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Earth's Water: a Refrigerant that Manages Anthropogenic and Solar Heats and Fights Global Warming

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Abstract: The role of anthropogenic carbon dioxide (CO₂) in global warming and climate change is confusing. Experts in greenhouse effects predict that changes in ocean level and atmospheric temperature, which are still presently very small, will increase considerably in distant future. On the other hand, the melting of ices is already dramatic. Greenhouse gases, in particular CO₂, are said responsible but do not explain the dominance of ice melting. Nevertheless, the reduction of fossil sources of CO₂ is universally recommended. A correlation between ice melting and anthropogenic heat releases was recently proposed on the basis of well-identified chemical and physical fundamentals. To further investigate this original approach, the present contribution compares the management of the fraction of solar heat absorbed on Earth to the thermodynamic cycle used to control the temperature in refrigerators. The discussion shows that absorbed solar heat and anthropogenic heat are managed similarly using water as refrigerant. It is also shown that the combustion of hydrocarbons releases a huge amount of new water on Earth. However, this extra water remains minor compared to the water issued from the ices melt cumulated year after year. The last part proposes to use heat-cycle assessment from cradle to grave as means to compare different energy sources in the search for ways to minimize anthropogenic heat release. Water electrolysis could be a climate- and environment-friendly source of renewable hydrogen-based energy if the required electricity to generate hydrogen can be produced on a large scale with better heat-cycle and life-cycle than traditional sources.

Keywords: Climate changes, Fossil sources of energy, Anthropogenic heat release, AHR, Greenhouse effect, Heat-cycle assessment, Water phases equilibria.

1. Introduction

So far, the predictions of climate changes are based on hypotheses and calculations of data for the far future. There is a large consensus to assign the temperature control on Earth to balanced capture and reemission of solar energy by in and out exchanges of electromagnetic radiations and by greenhouse effects. Atmospheric carbon dioxide is considered as playing the role of thermostat in setting the equilibrium temperature on the Earth. It differs from a house thermostat in that carbon dioxide itself is a potent greenhouse gas warming the environmental elements. Global balance meant that Earth does not retain the Solar energy when input and output are said equivalent [1-2]. However, balancing is no longer claimed. A small part of the solar energy is now proposed as absorbed by the environment where it causes heating that has to be globally balanced otherwise the Earth would grow warmer and warmer [3-5]. If part of the solar energy is retained, it has to come in addition to the excess of greenhouse heating due to CO₂ to predict atmosphere and ocean temperature rises. A few years ago, NASA introduced the cycle water as means to control the global climate according to a mechanism based on evaporation-precipitation of water and proposed a program intended at monitoring polar ice evolution [6]. The occurrence of dramatic ice melting is now clearly observed at the levels of ice caps, glaciers, and permafrost [7]. However, ices melt is generally considered as a source of ocean rise and not specifically as a climate regulator.

In a previous article [8], we suggested that the concepts and methodologies of chemistry and physics can be exploited to speculate about Earth's global climate despite the absence of

possibility to demonstrate climate-related phenomena experimentally because of the complexity and the size of the planet. Anthropogenic heat release (AHR) was introduced as alternative or as complement to the greenhouse-based heat-generation mechanism. This approach led to several major conclusions that may be confirmed or ruled out in no more than a decade. Firstly, the climate anomalies that warn a majority of scientists, politicians, media, and at the end each of us, may be related to anthropogenic heat supply issued from the different sources of energy via conductive transfers by the chaotic atmospheric turbulences and the ocean streams without calling on greenhouse contribution. Secondly, the anthropogenic heat released in the environment can be reasonably correlated to the evaluated global ices melt in fast growing since year 2000, something that could be neglected before when AHR was much smaller than today. Thirdly, fighting anthropogenic CO₂ as source of greenhouse effect may not be the right solution if the replacing sources of energy generate similar amounts of anthropogenic heat releases. Last but not least, the present and continuous production of anthropogenic heat should lead to disappearance of ices. Until this occur, ices melt will continue to absorb AHR and the retained solar heat until no more ice is available. The balancing of these heat sources will be then ensured by the physical back and forth moves of the equilibria that govern reversible liquid ↔ vapor water phase transitions. This analysis led to the conclusion that controlling the population growth and searching for solutions to access climate-friendly energies with better yields in work and less in residual heat production may be the right policy, fossil oil remaining essential to specific applications like chemistry and productions of derived matters unless Green Chemistry provides alternative accesses.

The present contribution aims at strengthening the above conclusions by showing that solar radiations that have been heating the global environment for billions of years and the heat newly appeared as by-product of the energies consumed by humans are both managed similarly and simultaneously to keep Earth's environmental elements under relative control. For billions of years, the Earth was a huge globe, the solid surface, the surface water and the atmosphere of which heat because of excitation of molecules by interaction with the absorbed radiative Sun energy. The heating remained more or less balanced otherwise the temperature would have grown continuously. Several thousand years ago, humans mastered the fire and started using biomass as source of energy in addition to solar one. There was a change 150 years ago when they started exploiting oil, producing electricity, and extracting natural gas, all for the production of the goods, the work, and the heat they needed. The side effect was the appearance of anthropogenic heat that started complementing the solar one. This extra energy had to be compensated too. In other words, Earth is like a huge mammalian body. She has to be cooled in one way or another to absorb the solar and anthropogenic heats that warm her. In the following, we are going to show that the control of heat on Earth resemble that of the temperature inside a refrigerator, water playing the role of refrigerant through its interdependent physical states of water, namely ice, liquid, and vapor.

Let us see first the principle of a refrigerator

From a thermodynamic viewpoint, an air-conditioning system and a refrigerator are both based on the same physical rule, i.e. when two substances are in contact, the hot one supplies heat to the cold one up to equilibrium. In a cooling device, the transfer of heat proceeds by change of physical state of a volatile fluid, the refrigerant. Heat is absorbed locally by the evaporation of the fluid, transported by the gas and released from it by condensation in a different place. To some extent this is how the temperature of humans and mammals is fixed. An amount of warm liquid water present in the body is expelled through the skin by perspiration. The sweat cools the surface and the interior of the body by evaporation in the

atmosphere. However, the diffusing the water in the atmosphere. Any transfer of heat from a atmosphere. Here the transfer of heat from the hot body to the cold atmosphere is spontaneous and rather slow. In contrast, heat exchanges from a cold medium to a hot one cannot be spontaneous. Some energy must be supplied. It is the role of the compressor that is present in air-conditioning machines and refrigerators. For humans, there is no compressor and the pressure in tissues is the sole driving force that pushes water outside prior to its evaporation to keep the inner temperature constant. A schematic representation of a refrigerator is shown in Figure 1. The main stages of the cooling process are the following:

Stage 1: Evaporation

From 1 to 2 in Figure 1, the refrigerant enters the inner evaporator as a liquid. Going through this multi-tube device, the liquid absorbs part of the heat present in the closed space and from what is in it. As a result, the liquid is turned to gas at the outlet of the evaporator while the temperature inside the closed space decreases slightly.

Stage 2 : Compression

From point 2 to point 3, the gas is pressurized in the compressor where it is super-heated by compression prior to transfer to the multi-tube condenser located outside.

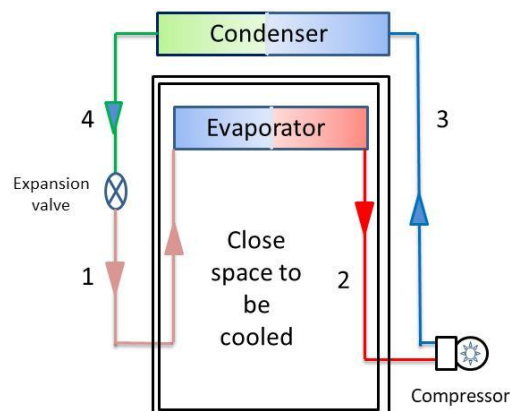


Figure 1 - Schematic representation of a Vapor Compression-Refrigeration cycle

Stage 3 : Condensation

From point 3 to point 4, the pressurized gas enters the condenser. The initial part of the cooling process in the condenser is contact with the outer cold air that decreases the temperature of the gas before turning it back to liquid. This step is where the heat absorbed by the refrigerant at the evaporation stage is vented out to atmosphere.

Stage 4 : Expansion of the subcooled and highly pressurized refrigerant

From point 4 to point 1, the high-pressure subcooled liquid passes through the expansion device which reduces its pressure and controls the flow into the evaporator. The cycle is repeated until the temperature in the refrigerator reaches the temperature set at the thermostat.

2. Application to Solar thermal energy managing on Earth

If Earth is an opened system in terms of electromagnetic radiations, it is a close system in terms of heat of solids, liquids and gas she is made of. Accordingly, the ground surface, the water (oceans, seas, ponds and rivers), the atmosphere bound to the globe by gravity, and the ices (polar caps, glaciers and floating ices) have been heated by the Sun for billions of years in the past without heat accumulation. These environmental elements can be compared to the goods inside the refrigerator when the temperature is fixed. However, there are differences. The compressor present in Figure 1 to speed up the thermal exchanges from hot to cold zones is replaced by chaotic turbulences in atmosphere (winds, streams, tornadoes, hurricanes) and oceans (hot and cold streams). The condenser is replaced by the cold atmosphere where vapor condensates to form clouds. The refrigerant present in the cooling circuit of the refrigerator is replaced by water, and the heat release during cloud formation is eliminated by radiation out to the space. The whole process is schematized in Figure 2.

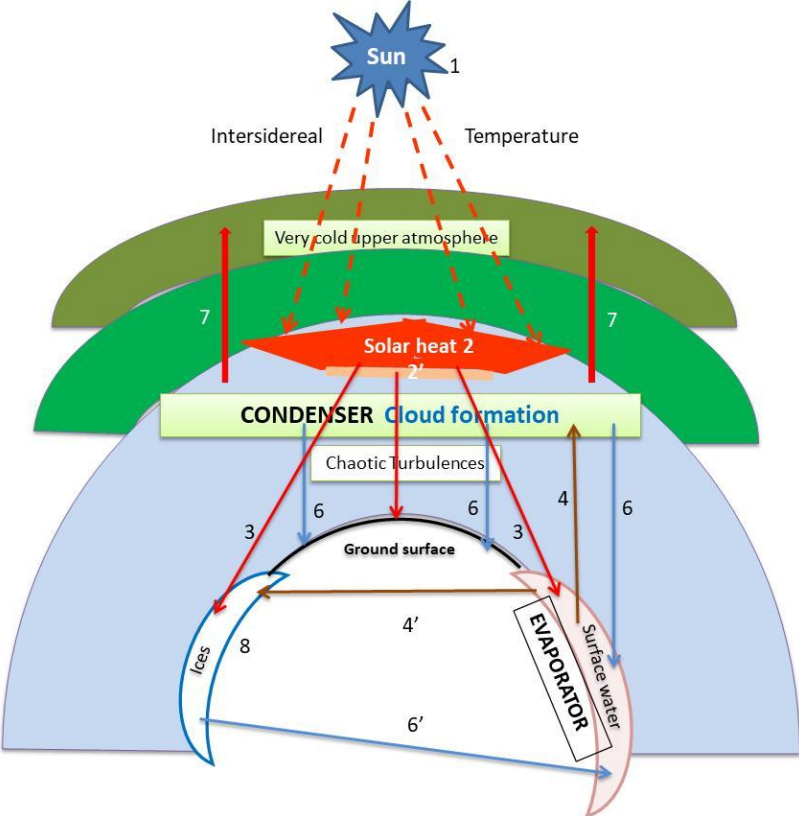


Figure 2 : Schematic representation of the machinery that manages residual solar heat energy through water phase exchanges

The Sun (1) heats the whole environment as everybody feels it under sunshine (2 and 3). Greenhouse effect-dependent energy (2') comes in addition. The turbulences dispatch these heats within the multilayered atmosphere in contact with the very cold intersidereal medium on one side, and with ground, ices and surface water through the low atmosphere on the other side. The supply of geothermal heat is generally considered as negligible. The temperatures of the ground surface and of the ocean tend to increase but part of the responsible heat is slowly balanced by the melting of ices (4' and 6'), at least globally. The other part is balanced by the process of evaporation (evaporator) that cools the water and transfers the corresponding heat to the atmosphere as slightly warm vapor (4). The air enriched in warm vapor being less dense than dry air rises up to a zone cold enough to condense the vapor as dispersed droplets forming clouds while the heat stored in the vapor is released to the upper cold atmosphere

which irradiate it away like at the stage of the condenser in a refrigerator (7). Once clouds are formed, rains (6) close the cycle and return water to the surface. Such cycle is not uniform. In reality, the Sun does not heat continuously. Earth inclination and rotation lead to cyclic heating and cooling according to day and night, summer and winter, North and South hemispheres, and Sun long cycles. The process of melting and reforming of ices is thus cyclic with ups and downs as in a refrigerator. As in a refrigerator too, if all the ices disappear, the inner temperature starts rising unless the thermostat restarts the cycle that reformed ice. In the case of Earth, when all the ices will have melted, temperature balancing will then be handled by right shift of the water evaporation↔condensation interphase equilibrium, i.e. up to the formation of a thick cover of clouds that will block the input of solar heat and regenerate ices [8].

3. The evolution after the appearance of Anthropogenic Heat

The climate controlling process described in the previous section worked for billions of years managing Sun and biomass-related heat by cyclic ice melt and reformation and by radiation to space. The exploitation of fossil oil-derived energy started bringing in extra heat in the middle of the 19th century. Then, natural gas and more recently electricity came that all were sources of cumulated extra heat to be balanced. The new situation is schematically represented in Figure 3.

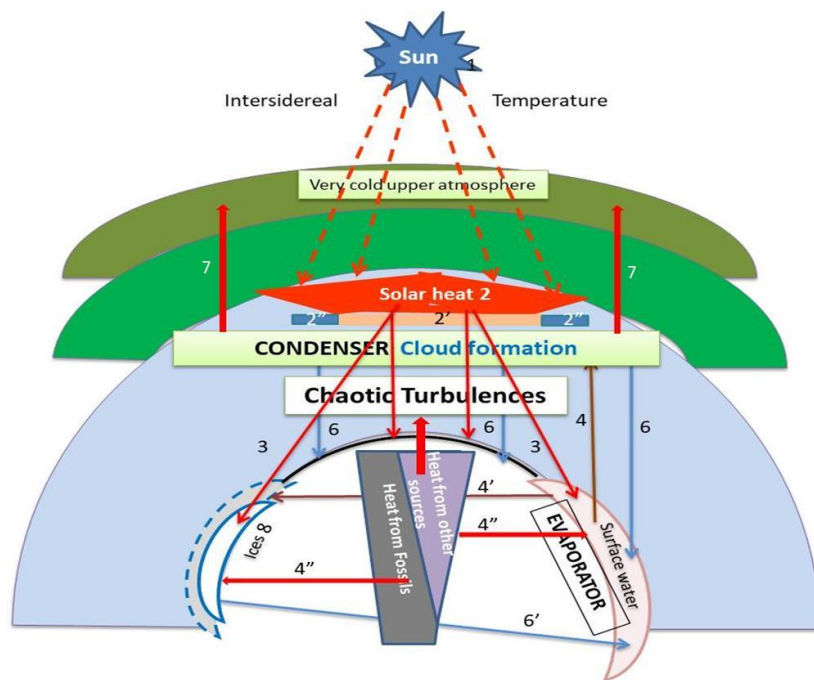


Figure 3: Schematic representation of the management of increasing amount of anthropogenic heat through evaporation-condensation-evaporation and balanced by ices melt.

The comparison between Figures 2 and 3 does not reveal great change relative to the whole thermal machinery. The solar energy still heats the Earth dominantly (2) but the resulting greenhouse part (2') is now complemented by the contribution of anthropogenic greenhouse gas (2''). On the other hand, the released anthropogenic heat from fossil sources and electricity complements the usual solar heat supply and thus contributes as a surplus to the heating of atmosphere, surface water, and ices. As consequences, more surface water evaporates (4) and more ices melt (8). Extra warmed vapor is generated to absorb the surplus

of heat. This warm vapor rises to the cold zone of the atmosphere where it condenses to release the stored heat and to form more clouds than when Sun was alone. This cold water is like the cooled refrigerant leaving the condenser of a refrigerator. It goes back to surface water as rains but raining is now more frequent and more important relative to the case in Figure 2 (6). The temperature of the atmosphere and that of ocean water are then partly controlled by the evaporation-condensation mechanism and by more important chaotic turbulences (hurricane, tornado, rain, flooding, etc..) that occur locally to increase the dispatching and the averaging of heat exchanges over the whole world. In parallel, ices melt to cool atmosphere and oceans as it did in the far past for the part of the solar heat absorbed by Earth. The difference between the past and today's situations is that the Sun activity is still modulated by daily, annual and longer cyclic ups and downs while AHR occurs almost continuously over days and nights, this in acceleration year after year.

4. What about the water generated from fossil hydrocarbons?

For a majority of scientists who try to understand and account for climate changes, the anthropogenic heat generated by humans and human's activities is negligible relative to the effects of greenhouse gas, especially those related to the CO₂ issued from fossil sources of energy. Among these sources, coal, which is mainly composed of carbon, generates hot carbon mono and dioxide on burning but no water, at least directly. In contrast, all the hydrocarbons (oil, natural gas, and biomass) generate hot CO₂ from the carbon content and hot water vapor from the hydrogen one. We already discussed the contribution of this anthropogenic hot vapor as part of AHR [8]. However, once the heat is transferred to the environment, the cooled water previously chemically stored in hydrocarbons behaves as a surplus of water on Earth.

Quantifying the amount of such extra water is as difficult as quantifying heat releases. Nevertheless, data on the overall production of fossil oil and natural gas are available and provide means to estimate the extra water produced by the combustion of hydrocarbons of fossil origin. Between 1870 and 2018, about 180 Gt of oil and 30 Gt of natural gas have been extracted [9-10], i.e. about 210 Gt of hydrocarbons. To compensate the complex composition of oil and natural gas, one can assume that these fossil hydrocarbons including methane (CH₄) are composed of alkanes the general chemical formula of which is C_nH_{2n + 2} reasonably simplified to nCH₂. Accordingly, 210 Gt of oil or oil equivalent contain c.a. 180 Gt of carbon and 30 Gt of hydrogen. From the general equation CH₂ + 3 O₂ → CO₂ + H₂O + heat where 14 g of hydrocarbon (12 + 2) generates 44 g of CO₂ (12 + 32) and 18 g of water (16 + 2), both compounds being hot, one can deduce that 210 Gt of hydrocarbons produced about 270 Gt of extra water that join the pool of water already present in 1870. Compared to the water released by 240 Gt of ices lost in 2018 [8], the estimated 270 Gt of extra water cumulated on Earth since 1870, that corresponds to c.a. 1 year of recent ices losses, is rather small but may not be negligible. This water was inserted in the environment and dispatched between atmosphere, ground and liquid water. The part that ended in the atmosphere may have added extra greenhouse-type heating considering the higher efficiency of water relative to CO₂. This possibility has not yet been addressed as far as we know. Anyhow, AHR will become more and more problematic if oil and natural gas consumption continue growing year after year as is doing the energy production [11]. Fighting the sources of CO₂ is a solution in the context of surplus of greenhouse effects. However, this policy looks inadequate and nonsense relative to AHR-related climate changes since the growing humanity is going to need more and more energy for comfort, activities and more generally the economy. Trying to

minimize the consequences on the climate while keeping the growth of energy consumption may rapidly appear like attempting to square the circle.

5. An attractive potential solution

Any solution will have to satisfy the energy demand with much less production of heat than today. This is going to be essential to slow down ices melt and avoid chaotic turbulences amplification. Hydrogen is a potential solution because it can be produced from water and it regenerates water after exploitation as source of energy according to the reaction: $\text{energy} + \text{H}_2\text{O} \rightarrow \text{H}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{energy} + \text{H}_2\text{O}$. This chemistry is of particular interest if the energy needed to dissociate water by electrolysis is produced by low heat-producing renewable sources of electricity [12]. However hydrogen is still largely issued from oil-based chemistry. What is presently missing to decide whether a source of energy is better than another relative to AHR is a heat-cycle assessment from cradle to grave as it is currently done when life-cycle assessment is used to compare matters and materials relative to their impact on the environment [13]. So far it seems that no information is available regarding the heat-cycle of wind turbines and solar sources of electricity to compare with the other sources of energy and their relative thermal impact on the climate. Hydro-electricity may be of particular interest in this regard. It should be the task of specialists of thermodynamics together with climatologists and maybe scientists of other disciplines to make such evaluations.

6. Conclusion

To complete the previous analysis that led to the attribution of the important ice melt observed during the last 19 years to anthropogenic heat releases, heat management on Earth was compared to that which cools the inner part of a refrigerator. The comparison showed that water acts as a refrigerant to transfer absorbed solar heat, and anthropogenic heat as well, to the upper atmosphere cooled by radiative transfer to space. It was also shown that on Earth, as in a refrigerator, ice helps to control the temperature until it disappears completely. In addition to their contribution to the formation of anthropogenic heat, this work emphasized that hydrocarbon-based sources of energy generate hot water. This newly formed water, once condensed, joins year after year the water present before the exploitation of oil and gas. However, this additional water is still minor compared to the water generated by ice melt. Finally, an assessment of the heat-cycle of the sources of energy is proposed to compare them and determine which ones may replace those currently exploited while producing less heat and CO₂ too. Water seems to be an interesting candidate if the derived hydrogen can be produced by electrolysis with competitive heat-cycle and life-cycle assessments in relation to climate and environment, respectively. The comparison relative to other sources of energy on the basis of heat-cycle and life-cycle assessments will have to be done by scientists of different disciplines working cooperatively.

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