# Research team explores the mechanism of tropical expansion under changing climate

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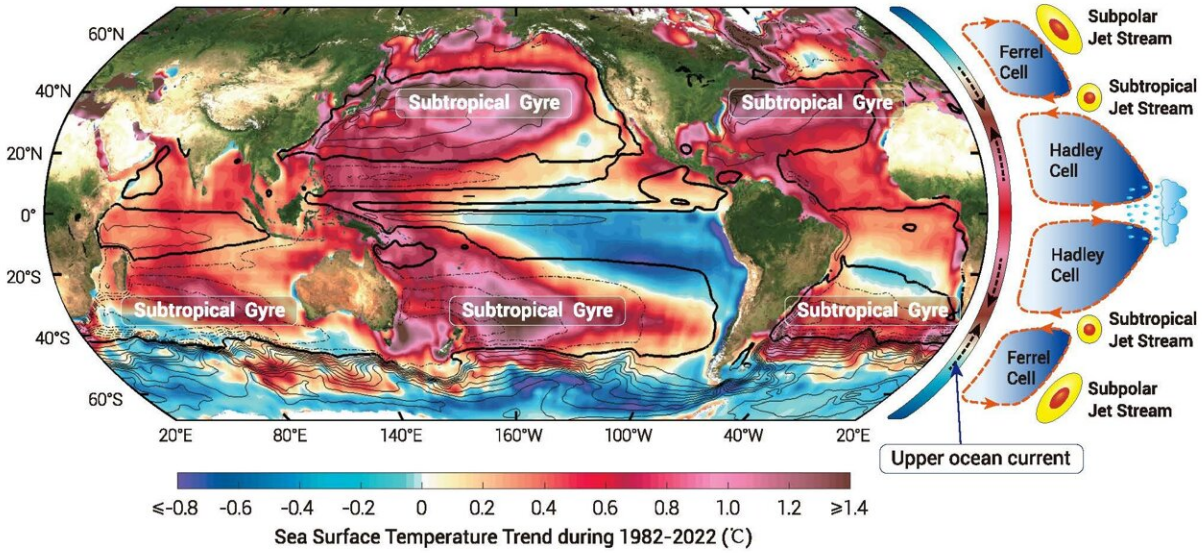


Contours present the climatological oceanic barotropic stream function [69], which locates the major subtropical ocean gyres. On the right panel, the arrows illustrate the significant features of atmospheric (red) and upper oceanic (black) circulation. Under the forcing of increasing greenhouse gases, background subtropical ocean gyres promote enhanced subtropical ocean warming by converging the upper ocean water. The enhanced subtropical warming expands the low latitude warm water zones, pushes the mid-latitude MTGs toward higher latitudes, and thus forces tropical expansion. Figure modified from Yang et al. [10]. The National Oceanic and Atmospheric Administration OISSTv2 data [70] were used to calculate the linear SST trend. Please refer to the article for the references cited here. Credit: *Ocean-Land-Atmosphere Research* (2023). DOI: 10.34133/olar.0004

Scientific evidence shows that the tropical belt around the middle of the globe is expanding. For years scientists have proposed different mechanisms that might explain this expansion. A team of researchers has now determined that the poleward advancing mid-latitude meridional temperature gradient plays a leading role in the tropical expansion.

Their work is published in the journal *Ocean-Land-Atmosphere Research*.

In 2006, scientists discovered that the Hadley Circulation, which determines the tropical belts, is expanding towards higher latitudes under changing climate. This expansion reshapes the patterns of precipitation, winds, clouds, and storms, and may potentially contribute to the migration of global populations.

"Despite the importance of this phenomenon, the underlying mechanisms driving tropical expansion have been debated for more than 17 years without reaching a consensus," said Hu Yang, now a principal investigator at the Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai), China. "Many scientists believe that the mechanism is very complex."

However, Yang and his colleagues think it can be very simple. In 2020, they published a paper, suggesting that tropical expansion is driven by poleward advancing of the meridional temperature gradient, which arises from the spatially non-uniform ocean warming pattern.

However, this idea was questioned by several existing studies based on idealized experiments. For example, an earlier study found that in the abrupt 4x$CO_2$ experiment, when the atmospheric $CO_2$ content is instantaneously quadrupled on the coupled ocean–atmosphere models, it results in an abrupt expansion of the tropics. Other scientists with differing views do not believe that the ocean can introduce a rapid

migrations of temperature gradients because of the thermostat of the ocean.

Furthermore, without involving any sea surface temperature warming pattern, the amip4K experiment, which introduce uniform 4 K ocean temperature anomaly into the atmospheric model, also reproduce tropical expansion, seeming contradict Yang's hypothesis.

In 2023, the research team revisited these experiments, and found that they in fact all support the idea that the shift of meridional temperature gradients drives tropical expansion.

The abrupt 4x$CO_2$ experiment they revisited demonstrated a rapid subtropical ocean warming, which promotes abrupt migration of the mid-latitude meridional temperature gradient and tropical expansion. The amip4K experiment they revisited showed a consistent poleward shift of the mid-latitude meridional temperature gradient and jet streams in the troposphere, despite uniform surface warming. These are all in line with the meridional temperature gradient mechanism.

The team also used an idealized global cooling experiment, to further simulate tropical expansion under conditions of reducing static stability and poleward shifting of the meridional temperature gradient. All of their results supported their hypothesis that meridional temperature gradient migration is the key driver of tropical expansion.

"The shift of the meridional temperature gradient can simply and consistently explain almost all the features of tropical expansion," said Hu Yang. Looking ahead, the team hopes their study of tropical expansion is helpful for future research. "We hope this study can end the long debate of mechanism of tropical expansion, and scientists can use this mechanism to better understand and predict the tropical expansion in a changing climate."

**More information:** Hu Yang et al, Evaluating the Mechanism of Tropical Expansion Using Idealized Numerical Experiments, *Ocean-Land-Atmosphere Research* (2023). DOI: 10.34133/olar.0004