MEECS Climate Change Unit
Introduction

Climate Change: Science and Impacts is the newest unit in the Michigan Department of Environmental Quality MEECS Project. The unit was developed with funding from the United States Environmental Protection Agency through the Great Lakes Restoration Initiative. The goal of the Climate Change Unit is to expand the MEECS project to bring issues associated with climate change and Great Lakes sustainability to Michigan teachers and students.

As with all MEECS units, Climate Change: Science and Impacts is science-based, Michigan specific, and tries to help students develop an information-based assessment of a complex issue. MEECS units try to provide students with the understanding they need to make decisions, not to tell them which decisions to make.

Climate change is an especially difficult topic to teach because so much of the data is not directly observable. In addition, measuring climate change is difficult because change happens over relatively long time spans, is caused by a range of natural and human factors, and is characterized by high levels of year to year and place to place variability. These same factors make climate change an important and useful topic for helping students grapple with the complexity of understanding global environmental issues.

In an attempt to frame this topic an interagency group, led by the National Oceanic and Atmospheric Administration (NOAA) developed *Climate Literacy: The Essential Principles of Climate Science* to promote greater *climate science literacy.* The principles are:

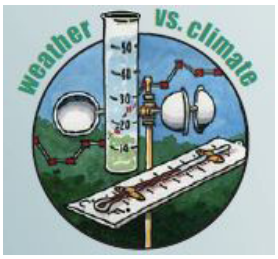
Climate Literacy: The Essential Principles of Climate Science

1. The Sun is the primary source of energy for Earth's climate system.
2. Climate is regulated by complex interactions among components of the Earth system.
3. Life on Earth depends on, is shaped by, and affects climate.
4. Climate varies over space and time through both natural and man-made processes.
5. Our understanding of the climate system is improved through observations, theoretical studies, and modeling.
6. Human activities are impacting the climate system.
7. Climate change will have consequences for the Earth system and human lives.

To which they add the belief that humans can take actions to reduce climate change and its impacts. These principles, along with the Michigan Grade Level and High School Content Expectations, helped guide the development of the Michigan Environmental Education Curriculum Support (MEECS) climate change unit. A core concept of these content expectations is that predicting and mitigating the potential impact of global climate change requires an understanding of the mechanisms of Earth's climate, studies of past climates, measurements of current interactions of Earth's systems and the construction of climate change models. Additionally, the *Climate Change: A Wisconsin Activity Guide* developed by Wisconsin Department of Natural Resources served as a model for this unit and lessons were adapted with permission from this publication.

The Climate Change: Science and Impacts provides an interdisciplinary approach to climate change concepts using Michigan examples. Lessons are designed for use in earth science, physical science, life science, and social studies. The first part of the unit focuses on climate science and the second part focuses on the potential impacts of climate change in Michigan and the Great Lakes. The two parts can be used independently or together.

Part 1: Climate Science is an attempt to provide teachers with a relatively compact overview of climate science, emphasizing data relative to Michigan and the Great Lakes. The lesson sequence begins with distinguishing between weather, climate, and climate variability. Students then gain a basic understanding of the natural mechanisms of climate change through exploration of the Earth's energy balance, the greenhouse effect, and the carbon cycle (sources and sinks). This is followed by a look at climate forcing and uncertainty, evidence of change, and climate models. Climate Science includes the following lessons:



1. What is climate?
2. Earth's Energy Balance
3. Greenhouse Effect
4. Carbon Cycle
5. Climate Forcings and Uncertainty
6. Evidence of Change
7. Climate Models

Climate Science presents the scientific perspectives, data and understanding which make the overwhelming majority of scientists believe that the climate is changing rapidly and that change is largely a result of human activity. The unit also tries to help students understand there is always uncertainty when making predictions about the future, and scientists try to include variability and uncertainty into their predictions.

Part 2: Climate Impacts on Michigan and the Great Lakes begins where Climate Science ends, with a review of the indicators of climate change, and then focuses on the potential impacts of changes in Michigan. Three lessons focus on the social science perspective and on the decisions which might confront citizens of Michigan in the future. The lessons are:

1. Climate Change Indicators
2. Plant and Animal Phenology
3. Ecosystem Relationships
4. Water balance in the Great Lakes
5. What Can I do?
6. Community Conversations
7. Climate Change in the News.

	Essential Questions	Core Lesson	Extensions
1	What is weather? What is climate? Do our climate records indicate climate change?	1. **What is Climate** – Students are introduced to the distinction between weather and climate. They will then examine and graph temperature and precipitation climate records at the local, state, and national level to draw conclusions about climate change trends.	- Climate Across the United States - NCDC Webquest
2	How does the sun heat the Earth? How does the atmosphere help balance the energy received?	2. **Energy Balance** – Students will work through an example of what happens to the energy from the sun and how it balances (radiative equilibrium) to keep the Earth warm.	- Changes in Earth's Energy Balance - Investigating Earth's Energy Balance
3	What is the greenhouse effect? The enhanced greenhouse effect? What are the main greenhouse gases and sources, and how do their heat trapping mechanisms vary?	3. **The Greenhouse Effect** – Students develop an understanding of the greenhouse effect and the enhanced greenhouse effect (global warming) as it relates to the Earth's energy balance through a series of activities, readings and diagrams.	- Extension Lesson: Modeling Greenhouse Gases - Investigating Greenhouse Gases Activity
4	What is the Carbon Cycle? How do human actions (in Michigan) affect the Carbon Cycle?	4. **The Carbon Cycle** – Students examine the carbon cycle, and identify sources and sinks within the environment. Students relate this information to greenhouse gas emissions of carbon dioxide in the context of greenhouse gas emissions in Michigan.	- Explore the potential of carbon sequestration in Michigan - Outdoor carbon hike - Create a carbon cycle game
5	What are the major factors which can influence climate change? Why is making climate prediction so hard?	5. **Climate Forcing and Uncertainty** – Students identify the factors which can influence climate change and identify reasons for uncertainty.	
6	How are atmospheric carbon dioxide and temperature related, and what is the predicted global temperature increase in 2100? What other evidence suggests climate change?	6. **Evidence of Change** – Students explore the evidence and impacts of climate change. The students graph atmospheric carbon dioxide, emissions of carbon dioxide, and temperature throughout the years and compare the trends. They explore models of future climate projections and impacts of climate change.	- Read *Frequently Asked Questions about Global Warming and Climate Change* - Use the *Gathering the Evidence* student activity - Design a method for determining Earth's average temperature. - View NASA's animations
7	How do scientists model the climate system? What do the models predict?	7. **Climate Models** – Students explore the basis of models which project climate change	- Use *The Educational Global Climate Modeling Suite* - Run Great Lakes Climate Scenarios - Use Climate Wizard - Show *Climate Models* and *Climate in a Box* videos

Essential Questions	Core Lesson	Extensions
8 What are some indicators of climate change? What are the expected regional impacts?	**8. Climate Change Indicators** – Students synthesize evidence about climate change, specifically in the Great Lakes region, and explore potential impacts.	- Climate Ready Great Lakes Training Module 1 - Explore Your Eco-Region - Comparing projections from a variety of websites
9 What is phenology and what are possible implications of phenological changes to the state economy? What impacts could these changes have on Michigan agriculture?	**9. Plant and Animal Phenology** – In this two-part lesson, students first explore changes through an analysis of phenological observations. In part two students examine the effects of seasons with longer degree days and spring freeze, and consider projections into the future, focusing their efforts on tart cherry production in Michigan.	- Going Outdoors with Phenology - Discussing Regional differences - *Sand Country Almanac* class reading - Video clips: tart cherry industry, honey bees.
10 What is the **geographic range** of a plant or animal species? How do species adapt to climate change?	**10. Ecosystem Relationships** – The geographic range of a plant or animal species is an indication of its environmental "preferences," the conditions that it finds ideal, acceptable, or intolerable. If the climate changes, therefore, it is reasonable to expect that plant and animal species might "move" to occupy different places. The big question is: "What species will move, and where will they go?" In this lesson, students approach this question through three activities.	- Mixed Pine Ecosystem of Michigan - Alternative Model Projections - Using DNR Posters - Measuring carbon storage of school-yard trees.
11 What is water balance and how does it affect lake levels in the Great Lakes? How does climate change affect the Great Lakes region?	**11. Water Balance** – Climagraphs can tell us about the seasonal shifts in climate due to climate change. Changes in growing season and water balance in the Great Lakes region will have economic impacts.	- *Making a Climagraph* to show water balance
12 What can be done to help mitigate climate change? What can one person do?	**12. What Can I Do** – Students will review potential impacts of climate change on Michigan and determine both adaptive and individual mitigation strategies. Through an optional service learning project, they will get the word out about climate change and that actions can be taken to reduce emissions of greenhouse gases.	- Play *The Global Climate Game* - Host a Community Conversation - Discuss the Carsey Institute Report - What are communities and companies in Michigan doing about sustainability and climate change?
13 What are the social, economic, and environmental impacts of climate change in Michigan? How could climate change affect Michigan citizens differently?	**13. Community Conversation** – Students participate in a class wide dialogue after conducting research on one of many Michigan personas on their views and solutions to climate change.	- Play *The Global Climate Game* - Host a Community Conversation - Discuss the Carsey Institute Report - What are communities and companies in Michigan doing about sustainability and climate change?
14 How is climate change represented in the news? What kind of research is being conducted about climate change?	**14. Climate Change In the News** – Students examine news sources and compare the type of coverage climate change receives as well as the objectivity of the sources.	- Meet the Researcher - Plan a climate change symposium - Compare news reports from the past

Michigan Grade Level Content Expectations for Climate Science	
1	• Analyze information from data tables and graphs to answer scientific questions. **S.IA.06.11, S.IA.07.11** • Compare and contrast the difference and relationship between climate and weather. **E.ES.07.71** • Describe the difference between weather and climate. **E4.p2B** • Construct and analyze climate graphs for two locations at different latitudes and elevations in the region to answer geographic questions and make predictions based on patterns. **6-G3.1.1**
2	• Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation. **E2.2C** • Identify the main sources of energy to the climate system. **E2.2D** • Describe natural mechanism that could result in significant changes in climate. **E5.4B** • Recognize that, and describe how human beings are part of Earth's ecosystems. Note that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. **L3.p4A** • Describe the environmental effects of human action on the atmosphere, biosphere, lithosphere and hydrosphere. **6-G5.1.1 7-G5.1.1**
3	• Describe the origins of pollution in the atmosphere, geosphere, and hydrosphere (car exhaust, industrial emissions, acid rain and natural sources) and how pollution impacts habitats, climatic change, threatens or endangers species. **E.ES.07.42** • Describe the atmosphere as a mixture of gases. **E.FE.07.11** • Explain the natural mechanism of the greenhouse effect, including comparisons of the major greenhouse gases (water vapor, carbon dioxide, methane, nitrous oxide, and ozone). **E5.4A** • Compare and contrast the heat-trapping mechanisms of the major greenhouse gases resulting from emissions (carbon dioxide, methane, nitrous oxide, fluorocarbons) as well as their abundance and heat- trapping capacity. **E5.4g** • Describe the greenhouse effect and list possible causes. **B3.4d**
4	• Describe the origins of pollution in the atmosphere, geosphere, and hydrosphere (car exhaust, industrial emissions, acid rain and natural sources) and how pollution impacts habitats, climatic change, threatens or endangers species. **E.ES.07.42** • Explain how carbon exists in different forms such as limestone (rock), carbon dioxide (gas), carbonic acid (water), and animals (life) within Earth systems and how those forms can be beneficial or harmful to humans. **E2.3A** • Explain how carbon moves through the Earth system (including the geosphere) and how it may benefit (e.g., improve soils for agriculture) or harm (e.g., act as a pollutant) society. **E2.3d** • Compare and contrast the heat-trapping mechanisms of the major greenhouse gases resulting from emissions (carbon dioxide, methane, nitrous oxide, fluorocarbons) as well as their abundance and heat- trapping capacity. **E5.4g**
5	• Describe the origins of pollution in the atmosphere, geosphere, and hydrosphere (car exhaust, industrial emissions, acid rain, and natural sources) and how pollution impacts habitats, climatic change, threatens or endangers species**.** **E.ES.07.42** • Analyze the empirical relationship between the emissions of carbon dioxide, atmospheric carbon dioxide levels, and the average global temperature over the past 150 years. **E5.4C** • List the possible causes and consequences of global warming. **B3.4e**
6	• Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information. **E1.2C** • Analyze the empirical relationship between the emissions of carbon dioxide, atmospheric carbon dioxide levels, and the average global temperature over the past 150 years. **E5.4C** • Predict the global temperature increase by 2100, given data on the annual trends of CO_2 concentration increase. **E5.r4j**
7	• Describe the origins of pollution in the atmosphere, geosphere, and hydrosphere (car exhaust, industrial emissions, acid rain, and natural sources) and how pollution impacts habitats, climatic change, threatens or endangers species. **E.ES.07.42** • Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information. **E1.2C** • Analyze the empirical relationship between the emissions of carbon dioxide, atmospheric carbon dioxide levels, and the average global temperature over the past 150 years. **E5.4C** • Predict the global temperature increase by 2100, given data on the annual trends of CO_2 concentration increase. **E5.r4j** • List the possible causes and consequences of global warming. **B3.4e**

Michigan Grade Level Content Expectations for Climate Impacts	
8	• Describe the origins of pollution in the atmosphere, geosphere, and hydrosphere (car exhaust, industrial emissions, acid rain and natural sources) and how pollution impacts habitats, climatic change, threatens or endangers species. **E.ES.07.42** • Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans and changing climatic zones. **E5.4D** • Examine the negative impact of human activities **B3.4C** • List the possible causes and consequences of global warming. **B3.4e** • Describe the environmental effects of human action on the atmosphere, biosphere, lithosphere and hydrosphere. **6 - G5.1.1** • Describe the effects that a change in the physical environment could have on human activities and the choices people would have to make in adjusting to the change. **6 – G5.2.1** • Describe the environmental effects of human action on the atmosphere, biosphere, lithosphere and hydrosphere. **7 - G5.1.1** • Describe the effects that a change in the physical environment could have on human activities and the choices people would have to make in adjusting to the change. **7 – G5.2.1**
9	• Identify the factors in an ecosystem that influence changes in population size. **L.EC.06.32** • Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans and changing climatic zones. **E5.4D** • Describe common ecological relationships between and among species and their environments (competition, territory, carrying capacity, natural balance, **L3.p2B** population, dependence, survival, and other biotic and abiotic factors). (prerequisite) • Explain how two organisms can be mutually beneficial and how that can lead to interdependency. (prerequisite) **L3.p2D** • Explain how stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of disease agents. **B2.3C** • List the possible causes and consequences of global warming. **B3.4e** • Describe the effects that a change in the physical environment could have on human activities and the choices people would have to make in adjusting to the change. **6 – G5.2.1** • Describe the effects that a change in the physical environment could have on human activities and the choices people would have to make in adjusting to the change. **7 – G5.2.1**
10	• Predict how changes in one population might affect other populations based upon their relationships in the food web. **L.EC.06.23** • Identify the factors in an ecosystem that influence changes in population size. **L.EC.06.32** • Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans and changing climatic zones. **E5.4D** • Describe common ecological relationships between and among species and their environments (competition, territory, carrying capacity, natural balance, population, dependence, survival, and other biotic and abiotic factors). **L3.p2B** • Explain how stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of disease agents. **B2.3C** • List the possible causes and consequences of global warming. **B3.4e**
11	• Predict how changes in one population might affect other populations based upon their relationships in the food web. **L.EC.06.23** • Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans and changing climatic zones. **E5.4D** • List the possible causes and consequences of global warming. **B3.4e** • Describe the environmental effects of human action on the atmosphere, biosphere, lithosphere and hydrosphere. **6 - G5.1.1** • Describe the effects that a change in the physical environment could have on human activities and the choices people would have to make in adjusting to the change. **6 – G5.2.1** • Describe the environmental effects of human action on the atmosphere, biosphere, lithosphere and hydrosphere. **7 - G5.1.1** • Describe the effects that a change in the physical environment could have on human activities and the choices people would have to make in adjusting to the change. **7 – G5.2.1**

12	• Describe renewable and nonrenewable sources of energy for human consumption (electricity, fuels), compare their effects on the environment, and include overall costs and benefits**. E2.4A** • Examine the negative impact of human activities **B3.4C** • Conduct and research on contemporary global topics and issues, compose persuasive essay, and develop a plan for action **6 – G6.1.1** • Clearly state an issue as a question or public policy, trace the origins of an issue, analyze various perspectives, and generate and evaluate alternative resolutions. Deeply examine policy issues in group discussions and debates to make reasoned and informed decisions. Write persuasive/argumentative essays expressing and justifying decision on public policy, report the results, and evaluate effectiveness. **6 – P3.1.1** • Demonstrate knowledge of how, when, and where individuals would plan and conduct activities intended to advance views in in matters of public policy, report the results, and evaluate effectiveness. **6 – P4.2.1** • Participate in projects to help or inform others. **6 – P4.2.3** • Clearly state an issue as a question or public policy, trace the origins of an issue, analyze various perspectives, and generate and evaluate alternative resolutions. Deeply examine policy issues in group discussions and debates to make reasoned and informed decisions. Write persuasive/argumentative essays expressing and justifying decision on public policy, report the results, and evaluate effectiveness. **7 – P3.1.1** • Demonstrate knowledge of how, when, and where individuals would plan and conduct activities intended to advance views in in matters of public policy, report the results, and evaluate effectiveness. **7 – P4.2.1** • Participate in projects to help or inform others**7 – P4.2.3**. • Clearly state an issue as a question or public policy, trace the origins of an issue, analyze various perspectives, and generate and evaluate alternative resolutions. Deeply examine policy issues in group discussions and debates to make reasoned and informed decisions. Write persuasive/argumentative essays expressing and justifying decision on public policy, report the results, and evaluate effectiveness. **8 – P3.1.1** • Demonstrate knowledge of how, when, and where individuals would plan and conduct activities intended to advance views in in matters of public policy, report the results, and evaluate effectiveness. **8 – P4.2.1** • Participate in projects to help or inform others. **8 – P4.2.3**
13	• Evaluate data, claims, and personal knowledge through collaborative science discourse. **S.IA.06.12** • Describe the origins of pollution in the atmosphere, geosphere, and hydrosphere (car exhaust, industrial emissions, acid rain and natural sources) and how pollution impacts habitats, climatic change, threatens or endangers species. **E.ES.07.42** • Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans and changing climatic zones. **E5.4D** • Recognize that, and describe how, human beings are part of Earth's ecosystems. Note that human activities can deliberately or inadvertently alter the equilibrium in ecosystems (prerequisite) **L3.p4A** • Examine the negative impact of human activities **B3.4C**
14	• Evaluate data, claims, and personal knowledge through collaborative science discourse. **S.IA.06.12, S.IA.07.12** • Evaluate the strengths and weaknesses of claims, arguments, and data. **S.RS.06.11, S.RS.07.12** • Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information. **E1.2C** • Evaluate the future career and occupational prospects of science fields. **E1.2E** • Analyze how science and society interact from a historical, political, economic, or social perspective **E1.2k** • Identify the point of view (perspective of the author) and context when reading and discussing primary and secondary sources. **6 - H1.2.3, 7 - H1.2.3**

Climate Science Master Materials List

(*on MEECS Climate Change Resource DVD)

Lesson 1: What is Climate?

Reproducible Materials

per class
- *Weather or Climate* (answer key)
- *Midland Precipitation* (answer key)
- *Climagraph Example* (transparency master)
- *Making a Climagraph* (answer key)
- *Climates and Places* (answer key)
- *Michigan Temperature Variability* and *Midland Precipitation* (transparency masters)
- *What is the Difference?* (transparency master)

per pair
- *Weather or Climate Cards* (student activity)
- *Weather or Climate* (student activity)

per student
- *Midland Precipitation* (student resource)
- *Midland Precipitation* (student activity)
- *Making a Climagraph* (student activity)
- *Climates and Places* (student activity) optional

Additional Materials on the Resource DVD

Lesson Materials
- *What is Climate* PPT

Adaptations/Extensions/Enhancement
- *Climate Across the United States* Word Document
- *NCDC webquest* Word Document

Lesson 2: Energy Balance

Reproducible Materials

per class
- *Electromagnetic Spectrum* (transparency master)
- *Radiation from the Sun and Earth* (answer key)
- *Earth's Energy Budget Parts 1-4* (transparency masters)
- *Earth's Energy Budget Parts 1-4* (answer key and PowerPoint Notes)

per student
- *Radiation from the Sun and Earth* (student activity)
- **Earth's Energy Budget Parts 1-4* (student activity)

Additional Materials on the Resource DVD

Lesson Materials
- *Earth's Energy Budget* PPT
- *Electromagnetic Spectrum* Transparency PPT
- *Earth's Energy Balance* QuickTime Movie
- *Radiation from the Sun and Earth* (QuickTime Movie – 2:17 minutes)
- *Energy Budget Activities*

Adaptations.Extensions.Enhancements
- Investigating Energy Balance
- Changes in the Earth's Energy Balance

Lesson 3: Greenhouse Effect

Reproducible Materials

per class
- *Earth's Greenhouse Effect* (answer key)
- *Michigan Greenhouse Gases per Sector in Michigan* (transparency master)
- *Sources of Greenhouse Gases* (answer key)

per student
- *Greenhouse Gases* (student reading)
- *Earth's Greenhouse Effect* (student activity)
- *Sources of Greenhouse Gases* (student activity)

Additional Materials on the Resource DVD

Lesson Materials
- *The Greenhouse Effect* PPT
- *Earth's Greenhouse Effect* (QuickTime Movie -3:29 minutes)

Adaptations/Extensions/Enhancements
- Extension Lesson: *Modeling Greenhouse Gases*

Lesson 4: The Carbon Cycle	
Reproducible Materials *per class* • *Carbon Cycle* (transparency master) • *Explore the Carbon Cycle* (answer key) • *Michigan Land, Air, and Water* (answer key) *per group* • *Michigan Land, Air, and Water* Placemats *per student* • *Explore the Carbon Cycle* (student activity) • *Michigan Land, Air, and Water* (student activity)	**Additional Materials on the Resource DVD** **Lesson Materials** • *Carbon Cycle* PPT • *Carbon Cycle* QuickT ime Movie • *Keeping Up with Carbon MP4 video*
Lesson 5: Climate Forcing and Uncertainty	
Reproducible Materials *per class* • *Changes in Earth's Energy Balance* (answer key) • *Feedback Cycles* (transparency master) *per student* • *Radiative Forcing* (student resource) • *Changes in Earth's Energy Balance* (student reading) • *Changes in Earth's Energy Balance* (student activity)	**Additional Materials on the Resource DVD** **Lesson Materials** • *Climate Forcing and Uncertainty* PPT
Lesson 6: Evidence of Change	
Reproducible Materials *per student* • *Graphing Temperature and carbon dioxide in the 20th century* (student activity) • *Graphing temperature and carbon dioxide over the last 450,000 years* (student activity)	**Additional Materials on the Resource DVD** **Lesson Materials** • *Evidence of Change* PPT • *Temperature Puzzle MP4* video **Adaptations.Extensions.Enhancements:** • *Gathering the Evidence* teacher resource and student activity • *Taking the Earth's Temperature* Windows Media Video • *Frequently Asked Questions* • More NASA Videos **Other Materials** • *Global Warming* – Thomas Karl

Lesson 7: Climate Models	
Reproducible Materials *per class* • *Modeling the Climate System* (transparency master) • *Evolution of Climate Models* (transparency master) • *Relationships in a Climate Model* (answer key) • *How Much and When* (answer key) • *Climate Scenarios* (transparency master) *per small group*: • Computer *per student* • *Relationships in a Climate Model* (student activity) • *A Very, Very Simple Climate Model* (student activity) • *How Climate Models are Developed and Tested* (student resource) • *How Much and When?* (student activity)	**Additional Materials on the Resource DVD** **Lesson Materials** • *Climate Model Transparencies* PPT **Adaptations.Extensions.Enhancements** • *Climate Models* QuickTime Movie • *Climate in a Box* MP4 video

Climate Impacts Master Materials List

(*on MEECS Climate Change Resource DVD)

Lesson 8: Climate Change Indicators

Reproducible Materials

per class
- *Describing Trends and Writing Hypotheses about Causes* (possible answers)
- *Climate Indicators for Michigan* (answer key)
- *Potential Climate Change Impacts* (transparency master)

per student
- *Describing Trends and Writing Hypotheses about Causes* (student activity set)
- *Climate Indicators in Michigan* (student activity)

Additional Materials on the Resource DVD

Lesson Materials
- *Climate Change Impacts* Instructional PPT
- *Climate Change in the Great Lakes* video, script, and time-summary

Adaptations/Extensions/Enhancement
- *Climate Change Indicators*
- *Climate Ready Great Lakes PPT*

Other Materials
- Additional Lines of Evidence
- GLISA: Climate Change in the Great Lakes Region

Lesson 9: Plant and Animal Phenology

Reproducible Materials

per class
- *Comparing Phenological Observations* (answer key)
- **Michigan Cherries and Climate Change* (answer key)

per student
Phenology Over Time (student resource)
- *Comparing Phenological Observations* (student activity)
- **Michigan Cherries and Climate Change* (student booklet)

Additional Materials on the Resource DVD

Lesson Materials
- *Plant and Animal Phenology* Instructional PPT
- *Michigan Cherries and Climate Change* (student booklet)
- *Michigan Cherries and Climate Change* (answer key)

Adaptations/Extensions/Enhancement
- Extension Lesson: *Going Outdoors with Phenology*
- Honey Bees

Other Materials
- Plant Hardiness Zones
- Agriculture and Climate Change (teacher resource)

Lesson 10: Ecosystems Relationships

Reproducible Materials

per class
- **Ecological Habitat Diagrams* transparency
- **Predicting the Future Ranges of Important Tree Species* (transparencu masters)
- *Matching Tree Species with Ecological Habitat Diagrams* and *Predicting the Future Ranges of Important Tree Species* (answer key)
- *Model Projections* (answer key)

per student
- *Matching Tree Species with Ecological Habitat Diagrams* (student activity)
- *Background about Tree Species in the Eastern United States* (student resource)
- *Predicting the Future Ranges of Important Tree Species* (student activity)

per pair
- *Model Projections* (student activity)

Additional Materials on the Resource DVD

Lesson Materials
- *Ecosystem Relationships* Instructional PPT
- *Lesson 10 Transparencies*

Adaptations/Extensions/Enhancement
- Materials for Alternate Projections
- Extension Lesson: *Mixed Pine Ecosystem of Michigan*

To be provided by the teacher
- Computer with internet access

Lesson 11: Water Balance in the Great Lakes

Reproducible Materials

per class
- *Climagraph of Detroit and Climagraph of Detroit, redesigned* (transparency master)
- *Level of Lake Michigan* (transparency master)

per student
- *How Climate Change Can Alter the Water Balance* (student activity)
- *Water Level in Lake Michigan* (student activity)
- *Climate Change and the Great Lakes* (student resource)
- *Effects of Climate Change on the Great Lakes* (student activity)

Additional Materials on the Resource DVD

Lesson Materials
- *Water Balance and the Great Lakes* Instructional PPT

Adaptations, Extensions
- *Making Climagraph 2 Solve Water Balance* PPT

Lesson 12: What Can I Do?

Reproducible Materials

per class
- *Six Reasons Why We Should Prepare for Climate Change in Michigan* transparency master
- *Michigan's Greenhouse Gas Emissions by Sector* (transparency master)
- *Guiding Principle for Informed Climate Decisions* (teacher resource)
- *Template for DOT Tree Leaves* (Teacher Resource)

per group
- *Climate Change Review* (student activity)
- *Education Campaign Preparation* (student activity)
- *Campaign Follow-Up* (student activity)

per student
- *Adaptation or Mitigation* (student activity)
- *Climate Change Check Sheet* (student resource)

Additional Materials on the Resource DVD

Lesson Materials
- *What Can I Do* Instructional PPT

Adaptations, Extensions
- *EPA's Emissions Calculator*
- *Climate Literacy Principles*

To be supplied by the teacher (optional activity)
- Poster board
- Materials to create education materials
- Paper or access to computer spreadsheet
- Access to computer

Lesson 13: Community Conversation

Reproducible Materials

per class
- **Student Participation Rubric* (teacher resource)
- *Some Effects of Climate Change in Michigan* (teacher resource)

per student
- *Before-the-Conversation* (student activity)
- *After-the-Conversation* (student activity)
- **Community Conversation Cards* (student activity)
- *What's the Impact?* (student activity)

Additional Materials on the Resource DVD

Lesson Materials
- *Dialogue Preparation: Dialogue, Debate, & Careful Listening* (student resource)
- *Community Conversation Cards*
- *Revolving Conversation Guidelines* (Teacher Resource)
- *Student Participation Rubric*

Adaptations, Extensions
- *The Global Climate Game*
- Carsey Report Climate-Change-2011

Other Materials
- Lesson 13 References

Lesson 14: Climate Change in the News	
Reproducible Materials *per class* • *Three Prong Approach to Climate Change Research* (transparency master) *per group* • *Climate Change Headlines* (student activity) *per student* • *Making Sense of Climate Change* (student resource) • *News Analysis* (student activity) • * *Newspaper Research* (student activity)	**Additional Materials on the Resource DVD** **Lesson Materials** • *Three Prong Approach to Climate Change Research* (transparency master) • *Newspaper Research* (student activity) **Adaptations/Extensions/Enhancements** • *Natural Inquirer* • Scientist Profiles • *Meet the Researcher* (student activity)

Michigan Grade Level Content Expectations
MEECS Climate Science
(Lessons 1-7)

X = Addresses/Supports

		1. What is Climate?	2. Earth's Energy Balance	3. The Greenhouse Effect	4. The Carbon Cycle	5. Climate Forcing and Uncertainty	6. Evidence of Change	7. Climate Models
Science 6-7	**S.IA.06.11** Analyze information from data tables and graphs to answer scientific questions.	X						
	E.ES.07.42 Describe the origins of pollution in the atmosphere, geosphere, and hydrosphere (car exhaust, industrial emissions, acid rain and natural sources) and how pollution impacts habitats, climatic change, threatens or endangers species.			X	X	X		X
	E.ES.07.71 Compare and contrast the difference and relationship between weather and climate.	X						
	E.FE.07.11 Describe the atmosphere as a mixture of gases.			X				
Science High School	**E1.2C** Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.						X	X
	E2.2C Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.		X					
	E2.2D Identify the main sources of energy to the climate system.		X					
	E2.3A Explain how carbon exists in different forms such as limestone (rock), carbon dioxide (gas), carbonic acid (water), and animals (life) within Earth systems and how those forms can be beneficial or harmful to humans.				X			
	E2.3d Explain how carbon moves through the Earth system (including the geosphere) and how it may benefit (e.g., improve soils for agriculture) or harm (e.g., act as a pollutant) society.				X			
	E4.p2B Describe the difference between weather and climate. *(prerequisite)*	X						
	E5.4A Explain the natural mechanism of the greenhouse effect, including comparisons of the major greenhouse gases.			X				
	E5.4B Describe natural mechanisms that could result in significant changes in climate.		X					
	E5.4C Analyze the empirical relationship between the emission of carbon dioxide, atmospheric carbon dioxide levels, and the average global temperature over the past 150 years.					X	X	X
	E5.4g Compare and contrast the heat-trapping mechanisms of the major greenhouse gases resulting from emissions (carbon dioxide, methane, nitrous oxide, fluorocarbons) as well as their abundance and heat-trapping capacity.			X	X			
	E5.r4j Predict the global temperature increase by 2100, given data on the annual trends of CO_2 concentration increase (recommended)						X	X
	L3.p4A Recognize that, and describe how, human beings are part of Earth's ecosystems. Note that human activities can deliberately or inadvertently alter the equilibrium in ecosystems (prerequisite)		X					
	B3.4d Describe the greenhouse effect and list its possible causes			X				
	B3.4e List the possible causes and consequences of global warming.					X		X
Social Studies	**6 – G3.1.1** Construct and analyze climate graphs for two locations at different latitudes and elevations in the region to answer geographic questions and make predictions based on patterns. (e.g., compare and contrast Buenos Aires and La Paz; Mexico City and Guatemala City; Edmonton and Toronto).	X						
	6 - G5.1.1 Describe the environmental effects of human action on the atmosphere, biosphere, lithosphere and hydrosphere.		X					
	7 - G5.1.1 Describe the environmental effects of human action on the atmosphere, biosphere, lithosphere and hydrosphere.		X					

Climate Literacy Principles Alignment

MEECS Climate Science

(Lessons 1-7)

X = Addresses/Supports

	1. What is Climate?	2. Earth's Energy Balance	3. The Greenhouse Effect	4. The Carbon Cycle	5. Climate Forcing and Uncertainty	6. Evidence of Change	7. Climate Models
1. The sun is the primary source of energy for earth's climate system.		X					
2. Climate is regulated by complex interactions among components of the earth system.		X	X	X			
3. Life on earth depends on, is shaped by, and affects climate.			X	X			
4. Climate varies over space and time through both natural and man-made processes.	X		X	X	X	X	X
5. Our understanding of the climate system is improved through observations, theoretical studies, and modeling.	X				X	X	X
6. Human activities are impacting the climate system.	X		X		X	X	X
7. Climate change will have consequences for the earth system and human lives.							

Michigan Grade Level Content Expectations

MEECS Climate Impacts

(Lessons 8-14)

X = Addresses/Supports

		8. Climate Change Indicators	9. Plant and Animal Phenology	10. Ecosystem Relationships	11. Water Balance and the Great Lakes	12. What Can I Do?	13. Community Conversation	14. Climate Change in the News
6th - 7th Grade Science	**S.IA.06.12** Evaluate data, claims, and personal knowledge through collaborative science discourse.						X	X
	S.RS.06.11 Evaluate the strengths and weaknesses of claims, arguments, and data.							X
	L.EC.06.23 Predict how changes in one population might affect other populations based upon their relationships in the food web.			X	X			
	L.EC.06.32 Identify the factors in an ecosystem that influence changes in population size.		X	X				
	S.RS.06.11 Evaluate the strengths and weaknesses of claims, arguments, and data.							X
	E.ES.07.42 Describe the origins of pollution in the atmosphere, geosphere, and hydrosphere (car exhaust, industrial emissions, acid rain and natural sources) and how pollution impacts habitats, climatic change, threatens or endangers species.	X					X	
High School Science	**E1.2C** Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information							X
	E1.2E Evaluate the future career and occupational prospects of science fields							X
	E1.2k Analyze how science and society interact from a historical, political, economic, or social perspective							X
	E2.4A Describe renewable and nonrenewable sources of energy for human consumption (electricity, fuels), compare their effects on the environment, and include overall costs and benefits**.**					X		
	E5.4 Climate Change							
	E5.4D Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans and changing climatic zones.	X	X	X	X		X	
	L3.p2B Describe common ecological relationships between and among species and their environments (competition, territory, carrying capacity, natural balance, population, dependence, survival, and other biotic and abiotic factors). (prerequisite)		X	X				
	L3.p2D Explain how two organisms can be mutually beneficial and how that can lead to interdependency. (prerequisite)		X					
	B2.3C Explain how stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of disease agents.		X	X				
	B3.4C Examine the negative impact of human activities.	X				X	X	
	B3.4e List the possible causes and consequences of global warming.	X	X	X	X			

Middle School Social Studies	**6, 7 - G5.1.1** Describe the environmental effects of human action on the atmosphere, biosphere, lithosphere and hydrosphere.	X			X		X	
	6 – G5.2.1 Describe the effects that a change in the physical environment could have on human activities and the choices people would have to make in adjusting to the change.	X	X		X			
	6, 7, 8 – P3.1.1 Clearly state an issue as a question or public policy, trace the origins of an issue, analyze various perspectives, and generate and evaluate alternative resolutions. Deeply examine policy issues in group discussions and debates to make reasoned and informed decisions. Write persuasive/argumentative essays expressing and justifying decision on public policy, report the results, and evaluate effectiveness. • Identify public policy issues related to global topics and issues studied. • Clearly state the issue as a question of public policy orally or in written form. • Use inquiry methods to acquire content knowledge and appropriate data about the issue. Identify the causes and consequences and analyze the impact, both positive and negative. • Share and discuss findings of research and issue analysis in group discussions and debates. • Compose a persuasive essay justifying the position with a reasoned argument. Develop an action plan to address or inform others about the issue at the local to global scales.					X		
	6, 7, 8 – P4.2.1 Demonstrate knowledge of how, when, and where individuals would plan and conduct activities intended to advance views in in matters of public policy, report the results, and evaluate effectiveness.					X		
	6, 7, 8 – P4.2.3 Participate in projects to help or inform others.					X		
	7-H1.2.3 Identify the point of view and context when reading and discussing primary and secondary sources.							X

Climate Literacy Principles Alignment

MEECS Climate Impacts

(Lessons 8-14)

X = Addresses/Supports

	8. Climate Change Indicators	9. Plant and Animal Phenology	10. Ecosystem Relationships	11. Water Balance and the Great Lakes	12. What Can I Do?	13. Community Conversation	14. Climate Change in the News
1. The sun is the primary source of energy for earth's climate system.							
2. Climate is regulated by complex interactions among components of the earth system.							
3. Life on earth depends on, is shaped by, and affects climate.	X	X	X	X		X	
4. Climate varies over space and time through both natural and man-made processes.	X	X		X	X		
5. Our understanding of the climate system is improved through observations, theoretical studies, and modeling.		X	X				
6. Human activities are impacting the climate system.	X		X	X	X	X	X
7. Climate change will have consequences for the earth system and human lives.	X	X	X	X	X	X	X