they have also apparently been useful avenues for increasing diversity.

*ANALYSIS: Although these bridge programs effectively stand on their own currently and may not be appropriate to directly utilize the course materials we intend to produce, it may be valuable to design some type of interface or coordination with them to enhance progress towards our big-picture objectives.*

Recruitment strategies that occur during courses or outreach events included exposure to concepts during labs, required research experiences for undergrads, directly approaching freshman, encouraging double-majors/minors, and advising interactions. These strategies may require more effort on the part of the instructor on a per-student basis, however they may also be more effective because of the dedicated attention.

*ANALYSIS: There may be value in providing guidance, materials, and planning to enhance the effectiveness of these strategies while reducing the burden on the instructors.*

The most passive recruitment tools include email blasts, posters, highlighting diverse scientists in courses, and offering a variety of courses to increase the probability of exposure. These are important efforts that may reach the largest possible number of students; however, the effectiveness of these approaches is not clear.

Several other ideas were discussed that are not as easily categorized and may not be options for all instructors: university-sponsored diversity programs, engaging offices of Native American Studies, including diversity funding in federal proposals, and peer-support networks. There may be creative opportunities within this context and additional consideration may be given here to how to leverage these ideas.

A common theme reported as a barrier to increasing diversity was basically that students know very little about the geosciences as early career undergrads, or they have misconceptions. For example, students may have only had a small component in a middle school class related to geosciences, or no coursework at all due to curriculum requirements pre-college. Related to this are the cultural barriers where family may perceive ‘professional’ type academic training (e.g., MD, JD, engineering) as the preferred route and therefore only encourage students in this direction. The path towards a well-paying profession through geosciences may not be clear, or they may only understand that a career in oil and gas is the outcome of a geoscience education. Economic barriers were also discussed. For example, taking time out of the summer to do a research experience may not be an option for someone who needs to hold down a job to make money for the entire summer. This may be further exacerbated in geographic regions that have a higher cost of living. Field experiences may not be attractive to all students – some may simply be turned off by having to be outside, “fieldwork” has negative connotations in some cultures and in other cases physical disabilities may prevent participation in field activities. A final note was that tracking of successful students post-graduation is often poor. Even if enthusiastic students are recruited, they are often lost after the program, therefore making it difficult to learn from successes and turn those lessons into future successes.

Retention efforts largely fall around sustained attention to students as they progress through their degree. This may include a second level of advising (beyond primary academic advisor), interactions during field/lab work sustained through time, and engagement by alumni groups. Programmatic efforts that were perceived to improve retention were reducing the time to degree, having parallel tracks within a major in order to cater to diverse student interest, and the implementation of tracking databases. Availability of funding for summer or academic year research experiences was noted as being an important prerequisite. Furthermore, making the science applications locally relevant was discussed as important for engaging the students and increasing likelihood of continued participation.

Judging success in increasing participation from underrepresented groups was broad and likely varied depending on regional differences. At the most basic level, several participants said that any increase in participation would be viewed as a success. Even achieving a student population that knows of the existence of geoscience could be a win. In other cases, achieving a geoscience student population in the department that reflects national diversity levels of the general population would be desirable. Career success was a commonly reported metric – increasing the number of students placed in geoscience jobs.

### Breakout #3: Key learning objectives and teaching materials

The questions posed to all teams for this breakout were as follows:

- What are the key learning objectives and associated content topics to include in the course?
- What types of teaching materials and/or strategies will be most useful to you (e.g., labs, assignments, ppt slides, pre-recorded lectures, classroom exercises)?
- If you had a particular instrument (e.g., loaned from PASSCAL or the University of Wyoming Near-Surface Geophysics facility, or have your own equipment), what teaching materials would be useful to you to go along with that equipment?

Breakout #3 was run in the group format as before, however all responses were recorded on post-it notes and hung on the wall for viewing and subsequent integration for discussion. A summary of generalized desirable teaching materials is as follows:

- Computer-based classroom exercises (simulations, data processing and interpretation)
- Classroom exercises and demonstrations
- Forward modeling apps
- Pre-recorded video or video instructions, lectures for students and educators
- Incorporate research into classroom
- Tutorials on open-source software
- Recommendations for course content that should proceed assignment
- Powerpoint slides
- Simple animations to show principles
- Labs and challenging questions
- Lab with a backup canned/already recorded dataset in case your field trip goes wrong
- Pen casts to explain math or draw schematics
- Outside resources - i.e., geophysics for practicing geoscientists ([gpg.geosci.xyz](http://gpg.geosci.xyz))
- Problem-based modules explaining methods via single environmental “challenge” (e.g., mag but via tank detection as an example problem)

A summary of generalized desirable instrumentation and instrumentation resources is as follows:

- GPR
- ERT
- Raspberry Shakes
- Land streamers
- Tutorial video how to work the instrument
- Pre-processed datasets
- Manuals
- Step-by-step exercises
- Open source, GUI-based processing software that can be installed on students’ computers such as GPRPy
- Large group licenses at facilities



- Elementary introductions to various geophysical tools
- Training for trainers, short courses
- A PASSCAL technician
- pre-AGU workshop on how to use instrument by PASSCAL
- Plug-and-play software online
- Operating principles in laymen's terms

#### Breakout #4: Demographics:

The following questions were posed to the whole group for discussion (no breakouts):

- What are the perceived barriers for the students you teach? What topics and skills do students appear most interested in?
- Imagine yourself as an employer, what are you looking for? What skills and content knowledge would you like new employees to have?

#### Perceived Barriers:

- they need to take a science class; they are fulfilling a science requirement but not at all interested in the class
- Need to be in pre-calc to take geology 101
- Lack of making connections, haven't applied what they learn to real datasets
- Plotted the number of SnapChats and/or Insta responses over the weeks time - give them something familiar and they can likely overcome their perceived barriers
- Want to do some data processing, as that's a key learning goal
- Even the bright students in the class may be younger and come from home school or early college high school situations

#### Job Employment:

- Understanding data is very important
- Reminder that field work is a professional environment
- Emails will be 'graded', so make sure that they are professional with an appropriate signature and proper grammar.

#### Breakout #5: Modules

The questions posed to all teams for this breakout were as follows:

- What local or regional urban and environmental issues could be addressed with a *short, single technique or tool module*?
- What local or regional urban and environmental issues could be addressed with a *longer problem-based, multi-technique module*?
- How would these be relevant to a diverse audience?
- What workforce opportunities exist under this theme?

Suggestions for a short, single technique module from all groups centered around engineering challenges and the built environment. The most common theme was locating discrete targets: rebar, pipes/utilities, storm sewers, and tree roots. Closely associated with this was the idea of predetermined targets, such as pipes or UXO installed at known locations by the instructor ahead of the class. Another idea that was presented by two groups was a classic landfill imaging or

plume detection module or more generally urban excavation/fill. The idea of structural stability and geotechnical assessment was also suggested.

Other groups suggested the landfill project as a longer problem-based module. Related to this was a more general ground water contamination problem-based topic. Additionally, it was considered that passive seismic could be a possibility for monitoring building structures if sufficient time was available. In the context of a longer module, it was suggested that environmental justice content could be included. Other suggestions for problem-based modules include: geohazards, groundwater, levees, urban stormwater, saltwater intrusion, traffic monitoring using seismic.

These types of projects would be relevant to a diverse audience because the topics are local and related to daily-life experiences of the students in urban settings. For example, some contamination problems may directly affect the community and link to environmental justice. Another advantage is that in some cases (e.g., built environment topics), field sites may be readily accessible with low logistical costs. These may provide opportunities for students to develop more familiarity with their own local built environment, and make connections between geoscience and engineering (e.g., as established earlier, engineering professions may already be perceived positively, so linking to the geosciences may open that door). It was suggested to provide information to the students on pathways to licensure (e.g., PG).

The workforce opportunities related to these modules include:

- Utility detection
- Civil/Environmental Engineering
- Public sector jobs
- NGOs
- Building infrastructure inspection
- Mining

### **Learning objectives discussion**

The discussion about learning objectives raised several points about presenting geophysical problems at a realistic level for freshman/sophomore students, as well as some fundamental (pre-geophysical?) abilities students may need to develop that could be addressed in the context of geophysics. For example, simply plotting data, understanding cross sections, reading maps, and reading contour lines were suggested as core abilities that may not be exclusive to geophysics but could be addressed in the class. The perception was that if we are trying to bring in new students, we need to have modules that challenge them but don't "overchallenge" (i.e., discourage) them. While learning objectives are typically developed "top-down" by the instructor or program, there may be a possibility to use some sort of needs/wants assessments to gauge understanding, and then lead them down the path of what the perceived needs are. That way, instructors can start the modules for their specific students. SERC and NAGT already have assessments to how to assess your students and figure out what math level students are at. Even though the course is intended to be introductory at the freshman/sophomore level, it was suggested that we may need to think about prerequisites or foundational classes that may be

necessary to get to some of these learning objectives. A general learning goal suggested was: “to understand that you can learn about the subsurface without seeing it.” Other general learning goals were: 1) to develop critical thinkers, and 2) on some level communication should be addressed by every module.

### **Parting Thoughts**

- Think of STEAM
  - incorporating graphics and arts, and to engage a graphic designer
  - Critical Zone pieces
- Can rely on participants and use open-source software to work with others; lofty goal, especially with the SERC framework
- How to make interpretations of the data and how to review the data

### **Key Takeaways**

- **Kruse:** Would like to hear about animations
  - Hydrogeology animations - how water lowers and changes, how saturation changes, and how we can look at this via animations (cone of depression)
  - Acquisition of hyperbola over a pipe
- **Parsekian:**
  - Small details and pedagogy to go into next steps of development
  - Consensus on big picture direction - smaller, and more tractable instrumentation
  - Practical problems to develop for modules
- **Slater:**
  - Don't know if this will have a big impact on diversity, and can't really see where this is going to go - as you need investment on time and money
  - Modules - improving teaching methodologies of early career geoscience faculty, and will likely have an impact on recruitment and retention of students
  - Modules will be a huge gift to the early career faculty, and how this could help effectiveness of teaching
  - If you free up time for teachers, they can engage in diversity related projects and work on larger diversity themes

### **Exit-Survey Summary:**

Attendees were given a short survey at the end of the workshop to gauge their perceptions on strengths and weaknesses of the activities. Around 50% of attendees responded to the survey. 75% of those who responded felt that the workshop was either “successful” or “highly successful.” Furthermore, 80% of respondents believed that the workshop met their expectations. Generally, the most valuable thing that participants got out of the workshop was the opportunity to meet and interact with other like-minded educators. Learning about teaching resources and engagement programs (e.g., GEOPATHS) was also viewed as a strong benefit.

Participants were asked what topics could have been addressed more thoroughly, and generally there was a sense that we did not get enough time to discuss specific modules, targets, and problems. Other important topics that could have been developed more:

- How to target underrepresented groups without being discriminatory?

- Some attendees were disappointed that they would not be involved in the next steps of course development.
- Consideration of the potential Community College student audience.

In several cases, attendees reported that their view on diversity in the geosciences was unchanged after the course. Some examples of comments from attendees who's view *did change* are as follows:

- Learned that aspects of a geophysics career like working outdoors and traveling far from home, which are often selling points for privileged students, may be undesirable to certain communities.
- realized how much ongoing personal interaction is required
- Getting under-represented groups into the pipeline of geoscience is a challenging task. This course could help, but is unlikely to have a major impact, as experience suggests that one on one interactions with students are critical.

Several respondents noted that it would be valuable to engage someone from HBCU's to provide input as development of the course proceeds. Victor Ricchezza was also specifically suggested as people to reach out to. Eight of the respondents offered to pilot-test course modules once they are developed.

## **Appendix A – Detailed notes on “what U&E geophysics means to me” talks**

Andy Parsekian (U. Wyo.)

- Students need more attention going through the math, so Andy uses a flipped classroom - records lectures, has the students watch beforehand, and then works through problem sets during formal lecture times, so he can help them with the math
- U&E geophysics is compelling because the students can connect to their surroundings and environment
- Develop non-technical ‘soft’ skills - e.g., project management and budgeting, etc.
- U&E has developed to answering scientific questions from drawing maps
- Broad success with student-lead research projects

Lee Slater (Rutgers - Newark)

- Rutgers Newark is an HSI, and labeled as the most diverse university in the US
- Headed more towards near-surface petrophysics
- Problem of student perception of geosciences as a career, and to have NYC as a backdrop, strong students focused on business, law, finance, medical
- Newark’s local setting is historically heavily industry impacted; contamination issues
- Research integrated into teaching with paid internship pathways
- Local urbanized field sites used as teaching platform
- Perceived contributions of the U&E course:
  - Catalyst for stimulating interest in geophysics/geosciences in a diverse student body
  - A recruitment & retention strategy
  - Feed existing activities (undergraduate research, upper level applied geophysics, GEOPATHS)

Sarah Kruse (USF)

- Urban geophysics presents unique and complex challenges
- Opportunities for novel acquisition and analysis; utilize urban noise
- Karst/sinkhole examples in developed areas of FL
- Attempting to resolve software bottlenecks with new open-source codes
- The freedom and flexibility to be truly yourself in the field (vignette from an all women field experiment)
- Goal: have people who feel like that can’t do physics, do physics!
- Goal: Inquiry and data ownership

**Appendix B: Notes on Geoscience Outreach talks**

Yes, Sign Me Up for a Geoscience Degree - Stefany Sit

- Graduating more women in the geoscience, but behind in POC
- Students are interested in the place-based aspects at her institution in UIC - like induced seismicity, mining and effects on farmland, etc.
- Authentic data collection and analysis, and tiered collaboration and support

Recruitment and Retention - Tina Carrick

- Found better success with Freshman and Sophomore students
- Students at the junior-senior high school level were also 'stuck' on what they wanted to do as undergraduates