Press Releases

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JAMSTEC

Forest Decline Due to Elevated Moisture in the Eastern Siberian Permafrost Region

Overview
Senior Scientist Yoshihiro Iijima of the Japan Agency for Marine-Earth Science and Technology's (JAMSTEC, Asahiko Taira, President) Research Institute for Global Change and colleagues have determined that, in conjunction with global warming-caused climate change in arctic region, winter snowfall and summer rainfall amounts have increased in eastern Siberia. This has promoted the thawing of surface permafrost and the resulting elevated soil moisture is expediting forest decline.

It was previously known that forest fires occurring in eastern Siberia in dry years ravage the forests, and thaw the permafrost directly beneath. However, we have found that due to climate change occurring in conjunction with the recent pronounced decrease of ice in the Arctic Ocean, Siberian snowfall and rainfall have increased since 2004, and permafrost has been thawing. Additionally, soil moisture has increased to levels where the environment is no longer conducive to tree growth, leading to forest decline and degradation. Our research is the first to scientifically explain this series of changes using data from field observations. These ground breaking results have clarified the series of phenomena by which the influence of global warming proceeds from the oceans to the atmosphere and land through climate change in arctic region.

The advance of permafrost thawing and the increase of surface soil moisture have caused forest decline, led to the expansion of wetlands, which enhance the emission of carbon dioxide, methane, and other greenhouse gases. There are concerns that this could further exacerbate global warming. Additionally, major changes in forests bring about changes in the exchange of heat and water vapor between the atmosphere and land in eastern Siberia, and is a factor affecting climate in the Northeast Asia region including Japan. We plan to build a systematic observation system and contribute to assessment of the impacts and forecasting studies on global warming-caused, chain-reaction phenomena occurring on land.

This research will appear in the February 11 issue of the international academic journal *Ecohydrology*.

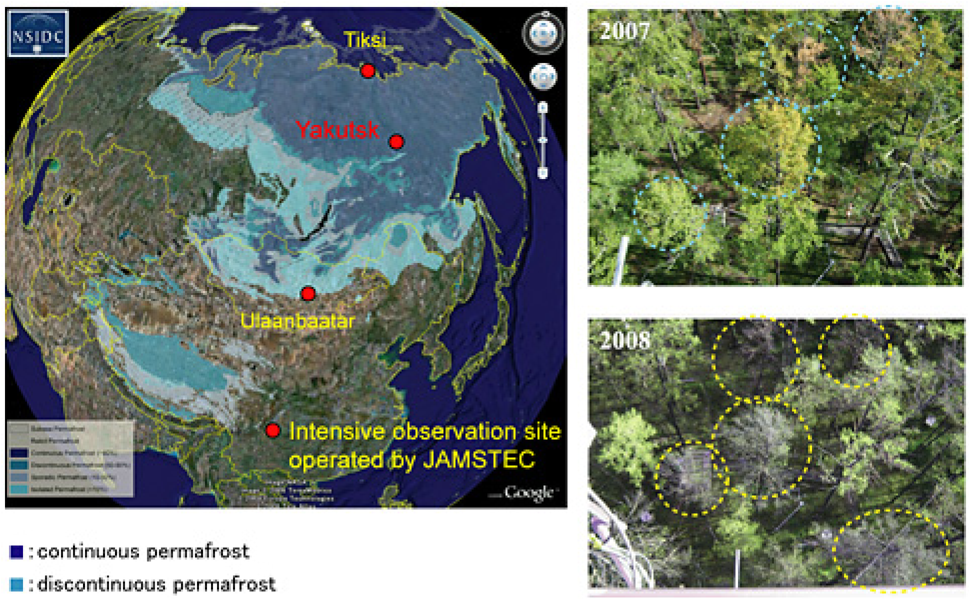

Figure 1. Intensive observation sites on land (red dots in left image), and forest changes at Yakutsk observation site from 2007 to summer 2008 (photos at right). Blue regions in figure at left indicate permafrost distribution ranges. Larch leaves started to yellow in 2007 and dead trees were found the following year.

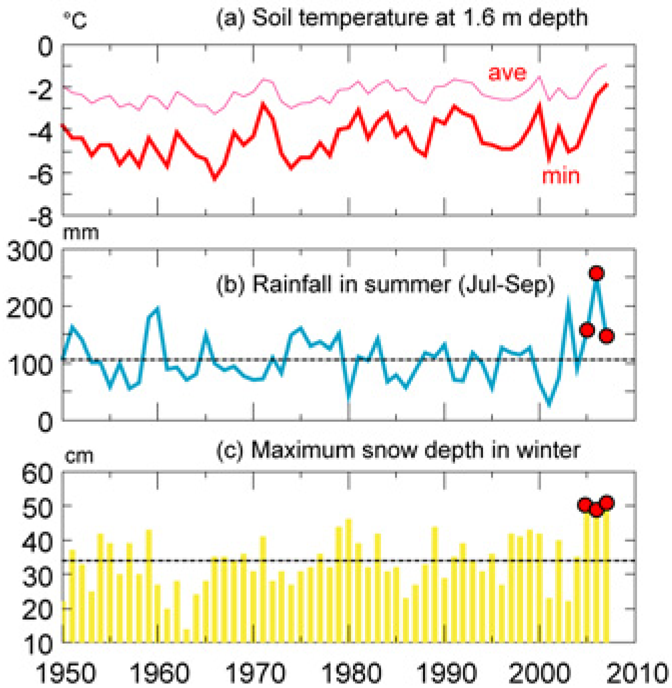

Figure 2. Long-term changes in ground temperature, summer precipitation, and maximum winter snow depth (1950–2008). (a) Lowest monthly mean ground temperature (thick line) near Yakutsk (Pokrovsk) and annual mean ground temperature (thin line). (b) Summer precipitation (integrated values from July to September; broken line indicates long-term mean of 106 mm). (c) Maximum snow depth (broken line indicates long-term mean of 34 cm).
Red dots in graphs indicate wet years of 2005 through 2007. Every year from the winter of 2004–2005 (first red dot in graph (c)) winter snow depth and summer rainfall are considerably larger than those for average years.

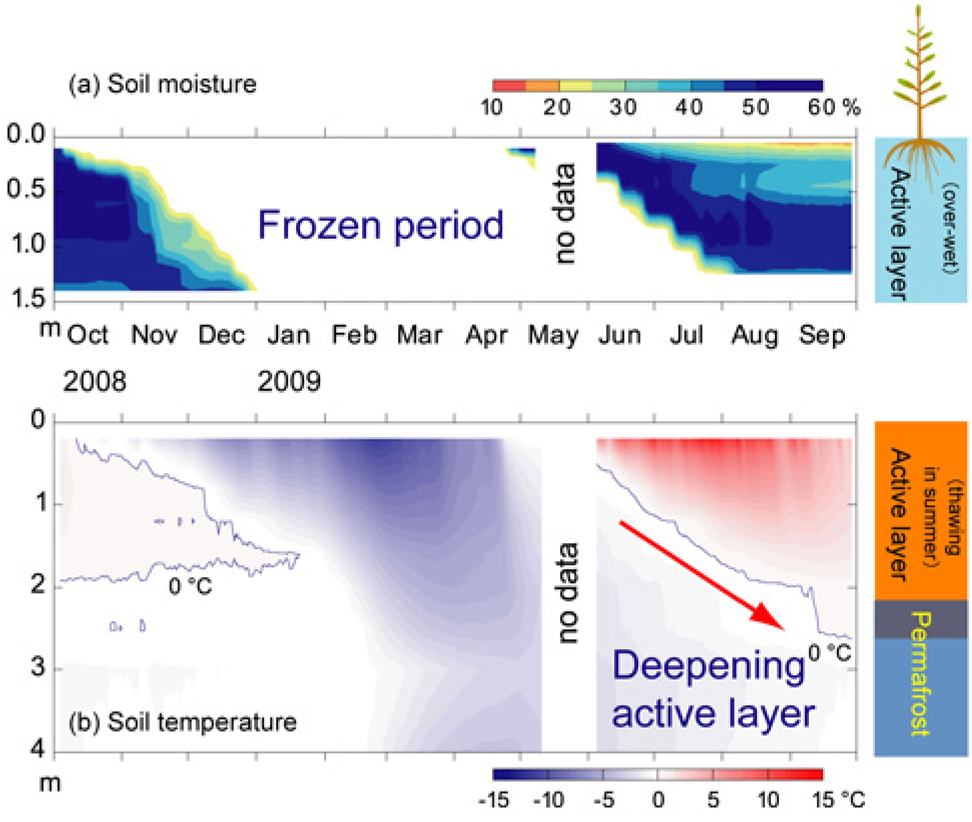

Figure 3. Vertical structures of soil moisture (showing excessive accumulated moisture in surface soil) and ground temperature (showing the advanced state of frozen soil thawing) in 2008 and 2009 at the Yakutsk observation site.
The upper figure shows soil moisture change. Even in autumn 2008 plenty of soil moisture remains, and although moisture near the surface was used by plant transpiration in summer 2009, moisture remained in deep soil. The lower figure shows ground temperature change. The blue line shows the 0°C (freezing/thawing) boundary, and indicates that in 2009 thawing proceeded to below 2 m.

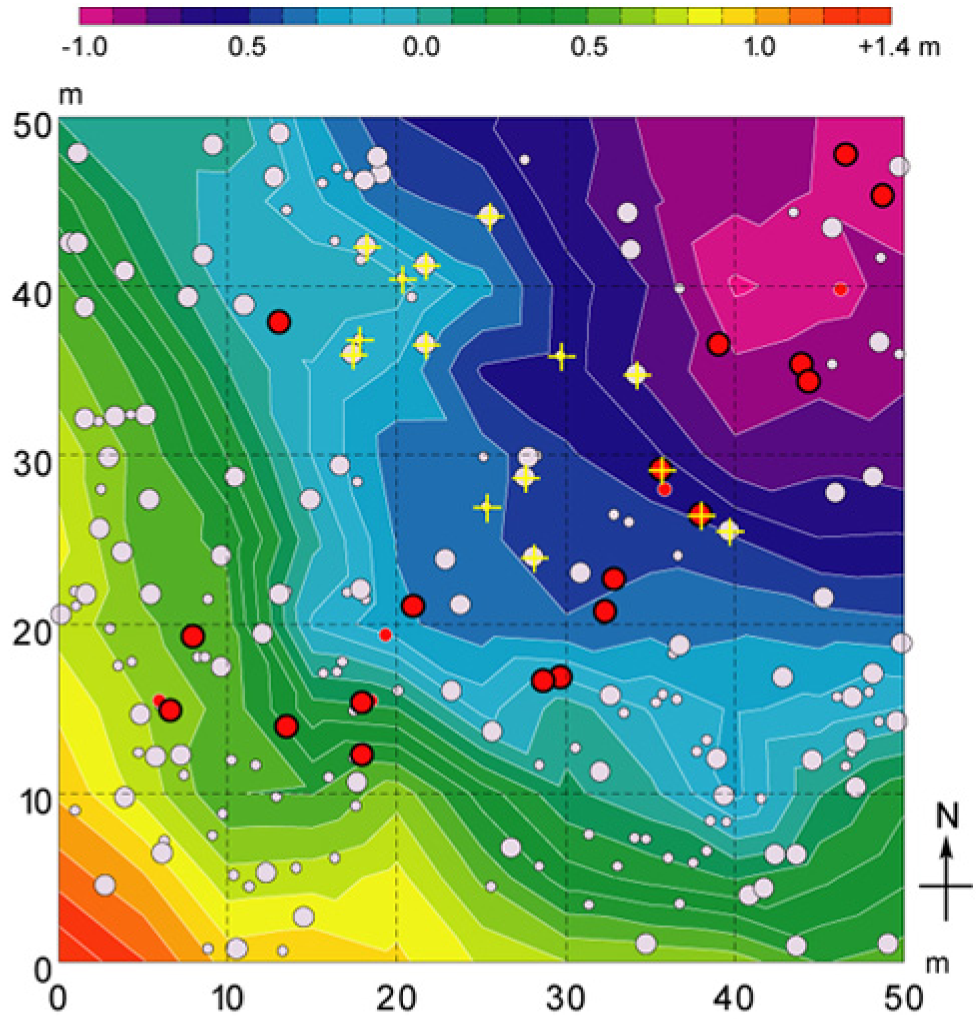

Figure 4. Topography of permafrost table and distribution of larch trees (50 m × 50 m).
Red circles are dead trees. Large circles are trees 15 m or higher; small dots are trees under 15 m. Plus signs show trees whose sap flows (the upward flow of water through tree trunks arising as trees take in water from their roots and give it off from their leaves through transpiration) were measured. Colors indicate elevation of the permafrost table (the boundary between the active layer and the permafrost layer) from the spatial average. The permafrost table is sloped from southwest to northeast, and the place where dead trees are mainly distributed is a valley where water tends to collect.

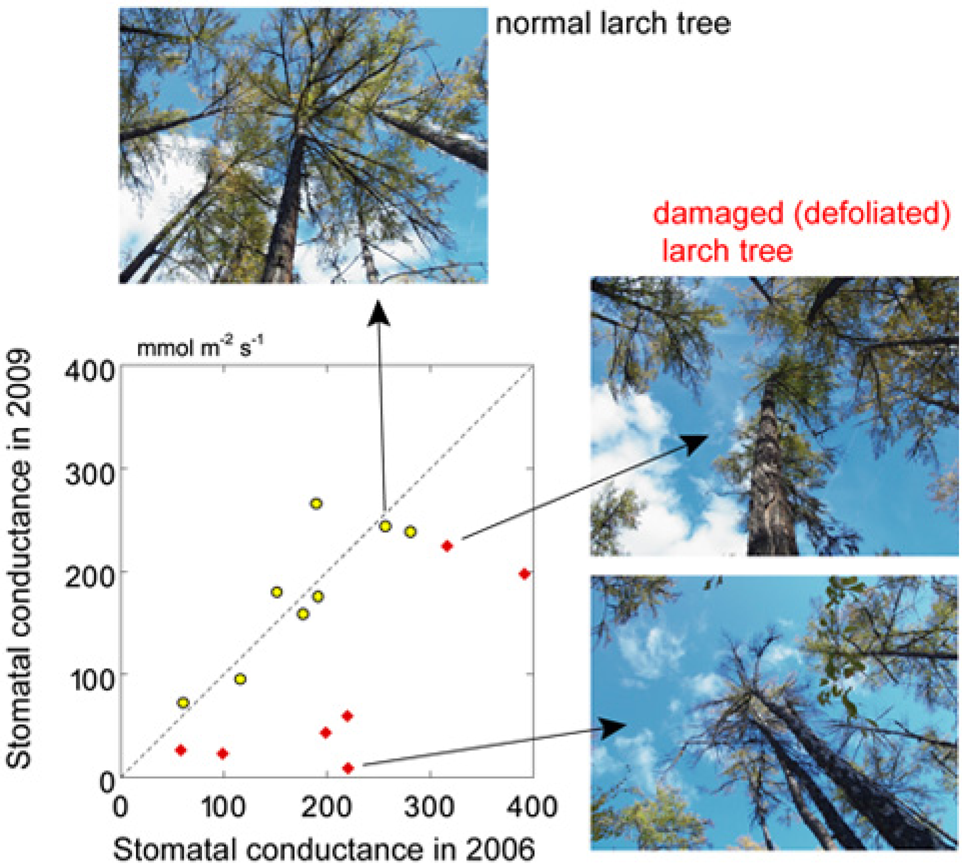

Figure 5. Changes in stomatal conductance (an indicator of transpiration capacity) of individual larch trees.
These are the stomatal conductance values in the tops of 15 larch trees whose we measured sap flow (Figure 4). Changes are based on summer 2006 and 2009 observations. Red diamonds indicate trees with large conductance drops of at least 20% compared with 2006, which had been damaged by excessive moisture and had reduced their leaf area, thereby losing much transpiration capacity (see photos).

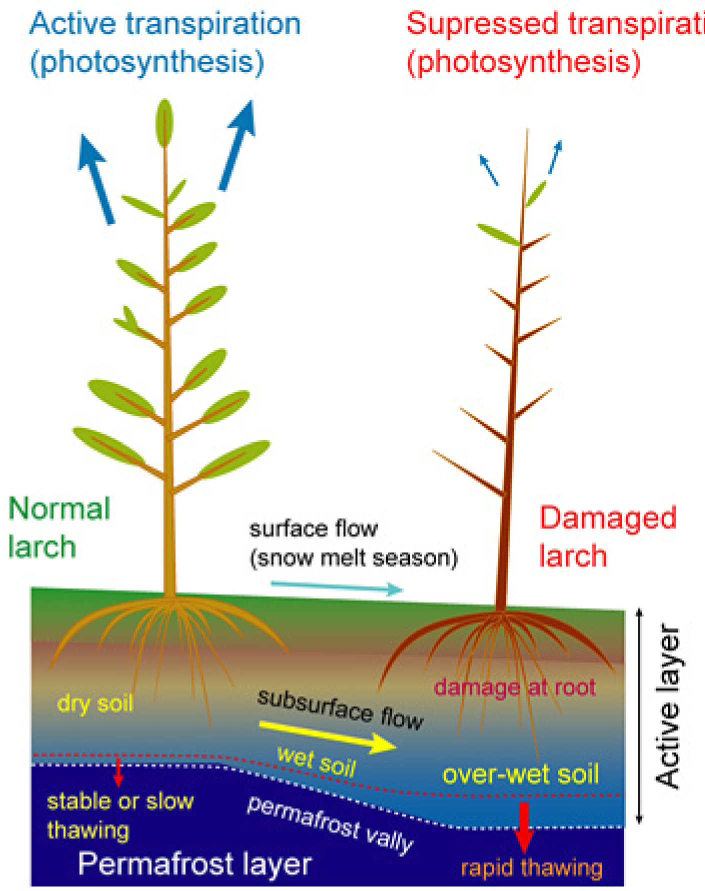

Figure 6. Permafrost thawing and larch mortality due to elevated moisture (schematic diagram). Topographically high places had little permafrost thawing, and soil moisture flows down and away. Their larch trees were therefore healthy. On the other hand, low places have moisture inflows and more permafrost thawing, which keeps soil in an excessively moist state for a long time. This damages larch roots and leads to death.

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