



UNITED STATES DEPARTMENT OF COMMERCE
Office of the Under Secretary for
Oceans and Atmosphere
Washington, D.C. 20230

July 29, 2010

TO: Helen Quinn, Chair, Committee on Conceptual Framework for New Science Education Standards

Louisa Koch

FROM: Louisa Koch, Chair, NOAA Education Council

SUBJECT: Comments on the climate sections of the Draft NRC Science Framework for Science Education

NOAA led the development of the Climate Literacy essential principles, adopted by the federal agencies under the U.S. Global Change Research Program. We commend the committee for using these principles to help inform the development of the Framework for Science Education and are encouraged to see climate more prominently represented than in the previous National Science Education Standards.

Why does climate science literacy matter? 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.

In the AAAS Project 2061 *Atlas of Science Literacy*, Volume 2, they concluded that "*Science, mathematics, and technology have a profound impact on our individual lives and our culture. They play a role in almost all human endeavors, and they affect how we relate to one another and the world around us. . . . Science Literacy enables us to make sense of real-world phenomena, informs our personal and social decisions, and serves as a foundation for a lifetime of learning.*" To that end, climate is an ideal interdisciplinary theme for lifelong learning about the scientific process and the ways in which humans affect and are affected by the Earth's systems. Climate change will continue to be a significant and growing element of public discourse. Understanding the essential principles of climate science will enable all people to assess news stories and contribute to their everyday conversations as informed citizens.



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. We would like to provide some comments to further refine the draft framework.

General Comments:

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 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.

We address the carbon cycle extensively in the Climate Literacy guide. 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.

Specific Comments:

Page 139 (7-29) - Earth’s History – Grades 9-12, strongly recommended replacing “rhythmic” climate change with cyclic– > cyclic climate change

Page 140 (7-30) - ESS3 Core idea needs to have an explicit mention of Atmosphere/air; and the cycling of water and materials

ESS3.A The Roles of Water in the Earth’s Surface Processes (take out “Surface”)

There is no mention of climate and related variability with respect to the Role of Water. Earth systems is mentioned in Sub-question

Page 141 (7-31) - The geo-centric focus of this EES is problematic. Suggested new ESS3 – *In the Earth system the flow of energy drives the cycling of matter*

Page 142 (7-32) Weather and climate

There is a problem with “regulates” in the Sub-question. Suggest changing to: What “drives” weather and climate? Change the next comment:

“Weather and climate are shaped by complex interactions among the components of the Earth’s system, and change over varying time scales.”

For Grades K-2, change “sun” to “sunlight.”

For Grades 3-5, “Weather is a minute-by-minute to day-by-day variable...”

The definition of climate should include a time average as well as area averages; and can address seasonal as well as annual conditions. The Federal community has defined Climate as “The long-term average of conditions in the atmosphere, ocean, and ice sheets and sea ice described by statistics, such as means and extremes.” (Climate Literacy, 2009, USGCRP)

For Grades 6-8, “Sun” should be changed to “sunlight.”

Greenhouse effect -> “Without this natural phenomenon, the Earth would be too cold to be habitable.”

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

Page 143 (7-33) “The Earth’s surface continually changes”

For Grades 9-12, this is a generally good overview of energy balance and dynamics. It appears to draw from Climate Literacy principles.

4th paragraph “... small increases in atmospheric concentrations...” add “aerosols and volcanic ash...”

Page 144 (7-34) Biogeology – “How does life interact with Earth’s other systems?” “Earth’s other systems” seems a strange way to phrase it. “How does life influence the Earth system?” We recommend using more of the language from Fundamental concept 3E. “Life—including microbes, plants, and animals and humans—is a major driver of the global carbon cycle and can influence global climate by modifying the chemical makeup of the atmosphere. The geologic record shows that life has significantly altered the atmosphere during Earth’s history.”

For Grades 6-8, remove *geology* since it is confusing and inaccurate. “How does life influence and how is it influenced by the geosphere, hydrosphere and atmosphere?”

For Grades 9-12, remove *geology*. How has the Earth system affected the evolution of life?

For Grades 6-8, change “How does life affect Earth’s geology?” to “How does life affect the Earth system?” or “How does life affect the atmosphere, hydrosphere, and geosphere?”

Change “How does Earth’s geology affect life?” to “How do the atmosphere, hydrosphere, and geosphere affect life?”

For Grades 9-12, change “How has geology affected the evolution of life?” to “How have changes in the Earth system affected the evolution of life?”

Page 145 (7-35) - How do natural hazards affect civilization?

9-12 “...the last 10,000 years have been a relatively stable period...” rather than “unusually stable”

Here is the approved quote from the Climate Literacy 2009 version:

“While global climate has been **relatively** stable over the last 10,000 years—the span of human civilization—regional variations in climate patterns have influenced human history in profound ways, playing an integral role in whether societies thrived or failed.” Please appreciate the extensive process the climate science and education community underwent to develop this specific text. In many areas of the guide, each word was negotiated through a substantial public and scientific review process.

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

Recommend changing orange box 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 we are interdependent with.”

For Grades 3-5, change last sentence to:

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

For Grades 6-8, should include solutions. See Climate Literacy Guiding Principles.

For Grades 9-12, “How can humans exist sustainably on Earth?” Take out “indefinitely,” as it is much too vague.

First paragraph 2nd sentence....As human populations and per capita consumption of natural resources and energy increase, so does the rate of our impact on Earth.”

For the next paragraph on "...natural resources and energy," concepts of building resilient communities and preparedness should be included.
Need to also add in conservation and efficiency of energy use.

Page 149 (7-39) Global Climate Change

Sub question – change "Earth's surface systems" to "Earth system"

Grades K-2 should not be left blank. Start an understanding of Earth system – connections between the components of the Earth system.... AAAS strand maps at K2 level include "The sun warms the land, air, and water (4E/P1)," "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 (4B/P2)," "Water left in an open container disappears, but water in a closed container does not disappear (4B/P3)," "The temperature and amount of rain (or snow) tend to be high, low, or medium in the same months every year.(4B/P1)," and "Change is something that happens to many things (4C/P2)"

It is not clear if the AAAS Benchmarks and the research behind them have been utilized to their full potential.

For Grades 3-5, for discussion on how to avoid gloom and doom while helping instill concept of change and responding to change: Focus on how things have changed from the past to now and put it in a positive context that people have adapted to change.

How has life changed in response to changes in the climate system in the past?

For this concept, one could focus on temperature and precipitation changes, and can obviously link to simple citizen science programs and studying seasonal change.

This concept is addressed in the Climate Changes section of the guide. "While global climate has been relatively stable over the last 10,000 years—the span of human civilization—regional variations in climate patterns have influenced human history in profound ways, playing an integral role in whether societies thrived or failed. We now know that the opposite is also true: human activities—burning fossil fuels and deforesting large areas of land, for instance—have had a profound influence on Earth's climate."

For Grades 9-12, bring energy into the discussion. Focusing only on climate models is not acceptable. Look at Guiding Principle for Informed Climate Decisions....along the lines of reducing energy use by individuals, communities governments, etc.

Principles of Climate Literacy could also help inform other ESS relating to solutions and sustainability.

Page 148 Human Impacts on the Earth

Orange Box statement: "How can society and the ecosystem on which depend be made more resilient in the face of change in the Earth system?"

Change “...process at the Earth’s surface” to “... processes in the Earth system”
In orange box – drop geological and surface

“...agents of change in the Earth system”

“...sustainability of these civilizations and the ecosystems we are interdependent with.”

Page 149, ESS Core Idea 4: Human activities are constrained by and, in turn, affect all other processes at Earth’s surface. [Human Interactions with Earth]
Grades 9 – 12

What can be done to reduce global climate change and its negative impacts?

Change “Measurements of greenhouse gas emissions and other factors that drive climate change are used in climate models to make predictions about climate change. These models aid in decision-making for individuals, institutions, communities, and governments.” to reflect more of the concepts included in the Climate Literacy Guiding Principle:

A. 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.

B. 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 inter-connections among the physical and biological components of the Earth system as well as the consequences of such decisions on social, economic, and cultural systems.

Additionally Essential Principle 5 concepts should also be considered:

C. Observations, experiments, and theory are used to construct and refine computer models that represent the climate system and make predictions about its future behavior. Results from these models lead to better understanding of the linkages between the atmosphere-ocean system and climate conditions and inspire more observations and experiments. Over time, this iterative process will result in more reliable projections of future climate conditions.

E. Scientists have conducted extensive research on the fundamental characteristics of the climate system and their understanding will continue to improve. Current climate change projections are reliable enough to help humans evaluate potential decisions and actions in response to climate change.

Draft revision:

Observations, experiments, and theory are used to construct and refine computer models that represent the climate system and make predictions about its future behavior. Current climate change projections are reliable enough to help humans evaluate potential decisions and actions in response to climate change. Decisions that involve Earth’s climate must be made with an

understanding of the complex inter-connections among the physical and biological components of the Earth system as well as the consequences of such decisions on social, economic, and cultural systems.

Pages 174 to 176 (7-64 to 66), where ET Core Idea 4 is expressed: “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]