Who can we trust?

Is it true, as is often claimed, that science is united around the theory that global warming is man made? In order to answer this question, we need to specify what is meant both by the theory in question and by scientific consensus. Olle Häggström examines these notions and comes to the conclusion that science is in agreement that, at present, there are no reasonable grounds to believe that the theory is incorrect.

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Think for yourself! Think critically! For hundreds of years, these slogans by 18th century Enlightenment philosophers have helped people to break free from the dogmatic thought systems of the church and other authorities, and they are still valuable today.

However, living up to the slogans' ideals can today seem lika a daunting task. As the mass of knowledge provided by science branches out to become increasingly vast, there are a number of issues that involve advanced and topical research, and that at the same time must be taken into consideration by democratically minded members of society.

We can find obvious examples of these within the climate issue: Should society take steps to reduce greenhouse gas emissions that otherwise risk exacerbating an already accelerating climate change? Or should we rather focus on preparing ourselves for climate changes that will occur, regardless of what we do about greenhouse gas emissions? Or is the entire climate problem exaggerated, and would we therefore be better to ignore it and focus our efforts on other, more acute, problems?

These questions affect the future of all of us, and we cannot simply hand them over to a small group of experts to reach decisions on their own. Citizens need to form an opinion. However, in order to make sensible and rational decisions, we need to know a considerable amount within the field of natural sciences. To adopt a stance on whether there is any point in reducing our greenhouse gas emissions in order to slow down global warming, we first and foremost need to have an understanding of whether these emissions influence the climate, and if so how much.

So what attitude should a committed member of society take towards scientific issues of this kind? I will use the climate issue as an example to discuss what might be a reasonable attitude. Much of the current debate surrounding the climate issue has focused on whether there is scientific consensus – agreement – regarding the theory of anthropogenic (man made) global warming. I will start by discussing the concept of scientific consensus in principle, and only then will I look at whether such consensus can be deemed to exist in the climate field and, if so, what this means.

What does scientific consensus mean?

The core issue is: How should we rationally go about adopting a position on scientific issues when there are conflicting messages regarding what the situation actually is? A typical example is the issue of whether the greenhouse gas emissions that we humans cause (primarily carbon dioxide) in turn cause global warming. We are often told that such a causal link exists, although

at times we also come across pronouncements that firmly deny that this is the case. So how should we decide who is right and who is wrong?

An initial approach might be to rely on opinion polls – the simple counting of how many think this and how many thing that – and then go with the majority. This strikes me as an extremely unreliable and even objectionable method. People can (and should) certainly vote regarding political values – but about facts? Facts are what they are, regardless of what the majority happen to think about the issue. Hence, if the notion of consensus is to serve as a guide to the truth, it needs to be more refined that simply summarising votes or opinion polls.

In my opinion, it is better not to focus on majority, but instead on who has the best arguments, in the sense of logically coherent and sensible scientific reasoning that is supported by observations. This is the ideal. Unfortunately, this is generally unachievable in practice, for the simple reason that most of us do not possess the knowledge required in order to determine for ourselves the quality and strength of the scientific arguments. For the vast majority, acquiring this knowledge would require at least a few years of university studies in the subject in question – and often more.

In practice, we have no choice other than to rely on somebody else whom we have reason to believe possesses greater knowledge than we do in the area in question. But who? When given the choice between the prophet, the priest and the scientist, I would recommend the scientist – simply because science has, in recent centuries, convincingly established itself as the best and most accessible route to knowledge about how the world about us works.

Scientific journals as a stamp of quality

In other words, if we do not ourselves have the time, the energy or the ability to examine the scientific arguments in detail – let's trust the scientists! If all scientists in a field give the same answer to the issue in question, then it is clear what stance we should adopt. But what should we do if this is not the case? Should we follow the majority opinion among the scientists? I have already discussed the problem with relying on majorities, and there is an additional problem here regarding how we should define scientists as a group. Should we go by academic qualifications and titles, or should only those who, say, have published in a scientific journal in the area in question during past five years be counted as scientists? Whatever approach we take to the definition, there is a certain amount of arbitrariness. Even worse, there is always a risk that individual scientists will express opinions based not on scientific considerations, but rather on political or religious convictions, for example.

In my view, the best solution to this problem is to look for the answer not from a particular category of scientists as *individuals*, but instead in the *scientific journal literature*. Scientific journals apply a strict process of so-called peer review. This means that when a scientist submits a manuscript for publication, it is reviewed by a number of (usually anonymous) research colleagues. The manuscript is only accepted for publication if it satisfies stringent demands for scientific quality. Keeping to the scientific literature when assessing the research situation is therefore a way of ascertaining as far as possible that only the best scientific arguments are taken into consideration.

There are two natural objections here. Firstly, the method I am recommending relies on the journals' peer-review system working properly. But what if it is corrupt? Just imagine if the journals and their peer-reviewers had simply decided to reject anything that did not support their favourite theories, regardless of whether the arguments put forward were good or bad!

This is sometimes claimed and is difficult to disprove, although in the absence of good evidence for such corruption, I believe that we have reason to assume that the system works fairly well. We cannot know for certain that the assertions made in a scientific journal are true (science is not infallible), but these journals are considerably more reliable than other sources that, with a few exceptions, do not have an equivalent system of quality control.

Another objection is that it is difficult or impossible for a layman to follow my advice and determine the state of science based on what is written in scientific journals. Once again, we do not have the time, the energy or the prerequisites to go through the relevant literature. As a result, we are in practice dependent on skilled and reliable researchers summarising what is contained in the journal literature. Hence, the matter of whom we can trust comes up again here, and in the final analysis appears unavoidable. In the next section, however, I will demonstrate how convincing the state of the research is on the issue of anthropogenic global warming.

Scientific consensus on anthropogenic warming

In order to answer whether consensus exists on the climate issue, and how strong and solid it is, we must first specify which climate issue we are referring to. What do we mean when we talk about "the climate science consensus"? Perhaps the most important question is whether it is correct that a) anthropogenic emissions of carbon dioxide tend to contribute to global warming in a way that, in the long term, can be expected to have far-reaching consequences. In the current debate regarding scientific consensus, however, it is more common to refer to the hypothesis b) that these emissions have already caused a considerable part of the warming observed in recent decades.

For the sake of clarity, we need to distinguish between these two theories, as it is fully possible to accept theory a) without necessarily accepting b) as well. In fact, it was precisely this – accepting a) but not b) – that was the dominant view among climate scientists when the climate issue began to climb on the scientific and then the political agenda in the 1970s and 1980s.

When it comes to hypothesis b), that the increase in the Earth's average temperature in recent decades is largely due to anthropogenic carbon dioxide emissions, a study of the scientific literature shows that there has been increasing agreement about this over the past 10–15 years. The fact that this agreement is relatively recent may give some reason to believe that it is not yet completely robust, and that there is therefore reasonable scope for doubt.

As regards theory a) that carbon dioxide emissions in the long-term affect the climate, the situation is different and much more clear. The theory can best be divided up into two sub-theories, namely a1) that human carbon dioxide emissions contribute to a raised carbon dioxide concentration in the atmosphere, and a2) that a raised carbon dioxide concentration in the atmosphere drives global warming via the greenhouse effect. The physical understanding of these two phenomena, a1) and a2), is today very solid, and it is no longer possible to find articles that disassociate themselves from a1) or a2), either in the leading journals Nature and Science, or in more specialised climate science journals. Both sub-theories also go a long way back in science history.

The notion a1) that our carbon dioxide emissions lead to an increased carbon dioxide concentration in the atmosphere may appear obvious. However, the matter is not quite as simple as it may seem. It was long believed that the oceans could easily absorb almost all the carbon dioxide that was released into the atmosphere. This perception was corrected in the 1950s, however, when the sea's absorption capacity was shown to be more limited, primarily due to

the very slow circulation between surface and deep sea. These and other discoveries, together with sound measurement series detailing the change in carbon dioxide concentration in the atmosphere since the end of the 1950s, mean that phenomenon a1) is now beyond all reasonable doubt. Our quantitative understanding of it is also good.

The understanding of the greenhouse effect a2) goes back even further, and is largely a matter of 19th century physics. In the 1890s, the Swedish chemist Svante Arrhenius found a brilliant method for assessing the extent of the greenhouse effect, and we can now establish that his estimate was of a correct order of magnitude. Our knowledge about the greenhouse effect has been consolidated and refined since Arrhenius's day, not least thanks to quantum physics models for molecular radiation absorption.

In summary, it is of course possible to question a1) and a2) (just like all other scientific results), but they are so well established that it would require a scientific revolution of sensational proportions in order to overthrow either of them. As a result, the conclusion a) that anthropogenic carbon dioxide emissions contribute significantly to global warming can be established beyond all reasonable doubt.

Feedback effects and other sources of uncertainty

However, if our understanding of a1) and a2) is now so solid, how can it be that predictions by climate experts are so imprecise? Estimates, under given emissions scenarios, of what the global average temperature will be fifty or a hundred years from now cover intervals spanning several degrees Celsius.

This is due to the many other factors that influence the climate, and the complicated ways in which they interact. Feedback effects, which can have an accelerating effect on warming (positive feedbacks) or a decelerating effect (negative), are of particular interest. We do not fully understand the dynamics of many positive feedbacks. This includes for example how the warming is causing the Siberian tundra to thaw and release greenhouse gases, which in turn drive the warming. Another example is how the reflecting capacity (albedo) decreases when the warming causes the sea ice in the Arctic to melt. More solar radiation is then absorbed, and this leads to continued warming. A third example is how the warming leads to an increased amount of water vapour in the atmosphere, and hence an increased greenhouse effect, as water vapour is a greenhouse gas.

A final approach for those who accept a1) and a2) but still want to downplay the danger of anthropogenic global warming is to maintain that the negative feedbacks dominate the positive ones, and that they do so to such a degree that the most the warming will come to nothing. The American climate researcher Richard Lindzen has speculated in this direction, but the scientific literature as a whole points in the opposite direction.

No dissenters from anthropogenic warming

In case the reder happens to distrust my description of the state of the research, it may be of interest to look at the literature search conducted by the historian of science Naomi Oreskes in the journal Science in 2004. She analysed the content of the 928 papers that had been published in peer-reviewed scientific journals during the period 1993–2003 and that include the term "global climate change" among their key words. Oreskes counted how many of the papers disassociated themselves from the scientific consensus opinion regarding anthropogenic global warming. Despite the fact that she chose to interpret this in the narrower sense b) above, she found that out of the 928 papers, there were zero dissenters!

Admittedly, with her keyword search, Oreskes has not captured all the scientific papers about the climate issue from the relevant period, and it is probably possible to find the odd deviating opinion. Nevertheless, her study gives an idea of how much climate scientists agree regarding the theory of anthropogenic global warming.

Oreskes's study is naturally troublesome for those who want to maintain that there is scientific disagreement in this area, and attempts to discredit her have been made. However, if we look at the detailing of papers that are claimed to counter her conclusion (such detailing can be found in works by Benny Peisner and Klaus-Martin Schulte), we see how far they twist what the scientific studies actually say. For example, studies are highlighted that focus on other factors that could drive the climate alongside human influences, such as astronomical factors. There are also papers that argue that the effect on the climate of the increase in carbon dioxide is slightly smaller than others have maintained. The assertion that such results entail an automatic disassociation from the theory of anthropogenic global warming is clearly wrong, regardless of whether it refers to a) or b) above.

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Recommended reading

- Olle Häggström. *Att skilja vetenskap från pseudovetenskap: exemplet Stockholmsinitiativet [Distinguishing science from pseudo-science: the Stockholm Initiative example],* in Folkvett 4/2008, where the arguments of the leading group of Swedish climate sceptics are examined (http://www.math.chalmers.se/ ~olleh/Stockholmsinitiativet.pdf).
- Naomi Oreskes. *The scientific consensus on climate change: how do we know we're not wrong?* In the book Climate Change: What it Means for Us, Our Children and Our Grandchildren, MIT Press, Cambridge (http://www.ametsoc.org/atmospolicy/ documents/Chapter4.pdf).