Panel 1: Can Space Do More to Support Action on Climate Change?

Spotlight Talk Speaker: Waleed Abdalati, Director, Cooperative Institute for Research in Environmental Sciences at University of Colorado Boulder (CIRES)

Moderator: Krystal Azelton, SWF Director of Space Applications Programs

Panelists:

- **Dr. Mariane Diop Kane**, Programme Manager for the African Ministerial Conference on Meteorology (AMCOMET), WMO Regional Office for Africa
- **Lori Garver**, CEO, Earthrise Alliance
- **Steve Hamburg**, Chief Scientist, Environmental Defense Fund
- **Thelma Krug**, Vice-Chair, The Intergovernmental Panel on Climate Change (IPCC)

(Spotlight Video)

Waleed Abdalati: Hi. My name is Waleed Abdalati. I'm the director of CIRES, the Cooperative Institute for Research in Environmental Sciences. With regard to the question, "Can space do more to support action on climate change?" the first part of my answer to that is space has already done plenty, but the second part is yes, of course, it can do more to support action.

As far as what it is done, space-based perspective has provided foundational knowledge and information. In other words, the data to help us understand climate change and inform action.

It does this in part by allowing us to access otherwise inaccessible places -- the Arctic, the middle of the Sahara Desert, the Amazon rainforest. Now, we can go to these places, but to observe large scale behavior really requires satellite observations.

The second is the space-based perspective allows us to see the world in ways our eyes can. By using the full part of the electromagnetic spectrum, ultraviolet, microwave , radiation, thermal infrared in addition to visible, we're able to "see things" that our eyes otherwise couldn't.

The third is perspective, the large scale perspective of global processes and the Earth system and the interactions among the elements of the Earth system. What has space-based observations told us with regard to climate change that have helped us understand the situation.

I'm just going to give you a few examples that illustrate the points I made before about how we observe from space and what that enables us to do. The first is the shrinking Arctic Sea ice cover. We're all aware that over the last several decades Arctic Sea ice has been shrinking substantially. We know this because of satellite observations.

If we physically went a few 100 miles above the Earth and looked down at the Arctic, we wouldn't see the sea ice. The clouds would be in the way, but because we measure it at microwave wavelengths, the microwaves penetrate the clouds, and we're able to see the ice below and its behavior. We can see in the late-'70s, compared to just last year, substantial losses of Arctic Sea ice cover.

Another area that's close to home for me is wildfires. Again, the satellite observations allow us to see fires on a continental scale -- their number, their duration, their intensity, and subsequently the fire damage that's done, the spatial extent of these fires.

Looking from space helps us get a sense of the behavior of these fires and their evolution with time, both evolution within a fire incident but evolution from year to year as to how much these are growing, how more widespread they're becoming.

Another area from a global perspective standpoint is sea level rise. Using satellites, we've measured sea level rise reliably since the early 1990s. What you see here is the spatial distribution of sea level rise.

We can estimate global rise but also how it varies from location to location, which is dependent on where the energy is being absorbed in the ocean, where the water and ice that are causing the seas to rise in addition to thermal expansion are coming in from.

The satellite perspective by orbiting the Earth repeatedly over, and over, and over for decades tells us the regional characteristics, which makes a huge difference in the implications for coastal regions. A difference of a few inches has tremendous implications for people worldwide.

This last example is really a great illustration of interaction between components of the Earth system. This is the carbon dioxide uptake from vegetation. What you see is CO2, carbon dioxide, overlaid on the annual vegetation patterns. You can see a spring arrives in the Northern Hemisphere. We can watch the CO2 uptake by the vegetation in the Northern Hemisphere.

As fall comes, we watch the increase in CO2 as there is less vegetation to take up that carbon dioxide. The space-based perspective has already told us much, but it's got a lot to tell us going forward.

Now, ultimately the solutions to the climate change challenge is going to depend on policy and sound decision-making, the choices we make as a society. Those policies and those choices need data to be made in an informed way. That, again, is what the space-based perspective tells us.

What can these observations do in the future? One, we can continue watching the climate change story unfold, whether it'd be manifested through rising oceans, increased fire, changes in hurricane behavior, just plain warming, the implications for vegetation, whatever.

The space-based perspective allows us to look at the global scale and understand how that story is unfolding. We can also, through new investments, make new kinds of observations that can help us get at the root of these changes but also inform the implications of our choices that we can make our choices better or provide information on the implications of our choices.

These data improve models. When we observe and understand, we get better at predicting. Taking these data, and understanding the processes at work, and improving our models accordingly allows us to better predict the future, better understand what we're in for, better prepare for what's coming, and better mitigate the changes that will happen.

Ultimately, this information through the direct observations or how we inform our models will inform policy, will inform our choices. The good news is we've got the technology. We've got the scientific expertise and capability.

What we need is the investment. We've been lucky that there've been robust investments for quite some time, but when compared to the implications of the climate change challenge and the costs associated with it, those investments have been comparatively small. With increase in investments, we'll be able to do more. We'll be able to better position ourselves to meet the challenges that are undoubtedly coming.

I'm going to leave you with a quote, a pretty powerful one in my view by Socrates from 400 BC. Even then, he knew, "Man must rise above the Earth -- to the top of the atmosphere and beyond -- for only thus will he fully understand the world in which he lives." It was true then. It was true today, and it'll be true tomorrow.

Thank you for your attention, and thank you to the organizers for putting this session together and to the other members of this session contributing on the panel. I appreciate being a part of it.

Krystal: That certainly got us off to a good start. I think it comes as no surprise to anyone that space technologies can contribute significantly to global efforts to mitigate and adapt to climate change, and that indeed, technologies have already been instrumental in helping scientists gain a better picture of the urgency of climate change.

What we're here to discuss today is the knowledge and the technology gaps. What's needed? What's next in terms of new technologies, in terms of how we process and manage current data to ensure that humanity has a full understanding of the problem and is able to take informed action?

To try to answer those questions, I will turn to my panel. While that's up, just a quick reminder that we do have a poll on Mentimeter. Please follow the link just below your streaming feed to participate. I am incredibly honored to introduce this panel. It's not often that I get starstruck, but we have a really incredible lineup for you today.

To start with, Mariane Diop Kane is a meteorologist with long experience in forecasting and research into the African Monsoon and weather systems. Following a period as the director of Meteorology at the National Agency for Civil Aviation and Meteorology of Senegal, she is currently a program manager at the WMO Africa Regional Office in Addis Ababa, Ethiopia.

Lori Garver is CEO of Earthrise Alliance, a philanthropic initiative established to fully utilize Earth science data to combat climate change. In her illustrious career, she was also the deputy administrator of NASA and the executive director at the National Space Society, among many other roles.

Steve Hamburg is chief scientist at the Environmental Defense Fund. He has served as the lead author for the Intergovernmental Panel on Climate Change at the UN and was recognized as one of the scientists contributing to the award of the 2007 Nobel Peace Prize.

Finally, we have Thelma Krug, who is the former deputy national secretary at the Secretary of Policies and Programs of Science Technology at the Ministry of Science, Technology, Innovation, and Communication in Brazil. In 2015, she was elected vice chair of the Intergovernmental Panel on Climate Change.

Welcome to my panel. It's wonderful. Hello, everyone. Great. You're all live now.

Steve Hamburg: Good morning.

Krystal: Good morning. You're all live now. I'm actually going to start with Ms. Krug. The IPCC is currently undertaking the sixth assessment report on science related to climate change. I'd like you to start by telling us what role does Earth observation play in this process. In your opinion, what has changed since the last assessment report?

Thelma Krug: Thank you very much, Krystal. Before I start, let me also congratulate the winners of the contest. We've really made all stimulating young people to get interest in this subject. Also, thanks for the opportunity to be here.

I think that has really set up the scene for this discussion here. He said that we already have a lot of remotely sensed data, but this can do more. Satellite information can do more. We see this increasingly with the IPCC assessment reports.

If I can give just a little bit of the background, the IPCC does not do the research itself. It relies on the assessment of a broad range of literature that is relevant for climate change, including the physical biases of climate change, impacts, adaptation and vulnerability, and mitigation of climate change.

We have these three big working groups in the IPCC that work in the assessment of the literature worldwide. This is why it's so important that we have scientific publications, information from the socioeconomics, and technological information. If we look, increasingly, IPCC has been more than 30 years doing these assessments. We are in the sixth cycle now.

If we go back and see how it improves and how much it relies on remotely sense today not only to improve the model capacity to protect future climate change but also on many of the relevant points that we lead has put forward, including the shrinking of the sea ice cover, the fires in terms of their intensity, their frequency.

We know with climate change increasing, we project more fires, greater intensity, and so on. Remotely sensed data is incredible too that we can use to look at this and look at shifts and the trend of the observations.

To respond to your question objectively, I started to consult Working Group I that works on the fiscal basis of climate change. Why is that? It's because their assessment report is coming up for

approval of the 195 governments now in July and August, so we are going to have new information coming up.

From the point of view of remotely sensed data, Working Group I selected five points where they see improvements. I'm going to highlight those five very quickly. One is the improved understanding of the drivers and their role in the Earth energy imbalance.

We know that, for instance, some publications, both satellite and in situ observations independently show an approximate doubling of this unbalance from mid-2005 to mid-2019. It's an imbalance in the incoming flux to the outgoing one.

The second one is the closure of the Earth's energy budget through atmosphere, ice, ocean, land monitoring. Remotely sensed information is important when we look at this energy budget because we wanted to include information from the atmosphere -- aerosols, greenhouse gases, surface, albedo clouds, vegetation, land use patterns. Remotely sensed data is a huge contribution for us to assess these.

The third one is on the closure of the sea level budget, which aims to reduce the current uncertainties on sea level change and the digital components for this change. When we reduce uncertainties of sea level change, it improves our understanding of the processes involved in causing this global mean sea level rise and the regional variability.

This is the third one. When we talk about closure of both the energy budget and sea level budget, we made to reduce uncertainties. Throughout the assessment of the IPCC, you see this very clearly. One of the real challenges they have is to improve their ability to project the future and see the changes, and remotely sensed data is there.

The first issue is also narrowing the range of equilibrium climate sensitivity including through improved observation constraints on feedbacks. We see, for instance, that in AR4 of 2007, we did have this range of equilibrium climate sensitivity using a model which was the CMIP3, changed in the assessment of 2014 using another model based on another characteristics.

Now in AR6, we're going to even have an improved modeling approach, which will help us to narrow the range of equilibrium in climate sensitivity.

Finally, the last one is the growing field of constraining climate projections. We are talking about this new area of emerging constraints that is coming up combining these emerging constraints and relating them with observations that could reduce uncertainty surrounding future climate.

On the last two points that were made by Working Group I -- and I think that this is very general -- the points I made were very technical in nature but two important issues that they highlighted. One is the importance of remotely sensed data for the quality of reanalysis in the challenges that are linked to the continuity and also homogeneity of the measurements for doing that.

We see that remotely sensed data needed to ensure this continuity so that we can do reanalysis, looking from past information and observations, but we need to have continuity of this. We see that the need for the programs to have continuity and consistency.

Krystal: Thelma, I want to come back to that point. What we'll do, I'm going to go to the next question, but I'd like to come back to this idea of the consistency of data because I think that's really going to be key for our audience to understand that talent.

Thelma: That's perfect. It's my point, Krystal, and it's also the regional information. It's the importance of going from the broad to the smaller scale. Those are the two points that Working Group I finally made. Thank you.

Krystal: It's actually the perfect segue into our next speaker, Ms. Kane. I wanted to ask you about climate services for adaptation and how they're generated through the global framework for climate services and specifically about that situation in Africa. What are the unique challenges that you face there?

[background sounds only]

Krystal: Mariane?

Mariane Diop Kane: Thank you, Krystal. Do you hear me? My Internet is going on and off. I hope you can hear me.

Krystal: You're fine right now.

Mariane: It's a pleasure to be part of this panel. Climate change is definitely inevitable. We are already in it. With climate variability, an increase of extreme events was in frequency and intensity. All parties are working to keep the Paris Agreement and keep the temperature change down to 1.5 degrees Celsius increase.

Meanwhile, we need to adapt and move to climate-resilient, climate-smart activities to get the best out of it and minimize impact on societies and economies. Climate services can help surely the essential tools for adaptation to climate change. Many [inaudible 44:41] , as you may know, have shown that investing in climate services has many benefits.

It's being related to one out of four, so climate services are really essential for climate adaptation. Following the 3rd World Climate Conference, the GFCS was established with a sweet-tire organization at global level, regional and national level.

Climate services realize value chains from operational hydrometeorological systems, including observation networks, data and databases, climate monitoring and forecasting products, and provision and delivery of services, and all partnership, with research and development, as well as user-interface platform.

WMO global publishing centers will feed information into the regional climate centers, which in turn process regional products to be used and adapted by National Meteorological and Hydrological Services to meet their users' needs.

National Meteorological and Hydrological Services develop tailored product, so a user interface platform, as I just said, and so collaborative research, both at national level and international

level, and partnership to support planning and decision-making in climate-sensitive sectors, such as agriculture and food security, water resources management, health, energy, disaster risk reduction to achieve improved climate-related outcomes and generate socioeconomic benefit.

One example of climate services is the seasonal forecasts produced during the regional climate outlook forums, the RCOFs. These have been established over 20 years now and have a nearly global...

[audio glitch]

Mariane: ...organize their national climate outlook for all, where they define, refine these forecasts at a national level and update [inaudible 7:15] rainy season. The tendency of the rainy season is then well known well in advance, as well as perspective for food security or insecurity. It is very important for Africa, which is highly dependent...

[audio glitch]

Mariane: ...Africa are many. The main one, I will say, is for data and infrastructure as well as expertise. For expertise, we have a growing number of experts, but the issue is to have a critical mass of experts being retained at national level and develop those climate services.

For the data and infrastructure, we've been having a steady decrease of observation data. This is not...

[audio glitch]

Krystal: Thank you, Mariane. We're losing you a little bit, so hopefully that...

[crosstalk]

Krystal: Mariane? We're losing you a little bit, so I'm going to move onto our next question and swing back to you, because you were just getting into the challenges. I'd like to hear more about that. My next question is for Lori.

Your organization works to convert Earth data systems into relevant and actionable knowledge to combat climate change. Can you talk to us about how the different audiences, ranging from the general public to policymakers to scientists? What are the different needs when it comes to understanding the climate change data that is generated by Earth observation satellites?

Lori Garver: Sure. Thanks for having me. It's great to be here. Earthrise, when we began just a few years ago, looked into the data that was available and determined that the biggest gap, really, was in connecting the unbelievable amounts of data we have to users.

Those users can range, of course, from the public all the way to policymakers and a number of parties in between for uses that are perhaps unlimited, based on the fact that as Waleed well outlined in his earlier talk, the unique perspective of space offers us something that we cannot get otherwise.

I named it Earthrise, because of course, connecting space to the Earth, that Earthrise photo that was taken by the Apollo 8 astronauts was the first look-back we had in the mirror that really captured the public's attention.

I also capitalized Rise, because I looked at NASA [inaudible 50:14] acronyms, and rise is a renaissance in sensing the environment. We have not only, with the new developments in sensor technologies and satellites, lower costs of launchers and satellites, and all the new ways we have of storing and accessing data, and modeling techniques.

We have had a -- I fully agree with this morning premise -- so much value to the climate change discussion we wouldn't even know about without our satellite constellations. It's time for us to really figure out how to best utilize that data between resilience, things that we can do to mitigate, and things that we can do to adapt.

For the public, we at Earthrise primarily work through journalists to tell stories. No matter what, it's a local story. The public around the planet needs to see and can see now from space what is changing in their own backyard.

I think Earthrise making that connection by seeding stories around the world to journalists who can then utilize the data within what is happening in their neck of the woods. We utilize all the free government satellite data but also have agreements with the private sector providers like Airbus.

Being able to add value-added analysis and show the public what is happening so they can recognize and take action to prevent it is one aspect of this. We also reach students through teachers and allow them to access the data.

Again, there is so much wonderful data out there from space. They can build on their own tablets or phones a story that shows in their own backyard how climate has affected their own environment.

Ultimately leading to policymakers, I think the major issue for policymakers is having people beyond the agencies that make the data, like NASA, really recognize how they can utilize it and to be able to share that information.

If we are to do what I think most people agree would be necessary to really address Climate change, we have to be able to measure it more precisely, emissions in particular. If we can do that both with I think all the greenhouse gases -- but we're starting to do that with methane and certainly with CO2 -- that you can have a monetization scheme that is built on something that is verifiable.

This would also work for trade agreements, and I think policy can be set. It's somewhat of a chicken or an egg. I always thought, "Well, let's set the policies, and certainly, the private sector will come along if governments can buy that data to be able to fulfill the needs," but it is also now a push and a pull because right now, we have organizations developing data that will inform policymakers so it can drive policies.

The technology is just an amazing renaissance where we are able to utilize more of the data, but we don't utilize it in a way that -- as I think every single speaker has said already -- is as meaningful as it can be.

As an insurance company, you probably have found a way to get that information. If there's a way to make money, maybe more and more people will do that, but in a policy sense, we really, I think can do a better job. At least, this administration is working to do that.

I will note that we often...One of the gaps in the policy world is NASA, for instance, think, "Well, we measure the climate, but we're not the ones to set a policy to do anything about it. NOAA is the operational agency, and they are there to convey what's happening around the operational side." The hole in this, the gap, is going to analyze that data in order to influence policy.

It would go back to the '80s, where we had the determination by not just NASA but other agencies on the ozone hole. NASA scientists did help contribute to the ultimate recognition and solution. Recognizing that CFCs were contributing to the deterioration of the ozone hole led to them being banned through policy.

That's the feedback loop that we are trying to incentivize by people. Seeing that this data isn't just for science there, there should be things that connect that data to actions that make meaningful change, and that's what we're all about.

Krystal: Absolutely. Lori, you hit on two points. One, you gave me a great lead in to Steve, just an organization that is actually seeking to do exactly what you're saying, which is address a very specific need within the community.

Before I turn it to him, I absolutely agree with you that I think, sometimes, we make the mistake when you're a geek and when you're scientists. Build it, and they will come. We're excited about the data. It shows us so much, and that there's an absolute truth in that, but you really hit on the point that it's about building a chain of information.

It builds on what Mariane was saying about that turning this into private services, turning this into the ability to make decisions, and then motivating people to do so. As we all unfortunately know, just because we know something doesn't mean something happens next.

Having the data is incredibly important, but then building out information, attitudes, services, and interpretation, all of those things matter just as much...That was a great overview.

Steve, I'd like to turn to you next. You're engaged in some exciting new work by a non-governmental and non-commercial organization, essentially, as I understand it, custom-designing a satellite to provide much data climate data. In fact, just recently, Governor Newsom of California set up another related project that these homegrown satellites are a game-changer.

I'd like for you to tell us about how that came to be and especially what other possibilities you see in the future in this particular area.

Steve: Thanks so much, Krystal, and thanks for the great talks. It's great to be here with these distinguished colleagues. Lori set it up wonderfully. I describe it as we're trying to build the data to action pipeline. What we need to do is not only have that intact pipe but also fill it with high-quality data.

MethaneSAT is a satellite being built by MethaneSAT, LLC, which is a wholly owned subsidiary of the Environmental Defense Fund, a nonprofit.

What we're trying to do is to produce high-quality, actionable data and fill the gaps that Lori described so that we can provide free of charge across the globe highly resolved, spatially resolved, and fully quantified methane emissions data from the oil and gas industry as well as hopefully agriculture, which we're still working on.

The satellite will launch late 2022. It really is a game-changer and trying to think through in a way the reverse order. Thelma talked about critically important scientists, as a scientist who's worked on climate change for many decades on the ground. Mariane talked about adaptation, another centerpiece, and Lori talked about how to build the civil society [indecipherable 58:41] .

What we need, though, is increasing quantities of actionable data. We have to start with what data do we need and then work backwards to what technology will be required? That's exactly what we did in the MethaneSAT case.

We didn't start with the technology. We started with, what data is missing? We started by using on-the-ground data collected intensively in the United States to say, "What do we need to understand in order to map and quantify methane emissions from oil gas industry?"

Why look at oil and gas? Because it represents a significant source of methane and most people don't even recognize that methane accounts for more than a quarter of the warming we're experiencing today.

Because it's a short-lived climate pollutant, roughly half of the warming we'll experience from climate emissions from this year will be the result over the next 20 years. Excuse me, let me make that clearer.

The impact of this year's greenhouse gas emissions over the next 20 years will be dominated by methane emissions. CO2 is a critically important greenhouse gas which we have to reduce, because that determines the long-term warming. In the near term, if we want to slow the rate of warming which is creating so much of the damages, we've got to reduce methane emissions.

Oil and gas industry has demonstrated they have the technology and the ability to reduce those emissions. The IEA has shown that 75 percent of emissions can be reduced with existing technology, and roughly half of the emissions can be reduced at no net cost.

We have a great opportunity, but we don't have enough data. We started with, what specific data do we need? Then we went and said, "Can we measure it from space?"

Ultimately, as everyone said, we need to do this across the globe, and the best place to do it is from space. That resulted in a partnership between a range of different groups and academia, former government employees, the government in New Zealand, as well as the commercial space industry.

We brought all of this expertise together to develop this capacity in relatively rapid time to create the most highly effective satellite. It's the most precise satellite currently being built or planned to measure methane emissions from space. This will give us an unprecedented ability to see.

In addition to the data, we have to have the software that allows us to quantify those emissions. Generally, we see data on concentrations. Those don't easily correlate with quantification. We're developing a fully automated inversion technique for the first time that allows us to map in near real time, the total emissions.

We believe that building these kinds of pipelines through collaborations across civil societies, with government, with private sector, as well as with academics and NGOs, will allow us to greatly accelerate what we know, which will allow us to take action much more rapidly.

We believe that is a game changer. We think that we can make rapid progress by using this combination. Lori spelled it out wonderfully, showing how traditionally, we have siloed approaches. Different agencies or groups responsible for individual segments of the problem.

We need to bring all of that together, create a pipeline, and fill it with high-quality data, and give policymakers and civil society the data they need to take the action that's required to reduce the rate of warming over the near term and the long term.

Only with that kind of dramatic action are we likely to be able to put off the most dramatic impacts of climate change, which we all fear.

Krystal: You're exactly right, and we know that. One thing I wanted to do was take a look at this word cloud that we put as our first poll. We asked our audience to weigh in on, what is the first type of benefit they think of regarding satellites and climate change?

One of the most interesting things that I see -- I know some of it's a little small for everybody to read -- some of the biggest words that got put in the most don't relate to super specific technology. They relate to the actions that you all have been discussing. Observing, knowledge, measuring, monitoring, having a global view, having perspective.

I'd like to get all of your thoughts in terms of...We've identified as a group some of the important needs, but one of the things I'd like to ask is about resources. In his initial remarks, Waleed specifically brought up resources.

I want to ask you all, all of you to weigh in any thoughts you have. Is the problem here money? Is this that we need more resources put to this problem, or do you think that it's a lot more complex than that? Maybe Lori, I'll start with you, and then anyone else who's interested can chime in.

I'd like your thoughts on do we have enough resources to enact what you all are just describing?

Lori: It's a great question. Resources can mean a lot of things, and I would never say we don't need more resources.

Krystal: [laughs]

Lori: I believe we could effectively double NASA's budget and utilize it very well, but it's an and, not a just do that. That wouldn't solve much, honestly. It is -- as we were discussing and as Steve just said as well -- a combination of users in the government, the private sector, and the nonprofits, as well as global organizations.

As we're here, I'd love to hear from the IPCC, what do they really need? We have models. We have gaps because of data. We have gaps because people don't know about utilization, and we have gaps [indecipherable 64:46] along pretty much every point.

I have found that both the government and the private sector want to do the right thing, but they don't talk to each other well or interact well. I think the government really does want to do a better job, but the government doesn't speak with one voice and has a lot of priorities.

Even the great emphasis we have in the Biden administration on addressing climate change, NASA wasn't even within the first dozen agencies they thought of to be on their climate policy team. We really have a lot of work to do, and we can always use resources and money in other ways.

Krystal: Thank you. I'll just kick it over to Thelma. Lori has a great point. Then we'll go to Steve and Mariane. What's your perspective on this at the IPCC, Thelma?

Thelma: Obviously, I think I mentioned briefly [indecipherable 65:52] that at every assessment that comes every six years, so if it's voluntary work of hundreds of authors coming from all over the world.

Obviously, as I said, SSA models and using these models to improve or to reduce the uncertainty, this is the real benefit that we have from one assessment to the other. It's not that we go wrong in one assessment.

We can do better in the next because you are improving the accuracy of your models. You are putting more data into the models to make them every time more reliable. From the point of view of the IPCC, obviously, we rely a lot on the modeling community, and the modeling community relies on better and better data.

I say that when we talk about the issue of the resources, obviously as Lori has said, resources is always an issue. This is why we see a lot of partnerships. Also, Lori, if you allow me, I have been in the Remote Sensing Space Agency for a long time. I'm now retired.

At the beginning, 1982, the data was [indecipherable 67:16] data, not so many data available. Now, through time, you see more and more data becoming available for people to use. Why do we say, the importance of that is really so that everyone is [indecipherable 67:32] .

Everyone could have a chance of getting the data, extracting information from that data, to as many have said, to inform policymakers for action. I don't know of a better example than the monitoring of the Brazilian Amazon for the deforestation.

Maintaining the consistency, and that's what's important, the consistency of the data availability that allows to every single year wall-to-wall to inform the government. Now, if that three years action, [laughs] at least the information is there.

From the point of view of the IPCC, that's what matters. Science is there. We inform. The data is there. Now, action should come from every single government, and that's what we are expecting from all governments in climate change.

It's really an important issue here. Resources availability, free access to data. It's not only me saying that. A lot of communities are saying the importance of free, accessible data to extract information, to inform policymakers. Then it's up to them how to manage that. I can't hear you.

Krystal: I agree, Thelma. I sit on the program board of the Group on Earth Observation that focuses on exactly this. Sometimes, it's not just about putting more money into new data. It's about how much we have access to, and what we can do with that. Is there enough resources to access the data that is available? Steve, I'd like to get your thoughts on this topic.

Steve: Thelma pointed out the two key things. Obviously, open access data is critically important. While private sector is important, it doesn't replace that open access data. The second one is policy-relevant data.

The example in the Amazon is a fabulous one, but regrettably, much of the data that's collected is not policy-relevant, and there's no mandate to make it policy-relevant. We really need to ensure that the funds that we do have lead to the full filling of that pipeline, not just data for data's sake.

While that is harsh, I can say that. I was an academic for most of my career. I've been doing academic research for a long time, for many decades. I think we need a mandate to say that all of the data needs to lead there. That's not to say that basic research isn't important, but we haven't filled the gap and given that mandate to public spending.

We have to recognize, as we're doing MethaneSAT, that a philanthropic investment is also critically important. We're able to make all the data for MethaneSAT publicly available and do all of this work in [inaudible 70:34] time by using philanthropic funding. That's, we're taking no corporate funding, and we do have government funding from New Zealand.

Krystal: Great. Mariane, I'd like to hear your thoughts on this, as someone who is focused on climate services in Africa. What are your resource needs? Where are the areas where you think there is more need for funding or other resources?

[pause]

Krystal: Mariane?

Mariane: Oh, I can barely hear you. Thank you. Sorry. I was working up, but I was going to come back to resources before my Internet fixed up. I think that resources are very important. It depends just on where you're sitting in the word [indecipherable 71:23] who's having access to the data, and I would even add infrastructure as capital.

I say that it is even the main challenge, and I will put it under the budget cost hand of the National Meteorological and Hydrological Services, which having very limited resources. It's important.

This is even well highlighted in the African Ministerial Conference on Meteorology, which is working very hard with African Union Commission to increase the political support, mission, and services and ensure that climate services are adequately delivered.

In this delivery, I think that all of the value chain of the climate services needs to be constant. Access to data, being aware to data, getting infrastructure to process those data are real key for Africa. Thank you.

Krystal: Thank you, Mariane. That takes us to some of our audience questions which are starting to roll in. A reminder to everyone, if you'd like to ask this panel or any of our panels, you can click on the link at the bottom of the livestream. I'm excited.

One of the first questions that has already gotten some up-votes in our voting people from the audience is related to exactly what Mariane was just talking about. I'd like to see if anyone else has any comments on it. Starting with this question, you policymakers know how important satellites are for tackling climate change? If not, what can we do to improve that awareness?

I'd like to add this is a great question, because to a certain extent, the answer is yes but not entirely. All of you have interacted with government in different ways. I'd like to hear your thoughts on what we can do to improve the understanding among non-scientist policymakers that this data and these apps, this information is there. Thelma, I saw you nodding. What are your thoughts?

Thelma: Exactly as you say. They all know but not everything. All the very technical issues that I put forward from Working Group I, most likely, the government did not know in-depth the implications of these measurements and these models and so on. What did the governments know more readily? They more readily know about land use change.

That's my assessment, because of inventories, because of submissions to the ANF, people see forest changes like degradation, deforestation. They are more interested or know more about the importance of remote sensing to assess these changes in land use and the implications of that.

That is the number one for governments, I would say, and then that build up their knowledge, depending on how is their surrounding in terms of technical people, making them knowledgeable

of the increases in CO2 and CH4 as Steve has said. I don't think that many governments know about the CH4, Steve, although we do have satellites already that measure that.

I think that one of the implications -- Krystal, just to finalize -- is remotely sensed data cannot separate the implications from anthropogenic actions in natural variability. Many governments put that in front saying, "Well, maybe this is not really...Because of anthropogenic actions or measures, but they come from natural variability." That, for instance, is the case for fires, just to give you an example.

Steve: Let me jump in. Thelma is right. I'm going to suggest that in fact what we need to do is ask the policymakers what data they need to create effective policy and then make sure we have it because in most cases, we do not have the data. That's why I call it policy-relevant data. Not at all, it would some.

Where I would maybe disagree a little with Thelma is that I think we do have the capacity for many types of sources of greenhouse gases to separate anthropogenic from natural emissions. Now, there are some tough places, absolutely, where they're angled makes it very hard.

We can do a lot better than we have by building instruments to provide the data needed by the policymakers with a deliberate mind to that and not the science. As a scientist, I did most of my career thinking about, "What do I need for science? Very important.

We need to turn that around. What do we need to help humanity address the problems and build the tools to give that data in addition? We have done a terrible job. I would argue at that. What we can do certainly what we found in methane is the tools were out there, and we're not being deployed.

Again, we need to run from the pipeline the opposite way. What do we need for policymakers then back up to the data and the technology? What we'll do is we'll see a rapid acceleration in the usefulness of recognition of the power of remote sensing in just a few years. We have all the tools. We just need to put them together and create a new generation of satellites that are much more policy-relevant.

Krystal: That's a great point. It's impossible to separate out scientists doing things for science and then incredible need that we have as a society right now. It's always going to be both that this is one area or changing our frame.

At least adding that frame of trying to think of it from the other direction is key particularly when it comes to making useful data. Lori, did you want to chime in on this one?

Lori: Only to emphasize the point. I could not agree more. NASA, science and applications, but the applications parts are tiny and not starting with the end state user in mind. The end state user is and has banned that researcher to what Steve used to be. [laughs]

We need to transition to policymakers outside of just the domain of setting Earth as a system, and in addition to doing that, be able to identify users so we can [indecipherable 78:00] to their needs. It's not something NASA likes to do. I guess, I would ask Steve if this is even for me.

10 years ago, I was frustrated at NASA's insistence on sticking with the exact decadal plan for Earth sciences, and it will take 30 years to fly it all out with these big missions that were not based on any of the applications that were current and in talking to Byron Lamar who at the time had led the science decadal report.

Now, while we follow up with the next decadal report, they both acknowledge that things in Earth sciences changed faster so that the investments probably can't be the side effect that far in advance, those work for astronomy, for instance. Steve, do you think that is something we could do differently?

Steve: Absolutely. Again, it's an and. I am not in any way pushing back against science. That would be against my whole training background...

[crosstalk]

Steve: We need to exactly be nimble, and that's where I have to accredit the folks that we brought in from commercial space. They knew how to be nimble in a way, but that wasn't sufficient. We also needed the best leading academics, which we brought in.

We have two great institutions at Harvard and the Smithsonian Astrophysical Observatory's key partners. It was bringing all of that together. Historically, we've not brought all those sectors together, the policymakers.

Our team, we have a whole series of people who do nothing but interact with the policymakers so we can get that input. What do they need? What is the finance committee need? What do all these different communities need?

We need to have that voice there. I've worked with Byron over many years, a lot of great scientists. That's unique.

Other types of voices when we do these reviews -- and they can't be decadal or multi-decadal -- they have to be both long term and near term. Just like the climate problem, we have a near-term problem and a long-term problem. It's big, and we got to solve both.

Krystal: That's a great way...

Mariane: It's all about implementing effectively the global climate framework services. As I said in its beginning, it's defining who needs the data, what for? Policymakers? Users? That can be done for a user interface platform. Implementing the global chairman is at national level or regional level is a key point.

Krystal: Absolutely. This is such a fascinating topic, but I also wanted our audience a chance to ask more questions. The next one is really interesting.

The question is, in the past few years, young climate activists have made global headlines. What can young space professionals do -- or any space professional, for that matter -- to boost the utilization of space systems for climate change in action?

I think a way of rewording this is, we've been talking about all these different end users. This is a really interesting group. Does anyone have any thoughts on, as a public, what about these young people who are really pushing for action, and in some cases, making a lot of progress? Is there a way that we can try to connect space data to them?

Lori: I have a concept that I put out in a couple ways that I'll just outline quickly, which is the Climate Data Corps, or something like Biden has proposed, and I think he's both the Interior Department and the Agriculture Department lead it.

NASA, NOAA, USGS could play a role because young people need to be well-versed in reading satellite data and interpreting it. If you put people into training who do this or have people coming out of academia who have this ability, they can go into local communities across the United States, but hopefully the world, more like Peace Corps, to work with the decision-makers on the local level.

We understand the impacts of this are local, at least, for adaptation and resilience. To me, there are so many people coming -- my kids are in their 20s -- who this should and is their number-one priority. They would sign up to do some kind of service corps, and space needs to play a role.

Our data can be utilized better if we put people out who are trained, who can connect that information, people [indecipherable 82:51] .

Krystal: Steve, do you have any thoughts on this? You work with a university as part of your project. I'm just curious if it's something you all have considered.

Steve: Certainly, we try. There is a lot of younger folk, part of our project, through universities. I think also satellites bring one set of data. They're not the only source of data. There's a lot of on-ground truthing.

There's a lot of remote sensing, more visible spectrum mapping, because one of the key things is you need to be able to understand what is where on a global basis. We don't have those global maps. I think there's, to Lori's point, just a whole host of ways to interact.

What we have to do is also be realistic. Some of this is highly technical and requires a fairly sophisticated math. There are fabulous young people who can do it, but it isn't something that the average 18-year-old or even the average 25-year-old can do.

We need to basically create a menu of options for people to get involved. I think they exist. There are lots and lots of organizations utilizing a range of citizen science, as well as advanced computing. We see it in the data science world where we have all kinds of competitions that take advantage of a younger generation's commitment.

Krystal: Absolutely. I think you're right that it's not everything, but there's an opportunity for visualization here and outreach that doesn't fit into our usual paradigm of government and scientists. Trying to think of what we turn data into in certain circumstances for that outreach, I think, has a real, real possibility there.

I'd like to move onto one more audience question. I think I'll have Mariane maybe take this one first. We've talked a lot about satellite data here, but that's not the only data source. This person was asking, "Is there a need for the space community to develop more interactions with other sources of climate data?" Thelma or Mariane, I'd love to hear from you on this one.

Mariane: Sure. I think that we need to mix up these non-series of satellite data with in situ data and any other data that can allow the computation of climate records to study climate change. I can give the example of Copernicus Climate Change Service, which is very useful.

The African users need to be aware of those data to be able to develop their capacity to access them, use them, and process them for their own needs. [indecipherable 85:34] , I think, had been organizing lots of series of webinars, but there are other satellite providers whose data can be of interest.

The African community needs to be aware of that so we need to really do some awareness campaign so that those youngsters and other users have access to them.

What is very good and very promising is that many satellite operators are working together through the Coordination Group of the Meteorological Satellite, CGMS, and the Committee of Earth Observation Satellite, CEOS, Working Group on Climate Monitoring to produce good climate data records without gaps.

I'm very excited about the new generation of satellites that are coming as they've been offered tremendous atmospheric and atmospheric composition data, as well as surface, ocean data with a much better spatial and temporal resolution.

I think that this will, in the long run, offer better climate data records with a much higher resolution that will enable better knowledge of local climate change and local adaptation.

Krystal: Thank you. Thelma, what do you think about how the space community interacts with other data sources?

Thelma: Wow, it's essential. [laughs] I would say that, if you take, for instance, remotely-sensed data as an example to assess land use change, and then you would need some data in field, ground data, to validate your satellite data. That's essential.

Depending on the classifier that you are going to use to instruct that information, it has to be trained to do that. Training means that you would input data that you have collected elsewhere. Field data is essential here. Ice core data.

We are talking about a whole set of other datasets that really fit into the system. It was really interesting, because when we didn't have, for instance, satellite data to look at the concentration of CO2 versus all other gases, and when they came up into reality, you see how much they fit into previous observations.

That gives a much more, let's say, confidence to governments that you are putting a whole set of data coming from different and independent sources that obviously add to the reliability of what you are talking about. It's essential, I would say. It's essential to have diverse sets.

Steve: I just want to emphasize that. I think there's some wonderful programs like IGOS at WMO. I'll plug Mariane's wonderful institution as well as now at UNAP, starting the International Methane Emissions Observatory, which is trying to link all these data.

Bring them together in a way that allows us to create, because they give you very different perspectives. I totally agree with Thelma. It's absolutely critical for validation. You need this kind of data.

But on the methane front, there are hundreds and hundreds of scientists, literally, many, many hundreds collecting field data that absolutely creates a granularity that will well away from being able to ever produce with remote sensing.

They're complimentary. They also provide the capacity building around the globe as these studies occur in a diversity of nations where you have good science but maybe hadn't worked on it. It's really that combination that gives us the confidence against the thumbless point. There are institutions that are working across these different scales, and we need to support those.

Krystal: I'll be honest. I could continue this conversation forever. We have more great questions coming in from the audience, but we have to end on time. I want to close with one opportunity for one final comment here and maybe give 30-second to minute answers to just say this isn't a new problem. I'm really excited about everything we've talked about.

The opportunities are amazing, but there is also a concern that we're not taking action fast enough. As we talked about with young people, they're very concerned for a very good reason. We have a focus on the UN sustainable development goals and whether we're going to reach those in this area.

I'd like to close with just an opportunity for you to say 30 seconds of what do you think the most important form of action that we could take in this area in, say, the next 10 years. If you could tell governments, or academia, or the commercial industry one thing that you think they should do, what would that be?

Steve, I might start with you. I suspect you might know the answer, but I'm curious what you have to say. Then we'll just go around the panel.

Steve: As I mentioned, we need to reduce methane emissions dramatically. It can slow the rate of warming incredibly quickly, which will reduce damages. Related to that, I think the satellite community needs to think about, as I said before, what data does the policy community need? We have to ask them.

We have to go out and produce some in the next few years so that a decade from now, we have a picture of what's happening that we never had before. I think that's a game-changer.

Krystal: Absolutely. Lori, what about you?

Lori: The greatest gap is in leadership. To me, it does take people around the world and senior positions, who show real leadership, and stand up, and recognize what we now know is happening, how we can get even more of that information, and make decisions that will be impactful from that data in the US.

I believe that NASA could take a much larger role. I think NASA was formed to address what the US at the time and vision as a global crisis. They stepped up to it. They could do more now, but there needs to be greater coordination in the US government for managing the data as part of the greater issue.

Krystal: Great, thank you. Thelma, what about you? If you were working for a day, what would you tell everyone to do?

Thelma: I'm going to do bullet-wise. Lori was right when she said we need leadership. Also, we need to recognize that different governments have different capacities to implement government responses, like adaptation, mitigation.

A bullet point is leadership as Lori has said. We need international cooperation. That's fundamental, and IPCC recognizes that. We need partnerships in terms of research, in terms of technology transfer, capacity building. We need improved governance. Most international governments or some, they research issues that are necessary and also national government, strengthening of institutions.

Moreover, I think that governments are lacking to look at climate change and the opportunities to address this to limit climate change, the opportunities in so many areas.

They are looking more from the negative side in terms of how much this is going to cost, etc., but they are not looking at the benefits and the opportunities before addressing climate change and limiting global warming. I would say that these are main points.

Krystal: Thank you. Mariane, what are your thoughts?

Mariane: Thelma nearly said it all, but I would say a win-win partnership and cooperation to transfer technology that enable access to all data including satellite and hubs infrastructure, which very important in Africa to process the products that users need both policymakers and local users.

Krystal: Thank you. We are about to head to our break. Before I do that, I just want to say thank you to Lori, Steve, Thelma, and Mariane. This has been an amazing conversation. Honestly, I hope it's not the first.

I admit when we built our agenda, we were really thinking about changes that had happened in the world in the last year in the United States government, and just really trying to say, "OK, what can we talk about that will help people understand?"

In the space world, we often talk about the value of satellites, and we assume their value. But I really wanted to dig into where are the opportunities and the gaps, and what could we do to do even more. I think we've done that today.

Thank you all so much for being here, for being an amazing kick-off for our Summit for Space Sustainability. Thank you so much. I really appreciate your time today.

For now, we're going to go to the break. We will be back at 10:30, everyone. I am really excited. We will be having a panel on megaconstellations. If you have any questions at all, please reach out to us. In the meantime, enjoy your short break.

[music]