

Climate Literacy Network

Working Towards a Sustainable Future



August 1, 2010

To: The National Research Council Committee on K-12 Science Education
From: The Climate Literacy Network
Re: Comments on the Draft NRC Science Framework for Science Education

Over the 21st century, climate scientists expect Earth's temperature to continue increasing, very likely more than it did during the 20th century. Two anticipated results are rising global sea level and increasing frequency and intensity of heat waves, droughts, and floods. These changes will affect almost every aspect of human society, including economic prosperity, human and environmental health, and national security (Climate Literacy, 2009, USGCRP). Climate change will bring economic and environmental challenges as well as opportunities, and citizens who have an understanding of climate science will be better prepared to respond to both. To increase the nation's climate literacy, education will play a critical role over the coming decades to prepare our citizens. Society needs citizens who understand the climate system and know how to apply that knowledge in their careers and in their engagement as active members of their communities. To this end, as the educational systems continue to revise their educational standards, climate will need to play a much more central role.

To ensure that both future citizen and the workforce understand climate change and are skillful in making informed and responsible decisions with regard to actions that may affect climate the *Guiding Principle for Informed Climate Decisions* was developed. It states that —Humans can take actions to reduce climate change and its impacts. When the committee reviews this requirement for education, it presents a significant challenge to our nation's educational systems. Students and teachers need to understand that actions taken by individuals, communities, states, and countries all influence climate. Practices and policies followed in homes, schools, businesses, and governments can affect climate. And climate-related decisions made by one generation can provide opportunities as well as limit the range of possibilities open to the next generation. These challenges offer a substantial opportunity for education in our perspective. We are pleased to see significant increases in climate education over the last few years have been captured by the committee.

The Climate Literacy Network (CLN) provides a forum for organizations, agencies and individuals to collaborate for climate education. Members share ideas, coordinate efforts, promote policy reform, develop learning resources and support integration of climate literacy into formal and informal education venues.

These notes were developed through a collaborative process that included CLN members from the TERC, University of Colorado Boulder (CIRES), NOAA, College of Exploration, Museum

of Earth, Lawrence Hall of Science, North American Association for Environmental Education, University of Oregon, George Mason University and the National Science Digital Library team.

With a particular interest in how climate is addressed in the Draft NRC Science Framework, the Climate Literacy Network held a telecon on July 20th for two hours to discuss the overall framework and specific aspects that relate to climate science. It should be noted that while we had hoped to look at energy and sustainability/solutions related topics as well as the entire document, time constraints did not permit this.

General Comments

Earth System Science

A key question that arose early in the discussion arose around why the term “Earth System Science” wasn’t used since many of us were familiar with this phrase, which includes the geosphere, atmosphere, hydrosphere and biosphere. (Some have also added the technosphere, which would include human activities, which impact the other spheres.) In the framework document the phrase “earth systems” is more common.

However, of more concern to was the focus on “earth’s surface” which felt confusing and inconsistent with other documents. Does the earth’s surface include the atmosphere and ocean, or is it primarily the surface of the geosphere and ocean?

The Carbon Cycle

The carbon cycle, which is essential for understanding climate dynamics and fossil fuels, wasn’t well represented in the framework. While carbon is mentioned here and there throughout the document, carbon cycle is only mentioned once, and much more could be done to —close the loop’ in helping learners more fully connect climate, photosynthesis, carbon and energy consumption.

The carbon cycle is represented extensively in the Climate Literacy guide (<http://cleanet.org/cln/index.html>). The most specific alignment is to: 2D. The abundance of greenhouse gases in the atmosphere is controlled by biogeochemical cycles that continually move these components between their ocean, land, life, and atmosphere reservoirs. The abundance of carbon in the atmosphere is reduced through seafloor accumulation of marine sediments and accumulation of plant biomass and is increased through deforestation and the burning of fossil fuels as well as through other processes.

Examining the Climate Topics

Climate is an ideal big picture issue. This rich topic can be approached at many levels, from comparing the daily weather with long-term records to exploring abstract representations of climate in computer models to examining how climate change impacts human and ecosystem health. Learners of all ages can use data from their own experiments, data collected by satellites and other observation systems, or records from a range of physical, chemical, biological,

geographical, social, economic, and historical sources to explore the impacts of climate and potential adaptation and mitigation strategies.

The group determined that, while the first chapters of the framework were important to consider in terms of the “big picture,” since climate wasn’t specifically called out except as an example of important topics students should learn, we would not focus our input there. Time constraints mandated that we confine our attention to the section of the framework which contained the most specific climate related ideas and concepts. This is contained in chapter seven Prototype Learning Progressions and more specifically the Earth and Space Science Core Ideas.

Specific Recommendations for Changes/Additions

Notations use both the overall page number in the pdf document and the chapter#-page #

Page 139 (7-29) ESS Core Idea 2, ESS2.C: Earth’s History

In the Grades 9-12 section we recommend that the last sentence of the second paragraph read “Some other absolute dating methods use tree rings and sedimentary records of cyclic climate changes.” The word “cyclic” replaces the word “rhythmic”.

Page 140 (7-30)

The focus on “Surface” in ESS Core Idea 3 is too narrow. Earth systems mentioned in Sub-question but should be more overarching. We suggested a new ESS3 – **In the Earth system the flow of energy drives the cycling of matter**

ESS3 Core Idea 3 If this replacement is not made then there needs to be an explicit mention of Atmosphere/air. In addition the phrase “the cycling of water and rock” should be changed to “the cycling of water and materials”

ESS3.A “The Roles of Water in the Earth’s Surface Processes” should be changed to “The Roles of Water in the Earth System Processes.” Water plays an important role in all of the components of the Earth system.

There is no mention here of climate and related variability with respect to the role of water.

Page 141 (7-31)

In the section Grades 9-12 - How do the Earth’s surface systems interact? The first sentence “Earth’s climate and plate tectonic systems are dominated by the unique physical and chemical properties of water.” is wrong and it does not match with the high level ESS 3 Core Concept. Are plate tectonics really dominated by water properties? It is confusing to lump plate tectonics with other processes driven more by sunlight.

Page 142 (7-32) ESS3.C Weather and climate

There is a problem with word “regulates” in the Sub-question “What regulates weather and climate?”. It is suggested that the sub-question be changed to “What drives weather and climate? Then change the text immediately following the sub-question to...
“Weather and climate are shaped by complex interactions among the components of the Earth’s system, and change over varying time scales.”

In the Grades K-2 section change the word “sun” to “sunlight.” This is more accurate while using language that can be understood by young children.

In the Grades 3-5 section last paragraph starting “Weather is a minute-by-minute to day-by-day variable...”

The definition of climate should include time average and area averages. The definition of climate should also encompass seasonal as well as annual conditions.

In the Grades 6-8 section first paragraph the word “Sun” should be changed to “sunlight”
Grades 6-8: In the paragraph on the Greenhouse effect it should be explicitly stated that the greenhouse effect is a natural phenomenon. Maybe restate the last sentence to read “Without this natural phenomenon, the Earth would be too cold to be habitable.”

Ideally the reasons for the seasons - axial tilt should be included here, but it is mentioned elsewhere.

Page 143 (7-33) ESS Core Idea 3

There is a lot in the Grades 9-12 section.

In the 4th paragraph the word “aerosols” should be added as follows
“Small increases in the atmospheric concentration of carbon dioxide and other greenhouse gases tend to increase the capacity of the Earth to retain heat, while clouds, aerosols, and volcanic ash in the atmosphere tend to decrease the amount of solar heat that can enter the system”

Page 144 (7-34)

ESS3.D Biogeology - How does life interact with Earth’s other systems? “Earth’s other systems” seems a strange way to phrase it. A better way would be “How does life influence the Earth system?”

In the Grades 6-8 section it is recommended that the phrase “How does life affect Earth’s geology?” be replaced by “How does life influence and how is it influenced by the geosphere, hydrosphere and atmosphere?”

In the Grades 9-12 section it is recommended that the question “How has geology affected the evolution of life?) be replace by “How has the Earth system affected the evolution of life?”

Page 145 (7-35)- ESS4

ESS Core Idea 4 should be changed to read “Human activities are constrained by and, in turn, affect all other processes in the Earth system”

In the Grades 9-12 section in the first sentence of the last paragraph the word “relatively” should replace “unusually” to read “A range of natural records shows that the last 10,000 years have been a relatively stable period in the Earth’s climate history.”

Page 146 (7-36)

In addition, opportunities to emphasize that fossil fuels are concentrated forms of buried solar energy are included in some of the ESS (146 (7-36)) but can be made more explicit. Links to energy related pages is important, and, while the group didn’t look closely at the Solutions page (169 (7-59)) we feel this is important and, where possible and appropriate, should be integrated with other relevant climate, energy, and environment pages.

Page 148 (7-38) Human Impacts on the Earth

It is recommended that the two sentences after the sub-question be revised to read “Humans have become one of the most significant agents of change in the Earth system. The activities that have built human civilizations have both positive and negative consequences related to the sustainability of these civilizations and the ecosystems they are interdependent with.” The main focuses of the changes are to recognize the importance of the Earth system and that it is broader than the Earth’s surface.

The statement below the sub-question, mentioned above should include the question “How can society and the ecosystem on which it depends be made more resilient in the face of change in the Earth system?”

In the Grades 3-5 section the last sentence should be changed to read:

Modest change in individual and societal activities, practiced by many, can significantly impact pollution – either positively or negatively.

The Grades 6-8 focuses on the negative impacts of human activities. It should be countered by including solutions as described in the Climate Literacy: Essential Principles of Climate Science (<http://cleanet.org/cln/index.html>).

In the Grades 9-12 section the question “How can humans exist sustainably and indefinitely on Earth? Should be changed to “How can humans exist sustainably on Earth?” Take out the word “indefinitely.”

In the Grades 9-12 section, the first paragraph 2nd sentence add the phrase “and energy” so that it reads. As human populations and per capita consumption of natural resources and energy increase, so does the rate of our impact on Earth.” Also in the next paragraph first sentence add “energy” so that it reads “...management of natural resources and energy.”

It is suggested that the concept of building resilient communities and being prepared for changes should be included.

Page 149 (7-39) ESS4.D Global Climate Change

The first sentence after the sub-question should be changed to “Climate change, driven by both natural and human activities, has large consequence for all of Earth’s systems” taking out the word “surface”.

The Grades K-2 section should not be left blank. You can start an understanding of Earth system, i.e. begin to have the children understand that there are connections between the components of the Earth system. The AAAS benchmark strand maps at K-2 level include “The sun warms the land, air, and water,” “Water can be a liquid or a solid and can go back and forth from one form to the other. If water is turned into ice and then the ice is allowed to melt, the amount of water is the same,” and “Water left in an open container disappears, but water in a closed container does not disappear.”

AAAS benchmarks and the research behind them can be utilized to assure that Earth system science, weather, and climate concepts are introduced at the appropriate grade levels.

In the Grades 3-5 section there should be a statement that will address how to respond while helping instill the concept of change. How about how have things changed from the past to now, and put it in the positive context of - how has life changed in response to changes in the climate system in the past?

In the Grade 9-12 section energy should be brought into the discussion. In the section on “What can be done to reduce global climate change and its negative impacts” focusing only on climate models is not acceptable. Look at Guiding Principle for Informed Climate Decisions in the Climate Literacy Essential Principles (bottom of this document). Include text along the lines of reducing energy use by individuals, communities’, governments, etc.

Pages 174-176 (7-64 to 7-66)

ET Core Idea 4: “In today’s modern world everyone makes technological decisions that affect or are affected by technology on a daily basis. Consequently, it is essential for all citizens to understand the risks and responsibilities that accompany such decisions.” [Technology and Society] is a place that the Guiding Principle for Informed Climate Decisions could inform the content.

The Guiding Principle for Informed Climate Decisions could also help inform other Core Ideas (especially ESS and ET) relating to solutions and sustainability.

Guiding Principle (GP) for Informed Climate Decision

Concept GPA. Climate information can be used to reduce vulnerabilities or enhance the resilience of communities and ecosystems affected by climate change. Continuing to improve

scientific understanding of the climate system and the quality of reports to policy and decision-makers is crucial.

Concept GPB. Reducing human vulnerability to the impacts of climate change depends not only upon our ability to understand climate science, but also upon our ability to integrate that knowledge into human society. Decisions that involve Earth's climate must be made with an understanding of the complex interconnections among the physical and biological components of the Earth system as well as the consequences of such decisions on social, economic, and cultural systems.

Concept GPC. The impacts of climate change may affect the security of nations. Reduced availability of water, food, and land can lead to competition and conflict among humans, potentially resulting in large groups of climate refugees.

Concept GPD. Humans may be able to mitigate climate change or lessen its severity by reducing greenhouse gas concentrations through processes that move carbon out of the atmosphere or reduce greenhouse gas emissions.

Concept GPE. A combination of strategies is needed to reduce greenhouse gas emissions. The most immediate strategy is conservation of oil, gas, and coal, which we rely on as fuels for most of our transportation, heating, cooling, agriculture, and electricity. Short-term strategies involve switching from carbon-intensive to renewable energy sources, which also requires building new infrastructure for alternative energy sources. Long-term strategies involve innovative research and a fundamental change in the way humans use energy.

Concept GPF. Humans can adapt to climate change by reducing their vulnerability to its impacts. Actions such as moving to higher ground to avoid rising sea levels, planting new crops that will thrive under new climate conditions, or using new building technologies represent adaptation strategies. Adaptation often requires financial investment in new or enhanced research, technology, and infrastructure.

Concept GPG. Actions taken by individuals, communities, states, and countries all influence climate. Practices and policies followed in homes, schools, businesses, and governments can affect climate. Climate-related decisions made by one generation can provide opportunities as well as limit the range of possibilities open to the next generation. Steps toward reducing the impact of climate change may influence the present generation by providing other benefits such as improved public health infrastructure and sustainable built environments.

Key Climate Terms

In examining how a small informal list of key terms relevant to climate science education, energy and sustainability are addressed in the document, we did an initial inventory of indicator words with the following results:

Following are indicators of how often key terms are covered:

Energy -370

System- 255
Climate- 64
Climate change- 30
Carbon- 26
Fossil fuel- 12
Greenhouse- 10
Earth's systems- 10
Greenhouse gas- 8
Human impact- 6
Infrared- 5
Adaptation- 5
Solar energy- 4
Photosynthesis- 4
Resilient- 2
Resilience- 2 (Note: The new NOAA Next Generation Strategic plan uses resilient or resilience 49 times)
Carbon cycle- 1
Incoming solar- 1
Global warming- 0
Climate variability- 0
Variability- 0
Mitigation- 0

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