

Current Climate Studies 4:

CLIMATE CHANGE: PLANETARY AND NATIONAL PERSPECTIVES

1. Print this file. Also answer the "Concept of the Week" questions in the *Weekly Climate News File*. (Check for additional *News* updates during the week.)
2. Complete the Investigation by responding to the *Chapter Progress Questions (Study Guide)* and the Investigations 4A and 4B from the *Climate Studies Investigations Manual*, and this *Current Climate Study*.

Enduring ideas are statements summarizing important concepts, principles and core processes that are central to a discipline. Among enduring ideas we know about climate and climate change are the following:

- Fundamentally, climate is the story of how the solar energy intercepted by Earth is absorbed, scattered, reflected, stored, transformed, put to work, and eventually emitted back to space as infrared radiation.
- Earth's climate evolves through changes in external agents that affect the climate system and the climate system's internal dynamics.
- Earth's climate is undergoing change, as it always has and always will. The climate record shows change can be gradual or abrupt.

With these enduring ideas in mind, we will explore climate change and impacts based on the observational record. Our initial goal is to gain an overview of climate change from a planetary perspective.

Evidence of a Warming World:

As already reported in *Current Climate Studies 2 and 3 (CCS2 and CCS3)*, the instrument-based observational record from 1880 through 2015 as analyzed independently by NASA and NOAA reveals a generally rising global mean surface temperature that unequivocally confirms change in the state of Earth's climate system.

As stated in the NOAA *Global Analysis – Annual 2015* report, 2015 “marks the fourth time in the 21st century a new record high annual temperature has been set (along with 2005, 2010, and 2014) and also marks the 39th consecutive year (since 1977) that the annual temperature has been above the 20th century average. To date, including 2015, 15 of the 16 warmest years on record have occurred during the 21st century. 1998 is currently tied with 2009 as the sixth warmest year on record. ... Overall, the global annual temperature has increased at an average rate of 0.07° C (0.13° F) per decade since 1880 and at an average rate of 0.17° C (0.31° F) per decade since 1970.” (<https://www.ncdc.noaa.gov/sotc/global/201513>)

This global warming results from the addition of extra heat to Earth's climate system, primarily arising from the build-up of heat-trapping gases in the atmosphere. As you also recall from *CCS3*, the impact of such a build-up was explored via the *AMS Conceptual Climate Energy Model's (AMS CCEM)* comparison of the effects of an imaginary planet when the atmospheric CO₂ changes.

Numerous research studies, based exclusively on the observational record and fundamental principles of physics and chemistry, have quantified how much heat has been and is being added to Earth's climate system and where it is located. **Figure 1**, which also appears in your textbook, summarizes where the additional heat responsible for global warming resides in Earth's climate system.

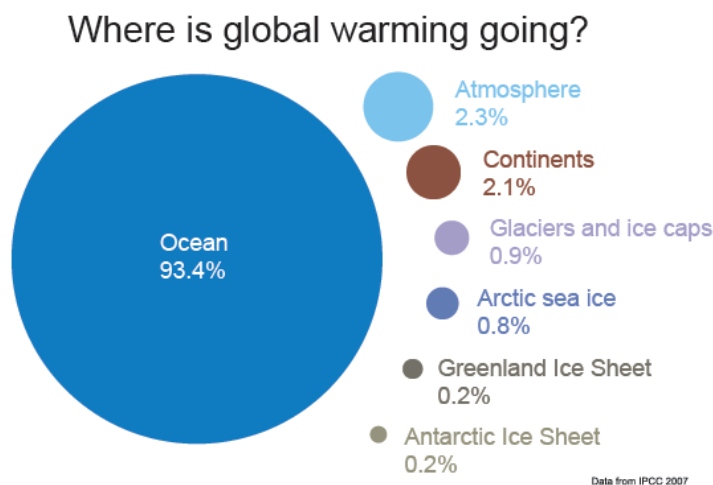


Figure 1. Reservoirs for heat added to Earth's climate system responsible for global warming. [2009 State of the Climate Highlights, NOAA]

- Figure 1 shows that most of the heat responsible for global warming that has been added to Earth's climate system resides in the _____.

- glaciers, ice caps, and ice sheets
- atmosphere
- continents
- ocean

About 71% of Earth's surface is covered by ocean, which contains 97% of the planet's water. Because of factors including its fluid motions and ecosystems, the global ocean plays a major role in shaping Earth's climate, its variability and change. Because of water's high heat capacity, the ocean holds the heat it accumulates while warming and cooling far more slowly than air. This sluggishness extends the impacts of human activity on the state of the climate for decades, centuries, and millennia into the future. **This is one example that demonstrates what we do today to perturb Earth's climate system will have far greater consequences on future generations than on us.**

Change in Total Heat Content of Global Ocean’s Top 2000 m

Figure 2 displays the change in heat content in the top 2000 m of the global ocean. In the figure, the blue line represents the pentadal (5-year) running average from the 1950s through 2011-2015, the black line the yearly average from 2005 through 2015, and the red line represents the 3-month running average from 2005 through April-June 2016. The year 2005 is significant as the beginning of the “Argo Era”, when the high-quality data collected by the global array of free-floating profiling floats began to be incorporated into global ocean heat content analyses.

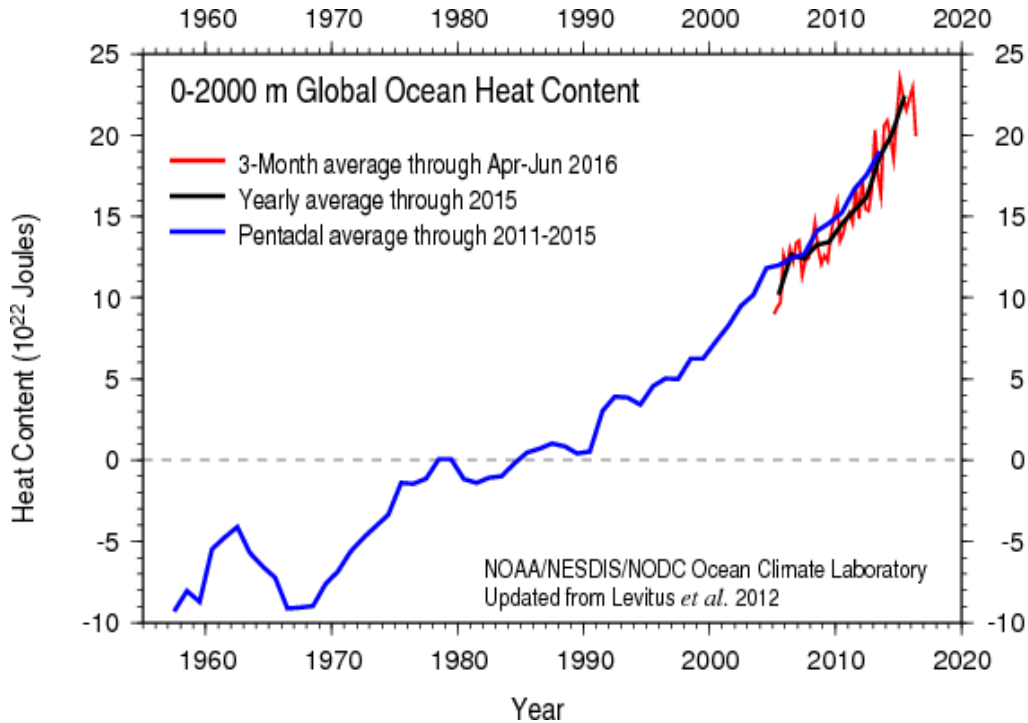


Figure 2. Global Ocean Heat Content in 0-2000 m layer. [NCEI/NOAA]

2. Figure 2 shows that from the late 1960s through 2015 the overall trend of 0-2000 m global ocean heat content was _____.
 - downward
 - no change
 - upward

3. NASA has reported that global ocean surface temperature since 1998 has been relatively steady with a slight upturn in the most recent years. As seen in Figure 2, the **0-2000 global ocean heat content has experienced an essentially continuous increase in yearly heat content over the same time period.** Because the ocean surface temperature has shown little change, it has to be assumed the additional heat content was _____.

- [] evenly distributed in the seawater from the surface downward
- [] positioned in the seawater somewhere below the ocean surface

The *Yale Climate Connections* website article “Examining the Recent Slow-Down in Global Warming”, September 2013, indicated that the top 2000 m of the world ocean warmed about 0.09 C degrees during the time period from 1970 to 2013. It also reports the UK’s Met Office calculated that if the same amount of energy had gone into the lower atmosphere, it would have raised its temperature about 36 C degrees!

A Global-scale Climate Change Impact Example: Coral Bleaching

Many changes have been directly observed in the global climate over the past century or so, with more significant changes evident in recent decades. Of the many that could be cited, a striking example is the increasing frequency that coral reefs around the world experience high enough water temperatures to produce **coral bleaching**. Coral bleaching results from conditions that cause coral death, and the loss of vibrant ocean ecosystems and their fisheries that feed millions of people. As the world ocean continues to warm, an increase in the number and intensity of coral bleaching episodes is inevitable.

Corals are marine colonial organisms. Most reef-building corals contain brightly colored photosynthetic algae, called *zooxanthellae*, which live in their tissues. The corals and algae have a symbiotic relationship, each benefiting the other, and many are unable to survive unless together. When corals become physically stressed, they expel their algae and become stark white, appearing bleached. Without zooxanthellae, corals starve to death.

Corals are vulnerable to bleaching when the sea-surface temperature (SST) exceeds what they would normally experience during the hottest month of the year. NOAA’s ***Coral Bleaching HotSpots*** report, which is updated daily, depicts a 5-km spatial resolution satellite view of sea surface temperature (SST) for a 7-day period ending on the date of the image. **Figure 3** describes the worldwide HotSpots during the week ending on 15 August 2016, approaching the last month of the Northern Hemisphere summer.

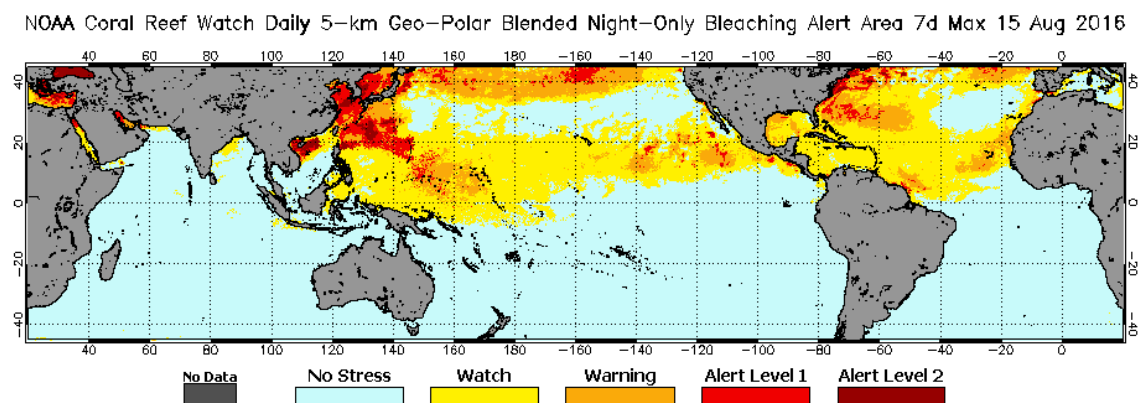


Figure 3. NOAA Global Coral Bleaching HotSpots, 15 August 2016. The more intense the red color, the greater the coral bleaching threat.

4. Figure 3 shows an extensive coral bleaching HotSpot in the _____ in mid-August 2016. For animations of a similar product for up to six months ending with the most recent: <http://www.ospo.noaa.gov/Products/ocean/cb/baa/anim.html>.

- Caribbean Sea
 western North Pacific Ocean
 Cape Verde islands off western Africa

5. Figure 3 is a NOAA product that assigns alert levels to places experiencing coral bleaching stress. The figure shows the general area identified in Item 4 above as having alert areas as high as _____. This level indicates mortality is likely. Definitions of the different stress levels, track current conditions or impacts of coral bleaching, and possible relationships to global warming by going to: <http://coralreefwatch.noaa.gov/satellite/baa.php>.

- Watch
 Warning
 Alert Level 1
 Alert Level 2

What Has Been Happening to the Nation's Climate?

The evidence is strong that global climate has demonstrated significant change, and so has the nation's climate. NOAA's *National Overview – Annual 2015* reports “In 2015, the contiguous United States (CONUS) average temperature was 54.4°F, 2.4°F above the 20th century average. This was the second warmest year in the 121-year period of record for the CONUS. The warmest year on record was 2012 when the annual average temperature was 55.3°F. This marks the 19th consecutive year that the annual average temperature for the CONUS was above the 20th century average. Since 1895, when the national temperature records began, the CONUS has observed an average temperature increase of 0.14°F per decade.” [<https://www.ncdc.noaa.gov/sotc/national/201513>]

Because its contents have been consistently validated by numerous independent research findings, the highly detailed USGCRP's third *U.S. National Climate Assessment (NCA3)* will be the AMS climate science *Current Climate Studies (CCS)* primary reference.

The *NCA3 Highlights* report will be the document most commonly referred to in the *CCS* course component.

To access *NCA3 Highlights*, go to the *RealTime Climate Portal* course website, scroll down to the Societal Interactions and Climate Policy section, and click on “National Climate Assessment (NCA3) Highlights”. Or, you can go directly to the Highlights report at http://www.globalchange.gov/sites/globalchange/files/NCA3_Highlights_LowRes-small-FINAL_posting.pdf. It is suggested that you “bookmark” this address as you will be returning to it frequently.

6. Read the section *Climate Change and the American People* starting on page 2. It reports evidence abounds that climate change is occurring. Observed warming and other changes in climate are producing impacts in nearly every region of our county that are _____.

- all negative
 all positive
 negative or positive, but mostly negative
 negative or positive, but mostly positive

7. Many of these wide-ranging impacts of climate change are detrimental largely because our society and its infrastructure are designed for the _____ climate. Next, begin reading the *Overview* section starting on page 4.

- past
 future

8. Independent evidence confirms that the primary cause of the global warming during the past 50 years resulted from human activities. The evidence shows that if there had been no human activities during that time, the global climate would have _____ during the past half-century. (Note the upper figure on page 5.)

- warmed about one-third of the observed amount
 remained steady
 cooled slightly

9. It is stated on page 5 that the U.S. average temperature increased 1.3 to 1.9 F degrees since 1895, and most of this increase occurred since 1970. It is further stated that in the next few decades temperatures are projected to increase _____ F degrees.

- 1 to 2
 2 to 4
 6 to 8

10. On page 6, the figure shows the observed changes in very heavy precipitation from 1958 to 2012, revealing a national trend toward a greater amount of precipitation being concentrated in very heavy events. The figure shows that the greatest observed changes occurred in the _____.

- Southwest
 Southeast
 Midwest
 Northeast

11. According to page 6, global sea level has risen about 8 in. in the past century, primarily due to expansion of warming seawater. It is projected sea level will rise another

to 4 feet in this century. It is mentioned on page 7 that nearly _____ million Americans live in areas less than four feet above the local high-tide level.

- 1
- 3
- 5

12. On page 9 it is mentioned that climate change affects human health in many ways. Certain groups of people are more vulnerable than others to the impacts of climate change. These include the _____.

- elderly
- children
- poor
- sick
- all of these

13. It is stated on page 10 that as the impacts of climate change become more evident, Americans face choices called response options. The magnitude of climate change will be largely determined by emissions of heat-trapping gases. Efforts referring to actions reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere belong to a category of response options known as _____.

- mitigation
- adaptation

14. The other major category of response options that refer to actions to prepare for and adjust to new conditions to reduce harm or take advantage of new opportunities, is called _____.

- mitigation
- adaptation

15. It is stated on page 10, that both mitigation and adaptation are essential parts of a comprehensive climate change response strategy. However the threat of irreversible impacts makes the timing of _____ especially critical.

- mitigation
- adaptation

Summary:

The observational record and scientific analysis verify that we are living in a warming world, with most of the extra heat added to the Earth system residing in the ocean. Coral bleaching is an example of the impacts of rising ocean temperatures resulting from the additional heat energy.

Focusing on the national scale, it is evident our country is experiencing climate change within ranges consistent with changes on the global scale. As with other locations on Earth, our climate variability and climate change have unique character. We will examine these by analyzing impacts on seven sectors – human health, water, energy, transportation, agriculture, forests, and ecosystems – and the interactions among sectors at the national level. The report also assesses impacts on U.S. regions: Northeast, Southeast and Caribbean, Midwest, Great Plains, Southwest, Northwest, Alaska, Hawaii and Pacific Islands, as well as the country’s coastal areas, oceans, and marine resources.

Instructions for Communications with Mentor:

Transmit this week’s work to your LIT mentor by Monday, 26 September 2016, or as coordinated with your mentor. Include:

- **Chapter Progress Response Form** from the *Study Guide* or the *RealTime Climate Portal* website.
- **Investigations Answer Form** for 4A and 4B from the *Study Guide* or *RealTime Climate Portal* website.
- **Current Climate Studies Answer Form** from *RealTime Climate Portal* website.

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