K-12 Climate Science Concepts and Skills for Pacific Island Students

This draft document has been developed by members of the Pacific Islands Climate Education Partnership (PCEP). It has been developed for partners of PCEP, as part of our work to systemically improve climate education in the U.S. Affiliated Pacific Islands (USAPI). This document describes what USAPI **students** should know and be able to do with respect to climate science **by the end of Grades 2, 5, 8 and 12**.

This document aims to serve multiple purposes:

- Provide a climate science foundation as students progress through high school;
- Guide revisions of USAPI state and national science standards that describe what students should be learning in elementary, middle and high school levels;
- Guide professional development of USAPI teachers and other educators;
- Guide selection and modification of existing curricular materials as well as any new curriculum development; and
- Guide student assessment and project evaluation.

While addressing science that applies to all locations, this document has been specifically designed for the USAPI. It emphasizes concepts and skills that are particularly important and grade appropriate for these island locations, cultures and education systems. If you have any questions, comments or concerns, please contact Dr. Art Sussman at asussma@wested.org

Weather (Grades K-2)

What is weather, and how do people measure and describe it?

K-2Weather.A	**Weather**
K-2Weather.A.1	Weather is the sunlight, wind, rain, and temperature in a place during a time, such as an hour or a day.
K-2Weather.A.2	People measure and describe the temperature, how strong the wind is blowing, where the wind is coming from, how much and what kinds of clouds there are, if it is raining, and how much rain there is. These descriptions help us know the weather that happens in a place.
K-2Weather.A.3	Examples of extreme weather include very heavy rains, very strong winds, and unusually long periods of time with no or very little rain.
K-2Weather.A.4	Pacific languages have words that describe different kinds of rain, clouds, winds, or storms.
K-2Weather.A.5	English has words that describe different kinds of rain, clouds, winds, or storms.

Systems (Grades K-2)

What are examples of systems?

K-2Systems.A	**Systems**
K-2Systems.A.1	Plants and animals have parts that work together. Plants and animals are examples of systems.
K-2Systems.A.2	Things that people make, such as a table or a boat, have parts that work together. These things that people make are examples of systems.
K-2Systems.A.3	Any place that people live has parts such as houses, fences, and pipes to move water. These places are examples of systems.
K-2Systems.A.4	Schools have parts that work together such as the teachers, the students, and the classrooms. Schools are examples of systems.
K-2Systems.A.5	Scientists use the word system to describe anything that is made of parts that work together.

Energy (Grades K-2)

What are examples of kinds of energy?

K-2Energy.A	**Energy**
K-2Energy.A.1	Some very hot objects give off light (e.g., a fire, the Sun).
K-2Energy.A.2	Sunlight warms the land and the ocean.
K-2Energy.A.3	Wind is air that moves from one place to another place. During big storms, air moves so fast that it can blow over big trees.

Earth's Matter (Grades K-2)

What are the kinds of matter, and in what ways does matter change?

K-2Matter.A	**Matter**
K-2Matter.A.1	Every thing is made of matter and takes up space.
K-2Matter.A.2	A piece of matter, such as a rock or a ball or a drop of water, can be weighed, and its size can be described and measured.
K-2Matter.A.3	Sand, wood, metal, water, and plastic are different kinds of matter.
K-2Matter.A.4	Heating or cooling something can cause changes that we can see.
K-2Matter.B	**Water**
K-2Matter.B.1	Liquid water is found in the ocean, rivers, lakes, and ponds.
K-2Matter.B.2	Most of Earth's water is in the ocean, and ocean water is salty.
K-2Matter.B.3	Most rivers flow into the ocean.
K-2Matter.B.4	Rain that falls on islands comes from water that was in the ocean.
K-2Matter.B.5	When liquid water is very cold, it freezes into a solid called ice. When ice gets warm, it melts back into liquid water.
K-2Matter.B.6	Solid water (ice) is found in very cold places such as the North Pole.

Living Systems (Grades K-2)

How do plants and animals get what they need to live, and where do they live?

K-2Life.A	**Plants and Animals**
K-2Life.A.1	There are names in Pacific languages for the different animals and plants that live on and around Pacific Islands.
K-2Life.A.2	Plants and animals have parts that we can see.
K-2Life.A.3	Animals use the parts of their body (such as eyes, ears, teeth and legs) to see, hear, protect themselves, and move from place to place.
K-2Life.A.4	Many of the things which animals do help them find and get food and water.
K-2Life.A.5	Animals eat plants or other animals. When animals cannot find enough food or water, they may die.
K-2Life.A.6	Plants have different parts (such as roots, leaves, flowers, and fruit) that help them live, grow, and make more plants.
K-2Life.A.7	Plants that live on land need water, soil, and light to grow.
K-2Life.B	**Pacific Island Environments**
K-2Life.B.1	Different environments usually have different kinds of plants and animals. There are names in Pacific languages for the different environments on and around an island.
K-2Life.B.2	Animals that live on and around Pacific Islands get what they need from their environment, including food, water, and shelter.
K-2Life.B.3	Different plants live in different environments because they have different needs for water, kinds of soil, and sunlight.
K-2Life.B.4	Animals that live in the ocean range in size from very small to as large as whales. Ocean animals have different kinds of body parts than animals that live on land.
K-2Life.B.5	The environments where plants and animals live can change, sometimes slowly and sometimes quickly.

Climate Changes (Grades K-2)

No standards at these grade levels.

Climate Change Impacts (Grades K-2)

No standards at these grade levels.

Climate Adaptation (Grades K-2)

No standards at these grade levels.

Practices (Grades K-2)

Ask Questions and Define Problems
- Ask questions based on observations.
- Ask a question about how a tool works or describe a way that it could be made to work better.
- Compare an Indigenous way to catch fish or grow food with a modern way to do it.
- Identify questions and make predictions based on prior experiences.

Use Models
- Distinguish between a model and the actual object, processes, and/or events that the model represents.
- Compare models to identify common features and differences.
- Develop or use models (diagrams, drawings, physical replicas, dramatizations) that represent amounts, relative sizes (bigger, smaller), or patterns in the things made by nature or made by people.

Investigate
- Describe and demonstrate values and attitudes that are important in working together as a team.
- Describe and demonstrate safety considerations in planning and carrying out an investigation.
- Read and understand grade-appropriate texts in native language or English, or use other ways to get scientific or technical information related to a simple investigation.
- With guidance, work together to plan and carry out a simple investigation.
- Evaluate different ways of observing or measuring an attribute of interest.
- Make observations or measurements to collect data that can be used to compare objects (for example, toys or plants) or the way something happens (for example, water evaporating).
- Make observations or measurements of a tool to decide how well the tool does what it was made to do.
- Record observations, thoughts, and ideas.

Analyze Data
- Use and share pictures, drawings, and/or writings of observations.
- Use observations to describe patterns and/or relationships in order to answer scientific questions or solve problems.
- Make measurements of length to quantify data.
- Use counting and numbers to identify and describe patterns in nature.
- Analyze data from tests of a proposed object or tool to determine if it functions as intended.
- Describe, measure and compare quantitative features of different objects and display the data using simple graphs.

Explain and Design
- Explain observations using information that you have gathered by making observations.

- Use tools and materials provided to design a device or a solution to a specific problem.
- Distinguish between opinions and evidence.
- Working together generate and compare multiple solutions to a problem.
- Listen respectfully to explanations made by others and ask questions for clarification.
- Critique and communicate information or ideas for a design in oral or written forms using models, drawings, writing, or numbers.

Weather and Climate (Grades 3-5)

What are weather and climate?

3-5Weather.A **Weather**

3-5Weather.A.1 By measuring weather conditions (temperature, amount and kind of precipitation, amount and kinds of clouds, wind direction and wind speed), scientists learn how the weather changes from day to day, month to month, and during the year.

3-5Weather.A.2 Scientists analyze records of the weather that has happened in different places in the different times of the year. There are patterns to the kinds of weather that happen in a place and at different times of the year.

3-5Weather.A.3 Scientists predict the weather that might happen in the next couple of days using measurements of the weather that is happening right now in a place and also about the weather patterns that happen in that place.

3-5Climate.A **Climate**

3-5Climate.A.1 Climate is the description of the pattern of weather in an area over many years. Different locations on our planet have very different climates.

3-5Climate.A.2 Pacific islands that are near the equator have warm climates. The temperature does not change very much from day to night. Temperatures do not change very much from month to month over the course of a year.

3-5Climate.A.3 Many tropical Pacific islands have a wet season and a dry season.

3-5Climate.A.4 Many tropical Pacific islands that have at least one high mountain have one part of the island that gets a lot of rain, and other areas that get very little rain.

3-Climate.A.5 Extreme weather events (for example, tropical storms, typhoons, hurricanes, and long droughts) happen more in some places than in other places, and more in some times of the year than other times of the year.

Earth System Science (Grades 3-5)

What are the parts of the Earth system, and what is the relationship between the Sun and our planet?

3-5Systems.A **Systems**

3-5Systems.A.1 A system is a group of interacting parts that form a whole. A system can be described in terms of its parts and their interactions.

3-5Systems.A.2 A whole object, plant, or animal may not continue to work the same way if some of its parts are missing or damaged. Most objects need to have their parts connected in a specific way in order to work well as a whole.

3-5Systems.A.3 A whole, object, plant, or animal can do things that none of the parts can do by themselves.

3-5Systems.B **Earth System Science**

3-5Systems.B.1 Indigenous cultures describe, explain and respect the connections among land, ocean, sky, and all organisms, including people. The Indigenous way of life is strongly connected with the local land, water, air and organisms.

3-5Systems.B.2 Scientists describe and explain planet Earth as a system that has many connected parts. This way of understanding planet Earth is called Earth System Science.

3-5Systems.B.3 Earth system scientists investigate the solid, liquid, and gas parts of the Earth system. Solid matter includes rock, soil and sand. The main liquid matter is water. The main gases that make up the atmosphere are nitrogen and oxygen.

3-5Systems.B.4 Maps can show the locations, shapes and kinds of land and water in an area. Different kinds of maps, including a globe, can show the shapes of land and water on our planet.

3-5Systems.B.5 The ocean covers most of Earth's surface and has most of the planet's water.

3-5Systems.B.6 The ocean is a single, huge, interconnected body of salty water, which circulates through all the ocean basins and continents. Different parts of the world ocean have different names, but all these different parts are connected. The Pacific Ocean is the largest part of the world ocean.

3-5Systems.B.7 Earth supports many different kinds of organisms that live on land and in the water. Many of these organisms live in different places in the ocean.

3-5Systems.B.8 Earth is shaped like a huge ball. Things on or near the Earth are pulled towards Earth's center by gravity.

3-5Systems.B.9 The Sun is a star. It is the central and largest body in our solar system. The Sun appears much brighter and larger in the sky than other stars

because it is many thousands of times closer to Earth.

3-5Systems.B.10 Earth's daily spin causes day and night.

3-5Systems.B.11 Earth's nearly circular orbit around the Sun causes us to see different constellations at different times of the year. A year is the amount of time it takes for Earth to go one complete orbit around the Sun.

Energy and the Earth System (Grades 3-5)

What key science concepts about energy help us understand weather and climate?

3-5Energy.A	**Nature of Energy**
3-5Energy.A.1	Whenever anything happens or changes, energy is involved. For example, whenever there is a change in an object's motion or temperature, energy is involved in those changes.
3-5Energy.A.2	Light is a form of energy that moves from one place to another place.
3-5Energy.A.3	Humans are warm and can move because we use the energy that is stored in food.
3-5Energy.A.4	A fuel, such as gasoline, has stored chemical energy. When we drive a car or boat, we change chemical energy in the fuel into motion energy.
3-5Energy.B	**Flows of Energy Into and Within the Earth System**
3-5Energy.B.1	Energy from the Sun travels to the Earth as light. When this sunlight is absorbed, it warms Earth's land, water, and air.
3-5Energy.B.2	The ocean has a major influence on weather and climate because it absorbs and holds much of the sunlight energy that reaches Earth.
3-5Energy.B.3	Ocean currents move heat throughout ocean basins and affect weather on the planet.
3-5Energy.B.4	Wind currents move heat energy and affect weather on the planet.

Earth's Matter (Grades 3-5)

What key science concepts about matter help us understand weather and climate?

3-5Matter.A **Nature of Matter**

3-5Matter.A.1 All matter can be divided into particles that are so small that they cannot be seen.

3-5Matter.A.2 Matter can generally be classified as being a solid, liquid or gas. Water is very unusual in that it exists as a solid (ice), liquid (liquid water) and gas (water vapor).

3-5Matter.A.3 Even if we cannot see, smell or taste a gas (such as air or water vapor), it is still a form of matter.

3-5Matter.A.4 Some materials and fuels that people use are renewable over time, and others are considered nonrenewable.

3-5Matter.B **Earth's Water Cycle**

3-5Matter.B.1 Water is found almost everywhere on Earth. Nearly all of Earth's water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. Water is also in the air in the form of a gas.

3-5Matter.B.2 The Sun provides the energy that powers the water cycle. The Sun's energy evaporates the water. The energy from the Sun also causes the winds that move water in the air and in the ocean.

3-5Matter.B.3 The ocean has a major influence on weather and climate because it plays a major role in the water cycle. Most water in the air comes from the ocean. This water vapor in the air eventually cools, condenses into clouds, and returns to the ocean or the land as precipitation.

Earth's Living Systems (Grades 3-5)

What key science concepts about living systems help us understand organisms, and how they are affected by each other and by the physical environment?

3-5Life.A	**Earth's Organisms**
3-5Life.A.1	Plants and animals have structures that help them grow, survive, and reproduce. Some of these structures are easy to see. Some of these structures are hard to see because they are inside the organism or under the ground or very small.
3-5Life.A.2	Reproduction is important in the life cycle of every kind of organism.
3-5Life.A.3	Animals and plants have life cycles that include being born (sprouting in plants), growing, developing into adults, reproducing, and dying.
3-5Life.A.4	Animals need to take in air, water, and food. Food provides animals with the materials they need to grow. Food also provides the energy that animals need to be warm and to move.
3-5Life.A.5	Plants need to take in air and water. They also need minerals and light. Plants make the materials they need mostly from air and water. They use these materials for both growth and for energy.
3-5Life.A.6	Humans, like all other organisms, obtain living and nonliving resources from their environments.
3-5Life.B	**Pacific Island Ecosystems**
3-5Life.B.1	All animals are consumers. Some animals eat plants for food and other animals eat the animals that eat plants.
3-5Life.B.2	Plants are producers. The food of almost any kind of animal can be traced back to plants. Food webs are one way to diagram the food relationships among plants and animals that live in the same ecosystem.
3-5Life.B.3	Some organisms, such as fungi and bacteria, are decomposers. They break down dead organisms or waste material for food. Decomposers help return some materials back to the soil that plants can use.
3-5Life.B.4	An ecosystem includes all of the living organisms and nonliving physical factors in a given area. Living organisms depend on one another and the nonliving physical factors in their ecosystem to help them survive.
3-5Life.B.5	Pacific Islands have many different kinds of ecosystems (e.g., tidepools, coral reefs, mangrove forests, creeks). Some Pacific Island organisms live in just one kind of ecosystem, and some live in more than one kind of ecosystem.

3-5Life.B.6	Living things affect the physical characteristics of their regions (e.g., plants' roots hold soil in place, coral reefs and mangrove trees reduce erosion of coasts, and animal shells help form beaches).
3-5Life.B.7	Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.
3-5Life.B.8	When the environment changes, some organisms survive and reproduce, others move to new locations, and some die. Some new kinds of organisms may move into the changed environment.

Climate Changes (Grades 3-5)

What is climate change?

3-5Changes.A	**Climate Change**
3-5Changes.A.1	Our planet's ocean temperatures and air temperatures are becoming higher than they have been for the past centuries. This change is called global warming.
3-5Changes.A.2	Rain patterns and other climate features are also changing. Scientists use the term global climate change as the name that describes all these changes.
3-5Changes.A.3	Pacific Islanders and other people who have lived in a place for a very long time have knowledge about their local climate that is based on centuries of experience. Comparing today's climate conditions to this historical knowledge provides evidence of global climate change.
3-5Climate.A.4	Scientists get evidence of today's climate and also of past climates by making scientific observations. These observations indicate that global climate change is happening now.

Climate Change Impacts (Grades 3-5)

How is climate change affecting communities in the Pacific Islands?

3-5Impacts.A **<u>Climate Change Impacts</u>**

3-5Impacts.A.1 Erosion is the movement of Earth materials (such as coastal land) by forces such as moving water (waves, currents, floods) and wind. Erosion and floods threaten homes, roads and other coastal development.

3-5Impacts.A.2 Global climate change is causing sea levels to rise. Higher sea levels cause more erosion of coastal areas such as beaches. Higher sea levels also cause more damage from flooding events such as very high tides, storm surges, and very heavy rainfall.

3-5Impacts.A.3 Changes in temperature and rainfall affect land and ocean organisms and ecosystems. Changes in climate can cause big changes to island ecosystems that can then have significant impacts on island communities.

3-5Impacts.A.4 People who live on small islands depend on **freshwater sources** that can be affected by changes in climate that include higher temperatures, changing rainfall patterns, and erosion/flooding by ocean water.

3-5Impacts.A.5 People who live on small islands depend on **local food resources** that can be affected by changes in climate that include higher temperatures, changing rainfall patterns, and erosion/flooding by ocean water.

Climate Adaptation (Grades 3-5)

What can Pacific Island nations and communities do to reduce the damage caused by climate change?

3-5Adapt.A	**Climate Adaptation**
3-5Adapt.A.1	Human activities such as agriculture, fishing and transportation can have major effects on the land, vegetation, animals, water, ocean, and air.
3-5Adapt.A.2	Individuals and communities can do things to help protect Earth's resources and environments. Examples include treating sewage, recycling waste materials, reducing runoff from agricultural activities, and using good fishing practices.

Practices (Grades 3-5)

Ask Questions and Define Problems
- Identify scientific (testable) and non-scientific (non-testable) questions.
- Ask questions based on careful observations of phenomena and information.
- Ask questions based on cause and effect relationships to clarify ideas or request evidence.
- Ask questions that relate one variable to another variable.
- Ask questions that can be investigated about weather, climate or an impact of climate change.

Developing and Use Models
- Explain how a model related to weather, climate, or an impact of climate change represents relationships or processes.
- Use simple models to describe phenomena and test cause and effect relationships concerning the functioning of a natural or designed system.
- Use models to share findings or solutions in an oral or written presentation or in a group discussion.
- Identify limitations of models in terms of how useful and accurate they are.

Plan and Carry Out Investigations
- Collaboratively plan and carry out simple investigations using fair tests in which variables are controlled and the number of trials considered.
- Demonstrate values and attitudes that are important in working together as a team.
- Demonstrate knowledge of safety and ethical considerations in planning and carrying out an investigation.
- Evaluate appropriate methods and tools for collecting data.
- Use standard units to measure area, volume, weight, and temperature.
- Make observations and/or measurements, collect appropriate data, and identify patterns that provide evidence to explain a phenomenon or test a design solution.

Analyze and Interpret Data
- Display data in tables and graphs, using digital tools when feasible, to reveal patterns that indicate relationships.
- Use data to evaluate claims about cause and effect.
- Compare data collected by different groups in order to discuss similarities and differences in their findings.
- Use data to evaluate and refine design solutions.

Construct Explanations and Design Solutions
- Construct explanations of observed quantitative relationships (e.g., the numbers of different kinds of organisms in a location).
- Use evidence (e.g., measurements, observations, patterns) to construct a scientific explanation or design a solution to a problem.
- Identify the evidence that supports particular points in an explanation.
- Distinguish whether an explanation relies on facts, reasoned judgments based on

research findings, or on unsupported speculation.
- Apply scientific knowledge to solve design problems.

Analyze and Investigate Environmental Issues
- Respectfully gather local indigenous knowledge related to an environmental issue.
- Collaboratively develop simple explanations in response to questions they have formed about the environment.
- Locate, collect and organize simple information on nature, communities and environmental topics.
- Communicate information obtained from reliable source about potential solutions to an environmental issue.

Decide and Act
- Decide and act with the understanding that Indigenous beliefs and values are based on the idea and experience that all living and non-living things remain in balance for continued existence.
- Understand that people can act as individuals but that the community influences and is affected by individual actions.
- Understand the importance of sharing ideas, hearing other points of view, and honoring community values.
- Explain that people and nature are connected at many levels, including the global level.
- Have age appropriate and realistic self confidence in their effectiveness and role as citizens.

Weather and Climate (Grades 6-8)

What major science concepts help us understand weather and climate in the Pacific Islands and globally?

6-8Weather.A **Weather**

6-8Weather.A.1 Weather is described by conditions in the local atmosphere. The conditions include the air temperature, how the air is moving (wind speed and direction), the air pressure, and the condition of water in the air (humidity, precipitation, and cloud cover).

6-8Weather.A.2 Winds, landforms, ocean temperatures, and ocean currents result in patterns in the local water cycle. For example, winds that have traveled over the ocean are often warm and contain lots of water vapor. When these winds encounter a high mountain, the air gets cooler as it rises, and the moisture precipitates as rain.

6-8Weather.A.3 Weather conditions change when air masses of different temperatures move and interact with each other.

6-8Weather.A.4 Due to the complexity of the systems that interact and result in local weather, the weather several days in the future can be hard to predict.

6-8Climate.A **Climate in the Tropical Pacific Islands**

6-8Climate.A.1 Climate describes the ranges of typical weather conditions in an area and how much those conditions change over years to centuries. Climate describes the conditions that are typical for a place at different times of the year. Weather describes the conditions that are actually happening in that place at a specific time.

6-8Climate.A.2 Climate in a region is influenced by interactions involving sunlight, ocean temperatures, ocean currents, air temperatures, winds, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, and explain why different regions of the planet have different climates.

6-8Climate.A.3 Each island has a pattern of rainfall that is related to wind directions, presence or absence of mountains, its latitude, and its longitude.

6-8Climate.A.4 Mountains can cause one side of an island to have a very wet climate while the other side of the island has a very dry climate.

6-8ClimateA.5 Because of their location close to the equator, tropical islands tend to have warm weather throughout the year.

6-8Climate.A.6 Tropical Pacific islands do not experience the large seasonal changes in temperature, hours of daylight, and height of the Sun that occur in other regions of the planet. The main seasonal changes are in amounts of precipitation, wind patterns, and occurrence of extreme weather events.

Earth System Science (Grades 6-8)

How does Earth System Science help us understand climate and its impacts in the Pacific Islands and globally?

6-8Systems.A **Systems**

6-8Systems.A.1 A system is a group of interacting parts that form a whole. A system needs to have its parts organized in a certain way in order to function as a whole.

6-8Systems.A.2 The parts of a system are often themselves systems that are made of parts. For example, a school is a system that has parts, such as classrooms, outdoor areas and people. Each classroom is a system that has parts such as desks, a teacher, and students,

6-8Systems.A.3 A change in one part of a system can lead to large changes in other parts of the same system, or to changes in other systems with which it interacts. For example, building a new road to improve community transportation can cause runoff of sediments that harm the coral reef, reduce the fish populations, and cause the community to have less food.

6-8Systems.A.4 Models can be used to represent systems such as an island watershed or how a community gets food.

6-8Systems.B **Earth System Science**

6-8Systems.B.1 The major parts of the Earth system are the atmosphere (air), geosphere (soil, sediments and solid and molten rock,), the hydrosphere (water and ice), and the biosphere (living things, including humans).

6-8Systems.B.2 Each of the parts of the Earth system (atmosphere, geosphere, hydrosphere and biosphere) is itself a system that is made of many interacting parts.

6-8Systems.B.2 The Earth system is complex because its parts interact with each other in many ways, and because each of these parts is itself a system that is made of many interacting parts.

6-8Systems.B.3 The parts of the Earth system interact with incoming sunlight and with each other. These interactions play very important roles in weather and climate. For example, a large volcanic eruption changes the atmosphere in ways that affect climate locally and globally.

Energy and the Earth System (Grades 6-8)

What key science concepts about energy help us understand climate and its impacts in the Pacific Islands and globally?

6-8Energy.A **Nature of Energy**

6-8Energy.A.1 Every system includes forms of energy that can be described and measured. The amount of energy within a system determines how much change can happen within that system.

6-8Energy.A.2 Within a system, energy continually moves between the parts of the system. Energy also changes forms as it moves. These forms of energy include motion, electrical and magnetic fields, and heat.

6-8Energy.A.3 The energy of a system can change if energy enters the system (for example, sunlight shines on sand) or if energy leaves the system (for example, heat radiates away from sand at night).

6-8Energy.A.4 When matter absorbs light, the energy in the form of light changes into energy in the form of heat (thermal energy).

6-8Energy.A.5 Energy moves from hotter regions or objects to colder ones by the processes of conduction, convection, and radiation.

6-8Energy.A.6 In conduction, heat energy flows between objects that are in direct contact with each other. For example, conduction will cause a metal spoon in a hot liquid to become hot.

6-8Energy.A.7 In convection molecules move and transfer the thermal energy from one location to another. Hot air rising is an example of convection.

6-8Energy.A.8 In radiation, electromagnetic waves travel through the air or through space and transfer energy from one location to another. Sunlight shining on Earth is an example of radiation. Sunlight transfers energy from the Sun to Earth.

6-8Energy.B **Flows of Energy Into, Within and Out of the Earth System**

6-8Energy.B.1 Planet Earth receives a fairly constant input of light energy from the Sun. The absorbed sunlight heats the planet. The heat energy circulates within the Earth system. The heat energy eventually radiates from the Earth system to outer space.

6-8Energy.B.2 Sunlight heats the land, ocean, and atmosphere. About two-thirds of the sunlight that reaches Earth is absorbed and warms the planet. About one-third of the sunlight is reflected to outer space and does not warm the planet.

6-8Energy.B.3 Areas closer to the equator receive much more direct sunlight energy than areas closer to the poles. Areas that receive more direct sunlight

energy generally have warmer climates than areas that receive less direct sunlight energy.

6-8Energy.B.4 The unequal heating of the planet combined with Earth's daily rotation on its axis cause circulation patters in the atmosphere and ocean. These winds and ocean currents move heat energy around the planet, and strongly affect regional climates.

6-8Energy.B.5 As heat radiates from Earth's surface toward outer space, specific gases in the atmosphere absorb that thermal energy and keep the heat longer within the Earth system. This natural greenhouse effect traps the heat energy, warms the planet and keeps it habitable. Without the natural greenhouse effect, Earth would be about 33^{o}C (60^{o}F) colder.

6-8Energy.B.6 From a systems point of view, Earth is an open system with respect to energy. Energy enters the Earth system, flows within it, and then flows out of the Earth system.

Earth's Matter (Grades 6-8)

What key science concepts about matter help us understand climate in the Pacific Islands and globally?

6-8Matter.A **Nature of Matter**

6-8Matter.A.1 Substances that are particularly important with respect to Earth's climate are water (H_2O), carbon dioxide (CO_2), and methane (CH_4, also known as natural gas].

6-8Matter.A.2 Matter exists in different physical states, notably solids, liquids and gases. Changing the conditions of temperature and pressure can change a substance's physical state through processes such as evaporation, condensation, freezing, and melting**.**

6-8Matter.A.3 Physical changes such as evaporation and freezing do not change the bonds that connect atoms *within a molecule*. Water vapor, liquid water, and ice are all H_2O. Physical changes involve changes in how strongly the molecules connect with each other.

6-8Matter.A.4 Chemical changes involve changing the bonds between atoms within a molecule so that the molecules themselves change. When natural gas burns, methane (CH_4) combines with oxygen (O_2) to form carbon dioxide (CO_2) and water (H_2O).

6-8Matter.A.5 Every substance has different properties. For example, copper conducts electricity and can easily be made into wires. Sand does not conduct electricity and cannot easily be made into wires.

6-8Matter.A.6 Properties of a substance arise from the kinds of atoms that make up the substance and how those atoms are connected with each other.

6-8Matter.A.7 The pH (acid-base balance) is a property of liquid solutions that is particularly important for life. Dissolving of carbon dioxide in water causes the water to become more acidic (lower pH).

6-8Matter.A.8 Dissolving salt in water increases its density. A less dense fluid (liquid or gas) floats on top of a more dense fluid. Due to differences in density, freshwater floats on top of saltwater.

6-8Matter.B **Matter in the Earth System**

6-8Matter.B.1 Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation, and precipitation as well as downhill flows on land. Earth's water cycle primarily involves physical changes as water molecules change from being in the gas, liquid, and solid states.

6-8Matter.B.2 Precipitation is water falling to Earth's surface in forms such as rain, fog, and snow. Since humans and other terrestrial organisms depend on

freshwater, the water cycle plays a major role in Earth's ecosystems and human social systems.

6-8Matter.B.3 Water vapor (H_2O) in the atmosphere traps heat that is radiating away from the planet's surface. This property of H_2O is another important way that the water cycle plays a major role in Earth's climate.

6-8Matter.B.4 Carbon continually cycles among land, ocean, organisms, and atmosphere. The carbon cycle includes both chemical and physical changes as carbon atoms bond in different combinations with other carbon atoms and with other elements.

6-8Matter.B.5 Carbon dioxide and methane in the atmosphere trap heat that is radiating away from the planet's surface. This property of CO_2 and CH_4 is the main reason that the carbon cycle plays a major role in Earth's climate.

6-8Matter.B.6 In each cycle of matter, such as the carbon cycle or water cycle, the element or molecule exists in different locations such as the ocean, the atmosphere and living things. These locations, called the reservoirs of that cycle, hold different amounts and forms of the matter.

6-8Matter.B.7 An important feature of each cycle of matter is how the atoms or molecules move between the different reservoirs of that cycle of matter. For example, when we burn oil, carbon moves from being a liquid underground to being a gas in the atmosphere.

6-8Matter.B.8 A cycle of matter affects Earth's climate if any of the matter in that cycle changes the amount of sunlight that enters the Earth system, how the heat energy circulates within the Earth system, or how the heat energy radiates out of the Earth system.

6-8Matter.B.9 Each of the elements that is vital for life exists on Earth in a closed loop of cyclical changes. From a systems point of view, Earth is essentially a closed system with respect to matter.

Earth's Living Systems (Grades 6-8)

What key science concepts about living systems help us understand climate and its impacts in the Pacific Islands and globally?

6-8Life.A **Ecosystems**

6-8Life.A.1 An ecosystem consists of all the organisms that live in a particular area and all the nonliving parts of the environment with which the organisms interact (for example, air, water, soil, and sunlight). Temperature and water conditions have very large effects on which organisms can live in a location.

6-8Life.A.2 The communities of plants and animals that live in an ecosystem are adapted to live in that environment and with each other. These communities of organisms are affected by changes to their environment such as climate change or the introduction of new species.

6-8Life.A.3 Food webs are models that can help scientists understand some of the interactions among organisms in an ecosystem. Food webs illustrate how matter and energy are transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers.

6-8Life.A.4 The organisms that live in an ecosystem can have large effects on each other. Changes to the population of one organism can have large and unexpected effects on the populations of other organisms in the ecosystem.

6-8Life.A.5 Environmental changes can impact an organism at just one or multiple stages in the organism's life cycle. The resulting changes in the populations of that organism can increase or decrease the populations of other organisms.

6-8Life.A.6 All ecosystems have essentially the same pattern of organization.

6-8Life.B **Pacific Island Ecosystems**

6-8Life.B.1 Organisms that live in island terrestrial and marine environments have adaptations that enable them to survive and reproduce in these ecosystems.

6-8Life.B.2 Coral reef ecosystems are particularly important to Pacific islands because they provide food and protection from the ocean. Coral are animals, but they get most of their food from photosynthesis done by plant-like cells that live symbiotically within them.

6-8Life.B.3 Different ecosystems on an island affect each other. Changes to one island ecosystem can have large effects on other ecosystems on the same island.

Climate Changes (Grades 6-8)

What is climate change, why is Earth's climate changing now, and how is climate changing in the USAPI?

6-8Changes.A **Climate Change**

6-8Changes.A.1 Local climate change is a large and long-lasting change in an area's average climate conditions or in its weather extremes, such as drought or typhoons.

6-8Changes.A.2 Global climate has changed in the past, is changing now, and will change in the future. The amount and kinds of changes are not the same in all locations on Earth.

6-8Changes.A.3 Scientists observe and measure environmental conditions to understand how the climate is changing. Scientists collect data from the bottom of the ocean to the surface of the Sun using instruments on weather stations, buoys, balloons, and satellites.

6-8Changes.A.4 To learn about past climates, scientists use natural records, such as coral growth bands, tree rings, ice cores, and layers of mud from swamps, the seafloors, and lakes. Historical observations, such as native knowledge and personal journals, also document past climates.

6-8Changes.A.5 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.

6-8Changes.A.6 The scientific evidence indicates that climate is changing now because human activities are increasing Earth's natural greenhouse effect. By adding heat-trapping gases to the atmosphere, human activities are blocking heat energy from leaving the Earth system. This trapping of heat energy causes our planet to be warmer.

6-8Changes.A.7 The burning of fossil fuels in engines and power plants as well as the burning and clearing of forests to harvest wood and create farmland has resulted in a huge amount of carbon dioxide that has collected in the atmosphere. These activities have caused the concentration of this heat-trapping gas to increase by about 40% over the last 150 years, to the highest levels in more than 800,000 years.

6-8Changes.B **Changes in USAPI Climate**

6-8ChangesB.1 In general air temperatures and ocean temperatures in the tropical Pacific Islands are increasing and are projected to continue to increase.

6-8ChangesB.2 Historical patterns of rainfall and winds will probably change in currently

unpredictable ways. For examples, some areas will get less rainfall and other areas will get more rainfall.

6-8ChangesB.3 Historical patterns of extreme weather events (such as droughts, typhoons, and heat waves) will probably change in currently unpredictable ways.

6-8ChangesB.4 The increases in carbon dioxide in the atmosphere will continue to increase the acidity of the ocean. This change in acid-base balance is included in climate change because it is caused by the same gas (carbon dioxide) that is currently causing most of the changes in climate.

Climate Change Impacts (Grades 6-8)

How will changes in climate impact ecosystems and human societies in the Pacific Islands?

6-8ImpactsA **Sea Level Rise**

6-8Impacts.A.1 Sea levels in the Pacific and around the world are rising. This rise in sea level is caused by the warming of the oceans, and by the increased melting of the world's polar ice sheets and mountain glaciers.

6-8Impacts.A.2 Rising sea levels threaten the security of coastal human development including homes, roads and agriculture. Rising sea levels also damage coastal ecosystems such as wetlands. These impacts endanger home security and food security.

6-8ImpactsA.3 Rising sea levels threaten the availability of freshwater. Underground sources of freshwater on Pacific islands float on top of seawater. As sea level rises, these freshwater lenses can be shrunken and contaminated by salt from below. Freshwater lenses can also be contaminated from above as the ocean surges over the land in a storm or very high tide.

6-8Imapcts.A.4 As sea levels continue to rise, flooding from high tides and storm surges will happen more frequently and cause more harmful impacts.

6-8Impacts.B **Climate Change Impacts on Pacific Island Ecosystems**

6-8Impacts.B.1 Rising sea levels, increasing ocean temperatures, changes in precipitation, and ocean acidification can have large impacts on Pacific Island ecosystems. These impacts can reduce the availability of food, reduce income from tourism, and increase erosion of coastal areas.

6-8Impacts.B.2 Ocean acidification harms marine organisms that have shells made from carbonate. These organisms, such as corals and many kinds of plankton, have very important roles in many Pacific Island ecosystems.

6-8Impacts.B.3 Humans are impacting Pacific Island ecosystems in many ways, such as by overfishing, cutting down trees, and polluting watersheds.

6-8Impacts.C **Climate Change Impacts on USAPI Communities**

6-8Impacts.C.1 Changes in climate pose serious challenges to many human societies. Inhabitants of small islands, such as many locations in the tropical Pacific, are particularly vulnerable to the changes caused by global warming.

6-8Impacts.C.2 Availability of freshwater can be impacted by changes in precipitation patterns, especially if droughts happen more frequently or are more severe. Changes in the local water cycle pose even greater danger to freshwater security if freshwater lenses are also impacted due to sea level rise.

6-8Impacts.C.3 Agricultural food availability, such as taro, can be impacted by changes in

precipitation and temperature. These impacts are even greater if rise in sea level is also damaging agricultural areas.

6-8Impacts.C.4 Climate change impacts on land and ocean ecosystems can reduce the availability of food, especially from fishing.

6-8Impacts.C.5 The combined impacts of climate change can force people to migrate to different locations on their home island, different islands, or even to entirely leave their home country.

Climate Adaptation (Grades 6-8)

What can Pacific Island nations and communities do to reduce the damage caused by climate change?

6-8Adapt.A **Climate Adaptation**

6-8AdaptA.1 Climate adaptation refers to efforts to reduce the damage caused by the climate change that is already happening or that is projected to happen.

6-8AdaptA.2 Adapting to the effects of climate change poses serious challenges to societies at national and local levels. For example, challenges include protecting ecosystems, homes and roads from rising seas, and having reliable supplies of clean water and food.

6-8AdaptA.3 Climate adaptation can involve making the systems that support island communities more sustainable, efficient and flexible. For example, adaptation strategies that increase freshwater security include improving rain catchment, fixing leaking pipes, reducing pollution of the water lens, and building more water storage capacity.

6-8AdaptA.4 Climate adaptation can involve protecting local ecosystems so they are as healthy as possible. For example, adaptation strategies that can help ecosystems to experience less damage and recover more quickly from climate change impacts include protecting ecosystems from pollution, exotic species, and excessive harvesting.

6-8Adapt.A.5 Planning and activities that reduce the risks of natural hazards, such as typhoons, to Pacific Island communities also reduce the risks of climate change impacts.

6-8Adapt.B **Indigenous and Western Climate Adaptation Strategies**

6-8Adapt.B.1 Adaptation strategies based on both Indigenous and Western knowledge and practices can increase the abilities of local communities to adapt to the impacts of climate change.

6-8Adapt.B.2 Indigenous communities have knowledge and practices that have enabled them to live sustainably for centuries in the Pacific Islands. These Indigenous knowledge and practices can help Pacific Island communities to adapt to current and future changes in climate.

6-8Adapt.B.3 Some projected climate change impacts, such as ocean acidification and the height of sea level rise, represent changes that have not been experienced by local island cultures or by technological societies.

6-8Adapt.B.4 Western science and technologies have played a large role in causing the current and projected changes in climate. Western science and technologies also provide tools and approaches that can help Island communities to adapt to climate change impacts.

6-8Adapt.B.5 Engineers begin by defining a problem, and specifying the criteria and constraints for potential solutions. Criteria are features that the solution needs to have (such as having enough freshwater for a month even if there is no more rainfall). Constraints include the limits of resources or skills (for example, roof area and materials available for rain catchment).

6-8Adapt.B.6 The more precisely the criteria and constraints can be described, the more likely it is that a designed solution will be successful. Cultural knowledge and scientific research can help define the criteria and constraints.

6-8Adapt.B.7 Indigenous, scientific and engineering communities have very different and also very similar ways to answer questions, analyze problems and develop solutions. Honest and respectful communications are necessary to maximize the potential benefits of collaborations among these communities to plan and implement climate adaptation strategies that are culturally and technologically appropriate.

6-8Adapt.B.8 Some culturally shared features of developing solutions to problems include researching possibilities, collaboratively working in a team to develop and test ideas, using the results of testing to improve designs, and communicating honestly about the benefits and problems of proposed solutions.

Practices (Grades 6-8)

Ask Questions and Define Problems

- Locate and collect reliable information about an environmental subject using many methods and sources.
- Develop and explain questions about the environment that are based on careful observations and other reliable information.
- Ask questions to determine relationships between independent and dependent variables.
- Develop a scientific question related to weather or climate that can be investigated with available resources either in or beyond the school.

Develop and Use Models

- Develop a model that explains how a family or community meets its needs for clean water, food, or shelter.
- Explain the uses and limitations of a model that describes a science concept such as the carbon cycle, the greenhouse effect, the ways that heat energy flows, or an ecosystem food web.
- Develop a model of a local ecosystem and use the model to predict what will happen if the climate changes in a specific way.

Plan and Carry Out Investigations

- Demonstrate knowledge of and apply safety and ethical procedures when conducting a scientific investigation.
- Collaboratively design and carry out an environmental investigation to answer a specific question.
- Collect, measure and record a variety of weather data after determining what tools are needed to gather the data and how the data will be recorded.
- Collaboratively design and conduct an investigation that includes independent and dependent variables and controls, and evaluate the experimental design after conducting the investigation.
- Evaluate the accuracy of various methods for collecting data.
- Research an example of a severe weather or environmental event (e.g., drought, typhoon, king tide), and design a plan to minimize its impacts.
- Demonstrate values and attitudes that are important in working together as a team to solve a problem or answer a scientific question.

Analyze and Interpret Data

- Use mean, median, mode, and variability to analyze and characterize data.
- Organize collected data and display the information in ways that help the analysis and interpretation of the data.
- Construct, analyze, and interpret graphical displays of data to identify linear and nonlinear relationships.
- Seek to improve the precision and accuracy of data with better tools, experimental procedures, and methods such as multiple trials.
- Distinguish between causal and co-relational relationships.
- Use graphical displays (for example, maps) to identify temporal and spatial relationships.

• Use mathematical concepts such as ratios, averages, percents and linear relationships to a scientific question or an engineering problem.

Construct Explanations and Design Solutions

• Logically explain observations and findings related to a scientific question or a design problem.
• Develop an explanation for a qualitative or a quantitative relationship between two variables.
• Use scientific reasoning to show that the data are strong enough to support the explanation or conclusion.
• Base explanations on evidence and the assumption that natural laws operate today as they did in the past and will continue to do so in the future.
• Undertake design projects, engaging in the design cycle, to construct and implement a solution that meets specific design criteria and constraints.
• Apply scientific knowledge and evidence to explain a natural phenomenon or the results of a scientific or engineering investigation.
• Improve the performance of a designed solution to a specific problem by prioritizing criteria, making tradeoffs, testing, revising and retesting.

Analyze and Investigate Environmental Issues

• Gather and help organize local Indigenous knowledge related to an environmental issue.
• Use primary and secondary sources of information and apply research and analytical skills to investigate environmental or climate issues of concern to the local community.
• Use valid information and knowledge to identify the consequences of a specific environmental issue and the potential actions to address that issue.
• Evaluate ways that people use the island's natural resources and explain ways to optimize the management and uses of those resources for long term sustainability of the resources and the community.

Decide and Act

• Decide and act with the understanding that Indigenous beliefs and values are based on the idea and experience that all living and non-living things remain in balance for continued existence.
• Explain how human actions have consequences for the immediate environment as well as for other places and future times.
• Demonstrate a realistic self-confidence in student effectiveness as citizens and a responsible understanding that personal actions have broad consequences.
• Participate meaningfully in local practices designed to increase the ability to adapt to climate change and its impacts.
• Work with the community to increase understanding of climate change impacts and plan or implement community adaptation for natural systems or human social systems.

Weather and Climate (Grades 9-12)

What major science concepts help us understand weather and climate in the Pacific Islands and globally?

9-12Climate.A	**Weather and Climate**
9-12Climate.A.1	Weather and climate are influenced by interactions involving sunlight, the atmosphere, the ocean, ice, landforms, and living things. Alterations to the atmosphere, hydrosphere, geosphere and biosphere can change the climate at local, regional and global scales.
9-12Climate.A.2	Latitude, altitude, and local geography influence weather and climate. For example, locations close to the equator generally have warm climates. However, a location close to the equator that has a very high elevation will have a much colder climate.
9-12Climate.A.3	Winds and ocean currents distribute heat energy around the planet, and strongly influence weather and climate.
9-12Climate.B	**Climate in the USAPI**
9-12Climate.B.1	Each Pacific island has a pattern of rainfall that is related to wind directions, presence or absence of mountains, its specific latitude, and regional patterns, especially the El Niño Southern Oscillation (ENSO).
9-12Climate.B.2	Approximately once every 2 to 7 years, the winds blowing west across the equatorial Pacific Ocean decrease in intensity. During an El Niño event, in Micronesia the weather is typically cooler, there may be more typhoons in the wet season, and lower sea levels in the Western Pacific. A strong El Niño tends to bring increased and severe drought the following year.
9-12Climate.B.2	An El Niño event is typically followed by a La Niña event where the winds blowing west are stronger than normal. During a La Niña event, sea levels rise even more in the western Pacific. La Niña events in Micronesia are associated with warmer and wetter weather.
9-12Climate.B.3	Because of their location at latitudes close to the equator and surrounded by the Pacific Ocean, the islands of the USAPI tend to have warm weather and steady temperatures throughout the year.
9-12ClimateB.4	The islands in the region do not experience the large seasonal changes in temperature, hours of daylight, and height of the Sun that occur in temperate and polar areas of the planet. The main seasonal changes in the USAPI are in amounts of precipitation, wind patterns and occurrence of extreme weather events, such as typhoons and hurricanes.

Earth System Science (Grades 9-12)

How does Earth System Science help us understand climate and its impacts in the Pacific Islands and globally?

9-12ESS.A **Systems**

9-12ESS.A.1 Systems tend to have properties that are qualitatively different than the properties of their parts. No part by itself causes or has the system property. For example, Earth's climate is property of the Earth system, but the atmosphere does not have a global climate. Water (H_2O) has the property of putting out fires, yet neither of its parts has that property. Hydrogen explodes and burns, while oxygen is necessary for fires to burn.

9-12ESS.A.2 Learning to define, observe, and analyze systems can lead to deeper understanding. When investigating or describing a system, first the boundaries of the system need to be chosen and defined. Then the starting conditions, inputs to the system, and the outputs from the system also need to be described and analyzed.

9-12ESS.A.3 When a system changes, that change can cause further changes. In a negative feedback loop (also called balancing feedback loop), the initial change causes something to happen that makes the system return to its original condition. For example, in a room that gets too hot, an air conditioner will turn on to cool the room. If the room becomes too cold, the air conditioner turns off, and the room returns to its original temperature.

9-12ESS.A.4 In a positive feedback loop (also called reinforcing feedback loop), a change to a system tends to cause the system to change even more in the same direction. At the start of an Ice Age, more snow and ice cover Earth's surface. Instead of absorbing the sunlight and becoming warmer, the ice and snow reflect sunlight away from the Earth system. This reflection causes more cooling, which results in even more ice and snow.

9-12ESS.A.5 Models can help people understand how a system works. A three dimensional physical representation, a computer simulation, or an equation are examples of different kinds of models. The model can illustrate the system's boundaries, initial conditions, inputs, outputs, and interactions between the parts, including any feedback loops.

9-12ESS.A.6 Changes to the parts or connections in a complex system may result in changes that are very hard to predict.

9-12ESS.B **Earth System Science (ESS)**

9-12ESS.B.1 From a systems point of view, Earth is essentially a closed system with respect to matter, an open system with respect to energy, and a networked system with respect to life.

9-12ESS.B.2 Global climate is a property of the Earth system. Global climate arises from the many ways that the parts of the Earth system interact with the incoming solar energy and with each other.

9-12ESS.B.3 Changes to Earth's carbon cycle or water cycle can change how energy flows into, within and out of the Earth system. These alterations can then change climate both locally and globally.

9-12ESS.B.4 Balancing feedback loops tend to keep the global climate relatively steady. In contrast, reinforcing feedback loops tend to increase the amount of change, and can result in Ice Ages or extremely warm global climates.

Energy and the Earth System (Grades 9-12)

What key science concepts about energy help us understand climate and its impacts in the Pacific Islands and globally?

9-12Energy.A **Nature of Energy**

9-12Energy.A.1 Electromagnetic radiation travels as a wave that can move energy from one location to another. The electromagnetic spectrum illustrates the very wide range of wavelengths in the universe, and the kinds of radiation associated with different wavelengths.

9-12Energy.A.2 A wave of electromagnetic radiation has a repeating pattern with a specific wavelength and amplitude.

9-12Energy.A.3 When electromagnetic radiation (such as light) shines on an object, it is reflected away from the object, absorbed within the object, or transmitted through the object. The amount of reflection, absorption or transmission depends on the object's material and on the wavelength of the electromagnetic radiation.

9-12Energy.A.4 Essentially all objects give off electromagnetic radiation. The wavelength of the radiation depends on the temperature of the object. Compared with cooler objects, a hot object gives off electromagnetic radiation that has more energy and a shorter wavelength.

9-12Energy.A.5 When light shines on an object, the amount of absorption depends on the angle at which this radiation hits the object. When light shines more directly on an object, it absorbs more of the light and becomes warmer. This principle explains why regions near the equator are much warmer compared to the polar regions, and why the Northern Hemisphere is warmer in August than it is in February.

9-12Energy.B **Flows of Energy Into, Within and Out of the Earth System**

9-12Energy.B.1 Sunlight consists primarily of radiation in the visible region of the electromagnetic spectrum and also includes some ultraviolet (UV) radiation.

9-12Energy.B.2 Earth rotates one time each day and travels around the Sun one time each year. Earth's spin axis of rotation is tilted relative to its orbit around the Sun. This tilt causes sunlight to hit tropical regions much more directly than temperate or polar regions. As a result, tropical regions of the planet absorb much more solar energy over the course of a year than do temperate and polar regions.

9-12Energy.B.3 Earth's orbit around the Sun and the tilt of its axis causes the angle of the sunlight hitting temperate and polar regions to change a lot over the course of the year. This change in angle causes the large changes in seasons that occur in temperate and polar regions. Tropical regions do not have such large changes in the angle of sunlight over the course of a

year, and their climate does not change that much over the year.

9-12Energy.B.4 The ocean exerts a major influence on weather and climate by absorbing light energy from the Sun that changes into heat energy. The ocean stores huge amounts of this heat energy because of its large size (covering about 70% of the planet) and the high heat capacity of water.

9-12Energy.B.5 Water currents in the ocean globally redistribute heat energy from tropical regions to higher latitudes. This global movement of water is influenced by Earth's rotation on its axis and by the locations of the continents.

9-12Energy.B.6 Ocean currents move heat energy across large distances on the planet. Variations in density help drive this global circulation of interconnected surface, near-the-surface, and deep ocean currents. The variations in ocean density are due to differences in temperature and salinity of the water.

9-12Energy.B.7 Regional wind patterns arise from differential heating of the air combined with the effect of Earth's rotation on its axis. These winds move thermal energy across large distances on the planet, and also power surface ocean currents.

9-12Energy.B.8 Some trace gases in the atmosphere (notably water vapor and carbon dioxide) absorb infrared radiation (heat) but do not absorb light radiation. These gases in the atmosphere trap heat and are called greenhouse gases.

9-12Energy.B.9 The most abundant gases in Earth's atmosphere (nitrogen and oxygen) do not absorb either light radiation or infrared radiation. Nitrogen and oxygen are not greenhouse gases.

9-12Energy.B.10 Earth is much cooler than the Sun and radiates energy in the infrared (heat) region of the electromagnetic spectrum. Humans are altering the outflow of this radiated heat energy by increasing the amounts of heat-trapping gases in the atmosphere. As a result, the global average temperature is increasing. This change is called global warming.

Earth's Matter (Grades 9-12)

What key science concepts about matter help us understand climate and its impacts in the Pacific Islands and globally?

9-12Matter.A **Nature of Matter**

9-12Matter.A1 When heat energy is added to matter, the molecules making up the matter move faster and tend to move further apart from each other. If the matter can occupy a larger volume, this heating will cause the volume to expand. As global warming heats the oceans, the warmer water occupies a larger volume causing sea level to rise.

9-12Matter.A.2 Volumes of matter that are less dense float on top of volumes of matter that are more dense. Warm air is less dense than cooler air, and rises above the cooler air. Warm water is less dense than cooler water, and rises above it. Differences in density play important roles in climate because these density differences cause the wind patterns and ocean currents that move matter and energy around the planet.

9-12Matter.A.3 In both physical and chemical changes, the amount of matter remains the same. This rule is called the Conservation of Matter. Throughout Earth's cycles of matter, the total mass of matter involved remains the same.

9-12Matter.B **Earth's Biogeochemical Cycles**

9-12Matter.B.1 Water plays a central role in global climate and local climates. A deep understanding of the water cycle requires analyzing the processes and rates at which water enters and leaves each of its reservoirs.

9-12Matter.B.2 On small islands made of coral or limestone, freshwater occurs below the surface as a lens floating on top of oceanic saltwater. These lenses also can be located in the shore areas of larger islands. This freshwater reservoir is part of the water cycle on these islands just as groundwater is part of the water cycle on continents.

9-12Matter.B.3 The carbon cycle plays an important role in global climate because carbon dioxide and methane are both heat-trapping gases that are in the atmosphere. A deep understanding of the carbon cycle requires analyzing the processes and rates at which carbon enters and leaves each of its reservoirs.

9-12Matter.B.4 Living systems are intimately connected with the carbon cycle. The processes of photosynthesis and respiration move carbon between the atmosphere and organisms.

9-12Matter.B.5 Each element that is vital for life exists on Earth in a closed loop of cyclical changes (for example, the carbon cycle). Understanding Earth's biogeochemical cycles involves analyzing the amounts and forms of an

element in its different reservoirs and analyzing the processes that move that element between those reservoirs.

Earth's Living Systems (Grades 9-12)

What key science concepts about living systems help us understand climate and its impacts in the Pacific Islands and globally?

9-12Life.A **Earth's Web of Life**

9-12Life.A.1 A complex network of relationships connects all of Earth's organisms with each other. Earth's web of life is deeply connected with the planet's cycles of matter and flows of energy. From a systems point of view, Earth is a networked system with respect to life.

9-12Life.A.2 Scientists use the word biodiversity to describe the variety of life on Earth. Biodiversity exists on many different scales. There is biodiversity within a species, within an ecosystem, and across all of Earth's ecosystems.

9-12Life.A.3 Disruptions to any physical or biological part of an ecosystem can lead to shifts in all of its populations. Some organisms, especially the producers, have particularly important roles in ecosystems.

9-12Life.A.4 Organisms depend upon their interactions with other living things and with nonliving factors. The number of organisms that an ecosystem can sustain is limited.

9-12Life.A.5 Some ecosystems tend to be stable over long periods of time. An ecosystem is considered to be resilient if the numbers and types of organisms remain relatively constant even after the ecosystem has been disturbed.

9-12Life.A.6 Conditions that do not harm grown members of a species can still reduce populations by harming different parts of that organism's life cycle or its ability to reproduce.

9-12Life.A.7 Human activities are harming biodiversity at local, regional and planetary scales. These activities include pollution, excessive harvesting, destruction of habitat, introduction of exotic species and climate change. Many ecologists are concerned that the combined effects of these human activities are causing a major decrease in Earth's biodiversity.

9-12Life.A.8 Humans depend on the living world for the many benefits that biodiversity provides such as food, natural building materials, and medicines. Humans are able to alter the natural environment to meet their needs, but there are limits to the ability of the natural environment to absorb impacts or meet human physical needs.

9-12Life.A.9 Humans are an integral part of Earth's web of life. Indigenous cultures teach that we are profoundly related to the places where we live and the organisms that also live there. Indigenous knowledge and practices are based on humans being embedded within the natural world rather than being separate from it. Indigenous knowledge and practices also reinforce

that humans are part of natural balances and have special responsibilities to maintain those balances.

9-12Life.B **Pacific Island Ecosystems**

9-12Life.B.1 Ecosystems on islands are linked from the reef to the highest local land elevation. Changes to one kind of ecosystem on an island or in its coastal waters can have dramatic effects on other ecosystems on that island.

9-12Life.B.2 Many Pacific Islands are home to species that do not naturally occur elsewhere on the planet. Despite the differences in organisms, Pacific Island ecosystems generally have the same pattern of organization as ecosystems on and around continents.

9-12Life.B.3 Many Pacific island marine organisms such as coral have shells that are made from carbonate. These organisms, and the organisms that depend upon them, are likely to be especially threatened by increases in ocean acidity.

9-12Life.B.4 Corals are animals that have a symbiotic relationship with microscopic producers that live within them and provide the coral with food. Under conditions of increased temperature, the corals may expel the microscopic producers and become bleached. Under severe conditions of bleaching, the coral may die resulting in severe damage to the reef ecosystem.

9-12Life.B.5 Coral reef ecosystems provide essential habitat for the largest diversity of marine life. Coral reefs are very sensitive to changes in both ocean temperature and acid-base balance. Because of this sensitivity, coral reefs can provide dramatic evidence of the health of ocean biodiversity and the impacts of climate change on ocean life.

Climate Changes (Grades 9-12)

What are current and projected changes in climate globally and in the USAPI?

9-12Changes.A **Global Climate Change**

9-12Changes.A.1 Global climate is a result of many system interactions. These interactions include the input of energy from the Sun into the Earth system; the energy's absorption, storage, and movement within the Earth system (atmosphere, hydrosphere and geosphere); and the energy's radiation out of the Earth system.

9-12Changes.A.2 Carbon dioxide and methane are heat-trapping gases that are increasing in concentration in the atmosphere due to human activities such as burning fossil fuels, clearing forests, and growing rice. Both of these gases have increased to atmospheric levels that have not occurred on Earth in more than 800,000 years.

9-12Changes.A.3 The current global climate change results from human activities that change Earth's cycles of matter, particularly the carbon cycle. The extra heat-trapping gases in the atmosphere keep more of the heat energy in the Earth system. As a result, the temperatures of Earth's ocean and atmosphere are increasing.

9-12Changes.A.4 The extra heat energy trapped in the Earth system alters the global climate in ways that impact ecosystems on land and in the ocean. These changes to ecosystems around the planet cause changes in major human activities such as fishing and agriculture.

9-12Changes.A.5 Scientists use global climate models to predict future climate conditions. These global climate models are very complex computer programs that simulate how different parts of the Earth system interact with each other. One way that scientists test these computer models of Earth's climate is by checking how well these models explain the current and past climate conditions.

9-12Changes.B **Changes in USAPI Climate**

9-12Climate.B.1 Global climate models are more specific in their projections for the planet as a whole and for large geographic areas than they are for smaller geographic locations. It is difficult to use these climate models to make reliable specific predictions for small islands in the middle of the vast Pacific Ocean.

9-12Climate.B.2 Climate in the USAPI naturally varies a lot from year to year. This natural variation makes it more difficult to determine exactly how much the climate has been changing in the USAPI because of global warming.

9-12Climate.B.3 In general for the USAPI, both the average air temperature and sea surface temperature are projected to continue to increase. Global climate

models predict that significantly larger changes will happen if human activities continue to emit high levels of heat-trapping greenhouse gases into the atmosphere.

9-12Climate.B.4 Sea levels will continue to rise and the ocean acidity will continue to increase. Global climate models predict that significantly higher sea levels and increased ocean acidity will occur if human activities continue to emit high levels of carbon dioxide into the atmosphere.

9-12Climate.B.5 Amounts and patterns of rainfall in the USAPI will probably change. The frequency and intensity of extreme weather events will probably also change. Global climate models cannot accurately predict these changes at the present time.

Climate Change Impacts (Grades 9-12)

How will climate changes impact ecosystems and human societies in the Pacific Islands and globally?

9-12Impacts.A **Climate Change Impacts on Ecosystems**

9-12Impacts.A.1 Increased air temperatures and reduced precipitation in some areas will have negative impacts on native Pacific Island plants and animals, especially in high-elevation ecosystems. There will be more exposure to fire and to non-native biological invasions. Some native species are likely to become extinct.

9-12Impacts.A.2 Rising sea levels will reduce habitat for endangered species and will threaten shallow reef systems. Higher sea levels will also inundate protective barriers such as mangroves and cause floods that damage ecosystems.

9-12Impacts.A.3 Higher sea surface temperatures will increase coral bleaching and cause changes in the distribution of coral species. Prolonged bleaching events can lead to coral death and loss of coral-based ecosystems.

9-12Impacts.A.3 Increased ocean acidification will harm many marine ecosystems. While the damage could be very large, the exact nature of the impacts is not yet clear.

9-12Impacts.B **Climate Change Impacts on USAPI Communities**

9-12ImpactsB.1 Threats to traditional lifestyles of indigenous communities include destruction of coastal artifacts and structures, reduced availability of traditional food sources and subsistence fisheries, migration of young people and families, and the loss of the land base integral to Pacific Island cultures.

9-12ImpactsB.2 Community water security will be threatened by sea level rise, potential decreases in total precipitation and increases in drought. Sea level rise can damage freshwater lenses by inundation from above and contamination from below.

9-12ImpactsB.3 Community food security will be threatened by changes in weather patterns, increased air and ocean temperature, increased ocean acidification, and flooding from higher sea levels.

9-12ImpactsB.4 Human health and mortality rates will be affected to different amounts in specific regions of the world as a result of climate change. The incidence and geographical range of climate-sensitive infectious diseases (such as malaria, dengue fever, and tick-borne diseases) will increase. 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.

9-12Impacts.B.5 Community financial security will be threatened by decreased income from fishing and tourism, higher costs for food and water, and expensive damages to homes and social infrastructure such as roads.

9-12Impacts.B.6 Small islands are especially vulnerable to the impacts of sea level rise, ocean acidification, increasing temperatures, changes in precipitation patterns, and increases in extreme weather events. These impacts threaten security with respect to having a home, freshwater, food, health, and sufficient income.

Climate Adaptation (Grades 9-12)

What can Pacific Island nations and communities do to reduce the damage caused by climate change?

9-12Adapt.A **Climate Adaptation**

9-12AdaptA.1 Many communities face current and potential future challenges because changes in climate can seriously affect their security with respect to shelter, freshwater, food, economy, or health. Climate adaptation involves actions that reduce the damage caused by the climate change impacts that are already happening or that are projected to happen.

9-12Adapt.A.2 Indigenous communities have a long history of successfully adapting to changes in climate. These climate adaptation strategies can inspire and provide models for climate adaptation today.

9-12Adapt.A.3 After external stresses, a **resilient** ecosystem or social system can maintain its core functions, suffer less damage, and recover much better than a **vulnerable** ecosystem or social system.

9-12Adapt.A.4 Climate exposure is the extent to which a system comes into contact with climate conditions or climate impacts. For example, the exposure of homes to storm surges depends on how close to the shore the homes are built, how high they are, and whether they are located behind a barrier such as a healthy mangrove ecosystem.

9-12Adapt.A.5 Climate sensitivity is the extent to which a system is negatively affected by climate conditions or specific climate change impacts. For example, the climate sensitivity of a community to drought depends on the efficiency of the rainwater catchment, the amount of community water storage capacity, and the availability of different sources of freshwater.

9-12Adapt.A.6 Climate adaptive capacity is the ability of a system to adapt to impacts of climate change with minimal damage or cost. For example, the climate adaptive capacity of an ecosystem depends on how many impacts it already has from stresses such as pollution, excessive harvesting and invasive species.

9-12Adapt.A.7 Compared to vulnerable systems, systems that are resilient with respect to climate changes have less climate exposure, less climate sensitivity, and more climate adaptive capacity.

9-12AdaptB **Climate Adaptation in the USAPI**

9-12Adapt.B.1 Island communities can help make their ecosystems more resilient with respect to climate change by reducing or eliminating human activities that are damaging those ecosystems. Pollution and overharvesting are

examples of these harmful practices. Reducing harmful ecological practices reduces climate sensitivity and increases climate adaptive capacity.

9-12Adapt.B.2 Island communities can help make their social systems more resilient with respect to climate change. Examples of these social systems are agriculture, fishing, transportation, tourism, public health, availability of freshwater, and treatment of wastes.

9-12Adapt.B.3 In general, communities that are more resilient with respect to climate change impacts strongly support shared community participation, respect for cultural practices, and utilization of indigenous knowledge and practices.

9-12Adapt.B.4 In general, social systems that are more resilient with respect to climate change impacts rely more on renewable resources and provide more ways to meet the different needs. For example, community food security can become more climate resilient by relying more on multi-crop agriculture, harvesting seasonal fruits, and catching a wider range of diverse marine species from locally protected mangrove and reef ecosystems.

9-12Adapt.B.5 An island community can increase climate adaptive capacity by forming community teams to develop and implement climate adaptation strategies. These teams can provide community outreach and awareness programs, partner with relevant local and governmental organizations, work with adjacent communities to protect resources and obtain funding, help build strong social networks, and guide the progress of the climate adaptation work.

Practices (Grades 9-12)

Ask Questions and Define Problems

• Develop and explain questions that are based on observations and that can guide a scientific investigation or help solve a societal problem.
• Locate and collect reliable information for environmental investigations of many types, including using technology to collect and display information. Apply basic logic and reasoning skills to evaluate the completeness and reliability of information sources.
• Ask questions that require collecting relevant empirical evidence to answer.
• Define a community issue related to climate and identify the social, cultural, scientific and technical factors that are involved
• Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.
• Ask and evaluate questions that relate to the premise of an argument, the interpretation of a data set, or the suitability of a design.

Develop and Use Models

• Create, use and evaluate models to understand environmental phenomena or analyze an impact of climate change on a community or ecosystem.
• Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.
• Develop a way to test the reliability of a model.
• Examine merits and limitations of two different models of the same proposed tool, process, or system in order to select or revise a model that best fits the evidence or the design criteria.

Plan and Carry Out Investigations

• Collaboratively plan and carry out an investigation to answer specific questions about local climate, a local ecosystem, or an impact of climate change.
• Collaboratively plan an investigation that analyzes the validity of explanations for a phenomenon or tests solutions to a problem. Consider and evaluate possible confounding variables. If necessary, refine the investigation to ensure that variables are controlled.
• Decide on the types, amounts, and accuracy of data needed to produce reliable measurements. Select appropriate tools to collect, record, analyze, and evaluate data. Consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the plan accordingly.
• Collaboratively conduct investigations and test design solutions in a safe and ethical manner including considerations of environmental, social, cultural, and personal impacts.
• Based on initial results, refine the investigation of a phenomenon or the design of a solution so it provides improved data or results.

Analyze and Interpret Data

• Organize and display information in ways that are appropriate to different types of investigation.
• Use tools, technologies, and/or models (e.g., computational, mathematical) to analyze data in order to make valid and reliable scientific claims or to determine an optimal design

for a solution to a problem.
• Consider limitations (e.g., measurement error, sample selection, changes in conditions) when analyzing and interpreting data.
• Compare and contrast various types of data sets to examine consistency of measurements and observations.
• Using criteria for success as a guide, analyze data to identify improvements to the design or components of a proposed solution to a problem.

Construct Explanations and Design Solutions
• Use evidence and logic to develop proposed explanations or conclusions that directly relate to the original question or problem.
• Use evidence that has been gathered to assess how well the reasoning and data support your own or other people's explanations or conclusions.
• Construct and revise explanations and arguments based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.
• Base causal explanations on valid and reliable empirical evidence from multiple sources and the assumption that natural laws operate today as they did in the past and will continue to do so in the future.
• Apply scientific knowledge and evidence to explain phenomena and solve design problems, taking into account possible unanticipated effects.
• Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Analyze Environmental Issues
• Apply research and analytical skills to investigate environmental issues of all scales and evaluate the consequences of specific changes, conditions and issues to human and ecological systems.
• Evaluate a claim for a design solution to an environmental problem based on scientific knowledge, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, cultural, environmental, ethical considerations).
• Collaborate with other students and discuss with community members in a respectful spirit of open inquiry.
• Identify and propose action strategies that are likely to be effective in addressing an environmental issue that affects the community.
• Evaluate and communicate about environmental issues at scales from local to global, and understand that these scales are often linked.

Decide and Act
• Decide and act with the understanding that Indigenous beliefs and values are based on the idea and experience that all living and non-living things remain in balance for continued existence.
• Plan for action based on research and analysis of an environmental issue, and if appropriate take actions that are within the scope of student rights and are consistent with community values, student abilities and responsibilities as citizens.
• Understand and assess the relative value and efficacy of solutions based on scientific and

cultural considerations.

- Possess a realistic self-confidence in student effectiveness as citizens and understand the importance of responsibly exercising one's rights as a community member and citizen.
- Analyze the influence of shared and conflicting societal values, and take into account that actions have broad consequences.

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The current version of the "Practices" section draws from the Science and Engineering Practices in the January 2013 Public Draft of the *Next Generation Science Standards* and from the National Wildlife Federation document cited above. It is expected that the "Practices" section will be significantly revised based on continuing consultation with USAPI education practitioners.