Press Releases

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JAMSTEC
Nagoya University

Decrease in Terrestrial Water Storage in Arctic Region
- Tundra is rapidly drying up due to summer warming -

Overview

A research team led by Dr. Kazuyoshi Suzuki at Department of Environmental Geochemical Cycle Research (DEGCR), the Japan Agency for Marine-Science and Technology (JAMSTEC: Asahiko Taira, President) estimated terrestrial water storage in the Arctic region based on observation data from the Gravity Recovery and Climate Experiment (GRACE)[*1]. It revealed increased summer evapotranspiration in the Siberian tundra from 2002 to 2015, which is associated with rapid increase of summer air temperatures. It also made it clear that terrestrial water storage from November of the previous year to the following May is significantly affecting the amount of river run-off into the Arctic Ocean from the Lena River basin, which is the second largest source of freshwater amoung rivers in the region. This work was carried out in collaboration with researchers from Nagoya University.

On Earth, all elements such as heat and water are circulating over and over again, giving significant impacts on climates and other environments. To clarify circulation of water vapor, carbon dioxide and methane as influencing factors of recently accelerating global warming, it is necessary to understand the processes how these elements are stayed in lands and seas as well as how they are generated, transported, and absorbed.

The Siberian tundra is known to be one of the most remarkable areas that are affected by global warming. This study confirmed that terrestrial water storage decreased by about 6 mm water equivalent per a year, caused by increase in average summer temperatures by 0.36°C in the region. It also suggests that terrestrial water stored frozen in the Lena River basin strongly affects the amount of river run-off in the following year.

This is the first study to apply data from the Gravity Recovery and Climate Experiment (GRACE) to evaluate terrestrial water storage in tundra regions. These findings should help further clarify methane cycles in wet lands as a major source of emission to the atmosphere. It is expected to contribute to better understanding of climate variability on a global-scale.

The above results were published in the online version of *International Journal of Remote Sensing* issued by Remote Sensing and Photogrammetry Society on April 29, 2016 (JST).

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Title: Satellite gravimetry-based analysis of terrestrial water storage and its relationship with run-off from the Lena River in eastern Siberia

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*1 Gravity Recovery and Climate Experiment(GRACE)
It is twin satellites launched by National Aeronautics and Space Administration (NASA) and the German Aerospace Center (Deutsches Zentrum für Luft-und Raumfahrt: DLR) in 2002. It can detect small changes in the Earth's gravity fields based on the satellite positions and velocity changes. As gravity is determined by mass, it helps grasp mass distributions and time-series changes on the Earth. These data could also be applied to research on water cycle and sea level changes on the Earth.

*2 Terrestrial water storage (TWS)
It refers to all water stored on the land surfaces such as soil moisture, lakes and wetlands, underground water and ice, and snow. The TWS can be defined as the residual; precipitation minus the amount of water that evaporates from surfaces and discharges as river run-off.

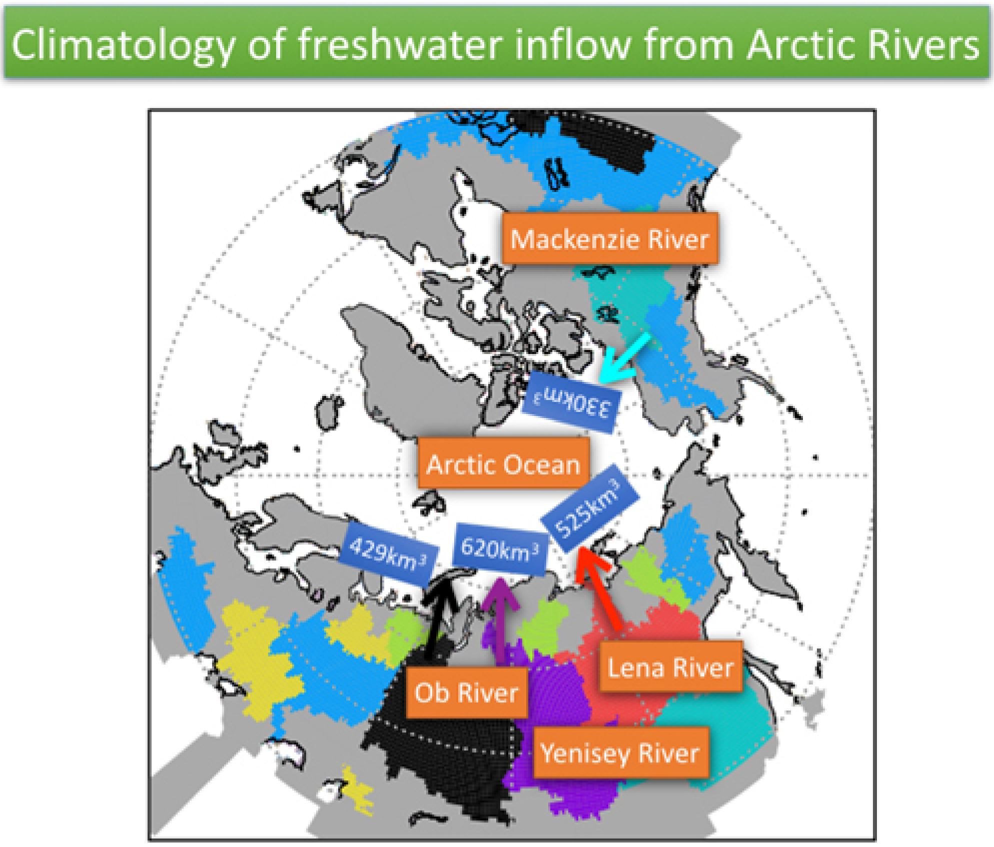

Figure 1. Overview of freshwater supply into the Arctic Ocean. A total amount of 75% is occupied by four rivers; Yenisei River, Lena River, Ob River, and Mackenzie River. Lena River is the second largest sources of freshwater among major rivers in the Arctic region, accounting for 20% of the total. The figures indicate annual run-off of freshwater from these rivers. (Prepared based on Serreze et al,2006 and Lewis et al. 2012.)

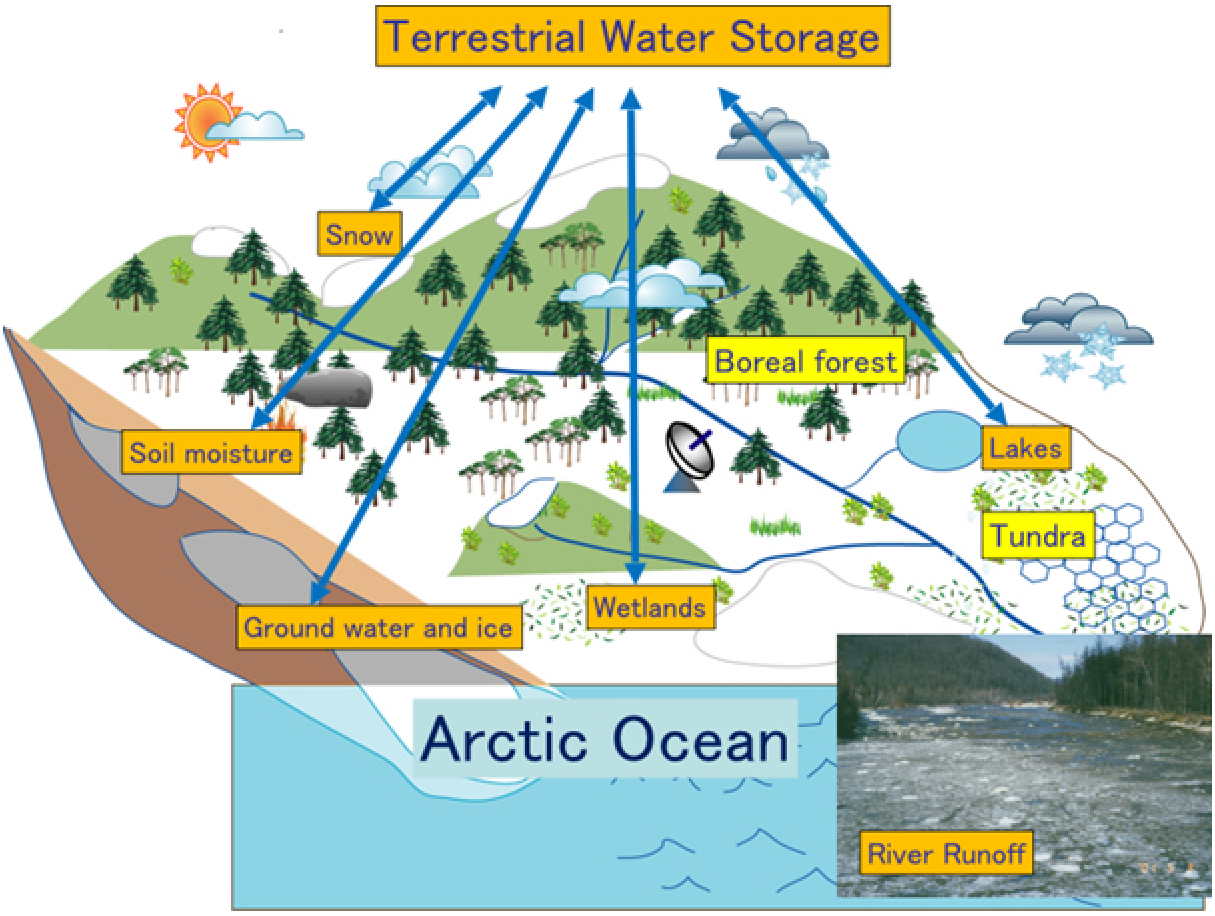

Figure 2. Diagram showing terrestrial water storage
TWS refers to all water stored on land surfaces such as soil moisture, lakes and wetlands, underground water andice, and snow. Some of water as rain or snow that falls on the ground gets into the atmosphere after evaporation from the surfaces of plants, water, snow or other lands. Effective rainfall is the total precipitation minus river run-off and evaporation. TWS is the rest that remains on lands.

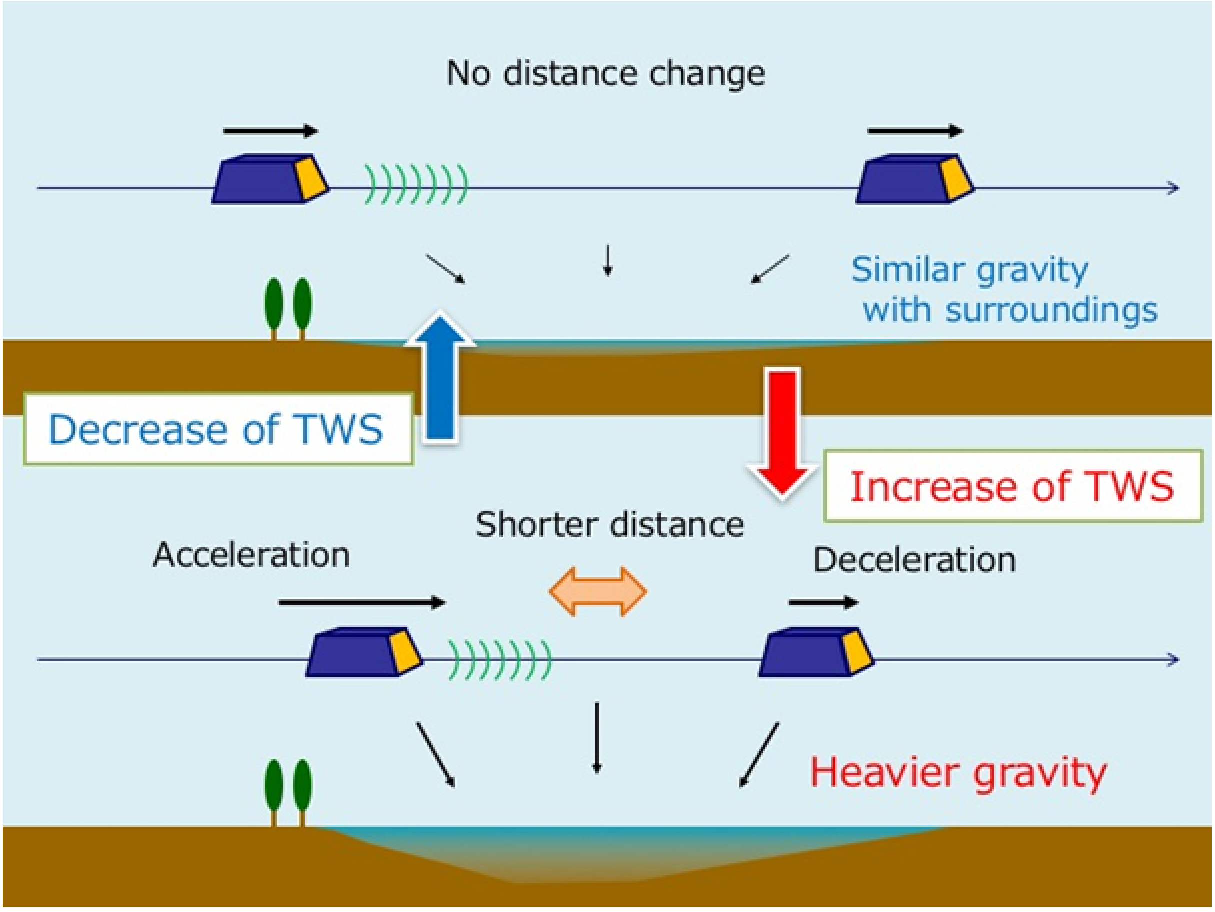

Figure 3. Measurement of terrestrial water storage by GRACE
GRACE is a pair of twin satellites installed highly-precise distance measuring instruments, both of which detect distance changes between the satellites. The distance between satellites changes every moment based on gravity strength or weakness on the Earth because the closer it becomes to the strong gravitational fields, the speed accelerates, while the more it become distant, it decelerates. GRACE uses this principle to measure time series of gravity changes by continuous observations of satellite distance changes in the same field. The variations in terrestrial water storage are evaluated with numerical calculations of these data.

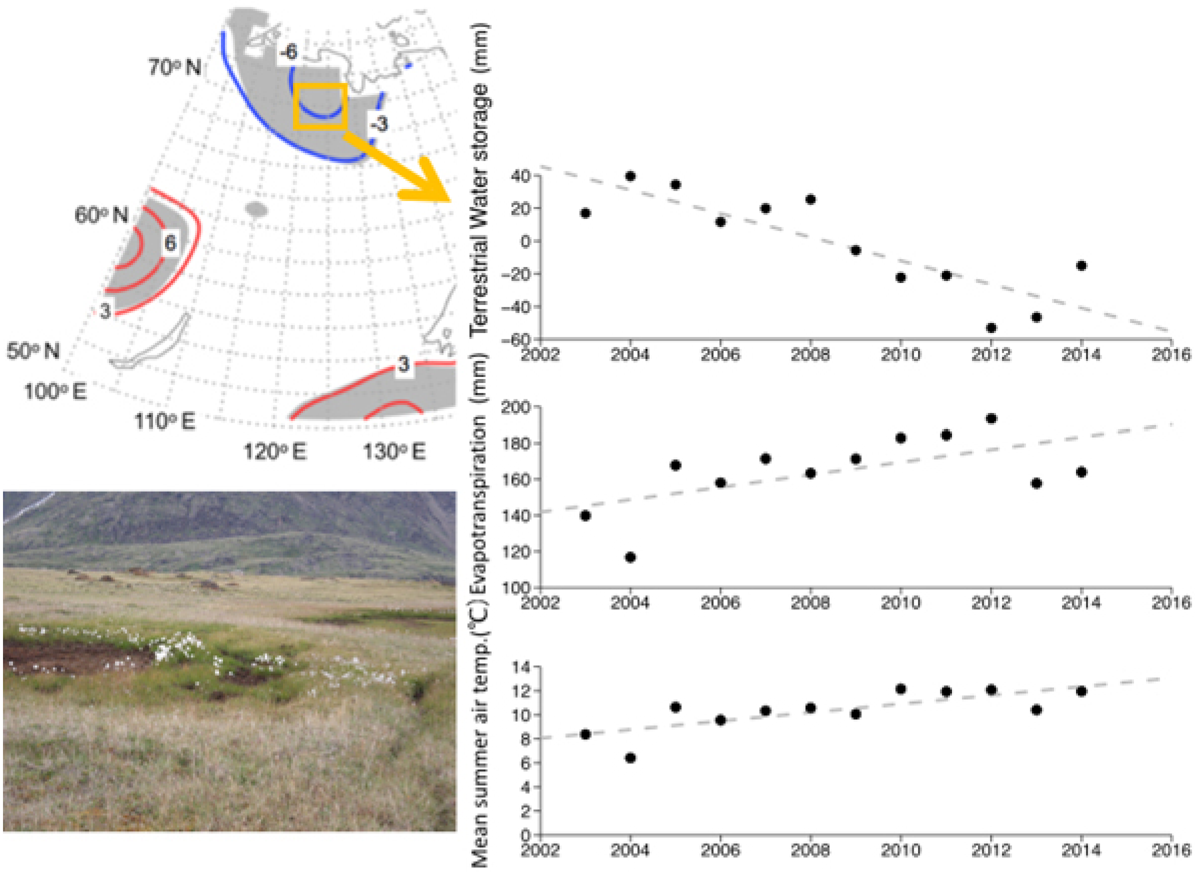

Figure 4. Tundra regions progressing drying
In the tundra regions along the Aractic Ocean, TWS has decreased by more than 6 mm a year since 2002. In the region, average temperatures between June and August during summer are increasing by 0.36°C. It causes increase in evapotranspiration, which is resulting in drying up at fast pace.

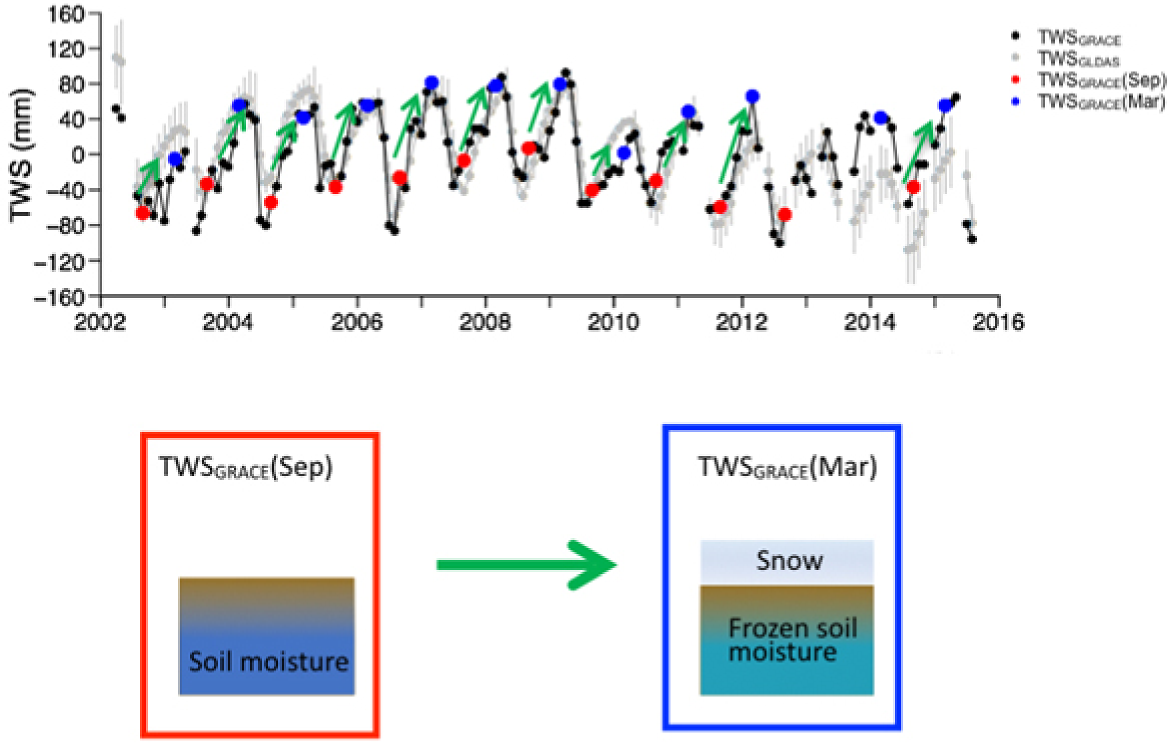

Figure 5. Monthly TWS variations
By correlating TWS in September and the following March, it becomes clear that, if

the amount of TWS is large in September, that of March also increases. It indicates TWS in autumn is kept as the frozen state under snowpack during winter.

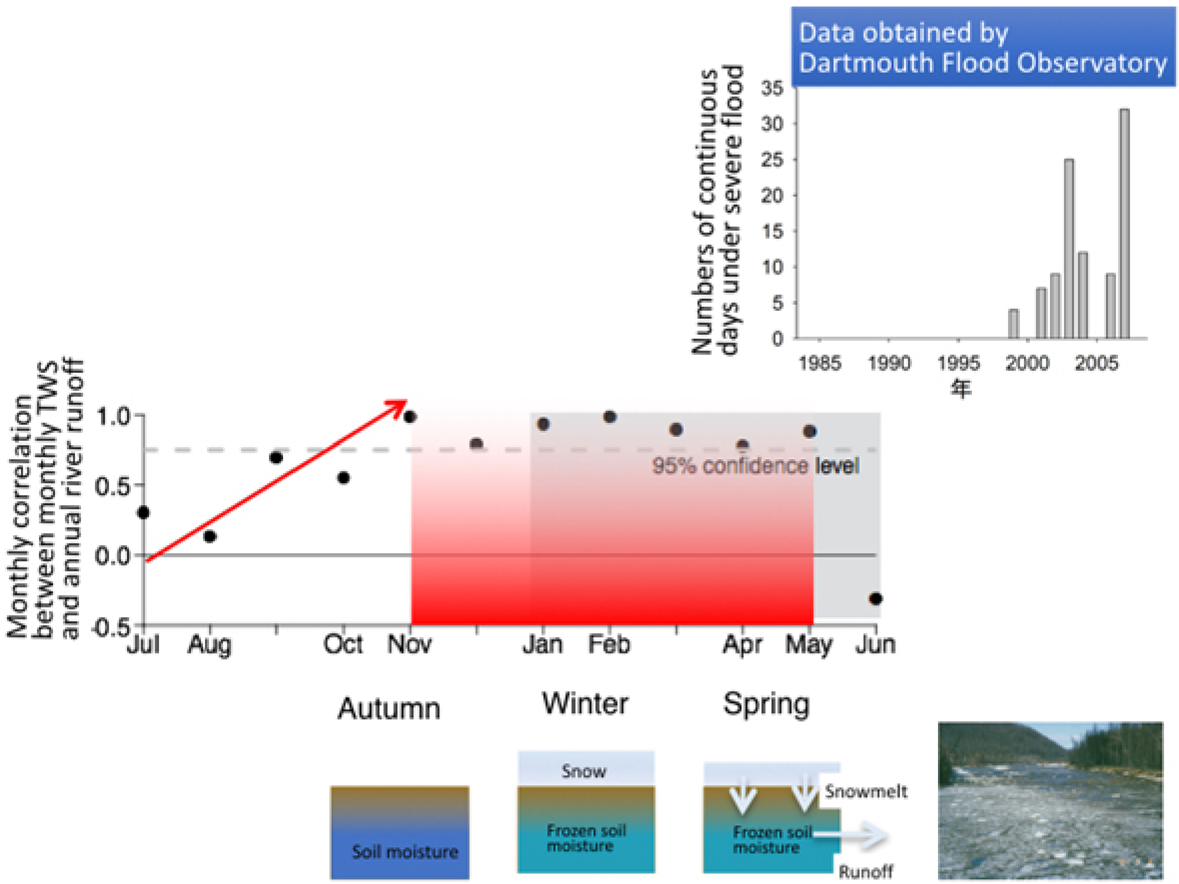

Figure 6. Changes in the Lena River flooding days over years and seaonal changes of correlation coefficients between annual river run-off and monthly TWS
In the Lena River, where flood recently occrs almost every year, the number of flood days has been increasing since 1999. In comparison of the annual Lena River run-off and monthly TWS, there is a strong correlation from summer to autumn. Also, the correlation relationship is statistically high from November when the land frozen starts and May when snow melting starts. It indicates that correlation coefficient between annual river run-off and monthly TWS from the previous November to the following May is positive, drawing liner correlations in TWS and annual river run-off. These results suggest it could be possible to predict floods and river run-off in the follwing year by using TWS data in the previous November.

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