Unprecedented drought conditions projected to be more frequent and consecutive in certain regions

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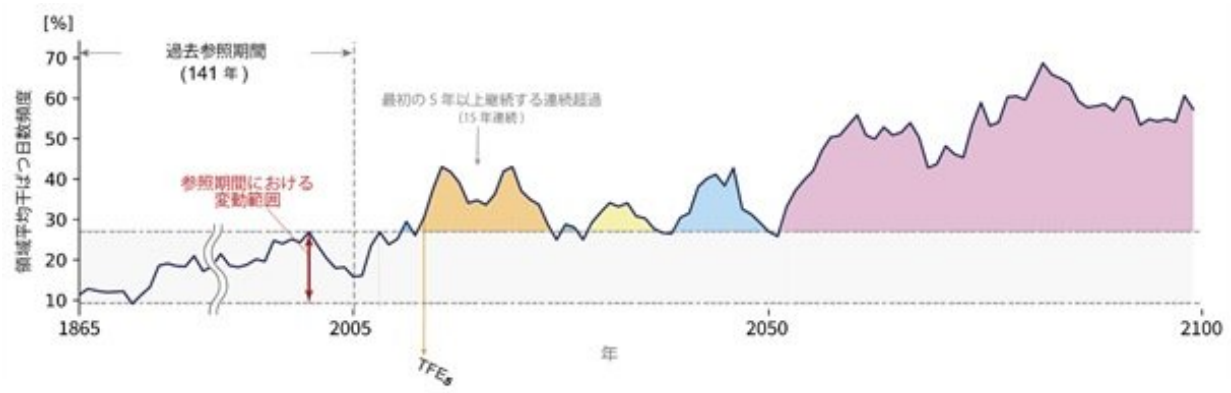


The thick black line represents the time series of the regional average frequency of drought days (FDD), and the gray-shaded area shows the historical value range based on the minimum and maximum values observed during the reference period (1865-2005). When the time series of the statistics deviates from the experienced historical range consecutively for x-years, TFEx is defined as the first year of the x-year period. For example, TFEs with x=3-15, including TFE5, are the years indicated by the orange arrows. Credit: Satoh et al.

A new study presents the future periods for which aberrant drought conditions will become more frequent, thereby creating a new normal. The projected warming impacts show significant regional disparities in their intensity and the pace of their growth over time. In approximately

30–50 years, unprecedented drought conditions are projected to be more frequent and consecutive in certain regions even with a low greenhouse gas concentration scenario. The results imply unavoidable unprecedented states in these regions.

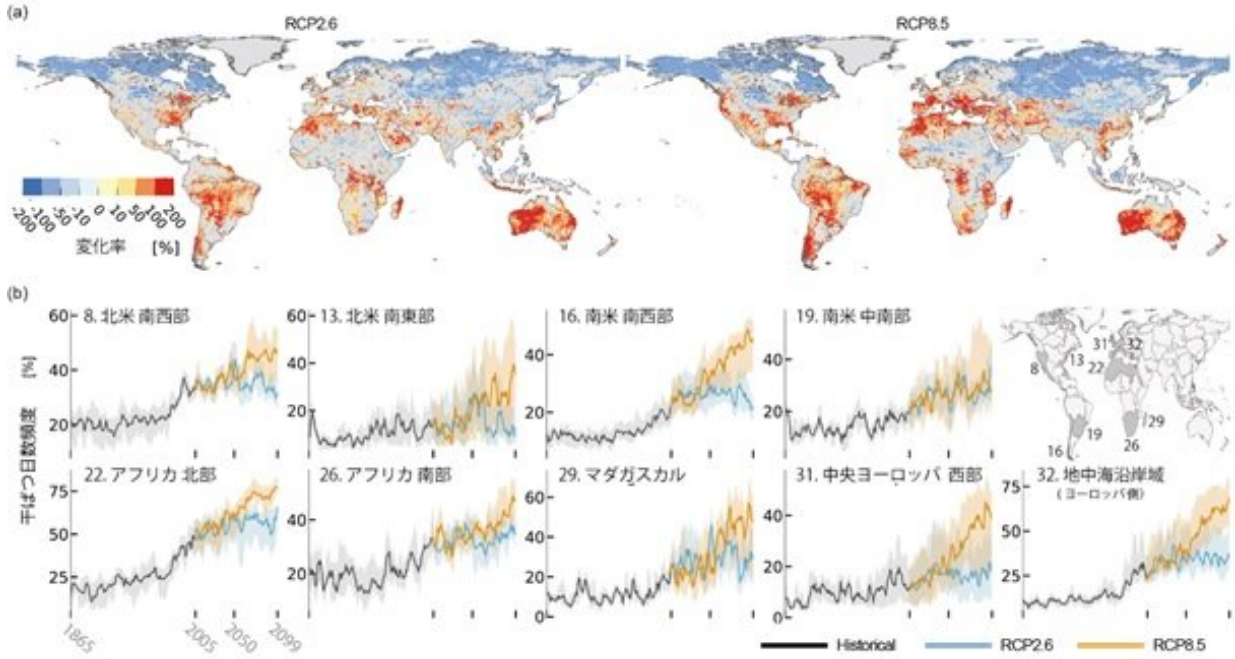
For a successful climate change strategy, it is crucial to understand how the impacts of global warming may evolve over time. A new study led by the National Institute for Environmental Studies (NIES) presents the future periods for which aberrant drought conditions will become more frequent, thereby creating a new normal.

Global warming is expected to increase the intensity and frequency of future drought in several global regions, adversely affecting the water resource, agriculture, and energy sectors. Given that the current water management practices and existing infrastructures in these sectors are based on historical statistics or experiences, under a changing climate, these practices and infrastructures may eventually become insufficient. Therefore, it is critical to better understand when severe drought conditions expressed as "unprecedented" will become frequent.

"Regarding precipitation and temperature, preceding studies report the timing at which the impact of climate change emerges. However, no study had successfully estimated the timing in terms of drought focusing on river discharge at a global scale," said Tokuta Yokohata, a coauthor and a chief senior researcher of the Earth System Risk Analysis Section at the Earth System Division, NIES. "A temporal evaluation about future drought conditions in comparison to our historical experiences is essential to take appropriate climate change strategies, especially for climate adaptations, in the long term and in time."

The paper published in *Nature Communications* estimates the periods when drought conditions will shift to an unprecedented state in a warmer world. The research group evaluated changes in drought day frequency

for 59 global subcontinental regions until the end of the 21st century. They estimated the time of first emergence (TFE) of consecutive unprecedented drought, which is the first onset of exceedance beyond the maximum bound of the historical climate variability during the reference period (1865–2005) that occurs consecutively for a certain number of years. For instance, TFE5 indicates that the regional drought frequency remains larger than the maximum value during the reference 141-year period for more than five years. The scientists analyzed their river discharge simulation dataset, which was derived from combinations of five global hydrological models and four climate model projections. The study considered low and high greenhouse gas concentration scenarios to evaluate the consequences of society's decisions on the climate mitigation pathway.

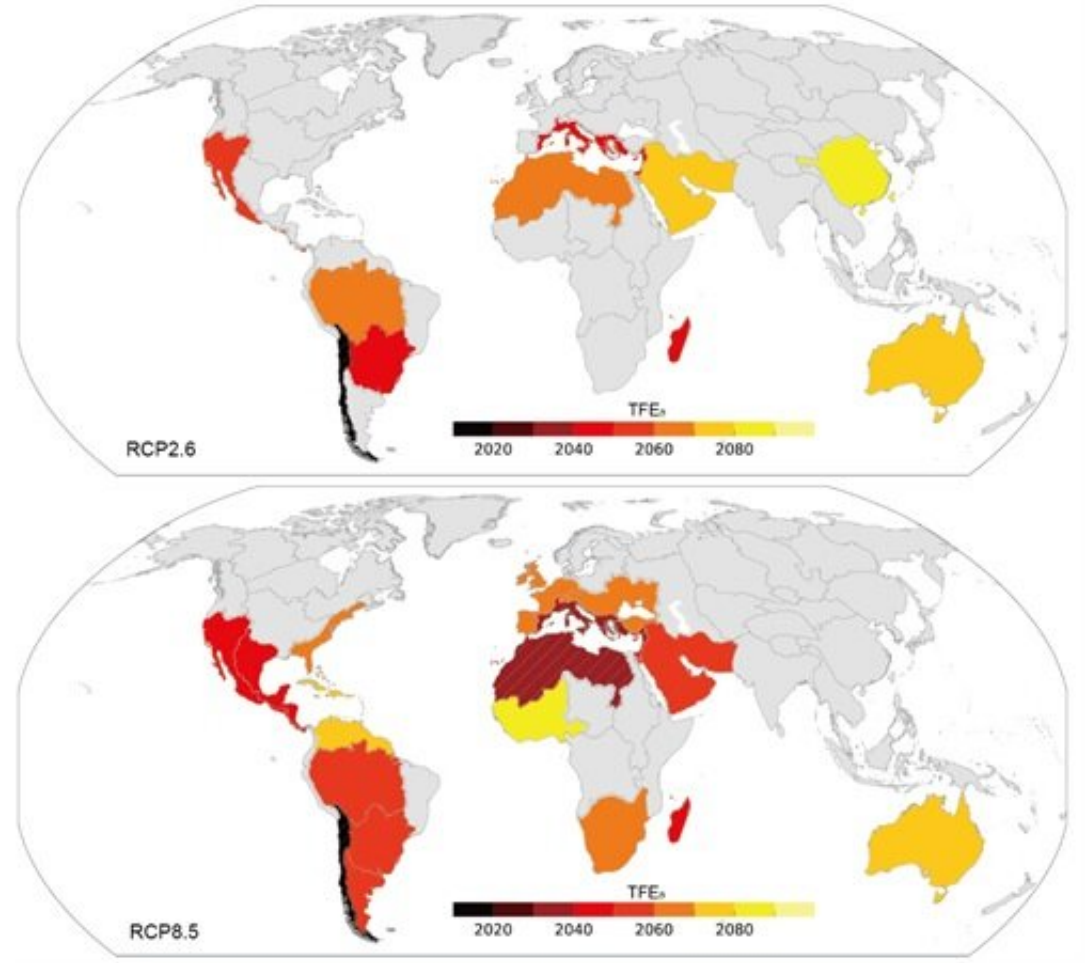


(a) The maps show the ensemble median values of the climatological percent changes derived for the FDDs in the mid-21st century (2036-2065) under low (RCP2.6) and high (RCP8.5) greenhouse gas concentration scenarios compared

to the historical period (1971-2005). The colors indicate the direction and magnitude of the change [%]. Grids with nonsignificant changes between two periods are marked with gray, and grids in which agreement in the sign of change among ensemble members is lower than 60% are also shown in gray. Additionally, Greenland is masked out in gray. (b) The plots present the time series of the regional average frequency of drought days [%] from 1865 to 2099 under RCP2.6 and RCP8.5 in the nine selected regions. The lines present the ensemble median time series, and the shading shows the uncertainty in terms of the interquartile range across ensemble members. Credit: Satoh et al.

Large regional disparity in the pace of growing warming impacts

"The projected impacts of warming show significant regional disparities in their intensity and the pace of their growth over time," said the corresponding lead author Yusuke Satoh, a research associate professor at Korea Advanced Institute of Science & Technology. By the middle of this century, increases in drought frequency are statistically significant in 25% and 28% of the global land under low and high greenhouse gas concentration scenarios, respectively. Specific regions show substantial increases of more than double the current frequency. Under both scenarios, so-called hotspots of drought increases include the Mediterranean regions, southern and central South America, Australia, etc. "Some regions exhibit steady increases in drought frequency. The projected increases are highly likely by the middle of this century compared to the historical period."



Timing of the first onset of consecutive exceedance equal to or more than five years compared to the historical maximum value (TFE5) under low (RCP2.6) and high (RCP8.5) greenhouse gas concentration scenarios in the 59 regions. Credit: Satoh et al.

This new study considers consecutive exceedances of more than five years and detects TFE5 in 18 out of 59 regions by the end of this century under a high greenhouse gas concentration scenario. Even for a low greenhouse gas concentration scenario that assumes stringent mitigation strategies, 11 regions are projected to reach TFE5 within the century.

"Under high and low greenhouse gas concentration scenarios,

respectively, seven and five regions show TFE5 in approximately 30 years, which is before or around an expected climate stabilization in case of the low climate change scenario. Importantly, the results imply unavoidable unprecedented states in these regions," said Hideo Shiogama, a co-author and the head of the Earth System Risk Analysis Section at NIES.

In particular, southwestern South America and the Mediterranean regions consistently show early and robust TFE5 in both scenarios. On the other hand, the differences between greenhouse gas concentration scenarios indicate that our choice of mitigation strategies produces a noticeable difference in the timing and robustness of the projection. "Appropriate and feasible climate mitigation and adaptation plans are essential for overcoming the expected extraordinarily severe dry conditions. Particularly regarding adaptation, it is crucial to improve our preparedness in the given time horizon before unprecedented drought conditions emerge," said Satoh.

More information: Yusuke Satoh et al, The timing of unprecedented hydrological drought under climate change, *Nature Communications* (2022). DOI: 10.1038/s41467-022-30729-2

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