Refrigerator as Model of How Earth's Water Manages Solar and Anthropogenic Heats and Controls Global Warming

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Key points

- Water controls Earth's global temperature via interphase equilibria as a refrigerant does in a refrigerator heated from inside and outside
- Applying water thermodynamic properties showed the predominance of evaporation-condensation in heat absorption and dispatching
- Fighting CO_2-producing fossil sources of energy may not be sufficient to avoid worsening of climate events in the future

Abstract:

The relation between global warming and the role of anthropogenic carbon dioxide (CO_2) is confusing. Ocean level and atmospheric temperature rises are predicted dramatic in distant future whereas global ices disappearance is already dramatic and increasing. In this article, we called on the heat control machinery exploited in a refrigerator to show that water behaves as a refrigerant to manage solar and anthropogenic heats and also any heat generated from sources localized on Earth. Year 2018 was taken as example for quantitative evaluation of heat energy transfers involved in water phases and interphase exchanges. It was concluded that ice melting and evaporation-condensation equilibria are efficient physical factors to fight global warming. It is also shown that the pool of water present on Earth is progressively augmented by the water liberated parallel to CO_2 during the combustion of fossil hydrocarbons in which it was stored millions years ago. Water as source of hydrogen may be an alternative to the sources of energy produced and consumed by humanity provided that heat-cycle assessment from cradle to grave complements the life cycle assessment favorably.

Plain language summary

Today, successive IPCC global warming-related reports predict dramatic atmosphere temperature and ocean rises in rather distant future. These evolutions are assigned to anthropogenic greenhouse gas, notably carbon dioxide, generated by fossil sources of energy exploited in the world. However, everybody can observe that heat is also generated directly in the low atmosphere by the

exploitation and consumption of all sources of energy and not only fossil ones. Production of electricity and its exploitation by cars, trains, planes, electric appliances, wildfires, etc.… heat the entire environment. The present work compares the management of solar and heat released in the environment to the mechanism that controls the temperature in the interior of a refrigerator. It is concluded that water plays a role of refrigerant via ice melting and evaporation-condensation phenomena and manages solar and anthropogenic heats similarly. According to the present study and in contrast to present predictions, the global temperature should not raise as much as predicted by IPCC. In contrast, cloud formation, rains, winds, storms, hurricanes, etc. should increase in frequency and damages. Hydrogen is proposed as alternative to fossil sources of energy. However its potential must be assessed positively relative to both thermal and environmental impacts.

1. Introduction

So far, the predictions of climate changes are those reported in successive Intergovernmental Panel on Climate Change (IPCC) reports (IPCC, 2014; IPCC, 2022) issued from an international consensual exploitation of the available literature to predict climate changes in distant future. The trends are still small but nevertheless detectable today. The consensus is adopted almost universally although controversies exist, the dispatching of which is limited to articles in open access archives, blogs and magazine outlets [Dunlap & Jacques, 2013].

Until recently, global climate changes were assigned to imbalanced inputs and outputs of electromagnetic infrared radiations and to anthropogenic greenhouse gas, especially CO_2, considered as sources of radiative anthropogenic heat release at the top of the troposphere (rAHR) (IPCC, 2014; NASA, 2009; Mackenzie & Lerman, 2006) without consideration to heat in the low atmosphere, notably anthropogenic heat release (eAHR), also known as waste heat energy, generated by the sources of energy produced and exploited by humanity for works. In the past, only rAHR related to greenhouse gas was taken into account and considered as absorbed predominantly by oceans (Hansen, et al., 2011**;** Trenberth et al., 2014; IPCC, 2014). rAHR is said resulting from electromagnetic radiative flux that amounted annually from 0.5 to 1 W/m^2 in the early 2000s (Trenberth et al., 2014; IPCC, 2014), i.e. between about 8 and 16 x 10^{21} Joules (8 and 16 Zeta Joules (ZJ)). The AR6 IPCC reports an observed annual average rate of heating of the climate system at 0.79 [0.52 to 1.06] W m^{-2} (12.7 ZJ) for the period 2006–2018 (IPCC, 2022). Regardless of its origin, heat energy released or generated in the atmosphere has to be evacuated to space otherwise it is absorbed and causes warming as it is proposed in the case of residual radiative forcing assigned to greenhouse gas. According to (IPCC, 2022), "*ocean warming accounted for 91% of the heating in the climate system, with land warming, ice loss and atmospheric warming accounting for about 5%, 3% and 1%, respectively (high confidence)*".

In general, global ice was considered a negligible heat absorber relative to oceans (Hansen et al., 2011; IPCC 2022). Based on outstanding facilities including satellites, NASA is the reference body to quantify ice imbalance and its role on the polar environment (Scott & Hansen, 2016). The occurrence of dramatic global ice loss is now certain, especially over the recent years, and concerns different ices, namely ice caps, sea ice, glaciers and permafrost (Rignot et all, 2019; Slater et all, 2021). Ices melting is generally considered as a source of ocean rise (Allan & Liepert; 2010) on top of temperature-dependent dilatation. Long considered negligible, eAHR is now more and more regarded as a contributing factor to climate changes. The context and the history are well introduced in a recent publication (Yang et al, 2017) in which the authors proposed an algorithm to evaluate global eAHR. This approach consisted in calculations based on heat energy estimates derived from urban zones. Although there were limitations, the algorithm provided multi-scale anthropogenic heat information said reliable and useable for further research on regional or global climate changes and on urban ecosystems despite difficulties to establish ratios for converting energy consumption to anthropogenic heat.

Earth, as living systems, is too complex to be represented experimentally so that exploitations using climate models is necessarily based on local measurements or on global averaged data like radiative forcing in term of flux in W/m^2. We recently attempted a different approach (Vert, 2021) based on ice loss, fundamentals of chemistry and physics and annual global energy consumptions derived from various sources (fossil ones, biomass, nuclear electricity, etc.) found converted in oil-equivalents (Martin-Amouroux, 2015; BP, 2019). According to (Manowska, & Nowrot (2019), eAHR corresponds to c.a. 60 % of the global energy consumption, the rest being consumed to provide work. On the basis of this estimate, it was deduced that eAHR released from all the energy sources in the low atmosphere between 1994 and 2017 provided enough thermal energy (7.2 ZJ) to melt 77% (Vert, 2021) of the 28 trillion tonnes of disappeared ice reported recently for the same long period (Slater et all, 2021). The corresponding 0.31 ZJ annual average eAHR estimate was effectively negligible when compared with the 12.7 ZJ estimate of annual average rAHR deduced from the 0.79 W/m^2 annual average rate of heating of the climate system applied to the surface of the planet (IPCC AR6, 2022). As ices imbalance is a partial signature of heat energy supply regardless of its origin, the large dominance of rAHr, a source of energy assigned to CO_2-based radiative forcing, raises a question: why rAHR that is said warming the environment does not cause much greater ices imbalance than presently observed since, in physics, any source of heat tend to transfer part of it to its environment up to equilibrium?

In attempt to answer this question, , let us consider that solar radiations have been heating the global environment over billions of years without dramatic heat accumulation despite occurrence of short and long and more or less important local ups (high temperature) and downs (glaciation) periods. The relative stability included natural greenhouse effect assumed the origin of a 15°C excess of average temperature relative to an atmosphere-free Earth. eAHR, rAHR and any other sources of heat on Earth have to be managed similarly and simultaneously to solar heat to keep Earth's environment and climate under relative control and compatible with Life. Indeed, the Earth can be schematically considered as a huge globe with land, solid matters, surface water and atmosphere heated locally since no matter or molecule can escape in intersidereal space. Only the energy stored in molecules can escape to space through radiation phenomena.

A few thousand years ago, humans began to use biomass as sources of heat and light. The generated eAHR remained very small compared with solar inputs until about 150 years ago when humans began to exploit fossil sources and, more recently, nuclear energy and renewable resources for the production of electricity in order to satisfy work, heat and comfort needs. The side effect was the appearance of increasing eAHR in the low atmosphere in addition to rAHR in the high troposphere (Yang et al.; 2017). Therefore, Earth can be compared to a mammalian body which has its metabolism generating heat in a closed space, the body. This body which burns foods has to be cooled to keep its temperature constant. Cooling is provided by the evaporation of sweat. If water cycle has been recognized for years as an important factor in climate control (Allan & Liepert; 2010), water evaporation and condensation have not been considered as important to limit the storage of radiative forcing in oceans.

The present article aims to compare Earth's water with the refrigerant that controls the temperature inside a refrigerator, a simpler example than human body, where inner heat has to be eliminated. Results are discussed relative to global warming and climate changes.

2. The refrigerator

From a thermodynamic viewpoint, a refrigerator is based on a simple rule: "when two substances are in contact, the hot one supplies heat to the cold one up to equilibrium". In a refrigerator, the transfer of heat proceeds by evaporation-condensation of a volatile fluid: the refrigerant. Heat is absorbed locally by the evaporation of the fluid, transported by the gas phase, and released from this gas by condensation outside as human and mammalian bodies do. The expulsed sweat cools the surface and the interior of the body by evaporation in the atmosphere until perspiration is no longer necessary.

The transfer of heat from a hot medium to a cold one 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 present in air-conditioning machines and refrigerators. For humans, there is no compressor and the pressure in tissues is the sole driving force to push water outside. A schematic representation of a refrigerator is shown in Figure 1. There are four main stages to control the inner temperature:

2.1 Evaporation

From 1 to 2 in Figure 1, the volatile 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, including that of foods 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.

2.2 Compression

From point 2 to point 3, the gas is pressurized in the compressor where it is super-heated by compression and then transferred to the multi-tube condenser located outside, generally in the back.

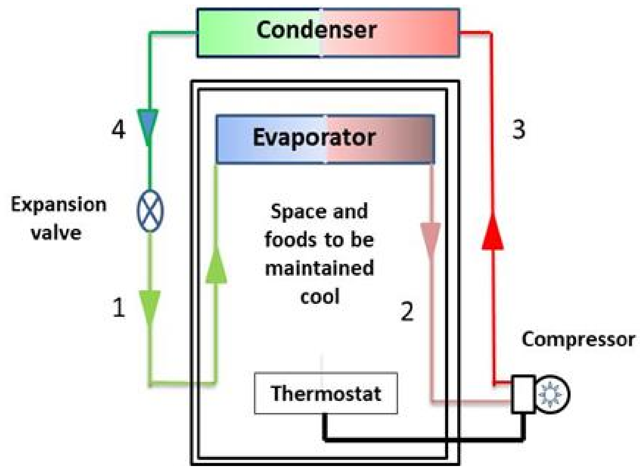

Figure 1**:** Schematic representation of a Vapor Compression-Refrigeration cycle.

2.3 Condensation

From point 3 to point 4, the hot pressurized gas enters the condenser. The initial part of the cooling process in the condenser is contact with the outer cold surface that decreases the temperature of the gas and finally turns it back to liquid. This step is where the inside thermal energy absorbed by the refrigerant at the evaporation stage is vented out to atmosphere. The condenser in the back of the refrigerator is hot as it can be easily observed.

2.4 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 of liquid into the evaporator (stage 1). The cycle is repeated until the temperature in the refrigerator reaches the temperature set at the thermostat otherwise the inner temperature would continue to decrease with ice formation on the walls of the internal compartment, something everybody can observe in a freezer.

3. Application to Solar energy management on Earth

The components of the environment (atmosphere, land, oceans, etc.) have been heated by the Sun for billions of years and kept without dramatic heat accumulation. These environmental elements can be compared to the foods placed inside a refrigerator where the temperature is controlled. However, there are differences. The compressor present in Figure 1 that allows and speeds up thermal exchanges from cold inside to hot outside is replaced by the mechanical and mixing actions of chaotic turbulences in atmosphere (winds, streams, tornadoes, hurricanes, storms, etc.) and oceans (hot and cold streams) that dispatch heat within the whole environment. The condenser is replaced by the cold zone of the atmosphere where vapor condenses at dew temperature to form clouds from which the heat stored at the evaporation stage is released to space. The refrigerant present in the cooling circuit of the refrigerator is replaced by water, and the heat energy released during cloud formation is eliminated from the high atmosphere partly by radiation to space, partly by return to the surface via rain and snow. The whole process is schematized in Figure 2. It is important to note that the concentration of water molecules above clouds is much lower than below. This low concentration is favorable to radiation transmission to space according to the Beer-Lambert law, in contrast to the case of $CO_{2,}$ the concentration of which is not affected by condensation (Sirroco, 2018).

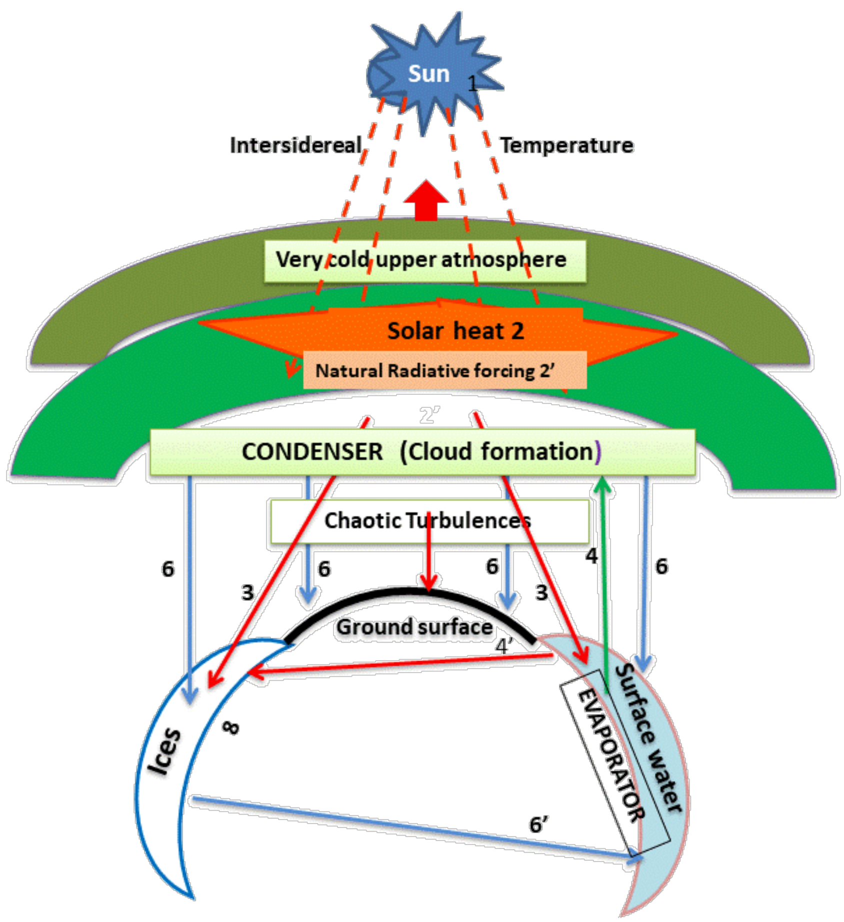

Figure 2: Schematic representation of the machinery that manages residual solar

heat energy through water phase exchanges.

In this scheme, the Sun (1) heats the whole environment as everybody feels it under sunshine (2 and 3). Natural greenhouse effect is included in (2'). Humid air ascension and atmosphere turbulences dispatch and tend to average local imbalanced heat and raise it to the multilayered atmosphere in contact with the very cold intersidereal medium on one side, and with ground, ice and surface water on the other side. It is worth noting that in contrast to humid air, the dense CO_2 tends to go down. The supply of geothermal heat is generally considered negligible as many other heat sources on Earth are, including the combustion of fossil fuels ((Zhang & Caldeira, 2015) and electricity-related ones. The temperatures of land surface and of oceans tend to increase but rising is unavoidably limited by heat absorption by the melting of ices (4' and 6') over the whole globe and also by the process of evaporation (evaporator) that cools ocean and surface liquid water (the refrigerant) and transfers the corresponding heat to the atmosphere as warm vapor (4). The air enriched in warm vapor being less dense than dry air, it rises up to a zone cold enough to condense the vapor as dispersed droplets and ice particles forming clouds from which the released heat is eliminated by radiation (7) and rains and snow (6) that close the cycle. In reality, the Sun does not heat continuously. Earth inclination and rotation lead to cyclic heating like day and night, summer and winter, North and South hemispheres, and the Sun long cycles. The process of ices melting and reformation is thus cyclic with ups and downs as in a refrigerator. If all the ice disappears inside the refrigerator, the inner temperature starts rising up to the outside one unless the thermostat restarts the cycle to reform ice. On Earth, the thermostat consists in water interphase equilibria. In hot summers, ices melt. In cold winter, ices are restored but the process is more and more imbalanced. If ice imbalance continues to grow, all ices will disappear sooner or later and warming will then be controlled by the sole right shift of evaporation vapor condensation interphases equilibria. This will occur progressively over the years with more and more clouds to form a thick cover that will tend to limit the solar input like durst particles and aerosols do. Less solar heat will lead to ices regeneration like in past glacial eras (Miller et al., 2012). The temperature control by evaporation-condensation depends on the latent heat of evaporation but it depends also on many dynamic factors that are major obstacle to quantification. Anyhow, temperature rise or not, the more heat to be dispatched over the globe, the stronger and the more frequent chaotic environmental have to be, at least qualitatively (Fig. 2), a trend already observed today (Reed et al., 2021) although temperature rise is no more than a few hundredths of a Celsius degree annually. Water cycle has been already proposed as climate factor but generally without involving ices and not in terms of quantitative water interphase equilibria.

4. The evolution after the appearance of Anthropogenic Heat

The controlling process described in the previous section worked for billions of years to manage Sun, volcanoes and biomass-burning heats by cyclic ice melt and reformation and by radiation to space. The exploitation of fossil energy started bringing in extra heat in the middle of the 19th century and alerted people recently. In parallel, both natural gas and, more recently, electricity provided progressively more waste heat in the low atmosphere. The new situation is schematically represented in Figure 3.

The comparison between Figures 2 and 3 does not reveal important differences relative to the heat managing thermal machinery. Solar energy still heats the Earth dominantly (2) but now with anthropogenic heat releases eAHR (2”). Both rAHR and eAHR anthropogenic heat issued from the consumed energy are dispatched in the atmosphere (4’ and 4”) for averaging over the whole planet. The corresponding surplus of heat is absorbed by oceans, ices melt (8) and water evaporation (4) to close the ring like in section 2.

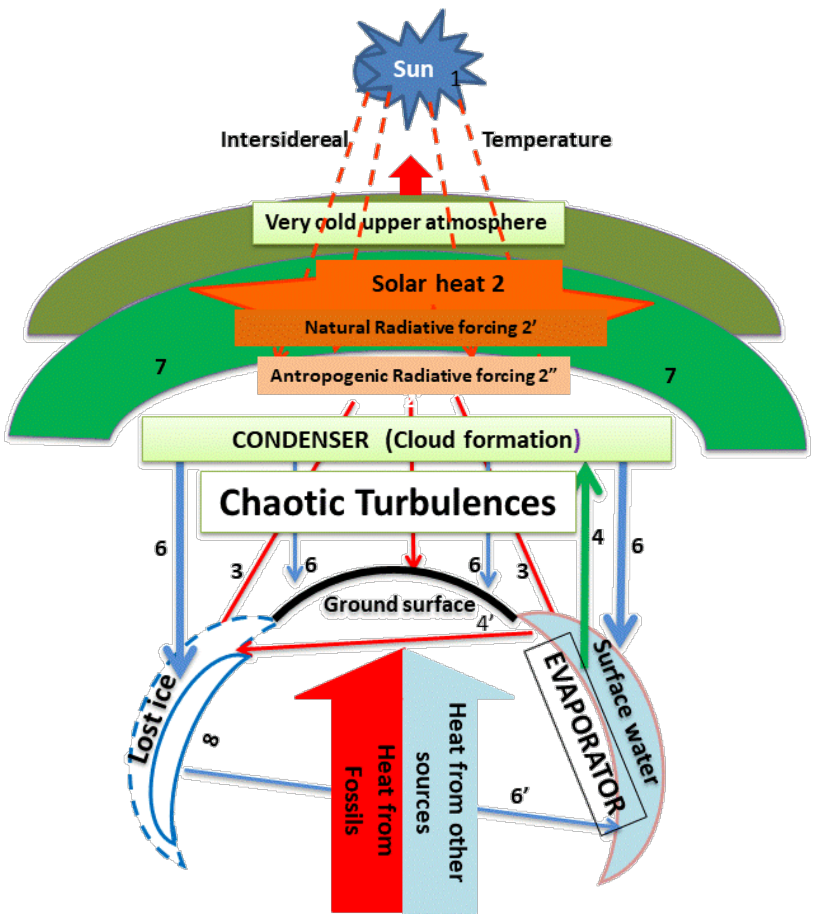

Figure 3: Schematic representation of the management of increasing amount of anthropogenic heat through evaporation-condensation-evaporation and ices melting.

Having to dispatch more thermal energy, local chaotic climate perturbations (hurricanes, tornados, storms, rains, streams, etc...) become more important and more frequent. In contrast to Sun, rAHR and volcanoes that caused discrete heating, eAHR warming related to human activities around the globe occurs over days and nights.

5. Attempts to quantify the action of water as refrigerant

In this section, we look at where the mechanisms schematized in Figures 2 and 3 can lead on the basis of thermodynamics characteristics typical of the water cycle, namely, the 333.55 KJ/Kg latent heat of ice melting, the 2,447 KJ/Kg latent heat of evaporation at 14°C, the 2.11 KJ/Kg/°C specific heat capacity of solid ice and the 4.184 KJ/Kg/°C specific heat of water, various factors with minor effects like salinity, CO2 dissolution in ocean and cloud liquid water, dusts, etc. being neglected (Engineering Tool Box, 2003).

To estimate and compare rAHR and eAHR in terms of Joules, the following data available for year 2018 were used:

- 14°C, the average temperature of Earth's surface determined from multiple land and ocean local measurements (NOAA; 2021), a value considered common to low atmosphere and ocean surface water;

- 0.79 W/m2 the average radiative forcing (IPCC, 2022);

- 0.03°C and 3.7 mm, the temperature and ocean level respective changes (IPCC, 2022);

- 1.5 trillion tonnes ice imbalance assumed similar to the estimate of 2017 deduced from Figure 4 in (Slater, 2021);

- 20°C, the average temperature of global ices, a temperature proposed in (Slater, 2021); and

- 13.864 GT of oil equivalent, the global energy consumption (BP, 2019), 60 % of which generated 0.35 ZJ eAHR according to 44 MJ/Kg, the average heat of combustion.

According to the specific heat capacity of ice, 1.5 trillion tonnes of ice at -20°C required about 0,063 ZJ to reach 0°C, the melting temperature of ice. Then, the temperatures of ice and formed liquid water remained constant at 0°C during the melting of the whole mass of disappeared ices that required c.a. 0.50 ZJ of thermal energy according to ice latent heat of fusion. The heat energy necessary to melt 1.5 trillion tonnes of ice at -20°C and form 1.5 10^{15} Kg of liquid water at 0°C required about 0.56 ZJ. In addition, bringing 1.5 trillion tonnes of water from 0 °C up to 14°C, required about 0.09 ZJ according to the specific water heat capacity. In total, the heat energy necessary to turn the disappeared ices at -20°C to water at 14°C was thus about 0.65 ZJ (0.56 + 0.09). In other words, the disappeared 1.5 million tonnes of ices absorbed 0.65 ZJ of heat energy introduced in the low atmosphere, regardless of its origin.

The estimate of eAHR did not take into account the injection of Joules in the atmosphere by mammalians (humans, cattle and animals with hot blood), hydrogen-using rockets, criminal wildfires and volcanoes. Based on 80 W per capita, 7.5 billion humans generate about 0.02 ZJ annually to which a minimum of 0.01 ZJ can be added due to cattle. In 2018, 80 volcanoes were active, the Hawaii eruption being the largest with c.a. 0.76 10^9 cubic meters of lava. Assuming density, specific heat capacity and difference of temperature of lava being 2.6, 840 J/Kg/°C and 1000°C, respectively, the heat released by the Hawaiian volcano after cooling was c.a. 0.002 ZJ. Assuming an average of 0.001 ZJ/volcano, heat released by volcanoes was in the range of 0.08 ZJ. Wildfires could hardly be estimated but like volcanoes, they are very likely negligible relative to the 0.35 ZJ of eARH that finally represent less than 3% of the 12.7 ZJ of radiative forcing deduced from the 0.79 W/m^2 annual average rate of heating of the climate system for the period 2006-2018 applied to the surface of the planet (IPCC, 2022). This large difference of magnitude between annual e and rAHRs has already been pointed out in the literature (Chaisson, 2008; Zhang & Caldeira, 2015) but for different systems and under different conditions.

In terms of thermodynamics, the estimate of total anthropogenic heat energy released in the atmosphere in 2018 stored in the climate system was about 13 ZJ (0.35 + 12.7). 0.65 ZJ were absorbed by the lost ices, leaving 11.7 ZJ absorbed by oceans (90% of 12.35 ZJ) and land and atmosphere for the rest based on IPCC's mechanisms. Basically, the storage of heat energy in liquid raises the temperature of this medium unavoidably. However, when ice is present, melting fights temperature rise like when an ice cube is in a glass of water under summer sun. Therefore, one may ask why the 2018 ice imbalance was not much greater than the 1.5 trillion tonnes estimate (Slater, 2021). There are several possible reasons. Firstly, radiative forcing was largely overestimated, a hypothesis going against the current universal CO_2-based claim but defended by some specialists of electromagnetic radiations who goes up to denying CO2-related anthropogenic warming (Sirroco, 2016; Humlum, 2022; Guesken, 2020). In this case, the share of eAHR would become predominant or the only source of anthropogenic heat to be eliminated. Secondly, atmospheric and oceanic streams were far from equilibrium and thus were not efficient enough to dispatch and homogenize the radiative forcing up to the surface. Last but not least, the heat absorbing capacity of evaporation was able to absorb the huge excess of eAHR and justify the absence of more important ice imbalance. Evaporation was mentioned about 200 times in IPCC's AR5 WG1 report (IPCC, 2014), but only relative to its effect on salinity, pan evaporation, balance of evaporation-precipitation, localization and not in terms of heat absorption and temperature regulation. Secondly, the AR6 2022 report mentions only "it is virtually certain that evaporation will increase over the oceans" with no consideration to associated heat exchanges.

In 2018, the average ocean level rise was about 3.7 mm in rather good agreement with the 4 mm generated by a surplus of 1.5 trillion tonnes of ice-derived liquid water in oceans. In parallel, the annual average global ocean and land temperature rises was estimated about 0.02-0.03 °C (NOAA, 2021). Temperature rising observed when a compound is heated depends on the thermal characteristics and the mass of this compound. Based on the 4.184 KJ/Kg/°C heat capacity of salt-free water, a 1 dm thick layer of ocean surface water (361 10^{14} dm3 or 361 10^{14} Kg) is able to absorb about 0.15 ZJ of heat energy for 1° C rise. This means that a minimal layer of more than 200 m would be necessary to absorb 11.7 ZJ with 0.03°C homogeneous temperature rise. In contrast, evaporation, that plays an essential role in a refrigerator, is able to absorb 2,247 KJ/Kg according to the latent heat of water evaporation at 14°C, the temperature of the warmly heated source being maintained constant, basically. The surface of Earth covered by water being about 390 10^6 km^2 or 390 10^{14} dm^2, the evaporation of 1dm layer of ocean water can absorb 95.5 ZJ without temperature change. Therefore, evaporation is about 600 times more efficient than ocean surface water to absorb global anthropogenic heat energy and fight global temperature change due to warming conditions.

6. Water released from fossil hydrocarbons

In the previous section, the discussion was based on a constant mass of water on Earth dispatched as solid, liquid, vapor and clouds since matter cannot escape to space. However, the combustion of all hydrocarbons (oil, natural gas, and biomass) that generates hot CO_2 from the carbon content generates also water as hot vapor from the atoms of hydrogen included in molecules. Once the heat stored in these hot gases is transferred to the environment; the cooled and condensed hot water constitutes a surplus that joins the existing pool of liquid water. It is important to note that heat produced by biomass burning is not compensated at the stage of biomass formation because this renewal requires solar light at ambient and not heat.

Quantifying the amount of extra water from hydrocarbons is as difficult as quantifying heats of e and rAHR-types. Nevertheless, estimates of the overall consumptions (close but slightly less than productions when heat release is concerned) of fossil oil and natural gas are available in oil equivalents and provide means to estimate the surplus of water. Between 1870 and 2018, about 180 Gt of oil and 30 GToe of natural gas have been extracted (Martin-Amouroux, 2015; BP, 2019) i.e. about 210 Gt of hydrocarbons. To compensate the complex composition of oil and natural gas, one can assume these fossil hydrocarbons, including methane (CH_4), composed of alkanes only, the general chemical formula of which is C_nH_{2n+2} reasonably simplified to nCH_2. Accordingly, 210 Gt of oil equivalent contain c.a. 180 Gt of carbon and 30 Gt of hydrogen. From the general equation $CH_2 + 3\ O_2 \rightarrow CO_2 + H_2O$ + heat, 14 g of hydrocarbon (12 + 2) generates 44 g of CO_2 (12 + 32) and 18 g of water (16 + 2), both compounds being hot. One can deduced that 210 Gt of hydrocarbons produced about 270 Gt of hot water in about 150 years. In 2018, 8 GT of oil equivalent of the hydrocarbon-type generated about 11.3 GT of hot water, an amount negligible compared with the heat absorption capacity of 1,500 GT of disappeared ices and of surface water evaporation.

According to section 5 and 6, the waste heat derived from the production and the consumption of energy on Earth seems negligible today relative to the radiative forcing estimate. However, this may change in the future if the production of energy continues to grow while the production of anthropogenic CO_2 and the corresponding radiative forcing are decreased as recommended to politicians by IPCC.

7. Can hydrogen from water be a solution?

Apart from limiting CO_2 production, climate scientists propose the development of new sources of energy among which hydrogen is more and more regarded as an attractive alternative (Johnston et al, 2005) provided it can be produced from water with regeneration of water after exploitation as source of electric energy according to the following catalyzed reactions: energy + $H_2O \rightarrow H_2 + ½\ O_2 \rightarrow H_2O$ + electricity. So far, hydrogen is primarily produced from fossil resources. Catalytic electrolysis is of interest only if the energy needed to dissociate water in hydrogen and oxygen is produced using environmentally-friendly sources of electricity (Gardner, 2009). What is presently missing to decide whether a source of energy is better than another is a heat-cycle assessment from cradle to grave, as it is currently done with life-cycle assessment to compare processes and materials that impact the environment (Muralikrishna & Manickam, 2017). So far, we did not find any quantitative information relative to heat-cycles of wind turbines and of other CO_2-free sources of electricity in comparison with fossil and radioactive sources of energy in terms of thermal impact on the climate. Hydro-electricity may be of particular interest in this regard. However, one can wonder whether large enough amounts of hydrogen will be producible from CO_2-free sources of energy. It will be the task of specialists in thermodynamics, and physics together with climatologists and chemists to collect information's necessary to decide.

8. Conclusion

The mechanism by which the temperature in a refrigerator is controlled appeared a rather consistent model of how the average temperature of the global environment may be controlled if water is given the role of refrigerant with: - ice melting and water evaporation as heat absorbing phenomena, - chaotic climatic events like hurricanes, tornadoes, ocean streams and humid air ascension to move the warm vapor to condensation zones as the compressor does in a refrigerator; and - clouds as source of radiative elimination to space of the transferred heat they release because of water condensation. Accordingly, surface temperature and thus sea level rises should be smaller than IPCC's calculated values for the next decades. In contrast, climatic events (flooding, drought, local temperatures, etc.) should increase in strength or magnitude and frequency if human population and its standard of living continue to grow and generate more and more anthropogenic heat release, regardless of its origin. In terms of thermodynamics, the refrigerant role of Earth's water appears a credible means to avoid heat accumulation on Earth and promote radiative elimination to space. The predominance of radiative forcing relative to anthropogenic heat releases suggested that 2018 ice imbalance should have been much larger than observed except if evaporation is taken into account or if scientists who deny radiative forcing turn to be right. In parallel, the amount of liquid water stored for millions of years in fossil hydrocarbons and released by combustion was shown negligible relative to the amount generated by disappeared ices. In the future, the contribution of anthropogenic heat residue of energy sources could become no longer negligible if the deny of CO2 as source of radiative forcing defended by some specialists of electromagnetic radiations is recognized. Presently, relying on the reduction of carbon-containing sources of energy may appear insufficient to limit climate evolution and ice imbalance growth if the replacing sources of energy, including water as source of hydrogen, generate similar amounts of waste heat. Heat amounts and heat transfers estimated in the present essay will have to be assessed more precisely by suitable interdisciplinary consortia attempting to understand and to take into account the complexity of Earth like biologists are doing for the human body.

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Data availability statement

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Conflict of Interest

The author does not have any conflict of interest to report

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