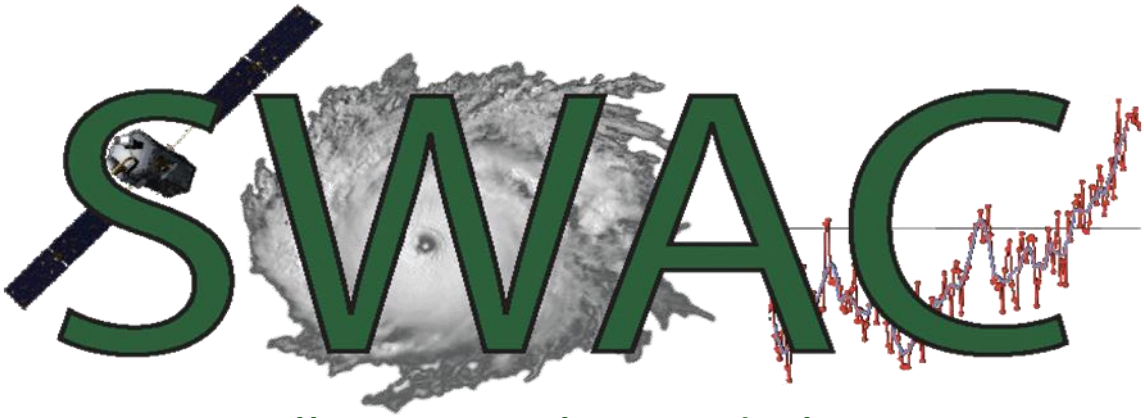

Satellites Weather and Climate

Core Concepts

and the

Next Generation Science Standards

SWAC Core Concept

Anthropogenic influences on the earth-atmosphere-ocean system

NGSS Standards

Elementary School (K-5)

- K.LS1.C (K-LS1-1); K.ESS2.E (K-ESS2-2); K.ESS3.A (K-ESS3-1); K.ESS3.C (K-ESS3-2);
    - Crosscutting Concepts:
        - Patterns
            - Patterns in the natural and human designed world can be observed and used as evidence (K-LS1-1)
        - Cause and Effect
            - Events have causes that generate observable patterns (K-ESS3-3)
        - Systems and System Models
            - Systems in the natural and designed world have parts that work together (K-ESS2-2),(K-ESS3-1)
    - Link: http://www.nextgenscience.org/kire-interdependent-relationships-ecosystems-animals-plants-environment
- 1.LS1.A (1-LS1-1)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. (1-LS1-1)
        - Structure and Function
            - The shape and stability of structures of natural and designed objects are related to their function(s). (1-LS1-1)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Science, Engineering, and Technology on Society and the Natural World
                - Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world. (1-LS1-1)
    - Link: http://www.nextgenscience.org/1sfip-stucture-function-information-processing
- 2.LS2.A (2-LS2-1),(2-LS2-2); 2.LS4.D (2-LS4-1)
    - Crosscutting Concepts
        - Cause and Effect
            - Events have causes that generate observable patterns. (2-LS2-1)
        - Structure and Function
            - The shape and stability of structures of natural and designed objects are related to their function(s). (2-LS2-2)
    - link: http://www.nextgenscience.org/2ire-interdependent-relationships-ecosystems

- 3.LS2.C (3-LS-4); 3.LS4.A (3-LS4-1); 3.LS4.C (3-LS4-3); 3.LS4.D (3-LS4-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships are routinely identified and used to explain change. (3-LS2-1), (3-LSL4-3)
        - Scale, Proportion, and Quantity
            - Observable phenomena exist from very short to very long time periods. (3-LS4-1)
        - Systems and System Models
            - A system can be described in terms of its components and their interactions. (3-LS4-1)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of Engineering, Technology and Science on Society and the Natural World
                - Knowledge of relevant scientific concepts and research findings is important in engineering. (3-LS4-4)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes consistent patterns in natural systems. (3-LS4-1)
    - Link: http://www.nextgenscience.org/3ire-interdependent-relationships-ecosystems
- 3.LS1.B (3-LS1-1); 3.LS3.A (3-LS3-1),(3-LS3-2); 3.LS3.B (3-LS3-1),(3-LS3-2); 3.LS4.B (3-LS4-2)
    - Crosscutting Concepts
        - Patterns
            - Similarities and differences in patterns can be used to sort and classify natural phenomena. (3-LS3-1)
            - Patterns of change can be used to make predictions. (3-LS1-1)
        - Cause and Effect
            - Cause and effect relationships are routinely identified and used to explain change. (3-LS3-2), (3-LS4-2)
    - Link: http://www.nextgenscience.org/3ivt-inheritance-variation-traits-life-cycles-traits
- 4.ESS3.A (4-ESS3-1)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1)
        - Connections to Engineering, Technology, and Applications of Science
            - Interdependence of Science, Engineering, and Technology
                - Knowledge of relevant scientific concepts and research findings is important in engineering. (4-ESS3-1)
            - Influence of Engineering, Technology, and Science on society and the Natural World

            - Over time, people's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-)
    - Link: http://www.nextgenscience.org/4e-energy
- 5.PS3.D (5-PS3-1); 5.LS2.A (5-LS2-1); 5.LS2.B 95-LS2-1)
    - Crosscutting Concepts
        - Systems and System Models
            - A system can be described in terms of its components and their interactions. (5-LS2-1)
        - Energy and Matter
            - Matter is transported into, out of, and within systems (5-LS1-1)
            - Energy can be transferred in various ways and between objects. (5-PS3-1)
- Link: http://www.nextgenscience.org/5meoe-matter-energy-organisms-ecosystems

Middle School (6-8)

- MS.ESS3.C (MS-ESS3-3),(MS-ESS3-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MA-ESS3-3)
            - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-4)
        - Connections to Engineering, Technology, and Applications of Science
            - Influence of Science, Engineering, and Technology on Society and the Natural World
                - All human activity draws on natural resources, and has both short and long-term consequences, positive as well as negative, for the health of people and the environment. (MS-ESS3-4)
                - The uses of technologies and any limitations on their uses are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region over time. (MS-ESS3-3)
        - Connections to the Nature of Science
            - Science Addresses Questions About the Natural and Material World
                - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-ESS3-4)
    - Link: http://www.nextgenscience.org/msess-hi-human-impacts
- MS.LS2.A (MS-LS2-2); MS.LS2.C (MS-LS2-5); MS.LS4.D (MS-LS2-5);
    - Crosscutting Concepts
        - Patterns

                - Patterns can be used to identify cause and effect relationships. (MS-LS2-2)
            - Stability and Change
                - Small changes in one part of a system might cause large changes in another part. (MS-LS2-5),
            - Connections to Engineering, Technology, and Applications of Science
                - Influence of Science, Engineering, and Technology on Society and the Natural World
                    - The use of technology and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5)
            - Connections to Nature of Science
                - Science Addresses Questions About the Natural and Material World
                    - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5)
    - Link: http://www.nextgenscience.org/msls-ire-interdependent-relationships-ecosystems
- MS.LS2.A (MS-LS2-1); MS.LS2.C (MS-LS2-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)
        - Stability and Change
            - Small changes in one part of a system might cause large changes in another part. (MS-LS2-4)
    - Link: http://www.nextgenscience.org/msls-meoe-matter-energy-organisms-ecosystems

High School (9-12)

- HS.LS.2.B (HS-LS2-3),(HS-LS2-4),(HS-LS2-5)
    - Crosscutting Concepts
        - Systems and System Models
            - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)
        - Energy and Matter
            - Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS2-4)
            - Energy drives the cycling of matter within and between systems. (HS-LS2-3)

    - link: http://www.nextgenscience.org/hsls-meoe-matter-energy-organisms-ecosystems
- HS.LS2.A (HS-LS2-1),(HS-LS2-2); HS.LS2.C (HS-LS2-2),(HS-LS2-6),(HS-LS2-7); HS.LS4.C (HS.LS4-6); HS.LS.4.D (HS-LS2-7),(HS-LS4-6)
    - Crosscutting Concepts
        - Cause and Effect
            - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS2-8), (HS-LS4-6)
        - Scale, Proportion, and Quantity
            - The significance of a phenomena is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1)
            - Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2)
        - Stability and Change
            - Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6), (HS-LS2-7)
    - link: http://www.nextgenscience.org/hsls-ire-interdependent-relationships-ecosystems
- HS.ESS3.C (HS-ESS-3),(HS-ESS3-4); HS.ESS3.D (HS-ESS3-6)
    - Crosscutting Concepts
        - Systems and System Models
            - When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6)
        - Stability and Change
            - Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3)
            - Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)
        - Connections to Engineering, Technology, and Applications of Science
            - Influence of Science, Engineering, and Technology on Society and the Natural World
                - Modern civilization depends on major technological systems. (HS-ESS3-1),(HS-ESS3-3)
                - Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-ESS3-2),(HS-ESS3-4)
                - New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3)
        - Connections to the Nature of Science
            - Science is a Human Endeavor

        - Science is a result of human endeavors, imagination, and creativity. (HS-ESS3-3)
    - Science Addresses Questions About the Natural and Material World
        - Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2)
- link: http://www.nextgenscience.org/hsess-hs-human-sustainability

Potential Application

Satellites

- Eutrophication of water bodies by agricultural processes
    - False Color Composite using NIR band
- Acid Rain harming vegetation
    - NIR band
- Recolonization of Abandoned farms in Pripyat, Chernobyl, Ukraine
- Flooding and damming of rivers (interpretation)

Weather

- Acid Rain
- Cloud seeding
- Air Pollution/Release and spreading
    - Case Study Japan

Climate

- Link anthropogenic emissions data to changes in Global Climate Change Proxies
    - Ice Cores
    - Tree Rings
    - Boreholes
        - Swiss Alps Example
    - Coral Health
    - Pollen

SWAC Core Concept

The atmosphere is made up of vertical layers, each of which are important to life here on Earth

NGSS Standards

Elementary School (K-5)

- K.PS2.A (K-PS2-1),(K-PS2-2); K.PS2.B (K-PS2-1); K.PS3.C (K-PS2-1)
    - Crosscutting Concepts
        - Cause and Effect
            - Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1),(K-PS2-2)
    - LINK: http://www.nextgenscience.org/kfi-forces-interactions-pushes-pulls
- K.PS3.B (K=PS3-1),(K-PS3-2)
    - Crosscutting Concepts
        - Cause and Effect
            - Events have causes that generate observable patterns. (K-PS3-1), (K-PS3-2), (K-ESS3-2)
    - LINK: http://www.nextgenscience.org/kwc-weather-climate
- 2.PS1.A (2-PS1-1),(2-PS1-2),(2-PS1-3); 2.PS1.B (2-PS1-4)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural and human designed world can be observed. (2-PS1-1)
        - Cause and Effect
            - Events have causes that generate observable patterns. (2-PS1-4)
            - Simple tests can be designed to gather evidence to support or refute student ideas about causes. (2-PS1-2)
        - Energy and Matter
            - Objects may break into smaller pieces and be put together into larger pieces, or change shapes. (2-PS1-3)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Engineering, and Technology, and Science on Society and the Natural World
                - Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world. (2-PS1-2)
    - LINK: http://www.nextgenscience.org/2spm-structures-properties-matter
- 3.PS2.A (3-PS2-1(3-PS2-2); 3.PS2.B (3-PS2-3, (3-PS2-4)
    - Crosscutting Concepts
        - Patterns
            - Patterns of change can be used to make predictions. (3-PS2-2)

        - Cause and Effect
            - Cause and effect relationships are routinely identified. (3-PS2-2)
            - Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-4)
    - LINK: http://www.nextgenscience.org/3fi-forces-interactions
- 4.PS3.A (4-PS3-2),(4-PS3-2),(4-PS3-3); 4.PS3.B (4-PS3-2),(4-PS3-3),(4-PS3-4); 4.PS3.C (4-PS3-3)
    - Crosscutting Concepts
        - Energy and Matter
            - Energy can be transferred in various ways and between objects. (4-PS3-1), (4-PS3-2), (4-PS3-3), (4-PS3-4)
        - Cause and Effect
            - Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1)
    - LINK: http://www.nextgenscience.org/4e-energy
- 5.PS1.A (5-PS1-1),(5-PS1-2),(5-PS1-3); 5.PS1.B (5-PS1-4),(5-PS1-2)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships are routinely identified and used to explain change. (50PS1-4)
        - Scale, Proportion, and Quantity
            - Natural objects exist from the very small to the immensely large. (5-PS1-1)
            - Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. (5-PS1-2),(5-PS1-3)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes consistent patterns in natural systems. (5-PS1-2)
    - LINK: http://www.nextgenscience.org/5spm-structures-properties-matter
- 5.PS2.B (5-PS2-1)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
    - LINK: http://www.nextgenscience.org/5ss-space-systems-stars-solar-system
- 5.ESS2.A (5-ESS2-1); 5-ESS2.C 95-ESS2-2)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - Standard units are used to measure and describe physical quantities such as weight and volume. (5-ESS2-2)
        - Systems and System Models
            - A system can be described in terms of its components and their interactions. (5-ESS2-1),

- LINK: http://www.nextgenscience.org/5es-earths-systems

Middle School (6-8)

- MS.PS1.A (MS-PS1-1),(MS-PS1-2),(MS-PS1-3),(MS-PS1-4); MS.PS1.B (MS-PS1-3), (MS-PS1-5); MS.PS3.A (MS-PS1-4)
  - Crosscutting Concepts
    - Cause and Effect
      - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)
    - Scale, Proportion, and Quantity
      - Time, space and energy phenomena can be observed at various scales using models to study systems that re too large or too small. (MS-PS1-1)
    - Structure and Function
      - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS1-3)
    - Connections to Engineering, Technology, and Applications of science
      - Interdependence of Science, Engineering, and Technology
        - Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-PS1-3)
      - Influence of Engineering, and Technology, and Science on Society and the Natural World
        - The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and value; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
  - LINK: http://www.nextgenscience.org/msps-spm-structure-properties-matter
- MS.PS2.B (MS=PS2-3), (MS-PS2-4), (MS-PS2-5)
  - Crosscutting Concepts
    - Cause and Effect
      - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3), (MS-PS2-5)
    - Systems and System Models
      - Models can be used to represent systems and their interactions - such as inputs, processes and outputs - and energy and matter flows within systems. (MS-PS2-4)
  - LINK: http://www.nextgenscience.org/msps-fi-forces-interactions
- MS.PS3.A (MS-PS3-1),(MS-PS3-2),(MS-S3-3),(MS-PS3-4); MS.PS3.B (MS-PS3-5); MS.PS3.C (MS-PS3-2)
  - Crosscutting Concepts
    - Scale, Proportion, and Quantity

            - Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-1), (MS-PS3-4)
        - Systems and System Models
            - Models can be used to represent systems and their interactions- such as inputs, processes, and outputs - and energy and matter flows within systems. (MS-PS3-2)
        - Energy and Matter
            - Energy may take different forms (e.g. energy in field, thermal energy, energy of motion). (MS-PS3-5)
            - The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)
    - LINK: http://www.nextgenscience.org/msps-e-energy
- MS.ESS2.C (MS-ESS2-5),(MS-ESS2-6); MS.ESS2.D (MS-ESS2-5),(MS-ESS2-6)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)
        - Systems and System Models
            - Models can be used to represent systems and their interactions - such as inputs, processes and outputs- and energy, matter and information flows within systems. (MS-ESS2-6)
    - LINK: http://www.nextgenscience.org/msess-wc-weather-climate

High School (9-12)

- HS.PS1.A (HS-PS1-1),(HS-PS1-3),(HS-PS1-6); HS.PS2.B (HS-PS1-1),(HS-PS1-3),(HS-PS1-6)
    - Crosscutting Concepts
        - patterns
            - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-3)
        - Structure and Function
            - Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)
    - LINK: http://www.nextgenscience.org/hsps-spm-structure-properties-matter
- HS.PS2.B (HS-PS2-4),(HS-PS2-5)
    - Crosscutting Concepts
        - Patterns
            - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4)

        - Cause and Effect
            - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-5)
    - LINK: http://www.nextgenscience.org/hsps-fi-forces-interactions
- HS.PS3.B (HS-PS3-1),(HS-PS3-4)
    - Crosscutting Concepts
        - Systems and System Models
            - When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)
            - Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)
        - Connections to the Nature Of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)
    - LINK: http://www.nextgenscience.org/hsps-e-energy
- HS.ESS1.B (HS-ESS2-4): HS.ESS2.D (HS-ESS2-4),(HS-ESS2-6)
    - Crosscutting Concepts
        - Cause and Effect
            - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)
    - LINK: http://www.nextgenscience.org/hsess-wc-weather-climate
- HS.ESS2.C (HS-ESS2-5)
    - Crosscutting Concepts
        - Structure and Function
            - The function and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)
    - LINK: http://www.nextgenscience.org/hsess-es-earth-systems

Potential Application

Satellites

- “Haze” and atmospheric implications in Satellite and Aerial Imagery
- Ozone Measurements from Satellites

- Failure of NASA Glory Program
- Aerosol Measurements from Space-borne and Terrestrial Sensors
- Oblique photos from Space Shuttle showing Earth's curvature with Atmosphere

Weather

- "Good" vs. "Bad" Ozone
- Cloud Type Identification
- Atmospheric Pressure Changes
- Inversion layers(pictures from Air Pollution Illustrate)
- Lapse rates and parcel rising
- Discussion of Weather Balloons and the data from SWAC launches
- CricketSWAC

Climate

- Changes in "Ozone Holes" over time
- Ice core record of Atmospheric Content over past 420,00 years (Vostok Core)
- Climate Change Proxies
- Permafrost Melt and Implications of Methane Releases
- Differentiation of Greenhouse Gases

SWAC Core Concept

Climate controls: elevation, topography (landscape), precipitation proximity to water,

Latitude ocean currents and vegetation

NGSS Standards

Elementary School (K-5)

- K.PS3.B (K-PS3-1),(K-PS3-2); K.ESS2.D (K-ESS2-1); K-ESS3.B (K-ESS3-2)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (K-ESS2-1)
        - Cause and Effect
            - Events have causes that generate observable patterns. (K-PS3-1),(K-PS3-2),(K-ESS3-2)
        - Connections to Engineering, Technology, and Applications of Science
            - Interdependence of Science, Engineering, and Technology

            - People encounter questions about the natural world every day. (K-ESS32)
        - Influence of Engineering, Technology And Science on Society and the Natural World
            - People depend on various technologies in their lives; human life would be very different without technology. (K-ESS3-2)
    - LINK: http://www.nextgenscience.org/kwc-weather-climate
- 1.ESS.1A (1-ESS1-1); 1.ESS1.B (1-ESS1-2)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-ESS1-1),(1-ESS1-2)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes natural events happen today as they happened in the past. (1-ESS1-1
                - Many events are repeated.(1-ESS1-1)
    - LINK: http://www.nextgenscience.org/1ss-space-systems-patterns-cycles
- 2.ESS1.C (2-ESS1-1); 2.ESS2.A (2-ESS2-2); 2.ESS2.C (2-ESS2-3)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural world can be observed. (2-ESS2-2),(2-ESS2-2)
        - Stability and Change
            - Things may change slowly or rapidly. (2-ESS2-1)
        - Connections to Engineering, Technology, and Applications Of Science
            - Influences of Engineering, Technology, and Science On Society and the Natural World
                - Developing and using technology has impacts on the natural world. (2-ESS2-1)
        - Connections to Nature of Science
            - Science Addresses Questions About the Natural and Material World
                - Scientists study the natural and material world. (2-ESS2-1)
    - LINK: http://www.nextgenscience.org/2es-earths-systems-processes-shape-earth
- 3.ESS2.D (3-ESS2-1),(3-ESS2-2); 3.ESS3.B (3-DSS3-1)
    - Crosscutting Concepts
        - Patterns
            - Patterns of change can be used to make predictions. (3-ESS2-1), (3-ESS2-2)
        - Cause and Effect
            - Cause and effect relationships are routinely identified, tested, and used to explain change. (3-ESS3-1)
        - Connections to E, T, and applications of S

                - Influence of Engineering, and Technology, and Science on Society and the Natural World
                    - Engineers improve existing technologies or develop new ones to increase their benefits (e.g. better artificial limbs), decrease known risks (e.g. seatbelts in cars), and meet societal demands (e.g. cell phones). (3-ESS3-1)
            - Connections to Nature of Science
                - Science is a Human Endeavor
                    - Science affects everyday life. (3.ESS3-1)
    - LINK: http://www.nextgenscience.org/3wc-weather-climate
- 4.ESS2.A (4-ESS2-1), 4.ESS2.B (4-ESS2-2)
    - Crosscutting Concepts
        - Patterns
            - Patterns can be used to support an explanation. (4-ESS2-2)
        - Cause and Effect
            - Cause and effect relationships are routinely identified, tested and used to explain change. (4-ESS2-1)
    - LINK: http://www.nextgenscience.org/4es-earths-systems-processes-shape-earth
- 5.ESS2.A (5-ESS2-1); 5.ESS2.C (5-ESS2-2)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - Standard units are used to measure and describe physical quantities such as weight and volume. (5-ESS2-2)
        - Systems and System Models
            - A system can be described in terms of its components and their interactions. (5-ESS2-1)
    - LINK: http://www.nextgenscience.org/5es-earths-systems
- 5.PS2.B (5-PS2-1); 5.ESS1.B (5-ESS1-2)
    - Crosscutting Concepts
        - Patterns
            - Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)
        - Cause and Effect
            - Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
        - Scale, Proportion, and Quantity
            - Natural objects exist from the very small to the immensely large. (5-ESS1-1)
    - LINK: http://www.nextgenscience.org/5ss-space-systems-stars-solar-system

Middle School (6-8)

- MS.ESS2.A (MS-ESS2-1); MS.ESS2.C (MS-ESS2-4)
    - Crosscutting Concepts

        - Energy and Matter
            - Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)
        - Stability and Change
            - Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and process at different scales, including the atomic scale. (MS-ESS2-1)
    - LINK: http://www.nextgenscience.org/msess-es-earth-systems
- MS.ESS2.C (MS-ESS2-5),(MS-ESS2-6); MS.ESS2.D (MS-ESS2-5), (MS-ESS2-6)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)
        - Systems and System Models
            - Models can be used to represent systems and their interactions – such as inputs, processes and outputs-and energy, matter and information flows within systems. (MS-ESS2-6)
    - LINK: http://www.nextgenscience.org/msess-wc-weather-climate
- MS.ESS2.C(MS-ESS2-2)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - Time, space and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS2-2)
    - LINK: http://www.nextgenscience.org/msess-he-history-earth
- MS.ESS1.B (MS-ESS1-1), (MS-ESS1-2), (MS-ESS1-3)
    - Crosscutting concept
        - Patterns
            - Patterns can be used to identify cause-and-effect relationships. (MS-ESS1-1)
        - Scale, Proportion, and Quantity
            - Time, space and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-3)
        - Systems and System Models
            - Models can be used to represent systems and their interactions. (MS-ESS1-2)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of Science, Engineering and Technology
                - Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. (MS-ESS1-3)
        - Connections to Nature of Science

- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
    - Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-ESS1-1), (MS-ESS1-2)
- LINK: http://www.nextgenscience.org/msess-ss-space-systems

High School (9-12)

- HS.ESS2.C (HS-ESS2-5); HS.ESS2.D (HS-ESS2-2),(HS-ESS2-6),(HSS-ESS2-7)
    - Crosscutting Concepts
        - Energy and Matter
            - The total amount of energy and matter in closed systems is conserved. (MS-ESS2-6)
        - Structure and Function
            - The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)
        - Stability and Change
            - Much of science deals with constructing explanations of how things change and how they remain stable (HS-ESS2-7)
            - Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Engineering, and Technology, and Science on Society and the Natural World
                - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)
    - LINK: http://www.nextgenscience.org/hsess-es-earth-systems
- HS.ESS1.B (HS-ESS2-4); HS.ESS2.D (HS-ESS2-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)
    - LINK: http://www.nextgenscience.org/hsess-wc-weather-climate

Satellites

- Shuttle Radar Topology Mission (SRTM) digital elevation models
- Interpret Imagery

    - Wet vs. Dry side of mountain – vegetation lush or not?
    - Snow
        - Aspect
        - Elevation
        - Shading
    - Vegetation Differences
        - Conifer vs. deciduous
        - Dry vs. lush
- Desert areas in context of Latitude and Insolation

Weather

- Inter-Tropical Convergence Zone and wind convergence
- Circulation Cells as Explained by Insolation
- Weather Characteristics of different geographies
- Lake Effect Snow
- Cloud Seeding
- Aerosol Formation
- Acid Rain Formation
- Global Ocean Circulation
    - Northern California Beaches Cold, England Warm

Climate

- Koeppen Climate Map
- Bergeron Air Mass Map

SWAC Core Concept

Radiant energy (EMR) is converted to other forms and transferred to other parts of the earth-atmosphere-ocean system

NGSS Standards

Elementary School (K-5)

- K.PS3.B (K-PS3-1),(K-PS3-2)
    - Crosscutting Concepts
        - Cause and Effect

                - Events have causes that generate observable patterns. (K-PS3-2).(K-PS3-2)
        - LINK: http://www.nextgenscience.org/kwc-weather-climate
- 1.PS4.B (1-PS4-2),(1-PS4-3)
    - Crosscutting Concepts
        - Cause and Effect
            - Simple tests can be designed to gather evidence to support or refute student ideas about causes. (1-PS4-2),(1-PS4-3)
    - LINK: http://www.nextgenscience.org/1w-waves-light-sound
- 2.ESS2.C (2-ESS2-3)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural world can be observed. (2-ESS2-3)
    - LINK: http://www.nextgenscience.org/2es-earths-systems-processes-shape-earth
- 3.PS2.A (3-PS2-1),(3-PS2-2); 3.PS2.B (3-PS2-1),(3-PS2-3),(3-PS2-4)
    - Crosscutting Concepts
        - Patterns
            - Patterns of change can be used to make predictions. (3-PS2-2)
        - Cause and Effect
            - Cause and effect relationships are routinely identified. (3-PS2-1)
            - Cause and Effect relationships are routinely identified, tested and used to explain change. (3-PS2-3)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of Science, Engineering, and Technology
                - Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (3-PS2-4)
    - LINK: http://www.nextgenscience.org/3fi-forces-interactions
- 4.PS3.A (4-PS3-1), (4-PS3-2),(4-PS3-3); 4.PS3.B (4-PS3-2), (4-PS3-3), (4-PS3-4); 4.PS3.C (4-PS3-3); 4.PS3.D (4-PS3-4);
    - Crosscutting Concepts
        - Energy and Matter
            - Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Science, Engineering, and Technology on Society and the Natural world
                - Engineers improve existing technologies or develop new ones. (4-PS3-4)
        - Connections to Nature of Science
            - Science is a Human Endeavor
                - Most scientists and engineers work in teams. (4-PS3-4)
                - Science affects everyday life. (4-PS3-4)
    - LINK: http://www.nextgenscience.org/4e-energy

- 4.PS4.A (4-PS4-1)
    - Crosscutting Concepts
        - Patterns
            - Similarities and difference in patterns can be used to sort, classify and analyze simple rates of change for natural phenomena. (4-PS4-1)
    - LINK: http://www.nextgenscience.org/4w-waves
- 4.PS4.B (4-PS4-2)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships are routinely identified. (4-PS4-2)
    - LINK: http://www.nextgenscience.org/3sfip-stucture-function-information-processing
- 5.PS3.D (5-PS3-1)
    - Crosscutting Concepts
        - Energy and Matter
            - Energy can be transferred in various ways and between objects. (5-PS3-1)
    - LINK: http://www.nextgenscience.org/5meoe-matter-energy-organisms-ecosystems

Middle School (6-8)

- MS.PS3.A (MS-PS3-1),(MS-PS3-2),(MS-PS3-3),(MS-PS3-4); MS.PS3.B (MS-PS3-5),(MS-PS3-4),(MS-PS3-3); MS.PS3.B (MS-PS3-5),(MS-PS3-4),(MS-PS3-3); MS.PS3.C (MS-PS3-2)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-1),(MS-PS3-4)
        - Systems and System Models
            - Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)
        - Energy and Matter
            - Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-3)
    - LINK: http://www.nextgenscience.org/msps-e-energy
- MS.PS4.A (MS-PS4-1),(MS-PS4-2); MS.PS4.B (MS-PS4-2)
    - Crosscutting Concepts
        - Patterns
            - Graphs and charts can be used to identify patterns in data. (MS-PS4-1)
        - Structures and function
            - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS4-2)
    - LINK: http://www.nextgenscience.org/msps-wer-waves-electromagnetic-radiation

- MS.PS3.A (MS-PS1-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)
    - LINK: http://www.nextgenscience.org/msps-spm-structure-properties-matter
- MS.ESS2.A (MS-ESS2-1)
    - Crosscutting Concepts
        - Stability and Change
            - Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (MS-ESS2-1)
    - LINK: http://www.nextgenscience.org/msess-es-earth-systems

High School (9-12)

- HS.PS3.A (HS-PS3-2),(HS-PS3-2); HS.PS3.B (HS-PS3-1),(HS-PS3-4); HS.PS3.C (HS-PS3-5); HS.PS3.D (HS-PS3-3),(HS-PS3-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)
        - Systems and System Models
            - When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)
            - Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)
        - Energy and Matter
            - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3)
            - Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Science, Engineering, and Technology on Society and the Natural World
                - Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)
        - Connections to Nature of Science

- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
    - Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)
- LINK: http://www.nextgenscience.org/hsps-e-energy

- HS.PS3.D(HS-PS4-5), HS.PS4.A (HS-PS4-2),(HS-PS4-2),(HS-PS4-3),(HS-PS4-5); HS-PS4.B (HS-PS4-3),(HS-PS4-4),(HS-PS4-5)
    - Crosscutting Concepts
        - Cause and Effect
            - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)
            - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4)
            - Systems can be designed to cause a desired effect. (HS-PS4-5)
        - Systems and System Models
            - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-PS4-3)
        - Stability and change
            - Systems can be designed for greater or lesser stability. (HS-PS4-2)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of Science, Engineering, and Technology
                - Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5)
            - Influence of Engineering, and Technology, and Science on Society and the Natural World
                - Modern civilization depends on major technological systems. (HS-PS4-2),(HS-PS4-5)
                - Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)
    - LINK: http://www.nextgenscience.org/hsps-wer-waves-electromagnetic-radiation
- HS.PS4.B (HS-ESS1-2)
    - Crosscutting Concepts
        - Energy and Matter
            - Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of Science, Engineering, and Technology

            - Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2),(HS-ESS1-4)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)
                - Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)
    - LINK: http://www.nextgenscience.org/hsess-ss-space-systems
- HS.ESS2.D (HS-ESS2-2)
    - Crosscutting Concepts
        - Stability and Change
            - Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Science, Engineering and Technology on Society and the Natural World
                - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)
    - LINK: http://www.nextgenscience.org/hsess-es-earth-systems

Potential Application

Satellites

- Interpretation of Satellite Imagery in context of EMR
- Parallel interpretation of meteo sat content with terrestrial datasets
- Time series animations of Satellite data to study atmospheric system
- Discuss EMR in context of Satellite bands/bandwidth

Weather

- Heat Islands
- UV Radiation Frisbee exercise
- Understanding pressure systems in context of Convective Cells

Climate

- Thermohaline Circulation and the ramifications of belt changes

- Convective Cells on Earth (see animations)
- Positive Feedback loops in global climate change
- Albedo

SWAC Core Concept

Forces in the earth-land-ocean system, pressure differences, gravity, Coriolis Effect

NGSS Standards

Elementary School (K-5)

- K.PS2.A (K-PS2-1), (K-PS2-2); K.PS2.B (K-PS2-1); K.PS3.C (K-PS2-1)
    - Crosscutting Concepts
        - Cause and Effect
            - Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1),(K-PS2-2)
    - LINK: http://www.nextgenscience.org/kfi-forces-interactions-pushes-pulls
- 1.ESS1.A (1-ESS1-1); 1.ESS1.B (1-ESS1-2)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-ESS1-1),(1-ESS1-2)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes natural events happen today as they happened in the past. (1-ESS1-1)
                - Many events are repeated. (1-ESS1-1)
    - LINK: http://www.nextgenscience.org/1ss-space-systems-patterns-cycles
- 2.ESS2.B (2-ESS2-2)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural world can be observed. (2-ESS2-2)
    - LINK: http://www.nextgenscience.org/2es-earths-systems-processes-shape-earth
- 3.PS2.A (3-PS2-1),(3-PS2-2); 3.PS2.B (3-PS2-1),(3-PS2-3),(3-PS2-4)
    - Crosscutting Concepts
        - Patterns
            - Patterns of change can be used to make predictions. (3-PS2-2)
        - Cause and Effect

                - Cause and effect relationships are routinely identified. (3-PS2-1)
                - Cause and effect relationships are routinely identified, tested and used to explain change. (3-PS2-3)
            - Connections to Engineering, Technology and Applications of Science
                - Interdependence of Science, Engineering, and Technology
                    - Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (3-PS2-4)
        - LINK: http://www.nextgenscience.org/3fi-forces-interactions
- 4.PS3.A (4-PS3-1), (4-PS3-2),(4-PS3-3); 4.PS3.B (4-PS3-2), (4-PS3-3), (4-PS3-4); 4.PS3.C (4-PS3-3); 4.PS3.D (4-PS3-4)
    - Crosscutting Concepts
        - Energy and Matter
            - Energy can be transferred in various ways and between objects (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of E, S and T on society and the natural world
                - Engineers improve existing technologies or develop new ones. (4-PS3-4)
        - Connections to Nature of Science
            - Science is a Human Endeavor
                - Most scientists and engineers work in teams. (4-PS3-4)
                - Science affects everyday life. (4-PS3-4)
    - LINK: http://www.nextgenscience.org/4e-energy
- 5.PS2.B (5-PS2-1); 5.ESS1.A (5-ESS1-1); 5.ESS1.B (5-ESS1-2)
    - Crosscutting Concepts
        - Patterns
            - Similarities and differences in patterns can be used to sort, clarify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)
        - Cause and Effect
            - Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
        - Scale, Proportion, and Quantity
            - Natural objects exist from the very small to the immensely large. (5-ESS1-1)
    - LINK: http://www.nextgenscience.org/5ss-space-systems-stars-solar-system

Middle School (6-8)

- MS.ESS1.A (MS-ESS1-1), (MS-ESS1-2); MS.ESS1.B (MS-ESS1-1),(MS-ESS1-2),(MS-ESS1-3)
    - Crosscutting Concepts
        - Patterns
            - Patterns can be used to identify cause-and-effect relationships. (MS-ESS1-1)

        - Scale, proportion, and quantity
            - Time, space, and energy phenomena can be observed at various time scales using models to study systems that are too large or too small. (MS-ESS1-3)
        - Systems and System Models
            - Models can be used to represent systems and their interactions. (MS-ESS1-2)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of E, S and T
                - Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems (MS-ESS1-3)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-ESS1-1), (MS-ESS1-2)
    - LINK: http://www.nextgenscience.org/msess-ss-space-systems
- MS.ESS2.A (MS-ESS2-1); MS.ESS2.C (MS-ESS2-4)
    - Crosscutting Concepts
        - Energy and Matter
            - Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)
        - Stability and change
            - Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (MS-ESS2-1)
    - LINK: http://www.nextgenscience.org/msess-es-earth-systems
- MS.ESS2.C (MS-ESS2-6)
    - Crosscutting Concepts
        - Systems and System Models
            - Models can be used to represent systems and their interactions – such as inputs, processes and outputs – and energy, matter, and information flows within systems. (MS-ESS2-6)
    - LINK: http://www.nextgenscience.org/msess-wc-weather-climate
- MS.PS2.A (MS-PS2-1),(MS-PS2-2); MS.PS2.B (MS-PS2-3), (MS-PS2-4), (MS-PS2-5)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
        - Systems and System Models

- Models can be used to represent systems and their interactions – such as inputs, processes and outputs – and energy and matter flows within systems. (MS-PS2-1), (MS-PS2-4)
    - Stability and change
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Science, Engineering, and Technology on Society and the Natural World
                - The uses of technologies and any limitations on their use are driven by individual or societal needs, desires and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1)
- LINK: http://www.nextgenscience.org/msps-fi-forces-interactions

High School (9-12)

- HS.ESS1.A (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3); HS.ESS1.B (HS-ESS1-4)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs (HS-ESS1-1)
            - Algebraic thinking is used to examine scientific data and predict the effect of change in one variable on another (e.g. linear growth vs. exponential growth. (HS-ESS1-4)
        - Energy and Matter
            - Energy cannot be created or destroyed – only moved between one place and anther place, between objects and/or fields, or between systems. (HS-ESS1-2)
            - In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)
        - Connections to Engineering, Technology, and Applications of Science
            - Interdependence of Science, Engineering, and Technology
                - Science and engineering complement each other in the cycle knows as research and development (R&D). Many R&D projects may involve scientists, engineers and others with wide ranges of expertise. (HS-ESS1-2), (HS-ESS1-4)
        - Connections to the Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)
                - Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)
    - LINK: http://www.nextgenscience.org/hsess-ss-space-systems

- HS.PS2.A (HS-PS2-1), (HS-PS2-2), (HS-PS2-3); HS.PS2.B (HS.PS2-4), (HS-PS2-5)
    - Crosscutting Concepts
        - Patterns
            - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4)
        - Cause and Effect
            - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1), (HS-PS2-5)
            - Systems can be designed to cause a desired effect. (HS-PS2-3)
        - Systems and System Models
            - When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)
    - LINK: http://www.nextgenscience.org/hsps-fi-forces-interactions
- HS.PS3.B (HS-PS3-4)
    - Crosscutting Concepts
        - Systems and System Models
            - When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)
    - LINK: http://www.nextgenscience.org/hsps-e-energy

Potential Application

Satellites

- Gravity Map of Earth
- Solar Radiation Map
- Heat Islands/Sinks from Satellite Data
- Ocean circulation based on surface temp derived from Satellites

Weather

- Discussion of Circulation cells (Hadley, Ferrell, Polar, etc.)
- Coriolis effect and cyclonic system development
- Parcel Rising model and Heat Islands
- Implications of warm bodies of water (i.e. Gulf of Mexico and severe weather in the U.S.)

Climate

- Ocean Circulation from Gulf of Mexico keeps UK warm
- Volcanic Injection Global Cooling

- Positive feedback loops in Global Climate Change
- Ice core record of Atmospheric Content over the past 420,000 years (Vostok Core)

SWAC Core Concept

Hydrological cycle or water cycle – there is no new water on the planet

NGSS Standards

Elementary School (K-5)

- K.ESS2.D (K-ESS2-1)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (K-ESS2-1)
    - LINK: http://www.nextgenscience.org/kwc-weather-climate
- 2.ESS2.A (2-ESS2-2); 2.ESS2.C (2-ESS2-3)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural world can be observed. (2-ESS2-2), (2-ESS2-2)
    - LINK: http://www.nextgenscience.org/2es-earths-systems-processes-shape-earth
- 2.PS1.B (2-PS1-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Events have causes that generate observable patterns. (2-PS1-4
    - LINK: http://www.nextgenscience.org/2spm-structures-properties-matter
- 3.PS2.B (3-PS2-1), (3-PS2-3), (3-PS2-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships are routinely identified. (3-Ps2-1)
            - Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-3)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of Science, Engineering, and Technology
                - Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (3-PS2-4)
    - LINK: http://www.nextgenscience.org/3fi-forces-interactions

- 4.PS3.D (4-PS3-4)
    - Crosscutting Concepts
        - Energy and Matter
            - Energy can be transferred in various ways and between objects. (4-PS3-4)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Engineering, and Technology, and Science on Society and the Natural World
                - Engineers improve existing technologies or develop new ones. (4-PS3-4)
        - Connections to Nature of Science
            - Science is a Human Endeavor
                - Most scientists and engineers work in teams (4-PS3-4)
                - Science affects everyday life. (4-PS3-4)
    - LNK: http://www.nextgenscience.org/4e-energy
- 5.ESS2.A (5-ESS2-1); 5.ESS2.C (5-ESS2-2)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - Standard units are used to measure and describe physical quantities such as weight and volume. (5-ESS2-2)
        - Systems and System Models
            - A system can be described in terms of its components and their interactions. (5-ESS2-1)
        - Connections to Nature of Science
            - Science addresses questions about the natural and material world.
                - Science findings are limited to questions that can be answered with empirical evidence. (5-ESS3-1)
    - LINK: http://www.nextgenscience.org/5es-earths-systems
- 5.PS1.B (5-PS1-2), (5-PS1-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships are routinely identified and used to explain change. (5-PS1-4)
        - Scale, Proportion, and Quantity
            - Standard units are used to measure and describe physical quantities such as weight, time, temperature and volume. (5-PS1-2)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes consistent patterns in natural systems. (5-PS1-2)
    - LINK: http://www.nextgenscience.org/5spm-structures-properties-matter

Middle School (6-8)

- MS.PS1.A (MS-PS1-2); MS.PS1.B (MS-PS1-2), (MS-PS1-5), (MS-PS1-6)
    - Crosscutting Concepts
        - Patterns
            - Macroscopic patterns are related to the nature of microscopic an atomic-level structure. (MS-PS1-2)
        - Energy and Matter
            - Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5)
            - The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6)
    - LINK: http://www.nextgenscience.org/msps-cr-chemical-reactions
- MS.ESS2.C (MS-ESS2-4)
    - Crosscutting Concepts
        - Energy and Matter
            - Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)
    - LINK: http://www.nextgenscience.org/msess-es-earth-systems

High School (9-12)

- HS.PS1.A (HS-PS1-1), (HS-PS1-4); HS.PS1.B (HS-PS1-2), (HS-PS1-4), (HS-PS1-5), (HS-PS-6), (HS-PS1-7)
    - Crosscutting concepts
        - Patterns
            - Different patterns may be observed at each of the scales at which a system is studied and can provided evidence for causality in explanations of phenomena. (HS-PS1-2), (HS-PS1-5)
        - Energy and Matter
            - The total amount of energy and matter in closed systems is conserved (HS-PS1-7)
            - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)
        - Stability and change
            - Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)
    - LINK: http://www.nextgenscience.org/hsps-cr-chemical-reactions
- HS. ESS2.C (HSS-ESS2-5)
    - Crosscutting Concepts
        - Structure and Function

        - The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)
    - LINK: http://www.nextgenscience.org/hsess-es-earth-systems

Potential Application

Satellites

- Glacial Mass Monitoring and Energy Budget
    - Time series of Satellite, Aerial, Ground imagery
    - Use of Interferometry in change detection
    - Use of photogrammetry in change detection
- Permafrost formation and Melt – Earth surface changes
    - Siberia exercise
    - Swiss Alps Example
- Ocean Surface Temperatures reveal addition of melted fresh water in Arctic "capping" warmer salt water arriving along Eastern coast of North America
- Hydrological Change Detection (Satellite Image Interpretation)
    - More or Fewer Lakes?
    - Vegetation healthier or more stressed?

Weather

- Lake Effect Snow
- Water Resources in Arid Regions
- Snow Ablation and Sublimation in Vermont
- Precipitation timing (heavy rains periodically or spread out?)

Climate

- Positive Feedback Loops in the Arctic
- Implications of warm bodies of water on severe weather
    - Supercell and Tornado development in the United States in context of warmer Gulf of Mexico

SWAC Core Concept

Electromagnetic Energy (EMR) from the Sun drives atmospheric processes on Earth

NGSS Standards

Elementary School (K-5)

- K.PS3.B (K-PS3-1), (K-PS3-2)
    - Crosscutting Concepts
        - Patterns
            - Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (K-ESS2-1)
        - Cause and Effect
            - Events have causes that generate observable patterns. (K-PS3-1), (K-PS3-2)
    - LINK: http://www.nextgenscience.org/kwc-weather-climate
- K.PS2.A (K-PS2-1), (K-PS2-2); K.PS2.B (K-PS2-1); K.PS3.C (K-PS2-1)
    - Crosscutting Concepts
        - Cause and Effect
            - Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1), (K-PS2-2)
    - LINK: http://www.nextgenscience.org/kfi-forces-interactions-pushes-pulls
- 1.PS4.B (1-PS4-2), (1-PS4-3)
    - Crosscutting Concepts
        - Cause and Effect
            - Simple tests can be designed to gather evidence to support or refute student idea about causes. (1-PS4-2), (1-PS4-3)
    - LINK: http://www.nextgenscience.org/1w-waves-light-sound
- 3.PS2.A (3-PS2-1), (3-PS2-2); 3.PS2.B (3-PS2-1), (3-PS2-3), (3-PS3-4)
    - Crosscutting Concepts
        - Patterns
            - Patterns of change can be used to make predictions. (3-PS2-2)
        - Cause and Effect
            - Cause and effect relationships are routinely identified. (3-PS2-1)
            - Cause and effect relationships are routinely identified, tested and used to explain change. (3-PS2-3)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of Science, Engineering, and Technology
                - Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (3-PS2-4)
    - LINK: http://www.nextgenscience.org/3fi-forces-interactions

- 4.PS3.A (4-PS3-1), (4-PS3-2), (4-PS3-3); 3.PS3.B (4-PS3-2), (4-PS3-3), (4-PS3-4); 4.PS3.C (4-PS3-3)
    - Crosscutting Concepts
        - Energy and Matter
            - Energy can be transferred in various ways and between objects. (4-PS3-1), (4-PS3-2), (4-PS3-3), (4-PS3-4)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Engineering, and Technology, and Science on Society and the Natural World
                - Engineers improve existing technologies or develop new ones. (4-PS3-4)
        - Connections to Nature of Science
            - Most scientists and engineers work in teams. (4-PS3-4)
            - Science affects everyday life. (4-PS3-4)
    - LINK: http://www.nextgenscience.org/4e-energy
- 5.PS1.A (5-PS1-1), (5-PS1-2), (5-PS1-3)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - Natural objects exist from the very small to the immensely large. (5-PS1-1)
            - Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. (5-PS1-2), (5-PS1-3)
        - Connections to Nature of Science
            - Scientific knowledge assumes an order and consistency in natural systems
                - Science assumes consistent patterns in natural systems. (5-PS1-2)
    - LINK: http://www.nextgenscience.org/5spm-structures-properties-matter

Middle School (6-8)

- MS.PS4.A (MS-PS4-1); MS.PS4.B (MS-PS4-2)
    - Crosscutting Concepts
        - Patterns
            - Graphs and charts can be used to identify patterns in data. (MS-PS4-1)
        - Structure and Function
            - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS4-2)
        - Connections to Engineering, Technology, and applications of Science
            - Influence of Science, Engineering and Technology on Society and the Natural World
                - Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (MS-PS4-3)
        - Connections to Nature of Science

                - Science is a Human Endeavor
                    - Advances in technology influence the progress of science and science has influenced advances in technology. (MS-PS4-3)
        - LINK: http://www.nextgenscience.org/msps-wer-waves-electromagnetic-radiation
- MS.PS2.B (MS-PS2-3),(MS-PS2-4), (MS-PS2-5)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
        - System and System Models
            - Models can be used to represent systems and their interactions – such as inputs processes and outputs – and energy and matter flows within systems. (MS-PS2-4)
    - LINK: http://www.nextgenscience.org/msps-fi-forces-interactions
- MS.PS2.B (MS-PS3-4)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-4)
    - LINK: http://www.nextgenscience.org/msps-e-energy

High School (9-12)

- HS.PS4.A (HS-PS4-1), (HS-PS4-2), (HS-PS4-2), (HS-PS4-3), (HS-PS4-5); HS.PS4.B (HS-PS4-3), (HS-PS4-4), (HS-PS4-5)
    - Crosscutting Concepts
        - Cause and Effect
            - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)
            - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4)
            - Systems can be designed to cause a desired effect. (HS-PS4-5)
        - Systems and System Models
            - Models (e.g. physical, mathematical, computer models) can be used to simulate systems and interactions – including energy, matter, and information flows – within and between systems at different scales. (HS-PS4-3)
        - Stability and change
            - Systems can be designed for greater or lesser stability. (HS-PS2-4)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of Science, Engineering, and Technology

            - Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5)
        - Influence of Engineering, and Technology, and Science on Society and the Natural World
            - Modern civilization depends on major technical systems. (HS-PS4-2), (HS-PS4-5)
            - Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)
    - LINK: http://www.nextgenscience.org/hsps-wer-waves-electromagnetic-radiation
- HS.ESS2.B (HS-ESS2-3); HS.ESS2.D (HS-ESS2-2)
    - Crosscutting Concepts
        - Energy and Matter
            - Energy drives the cycling of matter within and between systems. (HS-ESS2-3)
        - Stability and change
            - Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)
        - Connections to Engineering, Technology, and Applications of Science
            - Interdependence of Science, Engineering, and Technology
                - Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS2-3)
            - Influence of Science, Engineering, and Technology on Society and the Natural World
                - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)
    - LINK: http://www.nextgenscience.org/hsess-es-earth-systems
- HS.ESS1.B (HS-ESS1-4)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g. linear growth vs. exponential growth). (HS-ESS1-4)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of Science, Engineering, and Technology
                - Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-4)
    - LINK: http://www.nextgenscience.org/hsess-ss-space-systems

Potential Application

Satellites

- Radiation/Insolation Maps of Earth from Space
- Theory of Image Sensors
    - Capturing different wavelengths of energy
- Satellite Time Series of Cloud Development (Visible/IR)
- Various sensors capture data in different ranges/spectrums
- Airport "Full Body Scan" sensing

Weather

- Heat Islands
- Cloud Development (parcel model)
- Lapse Rates
- UV Radiation Frisbee exercise
- Understanding pressure systems in the context of Convection Cells

Climate

- Thermohaline Circulation and ramifications of belt changes
- Convective Cells on Earth (see animations)
- Positive Feedback loops in global climate change
    - Arctic Sea Ice
    - Permafrost Melt

SWAC Core Concept

The unequal heating of water or air leads to a thermal gradient and energy transfer

Elementary School (K-5)

- K.PS3.B (K-PS3-1), (K-PS3-2)
    - Crosscutting Concepts
        - Cause and Effect
            - Events have causes that generate observable patterns. (K-PS3-1), (K-PS3-2)
    - LINK: http://www.nextgenscience.org/kwc-weather-climate
- 2.PS1.A (2-PS1-1), (2-PS1-2),(2-PS1-3); 2.PS1.B (2-PS1-4)
    - Crosscutting Concepts
        - Patterns

                - Patterns in the natural and human designed world can be observed. (2-PS1-1)
            - Cause and Effect
                - Events have causes that generate observable patterns. (2-PS1-4),
                - Simple tests can be designed to gather evidence to support or refute student ideas about causes. (2-PS1-2)
            - Energy and Matter
                - Objects may break into smaller pieces and be put together into larger pieces, or change shapes. (2-PS1-3)
            - Connections to Engineering, Technology and Applications of Science
                - Influence of Engineering, and Technology, and Science on Society and the Natural World
                    - Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world. (2-PS1-2)
    - LINK: http://www.nextgenscience.org/2spm-structures-properties-matter
- 3.PS2.A (3-PS2-1), (3-PS2-2); 3.PS2.B (3-PS2-1), (3-PS2-3), (3-PS3-4)
    - Crosscutting Concepts
        - patterns
            - Patterns of change can be used to make predictions. (3-PS2-2)
        - Cause and Effect
            - Cause and effect relationships are routinely identified. (3-PS2-1)
            - Cause and effect relationships are routinely identified, tested and used to explain change. (3-PS2-3)
        - Connections to Engineering, Technology and Applications of Science
            - Interdependence of Science, Engineering, and Technology
                - Scientific discoveries about the natural world can often lead to new and improved technologies which are developed through the engineering design process.
    - LINK: http://www.nextgenscience.org/3fi-forces-interactions
- 4.PS3.A (4-PS3-1), (4-PS3-2), (4-PS3-3); 4.PS3.B (4-PS3-2), (4-PS3-3), (4-PS3-4); 4.PS3.C (4-PS3-3)
    - Crosscutting Concepts
        - Energy and Matter
            - Energy can be transferred in various ways and between objects. (4-PS3-1), (4-PS3-2), (4-PS3-3), (4-PS3-4)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Engineering, and Technology, and Science on Society and the Natural World
                - Engineers improve existing technologies or develop new ones. (4-PS3-4)
        - Connections to Nature of Science
            - Science is a Human Endeavor
                - Most scientists and engineers work in teams. (4-PS3-4)
                - Science affects everyday life. (4-PS3-4)

    - LINK: http://www.nextgenscience.org/4e-energy
- 5.PS1.A (5-PS1-1), (5-PS1-2), (5-PS1-3); 5.PS1.B (5-PS1-2), (5-PS1-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships are routinely identified and used to explain change. (5-PS1-4)
        - Scale, Proportion, and Quantity
            - Natural objects exist from the very small to the immensely large. (5-PS1-1)
            - Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. (5-PS1-2), (5-PS1-3)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes consistent patterns in natural systems. (5-PS1-2)
    - LINK: http://www.nextgenscience.org/5spm-structures-properties-matter
- 5.ESS2.A (5-ESS2-1)
    - Crosscutting Concepts
        - Systems and System Models
            - A system can be described in terms of its components and their interactions. (5-ESS2-1)
    - LINK: http://www.nextgenscience.org/5es-earths-systems

Middle School (6-8)

- MS.PS1.A (MS-PS1-2); MS.PS1.B (MS-PS1-2), (MS-PS1-5), (MS-PS1-6)
    - Crosscutting Concepts
        - Patterns
            - Macroscopic patterns are related to the nature of microscopic an atomic-level structure. (MS-PS1-2)
        - Energy and Matter
            - Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5)
            - The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6)
    - LINK: http://www.nextgenscience.org/msps-cr-chemical-reactions
- MS.PS3.A (MS-PS3-1),(MS-PS3-2),(MS-PS3-3),(MS-PS3-4); MS.PS3.B (MS-PS3-5),(MS-PS3-4),(MS-PS3-3); MS.PS3.B (MS-PS3-5),(MS-PS3-4),(MS-PS3-3); MS.PS3.C (MS-PS3-2)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-1),(MS-PS3-4)

        - Systems and System Models
            - Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems (MS-PS3-2)
        - Energy and Matter
            - Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-3)
    - LINK: http://www.nextgenscience.org/msps-e-energy
- MS.PS3.A (MS-PS1-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)
    - LINK: http://www.nextgenscience.org/msps-spm-structure-properties-matter

High School (9-12)

- HS.PS3.A (HS-PS3-2),(HS-PS3-2); HS.PS3.B (HS-PS3-1),(HS-PS3-4); HS.PS3.C (HS-PS3-5); HS.PS3.D (HS-PS3-3),(HS-PS3-4)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)
        - Systems and System Models
            - When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)
            - Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)
        - Energy and Matter
            - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3)
            - Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Science, Engineering, and Technology on Society and the Natural World
                - Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)
        - Connections to Nature of Science

                - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                    - Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)
    - LINK: http://www.nextgenscience.org/hsps-e-energy
- HS.PS1.A (HS-PS1-1), (HS-PS1-4); HS.PS1.B (HS-PS1-2), (HS-PS1-4), (HS-PS1-5), (HS-PS-6), (HS-PS1-7)
    - Crosscutting Concepts
        - Patterns
            - Different patterns may be observed at each of the scales at which a system is studied and can provided evidence for causality in explanations of phenomena. (HS-PS1-2), (HS-PS1-5)
        - Energy and Matter
            - The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)
            - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)
        - Stability and change
            - Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)
    - LINK: http://www.nextgenscience.org/hsps-cr-chemical-reactions
- HS.PS1.A (HS-PS1-1), (HS-PS1-3), (HS-PS2-6); HS.PS1.C (HS-PS1-8)
    - Crosscutting Concepts
        - Patterns
            - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1), (HS-PS1-3)
        - Energy and Matter
            - In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)
        - Structure and Function
            - Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)
    - LINK: http://www.nextgenscience.org/hsps-spm-structure-properties-matter
- HS.ESS2.C (HS-ESS2-5)
    - Crosscutting Concepts
        - Structure and Function

        - The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)
    - LINK: http://www.nextgenscience.org/hsess-es-earth-systems

Potential Application

Satellites

- Thermal Satellite Data showing heat retention in water bodies during fall/spring as compared to land surfaces
- Gravity map of Earth
- Solar Radiation Map
- Heat Islands/Sinks from Satellite Data

Weather

- Large/Small Scale Wind Patterns
- Lake Effect Snow
- Fog formation

Climate

- Fresh/Salt water mixing from ice melt in the Artic – implications for ocean circulation/climate change
- Implications of warm bodies of water (i.e. Gulf of Mexico and Severe weather in the US)
- Ice core record of Atmospheric Content over past 420,000 years (Vostok Core)

SWAC Core Concept

Weather differs from climate in terms of the time scale of interest, methods used for analysis, prediction vs. trends/patterns

NGSS Standards

Elementary School (K-5)

- K.PS3.B (K-PS3-1), (K-PS3-2); K.ESS2.D (K-ESS2-1); K.ESS3.B (K-ESS3-2)
    - Crosscutting Concepts
        - patterns

                - Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (K-ESS2-1)
            - Cause and Effect
                - Events have causes that generate observable patterns. (K-PS3-1), (K-PS3-2), (K-ESS3-2)
            - Connections to Engineering, Technology and Applications of Science
                - Interdependence of Science, Engineering, and Technology
                    - People encounter questions about the natural world every day. (K-ESS3-2)
                - Influence of Engineering, and Technology, and Science on Society and the Natural World
                    - People depend on various technologies in their lives; human life would be very different without technology. (K-ESS3-2)
    - LINK: http://www.nextgenscience.org/kwc-weather-climate
- 1.ESS1.A (1-ESS1-1); 1.ESS1.B (1-ESS1-2)
    - Crosscutting Concepts
        - patterns
            - Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-ESS1-1), (1-ES1-2)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes natural events happen today as they happened in the past. (1-ESS1-1)
                - Many events are repeated. (1-ESS1-1)
    - LINK: http://www.nextgenscience.org/1ss-space-systems-patterns-cycles
- 2.ESS2.A (2-ESS2-1); 2.ESS2.B (2-ESS2-2); 2.ESS2.B (2-ESS2-3)
    - Crosscutting Concepts
        - patterns
            - Patterns in the natural world can be observed. (2-ESS2-2), (2-ESS2-3)
        - stability and change
            - Things may change slowly or rapidly. (2-ESS2-1)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Engineering, and Technology, and Science on Society and the Natural World
                - Developing and using technology has impacts on the natural world. (2-ESS2-1)
        - Connections to Nature of Science
            - science addresses questions about the natural and material world
                - Scientists study the natural and material world. (2-ESS2-1)
    - LINK: http://www.nextgenscience.org/2es-earths-systems-processes-shape-earth
- 3.ESS2.D (3-ESS2-1), (3-ESS2-2); 3.ESS3.B (3-ESS3-1)
    - Crosscutting Concepts
        - patterns

                - Patterns of change can be used to make predictions. (3-ESS2-1), (3-ESS2-2)
            - Cause and Effect
                - Cause and effect relationships are routinely identified, tested, and used to explain change. (3-ESS3-1)
            - Connections to Engineering, Technology and Applications of Science
                - influence of Engineering, Technology, and Science on Society and the Natural World
                    - Engineers improve existing technologies or develop new ones to increase their benefits (e.g. better artificial limbs, (decrease known risks (e.g. seatbelts in cars), and meet societal demands (e.g., cell phones). (3-ESS3-1)
            - Connections to Nature of Science
                - Science is a Human Endeavor
                    - Science affects everyday life. (3-ESS3-1)
    - LINK: http://www.nextgenscience.org/3wc-weather-climate
- 5. ESS2.C (5-ESS2-2)
    - Crosscutting Concepts
        - Scale, Proportion, and Quantity
            - Standard units are used to measure and describe physical quantities such as weight and volume. (5-ESS2-2)
    - LINK: http://www.nextgenscience.org/5es-earths-systems
- 5.ESS1.B (5-ESS1-2)
    - Crosscutting Concepts
        - Patterns
            - Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)
    - LINK: http://www.nextgenscience.org/5ss-space-systems-stars-solar-system

Middle School (6-8)

- MS.ESS2.C (MS-ESS2-5), (MS-ESS2-6); MS.ESS2.D (MS-ESS2-5), (MS-ESS2-6)
    - Crosscutting Concepts
        - Cause and Effect
            - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)
        - Systems and System Models
            - Models can be used to represent systems and their interactions - such as inputs, processes and outputs - and energy, matter, and information flows within systems. (MS-ESS2-6)
    - LINK: http://www.nextgenscience.org/msess-wc-weather-climate
- MS.ESS1.B (MS-ESS1-1)
    - Crosscutting Concepts
        - Patterns

            - Patterns can be used to identify cause-and-effect relationships. (MS-ESS1-1)
        - Connections to Nature of Science
            - Scientific Knowledge Assumes an Order and Consistency in Natural Systems
                - Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-ESS1-1)
    - LINK: http://www.nextgenscience.org/msess-ss-space-systems
- MS.ESS2.C (MS-ESS2-4)
    - Crosscutting Concepts
        - Energy and Matter
            - Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)
- LINK: http://www.nextgenscience.org/msess-es-earth-systems

High School (9-12)

- HS.ESS1.B (HS-ESS2-4); HS.ESS2.A (HS-ESS2-4); HS.ESS2.D (HS-ESS2-4), (HS-ESS2-6)
    - Crosscutting Concepts
        - Cause and Effect
            - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)
        - stability and change
            - Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-5)
    - LINK: http://www.nextgenscience.org/hsess-wc-weather-climate
- HS.ESS2.D (HS-ESS2-2), (HS-ESS2-6), (HS-ESS2-7)
    - Crosscutting Concepts
        - Energy and Matter
            - The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6)
        - stability and change
            - Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7)
        - Connections to Engineering, Technology and Applications of Science
            - Influence of Engineering, and Technology, and Science on Society and the Natural World
                - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefit is a critical aspect of decisions about technology. (HS-ESS2-2)
    - LINK: http://www.nextgenscience.org/hsess-es-earth-systems

Potential Application

Satellites

- GOES and POES Satellites and Purposes
- Interpretation and Exploitation of various Satellite Products
    - IR Temp
    - Water Vapor
    - Visible
- Do we have enough Satellite Data to make inferences about Climate?
- Land Surface Interpretation
    - Landsat dates back to 1970s
    - Climate Changes as seen in Landsat
        - Vegetation differences
        - Hydrological and Cryospheric differences

Weather

- Compare daily weather and historical data
- Highlight extreme weather instances that are outside the climatic “norms” for an area

Climate

- Climate Maps
    - Koeppen Climate Zone Map
    - Bergeron Air Mass Map