SECURE
WORLD
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Space, Climate Change, and International Cooperation

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Virtual Event

Panel Participants:

Video welcome/announcement from Ian Annett, Acting CEO, UKSA

Moderator: Krystal Azelton, Director of Space Applications Program, Secure World Foundation

Speakers:

- Ray Fielding, Head of International Partnerships Programme, UKSA
- Ian Pilling, Director of Consulting Services, CGI
- John Remedios, Director, UK National Centre for Earth Observation
- Gavin Schmidt, Senior Climate Advisor, NASA
- Briony Turner, Climate Services Development Manager, Space4Climate

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Krystal Azelton: Welcome all. Thank you for joining us today for our panel discussion on Space, Climate Change, and International Cooperation. I'm Krystal Azelton, Director of Space Application Programs at the Secure World Foundation.

I'll be your moderator today, and I'm delighted to be hosting this event in partnership with the United Kingdom embassy. We would like to start with some welcoming remarks from Ian Annett from the UKSA.

Ian joined the UK Space Agency in January 2020 as the Deputy CEO for project delivery, responsible for overseeing major national space programs, including Spaceflight, Regulatory Control, and GNSS. He is currently serving as the Acting CEO.

Ian Annett: Hello and welcome. My name is Ian Annett. I'm Acting Chief Executive of the UK Space Agency. I'm absolutely delighted to have this opportunity to welcome you to this important event on space sustainability, hosted by our Foreign, Commonwealth & Development Office today.

Please do accept my apologies for not being present at the event today, but I didn't want to miss the opportunity to introduce the UK Space Agency to you, and some of our ongoing and planned work to support our collective endeavor to tackle climate change.

Firstly, what does the UK Space Agency do? We are an executive agency of the UK government's Department for Business, Energy & Industrial Strategy. We do what it says on the tin -- we inspire and lead the UK in space to benefit our planet and its people.

International collaboration is at the heart of everything we do. We work in partnership with the European Space Agency, the UN, and other institutions, to help the UK grow trade and

investments, to take part in global space programs and missions, and promote an open, safe, sustainable space environment.

As such, in line with the UK government's commitment to address the climate emergency and achieve net zero by 2050, a core component of the UK Space Agency's remit is to improve our understanding and help tackle the challenges facing our planet, including climate change of course, by supporting space programs which play an important role in delivering the goals for sustainable development.

Space-based data, of course, builds a better understanding of our planet, as it can extend the reach, resolution, and richness needed to sufficiently monitor Earth's climates.

The Global Climate Observing System has developed a set of 50 measurable Earth system parameters that are considered vital for the detection and quantification of climate-related changes. These are known as the Essential Climate Variables. These variables include atmospheric, terrestrial, ocean observations, and are used to provide a clear message on historic and future climate change.

Of these 50 ECVs, around half are measurable only from space. As a leader in the analysis and exploitation of climate data from satellites, the UK is in a unique position to leverage this expertise to help development of global policy on climate change, and net zero in particular, as we approach the 26th UN Climate Change Conference, or COP26, in the UK later this year.

What are we already doing, and our plans? Let me give you a flavor of some of the UK Space Agency's key climate initiatives.

First of all, Space4Climate. I'm sure you agree, having experts in development and delivery of initiatives is critical. To achieve this, we co-fund and chair Space4Climate, which supports the UK's world-leading climate community to deliver and make use of climate information from space.

Space4Climate brings together experts across government, industry, academia, and in the development of satellites, analysis, the exploitation of data and production of that data, and climate services. I'm pleased to say that Briony Turner from Space4Climate is able to attend the panel discussion today, and can share further information with you on our plans.

I'd also like to mention the International Partnership Program, or IPP. It's the UK Space Agency's award-winning space for sustainable development initiative, which utilizes the UK space sector's capabilities in satellite technology and data services to deliver sustainable economic, societal, and environmental benefits to developing countries.

Since launch in 2016, IPP has grant funded 43 projects across 47 different countries as far as Africa, Asia-Pacific, and Latin America, which tackle global development challenges, including climate and disaster resilience.

Some of these have included common sensing, using satellite remote sensing to support Fiji, the Solomon Islands, and Vanuatu, to improve national resilience towards climate change. The Earth and Sea Observation System, EASOS, which uses satellite data to detect, monitor, and produce rapid early warnings for flooding, marine pollution, and deforestation.

Another is the Coastal Risk Information Service, appropriately names C-RISe, providing satellite-derived data on sea levels, winds, waves, currents, and coastline change, to support vulnerable coastal populations in adapting to the consequences of climate variability and change, in countries such as Madagascar, Mozambique, South Africa, and Mauritius.

Also, Forests 2020, helping protect and restore up to 300 million hectares of tropical forests by improving forest monitoring in Indonesia, Brazil, Colombia, Mexico, Belize, Ghana, and Kenya. That's helping to deliver accurate, up-to-date deforestation data through advanced use of satellites. You'll hear more about this excellent program in the panel session, though.

There are a couple of others that I'd like to touch on as well. We're doing a range of initiatives through bilateral collaborations. MicroCarb is one such example, a joint mission between the UK Space Agency and CNES, the French space agency.

It's the first European mission intended to characterize greenhouse gas fluxes on earth's surface and gauge how much carbon is being absorbed by oceans and forests, the main sinks of the planet, of course. TRUTHS is another.

We're invested in a range of European Space Agency earth observations, investing 200 million in earth observation programs during the last Council of Ministers meeting. That is, of course, one that I would want to mention is the TRUTHS mission.

It's the first UK-led European Space Agency earth watch mission to create a space-based climate observatory. This will improve confidence in climate change forecasts by enabling a tenfold improvement in accuracy of data and halving the time required for making decisions.

Development of TRUTHS started in spring 2020, with a launch date planned for 2026 to '28, followed by operations for a further five to eight years.

The mission, which is majority-funded and has been developed by British scientists, will collect the most accurate data measurements of energy coming into the earth from the sun and light reflected from the earth's surface to help understand changes in balance for global warming, of course, and humanity's impact on the planet.

Another I'd like to mention is the UK Space Agency's investment in NovaSAR, which is the first radar spacecraft of its kind to be manufactured entirely in the UK. The imagery acquired can be used in a wide range of applications such as crop analysis and flood and forestry mapping.

Therefore, a key asset for UK's plans in climate change mitigation and adaption. Let me quickly mention our participation in Copernicus, the EU-led earth observation program. The UK, as part of the UK-EU trade negotiations, agree in principle to participate in the EU's Copernicus earth observation program.

This gives us the opportunity to collaborate in the world's largest earth observation system and an important tool in the global efforts to monitor and combat climate change. We're currently working closely with the European Commission to formalize our participation in the program.

The list of activities could, of course, go on and on, but I do have to stop here. However, I do hope that this has given you a real taste of the breadth and depth of the UK Space Agency's

climate-focused activities, all of which, I would fundamentally reiterate, are dependent on international collaboration.

Thank you for listening. I do hope that you enjoy today's event.

Krystal: Great. Thank you, Ian, for an insightful set of comments about what's happening in the UK. I'd like to dive right into our panel right now. The need for accurate and precise data on the current state of the planet has never been more urgent.

Space is increasingly playing an important role, as we just heard, in enabling us to monitor and tackle climate change, helping the global community gain a much better picture of the urgency to take action.

Earlier this month, the Intergovernmental Panel on Climate Change, for instance, released the first portion of its sixth assessment report on how climate change is altering the planet's natural systems and worsening extreme weather events around the world. Unsurprisingly, it's the most dire report yet.

This panel will focus on the applications of space technologies such as satellites to help track climate change on earth and provide critical data for scientists and policymakers, how space will fit into the 26th UN Climate Change Conference of the Parties, COP26, which will be held in Glasgow later this fall, and the UK's global leadership in climate action.

This event will also underscore the imperative to work through the multilateral forum international agreements to address this global priority. I'd like to do a quick introduction to my panel right now. We have an impressive set of experts from around the world.

I want to introduce first, Ray Fielding, who is the head of International Partnerships Programme at UKSA. Ian Pilling is the director of CGI in the UK. Professor John Remedios is the executive director of the National Centre for Earth Observation.

Gavin Schmidt is the acting senior advisor on climate to the NASA administrator. Briony Turner is the Climate Service development manager at Space4Climate change. You can see their full bios on our event page.

Welcome, everyone. I'm excited to have you here today. Before I dive into my first question, one final note, I do have a few housekeeping remarks. This is a public event and will be recorded for later viewing.

We're also taking questions from the audience for our panelists later in our session. You can click below the live stream on the web page where you're viewing this to ask your questions, or you can also go to menti.com and enter the code you see below on the screen.

I'd like to start with John and Ray. John, for instance, why are space technology so important to the climate debate? Everyone is aware of this importance, something we say reflexively, like, "Of course, it's important."

I'd like to understand the specific initiatives that your organization is involved with, in terms of space technologies and monitoring climate change and why you think this is so important. I'll start with John, and I'd also like to hear from Ray on this question.

John Remedios: First of all, can I say how happy I am to be here talking to you? The wonders of modern technology, it's just like this use of satellites in space, of course. We are not present face to face and we're not hands-on with our satellites, but the instruments on them, it's crucial how well they work.

In fact, that's been one of the big challenges for space technology in the climate area. For climate, space is absolutely vital, because there are situations and there are datasets that we cannot acquire any other way.

Give you a couple of examples. If you want to see how the ice is changing in the poles, a fundamental part of our weather systems, you can't do that by being in the pole all the time. We all know that. It's a harsh environment. It's hard to live in. It's still being explored.

We can explore it from space. We can also explore other parts of the world and we can do it in a consistent way. We can take the same instruments and fly them over the forests, over the inhabited regions, over the mountainous regions and get consistent data, and that's incredibly important.

Underlying all of that is the fact that we can build instruments that are very accurate, very precise, and that we can calibrate them in a way that we would regard as metrological. If you think about the kilogram or the unit of length, the meter, then we have standards by which we achieve those things.

Climate studies require that sort of accuracy. They require instruments that can work thousands of kilometers away from you, but be accurate.

We can think of hundreds of examples. I'll just give you a couple where this has made a huge difference in the past. If you think about ozone depletion, actually, America built instruments initially, led by NASA that showed us the ozone hole. We saw it from the ground.

Satellite instruments really showed the true picture of how that was happening. We found the same with the polar ice. We also found that polar ice was changing, in particular in the North Pole in ways that were faster than climate models predicted. There was a greater decrease in the summer ice than was expected.

We can talk about the details of that and the ways in which you can interpret the data. Essentially, you have to have really top quality technology in order to do this job.

You have to have a commitment to fly that technology on a regular basis. It's not as powerful. If that's mission lasts for 5 years and is not replaced by another mission, we need 20, 30, 40, 50 years of data, and satellite data sets have really started to achieve that sort of longevity.

Krystal: Great. Thank you. Ray, I'd like to hear your thoughts on this as well. What is your organization doing? Why is this so important, and what are some of the main messages here?

Ray Fielding: Yeah, sure. I suppose you could say about my program. It's really where we use climate data in a way where you can say, when the rubber hits the road.

My program, the International Partnership Programs, funded 15 million pounds initiative by the UK space agency to actually help people offset and mitigate against the effects of climate change. They're seeing now, and they're going to see in a very, very short-term and mid-term future.

We use the data that John's been talking about just now to move forward farmers, when they may be facing extended weather events such as climate related drought or in your spectrum of flooding as well that's something that that hits many, many subsistence farmers across the world.

We use common data to provide prediction models, to help people maximize their crop yields, to mitigate against those events, and also to upskill capability on the ground.

My program really is developing partnerships. It's not just us providing data to people, but it's training the people on the ground in countries from Vanuatu, to Mongolia, to sub-Saharan Africa, right across the world...

To be able to use climate data, understand climate data, and upskill their own capabilities in their own countries, to help mitigate and fight against some of the climate-related effects that we're actually seeing now.

Krystal: Thank you, Ray. I'd like to return to that point because that's something that often gets overlooked. We talk a lot about the high-level data, and where it's coming from, and what that tells us. I'd like to hear more about some of the more on-the-ground programs. What do climate services look like? What is your group doing on that? We'll come back to that in just a minute.

Turning to Briony, the UK will host COP26 this November, which will be an important moment, hopefully, for reinvigorating global commitment to tackling climate change. How can space technologies be used to help compel climate action around the world? What role do you see space playing within this much broader multilateral discussion?

Briony Turner: Given the Paris framework itself, it leaves it largely up to the countries themselves to decide how much climate action to take. It's actually quite important in the way that we look at how we're using space data, is about how space technologies can facilitate, inspire, and support climate action.

Climate action can be quite a broad term. In terms of the roles in which the, particularly the climate satellite data can be used, it can be used for both climate mitigation.

For activities that are reducing greenhouse gas emissions, detecting them and reducing them, as well as climate change adaptation, so helping to inform decisions perhaps in maybe our cities, some of the cities where they'll be facing perhaps more overheating environments.

Understanding maybe things like urban heat islands and also things like nature-based solutions, how vegetation is faring as our climate's changing, and how we can help detect, monitor, and

look at actions where we're hoping are helping with reducing carbon emissions and adapting our environments to our changing climate.

For some of that, it will be experimental, and that's one of the important roles of climate satellite data going forward, is to actually help us to monitor the efficacy. Increasingly, also we will see for those of you not aware of the task force on climate-related risks disclosures, are often shortened on to TCFD. The financial services sector worldwide is looking very carefully at the task force climate engagement.

There's quite a number already voluntarily adopting those reporting requirements. Quite a lot of countries, including the UK, have been moving towards that being mandatory.

The reason I raise that is that requires organizations to look at what their activities are and the supply chains and too look at, "What are the physical risks posed by a changing climate on them?" and also their actions to mitigate greenhouse gas emissions.

In terms of this Space4Climate group, we were given a brilliant instruction by the UK Space Agency that we will unite the UK expertise in climate satellite data right from some of the missions you heard about, like MicroCarb with this joint with the French Space Agency, through to decision support tools where you heard from Ray about the IPP program and all sorts of exciting projects that are coming through.

They aren't projects anymore. They're real-live decision support tools that are being used right at this moment to help with action to reduce emissions. An example being RESAP by one of our group members, Institute for Environmental Analytics that helps Small Island Developing State nations understand and better plan a renewable mix, integrating a lot of different types of data.

That includes satellite data particularly where there are perhaps not weather-based data records. You can look historically back. Those are some uses of the climate satellite data.

We shouldn't forget that the climate satellite data is very, very important for informing and helping scientists to continually improve our climate projections so that we can better understand our changing climate. We've got a few different examples. Some have already been mentioned.

I thought I'd also mention some of the other aspects of the climate data supply chain. Often we think about the actual climate data itself. We need to think very carefully internationally.

It's why this is an exciting platform to be speaking at, about where we take international collaboration, and how COP26 can actually look at data and the data story, which is so important for informing climate action and, perhaps, move us forward in terms of our international efforts on that.

In one of our examples of our group member's Earth Blocks, helps to take away the pain of the analytics and the processing of satellite data to make it more, and they call it, LEGO blocks, as a way to help people do that in analytics.

They've worked with the United Nations Environments Programme on, what's called, the STRATA platform, as an example, if any of you want to have a look at it, and to determine

where environmental and climate stresses are converging and contributing to the increased risk of maladaptation.

That's one example. Where I'd personally like to see COP26 in terms of maybe the climate data supply chain. There are three areas that I'd be quite keen to see discussions on. One is ground segments, ground truthing. We've got some fantastic international effort on that.

The more ground truthing areas of satellite data, the more quality assurance we can have, the more confidence we can give to others making use of satellite data. It does take investment. We need it in some of the really remote areas in the world.

We also can use it in some of the areas that aren't so remote, but we haven't had to actually to do much ground truthing in necessarily before, like cities. I'd draw your attention on the ground truthing. There was a document by [indecipherable 26:58] for above-ground biomass.

It was very clear on when they'll get some data in. I know that our world-leading scientists in the UK have raised carbon dioxide and particularly in city locations who need the ground truthing there.

The secondary that I'd like to see arising from COP -- Don't forget that COP is not just about negotiations. It's also about a converging of the climate community to focus and talk about how action is evidenced and how science informs climate action as well as those negotiations -- it's to build in rather than scope out inadvertently an inclusivity into the data supply chain.

We've done some work recently with the Global Partnership for Sustainable Development Data to look at the supply chain right from the planning and scoping of missions through to decision support tools. It's thinking about not just the open data products at the end, but also in terms of the, who's got the supercomputer processing power to then use that, modify it. It's not just about data.

Also, how is it going to be sustained in the long term? There's a lot that's done through international collaboration with science and for the science agenda, increasingly as we're seeing a scientific quality data being used.

For instance, the ESA CCI, the Climate Change Initiative program, and there's the open Climate Data Store. We can access data from that, for instance, but it's devised for scientific purposes.

As we go towards exploiting it for societal and economic purposes, we need to think very carefully about who's going to sustain that data and how do we bring the commercial entities benefiting from it -- and I expect the carbon markets and other emissions markets will in time be very much using the data supply chain satellites -- how do we make sure that part of that action towards net zero that many countries have been pledging...

How do we make sure that the commercial investment goes back into the open data supply chain, to ensure that there's access for all on crucial climate data sets.

The last thing I'd point to, which is probably where we go back to our colleagues in the space agencies that are here from NASA and ESA, is on the security of climate data from space.There's already quite a lot of work underway, in terms of protecting scientific mission

orbits and other types of orbits and pathways. I would obviously advocate that we make sure we include climate satellite missions in that.

Also, in terms of having and maintaining international checks on the climate data supply chain, particularly as this data, increasingly, will be used to inform decisions that are already saving lives, and also that could relate to substantial funding decisions in time, and of course, our trading markets.

The last thing, I'll just end on this activity, is around COP26. It's when we bring together...and I'm sure listening today, there will be many people not just in the space community, but interested investors and those that want to have a role to play in the climate data supply chain and action arising from it, is that this all provides a lot of opportunities for jobs worldwide.

As we get the new mission ideas of today, that becomes a data supply chain of tomorrow.

I'll end with one example of one such mission. We've got our scientists at the University of Edinburgh and the UK Astronomy Technology Centre, they've developed a mission concept -- it was funded by the UK Space Agency -- to measure methane on the spatial scales relevant to monitor net zero targets, and those associated with the TCFD reporting I've just mentioned.

They're working alongside our National Physical Laboratory, which specializes in meteorology, particularly of earth observation data, to look at, alongside having such a mission, Kitemarking concept for the quality assurance.

Once they've got the leadership and expertise in greenhouse gas retrieval algorithms, and then how you translate the data that's collected by the satellites into flux estimates, and eventually will support regulatory markets, what they're seeking is international collaboration and investors to get from mission concept design to launch operations.

It's a fantastic time for the space sector. It's brilliant to have a wider audience than the space sector involved, and dependent to some extent, on the emerging climate data sets that are coming through from mission concepts today and, of course, our past climate data sets that we've been working hard on to provide, through initiatives like the Climate Change Initiative.

I myself am very excited about the opportunities for collaboration with NASA on the Earth System Observatory that was recently announced. I'm looking forward to hearing more about that today. Thank you.

Krystal: Thank you, Briony. You hit on a lot of types of broad question, and you very successfully hit on a lot of important themes that we'll return to at later points.

I'd love to hear the panel's thoughts there on this idea of sustainability. At Secure World Foundation, that's our mission, and that's why we're so interested in this, is that we care about what's happening in space, on a sustainable perspective because of these benefits and how can we make sure that they're protected.

I also liked your point about the different goals of some of these activities. The importance of understanding the science goal and climate action, so to speak, as you said is quite broad, can be different.

They're obviously complementary, there's obviously a lot of overlap, but there are different people and there are different groups working on them, and so occasionally the needs can be different. I'd like to dig a little deeper into that in a minute.

For now, I'm going to go on to Ian. Ian, I wanted to just say, can you talk a little bit about the role that industry plays in the global climate dialogue? What are the gaps in data or technologies exist, and how do you think the space industry is, or can in the future, work to help fill these gaps?

Ian Pilling: The industry actually has two or three ways that it can get involved with the climate discussion. Industry works with the scientists. We have to work alongside, we have to understand the models and the equations that are being generated.

As Briony was saying, we generate a lot of the decision aids that are used. You can create a decision aid based on sub-samples of the data, generate a useful model and a useful decision aid.

Industry takes those decision aids and turns them into production systems that can generate results continuously as the data comes in, processing the data, generating the climate statistics, etc., to be able to be used operationally by the authorities that need to use them, and also, visualize it for the communities.

We also get involved, obviously, with the design and building of the satellites that are designed to measure the climate indicators. Without the support of industry and the scientists, we wouldn't be able to generate the satellites and the sensors that we need.

It is an ongoing process as we improve the technology, to be able to then use that technology to improve the accuracy of the measurements, as we've proposed from the UK with the TRUTHS mission. CGI is involved with the TRUTHS mission, looking at the ground segment for TRUTHS.

We also work a lot with decision aids and monitoring aids to help detect, for instance, wildfires, using our GeoData360 platform, which takes in a lot of satellite data from the central missions, automatically processes it with algorithms that we have taken from our scientific partners like University of Leicester...

And converted them into something that can run autonomously on the systems with very little intervention, but produce the maps of not only where there are wildfires, but on what damage has been done, what area's been burnt. We've done this is conjunction with the Australian authorities as well.

We work internationally. An industry now works internationally. We are always working with our international partners, be it through ESA, or the EU, or through commercial arrangements.

Industry, on a wider note, has another role. We have to start looking to the future. What are the products and services we are generating now? What impact do they have on climate? How can we change those products to be more climate aware, so that the products aren't in themselves causing more climate damage?

Can we be more socially aware rather than just profit-oriented? We have to go for profit but with sustainability and fairness for all the world's populations.

Within CGI, we have a management framework that balances the needs of our clients, our members, our employees, and our shareholders. [inaudible 36:57] aside, 86 percent of our members are also our shareholders.

We're all involved. The communities we live in and work in are involved in that process of looking after our environment, our customers, and our shareholders.

It was actually interesting here. I think it was Ian saying about Brazil early on. I did a trip on an ESA course introducing the use of ERS-1 back in 1987, I think it was. One of the questions that came up was why did the Western populations feel we had the right to tell the Brazilians, you can't cut down the rain forests?

To stop them effectively, improving their lives while using their resources. The comment was, how come you're telling us not to cut our forest down when you've removed all of yours in Europe?

That made me think a lot about, yes, we have to do the best we can. In making our lives better say, in Europe, we can't make them worse somewhere else. It has to be to the benefit of the whole world.

The last bit that industry do and role plays is we have to take the information the scientists give us and we have to take the policy decisions from government and implement them in full awareness of the impact that if we change certain things, we may be affecting other people's livelihoods.

We have to make sure that we do that to the minimum or we bring everybody's lives and lifestyle better. That's my main messages, that we have to, at industry, be a lot more aware of the decisions we make and how they affect the future of everybody.

Krystal: Thank you, Ian. It's an important point that we can often be very focused on what we're trying to achieve, which is incredibly important, but that it's not done in a vacuum. We have to be modeling that. Space has an important role to play in understanding the options, and the possibilities, and the potential impacts there.

I also wanted to highlight commercial data versus, say, government data and the importance of free and open data but how that can be complemented and built upon with commercial data. I'm hoping that you'll speak a little bit to that in the future of this conversation as well. Before we do that, I want to move to our final speaker.

Welcome, Gavin. I'd like to ask you, given the current diplomatic relationships between the US and the UK and their long history of cooperation, what are some of the additional ways in which these two countries can collaborate to leverage space to help tackle climate change? What do you see coming?

Gavin Schmidt: Thank you very much for having me on and being able to give a perspective from NASA. I'm a Brit. I am a living embodiment of the UK-US collaborations on climate science.

There are a number of things that we need to be moving forward on. People have mentioned all of them. I will try and be super brief.

We have monitoring of climate, the long-time trends that we have. A lot of that comes from early work that was done by NASA. We have the Landsat data that started in 1972. We have the sea ice data, which started in 1974. We have long timescale records of how things are changing. That's vitally important that we continue that.

We will be continuing that in partnership with both the European Space Agency and the Japanese Space Agency and our other international partners, particularly as we move into this new Earth System Observatory project that we're getting going over the next decade.

It's also important that we think about how satellite data feeds into decisions. Decisions are forward-looking, whereas satellite data is backwards-looking. The bridge between those two things are the models. How do we use the satellite data to best inform how the models are constructed, how they're built, how they're tested, how they're calibrated.

We have multiple modeling efforts in the US, they have modeling efforts in the UK, particularly at the Hadley Centre, but these modeling efforts go on around the world. It's only by collaborating with multiple models that we can get a sense of what structural uncertainty is in these model predictions. If we just had one model, we wouldn't know how uncertain it was.

Having multiple models and having multiple ways of feeding in the satellite data into those models, both in terms of producing new ways of thinking about some of the subsequent scale processes like cloud formation and convection, but also how the models, overall, are calibrated.

We're using machine learning and satellite data to better calibrate some of our models, so that they have, hopefully, better predictions going out into the future.

Those predictions are quite wide. Knowing which predictions are more or less valid is absolutely essential to being able to use those predictions for decision-making purposes. That is an area where we're in active collaboration with folks at the Hadley Centre, with folks at IPSL in France, in Germany, and in Japan.

Krystal: Thank you, Gavin, for that answer, and thank you to all my panelists again for being here and for having this conversation.

We're now going to move to a few general questions and then we'll take some questions from the audience. Just a reminder to our audience, we do have the opportunity for you to input your questions. It's right underneath your livestream. Just click on that link, and then I will be asking those in just a minute. You can also see in the bottom of the screen and go to menti.com if you prefer.

This is a question open to all of our panelists. Since several of you have touched on this theme, I wanted to get a sense of, what other stakeholders need to be part of the discussions?

We've talked about a lot of ways that we can use climate data, a lot of ways that we can collaborate, but do we feel like we've addressed, whether the fact is, is everyone at the table, is

everyone getting the data that they need, are they participating in discussions about future missions, about data use?

How can we use space data to bring in a new set of actors, to make sure that this is an equitable discussion, and that we're taking steps that we need to do?

I will turn to...

Gavin: Let me jump in if nobody else is going to. Absolutely not. We're not providing sufficient data accessibility to the people that need it.

We have a lot of data. We have petabytes of data that, theoretically, people can download, but nobody has a laptop with 9 petabytes, 10 petabytes, 100 petabytes of data storage. We have to move beyond the old models that we had that were a loading dock model. We'd make the data and, "Here it is! Take it and use it."

We have to be far more active in both transferring this data to platforms that allow you to slice it and dice it in different ways. We have to move to the cloud. We have to move to different kinds of formats like -- this is a little technical -- but Zarr formats and the like, so that we can search through this data for things and events and issues that people need.

Then we have to build the front ends for that, so that people don't need to download petabytes of data in order to get the answers that they want. We have to do a lot of processing, we have to do a lot of work on the front ends. We have to work in consort with the users, because otherwise, the people at the top of the stream don't know what people are going to use it for.

We have a great example just recently, where we put together a whole data stream associated with fires, working with people who are working on wildfires right now. It turns out that the metrics they wanted were very much not the kind of grid-point-level data that we were producing, but much more regional, like the fire edges.

We had to build all of that into the front end. All of that happened in a data-transformed way in the cloud, in a native way. That was very successful.

Briony: I wanted to reiterate with the points that were just made there, because we recently held a workshop on this which I referred to earlier, with GPSDD. We had 40 participants. It was over 16 countries represented, with various different affiliations.

When we asked what are the issues in the supply chain, what was interesting was that there was a lot of debate about whether the system is even circular, with healthy feedback loops, or if it's more linear, reinforcing inherent power structures.

When we asked where the weakest links were, in terms of inclusive evidence-based climate action, the collective view was that the links are at the opposite ends of the chain.

At the funding procurement end, with assumptions around who'll be able to access and use the data, just inherent biases that are perhaps in there, along with at the other end, the community input and feedback, given as this weakness and disconnectedness of this supply chain, it's quite linear, thinking about what we can do to make it far more circular.

Then, I just wanted to pick up and probably hand over, maybe to John on this point, who'll be much more technically able to comment on it, but I know that one of the things the UK has been working on is the use of Jupyter Notebooks in capacity building and enabling other countries -- I'm sure NASA have similar capabilities -- to be able to remote-in to our supercomputer processing.

That aspect is important, not just in terms of access so you don't have to have a supercomputer, but also in terms of the emissions the space sector can save in its footprint, by people not continuously reprocessing the same data.

The last thing, I was just going to add with what Gavin said was that...There might be, forgive me for getting this incorrect, but NASA have a ocean-focused site.

I've had quite a lot of group members rave about it, because it allows people if they are manipulating the data and moving it around for their own purposes -- maybe decision support -- that they can put their algorithms in on and other people can find it. We need to look internationally at more platforms that can enable that kind of sharing, so that we can move the innovation on.

The other point with what Gavin was making, was that there's some processing that we could go further in doing internationally, in terms of then making it easier for people to query locations or events, as Gavin was saying. That needs some international effort and some investment and sustainment in that effort. I'll hand over to John.

John: I'll keep it brief. Perhaps I'll maybe summarize it by saying, maybe we just all need a bit more bravery and commitment in what we're doing. It's very easy to fall into some traps, to say, "Oh, it's scientists versus the needs of other stakeholders." We certainly don't get those other stakeholders to the table, but it's not that sort of distinction.

It's a bit more about letting go of the data and saying "Right, actually, we're going to get it to the point where you all can use it, but we're going to make it easier."

Briony mentioned the Jupyter Notebook project, which is an international effort, including the US, to improve that accessibility. It's about also saying, "These systems are here for the long term."

We more or less know that, but I'm not sure people out there believe it, people who are not in space or people who are not in climate data are sure. Those systems are going to be there. Maybe we need to just put much more resource as well behind helping those people.

I just want to make one more point, which is that sometimes we see that, as I said, about science versus other drivers. The scientists here are responding or trying to respond to the requirements from other people. It's been true of the whole climate debate.

What we're asking is that there are more people who are able to do this intermediary work, and how we get more people into the field and working hard on it is one of the questions out there. Companies are crying out for people with these skills. How do we provide them?

Krystal: John, that's a great point, that it is about that line of communication and understanding that the user base is incredibly broad and growing and we want that to happen, but how do we set up the channels, and the feedback loop, as Briony was saying, to make sure that that is happening.

Ray, did you want to comment on this at all, anything, because I know you mentioned that you all have some training programs within the international programs?

Ray: Yes, sure. It's an interesting one. It is the reason my program exists. What we try and do is understand our users' requirements, with the users being the people in the countries in developing and emerging economies. It's exactly, what problems they're facing and how we can help them.

Very interesting listening to Ian's point about Brazil, about him saying, "What makes you think you can come here and tell us not to cut down the trees." You need to work with the people on the ground and realize that sustainable logging in a sustainable way is a big part of people's economy. They must be allowed to. There's no other source of income.

You need to allow them to do it in both a way which meets the local economy needs, yet meets some of the greater climate challenges of not stripping the rain forests. There are ways and means of doing that.

The points others have made about getting data both in a format that people can use and the people upskilled in a way to use that data as well, so twin problems there. It's something that we face all the time and try to help with.

For instance, we're putting data cubes together for a variety of...I lose track of how many data cubes we've put together now. There's one in Kyrgyzstan, there's one in Vanuatu, there's the African data cube as well. That provides climate data which meets specific peoples' needs on the ground, in a way that's easily accessible.

Where there is a lack of capability on the ground, there's where [inaudible 52:43] also step in to help upskill the people so they can use the data themselves.

More and more we see that people on the grounds either have a very high capability...Places like Malaysia, incredibly skilled in the ability to use space data and then climate data. They just need the data, or people are very keen to have data on their own home soil or a way to access it...

Which is affordable, cheap, and accessible, using hosted data platforms, using hosted data profiling as well, because they might not have the capability in their own country. We try to enable that. Plethora of ways of doing that.

Everywhere we go, and all of our partners -- there are 44 partners we work with -- are all interested in understanding the data, hosting the data themselves, or the ability for them to easily access the data. That's something we build into our program, and will continue to do as we go forward.

Krystal: Thank you. Before we take...

Ian Pilling: I'd just like to...

Krystal: Oh, please go ahead, Ian.

Ian Pilling: If I can jump in...Just following up on that slightly, the idea of the data cubes and having the local data, that's an important point, which answers partly as well your question earlier, Krystal.

We have a lot of basically free to the air data that's provided by the Copernicus program and some of the US programs. There is also lots of now commercial data. The commercial data tends to be a lot higher resolution and possibly a higher repeat imaging rate. That data is more applicable for local process monitoring where you do need to go down into the weeds.

It plays a very important part in the more detailed studies as opposed to the broader country-wide, continent-wide studies. It is scaling with the scaling of the processes you're looking at.

Krystal: Absolutely. What I want to turn to next before we go to audience questions is policy. Getting a sense from all of you who have this incredibly wide experience across space and climate change, I wanted to get your thoughts on what types of policies, both nationally and internationally, do you think we need to facilitate the creation of this data, the better use of it?

What are some of the policy gaps that you potentially think exist out there? Yep, Gavin?

Gavin: Open science data has to be available. It can't be behind paywalls. It has to be there. The experience that we've had in the US, where NASA data has been free to use to anybody with an Internet connection for decades now, has been that the enormous enthusiasm and skill of people who are downloading it and working with it...

And not just in the academic sector, but also in the application or decision-making sector, has just been enormously benefited by the fact that the data is free and open.

When we're going forward now with the new Earth System Observatory, open science will be one of the key themes going through all of that. We will be building a fully-open, fully-transparent platforms where all of this data will be linked together.

We need to be able to link that data together more, and not just...and you mentioned commercial applications. They're complementary to a lot of the things we're measuring. That has to be linked together. We have to be able to link together the European and the American and the Japanese satellites.

We can't just think that we have a national imperative to only use our own national data. The problem is too big for that. We need to be able to bring all of these data sets together on single platforms, or at least that looks like a single platform, and apply the best principles of open science towards it. Any policies that push towards that are going to repay in multiple ways.

Krystal: Absolutely. John?

John: Gavin said it very well. When I put my hand out, I was thinking, that international cooperation point, absolutely incredibly important. It's to everyone's benefit. I just wanted to emphasize that.

A lot of the issues we've touched on, there are problems that occur anywhere around the planet caused by anyone around the planet. There's a huge interconnection anyway in the whole climate area. We need to respond to it collectively.

I just want to make one other point...to add a couple of other points. One is, there's a great belief in the power of space within at least our government, and I'm sure in many governments. You see this in many developing countries. They want to get into space themselves.

There seems to be a little bit of a disconnect between recognizing the power of space to help in this problem and recognizing the usage and almost regulating the use of that data within the metrics that we'll need. Say, the Paris Agreement. We'll need metrics around how well are we doing, what is the carbon change. We should be joining up that policy.

The other bit, I'd just like to see more of an emphasis on how we get data down to a local scale for people, and giving space agencies, or whatever it is, the incentive to do that.

There is a lot of discussion by the local politicians and government politicians. They're very keen, but they're less keen to come up with the resource that the agencies need to truly enable that and work with those sectors. We're a little bit in this Catch-22, so there's a real need for non-space policy to come and meet space policy and work that out together.

Krystal: Do any of you think there's an opportunity for that sort of thing, leading into COP26. Is this the right time to push for that sort of integration that you're talking about?

John: Absolutely. It comes at the global level anyway. We will need to, as countries, internationally, collectively need to be assured that we're heading in the right direction.

It's a great time to say, for the man in the street, the woman in the street, the person in the street, they need to know what the risks are, what they can tell about their own neighborhood.

We're terribly bad about giving that information. We've done it in weather forecasting, we've done it with Google Earth, but somehow in the climate debate, we are yet to do it, and they want that.

Krystal: Any other comments about policy?

Briony: Just maybe a follow-up with the work I mentioned with GPSDD, and just in terms of policy, not just on technology and funding programs for the missions, but on the data architecture, infrastructure, sustainment of data.

Anvil is not just the kind of capital funding of technology kit supercomputer processing power that's sitting behind it all, but it involves investment in very skilled people and support staff, so that those that are maybe accessing remotely as we've heard via schemes like Jupyter Notebooks and that, can have support from those that understand Python coding or whatever else is required to help break down the barriers to utilizing the data to inform action.

That does take investment and it's a tough ask, appreciating a global pandemic and recovery from it, but if we don't invest in that now, we can't open up properly the science-informed data sets for people to take action based on. That would be my personal policy request.

Krystal: More money is definitely a policy. It is something that can be easy to overlook in these conversations. You probably want to talk about the exciting things with the possibilities, but you're absolutely right, that building all of the infrastructure from the top to the bottom is going to continue to be key.

Ian, did you have a comment?

Ian Pilling: I did. It's partly policy, I suppose, in some ways. Two points. First, there is no such thing as free data. Somebody is paying for it somewhere. Most of us through our taxes.

Also, probably going on what Briony has just said, in my 30-odd years of working in the space industry, we have developed no end of decision-making tools for various space agencies, customers, clients. A lot of them end up being developed, run for six months, and nothing.

We need to have the continuity, that once we've developed these things, there is still the money there, routinely, to pay for their operations and to pay for them to be updated as the science changes, and we get improved methods of measuring or improved measurements to then be able to build the data sets and continually develop those decision aids, without them being reinvented time and time again.

Krystal: It's definitely a thorny issue.

Unless anyone has any final closing thoughts on this or comments they'd like to make, I'd like to move to audience questions.

We have a lot of great questions coming in on a lot of different topics, all on climate change, but all over the board. Which is wonderful, that we have an engaged audience.

I'm going to start with two of the political questions, since we do have such a great mix of US and UK experts here, although Gavin, you obviously...We just wanted everyone to be from the UK, so we picked you. I think we have an opportunity to have some insight on this.

The first audience question that I wanted to ask is, what effect has Brexit had on Britain's work with the EU on climate change? Obviously, this is an ongoing situation. Can any of you offer some insight on what you think the future there is? Go ahead, John.

John: Well, I would say so far, I think this is ongoing. That is the real message here so far. Scientifically, and indeed, from a society's point of view, we have great relations with the individuals who work in the EU system on climate change. There is still a huge common understanding of what we want to achieve.

The catch is that we aren't really out of the woods of this, if I can speak perhaps individually and personally. My personal view is that there is still a lot riding on the next year or so. Not in terms of perhaps the high-level responses, because we're agreed on the high-level responses. We're absolutely all committed to net zero.

We're committed to demonstrating how we respond to that and showing that we've done it. In terms of space, there are still real difficulties. We know that actually, we can't really afford, from my view, for the UK and Europe to be divided. Just like we wouldn't want the UK to be divided from the US, or from Japan, or from any other countries.

As people who really care about climate change and want to help society deal with that, we are really working together on this. I'm hoping these politics will not get in the way. We'll have to see.

Briony: I'd also follow on from that just to remind people that the UK remains a member of the European Space Agency, and we continue to participate in that, particularly, in the climate change initiative.

We're really delighted recently to have heard that the European Space Agency's Climate Office, which is hosted in Harwell in the UK, has been selected by the World Climate Research Program as the host for a new Coupled Model Intercomparison Project international project office.

That's particularly important in terms of bringing the satellite data through into the climate modeling which informs global climate projections. We're certainly still seeing great activities coming through with our joint working through the European Space Agency.

Krystal: Ray, as head of international programs for UKSA, are you seeing any effects on your work? What would you comment here?

Ray: So far, it's not had any impact on our work. We use the [inaudible 65:59] the sentinel data as much as we can. Combined with a whole host of other data platforms from across the world. From a UK government point of view, there is no doubt that we still want to maintain and work as close as we can with the EU going forward.

It's just, as you said, it's a question of how. [laughs] The paperwork's now going to get in the way. How do we negotiate the treaties going forward? There is a clear commitment from the UK Space Agency to try and enable and continue the close cooperation and the input and the output that we see from the [inaudible 66:33] Program going forward.

Krystal: Great. Turning to the US here. Gavin, we have a question about the Biden Administration's priorities in terms of climate data and space. Are there any insights that you can give us on what NASA and perhaps the broader administration are thinking in this area?

Gavin: Sure. As you will have noticed, the Biden Administration has come in with a much greater focus on climate than the previous administration. There are a lot of initiatives that they're undertaking, both to improve things like coastal resilience, carbon accounting, and data more generally.

If you look at the proposed budgets that have come out for the next financial year, there is a lot of climate-related investment. Investments proposed for environmental justice issues, data accessibility issues, and practical adaptation.

The way that the American government works is that you don't really know what's going to happen until the budget is passed halfway through the financial year, unfortunately. It's still a little bit unclear exactly what parts of that will be enacted. There is certainly a much greater focus at the administration level than there was previously.

I mean, at NASA, we're very much focused on the Decadal survey results and the development of the Earth System Observatory. As many of you will know, we have the A-train constellation, which has been flying for upwards of 20 years for some of the instruments. They don't have that much longer to go.

They have maybe one or two years left of fuel on the main satellites, and we need to be working on the replacements, and with better technology. We have five missions that are upcoming. There is one jointly with the Indians on synthetic aperture radar, NISAR, which is going to look at vertical land motion, which is key for relative sea level issues.

We're going to have a follow on for the gravity missions. We're going to have a new mission for aerosols and clouds following on from GPM. There will be a lot of new and exciting things that we're working towards on this.

Krystal: Absolutely. There is so much going on in the world right now that this is obviously one of the biggest priorities, but at the same time, there are a lot of other things that will be very interesting to see how all of that plays out. Thank you for sharing. I'm [inaudible 69:18] a couple of questions. We're getting several questions actually about launch.

Which was a bit of a surprise for me, but I think that it really shows that people are really trying to be very aware of the environmental impacts of a variety of types of activities. One of the things that I think...I'll throw this out there and see if anyone...

I know none of you are necessarily launch experts, but if anybody wants to comment on the environmental feasibility of launches. Are we aware of the effects of this? We're talking about all this data, but putting these things into space does have an environmental impact. It looks like several of our audience members are interested in hearing your thoughts on that.

[crosstalk]

Krystal: ...and then Ray?

Gavin: Yeah. We get asked this a lot. There are local polluting effects, particularly if you have solid-fuel rocket boosters that can create local pollution and affect the stratosphere. When we've looked at studies that look at the global impact of the rate of launches that we're having right now, the answer is it's a very small impact.

Much, much smaller than any of the other sectors that we think about in terms of affecting the climate. You'd have to increase the launch rate by about a factor of 100 to have a detectable effect on the environment.

Krystal: And Ray?

Ray: Everyone's probably aware the UK is not a big participant in launches and such, although we aim to be with our [inaudible 70:50] plans. Then we have commissioned somewhat to look at low impact rocket fuels going forward to inform our launch program.

We're also looking at, exactly as Gavin said, the impact versus the outcome of a launch and the data that can be provided by whatever you do launch into space. There's a twin chunk of activities that the UK Space Agency is undertaking at the moment.

Briony: Also, it's important to mention the ways in which technology is evolving, in terms of small satellites. That methane detection mission concept I was talking about earlier, NIMCAM, they've been working on how small can they get it, and in terms of weight as well. Of course, that then reduces fuel for launch and that side of things.

We're also seeing the technology evolving, and with that, efforts by the space sector to reduce what emissions there are from the launch capability, particularly with small SATs and going forwards nanosatellites.

Krystal: Thank you, guys. I found that helpful as well. What I want to turn to next is a bit more of a broader question from our audience. Again, this is something that we have touched on, but this person is interested in some more specific examples, or if we could deep dive into this a little bit more.

The question is, "What needs to be done to provide understandable, relevant local information about climate change effects to the public?" What I thought was interesting about this question is that it focuses on the public.

We've talked a lot about climate decision-makers and end-users, but there's a lot of climate skepticism in the world, and even among people who are not, there's not necessarily a deep understanding of localized effects. I'd like to get your thoughts on this.

John: I can have a first go and see what people say. This question, we touched on this earlier, haven't we? How do we get information flow at a much better rate? There's something about using the platforms or the access that people are most used to, or most likely to then use.

To give you a slightly different example, and then come back to the public. We've been looking at whether the right way to supply some of our space data is via our own service if you like and that's traditionally what people have done in the space and Earth observation data area, or whether it is to mix it in through a platform that already does that, so it could be a mapping agency.

In the UK, we have a renowned Ordnance Survey, those mapping in the UK. We could feed data through that. Now, if you think about that, that's then not a platform that the agencies normally provide. It's not the platform the scientists usually use. It's a very different thing.

I remember when I was growing up, people talked about the advent of computers and how computer technology would change the face of the earth.

I don't remember reading anything that said I would walk into a supermarket and I'd scan my food item, and then that would go onto a computer and the whole till system, the mechanism of it, would be automated. That's how computers could make a difference in one area.

Getting data onto apps that people might use is one way. The question is out there, is what is the public platform? It's as much TV, and if you like, the online entertainment industry. We already see that in films, in media.

There's lot of films and productions that talk about climate change and environmental change. There are lots of documentaries. What there isn't is a service that people think they need to look at. I can see how you could do it, but I'm not sure how you persuade them they want it in that form. What people often want is the answers, not always the data by itself.

Ian Pilling: Krystal, if I can?

Krystal: Yeah, go ahead.

Ian Pilling: The key bit here is to provide understandable relevant local information. If you think back to 10 to 20, 30 years ago and look at the weather forecasts on the BBC, you would see pretty much the meteorological chart with wind arrows and the isobars on the image and fronts drawn on it. How many weather forecasts do you see today with that level of information?

If you understand the symbology and you've had training in looking at a Met picture, you can understand it. To enable everybody on the High Street to understand it, we brought it down to simple symbols of where it's raining, where it's sunny, where the clouds are, and how it progresses during the day.

It's not about providing the climate data, it's about providing the information that people need, people want. Is it going to be too hot, how long is it going to be too hot, where's it going to be a drought, how's it going to affect the local area, where's the flood coming and when's it coming, those are the things.

Yes, you could start making it as, "You want to check this before you go out today, or you go away for a holiday." It's finding the way of making it understandable to everybody so that they want to look at it, and they want to see what the effects are.

Briony: There are some existing initiatives that the World Resources Institute climate change...I call it climate change watch, but where some of the members of the public do go to. Some of that does incorporate and use satellite data. There's much more the space community needs to do, in terms of getting the information to that regional, local level.

The Met Office, for instance, for the UK climate projections, recently teamed up with the BBC and gave a postcode checker, so people could then see some of the highlights of what the climate change is like in their area, where they live. That's the kind of thing that makes very complex, in that case climate projection data, much more tangible and real and useful to members of the public.

I certainly can say, through COP26 there are great efforts underway, certainly by Space4Climate and European Space Agency, to develop resources that help to explain the

effects and causes of climate change, and how space and how society address the challenges for the public.

There will be more resources coming through from that, but perhaps far more of an international effort, particularly on communications, that's needed, as well as that data downscaling, to make it more tangible and usable.

Krystal: Gavin?

Gavin: Let me just follow on from what Ian said. We shouldn't be looking at weather forecast as an example of something else, we should be looking at weather forecasts. Why isn't climate change more discussed in weather forecasts?

We have massive heat waves in the Pacific Northwest. It should be discussed, how impactful climate change has been on the magnitude of these heat waves.

Not just heat waves, the intense precipitation, the intensity of storms. All of these things have a climate component which, as we get much, much better at doing extreme event attribution, that should be part of the weather story.

The climate is not separate from the weather. It's how people will be impacted by the climate change. It'll be through extreme weather events. Nobody is being affected by the changes in the global mean temperatures, other than how that impacts the weather where they are, or the sea level where they are.

We have to not set up something independent, where you go, "Oh well, go look over there for the climate change part of this," but in the basic communication that we already have for talking about local weather, local flooding.

The climate part of it has to be there, it has to mentioned, it has to be made understandable, because these things are not changing in a vacuum. Those record temperatures that you're seeing, and not just in the US, but in Siberia, and the wildfires and all the rest of it, there's a very high attribution to the climate changes that we've caused.

Krystal: Gavin, a quick pursuit on that, because I completely agree with you, but I also see a lot of the news will reference climate change -- wildfires exacerbated by climate change or some form of that -- when they're happening.

Given the political nature of this debate, particularly in the US -- although it's not just in the US -- how do you think we can take the data to make those conversations a little bit more tangible? It's almost like, give the world that believes and the world that doesn't sometimes.

In order to change that, we're going to have to talk about, like we've been saying here, the data itself and what it's saying and what it's doing. Have you seen any good examples, or do you have any thoughts on how we could incorporate it more into broader news stories about a lot of these events?

Gavin: Absolutely.

Climate change, particularly on television and particularly on television news, is often siloed into, "We'll have a climate change story now," as opposed to climate change being an element on, "Food prices have gone up," or "There's this that's happening over here and there's a climate connection," and, "This flooding, and there's a climate connection," and, "Here, and there's a climate connection."

People don't see how connected everything is to the climate. What we have is, "Oh, it's the environmental reporter who's gonna talk about climate. The news reporters, they're not gonna bother with that."

We have to have an educational process for the media, for journalists, for people that are covering this so they can feel confident that when they make a connection to climate or when they bring in the climate changers, that they're not going to get jumped on by folks.

We can spend too much time worrying about political damage. I think things have moved on from where they were 10 years ago. There's now a very broad acceptance that this is something we should be worrying about. We should be doing something about it.

We should be investing the people that have genuine concerns and interests there as opposed to spending all of our time arguing with, quite frankly, right-wing nutjobs on the edges.

John: To make further comment as well. I think it's, there is, sometimes, perhaps, a reluctance to put environmental information and climate information into people's hands more often. Perhaps, it's the green tag and being an eco-warrior side of things but, really, this is common-sense information about the place where you live.

I think what really struck me about looking at the satellite data for the first time as a young man and trying to understand it, it actually made the unbelievable suddenly believable. I could actually see it happening. I couldn't actually deny it.

There's an interesting bit of work going on. It's a company called Earth Sense here that we work with and it's really spun out of the University of Leicester, but very connected in terms of taking this satellite data and model data out into the world.

One of the things they've done is they've actually supplied...They specialize more in looking at air pollution, air quality, the indexes of that. They've actually started including that working with a company into a state agent reports.

When I buy a house, there's no environmental information there. The only way I found out about flooding in a house I went to look at was because there was a picture on the wall of the car and the water was up to the top of the car. I thought this is a bit strange.

[laughter]

John: There was nothing in the report that actually said this house had a chance of flooding. I think you'd see quite a different reaction from everybody if that information was much more used and part of what we expect to see.

It's also about expectation. What we expect to see when we're doing something in our area. We want to know about this stuff. I think there is a cultural need there. For me, it's all about common sense. This is the world in which I live. I want to know about it.

Gavin: I think, in one way, we do currently live in a world of the click. You see something, you click on it, and you look up more information. If you look at the early news before six o'clock or six o'clock to seven o'clock in the UK, there's always the ticket type at the bottom where it's such and such information coming up. More information on such and such a website.

That sort of thing on the weather forecast where they start saying, "We had the season effect of climate change. For more information, look at..." Give people, spoon-feed people where they can find the information.

We all know you search on the Internet for things and you look through 20 or 30 sites that have got absolutely no relevance to what you want to look at before you get to one that actually, maybe, is telling you the truth.

Krystal: It's interesting, I notice in China in a lot of online articles for providing references in an accessible format, not just, "See here, this paper," but actually sending people in a direction ad that they can do.

Where I want to move now is to take this back to a slightly different level. We touched on it a little bit earlier on policymakers, and not necessarily space policymakers, and their understanding of the value of the kind of data that we work with and are interested in here.

Looking back to COP26, one of the questions that we got in terms of that was, do policymakers understand this issue? Are they aware of it? I just wanted to get your thoughts on a little bit more detail on that.

Do you think we need to have a wholesale space community push to have people understand the importance of this or do you think it's fairly well understood? Yep, go ahead, Ray.

Ray: It depends on what countries you're talking about, I think. I think, certainly, around Europe, the effects are well understood but when you look at some of the rest of the countries in the world, which is the majority of the rest of the world, there's an understanding there but climate change gets pushed out of priority because they have other problems.

They have other societal and economic issues to address and look at. The way we try to tackle that is to show the cost-benefit analysis to the policymakers and the cost-effective analysis, of actually making some of these changes. It's working out the cost of what mitigation might be and what that will save you backed up by hard evidence.

That is when we've, typically, seen people come rest the way around from saying, "Yeah, climate change is good but I have sanitation issues to be concerned about," or the value of deforestation to turn into livestock areas is far outweighed by the long-term what they perceive as damage of planet change.

Then, understanding that, this is actually going to save money by taking action in its way, which also prevents or mitigates against climate change or it's going to be valuable for the maintenance of societal benefits.

I suppose what I'm trying to say is, giving the policymakers the total picture and the wider picture of the economic and societal cost which taking action can actually save and provide them.

Krystal: Thank you. Any other thoughts on this?

Briony: I was just going to add the work that we do of our group member GPSDD, they bring us in contact with these statistical offices. Sometimes, it's maybe about where you're working in government as well.

I think the point at which we got climate change acknowledged and many, many countries have already signed up to some kind of timetable for net zero. There are websites where you can go and see and track the progress. The acknowledgment is there. Even the policy intention is there.

But, how you, then, bring the data to help inform climate action, that's when we need to be working with the other parts of the government framework. That's when organizations like GPSDD, it's a UN Foundation family member where they bridge...I think we talked about Knowledge Brokerage earlier.

I think John Remedios pointed out that we're going to need more intermediaries. That's where we need to bridge. We work so well in this space community through the International Disaster Charter.

Do we need something more on an international resilience charter and how we deploy and bring more of the climate satellite data into the rebuilding during recoveries, a way to perhaps reach out to more government departments involved in the policymaking process?

Krystal: Briony, that's such a great point, that governments are non-monoliths and we have to think quite broadly about engagement with governments because we've definitely seen, you mentioned the statistical offices have grown more and more interested in space data, especially since the advent of the Sustainable Development Goals. Wonderful point.

Any other comments on this? All right. I'm going to move to the last question. It was a late-breaking one, but I thought it was a particularly great question.

A lot of the most dramatic effects from climate change can be seen in the Arctic, but that's also where some satellite coverage can be lacking. Do you guys think that this is major hole? Is this something that we need to improve on? Is this already in the works? What are your thoughts on the effects of climate change on the Arctic?

Gavin: The premise of the question is absolutely right. Changes in the Arctic are happening roughly three times as fast as in the global mean in temperature. We've already seen something like a 40 percent decrease in summer sea ice, even since the 1980s. We're seeing, again, a

massive loss of ice from Greenland that we can detect using the gravity lights on GRACE and GRACE Follow-on.

Those are very dire and significant changes. In fact, by adjusting the orbits and changing instruments a little bit, we've managed to reduce the polar hole as it were, which is the little area right at the North Pole where it's very hard for the satellites to see through there, fly directly over the pole.

Now, we have a very good view of what's happening, particularly with sea ice, and things like carbon dioxide levels around the Arctic. Things have improved, but we still need ground truthing. We still need people to go there and tell us that what we're seeing in the infrared, what we're seeing in the microwave, is actually what's happening on the ground.

There are some issues with what happens when you have a very rapidly changing environments, and how that might be biasing some of the satellite records. That would still need to be [inaudible 91:03] .

John: Just to comment there, you're absolutely right. As Gavin said, the Arctic is, I would say, a worrying place. The sensitivities not only predict to models, but what we actually see happening year-on-year is quite dramatic. The next decade will tell us a lot.

Just coverage is not the whole problem. It's a challenging place to work. We absolutely need the ground truthing. There's no doubt about that. It's not a very easy place to get to and work if you really want to cover all of the Arctic. The Arctic, we tend to think of the ice, but there's sea ice, there's open water, there's permafrost, there's cultivated land, there's forests, and forest fires.

There's an awful lot going on. One of the things that we need to see is more dedicated design for the Arctic, in a clear-thinking manner. We do quite well on coverage of using several instruments there, but we need an awful lot more microwave data, I think, and some real emphasis on producing improved microwave and radar data, with perhaps some different orbits to get better coverage of the Arctic.

The other thing I just want to touch on a little bit was something Briony mentioned before. It was about constellations. The other way to improve on coverage is to have more constellations. We're a bit one-dimensional in our constellations commercially. We tend to really have lots and lots of optical payloads.

We have some radar payloads increasing, but there's no real commercial thermal infrared imagery on a regular basis. There are definite projects to improve this, new missions we're working on for land surface temperature, that would run alongside Landsat that will improve this on the European side.

Given the scale of time, we're talking about, I'd like to see organizations like the Arctic Council take more of a lead in working with agencies. There's some great agencies concerned with the Arctic, but some international coordination and some real emphasis on some quick wins would actually help us a lot here.

Ian Pilling: The other thing is, as you just said there, John, a lot of the sensors that are currently flown on satellites are optimized for looking at land, forestry crops, urban areas. You

need totally different sensitivities for looking at that snow, and ice, and water. You need to start dedicating missions to looking at the Arctic, and I would also say the Antarctic.

There are big changes going on in the Southern Ocean, as well as in the North. I don't think people really appreciate some of the size of some of the icebergs that are carving off in the Antarctic. They are absolutely stunning in the size of them. One I actually did see was 25 miles by 45 miles in size.

Somebody on board actually calculated. It was the equivalent to something like two ice cubes in a drink for everybody in the UK for 10 years. That was the amount of ice in that iceberg, but then you start thinking, that's an awful lot of ice.

[laughter]

Krystal: You know what, Ian, you win the prize for ending us on a lighter note for what is obviously an incredibly serious topic.

Ian Pilling: [laughs]

Krystal: Unfortunately, we have come to end of our time. I could keep talking to you all for a long time. I can't say thank you enough for joining us. It's such an illustrious crew with so much information. I also want to say thank you to our audience for joining us. This is our second climate change event of the year.

We're very interested in looking more at this, and I encourage you to take a look at our previous event. We're going to have a video of this one up.

We are looking forward to doing a lot of follow up here, but this was an opportunity to look at what's happening in the next few months and where we are, and to think as a space community about the value of this technology and data -- what we're doing with it, what's happening, both politically, scientifically, and across the board, and to develop a good understanding of what needs to happen in the future.

Again, thank you to all of my speakers for sharing your thoughts on this, and I look forward to continuing this conversation. Thank you so much.