Press Releases

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Arctic Summer Temperatures Increase by approximately 2 °C in 15 Years -Spiral of Summer Warming and Drying

Overview

A research group led by Senior Research Scientist Kazuyoshi Suzuki of the Institute of Arctic Climate and Environment Change Research of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC: President; Asahiko Taira) has analyzed the spatiotemporal variations in the terrestrial water storage (TWS) of the arctic circumpolar tundra region (ACTR) (as shown in figure 1a) and three of the largest pan-Arctic river basins (Lena, Mackenzie, Yukon). Using statistical analyses of global land data analysis system data[*1], and the satellite-based gravimetric data (Gravity Recovery and Climate Experiment, GRACE)[*2], their research has observed an increase of approximately 2 °C in summer temperatures over a 15-year period (as shown in figure 2b).

These results are the first to show that a “summer warming” is widely progressing in the vicinity of the Arctic Ocean notwithstanding the lack of signs of this warming in the mean annual temperature (as shown in figure 2d). This study further demonstrated that, in addition to warming, evapotranspiration from the Arctic tundra region has increased (as shown in figure2c), which has led to aridification equivalent to a water depth of 2 cm (approximately 110.6 billion ton) over the past 15 years (as shown in figure 2a). Moreover, analyses on varying permafrost[*3] distribution (as shown in figure 1b) among the largest Arctic rivers revealed that the presence of permafrost slowed the acceleration of hydrological cycle and warming.

The circulation of heat, water, and various materials in the atmosphere, land, and oceans has a significant impact on the environment, including the climate. Understanding the generation, transport, and absorption processes of water vapor, carbon dioxide, methane, and other influential factors in global warming, which has escalated in recent years, is critical in shedding light on the circulation of these materials.

This study has not only led to the clarification of existing summer Arctic warming conditions but has also produced important results that will inform studies predicting global climate, water circulation, and warming. We anticipate that the clarification of the role of permafrost revealed by this study will contribute to the prediction of future disaster prevention in the Arctic tundra region and will aid in the management of water resources. Since Siberia extends to the western side of Japan, we further expect that the changes in warming and water circulation in the Siberia tundra region will affect Japan's climate.

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*1 Global land data system (GLDAS) data: Dataset created by the National Aeronautics and Space Administration (NASA) using advanced data assimilation techniques to merge land-surface models with meteorological observations, satellite observations, and other observational data. This dataset differs from atmospheric reanalysis data in that it uses ground-based observations and other methods as bias compensation. It is widely used in verifying climate models and climate change research. Here, we used two GLDAS datasets: GLDAS version 1 (GLDAS1) and GLDAS version 2 (GLDAS2).

*2 Gravity Recovery and Climate Experiment: Man-made satellite joint-launched in 2002 by NASA and the German Aerospace Center. It is a twin satellite with two cooperating components, which are able to accurately measure even slight variations in the Earth's gravitational field from changes in their location and velocity. Since gravity is dependent on mass, this satellite is useful for understanding the mass distribution on the Earth's surface and its changes over time. The satellite was used until the summer of 2017 to study the Earth's water circulation and sea level fluctuations, amongst others.

*3 Permafrost: Soil that remains at temperatures of ≤0 °C for at least two consecutive years. The surface is an active layer that thaws in the summer and re-freezes in winter. Permafrost distribution are grouped into "continuous permafrost", "discontinuous permafrost", "sporadic permafrost", and "isolated patches permafrost" in Figure 1 according to the percentage of permafrost distribution.

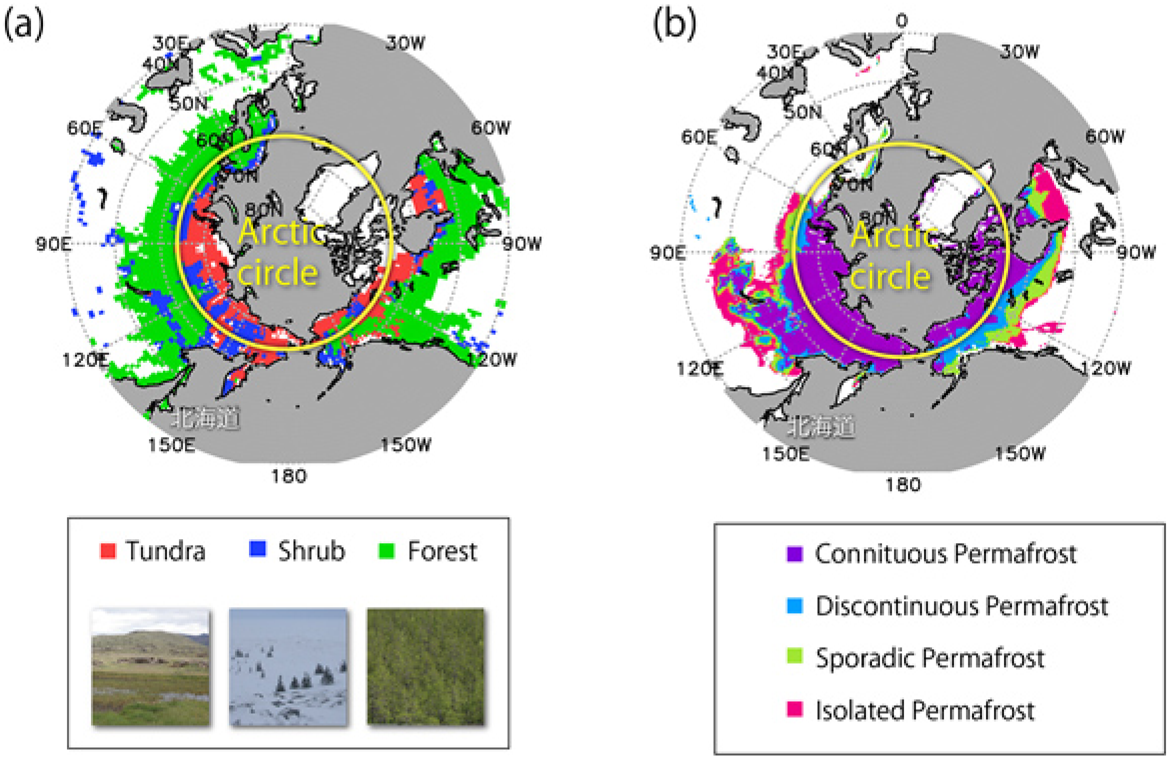

Figure 1: Vegetation map of the Arctic region (a) and distribution of permafrost (b). The four types of permafrost areas in Figure 1(b) are classified as shown by the percentage of ground underlain by permafrost: Continuous Permafrost is found where the percentage of subsurface permafrost is ≥90%. Discontinuous Permafrost is found where the percentage of subsurface permafrost is 50–90%. Sporadic Permafrost is found where the percentage of permafrost distribution is 10–50%. Isolated Permafrost is found where the permafrost makes up ≤10% of the ground.

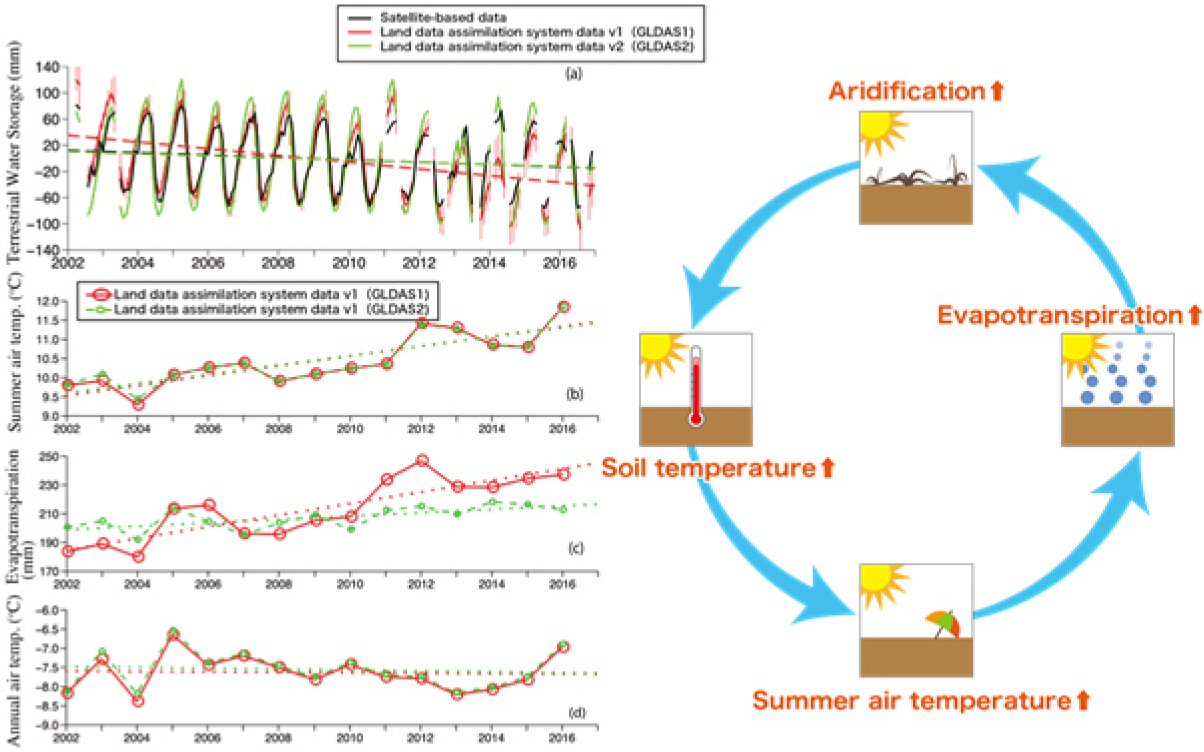

Figure 2: Temporal variations in hydrometeorological conditions in the Arctic circumpolar tundra region, and a schematic diagram on spiral of summer warming and drying. (a) Monthly terrestrial water storage, (b) summer air temperature (June, July and August), (c) annual evapotranspiration, and (d) annual air temperature.

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