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# Domestic Livestock and Its Alleged Role in Climate Change

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## Abstract

It is very old wisdom that climate dictates farm management strategies. In recent years, however, we are increasingly confronted with claims that agriculture, livestock husbandry, and even food consumption habits are forcing the climate to change. We subjected this worrisome concern expressed by public institutions, the media, policy makers, and even scientists to a rigorous review, cross-checking critical coherence and (in)compatibilities within and between published scientific papers. Our key conclusion is there is no need for anthropogenic emissions of greenhouse gases (GHGs), and even less so for livestock-born emissions, to explain climate change. Climate has always been changing, and even the present warming is most likely driven by natural factors. The warming potential of anthropogenic GHG emissions has been exaggerated, and the beneficial impacts of manmade CO<sub>2</sub> emissions for nature, agriculture, and global food security have been systematically suppressed, ignored, or at least downplayed by the IPCC (Intergovernmental Panel on Climate Change) and other UN (United Nations) agencies. Furthermore, we expose important methodological deficiencies in IPCC and FAO (Food Agriculture Organization) instructions and applications for the quantification of the manmade part of non-CO<sub>2</sub>-GHG emissions from agro-ecosystems. However, so far, these fatal errors inexorably propagated through scientific literature. Finally, we could not find a clear domestic livestock fingerprint, neither in the geographical methane distribution nor in the historical evolution of mean atmospheric methane concentration. In conclusion, everybody is free to choose a vegetarian or vegan lifestyle, but there is no scientific basis, whatsoever, for claiming this decision could contribute to save the planet's climate.

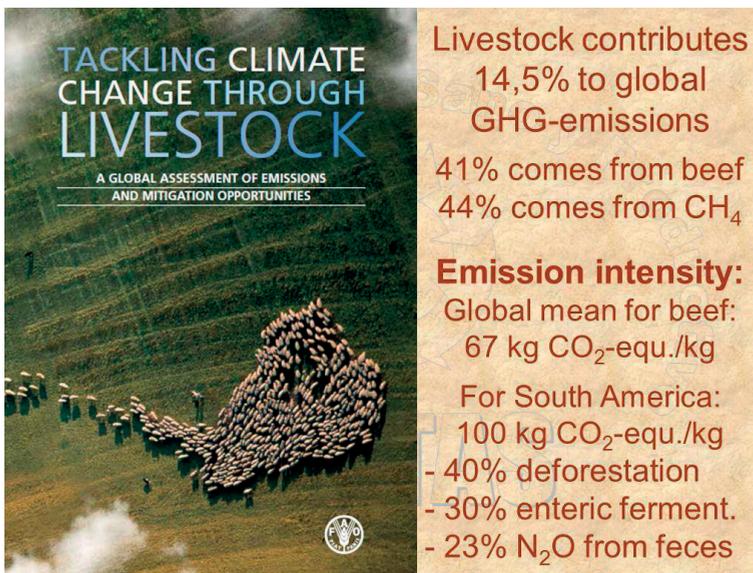
**Keywords:** greenhouse gas emissions, carbon dioxide, methane, nitrous oxide, agro-ecosystems, deforestation, climate change

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## 1. Introduction

Since its early origins, mankind adapts to the prevailing climatic conditions (from the arctic to the tropical rainforest) and copes fairly successfully with natural climate variability. It is very old wisdom that climate dictates farm management strategies. Fairly new, however, is the idea that agriculture, livestock husbandry, and food consumption habits are forcing supposedly the climate to change. This idea spread across the globe when thousands of media reports picked up the central message of the famous FAO report “Livestock’s Long Shadow” [1], which blamed domestic livestock of causing serious environmental hazards such as climate change, through greenhouse gas (GHG) emissions. Another FAO report [2] basically transmitted the same message, reducing, however, somewhat the livestock contribution to global GHG emissions from 18 to 14.5%. But dramatic figures of emission intensity were still maintained particularly for South American pasture-based beef production (**Figure 1**).

The worrisome messages launched by the FAO were eagerly disseminated by several environmentalist and even ecclesiastic organizations. They also triggered political action: there was a public audience in the European Parliament in November 2009 about the topic “Less Meat = Less Heat.” And at the Conference of Partners in Paris COP21 in 2015, this topic was also subject in the climate negotiations. And even in scientific literature, reduction of livestock numbers and meat consumption was recommended [3]. These concerns expressed by public institutions, the media, politics, and even science evoke the question: is global climate really at risk from livestock husbandry and cropping?



**Figure 1.** Key conclusions from Gerber et al. [2].

## 2. Methodological procedure

To answer this question, we did extensive review work, cross-checking critically coherence and (in)compatibilities between several published papers and data, and came to distinct results to what one would expect when listening to environmentalists and political climate change activists.

## 3. Results and discussion

### 3.1. About GHG emissions in the context of livestock husbandry

#### 3.1.1. Carbon dioxide (CO<sub>2</sub>)

CO<sub>2</sub> emitted by human consumption of cereals, meat, and milk, by livestock respiration and forage digestion, does not increase atmospheric CO<sub>2</sub> levels, as this is part of the natural carbon cycle. Not a single human- or livestock-born CO<sub>2</sub> molecule is additionally released into the atmosphere, as it has previously been captured through photosynthesis. The amount of CO<sub>2</sub> released annually by humans and livestock is offset by regrowing CO<sub>2</sub>-assimilating forages and crops. The only sources of *additional* CO<sub>2</sub> emissions caused by agriculture and livestock husbandry, beyond the natural carbon cycle, are:

- fossil fuel consumption during production, processing, and marketing, such as transportation, soil tillage, harvesting, and fertilizer manufacturing,
- deforestation for reclamation of pasture and cropland, and
- soil organic matter decomposition from degrading grasslands and arable lands, as determined by the difference of ecosystemic carbon stocks before and after certain human interventions.

Usage of fossil fuels is considerable in industrial livestock production systems which rely on forage cropping and feed transportation to the confined animals. In grazing systems, however, fuel consumption is rather low. Fossil fuel-related emission intensity of feed is less than 0.05 CO<sub>2</sub> kg<sup>-1</sup> of dry matter intake in grazing systems and around 0.3 in feedlots [4]. The widespread perception that only feedlot intensification can reduce the overall GHG emission intensity (per kg of beef produced) was recently challenged by Paige et al. [5] who found considerable soil organic carbon sequestration in certain grazing systems which even offset methane emissions from enteric fermentation. However, after any sort of land use change, the rate of soil carbon sequestration or of carbon loss is changing over time until a new equilibrium level is reached for each kind of land management [6].

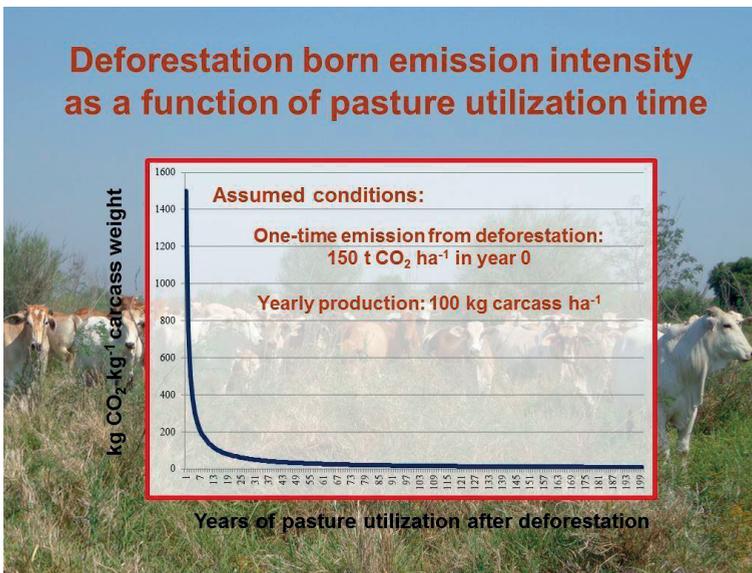
Deforestation for pasture establishment causes a unique one-time CO<sub>2</sub> release from burning and decomposition of woody vegetation. For emission intensity calculations, deforestation-born emissions have to be shared out over the accumulated animal products generated during the total utilization period of the very pasture, which replaced the forest. This may easily

be hundreds of years (as in the case of European grasslands). In the long run, total production accumulates to huge quantities and the deforestation part of the emission intensity ( $\text{CO}_2$  emitted per kg of carcass weight) approaches zero (**Figure 2**).

Unfortunately, in published literature, emissions from deforestation are treated inconsistently. They are either neglected or charged entirely to the year of their appearance onto a product which is not necessarily related to the ongoing deforestation, such as total beef production in South America (e.g., **Figure 1**). For Europe, however, these emissions are usually ignored as they took place 500 years and longer ago.

In spite of ongoing deforestation, world vegetation cover, particularly in (semi-)arid regions, has improved in the past 30 years due to rising  $\text{CO}_2$ , as a satellite image-based analysis by CSIRO Australia [7] and Geoscience Institutes in Denmark and Spain [8] has shown. Another study of 32 authors from 24 institutions from 8 countries, published on the NASA website, found a significant increase in the leaf area index on most of the earth's vegetated surface, during the past 35 years, for which increasing  $\text{CO}_2$  emissions are considered responsible at a 70% level [9, 10].

In the Northern Hemisphere with big landmasses covered with vegetation, the annual oscillation of  $\text{CO}_2$  rose considerably in the past decades. In 2013, 36% more  $\text{CO}_2$  was captured in spring and summer and released again in wintertime than 45 years ago. The growing annual amplitude with more  $\text{CO}_2$  in the air is a clear indicator of a tremendous vegetation response to increased  $\text{CO}_2$  levels [11]. Fully in line with this finding is another paper published in *Nature* providing evidence that twentieth-century  $\text{CO}_2$  emissions caused an over 30% increase in Global Terrestrial Gross Primary Production [12].



**Figure 2.** Modeling deforestation-born emission intensity (kg  $\text{CO}_2$  emitted per kg of carcass weight produced).

Former IPCC author and reviewer Indur Goklany [13] estimated the global fertilization value of manmade CO<sub>2</sub> in the atmosphere to 140 billion US\$ every year. Therefore, anthropogenic CO<sub>2</sub> contributes considerably to global food security. There are dozens of studies corroborating the efficiency of CO<sub>2</sub> as a fertilizer of our crops, pastures, and forests [14]. Nevertheless, UNEP projects (United Nations Environmental Program) such as the initiative TEEB (The Economy of Ecosystems and Biodiversity for Agriculture and Food) categorically ignore the obvious beneficial effects of manmade CO<sub>2</sub> emissions in their economic assessments. So do the authors of a recent assessment of potential economic damages under UN mitigation targets [15]. The well-established desirable effects of manmade CO<sub>2</sub> are entirely disregarded, whereas the global warming thresholds of future emission scenarios, as proposed by the IPCC, are fully accepted and related to potential economic losses, differentiated by regions. However, this widely accepted approach does not represent an objective and trustworthy method (see Chapter 3.2).

During most of the geological eras, atmospheric CO<sub>2</sub> concentrations were higher than today. At the last glaciation maximum, however, 18,000 years ago, CO<sub>2</sub> concentration reached as little as 180 ppm, low enough to stunt plant growth [16]. Therefore, quite a number of authors celebrate the recirculation of CO<sub>2</sub> by fossil fuel burning to secure long-time survival of life on earth. Taking into account that CO<sub>2</sub> is essential nutrient for life, is the only carbon source of all biomass, is fertilizing our crops and pastures, and is greening our deserts as it improves water use efficiency and therefore drought resistance of plants [17], this trace compound in the air (0.04% vol.) qualifies for being the most important, however limiting, nutrient for life. It is not the air pollutant as which it is seemingly exposed in the media and even by members of the scientific community. CO<sub>2</sub> is a transparent and odorless trace gas of which we are respiring about 5 kg every day.

### 3.1.2. Non-CO<sub>2</sub> GHGs: methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O)

Other agricultural GHGs such as methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) also form part of natural cycles, just like CO<sub>2</sub>. An easily understandable overview on methane and nitrous oxide dynamics in the atmosphere has been worked out by Stephen Zwick in LA Chefs Column [18]. There are natural and manmade sinks and sources for CH<sub>4</sub> and N<sub>2</sub>O (**Figure 3**); there is, however, some confusion in the quantification of the manmade part of their emissions from agro-ecosystems. The IPCC Guidelines for National Greenhouse Gas Inventories [19] meticulously provide instructions, emission factors, and formulas to estimate the emissions from the various sources in managed ecosystems. Emissions from pristine or native ecosystems are explicitly not taken into account, as they are not manmade. However, all managed agro-ecosystems replaced native ecosystems at some stage in history which also had been sources of considerable methane and nitrous oxide emissions.

In order to get the effective manmade part of the emissions from managed ecosystems, one has to subtract the baseline emissions of the respective native ecosystems or of the pre-climate change-managed ecosystems from those of today's agro-ecosystems (**Figure 4**). Omitting this correction leads to a systematic overestimation of farm-born non-CO<sub>2</sub> GHG emissions. Scientific publications generally do not take this consideration into account, as farm-born CH<sub>4</sub> and N<sub>2</sub>O emissions are consistently interpreted at a 100% level as an *additional* anthropogenic GHG source, just like fossil fuel-born CO<sub>2</sub>. As the mentioned IPCC guidelines [19] are taken for the ultimate reference, this severe methodological deficiency propagated through scientific literature.

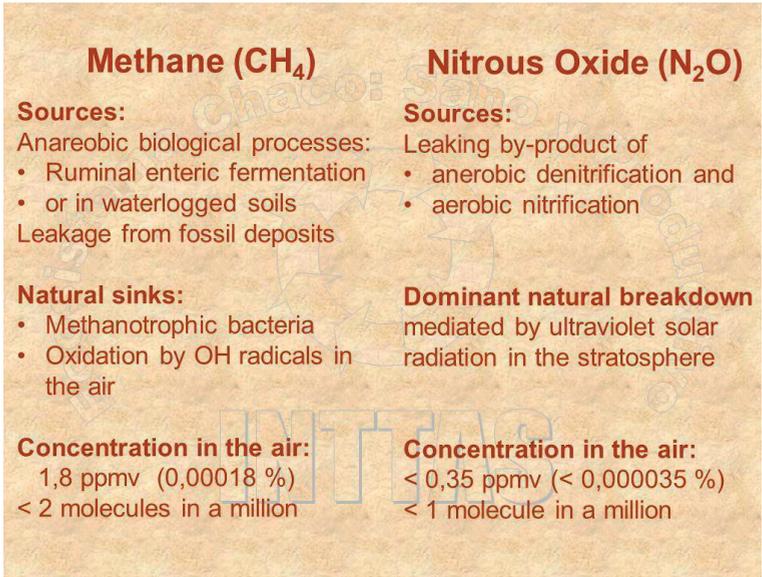


Figure 3. Natural and anthropogenic sources and sinks of the non-CO<sub>2</sub> GHGs methane and nitrous oxide.

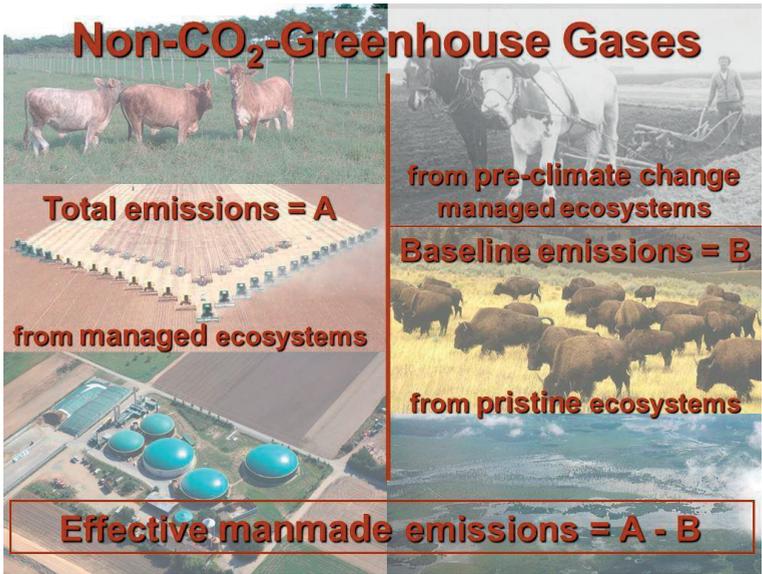


Figure 4. How to estimate correctly manmade non-CO<sub>2</sub> GHG emissions from agro-ecosystems.

Temporarily waterlogged or flooded pristine ecosystems or those with a high density of wild ungulates might have emitted the same amount or even more methane per hectare and year than they did after land reclamation and utilization. So net anthropogenic methane emissions from certain agro-ecosystems could be zero or even assume a negative value.

The same applies to nitrous oxide, particularly in farming systems where no or little synthetic nitrogen fertilizer is used such as most pastoral systems: ecosystem management and herbage consumption by livestock might increase somewhat the turnover rate of nitrogen but does not increase the quantity of nitrogen in circulation from which  $N_2O$  is emitted as a by-product from nitrification and denitrification.

Dung patches concentrate the nitrogen ingested from places scattered across the pasture. Nichols et al. [20] found no significant differences between emission factors from the patches and the rest of the pasture, which means the same amount of nitrous oxide is emitted whether or not the herbage passes livestock's intestines. However, the IPCC and FAO do consider mistakenly all nitrous oxide leaking from manure as livestock-born and therefore manmade.

Comparing, for instance, sown grassland with native bushland in the Gran Chaco, which contains many leguminous species, it becomes evident that nitrogen stocks are higher and more nitrogen is circulated annually in native bushland than in sown pasture (Figure 5). Therefore, in spite of the presence of grazing animals in the grassland, there is likely more nitrous oxide produced from bushland than from grassland after bush clearing and pasture establishment.

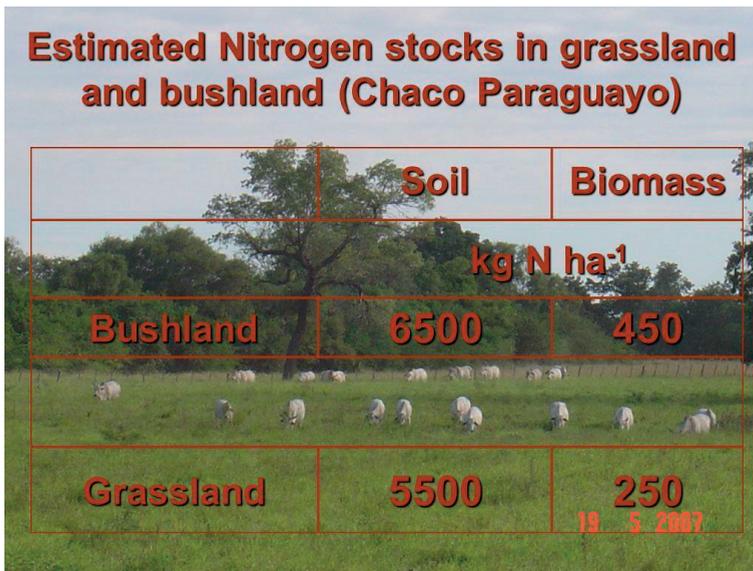


Figure 5. Ecosystemic nitrogen stocks in grassland and bushland (Chaco, Paraguay).

Hence, instead of charging the emission intensity of South American Beef with 23 kg of CO<sub>2</sub>-equ. kg<sup>-1</sup> of CW (carcass weight) for nitrous oxide emissions from animal feces (**Figure 1**), there should rather be a negative value when corrected for the emissions from the respective pre-land use pristine ecosystem. Similar thoughts can be made for the enteric fermentation and deforestation part of emission intensity charges.

### 3.1.3. Global methane emissions and livestock

The rise of methane emissions beginning around 1850 coincides perfectly with the progressive use of fossil energy. But the methane growth rate fell to zero at the turn of the millennium as shown by Quirk [21], cited from [22]. The stabilization of methane emissions in the 1990s is very likely associated with the adoption of modern technology in fossil fuel production and use, particularly the replacement of leaking pipelines in the former Soviet Union [21].

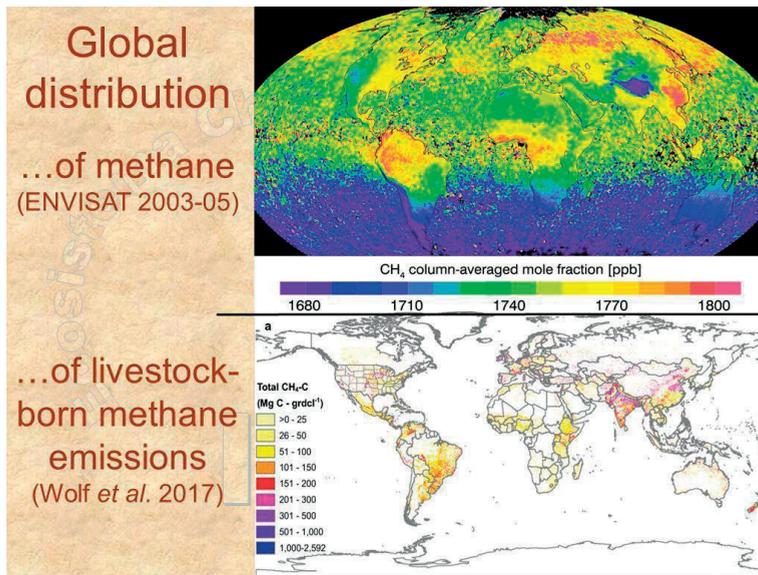
Between 1990 and 2005, the world cattle population rose by more than 100 million head (according to FAO statistics). During this time, atmospheric methane concentration stabilized completely. These empirical observations show that livestock is not a significant player in the global methane budget [23]. This appreciation has been corroborated by Schwietzke et al. [24] who suggested that methane emissions from fossil fuel industry and natural geological seepage have been 60–110% greater than previously thought.

When looking to the global distribution of average methane concentrations as measured by ENVISAT (Environmental Satellite) [25] and the geographical distribution of domestic animal density, respectively [1], no discernible relationship between both criteria was found [22].

Although the most recent estimates of yearly livestock-born global methane emissions came out 11% higher than earlier estimates [26], we still cannot see any discernible livestock fingerprint in the global methane distribution (**Figure 6**). The idea of a considerable livestock contribution to the global methane budget relies on theoretical bottom-up calculations. Even in recent studies, e.g., [27], just the emissions per animal are measured and multiplied by the number of animals. Ecosystemic interactions and baselines over time and space are generally ignored [28]. Although quite a number of publications, such as the excellent most recent FCRN report (Food Climate Research Network) [29], do discuss extensively ecosystemic sequestration potentials and natural sources of GHGs, they do not account for baseline emissions from the respective native ecosystems when assessing manmade emissions of non-CO<sub>2</sub> GHGs from managed ecosystems. This implies a systematic overestimation of the warming potential, particularly when assuming considerable climate sensitivity to GHG emissions. However, even LA Chefs Column [18], in spite of assuming a major global warming impact of methane, came to the conclusion: “When methane is put into a broader rather than a reductive context, we all have to stop blaming cattle (‘cows’) for climate change.”

## 3.2. About the climate response to manmade GHG emissions

Having shown considerable beneficial effects of manmade CO<sub>2</sub> emissions on nature, agriculture, and global food security and having shown severe IPCC and FAO deficiencies in the quantification of the manmade part of non-CO<sub>2</sub> GHG emissions, we need to have a closer look to the alleged evil human emissions of natural GHGs are accused of: causing climate change through global warming.



**Figure 6.** Domestic livestock-born methane emissions are of negligible importance for the global geographical methane distribution [25, 26].

There is, however, a growing divergence between observed and modeled temperatures. In spite of steadily increasing CO<sub>2</sub> levels, observed temperatures are ways below most published temperature projections (**Figure 7**).

Critical scientists are not surprised of this reality, showing that model validation has pitifully failed. In Table 2.11 of the Fourth IPCC Assessment Report AR4 [30], 16 variables were identified as global warming-forcing agents and used for modeling. The level of understanding for 11 of them is specified as “low to very low.” Under such premises, reliable modeling is impossible. Yet the IPCC comes up with a 90–95% certainty that human activity has been the main single driver of the slight warming observed during the past century.

According to Gervais [11], published estimates of climate sensitivity to CO<sub>2</sub>, as defined as temperature rise with CO<sub>2</sub> doubling, are in rapid decline since the turn of the millennium. The logical implication of this finding is that, in the past, climate models systematically exaggerated temperature projections into the future. Moreover, for the time between 1993 and 2015, when about 40% of total CO<sub>2</sub> was emitted since the beginning of the industrial revolution, Gervais could not find any discernible correlation between atmospheric concentration of CO<sub>2</sub> and mean global temperature anomaly in the low stratosphere (as measured by satellites), where according to the radiative-convective models, the most marked signature of temperature change was predicted [11]. Recent investigations support the idea of biases in IPCC climate model simulations, most of which show spurious warming associated with its alleged impacts such as glacier melting and sea level rise [32–36].

Furthermore, a growing number of peer-reviewed papers give evidence of pronounced warm periods during the Holocene, since the end of the last ice age, 10,000 years ago, in spite of the preindustrial atmospheric CO<sub>2</sub> levels in those times [28]. Gernot Patzelt from Innsbruck

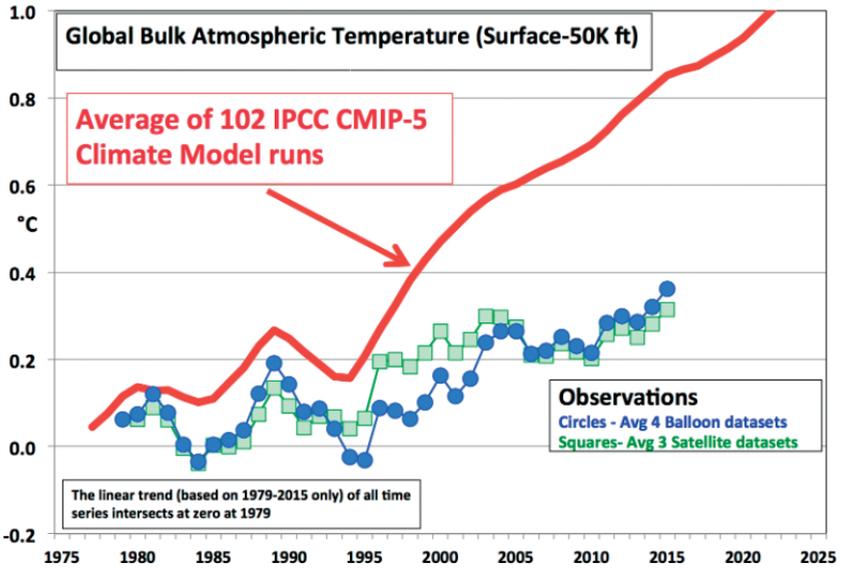


Figure 7. Midtropospheric temperature variations: observations (by satellite and balloons) versus IPCC models [31].

University [37] recovered ancient tree trunks conserved in moors and glaciers well above the present day tree lines, all across the Alps (Figure 8).

Patzelt irrefutably concluded that 65% of the Holocene summer temperatures had been warmer than today because the tree lines were at higher altitudes than today. Other studies



Figure 8. These tree trunks uncovered from retreating glaciers are irrefutable witnesses of extended preindustrial warm periods as they grew up well above the present-day tree lines [38].

from stalagmites in the Alps [39] and tree line investigations in Lapland [40] gave similar results, just as did ice core analyses from Greenland [41] and from the Antarctica [42].

The IPCC faces considerable problems of explaining the numerous preindustrial warm periods: among the radiative forcing components as published in the latest IPCC report in 2013 [43], anthropogenic CO<sub>2</sub>, methane, and nitrous oxide emissions are represented with prominent bars and hence are supposed to be the key drivers of global warming. On the other hand, the solar influence has been reduced to a tiny effect, just representing the observed small variation of direct solar irradiation (Figure 9).

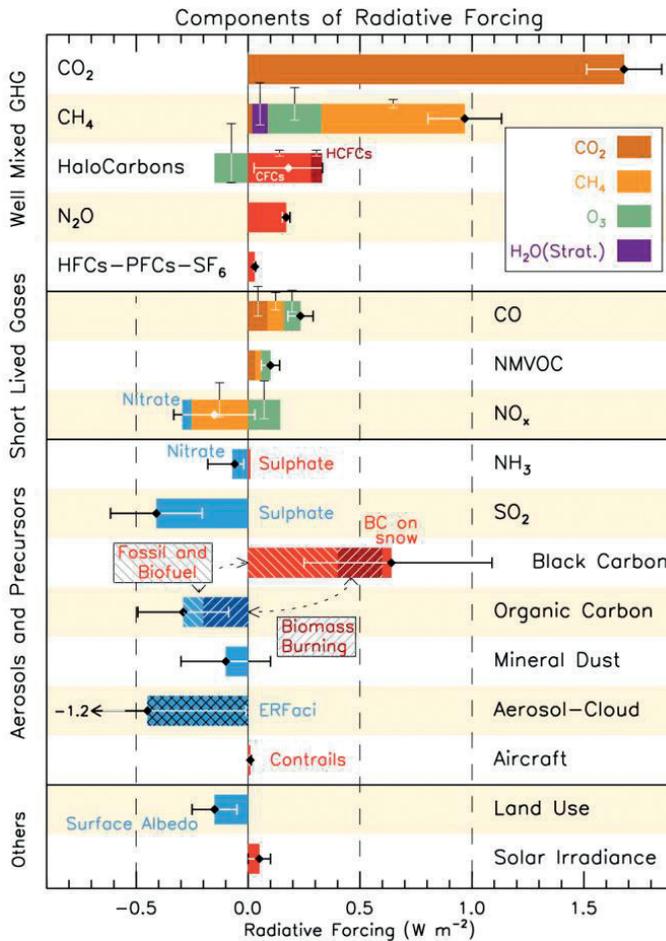


Figure 9. Natural and anthropogenic global warming forcing agents as defined and quantified by the IPCC (Figures 8-17 from [43]). These are incompatible with the well-documented prominent warm periods, which occurred in spite of preindustrial CO<sub>2</sub> levels.

These global warming forcing agents defined by the IPCC [43] obviously ignore the potent indirect solar influences produced by solar magnetic activity associated with sunspot occurrence. Lockwood et al. [44] clearly showed the relevance of solar activity indicators for the heliospheric cosmic ray modulation potential and the associated cooling and warming of the earth during the past 400 years. The causal chain between solar magnetic activity, cosmic ray flux hitting the earth, cloud formation potential, and mean global temperature has been shown by Svensmark and Friis-Christensen [45] and was convincingly defended against premature critics [46].

## 4. Conclusion

There is no need for anthropogenic emissions of GHGs, and even less so for livestock-born emissions, to explain climate change. When looking closely to published scientific data and facts, we conclude that

- eternal climate change, also the present one, is most likely driven by natural factors,
- the warming potential of anthropogenic GHGs has very likely been exaggerated by the IPCC and the media, and
- beneficial impacts of anthropogenic CO<sub>2</sub> emissions for nature, agriculture, and global food security have been systematically ignored.

Furthermore, we exposed important methodological deficiencies in IPCC and FAO instructions and applications for the quantification of the manmade part of non-CO<sub>2</sub> GHG emissions from agro-ecosystems. Finally, we could not find a domestic livestock fingerprint, neither in the geographical methane distribution nor in the historical evolution of the atmospheric methane concentration.

Consequently, in science, politics, and the media, climate impact of anthropogenic GHG emissions has been systematically overstated. Livestock-born GHG emissions have mostly been interpreted isolated from their ecosystemic context, ignoring their negligible significance within the global balance. There is no scientific evidence, whatsoever, that domestic livestock could represent a risk for the Earth's climate.

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## Conflict of interest

The author has no conflict of interest to declare.

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