The River Mile
Water Quality

Lesson # 9

Water Quality: Climate Change

Developed by the Lake Roosevelt Forum to support “The River Mile” National Park Service Program

Suggested duration:
90 minutes

Inquiry Question:
How is water quality altered by changes in temperature and precipitation?

Inquiry Process:
Asking new questions based on results of an inquiry.

Standards:
PS2, PS3, ES2, LS2, LS3

Assessment:
Write 3 new questions that could be developed into a research study

Materials:
You Tube video excerpts from Climate Change proponents and skeptics

PPP Climate Change Indicators NOAA & NASA

Handouts:
EPA Climate Change Science Facts

EPA FAQ About Global Warming & Climate Change: Back to Basics.

Socratic Seminar

Credits/Citations:
Socratic Seminar
www.socratic.com
You Tube
www.youtube.com/

LESSON # 9

Water Quality: Climate Change

INTRODUCTION:

What is the difference between climate and weather? Weather is what's going on right now and climate is a long term pattern. Climate determines the clothes you buy and weather determines the clothes you wear on any given day. What are the indicators that scientist track to predict climate? Scientists create models to look at annual patterns of temperature and precipitation. They add indicators to the models like: the amount of solar energy, ocean temperature, clouds, color of the ground, things in the atmosphere like, smoke, sulfates, nitrates, ozone, methane, and carbon dioxide. Then they calculate how much each of these contributes to warming or cooling and test how well their model matches the results over time. As climate changes occur, how could local and global precipitation be affected? How might precipitation changes alter the Columbia River flow, Lake Roosevelt levels and available fresh water?

STUDENT WORK AND ASSESSMENT

View and discuss varying positions on the theory of climate change. What additional questions do you think should be studied?

QUESTIONS TO EXPLORE/INSTRUCTIONS/PROCEDURE

1. Introduce Climate Change as a scientific theory using the power point and handouts from EPA, NOAA, & NASA
2. Discuss what data constitute scientific evidence?
3. View video excerpts from climate change proponents and skeptics. *Links to videos provided in Appendix Lesson 9*
4. Identify and distinguish between scientific evidence, scientifically valid questions, personal opinions and propaganda techniques
5. Prepare questions and supporting evidence for a discussion of climate change
6. Engage in a group discussion using the Socratic Seminar guidelines. *Note: Socratic Seminar procedures are provided in full detail in the appendix: Lesson 9 handouts.*

OPTIONAL HOMEWORK ACTIVITY

Interview 5 people regarding their views on climate change. What evidence do they provide for their point of view?

WATER QUALITY: CLIMATE CHANGE

Name: _____Date: _____

Essential Question:

- How is water quality affected by local and global changes in temperature and precipitation?

Inquiry Question:

What are the indicators of climate change?
What data and evidence are valid for evaluating different perspectives on climate change?

Objectives:

You will:

a. Learn about Climate Change indicators
b. Discuss what data constitute scientific evidence?
c. View video excerpts from climate change proponents and skeptics
d. Identify and distinguish between scientific evidence, scientifically valid questions, personal opinions and propaganda techniques
e. Prepare questions and supporting evidence for a discussion of climate change
f. Engage in a group discussion using the Socratic Seminar guidelines.
g. OPTIONAL ACTIVITY: Interview 5 people regarding their views on climate change. What data and evidence do they provide for their point of view?

Introduction:

What is the difference between climate and weather?

Weather is what's going on right now and climate is a long term pattern. Climate determines the clothes you buy and weather determines which clothes you wear on any given day.

What are the indicators that scientist track to predict climate?

Scientists create models to look at annual patterns of temperature and precipitation. They add to the models indicators like: the amount of solar energy, ocean temperature, clouds, color of the ground, things in the atmosphere like, smoke, sulfates, nitrates, ozone, methane, and carbon dioxide. Then they calculate how much each of these contributes to warming or cooling and test how well their model matches the results over the years.

As climate changes occur, how could local and global precipitation be affected? How might precipitation changes alter the Columbia River flow, Lake Roosevelt levels and available fresh water?

Assignment:

Congratulations! You have been awarded a $2.5 million dollar contract with National Geographic! You are a well respected science writer and the NG editors have hired you to develop a scientifically accurate video presentation on climate change for the "NetGen" (young people ages 12-20). If this video is successful you will get an additional contract to explore the possible impact climate change could have on Lake Roosevelt over the next 100 years. They have given you a number of video clips from climate change proponents and skeptics as well as some written information from EPA, NOAA, and NASA. Your first step is to analyze the information provided and have a discussion with the editorial staff and other writers. Determine what evidence and data you think should be included in your video, which items you will avoid because they are propaganda or unsubstantiated opinion, and what additional information you might need. Prepare 2-4 new questions that will help guide the development of this video project.

Think Time:

What will the "NetGen" audience want & need to know about climate change?

How will you keep the "NetGen" audience interested?

What information do you need?

View the You Tube Video Clips

As you view each video, identify climate change proponents and skeptics. Use the chart below to record your observations. Identify and distinguish between scientific evidence, scientifically valid questions, personal opinions and propaganda techniques

Video Title	Scientific Evidence and Questions	Personal Opinions	Propaganda Techniques

<u>View the NOAA /NASA Climate Change Indicators Power point</u> and read the EPA FAQ's and Facts. Analyze the precipitation change maps. Think about how you will translate this information into something that will inform and engage your "NetGen" audience.

Note information, graphics, language, descriptions are important to include. Remember to cite where you found the information so you can easily find it again.

What patterns or trends do you see in precipitation changes in the Pacific Northwest and around the world? Is the "NetGen video on climate change the same for youth in Washington State as it is for youth in Australia? SE Asia? Chile?

<u>Prepare notes, evidence & questions for the Socratic Seminar discussion</u> with the National Geographic editors.

What evidence and data do you think should be included in your video?

Which items will you avoid because they are propaganda or unsubstantiated opinion?

What additional information you might need.

Prepare 2-4 new questions that will help guide the development of this video project.

1.

2.

3.

4.

You Tube Videos Search key words: Climate Change: Science, Debate, Hoax, Rebuttal

Proponents:

Climate Change the Scientific Debate	
URL	http://www.youtube.com/watch?v=52KLGqDSAjo
Producer	potholer54
Posted Description	This video is a basic look at how climate scientists infer that man-made carbon gases are changing the climate, and how this view is contradicted by other climate scientists who are skeptics. I am a former science correspondent with an interest in reporting the facts, not the media hype. My thanks go to 9thgate for checking my script for errors.
Length	10 minutes and 43 seconds
# Views	**133,489**
Selection Comments	Presentation compares statements made by climate change "Believers" & "Deniers" and places them in context with scientific proponents and skeptics. Data and evidence are presented to identify inaccurate statements by both sides. Appears to be solid science information with diagrams and graphs to clarify concepts.

Climate Change the Objections	
URL	http://www.youtube.com/watch?v=PoSVoxwYrKI&feature=related
Producer	Potholer 54
Posted Description	This video, the second in the series, looks at alternative hypotheses explaining global warming. I am only looking at alternative hypotheses put forward by real, professional climate researchers, and the findings of real, professional climate researchers who disagree with them. Yes, I've left a lot of the detail out. This is a 10-minute video summarizing the arguments and counter-arguments, not a PhD thesis. The comments forum will be free and open, as always, but if you disagree with what real, professional climate scientists say, please take it up with them and don't expect me to defend their point of view. If you have a stunning piece of scientific evidence that disproves one side or the other, don't waste time on my channel, write a paper, and get it peer-reviewed and published in a reputable journal
Length	10 min. 19 seconds
# Views	71,764
Selection Comments	The producer's statement above is born out by the content of the video. Arguments by skeptics of climate change are clearly represented with facts. There are 3 more videos in this series for those who wish to dig deeper.

Global Warming 101	
URL	http://www.youtube.com/watch?v=oJAbATJCugs
Producer	**National Geographic Society** http://video.nationalgeographic.com/v...
Posted Description	Global warming could do more than just melt polar ice. It could change our maps, and displace people from cities and tropical islands
Length	3 min 3 sec
# Views	**1,077,956**
Selection Comments	Short documentary format with lots of images and an opportunity to analyze some of the following questions. What does the producer want the viewer to think or do at the end of the video? Is scientific evidence presented? Is there a social media message with a specific purpose? Is it effective, entertaining, frightening, upsetting, inspiring? Does it make assumptions with or without sufficient evidence?

You Tube Videos Search key words: Climate Change: Science, Debate, Hoax, Rebuttal

Skeptics

Climate Change - Is CO2 the Cause? - Pt 1 of 4	
URL	http://www.youtube.com/watch?v=FOLkze-9GcI&feature=related
Producer	**Bushvision** | September 11, 2007 Australia
Posted Description	The first of four parts where Professor Bob Carter uses the scientific method on the popular theory with global warming being linked to CO2 levels. He examines the hypothesis and it fails the test. Inconvenient Truth author Al Gore would find his presentation contradicted by this presentation? Will Kyoto's greenhouse reduction goals be in vain?
Length	9 mins. 42 sec
# Views	**315,129**
Selection Comments	I found this hard to view because it was a live presentation and the slides shown are at an angle making it hard to see well. I decided to include these to be fair & balanced to the Potholer 54 series listed first. This is the most scientific information I could find from those who refute climate change.

Al Gore Sued by Over 30,000 Scientists for Fraud	
URL	http://www.youtube.com/watch?v=FfHW7KR33IQ&feature=related
Producers	**WakeUpCall4World** | July 05, 2008 shown on Red Eye @ Fox News Visit:http://www.infowars.com/ Run by Kurt Nimmo, http://www.prisonplanet.com/ Run by Paul Watson, http://jonesreport.com/ Run by Aaron Dykes, http://www.truthnews.us/ Run by Steve Watson
Description	None
Length	5 min 25 sec.
# Views	**500,242**
Selection Comments	The title of this video is misleading as the interview is with a Fox channel weatherman, John Coleman, who "wants to sue" Al Gore. Students can listen to distinguish facts and opinions. Look for the propaganda tactic of undermining personal credibility in place of scientific evidence. Is this information or sensationalism? Look at the Producers other videos

Global Warming Hoax	
URL	http://www.youtube.com/watch?v=Io-Tb7vTamY
Producer	Glenn Beck & **macumba29** | May 07, 2007
Description	The reason why it is a Hoax
Length	9 mins. 22 sec
# Views	**436,380**
Selection Comments	"Hoax." The video is full of innuendo, propaganda, showmanship, and rhetoric. Students can discuss the use of movie clips, sound tracks and voice inflection to undermine and negate. I felt it important to include due to the number of viewings it received.

Al Gore Debates Global Warming	
URL	http://www.youtube.com/watch?v=XDI2NVTYRXU&feature=related
Producer	Demand Debate **junksciencecom** | October 03, 2007
Description	Al Gore debates expert climatologists (at last) on whether carbon dioxide causes global warming
Length	8 min 53 sec
# Views	**405,238**
Selection Comments	This video uses a short clip of Al Gore in the Inconvenient Truth Video and calls it a debate. Students have an opportunity to distinguish between factual rebuttal, opinion & propaganda.

Socratic Seminar Guidelines

A Socratic Seminar is designed to allow participants to collaboratively analyze an issue by discussing supporting evidence in the form of written documents, video, interviews and web resources. Participants develop a deeper understanding of divergent evidence meanings, values, and perspectives. Socratic Seminars are effective for evaluating different perspectives while engaging with one another and following the expected norms of social interaction.

How to:

1. Select pertinent information and become familiar with it, write down several questions that are required to adequately analyze the information. These questions need to be related to factual evidence, perspective, motive, and the significant aspects of what is being asserted. Use these questions to guide discussion. It is also helpful to write down controversial issues the subject brings up and to use those topics for a post-seminar discussion or informal debate.
2. Sit in a circle so you can make eye contact with each other.
3. Review the rules and make sure everyone understands the key components. **Rules of the Socratic Seminar**
    a. You do not have to raise your hands to be called on to speak; you can go ahead and speak as long as you are not interrupting another speaker.
    b. Address each other by name, look at the speaker, and show respect at all times by refraining from name calling or making condescending remarks.
    c. This is not a debate, it is an analysis. Therefore, do not state or defend opinions since it does not matter whether or not you agree or disagree with each other. Instead refer to the evidence itself and quote it whenever possible to make clear the ideas and opinions conveyed in the video, interview or text.
4. Prepare for the seminar by reading/viewing the selected materials. Highlight important points. Record factual notes or accurate quotes from a video or an interview. Write several pertinent questions relating to the issue that you will bring to the seminar.
5. The seminar begins with a volunteer who cites a passage, quote, or evidence that provides information regarding differing perspectives. Participants react and speak to one another. The leader refrains from interrupting the seminar unless the discussion needs to be re-focused on the topic or to remind participants of the seminar rules.
6. The seminar ends when no one speaks, time runs out, or if the discussion becomes repetitive.
7. You may have a follow-up, informal debate on controversial issues brought up by the evidence.

TRM

Water Quality & Climate Change

How is water quality affected by global interactions beyond the local watershed?

http://www.ncdc.noaa.gov/indicators/
http://www.giss.nasa.gov/

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

National Climatic Data Center
U.S. Department of Commerce

Goddard Space Flight Center
National Aeronautics and Space Administration

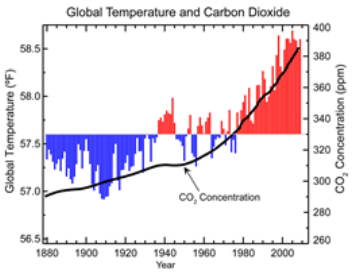
Information on slides 3-13 was provided by NOAA, NESDIS and NCDC.
Slides 15-17 use maps and data provided by NASA's Goddard Institute for Space Studies.
See websites above for more information.

Global Climate Change Indicators

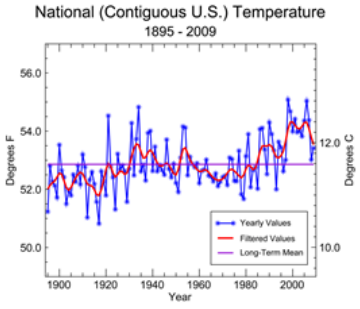
- How do we know the Earth's climate is warming?
  - **Temperatures are recorded daily around the globe**
    - Weather Stations
    - Ships & Buoys
    - Gliders & Satellites
  - **Independent observations are documented**
    - Melting glaciers on every continent
    - Reduced snow cover
    - Earlier blooming plants in spring
    - Shorter ice season on lakes and rivers
    - Reduced arctic sea ice
    - Rising sea levels

The Global Surface Temperature is Rising

- Global annual average temperature measured over land and oceans. Red bars indicate temperatures above and blue bars indicate temperatures below the 1901-2000 average temperature. The black line shows atmospheric carbon dioxide concentration in parts per million

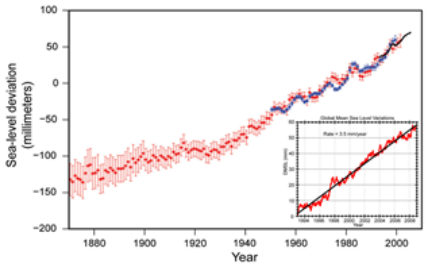


U.S. Surface Temperature is also Rising



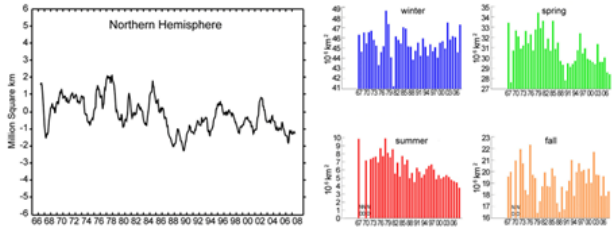
- Annual surface temperatures for the contiguous U.S. compared to the 20th Century (1901-2000) average. Calculated from the U.S. Historical Climatology Network (USHCN version 2). More information: U.S. Surface Temperature Data, USHCN v2.

Sea Level is Rising



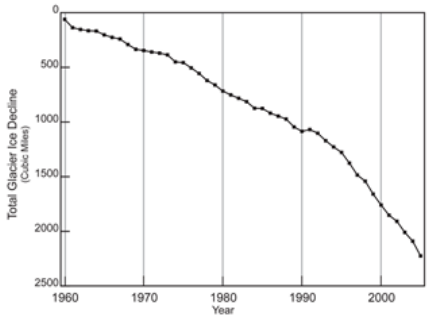
- Annual averages of global sea level. Red: sea-level since 1870; Blue: tide gauge data; Black: based on satellite observations. The inset shows global mean sea level rise since 1993 - a period over which sea level rise has accelerated. More information: Coastal Sensitivity to Sea Level Rise (USGCRP) and Climate Change 2007: The Physical Science Basis.

Northern Hemisphere Snow Cover is Retreating



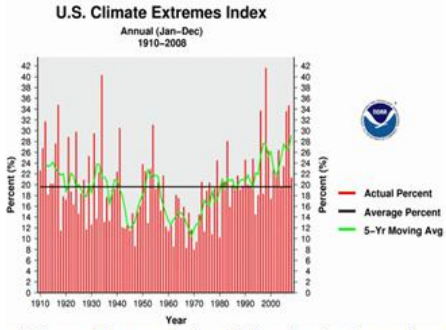
- Left: Average of monthly snow cover extent anomalies over Northern Hemisphere lands (including Greenland) since Nov 1966. Right: Seasonal snow cover extent over Northern Hemisphere lands since winter 1966-67. Calculated from NOAA snow maps. From *BAMS* State of the Climate in 2008 report.

Glacier Volume is Shrinking



Cumulative decline (in cubic miles) in glacier ice worldwide. More information: Global Climate Change Impacts in the U.S.

U.S. Climate Extremes are Increasing



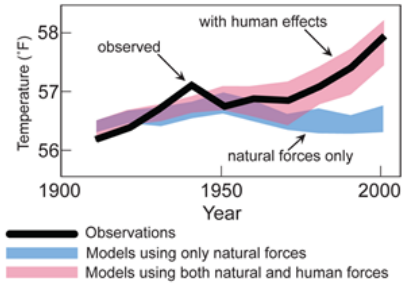
- Annual Climate Extremes Index (CEI) value for the contiguous United States. Larger numbers indicate more active climate extremes for a year. More information: CEI.

Why do we think humans are the primary cause of the warming?

Evidence supports the conclusion that human activity is one of the primary drivers of recent warming.

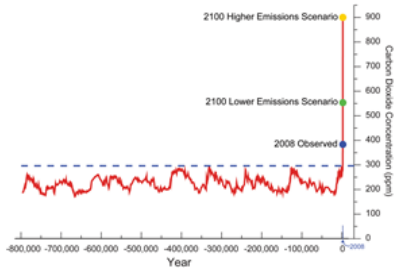
- The first line of evidence is our basic physical understanding of how greenhouse gases trap heat, how the climate system responds to increases in greenhouse gases, and how other human and natural factors influence climate.
- The second line of evidence is from indirect estimates of climate changes over the last 1,000 to 2,000 years.
- The third line of evidence is based on comparisons of actual climate with computer models of how we expect climate to behave under certain human influences.

Climate Model Indications & Observed Climate



- Simulated global temperature in experiments that include human influences (pink line), and model experiments that included only natural factors (blue line). The black line is observed temperature change.

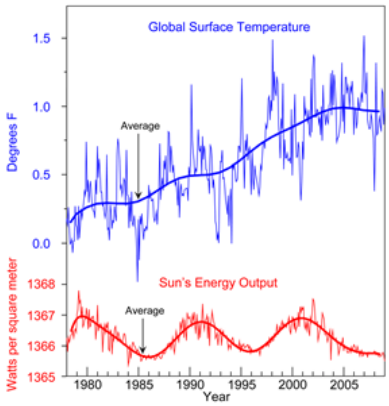
800,000 Year Record of (CO2) Concentrations

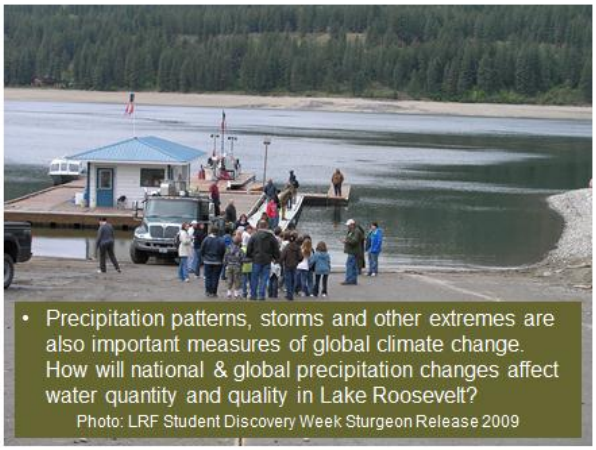


- Carbon dioxide concentration (parts per million) for the last 800,000 years, measured from trapped bubbles of air in an Antarctic ice core. More information: *Climate Change Impacts on the U.S.*

Energy from the Sun Has Not Increased

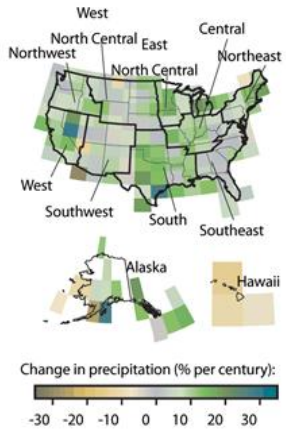
- Global surface temperature (top, blue) and the Sun's energy received at the top of Earth's atmosphere (red, bottom). Solar energy has been measured by satellites since 1978.





- Precipitation patterns, storms and other extremes are also important measures of global climate change. How will national & global precipitation changes affect water quantity and quality in Lake Roosevelt?

Photo: LRF Student Discovery Week Sturgeon Release 2009



USA - Annual Precipitation Trends 1901-2005

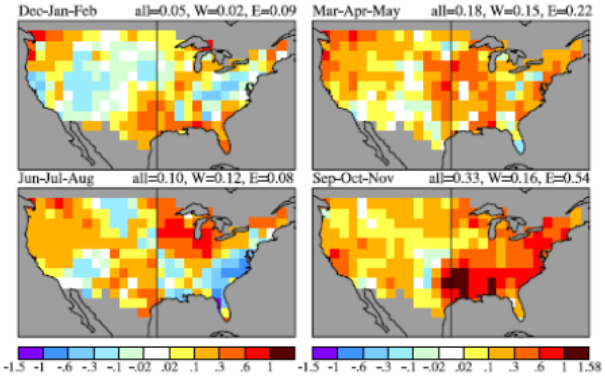
Where is the greatest increase in Precipitation?

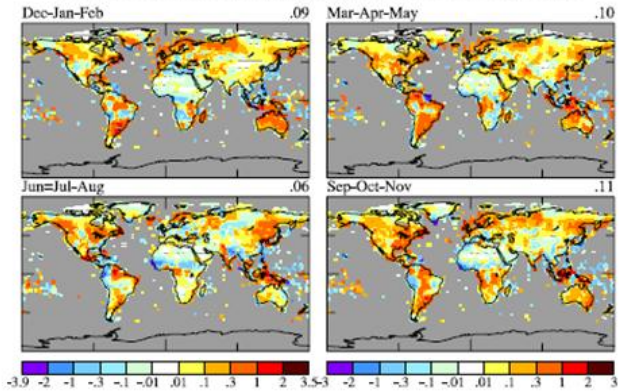
Where is the greatest decrease in precipitation?

15

USA Precipitation Changes 1901-2000

http://www.giss.nasa.gov/





What patterns do you see in precipitation changes?

Water Resources

Related Links

National Water Program Strategy: Response to Climate Change

USGCRP: Synthesis and Assessment Product 4.3: The effects of global change on agriculture, biodiversity, land, and water resources

IPCC Working Group II, Fourth Assessment Report, Chapter 3 (PDF, 38 pp., 3.59 MB, About PDF)

EXIT Disclaimer

All regions of the world show an overall net negative impact of climate change on water resources and freshwater ecosystems. Areas in which runoff is projected to decline are likely to face a reduction in the value of the services provided by water resources. The beneficial impacts of increased annual runoff in other areas are likely to be tempered in some areas by negative effects of increased precipitation variability and seasonal runoff shifts on water supply, water quality and flood risks (IPCC, 2007)

The future effects of climate change on water resources in the U.S. and other parts of the world will depend on trends in both climatic and non-climatic factors. Evaluating these impacts is challenging because water availability, quality and streamflow are sensitive to changes in temperature and precipitation. Other important factors include increased demand for water caused by population growth, changes in the economy, development of new technologies, changes in watershed characteristics and water management decisions.

In addition to the typical impacts on water management, climate change introduces an additional element of uncertainty about future water resource management. Water resources in the United States are heavily managed and supplies are scarce in some regions of the country. Strategies have been developed and continue to evolve to address these issues. Implementation of adaptation measures, such as water conservation, use of markets to allocate water, and the application of appropriate management practices will have an important role to play in determining the impacts of climate change on water resources.

The U.S. Global Change Research Program: Synthesis and Assessment Product 4.3 (SAP 4.3) addresses the effects of climate change on agriculture, land resources, water resources (water quantity and quality), and biodiversity. The primary goal of the report is to enhance understanding and ability to estimate impacts of future climate change on these systems.

The sections that follow will describe:

Water Availability: How changes in temperature, precipitation patterns, and snowmelt may affect water availability
Water Quality: How higher water temperatures and changes in the timing, intensity, and duration of precipitation may affect water quality
Possible Water Resource Impacts in North America

References

IPCC, 2007: Climate Change 2007: Impacts, Adaptation, and Vulnerability. EXIT Disclaimer Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Parry, Martin L., Canziani, Osvaldo F., Palutikof, Jean P., van der Linden, Paul J., and Hanson, Clair E. (eds.)]. Cambridge University Press, Cambridge, United Kingdom, 1000 pp.

http://www.epa.gov/climatechange/effects/water/quality.html

Water Quality

Higher water temperatures and changes in the timing, intensity, and duration of precipitation can affect water quality. Higher temperatures reduce dissolved oxygen levels, which can have an effect on aquatic life. Where streamflow and lake levels fall, there will be less dilution of pollutants; however, increased frequency and intensity of rainfall will produce more pollution and sedimentation due to runoff (IPCC, 2007).

Flood magnitudes and frequencies will very likely increase in most regions — mainly a result of increased precipitation intensity and variability — and increasing temperatures are expected to intensify the climate's hydrologic cycle and melt snowpacks more rapidly (IPCC, 2007). Flooding can affect water quality, as large volumes of water can transport contaminants into water bodies and also overload storm and wastewater systems.

Higher temperatures, particularly in the summer, earlier snowmelt, and potential decreases in summer precipitation could increase risk of drought. The frequency and intensity of floods and droughts could increase, even in the same areas.

Sea level rise may also affect freshwater quality by increasing the salinity of coastal rivers and bays and causing saltwater intrusion, movement of saline water into fresh ground water resources in coastal regions.

Changes in water quality could have implications for all types of uses. For example, higher temperatures and changes in water supply and quality could affect recreational use of lakes and rivers or productivity of freshwater fisheries. Certain species of fish could find temperatures too warm and migrate to more northern or higher altitude locations where water is cooler.
http://www.epa.gov/climatechange/effects/water/availability.html

Water Availability

Related Links

EPA's Climate Change Kids' Site: Water Cycle Animation

USGS: The water cycle

The movement of water between the land surface, oceans and atmosphere is called the hydrologic cycle. Water in the atmosphere is transported to the land surface and oceans as precipitation (rain,

snow or sleet). Upon reaching the land surface, water may immediately become streamflow, or it may infiltrate into the soil where it may later be taken up by plants or it can percolate to the groundwater. Surface streamflow and groundwater flow move water from the land surface to lakes and the ocean. Water re-enters the atmosphere as vapor either via evaporation from surface waters (ocean, lakes, etc) or transpiration from plants. This cyclical movement of water is driven by solar energy. An increase in net solar radiation or temperature will effectively speed up the processes within this cycle (evaporation, condensation, precipitation, etc).

Figure 1: The Water Cycle Click on Thumbnail for full size image

Due to complex interactions of changes in the hydrologic cycle with global circulation patterns and local weather patterns, an increase in energy in the hydrologic cycle does not necessarily translate into an increase in precipitation in all geographic regions. It is difficult to predict future changes in regional precipitation patterns. Predicting regional changes in streamflow and groundwater recharge due to climate change also remains challenging, particularly because of the uncertainty in regional projections of how precipitation may change (IPCC, 2007).

Changes in temperature, precipitation patterns and snowmelt can have impacts on water availability. Temperature is predicted to rise in most areas, but is generally expected to increase more in inland areas and at higher latitudes. Higher temperatures will increase loss of water through evaporation. The net impact on water supplies will depend on changes in precipitation (including changes in the total amount, form, and seasonal timing of precipitation). Generally speaking, in areas where precipitation increases sufficiently, net water supplies may not be affected or they may even increase. In other areas where precipitation remains the same or decreases, net water supplies would decrease. Where water supplies decrease, there is also likely to be an increase in demand, which could be particularly significant for agriculture (the largest consumer of water) and also for municipal, industrial and other uses.

Increases in temperature can affect the amount and duration of snow cover which, in turn, can affect timing of streamflow. Glaciers are expected to continue retreating, and many small glaciers may disappear entirely. Peak streamflow may move from late spring to early spring/late winter in those areas where snowpack is important in determining water availability. Changes in streamflow have important implications for water and flood management, irrigation, and planning. If supplies are reduced, off-stream users of water such as irrigated agriculture and in-stream users such as hydropower, fisheries, recreation and navigation, could be most directly affected (IPCC, 2007).

http://www.epa.gov/climatechange/effects/water/northamerica.html

Possible Water Resource Impacts in North America

Related Links

EPA's Global Change Research Program, Climate Change and Water Quality in the Great Lakes Region

USGS: Water Resources of the United States

Assessing Climate Change Risks to California EXIT Disclaimer

Climate Warming and Water Supply Management in California EXIT Disclaimer (PDF 49pp., 1.06MB, About PDF) EXIT Disclaimer

In general, the Intergovernmental Panel on Climate Change (IPCC, 2007) concludes that climate change will strain many of North America's water resources, increasing the competition for water. A warmer climate will affect the seasonable availability of water by increasing evaporation and reducing snowpacks. The Columbia River and other heavily used water systems of western North America are expected to be particularly vulnerable. Groundwater-based systems in the Southwest are also likely to be stressed by climate change. Heavier precipitation will very likely increase waterborne diseases and affect water quality, and higher variability of precipitation will make water management more difficult.

Potential water resource impacts for North America are listed below by region. (IPCC, 2001 and IPCC, 2007)

Alaska

The state is lightly settled and abundant in water resources. Potential ecological, hydropower, and flood impacts include:

Increased spring flood risks
Glacial retreat/disappearance in south, advance in north; impacts on flows, stream ecology
Increased stress on salmon, other fish species
Flooding of coastal wetlands
Changes in estuary salinity/ecology
Increased frequency of intense precipitation events - increased risk of flash floods

Northwest

The Pacific Northwest has a large and rapidly growing population, particularly along the coast; with lightly populated rural areas. Water abundance decreases from north to south. The region relies heavily on irrigation for agriculture and on hydropower for electricity production. These uses, along with endangered species issues, are increasing competition for water in the region.

Rise in snow line in winter-spring, possible increases in snowfall, earlier snowmelt, more frequent rain on snow, changes in seasonal streamflow, possible reductions in summer streamflow, reduced summer soil moisture
Possible increases in annual runoff in Cascades
Changes in lake and stream ecology - warmwater species benefiting; damage to coldwater species (e.g. trout and salmon)

West and Southwest

The West and Southwest have experienced rapid population growth but depend heavily on limited groundwater and surface water supplies. In the southern border region, there are also water quality concerns. Some rivers and canyons in the region are also subject to periodic flash flooding.

Likely reduction in snowpacks and seasonal shifts in runoff patterns
Possible declines in groundwater recharge - reduced water supplies
Increased water temperatures - further stress on aquatic species
Increased frequency of intense precipitation events - increased risk of flash floods
Possible summer salinity increase in San Francisco Bay and Sacramento/San Joaquin Delta

Midwest

America's agricultural heartland is mostly rainfed, with some areas relying heavily on irrigation.

Annual streamflow decreasing/increasing; possible large declines in summer streamflow
Increased likelihood of severe droughts
Possible increasing aridity in semi-arid zones
Increases or decreases in irrigation demand and water availability - uncertain impacts on farm-sector income, groundwater levels, streamflows, and water quality

Great Lakes

The states surrounding the Great Lakes are heavily populated. Variations in lake levels and flows would affect hydropower, shipping, tourism and recreation, municipalities, shoreline structures, and human health.

Possible lake-level declines
Reduced hydropower production; reduced channel depths for shipping
Decreases in lake ice extent - some years without ice cover
Changes in phytoplankton/zooplankton biomass, northward migration of fish species, possible loss of coldwater species in certain areas
Declines in water quality

Northeast

The Northeast states have a large, mostly urban population. The region has generally adequate water supplies, with a large number of small dams, but limited total reserve capacity. Floodplains in the region are heavily populated.

Decreased snow cover amount and duration
Possible large reduction in streamflow
Accelerated coastal erosion, saline intrusion into coastal aquifers
Changes in magnitude, timing of ice freeze-up/break-up, with impacts on spring flooding
Possible elimination of bog ecosystems
Shifts in fish species distributions, migration patterns

Southeast, Gulf, and Mid-Atlantic

These regions have experienced rapidly increasing population - especially in coastal areas. The region has some water quality and non-point source pollution problems, as well as stress on aquatic ecosystems.

Heavily populated coastal floodplains at risk to flooding from extreme precipitation events, hurricanes
Possible lower base flows, larger peakflows, longer droughts
Possible increases or decreases in runoff/river discharge, increased flow variability
Major expansion of northern Gulf of Mexico hypoxic zone possible - other impacts on coastal systems related to changes in precipitation/non-point source pollutant loading
Changes in estuary systems and wetlands extent, biotic processes, species distribution

References

IPCC, 2007: Climate Change 2007: Impacts, Adaptation, and Vulnerability. EXIT Disclaimer Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Parry, Martin L., Canziani, Osvaldo F., Palutikof, Jean P., van der Linden, Paul J., and Hanson, Clair E. (eds.)]. Cambridge University Press, Cambridge, United Kingdom, 1000 pp.
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