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Committee on the Peaceful Uses of Outer Space

Report on the United Nations/Austria Symposium on Integrated Space Technology Applications for Climate Change

(Graz, Austria, 12-14 September 2016)

I. Introduction

1. Climate change has been recognized as the defining challenge of our times. In the context of the United Nations, climate change began to be addressed at the beginning of the 1990s, when the United Nations Framework Convention on Climate Change was adopted, and later entered into force in 1994. Climate change, which recognizes no political boundaries, is being addressed at the highest international level through that Convention. Based on the assessment reports elaborated by the network of scientists belonging to the International Panel on Climate Change, and taking into consideration scientific contributions from parties to the Convention, along with international and regional research and development organizations, the Conference of the Parties to the United Nations Framework Convention on Climate Change in December 2015 launched the Paris Agreement on climate change with the aim "to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty".

2. The Paris Agreement reiterated the need to mitigate the impact of climate change by holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, as well as by increasing the ability of communities worldwide to adapt to the adverse impact of climate change and foster climate resilience and low greenhouse gas emissions development in a manner that did not threaten food production. The parties to the Paris Agreement reiterated the need to conduct systematic observations to track changes in the climate and those factors which are driving them.

3. Applications of satellite technologies to address climate change are being undertaken in two parallel ways: in efforts conducted under the umbrella of climate negotiations that are carried out by the parties, with systematic observations of essential climate variables falling into this category; and through efforts conducted by a variety of stakeholders worldwide to promote the use of such satellite technologies as a way to contribute to mitigation and adaptation.

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4. The Committee on Earth Observation Satellites, the Coordination Group for Meteorological Satellites, the Global Climate Observing System and space agencies such as the European Space Agency (ESA) are leading efforts to promote the use of satellite technologies in the area of systematic observations. In October 2015, the Global Climate Observing System launched *Status of the Global Observing System for Climate*,[1] a report whose stated purpose was to provide "an account of the current state of the global observing system for climate".

5. The Committee on the Peaceful Uses of Outer Space incorporated the topic of space and climate change in its agenda during its fifty-second session, in 2009. In annual sessions of the Committee, States members of the Committee report on their efforts related to climate change.

6. The Office for Outer Space Affairs of the Secretariat has conducted several international conferences and symposiums on topics related to climate change in the past two decades, for instance, a conference on integrated space technology applications to climate change held in Indonesia in September 2013 (see A/AC.105/1049).

7. The United Nations/Austria Symposium on Integrated Space Technology Applications for Climate Change was conducted in cooperation with the Federal Ministry for Transport, Innovation and Technology of Austria; the City of Graz; the State of Styria; Joanneum Research; and Austrospace, on behalf of the Government of Austria. The Symposium benefited from support provided by ESA, the Committee on Space Research and the Austrian Academy of Sciences. The Symposium brought together experts from national, regional and international organizations involved in space applications, as well as representatives of government agencies involved in efforts related to climate change, as well as universities and non-government organizations.

8. The Symposium was used to discuss ways in which countries affected by the impact of climate change, especially developing countries, could make better use of space applications to address those challenges. It was also used to take note of recent advances in the use of integrated space technology applications in the context of mitigation and adaptation to climate change.

9. The United Nations/Austria Symposium is part of the process relating to the upcoming fiftieth anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space, in 2018, which the Committee and the Office for Outer Space Affairs launched in 2015 to address challenges to humanity and sustainable development, to protect the space environment and to secure the long-term sustainability of outer space activities. The process is aimed at strengthening the efforts of the Committee to address current challenges and opportunities in areas of enhanced international cooperation.[2]

A. Background and objectives

10. In recent years, climate change has been recognized as a process which may deter sustainable development throughout the world. As a global phenomenon, climate change poses a threat to the economic, social and environmental dimensions of sustainable development. In the context of peaceful uses of outer space, Governments have reiterated the need to protect the Earth's environment, and to promote international cooperation on the use of satellite applications in areas such as climate

[1] Available from www.wmo.int/pages/prog/gcos/Publications/GCOS-195_en.pdf.

[2] For more information on the process, see www.unoosa.org/oosa/en/ourwork/unispaceplus50/index.html.

change. Satellites offer a unique point of view from which to observe climate-change-related variables and features at the global level, such as sea-level rise, deforestation trends and carbon emissions resulting from forest fires. They also offer the ability to measure on a permanent basis other parameters which may be too difficult or costly to observe from the ground, such as changes in polar ice caps and glaciers, and social trends, such as the increasing exposure of vulnerable communities to phenomena related to climate change.

11. The objectives of the Symposium were:

(a) To discuss ways in which countries affected by climate change, especially developing countries, could make better use of space applications to assess vulnerability to climate change and potential loss and damage;

(b) To present recent advances in the use of integrated space technology applications in the context of mitigation and adaptation to climate change;

(c) To improve synergies among space agencies and organizations specifically with regard to efforts on climate change;

(d) To strengthen international and regional cooperation in this area;

(e) To raise awareness of recent advances in space-related technologies, services and information resources that could be used to assess the impact of climate change and the effects of measures implemented to reduce that impact.

B. Attendance

12. Qualified experts and scientists from developing and industrialized countries in all regions were invited by the United Nations to participate in and contribute to the Symposium. Invitations to participate in the event were also disseminated through the worldwide offices of the United Nations Development Programme and permanent missions to the United Nations. Participants were selected from among the applications received on the basis of their academic qualifications and professional working experience and the relevance of their contributions to the Symposium. Applications from qualified female applicants were particularly encouraged.

13. The Symposium was attended by 46 experts from international, regional and national governmental and non-governmental institutions, universities and the private sector from the following 25 countries: Austria, Brazil, Bulgaria, Chile, China, Ecuador, France, Germany, Ghana, Greece, Guatemala, India, Ireland, Italy, Madagascar, Netherlands, Nigeria, Pakistan, Saudi Arabia, South Africa, Spain, Thailand, Trinidad and Tobago, United Kingdom of Great Britain and Northern Ireland and Uzbekistan.

14. Funds provided by the United Nations and the co-sponsors were used to defray, fully or partially, the costs of air travel and board and lodging for some of the participants. The sponsors also provided funds for local organizations, facilities and the transportation of participants.

C. Programme

15. The Symposium addressed a wide range of space-related technologies, services and information resources available to monitor climate change in terms of its manifestation, and ways to use this information and resources in the context of mitigation, adaptation, and loss and damage reduction.

16. The programme of the Symposium was developed by the scientific organizing committee, which included experts and representatives of the Office for Outer Space Affairs; the Federal Ministry for Europe, Integration and Foreign Affairs of Austria; ESA; Joanneum Research; and the Eurisy Association. An honorary committee and a local organizing committee also contributed to the successful organization of the Symposium.

17. The programme consisted of an opening session, six plenary sessions, a discussion session, a panel discussion, a poster session and a plenary discussion on observations and recommendations, followed by closing remarks by the co-organizers. The detailed programme, background information and full documentation of the presentations made at the Symposium have been made available on a USB memory stick and via a dedicated web page.[3]

18. A key segment of the Symposium was the plenary discussion on the final day, in which participating experts discussed and agreed on four policy-relevant recommendations addressed to the Committee on the Peaceful Uses of Outer Space related to thematic priority number 6 of the process to mark the fiftieth anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space, which specifically addresses climate change.

II. Summary of the Symposium programme

A. Opening session

19. The opening session included welcoming remarks by the Director of the Office for Outer Space Affairs, the Director of Joanneum Research, the Director of the Space Research Institute, and representatives of the Federal Ministry for Europe, Integration and Foreign Affairs of Austria; the Federal Ministry for Transport, Innovation and Technology of Austria, ESA, Austrospace and the City of Graz.

20. In their remarks, they stressed the need to address climate change and to enhance the use of integrated space technology applications with regard to the tracking of the manifestations of climate change through essential climate variables, as well as mitigation and adaptation. Recalling the Paris Agreement, they reiterated the need for similar symposiums to enable experts from developing countries and from developed countries to network, and to find ways to contribute to the implementation of the Paris Agreement. They made reference to the new open data policies in Europe and the United States of America that facilitated access to satellite imagery, which should be used to enhance the systematic observations of climate change that should be addressed in different regions of the world.

B. Plenary sessions 1 and 2: remote sensing and climate change

21. The first two plenary sessions were designed to provide the audience with an overview of ways in which satellite technologies were being used to address climate change and to raise awareness of particular applications of such technologies to monitor the manifestations of climate change in different types of environments.

22. The presentation by the Office for Outer Space Affairs gave participants an overview of the mandate and activities of the Office, as well as its efforts relating to climate change, and was aimed at raising awareness of the process to mark the fiftieth anniversary of the first United Nations Conference on the Exploration and

[3] www.unoosa.org/oosa/en/ourwork/psa/schedule/2016/symposium_austria_climatechange.html.

Peaceful Uses of Outer Space by describing its cross-cutting areas, the seven thematic priorities and how the initiative would be implemented.

23. A keynote presentation by ESA allowed the audience to take note of the efforts of that Agency relating to climate change, including the Climate Change Initiative. The presentation described how ESA was making use of space technologies to understand, from a European perspective, the Earth system and to contribute to the discussions regarding how to address the different manifestations of climate change. The presentation included examples of applications of integrated space technology applications for tracking sea-level rise, the melting of the polar caps and the ways in which international shipping was taking advantage of the melting of ice in the Arctic sea, Greenland and Antarctica, and in glaciers worldwide. In addition, the audience noted the usefulness of Earth observation for applications in adaptation, loss and damage reduction and global stocktaking.

24. Another keynote presentation provided examples of the use of space-based technologies to monitor ecosystems and water resources in South Africa. This presentation allowed the audience to pay attention to the severity of droughts in southern Africa in decades to come, fuelled by climate change, and of the impact of such droughts on water resources, agriculture, human health and livelihoods. Combined vegetation indices, such as the normalized difference vegetation index, were used to monitor the effects of droughts on pastures and on agricultural production. The presentation highlighted the usefulness of Earth observation technologies in characterizing and observing the frequency of climatic anomalies and aiding in identifying mitigation and adaptation strategies.

25. The fourth keynote presentation focused on the use of Earth observation technologies to characterize the effects of climate change on coastal and marine ecosystems, and the effects of typhoons on such marine ecosystems. The presentation addressed the effects of strong winds associated with typhoons and hurricanes on the spreading of harmful algae blooms, as well as on the dynamics, mixing and redistribution of plankton in marine ecosystems in South-East Asia and on the Pacific shores of Asia. Research efforts concerning that issue were necessary when taking into consideration that climate change would trigger more frequent and more intense typhoons and tropical storms worldwide.

26. The session included a keynote presentation on the Tandem-X radar mission and the proposed follow-up Tandem-L mission by the German Aerospace Centre (DLR). Those missions would continue to contribute to monitoring the environment from space, including forest biomass and its dynamics, surface moisture for water cycle research and glacial shifts and melting processes in polar regions. The audience took note of the enhanced resolution of the digital elevation models elaborated with Tandem-X in comparison with the Shuttle Radar Topography Mission of NASA, the application of radar imagery in agriculture to track the extent of floods and the dynamics of glaciers, and the use of radar interferometry to track volcanic activity and to assess ground deformation as a result of seismic activity. The presentation also addressed the upcoming Tandem-L mission and its concept of contributing to Earth observation of the biosphere, the geosphere, the cryosphere and the hydrosphere.

27. The audience was further made aware of the Copernicus programme, a flagship programme of the European Union that would provide the data necessary for operational monitoring of civil security. Copernicus had been designed with three components: a space component, an in-situ component and a services component. It would include 20 satellites covering six domains, and was expected to generate around 83,000 jobs by the year 2030. Five satellites had already been launched since 2014, and it was expected that two additional satellites would be launched in 2017. Those satellites would provide medium- and high-resolution optical

imagery, and radar imagery. One mission would be dedicated to low-Earth-orbit atmospheric chemistry. Furthermore, the open data policy of Copernicus would enhance the application of Earth observation to topics related to climate change, including the melting of glaciers and ice caps, land use and land-use changes, vegetation mapping, disaster management, sea and land surface temperature measurements, sea-level rise, ocean biogeochemistry and atmospheric chemistry.

28. These two initial sessions concluded with a keynote presentation on the work of the Adaptation Committee, which had been established by the parties to the United Nations Framework Convention on Climate Change. It had been established under the Convention in 2011 with the aim of providing recommendations to the Conference of the Parties on the means of incentivizing the implementation of adaptation efforts. The audience was reminded that the Paris Agreement included specific content regarding adaptation, and that the Adaptation Committee had been requested to conduct a technical examination process on adaptation, and to undertake five tasks and provide recommendations regarding methodologies and modalities:

(a) To support adaptation planning and implementation;

(b) To assess adaptation needs as a way to assist developing countries;

(c) To facilitate the mobilization of support for adaptation in developing countries in the context of the temperature limit defined in the Paris Agreement;

(d) To review the adequacy and effectiveness of adaptation and support.

29. Recognizing the potential of space technologies to enhance the effectiveness and efficiency of adaptation, the audience took note of suggestions in which the space community could promote the application of those technologies, including through continued and sustained outreach efforts to the climate change community, showcasing the benefits that could be achieved through the use of space-based information, success stories and lessons learned, and through capacity-building efforts so that relevant information could reach decision makers and stakeholders in a timely manner. The key challenge to be addressed was the need to transform the huge amount of space-based data into meaningful information for decision makers and those who were most vulnerable in a timely manner.

C. Plenary session 3: climate change and the environment

30. Climate scientists understand with medium to high confidence the relationship between atmospheric greenhouse gas concentrations and climate change. Climate projections suggest temperature increases, more frequent and intense extreme weather events, land degradation and desertification, the melting of glaciers and a rise in sea level. The third plenary session addressed the use of space technologies to address issues related to the environment.

31. The Secretariat of the Group on Earth Observations (GEO) started the session with a presentation on the efforts conducted by GEO to contribute to activities to address climate change at the global level. Being a strong advocate for sustained and coordinated climate observing systems, GEO was supporting an ambitious and multidisciplinary effort to strengthen the ability of Governments to minimize and adapt to the societal and environmental impacts of climate variability and change. A key effort conducted by GEO in recent years that had contributed to systematic observations was the Global Earth Observation System of Systems, a set of coordinated, independent Earth observation, information and processing systems that interacted with and provided access to diverse information for a broad range of users in both the public and private sectors. The audience was reminded of the role of GEO

in the Global Climate Observing System and the GEO work programme, which encompassed several efforts addressing climate change, including the GEO Carbon Initiative. The GEO Secretariat highlighted the need for open data policies to facilitate global monitoring and transparency, interoperability efforts to facilitate data discovery, and downstream services as a way to facilitate the generation of relevant information to be used by decision makers.

32. Taking into consideration the effects of climate change on glaciers, one presentation focused on the use of satellite imagery and ground-based data to track the cascading process of glacier melting and the development and/or expansion of glacier lakes in mountain areas of Uzbekistan. The audience was made aware of how the use of integrated space technology applications would allow researchers to assess the changes in glacier mass balance for the mountain areas of Uzbekistan, as well as to model the dynamics of glacier lakes and the formation of lakes resulting from glacier recession. The audience noted that the use of multitemporal, remote-sensing data integrated from various sources enabled a better temporal characterization of glaciers and naturally dammed lakes in mountains, and a higher level of inventory completeness.

33. The session included a presentation by the German Aerospace Centre on the upcoming joint German-French Methane Remote Sensing Lidar Mission (MERLIN), which was aimed at tracking concentrations of methane gas in the atmosphere. The relevance of methane in the context of climate change could not be overestimated. In the time horizon of one hundred years, methane had a global warming potential 28 times greater than that of carbon dioxide. In addition, after carbon dioxide, methane was the second most important well-mixed greenhouse gas contributing to human-induced climate change. The goal of MERLIN was to contribute to the understanding of the underlying processes of the methane cycle by characterizing its sources: both natural (e.g. wetlands and thawing permafrost) and anthropogenic (e.g. transport and burning of coal and natural gas, and ruminant livestock). MERLIN would make use of an integrated path differential absorption lidar as a way to deliver data day and night, at all latitudes, allowing monitoring of the tropical and Arctic regions.

34. Recognizing the effects of climate change on hydrometeorological hazards, an expert from the Technical University of Berlin made a presentation on the use of remote sensing methods and geographic information systems to monitor geographic areas prone to being affected by hydrometeorological hazards in the Black Hills area of South Dakota, Montana and Wyoming in the United States. The presentation showcased the integration of satellite data (Sentinel 1A and 1B, Landsat and Aster), digital elevation models, and meteorological, geological and geophysical data using geographic information systems to generate an overview of sites that could be affected by more frequent and intense flash floods.

35. As climate change would have an impact on regions around the world via more frequent and more intense floods and droughts, a presentation by the Asian Institute of Technology addressed a risk assessment effort in cities of various sizes in Pakistan that were experiencing floods. The presentation included a review of the concepts of hazard, vulnerability, exposure and risk, and methods of assessing them. Examples of vulnerability and flood risk were compared for three cities in Pakistan: Rawalpindi, Sialkot and Muzaffargarh.

36. Recalling the increasing importance of desert dust as a significant climate and weather modulator, and the role of forest fires in the generation of greenhouse gases, a presentation was made by the Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing of the National Observatory of Athens (Greece) on the use of Earth observation techniques to monitor smoke dispersion, dust concentrations and dust-atmosphere interactions in the greater Mediterranean region.

Participants were informed that, as a result of prevailing winds, dust was always present over the Mediterranean Sea. The audience was also made aware of ongoing research to model the nucleation of ice particles owing to dust at different elevations above sea level, and on the modelling of the effect of dust on cloud dynamics.

37. The final presentation of the session focused on the characterization of land-cover composition and its changes in Pakistan using normalized difference vegetation index data. Developed by scientists at the Space and Upper Atmosphere Research Commission of Pakistan, that procedure made use of hypertemporal remote sensing techniques. That allowed for more accurate representation and characterization of land cover and its changes, incorporating the notion of land cover gradients and the use of hypertemporal remote sensing. Examples of the use of that technique were presented to the audience.

D. Plenary session 4: climate change and livelihoods

38. In many countries, particularly developing countries, agriculture is a key sector of development; many rural communities base their livelihoods on it. The more frequent and intense droughts that are foreseen as a result of climate change in several regions of the world are putting many livelihoods at risk, particularly those which rely on rain-fed agriculture.

39. Irrigation is one of the ways in which the effects of droughts can be reduced in the context of agriculture. The establishment of reservoirs to store rainfall to be used as part of irrigation systems, where the terrain offers the possibility of establishing such reservoirs, could be a solution in geographic areas exposed to floods and droughts. In a similar fashion, such reservoirs could be used to minimize the extent of floods in areas that are prone to floods and droughts.

40. A presentation by the Ghana Irrigation Development Authority focused on a project that was being implemented with Global Water Partnership-Ghana to contribute to increasing the resilience of vulnerable communities in three administrative districts of the Upper East Region of Ghana through the establishment of an integrated flood-water harvesting and management scheme. The project involved the use of space-based technologies to identify and map flood-prone areas and flood regimes that would guide the selection of sites to establish flood-water harvesting systems for communities in those districts. In that project, remote sensing products would serve as baseline data for flood analysis of rivers and streams, and for the mapping of agricultural activities. Data from global navigation satellite systems would be used to survey and map properties and the land of the communities where water storage systems and irrigation schemes would be established.

41. Through a presentation made by the Indian Space Research Organization, the audience was informed of the use of Indian Earth observation satellites, such as Resourcesat-2, Cartosat-1, Cartosat-2, Cartosat-2A, Cartosat-2B, RISAT-1, RISAT-2, Oceansat-2, Megha-Tropiques and SARAL, to monitor water resources and to identify key measures to be taken towards their conservation and sustainable use. The data collected with those satellites allowed researchers to map several essential climate variables, to monitor agents of climate change such as greenhouse gas emissions, biomass burning and forest fires, and to model the impact of climate change in specific regions. The audience was made aware of the use of specific Indian satellites to track vegetation, land use, glaciers, sea surface heights, soil moisture and the water vapour profile, among other things, in several regions of India.

42. A final presentation by the Department of Geography and Geoinformatics of Bangalore University (India) addressed the use of Earth observation techniques to

track urban growth in Bangalore, in particular, to derive information on forestry loss and lake encroachment as a result of urban growth, and to model spatial growth and land transformation.

E. Plenary session 5: capacity-building and information management for climate change applications

43. Efforts relating to capacity-building and information management for climate change applications may include both human resource development and institution strengthening, along with training on improved data collection, processing and forecasting of hydrometeorological and agrometeorological data. The goal of such efforts should be to improve the availability and reliability of data on climate change available from space to be used in risk analysis, warning systems, recommended practices and knowledge-sharing.

44. A presentation by the State Key Laboratory of Remote Sensing Science of China made the audience aware of the upcoming Water Cycle Observation Mission. The audience noted that the mission was aimed at addressing the impact of snow on the global and regional energy and mass balance and the response thereto. The role of snow was very important when modelling the water cycle. To that end, measurements of the freezing and thawing of snow were essential, and Earth observation techniques had been found to be reliable for that purpose. The Mission would include a full polarized interferometric radiometer for soil moisture and salinity, a dual frequency polarized scatterometer, and a polarimetric microwave imager for measurements of temperature, rainfall, water vapour and atmospheric correction. The expected launch date would be in 2019 or 2020.

45. A representative of the National Office for Climate Change Coordination of the Ministry of Environment, Ecology and Forests of Madagascar briefed the audience on the Global Forest Watch project, which promoted the use of Earth observation applications to track forests in Madagascar. In that project, Earth observation was used to track changes in the geographical extension of forests and several climate change variables. The aims of that project included:

(a) To enhance the calibration and validation of the annual Landsat forest cover change analysis and to help develop a first-of-its-kind near-real-time Landsat-based alert system;

(b) To support research teams developing their own value-added analysis utilizing the wealth of data that would become available;

(c) To engage key user groups and stakeholders as contributors of information through crowdsourcing functions.

46. A third presentation during the session by a representative of the Space and Upper Atmosphere Research Commission of Pakistan allowed the audience to become aware of the use of satellite technologies to improve land-surface model simulations. The need for such models arose from the fact that a large portion of hydrological resources available to Pakistan was delivered through the melting of ice and frozen reserves in the northern part of the country. Those frozen reserves were comprised of seasonal snow cover and constant glaciated ice. An assessment of snow accumulation and depletion was necessary for the management of water resources in the region, where a large portion of annual precipitation fell in the form of snow.

47. Knowledge on the potential availability of water from those frozen hydrological reserves well before they melted would be highly valuable for hydroelectric power generation, flood control and hydroresource management. Equally important was

knowledge regarding how climate change might affect such frozen hydrological resources, as well as the livelihoods of the local population in rural areas that relied on such reserves.

F. Plenary session 6: future trends

48. The presentation during session 6 addressed the outcomes of a project carried out during the 2016 Southern Hemisphere Space Studies Programme of the International Space University, held in Adelaide, Australia. The project addressed space solutions such as the TIGER Initiative, which was led by ESA, in Africa and the Global Agricultural Monitoring initiative of the Group on Earth Observations, which could assist in tackling food and water security issues in regions exposed to climate change. Other types of solutions, including those which used mobile technology platforms in conjunction with crowdsourced data gathering, were also being addressed as part of that project.

G. Panel discussion

49. The panel discussion featured experts from government agencies in different regions of the world who were dealing with issues related to climate change. The panel addressed ways to advocate the use of integrated space technology applications at the international and national levels so as to contribute to the implementation of the Paris Agreement in the context of systematic observations. The panel included experts from Joanneum Research, the Indian Space Research Organisation, the National Institute of Space Research of Brazil, the Ghana Irrigation Development Authority, and the Federal Ministry of Science and Technology of Nigeria.

50. On the positive side, the panellists indicated that:

(a) Earth observation data were used in a variety of areas such as agriculture, water resources, environment, bioresources, rural and urban development, ocean resources and environmental monitoring (deforestation);

(b) Such data were very relevant in damage assessment, forest fires, drought and desertification;

(c) Low resolution data were publicly available, and high resolution data were made available in the event of disasters;

(d) Earth observation data were essential for developing countries.

51. The panellists also pointed out that:

(a) Government agencies in many developing countries were gradually incorporating the use of satellite applications in their routine activities, with the support of space agencies or space research organizations and ministries of science and technology;

(b) The degree in advancement in the institutionalization of the use of space technologies varied from country to country;

(c) The number of satellite data users was continually increasing.

52. Nevertheless, the panellists also identified several challenges that needed to be addressed, including:

(a) Although the European Union had an open data policy, at the national level there were still limitations on open data policies regarding weather data and data confidentiality;

(b) There were still some limitations on the use of satellite applications in groundwater assessment.

53. Taking into consideration mountain environments in particular, panellists noted that integrated space technology applications could be used to map mountain landscapes and to contribute to the assessment of socioeconomic conditions in rural communities, as well as in telecommunications.

H. Discussion session

54. In addition to the sessions described above, further discussions were held by three breakout groups.

55. Group 1 addressed very long-term issues, such as glacier melting, which was an extremely slow process that might have a very large effect, decades in the future, on rural communities in mountain environments, and in some large cities in developed and developing countries. The discussion addressed the question of how to structure a programme that was able to compile relevant information from geographic areas already facing some of those consequences. Participants suggested two parallel approaches: raising awareness; and research and systematic observations.

56. On the issue of raising awareness, the group suggested the need to raise awareness of methods that could be used to address different needs related to climate change, in particular long-term issues, and to serve as a bridge between those who were involved in space technology applications and modelling with those who were dealing with adaptation and loss and damage.

57. On the issue of research and systematic observations, the participants made the following suggestions:

(a) It was important to dedicate efforts to addressing interdependencies. For example, to facilitate comprehension of what effects were actually related to climate change, there was a need to facilitate the assessment of those effects which arose as a result of anthropogenic processes (the socioeconomic and sociocultural development processes of humans);

(b) There was a need to support the conducting of research needed to address some of those long-term issues. For example, it was difficult to track glacier dynamics from satellites when glaciers were obscured by clouds. Research on the use of radar satellites in glacier dynamics was necessary;

(c) There was a need to address and support efforts to validate models and products derived from satellite sensors as a way to encourage their use.

58. Group 2 addressed solutions for vulnerable communities. The group was asked to consider the types of applications or methods that needed to be developed, using space technology applications, that could assist decision makers in identifying, visualizing and assessing alternatives or options for adaptation in rural and urban areas. The group was also asked to discuss how to combine space applications and ground-based surveys to assess the vulnerability of communities in mountainous areas and their livelihoods.

59. Participants in this group suggested assessing those communities and institutions which were most vulnerable to climate change as a way of identifying and implementing measures to adapt to its manifestations. In addition, they suggested the establishment of networks to facilitate the sharing of knowledge and data, and the implementation of early warning systems to minimize the impact of natural hazards, along with comprehensive and rapid information dissemination systems.

60. Group 3 was tasked with addressing the issues of capacity-building and institutional strengthening, in particular with outlining the main elements that a capacity-building strategy should include as a way to promote the use of space-based technologies to address the challenges posed by climate change in different sectors of development.

61. Participants in this group noted that any recommendation on capacity-building should not only cover how to acquire data but actually put more emphasis on training on how to use those data. In addition, they suggested the conducting of surveys and gap analysis at the country level as a way to identify capacity-building needs. They noted that outreach efforts might be more important than capacity-building in some stages, and that such efforts should always go hand-in-hand with capacity-building programmes.

62. Regarding elements of a capacity-building strategy, the participants in this group suggested that capacity-building efforts should simultaneously target policymakers, decision makers, technical personnel and end users. The use of dedicated training courses and the modality of "train-the-trainers" was also suggested. The group highlighted the need for trust-building activities between specialists and scientists who were generating information, products and services on the one hand, and end users on the other, including through the conducting of pilot projects. Parallel efforts should also be conducted at schools and universities.

I. Poster session

63. In addition to the sessions described above, a poster session was held to share experiences, lessons learned and relevant content. The poster session included five presentations, from representatives of the following entities: National Institute of Space Research of Brazil; Chilean Weather Service satellite network; Ecuadorian Civilian Space Agency; Surveys and Mapping Division of the Ministry of Agriculture, Land and Fisheries of Trinidad and Tobago; and International Space University.

III. Policy-relevant recommendations related to the process to mark the fiftieth anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space

64. The final plenary session of the Symposium was used to discuss policy-relevant recommendations. Participants reviewed and discussed the specific texts of the following four recommendations:

(a) As a way to address the effects of climate change, it is important to promote the use of data from the new Earth observation satellites;

(b) As a way to increase the understanding of the drivers of climate change, it is important to support the efforts of the scientific community, which is focusing on the development of novel space-based sensors, and modelling techniques;

(c) The Committee on the Peaceful Uses of Outer Space should encourage the conducting of additional research on the drivers and effects of climate change, using space and in-situ data, and models;

(d) The Committee should encourage international cooperation and outreach efforts concerning the open access and exchange of data, products and services.

IV. Conclusions and recommendations

65. The six plenary presentations, as well as panel, poster and discussion sessions, allowed the audience to take note of examples of the use of space-based technologies to address climate change, efforts conducted by the space community, and efforts conducted in developed and developing countries as a way to address climate change. Specifically, the Symposium allowed participants:

(a) To discuss ways in which countries affected by climate change, especially developing countries, can make better use of space applications to assess vulnerability to climate change and potential losses and damages;

(b) To become aware of recent advances in the use of integrated space technology applications in the context of mitigation and adaptation to climate change;

(c) To take note of the process to mark the fiftieth anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space conducted by the Committee on the Peaceful Uses of Outer Space and the Office for Outer Space Affairs;

(d) To strengthen international and regional cooperation in this area;

(e) To highlight recent advances in space-related technologies, services and information resources which can be used to assess the impact of climate change and the effects of measures implemented to reduce such impact;

(f) To take note of upcoming satellite missions to be launched by the space community to contribute to an improved understanding of climate change in terms of its manifestations and ways to cope with its effects.

66. The presentations provided examples of the use of space technologies worldwide using satellites launched by many countries. They also made reference to open data policies that had been established by several space agencies, which were allowing researchers and professionals in developing countries to access satellite data to generate relevant and timely information.

67. Participants recommended the conducting of outreach efforts to promote greater use of space technology applications in the area of climate change worldwide. They also recommended that the Office for Outer Space Affairs and the Committee on the Peaceful Uses of Outer Space provide policy-relevant support for space agencies and researchers to carry out research on ways to improve the use of satellite technologies to track the manifestations of climate change, to identify and characterize the interdependencies of the effects of climate change in many sectors of development, and to contribute to differentiating those effects which were related to climate change from those which were related to existing socioeconomic development processes in many countries.

68. An explicit suggestion was made for the Office for Outer Space Affairs to contribute to bridging the gap between those who were involved with the development of space technology applications and modelling and those who were in charge of dealing with mitigation, adaptation and loss and damage in all regions of the world. A specific suggestion was to establish networks that could target the compilation, systematization and sharing of knowledge, as well as relevant information.

69. Taking note of the increasing amount of space-based data, a specific recommendation was made to dedicate efforts to transforming that huge amount of data into meaningful information in a timely manner so that decision makers and those who were vulnerable to climate change could use it.

70. While the space community had contributed extensively through space technology applications to tracking greenhouse gases and to assessing several of the essential climate variables that were required to track climate change, there was a key recommendation to identify, systematize and showcase examples of the use of space technology applications in the area of adaptation, along with their benefits, particularly to developing countries, as well as the lessons learned from the use of those novel technologies.

71. The need for capacity-building efforts was also identified, with the suggestion made that such efforts should go hand-in-hand with awareness-raising efforts. The recommendation was made that there was a need to ensure that capacity-building efforts simultaneously targeted policymakers and decision makers, technical personnel in institutions, and end users who were dealing with climate change. It was suggested that such capacity-building efforts could benefit from the use of "train-the-trainer" approaches, as well as the conducting of pilot projects under that notion of capacity-building.

72. The Symposium allowed participants and organizers to emerge with two key outcomes. The first one is the identification of ways in which space-based technologies can be used to generate relevant information for effective climate-change-related planning and management worldwide. The second one is a set of policy-relevant recommendations regarding how the international community can work together to enhance the use of integrated space technology applications to address challenges posed by climate change. These recommendations will find their way into the process to mark the fiftieth anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space, which is a major milestone in the design of the road map for United Nations space policy that the global community needs for the next 15 years and beyond. Furthermore, the outcomes of this Symposium will contribute to promoting the use of space technology applications for the benefit of humankind.