Press Releases

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JAMSTEC
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Scientists reveal the mechanism between the tide and climate: Does the Moon's gravity affect global warming on Earth?

Overview

Dr. Hiroaki Tatebe and his colleagues in the Advanced Climate Modeling Research Unit of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC: Asahiko Taira, President) have demonstrated that tide-induced micro-scale mixing in the deep Pacific Ocean has significant impacts on the wintertime Southern Ocean(*1). It is likely that basin-scale reorganization of ocean stratification and the resultant response of the global ocean conveyor(*2) are related to the mechanism.

General climate is determined as thermal energy provided to Earth from the Sun that is redistributed across the planet through atmospheric circulations involving the formation of rain and clouds. The ocean state is known to be subordinate to this predetermined atmospheric circulations.

Simulations for climate and tidal models using the Earth Simulator (Fig. 1) have revealed that the vertical mixing of seawater by tides causes 1) a decrease in water temperature and salinity at depths greater than 1,000 m in the Pacific Ocean (Fig. 2); 2) an increase in the sea ice area in the Southern Ocean (Fig. 3); and 3) the triggering of stronger westerlies and invigorated migratory anticyclones (Fig. 4). These findings indicate that changes in the potential energy caused by the gravitational pull of the Moon (i.e., the tide) promote a micro-scale ocean mixing and alter the ocean conveyor, particularly in the Pacific Ocean, thereby determining the state of the climate in the distant Southern Ocean. Through determination of the climate, the findings indicate that the relationship between the Moon and the sea has a significant impact, along with the relationship between the Sun and the atmosphere. Because the Southern Ocean also absorbs thermal energy and carbon dioxide, these findings provide significant insights for global warming projections.

The results of this study have high significance for the provision of highly reliable information on future climate change under global warming. The research group will apply these findings further to simulation models in which the global carbon cycle is included.

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Title: Impact of deep ocean mixing on the climatic mean state in the Southern Ocean
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*1 The Southern Ocean is the ocean that surrounds Antarctica. It connects the Pacific, Atlantic, and Indian oceans. The ocean is also important in oceanography because highly dense deep water forms within it.

*2 A climate model is a computer program that simulates the elements that constitute the climate, such as the atmosphere, ocean, and land, as well as the mutual interactions between these elements based on the laws of physics.

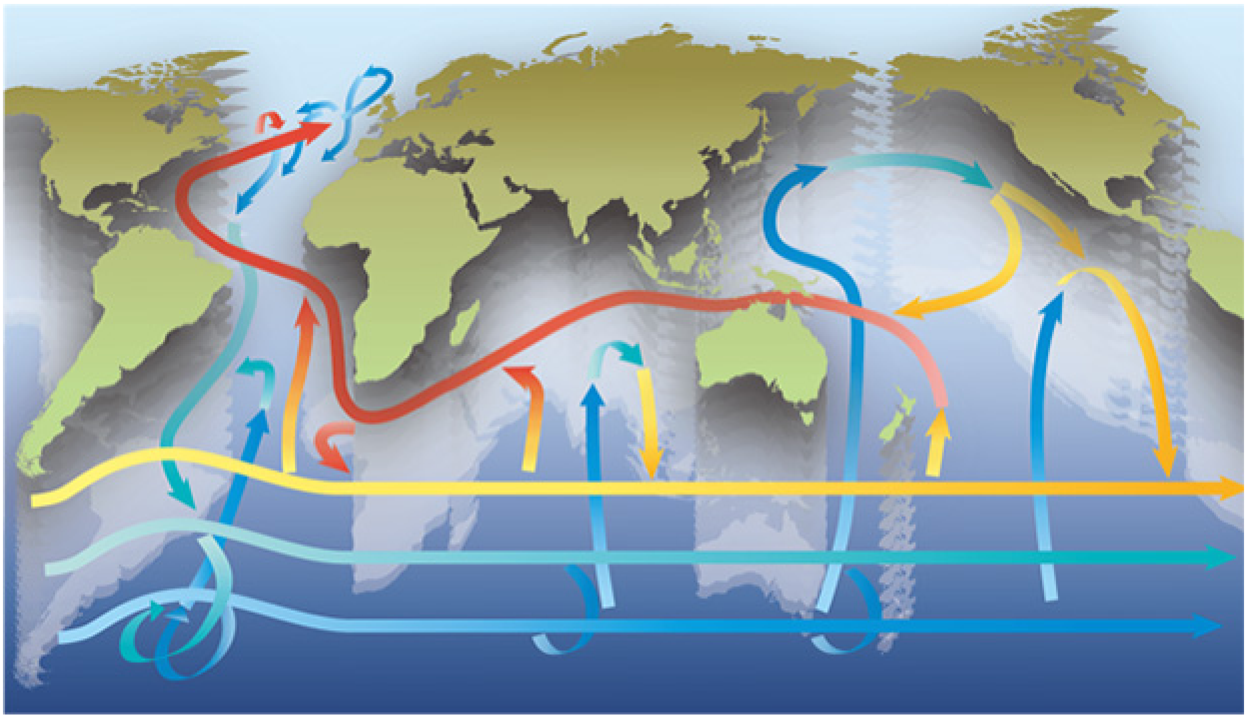

Fig. 1. A diagram of the ocean conveyor. Blue lines show currents in the deep ocean, and red lines show currents at the surface of the ocean. A deep ocean current flowing northward from the Southern Ocean can be observed in the Pacific Ocean. The deep water in the Pacific Ocean rises to the surface and intermediate layers (green lines) as it becomes lighter due to vertical mixing and either joins the surface current system or returns to the Southern Ocean (yellow line).

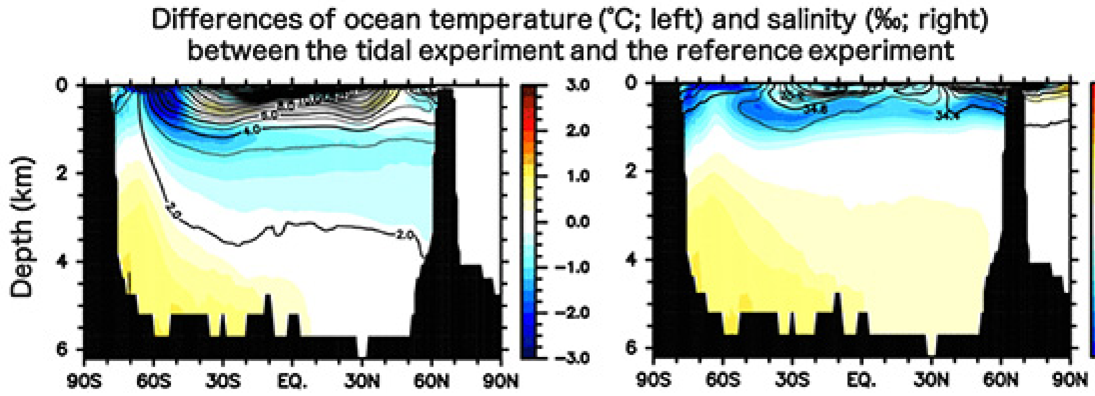

Fig.2. A comparison of an experiment that estimated the seawater mixing intensity induced by the tide using an ultra-high-resolution tide model (tidal experiment) and an experiment that provided mixing intensity in an empirical manner (reference experiment). Colors show the differences between the two experiments, and the black line shows the results from the reference experiment. In the tidal experiment, water temperature and salinity decrease in the Pacific Ocean at the region north of 50° S at depths of 1–3 km.

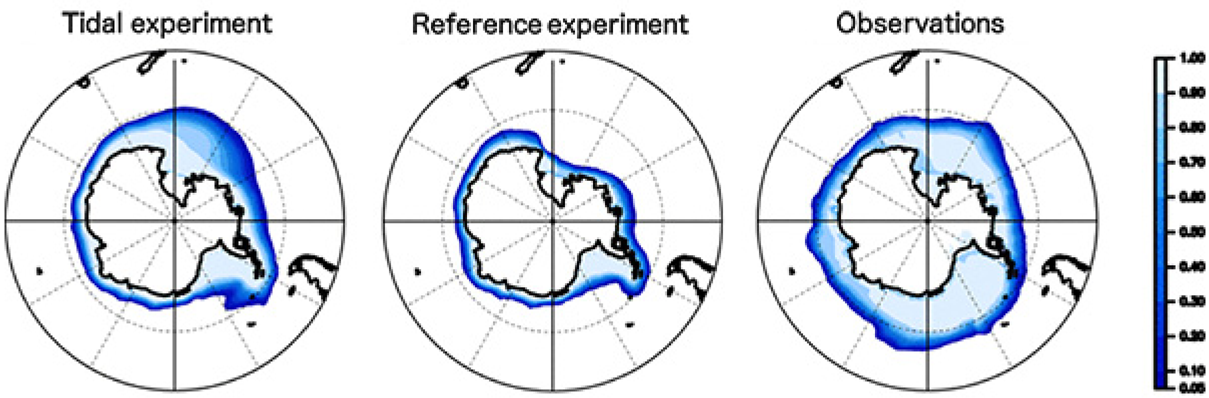

Fig.3. Comparison of the sea ice distribution between the tidal experiment (left), the reference experiment (center), and observed data (right). The colored bar at the right shows the ratio of the area covered by sea ice. Seawater transformed by the tide is transported to the Southern Ocean, altering the ocean conveyor of the Pacific Ocean along the way and causing the temperature at the sea surface in the Southern Ocean to decrease. As a result, the sea ice area in the Southern Ocean increases.

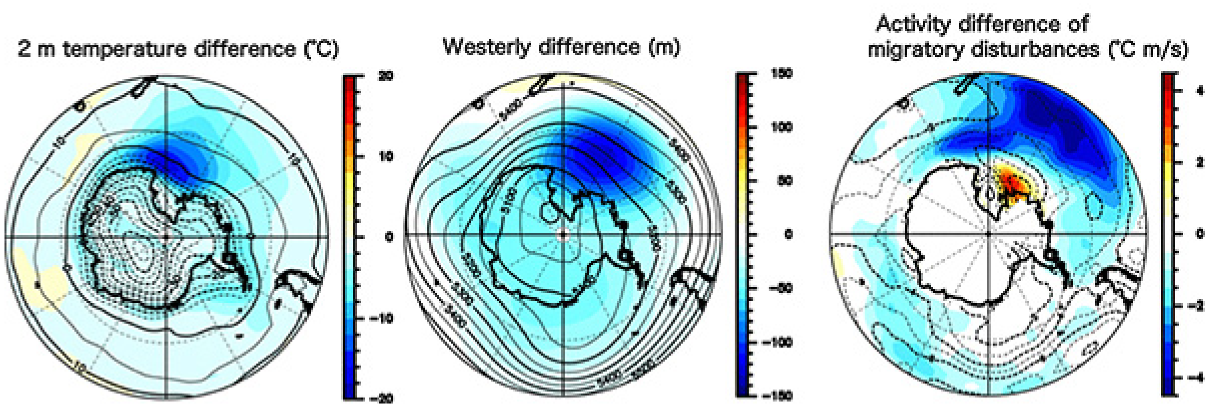

Fig.4. Temperature at 2 m above the sea surface in the atmosphere (left), intensity of the westerlies (center), and degree of activity of migratory disturbances (right) due to an increase in sea ice area. Colors show the differences between the tidal experiment and the reference experiment, and the black line shows the results by the reference

experiment. In the tidal experiment, heat transport from the ocean to the atmosphere is reduced due to the increased sea ice area in the Southern Ocean. Correspondingly, the temperature at 2 m is lowered. As a result, a clockwise circulation, with the lowest point of atmospheric pressure at its center, forms at approximately 5000 m above the sea surface, and westerlies in the tidal experiment are strengthened. Activities of migratory disturbances (defined by the southward heat transport that accompanies the changes in the atmosphere at a cycle shorter than one week) also intensify.

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