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Lost in translation: quantifying the overlap of popular media and non-majors science course assessment vocabulary

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Abstract. Earth's climate is rapidly changing, and citizens of the 21st century will need to act based on informed decisions about climate change. A liberal education should contribute to an informed and responsible citizenry who can think independently, reason analytically, and communicate effectively. Following college graduation, typical Americans will gain most of their science information through the media. How well are students prepared to be effective, critical consumers of media-reported science? We broach this subject by comparing the climate change vocabulary of undergraduate science courses for non-science majors with multiple popular media sources. Using PASW Text Analytics for Surveys, we objectively identified key terms from both classroom and media sources, and grouped these terms into major reservoirs and fluxes of the carbon cycle. Our classroom data include exams and quizzes from biology and physical science courses taught at a large, research intensive university. Media reports were collected the week before, after, and during COP15 from daily, weekly, and monthly media sources. Of the 253 items analyzed (183 media responses, 40 assessment responses), we extracted 310 relevant terms and grouped those into 19 categories based on the carbon cycle. The most frequently used terms in assessments included CO_2 and reservoirs such as the atmosphere, ocean, tree, and one flux, photosynthesis. Within the media, the most frequently used terms were socio-political in nature (e.g., country, Obama). Between the media and assessments, seven of the top 20 words overlapped and focused primarily on carbon reservoirs. Media and assessments differ substantially in the usage of terms associated with carbon fluxes. Many courses for non-science majors have a goal to improve students' abilities to apply scientifically sound reasoning and knowledge within their everyday lives. Our analysis reveals a discrepancy between the vocabulary used in media sources and in course assessments surrounding the topic of climate change. We suggest non-major science courses should do more to explicitly tie scientific processes to current political, economic, and social discussions. For many students, these courses represent the only science class they will take. The vocabulary they learn today should prepare them to make informed decisions tomorrow.

Key words: climate change; news media; scientific literacy; text analysis; undergraduate education.

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Introduction

Climate change. It's a common phrase but a complex concept that most Americans do not fully understand (Leiserowitz et al. 2010) and many do not 'believe in' (Pew Research Center for the People and the Press 2010*a*). And yet, Americans are cognizant of their shortcomings in understanding climate change—only 1 in 10 agree that they are "very well informed" about climate change and 75% indicate they would like to know more (Leiserowitz et al. 2010).

Formal schooling is an important venue for learning science, including the science behind climate change. In the US, 53% of Americans who are 25 years or older have taken some college courses, and 27% of all Americans have earned at least a Bachelor's degree (US Census Bureau 2006). A general model of higher education in the US requires students to take a year of general education courses, including science (Miller 2010). The most significant predictor of adult scientific literacy is the number of college-level science courses an individual completes (Miller 2001, 2010); thus, college-educated Americans learn much of their science through that liberal education, which translates to increased scientific literacy. These courses shape the mental frameworks with which students interpret scientific information throughout their lives. Indeed, although only 28% of American adults have a sufficient understanding of basic scientific ideas to read and understand the science section of the Tuesday *New York Times*, it is likely that figure would be far worse without post-secondary science education requirements (Miller 2004).

Outside of formal education, the majority of Americans learn science through the media (Friedman et al. 1986, Nisbet and Kotcher 2009). The fast pace of modern news and the 24-hour news cycle has resulted in a plethora of media outlets, including cable news networks, blogs, online news magazines, and news aggregators. Adults, especially young adults, increasingly turn to these outlets for news and information (Pew Research Center for the People and the Press 2010*b*). Media, therefore, is the avenue through which citizens learn about scientific innovations, breakthroughs and challenges, such as stem cells, nanotechnology, and climate change, and is a driving force in scientific literacy (Miller 2010). However, previous research has shown that science in the media typically omits relevant and important information (e.g., methodology, context) needed by the public to make informed decisions (e.g., Pellechia 1997). Indeed, when Treise and Weigold (2002) reviewed the literature to ask, "How well is science communicated to the public?," the result was, "... not very well" (p. 312).

Scientific literacy

Despite decades of research, defining scientific literacy remains complex and somewhat contentious (DeBoar 2000, Laugksch 2000). For this paper, we adopt the concept of civic scientific literacy. As set forth by Miller (1998, 2010), civic scientific literacy is a multidimensional construct that includes knowledge of (1) basic science vocabulary, (2) the scientific process, and (3) the impact of science on society.

The dynamic nature of science necessitates a dynamic basic science vocabulary, which presents a challenge to researchers interested in measuring scientific literacy. Miller (1998) used Project 2061 (AAAS 1989) to identify and then refine the scope of terms and concepts that could be considered foundational to scientific literacy. This approach represents an expert scientist defining the content area for scientific literacy.

Alternatively, a small body of research has used the media as a starting point to define expectations for scientific literacy. Hopkins (1925) categorized magazine and newspaper science articles by content area in order to identify relevant topics for high school science courses. Later, Koelsche (1965) repeated this method to identify core science vocabulary for scientific literacy. This approach is, however, somewhat subjective, relying on the categorization scheme of the expert scientist. Further, contemporary areas of scientific discovery that have not yet migrated into mass media outlets are underrepresented by this approach, regardless of their potential importance to society. In a more recent approach to measure the media's use of common scientific terms, Brossard and Shanahan (2006) searched six years of newspaper articles for occurrences of a subset of terms randomly chosen from the Oxford Dictionary of Science (Isaacs et al. 1999) While this approach removes the subjectivity of the single scientist, it nevertheless relies on the subjectivity of a collec-

tive of scientists, and may not allow comparison of terms important in both scientific and more general contexts. We therefore propose a more objective and organic approach, where key scientific vocabulary are not determined a priori, but emerge from a holistic analysis of text. Text analysis, which includes both simple word counts and the grouping of words, terms, and phrases into scientifically meaningful categories, provides a means to identify, describe, and compare lexical patterns that appear in blocks of texts. Such a tool facilitates the objective comparison of text from two distinctly different sources, such as university exams and magazine articles.

Climate change

Few would deny that a scientifically literate individual understands the causes and repercussions of climate change and can evaluate data to make informed decisions (Karl et al. 2009, Miller 2010). Such literacy necessarily relies on an understanding of a small but specific suite of scientific concepts and terms. For example, as part of a program developed to train 11th and 12th grade students as mentors and near-peer teachers of climate change for middle school students, four climate scientists created a list of 26 concepts they believed central to understanding climate change (Schuster et al. 2008). Many of these terms and concepts are scientific jargon (e.g., cryosphere and paleoclimates) while others can have a colloquial interpretation (e.g., energy [general motive forces] and models [simple depictions]). Further, understanding climate change also rests on a basic knowledge of the carbon cycle, a core concept in science (AAAS 1993, College Board 2009, AAAS 2011). Knowledge of carbon reservoirs and movement between those reservoirs is central to making sense of the causes and potential solutions to global climate change. Further, many of the terms used by scientists and media alike in describing climate change are vague or lexically ambiguous (Lemke 1990). As Hassol (2008) and Somerville and Hassol (2011) note, scientists employ common words, like enhance, positive, or fresh in decidedly different ways than the public. For example, an *enhanced* greenhouse effect may be a good thing (i.e., an *improved* greenhouse effect) or something else entirely (i.e., an *increased* greenhouse effect), depending upon the audience. Thus, a citizen who is scientifically literate about climate change must have a deep understanding of jargon and must recognize scientific meaning in otherwise colloquial terms.

Given the challenges of comprehending climate change vocabulary, where does the average citizen learn this vocabulary? Clearly the media is a primary source of scientific information for the average American; however, as Miller noted (2004, 2010), the unique core liberal education requirement of the US is a major driver of scientific literacy of college graduates. Through that liberal education, students build a framework of basic scientific understanding, which should, ideally, include some instruction on climate change. Thus, the role of the introductory science courses for non-science majors is particularly critical to creating a scientifically literate populace.

The work presented in this paper does not address the quality of the climate change science reported in the media; rather, it focuses on the overlap in terminology used by the media and by college-level courses that serve liberal education requirements and that, presumably, are intended to increase the scientific literacy of the average citizen. If the goal of education is to prepare students for citizenship (Brouillette 1996), then the acquisition of "a core vocabulary of basic scientific constructs" (p. 252) allows students to become and remain informed about scientific concepts (Miller 2010), thereby becoming scientifically literate citizens (Fink and Stoll 1998). We therefore ask how well vocabulary used in science courses for non-science majors aligns with vocabulary used in print and broadcast media. Specifically, we ask: (1) what vocabulary does the media use when reporting on climate change, (2) what vocabulary do science courses use in assessing student knowledge of climate change, and (3) what amount of overlap exists between these two vocabularies? Using text analysis, we objectively compared the vocabulary of assessments from undergraduate, non-major science courses with multiple popular media sources.

Methods

Assessments

Examinations use terminology that professors expect students to know. Therefore, we targeted

Table 1. Non-majors science courses used for analysis. The number of assessments refers to those assessments that contained content related to climate change or the carbon cycle. The number of items refers to climate change or carbon cycle items that were extracted for text analysis.

Course	No. assessments	No. items
Non-majors physical science†	2	9
Non-majors physical science‡	3	25
Non-majors life science§	1	6

† Spring 2009.
‡ Summer 2009.
§ Fall 2009.

Table 2. Media chosen for analysis. Number of articles refers to those articles and newscasts that contained content related to climate change or the carbon cycle.

Media source	No. articles		
	Week before	During COP15	Week after
Blogs[1]	720	1462	371
AP[1]	58	117	32
Network news[2]	4	22	1
Local news[2]	6	8	0
Time[2]	7	3	3
Newsweek[2]	1	6	0
Scientific American[2]	4	16	3

Note: Superscripted numbers refer to volume of media outlet: 1, high-volume media; 2, low-volume media.

exams (hereafter termed assessments) from 12 recently taught (i.e., since 2005) non-majors life science and physical science courses at a large, public, mid-western research university. These courses were chosen for their explicit goal of teaching science concepts to non-science majors. All assessments were searched for questions that contained content related to climate change or the carbon cycle (Table 1). Each of these questions, including response options for multiple-choice questions and the rubric for extended response questions, was extracted for text analysis.

Media

People have numerous ways to obtain their news, with media outlets ranging from web blogs to print articles in newspapers and magazines to television and on-line sources. We analyzed articles from daily, weekly, and monthly news sources (Table 2). To ensure a robust media sample, we focused our analysis on media in the period surrounding a major, climate-related world event, specifically, the United Nations Climate Change Conference of 2009 (COP15), held in Copenhagen, Denmark from December 7 to 18, 2009. To fully capture the language trends of the media, we categorized our search into articles published or broadcast in three distinct time periods: 7 days prior to COP15, the time period of COP15 itself (12 days), and the 7 days following COP15.

The variety of media sources in our data set required us to coarsely group our media sources into low- and high-volume media (Table 2). Low-volume media, such as nightly news broadcasts, weekly news magazines, and popular science magazines, included sources where we could read every article or watch every newscast and identify those with a content focus of climate change or the carbon cycle. News segments with a content focus on climate change or the carbon cycle were then transcribed for analysis. Low-volume media sources typically had a national audience, substantial or wide reader- and viewership, and were likely to be encountered by a wide range of audience demographics.

High-volume media produced more articles in the time period of interest than we could effectively read and categorize, generally publishing more than 25 articles in each of the time periods. We used LexisNexis Academic to search online blogs and Associated Press (AP) postings, and constrained our searches by source (either AP or blogs), by term ("climate change"), and by date (e.g., November 29–December 6, 2009). We retrieved a total of 207 AP articles and 2553 blog postings. Using a random number generator, we selected 10 articles from each time period to include in the text analysis. In total, 183 low- and high-volume media articles were used in the text analysis.

Text analysis

We chose two methods to perform text analysis: word frequency and lexical analysis. Word frequency is a simple count of the number of times each word appears in a given item (in this study, an item is either a media article or an assessment question). In contrast, lexical analysis software provides a method to objectively identify terms, including synonyms and abbrevia-

tions, and phrases within an item, and to group similar terms and phrases into categories of discrete concepts or ideas (e.g., atmosphere, combustion, etc). In the lexical analysis we report here, each item can be grouped into multiple categories. Binning of concepts into categories offers a key advantage of the lexical analysis approach over a strict tabulation of the usage frequency of individual words. For example, if a media article contained the term "ocean" ten times and the term "sea" five times, word frequency analysis would result in ocean = 10 and sea = 5. However, in the lexical analysis, this single media article would be counted only once in the category "water & ice", as both the terms "ocean" and "sea" are grouped in this category and there is no consideration for the number of times the terms appear within a single item.

Word frequency.—Assessments and media reports collected from the week before, after, and during COP15 were analyzed by an online word counting program, WriteWords (http://www.writewords.org.uk/word_count.asp). The output from the program included words from all parts of speech. To obtain a list of the most frequently used nouns and verbs, five researchers reviewed the output, removed conjugations, articles, etc., and combined singular and plural forms of nouns and various abbreviations for the United States of America (e.g., US, USA). Because of the many contexts of the term "carbon", such as carbon sink, carbon sequestration, etc, the term "carbon" was counted separately from the phrase "carbon dioxide". "Carbon dioxide" was grouped with the term "CO_2." The words "climate" and "change" and the phrase "climate change" were not included in the media list because these words were components of the original search parameters.

Lexical analysis.—We used lexical analysis software to support our goal of objectively grouping terminology from media and assessments into categories associated with different aspects of the global carbon cycle. Each media article (article, blog entry, newscast, etc.) and assessment item was stored as a unique entry in a datasheet. All entries from media and assessments were analyzed by PASW Text Analytics for Surveys, version 3.0 (current version of the software is called IBM SPSS Text Analytics for Surveys)(SPSS 2009). PASW Text Analytics for Surveys is a lexical analysis software designed to analyze and categorize open-ended responses on surveys but can be used with any block(s) of electronic text. The software identifies the words used (called terms) and allows the user to create custom libraries of scientific terms. Scientific terms and phrases not part of the standard libraries included with the software (e.g., anthropogenic, CO_2) were added to a custom library for this project. The software then classifies the recognized terms into one or more categories. Categories can contain one or more terms, phrases, or functions (based on Boolean logic) and may be created and/or modified by the user. Entries are assigned to one or more categories based on the terms they contain.

For this project, categories were designated for reservoirs and fluxes in the carbon cycle (as shown in Table 3; Fig. 1). We chose these categories because they align with how visual representations typically present natural cyclic systems. Elements or nutrients are commonly represented as residing in reservoirs with arrows indicating the fluxes between the reservoirs. These categories also delineate the major ways in which society interacts with carbon cycle. To simplify and limit the analysis, similar reservoirs or fluxes were further grouped in order to create the final 13 categories used for analysis. To determine which terms reside in each category, four researchers discussed the placement of each software-identified term into a carbon cycle category and where disputes occurred, the opinion of the majority was adopted. Terms unrelated to the carbon cycle but relevant to climate change were placed in a separate, non-reservoir and non-flux category and not used in further analysis.

Because the text analysis software recognizes terms independent of context within a sentence or entry, placement of the vast majority of terms into categories was also context-independent. However, three terms (carbon dioxide, methane, emissions) were not placed in a context-independent manner because that would have necessitated their inclusion in nearly all reservoirs and/or fluxes. Therefore, one researcher evaluated these terms by reading the sentence in which they appeared and assigning that appearance of the term to the corresponding reservoir or flux. A second researcher independently verified this

Table 3. Term categorization, based on major reservoirs and fluxes of the carbon cycle. Numbers reflect the percentage of assessment items and articles/newscasts in which carbon cycle terms were present.

	Term counts			
		Media		
Categories	Assessments (%)	Week before (%)	During COP15 (%)	Week after (%)
Fluxes				
Biologically mediated oxidation	8	9	11	11
Diffusion in and out of ocean	5	9	6	11
Man-made and combustion	15	56	74	57
Photosynthesis	13	2	3	7
Sedimentation, lithification, and weathering	3	0	4	4
Soil formation and sequestration	0	2	5	0
Volcanic eruptions	5	0	1	0
Reservoirs				
Atmosphere	70	65	68	61
Biota	28	44	48	43
Fossil and alternative fuels, clathrates	13	33	37	25
Rocks and reefs	10	14	14	11
Soils	8	16	27	11
Water and ice	53	47	51	40

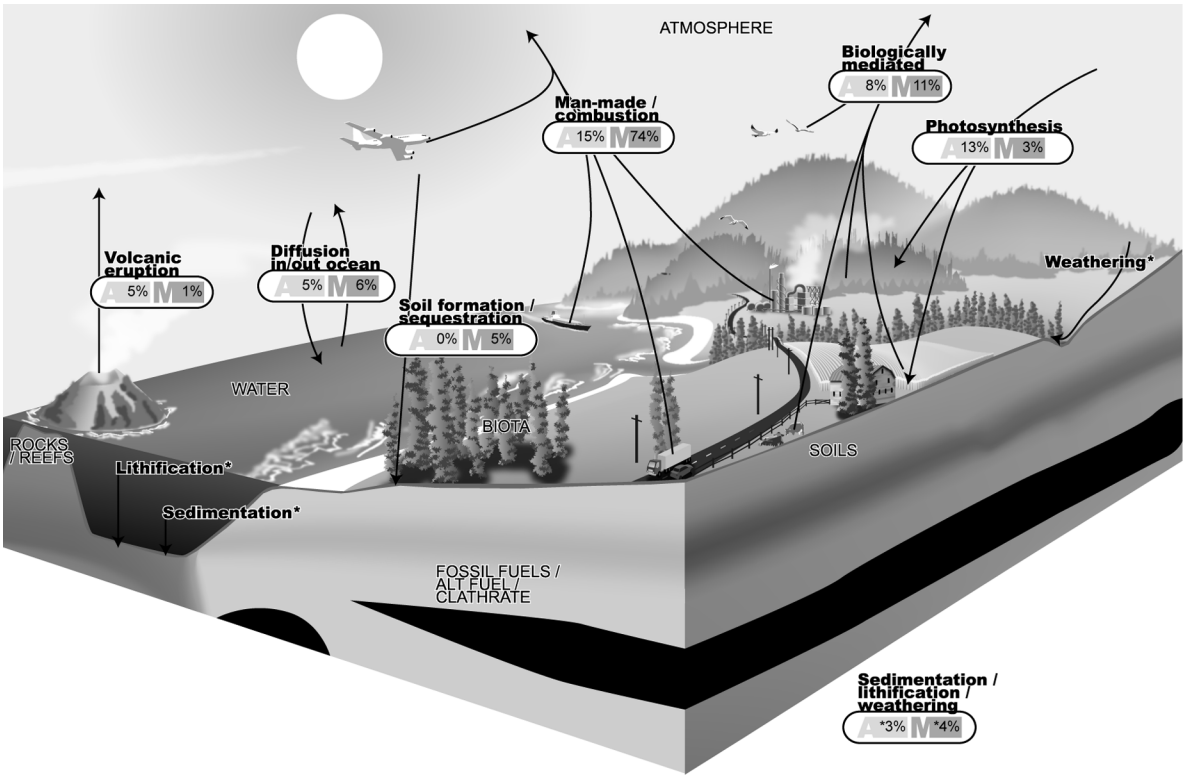

Fig. 1. Mapping the term categorization analysis onto a traditional depiction of the carbon cycle. For each type of item (A, assessment; M, media), we grouped terms by reservoirs and fluxes. For simplicity, we represent only the data from the fluxes here. For each flux, we present the percent of analyzed items (assessment (A) and COP 15 media (M)) that contain a relevant flux term.

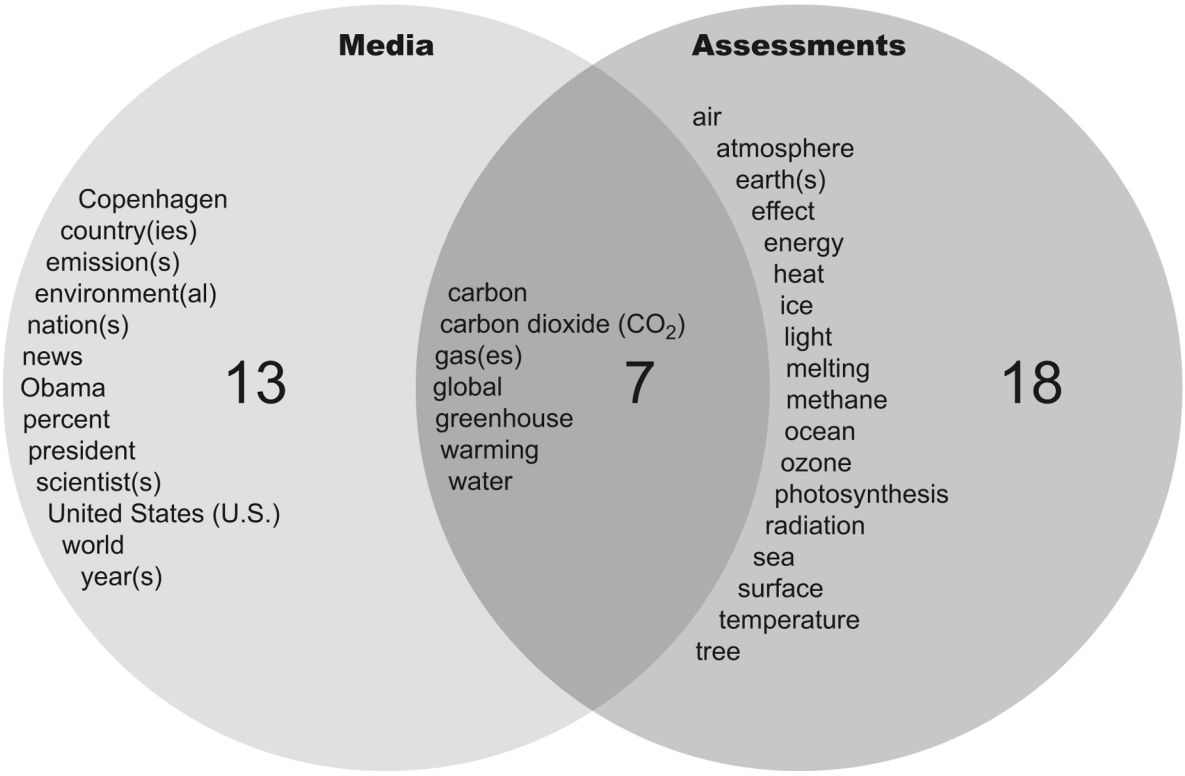

Fig. 2. Overlap of the most frequently used words by the media and in assessments. Because of ties, 25 words are listed under assessments.

category placement process and any discrepancies were resolved by the entire research group.

Results

Assessment terminology

Only three of the 12 courses we surveyed included assessments with items addressing climate change or the carbon cycle; all three courses were taught in 2009. Within these three courses, we identified six assessments, containing a total of 40 items related to climate change (Table 1). The most frequently used climate-related words in the assessments were CO_2 and atmosphere (Fig. 2). Other common words included forms of carbon (e.g., carbon, CO_2, methane), carbon reservoirs (e.g., atmosphere, ocean, tree), and one flux (photosynthesis). Several terms were energy-related, including energy, warming, temperature, radiation, and heat.

The categorization of terms based on the carbon cycle revealed a clear focus by assessments on carbon reservoirs, especially the atmosphere (Table 3). Both water and ice, and biota (also reservoirs) were found in large numbers of assessments items. Flux terms occurred less frequently and when they did appear, focused on photosynthesis and man-made/combustion processes (13 and 15% of assessment items, respectively).

Media terminology

Within the 183 media items analyzed, the most frequently used words were socio-political in nature, including country, nation and world, Obama and Copenhagen, although several more scientific terms, including carbon, CO_2, and greenhouse were also common (Fig. 2).

Over the selected time intervals, media focused heavily on people and places as evidenced by the prevalence of nouns and proper nouns (Table 4). Eleven terms related to climate change in media sources appeared in all three studied time periods. These terms were quite general, includ-

Table 4. Twenty most frequently used words in media articles during each of the three time periods under analysis. In several instances, two or more words tied in frequency, resulting in a list of greater than 20 words (see Appendix for further information, including frequency data for each term).

	Media time period		
Most frequently used words	Week before	During COP15	Week after
carbon	x	x	x
Copenhagen	x	x	x
country(ies)	x	x	x
emission(s)	x	x	x
gas(es)	x	x	x
global	x	x	x
nation(s)	x	x	x
United States (U.S.)	x	x	x
warming	x	x	x
world	x	x	x
year(s)	x	x	x
carbon dioxide (CO_2)	x	x	
China	x		x
environment(al)	x	x	
greenhouse	x	x	
Obama		x	x
percent	x		x
scientist(s)	x	x	
United Nations (U.N.)	x	x	
agreement			x
care			x
conference	x		
data	x		
deal			x
energy			x
health			x
mails	x		
news		x	
president		x	
species			x
summit			x
water		x	

ing political entities (nations, countries) and basic carbon cycling concerns (carbon, emissions, warming). Another set of terms ($n = 8$) occurred in two of three time periods, mostly reflecting ideas more related to the summit at Copenhagen (environmental, China, Obama). The remaining 13 terms in each of the time periods were found in only one time period. These terms, such as data, energy, health, water, and species, covered a broad range of subtopics.

The term categorization also revealed a media focus on reservoirs, especially atmosphere (Table 3), biota, and water and ice. Fluxes were generally absent, with the exception of man-made/combustion and biologically mediated oxidation (e.g., decomposition, livestock methane production, etc), which appear in roughly 60% and 10% of media items, respectively.

Comparison of media and assessments

Of the top 20 words identified in the media and assessments, seven words overlapped (Fig. 2). Note that Fig. 2 includes 25 terms in the "top 20" from the assessments. The word count analysis identified some terms that had equal frequency and thus, these tied terms were all included in the top 20 list of terms (see Appendix for complete count data).

In general, both media and assessments discuss carbon in reservoirs more often than they do fluxes of carbon between those reservoirs (Table 3). Reservoir terms used by media and assessment items were largely similar in their terminology; both mentioned primarily inorganic forms of carbon in the atmosphere and water (Table 3).

The largest differences between assessment and media terminology occur in the usage of terms associated with carbon fluxes (Fig. 1).

Specifically, media articles frequently describe combustion and other man-made carbon fluxes (74% of media items during COP15; Table 3), while very rarely mentioning photosynthesis (3% of items). Assessments mention a greater variety of flux processes more frequently, especially photosynthesis and other biologically mediated fluxes, but in no case are they common to many items, occurring in less than 15% of items in all cases.

Discussion

Although the goals and objectives of the media differ in several key ways from those of a non-majors science course, the audience for both is largely the same, and both intend to transmit scientific concepts to that audience. Indeed, if a liberal education in the US is meant to create scientifically literate citizens (Miller 2010), then there is a real need for non-majors science courses to prepare students to effectively consume media. Building scientific literacy is far from a trivial task, however, and the use of distinct vocabularies by the media and course assessments may impede the transfer of scientific content and process knowledge. Indeed, the results of this research confirm the use of distinct vocabularies by assessments of non-majors undergraduate science courses and popular news media. Further, our subsequent grouping of terminology into major reservoirs and fluxes of the carbon cycle reveals several trends that may impact public perception of climate change and subsequent solutions.

Distinct vocabularies

News articles have multiple purposes. In addition to entertainment, news articles are meant to inform readers about subjects that are particularly relevant to society (Russell 2010). It is not surprising, then, that our analysis of the most frequently used terms by the media on climate change was responsive to contemporary political events, and revealed a prevalence of socio-political vocabulary, including terms like nation, US, and Obama. Assessment terminology, however, was decidedly more clinical, focusing on forms and reservoirs of carbon.

The distinct vocabularies of the media and assessments may influence the transfer of scientific knowledge from the classroom to everyday life. Some research suggests that misconceptions and misapplication of concepts can occur when the terms in these distinct vocabularies are lexically ambiguous (Nehm et al. 2010*a*, *b*). Words shared by both vocabularies may have different meanings depending on the context (i.e., polysemous), or have different meaning in "everyday" language (Lemke 1990). Others argue that polysemy is an inherent characteristic of language and that misapplication and misconceptions are not caused by the scientific terminology, but by faulty scientific reasoning (Hodges 2008). Whether or not faulty scientific reasoning results from lexically ambiguous terms is an area of active research (e.g., Nehm et al. 2010*b*).

Carbon fluxes

Both media and course assessments focus on carbon reservoirs and generally ignore fluxes of carbon, as evidenced by term categorizations. Notably rare or absent in both media and assessments are mentions of carbon sequestration during soil formation and diffusion in and out of the ocean, both of which move large amounts of carbon through the earth's reservoirs in a given year. Such results are especially perplexing since fluxes are a key pathway by which society can impact the carbon cycle, and by extension, climate change.

Indeed, assessment items that included fluxes focused primarily on man-made emissions and photosynthesis; similarly, media reports also focused on man-made carbon emissions. Together, these foci may leave the impression that such fluxes are the only fluxes of significance. Although we acknowledge that limiting use of fossil fuels, either through private (as consumer) or public action (as voter), may be the most effective change students can make to control greenhouse gas levels, by no means are these the only fluxes of import to climate change. Societal land-use choices, for instance, have a large bearing on how much carbon is released from recalcitrant sources in soils. In addition, several key carbon fluxes (e.g., diffusion into sea water, release of methane from clathrates) are strongly affected, albeit indirectly, by anthropogenic carbon emissions into the atmosphere. Understanding these indirect feedback effects is becoming

increasingly important to understanding the scale of the challenge society faces in order to stabilize global temperatures. Furthermore, the scientific community has acknowledged that solutions to the climate change crisis will need to be multi-faceted, and may include such diverse approaches as subsidizing land use conversion from annual to perennial cropping systems, carbon sequestration in abandoned mines or wells, and increasing reliance on renewable fuels, including biofuels (Intergovernmental Panel on Climate Change 2007).

Linking science and society

Media presentations of the carbon cycle are replete with discussions of political and economic systems that are affecting imbalances in the carbon cycle. Elaborations on carbon reservoirs and fluxes are largely absent. Indeed, perhaps the most striking aspect of the media coverage during COP15 was the high proportion of terms used that were found to be common in at least one other time period. Only "news" and "water" were uniquely prevalent during the conference. Thus, it seems that most of the terms used during COP15 were reflective of a consensus on the major topics related to carbon and climate change: the importance of emissions and the difficulties of getting countries (especially the U.S. and China) to agree on a route forward. Again, although these are very much at the center of the issue, there are other topics, including other flux processes, such as carbon sequestration, which could deepen and enrich the public discussion of these issues. Limiting their appearance in public discourse does all of society a disservice.

We identified two general types of media articles about climate change in our survey. The first attempts to explain the science behind climate change for a lay audience, and often can be found in longer-format presentations, such as *Scientific American, Time,* and longer network news segments. The second type of article focuses on the implications of government policies or economic decisions for carbon cycling, and often assumes a good deal of background knowledge about the science of carbon cycling and climate change. We hypothesize that most of the articles retrieved from blogs and the Associated Press would fall into the latter category. This may be another explanation for the mismatch between terms used on the assessments and in the media in our study, although it doesn't diminish the potential importance of that mismatch to an engaged citizenry. We argue that the best media portrayals of climate change policy discussions will also include a diverse and relevant science background, while the most effective science courses will likewise frequently incorporate connections to public policy debates of the day.

Limitations

Of the 12 courses we surveyed, only three included assessments with items addressing climate change or the carbon cycle. The resulting pool of assessment items was, therefore, significantly smaller than the pool of media items. In addition, our focus on midterm and final exams assumes alignment of assessments with course goals and activities (via backward design, cf. Wiggins and McTighe 2005). Although our analysis focused strictly on midterm and final exams, these are not the only forms of assessment used by instructors. Faculty may employ group activities and clicker questions during classroom sessions, semester-long group projects, oral and poster presentations by students, and term papers in order to gauge the conceptual understanding of their students. These other types of assessment may include additional language related to climate change that is currently underrepresented in the assessment data, especially sociopolitical contexts to climate change concepts and carbon cycle fluxes. However, with a subject as complex and politically charged as climate change, faculty may choose to focus on core elements of the carbon cycle (e.g., reservoirs) in order to investigate these topics more deeply and may only bring up current events in climate change as a way to engage students in lecture without actually integrating these topics into the assessments. Future investigations should include an analysis of course syllabi, in-class assignments, homework, and grading rubrics to include a broader spectrum of classroom assessment.

Secondly, by focusing on COP15, a political event, we potentially skewed the media data towards the socio-political context. In a world where international negotiations unfold within

the general framework of democracy, any media coverage of societal responses to climate change is likely to include a significant attention to political ramifications of those responses. In other words, science and policy are rarely separable in media presentations.

Implications for teaching

In non-major science courses, building vocabulary is often a primary goal (Miller 2010). To this end, both reservoir terms and words describing the effects of and contributors to global climate change (e.g., melting, radiation) appear more frequently in course assessments than nearly all fluxes in the carbon cycle. However, if foundational vocabulary is indeed a course goal, it is important to note that very little of such language is used in every-day media reports (see Fig. 2), and such a course goal for a non-majors science course may need re-evaluation. The vocabulary proposed by Schuster et al. (2008), for example, provides a starting point for instructors whose goal is to introduce more technical scientific language associated with climate change. Because the Schuster et al. (2008) list was designed for students in 11th and 12th grades of high school, the terminology *should* align with the science standards for those grade levels. Explanation of such terms and concepts is necessary to promote scientific understanding, otherwise class lectures and activities may actually *promote* alternative scientific conceptions (Nehm et al. 2010*b*). Further, assessments that include this type of language without proper introduction would lack communication validity with these student populations. Even terms that are recognizable in everyday conversation may have different meanings in a scientific context (cf. Hassol 2008). Therefore, if incorporation of climate change terminology is a focus of a non-majors course, then it is imperative to set aside class time for students to investigate the meanings of these terms, provide precise definitions for scientific terminology, and have ample opportunity to use them in class.

We ask educators to revisit the goals of their non-science major courses. Is one goal to prepare students to make informed decisions about climate change in their communities? If so, consider incorporating news stories and current events in the media into the course content. By providing real-life application of the science to everyday activities, educators will be able to address preconceptions and misconceptions students may have coming into the classroom and to build upon student strengths by leveraging prior scientific knowledge in a familiar context. Furthermore, by presenting current scientific events in the classroom, educators have the opportunity to link language used by the media to present scientific information to the language used by the scientific community. Such an exercise would guide students in critical thinking by analyzing arguments presented in the media, while also developing an understanding of the processes of climate change. Ultimately, educators can be the link between scientists and the media by addressing topics that are prevalent in both communities and preparing students to make informed decisions regarding global climate change policy.

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SUPPLEMENTAL MATERIAL

APPENDIX

Table A1. Media word frequencies (Freq.) for the week of COP15, the week before, and the week after.

Week of (n = 81 entries)		Week after (n = 28 entries)		Week before (n = 43 entries)	
Freq.	Word	Freq.	Word	Freq.	Word
202	United States (US)	71	copenhagen	110	carbon
195	global	66	emission(s)	107	emission(s)
176	country(ies)	66	year(s)	93	year(s)
176	year(s)	52	United States (US)	86	global
167	world	52	carbon	86	United States (US)
164	emission(s)	50	gas(es)	79	gas(es)
162	copenhagen	50	nation(s)	67	warming
142	obama	46	global	66	scientist(s)
133	warming	43	country(ies)	59	world
119	carbon	36	species	58	United Nations (UN)
111	gas(es)	36	deal	54	copenhagen
110	president	32	world	53	country(ies)
108	nation(s)	31	health	50	nation(s)
95	water	31	energy	48	greenhouse
92	greenhouse	30	percent	43	percent
89	co2 (dioxide)	30	obama	43	co2 (dioxide)
88	environment(al)	29	china	38	data
87	news	28	care	38	conference
87	scientist(s)	28	agreement	37	environment(al)
80	United Nations (UN)	27	warming	35	mails
		27	summit	35	china