The effect of global warming on thermohaline circulation assignment

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Studies have been conducted in recent years on the effects of increase of greenhouse gases on the thermopile circulation. There are several hypotheses that state that the prolonged effect Of global warming could eventually “ shut down” the thermopile circulation and lead to cooling in certain regions in the North Atlantic Ocean. Several ocean-atmosphere models have been used to predict the effect of increase of carbon dioxide (a greenhouse gas) concentration on ocean circulation. Two such models are discussed and their results are analyzed. 1.

Introduction [2] Global temperatures have seen a dramatic increase since the Industrial Revolution. Several climate models have projected an increase of between 1. 10 C to 6. 0 C in the global average temperature due to the continued effect of global warming (EPIC (2007)). Apart from the resulting adverse effect on global climate, increasing global temperatures may result in species extinction, changes in agricultural production, deleterious effects on health, rise in the sea level, reductions in the ozone layer and disruption in the ice shelf.

Another possible outcome of global warming is what is now termed as the “ shutdown of the thermopile circulation”. Wallace S. Broker, the man responsible for the term “ Global Conveyor Belt”, called the thermopile recirculation the “ Achilles heel of our climate system” (Broker, 1997). There is much research that focuses on the effect of greenhouse gases on ocean circulation. Two such models are discussed in future sections. Some research has shown that the transfer of heat from regions around the CEQ tutor to the poles is due to the thermopile circulation in the ocean.

This implies that Europe does not have the same climate as the poles because of the thermopile circulation. The thermopile circulation therefore plays an important role in regulating the amount of sea ice in the Polar Regions. There re several schools of thought (Eager, Battista, Yin, Gordon, Nazi, Clement and Cane (2002)) that attribute this climate in Europe to its position with respect to the ocean basin and the warm atmospheric waves that blow up north from the tropics. Rhine and Hkeen (2003) challenged this claim.

According to Rhine and Hacking, “ it is the existence of the oceanic heat transport that allows the maritime effect to operate in the northern North Atlantic and to create a milder European climate than in the North America; without the heat transport, ice would likely extend over much greater areas of ocean and land”. Much research is currently focused on the role of ocean circulation in the supply of heat to Europe. 2. Thermopile Circulation [3] Ocean circulation is commonly divided into TV parts: the thermopile and the wind driven circulation.

In other words, circulation in the oceans is partly due to wind stress, and also partly due to changes in density because of changes in temperature and salinity. The term “ thermopile” originates from thermo for heat and haling for salt, which together determine the density of the water mass. [4] Thermopile circulation originates in pacific areas of the North Atlantic and in the Widely Sea of the Southern Ocean. In the North Atlantic, the evaporative cooling effect of winter is responsible for cooling the upper layers of seawater, increasing the salinity thereby increasing density and causing sinking.

The sinking cool water is the North Atlantic Deep Water (NADIA). The denser NADIA flows southwards into the ocean basins. The bulk of the water peels in the Southern Ocean, while some of the deep water causes further upwelling in the North Pacific and Indian Oceans. This movement of the deep water forms a giant conveyor belt hat covers a large part of the open ocean (figure 1). The Gulf Stream, for example, which is largely driven by thermopile circulation, transports warm water from the Caribbean northwards. Figure 1: Thermopile Circulation (Source: Brakes, 1 992, figure 10. 1, p. 186, as taken from Kerr, 1988). 3. Global Warming [5] The Intergovernmental Panel on Climate Change (EPIC), in February 2007, submitted a 21 -page report assessing the effect of global warming on global climate. The report stated that: “ most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations”. Emission of infrared radiation warms the Earth surface; the phenomenon is known as the Greenhouse Effect.

The dominant infrared absorbing gases in the Earth’s atmosphere are water vapor, carbon dioxide (ICC) and ozone (03). The interactions between greenhouse gas molecules and radiation can be explained by quantum mechanics. ICC and 03 molecules have vibration motions whose quantum states can be excited by collisions at energies encountered in the atmosphere. Industrial activities, such as fossil fuel ruining and other human activities such as cement production and tropical deforestation has increased the carbon dioxide concentrations in the atmosphere.

ICC is also a byproduct from automobiles, airplanes and building constructions. The importance of ICC as a greenhouse gas is very apparent and is therefore used as a parameter in determining the effects of global warming. 4. Review of models used to simulate the response of the Thermopile Circulation to increasing ICC [6] Several coupled ocean-atmosphere models have been used to simulate the response of ocean circulation to the increase in carbon dioxide in the atmosphere.

Mbabane and Stouffer (1993) conducted one such study; a coupled ocean-atmosphere model was used to simulate the increase of ICC in the atmosphere. Three integrations over a period of 500 years were conducted. In the first integration the atmospheric concentration of ICC was kept constant. The second and third integration involved increasing the atmospheric ICC at a rate of 1% per year, until it reached twice the original value at the 70th year (for the second integration) and four times the original value at the 14th year (for the third integration) and was maintained instant thereafter.

The change in ICC concentration caused the gradual disappearance of the thermopile circulation while doubling and quadrupling the concentration of ICC Most notably, in the North Atlantic Ocean, the thermopile circulation nearly vanished during the first 200 years in the coccyx integration (the integration carried out while quadrupling the ICC concentration in the atmosphere). During the first 140 years of the coccyx integration, the thermopile circulation rapidly weakens and continues to do so even after the concentration of ICC is held constant. The integration also showed a decrease in the formation of Antarctic Bottom Water.

The result of this integration shows that the gradual disappearance of the thermopile circulation leaves wind driven, shallow cells in the subtropics of the North and South hemisphere. Similar effects were observed in the coccyx integration. The thermopile circulation shows weakening intensity during the first 70 years of simulation, which continues until the 1 50th year, during which there is no change in the ICC concentration. But in the 50th year the thermopile circulation slowly begins to regain its original intensity, although not quite achieving it. 7] Mbabane and Stouffer concluded that the weakening of thermopile circulation in the coccyx integration is not due to its instability, but rather due to the adjustments made by the mechanism to the " evolving density structure" of the models Atlantic Ocean. This is apparent in the manner in which the circulation slowly regains strength in the later part of the coccyx integration. This does not happen in the coccyx integration, and the thermopile circulation shuts down. There were also notable changes in the Widely and Ross Seas, where he circulation became weak and shallow.

This in turn caused weakening of the deep-water formation and the northward flow of bottom water in the Pacific and Atlantic Oceans was affected. This weakening of the thermopile circulation is attributed to " the capping of the model oceans by relatively fresh water in high latitudes where the excess of precipitation over evaporation increases markedly due to the enhanced pollard moisture transport in the warmer model troposphere". [8] Schmeltzer and Stocker (1998) used a simplified coupled atmosphere-ocean model to study the possible effects of greenhouse gas emissions.

The findings were similar to Mbabane and Stouffer, with the model exhibiting a threshold value of ICC concentration beyond which the thermopile circulation shuts down and does not recover. The concentration of ICC is doubled here, and exhibits a shutdown; however the model is less sensitive than that of Mbabane and Stouffer. The model shows that the thermopile circulation breaks down for a value of 750 pump or higher. An equilibrium state is reached characterized by the absence of deep-water formation in the North Atlantic. 9] Mbabane and Stouffer (2003) revisited the effect of carbon dioxide on thermopile recirculation by conducting several integrations using a coupled atmosphere- ocean model for a time period varying between 4000 years to 1 5000 years. Similar to the study carried out in 1 993, the concentrations of ICC are doubled, quadrupled and halved. In each experiment " the response of surface temperature increases with increasing latitudes". In the coccyx experiment, thermopile circulation shows weakening before intensifying around the 200-year mark.

It fully regains its original intensity in the 60th year. The coccyx experiment shows the thermopile circulation reacting in a animal manner as earlier noted, however, it regained its intensity around the 1000-year mark. The weakening of the thermopile circulation in the coccyx and coccyx experiments is attributable to reduction in the surface salinity of the North Atlantic Ocean. With the warming of the troposphere (due to increased ICC concentrations), the moisture content in the air increases; this in turn enhances the transport of water vapor in the troposphere towards the poles.

The precipitation in the high latitudes goes up by a fairly high amount, which reduces the salinity and density of the North Atlantic waters. 5. Conclusion

[10] There are several hypotheses that state that the continued effect of global warming could eventually “ shut down” the thermopile circulation and lead to cooling in certain regions in the North Atlantic Ocean. Global warming could lead to an increase of freshwater in the upper oceanic regions, by melting glaciers, and thereby increasing precipitation into the ocean.

This increase in freshwater could have an adverse effect on the thermopile circulation which, as mentioned earlier, IS driven by changes in temperature and salinity. In 2004, NASA satellites recorded what seemed to be the slowing f the North Atlantic current. On April 15 of that year, NASA released a press statement stating that the “ slowing of this ocean current is an indication of dramatic changes in the North Atlantic Ocean climatic??’. A study of the ocean circulation in the North Atlantic by Harry Burden (2005) revealed that “ Atlantic meridian overturning circulation has slowed by about 30 per cent between 1957 and 2004”.

Burden’s finding Was viewed with speculation by the scientific and oceanographic community, especially since measurements conducted post 2005 showed a significant warming of the North Atlantic Current. However, the current overall climate is definitely changing; in particular sea- ice formation is less because of overall global warming. Burden predicts that the shutdown on the thermopile circulation could have severe repercussions on Europe, in that the temperature would change drastically. There could be major climatic changes such as an increase in floods and storms.

Warming or rainfall changes in the tropics or the poles could occur. While the rest of the scientific community felt Burden’s findings were not credible,

Delete Quadrates (2005) felt that there were a few observations that purported Burden’s work. Quadrates pointed out that climatic records have shown drops in air temperature by ICC in a few decades possibly caused due to abrupt changes in ocean circulation. Global warming is a very real threat to the human race. The question we face is whether global warming is in fact to going to affect the thermopile circulation.

Even though there is a large amount of research that is being conducted in this area, there is an equal amount of opposition to it. Sorrowing (2007) has called the increase of ICC concentrations the “ Greatest Scientific Scandal of our Time”. Sorrowing lams that the EPIC assessment of global warming in 2007 was purely a political move, “ prepared by governmental and United Nations bureaucrats”. In another article in 2007, Sorrowing also claimed that the increase of ICC is not due to human activity but by atmosphere-ocean gas exchange and other causes of natural climatic fluctuations.

Numerical models may provide a fairly decent idea of the functioning Of systems, but there is always the danger Of erroneous statistical methods and the use of boundary conditions that don’t necessarily reflect the real world. However, at the risk of sounding trite, reversion is better than cure. The risk of man entering a new ice age is very real as of now, and will remain so until research shows otherwise. There are studies that speculate that the shutdown of the thermopile circulation is what previously led to the Younger Dryads (the big freeze) period (Creameries, 2006).