Climate Literacy Principles and Concepts	Science and Engineering Practices (SEPs)	Disciplinary Core Ideas (DCIs)	Crosscutting Concepts (CCs)	Performance Expectations (PEs) (final)			
1. The Sun is the primary source of energy for Earth's climate system.		ESS1.B	CC2; CC5	HS-ESS1-1; MS-ESS2-4			
1a. Sunlight reaching the Earth can heat the land, ocean, and atmosphere. Some of that sunlight is reflected back to space by the surface, clouds, or ice. Much of the sunlight that reaches Earth is absorbed and warms the planet.	SEP2	ESS1.B; ESS2.A; PS3.A; PS3.B	CC5	K-PS3-1; K-PS3-2; MS-ESS2-6; HS-ESS2-2; HS-ESS2-4			
1b. When Earth emits the same amount of energy as it absorbs, its energy budget is in balance, and its average temperature remains stable.		ESS1.B; ESS2.A; PS3.A	CC5				
1c. The tilt of Earth's axis relative to its orbit around the Sun results in predictable changes in the duration of daylight and the amount of sunlight received at any latitude throughout a year. These changes cause the annual cycle of seasons and associated temperature changes.	SEP4; SEP6	ESS1.A; ESS1.B; PS2.C	CC1; CC5	MS-ESS2-6			
1d. Gradual changes in Earth's rotation and orbit around the Sun change the intensity of sunlight received in our planet's polar and equatorial regions. For at least the last 1 million years, these changes occurred in 100,000-year cycles that produced ice ages and the shorter warm periods between them.		ESS1.B; PS2.C	CC5	HS-ESS2-4			
1e. A significant increase or decrease in the Sun's energy output would cause Earth to warm or cool. Satellite measurements taken over the past 30 years show that the Sun's energy output has changed only slightly and in both directions. These changes in the Sun's energy are thought to be too small to be the cause of the recent warming observed on Earth.		ESS1.B; PS3.A	CC5	HS-ESS2-4			
2. Climate is regulated by complex interactions among components of the Earth system.		ESS2.D; ESS2.A; LS2.B	CC4; CC7	HS-ESS2-4			
2a. Earth's climate is influenced by interactions involving the Sun, ocean, atmosphere, clouds, ice, land, and life. Climate varies by region as a result of local differences in these interactions.	SEP2	ESS2.D; ESS2.A	CC4	5-ESS2-1; HS-ESS2-4			
2b. Covering 70% of Earth's surface, the ocean exerts a major control on climate by dominating Earth's energy and water cycles. It has the capacity to absorb large amounts of solar energy. Heat and water vapor are redistributed globally through density-driven ocean currents and atmospheric circulation. Changes in ocean circulation caused by tectonic movements or large influxes of fresh water from melting polar ice can lead to significant and even abrupt changes in climate, both locally and on global scales.	SEP8	ESS2.D; LS2.B	CC4	HS-ESS2-4			
2c. The amount of solar energy absorbed or radiated by Earth is modulated by the atmosphere and depends on its composition. Greenhouse gases— such as water vapor, carbon dioxide, and methane— occur naturally in small amounts and absorb and release heat energy more efficiently than abundant atmospheric gases like nitrogen and oxygen. Small increases in carbon dioxide concentration have a large effect on the climate system.		ESS2.D; PS3.B	CC5	HS-ESS2-4			
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.		ESS2.D	CC5	HS-ESS2-4; HS-ESS2-6			
2e. Airborne particulates, called "aerosols," have a complex effect on Earth's energy balance: they can cause both cooling, by reflecting incoming sunlight back out to space, and warming, by absorbing and releasing heat energy in the atmosphere. Small solid and liquid particles can be lofted into the atmosphere through a variety of natural and manmade processes, including volcanic eruptions, sea spray, forest fires, and emissions generated through human activities.		ESS2.D; PS3.B	CC5	HS-ESS2-4			
2f. The interconnectedness of Earth's systems means that a significant change in any one component of the climate system can influence the equilibrium of the entire Earth system. Positive feedback loops can amplify these effects and trigger abrupt changes in the climate system. These complex interactions may result in climate change that is more rapid and on a larger scale than projected by current climate models.	SEP2; SEP4; SEP6	ESS2.A	CC4; CC7	HS-ESS2-2; HS-ESS2-4			
3. Life on Earth depends on, is shaped by, and affects climate.		ESS2.A	CC5				
3a. Individual organisms survive within specific ranges of temperature, precipitation, humidity, and sunlight. Organisms exposed to climate conditions outside their normal range must adapt or migrate, or they will perish.	SEP7; SEP6; SEP3	LS1.C; LS2.A; LS2.C; LS4.C; ESS2.E; ESS3.A	CC1; CC5; CC7	HS-ESS2-7			
3b. The presence of small amounts of heat-trapping greenhouse gases in the atmosphere warms Earth's surface, resulting in a planet that sustains liquid water and life.		ESS2.A	CC3				
3c. Changes in climate conditions can affect the health and function of ecosystems and the survival of entire species. The distribution CC1. Patterns of fossils show evidence of gradual as well as abrupt extinctions related to climate change in the past.	SEP2; SEP4; SEP6; SEP7; SEP8	LS2.A; LS2.C; LS4.C; LS4.D	CC2; CC6; CC7	3-LS4-4; MS-LS2-4			
3d. A range of natural records shows that the last 10,000 years have been an unusually stable period in Earth's climate history. Modern human societies developed during this time. The agricultural, economic, and transportation systems we rely upon are vulnerable if the climate changes significantly.	SEP4	ESS1.C	CC7				
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.	SEP2; SEP3; SEP6; SEP8	LS1.C; LS2.A; LS2.B; LS4.D; PS3.D	CC2; CC4; CC5	5-LS-1; HS-LS2-5			
4. Climate varies over space and time through both natural and man-made processes.		ESS2.D	CC1	HS-ESS2-4			
4a. Climate is determined by the long-term pattern of temperature and precipitation averages and extremes at a location. Climate descriptions can refer to areas that are local, regional, or global in extent. Climate can be described for different time intervals, such as decades, years, seasons, months, or specific dates of the year.	SEP8	ESS2.D	CC3	K-ESS2-1; 3-ESS2-2			
4b. Climate is not the same thing as weather. Weather is the minute-by-minute variable condition of the atmosphere on a local scale. Climate is a conceptual description of an area's average weather conditions and the extent to which those conditions vary over long time intervals.	SEP2	ESS2.D	CC1; CC3	K-ESS2-1; 3-ESS2-1			
4c. Climate change is a significant and persistent change in an area's average climate conditions or their extremes. Seasonal variations and multi-year cycles (for example, the El Niño Southern Oscillation) that produce warm, cool, wet, or dry periods across different regions are a natural part of climate variability. They do not represent climate change.	SEP4; SEP5	ESS2.D; ESS3.B	CC7	K-ESS3-3			
4d. Scientific observations indicate that global climate has changed in the past, is changing now, and will change in the future. The magnitude and direction of this change is not the same at all locations on Earth.	SEP4; SEP6	EES1.C; ESS2.D	CC1; CC7				
4e. Based on evidence from tree rings, other natural records, and scientific observations made around the world, Earth's average temperature is now warmer than it has been for at least the past 1,300 years. Average temperatures have increased markedly in the past 50 years, especially in the North Polar Region.	SEP4	ESS3.D	CC7				
4f. Natural processes driving Earth's long-term climate variability do not explain the rapid climate change observed in recent decades. The only explanation that is consistent with all available evidence is that human impacts are playing an increasing role in climate change. Future changes in climate may be rapid compared to historical changes.	SEP7	ESS2.D	CC2	HS-ESS2-4			
4g. Natural processes that remove carbon dioxide from the atmosphere operate slowly when compared to the processes that are now adding it to the atmosphere. Thus, carbon dioxide introduced into the atmosphere today may remain there for a century or more. Other greenhouse gases, including some created by humans, may remain in the atmosphere for thousands of years.		ESS2.A	CC2; CC3: CC5	HS-ESS2-4			
5. Our understanding of the climate system is improved through observations, theoretical studies, and modeling	SEP1; SEP2; SEP3; SEP4; SEP5; SEP6	ESS3.D	CC4	HS-ESS2-4			
5a. The components and processes of Earth's climate system are subject to the same physical laws as the rest of the Universe. Therefore, the behavior of the climate system can be understood and predicted through careful, systematic study.	SEP1, SEP3	ESS2.A, ETS2.A	CC2; CC4	HS-ESS2-4			
5b. Environmental observations are the foundation for understanding the climate system. From the bottom of the ocean to the surface of the Sun, instruments on weather stations, buoys, satellites, and other platforms collect climate data. To learn about past climates, scientists use natural records, such as tree rings, ice cores, and sedimentary layers. Historical observations, such as native knowledge and personal journals, also document past climate change.	SEP3; SEP4; SEP8	ESS1.C	CC!; CC2	MS-ESS2-6			
5c. 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.	SEP1; SEP2; SEP4; SEP5; SEP6	ESS3.B; ESS3.C; ESS3.D; ETS1.A; ETS2.A; ETS2.B	CC2; CC4	K-ESS3-2; HS-ESS3-5			
5d. Our understanding of climate differs in important ways from our understanding of weather. Climate scientists' ability to predict climate CC1. Patterns months, years, or decades into the future is constrained by different limitations than those faced by meteorologists in forecasting weather days to weeks into the future.	SEP6; SEP4	ESS2.D; ESS3.C	CC2; CC3; CC7				
5e. 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.	SEP2; SEP6	ESS3.D	CC4	HS-ESS2-4			
6. Human activities are impacting the climate system		ESS3.C; ESS3.D	CC4				
6a. The overwhelming consensus of scientific studies on climate indicates that most of the observed increase in global average temperatures since the latter part of the 20th century is very likely due to human activities, primarily from increases in greenhouse gas concentrations resulting from the burning of fossil fuels.	SEP7	ESS3.C	CC2; CC5				
6b. Emissions from the widespread burning of fossil fuels since the start of the Industrial Revolution have increased the concentration of greenhouse gases in the atmosphere. Because these gases can remain in the atmosphere for hundreds of years before being removed by natural processes, their warming influence is projected to persist into the next century.		ESS3.C	CC2: CC5				
6c. Human activities have affected the land, oceans, and atmosphere, and these changes have altered global climate CC1. Patterns. Burning fossil fuels, releasing chemicals into the atmosphere, reducing the amount of forest cover, and rapid expansion of farming, development, and industrial activities are releasing carbon dioxide into the atmosphere and changing the balance of the climate system.		ESS3.C	CC2; CC5	5-ESS3-1			
6d. Growing evidence shows that changes in many physical and biological systems are linked to human caused global warming. Some changes resulting from human activities have decreased the capacity of the environment to support various species and have substantially reduced ecosystem biodiversity and ecological resilience.	SEP6; SEP7; SEP8	ESS2.A; ESS3.C; ESS3.D	CC4; CC7	5-ESS3-1			
6e. Scientists and economists predict that there will be both positive and negative impacts from global climate change. If warming exceeds 2 to 3°C (3.6 to 5.4°F) over the next century, the consequences of the negative impacts are likely to be much greater than the consequences of the positive impacts.	SEP2, SEP4	ESS3.D, ETS2.B	CC2, CC7				
7. Climate change will have consequences for the Earth system and human lives		ESS3.D	CC2				
7a. Melting of ice sheets and glaciers, combined with the thermal expansion of seawater as the oceans warm, is causing sea level to rise. Seawater is beginning to move onto low-lying land and to contaminate coastal fresh water sources and beginning to submerge coastal facilities and barrier islands. Sea-level rise increases the risk of damage to homes and buildings from storm surges such as those that accompany hurricanes.		ESS2.C; ESS3.D	CC2				
7b. Climate plays an important role in the global distribution of freshwater resources. Changing precipitation CC1. Patterns and temperature conditions will alter the distribution and availability of freshwater resources, reducing reliable access to water for many people and their crops. Winter snowpack and mountain glaciers that provide water for human use are declining as a result of global warming.	SEP1; SEP3	ESS1.C; ESS2.A; ESS2.C	CC1; CC2; CC5				
7c. Incidents of extreme weather are projected to increase as a result of climate change. Many locations will see a substantial increase in the number of heat waves they experience per year and a likely decrease in episodes of severe cold. Precipitation events are expected to become less frequent but more intense in many areas, and droughts will be more frequent and severe in areas where average precipitation is projected to decrease.	SEP4	ESS2.D; ESS3.B; ESS3.D	CC2	K-ESS3-2; K-ESS3-3			
7d. The chemistry of ocean water is changed by absorption of carbon dioxide from the atmosphere. Increasing carbon dioxide levels in the atmosphere is causing ocean water to become more acidic, threatening the survival of shell-building marine species and the entire food web of which they are a part.	SEP6	ESS3.D; LS2.C	CC5, CC7	HS-LS2-7; HS-LS4-5			
7e. Ecosystems on land and in the ocean have been and will continue to be disturbed by climate change. Animals, plants, bacteria, and viruses will migrate to new areas with favorable climate conditions. Infectious diseases and certain species will be able to invade areas that they did not previously inhabit.	SEP1; SEP6; SEP8	ESS3.D; LS4.D; LS2.A; LS2.B; LS2.C	CC7; CC3; CC4	HS-LS2-7			
7f. Human health and mortality rates will be affected to different degrees in specific regions of the world as a result of climate change. Although cold-related deaths are predicted to decrease, other risks are predicted to rise. The incidence and geographical range of climate-sensitive infectious diseases— such as malaria, dengue fever, and tick-borne diseases—will increase. Drought-reduced crop yields, degraded air and water quality, and increased hazards in coastal and low-lying areas will contribute to unhealthy conditions, particularly for the most vulnerable populations.	SEP4	ESS3.C	CC2; CC7				
Guiding Principle for Informed Climate Decision: Humans can take actions to reduce climate change and its impacts.		ESS3.C; ESS3.D	CC2				
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.	SEP1; SEP8	ESS3.B; ESS3.C; ETS1.A; ETS2.B	CC2	K-ESS3-2; HS-ESS3-5			
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.	SEP1; SEP6	ESS3.B; ESS3.C; ETS1.A; ETS2.B; LS2.C; LS4.D	CC2; CC4; CC7	3-ESS3-1; 4-ESS3-2; HS-ESS3-5			
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.		ESS3.A	CC2	HS-LS2-7			
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.		ESS3.C	CC2; CC7				
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.	SEP6	ESS3.C; PS3.D	CC5; CC7	HS-ESS3-5			
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.	SEP6	ESS3.D	CC2; CC7				
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.	SEP1; SEP4; SEP6; SEP8	ESS2.A; ESS3.C; ESS3.D; ETS2.B	CC2; CC4	5-ESS3-1			