Anthropogenic heat emissions affect significantly global warming

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Recently, an Editorial titled *Global warming is due to an enhanced greenhouse effect, and anthropogenic heat emissions currently play a negligible role at the global scale* (Kleidon et al., 2023) was published in the journal *Earth System Dynamics*. In it the Chief Editors state: "From time to time, we receive submissions at *Earth System Dynamics* claiming that global warming, or at least a significant part of it, is caused by factors other than the direct and indirect effect of anthropogenic greenhouse gas emissions. A number of these submissions claim that the increase in observed temperatures is due to the emission of heat from human activities… Such submissions would not have passed peer review in *Earth System Dynamics* as they ignore basic textbook knowledge and would indeed typically be rejected prior to entering the open-discussion peer review phase."

It should be emphasized that discoveries "ignoring basic textbook knowledge" are among the strongest drivers of science (Newton, 1687; Einstein, 1905; Galilei, 1590) and should not be ignored unless they are deemed incorrect. And the determination of their correctness is performed in a peer-review process. On a smaller scale, it was recently found that the assumption that the motion of free rising and free falling rigid bodies are governed by the same physical principles (Newton, 1687; Galilei, 1590) was incorrect (Karamanev and Nikolov, 1992). While this discovery was "ignoring basic textbook knowledge" at the time, the peer-review process confirmed that Galileo and later Newton were wrong in that regard (mainly because the phenomena of turbulence was unknown at their respective times), and the new discovery is now part of the mainstream knowledge base (Green, 2008; Chhabra and Basavaraj, 2019).

Further, the Editorial states: "A quick look at the global surface energy balance illustrates this clear picture: human primary energy consumption amounted to 595 EJ in 2021 (BP, 2022), which translates into an average heat release of 18.9 TW. When averaged over land, this yields 18.9 TW / (29% x 510x10^{12} m^2) = 0.13 W m^{-2} (as in Jin et al., 2019), while globally, this yields 0.04 W m^{-2} when evenly distributed over the Earth's surface. This heat release is minute compared to the downwelling flux of longwave radiation of 346 W m^{-2} (Stephens et al., 2012) and the observed radiative forcing change at the top of the atmosphere of 2.7 W $^{m-2}$ that can clearly be attributed to the increase in greenhouse gases (Forster et al., 2021). The greenhouse gas forcing can then explain very well the increase in global mean surface temperature of over 1 ∘C since preindustrial times (Eyring et al., 2021). This basis represents the wide scientific consensus reflected in the series of IPCC reports (which can be found at http://www.ipcc.ch, last access: 10 February 2023, with the latest comprehensive assessment of the physical science being IPCC, 2021), a basis that extends much further back to more than 50 years of scientific publications, even including internal scientific reports within the fossil fuel industry, as recently evaluated by Supran et al. (2023)."

The above statement contains two major errors.

First, current knowledge of the amount of anthropogenic heat emission to the atmosphere is based on the following statement: "Utilizing the second law of thermodynamics, it is assumed that all non-renewable primary energy consumption is dissipated thermally in Earth's atmosphere." (Flanner, 2009). This assumption has been widely used(Crutzen, 2004; Chen et al., 2016; Kleidon et al., 2023). For example, all of the Earth's primary energy totalling 595 EJ in 2021 has been presumed to be emitted to the atmosphere as heat (Kleidon et al., 2023). However, it was recently found that only 40% of the primary energy ends up in the atmosphere, while the rest heats land and water, for example in water-cooled thermal power generation (Karamanev, 2022). The anthropogenic heating of water (ocean and inland) and land are not considered significant atmospheric global warming factors due to their extremely high heat capacities compared to air (Forster et al., 2021).

Second, all the individual effective radiative forcings (ERFs) included in the total anthropogenic ERF of 2.7 W/m^2 (Kleidon et al., 2023) are based on the effects of different drivers such as greenhouse gases, aerosols, land use, which influence the radiation energy budget of the planet (Forster et al., 2021). The only notable anthropogenic energy input to the atmosphere that does not have a radiative nature (except for its infrared cooling effect), is direct sensible heat emission (Karamanev, 2022).

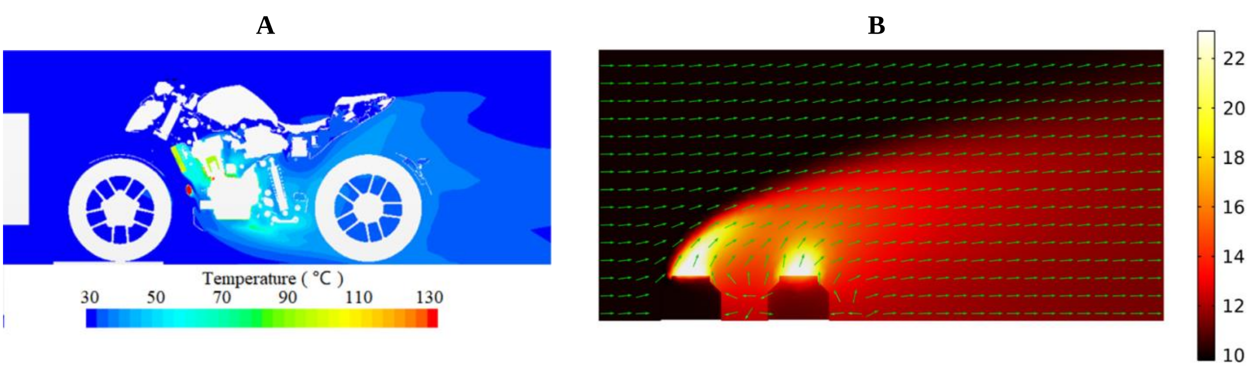

Fig. 1. The temperature profile (°C) in the air surrounding: (A) moving motorcycle (Tan et al., 2022); (B) cooling tower (Zhelnin et al., 2022)(14).

Figure 1 shows the 3D profiles of heat emitted by a vehicle and that of the cooling tower, which are among the largest anthropogenic heat emitters to the atmosphere (Karamanev, 2022). Clearly, these processes have a three-dimensional nature and have nothing to do with the radiative two-dimensional heat emission from the surface of the land or the ocean, as proposed (Kleidon et al., 2023). Therefore, while radiation energy has a two-dimensional nature having SI units of W/m^2, where the surface is usually the entire area of the Earth, the anthropogenic sensible heat emission (ASHE) is mostly three-dimensional, as heat is released to the atmosphere surrounding processes such as internal combustion engine operation, air-cooled power generation and jet propulsion in aviation, just to name a few. Part of the sensible heat emitted to the atmosphere is converted to radiation energy (infrared cooling) due to the temperature increase, while the remainder is mixed with the rest of the atmosphere. Therefore, ASHE has a 3D nature and should be described using the units of W/m^3, where the volume is that of the Earth's atmosphere. Alternatively, the ASHE can be expressed as relative to the total mass of the atmosphere (W/kg). Therefore, assuming that anthropogenic heat emissions represent a type of radiative forcing (Bing and Guang-Yu, 2015; Chen et al., 2016; Block et al., 2004; Crutzen, 2004; Flanner, 2009; Zhang et al., 2013) and calculating it to be 0.04 W/m^2 (Kleidon et al., 2023) is ultimately incorrect.

The fundamental equation relating the change of sensible heat (Q) and the corresponding change of temperature (ΔT) to/from a three-dimensional mass m having a specific heat capacity C, in the absence of phase change, is (Rathakrishnan, 2012):

$$Q = mC\Delta T \tag{1}$$

Using Eq. 1 it was found that the total temperature increase of the atmosphere due to ASHE (assuming no infrared cooling) during the industrial era (1850-2018) should have been 2.3°C (Karamanev, 2022), which significantly exceeds the actual temperature rise of 1.2°C (Met Office Hadley Centre observations datasets, 2022). Therefore, the statement that ASHE has an insignificant effect on atmospheric warming (Kleidon et al., 2023) is incorrect, and the main reason is the assumption that anthropogenic heat emission has a two-dimensional radiative nature. Of course, the assumption that there is no infrared cooling is a significant oversimplification. In the second model iteration, IR cooling was taken into account, and the total atmospheric temperature increase due to ASHE was found to be 0.58°C (Karamanev, 2022), or approximately half of the actual atmospheric warming. The second iteration, however, contained another simplifying assumption: that anthropogenic atmospheric heat emission is instantaneously mixed in the entire volume of the atmosphere. Therefore, a third iteration will be needed to take into account the spatial dispersion of ASHE within the atmosphere.

The big question is this: how do the above findings of the significant effect of ASHE on global warming fit the extensive amount of data summarized in the latest IPCC report (Forster et al., 2021)? Actually, the total anthropogenic ERF of 2.72 W/m^2 is not a fixed value but an average having a range between 1.96 and 3.48 W/m^2 with 5-95% confidence range (Forster et al., 2021). However, since ASHE does not have a radiative nature, it cannot be compared to effective radiative forcing. The comparison can be done using the human-forced global surface air temperature change, which was estimated to be approximately 1.29°C during the industrial era having a variation between 0.99 and 1.65°C with 5-95% confidence range (Forster et al., 2021). The current estimate of the effect of ASHE is 0.58°C, which fits into that variation.

The above clearly shows that anthropogenic heat emission has a significant effect on atmospheric warming.

The Editorial (Kleidon et al., 2023) wraps up with the following conclusion: "Our decision to generally not let such submissions enter the peer review phase is grounded in this well-established understanding. After all, the purpose of the peer review process, which includes considerable time and voluntary efforts from editors and reviewers, is not to point authors towards well-established knowledge from introductory climatology textbooks or to perform the literature review on behalf of the authors."

How lucky the young patent clerk with a teacher's diploma named Albert Einstein must have been that no such blanket editorial rule existed at *Annalen der Physik* in 1905. And he was challenging not just 50, but 350 years of "well-established knowledge".

References

Met Office Hadley Centre observations datasets: https://www.metoffice.gov.uk/hadobs/hadcrut5/data/current/download.html, last access: 9 February 2022.

Bing, C. and Guang-Yu, S.: Estimation of the Distribution of Global Anthropogenic Heat Flux, Atmospheric and Oceanic Science Letters, 5, 108–112, https://doi.org/10.1080/16742834.2012.11446974, 2015.

Block, A., Keuler, K., and Schaller, E.: Impacts of anthropogenic heat on regional climate patterns, Geophys Res Lett, 31, 2004.

Chen, B., Dong, L., Liu, X., Shi, G. Y., Chen, L., Nakajima, T., and Habib, A.: Exploring the possible effect of anthropogenic heat release due to global energy consumption upon global climate: a climate model study, Int. J. Climatol, 36, 4790–4796, https://doi.org/10.1002/joc.4669, 2016.

Chhabra, R. and Basavaraj, M. G.: Motion of Particles in a Fluid, Coulson and Richardson's Chemical Engineering, 281–334, https://doi.org/10.1016/B978-0-08-101098-3.00007-X, 2019.

Crutzen, P. J.: New Directions: The growing urban heat and pollution "island" effect - Impact on chemistry and climate, Atmos Environ, 38, 3539–3540, https://doi.org/10.1016/j.atmosenv.2004.03.032, 2004.

Einstein, A.: Zur Elektrodynamik bewegter Körper, Ann Phys, 891–921, 1905.

Flanner, M. G.: Integrating anthropogenic heat flux with global climate models, Geophys. Res. Lett, 36, 2801, https://doi.org/10.1029/2008GL036465, 2009.

Forster, P., Alterskjaer, K., Smith, C., Colman, R., Damon Matthews, H., Ramaswamy, V., Storelvmo, T., Armour, K., Collins, W., Dufresne, J., Frame, D., Lunt, D., Mauritsen, T., Watanabe, M., Wild, M., Zhang, H., Pirani, A., Connors, S., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J., Maycock, T., Waterfield, T., Yelekçi, O., Yu, R., and Zhou, B.: The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity. in: Climate Change 2021: The Physical Science Basis, Contribution of Working Group I to the Sixth Assessment Report of the

Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 923–1054, https://doi.org/10.1017/9781009157896.009, 2021.

Galilei, G.: On motion, and on mechanics. Comprising De Motu (ca. 1590) translated with introd. and notes, 1590.

Green, D. W.: Perry's Chemical Engineers' Handbook, McGraw-Hill Education, 2008.

Karamanev, D.: The effect of anthropogenic heat emissions on global warming, https://doi.org/https://doi.org/10.5194/egusphere-2022-5, 2022, 2022.

Karamanev, D. G. and Nikolov, L. N.: Free rising spheres do not obey newton's law for free settling, AIChE Journal, 38, 1843–1846, https://doi.org/10.1002/AIC.690381116, 1992.

Kleidon, A., Messori, G., Baidya Roy, S., Didenkulova, I., and Zeng, N.: Editorial: Global warming is due to an enhanced greenhouse effect, and anthropogenic heat emissions currently play a negligible role at the global scale, Earth System Dynamics, 14, 241–242, https://doi.org/10.5194/ESD-14-241-2023, 2023.

Newton, I.: Philosophiæ Naturalis Principia Mathematica, Societatis Regae, London, 1687.

Rathakrishnan, E.: Elements of Heat Transfer., CRC Press, 544 pp., 2012.

Tan, L., Yuan, Y., Tang, L., and Huang, C.: Numerical simulation on fluid flow and temperature prediction of motorcycles based on CFD, Alexandria Engineering Journal, 61, 12943–12963, https://doi.org/10.1016/J.AEJ.2022.07.001, 2022.

Zhang, G. J., Cai, M., and Hu, A.: Energy consumption and the unexplained winter warming over northern Asia and North America, Nat Clim Chang, 3, 466–470, https://doi.org/10.1038/NCLIMATE1803, 2013.

Zhelnin, M., Kostina, A., Plekhov, O., Zaitsev, A. , and Olkhovskiy, D.: Numerical Simulation on Temperature and Moisture Fields Around Cooling Towers Used in Mine Ventilation System, Fluids (Basel), 7, 1–18, https://doi.org/https://doi.org/10.3390/fluids7100317, 2022.