Japan welcomes the opportunity to submit its views on SBSTA Agenda Sub-item “Research and Systematic Observation”, in Agenda Item “Matters Relating to Science and Review”, regarding possible topics for consideration at the thirteenth meeting of the Research Dialogue (RD13).

Japan is pleased to submit following five themes with some possible topics for consideration.

1. **Climate science for policy making**

 Uptake of state-of-art climate science findings would be essential for science-based decision-making process in mitigation and adaptation. Considering that the IPCC AR6 reports are planned to be published soon in 2021/2022, it would be valuable to learn how IPCC has contributed to international and/or national decision-making process (e.g., role in UNFCCC process) and what messages the AR6 authors have. Case sharing from other international organizations and the Parties would be also useful.

In Japan, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Japan Meteorological Agency (JMA) recently published a report regarding observed and projected climate change in and around Japan and the provided physical science information has been referred by other government bodies in their analysis on climate change impacts and discussion on future strategy. Japan can share such examples.

 In addition to this, Japan can also provide the following two topics.

*1-a. Effective adaptation measures for extreme floods using a large ensemble of high-resolution climate simulation in Japan*

*1-b. Design of coastal storm surge protection system considering climate change in Japan*

1. **Impact of the COVID-19 pandemic on global climate**

The COVID-19 crisis has resulted in huge influence on human activities worldwide. It is expected that the COVID-19 pandemic also influences on global climate through these changes. More than one year has passed since the start of the pandemic, and some interesting results of the impact on global climate are reported by science community. Sharing such the latest information with policy makers and making an opportunity for discussion would be useful for considering future climate change issues. In this context, Japan can provide the following topic.

*2-a. Modelling impact on climate of the Covid-19 pandemic*

1. **Estimation of GHG emissions and variabilities for the Global Stocktake**

The first Global Stocktake will be conducted in 2023. It would be therefore useful to share the latest research on the relevant themes and deepen understandings at this time. For the better implementation of Global Stocktake, satellite remote sensing technology to accurately estimate GHG emissions plays a key role, contributing to the enhancement of the accuracy and transparency of the GHG emission inventory reports from each country. Besides, it is also important to deepen understanding of the long term GHG natural variability for visualization of emission reduction efforts. In this context, Japan can provide the following two topics.

*3-a. Satellite observation towards integrated understanding on source and sink of Greenhouse gases*

*3-b. Estimating and predicting global ocean and terrestrial carbon uptakes in a decadal time scale*

1. **Ocean and cryosphere in the climate system: impacts, effects, and observation**

As mentioned in the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC), all people on Earth depend directly or indirectly on the ocean and cryosphere. Also, these components play an important role in the climate system through global exchange of water, energy and carbon. As such, there is no doubt about the importance of ocean and cryosphere not only for human activities but also in the climate system. It would be therefore useful to have an opportunity to discuss and share the latest research on this theme. Japan can provide the following three topics in this regard.

*4-a. Assessing the impact of climate change on snow water resources – A case study in Japan*

*4-b. Effect on the Earth system of realizing a 1.5℃ global warming target after overshooting to the 2℃ level*

*4-c. An integrated ocean observation research by JAMSTEC*

1. **Findings from the latest research on climate change**

The latest progress and findings based on climate change research will be introduced and discussed in this theme. Japan can provide the following two topics.

*5-a. Robust nation-scale impact assessment on extreme floods using a large ensemble climate dataset – A case study in Japan*

*5-b. Findings from the Reduced Complexity Model Intercomparison Project*

Further details on the above topics with title are described below.

**Theme 1: Climate Science for policy making**

***1-a: Effective adaptation measures for extreme floods using a large ensemble of high-resolution climate simulation in Japan***

A research project (TOUGOU) which targets global climate projection to its impact on local disaster was started from 2017 (still in continuation) in Japan. The future flood control planning is being discussed based on the results of TOUGOU project. As the outcome of this research project, the large ensemble of high-resolution climate datasets enables us to consider various heavy rainfall patterns including many inexperienced patterns. Furthermore, the large ensemble datasets have a high affinity for the assessment of stochastic flood risk information (risk-based approach). We are working to make a new and more effective flood risk assessment method including spatiotemporal rainfall pattern and uncertainty of dike failure risk. The new assessment method is developed in collaborative research which is supported by the government of Japan and the government of the Netherlands. The detailed risk information obtained by the new climate data and new flood risk assessment method can be used for detecting suitable flood control investment, operation method, and evacuation planning. This information leads the implementation of adaptation planning and advised national and sub-national level committees for future flood control in Japan.

***1-b. Design of coastal storm surge protection system considering climate change in Japan***

Thirty percent of Japan's population is concentrated in coastal areas, with 4 million people living in the 0-meter zone above sea level. Osaka, the second largest city in Japan, has been protected by storm surge barrier since 1970’s after two catastrophic typhoons in 1934 and 1961, but the protection system needs to be rebuilt within ten years. Since 2018, discussions have been held on future projections and adaptation measures for the construction of storm surge barriers, considering climate change, especially future changes in sea level rise and typhoon-induced storm surges. This topic can present how the climate change predictions, conducted under the Japanese climate model development program (TOUGOU), is incorporated into the design of mega-scale infrastructures and the design policy as climate adaptation measures.

**Theme 2: Impact of the COVID-19 pandemic on global climate**

***2-a: Modelling impact on climate of the Covid-19 pandemic***

An unprecedented decrease in GHGs and anthropogenic aerosol emissions has been observed due to the lockdown caused by the Covid-19 pandemic.

MIROC-ES2L earth system model developed under the Japanese climate model development program (TOUGOU) and a number of climate models participating in CMIP6 were used to compare the impact of this decline of GHGs and aerosols on climate change, simulating scenarios in which there is a two-year blip in emissions in 2020 and 2021, followed by several patterns of recovery. The results show that the aerosol optical depth of the atmosphere will decrease in 2020 and 2021 due to reduced air pollution, especially in Asia. On the other hand, it is confirmed that there is unlikely to be a significant impact on the progress of global warming. The potential regional and short-term climate impacts in Asia will be presented.

**Theme 3: Estimation of GHG emissions and variabilities in support of Global Stocktake**

***3-a. Satellite observation towards integrated understanding on source and sink of Greenhouse gases***

JAXA is monitoring the global environment from space as its mission. GOSAT and GOSAT-2, joint projects of the Ministry of the Environment, the National Institute for Environmental Studies, and JAXA, have been conducting observations for more than 10 years to estimate greenhouse gas emission concentrations and the anthropogenic emissions. JAXA has also observed forests as sinks of greenhouse gases for many years, and also undertook research and development on biomass applying the knowledge acquired. Hereto, as space agency’s contribution to the Paris Agreement, JAXA will present the efforts on supporting the integrated understanding of greenhouse gases and each country‘s reduction efforts with the scientific knowledge on emission sources and sinks obtained from these satellite observations.

***3-b. Estimating and predicting global ocean and terrestrial carbon uptakes in a decadal time scale***

Toward the implementation of Global Stocktake, the need for estimation and prediction of variations in atmospheric CO2 concentration in a decadal time scale is increasing, because such an attempt will lead to visualization of emission reduction efforts and sophisticated estimate of carbon budget. Uptake of CO2 at the ocean and land surfaces is one of the fundamental processes in the global carbon cycle, and it is known to fluctuate in response to inherent climate variabilities.

Earth system models are models that can reproduce the global carbon cycle as well as inherent climate variabilities. By assimilating the observed climate data into Earth system models, it can make possible to estimate historical variabilities of global ocean and terrestrial carbon uptakes and make decadal-scale prediction in the future. In this study, observed climate data are assimilated into an Earth system model, developed under the Japanese climate model development program (TOUGOU), to reproduce the variations in global ocean and terrestrial carbon uptakes. In addition, it was found that the carbon uptake of the global ocean is predictable for approximately next six years.

**Theme 4: Ocean and cryosphere in the climate system: impacts, effects, and observation**

***4-a. Assessing the impact of climate change on snow water resources – A case study in Japan***

Large quantity of water resources is required for rice production and other economic activities in Japan. Climate change may have a significant impact on the use of water resources. In this study, the impacts of climate change on snow water resources in Japan and their uncertainty will be presented mainly based on the latest projections by Japanese climate change research project, including the TOUGOU program. The flow regime will be affected greatly especially in the snowy region, and the flow regime change in winter to spring season is consistent among many ensemble members. Due to the global warming, significant amount of snowfall will change into rainfall. Thus, the winter season runoff will increase but mostly remain unused. In addition, the snowmelt runoff in spring season will decrease while the water demand for rice production in that season is higher than others. Similar changes will be expected in other watersheds in the world where snowmelt water is an important source of water resources. The rice growth model and hydrological analysis are combined to assess the effectiveness of shifting crop calendar as an adaptation measure with consideration of both climate condition and water resources availability.

***4-b. Effect on the Earth system of realizing a 1.5℃ global warming target after overshooting to the 2℃ level***

We developed two scenarios that diverged after reached 2 °C temperature rise, one stays at the 2 °C level and the other cools to the 1.5 °C level, and input them to an Earth system model to investigate the effect of reaching the target of 1.5 °C warming (relative to preindustrial levels) after overshooting the 2 °C level with respect to selected global environment indicators.

A considerable difference was found between the two scenarios in terms of Arctic sea ice, whereas both scenarios indicated few corals would survive past the 21st century. The difference in steric sea level rise, reflecting total cumulative ocean heat uptake, between the two scenarios was <2 cm in 2100 (and around 9 cm in 2300) in the Pacific Island region. A large overshoot (i.e., 0.5 °C) may reduce the eventual difference between targets (i.e. 1.5 °C in contrast to 2 °C), particularly in terms of the indicators related to total ocean heat uptake, and to sensitive biological thresholds.

***4-c. An integrated ocean observation research by JAMSTEC***

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is now involved into ocean observation to grasp global a current ocean state, through activities such as high-quality oceanic observations by R/V Mirai, deployment of autonomous observation platforms equipped with multiple sensors, moored buoy systems.

Japan integrated available ocean-observation data into an ocean state estimation by using data assimilation technics. The obtained state estimation has started to be applied to construct a systematic observation scheme through, for instance, 3-d drift buoy simulation and observing system evaluation. Japan is also promoting a unique ocean-observation research inclusive of changes in the deep ocean state.

**Theme 5: Findings from the latest research on climate change**

***5-a. Robust nation-scale impact assessment on extreme floods using a large ensemble climate dataset – A case study in Japan***

Extreme floods and its frequency are largely affected by a changing climate; therefore, it isrequired to make decisions on the level of updating infrastructure and the risk to be remained for non-structural measures, for which solid future projections of flood frequencies are inevitable. However, enormous studies and literature have suffered from lacking ensembles in climate simulations, which reduces the reliability of estimating future changes of extreme floods. Recently, a large ensemble climate simulation dataset d4PDF, having 3000-year to the present and 5400-year to the future climate data, has become available. In the Integrated Research Program for Advancing Climate Models (TOUGOU) in Japan, d4PDF extreme rainfall data was applied with robust bias correction based on extreme value theory and converted to river discharge through catchment-scale rainfall-runoff models constructed on all the 109 class-A river basins in Japan. Frequency analysis of the large ensemble flood data clarified anticipated change ratios of 100- and 900-year floods in Japan and their regional characteristics. Furthermore, the flood dataset first realized impact assessment on simultaneous flood probability over multiple regions. As the result, future changes of catastrophic events at the same level as a typhoon Hagibis are quantified not only at a catchment scale but also a multiple-catchments scale.

***5-b. Findings from the Reduced Complexity Model Intercomparison Project***

The second phase of the Reduced Complexity Model Intercomparison Project has been conducted for the IPCC AR6. This project compares nine participating models for their probabilistic climate projection methods that underlie climate assessment of mitigation scenarios. The main focus is on the implementation and consistency of given constraints on radiative forcing, observed global warming, and climate sensitivity. One of the nine models was developed under the Japanese climate model development program (TOUGOU) and has produced results that well match the ranges of the constraints.

Experimental results for historical and future scenarios show that the climate sensitivity of the latest climate models is overestimated overall, suggesting that probabilistic climate projections need to be constrained with observed warming trends.