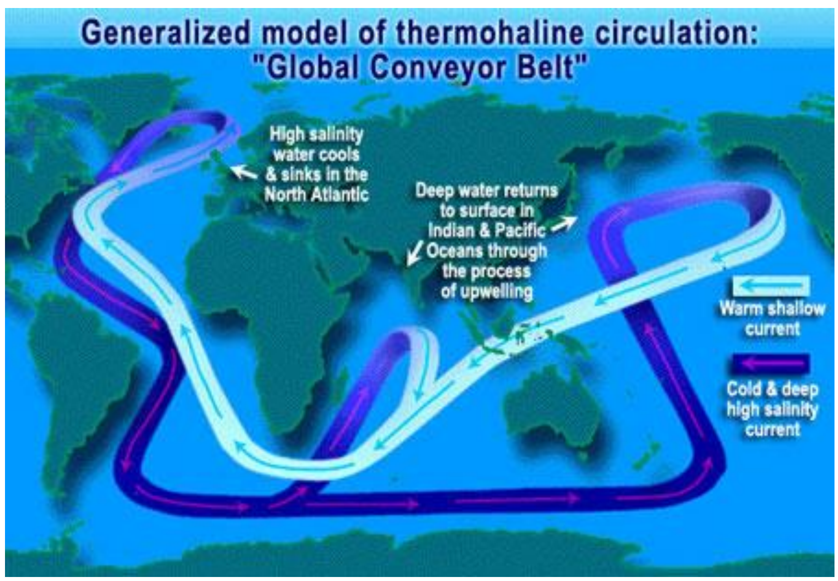
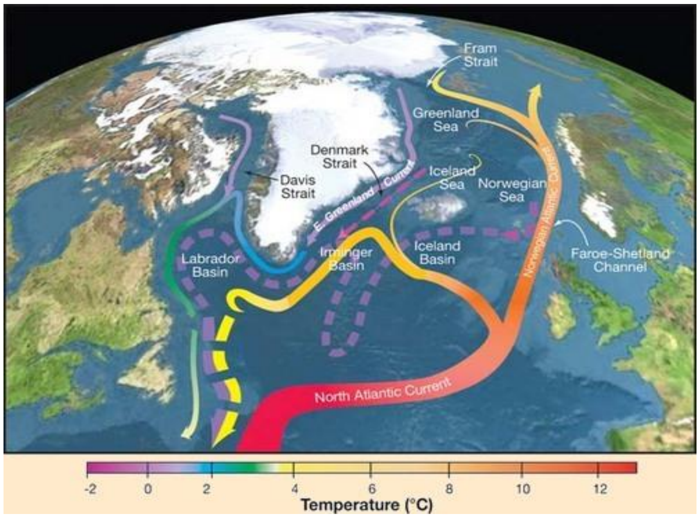
TEACHER BACKGROUND:
SOUND WAVES AND CLIMATE CHANGE

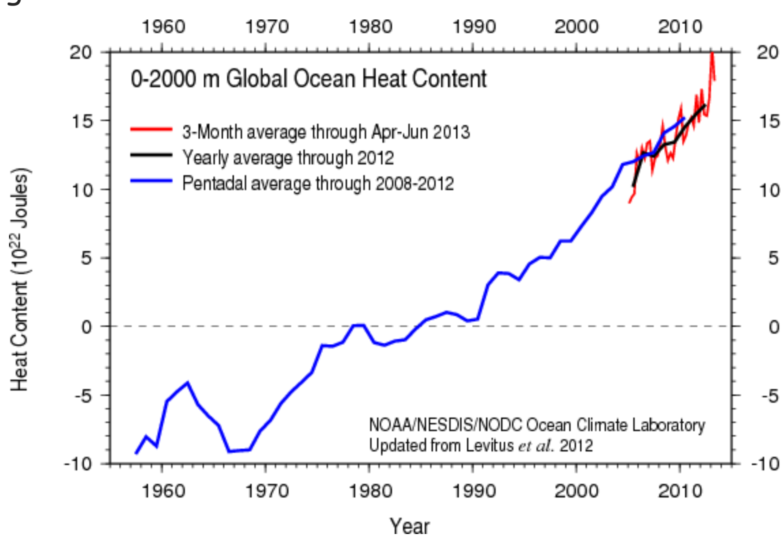
PART I: The Ocean- The atmosphere and ocean act as "heat engines," always trying to restore a temperature balance by transporting heat toward the poles. Our weather is an example of this phenomenon. Low-pressure systems, such as storms, which can be especially strong in winter, are one of nature's best ways of transporting heat toward the poles by atmospheric circulation. The oceans, by contrast, tend to transport heat in a slower and less violent fashion. Changes in the amount of sea ice alter how cold the poles are, which could affect atmospheric and ocean circulation.



Ocean currents transport heat from the equator to the poles through a heat- and saline-driven process called ***thermohaline circulation.*** Warm water moves from the equator northward along the ocean surface and eventually cools. As it cools, it becomes dense and heavy and sinks. This cold water then moves south along the lower part of the ocean and rises near the equator to complete the cycle. Like the atmospheric heat transport discussed earlier, this is a natural process that contributes to a proper temperature balance across the Earth. It also explains why Europe is relatively warm, because as northward flowing surface water in the Atlantic Ocean cools, heat is released to the atmosphere. However, this thermohaline circulation system can and is being disrupted, causing scientists to focus on events occurring in the northern most regions of the North Atlantic that maybe responsible.

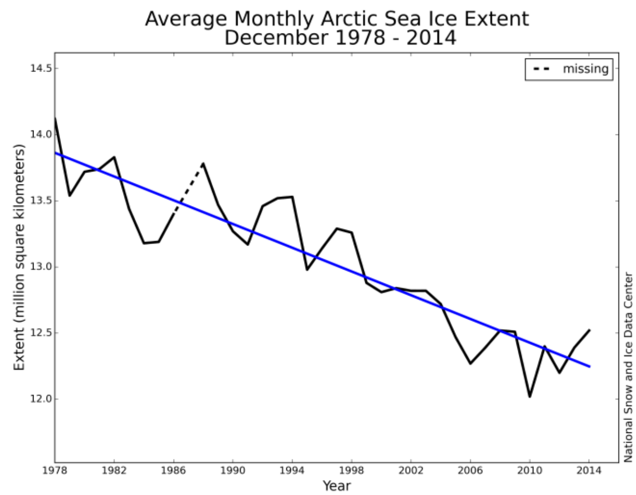


The Fram Strait is the only deep water connection between the Arctic Ocean and the World Ocean and therefore plays a crucial role for the exchange of surface and deep water masses in the high northern latitudes. Relatively warm surface waters that flow from the North Atlantic Ocean along the Scandinavian continental margin into the Arctic Ocean, and cold-ice covered waters that exit the Arctic Ocean through Fram Strait are sensitive elements of the oceanographic system. In particular the variable inflow of warmer waters that influence today the climate of northern Europe had also a considerable impact on the waxing and waning of large ice sheets in the Eurasian Arctic in the past. The passage is approx. 500 km wide separating the northeast of Greenland from the Svalbard archipelago in the east. Its sea floor depth and topography controls the exchange of water masses between the Arctic basin and the North Atlantic seas. The significant heat instability through transport of fresh water and sea ice southwards and transport of warm saline waters northwards, influences the thermohaline circulation at a global scale.



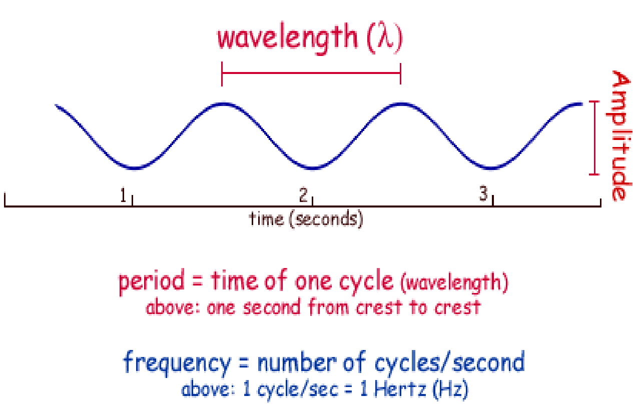
Water from the Fram Strait that runs between Greenland and Svalbard — an archipelago constituting the northernmost part of Norway — has warmed roughly 3.5 degrees Fahrenheit in the past century. The Fram Strait water temperatures today are about 2.5 degrees F warmer than during ***the Medieval Warm Period***, which heated the North Atlantic from 900 to 1300 and affected the climate in Northern Europe and North America.

Cold seawater is critical for the formation of sea ice, which helps to cool the planet by reflecting sunlight back to space and also allows Arctic air temperatures to be very cold by forming an insulating blanket over the ocean. Warmer waters could lead to major sea ice loss and drastic changes for the Arctic. The rate of Arctic sea ice decline is accelerating due to positive feedbacks between the ice, the Arctic Ocean and the atmosphere. As Arctic temperatures rise, summer ice cover declines, more solar heat is absorbed by the ocean and additional ice melts. Warmer water may delay freezing in the fall, leading to thinner ice cover in winter and spring, making the sea ice more vulnerable to melting during the next summer.



Air temperatures in Greenland have risen roughly 7 degrees F in the last several decades which is generally thought to be the result of an increase in Earth's greenhouse gases. Scientists feel that the accelerated decrease of the Arctic sea ice cover, the warming of the ocean and atmosphere of the Arctic measured in recent decades and the increased average temperature in Greenland are related to an increased heat transfer from the Atlantic and require further intense study.

PART 2: The Science-

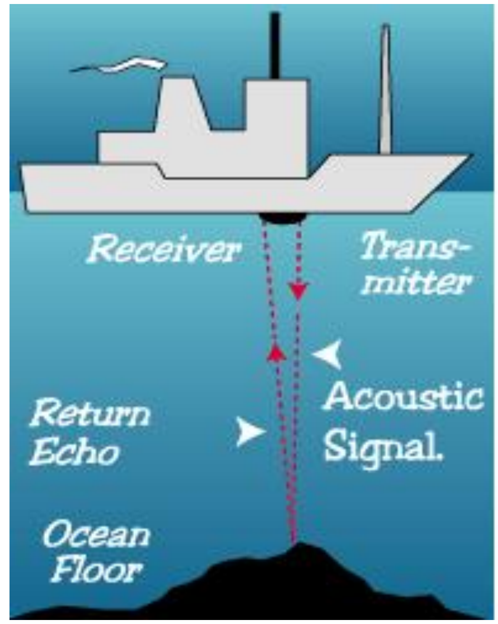


Sound is produced when matter vibrates and like light, travels through a medium in the form of ***waves.*** Sound waves are composed of a series of high and low points, much like the ***crest*** and ***trough*** of an ocean wave. The distance from one wave crest to another is known as a ***wavelength***. The rate at which a sound wave travels depends upon the type of medium (air, water, rock) that it is moving through. In air, sound travels approximately 1000 feet per second; in water it travels at about 4800 feet per second. A good example of how fast sound travels in air can be observed during a thunderstorm. If you see the flash of lightning, the distance from the lightning strike to your location can be calculated by counting the seconds until you hear the thunder and multiplying by 1000. For example, if you see lightning and count to five before you hear the thunder (5 x 1000=5000) then the lightning strike was about 5000 feet, or about 1 mile away.

Scientists know that in addition to the type of medium, its elasticity and density, the speed of sound is also determined by temperature. Lowering the temperature of a substance makes the motion of the wave particles more sluggish. The particles are more difficult to move and slower to return to their original positions. Therefore, sound travels faster at higher temperatures and slower at lower temperatures. Solids are much more elastic than liquids or gases, and allow sound waves to travel through them very quickly, at about 6000 feet per second. Liquids, because of their looser particle arrangement are not very elastic and so they are not good transmitters of sound.

PART 3: The Technology-Climatologists and oceanographers know that the effects of global warming will be 2-4 times greater in the Arctic than in the lower latitudes. The result would be the melting of the polar ice caps, adding fresh water to the ocean basins, raising global sea levels and disrupting the thermohaline circulation of the oceans. One way to know if and how much of an effect global warming has is to monitor the temperature of the northern ocean.

The basic idea behind the technology is simple and based on the fact that sounds travel faster in warm water than in cold water. The travel time of a sound signal from a ship to a land based receiver will decrease if the ocean water in between warms up and increase if it cools down. Scientists have designed and implemented an ***acoustic monitoring scheme*** between the coast of Greenland and Spitzbergen Island, an important location since about 80% of the heat flux into the Arctic Ocean occurs at this location.



Ice secured profilers transmit low frequency, “whale safe” sound across the strait to measure the average temperature of the water. The travel time is a direct measure of the average temperature between the source of the signal and the receiver. The measurements from this location will provide important information for reducing the uncertainty in global warming models as well as answers many questions.

The profilers go where scientists cannot, examining the ocean below the ice 24 hours a day, 365 days a year. These instruments are sleek sensor-carrying cylinders that crawl up and down a wire attached to bright yellow buoys implanted in the ice. The sensors measure water temperature, salinity, and pressure, sampling ocean properties from nearly a half-mile deep up to the ceiling of ice. Data are transmitted via satellite as soon as they are collected and are immediately available.