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How are the IPCC's scientific and technological reports compiled? On the basis of these reports, how is the Assessment Report developed? What are the main conclusions presented in the last report, particularly concerning greenhouses gases?

Thank you and hello to you all. I am from Milan and used to come to the Museum as a child, so it's quite exciting to be here. Thank you for the invite. I have been working in Zurich for several years now, and this is my university, Zurich Technical University. The dome you can see in this picture is covered with a globe, to symbolise that a great deal of research is dedicated to climatic, energy-related, environmental and sustainability issues in my University and it is a great pleasure to have the chance to talk to you about it here today (**vp – page 1**).

In my presentation, I will tackle a number of issues. I have been asked to explain how the IPCC works, which is something that I'm more than happy to do and therefore I will talk about impacts, adaptation to climate change and mitigation, followed by a number of conclusions. There are lots of students here today, just like those I talk to on a day-to-day basis. I hope that you can see my e-mail address down here. If you have any questions or any points of interest you wish to talk about later, please write to me.

The IPCC is the Intergovernmental Panel on Climate Change, established by two UN organisations – the World Meteorological Organisation and the United Nations Environment Program (**vp – page 2**). It was founded in 1988 and collects and assesses all the scientific, technical and socioeconomic literature relevant to understanding the risk associated with climate change, the potential impacts and countermeasures. The IPCC does not do any research itself, it does not measure climatic data or parameters, it does what is written in the previous point (**vp – page 2**). The organisation is what you see there (**vp – page 2**).

There is a plenary assembly, involving all countries belonging to the United Nations or World Meteorological Organisation; there is a Bureau, let's say a governmental office with about 30 members, currently chaired by Rajendra Pachauri, an Indian; and then there's a Secretariat, just nine people who work in Geneva and coordinate the work of the whole IPCC which is made up of these four groups: three working groups and a task force (**vp – page 2**).

The first working group deals with the basic physical principles, in order to understand the climate, the second deals with impacts, adaptations and vulnerability, the third with mitigation and here I'd like to mention my colleague Carlo Carraro of the University of Venice, who is deputy chair of this working group and is therefore the Italian member of the IPCC Bureau. Lastly, we have the task force, which deals with the national greenhouse gas inventories. The IPCC's main activity is the production of reports that represent the state of the art in climatic science and technology, which are written by hundreds of scientists, who can be divided into Main Authors and Authors who contribute to these reports and these reports are produced according to very important, well established conventional rules that govern scientific activity. In other words, during their preparation, these reports are examined by expert reviewers, then supervisors, who make sure that all the comments have been taken into account.

More specifically, the IPCC's reports are primarily the assessment reports, so far four have been published, the most recent one in 2007, which I will talk about in greater detail later. These are special reports on specific topics, such as carbon dioxide capture and sequestration, the role, if any, played by aviation on climate and then we have the more specific methodological and technical reports. The underlying principle of all these reports is to achieve a high scientific and technical quality and they are written in a complete, objective, open and transparent way, undergoing the review process I mentioned previously and that I will now explain in detail (**vp - page 3**).

When the IPCC decides to write a report, the plenary assembly approves this decision and compiles a report index. The index is essentially a list of questions that this report should answer. Authors who are essentially experts in this sector from all over the world are chosen and the authors prepare a first draft of the report. They compile this draft using technical and scientific literature, what we call peer-reviewed literature, available, the literature that have been published in international scientific journals following the review and arbitration mechanism typical of scientific literature. In other words, a scientific article is not merely the result of the work of the authors, it is also reviewed by anonymous expert colleagues who, before the paper was published, checked that it was scientifically valid. This first draft is reviewed according to the principles that I have just described, the authors prepare a second draft; the first reviewers are expert fellow scientists (**vp – page 3**).

The second review is conducted by both experts and governmental representatives, people with a technical background who work in the governmental organisations that deal with the climate and environment and on the basis of this second review a final draft is prepared that is then distributed, and approved by the plenary assembly that prepares an abstract for policymakers, together with a small group of experts (**vp - page 3**).

This is how these reports are prepared, it is a process that takes a few years and a great deal of commitment. It is important to highlight the fact that these reports are relevant from a political standpoint, rather they are supposed to be important, but they are not directive, they don't say what has to be done, rather they provide information to help the decision-makers to make decisions (**vp-page 4**).

The work of the IPCC was acknowledged in 2007, when the Nobel peace prize was awarded jointly to the IPCC and Al Gore, for "their commitment to forming and diffusing an awareness of climate change caused by mankind and laying the foundations for the action needed to counter this change" This is the current IPCC Chair, Rajendra Pachauri (**vp – page 4**).

The fourth and last assessment report, which was published in 2007, is known for short as AR4 (Assessment Report 4) and consists of a summary report and three volumes produced by the three working groups. It is available from the IPCC website and can be downloaded or consulted free. Each of these volumes is a thousand pages long, so it is a work of over three thousand pages (**vp – page 5**). The first group, rather the first volume of the report, deals with basic physical principles, therefore it analyses the progress made in understanding the human and natural contributions to climate change, the climate changes observed in climatic processes, their cause-effect relationships and evaluation of future climatic change forecasts (**vp - page 5**). The second deals with impacts, adaptation and vulnerability, on the basis of the scientific understanding of the impacts of climate changes on human systems, natural and non-natural systems, the ability of these systems to adapt and their vulnerability (**vp – page 6**). Lastly, the third deals with mitigation, i.e. the scientific, technological, environmental, economic and social aspects of the mitigation of climate change (**vp – page 6**).

Let's take a look at what we know today, what these reports say, what we have discovered and I want to think it through with you, it will take some time, but I believe it is worth it. Let's start with the value of the mean global temperature, we have already seen this, this curve shows how temperature has changed over the past 150 years, the grey curve is the mean value of temperature calculated over 10-year intervals and how it changes and the grey band indicates the statistical uncertainty of this data (**vp - page 7**). These straight lines are used for interpoling, to describe this data in the simplest way possible. What it is interesting to observe is that if we use the data for the last 150 years we obtain the red line, which is the variation in temperature over time, this red line is what we get for the last 150 years. If we consider the past 100 years, we get the purple line, the orange line if we consider the last 50 years and the yellow one for the last 20 years. They all follow an increasing trend and have increasingly steep slopes, meaning that we are observing global warming and a phenomenon that is accelerating over time.

This is the first piece of information, however, it goes without say, what I am interested in is the cause, I want to know how I can act or how I should react to these events, and this is where the models that Navarra was talking about earlier come in.

This is a very important slide that I have to explain to you very well. Here the black curve represents the measured temperature value, in other words how the temperature changes, the change in temperature compared to the average for last century, that's the black curve, these are the values measured (**vp – page 8**).

The light blue curves and that dark blue curve are simulations performed on models. There are several light blue curves because here we are dealing with simulations on a number of models developed in various research centres, including Navarra's, but there are also many more models based on the same mechanisms, on the same physics, but with differing assumptions or that are numerically solved in a different way. These models do not all say the same thing, however you can see that their results form a band. These are the reconstructions of temperatures that we know and not therefore are forecasts, the models are used to reconstruct the climate over the past 100 years. And this blue line is the mean: you see that there is a certain agreement and then in recent years the models deviate from the measurements.

However, these models have a characteristic, they only include natural elements in the temperature forecasts, in other words, they do not include the effects of human activity. We have already heard that models describe certain mechanisms, these purposely exclude the role of mankind.

Of course, some models also include the anthropic effect, such as these (**vp – page 8**). The black curve is the same, the yellow curves are models that also include the anthropic effects/forces, and

the red curve is the mean and as you can see, the models now describe the temperature changes observed in recent years, whereas the models involving natural forces alone follow a different trend and also show what we know, that today, natural effects alone would cause cooling, not warming. So for me, this is the clearest indication that man plays a key role in climate change.
This value concerns global temperature, but we see the same thing if we look at models describing local temperature; here we have got lots of things, but essentially, this is the graph I showed you earlier, the measured value curves in black, the models with human forces in red, models with natural effects alone in dark blue; we see that the red ones describe the data well and this is true in all parts of the world, in Europe, North America, Asia, over the ocean, over the land. So this data, despite being within the variation bands of the models, which are inevitable, give an answer that I believe to be indisputable (**vp – page 8**).
So let's take a quick look at the causes. Here we have a lot of curves, but I'd like you to concentrate on the red one. The red curve shows the concentration of carbon dioxide in the air over time and we are looking at 600 thousand years ago, which is here. The grey bands are the interglacial periods (**vp – page 9**).
We see that carbon dioxide (we have already seen this, I'm presenting it in a different way, but let me finish this reflection) CO_2 oscillates, varying from 180 to 280 ppm (parts per million) in the atmosphere.
If we come to the end, of course we don't see the last few years, we see the current situation, today we are here, the red dot, the red star: 380, in other words we are 100 ppm above the maximum of this oscillation observed over the past 600 thousand years. If we zoom in on these last few years, first we look at the last 10 thousand years, you see over the past 10 thousand years, CO_2 has remained 270/280 ppm, and then it suddenly shoots up, if we zoom in on the last 200 years, you will see the changes of the past few years. These are measured data, not forecasts.
It's as if the curve has crashed into a wall, almost and I think that this is a clear indication that what we are observing is a change in carbon dioxide concentration that has nothing to do with the natural mechanisms that caused these oscillations, rather it was caused by something else. We also know what, because we know about human activity on this planet and about carbon dioxide emissions, for example, and also about the other greenhouse gases that we produce. After all, if we, in this room, which is very full, were to close the doors and switch off the air conditioning and were to stay here for three or four days, we would start to feel a bit sleepy, due to a shortage of oxygen, and the concentration of CO_2 would increase. So, I have to say, it's not that surprising.
Allow me to close with the words of the IPCC: we have observed a change in temperature and we have seen that models show the cause to be human, not merely natural. The IPCC's conclusion is: "most of the observed increase in mean global temperatures since the mid-twentieth century is very likely due to the increase observed in the concentrations of greenhouse gases of anthropic origin". An index of probability is assigned to this conclusion, which is 90% (**vp – page 9**).
I believe that this index indicates the seriousness of the work, because it shows that it is true, we have seen it, performing measurements is difficult, there are uncertainties as regards the models however, globally, the scientific community that contributed to drafting these reports agrees in the conclusion that, with a 90% probability, this is the situation and this 10% that we leave out, I believe is a witness to our intellectual honesty in also taking into account uncertainty, which exists, but that does not change the conclusion of the words at the bottom here (**vp - page 9**).
I would also like to emphasise that the third report, published in 2001, concluded on the same topic: "most of the global warming observed over the past 50 years is probably caused by the increase observed in the concentration of greenhouse gases", 66% probability. This means that there has been an evolution: here the conclusion is given with a lower probability index because there was less data, because science was developing. There has been an evolution, however it is interesting to see that the conclusions are the same and today we know things better than we did 7 or 8 years ago.
What are the impacts of these climate changes that we are observing? Regardless of the temperature, we look at the physical and biological situation. The results I am quoting are from a very recent paper published in Nature, which we mentioned earlier, a very authoritative journal, published in 2008 (**vp - page 10**). A group of researchers looked at about 30000 physical and biological systems, over a 34-year period and observed how they changed. These are probably phenomena relating to migrating animals, flowers, glaciers, in other words, lots of biological and physical elements. This map, concerning Asia, indicates on the one hand the temperature change measured: here you see the temperature scale, so where it is red there has been a positive temperature change, and when it is blue the change is negative. This table shows how many physical systems are considered, in this case 98 physical and 16 biological, and the percentages of those that are changing in a direction consistent with warming, as you can see, are 96% and 88% (**vp - page 10**). They might not seem very many, in Oceania we have even fewer, however if we look at the rest of the world, Europe for example, there are 30000 observations. But look at the

row underneath, everywhere the percentage of biological and physical systems that are changing in a way consistent with global warming is higher than 90%, with perhaps an exception here. There are other impacts, so these are observations, factual data. So if we want to make forecasts, which are important, researchers have produced tables like this, which show, with a variation in temperature changes, one degree higher, two degrees higher, 3 degrees higher, 5 degrees higher, how the systems we have to take into account (water, ecosystems, food, coastlines, health) are impacted by these changes. Of course we do not have the time to go into this in detail (**vp – page 11**). This data depends on technological and socioeconomic climatic scenarios, i.e. we now have models that describe the past better but that must also project into the future, we have to make assumptions, however it is important to have a clear idea of the potential effects and impacts. For example, this is a map that shows how water run-off will change in the various continents. dark blue means there will be more water, red and yellow mean that there will be less. I'm not so interested in the detail, I would like to point out one thing: these are percentages, in other words we are talking about variations of up to 40% higher or lower, i.e. we are talking about significant changes in natural systems. You will see that there are white areas here, which I believe is proof of intellectual honesty, here the models do not agree and therefore the map does not show the result, however where the colour is clearly indicated it is because different models have reached the same conclusion (**vp - page 11**).

Adaptation: so, once we become aware of this situation and we know that we are in the presence of important climatic changes, we have two possibilities, we can either try to adapt, or try to mitigate these changes. Let's look at adaptation first. Certain measures have already been implemented by countries like Holland, which has an ocean level problem and therefore a great deal of research is being conducted in order to better understand the evolution of the climate, and a number of measures have been taken to protect the coastline and prevent flooding. This is a problem that affects many people first hand, the same situation exists in Bangladesh and the United Kingdom, where measures to protect the coastline are also taken. In countries in the Alpine arch, winter sports services are being changed in line with climate change (**vp – page 11**).

So, if we do not merely want to adapt, but rather we want to fight these changes, first and foremost we have to ask ourselves: where do these greenhouse gases come from? Which industrial sectors and sectors of human activity produce them? Here, in this table, I would like to answer this question, let me explain: here we give the amount of carbon dioxide or greenhouse gas measured in tonnes or billions of tonnes of CO_2 equivalent released by the various sectors (**vp – page 12**). Let's start with energy: the first bar indicates emissions in 1990 and the second emissions in 2004, the red band is carbon dioxide, the green band methane and the dark blue band nitrogen oxides. So we can see that emissions are concentrated in the energy, transport and industry sectors for carbon dioxide, but we also of course have construction, buildings, agriculture, especially for methane and nitrogen oxides, forests and forestry in general and waste processing. You will notice that in all cases between 1990 and 2004 there is an increase, and I would like to highlight that the sum of these emissions is a number that is easy to remember: 50 billion tonnes of CO_2 equivalent a year. Carbon dioxide alone accounts for 30 billion tonnes, of which 20 billions tonnes are concentrated emissions, in other words, emissions from industrial plant, where there are enormous emissions concentrated in a certain place, all the others, such as transport and buildings, are distributed emissions (**vp - page 13**). It is important to remember that 40% of total emissions are concentrated in thermoelectric power stations, industrial plant, chemical plant, cement factories, steelworks, etcetera. The message of this transparency is very simple: there is a whole series of possible countermeasures that can be implemented to reduce these emissions in the agricultural sector, in the energy producing sector (by using renewable energies, such as solar panels), in the transport sector, in the building sector (better building management and better urban development), and many of these countermeasures are possible today and we forecast that, with the development of technology, even better ones will be usable and available in 2030 and (here I'll skip this list), when we look at the potential, are they trivialities or are we talking about something significant. The potential is shown here and is very significant (**vp - page 13-14**). Let's take, for example, the energy sector, which is the first: these are the same business sectors that I used on the previous slide, total emissions are 50 billion tonnes a year, here you have the same measurement as a scale and here we see that in the energy sector in 2030, it is thought that we will be able to reduce emissions by 3 billion tonnes, in other words 15-20% of what is released. If we look at transport (**vp – page 14**), again a certain reduction can be achieved here. In building, look at this huge mitigation, the possibilities we have at our disposal also in industry, farming, forestry, refuse management. So why are there 3 levels, 3 bars for each sector? This is very important, because for each of these bars, you see that in each case the mitigation potential, when we move from left to right (these are of course estimates, forecasts) is associated with a cost of CO_2, In other words: today we release carbon dioxide and we do not pay for the environmental impact of this emission. A carbon tax has been proposed, the European Union already has a system for exchanging and selling emission rights with a certain price; were this cost 20 dollars in these units, we can use technologies that have a cost of 20 dollars or less per tonne of Co_2. So we have this mitigation potential, if the cost of CO_2 increases to 100 the mitigation potential increases as a consequence. Here there are also some details on the energy sector, I have to say that this graph is important, the source is the OECD, the Organisation of Developed Countries, of industrialised countries, the IEA is the International Energy Agency, which belongs to the OECD, and they made these forecasts, which describe how carbon dioxide emissions will change over the next 50 years. 15): we are now at 28. This graph contains a great deal of information. The first thing we have to look at is the top curve, which describes how CO_2 emissions will change, how they are expected to change over the next 50 years, from the 28 billion tonnes today to reach 62 billion tonnes in 2050. The bottom curve is the one to follow in order to reduce emissions to 14 billion tonnes by 2050, which corresponds to the stabilisation of CO_2 concentrations in the atmosphere at 450 ppm; to be able to do so, in order to reduce emissions, we have to do something, because this follows economic development, the development of energy consumption that we expect, we have to be able to compensate/reduce emissions for the difference between forecast emissions (expected CO_2 production) and the emissions that we can except and to do this we use technologies that do not release carbon dioxide, so we have to improve efficiency, reduce consumption, use renewable sources, nuclear power and CO_2 sequestration, which is given here and you can see the percentages. All of these elements have to contribute, because none of them is able to solve the whole problem, so I won't talk about CO_2 capture and sequestering, because the time has passed.

Allow me to make a few concluding comments. I would like to point out that I am not talking in the name of the IPCC, I am talking on a personal level, I do not represent the IPCC, rather these are my convictions that I am voicing: global warming is primarily due to human activity and the IPCC says that this is true with a probability of 90%; the impacts are and will be important and will particularly affect the most vulnerable systems that find it most difficult to adapt, to react to changes that are harmful to them; the intervention for adaptation to climate change and counter measures for its mitigation are available and can be implemented immediately, with appropriate legislation, and I believe that all of these actions contribute to making our development more sustainable and consequently, are important. Thank you for your attention.