Topic 1a - The threats to our fragile resource – why monitoring matters

[MUSIC PLAYING] The atmosphere is a shared resource on Earth. It hasn't got any boundaries. How does that change how we look at and how we study it?

It means that when we look at the atmosphere, we need to design our systems so that we can measure globally. It also means that they have to be able to look at a wide range of atmospheric concentrations. So the amount of molecules in the atmosphere is large, huge. But sometimes there are very small amounts of particulate gas that we want to see. So the sensitivity of the instruments needs to be really very high. But also if you have to cope with very large signals.

In terms of the science that we did, actually we want to integrate those observations and models so we get a complete picture. Because what we see at one point may not be happening at that point, even an hour later.

When we see the photography of Earth, we see that the atmosphere is a really thin layer. And in this layer, there is a mixing of different chemical compounds. And they chemically react. They are deposited. They interact with the atmosphere, with solar radiation. And so all this chemistry has really a huge impact on climate, and also on the human beings, and on ecosystems. The atmosphere is a melting pot where different chemical species, aerosols, clouds interact, and also have impact on the nature, the society, and climate.

You think about many of the contemporary problems that we face in society, climate change, air quality, and poor air quality. Both of those are actually driven by changing atmospheric composition. They're driven by changing concentrations of pollutants, one from fossil fuels, one from a range of other sources that are driving change in that composition of the atmosphere. So we need to absolutely be able to measure these compounds to understand how much there is, and whether when we take measures to reduce those that actually we're having an effect.

The picture of the planet Earth made by the first astronauts landing on the moon was a game changer. And one of the major things about flying and looking down on the Earth is that you realize how fragile and vulnerable the planet is as a whole.

They uniquely as a group all recognized the vulnerability. So this was a big game changer. And that was, I would say, the first satellite picture taken by man.

But what's happened is that, using our knowledge of our laws of physics and engineering, we're able to design satellites which provide the information on an objective base of how the planet is changing. The surface and its atmospheric constituents.

And the atmosphere is particularly important, because this is often an early warning signal. It's too late, to an extent, when you've measured that there's no more ice above the Arctic. You have to get the problem sufficiently early enough.

It's like heading towards a cliff. You have to turn early enough to avoid going over the cliff.

We are starting to look at the whole planet as an entire planet. But that also means we have to cooperate as humans.

In these complex problems we often need knowledge from another scientist somewhere else. And we would like to bring that together and integrate it.

The big change, I think, has been that internationally, whether at a government level or in big business, or in smaller businesses that cross boundaries, people have realized that. It's helped people to realize that, working together, the environment, the atmosphere is the same. We need to control it together. We need to think about the consequences together.

It's one system. But also, there's a lot of it. There's a lot of data. So much work to do. There's so much data. No one nation can do this alone, because it's just too big a task.

That's right. The whole system requires on countries, organizations banding together, sharing their data, sharing their satellite systems. Satellite systems themselves are expensive. You can't do that by yourself. And we need that, right from the space systems, through to the data systems. And then through to the users.

So it's really important that users can individually, in each country, access data, but then share that data, and recognize that other countries are looking at the same data in the same way. It enables us to come up with policies. But it enables us to talk to our industries as well, and to our societies, and develop common understandings, shared ways forward, because it's by working together we can do this.

There are a lot of things that we've been adding to our atmosphere, some of which weren't there, and some of which were. We're changing the mixture. We're changing the soup. And we're breathing this.

And maybe I'll start with the things that have never been in the atmosphere. And the chlorofluorocarbons are a really good example of that.

And there's a whole family of them. They're interesting chemicals. They have lots of good characteristics. They are not poisonous, toxic in that sense. They have strengths as chemical compounds. And the chemists of the early 20th century were very interested in their properties from this point of view.

The disadvantage is that when they get into the stratosphere they are decomposed by shortwave UV radiation and ozone killing species. Chlorine atoms and bromine atoms are released in large amounts. And so that's then modifying the system. But we actually introduce the new gas.

With respect to fossil fuel combustion, the issue is that we're adding and modifying gases that are already there, like oxides of nitrogen, like ozone, like trace constituents like aerosols. And this is where you see the smog, the classical photochemical smog in summer, or London winter smog.

We're creating, thereby, a lot more of acids. So the issue of acid rain that is partially resolved by desulfurization of power plants, there was large political debates about that in the late 1980s, but we removed these compounds.

And other compounds that have being removed, for example, lead in petrol. And that was found out to be, of course, bad for children's mental health, and is basically a poison.

So air quality is a really key issue for humans nowadays. It depends where you live. If you live in South Africa, most of your indoor pollution is what's bad for you, where people are still cooking and living in the same space. So in South Africa maybe the first issue is to clean up indoor pollution. And maybe in other similar countries with a similar tradition.

But for the rest of the world we're breathing outdoor pollution. And outdoor pollution is estimated to kill between 4 and 7 million people a year. So there's a huge impact on human health.

In Europe we see each year more than 400,000 people die prematurely because of their exposure to air pollution. This is why air pollution is a growing political issue. We realize there are unacceptable levels of harm happening to people. And politicians are increasingly facing requirements and requests from the public to deal with the issue.

Air pollution particularly affects vulnerable members of society. And by that we mean the young and the elderly, and also those with pre-existing medical conditions.

So, for example, if you have a child with asthma, high levels of air pollution can exacerbate that and lead to the need for medical treatment and interventions.

So the harm being caused by air pollution also creates a real economic cost. We can think of cases where parents have to stay home to look after their children. They can't go to work. There are economic costs associated with medical treatment, visits to hospital, and the loss to society as a whole.

Air quality is a major threat to health, to ecosystems, to agriculture, for instance, to buildings also. It's important to measure concentrations, and to assess concentrations of pollutants for policymakers, and also to take decisions.

And that's the issue, because there are many nonlinear processes in the atmosphere. For example, the ozone hole, just as an example, nobody predicted that.

And what we mean by a nonlinear relationship in this context is something where if you double the input, you don't just double the output. It has far more consequences.

Well, we call it autocatalytic. Instead of just moving in a linear fashion, it actually accelerates. It's to do with acceleration. Or it can also decelerate, but much more rapidly.

Mathematically, nonlinear systems are the most challenging to address. And the atmosphere and the Earth system is a nonlinear system. And that's why we need our biggest and best computers on these problems.

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