Human-induced climate change caused the northwestern Pacific warming record in August 2020

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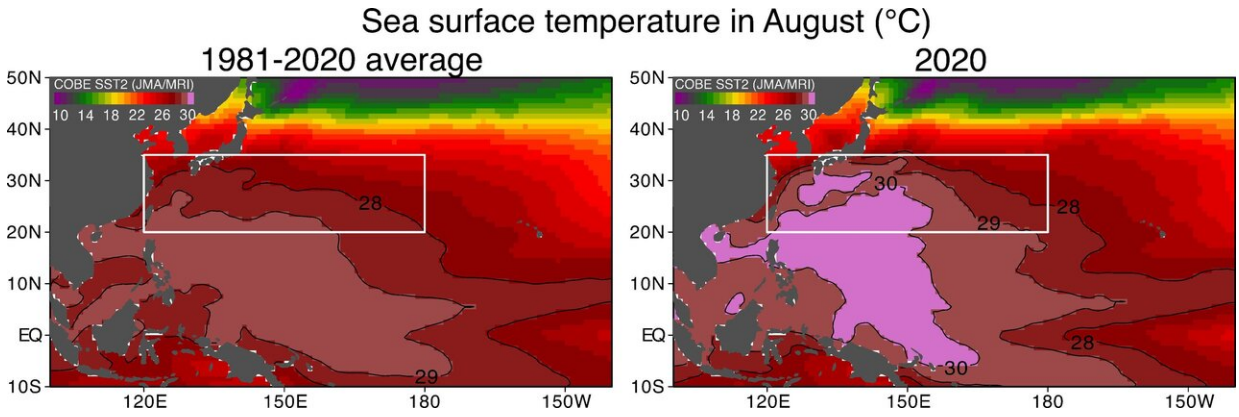


Observed sea surface temperatures in August over the northwestern Pacific Ocean. The white boxes are the region focused on in this new study. The COBE SST2 dataset from JMA-MRI is used. Credit: NIES

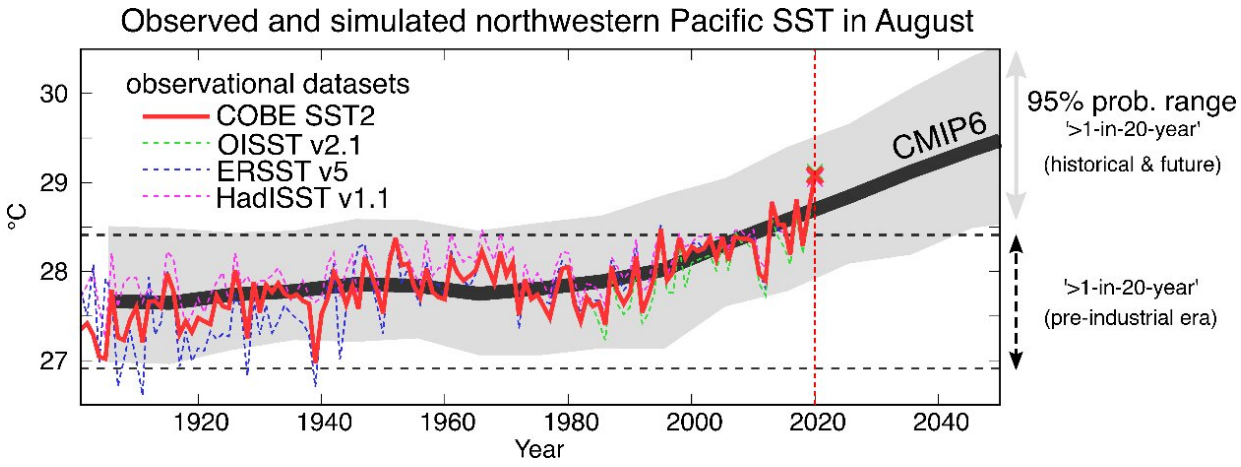
August 2020 set new record high sea surface temperatures (SSTs) in the northwestern Pacific Ocean and around the Japan coasts. A new study led by National Institute for Environmental Studies (NIES) researchers revealed that this warming record could not happen without human-induced climate changes.

The northwestern Pacific sea surface becomes warm seasonally around August every year. However, it was unprecedentedly high in August

2020, according to the Japan Meteorological Agency and the National Oceanic and Atmospheric Administration. The extremely high SSTs exceeding 30°C, which lasted until mid-September, may have intensified tropical cyclones such as Typhoon Haisheng, causing severe damages to the East Asian countries. Although human-induced greenhouse gas emissions such as carbon dioxide have gradually warmed the northwestern Pacific Ocean since the mid-20th century, it remains unclear yet how much past human activities may increase the occurrence likelihood of such regional record-warm SSTs.

"Understanding the tropical warm water expansion in the Indo-Pacific and Atlantic Oceans is essential for projecting changes in the characteristics of tropical cyclones and other weather events in the future," said Hideo Shiogama, a co-author and the head of Climate Risk Assessment Section at the Center for Global Environmental Research, NIES. "A quantitative evaluation of what drives regional extreme temperatures happening recently is necessary to take appropriate measures to reduce greenhouse gas emissions and the impacts of global warming."

The paper published in *Geophysical Research Letters* illustrates the quantitative impact of greenhouse gases emitted by human activities on the unprecedentedly high SSTs in the northwestern Pacific Ocean in August 2020. By analyzing multiple observational datasets from 1901 to 2020 and a large number of experimental outputs from the state-of-the-art numerical climate models, a climate research group at NIES statistically estimated changes in the occurrence probability of the northwestern Pacific Ocean (120°E-180° and 20°N-35°N) condition exceeding the record-warm SST in August 2020 from the past to future. The scientists revealed that its probability in the present climate was increased from once-in-1000 years to once-in-15 years because of human-induced climate changes.



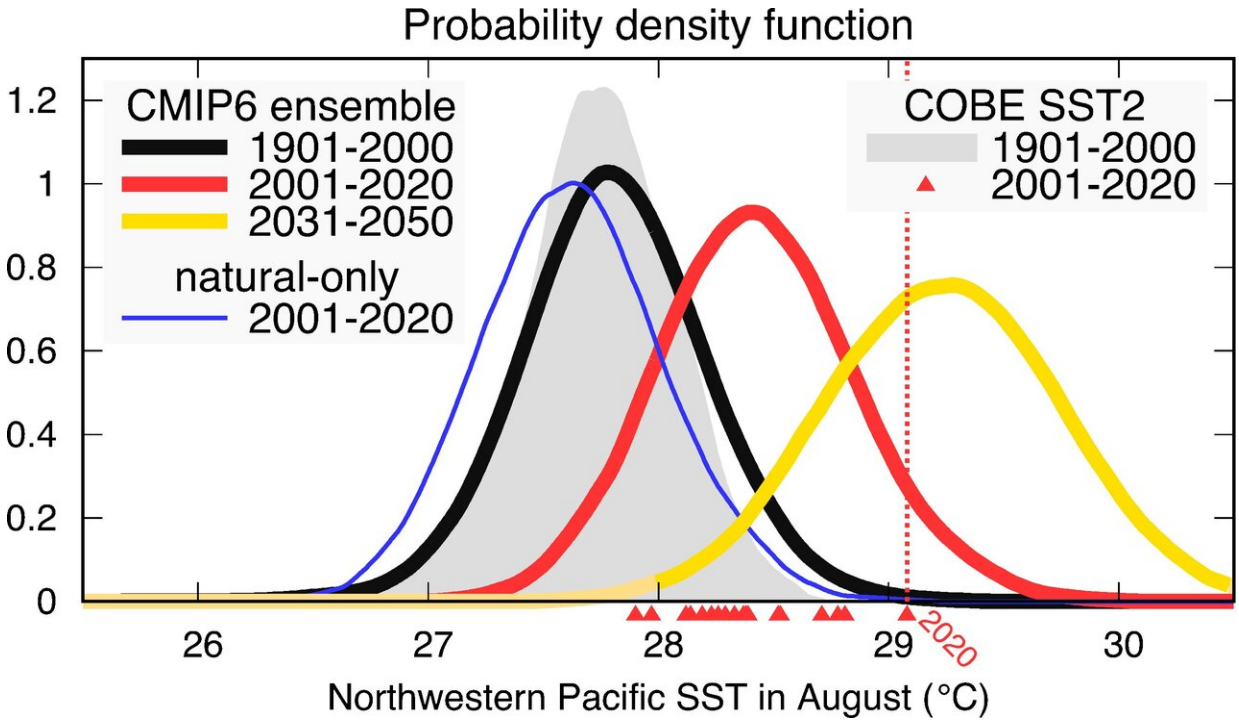
Time series of the northwestern Pacific sea surface temperature in August. Showings are the observational datasets and the simulation results from the climate model (CMIP6) ensemble: the global warming signal (solid black line) and the ranges of 'once-in-20-year' events (95% probability range) in the historical and future experiments (gray shading) and pre-industrial experiments (dashed lines). Credit: NIES

Detecting human-induced climate changes

"The numerical climate model ensembles are powerful tools to quantitatively distinguish between natural variability of the Earth system and climate changes caused by human activities," said corresponding lead author Michiya Hayashi, a research associate at NIES. The ensemble of 31 climate models participating in the sixth phase of the Coupled Model Intercomparison Project (CMIP6) consists of a series of historical experiments and future scenario experiments forced by greenhouse gas- and aerosol emissions from human activities and natural volcanic and solar variations from 1850 to 2100. "We can compare the historical and future experiments with a sub-ensemble of the CMIP6 climate models forced only by the natural volcanic and solar activities to

estimate to what extent human-caused climate changes have altered the northwestern Pacific Ocean condition until today."

"The northwestern Pacific warming has proceeded clearly since the 1980s," stated Shiogama. "The warming speed has been accelerated in the last four decades as the reduced aerosol emissions do not cancel the warming signal forced by increasing greenhouse gas concentration anymore." The results show that the CMIP6 ensemble well reproduces the observed long-term change in the northwestern Pacific August SST within the range of 'once-in-20-year' events in the historical simulations. "The SSTs that exceed the pre-industrial range are rarely observed during the 20th century but have occurred frequently since 2010, indicating that human influences on the northwestern Pacific Ocean are already detectable in observations," noted a co-author Seita Emori, deputy director of the Center for Global Environmental Research at NIES.



Probability distributions for the northwestern Pacific sea surface temperature in August. For 1901-2000, the climate model (CMIP6) ensemble (solid black line) reproduces the observational values (gray shading). For 2001-2020, the observed values (red triangles) are well covered by the CMIP6 ensemble (solid red line) but not by the sub-ensemble forced by natural variations only (thin blue line). For 2031-2050, the most likely level of the projected probability (solid yellow line) exceeds the 2020 level (dashed red line). Credit: NIES

This new study estimates that the occurrence frequency of high northwestern Pacific SSTs exceeding the August 2020 level has been increased from once-in-600 years in the 20th century (1901-2000) to once-in-15 years in the present climate (2001-2020) using the CMIP6 ensemble. On the other hand, in the sub-ensemble forced only by natural volcanic and solar activities, the frequency for 2001-2020 is estimated to be once-in-1000 years or less. "The record high level of the northwestern Pacific SST in August could have occurred approximately once per 15 years in 2001-2020, as observed, but it never likely occurred without human-induced greenhouse gases or in the 20th century," said Hayashi.

Importantly, the scientists also imply from the future scenario experiments that the 2020 record high SST is becoming a new normal climate condition in August at the northwestern Pacific region by 2031-2050 when the globally averaged air temperature relative to pre-industrial levels would exceed 1.5°C. In this case, the tropical warm sea surface water, exceeding 28°C, may reach Japan, the Korean Peninsula, the west coast of India, the east coast of the U.S. mainland, and the west of the Hawaiian Islands. "We might need to prepare for living with such warm ocean conditions even if we humans could achieve the 1.5°C goal of the Paris Agreement," said Hayashi.

"The human-induced ocean warming may have impacted tropical

cyclones, heavy rainfall, and marine life from the past to present and will continue in the future unless tremendous mitigation measures would be implemented," added Emori. "It is time to take prompt actions to transform our society for reducing the greenhouse gas emissions and for adapting to a changing climate."

More information: Michiya Hayashi et al, The Northwestern Pacific Warming Record in August 2020 Occurred Under Anthropogenic Forcing, *Geophysical Research Letters* (2020). DOI: 10.1029/2020GL090956

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