Integration of Science:
Research, Education, & Outreach in Climate Change

David Marchant
Boston University
Our Golden Opportunity: Climate change as a lure for STEM education

- Asking scientific questions
- Communicating results to the general public
- Educating the next generation of students to do the same
Seeding a Cultural Change in Undergraduate STEM Education: Climate Science as a tool to integrate research, science education, and outreach

<table>
<thead>
<tr>
<th>Current Paradigm</th>
<th>Our Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STEM</strong></td>
<td><strong>STEM</strong></td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td><strong>Education</strong></td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td><strong>Communication</strong></td>
</tr>
</tbody>
</table>

- Research
- Teaching
- Outreach
Program Elements

Engage a cohort of 20 first-year students interested in climate science across three schools and colleges at BU:

The College or Arts & Sciences, The College of Communication, and the School of Education

1.5 year long program:

1. University-wide seminar series on climate change

2. Hypothesis-driven, problem-based laboratory course

3. Summer internship program

4. Fieldwork in Antarctica
Seed a cultural change that places early, consistent, and simultaneous emphasis on science, science education, and science communication.
Summer internships: 10-12 weeks

Intern with any of the speakers in the Fall Seminar Series, or any other researcher studying an aspect of climate change at BU or at nearby schools.
Fall-Winter Antarctic Expedition

Research Themes

• Atmospheric evolution
• Antarctic Ice Sheet stability
• Vegetation history of Antarctica
• Antarctic geomorphology applied to ice ages on Mars

Field Instruments & Techniques

• Ground Penetrating Radar
• LiDAR terrain characterization
• Longitudinal strain analysis
• Time-lapse imaging
• Meteorological data collection
• Stratigraphic analysis
• Geological mapping

STEM Skills

• Integration of technology
• Spatial reasoning and problem solving
• Application of geological concepts
• Quantitative analysis
• Formulating and testing hypotheses

Field Research

Modeled; with surface debris
Modeled; no surface debris
Measured; InSAR (Rignot 2002)

Mullins horizontal surface velocity

\[ \varepsilon = \frac{At^s}{2} \]

\[ \rightarrow \]
Virtual Antarctic Exploration

**Operational Support**
- Access to satellite imagery
- Provide guidance on sample locations
- Plan traverse locations
- Highlight key areas to avoid with seasonal snow cover
- Data transfer and communications support

**Digital Image Analysis Laboratory (DIAL)**
- Digital Image Analysis Laboratory
- Web-based virtual fieldwork
- GIS analysis
- Computational modeling, DEM's
- Ultra-high resolution imagery

**Virtual Research and Exploration**
- Analyze raw data from field
- Return finished products
- Processing radar data
- LiDAR point cloud synthesis
- Meteorological data analysis
- Geospatial analysis: samples

**STEM Data Synthesis & Analysis**
- Operational Support
- Virtual Research and Exploration
- Digital Image Analysis Laboratory
Program Reach and Scalability

Antarctica

3-5 students / yr

DIAL

BU Earth & Env.

15-20 students / yr

HHMI Courses

CAS

COM

SED

30-50 students / yr

Local area middle schools

100-200 students / yr

Geo 1XX

Virtual field trips for the GeoSciences

350-750+ students / yr

Web-enabled Virtual Exploration and Fieldwork

Unlimited

Antarctic field blog (>25,000 visits)

All products archived on a dedicated BU HHMI website: BURECS.com
Virtual Fieldwork: Extension Beyond Antarctica
An ever expanding tool for teaching geosciences

It has long been known that the best geoscience education includes a significant fraction of fieldwork, but fieldtrips across the country have been greatly reduced in scope due to financial and logistical concerns. The impact is greatest in introductory courses, where the large numbers of students make it financially untenable to travel...

Expansion of digital products to local field sites: University Geo Labs

from Penrose Conference on Geoscience Education, 2012
# Basic considerations for virtual lab development

| **Context** | Class Level  
| Pre-requisite skills  
| Pre-requisite knowledge |
| **Goals** | Conceptual goals  
| Critical thinking  
| Technical skill improvement |
| **Assignment** | Present a problem  
| Propose hypotheses  
| Collaborative work  
| Produce tangible product |
| **Data** | Geologic maps  
| High-resolution imagery  
| Ice core data  
| Meteorological data  
| Excavation data |
| **Assessment** | Content comprehension  
| Critical thinking  
| Technical skills  
| Pre- and post-activity surveys  
| Comparison with control groups |

---

### Outcomes and Assessments

<table>
<thead>
<tr>
<th>HHMI Elements</th>
<th>Observational</th>
<th>Quantitative</th>
<th>Graphical</th>
<th>Conceptual</th>
<th>Communicative</th>
<th>Collaborative</th>
<th>Ethical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental</td>
<td>Mathematics</td>
<td>GIS</td>
<td>Integrate</td>
<td>Verbal</td>
<td>Interdisciplinary</td>
<td>Societal</td>
</tr>
<tr>
<td></td>
<td>Field-based</td>
<td>Statistics</td>
<td>Web design</td>
<td>observations &amp;</td>
<td>Written</td>
<td>teamwork</td>
<td>impacts</td>
</tr>
<tr>
<td></td>
<td>Virtual fieldwork</td>
<td>Geophysics</td>
<td>Multimedia</td>
<td>theory</td>
<td>Multimedia</td>
<td>Peer-to-peer</td>
<td>Integrity</td>
</tr>
<tr>
<td>Seminar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab Course</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internship</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Research</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Assessments

**Capitalize on faculty research in assessment strategies within the School of Education and College of Communication**

- Pre- and post-participation surveys
- Evaluation of products by CAS, SED, and COM collaborating faculty
- Focus group interviews
- Content and network analyses of social media
- Graduate research in assessment, media use, and media effects, BU’s Emerging Media Studies
- Track and analyze student retention in STEM and science education/communication
- Evaluate efficacy of virtual exploration in 1XX level course at BU and university partners; compare to control groups
Assessment Strategy

Capitalize on faculty research in assessment strategies within the School of Education and College of Communication. In addition utilize assessment strategy for collaborative GK-12 GLACIER grant.

1. Pre- and post-participation surveys for HHMI participants and control groups addressing science literacy, interest in science, expectations of program, and program outcomes.

2. Evaluation of products, reports, and presentations by faculty collaborators in CAS, COM, and SED.

3. Focus group interviews with student workgroups, and other combinations of students.

4. Content and network analysis of student social media use across the period of the program.

5. Proposed MS/PhD thesis work in focused areas of program (assessment, media use, media effects) for BU’s graduate program in Emerging Media Studies.

6. Analyze student retention in STEM disciplines and science education/communication at BU, and beyond, and compare to control groups; track progress beyond duration of award.

7. Evaluate efficacy of the digital media produced as part of this program (virtual fieldwork and exploration) in 1XX level courses in natural sciences at BU and in partnering schools; compare to control groups.