Meteorology

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Paul Crutzen on the Ozone Hole, Nitrogen Oxides, and the Nobel Prize**

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Carsten Reinhardt: How did you become involved in meteorology?

Paul Crutzen: I had studied civil engineering. I wanted to be a scientist really. One day I saw an advertisement in a newspaper for a programmer, and I applied for it. I didn't know what a programmer was, but I found out soon enough and got a position at a meteorological institute at the University of Stockholm. At the time it was a Mecca for meteorological research. I applied, and was chosen from 80 applicants—I was lucky. And the best thing was that I was at the university, so apart from the programming I could occasionally go to lectures. That is how I entered the world of academia. Work that I particularly liked was on ozone. […] I began to gain the freedom to carry out science, not just programming, but also thinking about what was going on in the atmosphere. As I was already working on the ozone problem, I expanded on that, and then I discovered the significance of the nitrogen oxides. Nitrogen oxide in the troposphere generates ozone, whereas it destroys ozone in the stratosphere. Bullseye. Furthermore, at the time the supersonic jets were being built that emit NO_x, nitrogen oxide. My interest in atmospheric chemistry, and how it takes place in nature, thus took on major significance. I came in as I was successful, and then one has a taste for blood and can't turn back…

Reinhardt: When was the first moment for you when you realized, on an atmospheric scale, that climate change exists that is caused by mankind? Was it a surprise for you to discover this?

Crutzen: No, I could see the relevance of the nitrogen oxides directly. And I also knew then of the significance for humankind, that dangerous radiation is filtered by ozone. At the time I dedicated my first publication on nitrogen oxides to my wife. I wrote "Let's hope that it doesn't disturb our future too much."

Gregor Lax: How was the situation as you moved to the MPI of Chemistry?

Crutzen: We were interested in returning to Europe, my wife and I. We had spent six years in the USA, and one day I received a call. That was in 1979, and I was asked whether I would be interested in coming to the Max Planck Society.

Reinhardt: How did you find it in Mainz? How was the institute, what was it like?

Crutzen: As I came to Mainz, programming and descriptions of models were my interests. You applied for resources, and you got them. I had my first students here at the institute. And many colleagues, and students from Holland, came over, and returned as professors to Holland or became professors here. One of them, Jos Lelieveld, was made my successor, that is, scientific Head of Department. In the meantime there is no longer one section, but rather three, which are involved with atmospheric chemistry, physics, and biogeochemistry. That is how it has developed.

Reinhardt: Was this intended by you and your colleagues, or did it simply evolve this way?

Crutzen: If you have the opportunity, when you are working in an interesting field, then you never have too many colleagues. You have more students, the students graduate, some stay, some leave. But we always kept in good contact with our students.

Reinhardt: What are, from today's standpoint, your most significant scientific achievements?

Crutzen: The significance of nitrogen oxides. Then the ozone hole. Its explanation by my colleagues and me was a breakthrough. And the newer research too. There are efforts to develop plant-like materials that can be burnt and thus relieve the CO_2 problem. And I have shown in a study that it is not worth it. What gets forgotten is this: For plants to grow, they need nitrogen, and that means that the nitrogen is converted into laughing gas, N_2O, and laughing gas is three hundred times worse than CO_2 when it comes to its effect on the climate. The advantage that you have by having some of the CO_2 coming from plants is canceled out – too much of it in any case. That was an important point. And then geo-engineering, which has now become a major player […] My aim was originally just pure science. And that was the situation for example in 1970. And then it became clear that the Americans, Russians, the French, and the British were planning supersonic jets, and when supersonic jets gain the upper hand, then so does nitrogen oxides. And down here nitrogen oxides are formed from the combustion of fossil fuels. These were two points that I made clear. Not because of their political significance at first, but rather purely for scientific reasons. That was until it became clear that it was

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more than just science. Humans were involved. And that then became an important part of my research. […] Going back somewhat, at the University of Stockholm, a large number of my colleagues were working on acid rain. And I said that I wanted nothing to do with that, I wanted to carry out my purely scientific work on nitrogen oxides. That was until I realized that if you are involved scientifically in atmospheric research, you simply cannot ignore the influence humans have. We play our part everywhere. Hence the word anthropocene.

***Lax*: You carried out highly political studies in the 1980s.**
Crutzen: Nuclear winter.[1] As a consequence of a hypothetical worldwide atomic war, huge fires spread through forests, industry, and cities, and the smoke particles absorb sunlight, leading to the surface of the earth becoming dark and cold. The consequence would be starvation. The direct consequence of an atomic war would be overshadowed by the indirect climatic consequences. More people would be killed, including those not living in the countries that are fighting. This idea is the most important that I ever had.

***Reinhardt*: The nuclear winter, then "the end of the blue planet?"[2] Almost…I don't want to say commissioned study…but encouraged by politics. Do these public debates that develop around such scientific publications also have an influence on the debates in science itself? Are discussions that are carried out on a professional level in science perhaps sometimes carried out in public?**
Crutzen: Yes. When you think that you have significant results, then you have the responsibility to explain them to politicians and to the general public. It is important to do this. There is no point in only saying it for your own good. […] For example: To stop CO_2 levels increasing, emissions of CO_2 have to be reduced by 60 percent. What we are seeing instead is that emissions are increasing by 3 percent from year to year. This is a huge gap. I hope, but don't really believe, that this can be solved by a conference like that in Durban.[3]

***Lax*: Have you been actively involved in public discussions?**
Crutzen: Yes. Particularly as I was a member of an Enquete commission of the Federal government. As you may know, half of the participants are scientists, the other half are politicians, and a topic is discussed. And in this case, the topic was consequences of the climate and the influence of the activities of mankind on the chemistry of the atmosphere. That was a very useful experience that I made. I have to say that I was surprised how quickly the politicians understood what we were working on. That was a positive surprise.

***Lax*: You were one of the contributors to the study "Schwarzer Himmel"[4] in 1985, and in 1986 came Chernobyl. Can you tell us what you thought at the time?**
Crutzen: That is difficult to answer. Chernobyl happened while I was with a group of the Enquete commission in Bonn, and during our talks the minister Riesenhuber had to leave the room. Then he came back shocked, because the disaster had been discovered. And what did I think? You do think that the world might end, but it didn't happen. And now there is what happened in Japan. Germany will now convert to natural fuel sources. Whether this is possible without using more carbon is questionable.

***Reinhardt*: Was this also discussed in your group?**
Crutzen: We had relatively few political discussions. And definitely not about political parties, we didn't discuss that. But in the case of a nuclear winter, several of my colleagues were of course active, but little in comparison to my activities.

***Reinhardt*: What role did the term anthropocene play in these discussions? Do you think that the fact that we know we are causing change on this planet and bringing on a new age will lead to something happening? Do you think that we can affect a change to our consciousness, to public awareness?**
Crutzen: If that were to happen, I would be over the moon of course.

***Reinhardt*: How did you come up with the term anthropocene?**
Crutzen: At a conference in Mexico. I was a member of a commission, and the chairman spoke of the holocene period the whole time. Suddenly it occurred to me that we were no longer in the holocene. In the holocene period human influence was limited. So I then said: "We are no longer in the holocene, we are in the anthropocene". And that struck a note, it was quiet in the room all of a sudden, and during the coffee break it was the topic of conversation.

***Reinhardt*: In other words, it was a spontaneous thought?**
Crutzen: Yes, it was sudden.

***Reinhardt*: You have also written about geo-engineering. Can we get things back on track with engineering?**
Crutzen: The reason that I wrote that paper in Climatic Change[5] was that I wanted to give people a wake-up call. I wanted to make it clear what serious compromises we are making to the climate and to atmospheric chemistry. If we carry on this way the consequences cannot be overseen. The most important thing is that we reduce CO_2 emissions. That is the number one issue. But we haven't seen anything of it yet. And that is why I wanted to make it quite clear how dangerous the situation is. Geo-engineering would then be a way of retaliating.

***Reinhardt*: What was the resonance from that?**
Crutzen: Of course there was a massive counter reaction.

***Reinhardt*: Why was there such an "anti" mentality also in the scientific world?**
Crutzen: We are playing with nature. That is always a bad thing. Perhaps it is in part the old way of thinking that humanity is much smaller than nature. What gets forgotten is that we have been on the way to changing the atmosphere and our environment for some time now. This isn't a recent thing, but rather perhaps 10000 years ago with agriculture. We have simply become too powerful. We have become so powerful that nature can only retreat.

***Reinhardt*: You have said that in 1970 you wanted to carry out pure science and that with your field you have more-or-less become part of a political theme. I wonder whether there is an intrinsic tension that is difficult to release. You have a great interest in these mathematical models, but they have been translated straight into the economic, political, and ecological reality. Perhaps a degree of distance is required so that these abstract models can evolve for themselves.**

Crutzen: Well, polemics don't help much.

***Reinhardt*: What do you do?**

Crutzen: I have great difficulty with it. Sometimes it was hard when you get attacked, such as with the geo-engineering. Or much earlier, as industry described CFCs as harmless. But this didn't harm me. It is somewhat of a dilemma, one that had probably kept me healthy. The science that you carried out is beautiful, that's how it was. You discover new things, you are often happy about it, or you ask yourself "how is it possible that I can discover something like this, why hadn't anyone done that before?" It is a great feeling to know that these thoughts are so meaningful and that I figured it out. It sounds so egocentric, but that's the way it is.

***Reinhardt*: How important was it for you to be awarded the Nobel Prize?**

Crutzen: I didn't expect it. My work is too political. I had no idea I could get it. It was sometimes talked about, but I said: It won't ever happen. When it did happen, it was a complete shock to me. It's an interesting story: We were, after being a long time without vacation, on a holiday and came back to the hotel in Cordoba after a walk. I had the feeling that people were looking at me strangely, but we went back to our room. We wanted to finish getting ready to go and have a meal, and then my wife said, "Hey Paul, you've got the Nobel Prize". And I was shocked. It wasn't elation at first, it was more like shock. I hadn't bargained on it at all. The next morning, we took off to Seville and went into hiding for five days. As we returned to Mainz, the house where we live was colorfully decorated. The door of the house was decorated by the neighbors. The next day I was told that I shouldn't go to work. Instead I was picked up and brought to the institute in a horse-drawn coach. It was fun in the end, but when I first heard that I had won the Nobel Prize, it was a complete surprise and at first it was nothing like a feeling of joy. That came later.

[1] Compare with Paul J. Crutzen and John W. Birks: The Atmosphere after a Nuclear War: Twilight at Noon. In: Jeannie Peterson (Ed.): Nuclear War. The Aftermath. Oxford 1983, pp. 73-96.
[2] Paul Crutzen (Ed.): Das Ende des blauen Planeten. Der Klimakollaps: Gefahren und Auswege, München 1989.
[3] In Durban, South Africa, between November 28 and December 11, 2011, the UN Climate Conference took place.
[4] Paul Crutzen et al. (Eds.): Schwarzer Himmel. Auswirkungen eines Atomkrieges auf Klima und globale Umwelt, Frankfurt am Main 1986.
[5] Paul J. Crutzen: Albedo enhancement by stratospheric sulfur injections. A contribution to resolve a policy dilemma? An editorial essay. In: Climatic Change 77 (2006), pp. 211–219.

