About Us

An Introduction to the POLCA and Climate Change Environmental Education

The **Climate Change Environmental Education POLCA** (Project-based Online Learning Community Alliance) was formed in the spring of 2013 to engage in a professional learning experiment. As part of the EE Capacity[1] project, we wanted to see if there was a group of 25 environmental educators who

- shared a sense of urgency about the need to expand efforts in the broader environmental education community to address climate change and wanted to work collaboratively to create one or more product(s) to support such efforts, and
- wanted to engage in professional discussions as a means of advancing their own skills and generating new insights and understandings.

By climate change environmental education (CCEE), we mean the full array of interdisciplinary learning opportunities that people of all ages need to develop the competencies, dispositions and knowledge to address climate change. This array includes an understanding of the socio-political and economic considerations; the scientific basis; and the communication, collaborative problem-solving and analytical skills needed to generate and implement feasible solutions.

We advertised this opportunity via NAAEE, EECapacity, and other listservs, and were overwhelmed with 94 applications. From those, we selected a diverse set of 25 formal and informal educators who committed themselves to investing at least 4 hours per month with colleagues to address our dual challenges. From April through November 2013, this group used e-mails, conference calls, archived recordings of those calls, and shared documents on Google Drive to reach consensus on:

- a shared view of the product we would create, and
- a process for creating the product in the limited time available to us.

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[1]EECapacity – Expanding Capacity in Environmental Education – is a multi-year partnership of the Cornell University Civic Ecology Lab and North American Association for Environmental Education (NAAEE) supported with funding from U.S. Environmental Protection Agency to improve environmental quality through diversifying and strengthening the field of Environmental Education (EE). EECap's overall strategy for building capacity within EE is to link an emerging cadre of diverse EE professionals working in urban environmental stewardship, community, and environmental justice organizations, with more established environmental educators who are active in nationwide professional and government networks.

We aimed to create a fairly unique product rather than wasting our time "reinventing the wheel." And we decided that we would craft a product that:

- could be posted on a website;
- would use and refer to accurate, reliable sources;
- would build on the NAAEE Guidelines for Excellence, the most recent education standards, and the Framework for Assessing Environmental Literacy.

We wanted to enable more people who are not currently including climate change education in their curricula and programs to do so, and felt we would serve that goal with a product that would:

1. Provide teachers and principals with strategies and tools for teaching this controversial issue – including the importance and ways to facilitate complex discussions about climate change, and the rationale for including climate change education in courses across content areas and programs based on standards (e.g., Common Core, NGSS, and new social studies standards).
2. Use an inquiry-based and dialogue-centered approach rather than a didactic, content specific orientation. We knew that our product would depend on a solid base of content from science and social studies.
3. Be relevant for environmental educators and teachers of language arts, social studies, science, and sustainability. We wanted the product to be usable by educators from a variety of disciplines/subjects.
4. Emphasize the need for systems thinking and systems learning.
5. Focus on multidisciplinary global and local phenomenon/processes and emphasize local action.
6. Emphasize some specific exemplary materials and strategies rather than attempting to point educators to all available materials and strategies for climate change education.
7. Be aimed at formal and informal educators and professional development providers rather than being directly for students. We do expect that educators will use the product to enable them to better serve and engage learners.

This website contains our product – the result of our Project-based Online Learning Community Alliance (POLCA) and the nine different collaborative working groups that took on each of the specific tasks we agreed to. As you look at the whole or at a specific part that is of particular interest to you, we hope you'll find something that inspires you, makes your work easier, or enables you to find ways to provide relevant learning experiences to the learners you work with.

On our Home Page following this introduction, you'll find four major sections:

→ **Educators' Needs**: The Rationale for our work and our Climate Change Education Needs Assessment Survey

→ **The Research**: A summary of the literature from research on how people learn, environmental psychology, and climate change concepts and suggested teaching/learning strategies for applying these research findings and theories

➔ **Standards & Teaching Suggestions**: Analyses of **Common Core, Science,** and **Social Studies Standards** show where climate change fits in the curriculum and the kinds of discipline-focused practices that learners can use while investigating climate change. For specific standards, we've suggested **lessons and units** (cohesive sequences of learning opportunities appropriate for specific grade bands) that enable students to pursue performance expectations and content in the Next Generation Science Standards, Common Core, and standards for civics and government, social studies, and geography.

➔ **Suggestions for Learner-Focused Inquiries**: Here we list "Essential Questions" for each grade band, suggest a template for use with groups of learners (from K to Gray), and give some examples of inquiries pursued by learners of different ages.

Those of us who have "danced together" in the Climate Change Education POLCA – who were, for the most part, strangers eight months ago – have been heartened by what we have been able to achieve by working together. In the coming months and years, we will spread the word about our product and encourage others to use it as we lead professional development webinars, workshops, and so forth, and will continue to conduct and publish research (e.g., additional analyses of our needs assessment findings and of the ways states are using national standards and frameworks in revising their social studies standards). And we will encourage future support for additional professional learning communities to pursue more professional development opportunities for informal educators, as well as the development of more resources and connections to enable social studies educators to engage learners in gaining the skills and knowledge necessary for addressing climate change.

We know that much more is needed to advance multidisciplinary climate change education. We hope that you will share our work with your colleagues and find others with whom you can collaborate to advance your climate change education efforts.

Amy B. Jolly, Climate Protection Campaign
Bethany Vosburg-Bluem, Otterbein University
Candace Lutzow-Felling, University of Virginia
Carrie Hawthorne, Roger Williams Park Zoo
Cheryl L. B. Manning, Jefferson County (CO) Schools
Christine Kelly, The Canadian Wildlife Federation
Christine Robertson, Earth Day Network
Christopher Johnson, Educational Consultant[2]
Clare Long, USDA Forest Service, White Mountain National Forest
Debbi Stone, The Florida Aquarium
Deborah Shiflett-Fitton, Cape Light Compact[2]
Janet Charnley, The Evergreen School (WA)
Jay Shuttleworth, Columbia University[2]
Jennifer Hubbard-Sánchez, Kentucky State University[2]
K. C. Busch, Stanford University

Kristen Poppleton, Will Steger Foundation[2]
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Laura Orsini, Columbus Zoo and Aquarium
Laura Tucker, Educational Consultant
Lisa LaRocque, Intercambios[2]
Lori Kumler, University of Mount Union[2]
Nette Pletcher, Association of Zoos and Aquariums (AZA)
Pat Stephens Williams, Stephen F. Austin State University[2]
Simone Parker, Trigg County (KY) Schools
Susan Jane Gentile, Antioch University and Living Routes[2]

Ray Darville, Stephen F. Austin State University
Wyvette Williams, Kentucky State University[3]

Karen S. Hollweg, North American Association for Environmental Education (NAAEE)
Jose Marcos-Iga, Environmental Education Exchange [4]

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[2]These people took on leadership roles, facilitating one of our nine working groups and representing their group's perspectives in conference calls designed to build cohesion into the final product.
[3]These two colleagues volunteered their expertise to enable us to complete our project, conducting analyses of our needs assessment data, and formatting our final text to create a professionally designed product, respectively.
[4]These two had the responsibilities of advertising, selecting, assembling, and facilitating the collaborative work of the Climate Change EE POLCA, and providing technical support, training in using our virtual tools, and coordination with the EECapacity Leadership Team, respectively.

*Images used in this publication are credited to thinkstockphotos.com

Suggested citation:

Downey, L., Gentile, S. J., Hollweg, K.S., Hubbard-Sánchez, J., Johnson, C., Kumler, L., LaRocque, L., Poppleton, K., Shiflett-Fitton, D., Shuttleworth, J (Eds.). (2013). ***Advancing Climate Change Environmental Education: Resources and Suggestions*****.** Ithaca, NY: EECapacity, Cornell University Civic Ecology Lab, and North American Association for Environmental Education. Retrieved from: http://www.eecapacity.net/climate-change-ee-project-based-online-learning-community-alliance.html

Educators' Needs

Assessment Survey of Climate Change Education In and Out of the Classroom

A review of the literature in the area of climate change education shows a number of surveys (Buhr, 2011, Johnson, 2011) looking at the needs of K-12 classroom teachers, as well as their knowledge as it relates to climate change. Additionally, several national surveys have been conducted (Yale Project on Climate Change Communication 2009, 2010, 2011, 2012, 2013) that gauge the attitudes and knowledge of Americans on climate change. Recognizing that the needs of informal and environmental educators may be different than formal K-12 educators as it relates to climate change education, we developed a needs assessment survey for distribution to the North American Association for Environmental Education (NAAEE) members and other educators who may integrate climate change in their educational settings. The results of this survey were meant to inform and support the creation of a product developed by NAAEE's Climate Change Education Professional Learning Community, supported by EECapacity.

Survey Instrument Development

Objectives of the survey included determining:

- What do formal and informal educators know about climate change?
- What do formal and informal educators do with what they know about climate change (this includes action/service learning applications)?
- What do formal and informal educators need to integrate climate change into their educational settings?
- What climate change education resources are formal and informal educators using?
- What audiences do formal and informal educators work with and engage regarding climate change?

The survey questions were developed through an iterative process that involved:

- Collection of previous surveys that had been conducted related to climate change, environmental, and science education (see end of this section for references used)

- Identification of questions from previous surveys that align with the survey objectives
- Refining questions for survey consistency
- Narrowing down questions to accommodate for survey length
- Sharing survey with EECapacity climate change education community for comments
- Finalizing survey and entering into Survey Monkey for distribution

The final survey included 31 questions, both multiple choice and open responses.

Survey Sample

Our main goal in gathering information through this needs assessment was not to have a closed survey, but to get as much input as rapidly as possible given the time constraints of the project. Respondents were solicited via email; in some cases directly, in some cases via an announcement in e-newsletters put out by parent organizations and in one case a Facebook post. Details of listservs utilized are found below (Table 1). The emails included objectives of the survey and gave a deadline for responding. The survey opened August 6, 2013 and closed September 13, 2013, with the intent of catching formal and informal educators while they were in teaching mode.

Table 1: Listservs Reached

Email Listserv or Organization	Number of Subscribers (to listserv or newsletter)	Number of Emails Sent
North American Association for Environmental Education	1600	3
National Science Teacher's Association	60,000 members- posted to website and sent to listservs once	1
Louisiana Association for Environmental Education	900	1
Social Studies and Science Teachers in NE Ohio	495	1
Climate Literacy Network	407	2
National Council of Social Studies Environmental and Sustainability Education Online Community	84	1

The US Partnership for Education for Sustainable Development K-12 NANS listserv Sustain12	429	1
Environmental and Sustainability Education Facebook Group	58	1
National Center for Geography Education	5000	2
Minnesota Association for Environmental Education	300	1
Rhode Island Environmental Education Association	228	1
New England Environmental Education Alliance	280	1

Results

Survey Demographics

A total of 316 individuals attempted the survey. However, only 225 (71.2%) completed the entire survey. Thus, the sample size for the latter half of the survey was less than 316.
Drs. Pat Stephens Williams and Ray Darville of Stephen F. Austin State University, Nacogdoches, TX, completed the Results Analysis.

Respondents were asked to identify their membership in related organizations in a check-all-that-apply type of question (see Table 2). They indicated that they were members of 337 organizations, or about one membership per respondent. Table 9 shows the results of the number of responses, percent of responses, and percent of cases. For organizational memberships, the National Science Teacher's Association (NSTA) was the most frequently identified (43.0% of responses and 56.9% of cases) while the North American Association for Environmental Education (NAAEE) was second most frequently identified (35.9% of responses and 47.5% of cases). Combined these two organizations represent about 80% of all individuals participating in the survey.

Table 2. Membership Types

Organizational Membership	Responses		Percent of Cases
	N	Percent	
NAAEE Member	121	35.9%	47.5%
NSTA Member	145	43.0%	56.9%
NAI[1] Member	24	7.1%	9.4%
NCSS[2] Member	16	4.7%	6.3%
NCGE[3] Member	12	3.6%	4.7%
AZA[4] Member	12	3.6%	4.7%
ASTC[5] Member	7	2.1%	2.7%
Total	337	100%	132.2%

[1]National Association for Interpretation
[2]National Council for Social Studies
[3]National Council for Geographic Education
[4]Association for Zoos and Aquariums
[5]Association of Science Technology Centers

Respondents were asked to self-identify the type of educator they were (Table 3). Most were formal educators (43.0%) followed by informal educators (29.1%). Some (25.9%) indicated that they saw themselves as both a formal and informal educator, while a handful self-identified as neither.

Table 3. Type of Educator

	Frequency	Percent	Valid Percent	Cumulative Percent
Formal educator	136	43.0	43.0	43.0
Informal educator	92	29.1	29.1	72.2
Both formal and informal educator	82	25.9	25.9	98.1
Neither formal or informal educator	6	1.9	1.9	100.0
Total	316	100.0	100.0	

Educator type and memberships were cross tabulated to present a more detailed picture of respondents (Table 11). Formal educators were most likely to be NSTA members (72.6% of cases) while informal educators were most likely to be NAAEE members (77.8%).

The majority of all respondents teach climate change to grade 9-12 students, adults, or university/preservice/in-service students. A large percentage also taught to formal and grades 6-8. The top four types of courses taught by classroom teachers represented environmental science, life science, earth science and physical science, with environmental and earth science being the areas where climate change is most often included.

Survey Respondents and Climate Change Education

Overall, educators self-reported being fairly or very well-informed about climate change, though there was a significant difference between how well-informed formal and informal educators felt they were on "how the climate system works" and "ways to communicate about climate change to students," with formal educators feeling more informed than informal. While 77% of respondents felt climate change was relevant to their subject area, 94% felt it was extremely or very important to teach their audience about climate change.

When asked the focus of their lessons on climate change, 5 of the 10 foci offered were selected by more than 50% of the respondents (see Table 4). Educators focused least often on civic engagement (19.7%), adaptation (29.7%), social, political and economic ramifications of climate change (31.9%), and climate solutions (38.1%).

Table 4: Focus of climate change lessons, highest to lowest

Focus	Percent
The greenhouse effect, human activity	85.0%
Impacts of climate change on wildlife and plant life	77.9%
Impacts of climate change on people and property, not in your area	63.7%
Mitigation– things people can do to lessen their impact on climate forces	59.3%
Impacts of climate change on people and property in your area	57.5%
Climate solutions-hands on action taking initiatives and the skills to perform them	38.1%

When compared, formal educators were more likely than informal educators to focus on: adaptation, causes of climate change, local impacts, social, political and economic ramifications, and civic engagement while informal educators were more likely to focus on mitigation, impacts not in local area, impacts on people and property in area, impacts on wildlife and plant life, and climate solutions.

When asked about what Climate Literacy Principles their course covered, respondents identified, "Human activities are impacting the climate system",

"Climate change will have consequences for Earth system and human lives," and "Humans can take action to reduce climate change," as the top three. Educators identified where they usually found their educational resources on climate change from a list of 13 different sources. Course textbooks were most often selected followed by the internet.

Educator Needs

Overall, 53.1% of all educators said they were either extremely confident or very confident teaching climate change. Yet comparing formal and informal educators, 58.9% of formal educators saw themselves as either very confident or extremely confident, while only 37.7% of informal educators saw themselves this way. In addition, over 10% of informal educators were either not very or not at all confident, whereas only 4% of formal educators saw themselves this way.

The greatest barriers identified to teaching climate change were time to develop and search for curriculum resources and the budget to develop new resources.

When asked what resources were needed to effectively teach about climate change two items tied (n = 165) for the highest counts:

- Content information that links climate change impacts to your local/regional wildlife
- Information about up-to-date regional/global climate science

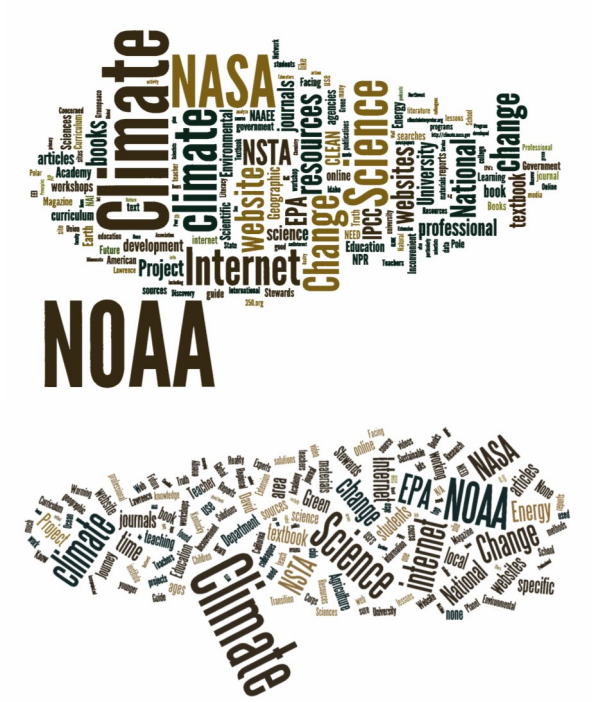
Financial resources had a rank of three (n = 144). Only 17 respondents indicated that they had no need for resources.

Educators were asked three questions (question 19) about whether they had adequate resources for teaching climate change. Responses provided were "disagree", "agree", and "strongly disagree". Some 34.4% of respondents (n=78) indicated that they disagreed or did not have adequate resources to teach the science of climate change while 65.6% either agreed or agreed strongly, indicating that they did have adequate resources. Opinion toward adequate resources for integrating climate solutions had a larger percentage disagreeing. About 45.5% of respondents (n = 95) said they disagreed — they believed that they did not have sufficient resources. Just over half of the respondents (54.5%) agreed or strongly agreed that they had adequate resources. Finally, we asked respondents whether they had adequate resources for teaching the ramifications of climate change. This particular item had the largest percentage of disagreement with 59.1% (n = 130) indicating that they did not have adequate resources. Only 40.9% said they

agreed or strongly agreed with the statement that they had adequate resources for teaching about ramifications of climate change.

Sources

We asked respondents in an open-ended question to identify their top sources of educational resources for teaching about climate change (question 21). Some 179 respondents provided sources. The data were transformed into a word cloud (http://www.wordle.net/). Wordle is a tool for generating "word clouds." It gives "greater prominence to words that appear more frequently in the source text." In other words, the more frequently a word appears in the text, the larger the word appears in the word cloud. The word cloud for this question highlights NOAA, NASA, Internet, books, IPCC, EPA, and journals. Additionally, respondents were asked to identify in an open-ended question (question 22) their top sources for teaching their audience about or for facilitating climate solutions. Data were analyzed for the 180 respondents answering this question using the word cloud approach. Top words of prominence include NOAA, internet, NASA, NSTA, textbook, journals, EPA, Time, and book.



Recommendations and Next Steps

Based on the findings of the survey we recommend the following actions:

1) Locate, share and develop resources that include content information with links to climate change impacts to local/regional wildlife and information about up-to-date regional/global climate science. Make the location of these resources widely known.
2) Locate, share and develop resources that highlight the political, social and economic ramifications of climate change and focus on learning and applying civic engagement skills.
3) Develop and provide professional development for informal educators to increase their confidence in teaching climate change.

We will continue to analyze the results of this survey and develop a lengthier literature review and discussion. Long-term goals involve developing a more controlled survey that includes a knowledge assessment for educators.

References Used

Assessments:

Pike, C., & Herr, M. (2011). *American climate attitudes. (*1st ed. ed.). The Resource Innovation Group (TRIG).

Buhr, S. M. (2011). *Navigating climate science in the classroom*. Boulder, CO: University of Colorado, Boulder.

Johnson, R. (2011). *Climate change education in k-12: Teacher preparation, understanding, needs and concerns*. Slingerlands, NY: National Earth Science Teachers Association.

Leiserowitz, A., Smith, N. & Marlon, J.R. (2011) *American Teens' Knowledge of Climate Change.* Yale University. New Haven, CT: Yale Project on Climate Change Communication.

http://environment.yale.edu/uploads/american-teens-knowledge-of-climate-change.pdf

Luebke, J.F., Clayton, S., Saunders, C.D., Matiasek, J., Kelly, L.-A. D., & Grajal, A. (2012).

Global climate change as seen by zoo and aquarium visitors. Brookfield, IL: Chicago Zoological Society.

Meehan, C. R. (2012). *Global warming in schools: An inquiry about the competing conceptions of high school social studies and science curricula and teachers.* Madison, WI: University of Wisconsin-Madison.

Cite as: Leiserowitz, A. & Smith, N. (2011) *Knowledge of Climate Change Among Visitors to Science & Technology Museums.* Yale University. New Haven, CT: Yale Project on Climate Change Communication. http://environment.yale.edu/climate/files/MuseumReport.pdf

Leiserowitz, A., Maibach, E., Roser-Renouf, C. & Hmielowski, J. (2012) *Global Warming's Six Americas, March 2012 & Nov. 2011.* Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication.

Maibach, E., Wilson, K & Witte, J. (2010) *A National Survey of Television Meteorologists about Climate Change: Preliminary Findings*. George Mason University. Fairfax, VA: Center for Climate Change Communication. http://www.climatechangecommunication.org/resources_reports.cfm

Rationale:

Simmons, B. (2011). *Climate change education in the formal k-12 setting: lessons learned from environmental education.* Eugene, OR: The National Academies Board on Science Education Committee on Human Dimensions of Global Change Division of Earth and Life Studies.

Marcinkowski, T., Noh, K., Sagy, G., & Erdogan, M. (2011). *Glimpses of the status of climate literacy, k-12, from national assessments of environmental literacy.* Florida Institute of Technology.

Hollweg, K. S., Taylor, J. R., Bybee, R. W., Marcinkowski, T. J., McBeth, W. C., & Zoido, P. (2011). *Developing a framework for assessing environmental literacy*. Washington, DC: North American Association for Environmental Education. Available at http://www.naaee.net/framework.

Simmons, B., Archie, M., & Hollweg, K. (2010).*Excellence in environmental education: Guidelines for learning(k–12).* (3rd ed.). Washington DC: North American Association for Environmental Education.

Marcinkowski, T. (2010). *Contemporary challenges and opportunities in environmental education: Where are we headed and what deserves our attention?.* Melbourne, FL: Florida Institute of Technology.

(2010). *Guidelines for k12 global climate change education.* Washington DC: North American Association for Environmental Education.

Fleming, M. L. (2010). *Practitioner's needs: Professional development priorities of informal and nonformal environmental educators.* Washington DC: Environmental Education and Training Partnership.

Fleming, M. L. (2010). *Teachers' needs: Professional development priorities of formal pre-k-20 environmental educators.* Washington DC: Environmental Education and Training Partnership.

Questions in Surveys developed from:

N*ational Survey of Zoo and Aquarium Visitors, CLiZEN questionnaire*.
Source: Alejandro Grajal, PI Climate Literacy Zoo Education Network, Brookfield Zoo

2013 NOAA Climate Stewards Pre-Assessment
2013 NOAA Climate Stewards Education Project Needs Assessment
2013 NOAA Climate Stewards Needs Assessment
Source: Peg Steffen, Education Coordinator NOAA

Parks Climate Change Survey
Source: Carol Lavoie, Project Manager, Applied Research Northwest

Understanding Global Change questionnaire
Source: Mark S. McCaffrey, Programs and Policy Director, National Center for Science Education

Other Material:

(2009). *Climate literacy: the essential principles of climate sciences .* (2nd ed.). Washington DC: US Global Change Research Project.

The Research

Summary of Research Relevant to Multidisciplinary Climate Change Education

What Research Says about Learning

In reviewing the diverse bodies of literature that have sought to document the process by which we come to know things and act upon that knowledge, we found striking similarities across theories. All of the theories we reviewed have at their heart the same purpose of education: to actively engage learners in work focused on transforming the world around them. For example, both action competence theory and activity theory focus on active participation in the world, and view learning as the process of engaging in experiences in both the social and physical world. Experiential education is at the heart of service learning theory, where learners engage in direct application of skills and reflection, geared toward changing the world around them.

This research indicates that those strategies that work best to promote engagement and learning are: experiential, place-based, active, student-centric, transformative, and cultivate systems thinking. Given what we know about the causes, impacts and possible solutions to climate change, and how to best engage learners on these issues, we have developed a set a strategies for teaching and learning about climate change. These strategies are derived from the education research reviewed and are focused on how to best support learning about complex issues like climate change. In an effort to bridge what can sometimes feel like the insurmountable divide between theory and practice, we have also included brief, general summaries of the literature we reviewed, and primary sources to refer to for a deeper exploration of a particular theory.

Relevant Learning Theories

The following summaries are not meant to be an exhaustive list of all learning theories. Many more exist that you may find helpful. But we encourage you to investigate those we have included here as an entry point for incorporating learning strategies based on research into your teaching practice.

Action Competence

Action Competence towards environmental goals means understanding and internalizing that our actions can have a positive effect on an outcome.

Building and strengthening a student's lasting capability and desire to help solve environmental problems increases action competence. The understanding is that actions are intentional. In the long run, action competence can guide the extent to which we see ourselves as agents of positive change. As such, there is a guiding principle to consider when we think of climate change education: that environmental degradation issues should be seen as human societal issues (human use of natural resources is the problem itself). Some strategies to consider:

1. Engage and develop willingness in students to work as a group to identify things in their immediate environment that they want to see changed and to act on these to make their future environment one they'd like to see, such as reducing the number of cars idling in parking lots or supporting renewable energy technology.
2. Utilize the tool of identifying "Conflicts of Interest" to help students understand that environmental problems are complex and that there are many facets to consider (both science and societal). This method can help develop critical thinking skills towards the many different perspectives on climate change and thus onward to effective action.

DIVE INTO ACTION COMPETENCE:

Jensen, B. B., & Schnack, K. (1997). The action competence approach in environmental education. *Environmental Education Research*, *3*(2), 163-178.

Activity Theory

Based on the work of Vygotsky, Levontv, Engeström, to name a few, activity theory holds that through our power to act, individuals have the ability to change the world around us, and in doing so transform the world and ourselves. Learning then, is thought of as the active process of manipulating the physical and social world, and passing the results of those actions along in the form of tools like knowledge and language. It is through this mutually evolving process that we learn, are transformed and are able to transform the world around us. Because we don't live and act in a void, these changes to individuals alter the structure of the collective communities and systems in which we exist.

Learning then, is thought of as the process of human development, a process that calls for the active participation of each of us in the world (or classroom). Activity theory also holds that in order to develop, our interactions must be oriented toward transformation, or in the case of climate change education, oriented toward empowering our students to make more environmentally responsible decisions and actions.

DIVE INTO ACTIVITY THEORY:

Krasny, M. E., & Roth, W. M. (2010). Environmental education for social–ecological system resilience: A perspective from activity theory. *Environmental Education Research*, 16(5-6), 545-558.

Place-Based Educational Theory

Placed-based education (PBE) uses students' local environment, heritage, culture, and opportunities as the context and content of learning. PBE emphasizes the importance of interacting with the natural world and community focused projects as a means for learning through participation in a local real-world setting. Originating in some ways from Dewey's concern that what is learned in school stands apart from students' lives outside the classroom, contemporary theorists like Lane-Zucker, Elder, Sobel, and Gruenewald have expanded this idea of project -based educational experiences focused in and on the local place, to include economic, historical, cultural, political, and social dimensions of what and how we learn.

DIVE INTO PLACE-BASED EDUCATION:

Promise of Place: Enriching Lives through Place-based Education: http:// www.promiseofplace.org/

Sobel, D. (2004). Place-based education. *Connecting Classrooms & Communities, Great Barrington, MA: The Orion Society*.

Significant Life Experience Literature

Significant life experiences (SLE) are those influential experiences that lead to positive environmental behaviors and attitudes among people in general, and specifically in those that lead to pursuit of an environmentally focused career. Since 1980, researchers have been exploring these influential factors, yielding a substantial body of literature. Over the years, the populations under study and the research methods have differed, but the conclusions reveal similar findings.

Participants (environmental educators, environmentalists, conservationists, young environmental leaders, etc.) consistently indicated that time spent outside; interacting with passionate teachers, mentors, friends and family members; and education were chief among the reasons for their involvement in an environmental field, and for their positive environmental behaviors and attitudes.

This body of work highlights the importance of ensuring that students have opportunities to engage with the natural world, the necessity of informed and motivated educators, and incorporating environmental issues like climate change into a student's educational experience.

DIVE INTO SIGNIFICANT LIFE EXPERIENCE:

Chawla, L. (2006). Research methods to investigate significant life experiences: Review and recommendations. *Environmental Education Research*, 12(3-4), 359-374

Systems Theory and Systems Thinking

Systems theory is a transdisciplinary area of study that identifies and explores the complex interconnected relationships and interactions among various elements in a system as a whole. Examples of social, technological and natural systems can include ecosystems, transport systems, physiological systems, education systems, the weather system, political systems and so on. Systems that are relevant to the specific context of climate change are self-regulating and are made up of objects, attributes, and internal relationships among its objects, all of which exist in an environment.

Some of the common characteristics in an open system include: interdependence, chain of influence, hierarchy, interactions with the environment, inputs/outputs, correlations, the need for balance, goal directed, subsystems, self-regulation, change, adaptability and perceiving causes (Gallopin, 2003).

Systems thinking, based on systems theory, emphasizes the linkages between the many systems that make up our world, and is an analysis tool that examines the interrelationships between and among the individual pieces within the framework of a larger system. The many systems this theory seeks to explore include the ecological, political, economic, social, and cultural, among others.

Systems thinking "unifies these into a holistic whole, revealing their interdependent nature" (Ben-Svi-Assarag & Orion, 2010, p. 1255). Rather than

focusing on discrete elements as separate entities standing apart from the system, it is possible to investigate how the processes between and among these various components affect other components and processes. In turn, impacting the whole system.

Systems thinking can be thought of as a set of habits or practices used to solve problems by examining how a system works in order to develop insights about the behavior of a whole system over time. It uses these insights to "improve decision-maker understanding of how to intervene and improve a systems performance" (Mathews & Jones, 2008, p. 76). For example, as students set out to examine climate change they will need to acquire an understanding of the complex, dynamic and cyclic nature of the four earth systems: the geosphere, hydrosphere, atmosphere, and biosphere through the context of the interrelationships among these systems as well as the social and technological systems that affect the earth over both space and time.

Systems thinking embraces the complexity of an issue such as climate change through the examination of the processes and components (natural, social and technological) as a whole, thus enabling students to see both the big picture as well as the individual actions that affect the earth's climate. Key tools used in systems thinking are feedback loops and computer modeling. Computer modeling facilitates the use of feedback loops which change human behavior through providing people with information about their actions in real time (or something close to it), then they are given the opportunity to change those actions, pushing them toward better behaviors, i.e. Action -> Information -> Reaction.

Everything about systems thinking is interdisciplinary. When examining any type of system all aspects of it must be considered, this includes social, economic, ecological, technological, etc. Thus, using systems thinking as a tool to examine issues such as climate change allows for the consideration of the interaction between the social, economic, ecological, technological, etc. systems that contribute to climate change as well as the potential actions that can be taken to mitigate its consequences. They are all part of the story and therefore must all be included in the efforts to create solutions.

DIVE INTO SYSTEMS THINKING:

Systems Thinking in Life, Systems Thinking in Schools: The Waters Foundation. http://watersfoundation.org/systems-thinking/overview/

Creative Learning Exchange: Systems Dynamics & Systems Thinking in K12 Education http://www.clexchange.org/

Service Learning

Service Learning theory draws directly from Dewey's premise that the interaction of knowledge and skills with experience is key to learning. Defined by the Alliance for Service-Learning in Education Reform (ASLER) service learning is,

> A method by which young people learn and develop through active participation in thoughtfully-organized service experiences that meet actual community needs, that are coordinated in collaboration with the school and the community, that are integrated into each young person's academic curriculum, that provide structured time for a young person to think, talk and write about what he/she did and saw during the actual service activity, that provide young people with opportunities to use newly acquired academic skills and knowledge in real life situations in their own communities, that enhance what is taught in the school by extending student learning beyond the classroom, and that help foster the sense of care for others.

Service-learning has moved beyond the more simple notions of community-service or volunteering. It can provide an opportunity for a deeper learning experience through the direct application of and reflection upon the skills and knowledge the students are learning in their classrooms. These opportunities allow students to make meaningful connections between what they are learning and how they themselves can directly impact the world around them, specifically their own community. The research indicates that linking curriculum to activities has multiple positive effects; however, particular efforts must be made in order for service-learning to achieve its maximum potential of empowering young people to address and solve problems within their community (Billig, 2011).

It is important to note that the many benefits associated with service-learning are dependent upon the opportunities including a number of design features which if not included can lead to little or no positive, long term learning or impacts. Shirley Billig identified six components typical to a successful service-learning design. These include: Investigation, Planning, Action, Reflection, Demonstration, and Celebration. In addition, a complete set of standards and indicators based upon research in the fields of service-learning and education have been created to guide educators and community partners. They include descriptive indicators which address: Meaningful Service, Link to Curriculum, Reflection, Diversity, Youth Voice, Partnerships, Progress Monitoring, and Duration and Intensity.

Educators from diverse disciplines such as science and social studies can implement service-learning to investigate and address climate change issues within their own community. Researching into the local historical roots and causes

of current environmental problems allows students to frame their service-learning experience from both disciplinary perspectives. By understanding the scientific and historical causes and effects they are better equipped to take informed action with a greater potential to make a significant impact on their community as well as their own learning.

DIVE INTO SERVICE LEARNING:

National Service-Learning Standards: http://www.servicelearning.org/library/resource/7509

Strategies for Teaching about Climate Change

- Build on the use of meaningful patterns of information. Use age-appropriate experiences, lessons, and resources to increase experience and knowledge through age-appropriate lessons on how the world works. Examples include using observational skills and data collection, and using cause and effect models in natural science/nature study with novice learners.

- We encourage you to plan lessons that are directly relevant for the learners you work with. Here we give examples appropriate for a school/community located near a marsh, but for a central city school/community, a more relevant focus could be learning about the carbon emissions from idling vehicles and the impact on asthma rates. Students might conduct an idling audit, tallying the number of cars, trucks, and buses that sit outside of their schools each day, comparing with school-wide rates of asthma, and brainstorming solutions to reduce the incidence of asthma. **For example**: Students in grades K-4 may learn about marshes through field trips to a local marsh to experience this ecosystem's physical traits and observe wildlife, plant life, and physical attributes. Grades 5-8 may study individual species found in the marsh, their adaptations, and population dynamics through transect studies and geologic formation. Grades 9-12 may study changes in depth of marsh peat, recent and past changes in coastal formations, as well as changes in population dynamics and species diversity. Inland schools may adopt a coastal school and, through social media "pen pals", can share their differences and experiences and learn about one another's natural resources. Older students can exchange ideas, thoughts, and observations regarding climate change and its effect on their particular environments.

- Transfer lessons learned to everyday life and experiences using recall and

knowledge applications (biological and ecological concepts such as the basic needs for life to population dynamics and how populations influence ecosystems). **For example**: Building on the base knowledge of marshes, students learn and internalize the importance of marshes to the overall health of neighboring ecosystems, the food chain that we are all a part of and the dynamic processes that contribute to our knowledge of how climate change is affecting our resources. With this knowledge, the importance of climate change can become concrete with rational and far-reaching thought and action.

- Emphasize students' life experiences for better transfer of information to the ultimate goal of action. Focus on learners' present life context; an urban student will view the natural world differently than a rural learner. **For example**: An urban high school may visit the docks where the fishing fleets come in to survey the catch of the day over a period of time and graph these results, along with tracing the individual species caught to the marsh through the food chain. Economic implications can be drawn to the effects of climate change on the commercial fisherman as well as the consumer.

- Keep the transfer of knowledge in the learner's present life context (an urban learner/student will view the natural world differently than a rural learner). Keep emphasis on their life experiences for better transfer of information to the ultimate goal of action. **For example**: An urban Boston high school may visit the docks where the fishing fleets come in to survey the catch of the day over a period of time and graph these results along with tracing the individual species caught to the marsh through the food chain. Economic implications can be drawn to the effects of climate change on the commercial fisherman as well as the consumer.

- Be a good role model – live what you teach (walk the walk and talk the talk) – Research shows that much is gained by students through this type of indirect learning. **For example**: Lead a sustainable lifestyle and act as a role-model by recycling, walking, drinking from reusable bottles for water, not wasting paper, turning off lights, etc. Track your classroom's carbon footprint on a daily basis to demonstrate to students that everyone has their part to play.

- Use questions to start a lesson and let the questions, and your students, guide the lesson. **For example**: Why do we care about marshes and why are marshes important to us? More generally, a well-known teacher uses "What questions do you have about yourself and what questions do you have about the world?"

- Use problem solving/solution seeking activities, creative play, and project-based learning to strengthen background knowledge as in interdisciplinary lessons. **For example**: Role play a town meeting with groups representing local commercial fishermen, coastal property owners, the Fish and Wildlife Service's shore nesting bird protection program, and the local chamber of commerce. Present the case that science shows a rising sea level. Have students considered what can and should our coastal towns do?

- Create effective learning environments which are knowledge-centered **and** learner-centered. Of these, community-centered environments can be very effective through collaborative participation and learning. **For example**: Form study/working groups of students with varying learning styles and abilities that meet regularly to help each other or complete projects.

- Use your local community (people, natural spaces, community organizations, topical issues, etc.) as teaching tools. Students relate to what is familiar and relevant, improving their ability to remember, and their likelihood of taking action. **For example**: Have students collect data outside their classroom, and compare to other aggregate data to investigate local fluctuations. Or ask students to identify a local environmental issue to research. Right now, in our own backyards and neighborhoods, this is what is happening….let's become aware!

- Use positive language, and frame problems as challenges to be solved. **For example**: Climate change is not a doomsday scenario, but instead gives us the opportunity to think creatively about how we can make a difference.

- Provide hands-on learning opportunities both inside the classroom/teaching space and outside. **For example:** Seek out activities for students to create models of ecosystems in the classroom, after having completed a field study around the school grounds and neighborhoods.

- Use the local environment as a subject of interdisciplinary learning and re search. **For example:** Use the changes in environmental quality of soil to teach about farming practices through history.

- Allow students the space to make their own decisions and take action in their own way on environmental problems. **For example:** Some students may decide they are able to advocate for more sustainable school practices at a school board meeting, while others may want to implement a recycling program, and others still will decide the best way for them to take action is

to remember to turn off the lights. All are valuable kinds of action, and if self-directed, can serve as powerful lessons of independence and action.

References

Alliance for Service-Learning in Education Reform (1993). *Standards of Quality for School-Based Service-Learning*. Chester, VT: ASLER.

Ben-Zvi-Assaraf, O. & Orion, N. (2010). Four case studies, six years later: Developing systems thinking skills in junior high school and sustaining them over time. *Journal of Research in Science Teaching*, 47 (10), 1253-1280.

Billig, Shelley H. (2011). Making the most of your time: Implementing the K-12 Service-Learning Standards for Quality Practice.

Breiting, S. R., & Mogensen, F. (1999). Action competence and environmental education. *Cambridge Journal of Education*, *29*(3), 349-353.

Chawla, L., & Cushing, D. (2007). Education for strategic environmental behavior. Environmental Education Research, 13(4), 437-452.

Chawla, L. (2006). Research methods to investigate significant life experiences: Review and recommendations. Environmental Education Research, 12(3-4), 359-374

Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen & R. Punamaki (Eds.), *Perspectives on Activity Theory* 19-38. Cambridge: Cambridge University.

Gallopin, G. (2003). A systems approach to sustainability and development. Sustainable Development and Human Settlements Division. Santiago, Chile: ECLAC.

Gruenewald, D. A. (2003). Foundations of place: A multidisciplinary framework for place-conscious education. *American educational research journal*, *40*(3), 619-654.

Hungerford, H. R., & Volk, T. L. (1990). Changing learner behavior through environmental education. Journal of environmental education, 21(3), 8-22. Retrieved from: http://www.cbtrust.org/atf/cf/%7BEB2A714E-8219-45E8-8C3D-50EBE1847CB8%7D/Changing%20learner%20behavior%20-%20H%20and 20V.pdf

Jensen, B. B., & Schnack, K. (1997). The action competence approach in environmental education. *Environmental Education Research*, *3*(2), 163-178.

Jonassen, D. H., & Rohrer-Murphy, L. (1999). Activity theory as a framework for designing constructivist learning environments. *Educational Technology Research and Development*, 47(1), 61-79.

Krasny, M. E., & Roth, W. M. (2010). Environmental education for social–ecological system resilience: A perspective from activity theory. *Environmental Education Research*, 16(5-6), 545-558.

Mathews, L.G. & Jones, A. (2008). Using systems thinking to improve interdisciplinary learning outcomes: Reflections on a pilot study in land economics. *Issues in Integrative Studies,* 26, 73-104.

Meadows, D., Meadows, D., & Randers, J. (2004). *Limits to growth: The 30-year update*. Chelsea Green Publishing.

Smith, G. A. (2013). Place-based education. *International Handbook of Research on Environmental Education*, 213.

Sobel, D. (2004). Place-based education. *Connecting Classrooms & Communities, Great Barrington, MA: The Orion Society*.

Stetsenko, A. (2010). Teaching-learning and development as activist projects of historical Becoming: Expanding Vygotsky‘s approach to pedagogy. Pedagogies: An International Journal (Special issue on Vygotskian approaches to pedagogy edited by W. -W. Roth and Y. -J. Lee), 5(1), 6-16 DOI 10.1080/15544800903406266

Tanner, T. (1980). Significant Life Experiences: A new research area in environmental education. Journal of Environmental Education, 11(4), 20-24.

The Research

Summary of Research Relevant to Multidisciplinary Climate Change Education

Environmental Psychology and Climate Change

It is easy to understand why environmental educators are concerned about climate change. We are emotionally connected with nature and steeped in all of the academic underpinnings related to it. But unless we are preaching to the choir, our message may not be heard.

Even though we like to consider that people are reasoned intellectual beings, we need to look at more primal drivers of human behavior. As social animals we respond to emotional cues within a trusted group context. The group's cues help us respond to the opportunities and threats around us. We feel safe when the message is presented in a familiar context from a trusted member (Lakeoff, 2010). Conversely, if the message is framed from another group's context, it is considered as less trustworthy. The challenge for environmental educators is to tap into the emotional cues and messengers for the groups we wish to engage.

A "If you just tell people the facts, they will reason to the right conclusion" (Lakoff, 2010, p. 73) position may align with objective scientific thinking but it does not support cognitive science research according to George Lakoff. Words, facts, and figures take a detour in our emotive brain as they seek out preexisting organizing frames intimately linked to our emotions. This pathway tells us right from wrong, shaping our judgment and conclusions. Objectivity takes a back seat. We are social constructivists.

Other primal drivers include a sense of immediacy, visibility, efficacy, complexity, and certainty. Our survival is dependent on responding to immediate threats, not future ones (Slovic, 2000 as cited in CRED, 2009.) If we can't clearly feel it we may not perceive it as a threat (Markowitz & Shariff, 2012.) If we do feel something is a threat, we respond to what we immediately see, not necessarily sizing up the entire dimension of the threat (Linville, 1991 as cited in CRED, 2009.) Our single response to it (efficacious or not) diminishes our concern and need for further action. If we are uncertain something is a threat, it decreases our willingness to take action (Markowitz & Shariff, 2012).

When considering how climate change communication has typically been presented, it is easy to see how it is contrary to everything we have learned in environmental psychology. The climate change issue is relatively complex solely based on the interdisciplinary nature of the science involved. This science is not taught at all or not taught effectively in schools, and misrepresentations of the science exist within the media. This complexity is further exacerbated by the temporal and spatial characteristics of the climate change. The effects of our actions are not immediately visible; for example, when we emit greenhouse gases by driving our car, the effects will be distributed across space (to those in other countries) and time (to future generations). Markowitz and Shariff (2012) argue that we are not morally equipped to act in this situation because "understanding climate change as a moral imperative does not occur automatically, at an intuitive level. Instead it requires cold, cognitively demanding and ultimately relatively less motivating, moral reasoning" (p. 244).

Uncertainty can breed over-optimistic behaviors, thereby reducing the motivation of individuals to change behaviors or take action. For example, the IPCC report used very carefully chosen labels to describe confidence and likelihood: "Very likely" was used to describe a 90-99% probabilistic chance of occurrence of a well-defined outcome (IPCC, 2007). However, "very likely" was systematically misinterpreted by the general U.S. public as being less likely than was intended by the experts who wrote the report (Markowitz & Shariff, 2012). Although the mechanism for over-optimism is not known, the effect is a decreased willingness to take action.

One final lesson from cognitive science speaks about the messages we shouldn't share. Opposing frames are the "elephant in the room." Lakeoff (2010) cautions communicators to quiet opposing frames so that they may atrophy as environmental frames develop.

Despite these barriers, the role of attitudes and beliefs and psychological responses, affecting human behavior and decision-making, as well as educational efforts, can call human behaviors and decision-making into play. Fortunately, The Center for Environmental Decisions (CRED) has invested much research in overcoming these barriers (CRED, 2009). The following chart summarizes CRED's findings, effective practices and psychological explanations. We have added educational strategies to provide ready applications for these principles.

The Center for Research on Environmental Decisions' 8 Principles of Climate Change Communication (CRED, 2009) with Additional Suggestions for Using these Principles in Educational Programs

Most Effective Practices *	Psychological Explanation*	Educational Strategies
1. Know your audience • Determine your students' mental model or current understanding about climate change • Discover what your students' misconceptions about climate change are • Know that all new information encountered will be filtered through a student's existing mental model	A mental model is a combination of an individual's understandings of facts, prior experiences, and intuitions. All of these factors influence what a person pays attention to and how she or he goes about solving problems. Understanding students' mental models will help to organize or emphasize certain dimensions of, strategies for, and relationships to climate change.	By surveying students' current understanding, (and misconceptions of climate change), and suggestions and concerns for addressing climate change before a lesson, instructors can get to know their audience. Surveys can range from a formalized pretest, to electronic student response systems, to dots on newsprint. Discussions about where we get our information, our perceptions of science, and what our role is in addressing issues can also help illuminate mental models.
2. Get your audience's attention • Consider framing the setting of the climate change issue in a context that is relevant to your students' lives • Carefully select words that will appeal to multiple perspectives of students • Use local examples, keeping it personally relevant (applying a "local" frame) • Portray risk as more immediate rather than distant (applying a "now" time frame) • Messages about avoiding loss tend to be more motivating than ones about realizing future gain • Broaden the frame to include effects on humans, for example, threats to national security or to human health	Framing puts issues into a certain context so that it will resonate with your audience. It is impossible not to frame when you communicate. CRED's collection of research indicates that a message should be local, focus on immediate risks with a greater emphasis on avoiding losses rather than realizing gains.	Here is an example that Illustrates how a message for teenagers could be framed: The cost of owning and driving a car is making it impossible to get around. As this country addresses practices that contribute to climate change the costs of cars, fuel, parking and other expenses are going to take a disproportionate bite out of your budget. Using less expensive options like ride shares, public transit, bikes, motor scooters, and renting or sharing a community car will keep you from missing out and help the environment!

3. Translate scientific data into concrete experience • Trigger stronger motivation for action with use of vivid imagery and personal or anecdotal narrative rather than use of statistics and graphs • Sustain long-term concern with more analytical messages such as trend forecasts, graphs or tables • Use words that make sense to students, avoiding jargon, scientific terms and acronyms • Provide time for group discussion which is more likely to bring in experiential and analytical perspectives • Use words that make sense to students, avoiding jargon, scientific terms and acronyms • Provide time for group discussion which is more likely to bring in experiential and analytical perspectives	We are emotional beings, and as a consequence, that is where we need to target our message. However, the primal brain is designed for immediate concerns, not future ones. Once people are concerned, analytical data provides tools to help you understand the details. Both are necessary touch points in our brain.	There are lots of opportunities for language arts activities to provide vivid imagery, anecdotal narrative and metaphors. Data analysis should highlight changes that are occurring now.
4. Beware the overuse of emotional appeals • Recognize that students have a finite capacity for worry and can become "numb" to climate change issues • Balance emotional messages with analytical messages • Draw students' attention to concept of "numbing" and discuss ways to prevent it • Gauge students' previous exposure to climate change issues (via media) • Focus on solutions to empower students • Provide a portfolio of possible solutions	According to research there is "a finite pool of worry." Immediate risks take precedence, but over time new worries replace old. Reactivating real or projected threats can have a numbing effect as can a host of problems presented on our many media sources. In response to the threat, people are inclined to take one action known as the single action bias. This action reduces the feeling of worry; few actions, if any, follow that. As one might	Create win-win strategies to pressing issues. Increase relevance, frame the issue, provide emotional and analytical explorations, and more connections in the brain for climate change. Making us aware of our single action bias can explain our tendency to pick one rather than all the suggested list of actions that we can take. You can also make that one action more substantive, e.g. increase home insulation and caulking rather than turn off the light. (See principle 8's educational strategies for video suggestions.)

	suspect, this can be detrimental to the sustained actions that are needed to address climate change.	
5. Address scientific and climate uncertainties • Use specific language • Be aware of differences between scientific use of words and common usage, for example, "error" in common usage means mistake, wrong or incorrect • When discussing scientific uncertainty, explain why it exists • Invoke the Precautionary Principle – taking action even when the risk is not a 100% certainty • Discuss probabilities in a group, allowing for a shared understanding	The nature of scientific uncertainty can be misunderstood as error or confusion on the part of scientists rather than an integral part of scientific research. This uncertainty can also decrease people's willingness to take action.	Educators can spend time discussing how science is a process for creating theory from evidence. In addition, educators can emphasize that these theories are dynamic, and that a theory is revised as new evidence comes to light. Promoting this as a strength, rather than a weakness, can help decrease student misunderstanding about scientific uncertainty. Additionally, educators can explicitly discuss decision-making strategies in light of uncertainty, calling upon the "Precautionary Principle" for example.
6. Tap into social identities and affiliations • Create group affiliation to activate social goals • Use smaller group sizes to allow for a stronger sense of group affiliation • Reward individual behaviors taken toward a group goal	Because people generally serve in several different roles in their daily lives – mother, daughter, and teacher – they may consider all or some of these roles important when making decisions about environmental action.	Educators can help students identify the social values and their affiliations they are using when making environmental action decisions. Educators can also, then, help students understand how others may be approaching an issue based on their own personal experience and motivations. Students can also be challenged to develop alternative frames for other affiliations, e.g. religion and protecting God's creation; parents and safeguarding their children's futures; teenagers changing their parents' antiquated system.

7. Encourage group participation • Establish appropriate group discussion norms: who speaks when, how to disagree • Allow ample time for questions and discussion • Use smaller group sizes for discussion • Recognize power and personal differences • Provide opportunity for verbal and non-verbal forms of participation • Represent multiple viewpoints • Establish the expected outcome for the discussion (consensus or not)	Climate change mitigation actions are dependent on the collective action of many individuals. As such, effective actions may be those that are agreed upon and conducted by a group. However, dynamics within groups can lead to inequitable participation and influence between members.	Educators can establish group discussion norms that allow for and give credence to multiple forms of communication – narrative, factual, verbal, non-verbal. Educators can elicit multiple perspectives by creating a classroom culture that encourages dissenting voices. Debrief or meta-cognate how those different forms of communication influence how we respond to climate change issues.
8. Make behavior change easier • Propose solutions that are feasible for students • Make the desired behavior option the easier one • Provide immediate incentives for desired behaviors	People generally choose behaviors with the lowest possible personal cost and the most immediate positive incentive.	Educators can challenge learners to work in small groups to investigate and propose achievable reductions in energy use/generation of greenhouse gas pollution. Consider using videos as examples to help the groups get started e.g., go to www.youngvoicesonclimatechange.com and click on "Movies" or http://earththeoperatorsmanual.com/ and click on "Watch Operators in Action" Additionally, educators can make some of the pro-environmental behaviors the "default" behavior, such as setting school printers to double-sided printing and providing recycling containers instead of trash cans in their rooms.

* Information in this table is adapted, with permission, from *The Psychology of Climate Change Communication,* a publication of The Earth Institute, at Columbia University, Center for Research on Environmental Decisions available at http://guide.cred.columbia.edu. The third column, titled educational strategies, was developed by K.C. Busch and Lisa LaRocque for this publication.

Literature Cited

Brown, Paige. (25 March 2012). Got Frames? Why How We Frame the Environment Matters. Retrieved from http://www.scilogs.com/from_the_lab_bench/got-frames-why-how-we-frame-the-environment-matters/

Center for Research on Environmental Decisions (CRED). (2009) *The Psychology of Climate Change Communication: A Guide for Scientists, Journalists, Educators, Political Aides and the Interested Public*. New York Retrieved from http://guide.cred.columbia.edu

IPCC. (2008). Climate change 2007: Synthesis report. Cambridge University Press.

Lakoff, G. (2010). "Why it Matters How We Frame the Environment." Environmental Communication: A Journal of Nature and Culture 4(1): 70-81.

Linville, P.W., Fischer, G.W. (1991). Preferences for separating and combining events: a social application of prospect theory and the mental accounting model. *Journal of Personality and Social Psychology*. 60, 5-23.

Markowitz, E. M., & Shariff, A. F. (2012). Climate change and moral judgment. Nature Publishing Group, 2(4), 243–247. doi:10.1038/nclimate1378

Slovic, P. (2000). *The Perception of Risk*. London: Earthscan. Slovic, P., M.L., Peters. E. et al. (2004). Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk and rationality: Risk Analysis, 24, 311-322.

The Research

Summary of Research Relevant to Multidisciplinary Climate Change Education

Climate Change Research: An Overview

Over the past 1 million years, the earth has gone through several cycles of warming and cooling, with ice ages alternating with warmer periods. Each of these cycles has lasted about 100,000 years.

By comparison, the earth's climate has remained relatively stable over the past 10,000 years. There is an important exception, though. Since the beginning of the Industrial Revolution in Europe in about 1750, climate scientists have measured a relatively rapid increase in global temperatures of approximately 1.3°F (0.7°C).

Evidence of Climate Change

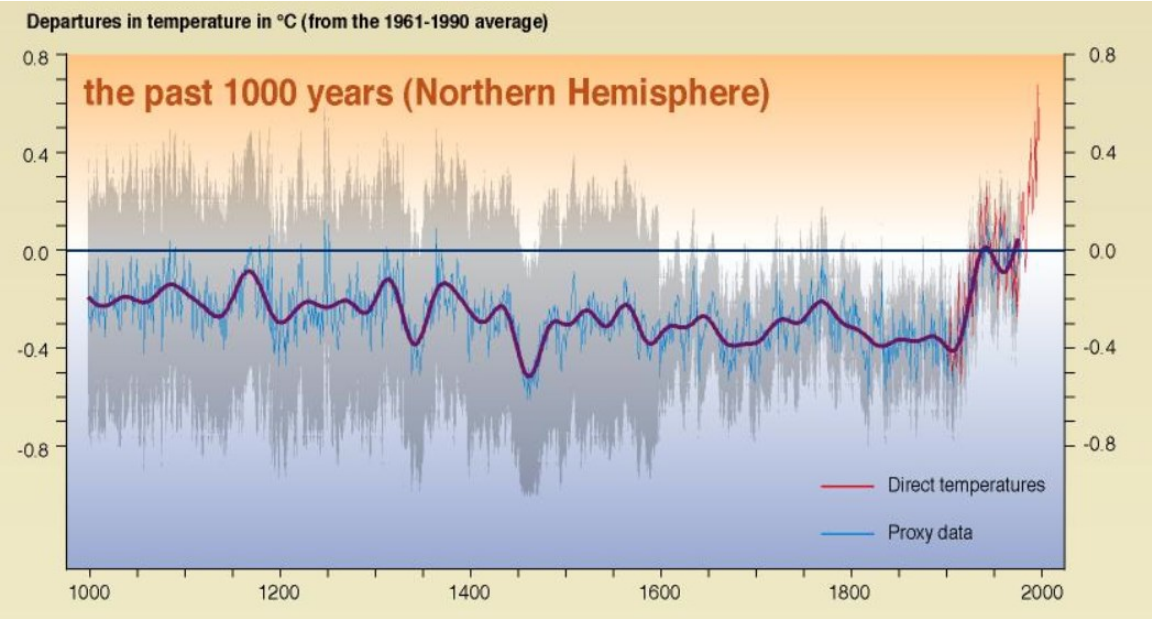
The Intergovernmental Panel on Climate Change (IPCC) is an agency formed in 1988 by the World Meteorological Organization and the United Nations Environment Program to study the extent of climate change and its effects. In August 2013, the IPCC prepared to issue its fifth assessment of the risks of climate change. According to the IPCC, there is at least a 95 percent certainty that humans have caused warmer temperatures through their activities.

The draft summary stated, "It is extremely likely that human influence on climate caused more than half of the observed increase in global average surface temperature from 1951 to 2010. There is high confidence that this has warmed the ocean, melted snow and ice, raised global mean sea levels, and changed some climate extremes in the second half of the twentieth

century." In its previous assessment, issued in 2007, the IPCC had predicted that global temperatures will rise between 2°F and 11.5°F by 2100.

The graph below was produced by the IPCC. Known informally as the "hockey stick" because of the shape of the graph, it shows the dramatic rise in global average temperatures since 1900. (Available at https://www.ipcc.ch/ipccreports/tar/slides/large/05.16.jpg)

Graph 1



Source: Intergovernmental Panel on Climate Change

The purpose of this section is to summarize research and provide links for further research into the causes of climate change (also known as global warming), the effects of climate change on the environment and on people, and potential solutions to slow the pace of warming. The IPCC has stated that if the earth continues to warm at current rates, the economic, ecological, and social consequences will be momentous.

In recent years, climate scientists have observed ample evidence of the warming of the earth's atmosphere. The decade from 2000 to 2010 was the hottest ever recorded, and global temperatures reached new highs in 1998 and 2010. Glaciers around the world are melting. Glacier National Park in Montana, for example, once had 150 glaciers but now has only 25. Scientists have estimated that glaciers will disappear completely from the park by 2030.

Similarly, ice is melting in the Arctic Circle, with widespread consequences for wildlife such as polar bears, which depend on ice to migrate and hunt for food. Scientists have observed that birds and other wildlife are migrating to higher latitudes in the northern and southern hemispheres to stay within their accustomed temperature ranges.

Greenhouse Effect Simulator-University of Colorado Boulder

http://phet.colorado.edu/en/simulation/greenhouse

Global carbon dioxide levels near worrisome milestone-nature.com

http://www.nature.com/news/global-carbon-dioxide-levels-near-worrisome-milestone-1.12900

Global land temperatures have increased by 1.5 degrees C over the past 250 years-BerkeleyEarth.org

http://berkeleyearth.org/summary-of-findings

Causes of Climate Change

Scientists have linked the rise in global temperatures to the increase in certain gases in the atmosphere since the beginning of the Industrial Revolution around 1750. These gases result from the burning of fossil fuels, particularly coal, oil, and natural gas. The fossil-fuel emissions cause gases to enter the atmosphere, where they trap radiation from the sun and prevent some of that radiation from being reflected back into space. The trapped radiation increases temperatures on the surface of the earth. These gases are called greenhouse gases (GHG) because they function somewhat like greenhouses.

The three most common GHG are carbon dioxide, methane, and nitrous oxide. Carbon dioxide (CO_2) is the gas that all vegetation on Earth absorbs in the photosynthesis process. The amount of CO_2, emitted from smokestacks and other exhausts has increased from 280 parts per million (ppm) in 1750 to nearly 400 ppm in 2013. (A part per million is a measure of the amount of a contaminate in the atmosphere or in a body of water.) A molecule of CO_2 stays in the atmosphere between 100 years and 500 years.

The second most common GHG is methane (CH_4), which is the main component of natural gas. Methane lasts in the atmosphere only for about 12 years, but it is 20 times more potent than CO_2 as a GHG. It leaks into the atmosphere primarily during the process of producing natural gas. Livestock also emit methane as part of the animals' natural digestive process. Methane has increased from 715 parts per billion (ppb) in 1750 to 1774 ppb in 2005.

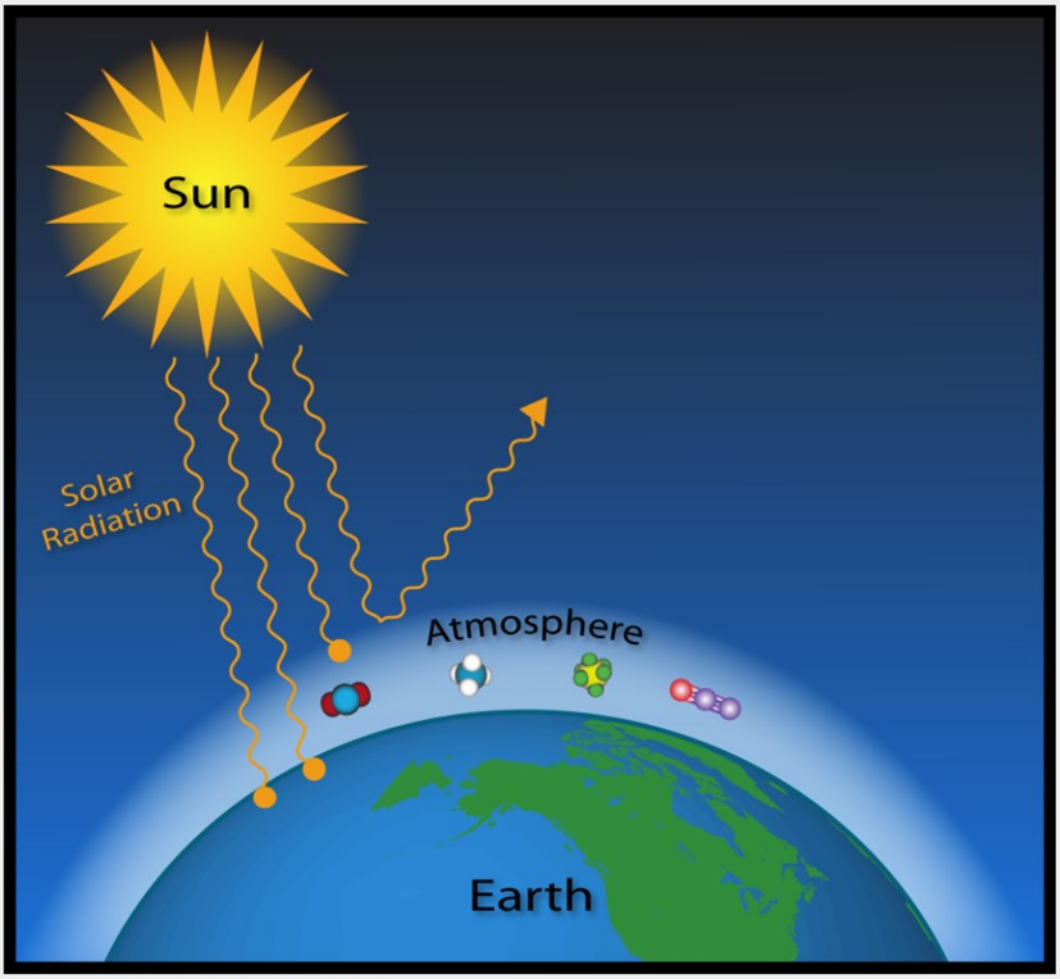
The third most common GHG is nitrous oxide (N_2O), which results from various industrial processes such as the burning of fossil fuels, agriculture, and the management of wastewater. This gas lasts in the atmosphere for about 120 years and is about 300 times as potent a GHG as CO_2. Nitrous oxide has increased from 270 ppb in 1750 to 319 ppb in 2005.

A fourth GHG is sulfur hexafluoride (SF_6), which is a human-made gas that is used primarily by the electric power industry.

Another major cause of climate change has been changes in land use. In the past 250 years, the human population has grown from 800 million to 7 billion. To accommodate this population expansion, people have cut down forests to harvest timber and cleared land for farms, cities, and suburbs. Trees absorb CO_2 as part of the photosynthesis process. However, because of deforestation, the earth has far fewer trees to absorb CO_2, leaving more of the gas in the atmosphere. Logging of rain forests, such as the vast rain forest of Brazil, has been a major contributor to deforestation and to climate change.

The two diagrams below show how GHG trap radiation in the earth's atmosphere.

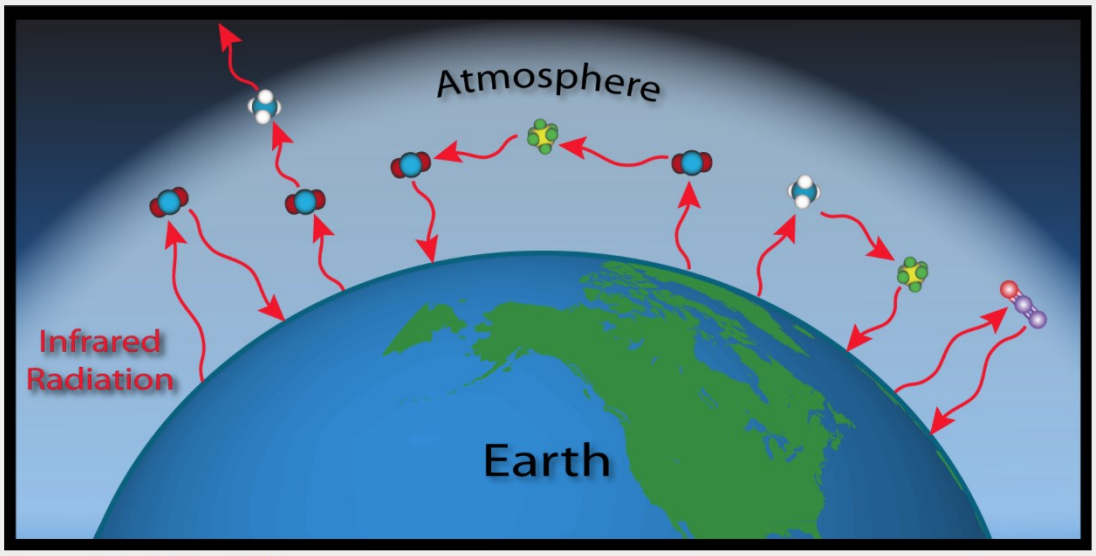
Diagram 1



Solar radiation enters the earth's atmosphere. Some escapes into space. The majority, though, is trapped in the atmosphere by gases, as the diagram shows (available at http://www.esrl.noaa.gov/gmd/education/carbon_toolkit/basics.html). These gases help make the earth warm enough for life to survive. From left to right, the gases represented are:

1. Carbon dioxide (CO_2)
2. Methane (CH_4)
3. Sulfur hexafluoride (SF_6)
4. Nitrous oxide (N_2O)

Diagram 2



Source: Barb Deluisi, NOAA

As more GHG gather in the atmosphere, the gases absorb infrared radiation, which causes increased warming. The diagram shows the process by which the GHG absorb radiation and reflect it back to earth. (Available at http:// www.esrl.noaa.gov/gmd/education/carbon_toolkit/basics.html)

Greenhouse Gas Emissions- EPA
http://www.epa.gov/climatechange/ghgemissions/

Climate Change Science-EPA
http://www.epa.gov/climatechange/science/

Climate Change Impacts and Adapting to Change- EPA
http://www.epa.gov/climatechange/impacts-adaptation/

Effects of Climate Change on Natural Environments

Climate scientists have observed and identified the effects of climate change in seven areas: (1) extreme high temperatures, (2) rising sea levels, (3) more floods and droughts, (4) increases in hurricanes and other extreme weather, (5) melting of glaciers, polar ice caps, and ice floes, (6) ocean acidification, and (7) loss of farmland.

As already noted, the decade from 2000 to 2010 was the warmest on record. In 2010, 19 countries experienced the hottest temperatures ever recorded, including Finland at 99°F, Niger at 119°F, and Saudi Arabia at 125°F. The scorching temperatures caused misery in cities such as Moscow, where few people had air conditioning and residents feared going outside because of the heavy smog.

As average temperatures have risen, the world's oceans have absorbed 80 percent of the atmospheric warming. As the water has warmed, it has expanded, raising ocean levels. In the draft summary of its fifth assessment, the IPCC predicted that if carbon emissions continue at current rates, ocean levels could rise by 21 inches to 3 feet by 2100, threatening coastal cities like New York and London.

The world has also experienced more severe floods and droughts, which most likely have resulted from changing weather patterns. In 2005, for example, more than 3 feet of rain fell on Mumbai, India, in 24 hours. Across the northern United States, the amount of precipitation has increased between 5 and 20 percent in recent years because rising temperatures have increased evaporation of water into the earth's atmosphere.

Yet other parts of the world have experienced greater drought as warmer temperatures take moisture out of the atmosphere. Several parts of the world, including the Sahel, the Mediterranean region, southern Africa, southern Asia, and the southwestern United States have suffered through extended droughts.

Climate scientists expect an increase in the severity of tropical storms, such as hurricanes, because rising temperatures will contribute to the build-up of energy unleashed by storms.

Warmer temperatures are causing glaciers, polar ice caps, and ice floes to shrink and even disappear. Arctic ice has shrunk by 2.7 percent per decade since 1978. Mountain glaciers and snow cover have been shrinking, contributing to the rise in ocean levels because of the runoff of water.

The large amount of CO_2 that the oceans are absorbing from the atmosphere is causing the ocean water to become more acidic. The increased acidity has a negative impact on shelled species, such as shellfish and corals, by impeding the process of building shells using calcium carbonate found in sea water.

Finally, rising ocean levels threaten farmland in coastal areas, where land in low-lying countries like Bangladesh will be lost for agriculture. For example, rising sea levels have already had negative effects on the growing of rice in the Mekong Delta in Southeast Asia and the growing of crops in several countries in coastal Africa.

All these changes will have a major impact on the species of life on the earth. Scientists estimate the potential extinction of between 20 percent and 30 percent of all species because of disappearing habitats. Global warming will have a negative effect on ocean ecosystems, including coral reefs.

New USDA plant zones clearly show climate change- Washington Post
http://www.washingtonpost.com/blogs/capital-weather-gang/post/new-usda-plant-zones-clearly-show-climate-change/2012/01/27/gIQA7Vz2VQ_blog.html

NOAA's Tides and Currents: Sea Level Trends Map
http://tidesandcurrents.noaa.gov/sltrends/sltrends.html

What is Ocean Acidification?-NOAA
http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F

The Antarctic's Ice Paradox-PBS.org
http://www.pbs.org/newshour/rundown/2013/05/why-climate-change-means-more----and-less----ice-for-the-antarctic.html

Effects of Climate Change on Humans

The effects of climate change will have major and perhaps catastrophic effects on humans, causing greater poverty, hunger and malnutrition, disease, injury, and death.

One of the major effects will be on food supply. In tropical regions, where much of the world's food is grown, crop yields will almost certainly decline because of increased drought. Malnutrition will increase as agricultural lands are lost to rising ocean levels and flooding. In addition, higher temperatures and dry conditions will bring more wildfires, which threaten the forests and croplands on which many people depend for their livelihoods. Today, 840 million people in the world are malnourished. With climate change, the IPCC estimates that the number of undernourished people will probably increase by 100 million to 240 million.

Climate change will probably worsen poverty in the world. Scientists predict that rising temperatures will lower the global gross domestic product by 20 percent during the 21st century, partly by eliminating agricultural lands that are now productive. The effects will be particularly serious in developing countries, causing mass migration from agricultural regions to cities and putting intense pressure on urban services ranging from education to medical care.

Scientists also predict that climate change will lead to higher occurrences of certain diseases. According to the World Health Organization, climate change caused more than 150,000 deaths in the year 2000. For example, malaria will probably increase because disease-carrying mosquitoes thrive in warm, moist weather conditions. Heat waves are major threats to people's health. In July 1995, 750 people in Chicago died as the result of record-breaking heat and humidity that plagued the city. Heart and lung diseases may also increase because of rising temperatures, ozone levels, and other forms of pollution.

Finally, climate change could well result in increased war and conflict. In its 2007 report, the IPCC pointed out that conflicts over fresh water, arable land, and food have played significant roles in wars in Malawi, Mozambique, Somalia, Ethiopia, Sudan, and other countries in Africa.

Climate Change Impacts and Adapting to Change
http://www.epa.gov/climatechange/impacts-adaptation/

Climate may crank storms into overdrive- Futurity.com
http://www.futurity.org/earth-environment/climate-may-crank-storms-into-overdrive/

Latest Forecast Shows the U.S. Drought Moving West-PBS.org
http://www.pbs.org/newshour/rundown/2013/05/latest-forecast-shows-the-us-drought-moving-west.html

Local Impacts

The global impact of climate change is very real, but students may ask, "How is climate change going to affect me and the area in which I live?" In fact, climate scientists have examined the likely impact of climate change on each of the major regions of the United States.

In the Northeast, the average temperature has risen by 2°F since 1970, and scientists expect temperatures to rise between 2.5°F and 4°F in the next century. Because of the region's long coastline, it will face potentially catastrophic floods, storm surges, property damage, and loss of wetlands. The region's large cities, such as New York and Philadelphia, could suffer through more than 30 days each year with temperatures over 100°F, with an accompanying increase in ozone and other forms of pollution. Such heat waves have the potential to cause hundreds, if not thousands, of fatalities.

The warm and humid region of the Southeast has experienced an average increase in temperature of 2°F since 1970. Average temperatures over the next several decades could rise between 4.5°F and 9°F. This region is particularly vulnerable to hurricanes, which scientists expect to increase in intensity as warmer ocean water feeds the energy that builds up in these storms. At the same time, scientists expect more prolonged droughts because of higher temperatures. Since the mid-1970s, the area of the Southeast suffering through long droughts has increased by 26 percent. Droughts could have widespread economic consequences for the agriculture in this region.

The Midwest has also experienced rising average temperatures. Throughout the region, the last frosts in spring now come a week earlier than they used to, and heavy thunderstorms are twice as frequent as they were 100 years ago. Flooding has also become more frequent, as evidenced by record-setting floods in the Mississippi River Valley in 1993 and 2013. As previously mentioned, Chicago experienced an unprecedented heat wave in 1997 that cost the lives of more than 700 people. Scientists expect this trend to continue, as the region may experience severe heat waves as often as every other year. Meanwhile, water levels in the Great Lakes have been falling because of increase evaporation, with economic consequences for shipping, tourism, and water quality.

In the Great Plains, average temperatures have risen by 1.5°F since the 1970s, and temperatures over the next century could rise between 2.5°F and 13°F. This region is semi-arid, and rising temperatures will cause heat waves, drought, and increasingly heavy thunderstorms, with serious impacts on agriculture, ranching, health. One of the greatest threats is from declining water tables in aquifers. For example, the Ogallala aquifer, which stretches from Texas to South Dakota and is critical to irrigation in the region, has declined by 9 percent since 1950. Scientists expect water tables to continue dropping, with major impacts on irrigation and agriculture.

In the Southwest, average temperatures have increased by 1.5°F since 1960, and they are expected to increase by another 4 to 10 degrees over the next several decades. This already-arid region has already suffered from water shortages because of drought and reduced snowpack in the Rocky Mountains. As a result, agriculture and ranching in the region have suffered. Another serious threat is that of forest fires. Long periods of drought have created conditions for runaway fires. Also contributing to the fire threat has been insects like the pine park beetle, which are now able to survive through winters because of somewhat higher average temperatures. The beetles have killed millions of trees, turning them into tinder for forest fires.

In the Northwest, temperatures have risen by an average of 1.5°F over the past several decades. Scientists estimate that the average temperatures will increase by 3 to 10 degrees by 2100. Higher temperatures have already reduced snowpack in the Cascades and other mountain ranges, reducing the water that runs off into rivers and streams. As a result, there has been a reduction in hydropower, which generates about 70 percent of the region's electricity. Rising temperatures will also have a major impact on the region's forests, which are central to the economy. Drier conditions are making forest fires worse, as are insects like the pine bark beetle. In British Columbia in Canada, beetles have destroyed 33 million acres of trees.

Perhaps no region of the United States has undergone as much impact from climate change as Alaska. Over the past several decades, summer temperatures have risen by 3.4°F, while winter temperatures have soared by 6.3°F. These higher temperatures have caused shrinking glaciers and melting sea ice, and thawing permafrost. Temperatures in Alaska could rise anywhere between 3.5°F and 13°F over the next several decades. As in the Northwest, higher temperatures will lead to drought and insect infestation, worsening forest fires and threatening an important part of Alaska's economy. Warming ocean temperatures will also affect fish populations, negatively affecting another important part of the state's economy.

Global Climate Change Impacts in the United States
http://nca2009.globalchange.gov

Union of Concerned Scientists, Global Warming Solutions: Prepare for Impacts
http://www.ucsusa/org/global_warming/solutions/prepare-for-impacts

Possible Global Solutions

According to the IPCC's 2007 report, "The ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC) is to achieve the stabilization of (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic [human-caused] interference with the climate system."

It is essential, climate scientists say, that countries limit the amount of carbon emissions into the atmosphere. The most important international effort to date has been the Kyoto Protocol to the UN Framework Convention on Climate Change, which was developed in 1997. It established binding goals for reducing emissions

of GHG. Most industrialized countries have ratified the Kyoto treaty, but the United States has not.

Countries signing the Kyoto Protocol agreed that by 2012, they would reduce GHG by an average of 5.2 percent below 1990 levels. The European Union met these goals, but emissions by the United States and China exceeded the reductions in Europe. In fact, global emissions increased by almost 40 percent from 1990 to 2009. If policies are not changed, fossil fuels will, by 2030, continue to supply 80 percent of energy needs, and GHG emissions will be 40 to 110 percent higher than they were in 2000.

The IPCC's 2007 report emphasized the need for countries to improve energy efficiency and shift to renewable sources of energy, including solar energy, wind turbines, geothermal energy, hydroelectric power, biomass, and nuclear fusion and fission. In addition, scientists are experimenting with methods of capturing and storing carbon below ground to prevent it from entering the atmosphere.

The IPCC cited six areas of the global economy in which countries must use far greater proportions of renewable energy: (1) transportation; (2) residential and commercial buildings; (3) industry; (4) agriculture; (5) forestry; and (6) waste management, recycling, and reuse.

Since the Kyoto climate change conference and the 2007 IPCC report, scientists and conservationists around the globe have grown increasingly alarmed that countries are not making enough progress in reducing GHG emissions. In 2009, world leaders gathered in Copenhagen, Denmark, to try to create a path toward greater progress. Progress at the conference was slow, but it did issue a clear goal: to hold future global temperature increases to 3.4°F (2°C). One hundred sixty-seven countries agreed to this goal, although it was nonbinding. Scientists maintain that the atmosphere already has enough carbon to increase temperatures by 3.4°F (.8°C). Consequently, the earth is already well on its way toward the 3.4° F mark.

According to the draft summary of the IPCC's 2013 report, computer models show that humans can emit 565 more gigatons of CO_2 into the atmosphere over the next 5 decades to hold global temperature increases to 3.4°F. However, according to the Carbon Tracker Initiative, a nonprofit organization in Britain, energy companies worldwide hold some 2,795 gigatons of fossil-fuel reserves. If such huge amounts of carbon were to enter the atmosphere, the earth would heat up by much more than 3.4°.

Scientists are continually adding to the store of knowledge about climate change and its impact on the earth, humans, and other forms of life. An excellent source

to find updated information is on the Web site of Global Systems Science, created by the University of California's Lawrence Hall of Science and available at http://www.globalsystemsscience.org/home. The GSS Web site includes updates from the IPCC, the UN, and the U.S. government. It also provides lesson plans for teaching about climate change.

What is EPA Doing About Climate Change?
http://www.epa.gov/climatechange/EPAactivities.html

Obama Moves to Limit Greenhouse Gases Emissions Through Executive Order- PBS.org
http://www.pbs.org/newshour/bb/science/jan-june13/climate1_06-25.html

UN Framework Convention on Climate Change, *Report of the Conference of the Parties on its fifteenth session, held in Copenhagen from 7 to 19 December 2009.*
http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf

Carbon Tracker Initiative, "Unburnable Carbon—Are the World's Financial Marketing Carrying a Carbon Bubble?")
http://www.carbontracker.org/carbonbubble

Global System Science, Lawrence Hall of Science, University of California, Berkeley
http://www.globalsystemsscience.org/home

Strategies for Students

The remainder of this e-workbook will suggest essential questions, activities, and projects to involve your students in slowing the pace of climate change and achieving sustainability through improved energy efficiency and use of renewable energy. The traditional touchstone has been the 3 R's: reduce, recycle, and reuse.

In these projects and activities, you will find individual and collective actions that are essential and achievable. Individual actions are those taken by an individual alone, such as voting, reducing resource use, managing habitat on one's own property, and taking action to encourage legislation (e.g., writing letters). For example, a student acting alone can ride a bicycle rather than rely on parents to drive him or her everywhere.

Students can also have an impact on their schools and households. They can measure their schools' and families' carbon footprints--the total of GHG that a person is responsible for emitting into the atmosphere. They can encourage their families to use LED light bulbs, use public transportation, and buy in-season, locally produced fruits and vegetables because less fuel is used in transporting these foods to market.

Collective actions are almost anything that can be done with more than one person. For example, students can work together on campaigns to legislate the use of renewable energies, organize outings to plant trees, and write to elected representatives to encourage the construction of wind turbines. The important thing is for such collective action to stem from students' questions about and desires to address a local situation. Their investigation of options for addressing the situation that are feasible from societal, legal, economic, and scientific perspectives, followed by their assessment of the initiative's success is important. Campaigns lacking such context and rigor may have a low or no likelihood of leading to improvements and may, in fact, lead to backlash.

Recent years have seen the emergence of important initiatives designed to increase sustainability and build community. These initiatives offer opportunities for students to do research and become involved.

One initiative is smart growth—the planning and creation of communities that are more energy-efficient and that use resources more wisely than do communities today. To reduce commuting time, for example, smart-growth communities include offices and industries so that people can live near where they work, reducing drive times. Smart-growth communities also include plans for public transportation.

Zero waste refers to efforts by industries, communities, and municipalities to reduce the amount of waste they generate by recycling, reclaiming used resources, and eliminating emissions. The ultimate goal is to eliminate waste completely, substantially reducing the amount of GHG released into the atmosphere.

A third initiative is biomimicry—the effort to imitate strategies and patterns found in nature. By emulating plants and animals, engineers can design products that use and recycle energy more efficiently. One Web site on biomimicry cited, for example, a solar panel that emulates a leaf in its design.

The projects and activities that follow draw on a variety of sustainability initiatives. There should be emphasis on engaging students in the designing of activities and scaffolding of them so that students will experience success. In the activities, the

students will develop the higher-level skills of analysis, synthesis, decision-making, communication, and self-assessment.

LED Light bulb prices are falling and so will household power consumption - Cleveland Plain Dealer
http://www.cleveland.com/business/index.ssf/2012/01/led_lightbulb_prices_are_falli.html - comments

What You Can Do- EPA
http://www.cleveland.com/business/index.ssf/2012/01/led_lightbulb_prices_are_falli.html
http://www.epa.gov/climatechange/wycd/

Collective Actions

Biomimicry 3.3
http://biomimicry.net/about/mimicry

Climate Smart Communities: Local Action to Combat Climate Change- New York State Department of Environmental Conservation
http://www.dec.ny.gov/energy/50845.html

Preparing for Climate Change- CityofBoston.gov
http://www.cityofboston.gov/climate/adaptation/

State and Local Climate and Energy Program-EPA
http://www.epa.gov/statelocalclimate/

Welcome to the Zero Waste Alliance
http://www.zerowaste.org/

Why Smart Growth?
http://www.smartgrowth.org/why.php

Resources to back up entire document:
Massachusetts Climate Change Adaptation Report
http://www.mass.gov/eea/air-water-climate-change/climate-change/climate-change-adaptation-report.html

Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)-IPCC

http://ipcc-wg2.gov/SREX/report/

Summary

http://ipcc-wg2.gov/SREX/images/uploads/SREX-SPMbrochure_FINAL.pdf

U.S. 2013 National Climate Assessment: Key Findings-Scott Doney (WHOI)
U.S. Global Change Research Program
http://www.whoi.edu/fileserver.do?id=149804&pt=10&p=91553

Global Warming & Climate Change Article Archive- New York Times
http://topics.nytimes.com/top/news/science/topics/globalwarming/index.html?inline=nyt-classifier

Sources

Cleannet.org. *Climate Literacy: The Essential Principles of Climate Sciences: A Guide for Individuals and Communities.* March 2009. www.climatescience.gov. (accessed 6/1/13).

Gillis, Justin. "Climate Panel Cites Near Certainty on Warming." *The New York Times,* August 20, 2013.

Henson, Robert. *The Rough Guide to Climate Change: The Symptoms, The Science, The Solutions*. London: Rough Guides Ltd., 2011.

Intergovernmental Panel on Climate Change. *Climate Change 2007: Working Group 1: The Physical Science Basis.* Cambridge, England: Cambridge University Press, 2007. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html (accessed 8/156/13).

Intergovernmental Panel on Climate Change. *Climate Change 2007: Working Group II: Impacts, Adaptation, and Vulnerability.* Cambridge, England: Cambridge University Press, 2007.

Intergovernmental Panel on Climate Change. *Climate Change 2007: Working Group III: Mitigation of Climate Change.*

Karl, Thomas R., Jerry M. Melillo, and Thomas C. Peterson, editors. *Global Climate Change Impacts in the United States.* New York: Cambridge University Press, 2009.

Union of Concerned Scientists. *Global Warming Solutions: Prepare for Impacts.* http://www.ucsusa.org/global_warming/solutions/prepare-for-impacts. (accessed 10/4/2013).

UN Framework Convention on Climate Change, *Report of the Conference of the Parties on its fifteenth session, held in Copenhagen from 7 to 19 December 2009* http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf

U.S. Environmental Protection Agency. "Climate Change: Overview of Greenhouse Gases: Methane Emissions." http://epa.gov/climatechange/ghgemissions/bases/ch4.html (accessed 8/15/13).

U.S. Environmental Protection Agency. "Climate Change: Overview of Greenhouse Gases: Nitrous Oxide Emissions." http://epa.gov/climatechange/ghgemissions/bases/n2o.html (accessed 8/15/13).

Standards and Suggestions

The Importance of Academic Standards

As with most real-world issues, addressing climate change calls on the knowledge and skills of many academic disciplines. To participate in shaping our democracy's responses to climate change, students need to have a basic understanding of:

- The main causes of climate change and the scientific principles that drive it;
- The scale of its impacts on humans, societies and on natural areas;
- The impact that collective versus individual actions can have;
- The ways in which decisions are made in our local and national governments and the kinds of economic considerations and public policies that can effect change;

In addition, students need to be able to:

- Reason and articulate evidence-based arguments,
- Critique their own ideas and those of others, and
- Individually and collectively, make forward-looking decisions as consumers and as participants in their communities.

Where does climate change belong in the curriculum of our schools and in informal education programs?

We investigated this question by analyzing the newest academic standards that drive teaching, learning, and assessment in our education systems – i.e., the Common Core, Science, and Social Studies standards. Time constraints and limited resources prevented us from including additional disciplines. Nevertheless, we acknowledge that other disciplines also have a place in climate change education.

The reason we focused on standards is that, within formal K-12 schooling today, subject standards play a central role in determining what content teachers cover in

classrooms, what informal educators build into their programs, and how they cover that material. The extent to which students meet educational objectives outlined in standards (what they know and are able to do) is generally assessed through standardized tests. While each state determines its own subject standards, professional associations affiliated with academic disciplines also create standards. In some cases, states adopt these standards directly (as is the trend with Common Core standards, for example). In other cases, states may use these standards as guidelines or not at all. In all cases, however, concepts that do not appear in standards are less likely to be emphasized in the classroom since they will not be covered in standardized tests.

Standards and Suggestions

Science Standards and Grade-Banded Exemplar Units

The Next Generation Science Standards (NGSS) (http://www.nextgenscience.org/) were completed in April 2013 (with subsequent revisions in June and November, 2013). Some state governments are electing to adopt them.

Shortly after their completion, Frank Niepold and Scott Carley of CLEAN (Climate Literacy & Energy Awareness Network) analyzed the NGSS to identify how their "Performance Expectations" related to the climate science principles and concepts in the Climate Literacy document (http://www.globalchange.gov/resources/educators/climate-literacy). Their analysis also included correlations between the climate science principles and concepts and the three dimensions ("Disciplinary Core Ideas", "Science and Engineering Practices" and "Cross-cutting Concepts") of the 2011 National Research Council document, *A Framework for K-12 Education* (http://www.nap.edu/catalog.php?record_id=13165#), which underlies the NGSS. This work is posted online at http://cleanet.org/clean/community/cln/NGSS.html .

Since this analysis had already been done, we chose to use it, along with the NGSS website, the Common Core standards, and the CLEAN Collection of reviewed digital resources (at http://cleanet.org/clean/educational_resources/index.html) to construct units for teaching climate change. Each unit ties a series of high quality lessons into a coherent sequence of learning opportunities appropriate for a certain grade band. Those exemplar units can be found below in this section of the POLCA web page.

Next Generation Science Standards and Exemplar Units

By teaching units on climate change, you can cover several of the Next Generation Science Standards (NGSS). These standards were developed by a consortium of the states and are based on the *Framework for K-12 Science Education,* developed by the National Research Council.

This section provides examples of units on climate change that will cover related science standards. Each of four grade bands is covered: K-2, 3-5, 6-8, and 9-12. For each grade band, you will find a chart with relevant standards and a clarification of how each standard is relevant to climate change. The chart is followed by an exemplar unit on climate change that applies those standards. For each unit, you will find:

- Overview
- Goals
- Background information
- Time requirements
- Materials and resources
- Activities for teaching the unit

Grade Band: K-2

Unit Title: Weather, Weather, Everywhere!

Next Generation Science Standards for K-2	
Standard	Clarification Statement
K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time.	Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm). Examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include the fact that it is usually cooler in the morning than in the afternoon, and the number of sunny days cloudy days varies in different months. Assessment Boundary: The assessment of quantitative observations should be limited to whole numbers and relative measures such as warmer or cooler.
K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.	The emphasis is on local forms of severe weather.
K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment	Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.
2-ESS1-1. Make observations from media to construct an evidence-based account that Earth events can occur quickly or slowly.	Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly, and erosion of rocks, which occurs slowly.

	Assessment Boundary: The assessment of quantitative observations should be limited to whole numbers and relative measures such as warmer or cooler.
2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid.	

Unit Overview

The first step to understanding climate change is to develop an understanding of weather and how weather impacts our day-to-day lives in our own communities. Students then have a strong foundation to begin to understand weather in other parts of the world and can begin to distinguish between weather and climate. In this unit, students will use and create instruments to make and record weather observations and data. Students will collect data over time and analyze for patterns associated with time of year and compared to data in other parts of the world. This analysis of data will begin to build preliminary understandings of climate.

Unit Goals

- Students will create and use weather measurement technology to collect data on wind speed, barometric pressure, wind direction, temperature, and precipitation.
- Students will collect data over time and will analyze patterns associated with time of year and compare local weather data to weather data in other parts of the world.
- Students will develop a preliminary understanding of the relationship between weather and climate.

Background Information:
THE DIFFERENCE BETWEEN WEATHER AND CLIMATE

http://beyondpenguins.ehe.osu.edu/issue/weather-and-climate-from-home-to-the-poles/weather-and-climate-the-short-and-the-long-of-it

Time Requirements

Estimated time to complete the initial unit activities with students is approximately four weeks with opportunities for students to continue to collect and analyze weather data throughout the school year.

Materials and Resources

- Big thermometer
- Art materials (paper, glue, crayons, scissors, etc.)
- 8 two liter pop bottles, (with scissors to cut them).
- 8 thermometers, (with tape).
- To build a barometer: wide-mouthed glass jar or small coffee can, balloon (recommended) or plastic wrap, rubber band, scissors, drinking straw, cardboard strip, glue (recommended) or tape, ruler and pen or pencil, small piece of modeling clay, shoe-box sized cardboard box
- To build a rain gauge: Clear plastic ruler, Cylinder shaped clear jar (e.g. an olive jar), Rubber band, Funnel, Transparent tape
- To build a thermometer: Rubbing Alcohol, Water, Cylinder shaped clear jar or bottle (bottles with a narrow neck work best), 1 straw, Modeling clay, Food coloring
- To build a weather vane: Tag board or manila file folder, Straight pin, Scissors, Glue, Pencil with a new eraser, Plastic drinking straw, Modeling clay, Paper plate
- To build an anemometer: 4 small paper cups, 4 plastic drinking straws, tape, scissors, straight pin, pencil with a new eraser, stapler
- For weather walks, materials are dependent on the type of walks you take—see lesson plan
- For How's the Weather…In Africa: Copies of a world map, Computer with Internet access, Index cards with weather words and images, Images of activities appropriate for different weather conditions and seasons

Activity 1: What's the Weather Outside Today?
This lesson is on reading a thermometer, collecting temperature data, and analyzing temperature data patterns as they connect to changing seasons. This is a good introductory lesson to explore one aspect of weather and build students' data collection and analysis skills.
http://lessonplanspage.com/ScienceMathMeasuringTempSeasonsK1.htm/

Activity 2: Make a Weather Station
This activity engages students in constructing weather measurement tools as students explore how weather data collection technology works. Students then collect weather data, including barometric pressure, wind direction, wind speed, temperature, and precipitation in a weather log. Students analyze the weather data, exploring patterns and changes over time.
http://www.ciese.org/curriculum/weatherproj2/en/lesson1.shtml

Activity 3: Weather Walks
Weather walks engage students in relevant and real-time exploration of weather events such as sunny days, rainy days, hot days, etc. Students note the characteristics of weather events with related literature connections.
http://www.uen.org/Lessonplan/preview?LPid=10665

Activity 4: How's the Weather…in Africa?
In this lesson, students describe and later compare how weather affects human activity in two places on opposite sides of the world. This initial exploration begins to build understandings of how weather impacts our lives and sets the stage for understanding climate.
http://education.nationalgeographic.com/archive/xpeditions/lessons/04/gk2/pgafrica1.html?ar_a=1

Grade Band: 3-5

Unit Title: Earth's Changing Climate

Next Generation Science Standards for Grade 3	
Category of Standard	Standard
3. Interdependent Relationships in Ecosystem	
LS2.C: Ecosystem Dynamics, Functioning, and Resilience	The environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources. As a result, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (secondary to 3-LS4-4)
3. Weather and Climate	
ESS2.D: Weather and Climate	Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (3-ESS2-1) Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2)
	Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2)

ESS3.B: Natural Hazards	A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (3-ESS3-1) (Note: This Disciplinary Core Idea is also addressed by 4-ESS3-2.)

Next Generation Science Standards for Grade 4	
Category of Standard	Standard
4. Energy	
ESS3.A: Natural Resources	Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3-1)
ETS1.A: Defining Engineering Problems	Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (secondary to 4-PS3-4)
4. Earth's Systems: Processes that Shape the Earth	
ESS3.B: Natural Hazards	A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2) (Note: This Disciplinary Core Idea can also be found in 3.WC.)
ETS1.B: Designing Solutions to Engineering Problems	Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary to 4-ESS3-2)

Next Generation Science Standards for Grade 5	
Category of Standard	Standard
5. Matter and Energy in Organisms and Ecosystems	
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems	Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)
5. Earth's Systems	
ESS2.A: Earth Materials and Systems	Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)
ESS3.C: Human Impacts on Earth Systems	Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)

Unit Overview

Students are introduced to global climate change, including weather and climate. They will understand some of the forces behind climate change-carbon cycle and greenhouse effect and how human activities can both negatively and positively impact Earth's climate. Students learn about the difference between weather and climate, collect weather data over time, and compare the data to climate data for their area. Students learn the basic scientific phenomena related to climate change, including the carbon cycle. They will gain an understanding of how the carbon cycle is linked to the greenhouse effect and its relation to climate change.

The students will investigate and identify sources of electricity in their community and learn how much energy typical appliances and electronics use. In a service-learning project, students learn about the impact of climate change and what they can do to reduce their individual and school's carbon footprint. By participating in the National Wildlife Federation's Cool School Challenge, students conduct an energy audit of their school and propose ways of reducing their school's energy use. Additional activities are offered for students to explore how climate change is impacting wildlife.

Goals

- Describe aspects of the environment that change on a daily, weekly, monthly, and yearly basis.
- Record weather observations such as precipitation, temperature, or cloud cover.
- Describe the area's climate and identify factors that contribute to it and have changed it over time.
- Understand what global climate change is and how it affects our lives.
- Learn how carbon is stored, and how it is moved and redistributed around the earth system via the carbon cycle.
- Learn about greenhouse gases and begin to consider what events are causing an increase in the amount of greenhouse gases in the atmosphere.
- Identify sources of electricity used in the community (e.g., hydroelectric, fossil fuels, solar, nuclear).
- Identify ways to reduce their school's carbon footprint and design and conduct a carbon-reduction action project.

Time Requirements

Two weeks or more. See each activity for suggested time frame.

Materials and Resources (identified in activities)

- Graph paper
- Pencils
- Colored pencils
- Projector/overhead for displaying information
- Internet access

Activity 1: Differences between Climate and Weather

http://eo.ucar.edu/educators/ClimateDiscovery/LIA_lesson1_9.28.05.pdf
As the first step in understanding global climate change, students need to understand the relationship between weather and climate. In this activity, students learn to collect and graph local weather data. Over several days or weeks, students graph temperature data and compare the data with average climate data where they live. They learn to distinguish between weather and climate.

Time:

- 30 minutes introduction
- 10 minutes daily (for one or more weeks)
- Part 1 graphing/analysis: 45 minutes
- Part 2 graphing/analysis: 45 minutes

Weather and Climate: What's the Difference?-A similar activity to Differences between Weather and Climate.

http://www.ciese.org/curriculum/weatherproj2/en/activityC5.shtml

Climate and Weather

http://video.nationalgeographic.com/video/player/science/earth-sci/climate-weather-sci.html

National Geographic

Supporting video on distinguishing the difference between weather and climate. Video length: 3:22 minutes.

Activity 2: Carbon Journey

Students learn the basic scientific phenomena related to climate change, including the carbon cycle. The Carbon Journey is a hands-on activity--a kinesthetic game illustrating the dynamics of the carbon cycle. Acting as carbon atoms, students

travel from one carbon reservoir to another. At each reservoir they determine, by rolling dice, how long they stay in the reservoir or how likely it is that they will move to another carbon reservoir.

http://www.andrill.org/education/elf_activities_1C.html

http://www.andrill.org/education/Activities%20PDFs/1%20Energy/1C/carbonJourneyWCredits.pdf

Time:

Two class periods for game and discussion

Materials:

- Beads to collect at each of the reservoirs in the journey (having a separate color for each bucket is recommended)
- Bracelet string to hold beads in order
- Buckets to represent reservoirs: Oceans, Plants, Soils, Atmosphere, Animals, Fossil Fuels, Rock, etc., labeled with photographs or pictures of carbon storage types
- Graphic of the carbon cycle
- Cardboard cubes with processes
- Labels and pictures for carbon reservoirs
- Scissors to cut out labels and string
- Glue sticks or tape -- to affix labels to buckets and cubes
- Carbon journey station labels

Activity 3: Climate Change and the Greenhouse Effect

The students will be introduced to the greenhouse effect and how it is heavily influenced by carbon emissions through a demonstration and/or hands-on lab activity. In this activity, students construct a physical model and discover that air trapped in a container will heat up more than air in an open container. The experiment/demonstration is followed by viewing a short video about the greenhouse effect and how it causes changes in global temperatures.

Time: 1 class period (approximately 45 minutes)

THE GREENHOUSE ACTIVITY IN A JAR

http://sln.fi.edu/tfi/activity/earth/earth-5.html

Materials (for every group of four students):

- 2 Small thermometers
- 1 Jar or other see-through container
- 1 Clock or watch
- 1 Copy of the worksheet
- Sunlamp or access to a sunny area to perform the experiment

A HOME RUN ON STEROIDS: BASEBALL AND CLIMATE CHANGE

http://www.climatecentral.org/blogs/steroids-baseball-and-climate-change

National Center for Atmospheric Research, Climate Central

This short cartoon video uses a simple baseball analogy (steroid use increases probability of hitting home runs) to explain how small increases in greenhouse gases can cause global temperature changes and increase the probability of extreme weather events.

Video length: 2:04 minutes

GLOBAL WARMING FAQ, NOAA SATELLITE AND INFORMATION SERVICE

http://www.ncdc.noaa.gov/oa/climate/globalwarming.html

The National Oceanic and Atmospheric Administration created this page to help kids (and adults!) learn more about the greenhouse effect and how it is impacting our planet.

Global Warming Movie, EPA Kids Sitehttp://epa.gov/climatechange/kids/global_warming_version2.html

This website, from the Environmental Protection Agency, provides an animated step-by-step breakdown of the greenhouse effect. The animation is narrated by two young students and is presented in kid-friendly language.

PHOTOSYNTHESIS, TREES, AND THE GREENHOUSE EFFECT, NATIONAL GEOGRAPHIC XPEDITIONS

http://www.nationalgeographic.com/xpeditions/lessons/08/g68/brainpopphoto.html

Designed for grades 6–8, this lesson plan leads students in a lab that will help them understand where greenhouse gases come from and also help them begin to think about how we can regulate greenhouse gases.

CLIMATE SCIENCE IN A NUTSHELL: WHERE CARBON DIOXIDE COME FROM?

http://www.planetnutshell.com/videos/climate-science-in-a-nutshell-5-where-does-carbon-dioxide-come-from

Planet Nutshell, Utah Education Network

This short video discusses where carbon dioxide, the gas that is mainly responsible for warming up our planet and changing the climate, comes from. It discusses how the rise in

atmospheric carbon dioxide comes directly from the burning of fossil fuels and indirectly from the human need for energy.

Video length: 2:49 minutes.

NPR short videos about carbon and global warming.http://www.npr.org/news/specials/climate/video/

Activity 4: Energy

In these activities and videos, students learn about sources of energy, how much energy typical appliances and electronics use, and how much carbon dioxide is released to produce the energy.

PLUGGED IN TO CO_2

http://www.windows2universe.org/teacher_resources/teach_pluggedCO2.html

Lisa Gardiner, Marie Johnson, Jonathan Hoffman, Windows to the Universe

In this classroom activity, students measure the energy use of various appliances and electronics and calculate how much carbon dioxide (CO2) is released to produce that energy.

Time: 1-2 class periods

Materials:

- Kill-a-Watt meter
- Power strip and outlet
- A collection of small appliances and lamps (may include toaster, microwave, hairdryer, lamp with CFL, lamp with incandescent bulb, cell phone and charger, laptop and charger, iPod and charger, CD player, TV, DVD, video game player, blender, nightlight, vacuum, coffee maker, fan)
- Pencils

ENERGY SOURCES

This video provides an introduction to benefits and limitations of many sources of energy including fossil fuels, nuclear, hydro, wind, solar, geothermal, and biomass. It also discusses hydrogen and hybrid cars.

Video length: 6:09 min.

http://www.pbslearningmedia.org/resource/phy03.sci.ess.earthsys.energysource/

WGBH - PBS, Teachers' Domain

SOLUTIONS AND SERVICE PROJECTS

Students learn about the impact of climate change and what they can do to

reduce their individual and school's carbon footprint. Students view a music video on the causes and effect of climate change and then view a short video on how one individual has worked to reduce his family's carbon footprint. The students conduct an action project by participating in the National Wildlife Federation's Cool School Challenge. Students conduct an energy audit of their school and propose ways of reducing their school's energy use.

TAKE AIM AT CLIMATE CHANGE

http://passporttoknowledge.com/polar-palooza/whatyoucando/taacc/

This music video features a rap song about some of the causes and effects of climate change with the goal of increasing awareness of climate change and how it will impact nature and humans. The website also includes links to short fact sheets with lyrics to the song that are annotated with the sources of the information in the lyrics. Video length 4 minutes

A STRICT CARBON DIET

http://www.pbs.org/wgbh/nova/tech/carbon-diet.html

Doug Hamilton, Producer, NOVA (WGBH-TV)

This short video follows San Francisco inventor and engineer Saul Griffith as he determines his family's carbon footprint and develops a special cargo bike to further reduce his individual footprint. This video highlights innovation, creativity, and design as solutions to problems. The overall message is inspiring and proactive.

Video length: 2:58 min.

THE COOL SCHOOL CHALLENGE-NATIONAL WILDLIFE FEDERATION ECO-SCHOOLS PROGRAM

Students challenge classrooms to reduce their carbon emissions and use a carbon calculator to evaluate progress. Students conduct classroom energy audits and identify major sources of carbon dioxide emissions and ways to reduce their school's energy use. The Cool School Challenge is an educational program intended to engage students and teachers in practical strategies to reduce carbon dioxide (CO2) and other greenhouse gas emissions schoolwide. Through improved energy efficiency, reduced consumption, increased recycling, and changes in transportation behaviors, Challenge participants will learn how simple actions, taken together, can create a climate of change.

Action project that includes an energy audit, evaluation and action project. Elementary and secondary materials.

http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Cool-School-Challenge.aspx

Additional Activities and Resources

National Wildlife Federation, Climate Change 101

NWF provides information for kids about climate change and lesson plans for the classroom on how climate change in impacting wildlife.

http://climateclassroomkids.org/

Climate Change Live

http://climatechangelive.org/index.php?pid=180#4

CURRICULUM RESOURCES

Global Warming & the Greenhouse Effect. Great Explorations in Math and Science (GEMS), Lawrence Hall of Science, University of California at Berkeley.

Climate Change: Connections and Solutions. An interdisciplinary Curriculum. Facing the Future.www.facingthefuture.org. Curriculum is under their free downloads section.

National Wildlife Federation: Energy Conservation Did I Remember to...

http://www.nwf.org/pdf/Schoolyard%20Habitats/EnergyConservation.pdf

Lessons designed to engage student in learning good conservation techniques and practices to use at home and at school. Grades 4-6

Grade Band: 6-8

Unit Name: Arctic Investigations

Next Generation Science Standards for Grades 6-8	
Disciplinary Core Ideas	
Category of Standard	Standard
ESS3.D: Global Climate Change	Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)

ESS3.C: Human Impacts on Earth Systems	Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)
Performance Expectations	
Category of Standard	Standard
MS-LS2-1	Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-4	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
MS-ESS3-2	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Unit Overview

By participating in inquiry-based activities, students become climate scientists as they investigate rapid changes happening in the Arctic regions. Students will use real data collected by climate scientists to determine the rate and severity of changes such as melting sea ice, population declines, and impacts on local peoples. The unit will conclude with activities geared toward a reduction of energy and natural resources that will help students connect their lifestyle choices to reducing the rate of changes in the Arctic.

Unit Goals

CLEAN is the Climate Literacy and Energy Awareness Network (http://cleanet.org/index.html). Using activities from CLEAN, the students will investigate the following questions:

- How is climate change impacting the Arctic region?
- What is causing these changes?

- How do scientists track changes? Predict future climate?
- How does arctic climate change affect people, wildlife, global climate?
- What can we do?

Time Requirements

The time requirements for each activity are only an estimate. This unit can be done in its entirety within a whole year, within a semester or over several weeks. Teachers can pick and choose various activities to accommodate for time constraints.

Materials

Materials needed for entire unit (see activity links for specific materials):

- Computer/iPad with internet access
- Pencils
- Notebook/scrap paper
- Posterboard
- Markers
- Graph paper
- Projector or Smart Board

Additional Resources

SEA ICE INDEX ANIMATION TOOL

http://nsidc.org/data/seaice_index/archives/image_select.html

Summary: This visualization presents a collection of sea ice data taken over a period of 34 years. Selected data can be animated to show changes in sea ice extent over time. Data is added by the National Snow and Ice Data Center as it becomes available.

COMBATING GLOBAL WARMING MIND MAP
http://media.learningfundamentals.com.au/combating-global-warming-map.jpg
Summary: An attractive concept/mind map that illustrates various human strategies for responding to climate change. It was developed by a psychologist and not by an educator or scientist but can be used to inspire discussion and artistic representations of the human dimension to climate and energy issues.

Activity 1: How is climate change impacting the Arctic region? (photo comparison activity only)

Investigation 4 - Changes in Our Local Environment

http://seagrant.uaf.edu/marine-ed/curriculum/grade-8/investigation-4.html

Time: One to two 45-minute periods to complete photo comparison activity

Summary: Based on the information and photos they acquired from the interview, students return to photo locations to observe and record changes. Finally, they develop ideas about potential impacts of a warming climate on the ecosystem that surrounds the students.

Activity 2: What is causing these changes?

GREENHOUSE GASES EXPOSED

http://www.ecohealth101.org/index.php?option=com_content&view=article&id=180%3Ateachers-lp-greenhouse-article&catid=130&Itemid=272

Time: One 45-minute period

Summary: In this activity, students learn about the relationship between greenhouse gases and global warming through a simple teacher demo or hands-on lab activity. Everyday materials are used: beakers, baking soda, vinegar, candle, thermometers, heat source such as a goose-necked lamp, etc. Students shine a light onto three thermometers: a control, an upside down beaker w/ a thermometer and air, and a beaker in which CO2 had been poured.

USING THE VERY, VERY SIMPLE CLIMATE MODEL IN THE CLASSROOM
http://www.windows2universe.org/teacher_resources/teach_climatemodel.html
Time: Two 45-minute periods
Summary: Through a simple online model, students learn about the relationship between average global temperature and carbon dioxide emissions while predicting temperature change over the 21st Century.

Activity 3: How do scientists track changes? Predict future climate? (Teacher picks one)

1) WHITHER ARCTIC SEA ICE?

http://serc.carleton.edu/eet/seaice/index.html

Time: Two or three 45-minute periods

Summary: In this activity, students work with real datasets to investigate a real situation regarding disappearing Arctic sea ice. The case study has students

working side-by-side with a scientist from the National Snow and Ice Data Center and an Inuit community in Manitoba.

2) GETTING TO THE CORE OF CLIMATE CHANGE

How can we use ice core data from the polar regions to investigate changes in Earth's climate past, present, and future?

http://tea.armadaproject.org/activity/leppik/gettingtothecoreofclimatechange_main.html

Time: Four to five 45-minute periods

Summary: Students investigate climate changes going back thousands of years by graphing and analyzing ice core data from Greenland and Antarctica. They use information about natural and human-caused changes in the atmosphere to formulate predictions about the Earth's climate.

Activity 4: How does arctic climate change affect people, wildlife, global climate?

PEOPLE

*Eyewitnesses to Change:*http://forces.si.edu/arctic/pdf/ACT%201_EYEWITNESS.pdf

Link to video: http://forces.si.edu/arctic/video/eyewitness.html.

Time: Two 45-minute periods

Summary: Students explore recent changes in the Arctic's climate that have been observed and documented by indigenous Arctic residents. Students watch a video, take notes, and create a concept map. Students also examine historical weather data for an Arctic community.

WILDLIFE

Students can choose one activity to complete for this section.

1) *Changes Ahoof: Could Climate Change Affect Arctic Caribou?*

http://forces.si.edu/arctic/pdf/ACT%205_CHANGES%20AHOOF.pdf

Time: One 45-minute period

Summary: Students run a simplified computer model and create board games to explore how climate conditions can affect caribou—the most abundant grazing animal in the Arctic.

2) *March of the Polar Bears: Global Change, Sea Ice, and Wildlife Migration*

http://mynasadata.larc.nasa.gov/lesson-plans/1332-2/?page_id=474?&passid=90

Time: Two 45-minue periods

Summary: Students will use NASA satellite data to study temperature and snow-ice coverage in the South Beaufort Sea, Alaska. The data can be used to correlate with USGS ground tracking of polar bears, and to relate this to global change, sea ice changes, and polar bear migration. The data can be used to draw conclusions surrounding any migration patterns in the region.

GLOBAL CLIMATE (FEEDBACK EFFECTS)

Changing Planet: Thawing Permafrost and Methane (Video)

http://www.nbclearn.com/changingplanet/cuecard/52627

Time: 20-25 minutes to watch video and discuss with class

Summary: This video examines the thawing of permafrost due to changes in climate and shows examples of the impacts that warming temperatures have on permafrost in the Arctic, including the release of the greenhouse gas methane. Dramatic results are shown, including sink holes forming on the landscape and beneath buildings, roads, and other infrastructure, causing some communities to relocate.

UNDERSTANDING ALBEDO

http://www.arcticclimatemodeling.org/lessons/acmp/acmp_912_ClimateChange_UnderstandingAlbedo.pdf

Time: One 45-minute period

Summary*:* Students learn about albedo and the ice albedo feedback effect as it relates to snow, ice, and the likely results of reduced snow and ice cover on global temperatures.

Activity 5: What can we do?

PLUGGED IN TO CO2

http://www.windows2universe.org/teacher_resources/teach_pluggedCO2.html

Time: One to two 45-minute class periods

Summary: Students investigate various appliances and electronics, discovering how much energy each uses and how much carbon dioxide (CO2) is released to produce that energy.

THE LIFESTYLE PROJECT

http://serc.carleton.edu/introgeo/enviroprojects/lifestyle.html

Time: Can be completed during entire unit or as an independent unit to complement this one

Summary: This three-week project challenges students to learn about environmental alternatives by modifying their own lifestyles. Throughout the project, students reduce their impacts on the environment by changing the way in which they live from day to day.

Grade Band: 9-12

Unit Title: Large Volcanic Eruptions and How They Affect Climate Change

Next Generation Science Standards:	
HS-ESS2-4.	Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]
HS-ESS3-5.	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

Unit Overview: Students will begin to analyze data and the results of global climate models to predict how regional climate will be altered after a large volcanic eruption. Students will be able to show an understanding of how using models can help explain how the variations in the flow of energy into the atmosphere and geosphere can result in changes in our climate over a time period of 10 years. In this unit, students will analyze and create models from evidence collected from satellite photos and NOAA data and predict the future impacts on regional climate and possible impacts on the whole world. Students will analyze collected data over

time and create a model comparing data to that of other parts of the world. This analysis of data will demonstrate a growing mastery in understanding climate change.

Unit Goals:

- Students will analyze and create models from evidence collected from satellite photos and NOAA data.
- Students will analyze data collected over time and will look for patterns associated with time of year and compare local weather data to weather data in other parts of the world.
- Students will predict the future impact of the climate on the regional climate and possible impact on the whole world.

Background Information: *Scientific American* article – "How Do Volcanoes Affect Climate?"

http://www.scientificamerican.com/article.cfm?id=how-do-volcanoes-affect-w

Time Requirements: Estimated time to complete the activities with students is approximately 5 or 6 (50 minute) periods.

Materials and Resources:

- Computer(s) for researching volcanic eruptions
- Poster size map of the world
- Student pages from Activity A and B
- A blank 8.5 x 11 in. map of the world with latitude and longitude lines found at the following link: http://www.freeusandworldmaps.com/images/WorldPrintable/WorldMercator6LinesPrint.jpg
- Data tables from activity A and B at the end of this lesson plan
- Coloring pencils
- Ruler
- Blank map of North America (US and Canada) found at: http://1.bp.blogspot.com/-ztwMAmt7hck/T12d0V0lYhI/AAAAAAAABkA/KaYFJC8qgjc/s1600/blank-north-america-map.png
- A copy of the Jet Stream Map found at: http://www.intellicast.com/National/Wind/JetStream.aspx

Day 1 Activity: 10 Biggest Volcanic Eruptions in History

Students will choose one volcanic eruption from this list and research the history of the eruption. As a class, students should brainstorm questions that will guide

their research of the eruption of their choice. Students will need to begin to create a list of critical vocabulary words and their definitions from their research. The students will need to compile this list as a class. This research will be used in Day 4 and 5 activities.
http://www.livescience.com/30507-volcanoes-biggest-history.html
VEI - Volcanic Explosion Index

http://www.unc.edu/~rowlett/units/scales/VEI.html

Days 2 and 3: Krakatoa - Youtube Video (52 minutes)

*Note to teachers: There are two parts to this video. Depending on time, we recommend Part 2 of this video if you only have one class period to spend studying the effect of volcanic eruptions. However, if time allows, Part 1 of this video shows the earth systems of how an eruption begins and builds. If you can show both parts of this video, you can make connections to HS-ESS-2-2 and HS-ESS-2-3. As always, preview the videos before you show them to your students.

Experience the volcanic eruption of Krakatoa - the loudest sound ever heard. Have the students create a timeline of events that lead up to the main eruptions and discuss the environmental impact of this massive eruption on the South Pacific islands and the World.

Creative Writing Activity: Students can create a journal entry that would be similar to those found from 1883 that help today's scientists understand what was happening around them. Have the students pretend to live in Sumatra and describe to future generations what they experience as a series of quakes, eruptions, and how a tsunami devastates the area.

Part 1: (52 minutes) http://www.youtube.com/watch?v=ha4LQGe6NxY

Part 2: (Recommended-52 minutes)http://www.youtube.com/watch?v=YgGkjDlEaMA

Days 4/5: Below is a link to NOAA activities that will take 2 days to complete. Students will need to answer all questions within the daily activities and complete all tables, charts and maps.

Activity A: Day 4 - Where and when have major volcanic eruptions occurred?

Activity B: Day 5 - How are aerosols dispersed through the atmosphere after a volcanic eruption?

Links to activities found at: http://www.esrl.noaa.gov/gmd/infodata/lesson_plans/Volcanoes%20and%20Climate%20Change.pdf

Day 6: Students will need to choose one of the following Cascade Mountains: Mt. Rainier, Mt. Baker, Mt. St. Helens, or Mt. Hood. Students will be given a copy of a map of North America, a copy of the Jet Stream map, a copy of a world map, and a ruler. Based on the location of the volcano they select in the Cascades Mountains, students will need to determine where the ash plume will be carried and predict a five-day progression of the ash across North America based on jet stream wind speeds. Have them investigate the following: a) How many days would it take for the ash cloud to reach the Atlantic Ocean? and b) If the jet stream were to continue at the same rate of speed, how many days would it take the ash to circle the Earth one time?

Enrichment Activities:

If time permits on any of the previous days:

- Have students explore the VAAC website and answer: What is its purpose? What information can geoscientists and environmental scientists all over the world gain from these pages? http://www.ospo.noaa.gov/Products/atmosphere/vaac/
- Have students watch webcams that are streaming data video from active volcanoes around the world at http://www.ospo.noaa.gov/Products/atmosphere/vaac/webcams.html

Grade Band: 9-12

Unit Name: What Can We Do About Climate Change?

Next Generation Science Standards	
Disciplinary Core Ideas	
Standard	Clarification Statement
ESS2.A: Earth Materials and Systems	The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4) Gradual atmospheric changes were due to plants and other organisms that captured CO_2 and released oxygen. (HS-ESS2-6),(HS-ESS2-7)
ESS2.D: Weather and Climate	The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4)

	Changes in the atmosphere due to human activity have increased CO_2 concentrations and thus affect climate. (HS-ESS2-6),(HS-ESS2-4) Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary to HS-ESS3-6)
ESS3.A: Natural Resources	Resource availability has guided the development of human society. (HS-ESS3-1). All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)
ESS3.C: Human Impacts on Earth Systems	The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3) Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)
ESS3.D: Global Climate Change	Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)
ETS1.A: Defining and Delimiting Engineering Problems	Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)

Performance Expectations	
Standard	Clarification Statement
HS-ESS2-4:	Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
HS-ESS2-6:	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
HS-ESS2-7:	Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

HS-ESS3-1:	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3-2:	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
HS-ESS3-3:	Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
HS-ESS3-4:	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
HS-ESS3-5:	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
HS-ESS3-6:	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
HS-ETS1-1:	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Unit Overview: During this unit, students engage in a wide variety of experiences to gain an understanding of the natural climate system, how this system is changing due to human activities, and how technology and engineering can help us learn more about problems and solutions associated with climate change.

Unit Goals: Using activities from the CLEAN Collection, students will:

- Identify how the climate system has changed over the history of the earth.
- Examine and explain historic climate data for a region.
- Measure and calculate the radiative budget for a variety of Earth surfaces.
- Identify how changing the composition by burning fossil fuels and adding CO_2 to the atmosphere is affecting the planet's radiative budget.
- Evaluate how different existing energy technologies can help to reduce the amount of CO_2 humans are adding to the atmosphere to make societies more sustainable.
- Model and predict the impacts of climate change.
- Investigate the role of engineering to help humans mitigate and adapt to climate change.

Time Requirements: Two to three weeks, depending on the depths of exploration.

Materials: (see activity links for specific materials)

- Computers with Internet access
- Pencils and pens
- Paper (blank, lined, and graph)
- Projector and/or SmartBoard

Extra Resources: *EarthLabs for Educators* found at: http://serc.carleton.edu/earthlabs/index.html. This link provides a rich and varied set of resources that will help the educator identify a variety of strategies that will enable a more rigorous and relevant approach to teaching about climate and climate change.

LASP: Climate Change Compendium

http://lasp.colorado.edu/home/education/k-12/climate-change-compendium/#Grades9-12

The Climate Change Compendium contains activities and lessons from a variety of sources that will help facilitate classroom studies about the serious issues involved in climate change. Students will be able to learn about the greenhouse effect, natural and human climate records, albedos, feedback loops, and how all of these factors are affecting the polar regions. The Compendium provides background readings, scope and sequences, image banks, and evaluation tools to help teachers bring climate change science into the classroom. At the end of each grade level are various activities outlining what we can do, as well as strategies to reduce the nation's greenhouse gas emissions.

Activities:

A. Interactive Geologic Timeline Activity (ESS2.A)

http://www.ei.lehigh.edu/eli/cc/sequence/day15.html

Environmental Literacy and Inquiry Working Group at Lehigh University

Time: One class period or homework assignment

Summary: Students use a web-based geologic timeline to examine temperatures, CO_2 concentrations, and ice-cover data to investigate how climate has changed in the last 715 million years.

B. Normal Climate Patterns (ESS2.D)

http://serc.carleton.edu/earthlabs/drought/3.html

Betsy Youngman, LuAnn Dahlman, Earthlabs from TERC

Time: Two class periods.

Summary: *Students make in-depth examinations of historical climate data in both graphical and map formats.*

C. Earth's Albedo (ESS2.D)

http://www.andrill.org/education/elf_activities_1D.html

Environmental Literacy Framework, ANDRILL

Time: One Class Period

Summary*:* Students measure albedo using maps and data tables. They estimate the Earth's energy budget by calculating the absorbed radiation of various Earth surfaces.

D. Climate Science in a Nutshell: Where CO_2 Come From? (ESS2.D)

http://www.planetnutshell.com/videos/climate-science-in-a-nutshell-5-where-does-carbon-dioxide-come-from

Planet Nutshell, Utah Education Network

Time: the first five minutes of class

Summary: Students view a short video that explains that burning fossil fuels is causing an increase in atmospheric CO_2 which is changing the composition of the atmosphere and causing the climate to warm. (Use as an introduction to the Mass Balancing Model by SERC)

E. Using a Mass Balance Model to Understand CO_2 and Its Connection to Global Warming (ESS2.D)

http://serc.carleton.edu/quantskills/activities/co2_global.html

Robert MacKay, SERC - Teaching Quantitative Skills in Geoscience Collection

Time: Two-three class periods

Summary: Students use an interactive online mode to examine the changes in atmospheric CO_2 for the past several decades. Students make predictions about current and future levels of CO_2 emissions. (Two-three class periods)

F. Stabilization Wedges Game (ESS3.A)

http://cmi.princeton.edu/wedges/game.php

Carbon Mitigation Initiative, Princeton University

Time: Two class periods.

Summary: Students work in teams to learn how existing technologies can be implemented and used to dramatically reduce carbon emissions. Students select carbon-cutting strategies to create a carbon mitigation profile, filling in the wedges of a climate stabilization triangle.

G. Earth-the Operator's Manual (ESS3.C)

http://earththeoperatorsmanual.com/feature-video/earth-the-operators-manual

Earth-The Operator's Manual, Richard Alley

Time: 1-3 class periods depending on how much of the video series is shown

Summary: This video series provides students with a detailed accounting of the resources that we have available to us and how we can change our usage to become a more sustainable civilization.

H. Changing Planet: Rising Sea Level (ESS3.D)

http://www.nbclearn.com/changingplanet/cuecard/53460

NBC Learn, Windows to the Universe

Time: 6:21 minutes

Summary: This video introduces students to some of the social and economic impacts of sea level rise due to global warming. Students hear from scientists who are using different types of technology to measure and observe changes that allow them to model and predict the changes they are witnessing.

I. Carbon Temperature Model (ESS3.D)

http://earth4u.challenger.org/

Time: One to two class periods.

Summary: Students select different scenarios (deforestation, volcanoes, hurricanes) and change the inputs and outputs in this interactive model on carbon-temperature relationships. As users change variables, the results are

graphically represented, demonstrating how selections affect the whole system.

J. Connecting Global Climate Change with Engineering (ETS1.A)

http://www.pbs.org/teachers/stem/professionaldevelopment/050/

NASA and PBS Teachers

Time: Three to five class periods.

Summary: As students explore engineering careers, they investigate the role of engineering solutions in mitigating and adapting to climate change. Options include removing and storing CO_2

Standards and Suggestions

Common Core Literacy Standards and Teaching Suggestions

The Common Core State Standards (CCSS) span grades K-12 and include skill sets like reading, writing, language usage, and speaking and listening. In this section, we do not aim to suggest all possible CCSS connections to climate change education. Instead, we offer examples to demonstrate the many possibilities for making the connections.

One point that deserves emphasis is that instruction on climate change provides ample opportunities for interdisciplinary teaching. To underscore the interdisciplinary opportunities, we have included writing activities to help language arts teachers connect language arts to science. We have done so by providing activities that explore the science of climate change *and then suggesting writing activities that use the science as a stimulus for writing.* You will find these writing activities under "Common Core" in the Standards section of this Web site.

In addition, we would like to call to your attention to two critical CCSS standards that may assist your climate change instruction.

1. Distinguishing between facts and speculation

The standard **CCSS.RST.6-8.1** reads as follows:

> Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (*Common Core State Standards,* Washington, D.C.: National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010, 62.)

Many debates about climate change pit scientific findings against beliefs. This CCSS establishes the literacy goal of having students distinguish between the

scientific knowledge and beliefs instead of considering them as equally-supported perspectives.

2. Should anything be done?

The standard **CCSS.SL.8.4** reads as follows:

> Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (*Common Core State Standards,* 49).

Consider challenging students to discuss *if* action needs to be taken to reverse climate change. Engaging students in a well-informed dialogue about this issue may generate more authentic action than if teachers skip this discussion and proceed immediately to solving the problem.

Common Core State Standards and Teaching Climate Change

A major goal of the POLCA is to be relevant not only to science professionals, but for teachers across disciplines. This section provides examples of activities for climate change education that will cover related common core standards. Each of the following three grade bands is covered: K-2, 3-5, and 6-8. For each grade band, you will find descriptions of or links to activities, suggestions for extension, and a chart with relevant common core learning standards.

Grade Band: K-2

Activity Title: Weather Walks

Weather walks engage students in relevant and real time exploration of weather events such as sunny days, rainy days, hot days, etc. Students note the characteristics of weather events with related literature connections. See full activity at: http://www.uen.org/Lessonplan/preview?LPid=10665

Language Arts Connection (K-2): Explanatory Writing About a Weather Walk

Purpose: The K-2 science unit, "Weather, Weather, Everywhere!" has students develop a deeper understanding of weather by engaging in a variety of activities. One of the activities is to have students engage in weather walks in which they observe details about the weather.

Objective: The students will develop their informative/explanatory writing skills by writing a description of the weather on one of their weather walks.

1. As the students take their weather walk, have them take notes about what they see, feel, taste, touch, and smell. Encourage them to write as many details as they can.
2. When they return to the classroom, have the students arrange their details in the order that they followed on their walk.
3. The students should write a topic sentence that summarizes the weather on the day on which they walked. For example, they might describe the weather as sunny, rainy, or snowy.
4. After they have their details in the order in which they want, ask them to write a first draft of their paragraph. Tell them to use as many vivid details as they can.
5. Ask the students to revise their paragraphs. Have they used as many details as possible? Will the order make sense? Have they checked their spelling?
6. Have the students share their paragraphs by reading them aloud to their class.

Reading Standards for Informational Text K-5 (for example, grade K)

CCSS.RI.K.1	With prompting and support, ask and answer questions about key details in a text.
CCSS.RI.K.2	With prompting and support, identify the main topic and retell key details of a text.
CCSS.RI.K.3	With prompting and support, describe the connection between two individuals, events, ideas, or pieces of information in a text.
CCSS.RI.K.4	With prompting and support, ask and answer questions about unknown words in a text.
CCSS.RI.K.5	Identify the front cover, back cover, and title page of a book
CCSS.RI.K.6	Name the author and illustrator of a text and define the role of each in presenting the ideas or information in a text.
CCSS.RI.K.7	With prompting and support, describe the relationship between illustrations and the text in which they appear (e.g., what person, place, thing, or idea in the text an illustration depicts)
CCSS.RI.K.8	With prompting and support, identify basic similarities in and differences between two texts on the same topic (e.g., in illustrations, descriptions, or procedures).

Writing Standards K-5 (for example, grade 1)

CCSS.W.1.1	Write opinion pieces in which they introduce the topic or name the book they are writing about, state an opinion, supply a reason for the opinion, and provide some sense of closure.
CCSS.W.1.2	Write informative/explanatory texts in which they name a topic, and provide some sense of closure.
CCSS.W.1.5	With guidance and support from adults, focus on a topic, respond to questions and suggestions from peers, and add details to strengthen writing as needed.
CCSS.W.1.8	With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

Language Standards K-5 (for example, grade 2)

CCSS.L.2.1	Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
CCSS.L.2.2	Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
CCSS.L.2.3	Use knowledge of language and its conventions when writing, speaking, reading, or listening.
CCSS.L.2.6	Use words and phrases acquired through conversations, reading, and being read to, and responding to texts, including using adjectives and adverbs to describe (e.g., When other kids are happy that makes me happy).

Speaking and Listening Standards K-5 (for example, grade 2)

CCSS.SL.2.1	Participate in collaborative conversations with diverse partners about grade 2topics and texts with peers and adults in small and larger groups.
CCSS.SL.2.2	Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.
CCSS.SL.2.4	Tell a story or recount an experience with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences.
CCSS.SL.2.6	Produce complete sentences when appropriate to task and situation in order to provide requested detail or clarification.

Grade Band: 3-5

Activity Title: Solutions and Service Projects

Students learn about the impact of climate change and what they can do to reduce their individual and school's carbon footprint. Students view a music video (link below) on the causes and effect of climate change, and then view a short video on how one individual has worked to reduce his family's carbon footprint. The students conduct an action project by participating in the National Wildlife Federation's Cool School Challenge or conduct an energy audit of their school and propose ways of reducing their school's energy use.

TAKE AIM AT CLIMATE CHANGE

http://passporttoknowledge.com/polar-palooza/whatyoucando/taacc/

This music video features a rap song about some of the causes and effects of climate change with the goal of increasing awareness of climate change and how it will impact nature and humans. The website also includes links to short fact sheets with lyrics to the song that are annotated with the sources of the information in the lyrics. Video length 4 minutes

A STRICT CARBON DIET

http://www.pbs.org/wgbh/nova/tech/carbon-diet.html

Doug Hamilton, Producer, *NOVA*, WGBH-TV

This short video follows San Francisco inventor and engineer Saul Griffith as he determines his family's carbon footprint and develops a special cargo bike to further reduce his individual footprint. This video highlights innovation, creativity, and design as solutions to problems. The overall message is inspiring and proactive.

Video length: 2:58 min.

THE COOL SCHOOL CHALLENGE-NATIONAL WILDLIFE FEDERATION ECO-SCHOOLS PROGRAM

Students challenge classrooms to reduce their carbon emissions and use a carbon calculator to evaluate progress. Students conduct classroom energy audits and identify major sources of carbon dioxide emissions and ways to reduce their schools energy use. The Cool School Challenge is an educational program intended to engage students and teachers in practical strategies to reduce carbon dioxide (CO2) and other greenhouse gas emissions school wide. Through improved energy efficiency, reduced consumption, increased recycling and changes in transportation behaviors, Challenge participants will learn how simple actions, taken together, can create a climate of change.

Action project that includes an energy audit, evaluation and action project. Elementary and secondary materials. http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Cool-School-Challenge.aspx

Language Arts Connection (3-5): Writing an Opinion About Climate Change

Purpose: The 3-5 science unit, "Earth's Changing Climate," has students develop a deeper understanding of global climate change through several activities. In one activity, the students look at solutions and service projects to reduce carbon use.

Objective: The students develop their writing skills by writing an opinion paragraph about an effective way to encourage people to take one step that will reduce the use of carbon.

1. Have students brainstorm a number of ways to save energy, such as by riding bicycles rather than riding in cars.
2. Have students select one energy-saving strategy about which they will write an opinion.
3. Ask the students to write a topic sentence in which they state why they think that the energy-saving strategy they have selected is important.
4. Have the students outline the reasons, facts, and examples that will support their opinion.
5. After they have organized their reasons, facts, and examples in the order in which they want, ask them to write a first draft of their paragraph. Tell them to use connects such as *because, for example,* and *as a result*.
6. Ask the students to revise their paragraphs. Have they clearly stated their opinion in the topic paragraph? Does the order of reasons, facts, and examples make sense? Have they checked their spelling?
7. Have the students share their paragraphs by reading them aloud to their class.

Reading Standards for Informational Text K-5 (for example, grade 3)

CCSS.RI.3.1.	Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
CCSS.RI.3.2	Determine the main idea of a text; recount the key details and explain how they support the main idea.

CCSS.RI.3.6.	Distinguish their own point of view from that of the author of a text.
CCSS.RI.3.7	Use information gained from illustrations (e.g., maps. photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur)
CCSS.RI.3.9	Compare and contrast the most important points and key details presented in two texts on the same topic

Writing Standards K-5 (for example, grade 4)

CCSS.W.4.1	Write opinion pieces on topics or texts, supporting a point of view with reasons and information.
CCSS.W.4.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
CCSS.W.4.4	Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
CCSS.W.4.5	With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.
CCSS.W.4.9	Draw evidence from literary or informational texts to support analysis, reflection, and research.

Language Standards (for example, grade 5)

CCSS.L.5.1	Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
CCSS.L.5.2	Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
CCSS.5.3	Use knowledge of language and its conventions when writing, speaking, reading, or listening.
CCSS.5.6	Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal contrast, addition, and other logical relationships (e.g., however, although, nevertheless, similarly, moreover, in addition).

Speaking and Listening Standards (for example, grade 5)

CCSS.SL.5.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5topics and texts, building on others' ideas and expressing their own clearly.
CCSS.SL.5.2	Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.

CCSS.SL.5.4	Report on a topic or text or present an opinion, sequencing ideas, logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
CCSS.SL.5.6	Adapt speech to a variety of contexts and tasks, using formal English when appropriate to task and situation.

Grade Band: 6-8

Activity Name: Arctic Investigations

CLEAN is the Climate Literacy and Energy Awareness Network (http://cleanet.org/index.html). Using activities from CLEAN, the students will investigate the following questions:

How is climate change impacting the Arctic region?

What is causing these changes?

How do scientists track changes? Predict future climate?

How does arctic climate change affect people, wildlife, global climate?

What can we do?

Language Arts Connection (6-8): Arctic Investigations

Purpose: The 6-8 science unit, "Arctic Investigations," invites students to examine how climate change is affecting the earth's arctic region. The students will research and write a news report on one species of animal that is being affected by climate change. For example, they might report on how disappearing Arctic ice will affect polar bears.

Objective: The students develop their informative/explanatory skills by writing a news report on how an animal species is being affected by climate change.

1. Have the students do preliminary research into animal species that are being affected by climate change. In addition to polar bears, some possibilities include turtles, frogs, whales, giant pandas, elephants, and tigers.
2. Once the students have decided on a species, they should do research to examine how the animal is being affected by warmer temperatures. They should also consider how rising sea levels may be affecting the species.
3. Encourage the students to present their information in a news report. Ask them to write a lead—one to three sentences that will capture the reader's attention.
4. Then have students outline the rest of their report. They should arrange the information about the animal in an order that is logical and will make sense to the reader.

5. Ask them to write a first draft of their paragraph. Tell them to use connectors such as *one effect* and *another impact*.
6. Ask the students to revise their paragraphs. Have they grabbed the reader's attention with a strong lead? Have they clearly explained how climate change will affect the species?
7. Have the students share their paragraphs by reading them aloud to their class.

Reading Standards for Literacy in Science and Technical Subjects 6-12

CCSS.RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.
CCSS.RST.6-8.2	Determine the central ideas or conclusions of a text: provide an accurate summary of the text distinct from prior knowledge or opinions.
CCSS.RST.6-8.6	Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.
CCSS.RST.6-8.8	Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
CCSS.RST.6-8.9	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Reading Standards for Informational Text 6-12(for example, a sixth grade focus)

CCSS.RI.6.1	Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
CCSS.RI.6.2	Determine a central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments.
CCSS.RI.6.6	Determine an author's point of view or purpose in a text and explain how it is conveyed in the text.
CCSS.RI.6.7	Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
CCSS.RI.6.8	Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.

Writing Standards 6-12 (for example, a sixth grade focus)

CCSS.W.6.1	Write arguments to support claims with clear reasons and relevant evidence.
CCSS.W.6.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of a relevant content.
CCSS.W.6.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Language Standards 6-12 (for example, a seventh grade focus)

CCSS.W.7.1	Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
CCSS.W.7.2	Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
CCSS.W.7.3	Use knowledge of language and its conventions when writing, speaking, reading or listening.
CCSS.W.7.6	Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Speaking and Listening Standards 6-12 (for example, an eighth grade focus)

CCSS.SL.8.1	Engage effectively in a range of collaborative discussion (one-on-one, in groups, and teacher-led) with diverse partners in grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
CCSS.SL.8.2	Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation.
CCSS.SL.8.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

RESOURCES FOR TEACHERS AND STUDENTS (6-8) FOR ARCTIC INVESTIGATIONS

Changes Ahoof: Could Climate Change Affect Arctic Caribou?
http://forces.si.edu/arctic/pdf/ACT%205_CHANGES%20AHOOF.pdf
Time: One 45-minute period
Summary: Students run a simplified computer model and create board games to explore how climate conditions can affect caribou—the most abundant grazing animal in the Arctic.

2) *March of the Polar Bears: Global Change, Sea Ice, and Wildlife Migration*
http://mynasadata.larc.nasa.gov/lesson-plans/1332-2/?page_id=474?&passid=90
Time: Two 45-minue periods
Summary: Students will use NASA satellite data to study temperature and snow-ice coverage in the South Beaufort Sea, Alaska. The data can be used to correlate with USGS ground tracking of polar bears, and to relate this to global change, sea ice changes, and polar bear migration. The data can be used to draw conclusions surrounding any migration patterns in the region.

GLOBAL CLIMATE (FEEDBACK EFFECTS)
Changing Planet: Thawing Permafrost and Methane (Video)
http://www.nbclearn.com/changingplanet/cuecard/52627
Time: 20-25 minutes to watch video and discuss with class
Summary: This video examines the thawing of permafrost due to changes in climate and shows examples of the impacts that warming temperatures have on permafrost in the Arctic, including the release of the greenhouse gas methane. Dramatic results are shown, including sink holes forming on the landscape and beneath buildings, roads, and other infrastructure, causing some communities to relocate.

Standards and Suggestions

Social Studies Standards for Climate Change Education

In this section of the report, we analyze educational standards developed by national professional groups for social studies classrooms.

The social studies standards analyzed and organizations producing them were as follows:

- National Standards for Civics and Government (Center for Civic Education)
- National Curriculum Standards for Social Studies (National Council for the Social Studies, NCSS)
- National Geography Standards (National Council for Geographic Education, NCGE)

Late in our process, another national level set of standards relevant to social studies was released, the C3 Framework. While we did not have time to conduct a thorough analysis of these standards, we did a quick analysis for references to climate or climate change. Because of time limitations, our study does not include an analysis of economics or psychology standards *(Voluntary National Content Standards in Economics*, 2010 or *National Standards for High School Psychology Curricula*, 2011). These subjects are often included in high school social studies course offerings.

We should note that with the exception of civics and government, we only examined standards at the middle and secondary levels due to time constraints.

We examined standards on two levels. First, we looked for explicit references to climate, climate change, and global change. Secondly, we looked for standards that could be met by using climate change content.

Summary of Findings

Of the three sets of standards we examined, civics and government standards had the fewest references to climate change terms with zero explicit references. Social

studies standards featured only one explicit reference to climate change terms, although notably, the term "climate change" did not appear at all in the standards document. Finally, geography standards included the greatest number of explicit references to climate change terms. It should be noted, however, that geography is an interdisciplinary subject that includes material from both the natural sciences and the social sciences, so not all standards would be relevant to social studies classrooms. Therefore, we separated out standards more likely to be used in social studies classrooms and standards less likely to be used in social studies classrooms.

The information is presented in a way that will facilitate their use in the classroom to teach about climate change. For each of the three sets of standards, you will find a specific standard in the left column. Then, in the corresponding right-hand column, you will find a suggested teaching activity or strategy that will help you teach this standard in your classroom.

You will find the standards and activities in the following order:

1. National Standards for Civics and Government
2. National Curriculum Standards for Social Studies
3. Geography for Life: National Geography Standards
4. A Brief Note regarding the C3 Framework

Civics and Government

We have reviewed the *National Civics and Government Standards* (2010) and have listed below content that is important in climate change education. The Civics and Government content standards highlighted in this document are important for students to understand and develop as they learn about environmental issues and policies, how government is involved, and how we as citizens can be an active participant in the democratic process and contribute to our communities.

Source

National Standards for Civics and Government. Calabasas, CA: Center for Civic Education, 2010. Address: 5145 Douglas Fir Road, Calabasas, CA, 91302, (818) 591-9321, www.civiced.org (2010). Available at http://new.civiced.org/resources/publications/resource-materials/national-standards-for-civics-and-government

Summary

The *National Civics and Government Standards* are divided into five organizing questions, which spiral up in complexity through grade bands: K-4, 5-8, and 9-12.

- What are civic life, politics, and government?
- What are the foundations of the American political system?
- How does the government established by the Constitution embody the purposes, values, and principles of American democracy?
- What is the relationship of the United States to other nations and to world affairs?
- What are the roles of the citizen in American democracy?

The standards do not explicitly mention climate, climate change, or global change. Standards where climate change may be used, but are not specifically referenced, are listed below.

K-4 Standards

K-4 STANDARD II: WHAT ARE THE BASIC VALUES AND PRINCIPLES OF AMERICAN DEMOCRACY?

Content Standards	Example of How Teacher Might Use Standard in Climate Change Education
A1. Fundamental Values and principles (pg. 52)	People exercise their authority directly by voting for or against certain rules, laws, or candidates as well as by voting in community or town meetings. People exercise their authority indirectly through representatives they elect to make, apply, and enforce laws and to manage disputes about them.
B. Important beliefs Americans have about themselves and their government. **1. Distinctive Characteristics (pg. 55-58)**	This part of content standard may be important to a discussion of policies and views: Another important purpose of government is to promote the common good: • individuals have the right to differ about politics, religion, or any other matter • individuals have the right to express their views without fear of being punished by their peers or their government • everyone should be concerned about the well-being of his/her school, community, state, and nation • people should try to improve the quality of life in their schools, communities, states, and nation

K-4 STANDARD III: HOW DOES THE GOVERNMENT ESTABLISHED BY THE CONSTITUTION EMBODY THE PURPOSES, VALUES, AND PRINCIPLES OF AMERICAN DEMORCRACY?

Content Standards	Example of How Teacher Might Use Standard in Climate Change Education
E. Who represents you in the legislative and executive branches of your local, state, and national governments? (pg. 77)	A discussion about who in government citizens could talk to about the effects of climate change on the environment. Learning about which government agency oversees issues that affect the environment. • explain which level of government they should contact to express their opinions or to get help on specific problems, e.g., the environment.

K-4 Standard V: WHAT ARE THE ROLES OF THE CITIZEN IN AMERICAN DEMOCRACY?

Content Standards	Example of How Teacher Might Use Standard in Climate Change Education
E. What dispositions or traits of character are important to the preservation and improvement of American Democracy? Pg. 87 E1. Individual responsibility, respect for rights, open mindedness, civic mindedness, compassion. (pg. 89)	The standard focuses on understanding the importance of individual dispositions. These include being willing to listen to other points of view with respect, willingness to consider other points of view, and concern for the well-being of one's community and nation. • The meaning of citizenship • Responsibilities of individuals • Dispositions that enhance citizen effectiveness and promote the healthy functioning of American democracy • Forms of participation

5-8 Standards

5-8 STANDARD I: WHAT ARE CIVIC LIFE, POLITICS, AND GOVERNMENT?

Content Standards	Example of How Teacher Might Use Standard in Climate Change Education
A. What is civic life? What is politics? What is government?A1. A1. What is civic life? What is politics? (pg. 99)	Student understanding of civic life and what role they have in helping to find solutions to problems. Civic life: concerns taking part in the governance of the school, community, tribe, state, or nation, e.g. helping to find solutions to problems, helping to make rules and laws.

5-8 STANDARD II: WHAT ARE THE FOUNDATIONS OF THE AMERICAN POLITICAL SYSTEM?

Content Standards	Example of How Teacher Might Use Standard in Climate Change Education
B. What are the distinctive characteristics of American society? B2. The role of voluntarism in American life (pg. 118)	Identifying opportunities for individuals to volunteer in their own schools and communities to better the environment.
D What value and principles are basic to American constitutional democracy? D3. Disparities between ideals and reality in American political and social life (pg. 127).	Students will be able to describe historical and contemporary efforts to reduce discrepancies between ideals and the reality of American public life including environmental protection movements.

5-8 STANDARD III: HOW DOES THE GOVERNMENT ESTABLISHED BY THE CONSTITUTION EMBODY THE PURPOSES, VALUES, AND PRINCIPLES OF AMERICAN DEMOCRACY?

Content Standards	Example of How Teacher Might Use Standard in Climate Change Education
B What does the national government do? B1. Major responsibilities for domestic and foreign policy (pg. 133-134).	Students will identify historical and contemporary examples of important domestic policies including National Environmental Policy Act of 1970.
F. How does the American political system provide for choice and opportunities for participation? F1. The public agenda (pg. 143-144).	Students will be able to explain that the public agenda consists of those matters that occupy public attention at any particular time, e.g. environmental protection.
F2. Political communication (pg. 144-145).	Students will be able to evaluate, take, and defend positions on the influence of the media on American political life. Evaluate the influence of television, radio, the press, newspapers, etc. on American politics. Media provide individuals with ways to communicate their concerns and positions on current issues.

F4. Associations and groups (pg. 145-146)	Students will be able to explain how interest groups, unions, and professional organizations provide opportunities for citizens to participate in the political process.
F5. Forming and carrying out public policy (pg. 146)	Students will be able to define public policy, describe how they are formed and implemented, how citizens can monitor and influence the formation and implementation of the policies. Explain why conflicts about values, principles, and interests may make agreement difficult or impossible on certain issues of public policy, e.g., environmental protection.

5-8 STANDARD IV: WHAT IS THE RELATIONSHIP OF THE UNITED STATES TO OTHER NATIONS AND TO WORLD AFFAIRS?

Content Standards	**Example of How Teacher Might Use Standard in Climate Change Education**
B What are the rights of citizens? B2. Political, demographic, and environmental developments (pg. 153).	Students will explain the effects of significant political, demographic, and environmental trends in the world. Describe environmental conditions that affect the United States, such as air pollution.

5-8 STANDARD V: WHAT ARE THE ROLES OF THE CITIZEN IN AMERICAN DEMOCRACY?

Content Standards	**Example of How Teacher Might Use Standard in Climate Change Education**
C What are the responsibilities of citizens? C2. Civic Responsibilities (pg. 164).	Being informed and attentive to public issues, identify and evaluate contemporary issues that involve civic responsibilities.
D What dispositions or traits of character are important to the preservation and improvement of American constitutional democracy? D1. Dispositions that enhance citizen effectiveness and promote the healthy functioning of American constitutional democracy (pg. 166-167).	Critical mindedness—Inclination to question the validity of various positions, including one's own. Civic mindedness—paying attention to and having concern for public affairs.

E How can citizens take part in civic life? E1. Participation in civic and political life and the attainment of individual and public goals (pg. 169-170).	Students will identify examples of their own individual goals and explain how their participation in civic and political life can help to attain them, e.g., living in a healthy environment.
E2. The difference between political and social participation (pg 170).	Students will explain what distinguishes political from social participation, e.g. participating in a campaign to change law as opposed to volunteering. Identify opportunities in their own community for both political and social participation.

9-12 Standards

9-12 STANDARD I: WHAT ARE CIVIC LIFE, POLITICS, AND GOVERNMENT?

Content Standards	Example of How Teacher Might Use Standard in Climate Change Education
A What is civic life? What is politics? What is government: What government and politics necessary? What purposes should government serve? A1 Defining civic life, politics, and government (pg. 177).	Students will describe politics as the process by which a group of people, whose opinions or interests might be divergent, reach collective decisions that are generally regarded as binding on the group and enforced as common policy.
A2 Necessity of politics and government (pg. 179).	Students will explain the major arguments advanced for the necessity of politics and government. Working collectively can accomplish goals and solve problems they could not achieve alone.

9-12 STANDARD II: WHAT ARE THE FOUNDATIONS OF THE AMERICAN POLITICAL SYSTEM?

Content Standards	Example of How Teacher Might Use Standard in Climate Change Education
B What are the distinctive characteristics of American society? B2 The role of voluntarism in American life (pg. 203).	Examine how citizens have volunteered to participate in environmental protection, such as by supporting legislation like the passage of the Wilderness Act of 1964.
B3 The role of organized groups in political life (pg. 204)	Examine how conservation groups Wilderness Society and the Sierra Club have played a role in focusing public attention on environmental issues.

9-12 STANDARD III: HOW DOES THE GOVERNMENT ESTABLISHED BY THE CONSTITUTION EMBODY THE PURPOSES, VALUES, AND PRINCIPLES OF AMERICAN DEMOCRACY?

Content Standards	**Example of How Teacher Might Use Standard in Climate Change Education**
B How is the national government organized and what does it do? B2 Major responsibilities of the national government in domestic and foreign policy (pg. 223).	Students should be able to explain the major responsibilities of the national government for domestic policy and how domestic policies affect their everyday lives and their community. Evaluate competing arguments about the proper role of government in major areas of domestic and foreign policy.
E How does the American political system provide for choice and opportunities for participation? E1 The public agenda (pg. 233).	Students explain that the "public agenda" consists of those matters that occupy public attention at any particular time, such as environmental protection. Describe how the public agenda is shaped by political leaders, political institutions, political parties, interest groups, the media, and individual citizens. Explain how individuals can help to shape the public agenda.
E2 Public opinion and behavior of the electorate (pg. 234)	Students should be able to evaluate, take, and defend positions about the role of public opinion in American politics.
E3 Political communication: televis ion, radio, the press, and political persuasion (pg. 235).	Students should be able to evaluate, take, and defend positions on the influence of the media on American political life.
E5 Associations and groups (pg. 237).	Students should be able to evaluate, take, and defend positions about the contemporary roles of associations and groups in American politics. Describe the contemporary roles of associations and groups in local, state, and national politics.
E6 Forming and carrying out public policy (pg. 238).	Students should be able to evaluate, take, and defend positions about the formation and implementation of public policy. Describe a current issue of public policy at local, state, or national level. Explain why conflicts about values, principles, and interests may make agreement difficult or impossible on certain issues of public policy, e.g., environment.

9-12 STANDARD IV: WHAT IS THE RELATIONSHIP OF THE UNITED STATES TO OTHER NATIONS AND TO WORLD AFFAIRS?

Content Standards	Example of How Teacher Might Use Standard in Climate Change Education
C How has the United States influenced other nations, and how have other nations influenced American politics and society? C4 Demographic and environmental developments (pg. 249).	Students should be able to evaluate, take, and defend positions about what the response of American governments at all levels should be to world demographic and environmental developments. Describe principal environmental conditions that affect the United States, e.g., air pollution. Evaluate historical and contemporary responses of the American government to demographic and environmental changes.
C5 United States and International organizations (pg. 249).	Evaluate, take, and defend positions about what the relationship of the United States should be to international organizations. Identify some important bilateral and multilateral agreements to which the United States has been involved. Evaluate the role of the United States in international organizations. The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty.

9-12 STANDARD V: WHAT ARE THE ROLES OF THE CITIZEN IN AMERICAN DEMOCRACY?

Content Standards	Example of How Teacher Might Use Standard in Climate Change Education
B What are the rights of citizens? B4 Relationship among personal, political, and economic rights.	Students should be able to evaluate, take, and defend positions on the relationships among personal, political, and economic rights.
D What civic dispositions or traits of private and public character are important to the preservation and improvement of American constitutional democracy? D4 Dispositions that facilitate thoughtful and effective participation in public affairs (pg. 264-265).	Evaluate the usefulness of the following traits in facilitating thoughtful and effective participation in public affairs: Persistence, or the willingness to attempt again and again to accomplish worthwhile goals. Civic mindedness—paying attention to and having concern for public affairs. Courage—the strength to stand up for one's convictions, when conscience demands.

National Curriculum Standards for Social Studies

In 2010, the National Council for the Social Studies (NCSS) issued its revised curriculum standards titled *National Curriculum Standards for Social Studies: A Framework for Teaching, Learning, and Assessment.* The standards encompass history, geography, government, sociology, psychology, and other disciplines in the social studies.

Source

National Curriculum Standards for Social Studies: A Framework for Teaching, Learning and Assessment. Silver Spring, MD: National Council for the Social Studies, 2010. Address: 8555 Sixteenth Street, Suite 500, Silver Spring, Maryland 20910.

Summary

The table below includes both middle school (MS) and high school (HS) standards of two different types:

- Knowledge: Learners will understand…
- Processes: Learners will be able to…

For both knowledge and skills, the table provides suggestions for how to connect the standard to climate, climate change, and global change.

Standards with Explicit Mention of Climate, Climate Change, or Global Change

Strand/standard that connects to climate change (include number or other ID used in document)
Standard 3 – People, Places and Environments *MS – Knowledge:* *The theme of people, places, and environments involves the study of relationships between human populations in different locations and geographic phenomena such as climate, vegetation, and natural resources. *Past and present changes in physical systems, such as seasons, climate, and weather, and the water cycle, in both nation and global contexts.

MS – Processes:
>Acquire, organize, and analyze information and use geographic tools to draw conclusions about historic or current national and global environmental change.
>Calculate distance, scale, and area, to inform study of historic or current national and global environments.
>Evaluate the consequences of human actions in environmental terms.

HS – Knowledge
*The theme of people, places, and environments involves the study of relationships between human populations in different locations and regional and global geographic phenomena such as landforms, soils, climate, vegetation, and natural resources.
*Consequences of changes in regional and global physical systems, such as seasons, climate, weather, and the water cycle.
*The causes and impact of resource management, as reflected in land use, settlement patterns, ecosystem changes.
*The social and economic effects of environmental changes and crises resulting from phenomena such as floods, storms and droughts.

HS – Processes:
>Evaluate the consequences of human actions in environmental terms.

Standard 9: Global Connections

HS – Knowledge:
*The actions of people, communities, and nations have both short- and long-term effects on the biosphere and its ability to sustain life

Standards in Which Climate Change Concepts May Be Used but Are Not Specifically Referenced

Strand/standard that connects to climate change (include number or other ID used in document) Knowledge: Learners will understand… Processes: Learners will be able to…	**Example of How Teacher Might Use Climate Change to Meet Standard** Learners might demonstrate understanding by…
Standard 1 - Culture:	**Example of How Teacher Might Use Climate Change to Meet Standard**
MS - Knowledge: *How culture influences the ways in which human groups solve the problems of daily living.	Researching and writing a paper about how the impacts of climate change have changed aspects (behaviors, beliefs, values, traditions, institutions, etc) of a particular culture.

*Culture may change in response to changing needs, concerns social, political, and geographic conditions. <u>HS – Knowledge:</u> *How culture develops and changes in ways that allow human societies to address their needs and concerns. *That the cultural values and beliefs of societies influence their analysis of challenges, and their responses to these challenges.	Evaluating how two (or more) different cultures address the issues related to climate change. How are they responding? How are their responses similar, how are they different?
<u>MS – Processes:</u> >Evaluate how data and experiences may be interpreted differently by people from diverse cultural perspectives and frames of reference. >Draw inferences from data about the ways in which given cultures respond to persistent human issues, and how culture influences those responses. HS – Processes: >Ask questions related to culture and find, select, organize, and interpret data from research to address research questions. >Compare and analyze behaviors for preserving and transmitting culture even while adapting to environmental or social change. >Evaluate how data and experiences may be interpreted differently by people from diverse cultural perspectives and frames of reference. >Analyze data from various cultural perspectives and evaluate the consequences of interpretations associated with the world views of different cultures >Analyze historic and current issues to determine the role that culture has played.	Researching and presenting a position paper on a current or past problem related to climate change (water shortages, flooding, forced migrations, wars over resources) through the analysis of the cultural patterns of the groups involved and the ways in which these contribute or present obstacles to finding solutions. Interviewing a number of sub-cultures to which they have access (e.g. student sub-groups, workplace groups, or community groups) to present the group's point of view on an issue of importance in an editorial to the local newspaper. Preparing a podcast highlighting the role of cultural unity and diversity in a past or present example of conflict or cooperation related to climate change ((water shortages, flooding, forced migrations, wars over resources)

>Explain and apply ideas, theories, and modes of inquiry from anthropology, sociology, history, geography, and economics in the examination of persistent issues and social problems.	
Standard 2 – Time, Continuity, and Change	**Example of How Teacher Might Use Climate Change to Meet Standard**
<u>MS – Knowledge</u> *Concepts such as: chronology, causality, change, conflict, complexity, multiple perspectives, primary and secondary sources, and cause and effect. *The influences of social, geographic, economic, and cultural factors on the history of local areas, states, nations and the world. <u>HS – Knowledge</u> *Concepts such as: era, chronology, causality, change, continuity, conflict, historiography, historical method, complexity, multiple perspectives, primary and secondary sources, and cause and effect. *The impact across time and place of key historical forces, such as nationalism, imperialism, globalization, leadership, revolution, wars, concepts of rights and responsibilities, and religion. *The contributions of philosophies, ideologies, individuals, institutions, and key events and turning points in shaping history. *Different interpretations of the influences of social geographic, economic, and cultural factors on the history of local areas, states, nations, and the world.	Developing an illustrated timeline of a sequence of events that are a result of events associated with climate change. (changing coastline, rising water lines, mass migrations, pandemics) Researching the impact of a variety of historical forces throughout history. Creating a "What would happen if" scenario addressing the potential for climate change to be recognized as a historical force.

*The importance of knowledge of the past to an understanding of the present and to informed decision-making about the future.	
MS – Processes >Research and analyze past periods, events, and issues, using a variety of primary sources (e.g. documents, letters, artifacts, and testimony) as well as secondary sources; validate and weigh evidence for claims and evaluate the usefulness and degree of reliability of sources to develop a supportable interpretation. >Evaluate the impact of the values, beliefs, and institutions of people in the past on important historical decisions and developments of their times. >Use methods of historical inquiry to make informed decisions as responsible citizens to propose policies and take action on an issue of importance today. HS - Processes >Formulate research questions to investigate topics in history, identify possible answers, and use historical methods of inquiry and literacy skills to select, organize, analyze, synthesize, and interpret sources, and present findings. >Research and analyze past periods, events, and issues, using a variety of primary sources (e.g. documents, letters, artifacts, and testimony) as well as secondary sources; validate and weigh evidence for claims, check the usefulness and degree of reliability of sources, and evaluate different interpretations in order to develop their own interpretation supported by the evidence. >Evaluate the impact of the values, beliefs, and institutions of people in the past on important historical decisions	Identifying and researching issues that were considered contentious during the particular time in history they arose. Analyzing what eventually happened with regard to the issue. Identifying potential alternative responses and analyzing what would have happened if responses to the issue had been different. Identifying an issue within the climate change discussion, then predicting the outcomes. Then examining alternative reactions/actions to the current issue and making predictions as to what might occur. (Futures thinking with solution seeking)

decisions and developments, and compare different interpretations of the causes and consequences of these decisions and developments. >Use historical facts, concepts, and methods to evaluate an issue of importance today, and make informed decisions as responsible citizens to propose policies, and take action on it.	
Standard 3 – People, Places and Environments	**Example of How Teacher Might Use Climate Change to Meet Standard**
<u>MS – Knowledge:</u> *Concept such as: location, region, place, and migration, as well as human and physical systems. *The concept of regions identifies links between people in different locations according to specific criteria (e.g. physical, economic, social, cultural, or religious). *Patterns of demographic and political change, and cultural diffusion in the past and present (e.g. changing national boundaries, migration, and settlement, and the diffusion of and changes in customs and ideas). *Human modifications of the environment *Factors that contribute to cooperation and conflict among peoples of the nation and world, including language, religion, and political beliefs. *The use of a variety of maps, globes, graphic representations, and geospatial technologies to help investigate the relationships among people, places and environments. **The theme of people, places, and environments involves the study of relationships between human populations in different locations and geographic phenomena such as climate, vegetation, and natural resources.* **Past and present changes in physical systems, such as seasons, climate, and weather, and the water cycle, in both nation and global contexts.* <u>HS - Knowledge</u> *Concept such as: location, physical and human characteristics of national and global regions in	Identifying past, present, and future migration patterns based upon significant changes in the geographic characteristics of a region. Creating visual representations of the immediate and long-term impact of natural disasters on the land and peoples living in affected areas. Interviewing members of the community about their position on a climate change/environmental issue that has/is affecting the local/ regional community.

the past and present, and the interactions of humans with the environment. *Factors that contribute to cooperation and conflict among peoples of the nation and world, including language, religion, and political beliefs. *The use of a variety of maps, globes, graphic representations, and geospatial technologies to help investigate spatial relations, resources and population density and distribution, and changes in phenomena over time. *The theme of people, places, and *environments involves the study of relationships between human populations in different locations and regional and global geographic phenomena such as landforms, soils, climate, vegetation, and natural resources.* **Consequences of changes in regional and global physical systems, such as seasons, climate, weather, and the water cycle.* **The causes and impact of resource management, as reflected in land use, settlement patterns, ecosystem changes.* **The social and economic effects of environmental changes and crises resulting from phenomena such as floods, storms and droughts*	Constructing a series of maps depicting changes in the relationships among people, places and environments over time in a given location. Researching, analyzing, synthesizing, and evaluating information from atlases, data bases, grid systems, charts, GIS, graphs, and maps to create a model illustrating the impact of rising water along coastlines in various regions of the world.
<u>MS – Processes</u> >Ask and find answers to geographic questions related to regions, nations, and the world in past and present. >Research, organize, analyze, synthesize, and evaluate information from atlases, data bases, grid systems, charts, graphs, maps, geospatial technologies, and other tools to interpret relationships among geographic factors and historic events. >Identify and interpret "push" and "pull" factors involved in the migrations of people in this nation and other parts of the world. *>Evaluate the consequences of human actions in environmental terms.* *>Acquire, organize, and analyze information and use geographic tools to draw conclusions about historic or current national and global environmental change.*	Evaluate the consequences of past and/or present human actions on various aspects of the environment.

>*Calculate distance, scale, and area, to inform study of historic or current national and global environments.* <u>HS – Processes</u> >Ask and find answers to geographic questions related to regions, nations, and the world in past and present. >Research, organize, analyze, synthesize, and evaluate information from atlases, data bases, grid systems, statistical presentations, charts, graphs, and maps to interpret relationships among geographic factors and events at the local, regional, national, and global levels, and assess policy options. >Acquire, organize, and analyze geographic information from data sources, geographic tools and geospatial technologies such as aerial photographs, satellite images, and geographic information systems (GIS) to determine patterns. >Analyze different interpretations of the causes and effects of migrations of people in various times and places on the globe. >Calculate distance, scale, area, and density, and construct maps and models of geographic information. >*Evaluate the consequences of human actions in environmental terms.*	Estimating the social and economic effects/consequences of the changes in regional and global physical systems, such as seasons, climate, weather and the water cycle.
Standard 5 – Individuals, Groups, and Institutions	**Example of How Teacher Might Use Climate Change to Meet Standard**
<u>MS – Knowledge</u> *Concepts such as: mores, norms, status, role, socialization, ethnocentrism, cultural diffusion, competition, cooperation, conflict, race, ethnicity, and gender. *That when two or more groups with differing norms and beliefs interact, accommodation or conflict may result. *That groups and institutions influence culture in a variety of ways. <u>HS – Knowledge:</u> *Concepts such as: mores, norms, status, role, socialization, ethnocentrism, cultural diffusion,	Researching and evaluating two opposing viewpoints on a particular climate change issue. Analyzing the concept of environmental justice and how it relates to social justice.

competition, cooperation, conflict, assimilation, race, ethnicity, and gender. *The influence of individuals, groups, and institutions on people and events in historical and contemporary settings. *The impact of tensions and examples of cooperation between individuals, groups, and institutions, with their different belief systems. *How the beliefs of dominant groups tend to become norms in a society. *How groups and institutions work to meet individual needs, and can promote the common good and address persistent social issues.	
<u>MS – Processes:</u> >Ask and find answers to questions about the various forms and roles of individuals, groups and institutions. >Analyze the effects of interactions between and among individuals, groups and institutions. > Identify and analyze the impact of tensions between and among individuals, groups and institutions. >Understand examples of tensions between belief systems and governmental actions and policies. >Analyze the role of institutions in furthering both continuity and change. >Evaluate how groups and institutions work to meet individual needs and promote or fail to promote the common good. >Gather information about groups and institutions, using such tools as surveys and interviews. <u>HS – Processes:</u> >Ask and find answers to questions about the various forms that institutions take, their impact, the role of individuals within them, and how they change over time.	Discussing real-world problems and the implications and solutions for individuals, groups, and institutions. Using computer-based technology and media/ communication research and presenting finding in illustrations or essays about environmental justice.

>Evaluate different interpretations of the influence of groups and institutions on people and events in historical and contemporary settings. >Understand examples of tensions between belief systems and governmental actions and policies. >Examine the belief systems of specific contemporary and historical movements that have caused them to advocate public policies. >Understand the role of institutions in furthering both continuity and change. >Investigate how groups and institutions work to meet individual needs, promote or fail to promote the common good, and address persistent social issues.	
Standard 6: Power, Authority, and Governance	**Example of How Teacher Might Use Climate Change to Meet Standard**
<u>MS – Knowledge:</u> *The ways in which governments meet the needs and wants of citizens, manage conflict, and establish order and security <u>HS – Knowledge:</u> *The need for respect for the rule of law, as well as recognition of times when civil disobedience has been justified. *Fundamental values of constitutional democracy (e.g. the common good, liberty, justice, and individual dignity) *Mechanisms by which governments meet the needs of the wants of citizens, regulate territory, manage conflict, establish order and security, and balance competing conceptions of a just society.	Examine ways in which citizens have lawfully supported legislation and governmental actions, such as raising mileage standards for automobiles.

MS – Processes: *Examine persistent issues involving the rights of individuals and groups in relation to general welfare. *Analyze and evaluate conditions and actions, and motivations that contribute to conflict and cooperation between groups and nations. HS- Processes: * Examine persistent issues involving the rights, responsibilities, roles, and status of individuals and groups in relation to general welfare. *Analyze and evaluate conditions and actions, and motivations that contribute to conflict and cooperation among groups and nations. *Evaluate the extent to which governments achieve their stated ideals and policies at home and abroad.	By addressing concerns such as nonrenewable resource depletion and management. Nations (between) and individual states (within) are beginning to have disputes over such issues as water rights, fracking, waste management, etc. Fracking/Energy company/industry versus farmers/landowners. Environmental protests Climate Change/Environmental protection/ regulation for the common good. Examine the mechanisms involved in creating legislation/regulations that seek to address CC Environmental justice, whose voices are not being heard/honored Carbon reduction, Kyoto Protocol
Standard 7: Production, Distribution, and Consumption	**Example of How Teacher Might Use Climate Change to Meet Standard**
MS – Knowledge: *Individuals, government, and society experience scarcity because human wants and needs exceed what can be produced from available resources. *How choices involve trading off the expected value of one opportunity gained against the expected value of the best alternative. *The economic choices that people make have both present and future consequences. *Economic incentives affect people's behavior's behavior and may be regulated by rules or laws. *How markets bring buyers and sellers together to exchange goods and services. *How goods and services are allocated in a market economy through the influence of prices on decisions about production and consumption.	Discussing and evaluating topics such as water scarcity, climate change impacts on food production/distribution.. Examining alternative incentives such as charging more for garbage going to an incinerator in order to encourage recycling and reuse.

HS – Knowledge: *Scarcity and the uneven distribution of resources result in economic decisions, and foster consequences that may support cooperation or conflict. *That regulations and laws (for example, on property rights and contract enforcement) affect incentives for people to produce and exchange goods and services; *Entrepreneurial decisions are influenced by factors such supply and demand, government regulatory policy, and the economic climate;	
MS – Processes: *Compare their own economic decisions with those of others, and consider the wider consequences of those decisions for groups, communities, the nation and beyond; *Analyze various methods for allocating scarce goods and services at the state, national and global levels, describing the possible impacts of these choices; HS – Processes: *Ask and find answers to questions about the production and distribution of goods and services in the state and nation, and in a global context; *Analyze complex aspects of production, distribution, and consumption, and evaluate the market forces and government policies that affect these aspects; *Evaluate the possible economic consequences of proposed government policies; *Gather and analyze data and use critical thinking in making recommendations for economic policies.	Compare the economics and environmental benefits and costs of different forms of energy: coal, oil, natural gas, wind, solar, nuclear, and hydropower.

Standard 8: Science, Technology, and Society	**Example of How Teacher Might Use Climate Change to Meet Standard**
<u>MS- Knowledge:</u> *Science is the result of empirical study of the natural world, and technology is the application of knowledge to accomplish tasks. *Society often turns to science and technology to solve problems; *Science and technology have changed people's perceptions of the social and natural world, as well as their relationship to the land, economy and trade, their concept of security, and their major daily activities; *Values, beliefs, and attitudes that have been influenced by new scientific and technological knowledge; *Science and technology sometimes create ethical issues that test our standards and values; **Science and technology have had both positive and negative impacts upon individuals, societies, and the environment in the past and present* <u>HS – Knowledge:</u> *Science is based upon the empirical study of the natural world, and technology is the application of knowledge to accomplish tasks. *Science and technology have had both positive and negative impacts upon individuals, societies, and the environment in the past and present; *Consequences of science and technology for individuals and societies; *Prediction, modeling and planning are used to focus advances in science and technology for positive ends; *Findings in science and technology sometimes create ethical issues that test our standards and values;	Examine how scientific knowledge of alternative forms of energy, such as wind and solar, have changed energy production in the United States over the past 20 years.

*Science, technology and their consequences are unevenly available across the globe; *Science and technology have contributed to making the world increasingly interdependent; *That achievements in science and technology are increasing at a rapid pace and can have both planned and unanticipated consequences *Developments in science and technology may help address global issues **Science and technology have had both positive and negative impacts upon individuals, societies, and the environment in the past and present*	
<u>MS – Processes:</u> *Use diverse types of media technology to read, write, create, and review variety of messages; *Seek and evaluate varied perspectives when weighing how specific applications of science and technology have impacted individuals and society; *Review sources to identify the purposes, points of view, biases, and intended audiences of reports and discussions of science and technology; *Select, organize, evaluate, and communicate information about the impact of science or technology on a society today or in the past; *Use scientific findings and forms of technology to formulate possible solutions to real-life issues and problems. <u>HS – Processes:</u> *Ask and find answers to questions about the impact of science and technology in the past and present, and in different places and societies; *Use diverse types of media technology to read, write, create, and review variety of messages;	Examine television commercials regarding energy use, both for their content and for the persuasive techniques used. Reach conclusions about the point of view represented in a television commercial.

Seek and evaluate varied perspectives when weighing how specific applications of science and technology have impacted individuals and societies in an interdependent world; *Identify the purposes, points of view, biases, and intended audience of reports and discussions related to issues involving science and technology * Select, organize, analyze, and evaluate information, and communicate findings regarding the impact of science or technology on a society today or in the past; *Identify and analyze reactions to science and technology from the past or present, and predict ongoing effects in economic geographical, social, political, and cultural areas of life; *Formulate possible solutions that utilize technology, address real-life issues and problems, weigh alternatives, and provide reasons for preferred choices and plans of action.	
Standard 9: Global Connections	**Example of How Teacher Might Use Climate Change to Meet Standard**
<u>MS – Knowledge:</u> *Global connections have existed in the past and increased rapidly in current times; *Global factors such as cultural, economic, (*should include environmental) and political connections are changing the places in which people live (through trade, migration, increased travel, and communication); *Spatial relationships that relate to ongoing global issues (e.g. pollution, poverty, disease, and conflict) affect the health and well-being of Earth and its inhabitants; *Global problems and possibilities are not generally caused or developed by any one nation;	Create a behavior over time graph that addresses these connections as they relate to both natural and man-made processes

HS – Knowledge: *Global connections are rapidly accelerating across cultures and nations and can have both positive and negative effects on nations and individuals; *The solutions to global issues may involve individual decisions and actions, but also require national and international approaches (e.g. agreements, negotiations, policies, or laws); *Conflict and cooperation among the peoples of the earth influence the division and control of the earth's surface; *The actions of people, communities, and nations have both short- and long-term effects on the biosphere and its ability to sustain life; *Individuals, organizations, nations and international entities can work to increase the positive effects of global connections, and address the negative impacts of global issues. **The actions of people, communities, and nations have both short- and long-term effects on the biosphere and its ability to sustain life*	Millennium Development Goals Where people will migrate to as a result of natural disasters, lack of water, infertile land, etc. Identify potential areas of conflict Kyoto Protocol 350.org Use of cloud seeding
<u>MS – Processes:</u> *Ask and find answers to questions about the ways in which people and societies are connected globally today and were connected in the past; *Use maps, charts, and databases to explore patterns and predict trends regarding global connections at the community, state, or national level; *Analyze examples of conflict, cooperation, and interdependence among groups, communities, regions, societies, and nations; *Explore the causes, consequences, and possible solutions related to persistent, current, and emerging	Find and analyze graphs showing the amount of oil that the United States has imported year by year in the past 50 years.

issues, such as health, resource allocation, economic development, and environmental quality; *Describe and explain the relationships and tensions between national sovereignty and global interests in such matters as territorial rights, natural resources, trade, the different uses of technology, and the welfare of people <u>HS – Processes:</u> *Ask and find answers to questions about the ways in which people and societies are connected globally today and were connected in the past; *Use maps, charts, and databases to explore patterns and predict trends regarding global connections at the community, state, or national level; *Describe and explain conditions and motivations that contribute to conflict, cooperation, and interdependence among groups, societies and nations; *Analyze and evaluate the effects of changing technologies on the global community; *Analyze the causes and consequences of persistent, contemporary, and emerging global issues, and evaluate possible solutions; *Analyze the relationships and tensions between national sovereignty and global interests in such matters as territorial rights, economic development, the use of natural resources, and human rights; *Describe and evaluate the role of international and multinational organizations in the global arena; *Illustrate how individual behaviors and decisions connect with global issues *Identify concerns, issues, conflicts, and possible resolutions related to issues involving universal human rights *Identify the roles of international and multinational organizations.	

Standard 10: Civic Ideals and Practices	**Example of How Teacher Might Use Climate Change to Meet Standard**
<u>MS – Knowledge:</u> *The theme of civic ideals and practices helps us to learn about and know how to work for the betterment of society; *Concepts and ideals such as: individual dignity, liberty, justice, equality, individual rights, responsibility, majority and minority rights, and civil dissent; *Key practices involving the rights and responsibilities of citizenship and the exercise of citizenship (e.g. respecting the rule of law and due process, voting, serving on a jury, researching issues, making informed judgments, expressing views on issues, and collaborating with other to take civic action.); *The common good and the rule of law; *Key past and present issues involving democratic ideals and practices, as well as the perspectives of various stakeholders in proposing possible solutions to these issues; *The importance of becoming informed in order to make positive civic contributions <u>HS – Knowledge:</u> *The theme of civic ideals and practices helps us recognize where gaps between ideals and practices exist, and prepares us to work for social justice; *Concepts and ideals such as: human dignity, social justice, liberty, equality, inalienable rights, responsibilities, majority and minority rights, citizenship, the common good, civil dissent and the rule of law;	How can/do these ideas both hinder and help efforts to bring attention to and to mitigate climate change U.S. Department of State position on climate change

*Key practices involving the rights and responsibilities of citizenship and the exercise of citizenship (e.g. respecting the rule of law and due process, voting, serving on a jury, researching issues, making informed judgments, expressing views on issues, and collaborating with other to take civic action.); *That seeking multiple perspectives is required in order to effectively grasp the complexity of issues involving civic ideals and practices.	
<u>MS – Processes:</u> *Ask and find answers to questions about how to become informed and take civic action; *Analyze and evaluate the effectiveness of various forms of civic action influencing public policy decisions that address the realization of civic ideals; *Build background through research in primary and secondary sources, make decisions, and propose solutions to address problems; *Identify assumptions, misconceptions, and bias in sources, evidence, and arguments used in presenting issues and positions; *Identify, seek, describe, and evaluate multiple points of view about selected issues, noting the strengths, weaknesses, and consequences associated with holding each position; *Develop a position on a public policy issue, and defend it with evidence *Evaluate the significance of public opinion and positions of policymakers in influencing public policy development and decision-making; *Evaluate the degree to which public policies and citizen behaviors reflect or foster their stated democratic ideals;	Write a white paper addressing a national, state, local policy regarding climate change. Send it to your state/local representative Invite a public policy speaker, pollster, etc. to address the process

*Participate in the process of persuading, compromising, debating, and negotiating in the resolution of conflicts and differences. <u>HS – Processes:</u> *Ask and find answers to questions about how to become informed and take civic action; *Identify examples of civic ideals and practices throughout history and in a variety of cultural settings; *Research primary and secondary sources to make decisions and propose solutions to selected civic issues in the past and present; *Identify assumptions, misconceptions, and biases in sources, evidence, and arguments used in presenting issues and positions; *Identify, seek, describe, and evaluate multiple points of view about selected issues, noting the strengths, weaknesses, and consequences associated with hold each position; *Develop a position on a public policy issue and defend it with evidence; *Evaluate the effectiveness and importance of public opinion in influencing and shaping public policy development and decision-making; *Evaluate the degree to which public policies, and citizen behaviors reflect or foster their stated civic ideals; *Participate in the process of persuading, compromising, debating, and negotiating in the resolution of conflicts and differences.	invite a public policy speaker, pollster, etc. to address the process

National Curriculum Standards for Social Studies: A Framework for Teaching, Learning and Assessment. Silver Spring, MD: National Council for the Social Studies, 2010. Address: 8555 Sixteenth Street, Suite 500, Silver Spring, Maryland 20910.

National Geography Standards

The Nation Geography Standards were developed by a consortium of organizations involved in geographic education: the American Geographical Society, the Association of American Geographers, the National Council for Geographic Education, and the National Geographic Society. The standards were first issued in 1994 and revised in 2012. They are available in a publication titled *Geography for Life: National Geography Standards.* They are organized around three grade bands: K-4, 5-8, and 9-12. Due to time constraints, we have analyzed only Grades 5-8 and Grades 9-12.

Source

Heffron, Susan Gallagher and Roger M. Downs, eds. *Geography for Life: National Geography Standards, Second Edition*. Washington, DC: National Council for Geographic Education, 2012. Address: 1145 Seventeenth Street, N.W., Room 7620, Washington, DC 20036.

Summary

The tables that follow show Geography Standards in the left column. In the right column are knowledge statements and examples of what students can do to show their knowledge. You will find eight tables, four for each grade band, organized as follows.

A. Standards with *Explicit* Mention of Climate, Climate Change, or Global Change and May Apply to Social Studies Classes
B. Standards in Which Climate Change Concepts May Be Used but Are Not Specifically Referenced and May Apply to Social Studies Classes
C. Standards with *Explicit* Mention of Climate, Climate Change, or Global Change and Are More Likely to Be Taught in Science Classes Rather Than Social Studies Classes
D. Standards in Which Climate Change Concepts May Be Used but Are Not Specifically Referenced and Are More Likely To Be taught in Science Classes Rather Than Social Studies Classes

Grades 5-8

A. Standards with *Explicit* Mention of Climate, Climate Change, or Global Change and May Apply to Social Studies Classes

Strand/standard that connects to climate change (include number or other ID used in document)	Knowledge statement and example of what student is able to do
Standard 3: How to analyze the spatial organization of people, places, and environments on Earth's surface	2. Processes shape the spatial patterns of people, places, and environments over time Therefore, the student is able to: A. Describe and compare the processes that influence the distribution of human and physical phenomena, as exemplified by being able to Describe and compare the changes in environmental systems that cause changes in cultural, political, or economic conditions (e.g., a species becoming endangered leads to protected locations and conservation management, climate change influences emissions control legislation, depletion of a natural resource results in higher costs and affects new technologies).

B. Standards in Which Climate Change Concepts May Be Used but Are Not Specifically Referenced and May Apply to Social Studies Classes

Strand/standard that connects to climate change (include number or other ID used in document)	Knowledge statement and example of what student is able to do
Standard 1: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information.	3. Geospatial technologies—Internet-based mapping applications, GIS, GPS, geovisualization, and remote sensing—can be used to construct geographic representations using geospatial data. Therefore, the student is able to: A. Construct and analyze geographic representations using data acquired from a variety of sources (e.g., student-generated data such as surveys, observations, fieldwork, etc., or existing data files) and formats (e.g., digital databases, text, tables, images), as exemplified by being able to:

	Analyze environmental change by annotating a series of remotely sensed images of the same location taken at different dates. 4. The use of geographic representations to ask and answer geographic questions Therefore, the student is able to: A. Analyze geographic representations to ask and answer questions about spatial distributions and patterns, as exemplified by being able to Analyze choropleth maps to examine spatial relationships (e.g., between the number of doctors and mortality rates, between corn production and hog production, between global energy production and consumption).
Standard 4: The physical and human characteristics of places	1. Personal, community, and national identities are rooted in and attached to places Therefore, the student is able to: A. Explain how personal, community, or national identities are based on places, as exemplified by being able to Explain how a place-based identity results from the characteris-tics of a place (e.g., environmentally conscious Inuit of Northwest Canada, seafaring traditions of Gloucester Harbor, Massachusetts, nomadic herders in the eastern steppes of Mongolia). 2. Physical and human characteristics of places change B. Explain the ways that human processes change places, as exemplified by being able to Describe and explain how the introduction of a new industry or the closing of an existing industry could change the characteristics of a place.
Standard 9: The characteristics, distribution, and migration of human populations on Earth's surface.	3. There are multiple causes and effects of migration

	Therefore, the student is able to: B. Identify and explain push and pull factors influencing decisions to migrate, as exemplified by being able to Identify and explain the role of push factors (e.g., political unrest or war, famine, loss of jobs) as reasons for migration.
Standard 11: The patterns and networks of economic interdependence on Earth's surface	1. The functions of different types of economic activities *Therefore, the student is able to:* A. Describe and analyze the functions of economic activities in the primary, secondary, tertiary, and quaternary sectors, as exemplified by being able to Identify a range of everyday items and describe the sequence of routes and steps that are followed as they are converted to a sec-ondary and then a tertiary product (e.g., Canadian forests become lumber that is used to build housing in US communities, Australian copper becomes circuits in wireless telephones made in China that provide a communications service, fish caught in the North Atlantic Ocean are processed into fish fillets that are prepared and served in restaurants).
Standard 16: The changes that occur in the meaning, use, distribution, and importance of resources	1. People can have different viewpoints regarding the meaning and use of resources *Therefore, the student is able to:* A. Describe examples of how cultures differ in their definition and use of resources, as exemplified by being able to Describe how cultures value things differently in terms of resource use (e.g., Old Order Amish choose not to use petroleum and electricity, Muslims and Jews choose not to use pork as a food source, many cultures around the world choose not to use insects as food source). 2. The formation and spatial distribution of types of resources

	Therefore, the student is able to: A. Describe the physical processes that influence the formation and therefore spatial distribution of renewable, nonrenewable, and flow resources, as exemplified by being able to: Explain how physical processes played a role in the formation and location of nonrenewable resources such as coal, petroleum, and diamonds. B. Explain the location and uses of major resources in the world, as exemplified by being able to: Identify countries in which resources (e.g., fossil fuels, minerals, agricultural products) are the primary source of export earnings and describe the advantages and disadvantages of this interdependency. 3. Humans can manage resources to sustain or prolong their use *Therefore, the student is able to:* A. Explain how renewable resources can be continuously replenished through sustainable use, as exemplified by being able to Explain how petroleum-based consumer products can be replaced by renewable resources (e.g., plastic bags, eating utensils, diapers replaced by corn- or bamboo-based materials). B. Explain how humans can use technology to prolong the supply of nonrenewable resources and utilize flow resources, as exemplified by being able to: • Explain how the development and use of technological advances, such as hybrid engines in cars, can extend the supply of nonrenewable resources.

	• Explain how the development of new technologies can maintain or prolong the supply of nonrenewable resources (e.g., deep-water ocean drilling platforms, advanced oil recovery techniques for oil-shale deposits).
Standard 18: How to apply geography to interpret the present and plan for the future	1. Geographic contexts (the human and physical characteristics of places and environments) provide the basis for problem solving and planning *Therefore, the student is able to:* A. Describe and analyze the influences of geographic contexts on current events and issues, as exemplified by being able to Explain the role of the geographic context in a current global conflict (e.g., boundary dispute, resource allocation, land-use issues) and identify strategies that might be used to settle the conflict. B. Describe and analyze the influences of geographic contexts on the process of planning for the future, as exemplified by being able Analyze areas of a community most prone to potential flooding from rivers, thunderstorms, and storm surges and suggest possible

C. Standards with *Explicit* Mention of Climate, Climate Change, or Global Change and Are More Likely to Be Taught in Science Classes Rather Than Social Studies Classes

Strand/standard that connects to climate change (include number or other ID used in document)	**Knowledge statement and example of what student is able to do**
Standard 4: The physical and human characteristics of places	2. Physical and human characteristics of places change *Therefore, the student is able to:* A. Explain the ways that physical processes change places, as exemplified by being able to

	Explain how changes in climate may result in changes to places (e.g., drought and stressed vegetation, more precipitation and increased vegetation, warmer temperatures and longer growing seasons at higher latitudes).
Standard 7: The physical processes that shape the patterns of Earth's surface.	1. The four components of Earth's physical systems (the atmosphere, biosphere, hydrosphere, and lithosphere) are interdependent A. Identify and describe patterns in the environment that result from the interaction of Earth's physical processes, as exemplified by being able to • Identify and describe the connections between ocean circulation system and climate (e.g., North Atlantic Drift and the mild climate of Western Europe, the climatic effects of El Niño or La Niña). • Identify and describe the patterns that result from the connections between climate and vegetation (e.g., examples of patterns of ecosys-tems and biomes).
Standard 8: The characteristics and spatial distribution of ecosystems and biomes on Earth's surface.	3. Climate primarily determines the characteristics and geographic distribution of biomes *Therefore, the student is able to:* A. Describe and explain how climate (temperature and rainfall) primarily determines the characteristics and geographic distribution of biomes, as exemplified by being able to Construct climographs (using temperature and precipitation data) for several different biomes to explain the distribution of biomes.
Standard 15: How physical systems affect human systems	2. The types, causes, and characteristics of environmental hazards occur at a variety of scales from local to global *Therefore, the student is able to:* A. Describe and explain the types and characteristics of hazards, as exemplified by being able to

	Construct a table of climate-related and tectonic-related hazards and explain the characteristics of each type of hazard.

D. Standards in Which Climate Change Concepts May Be Used but Are Not Specifically Referenced and Are More Likely To Be taught in Science

Strand/standard that connects to climate change (include number or other ID used in document)	**Knowledge statement and example of what student is able to do**
Standard 7: The physical processes that shape the patterns of Earth's surface.	1. The four components of Earth's physical systems (the atmosphere, biosphere, hydrosphere, and lithosphere) are interdependent *Therefore, the student is able to:* B. Analyze and explain patterns of physical features resulting from the interactions of Earth's physical processes, as exemplified by being able to • Analyze the pattern of glacial features as a result of glacial retreat (e.g., moraines, kettle lakes, cirques). • Analyze and explain factors influencing precipitation patterns and predict where the patterns will occur (e.g., convectional, orographic, frontal). 2. Earth-Sun relationship drives physical processes that follow an annual cycle and create patterns on Earth. *Therefore, the student is able to:* A. Explain how Earth-Sun relationships drive Earth's physical processes and create annual patterns, as exemplified by being able to:

	Explain the occurrences of weather phenomena in different loca-tions due to annual changes in the Earth-Sun relationship (e.g., hur-ricanes in the fall in subtropical areas, monsoon rainfall, tornadoes in the mid-latitudes during the spring and summer).
Standard 8: The characteristics and spatial distribution of ecosystems and biomes on Earth's surface	1. Components of ecosystems are interdependent *Therefore, the student is able to:* A. Describe how the components of ecosystems are connected and contribute to the energy of their own cycles, as exemplified by being able to: Identify and describe how carbon can be absorbed and stored in Earth's physical systems (e.g., oceans, tropical forests, vegetation). B. Construct a model to explain how an ecosystem works, as exemplified by being able to: Construct a flow chart to explain the interactions of components within an ecosystem (e.g., water cycle, oxygen and carbon dioxide exchange, producers, consumers, and decomposers). 2. Physical processes determine the characteristics of ecosystems *Therefore, the student is able to:* A. Describe and explain how physical processes determine the characteristics of ecosystems, as exemplified by being able to: Explain how ocean currents influence the characteristics of ecosys-tems (e.g., the Peru current and the Atacama Desert, the Benguela current and Namib Desert, East Indian current in the Bay of Bengal and monsoon season in India).

Standard 14: How human actions modify the physical environment	1. Human modifications of the physical environment in one place often lead to changes in other places *Therefore, the student is able to:* A. Describe and explain how human-induced changes in one place can affect the physical environment in other places, as exemplified by being able to: Explain how industrial activities (e.g., factories, electric power generating plants) affect other locations (e.g., acid rain downwind, thermal inversions, smog). 2. The use of technology has changed the scale at which people can modify the physical environment. *Therefore, the student is able to:* A. Describe and explain the ways in which technology has expanded the scale of human modification of the physical environment, as exemplified by being able to: Describe how changes in technology have altered the methods and amount of travel and therefore the effects on the physical environment (e.g., car emissions, road building, airplane jet exhaust and noise). 3. The physical environment can both accommodate and be endangered by human activities. *Therefore, the student is able to:* A. Analyze the positive and negative consequences of humans changing the physical environment, as exemplified by being able to: Analyze the ways humans can have positive effects on the physical environment (e.g., open green space protection, wetland restoration, sustainable forestry).

Standard 15: How physical systems affect human systems	1. The characteristics of a physical environment provide opportunities for and impose constraints on human activities B. Explain how the characteristics of different physical environments place constraints on human activities, as exemplified by being able to Explain how environmental characteristics (e.g., rainfall, length of growing season, temperatures, soil) restrict the range of crops that can be grown successfully in an area. 2. The types, causes, and characteristics of environmental hazards occur at a variety of scales from local to global *Therefore, the student is able to:* B. Explain the causes and locations of various types of environmental hazards, as exemplified by being able to Describe the physical environmental conditions that create or result in different environmental hazards (e.g., plate tectonics causing earthquakes, sea surface temperatures contributing to hurricane development in the Atlantic, strong frontal systems in thunderstorms spawning tornadoes).

Grades 9-12

A. Standards with *Explicit* Mention of Climate, Climate Change, or Global Change and May Apply to Social Studies Classes

Strand/standard that connects to climate change (include number or other ID used in document)	Knowledge statement and example of what student is able to do
Standard 9: The characteristics, distribution, and migration of human populations on Earth's surface.	2. Population distribution and density are a function of historical, environmental, economic, political, and technological factors. Therefore, the student is able to:

	B. Analyze demographic data and identify trends in the spatial distribution of population, as exemplified by being able to: Analyze the possible effects of climate change on the growth and distribution of people in areas such as the Sahel, Pakistan, China, etc.
Standard 13: How the forces of cooperation and conflict among people influence the division and control of Earth's surface	2. Cooperation between countries and organizations may have lasting influences on past, present, and future global issues. Therefore, the student is able to: A. Evaluate how countries and organizations cooperate to address global issues, as exemplified by being able to: Evaluate the success of United Nations (UN) agencies in dealing with global issues (e.g. peacekeeping and prevention of terrorist activities, disease prevention, emergency aid, climate change, education). Identify and describe the potential results of recommendations generated by international efforts to address global climate change (e.g., the series of agreements at Montreal, Kyoto, and Copenhagen).
Standard 15: How physical systems affect human systems	2: Humans perceive and react to environmental hazards in different ways. Therefore, the student is able to: B. Explain how environmental hazards affect human systems and why people may have different ways of reacting to them, as exemplified by being able to: Compare the human responses to the potential predicted effects of climate change on different regions of Earth (e.g., people living in coastal versus landlocked areas, high- versus low-latitude areas, Northern versus Southern Hemisphere areas).
Standard 18: How to apply geography to interpret the present and plan for the future	1. Geographic contexts (the human and physical characteristics of places and environments) provide the basis for analyzing current events and making predictions about future issues.

	Therefore, the student is able to: B. Analyze and evaluate the connections between the geographic contexts of current events and possible future issues, as exemplified by being able to: Evaluate the feasibility and long-range impacts in a series of scenarios for dealing with social and environmental issues (e.g., absorbing and dispersing refugees, responding to threats from global warming, managing the future of Antarctica). 3. Multiple and diverse perceptions of the world must be taken into account to understand contemporary and future issues. *Therefore, the student is able to:* A. Evaluate how perceptions vary and affect people's views of contemporary issues and strategies for addressing them, as exemplified by being able to: Identify and compare different perspectives about international climate change agreements regarding carbon emissions from the points of view of the developed countries and the less-developed countries.

B. Standards in Which Climate Change Concepts May Be Used but Are Not Specifically Referenced and May Apply to Social Studies Classes

Strand/standard that connects to climate change (include number or other ID used in document)	Knowledge statement and example of what student is able to do
Standard 6: How culture and experience influence people's perceptions of places and regions	2. Changing perceptions of places and regions have significant economic, political, and cultural consequences in an increasingly globalized and complex world. Therefore, the student is able to:

	A. Explain the possible consequences of people's changing perceptions of places and regions in a globalized and fractured world, as exemplified by being able to: Analyze the changes in the US perceptions of increasing consumer demand and consumption in emerging national economics, especially in such Asian nations as China, India, Singapore, and South Korea.
Standard 9: The characteristics, distribution, and migration of human populations on Earth's surface.	3. Migration is one of the driving forces for shaping and reshaping the cultural and physical landscape of places and regions. *Therefore, the student is able to:* C. Compare and explain the ways in which different groups and governments adjust to the departure and arrival of migrants, as exemplified by being able to: Describe the benefits and challenges migrants face in bridging cultures and adjusting to a new place (e.g., resolving conflicts between old and new traditions, resolving differences between rates of adjustment when children may learn the language and adjust faster than parents, resolving differences in access to food items and traditional cooking methods in a new place.
Standard 10: The characteristics, distribution, and complexity of Earth's cultural mosaics	1. Cultural systems provide contexts for living in and viewing the world *Therefore, the student is able to:* B. Explain how different cultures provide contexts from which people may view the world differently, as exemplified by being able to: "Describe and explain how a current event might be viewed differently from the context of different cultures (e.g., the results of a US presidential election, the impact of a natural disaster such as Hurricane Katrina or a tsunami in the Indian Ocean, the global spread of US companies such as Wal-Mart, Starbucks, or McDonalds).

	2. Cultural landscapes exist at multiple scales *Therefore, the student is able to:* B. Explain differences in the human imprints on the physical environment of different cultures, as exemplified by being able to: "Explain how predominant agricultural practices in different cultures result in different imprints on the physical environment (e.g., forest removal for cattle ranches in the Amazon, terrace construction for rice farming in China, changes in land use patterns as a result of center pivot irrigation in the western United States).
Standard 12: The processes, patterns, and functions of human settlement	1. The numbers, types, and range of the functions of settlements change over space and time. *Therefore, the student is able to:* A. Explain how and why the number and range of functions of settlements have changed and may change in the future, as exemplified by being able to: Analyze the reasons for and results of policies of municipal governments on the internal structure of cities (e.g., zoning ordinances to determine the location and characteristics of residential, commercial, and industrial sectors, incentives to encourage development, legislation of flood-plain regions restricting development).
Standard 15: How physical systems affect human systems	2. Humans perceive and react to environmental hazards in different ways. *Therefore, the student is able to:* A. Explain and compare how people in different environments think about and respond to environmental hazards, as exemplified by being able to:

	Construct a list of environmental hazards and compare and contrast how people in developed and developing world regions prepare for and cope with the aftermath of these disasters. Explain how environmental hazards affect human systems and why people may have different ways of reacting to them, as exemplified by being able to: Describe and explain the short- and long-term effects of hurricanes in the Gulf of Mexico and Atlantic coast on beaches, buildings, and human activities (e.g., insurance rates, zoning, building codes, beach replenishment, displaced populations). 3. Societies use a variety of strategies to adapt to changes in the physical environment. *Therefore, the student is able to:* A. Explain how societies adapt to reduced capacity in the physical environment, as exemplified by being able to: Explain how societies historically adapted to reduced capacity in the physical environment (e.g. migration, limiting population growth, building aqueducts and cisterns) and predict locations where adaptation strategies might be required in the future. Explain how societies use technology in dealing with resource shortages amidst growing human populations (e.g., recycling used water, recycling paper products, converting to drip irrigation systems, development of new alternative energy sources). Describe and explain how societies may change their use of building materials in response to changes in the physical environment. B. Analyze the concept of "limits to growth" to explain adaptation strategies in response to the restrictions imposed on human systems by .

	physical systems, as exemplified by being able to: Analyze how people have adapted to physical environments that vary in carrying capacity (e.g., slash-and-burn agriculture practices, nomadic herding or hunting, importation of needed products). Analyze the lifestyles of humans in extreme or island environments and explain strategies inhabitants use to survive and not overwhelm the limits of their environments (e.g., water collection and rationing in arid climates, Inuit seasonal seal hunting and fishing practices, Antarctic researchers using sustainable living practices). Identify world locations that have vulnerable environmental conditions (e.g., extreme temperatures, limited access to water, steep topography) and high population density and explain adaptation strategies used in these locations that address the limits to growth.
Standard 16: The changes that occur in the meaning, use, distribution, and importance of resources	1. The meaning and use of resources change over time. *Therefore, the student is able to:* B. Explain how globalization and higher standards of living affect the meaning and use of resources, as exemplified by being able to: Explain how and why per-capita consumption of resources (e.g. petroleum, coal, electricity, steel, water, food) differs between developed and developing countries now and in the past. 2. The spatial distribution of resources affects patterns of human settlement and trade. *Therefore, the student is able to:* B. Analyze and evaluate patterns of trade in resources, as exemplified by being able to:

	Identify countries that lead the world in petroleum production and explain how petroleum wealth influences internationals economic and political relationships. 3. Policies and programs that promote the sustainable use and management of resources impact people and the environment. *Therefore, the student is able to:* A. Explain and compare the costs and benefits of using various types of renewable, nonrenewable, and flow resources as exemplified by being able to: Analyze the efforts of countries with emerging global economies (e.g., China, India, Brazil) to develop and use renewable and flow energy resources and evaluate the economic and environmental costs and benefits of these efforts. B. Evaluate policy decisions regarding the sustainable use of resources in different regions and at different spatial scales in the world, as exemplified by being able to: Compare government policies and programs to promote sustainability (e.g., reducing fossil-fuel dependency, recycling, conserving water) in developed and developing countries.
Standard 17: how to apply geography to interpret the past	3. Historical events must be interpreted in the contexts of people's past perceptions of places, regions, and environments *Therefore, the student is able to:* A. Analyze and evaluate the role that people's past perceptions of places, regions, and environments played as historical events unfolded, as exemplified as being able to: Describe the changes in perceptions about a group, place, or geographic feature and analyze the effects of those changes

	(e.g., opinions about the role of fires in national forests and parks, attitudes towards and therefore treatment of wetlands in the United States from 1700 to today, changes in attitudes about the characteristics of the Great Plains from the idea of the Great American Desert to the Dustbowl to the Breadbasket). Analyze and compare the changing perceptions of the tropical Latin American rainforests on the development policies towards their use (e.g., as a source of rubber and timber, as a barrier to transcontinental travel, as a home to indigenous populations, as a source of raw materials, as areas rich in biodiversity and in need of preservation, as a carbon sink).
Standard 18: How to apply geography to interpret the present and plan for the future	1. Geographic contexts (the human and physical characteristics of places and environments) provide the basis for analyzing current events and making predictions about future issues. *Therefore, the student is able to:* A. Explain and evaluate the influences of the geographic context on current events and issues to make informed decisions and predictions about the future, as exemplified by being able to: Identify different views regarding contemporary social and environmental challenges and analyze the geographic factors influencing the stakeholders and their preferred policies (e.g. visions from local citizens about the relative importance of privacy versus security, opinions from residents of multiple states about a shared resource and about mechanisms for seeking resolution, viewpoints from around the world about relationships between economic development, resource consumptions, population, and environmental alteration). 2. The current and possible future causes and processes of change in the geographic characteristics and spatial organization of places, regions, and environments.

	Therefore, the student is able to: A. Identify and explain the causes and processes of current and possible future changes in the geographic characteristics and spatial organization of places, regions, and environments, as exemplified by being able to: Describe and explain the possible effects of new routes and technologies on world trade patterns (e.g., the effects of increasing the size of the Panama Canal, opening the route through the Arctic Ocean, the development of increasingly larger supertankers and cargo ships).

C. Standards with *Explicit* Mention of Climate, Climate Change, or Global Change and Are More Likely to Be Taught in Science Classes Rather Than Social Studies Classes

Strand/standard that connects to climate change (include number or other ID used in document)	**Knowledge statement and example of what student is able to do**
Standard 7: The physical processes that shape the patterns of Earth's surface.	1. The interactions of Earth's physical systems (the atmosphere, biosphere, hydrosphere, and lithosphere) vary across space and time. *Therefore, the student is able to:* A. Explain how the effects of physical processes vary across regions of the world and over time, as exemplified by being able to: Explain the changing relationships among climate, vegetation, and landforms (e.g., desertification and soil degradation, glacial advances and retreats). Analyze and explain the differential effects on the climate of the relationship between water and wind at different latitudes (e.g. cold currents influence the creation of deserts at 20 and 30 degrees north and south latitudes, the formation of hurricanes and tropical storms).

	Analyze and explain the relationships between physical processes and the location of land features (e.g., river valleys, canyons, deltas, glaciated lakes and moraines, limestone deposits, caves, alluvial fans, canyons). B. Explain the ways in which Earth's physical processes are dynamic and interactive, as exemplified by being able to: Explain how volcanic eruptions and forest fires change atmospheric conditions and disrupt the nitrogen and carbon cycles. Explain how increasing surface temperatures result in melting ice sheets and rising sea levels. Construct a diagram illustrating how El Niño and La Niña form and how these influence weather in different locations on earth. 2. Earth-Sun relationships are variable over long periods of time resulting in changes in physical processes and patterns on Earth. *Therefore, the student is able to:* A. Explain how variability in Earth-Sun relationships affect Earth's physical processes over time, as exemplified by being able to: Explain how cyclic changes (e.g., precession or Milankovich cycle) in Earth's orbit are responsible for changes in heating that results in climatic changes such as an ice age and glaciation of Earth's surface. Describe the variability in climate over historic periods of time (e.g., over the last 1500 years or during epochs such as the Pleistocene). Explain how changes in sea coral (including current observations and fossil records) are due to sea level rise or fall as a result of climate variability.

Standard 8: The characteristics and spatial distribution of ecosystems and biomes on Earth's surface.	1. Ecosystems are dynamic and respond to changes in environmental conditions Therefore, the student is able to: A. Explain how there are short-term and long-term changes in ecosystems, as exemplified by being able to: Explain how ecosystems respond to long-term changes in the physical environment (e.g., glacial retreat, volcanic eruptions, sea-level rise, increases in sea temperatures). B. Explain how local and global changes influence ecosystems, as exemplified by being able to: Explain how global climate change could influence the location and extent of existing ecosystems and the formation of new ones. 2. The characteristics and geographic distribution of ecosystems Therefore, the student is able to: A. Explain the geographic distribution of ecosystems, as exemplified by being able to: Analyze the impact of rising sea temperatures on the distribution and survival of coral reef ecosystems. 3. The distribution and characteristics of biomes change over time Therefore, the student is able to: A. Explain how climate can influence and change the characteristics and geographic distribution of biomes, as exemplified by being able to: Explain how rising global temperatures can cause changes in various biomes (e.g., melting

	permafrost in tundra, changes in the location of deserts, increases in the length of growing seasons). Analyze the changes in the biomes of a particular region over time (e.g., the change of the Sahara from a grassland to a desert) and describe the climatic changes that caused these changes to occur.

D. Standards in Which Climate Change Concepts May Be Used but Are Not Specifically Referenced and Are More Likely To Be taught in Science Classes Rather Than Social Studies Classes

Strand/standard that connects to climate change (include number or other ID used in document)	**Knowledge statement and example of what student is able to do**
Standard 1: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information.	4. The uses of geographic representations and geospatial technologies to investigate and analyze geographic questions and to communicate geographic answers. *Therefore, the student is able to:* A. Analyze geographic representations and suggest solutions to geographic questions at local to global scales using geographic representations and geospatial technologies, as exemplified by being able to: Analyze the possible relationships between global human and physical changes using GIS (e.g. the relationship between global climate change, sea level rise, and population distribution)
Standard 14: How human actions modify the physical environment	2. The use of technology can have both intended and unintended impacts on the physical environment that may be positive or negative. *Therefore, the student is able to:*

	A. Evaluate the intended and unintended impacts of using technology to modify the physical environment, as exemplified by being able to: Evaluate various types of contemporary agricultural techniques (e.g., no-till farming, herbicides, pesticides, center-pivot application of chemicals, crop rotation, irrigation, increased acreage in production), and compare the positive and negative implications of using these techniques. 3. People can either mitigate and/or adapt to the consequences of human modifications of the physical environment. *Therefore, the student is able to:* A. Describe and evaluate scenarios for mitigating and/or adapting to environmental changes caused by human modifications, as exemplified by being able to: "Compare the costs and benefits of alternative solutions for a human-caused environmental problem, such as acid rain (e.g., coal with lower sulfur content, scrubbers on smokestacks, nuclear waste disposal, use of alternative energies) or urban heat islands (e.g., green roof construction, increased public transportation, energy efficient buildings).

Heffron, Susan Gallagher and Roger M. Downs, eds. *Geography for Life: National Geography Standards, Second Edition*. Washington, DC: National Council for Geographic Education, 2012. Address: 1145 Seventeenth Street, NW, Room 7620, Washington, DC 20036. Excerpts reprinted with permission.

College, Career & Civic Life (C3) Framework: A Note

The new C3 Framework was released while we were in the process of standards analysis. We therefore had time to conduct only a brief analysis. The C3 Framework has four dimensions, of which disciplinary concepts are one. Civics, Economics, Geography, and History are the four disciplines that comprise this

dimension of the framework, and professional organizations affiliated with each discipline assisted in developing the framework.

Source

National Council for the Social Studies. *The College, Career, and Civic Life (C3) Framework for Social Studies State Standards: Guidance for Enhancing the Rigor of K-12 Civics, Economics, Geography, and History.* Silver Spring, MD: 2013. Address: 8555 Sixteenth Street, Suite 500, Silver Spring, MD 20910.

Summary

Of the four disciplines within the C3 Framework, only geography includes content containing the words "climate" or "climate change." They are:

- "By the end of grade 2, individually and with others, students...explain how weather, climate, and other environmental characteristics affect people's lives in a place or region." (*C3 Framework*, 42)
- "By the end of grade 12, individually and with others, students...evaluate the influence of long-term climate variability on human migration and settlement patterns, resource use, and land uses at local-to-global scales" (*C3 Framework*, 43)

Additionally, the Framework's glossary includes several references to climate and climate change. Each term in the glossary includes an example. For six of the terms, *climate* or *climate change* appears within the example. These terms are *adapt to an environment*, *complex causal reasoning*, *economic globalization*, *environmental characteristics*, *geography*, and n*atural hazard*. In addition, the terms *climate change* and c*limate variability* are included and explained within the glossary.

Learner-Focused Inquiries

Essential Questions for Each Grade Band

This section and the next two sections provide suggestions for initiating and facilitating learner-focused inquiries. Specifically, we suggest Essential Questions and examples of Inquiry-Based Action Projects for four grade bands (K-2, 3-5, 6-8, and 9-12), for adult learners, and for informal audiences.

The concept of Essential Questions grows out of the educational research of Grant Wiggins and Jay McTighe (*Essential Questions: Opening Doors to Student Understanding,* ASCD, 2013). Such questions guide teacher instruction and student learning by focusing on major issues, problems, and themes that invite students to explore a subject in meaningful ways.

The suggested Essential Questions for the study of climate change have been designed to be appropriate for the cognitive and affective levels of development for students at different ages. The questions spiral up in complexity.

In the next section of this e-publication, you will find a template to use in guiding the learners you work with in defining their own Action Projects and then an example of an Action Project for each grade band and for adults. The specific project included for each grade band and for adults is merely an example.

Essential Questions by Grade Band

Grades K-2
WEATHER

- What is weather?
- Is the weather the same every day?
- How is it different from one day to the next?
- Have you experienced very hot/cold/windy/rainy/snowy weather?
- How do these kinds of weather affect people, plants, and animals?

RESOURCES

- What do we need to live?
- What do other animals need to live?
- What do plants need to live?
- What do people need that other animals and plants need, too?

GREENHOUSE EFFECT

- Why is sunlight important to life on Earth?

Grades 3-5

WEATHER AND CLIMATE

- What is the difference between weather and climate?
- What are some ways to track weather patterns where you live?
- Why is it important to collect data about weather and climate?
- Are climates the same in other parts of the United States (3-4)? Of the world? (5)

GREENHOUSE EFFECT

- How does the sun warm the earth?
- What is the greenhouse effect?
- What might happen if the sunlight warms the earth too much, and how might that affect people, other animals, and plants?

RESOURCES

- What are natural resources, and how do we use them?
- Are some of these natural resources renewable? How?
- Could we ever run out of natural resources? Which ones?
- What are some ways we can conserve (or use less of) our natural resources, such as: water, soil, food, coal, oil, gasoline, etc.?
- What are some ways we can protect our natural resources?

CLIMATE CHANGE

- What are some examples of renewable energy sources/technologies that could reduce human impact on the climate? How would each reduce climate change impacts?
- What are some steps that we can take to reduce human impact on climate change?

Grades 6-8

WEATHER AND CLIMATE

- How is weather different from climate?
- How are weather and climate influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things?
- How does human impact change how these features regulate the climate?
- Why does severe weather happen?
- What are some ways that humans can decrease the impacts of severe weather?

RESOURCES

- How do some of the natural resources we use impact the climate? (Local, national, global)
- How has the use of energy resources increased over the past century, and what does this have to do with climate change?

GREENHOUSE EFFECT
- What are greenhouse gases, and how are they related to climate change?

CLIMATE CHANGE
- If climate has changed throughout the earth's history, why is there so much concern about climate change today?
- What factors are responsible for climate change?
- Why do most scientists think that Earth's climate is changing as the result of human activity?
- What human activities are likely contributing to climate change?
- Why might people disagree about climate change?
- What can individuals do to slow the rate of climate change?
- What are local communities trying to do about climate change, and what are countries around the world trying to do about climate change?
- How will efforts to slow climate change affect individual people, communities, countries, and the planet?
- Who is responsible for climate change?

Grades 9-12

WEATHER AND CLIMATE
- How is weather different from climate?

GREENHOUSE EFFECT
- What is the carbon cycle?
- What is the greenhouse effect?
- What countries produce the most carbon dioxide as a total for the country? Which countries produce the most per capita? Add in the projected population increases for these countries. What conclusions can you draw from this data?
- How does the increase in anthropogenic carbon dioxide and other greenhouse gases affect climate?

RESOURCES
- How has the availability of natural resources guided the development of human society?
- What are the associated economic, social, environmental and geopolitical costs and risks associated with energy production?
- What new technologies and social regulations balance the costs and risks of

energy production?
- Is it our responsibility to reduce carbon emissions to try to mitigate climate change? Why or why not?

CLIMATE CHANGE

- What are some of the possible outcomes of a warming planet in various areas? Describe these outcomes in terms of their impacts on the environment, humans living in the affected areas, and the economy.
- What are some examples of engineering and technology that have reduced carbon emissions?
- What are the social impacts of climate change? Economic impacts?
- How might climate change affect human health globally? Food access? Civil strife?
- What are the economic impacts of climate change?
- How can climate scientists predict how climate change will impact the future?
- What can be done to mitigate climate change:
  - by individuals?
  - by local/state/national government (in the United States)?
  - by local/state/national non-profit organizations (in the United States)?
  - by national and international corporations?
  - by other countries?

Learner-Focused Inquiries

Inquiry-Based Action Projects for Each Grade Band and Adults

The intention is for teachers/facilitators to use a series of questions to guide learners in creating and pursuing an Inquiry-Based Action Project. Teachers/ facilitators are strongly encouraged to allow the class/group to generate the idea for the project using the questions provided. The specific projects included below for each grade band and for adults are merely examples.

You will notice that for each set of learners, we suggest a slightly modified series of ten questions:

1) What can WE do about climate change? (generate list of possibilities)

2) What can WE do HERE about climate change? (decide which items are feasible)

3) What project will we do? (select from possibilities listed in #1 and #2)

4) What is the goal of our project? (what we will accomplish)

5) How will we accomplish this goal? (action steps)

6) What do we need to do our project? (resources—people, materials, equipment, money)

7) How will we distribute the work? (who will do what)

8) What is our timeline? (when action steps will be accomplished)

9) How will we know if we have accomplished our goal? (what the indicators of success are and how we will measure/assess them)

10) How will we celebrate our project? (how we will make others aware of our accomplishment and take pride in our work)

At the end of this section, you will find a worksheet with these questions that your group or class may use to create its own project.

One Example of an Action Project for Grades K-2

1) What can WE do to learn about and help plants and animals? (generate list of possibilities)

- Composting/worm farm
- Planting a window garden; butterfly garden; vegetable garden
- The Great Backyard Bird Count
- Wildlife Watch (observing weather, plants and animals throughout the year)
- Building birdhouses or feeders

2) What can WE do HERE about climate change? (decide which items are feasible)

- Creating a worm farm with compost gives worms a home and food and helps turn trash into soil for plants.
- Planting a window, butterfly or vegetable garden would give plants access to sunlight and provide a home and food for insects and animals; a herb or vegetable garden would provide us with food that we don't have to buy at a store.
- Building a birdhouse and feeders would provide a home and food for birds.
- Watching birds, animals, and weather throughout the year will help us know what animals like to come to this place during the seasons. Wildlife Watch will help tell scientists what plants, animals, and weather we see at our school. This can help them know where certain animals and plants prefer to live and whether the weather affects them.

3) What project will we do? (select from possibilities listed in #1 and #2)
We have decided to do the Watch the Wild program.

4) What is the goal of our project? (what we will accomplish)
By observing plants, animals and weather at our school during the year, we will give real scientists information about how habitats are changing in different places.

5) How will we accomplish this goal? (action steps)

a. Observe the yard outside our classroom window once a week at the same time of day.
b. Observe the animals we see and take pictures if we can of the trees and flowers that are growing there. In addition, observe the weather (temperature, precipitation, sunlight, etc.).
c. Fill out a pocket chart as a class after we make our observations. Our teacher will report what we find to the Watch the Wild website using this

online form.

d. Track our observations for the whole year on a chart so we can see how the weather and animals change during the year.

6) What do we need to do our project? (resources—people, materials, equipment, money)

To do this project, we will need:

- An outdoor thermometer to measure temperature
- Pictures of animals found around our school
- Pictures of plants/trees found around our school
- Pictures to represent types of weather

7) How will we distribute the work? (who will do what)

We will work as a class to observe the area outside of our classroom window; our teacher will help report what we find to the Watch the Wild website.

8) What is our timeline? (when action steps will be accomplished)

We will begin our observations on the first Tuesday in October; we will observe every Tuesday that we are in school until the end of May; we will observe at 10am.

9) How will we know if we have accomplished our goal? (what the indicators of success are and how we will measure/assess them)

We can write a letter to Watch the Wild asking how our observations helped the scientists know about the weather, animals, and plants in our area.

10) How will we celebrate our project? (how we will make others aware of our accomplishment and take pride in our work)

With the help of our teacher, we can create a poster or website about our project to share with other students, teachers and our families.

One Example of an Action Project for Grades 3-5

1) What can WE do about climate change? (generate list of possibilities)

Adding more carbon dioxide to the atmosphere makes the planet warmer. Here are ways we have found to reduce the amount of carbon dioxide we produce:

- Drive Less**:** More than half of our carbon dioxide comes from vehicles, so people can use public transit (like buses and trains), carpool, bike, or walk to school. You save one pound of carbon dioxide for each mile of driving you eliminate.
- Change Your Light Bulbs: Replace regular light bulbs with LED bulbs to eliminate 150 pounds or more of carbon dioxide for each bulb per year. You also can cut costs, energy use, and carbon dioxide emissions by turning out lights when you leave a room.
- Cut Hot Water Use: Hot water heater thermostats can be turned down to 120 degrees, and hot water heaters can be wrapped in insulation. People can use low-flow showerheads and wash clothes in cold or warm water. Run the dishwasher and washing machine only with full loads.
- Adjust Your Thermostat: Having your family move the thermostat down just 2 degrees in winter and up 2 degrees in summer can eliminate about 2,000 pounds of carbon dioxide each year by reducing power use. Turn the heat down before sleep at night and when leaving the house.
- Plant Trees and Vegetation: Trees absorb carbon dioxide and give off oxygen. One tree will absorb over a ton of carbon dioxide during its lifetime. Plant a garden. Your food will only have to travel from your yard to your house, not in a truck, on a train, or in a ship.
- Recycle and Reuse: Recycle your used newsprint, cardboard, glass, metal, and recyclable plastic containers. Reuse items instead of discarding them, donate to charity, or give them to others. It takes less energy to make products from recycled goods than from new raw materials.
- Shop Smart: Have your family bring your reusable bags to shop. Buy products with less packaging and reusable or recyclable packaging. Buy in bulk when you can and reuse the packaging.

2) What can WE do HERE about climate change? (decide which items are feasible)

In the United States, 28% of our greenhouse gases come from transportation and 33% come from electricity generation. If we want to make a bigger difference, these two categories are the most important.

The first 4 topics in step 1 above address transportation and electricity use.

Become a "Cool School" and reduce your carbon dioxide output schoolwide: http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Cool-School-Challenge.aspx

3) What project will we do? (select from possibilities listed in #1 and #2)

Encourage our families to drive less!

4) What is the goal of our project? (what we will accomplish)

We will take a survey of how many miles each student's family drives in an average week. Then families will be encouraged to try to take public transit, carpool, bike, or walk and calculate how many miles we drove in our own car and in alternative transportation.

5) How will we accomplish this goal? (action steps)

a. Each student will ask their parents to help them calculate how many miles the car is driven each day for seven days. Older students can break the miles up into categories (going to school, going to work, after-school activities, shopping, entertainment, etc.).

b. Each student will bring the total miles driven in one week to school and record it in her or his notebook.

c. In class, students will brainstorm ways they can get to school and after-school activities using alternative transportation. They can brainstorm ways their families can use their cars less and/or use alternative transportation more.

d. Students will design a survey sheet to record the miles they drove in their cars, and the miles they traveled by bus, carpool, bike, or walking. They can create a survey sheet that includes their family members as well.

e. Once they have designed the survey sheets, each student will record the miles driven by car or alternative transportation.

f. At the end of the week, they will compare their individual totals of their normal driving habits with the miles they saved by taking alternative methods of transportation.

g. Students can create class graphs of the most miles saved. They can also create graphs of the number of miles traveled using alternative methods.

h. Students can write summaries of their investigations and describe how they will change their modes of transportation to emit as little carbon dioxide as possible.

6) What do we need to do our project? (resources—people, materials, equipment, money)

We will need to talk with our families and explain our project. The classroom teacher can provide guidance with creating surveys. We will need paper and pencils and may use computers to create graphs and data sets.

7) How will we distribute the work? (who will do what)

We can work individually on our family surveys and then work in teams of four to record and compare our data. We can write our conclusions individually and then share them with the class.

8) What is our timeline? (when action steps will be accomplished)

- Explanation of project: 1 class session
- Survey of normal driving mileage: 7 days
- Recording of data: 1-2 class sessions
- Survey of alternative transportation methods: 7 days
- Recording and comparing data: 2 class sessions
- Writing conclusions, creating graphs and sharing our results with the class: 3-4 class sessions

9) How will we know if we have accomplished our goal? (what the indicators of success are and how we will measure/assess them)

We will compare the number of miles we normally travel in each family with the number of miles saved by using alternative transportation. If we can reduce the number of miles driven in a car, we will have accomplished our goal!

10) How will we celebrate our project? (how we will make others aware of our accomplishment and take pride in our work)

We will share our findings with other classes and encourage them to conduct their own surveys. We can create a bulletin board display in the school showing which

class was able to reduce their carbon dioxide emissions the most by taking alternative transportation. We can send an article to our local newspaper explaining our project and our successes!

We may want to become a 'Cool School' and take the challenge: http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Cool-School-Challenge.aspx

One Example of an Action Project for Grades 6-8

1) What can WE do about climate change? (generate list of possibilities)

There are many things we can do. All them have one thing in common: they change how people use energy.

- Organize a campaign to increase recycling.
- Encourage people to turn down their thermostats.
- Urge people to get home energy audits and plant trees.
- More globally, support efforts to use less gasoline and switch to renewable sources of energy, such as solar, wind, hydroelectric, and geothermal power.

2) What can WE do HERE about climate change? (decide which items are feasible)

Being realistic, we should probably focus on things that we as kids can actually do. We can definitely encourage our families to recycle more and use cloth sacks rather than plastic or paper bags when they shop. We can also encourage our school to take steps, such as planting vegetable gardens, because locally grown produce saves energy. Another interesting possibility is to plant trees, because trees are very important in absorbing carbon dioxide, which is a greenhouse gas.

3) What project will we do? (select from possibilities listed in #1 and #2)

We have decided to plant a tree, either at school or in our community. Trees are very important in absorbing carbon dioxide from the atmosphere, helping to slow the rate of climate change. Scientists estimate that forests around the world absorb about 4.4 billion tons of carbon dioxide every year. We can plant trees to offset our carbon footprint of travel and the amount of carbon emitted by our

home. One tree absorbs about a ton of carbon over 40 years. One plane trip across the United States emits about 3 to 4 tons of carbon. The average carbon output of a student is about 10 tons per year. This is the impact planting trees can make.

We can calculate how much carbon dioxide our tree will absorb by using this calculator: www.treebenefits.com

A tool from the U.S. Forest Service also allows us to calculate carbon absorbed by trees.

http://www.fs.fed.us/ccrc/topics/urban-forests/ctcc

We can calculate the carbon output of a specific car or plane trip, or the carbon footprint of our home:

http://terrapass.com/carbon-footprint-calculator-2

4) What is the goal of our project? (what we will accomplish)

To successfully plant and nurture a tree in our school or in our community.

5) How will we accomplish this goal? (action steps)

We did some research, and these are the steps involved in planting a tree:

a. Research the kinds of trees that grow in our area. To find out this information, we will talk to the appropriate agency of our local government, such as the forestry department.

b. Select a species of tree to plant.

c. Obtain a seedling to plant. A seedling is a very young tree. We might be able to get a seedling from our town or city government. Nurseries also sell seedlings.

d. Select a place where we will plant the tree.

e. Dig a hole that is deep enough and approximately twice as wide as the root ball of the tree.

f. Place the root ball into the hole, along with enriched soil and fertilizer. We will be careful to remove any stones or stocks that are in the hole because they can cause air pockets, which prevent the soil from holding water.

g. Fill in the hole with soil. We will be careful to make sure that the root of the seedling is covered but that the stem of the tree isn't covered with soil.

h. With our toes, we will softy press down on the soil surrounding the tree, allowing the soil around the root to retain water.

i. Place mulch around the trunk of the tree. The chips from cedar trees make good mulch, which helps to hold the moisture.

j. Water the tree root well over the next several weeks.

6) What do we need to do our project? (resources—people, materials, equipment, money)

If our local government does not have seedlings for people, then we will need the money to purchase seedlings from a nursery. We will need a shovel, rake, enriched soil, fertilizer, water, and mulch. One way to raise the money for the seedling and the other equipment would be to have a bake sale.

7) How will we distribute the work? (who will do what)

- Researcher—one member of the group will research the best kinds of tree species for our area.
- Obtain the tree—One or two members of the group will obtain the tree, either from the local government or from a nursery.
- Plant the tree—All members of the group will work on actually planting the tree.
- Record the planting—One member of the group will record our efforts on a video recorder or an I-Phone.

8) What is our timeline? (when action steps will be accomplished)

This depends on what time of the year it is. Possible Response: We will successfully plant the tree over the next two weeks.

9) How will we know if we have accomplished our goal? (what the indicators of success are and how we will measure/assess them)

The tree will take root and will begin to grow. We will be able to see new leaves as they sprout, indicating that the tree has successfully taken root.

10) How will we celebrate our project? (how we will make others aware of our accomplishment and take pride in our work)

We will use the video recording to write an account of our tree planting for the school newspaper, a local newspaper, or a local news broadcast.

One Example of an Action Project for Grades 9-12

1) What can WE do about climate change? (generate list of possibilities)
We will start by generating a list of project ideas. We will write idea lists individually and then list all of the ideas on the board or poster paper for everyone to see. We can also generate ideas in small groups and then share small group ideas with the full group. Or we can call out ideas for someone to record on the board or poster paper, depending on the size and/or culture of the group.

2) What can WE do HERE about climate change? (decide which items are feasible)

We will discuss the project ideas to determine what the students themselves can do in their school and/or community, what is truly feasible given the age and number of students, the context, and resources available.

3) What project will we do? (select from possibilities listed in #1)

After discussing possible projects, we voted to select the ideas, or a combination of these activities. We decided to start composting food waste in the school cafeteria.

4) What is the goal of our project? (what we will accomplish)

Our goal is to plan and implement a composting program at our school. We will compost as much food waste as possible from our cafeteria and use the compost locally, both at school and in our community.

5) How will we accomplish this goal? (action steps)

a. Be sure everyone in the group knows what composting is and how it helps to reduce the release of "greenhouse gases," thereby helping the school to reduce its carbon footprint and contribute less to climate

change. The group educates itself through research, guest speakers, and perhaps a field trip to see composting in action, preferably at another high school.

b. Develop a preliminary timeline for the project.

c. Interview school administrators, district food service director or food service contractor, cafeteria staff, and waste managers to gain their input as to how to best implement composting at the school.

d. Using information gained through interviews, draft a composting plan for the school. Be sure that it includes educating the school community about why composting is important and how composting will be done at the school so that composting is made as easy as possible for cafeteria diners and workers. Be sure that if funds are necessary to purchase materials that the plan includes action steps to acquire the funds.

e. Submit the draft plan to all of the people who were interviewed in Step d for their feedback.

f. Revise plan based on feedback.

g. Submit the plan to the appropriate administrator or review committee for approval.

h. Follow the approved plan to implement composting at the school.

i. Revise timeline and implement plan.

j. Evaluate the composting program to determine its effectiveness, perhaps by weighing the food waste from one meal that is thrown away (not composted) and then weighing the food waste that is composted on another day after the composting program has been instituted when the same meal is on the menu.

6)What do we need to do our project? (resources--people, materials, equipment, money)

a. People to be interviewed

b. Materials mentioned during interviews, such as containers to collect food waste in the cafeteria and composting system to be installed on the school grounds

c. Money to purchase necessary materials

7) How will we distribute the work? (who will do what)

We will decide who will be responsible for what aspects of the project work. We need to identify all of the tasks and a means to assign tasks or have students volunteer for them. Then we will write a set of agreements to hold themselves responsible for the project tasks.

8) What is our timeline? (when action steps will be accomplished)

We will develop a broad timeline early in the process (see 5b above) and then revise, update, or expand it after the plan has been approved for implementation. The timeline will likely need to be adjusted as the plan is implemented.

9) How will we know if we have accomplished our goal? (what the indicators of success are and how we will measure/assess them)

After the composting program has been underway for two months, food waste that is going into the compost bin from a meal and going into the garbage/trash will be weighed and compared to the amount of food waste from the same menu meal that was going into the garbage/ trash before the composting program was implemented

10) How will we celebrate our project? (how we will make others aware of our accomplishment and take pride in our work)

Throughout the planning and implementation of the plan, we will make others at the school and in the larger community aware of the composting project. We can contact local newspapers, websites, and television and radio stations. After the goal has been met, we will celebrate the success with announcements in school assembly and through local media and have a celebratory event at the school, which might include adding some of the fully composted material to a garden bed or other landscaped area of the school grounds as a soil enhancement.

One Example of an Action Project for Adults

This activity can be done by formal or informal community organizations and can be facilitated by an adult education professional or by the group members themselves. Have the group work through the following questions as the project is developed and implemented.

1) **What can WE do about climate change?** (generate list of possibilities)

We will begin by brainstorming possible projects. Working as a whole group or in small groups, we can share ideas "popcorn" style or write them on Post-Its or large sheets of paper.

There are many actions we can take. We could organize a campaign to increase recycling, encourage people to turn down their thermostats, do home energy audits, and plant trees and gardens. More globally, we can support efforts to use less gasoline and switch to renewable sources of power, such as solar, wind, and hydroelectric technologies. All the above actions have this in common: they reduce use of energy from fossil fuels, lowering the production of "greenhouse gases" that contribute to climate change.

2) What can WE do HERE about climate change? (decide which items are feasible)

Again, small- or full-group discussion can be used to answer this question. Being realistic, we should probably focus on actions that we can actually do. We can definitely recycle more within our own homes and use cloth sacks rather than plastic or paper bags when we shop and encourage others to do so. We can also encourage our community to reduce its carbon footprint in a variety of ways, such as planting vegetable gardens, because locally-grown produce saves energy, and planting trees because they absorb and store carbon dioxide (a greenhouse gas), helping to reduce the amount of carbon dioxide in the atmosphere. Perhaps we can combine a few possible actions in a single project.

3) What project will we do? **(select from possibilities listed in #1 and #2)**

We have decided to "green up" and "take back" an alley in our neighborhood.

4) What is the goal of our project?(what we will accomplish)

Goal: to make our alley a neighborhood resource where all feel welcome and safe.

5) How will we accomplish this goal? (action steps)

a. Some research may be required to clearly identify action steps to meet the project goal. Committees or individuals, depending on the project, might do research. The full group can create the project action steps when informed by the research, which might include finding out about and learning from similar projects in other communities.

b. Find out who owns the alley.

c. Get permission/approval to "green up" the alley.

d. Publicize in advance a meeting to discuss the project and solicit ideas from community members for how the alley can be improved and address climate change.

e. Hold a community meeting to discuss the project and solicit ideas from community members.

f. Have a city planner and/or landscape designer consult with the project group about ways to improve the alley to benefit the community and help to address climate change with consideration of community members' ideas.

g. Create a plan and drawings of the alley improvement. This might include creation of a raised bed garden, planting trees and other vegetation, designating and furnishing play areas, identifying space for a street food vendor, installation of photovoltaic outdoor lighting, etc.

h. Hold another community meeting to present the plan and drawings and engage citizens in the project. Many hands make light work! At this time begin to create a plan for the maintenance of the alley after it has been improved. Who will have responsibility for the raised bed garden, caring for the other trees and plants, sweeping and disposing of recyclables and trash, and seeing that play equipment is safe and well maintained? Committees can be created to identify, coordinate, and accomplish work after the alley has been improved.

i. Apply for grant funding for the project, including funding for alley maintenance after the project is completed.

j. Implement the alley "green up" plan.

6) What do we need to do our project (resources--people, materials, equipment, and money)

The alley improvement project will require citizen volunteers and the expertise of professionals, such as planners, landscape designers, urban gardeners, and public officials. Materials will be required, too, such as equipment to remove pavement if necessary, construct raised beds, and create play structures. We will also need soil seeds and plants. Some of these resources, including professionals' time, may be donated or paid for through grants and community contributions.

7) How will we distribute the work? (who will do what)

It will be important to have a project coordinator, and that can be a citizen volunteer or someone paid by a grant. It is likely that initially the project will require a citizen volunteer and that in the early stages of the project, interested community members will do most of the work until grants or other funding can be secured for implementation of the project. As adults, we will need to be willing to volunteer to do the work and take responsibility.

8) What is our timeline? (when action steps will be accomplished)

It will be important to create a timeline for our work, and it will be dependent on the availability of community members and professionals. After we have received approval for our alley "green up" project, we can create a timeline that is realistic and flexible.

9) How will we know if we have accomplished our goal?(what the indicators of success are and how we will measure/assess them)

When our alley is transformed, we will have accomplished our goal. We can document this through photos and video of the entire improvement process, from start to finish, so that we have "before" and "after" pictures as well as a record of how we met our goal. These will be useful in reporting to grant funders on the project. Of course, the clearest indicator of our success will be having community members enjoy the alley, using it as a place to meet neighbors, relax, and take pride in their neighborhood.

10) How will we celebrate our project? (how we will make others aware of our accomplishment and take pride in our work)

We will have an alley party and invite all of our neighbors as well as local public officials. We will also invite media to cover as many steps in our project process as possible, from preliminary meetings to removing pavement to building raised beds to our alley party when the project is complete.

Worksheet to Guide the Development of an Inquiry-Based Action Project

The purpose of these questions is to guide learners through the development of their very own Inquiry-Based Action Project. The questions should be modified to be developmentally and culturally appropriate for the group that will be doing the action project.

1. What can WE do about climate change? (generate list of possibilities)

_____

_____

_____

_____

2. What can WE do HERE about climate change? (decide which items are feasible)

_____

_____

_____

_____

3. What project will we do? (select from possibilities listed in #1 and #2)

_____

_____

_____

_____

4. What is the goal of our project? (what we will accomplish)

5. How will we accomplish this goal? (action steps)

6. What do we need to do our project? (resources--people, materials, equipment, money)

7. How will we distribute the work? (who will do what)

8. What is our timeline? (when action steps will be accomplished)

9. How will we know if we have accomplished our goal? (what the indicators of success are and how we will measure/assess them)

10. How will we celebrate our project? (how we will make others aware of our accomplishment and take pride in our work)

Learner-Focused Inquiries

Essential Questions and Activities for Informal Educators

For those of us who work in informal settings (science centers, outdoor schools, zoos, aquariums, etc.), we can agree that the science of climate change, its causes, its effects on all of us, and ways to address it in our homes, communities, and governmental institutions are extremely complex. Since the complexity is difficult to convey in a short time frame, especially with learners you may not see again, we offer links to some activities that can be done in about an hour that will help students understand some component of climate change, or learn ways they can reduce their carbon footprint.

Grades K-2

WEATHER

- What is weather?

This web page lists simple activities you can do outdoors during various kinds of weather: Sunny Walk / Hot Walk / Windy Walk / Rainy Walk / Snow Walk
http://www.uen.org/Lessonplan/preview?LPid=10665

RESOURCES

- What do plants need to live?

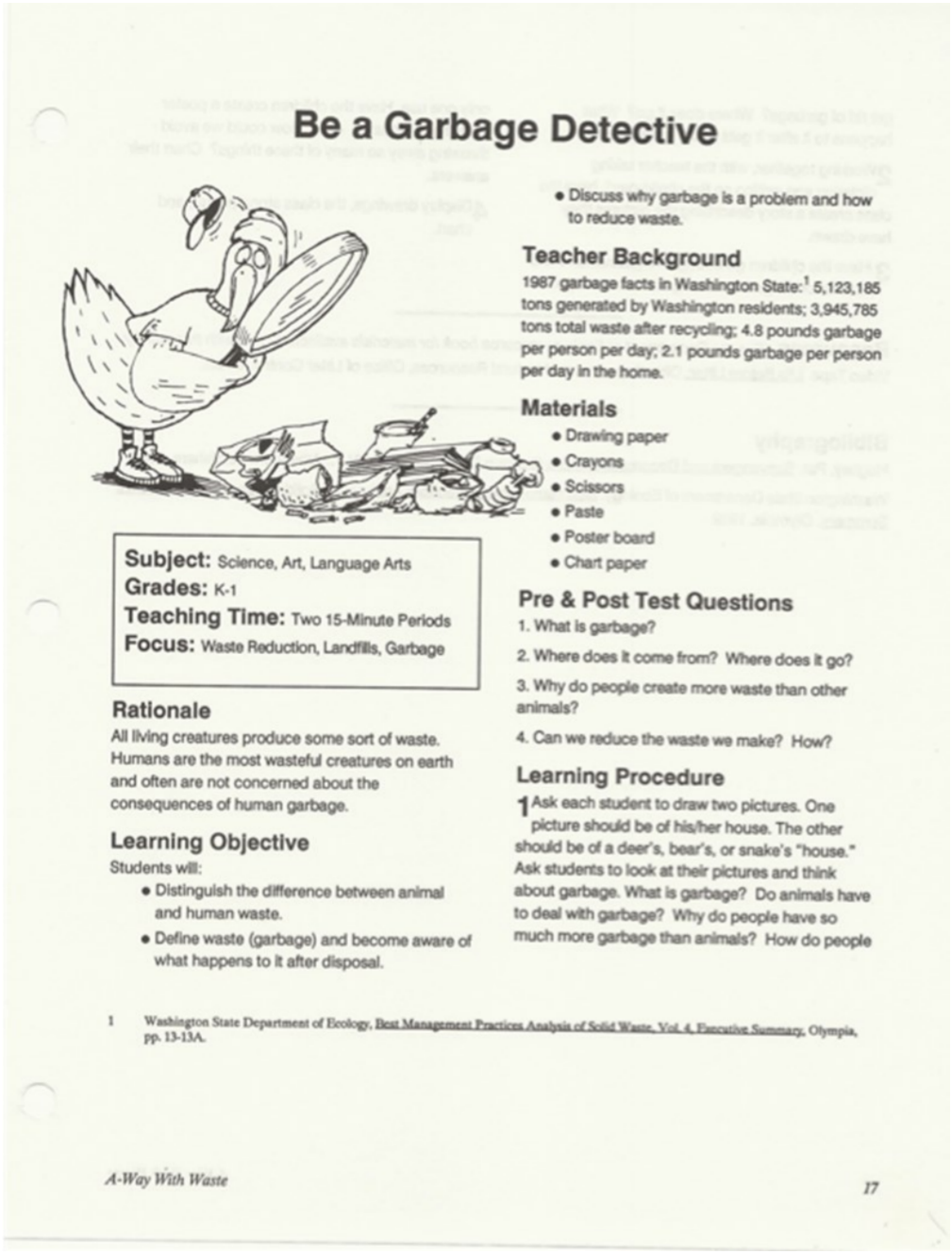
From Science and Plants for Schools "Plants in Their Natural Environment"
http://www.saps.org.uk/primary/teaching-resources/88-primary-article-one
Under 'Download Resources', click on 'SAPS Plants in Their Natural Environment, Part B'

GREENHOUSE EFFECT

- Why is sunlight important to life on Earth?

This site contains a simple experiment to demonstrate how rain is formed:
http://www.weatherwizkids.com/experiments-make-rain.htm

WHAT WE CAN DO TO ADDRESS THE ISSUE
Activity: "Be a Garbage Detective" teaches how to distinguish between animal and human waste and to better define waste (garbage) and become aware of what happens to it after disposal.



Be a Garbage Detective

Subject: Science, Art, Language Arts
Grades: K-1
Teaching Time: Two 15-Minute Periods
Focus: Waste Reduction, Landfills, Garbage

Rationale

All living creatures produce some sort of waste. Humans are the most wasteful creatures on earth and often are not concerned about the consequences of human garbage.

Learning Objective

Students will:

- Distinguish the difference between animal and human waste.
- Define waste (garbage) and become aware of what happens to it after disposal.
- Discuss why garbage is a problem and how to reduce waste.

Teacher Background

1987 garbage facts in Washington State:[1] 5,123,185 tons generated by Washington residents; 3,945,785 tons total waste after recycling; 4.8 pounds garbage per person per day; 2.1 pounds garbage per person per day in the home.

Materials

- Drawing paper
- Crayons
- Scissors
- Paste
- Poster board
- Chart paper

Pre & Post Test Questions

1. What is garbage?
2. Where does it come from? Where does it go?
3. Why do people create more waste than other animals?
4. Can we reduce the waste we make? How?

Learning Procedure

1 Ask each student to draw two pictures. One picture should be of his/her house. The other should be of a deer's, bear's, or snake's "house." Ask students to look at their pictures and think about garbage. What is garbage? Do animals have to deal with garbage? Why do people have so much more garbage than animals? How do people

1 Washington State Department of Ecology, Best Management Practices Analysis of Solid Waste, Vol. 4, Executive Summary, Olympia, pp. 13-13A.

Grades 3-5

GREENHOUSE EFFECT

- How does the sun warm the Earth?
- What is the greenhouse effect?

Activity: "Make Sun S'Mores"

Harness the energy of the Sun to make this yummy snack! Students create a solar oven out of a small cardboard box, foil, glue and plastic wrap, then heat a s'more to perfection using the sun's energy. View this activity on NASA's Climate Kids website: http://climatekids.nasa.gov/smores.

RESOURCES

- What are natural resources, and how do we use them?

Activity (web-based, interactive): "Where Does Energy Come From?" Students can click on the 'stars' that show where energy comes from for homes, humans, trees and industrial use. Go to: http://www.energystar.gov/index.cfm?c=kids.kids_index, click on "You Can Make Big Changes, Find Out How", then "Your Planet Needs You" on the bottom of the page, then on "Where Does Energy Come From?"

- Are some of these natural resources renewable? How?

Short activity (web-based, interactive): "What Are the Types of Energy?" Shows renewable energy (solar, wind, water, plants) and non-renewable energy (oil, coal, natural gas, nuclear) Go to: http://www.energystar.gov/index.cfm?c=kids.kids_index , click on "You Can Make Big Changes, Find Out How", then "Your Planet Needs You" on the bottom of the page, then on "Types of Energy".

- What are some ways we can conserve (or use less of) our natural resources, such as: water, soil, food, coal, oil, gasoline, etc.?

Activity (interactive, web-based): "You Can Make Big Changes in Your Own Bedroom" Students can click on the 'stars' on various items in their room to see how they can conserve energy. Go to: http://www.energystar.gov/index.cfm?c=kids.kids_index , click on "You Can Make Big Changes, Find Out How".

CLIMATE CHANGE

- What are some steps that we can take to reduce human impact on climate change?

Activity: "Extra Fancy Duds" from *A-way With Waste* from the Washington State Department of Ecology. Students will learn how to identify types of packaging from natural to recyclable to non-recyclable and to identify the ways that we're influenced to buy packaged products.

Extra Fancy Duds

Subject: Math, Science, Social Studies
Grades: K-5
Teaching Time: Two 15-Minute Periods
Focus: Packaging, Consumer Awareness, Waste Reduction, Biodegradation

Rationale

Packaging influences what people buy. People have choices and can reduce the amount of garbage (solid waste) they generate by making thoughtful choices when they buy packaged products.

Learning Objective

Students will:

- Be able to identify types of packaging and the ways that they are influenced to buy packaged products.

Teacher Background

Containers and packaging facts: Containers and packaging totaled 42.7 million tons in the municipal solid waste stream in 1986, or 30.3 percent of total municipal waste. The component by materials: glass, 7.6 percent; paper and paperboard, 14.5 percent; steel, 1.9 percent; plastics, 4 percent; aluminum 0.7 percent; and wood, 1.5 percent.[1]

Materials

- Two apples
- Plastic ribbon

Pre & Post Text Questions

1. What does "biodegradable" mean? (See Glossary)
2. Why do we need packaging?
3. What is plastic made of?

1 Franklin Associates LTD., Characterization of Municipal Solid Waste in the United States, 1960 to 2000: Update 1988, Prairie Village, KS: Franklin Associates LTD., pp. 15-16.

Grades 6-8

RESOURCES

- How do some of the natural resources we use impact the climate?

Activity: "Putting Your Product in a Package" From: Washington State Department of Ecology's "A-way With Waste." Students will understand some of the benefits and drawbacks of packaging and the function packaging plays in protecting and marketing products. From there, they learn to design packages which reflect their awareness of waste reduction and resources.

Putting Your Product In A Package

Subjects: Consumer Education, Business, Economics, Design, Industrial Arts
Grades: 7-12
Teaching Time: 45 Minutes
Focus: Packaging, Waste Reduction

Rationale

Packaging is the largest single component of household solid waste.[1] Many materials produced for the marketplace, however, need to be packaged in order to protect them during shipping. At the retail outlet, packaging serves to advertise products and identify contents, and may be required to meet regulatory standards.

Learning Objective

Students will:

- Understand som the benefits and drawbacks of packaging.
- Understand the function packaging plays in protecting and marketing products.
- Design packages which reflect their awareness of the waste reduction and resource conservation consequences of packaging decisions.

Materials

- The packaged products listed on the worksheet.
- "Packaging Information Sheet" and "Packaged Products Worksheet."
- Materials for design/construction of prototype packages.

Pre & Post Test Questions

1. Why are products packaged?
2. What are the benefits and drawbacks of packaging?

1 Peter T. White "The Fascinating World of Trash," National Geographic, April 1984, Vol. 165, No. 4, pp. 424-437.

GREENHOUSE EFFECT

- What are greenhouse gases, and how are they related to climate change?

A computer animation of the Greenhouse Effect (2 minutes) found on YouTube under "Greenhouse Gases: Climate Change, Lines of Evidence: Chapter 3" http://www.youtube.com/watch?v=3JX-ioSmNW8. Also, use the following interactive, web-based activity: Greenhouse Gas & Greenhouse Effect Simulation http://phet.colorado.edu/en/simulation/greenhouse.

CLIMATE CHANGE

- What human activities are likely contributing to climate change?

Activity: Through this web-based, interactive activity, students can calculate their carbon footprint on this page designed for middle and high school students: http://footprint.stanford.edu/calculate.html.

- What are local communities trying to do about climate change, and what are countries around the world trying to do about climate change?

Activity: "Climate Change Card Games" from *Climate Choices / Children's Voices* in the United Kingdom found at: http://www.climatechoices.org.uk/pages/activities0.htm#p1. This activity has a total of 32 cards. The cards cover 8 different countries (Bangladesh, Kenya, Nepal, Peru, Sri Lanka, Sudan, Zimbabwe, UK, USA) and each country card shows:

  - The effects of climate change in the country
  - A solution to help the people tackle the effects of climate change
  - A personal story
  - A map of the world with the country marked on it

The cards can be found at: http://www.climatechoices.org.uk/docs/card_games_cards.pdf

- Who is responsible for climate change?

Activity: (from "Understanding Climate Change" by Laura Tucker, ©2012; for complete curriculum, contact: ltucker@berkeley.edu).

- Have students work in groups of 4-6.
- Use the following graphs of temperature, carbon dioxide data, and human population growth to discuss the statements below.
- They should decide individually if they agree or disagree with each statement and write their evidence to support their claim. Students

take turns stating whether they agree or disagree with each statement. They should cite evidence from the graphs to support their claims.

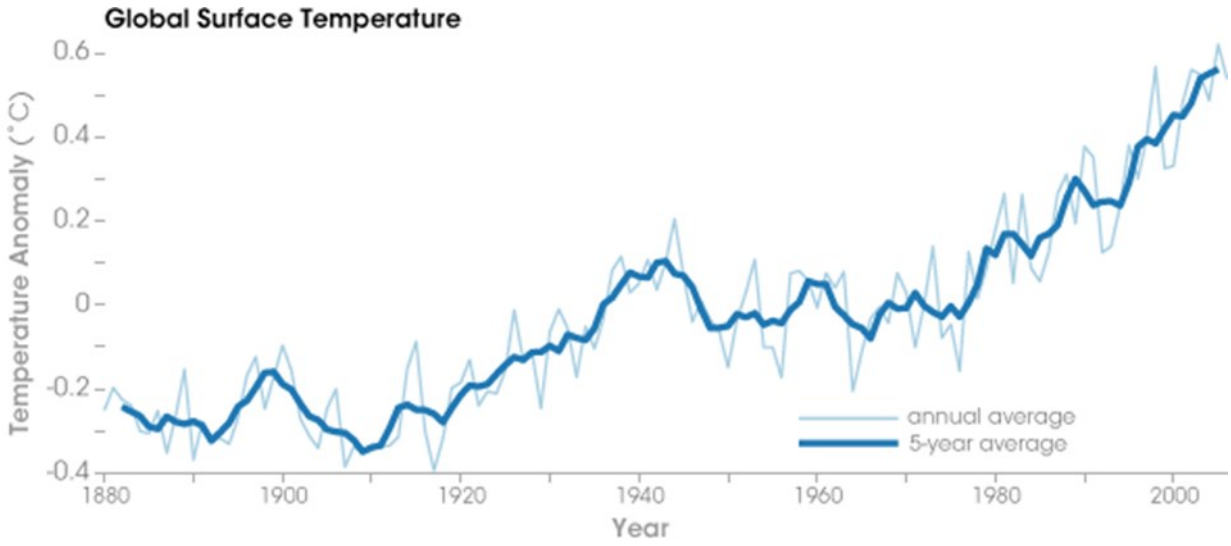
- After all students have taken a turn, have the group try to come to a conclusion for each statement. In a debriefing of the activity, have each group share their results with the class.

Do you agree or disagree with each statement?

1. The earth is warming, but it is a normal, cyclical pattern with no cause for concern.
2. There is a direct correlation between human beings and the increase of CO_2 in the atmosphere.

Graph 1: Global Surface Temperature

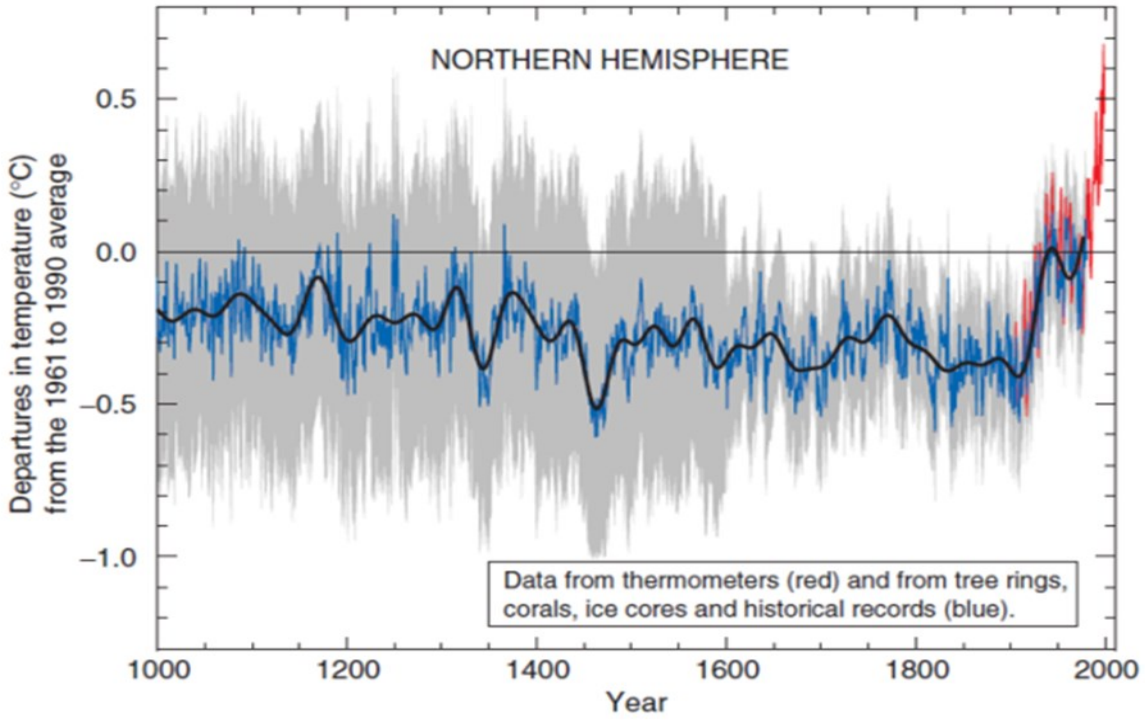
The graph shows one degree Fahrenheit rise in the temperature record of the entire Earth's surface during the 20th century.



Source: earthobservatory .nasa.gov

Graph 2: Temperatures in the Northern Hemisphere

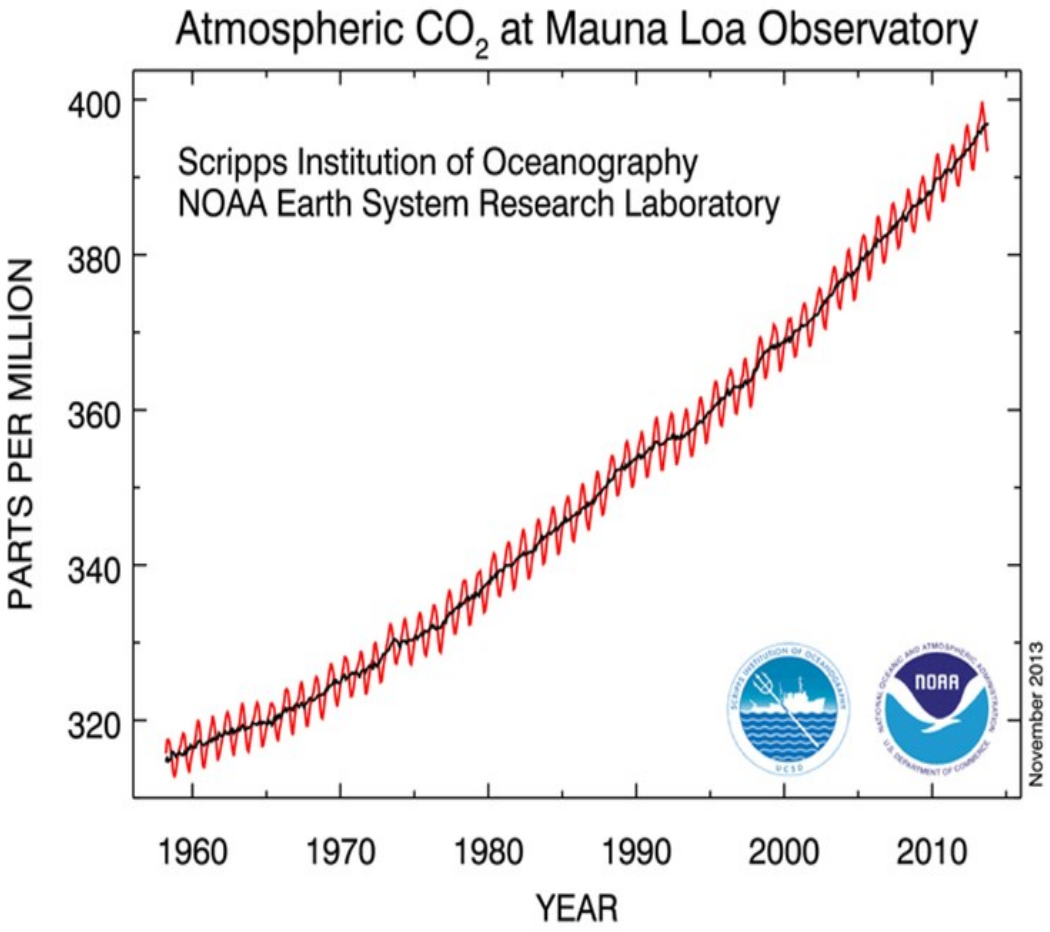
The graph shows 1,000 years of temperature in the northern hemisphere.



Source: IPCC Third Assessment Report, *Climate Change 2001*

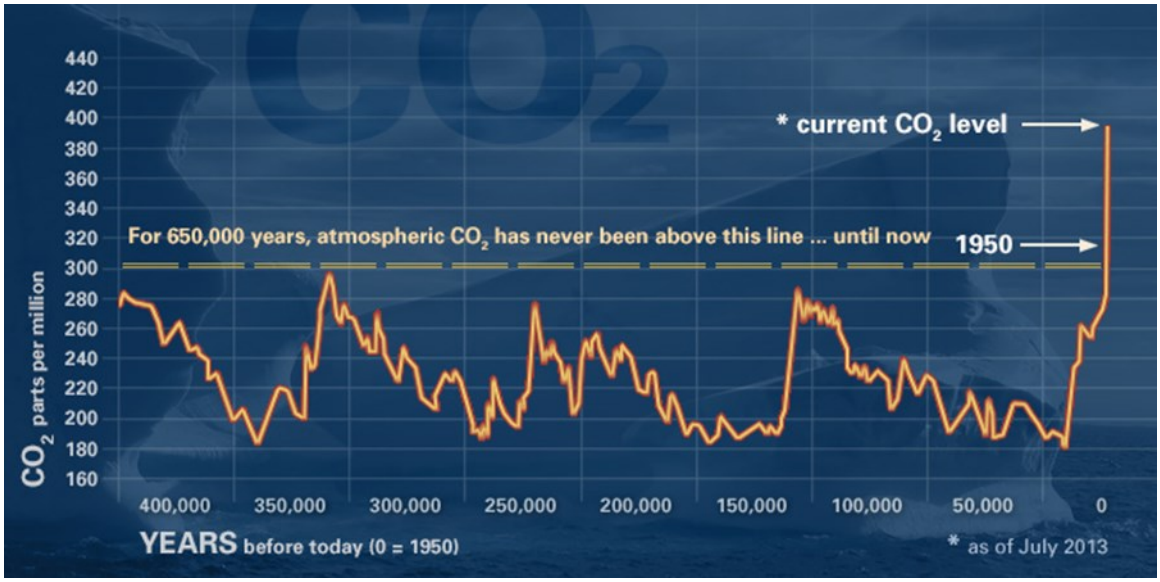
Graph 3: Carbon Dioxide Measurements on Mauna Loa

The carbon dioxide data (red curve) on Mauna Loa constitute the longest record of direct measurements of CO2 in the atmosphere. C. David Keeling of the Scripps Institution of Oceanography started the measurements in March, 1958. NOAA started its own carbon dioxide measurements in May of 1974. This unbroken record of the carbon dioxide content of the atmosphere shows how it's gone up from around 315 parts per million in 1958 to around 400 parts per million on average today.



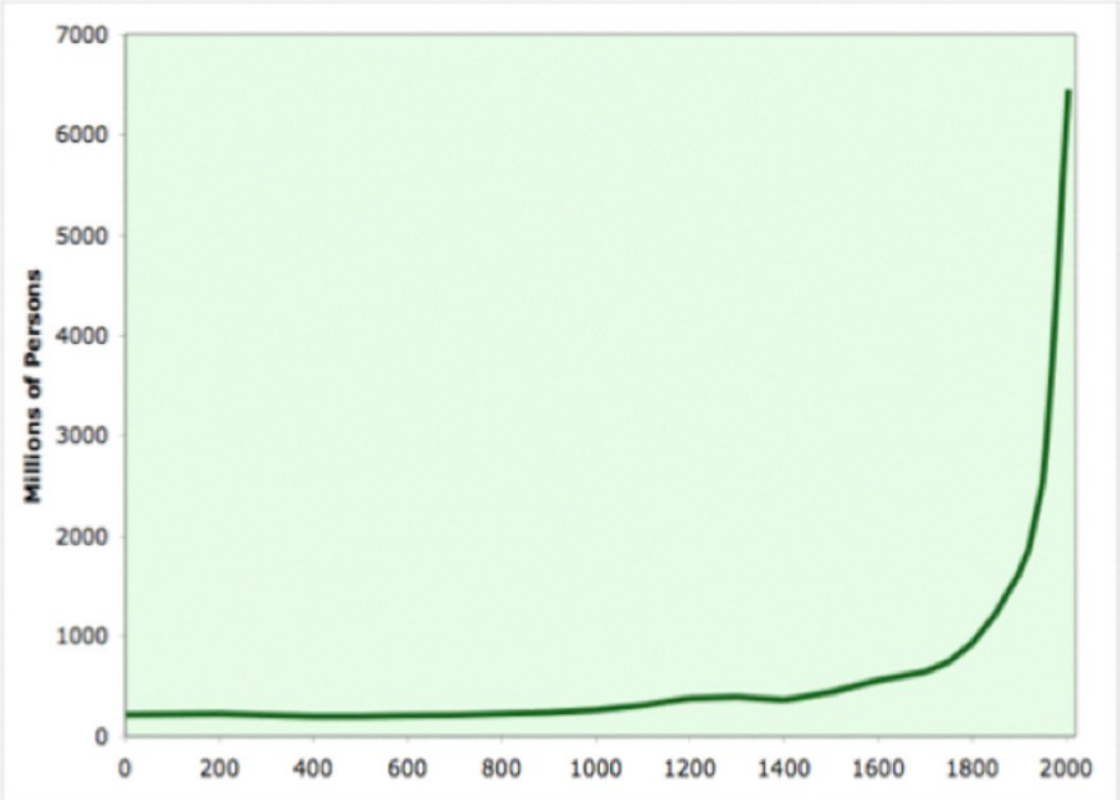
Source: Scripps Institution of Oceanography, National Oceanic and Atmosphere Administration Earth System Research Laboratory.

Graph 4: Measurements of Carbon Dioxide from Ice Cores and Other Sources
This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO2 has increased since the Industrial Revolution.



Source: National Oceanic and Atmosphere Administration

Graph 5: The Growth of the World Population since AD 0



Source: U.S. Census Bureau. The graph before 1900 is an average of the McEvedy/Jones and the Biraben estimates. After 1900, the UN data is used.