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## **On Adaptation.**

# **An essay about our perceptions and responses to the concern of anthropogenic climate change.**

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The climate problem has many facets. One is the question whether humans are capable of changing climate in a significant manner. Another question is if that is happening here and now, and how far future anthropogenic climate change will or may possibly go. Finally, the likely most important question is how humankind can or should deal with this change.

## Climate

Before we elaborate on these questions, we should define what is meant with "climate". Climate is the statistics of weather. The ensemble of all possible weather states, together with their frequency. For obvious reasons, this is a too broad definition; instead representative statistical parameters are considered - like mean values, dispersion ranges and extreme values. Such as mean summer temperatures and 100 year flood levels.

The term „climate projections" does not refer to forecasting the weather in 20, 50 or 100 years. Instead what is projected or envisaged is the statistics of the weather in 20, 50 or 100 years. This is often misunderstood; in popular debates sometimes the argument is voiced that since it is impossible to predict the weather of the next season it would be impossible to assess changes in a few years or even decades of years. Thus all attempts to predict climate would therefore be doomed. However, these attempts are not doomed – and contemporary climate models are indeed capable of envisaging possible future climate. Forecasts of future climate are, however, hardly possibly, because of our inability to predict with any accuracy how future human activities influencing climate will develop. But we can devise scenarios or projections of possible future climate change. We will come back to this later.

## The Climate Problem

The question whether human can significantly change or influence climate is a problem for natural sciences. The related question, whether and how strongly recent changes of climate are related to human activity, is equally a problem of natural sciences. I will come back to this later, but in order to avoid misunderstanding I am declaring already now: I am convinced that humankind can change climate, and I am equally convinced that humankind is presently changing climate.

Another question is how strongly the climate will or may change in the next, say, 100 years. This is only partially a natural science problem, because this depends crucially on the development of the human society in the next 100 years. Specifically, how many radiatively active substances will be released into the atmosphere; which proportion of these substances will be bound in



anthropogenic sinks of such substances? How much trust do we have in the predictive skill of economic scientists? My own trust in this skill is somewhat limited, I have to admit.

The last question is how humankind could deal with climate change, which responses to the threat, and reality, of climate change may be adequate. Principally there are two options – to live with the change or to avoid it. Adaptation and mitigation. Eventually we will pursue a combination of these two measures, but for some strange reasons it is only the mitigation–option which is discussed – at least in Germany. The other option – adaptation – is constructively considered by practitioners, but in the public discussion this option is mostly considered as morally inferior. In the following I will address this problem: adaptation and mitigation of possible future climate change.

## **Anthropogenic Climate Change?**

[The presently most effective human influence on climate operates via the additional greenhouse effect. This term “greenhouse effect” is certainly a misnomer but it is nevertheless widely used. The basic idea is that Earth will have that temperature which allows the system to emit the same amount of energy as it is receiving from the sun. The latter arrives in the form of short wave radiation; some of it is reflected in particular at bright surfaces such as clouds and ice. The loss of energy happens through the emission of thermal radiation, which becomes stronger with higher temperatures. The important point is that not all thermal radiation emitted near the surface and in the lower troposphere is lost for Earth (i.e., reaches space); instead substances in the troposphere absorb the radiation and re-emit the energy into all directions, among others back to the surface, where this additional energy causes further warming. In the end the system has a temperature that is high enough so that the proportion of the thermal energy “passing by” the “greenhouse substances” into space, equals the incoming short wave energy.]

Since the middle of the 19th century the concentration of greenhouse gases, in particular carbon dioxide and methane are steadily increasing. The accumulation was fastest in the last decades. At the same time we observe an accelerated warming since the 160s. Is this warming related to the increased levels of greenhouse gas concentrations? This is a far from simple question. Climate, i.e., the statistics of weather, is changing all the time because of natural causes – such as the Earth’s changing position relative to the sun, the changing energy output of the sun, the variable amount of volcanic material in the atmosphere and, last not least, the internal dynamics of the climate system. Air temperature has significantly changed on a global scale in the past thousand years; the warming during the first third of the 20th century has caused concern about anthropogenic climate change among scientists in the 1930s.



The problem is the rate of change. How fast can climate change when only natural causes are operating? This rate may be described by a probability distribution – but this distribution is not known but must be estimated from the limited evidence provided by the observational data base of the past 150 years and by indirect “proxy data”. It is not possible to prove that the estimation of the probability distribution is “right”; we can only show that it is consistent with the little knowledge we have. I personally believe that our estimates are approximately correct – but I have to admit that I may be wrong with this assessment.

After we have assessed the range of natural variations of climate, we have to decide whether the recent changes are within that range or if they are beyond that range. If the recent change is beyond that range we conclude that some non-natural causes are at work. Being non-natural this cause, or these causes, must be man-made. The technical term is “detection”. The next step is to identify the cause(s). This is done by comparing the characteristics of the recent change, which was found to be beyond the range of normal variations in certain aspects, with the changes our climate models generate as response to prescribed anthropogenic forcing anomalies, in particular as a response to increased levels of greenhouse gas concentrations. If this comparison yields favourable results – that is, the characteristics of recent change are consistent with the changes excited in a climate model when greenhouse gas concentrations are increased – then we “attribute” greenhouse gases as the cause of that part of the recent change which goes beyond the range of natural variations. The same attribution idea is also used to sort out, how much of the recent warming is due to changing solar output and other factors.

Commonly accepted knowledge is that only one third of the warming of the past hundred years can be explained by increased solar output; the remaining two thirds can be explained only by the effect of elevated greenhouse gas concentrations, i.e., the anthropogenic greenhouse effect.

There is a caveat, though, which I want to repeat: the quality of estimating the width of naturally caused variability is a key parameter in this exercise. This parameter is not known but estimated. Accepting this estimated parameter is a matter of trust. If somebody believes that the estimate is insufficient because of the limited data base, then I can not disprove this assertion. The same is true for my belief that the data base is good enough to have a reasonable educated guess of this parameter – possible opponents are not able to prove that I am wrong. This controversy has nothing to do with incapable scientists but with the fact that the data available to us are limited in time. The problem can be solved only by either waiting for a long time – so that the data base is significantly increased – or by accepting certain knowledge claims such as the realism of contemporary climate models.

There is an interesting problem for history of science – the perception that humans are changing climate seems to have prevailed since ancient times, at least in the West. My colleague, the sociologist Nico Stehr and I have compiled a list of knowledge claims, which have been used in



the past to explain conditions perceived as anomalous. Witches were among the causes of anomalous weather and climate. Another agent was lightning rods, who were ascribed anomalous precipitation; felling of trees in the high mountains was thought to cause floods in the lower parts of Switzerland.

This is not just a entertaining historical detail. Instead it has relevance for the present-day perception and discourse. We humans – at least in the western culture – seem to be predisposed to accept “anthropogenic climate change” as an acceptable explanation for uncommon events even if they are natural and simply rare. This may be one of the reasons why the prophets of “climate catastrophes” and disasters are so successful in communicating with the general public – they articulate a primal fear, so to speak an eigen-oscillation of public perception.

The concept of detection and attribution has so far mostly be applied to globally distributed air temperature. In the public discussion, however, often the implicit assumption is made that when a climate change signal is detected in the global mean temperature, which is attributable to increased greenhouse gas concentrations, then all extraordinary meteorological events, like disastrous storms or extensive floods, must also be causally related to this anthropogenic climate change. Sometimes the formulation is more cautious – these events are declared to be “consistent” with anthropogenic climate change. The causal link would not “yet” have been firmly be established, but there would be little doubt; only cautious scientists would still hesitate for drawing such an otherwise obviously right conclusion. There are even scientists who admit that exaggeration of the threat of climate change would be in order – because without exaggeration the public would not take the threat sufficiently seriously. I consider this practice a disservice – for the political decision process, for the culture of discussion and integrity of science. For a scientist such behaviour is dishonourable. Just imagine if all sciences would pursue this line of “explaining” facts.

If every extreme event is considered a support of the concept of anthropogenic climate change – how would we be able to falsify the hypothesis of anthropogenic climate change, if it would actually be false? Only by the absence of extreme events – which would, on the other hand, be a sure proof of climate change, as extreme events are an integral part of the statistics of weather.

## **Future Climate**

The Intergovernmental Panel of Climate Change IPCC has published a series of plausible but not necessarily probable economic and social global developments. Relevant parameters are the development of the world population, the usage of energy, economic exchange, development of the Third World and many other aspects. These parameters are used to construct scenarios of future emission of radiatively active substances into the atmosphere.



[In one of the possible future worlds concerns for local social environment are dominant; there is a fast economic development and high emissions of greenhouse gases – the atmospheric concentration of these gases may well have quadrupled in the early 22nd century. In another possible future world, emissions are smaller because more intense international cooperation allows a better spread of efficient technology. A third world is envisaged as being one of widely implemented de-materialization, with greatly expanded e-commerce and communication. Explicit measures for protection climate by dedicated agreements to limit emissions are not foreseen in these three scenarios.]

These economic and social scenarios lead to scenarios of future emissions. These emissions are then used as forcing functions in climate models, which calculate the expected climatic implications of elevated greenhouse gas concentrations. These climate change scenarios differ from model to model, but many aspects of the different models' scenarios are similar. Air temperatures are increased; sea level rises. However, scenarios for smaller areas, like Switzerland, for more complex quantities like the distribution of precipitation amounts or of the frequency and intensity of wind storms are not yet ready for use. ]

Scenarios are no forecasts. They are storylines for possible futures. They are intended to demonstrate people and decision makers what possibly could happen; what is at stake. Unfortunately this role of scenarios is often misunderstood in the public. Instead the worst-case scenarios become certain forecasts of the future, which inevitably will become true if no serious counteraction is taken. Without proper climate protection policy temperature will rise by 5.8°C until the end of the present century, and the sea level will rise by 88 cm, the public understands. However, these numbers are meant as upper margins of possible developments.

## **Adaptation and Mitigation**

In a rational world, the state of which is known, can be predicted and optimally planned, the right path to go would be to assess the costs of all possible options of how to deal with the expected future climate change. One extreme option is not to do anything at all; then society will develop in an unchecked manner with emissions increasing freely. Such a development will be associated with costs, in terms of money, life and morale. Another extreme is to reduce emissions; also this option is associated with costs – mostly in terms of money but also in terms of life and morale. The best decision in this rational "cost-benefit" framework would be that mix of actions which goes with least costs. The problem is that the costs are unknown; everybody determines the costs differently; the knowledge about climate sensitivity, vulnerability and counter measures is not only fragile but also unavoidably loaded with cultural or even ideological presumptions.

But nevertheless – we have to take a decision. How many efforts to reduce emissions, how



much need for adaptation? The public debate in Germany and Scandinavia favours the „protection of climate“, i.e., mitigation, reduction of emissions. This decision has the advantage that it seems to be morally superior – everybody feels the obligation to protect the Creation. Another advantage is that specific questions about the implications on regional and local scales are unnecessary. The response strategy is obvious: reduction of emissions as much as possible. However: anthropogenic climate change is ongoing now; it can not be stopped; all what we can do is to limit climate change. The foreseeable future will hardly see any reductions of emissions – but mere reductions of emission growth. If we continue with business-as-usual and no deus-ex-machina technological fit surprisingly emerges, we may end up with a quadrupling of greenhouse gas concentrations in the atmosphere at the end of the 21st century. A quadrupling will have severe implications. When serious attempts to reduce emissions are made, then we may be able to limit the increase the greenhouse gas concentrations to a doubling of pre-industrial levels. “Doubling” is to be considered an achievement; a successful limitation. But also a doubling will have serious implications.

Therefore we have to consider adaptation to climate change. Not instead but parallel to mitigation of climate change. The goal is to limit the accumulation of greenhouse gases to “only” a doubling (or any other achievable significant reduction) and to prepare societies and ecosystems to adapt to unavoidable future changes.

Can we adapt? I believe we can, as long as the changes are not too radical. A melting of the West-Antarctic Ice Shelf would cause very serious challenges, which would hardly be mastered. However such an event is not probable. But what about warming and heat waves at mid latitudes, the spread of malaria, increased frequency of severe flooding, Bangladesh – all these topical and typical examples of imminent climate disasters of the future? Can we adapt to these threats? I believe that we can. If we begin to better adapt to these threats now then we will be better protected against the contemporary dangers of climate already in the near future. Climate is already now dangerous; not only in 50 years because of human interference with climate. The disastrous 1953 storm surge in the Netherlands is a good example of this sort of “normal” threats – and it is just 50 years ago

A closer inspection of these climate impacts reveals that in all cases climate plays a certain role – but that social, technological and economic factors play an equally if not more important role. Take two examples, heat waves and malaria.

The heat wave of 1995 in Chicago was analysed in detail. It caused many deaths. The people died because of heat stress, but they would not have died if the city would have been properly prepared for the situation. The people, who perished, were not a random sample of the population; they were old, poor and lonely people; they did not dare to leave their insufficiently ventilated apartments because of real or perceived dangers of being assaulted by criminals. In the 1950s



people would sleep in the parks of the city, but in the 190s people were too afraid of visiting the park after dark. Other cities are prepared for such a situation; endangered individuals are contacted, when extreme temperatures are expected, and brought into air-conditioned shopping malls. It was the failure of social mechanisms, the absence of adequate adaptation which made the extreme temperatures lethal. Also, "climate" serves in this situation as a perfect scapegoat for the city administration – the killer was the heat wave. "We did not make the heat; we were not responsible". Or, as Berthold Brecht's Johanna is saying: "The calamity comes like the rain; made by nobody".

Malaria – lay people widely believe that the spatial distribution of malaria is determined by the air temperature. But malaria was common in Europe until the first half of the 20th century. In wetlands of The Netherlands and England, life expectancy was only half of that in other regions. That people in these regions no longer suffer from malaria is not to be explained by lower temperatures – but by modern hygienical and medical standards and better land usage. The return of malaria in some parts of the previous Soviet Union is also not related to a warming of climate but with the troubled medical systems in that parts of the world. Malaria is a problem of poor people. Thus, not only the heat wave case but also the malaria case demonstrates that the purportedly climatic problems are mostly social problems. Malaria is associated with poverty, and it deserves our full attention now and not only in some remote future, when climate change has caused additional problems.

Neither malaria nor heat stress is adequately dealt with by reduced usage of fossil fuels and reduced emissions of greenhouse gases; the proper response is to make people and societies less vulnerable to these dangers. This should be done now. If it turns out that these dangers are getting more serious as a consequence of climate change, then the adaptive measures will be even more useful. There is no doubt that we can reduce vulnerability today. However, many people concentrate on reducing vulnerabilities in some future, and forget about the basic fact that climate has always been and remains to be dangerous even without anthropogenic interference.

We will have to live with anthropogenic climate change, because it will not be possible to avoid it completely – at least as long as no surprise technical fixes become available. And we are able to do so, if we began well in time to prepare ourselves for what may come in the future. Humans, societies and ecosystems have proven to be flexible in the past, they will master this challenge as well. But it is prudent to reduce the climatic change as much as possible without compromising other important goals of sustainable and other essential conditions. Reduction as much as possible but only if affordable in terms of social costs.

Before concluding this essay, I want to briefly discuss an observation: The emphasis on „protection of climate" and the wrong causality of emissions and weather extremes is not a possibly





pedagogically acceptable simplification but on the contrary a detrimental disinformation. It causes people to falsely believe that normal weather extremes are causally related to climate change, and that such extreme would no more happen as soon as a successful climate policy is installed. The vulnerability against weather extremes is enhanced because of the false perception that we are facing a revengeful environment which is striking back against the perpetrator – instead of the view that extremes of this sort are “normal” and need preparation on our side even if these events are rare. It is prudent not to rebuild one's house in the flood plains. The Dutch 1953 storm surges caused a major re-definition of the national coastal defence concept; after the big flooding in Germany in 2002, people rebuilt their houses and demanded financial compensation by the state: “I do not need to be prepared; this disaster was caused by society – thus they have to pay for the damage and make sure that it does not repeat.”

[Climate science must return to its old mission of advising and not directing the public, and of providing a range of possible policies; the primacy of politics, which topics are to be dealt with which priority and with which action, needs to remain with the democratically legitimized representatives. They, and not the scientists, have the responsibility and task to decide how to deal not only with climate change but also with all the other pressing problems.

Climate is dangerous already now. It may become more dangerous in future. The unlimited growth of emissions must be limited; at the same time the vulnerability of societies, economies and ecosystems needs to be reduced as well. ]