Three Geoscience Modules To Improve Climate Literacy of Meteorology Students

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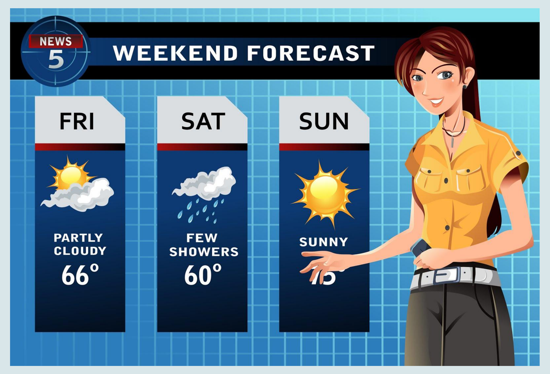
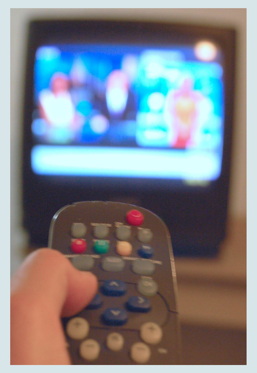
Introduction

Television news broadcasts are a primary source of information for the public on climate change. 70% of Americans watch local newscasts primarily to see the weather forecast (Miller et al, 2006; PEW, 2011), so broadcast meteorologists are well positioned to communicate climate science to the public. Since the public also tends to think that meteorologists are climate science experts (Leiserowitz et al., 2011), the prospective reach of broadcast meteorologists as disseminators of climate knowledge is enormous. But are broadcast meteorologists adequately prepared *and willing* to be climate communicators? Recent surveys indicate that about 30% of broadcast meteorologists remain skeptical of anthropogenic influences on climate and many more avoid public engagement on the topic (Syzmanski et al., 2014; Maibach et al., 2015).



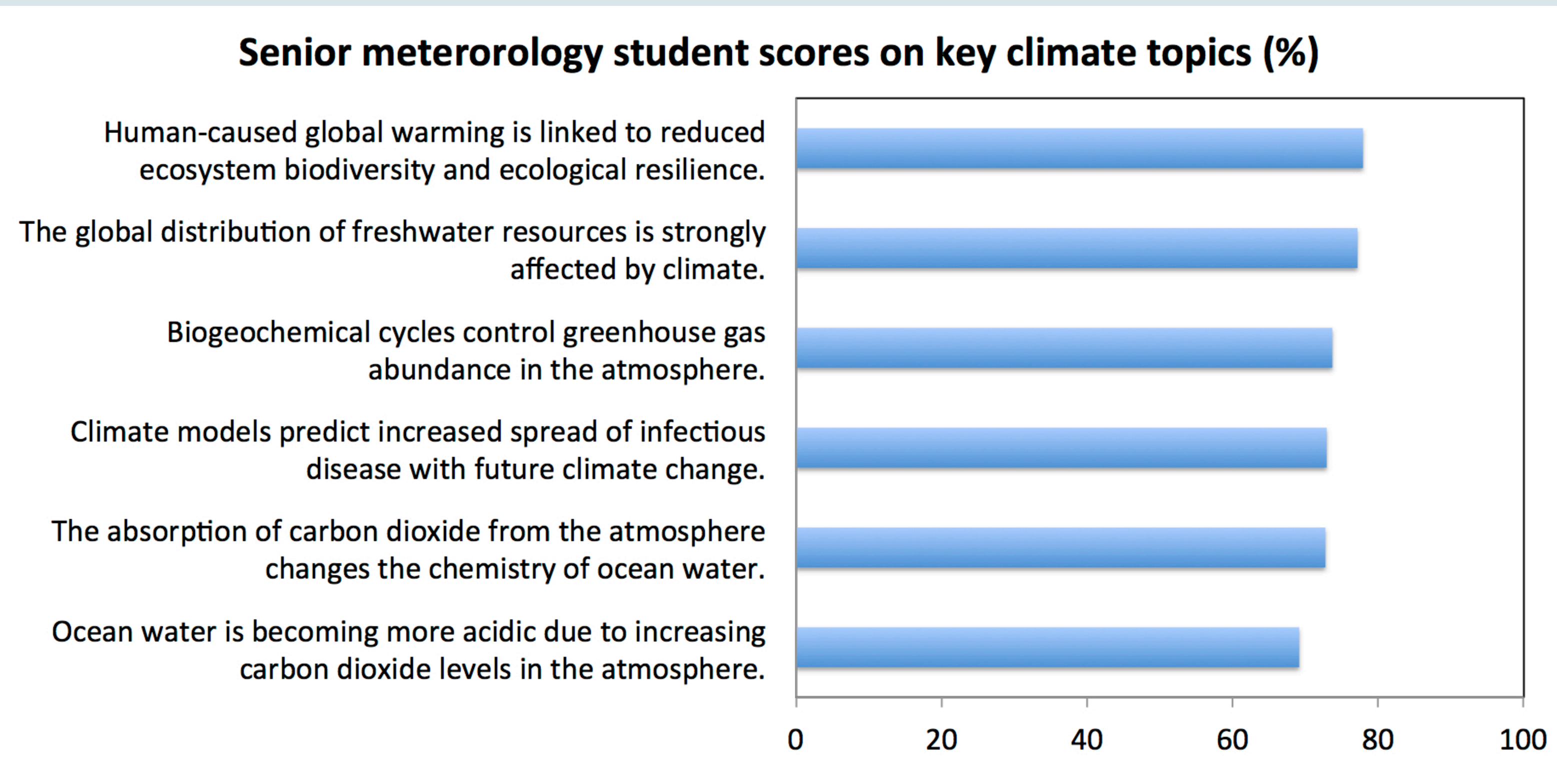


Source: http://www.dreamstime.com/photos-images/tv-weatherman.html, June 3, 2013.

To improve public engagement in climate communication by broadcast meteorologists, we tested several hypotheses about probable causes for their reticence/skepticism with support by a grant from NSF's Advancing Informal STEM Learning [AISL] program (DRL-1222752). We surveyed 86 workshop participants at the 2014 Northeast Storm Conference and 139 students (78 seniors; 61 freshmen) in 10 (of 70) meteorology degree programs across the U.S. on their understanding of climate change processes, climate model projections, and consequences to human and natural systems.

Results

We found significant climate literacy deficiencies in disciplines outside atmospheric sciences, especially in those that deal with geologic and biologic systems (see figure below). Students performed well on questions about scientific process, but on all climate-related topics were markedly less literate, especially when compared to public perceptions of meteorologists' climate expertise.

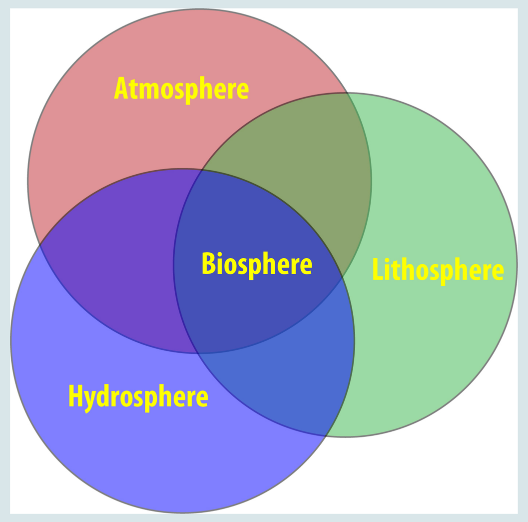


Results of the national undergraduate meteorology student survey (above, n=139).

Conclusions from survey

Meteorology students have significant learning gaps in interdisciplinary systems related to climate drivers, feedbacks and earth system responses. For example, to understand and convey the link between atmospheric CO_2 levels and climate, a meteorologist needs to comprehend the following biological and geological processes involving carbon, including

- what happens when it transitions out of the atmosphere,
- residence time in various reservoirs, including in the lithosphere,
- feedbacks with other systems and processes, such as oceanic buffers, and
- timescales at feedbacks have greatest impact on modern climate



Here we identify three, primary climate literacy gaps to address in introductory meteorology classes, and suggest a learning module for each. These modules emphasize *systems thinking* and interactions between Earth's spheres, depicted on the left. The three modules focus on: a) the effects of climate change on different aspects of the biosphere and hydrosphere, and the intersection of all the spheres; b) familiarizing students with the data associated with these effects; and c) evaluating the effects of continued increases in atmospheric CO_2 to Earth's systems.

MODULE 1: Climate Change and Phenology, Biodiversity and the Spread of Infectious Diseases

To improve student awareness of important, climate-related connections to the biosphere, we suggest a module that covers the following elements:

- Phenology, which is the study of annual responses to seasonal climate forcing, such as ice out on lakes, flowering of plants, insect emergence, and animal migrations. Thousands of phenology data records exist globally, many created by citizen scientists collecting local data related to climate change. Meteorology students should recognize the implications of phenologic change, the local connections it provides to the public, and the implied interdisciplinary, Earth system impacts.
- The World Health Organization identifies many emerging health problems related to changes in climate zones. Some diseases, like malaria, put millions of people at risk.
- It is now widely reported that a mass extinction event is underway, but effects of climate change on biodiversity received especially low scores in our survey.

http://www.gardeningknowhow.com/ornamental/shrubs/lilac/lilac-bush-not-blooming.htm

http://www.dreamstime.com/photos-images/biodiversity.html

http://www.organsofthebody.com/health/how-are-infectious-diseases-spread.php

Learning outcomes Module 1: Students will be able to

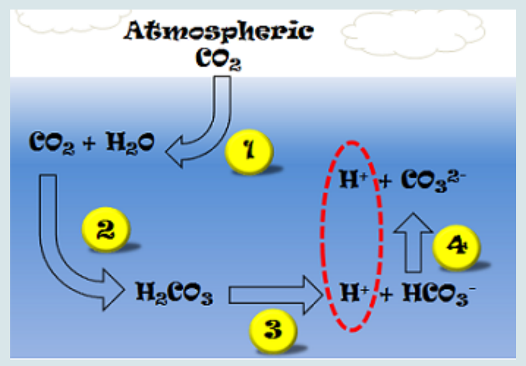
1. recognize the phenological nature, biodiversity and/or human health consequences of data and natural phenomena as they relate to climate change.
2. graph and apply climate interpretations to these kinds of biological datasets, including climate-species space, gradient, and range visualizations.
3. use these datasets to infer potential feedbacks, thresholds and hysteresis in Earth's biological systems as climate parameters change.

MODULE 2: Anthropogenic CO_2 and ocean acidification and buffering

Oceans absorb much of the atmosphere's CO_2 load and incorporate it into the ocean buffering system (see graphic below). Large CO_2 inputs drive the buffering reaction to new chemical endpoints, which lower oceanic pH. Although CO_2-driven changes in ocean pH provide strong, corollary evidence of anthropogenic climate change, meteorology students are largely unaware of these connections and implied consequences of ocean acidification. This module focuses on those connections and aims to foster student awareness that atmospheric chemistry affects oceanic chemistry, which in turn affects the entire marine ecosystem, with feedbacks to atmospheric O_2.

Learning outcomes Module 2: Students will be able to

1. diagram and explain the ocean buffering system.
2. define and explain the process of ocean. acidification as it relates to the buffering process.
3. evaluate the long-term and short-term impacts of changes in ocean pH to human systems.



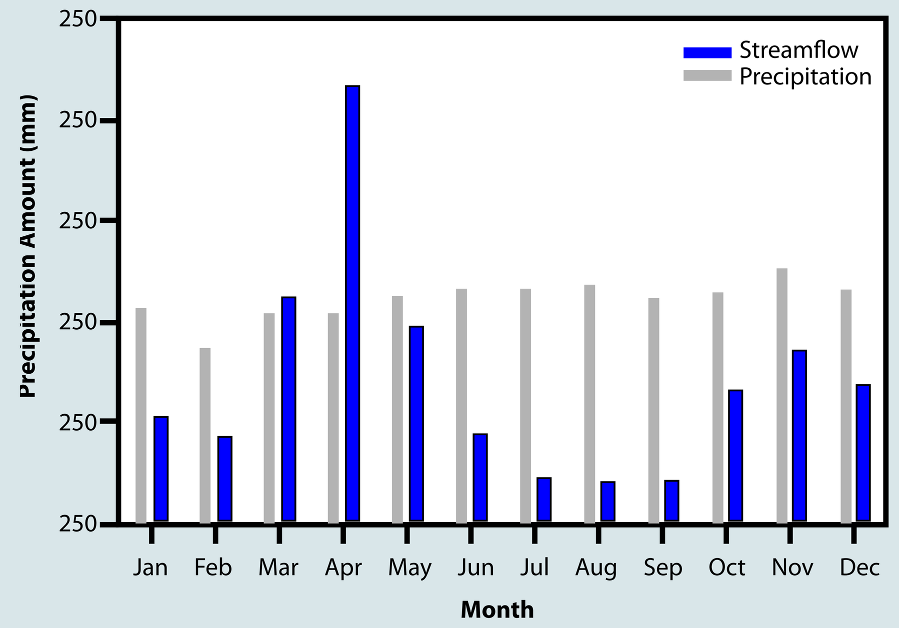
http://blog.massoyster.org/2013/05/ocean-acidification-and-oyster-shells.html

MODULE 3: Climate change feedbacks on the distribution of freshwater resources

The hydrologic cycle, a fundamental component of the climate system, has important climate-related feedbacks to the biosphere that affect agriculture, forestry, hydropower, irrigation, navigation, and other economic and social services. However, meteorology students display limited understanding of water reservoirs and how they respond to climate change, both spatially and temporally. Although meteorology texts expose students to characteristics of drought, little information is provided on relationships between precipitation and the lithosphere, including stream flow, soil moisture, and groundwater storage.

For example, the figure below compares annual precipitation with streamflow in New England. A critical analysis of this graph would help students identify how precipitation, groundwater and vegetation interact to create variations in discharge. This simple graph requires understanding of a complex system at the intersection of all four Earth system spheres.

Average monthly precipitation (gray bars) and streamflow (blue bars) at Hubbard Brook Watershed No. 3, NH (from Bailey et al., 2003, Fig 6, p 7).



Learning Outcomes Module 3: Students will be able to

1. describe interactions between precipitation, stream flow, groundwater, and vegetation in different zones and seasons.
2. apply model projections of precipitation to predict impacts on these same components of the hydrologic system.

Pedagogical strategies to emphasize interdisciplinary systems learning on climate change

- Invite professional guest speakers on different module topics.
- Promote small group exploration of different existing data sets related to the module topics, with presentations to peers, followed by whole-class discussions.

Assessment

Individual students will simulate being the station scientist at a news bureau and will develop and present a 1-minute broadcast on a recent scientific finding related to one of the three modules.

Rubric (evaluation criteria for delivery of 1-minute news broadcast)

- Provides clear definitions of scientific terms.
- Develops a graphic to illustrate a relevant concept.
- Presents science news accurately.

References:

Bailey, A.S., Hornbeck, J.W., Campbell, J.L., and Eagar, C., 2003. Hydrometeorological database for Hubbard Brook Experimental Forest: 1955-2000. U.S. Department of Agriculture, Forest Service General Technical Report NE-305, 40 pp.

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Climate Literacy Survey: https://www.surveymonkey.com/s/H6JDFC9