*Recycling of Heat in the Atmosphere is Impossible*

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*Introduction*

Some diagrams on the Earth's energy budget depicts an exchange of energy between the surface and the atmosphere and their subsystems considering each system as if they were blackbodies with emissivities and absorptivities of 100% [1, 2].

This kind of analyses show a strange "multiplication" of the heat transferred from the surface to the atmosphere and from the atmosphere to the surface which is unexplainable from a scientific viewpoint. The authors of those diagrams adduce that such increase of energy in the atmosphere obeys to a "recycling" of the heat coming from the surface by the atmosphere [1, 2], as if the atmosphere-surface were a furnace or a thermos and the heat was a substance.

Such "recycling" of heat by the atmosphere does not occur in the real world by the reasons that I will expose latter in this paper.

Few authors have avoided plotting such unreal recycling of heat and only show the percentages related to the flow of energy among systems and subsystems of the Earth [3, 4].

We do know that serious science makes a clear distinction between heat and internal energy. However, we will not touch this abnormal definition of heat from those erroneous diagrams[1, 2] on the annual Earth's energy budget.

In addition to the wrong concept of *heat* that the authors let glimpse in their articles [1, 2], the recycling of heat by the atmosphere does not and cannot occur in the real world. There are many physical factors, already proven experimentally and observationally[5], that nullify the ideas of the recycling of heat by the atmosphere.

The principal physical factor that inhibits the recycling of heat in the atmosphere is the degradation of the energy each time it is absorbed and emitted by any system[10, 11]. This degradation of energy is well described by the second law of thermodynamics[6], whose fundamental formulation is as follows:

***The energy is always dispersed or diffused from an energy field with lesser available microstates towards an energy field with higher available microstates***[5].

In other words, the energy is always dispersed or diffused from the system with a higher energy density towards the system with a lower energy density[5, 10].

The purpose of this essay is to demonstrate that some evaluations [1, 2] on the Earth's annual energy budget are not considering the laws of basic physics and thermodynamics, that the "recycling" of heat in the atmosphere is unphysical and that the carbon dioxide works like a coolant of the surface, rather than like a warmer.

*Analysis*

The Earth and all its subsystems are gray-bodies[3]; consequently, any calculations made on the basis of blackbodies greatly differ from the real world, but only provide us an idea about what could be happening in such or that physical situation[5]. This means that they cannot absorb all the energy that they receive from a source and that, equally, they cannot emit the whole amount of such absorbed energy in the form of energy capable to do work on other systems, but rather that the main part of that energy is no longer accessible for making work and it is lost irremediably into the natural heat sinks.

All the spontaneous processes occurring in nature are irreversible processes [7, 8]. **Absolutely-reversible processes do not exist in the natural world** [9], while absolutely-irreversible processes do exist in the natural world.

*Shift to Red of Dispersed Quantum/Waves and Emitted by the Atmosphere Quantum/Waves*:

Formulas:

$$E = \frac{hc}{\lambda} \qquad [1]$$

$$hc = 1.986\ x\ 10^{-25} J.m$$

$$h = 6.626\ x\ 10^{-34} J.s$$

$$c = 2.99792458\ x\ 10^{8} \left(\frac{m}{s}\right)$$

$$\lambda = \frac{1.986\ x\ 10^{-25} J.m}{E} \qquad [2]$$

$$\mu m \rightarrow m = \mu m * \left(1\ x\ 10^{-6} \left(\frac{m}{\mu m}\right)\right) \qquad [3]$$

There are three bands of absorption of IR radiation by the carbon dioxide, i.e. 2.6 µm, 4.3 µm and 14.77 µm.

In this assessment, we will analyze the absorption of the energy of quantum/waves with wavelengths of 4.3 µm and 14.77 µm

The energy of an IR quantum/wave with a wavelength of 4.3 µm, emitted from the Earth's surface is **4.62 x 10^-20 J**. From this energy, a molecule of $CO_2$ absorbs **9.24 x 10^-23 J**.

**4.61 x 10^-20 J** are dispersed to other systems, except to the molecules that dispersed it. This amount of energy corresponds to a wavelength of **4.31 µm**. The wavelength has been lengthened (redshift) by 0.01 µm.

A quantum/wave with wavelength $\boldsymbol{\lambda = 14.77}$ µ$\boldsymbol{m}$ –the band at which carbon dioxide exhibits its maximum absorption potential- has an energy density of $\boldsymbol{1.345\, x\, 10^{-20} J}$. If it hits a molecule of $CO_2$, the carbon dioxide molecule absorbs only $\boldsymbol{2.7\, x\, 10^{-23} J,}$ while the energy carried by the dispersed quantum/wave is $\lambda = 1.3423\, x\, 10^{-20} J$.

The carbon dioxide molecule emits a quantum/wave with energy $\boldsymbol{E = 5.4\, x\, 10^{-26} J}$, which corresponds to a wavelength $\boldsymbol{\lambda = 3.75\, m}$. The quantum/wave emitted by the carbon dioxide **is not an IR quantum wave, but a Radio quantum/wave**; therefore, its energy cannot be absorbed as heat neither by the surface neither by molecules of carbon dioxide.

Notice that $\boldsymbol{1.32145\, x\, 10^{-20} J}$ is dispersed towards another energy field with more available microstates that resides in other systems; for example, the outer space, water vapor molecules, or dust. The wavelength of the dispersed quantum/waves has been elongated up to **14.8 µm** (redshift); this elongation puts the IR quantum/wave out of the range of absorptivity of carbon dioxide by the ***specificity and sensitivity*** **of absorption and emission potentials**; consequently, **the energy of these quantum/waves cannot be reabsorbed by molecules of carbon dioxide**.

The following calculation over the resulting quantum/wave with wavelength of 14.8 µm **absorbed by the carbon dioxide does not happen in nature**; however, I decided to include it for readers take notice of the impossibility that heat can be "recycled" in the atmosphere.

Assuming that the absorption of that quantum/wave is still possible and another molecule of carbon dioxide could absorb it, we would have that:

For a wavelength **14.8 µm**, the energy absorbed by the molecule of $CO_2$ would be $\boldsymbol{E = 1.3215\, x\, 10^{-20} J}$.

The energy of a quantum/wave emitted by that molecule of carbon dioxide would be $\boldsymbol{E = 2.643 x\, 10^{-23} J}$, which would correspond to a wavelength of **0.7515 cm**. This magnitude would match with the band of microwaves in the EM spectrum (microwaves' wavelength $\boldsymbol{\lambda = 0.01}$ **to 20 cm**). It still contains usable energy, but this energy can no longer be absorbed by molecules of carbon dioxide and it is lost into any of the energy sinks.

At this point, let us remember that the longer the wavelength is, the lower the energy density of that quantum/wave is.

The energy required to excite an electron for it shifts from a lower quantum microstate to the next higher quantum microstate is $\boldsymbol{E = 5.4468\, x\, 10^{-19} J}$. [Ref. 5]

Therefore, the percentage of energy absorbed by a molecule of carbon dioxide with a wavelength of **14.77 µm** represents **0.2%** of the total energy required to excite an electron of the atoms of a molecule of carbon dioxide.

In that case, for an electron in the carbon dioxide molecule becomes excited and changes its energy configuration, a contribution of energy, supplied by 20554 IR quantum/waves, is required. Consequently, carbon dioxide in the Earth's atmosphere is in an energy field with higher number of available microstates.

This is the reason by which the flow of power is always transferred on a very specific directionality, i.e. from higher to lower and never the opposite.

How many molecules of carbon dioxide would be needed to get **249 Joules** of energy in the total volume of carbon dioxide in the atmosphere?

$\sim 4.6\ x\ 10^{20}$ molecules of carbon dioxide are needed to get a volume of air absorbing 249 Joules of energy within the wavelength 14.77 µm.

There are $\sim 2.61\ x\ 10^{9}$ molecules of carbon dioxide in one cubic meter of air; therefore, $1.76\ x\ 10^{11} m^3$ of air would be needed for the molecules of carbon dioxide can absorb, simultaneously, 249 J.

The total volume of the Earth's air is $4.2\ \times\ 10^{18}\ m^3$. There are $\sim 1.1\ x\ 10^{28}\ molecules$ of carbon dioxide in the whole volume of air on Earth; consequently, almost the whole volume of molecules of carbon dioxide in the Earth's atmosphere would absorb 249 J.

Therefore, there are $6.23\ x\ 10^{26}$ probabilities that the total amount of carbon dioxide in the Earth's atmosphere absorbs the whole load of energy of 249 J; however, each molecule of carbon dioxide would absorb only $\mathbf{2.3\ x\ 10^{-26} J}$.

The molecules of carbon dioxide which had absorbed $\mathbf{2.3\ x\ 10^{-26} J}$ of energy would emit quantum/waves with wavelength $\boldsymbol{\lambda} = \mathbf{4.3}$ **km**, which correspond to the spectrum of vertical gravity waves (buoyancy). Therefore, those waves are lost in the gravity field.

As a result, the carbon dioxide acts as a coolant, rather than a warmer, of the Earth.

*Conclusion*

The diagrams that plot the annual energy budget of the Earth describing a recycling in the atmosphere of the heat emitted by the surface are absolutely wrong.

The lengthening of the wavelength of quantum/waves emitted by the absorber systems and the decrease of their frequency inhibit any possibility of re-absorption of the absorbed energy -in the form of infrared radiation- by the same absorber once it has been emitted out from the absorber system.

Additionally, this assessment confirms that the second law of thermodynamics is applicable to molecular and quantum levels.

The carbon dioxide does not act like a warmer of the Earth's surface, but rather like a coolant of the Earth's surface. The carbon dioxide molecules absorb IR radiation and emit it into another form of electromagnetic quantum/wave, which cannot be absorbed by other molecules of carbon dioxide. Carbon dioxide takes energy from a higher energy density field and releases that energy with a lower level of energy density.

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