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Committee on the Peaceful Uses of Outer Space

Report on the United Nations/Austria Symposium on Space for Climate Action

(Graz, Austria (online), 13–15 September 2022)

I. Introduction

1. The United Nations/Austria symposium is one of the long-standing activities of the Office for Outer Space Affairs under the United Nations Programme on Space Applications. The symposium of 2022 was the twenty-eighth in the series.

2. The Office for Outer Space Affairs of the Secretariat and the Government of Austria jointly selected the theme of "Space for climate action: experiences and best practices in mitigating and adapting to climate change and supporting sustainability on Earth". In 2020, the symposium had focused on climate action and it continued to explore that topic further in 2022, in the light of the mandate of the United Nations Programme on Space Applications on climate change and in view of preparing a dedicated long-term initiative to address the contribution of space solutions to climate action.

3. The symposium included two and a half days of presentations and discussions. Users of space applications were invited to present lessons learned and experts to discuss increasing challenges posed by climate change and the potential of addressing them through advances in adaptation and mitigation technologies provided by space applications.

4. Owing to the coronavirus disease (COVID-19) pandemic, the symposium, originally scheduled to be held in Graz, Austria, was held online, from 13 to 15 September 2022. The event was co-organized by the Government of Austria and supported by Joanneum Research as the local organizer, in cooperation with Graz University of Technology. It was co-sponsored by the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, the Austrian Federal Ministry for European and International Affairs, the city of Graz and Austrospace. The European Space Agency (ESA) provided additional support.

5. The present report describes the objectives of the symposium, provides attendance details and summarizes the activities carried out.

II. Background and objectives

6. The Office for Outer Space Affairs disseminates knowledge with respect to the added value of space applications in addressing societal issues, notably through events of the Programme on Space Applications held at the request of Member States and organized jointly.

7. The Programme on Space Applications has been organizing events since 1971. Since 1994, the United Nations/Austria symposium has focused on innovative ways of responding to societal needs and has showcased the socioeconomic benefits of space applications in a wide range of areas. In 2022 the symposium had the following objectives:

(a) To promote the exchange of best practices to meet the demand and needs of developing countries with respect to mitigating and adapting to climate change;

(b) To demonstrate the ways in which initiatives based on space applications had been successfully developed and implemented in different countries;

(c) To share experiences and explore how space-based services could be used to comply with or support policies on climate action, according to national priorities, and how sustainability policies were being applied in the space sector;

(d) To present available toolboxes, through case studies or pilot projects at the country level, that had already been implemented to comply with regulations relating to climate action, with the aim of encouraging the adoption of tested tools and approaches;

(e) To raise awareness of relevant space-related activities, services and cooperation programmes among different user groups, in particular the United Nations and other international organizations, non-governmental organizations and the diplomatic community;

(f) To report to the Committee on the Peaceful Uses of Outer Space through the Scientific and Technical Subcommittee.

8. For the third consecutive year, the symposium was held in an online format. The organizers applied lessons learned in the previous two online symposiums to improve logistics. All presentations were made available online in advance of the symposium, ensuring that time differences and limited Internet bandwidth would not hinder access to information. The format of the sessions, panel discussions and short presentations, called “project pitch” presentations, was varied to avoid monotony and ensure lively exchanges between speakers despite the lack of face-to-face interaction.

III. Attendance

9. A total of 817 individuals, 60 per cent of whom were men, registered to attend the symposium and were granted access to the web-based communication platform.

10. A number of participants were members of the diplomatic community, including representatives of permanent missions to the United Nations at Vienna. Also present were representatives of space agencies, including the Algerian Space Agency, the Austrian Research Promotion Agency, the Australian Space Agency, the National Commission for Space Activities of Argentina, the National Space Science Agency of Bahrain, the Bolivian Space Agency, the Bangladesh Space Research and Remote Sensing Organization, the Bolivarian Agency for Space Activities, the Brazilian Space Agency, the Egyptian Space Agency, the Ethiopian Space Science and Technology Institute, ESA, the European Union Agency for the Space Programme, the National Centre for Space Studies (CNES) of France, the German Aerospace Center, the Indian Space Research Organization (ISRO), the Jordan Space Research Initiative, the Kenya Space Agency, the National Space Agency of Malaysia, the Mexican Space Agency, the Royal Centre for Remote Sensing of Morocco, the

National Aeronautics and Space Administration of the United States of America (NASA), the National Space Research and Development Agency of Nigeria, the Netherlands Space Office, the Pakistan Space and Upper Atmosphere Research Commission, the Paraguay Space Agency, the Peruvian Space Agency, the Philippine Space Agency, the Turkish Space Agency and the United Kingdom Space Agency.

11. The following 104 countries were represented: Afghanistan, Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Benin, Bhutan, Bolivia (Plurinational State of), Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Cambodia, Cameroon, Canada, Central African Republic, Chile, China, Colombia, Costa Rica, Croatia, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Finland, France, Gabon, the Gambia, Germany, Ghana, Greece, Guatemala, India, Indonesia, Iran (Islamic Republic of), Iraq, Italy, Japan, Jordan, Kenya, Lao People's Democratic Republic, Lebanon, Liberia, Libya, Lithuania, Luxembourg, Malaysia, Mexico, Mongolia, Morocco, Myanmar, Nepal, Netherlands, Nicaragua, Niger, Nigeria, North Macedonia, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Saint Lucia, Saudi Arabia, Senegal, Serbia, Sierra Leone, Singapore, Slovakia, Slovenia, Spain, Sri Lanka, the Sudan, Sweden, Syrian Arab Republic, Thailand, Trinidad and Tobago, Tunisia, Türkiye, Uganda, Ukraine, United Kingdom of Great Britain and Northern Ireland, United Republic of Tanzania, United States, Uzbekistan, Venezuela (Bolivarian Republic of), Yemen, Zambia and Zimbabwe.

12. The number of attendees online varied throughout the symposium, with a maximum of 138 attendees connected simultaneously.

IV. Programme

13. The programme was structured according to four types of intervention:

(a) Keynote speeches;

(b) Panel discussions;

(c) Presentation sessions with five or six successive speakers, followed by a question-and-answer period;

(d) Succinct "project pitch" presentations, each lasting five minutes.

14. To deepen the discussions held during the symposium of 2020 and to present available tools already implemented at the country level, three "country case" sessions were held, focusing on Austria, India and Nigeria.

15. The use of the "project pitch" format, intended as the online equivalent of a poster session, made it possible to increase the number of initiatives presented and to provide opportunities for young people to give presentations.

16. Attendees were encouraged to submit questions to speakers in writing using the online communication platform throughout the event, while the moderator used that function to highlight relevant initiatives. Questions to speakers conveyed via the communication platform were read out loud by the moderator at the end of each session and panel discussion, to provide some level of interaction.

17. In total, the event lasted for 13 hours; it included 61 speakers, comprising 23 women and 38 men.

18. All presentations were made available on the website of the Office for Outer Space Affairs before the start of the event to enable attendees who might have limited bandwidth during the event to download the content in advance. Presentations remain available on the website.[1]

[1] www.unoosa.org/oosa/en/ourwork/psa/schedule/2022/un-austria-symposium-2022.html.

19. During the welcome ceremony, Austrian authorities, co-organizers and sponsors provided information on previous sessions of the symposium and stressed the urgency of climate action. As the 2020 symposium had already demonstrated, while space applications and technologies would not mitigate climate change by themselves, they were essential adaptation and mitigation tools. The representatives of Graz University of Technology, Joanneum Research and the city of Graz explained the role of Austria in developing satellite Earth observation missions. They also noted that the university-level institutions and research institutes hosted in Graz were resources for activities aimed at addressing the climate crisis. The representative of the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology of Austria highlighted that the cost of a carbon-neutral economy would be significantly lower than the price of the issues caused by climate change. She reiterated the necessity of strengthening cooperation and coordination worldwide, both between different actors and between different policy sectors, so that the innovative solutions and tools developed were used for climate action. The Permanent Representative of Austria to the United Nations recalled the adoption by the General Assembly of the resolution on the "Space 2030" Agenda[2] and highlighted the ways in which space applications should be used with climate technologies and integrated into mechanisms to achieve the Sustainable Development Goals.

20. In his welcome address, the Acting Director of the Office for Outer Space Affairs, said that the world had 10 years to determine the quality of life for future generations of human beings and for all living organisms on the planet. With support from the United Kingdom, the Office had undertaken a strategic mapping of existing international efforts that were using space technologies to support climate adaptation, mitigation, monitoring and resilience. A dedicated website developed with support from Austria, to be launched by the end of 2022,[3] would provide information on using various space technologies for climate action and enable further exchanges for capacity-building and technical advisory services.

21. Session 1 started with presentations on the legal justifications for climate action, followed by an overview of policy developments in European countries. The representative of the University of Vienna described the university's exploration of a human rights-based approach, in addition to the Paris Agreement, as grounds for States taking legal action against climate change and described recent developments in national courts in that direction. She highlighted the landmark judgment in April 2021 of the German Federal Constitutional Court, which had led directly to an increase in the percentage by which Germany committed to lowering its greenhouse gas emissions by 2030, from 55 to 65 per cent. Such developments in the legal field provided an opportunity for activists to remind Governments that they needed to commit funds to support tools for use against climate change. Research by the European Space Policy Institute had found that, even though many essential climate variables were measurable only from outer space, explicit mentions of space remained sparse in the climate policies of European countries. Since that absence might represent a lack of understanding of the benefits of space-based data, producers of space data, such as space agencies, should make direct contact with national agencies producing inventories of greenhouse gas sources and agencies developing climate models. To increase the policy impact of space data, joint events were needed between policy makers and scientists to improve communication and reciprocal understanding of how space activities could support policies and vice-versa.

22. Session 1 continued with details of the activities of the Group on Earth Observations, including initiatives relying on satellite data in countries strongly affected by climate change. Most of the organization's initiatives supported climate adaptation using tools for collecting Earth observation data, and many of the initiatives would be replicable in other countries. However, the initiatives were not connected to the policy processes in the countries of implementation. To address that

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[2] General Assembly resolution 76/3.

[3] www.space4climateaction.unoosa.org.

gap, the organization had started to develop policy guidance for various sectors (e.g. coastal zones, biodiversity); the guidance for the agricultural sector had already been completed. Networks of experts were in place and such initiatives as Digital Earth Africa were providing access to free open data. It was likely that a high-level outcome regarding Earth observations, rather than the conclusions of subsidiary bodies only, would be achieved at the twenty-seventh Conference of the Parties to the United Nations Framework Convention on Climate Change: delegates were discussing the possibility of establishing a global goal on observation similar to the global goal on mitigation. An observation goal would respond to the need for a fully integrated system that would imply commitments by parties to the Convention.

23. The Philippine Space Agency and the Space Application Center for Response in Emergency and Disasters of Pakistan explained that their nations were exposed to numerous environmental and natural hazards. The Philippine Space Act of 2019, which had led to the creation of the Philippine Space Agency, acknowledged the use of space applications in climate change activities in various sectors, from the monitoring of crop growth to the assessment of air pollution to the impact of typhoons before they landed. In Pakistan, the Space Application Center produced satellite imagery of floods and to support efforts against deforestation. The centre was established after two major floods with support from the regional support office in Pakistan of the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER). The Space Application Center's national catastrophic modelling tool provided databases and web applications for floods, droughts, cyclones and other disasters, such as seismic activity. The tool's scope was being widened for other applications, including agriculture, as well as for such infrastructure as dams, which were dependent upon hydro-meteorological phenomena. To obtain daily assessments of damage from the current catastrophic floods in Pakistan, imagery originating from a satellite operated by Pakistan was being combined with data obtained from CNES and data from the European Sentinel-1 mission as well as commercial data from Airbus satellites. Whenever cloud coverage prevented the collection of optical satellite data usable for damage assessment, high-resolution synthetic aperture radar data were available. However, to benefit from such data, Pakistan needed more trained experts. In response to such issues, the United Nations Environment Programme (UNEP) was developing tools to support decision-making, moving from providing data to providing information. Many specific areas of application had been developed, including the monitoring of pollution and biodiversity loss. For example, models were available to show the consequences of a lack of deliberate action on marine plastic as well as the benefits of such action. UNEP was learning that local perspectives mattered and that data mattered differently to different cultures around the world; information needed to be targeted to specific regions to have an impact. As no action was possible without partnerships, UNEP was working with partners around the world focused on their particular areas of specialization.

24. In a keynote speech, the Director of the ESA Earth Observation Programmes presented the agency's achievements and activities in support of climate action. To observe the Earth, the agency was developing Copernicus satellites with the European Union, and was also developing its own spacecraft. The "Space for a green future" initiative would provide actionable information, including technical parameters on climate change obtained by combining data from its own observation missions, such as the CryoSat and Soil Moisture and Ocean Salinity missions for ice thickness, with data from missions undertaken jointly with the European Union and data from other space agencies. The agency was supporting the European Union in its goal of becoming carbon neutral by 2050 and was also supporting the European Green Deal. Future Earth observation missions were in preparation, notably a satellite mission to monitor anthropogenic emissions to support the global stocktake.

25. Session 2 presented a range of initiatives in which Earth observation satellites were being used to monitor natural or human-made phenomena that contributed to climate change. The first two speakers explained how they used satellite imagery to

monitor the production of greenhouse gases by the energy sector. A project for ground carbon storage in China had been injecting carbon deep into the ground and monitoring any leakages from space. Satellite data from the NASA Orbiting Carbon Observatory-2 and the Greenhouse Gases Observing Satellite of the National Institute for Environmental Studies of Japan were being complemented with local monitoring. For example, as gas flares at oil industry production sites were visible from space, notably using infrared satellite sensors, Algeria was identifying such flaring via satellite images and interfacing with the country's oil and gas companies to avoid unnecessary flaring.

26. The Egyptian Space Agency was developing a payload to monitor the effects of climate change from the International Space Station using a camera installed on the Airbus Bartolomeo platform, on the outer shell of the European Columbus module, to provide daily data for Eastern Africa. The project was being developed as part of the Access to Space for All initiative of the Office for Outer Space Affairs. The team, comprising university students from three African countries (Egypt, Kenya and Uganda) was consulting with the projected user communities in Africa to determine how to make the data useful, notably for agriculture, by monitoring coastal areas, vegetation, droughts and water resources as well as providing predictive models. The initiative was aimed at encouraging African countries to work collaboratively to expand their networks of engineers, researchers and academics with the aim of increasing the size of the qualified local and regional workforce.

27. The final presentations of session 2 provided an overview of the activities of the Space for Climate Observatory. Initially proposed by the French Government and currently comprising 37 members, the observatory was an international initiative to boost the use of satellite data for climate-related applications by bringing together, on the local level, those with ideas and those with needs. The observatory had accredited and supported projects for operational action all over the world, including several CNES projects focused on flood monitoring and forecasting and a collaboration between GlobEO, the developer of the TropiSCO alert system for tropical deforestation mapping, and the Gabon Space Agency, the Vietnam Space Agency and the National Institute for Space Research in Brazil, on local alert systems. The satellite data and associated models were validated with in situ data from forest agencies and used to assess forest cuts and associated carbon losses, with the information posted on a dedicated online platform. The Space for Climate Observatory was open to any interested parties, who were invited to contact the secretariat at spaceclimateobservatory.org.

28. In three "project pitch" presentations, speakers from Canada, Germany and Mongolia presented initiatives to detect carbon dioxide and methane, whether released by melting permafrost, wildfires, landfills or leaking pipelines.

29. In an overview of the five free online courses to be provided following the symposium, the Office for Outer Space Affairs and the respective trainers explained that they would cover Earth observation data processing and its contribution to climate monitoring and greenhouse gas reporting and ways to reduce the climate impact of space engineering activities. The courses, through which symposium attendees could further develop their technical skills, were being offered in response to the positive feedback received the previous year following similar post-symposium courses, as well as the young profile of those who had registered for the symposium in 2022, about 40 per cent of whom were younger than 30, with a large proportion of university students. The courses were a joint initiative of the Office in collaboration with the European Centre for Medium-Range Weather Forecasts, the Earth Observation Data Centre and Deltares as well as, in a renewal of their previous collaboration, with ESA, ISRO and NASA.

30. Session 2 started with a short "project pitch" presentation focusing on how to use open access patent information filed with the European Patent Office to identify stakeholders and research activities focused on using space applications for climate action. A second pitch explained how Earth observation data could be used to

successfully identify and monitor land use around current and prospective geothermal plants in Kenya, especially to map and forecast their impact on local communities.

31. Session 3 focused on Nigeria, with a review of how the country was using space applications to support its policy development around climate change and the presentation of five technical projects that used space applications. The National Space Research and Development Agency of Nigeria noted that the country was very exposed to climate change; all national stakeholders would need to become actively involved, with space tools used collectively. Nigeria was eager to join international research efforts on adaptation and mitigation to prevent impending disasters, including to address such issues as flaring from its oil and gas industry, which made Nigeria a large contributor to the greenhouse gas emissions of Africa, and the expectation that large portions of the coastal region around Lagos, the busiest commercial area in the country, would be submerged. The National Centre for Remote Sensing had used satellite images to map land use and cover as well as topography data to model the future low-tide limit associated with sea-level rise, and considered it important to raise awareness of the risks. The reduction of greenhouse gas emissions should be addressed by policies, which then needed to be enforced. In addition, public awareness-raising regarding waste should be considered to alleviate the issues caused by waste.

32. While sea-level rise would greatly reduce agricultural activities, especially in Lagos State, desertification was progressing in northern Nigeria. Research based on satellite data from Landsat combined with the country's own satellite data showed a clear decline in vegetation and a strong increase in the extent of sand dunes in the affected area from 1999 to 2015. The National Oil Spill Detection and Response Agency had conducted research to monitor desert encroachment and had concluded that rainfall had not greatly decreased. This meant that the desertification was not due to weather variables only, but had been caused mainly by the over-exploitation of natural resources by human beings, with the region's largest conversion of land use from natural vegetation to farmland having taken place within the period of study. At such a rate, it could be inferred that unless government policies were implemented, sand dunes could cover about 20 per cent of the landmass of the area by the year 2040. Dust storms were another common hazard in the arid and semi-arid regions of Nigeria, causing dry dust haze that had a direct impact on aviation as well as on human health, as the dust was a vector for viruses and bacteria. Since remote sensing data showed that the average number of days affected by dust storms was increasing, sustainable government initiatives would be required to mitigate the impact.

33. The National Space Research and Development Agency of Nigeria had developed a mapping tool to assess environmental sensitivity to desertification, using a combination of indicators (e.g. water quality, vegetation quality and a land management index). In a comparison of a different northern area of the country with the south, the maps showed strong differences between the two, with the amount of annual precipitation during the wet season having decreased in the north. As desertification affected the country's food security, more-stringent law enforcement was needed in the affected regions. Space data served as an important tool for socioeconomic development and would help policy makers to understand the challenges, their relative importance and the need for urgent action. To increase government efforts to combat desertification, Nigeria had recently established a climate council. The country would need to adopt or deploy space tools to improve the policies developed for its agricultural sector to reduce desertification and increase food security. While the National Agency for the Great Green Wall was focused on addressing desertification, tree-planting initiatives would need to involve local communities more effectively to become sustainable.

34. The final three "project pitch" presentations included: (a) a brief introduction to the climate action activities of the Space Generation Advisory Council; (b) a presentation on building values in space by means of policy initiatives addressing corporate law and governance; and (c) a presentation on using space technology to monitor glaciers in remote parts of Argentina.

35. Session 4 addressed the situation in India. The country was already using satellite data extensively for several types of applications and the National Remote Sensing Centre of the Indian Space Research Organization had developed collaborations with several universities, providing them with data and developing partnerships. For example, the Indian Institute of Technology in Mumbai had developed forecasts to help farmers to manage and minimize their water use. The model was able to provide up to four-week precipitation forecasts as well as propose optimal water management plans for up to three weeks. The model had initially relied on local sensors, but had progressed to exploiting satellite observations. An initiative of the Indian National Centre for Ocean Information Services, part of the Ministry of Earth and Sciences, was providing climate and marine-safety services. One goal was to assess the impact of rising sea levels using remote sensing data for ocean weather monitoring and assessing the coastal impact of tropical cyclones and sea-level rise. Data from Earth observation missions were being used for risk detection and to define risk mitigation actions. The Indian National Centre was raising awareness about the contributions of space applications by organizing meetings with user communities, inviting users to the research centre and making information easily accessible, notably on mobile phone applications, so that end users could obtain data directly.

36. Two presenters described the technologies already in use in India for disaster monitoring and for supporting emergency response. For example, the Vellore Institute of Technology had developed space data applications for disasters, including modelling the path of cyclones with data from different sources to help disaster management agencies to forecast needs on the local level and enable the Government to prepare. However, once a crisis had started, the emergency services did not have time to analyse a large quantity of data; they needed actionable information. Experience had shown that using social media channels was very effective for reaching front-line workers with such information during a disaster. Risk assessment for coastal erosion was also a local process, affected by site-specific factors. For example, the Sundarbans region was gravely threatened by climate change, with a large population directly affected. Satsense Solutions had provided a solution to insurance companies and landowners for assessing risks and planning for mitigation measures in advance. For instance, while mangroves could reduce exposure and vulnerabilities on the coast, their value needed to be better recognized locally. To improve the awareness of local authorities, the company was developing a hazards inventory using satellite data. Looking at environmental factors to predict future events, they had developed a risk index – represented on a map together with the causal factors contributing to each risk – to identify resilience factors and the areas that needed specific protection measures. The work was replicable in other regions and the demand for such solutions was expected to increase. Nevertheless, it remained difficult to obtain financing to develop such solutions owing to the fragmentation of the many stakeholders, including landowners and local government entities: all felt concerned about the risk, but none wished to invest, repeating the well-known pattern of the "tragedy of the commons".

37. The representative of the Department of Science and Technology explained that India had developed an institutional framework to tackle climate change. Several ministries, including the Ministry of Water and the Ministry of Environment and Forests were involved. Among other activities, the Department was coordinating projects focused on adaptation to climate change and on building national capacity in a variety of sectors in the use of satellite data. The expected effect of climate change on productivity would be large for some crops and marginal for others. For instance, a study of the maize crop foresaw a significant climate-related decrease in the harvest. In response, cartographic products were being developed at the national level to provide agricultural risk maps to farmers. Many other sectors were benefiting from satellite data in India, from ecosystems health to wildlife management to glacier mapping for water management. Priority areas for climate change activities for the next five years were urban climate, climate modelling, extreme events, Himalayan studies and glaciology.

38. Panel 1 addressed a relatively new topic for the space community: how to reduce the impact of space activities on the Earth's environment. Initiatives were under way in various spacefaring nations to modify space engineering practices, using such innovations as life-cycle assessment, design for demise and greener technologies, as well as incentives for their adoption. The panel gathered experts from the ESA Clean Space initiative and the Space Enabled teams of the Massachusetts Institute of Technology, the University of Kyoto and the Aerospace Corporation. While the agency and the universities were each developing alternatives to more-polluting technologies, the Aerospace Corporation had recently released a report about spaceflight emissions and the long-term challenges to the sustainability of the space industry. Owing to the period of national mourning in the United Kingdom, experts from its space agency were unable to participate in the discussion, but had provided written inputs, available on the symposium web page, on incentive measures to encourage the adoption of sustainability measures.

39. The discussion considered the ways in which space activities could be negatively affected by the general public's perception that they contributed to climate change and ozone depletion as well as stratospheric pollution. The speakers discussed what could influence public perception in the years to come, considering that even people from spacefaring nations seemed largely unaware of the number of daily activities that depended upon the use of satellites. Research was under way on the potential impact on the Earth's atmosphere of the thousands of satellites expected to launch and to burn up upon re-entry over the next few years. However, the rate of launches seemed to be increasing faster than scientific analysis could progress. In addition, while earlier satellites had remained in orbit for 15 years, spacecraft were increasingly being designed for a fraction of that duration. The impact of the resulting growth in emissions and the direct impact on the atmosphere needed to be anticipated to enable policy makers to develop regulations to manage space activities while allowing them to flourish, as space applications and technologies remained essential tools for managing the climate crisis. States should complement the efforts of the Office for Outer Space Affairs and the Committee on the Peaceful Uses of Outer Space to raise awareness, while some activities, such as developing sustainability ratings, could be private initiatives focusing on corporate social responsibility.

40. The speakers provided examples of sustainable technology alternatives that could be used in engineering, including the use of such organic materials as wood for satellite platforms and beeswax as fuel for the propulsion systems of small satellites. With the Clean Space initiative, ESA was assessing the potential environmental impact of products, processes and services, looking not only at the ways in which they contributed to global warming and ozone depletion, but also to mineral resource depletion and other processes. For instance, germanium, used in solar cells, was a "hotspot" of resource depletion. For future projects, the agency had been exploring the incorporation of greener technologies, still under development, that would improve solar cell performance. Anticipation was key: if new regulations were to ban materials owing to their impact on the environment, the implementation of space missions would be affected because developing any replacement space system would take a long time. Assessing the life cycle of space missions and their technical components would enable the identification of the necessary green technologies. The impact of technologies on the environment depended upon the materials used, but also on how they were sourced. While the development of green alternatives by some pioneering organizations was already under way, their commercialization within the space industry would take several more years. Drivers for research into such alternative technologies and incentives for their adoption needed to be further developed.

41. To add a measure of local culture to the symposium, a virtual visit of the city of Graz was offered on Wednesday evening. Carrying a camera, a tour guide walked the online audience through the old city, providing an overview of its rich history. The audience appreciated the opportunity to learn about Graz and to see its main cultural landmarks live on camera.

42. Session 5 began with a presentation on the use by Austria of space applications to support its policy development on climate action. This was followed by four presentations on current projects that were using such applications. The commitment of Austria to space activities covered a range of activities at the national, European and international levels. In particular, an ESA business incubation centre; the European Space Policy Institute; and the newly created European Centre for Space Economy and Commerce were all located in Austria. The Austrian space strategy had been released the previous year and regular workshops were being held with space stakeholders and user communities on such subjects as energy and mobility, with hackathons organized to engage start-ups and raise awareness about the topic of space in general. Using Earth observation data from Copernicus satellites, the "space for mobility" hackathon had tackled problems contributed by private companies, including an entity managing road infrastructure and a company renovating the Austrian flood protection systems. Beyond such specialized activities, it was necessary to increase the awareness of the general public and of policy makers at the national level regarding the potential contributions of space. To that aim, more dialogue was needed between potential users and the providers of space solutions.

43. Three presentations provided an overview of the ways in which Earth observation data could be used. The Technical University of Vienna provided soil moisture data from satellites to assess climatic extremes, using Metop and Sentinel-1 satellite instruments: one provided very good temporal coverage, but coarse resolution, while the other provided very high-resolution data, but with less-frequent measurements. To assess the impact of a drought or to predict a flood, additional variables were required, such as vegetation, temperature and rainfall or snow melt. The soil moisture data had been made available online and showed a clear increase in drought conditions in some regions of Austria over the previous few years. The university was particularly interested in working with countries in East Africa and invited expressions of interest in collaboration. In addition to adhering to international standards, the Austria Environment Agency used detailed models for each sector in national greenhouse gas emission inventories, with international experts reviewing the quality of submissions up to twice per year. GeoVille had been working since 2020 on enabling reporting on greenhouse gas emissions using Earth observation data, developing cooperative projects at the European level aimed at achieving operational reporting in a few years. The prototype provided a time series of activities that were contributing to greenhouse gas emissions in Austria as well as inverse-modelling to report on such emissions using a top-down approach. The Austrian Institute of Technology was using Earth observation products to digitally model resilient cities, focusing on various areas of urban planning, such as population, mobility patterns and service accessibility. For instance, models determined whether essential services for the population of a given area could be accessed within 15 minutes, while other models provided mappings of exposure to natural disasters, heat hotspots and potential industrial accidents. Such models could be used in a variety of contexts. The institute was enhancing standard data products from satellite data with local data sources, such as socioeconomic and traffic data, and the model's accuracy would depend upon the level of accuracy of the local data. Rather than provide data to the user, the philosophy of such initiatives was to provide the user with the solution to a problem, where satellite data were not at the centre of the discussion, but merely inputs into the information the user needed.

44. The Austrian PRETTY satellite (under development) would embark upon a dosimetry and passive reflectometry mission, with two payloads developed by Seibersdorf Laboratories and the Technical University of Graz together with ESA. The dosimeter had two types of sensors developed by Seibersdorf Laboratories in collaboration with the European Organization for Nuclear Research. Reflectometry measured the microwave transmissions of the navigation satellites of the European Satellite Navigation System (Galileo) and the Global Positioning System; the signals were collected by the PRETTY satellite after being reflected on the Earth's surface, together with the initial transmission signal. The two signals were correlated to deduce information about the Earth's surface, such as local altitude and physical

properties, including moisture, ice and snow coverage. The team had been conducting testing by correlating the reflections of satellite navigation signals from the Danube River with those obtained from the open sky. The satellite would be launched in 2023.

V. Recommendations for future activities

45. To conclude the discussions on Thursday morning, the Office for Outer Space Affairs co-chaired a panel discussion with the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology. The panel summarized the outcomes of each country case and proposed recommendations for future activities within the new "Space for climate action" initiative of the Office.

46. The discussion involved representatives of India and Nigeria, who had presented their country cases previously, and summarized the factors preventing the wider local use of satellite-based data. Recommendations were also provided by a representative of CNES, which was developing the activities of the Space Climate Observatory, and a representative of ESA, which was implementing a global development assistance initiative.

47. The main issue preventing Nigeria from making better use of Earth observation data remained the lack of freely accessible high-resolution data; most freely accessible satellite data were only at medium resolution and, while the European Union had signed an agreement with the African Union on the provision of Copernicus high-resolution data and Nigeria had been selected as a country to receive such data, the infrastructure required to receive and process the data locally was not yet fully in place. A lack of awareness of the benefits of satellite data had also been a problem within the country: while the Nigeria Climate Change Act had become law in 2021, it had been only a few months since the National Council for Climate Change had been established to develop the national climate change agenda and the associated action plan. The Nigerian Space Agency would work closely with the National Council and other institutions to reduce fragmentation so that existing tools were made available to multiple agencies. Nigeria also intended to continue its efforts in a joint project with other African countries to develop a constellation of satellites to monitor African environmental issues on a daily basis. That initiative, launched in 2013, would provide African data to Africans and enable its stakeholders to offer their own contributions to collaborations with other countries.

48. India was concerned about how to ensure the long-term availability of satellite data, especially for monitoring greenhouse gases and floods, so that human resources could be trained and directed to develop technologies for mitigation and resilience, with confidence in the value of such a capacity-building effort. Developing international collaborations to obtain high-quality data in the long term was currently the most pressing issue. Several entities were already involved in developing space-based solutions within India: space technology and Indian satellite systems were providing essential inputs to research institutes and several entities had already moved from using climate data to providing climate services. Some data were available only for use within India, but some were available for other partner institutes and surrounding countries. However, acceptance and awareness were still limited. Taking the example of a programme launched in 2012 to provide the physical parameters of the atmosphere, the speaker observed that there was little knowledge of what was already available.

49. CNES highlighted the challenge of linking various data sources to provide operational tools to decision-makers, especially satellite Earth observation data as well as varied sources of in-situ and socioeconomic data. When developing solutions, the main hurdles were operational: it was still quite difficult for end users to employ what the agency was providing without specific training. Services to end users should be easier to use and should ideally require no prior knowledge. Academics working on algorithms and data analysis also needed to build more bridges with the private companies that would design a sustainable business case and operate a usable service.

Sometimes the different actors did not know each other. Priority should be given to developing technologies for operational solutions that enabled adaptation to climate change in vulnerable territories. For instance, accurately mapping the impact of natural disasters should be a priority, including an inventory and a way to monitor hazards as well as the provision of near-immediate information to the territories concerned. The second priority should be the management of water resources, where each water authority needed dedicated tools to obtain actionable information at their own level, especially on water reservoirs, and provide such information to the territories concerned to manage their water stock.

50. ESA recommended a focus on user requirements and stakeholder needs in various sectors rather than on technological possibilities. Increasing the availability of solutions was not sufficient for wide adoption: in addition to broader access for end users, awareness and acceptance of the contributions of such solutions at the operational level were required. The capacity development of users was essential: while ESA was promoting its technology and facilities, it was as important to train end users to apply space technology solutions for their specific challenges. It was acknowledged that high-resolution data were often not freely available and that space agencies needed to collaborate to increase access to such data at lower cost. However, the delivery of high-quality services was not sufficient to ensure the adoption of sustainable solutions. In particular, developing countries often depended upon external entities and would need to build capacity and transfer skills locally. ESA supported development up to the pre-operational stage and then fostered uptake, while operational implementation was transferred to the users. Working with regional organizations or with such entities as the World Bank could be beneficial, especially to facilitate access to finance for the operational stage.

51. The panellists discussed what role the Office for Outer Space Affairs could fill, highlighting four areas of activity:

(a) As a convenor of initiatives, the Office was bringing countries and resources together. While some countries were in a position to provide human resources, but needed facilities, other countries had facilities and fewer human resources; countries would welcome initiatives from the Office to create opportunities for synergies;

(b) Since education about climate action was a prerequisite for action, training programmes would be welcome similar to those the Office was providing, in partnership with several space agencies, following the symposium. The Office could provide further training programmes for scientists and students as well as climate research fellowship programmes to support the development of expertise within developing countries, provided that the funding for such new programmes became available. Initiatives to fund local training, notably for indigenous communities in various countries, would also be welcome;

(c) Communication with the general public continued to be required. The Office was in a unique position to further enhance the visibility of the contributions to society of space activities and to advocate for the use of space applications. It was reiterated that space was an indispensable tool for fighting climate change and that collaboration at the international level was essential if space-based applications and technologies were to provide their full benefits. The Office should continue to broadcast the message to the general public that space was useful to people;

(d) In order to support initiatives from national space agencies, the Office could bring its expertise in dealing with different cultures and in understanding different national space policies to groups developing solutions, such as those working on awareness-raising, and in linking research to private companies within the Space Climate Observatory.

52. The panellists concluded that all parties, especially institutions and States, needed to co-design targeted, fitted solutions rather than invent fancy solutions in isolation, and to connect demand and supply. The space sector also needed to be more

active in seeking financing for space projects, including by tapping into development finance, while the Office could focus on policy, capacity-building and advocacy.

VI. Conclusions and lessons learned

53. The Office for Outer Space Affairs and the Austrian co-organizers concluded the symposium by providing an overview of the respective roles of those involved in preparing the event. The third online symposium had built upon lessons learned in previous years, and the logistical challenges of using an online platform had been well anticipated. Despite extensive testing beforehand, technical connection issues at the local level on one day had prevented some speakers from Nigeria from being clearly heard. To mitigate such a problem in the future, the organizing committee would consider the use of video recordings if the need arose.

54. The symposium had provided a wide-ranging overview of how space applications, and especially data from Earth observation satellites, were being used to support climate action. It had presented tools, initiatives and policies from individual countries that could be adopted by others and had raised awareness of successful initiatives.

55. Participants were encouraged to provide written feedback using a dedicated online form and the feedback received was overwhelmingly positive: participants rated the event 4.63 out of a maximum rating of 5. Words of appreciation were received from speakers and attendees, who had appreciated the interdisciplinary nature of the discussions and had found the technical presentations easy to understand for non-experts. They had particularly valued the country cases, which had deepened their understanding of how a variety of space solutions had been applied to the unique challenges of individual countries, and they had appreciated the innovative topic of the greening of space systems engineering.

56. A sizable portion of the attendees had registered to attend the post-symposium technical courses on Earth observation and remote sensing provided jointly by the Office of Outer Space Affairs, the European Centre for Medium-Range Weather Forecasts, the Earth Observation Data Centre, Deltares, ESA, ISRO and NASA.

57. All the presentations of the symposium and relevant materials from the post-symposium online training courses would remain available at unoosa.org.

58. As in 2020 and 2021, remote attendance had provided an opportunity for a much larger number of participants than would have been the case for a physical event in Graz; it had also decoupled the selection of speakers and participants from any financial limitations and made it possible to provide younger speakers with an opportunity to contribute to the event. Use of the online platform would continue to be considered for the symposium in the future.