Routledge
Taylor & Francis Group

Image Themes and Frames in US Print News Stories about Climate Change

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Research on frames in climate change (CC) news coverage has advanced substantially over the past decade, but the emerging understanding of the framing role of visual imagery that often accompanies news texts remains fragmented. We report on a set of image frames identified through content analysis of 350 images associated with 200 news articles from 11 US newspaper and magazine sources from 1969 through late 2009. We reliably identified and quantified the occurrence of 118 image themes. We then hierarchically clustered the themes based on their co-occurrence in images to identify an integrated framework of 42 image frames. We highlight frames associated with particular types of images (e.g., photographs and maps) or geographic regions. From among the full set of frames, we identify 15 that commonly appear in US CC news imagery and discuss the ways in which image frames make salient (or render invisible) particular categories of people, geographic regions, aspects of science, and spheres of activity.

Keywords: *CC communication; news media; imagery; framing; content analysis; cluster analysis*

Scholars in various disciplines have called for more research on climate change (CC) visuals. The past decade has seen growth in analyses and typologies or frames of visual constructions of the environment. Recent findings demonstrating that climate-related news imagery often presents messages unrelated or in contradiction to the

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messages presented in accompanying text (DiFrancesco & Young, 2011) serve to emphasize the importance of pursuing better understanding of how CC is communicated visually. Other researchers have made compelling arguments for the essential role of imagery in communication about CC. Lester and Cottle (2009) present a strong case for further exploring the role of visual rhetorics in fostering ecological citizenship; and O'Neill, Boykoff, Niemeyer, and Day (2013) demonstrate how visual representations moderate public engagement with CC by influencing perceptions of issue salience and self-efficacy. O'Neill and Smith's (2014) integrative and far-ranging review groups CC imagery research according to Hall's (1980) three stages of production (conditions and practices leading to the visual appearance, genres, and actors), the (visual) text (creation, composition, and arrangement), and consumption (display, positions, relationships to other text, applying competencies to interpret and make sense of the text/image). As Coleman (2010) notes, "visual framing provides an important new direction for theory building and future research" (p. 233).

This study extends understanding of visual framing of CC in news media and builds upon the considerable research on textual coverage and framing of CC in news content. After reviewing previous work demonstrating the influence of imagery on cognition and media communication and describing textual and visual framing of CC in news media, we present the results of a content analysis of climate-themed US print news imagery. Work described here includes development of a comprehensive and reliable coding scheme for analyzing this imagery, and application of a statistical clustering approach to identify image frames. Based on our results, we propose a set of dominant image frames that regularly appear in US-based print news media. We discuss relationships between the image frames we have identified and those identified by other researchers. We also consider how insights gained through our work can inform both the practice of visual CC media communication and future studies focused on extending understanding of the role of the visual in shaping public understanding of and action on the issue of CC.

Media Framing and the Public

Issues typically require mass media coverage before they can become part of the public agenda (Dearing & Rogers, 1996). The public gets much of its information about environmental issues in general and CC in particular from mass media (Corbett & Durfee, 2004; Meisner & Takahashi, 2013). Newspaper coverage of CC generates and frames meaning and engagement through discourses within and across media, and among audiences (O'Neill, 2013).

While media coverage seems to be an essential tool for raising public awareness, even large volumes of coverage do not necessarily promote public support for action on an issue. The issue of CC has been a case in point—several decades of media coverage of the expected dramatic consequences of a changing climate have engendered relatively little action to address the problem, especially in the USA. Indeed, this disconnect between news coverage and public action casts doubt upon a

notion of news coverage as "collections" of texts and images that are received and digested by the public; rather, its content is a mediation of a social relationship, co-constructed by creators and consumers and their norms and cultural perspectives (Boykoff, 2011; Gamson & Modigliani, 1989).

Framing theory (Entman, 1993) provides an appealing explanation for one way in which media coverage can influence public attitudes. Framing is the "process by which the emphasis or construction of a message affects the interpretation of the receiver" (Shah, McLeod, Gotlieb, & Lee, 2009, p. 85). Frames "select and present a subset of issue considerations or attributes over others to an audience" (Hart, 2010, p. 31). Entman (1993) identified two kinds of frames: *media frames*, which concern how content is constructed and represented by the creator, and *audience frames*, which concern individuals' mental maps or schemas associated with exposure to that content. Framing provides an essential link between new information and the audiences' existing knowledge and ideas. Framing exerts influence through complex interactions among audience characteristics, message features, and resonance with existing cognitions, as well as other situational and contextual factors.

We use the term *visual framing* here to refer to the ways in which visual imagery such as photographs, maps, charts, and drawings serve to focus attention on particular aspects or components of an issue. At one level, visual framing refers to how visual elements and relationships between those elements are represented within images themselves. These visual frames emerge as a result of choices made by creators and editors during the process of image creation (e.g., the selection of a particular subject, view, scene, or angle), editing (e.g., cropping), and selection (Coleman, 2010; Hansen & Machin, 2013). Such choices are sometimes intentional and sometimes unconscious, and are shaped by narratives and meta-narratives that reflect familiar public discourses (McComas & Shanahan, 1999).

Images, especially photographs, help shape meaning partially because they convey a sense of reality, even though they are highly framed representations. Visual framing strongly influences audience perspectives because relationships between elements of an image or between image and text are implied rather than explicitly stated. Such oblique representations of contested meanings often do not provoke rejection of the message in the way that an explicit representation would. Messaris and Abraham (2001) proposed three characteristics of images that underlie their ability to frame an issue. First, the *analogical quality* of images permits interpretation based on similarity to the entities represented; in contrast, understanding relationships between words and meanings relies on linguistic and cognitive processing and familiarity with social conventions. Images (especially photographs) also possess a high degree of *indexicality* or "true-to-life" quality that stems from their mode of production (interaction between light and lenses) and implies an authentic connection between image and reality. Finally, images *lack explicit proposition syntax* to characterize relationships. Whereas words can be used to explicitly describe causal relationships, comparisons, or generalizations, visual syntax can only be used to imply such connections in a loose and unsystematic way.

A deeper aspect of framing involves *relationships among discourses*. As Messaris and Abraham (2001) persuasively argue, visual representations that frame an issue do so implicitly by juxtaposing visual elements in a way that promotes a particular interpretation of the relationships between the entities represented. Following this logic, visual and textual information used together in a news story frame one another in a mutual fashion, with text highlighting certain elements of the imagery, and imagery drawing attention to particular aspects of the text. We return to this issue of associational juxtaposition and relationship among themes as a basis for our methodological approach to identifying frames.

Media Framing of CC

Framing is particularly important in bringing attention to, legitimizing, and providing interpretive context for the abstract, complex, and often unfamiliar topics associated with environmental issues (Doyle, 2007; Lakoff, 2010). It is not our intention to provide a comprehensive review of the considerable research on frames in text-based media coverage of CC; rather, we highlight a selection of previously described frames that provide a useful basis for comparison with the visual frames identified in our study. Hulme (2009) identified a set of CC meta-frames: *economic*, *national and global security*, and *morality and social justice*. Nisbet (2009) proposed a typology of policy frames applicable to CC that includes *social progress*, *economic development and competitiveness*, *morality and ethics*, *scientific and technical uncertainty*, *runaway science*, *public accountability and governance*, *middle way/alternative path*, and *conflict and strategy*. Shanahan (2007) based his discussion of audience engagement with CC information on a set of frames that include *scientific uncertainty*, *national security*, *polar bears*, *money*, *catastrophe*, and *justice and equity*. Olausson (2009) identified *collective action* and *scientific certainty* frames in Swedish news coverage of CC, and Boykoff and Mansfield (described in Boykoff, 2011) used critical discourse analysis to identify four primary frames in UK daily tabloid coverage of CC: *political-economic*, *scientific*, *ecological-meteorological*, and *cultural and societal*. Other studies have tested CC framing effects with various audiences, including *public health* frames (Myers, Nisbet, Maibach, & Leiserowitz, 2012) and *gain vs. loss* and *local vs. distant impact* frames (Spence & Pidgeon, 2010). Anderson (2011) explored the representation of *celebrity advocacy* as a CC communication strategy.

While visual framing of CC has received less attention than text-based framing, some recent studies provide insights into the effects media imagery. Smith and Joffe (2009) analyzed images published with CC news stories in six British newspapers between 2000 and 2006 and found representations of *immediate impacts*, *personification*, and *graphical representations*. Analysis of 27 stories from daily news programs in six countries revealed three rhetorics of TV news CC visuals: *scenes and spectacular images of nature(s)*, *places and people under threat*, and the infusion of different spheres of interest and action with *signs of trust and credibility* (Lester & Cottle, 2009). DiFrancesco and Young (2011) quantified the occurrences of denotative representations of *humans*, *nature*, and *industry/technology* in CC news

images from two Canadian newspapers, and used intertextual discourse analysis to explore latent meaning in four prototypical images: the *politician*, the *refinery*, the *polar bears*, and *climate change refugees*. O'Neill (2013) categorized over 1600 images from climate stories in 13 US, UK, and Australian newspapers, and found the most frequent image themes to be *people* (especially political figures), followed by *geographically or personally distant impacts*, *protest*, *causes*, *solutions*, *science and technology*, *weather*, and *other*. There was little display of climate causes or solutions, adaptation or mitigation, or renewable energy or recycling.

Images intended to communicate about CC outside of news media (e.g., for climate action campaigns) have also been the subject of recent study. Doyle (2007) examined Greenpeace UK campaign literature and found evidence of a temporal progression in visual communication strategies: *immanent and inevitable destruction from a warming planet*; *identifying causes, present impacts and future solutions*; *glacial impacts and renewable solutions*; *dirty oil, dirty politics*; and the *"here and now" of climate change*. Examining imagery from nonprofit CC communication campaigns, Manzo (2010a, 2010b) identified representations of both *scientific denotations* about global warming (globes and maps, damaged physical environments, and people and animals) and *cultural connotations* of vulnerability and hazard (passing thresholds and social justice), and proposed visual representations of *extreme weather* and *renewable energy* as alternatives to commonly observed themes of poverty and vulnerability. O'Neill and Smith (2014) review other venues for visual representations of CC, such as advertising, marketing, climate science, art, virtual reality systems, and participatory photography.

Critical Perspectives on the Framing Role of CC Media Imagery

Certain frames may become dominant, thus limiting other possible interpretations, and emphasizing some issues over others (Entman, 1993). Dominant image frames, while fulfilling the essential role of relating new information to audiences' existing understanding and perspectives, also serve to confine visual communication. In the case of climate news imagery, frames often reflect underlying values such as Western liberalism and individual responsibility, while ignoring other perspectives, complex interdependencies, gradual, long-term, or large-scale phenomena, and systemic factors that lead to social inequality (Boykoff, 2011). Frames suggesting perspectives of and from indigenous peoples, or non-Western regions, are ignored, invisible or subverted (e.g., Remillard, 2011). As O'Neill (2013, p. 12) notes, "The visualization of climate change is in itself political, as the repetition and normalization of particular visual frames (or their absence) manifests and enables (or witholds) power from particular groups or voices."

Critiquing underlying frames of *global unity* in the face of threats and international development in the context of *vulnerability* that reinforce Western/colonial discourse, Manzo (2010a) highlights types of imagery that subvert this worldview by emphasizing "connectedness" over "difference," de-emphasizing vulnerability, or raising political questions about why some people are more vulnerable than others. At a meta-framing

level, Doyle (2007) raises questions about the rhetorical use of photography in communication about CC, as it privileges a notion that something only becomes "truth" once it becomes visible in the "here and now." Further, because actions cannot be taken to prevent something that has already happened, Doyle cautions that continued use of photographs showing already-experienced CC impacts increases the risk of instilling defeatism in viewers. Other researchers (see Hansen & Machin, 2013) have critiqued the superficial use of standard and decontextualized CC images, arguing that they disconnect viewers from deeper and more complex issues of consumerism, global capitalism, or temporal processes and interdependencies. More conceptually, O'Neill and Smith's (2014) review uncovers three deep and reoccurring themes underlying CC images: time (how change and over-time effects are portrayed), truth (different media and audience frames interpret "accuracy" differently), and power (how all aspects of the production, content, and consumption of CC images are affected by power relationships).

Toward a Unified Framework for Visual Framing of CC

While CC research has made substantial progress in identifying and describing the variety of ways in which CC is represented in public discourse (especially news), our understanding of visual climate communication remains fragmented. Although individual researchers or groups have proposed frames and themes that capture important aspects of this visual communication, there is yet no scheme for integrating these insightful, yet disparate, observations into a coherent framework. Figure 1 shows our attempt to organize the frames and themes described in 14 often-cited studies on visual and other forms of climate communication. A majority of the themes and frames identified in this previous work can be classified into broad categories of *technology and society*, *nature*, and *disaster and risk*, although some themes or frames could arguably fit into more than one of these broad categories. Integrating such themes or frames into a cohesive framework, however, is difficult because descriptions of relationships between similar themes or frames from different studies, when available, generally lend themselves only to conceptual/impressionistic (and not quantitative) analysis. Furthermore, relationships between disparate but commonly identified denotative and connotative themes or frames from different studies are conspicuously absent.

   The work described here is motivated by a desire to take steps toward a more coherent and unified description of visual communication about CC. Such a framework will both unify our currently fragmented understanding of CC visuals, and also provide more efficient means of incorporating our understanding of image content into studies of sites of image production and consumption.

Defining Themes and Frames

The analyses reported here involve coding of images for a large set of relatively specific elements or concepts, which we refer to throughout as *themes*. Once these

Figure 1. Frames and themes identified in prior research on visual and textual climate change communication. Each box represents a theme or frame from one study, identified by box color. Boxes with dark borders refer to studies that involved analysis of visual imagery specifically; those without borders refer to studies of viewer responses to climate imagery or to studies of climate communication more generally. Boxes are arranged so that similar themes and frames are near one another, with more general or abstract concepts in the center of the circle and more specific or concrete concepts outside. Broad categories of *technology and society, nature*, and *disaster and risk* emerge when themes and frames are organized in this way. Each label on the gray ellipse is associated with the boxes in that area of the diagram, and describes a subcategory of one of the broad categories.

themes were identified and validated for each image, we used hierarchical clustering to identify groups of commonly co-occurring themes, or *image frames*. These groups or image frames represent frequent relationships of visual elements, which work in concert to indicate a particular perspective on CC (Messaris & Abraham, 2001).

Research Questions

Constructing visuals involves three major contexts (communicative, cultural, and historical) and sites (production, content, and consumption; Hansen & Machin, 2013;

Rose, 2012). We focus on the communicative context (medium and purpose, newspapers or films, and advertising or advocacy) and the content site (the components of the image itself and the media frame). We are concerned with five primary research questions related to these aspects of CC imagery.

Most prior research (with a few noted exceptions) on visual framing of CC is based on relatively small samples from limited time frames, and researchers often do not provide operational definitions of categories or coding reliabilities. Thus, *Research Question (RQ) 1: What reliably identifiable themes do US CC news images portray?* A number of prior studies have proposed diverse though nonetheless limited sets of frames, often generated without explicitly taking into account the interrelationships between simpler visual themes. Thus, *RQ2: What CC image frames emerge from the concurrent presentation of common image themes?* Perspectives or frames that are represented frequently are more likely to be observed or remembered by the public. Thus, *RQ3: Which image frames dominate US news coverage of CC?*

CC is a global phenomenon, yet it is experienced to varying degrees and in different ways in different regions. Thus, *RQ4: How frequently are specific geographic regions represented in US CC news imagery, and which image frames are strongly associated with representations of particular regions?* There is scant discussion in the literature of the presence or role of different types of CC images (photographs and maps), especially in relation to image frames. Thus, *RQ5: What image types are associated with the dominant frames?*

Method

Data selection and sources

The 350 images analyzed for this study appeared with 200 articles that were randomly sampled from among 5637 image-containing newspaper and magazine stories about CC that appeared in 11 US news source archives between the time each source first included any reference to CC (1969) and the date of data collection (September 2009).[1] Text stories were retrieved from the LexisNexis news database using a query for the subject terms "climate change" or "global warming." Queries returned 14,910 stories about CC, and, of those, 5637 (37.8%) were associated with metadata indicating inclusion of one or more images. Figure 2 lists data sources and shows monthly article frequencies over the sampling time period. (See Supplemental Information for more detailed information about sample selection.) Candidate articles from this image-containing set were randomly selected, and the first author read each article and excluded (1) stories that mentioned CC but were focused on an unrelated topic (e.g., referring to CC or global warming when describing a "hot" sports team), (2) stories that were about environment-themed topics (e.g., alternative energy, "green" lifestyles, and weather phenomena) but did not explicitly refer to CC or global warming, (3) stories that briefly referred to CC or global warming but provided only minimal information about the relationship between CC and the main topic of the story, and (4) news summaries that included only brief information about
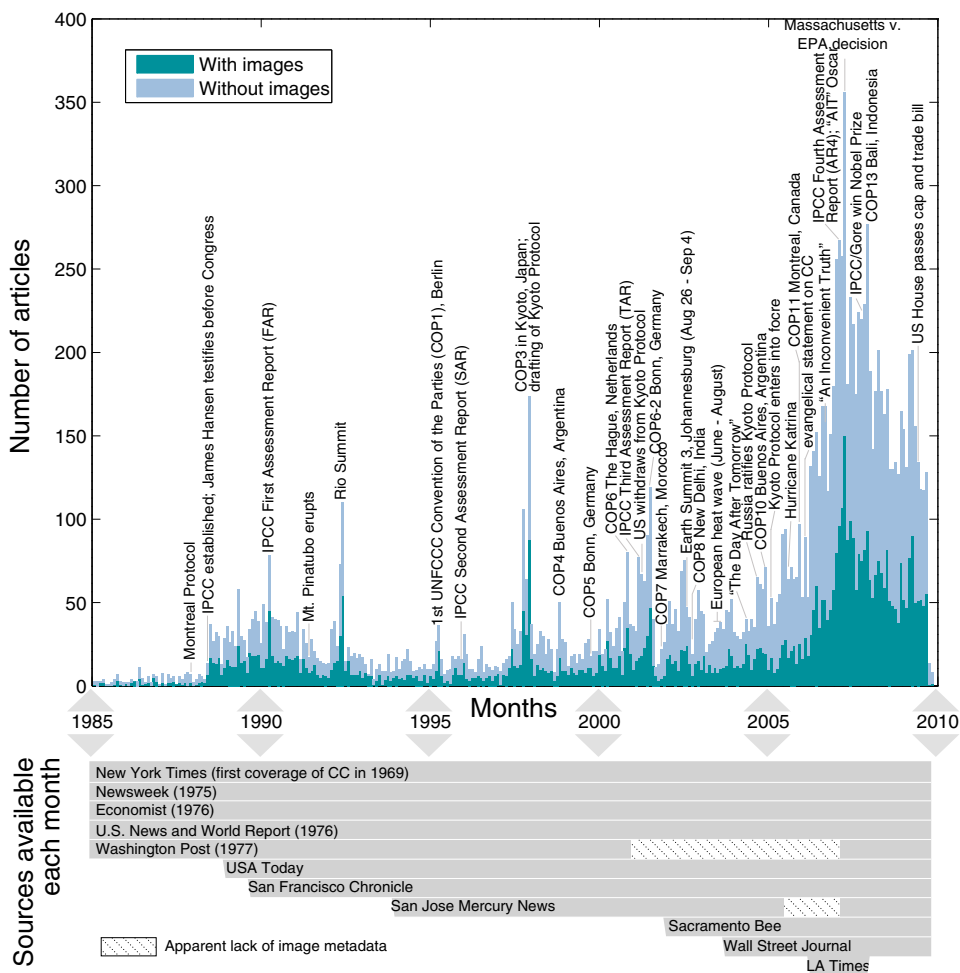
Figure 2. Key climate-related events and total number of articles per month about CC with and without images in 11 US print news publications between 1985 and September 2009. Top chart shows the total number of articles without (light blue) or with images (dark blue) retrieved with a query to LexisNexis® for subject terms "climate change" OR "global warming." Events were identified by Weart (2008) or based on the authors' knowledge of CC issues and events as reported in media in general.

Note: To maintain legibility, figure does not show the 210 articles retrieved by the query (of which 77 contain images) that were published between 1969 and 1985 in the five sources available for that early time period. Bottom chart shows the number of news sources available during each monthly time period. Dates following source names for sources available before 1985 indicate the publication year of the first article retrieved from that source.

multiple top stories of the day. Articles were selected iteratively until 200 articles met the selection criteria. Once image identity was determined through microfilm scans, all images that could be located via web search in high-quality digital format were acquired. All of the stories that were selected for the sample based on the presence of graphics metadata contained at least one image. The final data consisted of 350 images from 200 articles (Rebich-Hespanha & Hespanha, 2014), which were prepared in digital and printed formats for coding purposes.

Coding themes and identifying frames

We used a combined approach of manifest coding of objective characteristics, qualitative content analysis to identify themes, and cluster analysis of theme co-occurrence to identify frames.

Manifest coding. Date of publication and source were taken from the retrieved article metadata. Images were classified based on image type: charts, illustrations, photographs, diagrams, hedcuts,[2] infographics, maps, tables, and combinations. (Summary of image sources and types is included as Supplemental Information.)

Individual themes from latent coding content analysis. Most prior visual content analysis research classifies each image or image component as a member of a particular a priori or emergent category. Our coding scheme began with an initial set of themes based on existing research on themes and frames in climate imagery, and on knowledge of the basic concepts of CC science. Preliminary examination of the image set suggested additional themes, and the combined set of image themes served as a starting point for the coding process. Coding involved examining each image, caption, and associated headline to determine presence or absence of each potential theme (e.g., each image could be coded for multiple themes), and revising code operationalizations or adding new codes as necessary.

Once the initial codebook was ready, three coders (first, fourth, and fifth authors) coded each of the images independently and met for joint discussions and code clarifications. Because codes were operationalized as absent (0)/present (1), we used Perreault and Leigh's (1989) "index of reliability" (I_r), which determines expected levels of chance agreement without relying on marginal frequencies. We also computed Krippendorf's alpha (KA) to provide comparison with traditional measures of reliability, to verify most codes also had high traditional reliability values, and to identify themes that appeared in few images and were coded with some disagreement. (For example, energy/fuel efficiency has 99% agreement when all of the absence (0) judgments were considered, but a KA of .32 when only the few images that were coded as present (1) were considered.) Mean I_r was .99 (.93–1.00), and mean KA was .86 (.26–1.00) across the 118 codes. The two primary researchers (one of whom was a coder) and the two additional coders completed consensus coding for the remaining disagreements. The 118 final themes and wording of theme descriptions are the result

of multiple rounds of coding of the 350 images by three coders, involving over 175,000 separate codings over 20 weeks. Table 1 lists the final coding reliabilities; a codebook containing complete theme descriptions (Rebich-Hespanha et al., 2014) is available as Supplemental Information.

Image frames from clustering co-occurring themes. Although quantitative analytic approaches have been used to identify frames from coded themes (e.g., McComas & Shanahan, 1999), most prior research identifies frames solely on the basis of interpretative work. That approach does not reflect associations among themes, especially in a quantitative way, and, for substantial image datasets, is prohibitively time-consuming. From the prior discussion of frames as emerging from "juxtapositions" of visual and textual elements, it follows that higher-level visual frames can be identified based upon (statistical patterns of) relationships among lower-level themes. To identify these relationships, we used an agglomerative, hierarchical clustering approach (with the average linkage method for determining relatedness) to group themes based on patterns in co-occurrence of the 103 of the 118 coded themes across the 350 images.[3] (See Supplemental Information for more detail about the clustering and partitioning algorithms used.) The 42 resulting clusters comprise the set of image frames (see Figure 3 and Table 1).

Results

RQ1: themes

Table 1 presents the image themes and their descriptive statistics and reliabilities. The most frequent theme was an *explicit reference to CC or global warming*, occurring in half of all the images. Next most frequent were representations of *global (or many countries)* and the USA. Seven additional themes appeared in at least 20% of all images: *dominant anthropogenic contributors to greenhouse gas emissions (GHG) emissions*, *explicit reference to greenhouse gases*, *evidence or potentially verifiable evidence*, *visual representation of data or quantitative information*, *regular people*, *political figures*, and *energy generation*. The remaining 108 themes appeared with smoothly declining frequency.

RQ2: image frame identification and relatedness

Table 1 and Figure 3 group the themes by their association with the 42 image frames derived through hierarchical clustering based on theme co-occurrences. As demonstrated by Figure 3, the tree structure obtained through hierarchical clustering allows observation of both the clusters of themes that emerge as frames, and the degree of relatedness between different frames. Once frames were identified, criteria were established for determining which were associated with the themes observed in each image (see Supplemental Information).
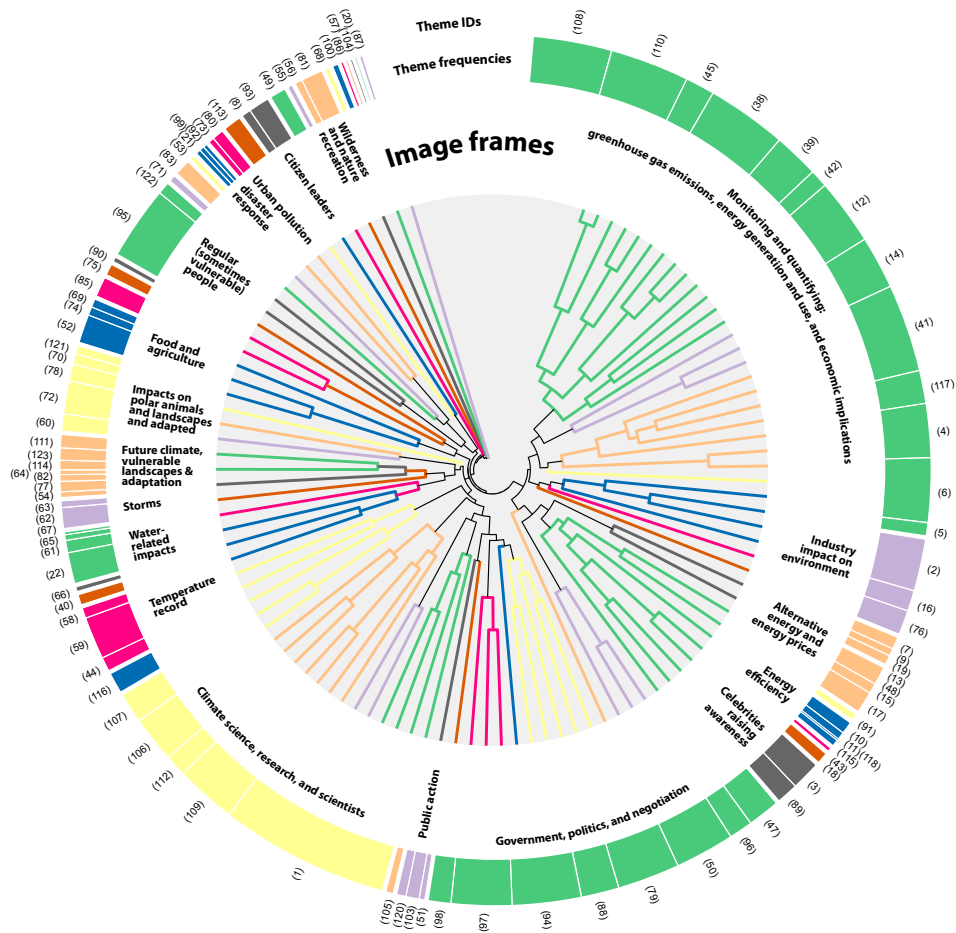
Figure 3. Hierarchical clustering of themes to identify image frames. The visual frames emerged through interpretation of cluster analysis of the individual visual themes. The dendrogram (hierarchical tree diagram) in the center represents each theme as a line, positioned and connected to show relationships between themes based on how often they co-occur in the images. (See Supplemental Information for more detail about the hierarchical clustering methodology.) A numeric threshold was used to break the tree structure into clusters, and color is used to emphasize breaks between adjacent clusters. (Color has no semantic associations and nonadjacent categories of the same color are not related.) The segmented arc that surrounds the dendrogram shows the frequency of appearance of each theme associated with each cluster. Each segment of the arc corresponds with one theme, and therefore one line in the dendrogram; for example, green lines in the dendrogram correspond with green segments on the arc. Arc segment lengths are scaled to demonstrate the relative frequency of appearance of each theme within the entire image set. Theme ID numbers are indicated outside the arc and correspond with theme numbering in the project codebook (see Supplemental Information). Interpretive titles for the frames that the clusters represent are included between the dendrogram and the outer arc.

Table 1. Climate change image theme clusters and associated image frames.

Image frames (numbered) and themes	Number of images	Number of themes	ID #	P	I_r	KA
1. *Monitoring and quantifying: greenhouse gas emissions, energy generation and use, and economic implications*	222	13				
Businesses/companies/brands			004	0.16	1.00	1.00
Cap and trade, carbon markets			005	0.04	0.99	0.85
Economic concerns			006	0.19	0.96	0.82
Energy generation			012	0.20	0.98	0.82
Fossil or combustible fuel type			014	0.16	0.97	0.88
Explicit reference to GHGs			038	.24	.95	.85
GHG emission levels			039	.14	.95	.74
Dominant anthropogenic contributors to GHG emissions			041	.27	1.00	.99
Carbon footprint calculations			042	.05	0.98	.29
Historic data trend			045	.09	1.00	1.00
Evidence or potentially verifiable evidence			108	.24	.95	.85
Visual representation of data or quantitative information			110	.24	.97	.93
Generic transportation vehicles			117	.10	1.00	.81
2. *Industry impact on environment*	76	3				
Art/entertainment/mass media representation of environment			002	.16	.98	.93
Smokestacks			016	.06	.99	.77
Industrial landscape			076	.07	.99	.90
3. *Alternative energy and energy prices*	50	7				
Energy/fuel prices			007	.04	.99	.32
People at risk of negative economic impact of environmental policies			009	.02	1.00	1.00
Energy intensity			013	.01	1.00	.87
Nuclear energy			015	.03	.99	.91
Alternative/emission-free energy sources			017	.07	.99	.90
Wind energy technology			019	.03	.99	.69
Independent commitment, pledge, or plan			048	.06	.99	.86
4. **Journalist/columnist**	7	1	091	.02	.99	.81
5. *Energy efficiency*	20	4				

Table 1 (*Continued*)

Image frames (numbered) and themes	Number of images	Number of themes	ID #	P	I_r	KA
Energy consumption levels/rates			010	.04	1.00	1.00
Energy efficiency			011	.02	1.00	1.00
LED or compact fluorescent			115	.01	.99	.66
High-efficiency and/or reduced carbon automobiles			118	.02	.99	.81
6. **Emissions projections**	4	1	043	.01	.99	.71
7. **Solar energy technology**	12	1	018	.03	1.00	.98
8. *Celebrities raising awareness*	43	2				
Efforts to distribute information/raise awareness about environmental issues			003	.09	.98	.82
Celebrity			089	.07	.99	.96
9. *Government, politics, and negotiation*	164	8				
Cooperative agreement, treaty, pact, or accord			047	.10	.98	.90
Disagreement, difference of opinion, debate, or controversy			050	.18	1.00	.99
Public or semi-public social space			079	.19	.93	.77
Audience			088	.11	.99	.93
Political figures			094	.21	.94	.82
International government programs or policies, legislation, and legal issues			096	.07	.98	.83
National government programs or policies, legislation, legal issues			097	.18	.97	.87
State government programs or policies, legislation, and legal issues			098	.07	.98	.87
10. *Public action*	20	3				
Protest/demonstration			051	.02	1.00	1.00
Political action including nonpolitical figures			103	.04	1.00	1.00
Public/alternative transportation			120	.03	.99	.78
11. **US iconography**	8	1	105	.02	.99	.58
12. *Climate science, research, and scientists*	221	5				
Explicit reference to CC or global warming			001	.51	.99	.96
Scientists			106	.14	.97	.86
Research equipment or technique			107	.09	.99	.88
Uncertainty			109	.18	.98	.93

Table 1 (*Continued*)

Image frames (numbered) and themes	Number of images	Number of themes	ID #	P	I_r	KA
Diagram or description of natural, and earth or human systems			112	.07	.99	.92
13. **View of globe from space**	22	1	116	.06	.98	.78
14. *Temperature record*	51	3				
Historic temperature trend			044	.04	.98	.83
Colder than usual temperatures			058	.03	.99	.95
Warmer than usual temperatures			059	.13	.97	.86
15. **Atmospheric GHG concentrations**	11	1	040	.03	.99	.77
16. **Drought or water shortage**	5	1	066	.01	1.00	1.00
17. *Water-related impacts*	43	4				
Map indicating location			022	.09	.99	.97
Precipitation			061	.04	.99	.90
Flooding			065	.02	.99	.93
Fire			067	.01	.99	.77
18. *Storms*	23	2				
Hurricanes or large storms			062	.06	1.00	.96
Land loss due to storms			063	.02	.99	.81
19. *Future climate, landscape vulnerability, and adaptation*	39	7				
Things people do to adapt to environmental conditions			054	.02	1.00	1.00
Sea level rise			064	.03	.99	.86
Ocean/coastal landscape			077	.03	.99	.83
Vision of future landscape			082	.02	.99	.90
Climate projections			111	.04	.99	.88
Geoengineering			114	.01	1.00	1.00
Places vulnerable to effects of CC **or other environmental degradation**			123	.04	.99	.90
20. *Impacts on polar animals and landscapes*	52	5				
Melting ice			060	.05	.99	.92
Impact on animals			070	.03	.99	.78
Impact on landscapes			072	.10	.98	.89

Table 1 (*Continued*)

Image frames (numbered) and themes	Number of images	Number of themes	ID #	P	I_r	KA
Ice/snow landscape			078	.05	.97	.68
Animals vulnerable to effects of climate change or other environmental degradation			121	.03	.99	.81
21. *Food and agriculture*	34	3				
Meat and food production and consumption			052	.09	.98	.81
Impact on agriculture			069	.03	1.00	1.00
Agricultural landscape			074	.03	1.00	.98
22. **Educational institution**	21	1	085	.06	.97	.77
23. **Private space, scene, or landscape**	12	1	075	.03	.99	.83
24. **Child/children**	5	1	090	.01	.99	.81
25. *Regular (sometimes vulnerable) people*	80	2				
Regular people			095	.22	.98	.93
People vulnerable to effects of CC or other environmental degradation			122	.04	.99	.81
26. **Impact on human health**	7	1	071	.02	1.00	1.00
27. **General environmental problems**	17	1	083	.05	.97	.78
28. **Recycling/waste disposal**	5	1	053	.01	1.00	1.00
29. *Disaster response*	10	3				
Human response to natural disasters or abrupt changes in environmental conditions			021	.01	1.00	1.00
Military/police/rescue personnel			092	.01	.99	.81
Local government programs or policies, legislation, and legal issues			099	.01	1.00	1.00
30. *Urban pollution*	13	2				
Pollution/emissions impact on people			073	.02	.98	.26
Urban landscape			080	.03	.99	.76
31. **General reference to science**	19	1	113	.05	.98	.64
32. *Citizen leaders*	27	2				
Entrepreneur/businessperson			008	.03	1.00	.95
Non-political leaders			093	.06	.99	.97
33. ' Green' or 'eco-' activities, choices, items, or lifestyles	17	1	049	.05	1.00	.99
34. **Tourism**	5	1	055	.01	1.00	1.00
35. *Nature recreation*	26	2				
People using natural world for recreation	5	1	056	.02	1.00	.97
Wilderness landscape	6	1	081	.07	.98	.89

Table 1 (*Continued*)

Image frames (numbered) and themes	Number of images	Number of themes	ID #	P	I$_r$	KA
36. **Forest/tree loss**	2	1	068	.01	1.00	1.00
37. **Non-specific government programs or policies, legislation, and legal issues**	1	1	100	.02	.98	.32
38. **Health and medical institutions, personnel, or conditions**	2	1	086	.01	1.00	1.00
39. **Public opinion**	1	1	104	.00	.99	.59
40. **Abnormal weather patterns**	3	1	057	.01	.98	.26
41. **Volcanic eruptions**	5	1	087	.00	1.00	1.00
42. **Forest management/tree planting**	6	1	020	.01	1.00	1.00
Geographic regions or countries						
Global (or many countries)	153	1	23	.44	.93	.85
Africa	8	1	24	.02	1.00	.98
Antarctic	9	1	25	.03	.99	.75
Arctic	28	1	26	.08	.99	.89
Asia (other than China, Japan, and India)	11	1	27	.03	1.00	1.00
Australia	7	1	28	.02	1.00	1.00
California	46	1	29	.13	.97	.85
China	12	1	30	.03	.98	.72
Europe	56	1	31	.16	.97	.90
Former USSR/Russia	7	1	32	.02	1.00	.90
India	8	1	33	.02	1.00	.97
Japan	15	1	34	.04	.99	.90
Latin/South America	12	1	35	.03	.99	.77
North America	15	1	36	.04	.98	.81
USA	149	1	37	.43	.99	.97

N = 350 images. Coding was 0 = absent; 1 = present; ID# corresponds with sequence in codebook (see Supplemental Information); P indicates the proportion of the 350 images associated with the theme.

I$_r$ = adjusted agreement (Perreault & Leigh, 1989); KA = Krippendorf's Alpha. Interpretive labels for the frames represented by each cluster are *italicized*; for singleton clusters, the theme label is used as the frame label, and is not italicized. Themes in bold were included as criteria when evaluating images for presence or absence of each frame. (See Supplemental Information for more detail about how criteria were applied during image classification.)

Note: Codes 23–37 (specific geographic regions) were not included in the cluster analysis to allow for evaluation of the co-appearance of individual geographic regions with each of the thematic frames identified through cluster analysis.

RQ3: image frame prevalence

After identifying the frame(s) represented in each image, we calculated frame frequencies across all 350 images to identify the most prevalent visual frames. We propose that visual coverage of CC largely consists of the following 15 dominant narrative image frames.[4] CC is associated with:

- Government and politics (represented in 34% of images). The *government, politics, and negotiation* frame supports the perspective that CC is a political issue, one that requires or depends upon government (whether local or international) action.
- Science and the people who do it (21%). The *climate science, research, and scientists* frame emphasizes the scientific nature of the issue and places focus on the people, equipment, and theories that underlie climate science, providing frequent visual reinforcement of the centrality of science to understanding and responding to the issue.
- Keeping track of stuff—mostly bad stuff—that we're doing to the environment (21%). The *monitoring and quantifying* frame includes representations of quantities (and changes in quantities) of phenomena such as greenhouse gas emissions levels, energy generation and use, and economic implications of climate-related activities or decisions. This frame emphasizes the status of knowledge about CC as grounded in evidence (as opposed to opinion) about the existence of and human contributions to global CC.
- The Earth heating up (15%). The *temperature record* frame focuses attention on comparisons between past, present, and future temperatures, and emphasizes the role of global temperature phenomena as diagnostic for changes to the climate system.
- "Regular" people affected by CC (no precise estimate). The *"regular" (sometimes vulnerable) people* frame directs attention to the relevance of CC to people who do not occupy positions of influence. This frame includes people vulnerable to or already experiencing impacts of CC, those whose livelihoods will be impacted by CC or policy decisions, and those participating in or observing public events related to CC.
- What we eat and the way we produce our food (10%). The *food and agriculture* frame emphasizes connections between the way humans produce and consume food and the climate system, and draws attention to food-related habits, businesses, and preferences that increase or decrease human impact. Risks to the agricultural sector due to impacts of CC are also highlighted.
- Innovative technologies that come with a hefty price tag (9%). The *alternative energy and energy prices* frame places emphasis on the technological and economic aspects of possible transitions to alternative sources of energy, as indicated by images containing references to energy or fuel prices, energy intensity, or nuclear, wind, or other alternative/emission-free energy sources.

- The inevitable result of industrial development (9%). The *industry impact on the environment* frame promotes the sense that industrial technologies are responsible for damages to the climate system. Industrial imagery is also often incorporated into the artistic representations (e.g., editorial illustrations and film imagery) that are embedded in climate news.
- Changing landscapes that will influence how we live in the future (9%). The *future climate, vulnerable landscapes, and adaptation* frame makes salient changes to landscapes that are happening or expected due to climate-related phenomena such as sea level rise. An important focus of this frame is on adaptive measures that can be taken to avoid severe hardship or disruption due to CC.
- Thought and action leaders (7%). The *citizen leaders* frame highlights people in leadership roles in businesses or nonprofit organizations, who are advocating particular positions or working toward implementation of specific actions related to CC.
- Enjoyment of nature at risk (7%). The *wilderness and nature recreation* frame is closely related to a conception of nature as sublime and directs attention toward natural landscapes that are undergoing (or predicted to undergo) climatic changes that (will) impact their aesthetic or recreation value.
- Severe weather (7%). The *storms* frame emphasizes relationships between CC and disastrous weather phenomena and the long-term changes in landscape brought about by such storms.
- Melting ice, polar bears, and penguins (6%). The *impacts on polar animals and landscapes* frame has achieved iconic status in the visual representation of CC, and focuses on climate-related disruption to species dependent upon polar ecosystems.
- Earth, the planet (6%). The *view of globe from space* frame places the viewer in a technologically enabled position that shows Earth as if viewed from space. Images representing this frame may surreptitiously distance CC from everyday experience by offering opportunities to view Earth as detached and impartial observers.
- Energy efficiency (6%). The *energy efficiency* frame places emphasis on a goal of reducing the amount of energy necessary for particular tasks or processes such as transportation and electricity generation and use.

RQ4: geographic regions

Interesting patterns emerge when examining relationships between representations of geographic regions and dominant image frames. (Figure and additional discussion available as Supplementary Information.) The "globalness" of the issue is very salient, with references to the *global* or inclusion of locations spanning at least four continents more frequent than any other individual region theme.

North America (and the USA in particular) is much more frequently represented than any of the other separate regions or countries, which is not surprising given that

the images were acquired from US news sources. California (from whose regional newspapers a portion of the images were drawn) is prominently represented, especially in conjunction with *solar energy, state government*, and *visions of future landscapes related to sea level rise*, but less related to *scientific research, energy production*, or *greenhouse gas emissions*.

Europe receives the next most representations in imagery, especially in relationship to *alternative energies, international government*, and *water-related impacts*. Asia in general receives scant image representation except in the context of *emissions calculations and projections*, and *carbon markets*. References to polar regions, while relatively rare, are usually associated with *climate change impacts, scientific research*, or *energy generation*. Countries or regions represented in fewer than 12 images included Australia, former USSR/Russia, Africa, India, and Asia (other than China, Japan, and India), Latin/South America, and China. The rare representations of Africa or Latin/South America are generally associated with *impacts*.

RQ5: image types

Certain image frames are more likely to appear in particular types of images (figure as Supplemental Information). The image set is dominated by photographs, but charts are often used to depict evidence, especially related to *energy production, greenhouse gases*, and *changes in temperature*. Illustrations are often used to represent *visions of the impacts of industrialization*, and maps are often used to present information about *water-related impacts*. The *monitoring and quantifying* image frame uses disproportionally more charts and maps; the *government, politics, and negotiation* image frame uses disproportionally more photos; the *water-related impacts* image frame most often appears in maps; and the *future climates, sea level rise*, and *landscapes* image frame includes proportionally more illustrations.

Discussion

A framework for integration of climate change image frames

An important outcome of this work is the development of a framework for relating the variety of visual frames used in CC representations. Because we report results as an emergent cluster solution that can be represented as a tree structure, it is possible to observe relationships between the frames identified. For this study, we chose a partitioning threshold that segments the tree into distinct clusters that correspond well with many of the frames identified in prior work on CC visuals. Figure 4 shows the dominant frames we identified in this study superimposed on the schematic of frames from prior research in Figure 1. The frames we have identified represent a comprehensive and integrated view of visual framing of CC that includes a wider variety of frames than were identified in previous work.

The strength of this image frame identification approach lies in its flexibility. One could choose a different threshold for tree segmentation that would yield fewer, more
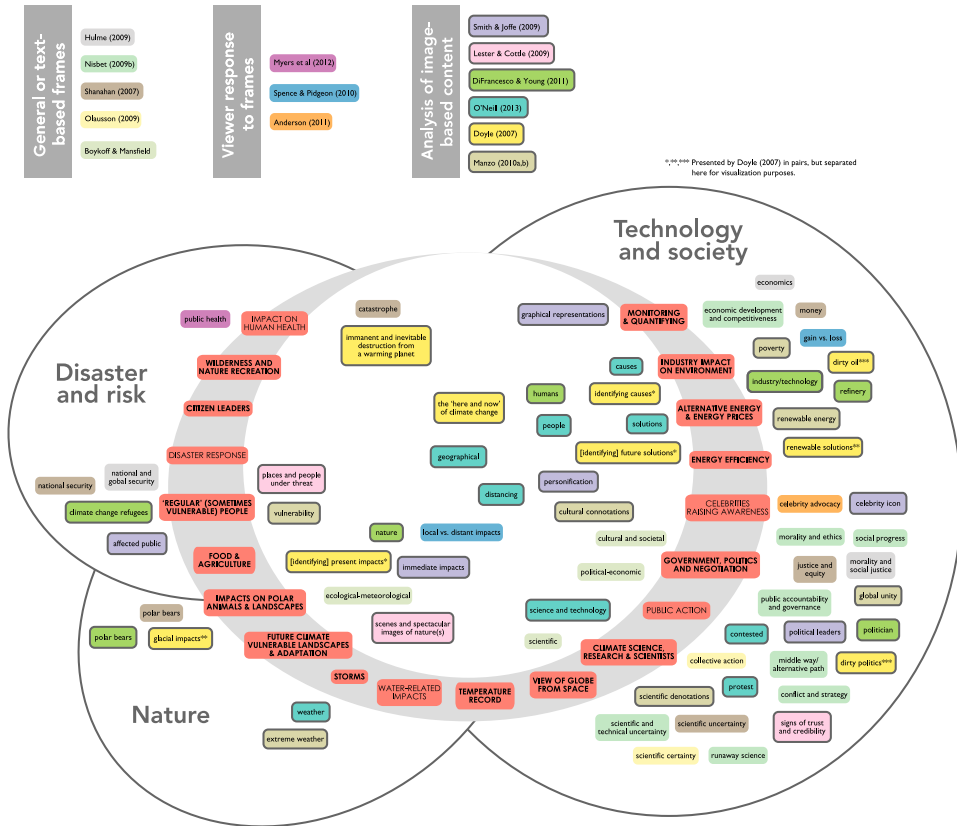
General or text-based frames
Hulme (2009)
Nisbet (2009b)
Shanahan (2007)
Olausson (2009)
Boykoff & Mansfield

Viewer response to frames
Myers et al (2012)
Spence & Pidgeon (2010)
Anderson (2011)

Analysis of image-based content
Smith & Joffe (2009)
Lester & Cottle (2009)
DiFrancesco & Young (2011)
O'Neil (2013)
Doyle (2007)
Manzo (2010a,b)

*,**,*** Presented by Doyle (2007) in pairs, but separated here for visualization purposes.

Technology and society

Disaster and risk

Nature

graphical representations; catastrophe; immanent and inevitable destruction from a warming planet; MONITORING & QUANTIFYING; economics; economic development and competitiveness; money; public health; IMPACT ON HUMAN HEALTH; poverty; gain vs. loss; WILDERNESS AND NATURE RECREATION; causes; INDUSTRY IMPACT ON ENVIRONMENT; industry/technology; dirty oil***; refinery; CITIZEN LEADERS; the 'here and now' of climate change; humans; identifying causes*; ALTERNATIVE ENERGY & ENERGY PRICES; renewable energy; people; solutions; renewable solutions**; geographical; [identifying] future solutions*; ENERGY EFFICIENCY; DISASTER RESPONSE; national and global security; places and people under threat; personification; distancing; cultural connotations; CELEBRITIES RAISING AWARENESS; celebrity advocacy; celebrity icon; national security; 'REGULAR' (SOMETIMES VULNERABLE) PEOPLE; vulnerability; morality and ethics; social progress; climate change refugees; nature; local vs. distant impacts; cultural and societal; GOVERNMENT, POLITICS AND NEGOTIATION; justice and equity; morality and social justice; affected public; FOOD & AGRICULTURE; [identifying] present impacts*; immediate impacts; political-economic; public accountability and governance; global unity; IMPACTS ON POLAR ANIMALS & LANDSCAPES; ecological-meteorological; science and technology; PUBLIC ACTION; contested; political leaders; politician; polar bears; polar bears; glacial impacts**; FUTURE CLIMATE VULNERABLE LANDSCAPES & ADAPTATION; scenes and spectacular images of nature(s); scientific; CLIMATE SCIENCE, RESEARCH & SCIENTISTS; collective action; middle way/ alternative path; dirty politics***; STORMS; WATER-RELATED IMPACTS; TEMPERATURE RECORD; VIEW OF GLOBE FROM SPACE; protest; conflict and strategy; weather; scientific denotations; scientific and technical uncertainty; scientific uncertainty; signs of trust and credibility; extreme weather; scientific certainty; runaway science

Figure 4. Frames identified in the current study in the context of frames and themes identified from previous research. Boxes representing frames and themes from prior studies are arranged as in Figure 1. Red boxes on the gray ellipse represent frames identified in the current study. Bold labels indicate frames that were identified as "dominant" (occurring in more than 5% of the image sample); labels in regular typeface indicate a few less frequently observed frames closely related to themes or frames identified by other researchers.

generalized image frames, or a threshold that yields a larger number of narrower image frames. Furthermore, frames identified in this way are easily updateable when new themes are added to the coding scheme or additional data become available. It is this flexibility and extensibility of cluster-based frame identification that renders this approach useful for consolidation and continued growth in understanding of visual CC frames. Below we describe future work that leverages these strengths.

Visible and invisible: people, places, and spaces

Discussion of what climate news imagery renders visible or salient is only part of the story of imagery impacts; dominant image frames also may intentionally or unintentionally de-emphasize, or render invisible, certain issues or actors. Here, we briefly

discuss three arenas in which image frames have served to emphasize or de-emphasize important characteristics of the issue. Our analytic approach was designed to be comprehensive, and involved identification and description of a priori and emergent themes that capture as many elements of the imagery and accompanying text as possible. Because our coding scheme is very comprehensive, we are able to go further than many previous studies in identifying not only which media frames were present, but which potential frames were absent.

People. CC news contains many images focused on people, most of whom are political figures, scientists, or other leaders; "regular" people appear relatively frequently, but are often hardly noticeable and serve only as background or context for the main subject. These people-focused image frames reflect the increasing politicization of the issue; the immediately recognizable faces of beloved/reviled political figures were generously distributed throughout the image sample. The contexts in which different types of people appear are circumscribed, with scientists studying and reporting, and celebrities and political figures urging or opposing action. "Regular" people, when in focus, are generally suffering impacts of environmental conditions or engaging in efforts to mitigate or adapt. Such representations serve to create or reinforce notions about who are authorized "agents of definition" for the issue of CC (Carvalho, 2007) and to marginalize or compartmentalize the ideas and perspectives of people who do not occupy these roles.

While many have expressed concern about the power of news media to heighten awareness of "outlier" perspectives that contradict the scientific consensus on CC (e.g., Boykoff, 2013; Shanahan, 2007), we found no evidence of disproportionate visual representation of individuals or groups representing these views. On the contrary, such figures or organizations appeared very infrequently in the images we analyzed and, when appearing, were nearly always political figures. In these rare instances, accompanying text often suggested a critical viewpoint on the individual or group represented. While from a certain perspective this relative "invisibility" may be interpreted as a sign that the "false balance" identified in CC news texts (Antilla, 2005; Boykoff & Boykoff, 2004) does not extend to the level of visual imagery, it may also be interpreted as a testimony to the success of a political strategy focused on framing the issue as a "non-problem" (McCright & Dunlap, 2003). Lack of visibility of these figures may simply be a result of a lack of investigative journalism on the issue, and stem from over-reliance on passive journalistic practices that involve selecting newsworthy stories from among the competing viewpoints that are actively promoted. Indeed, the images we studied do *not* portray the people who profit from maintaining traditional means of energy production and consumption, or those who work behind the scenes to delay action or spread misinformation (McCright & Dunlap, 2003). Beyond those who actively seek to misinform or distract in the public arena, there are invisible yet powerful people and corporations who regularly make decisions about the means of energy production and consumption that have real and lasting consequences for the Earth's climate. However, these powerful decision-

makers are not seeking public attention to their deliberative processes and decisions, and news organizations appear to be allowing them to continue with business as usual under a cloak of invisibility.

Geographic regions. As O'Neill (2013, p. 18) recommends, "Future research should look to investigate visual framings of CC, to explore how this varies across space (particularly in non-Anglophone nations) and time" (p. 18). In general, our results attest to a "fish-eye view" of this global environmental issue within US news imagery, which renders nearer aspects and perspectives more visible and more distant places nearly out of sight. While it is reasonable to expect such a bias in any national or regional source of information (e.g., DiFrancesco and Young, 2011, noted a similar pattern in Canadian print news), it is somewhat remarkable because of the high salience of the "globalness" of this particular issue. Indeed, it is paradoxical that regions of the world already experiencing some of the largest-scale CC impacts (and having large populations and few economic resources for adaptation) are rarely portrayed or referenced except under the vague and abstract notion of "global."

Science and scientists. The relatively frequent appearances of the *climate science, research, and scientists* and *monitoring and quantifying* visual frames may come as a surprise to those who lament the dearth of coverage of climate science and scientific evidence; the images here in fact frequently emphasize the centrality of science and quantitative evidence to the public discussion. These patterns suggest that scientists have been more successful than they might think at getting access to news media for communication of their work and perspectives. Worth noting, however, is the frequent use of charts and graphs in the context of these frames. Interpretation of graphical representations requires a relatively advanced skill set, and may therefore serve to distance some potential audiences. Furthermore, such representations lack the perceived realism of photographic images, potentially rendering them less memorable and less likely to be perceived as "truth."

Spheres of activity. While some of the most striking visual representations of impacts of CC may feature remote locations (e.g., melting glaciers and polar bears), most of the images focus on human activity that takes place in *public or semi-public social spaces* (often at events organized by government or special interests), or is represented in a way that de-personalizes the activity or distances it from personal everyday experience (e.g., images of smokestacks or industrial agriculture). Activities that take place in *private spaces*, over which members of the public enjoy the greatest level of control, remain largely unseen and therefore de-emphasized. While news reports are intended to cover public activities that are of interest to the public, many of the activities that contribute to or can be adopted to address CC take place in private spaces such as homes and businesses. Implications are two-fold. First, journalists seeking to provide actionable information to the public should focus more

attention on the private sphere. Second, because of the public focus inherent in news media, those who wish to communicate more about personal CC solutions and actions would do well to look beyond the major news media for this type of communication.

Conclusions

We have demonstrated an effective approach for identification of image frames and developed a framework for relating image frames across a variety of thematic domains and levels of analysis. Through rigorous and reliable content analysis and hierarchical cluster analysis, we identified 118 image themes comprising 42 image frames, generating 15 dominant visual narratives. These dominant image frames for US CC news are evidence of the variety of contexts and perspectives that have been brought to bear in US public discourse about CC. This study has provided several contributions to future research on mass media images of CC: the extensive and reliable framework for coding images, the analytical approach to identifying emergent cross-theme image frames, the suggested relationships between image frames and events and image types, the large sampling of images from a comprehensive set of CC news stories over many years, a rigorous baseline set of image themes and frames, and methods for graphically representing some of these complex relationships.

Limitations

The quality of the algorithmic clustering results for image frame identification is limited by the quantity of data available. Although a 350-image sample is relatively large by the standards of traditional content analysis, larger samples yield better results when using algorithmic pattern detection approaches. (Though our codebook would reduce much of the initial work, the time and effort required to reliably code much larger samples might be prohibitive.) Nonetheless, the relative ease of interpretation of the clustering results, the compatibility of the identified frames with prior knowledge of framing in media communication of CC, and the emergence of several novel frames lead us to conclude that the results, although imperfect, yield valuable insights.

Future research

While the study reported here represents progress toward a more integrated understanding of the media frames that appear in images that accompany news reports about CC, there is still much to be learned about the production, use, and impact of visual imagery in climate communication. The results presented here focus on articulation of an integrated framework for identifying visual frames and their inter-relationships, and are primarily quantitative in nature. We recognize, however, the additional value to be gained through deeper qualitative analysis of the images we studied. Representative images for each of the identified dominant frames should be

analyzed from multiple perspectives (e.g., the researcher's, the creator's, and the viewer's perspectives) using, for example, Rodriguez and Dimitrova's (2011) four systems of visual framing that include the *denotative*, the *stylistic-semiotic*, the *connotative*, and the *ideological*. O'Neill (2013) provided impressionistic accounts of how specific photographs from an online newspaper from each of three countries (the UK, the USA, and Australia) represented two main frames: a *contested* frame (political figures and protests) and a *distancing* frame (physically and psychologically far away from daily experience, using generic images and nonhuman impacts, disconnected from individual behaviors and decisions; see also Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007). To facilitate such analyses of this image set, we have made a list of the 200 articles used for this study publicly available (Rebich-Hespanha & Hespanha, 2014). We hope to work with other researchers to extend the current framework to include missing themes, or to incorporate new sources of imagery into our frame identification analysis.

We still know very little about how the content and use of images in CC news have developed over time or differ between different news sources (though see O'Neill, 2013), media (e.g., print vs. online vs. television), time periods, or geographic regions. In future work, we plan to explore temporal patterns using the data-set from which images for this study were sampled. In particular, we are interested in exploring the possible roles of key events (see Figure 2) and narrative cycles (McComas & Shanahan, 1999) in influencing image coverage and the specific frames and image types employed. This work will involve updating the data sampling frame to include more recent dates and coding additional images for time periods during which our data are currently sparse.

Our results also indicate that very few US CC articles contain visual representations of other countries and regions, suggesting that people who depend upon US print media for information about CC are likely to have a myopic view of the issue in which the importance of geographically proximate events is exaggerated while the salience of important events that are geographically distant is de-emphasized. Our work serves to quantify the strength of this proximity bias in visual representation of a global issue in US news media. Future studies involving non-US or cross-national image sets would shed light on whether the relative absence of images from distant regions is observed generally in news reporting about CC, or whether the US news represents a particularly pronounced case.

Content analysis of text or visuals by itself cannot provide complete insight into how images are perceived, interpreted, remembered, or used by audiences (Olausson, 2011). Different audiences may respond differently to CC frames (Hulme, 2009). At the scale of the individual, more research that elucidates relationships between media images of CC and people's mental images of CC and their perceptions of, attitudes toward, and intentions associated with those images (e.g., Leiserowitz, 2006; O'Neill & Hulme, 2009; O'Neill & Nicholson-Cole, 2009) is much needed. Because our approach supports identification of frames at different levels of generality or specificity, research to identify the levels at which frames more closely correlate

with patterns in viewer responses to images would provide insight into which types of frames are most relevant to designing communication strategies. Formative evaluation of images in media coverage or CC campaigns may provide the basis for developing messages with visual components corresponding to one or more of the image frames, and comparing their effectiveness on specific outcomes such as changed public or policy-maker knowledge, attitudes, emotions, and behaviors (see Rice & Atkin, 2013).

Certainly we need more joint analyses of textual and visual content, assessing how well they correspond, and what effect that correspondence has on audience interpretations. Furthermore, content analysis alone cannot uncover ways in which individual, institutional, and sociocultural factors influence the nature and prevalence of image frames that are produced or collected, distributed, and selected for use. Many factors, including journalistic cultures and norms, constraints, and organizational dynamics (Rice, et al., 2012), interact to create image frames, in both production (media frames) and interpretation (audience frames) processes (Boykoff, 2011; Hansen & Machin, 2013). O'Neill and Smith (2014) have extended Hall's (1980) encoding/decoding model to describe the "three moments" of the visual communication cycle, a framework that could be useful for integrating our findings (focused on the "moment of the image") with analyses of "moments of production," and "moments of consumption." Much work remains to be done to uncover how sites of image production (including issues of political economy, distribution and access) and consumption (from both a formative and summative evaluation orientation) interact with the content sites (Hansen & Machin, 2013).

Acknowledgments

Funding

Supplemental data

Supplemental data for this article can be accessed here. Additional underlying research materials can be accessed at http://dx.doi.org/10.6084/m9.figshare.1244882, figshare.org.

Notes

1. Sources were selected because they were associated with image metadata for at least some records, and were available on microfilm or as paper copy at the UC Santa Barbara library. Because this corpus was collected primarily for algorithmic text analysis (discussed elsewhere), only English-language articles were included.
2. Portraits created using a stipple method of drawing, such as that used to depict columnists in *The Wall Street Journal*.
3. Geographic region themes (the 15 remaining codes) were not included in the cluster analysis; rather, we separately examined co-occurrence of geographic themes with frames identified through cluster analysis.
4. See Supplemental Information for detail about dominant frame identification. Insufficient precision in operationalization of the "regular" people theme prevents a precise estimate of the prevalence of this theme.

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