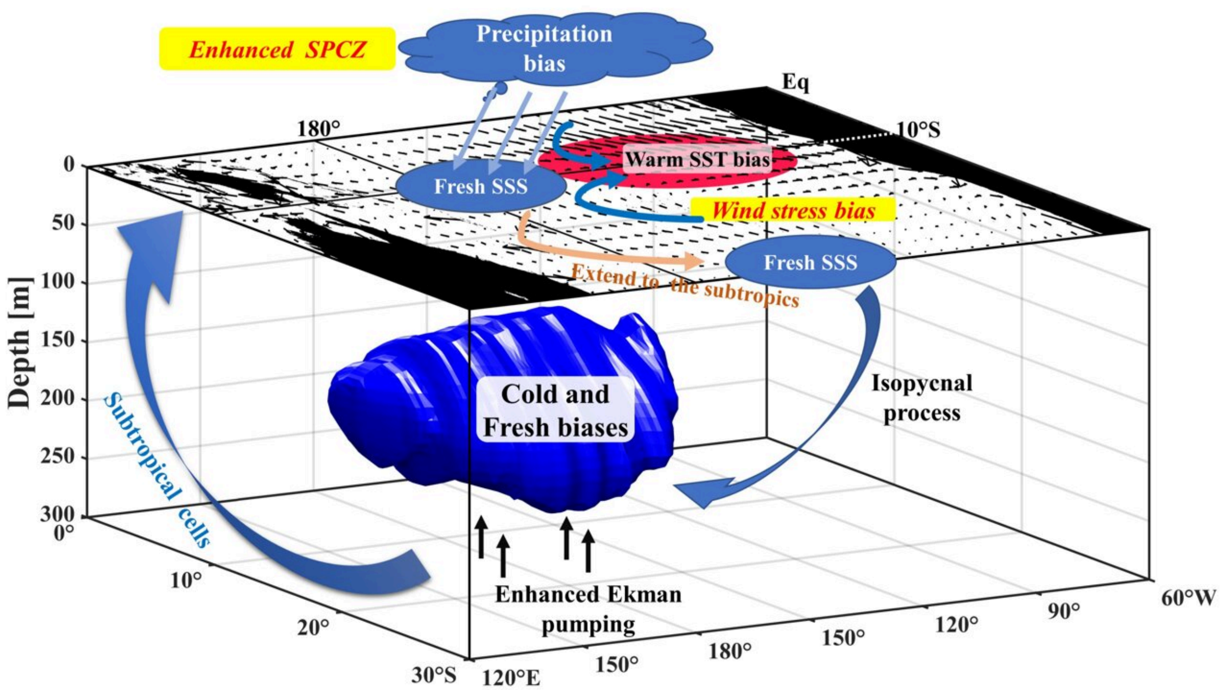
What causes subsurface thermohaline biases in southern tropical Pacific in latest climate models?

March 23 2023, by Li Yuan



A schematic showing the subsurface thermohaline biases, which can be attributed to effects of wind stress and precipitation. Credit: IOCAS

Realistic ocean subsurface simulations of thermohaline structure and variation are critically important to success in climate prediction and projection. Currently, substantial systematic subsurface biases still exist in the latest climate models. However, the characteristics and causes of these subsurface biases are still poorly understood.

Recently, a research team led by Prof. Zhang Ronghua from the Institute of Oceanology of the Chinese Academy of Sciences (IOCAS) has investigated the characteristics and causes of subsurface thermohaline biases in the southern tropical Pacific.

The study was published in *Journal of Climate* on March 10.

The researchers analyzed simulations from the Coupled Model Intercomparison Project phase 6 (CMIP6), and found that pronounced subsurface cold and fresh biases arose at a 200-m depth over the southern tropical Pacific. Similar bias structures also exist in CMIP5 outputs, indicating that these subsurface biases are systematic and caused by some common misrepresentation of physical processes in climate models.

Attribution analyses and numerical experiments showed that the subsurface thermohaline biases were attributed to model deficiencies in simulating wind stress and precipitation, which were caused by warm sea surface temperature (SST) biases in the southeastern tropical Pacific (SETP). The warm SST biases in the SETP acted to strengthen atmospheric convective activity, which induced low-level wind convergence and increased rainfall locally, leading to the negative wind stress curl (WSC) and excessive precipitation in the southern tropical Pacific.

"On the one hand, the negative WSC causes subsurface cold and fresh biases by enhancing local upwelling," said Prof. Zhang, corresponding author of the study. "On the other hand, the excessive precipitation-induced fresh sea surface salinity (SSS) bias signal extends to the subtropics gradually, and then propagates to the equator through isopycnal process, which further enhances the subsurface cold and fresh biases in the southern tropical Pacific."

Furthermore, the researchers analyzed the consequences of the subsurface thermohaline biases. Because the subsurface thermohaline structure in the southern tropical Pacific can modulate oceanic circulations and equatorial upper-ocean thermal structure, the CMIP6 simulations with serious subsurface thermohaline biases tend to have much flatter zonal isopycnal surfaces, less equatorward interior transport, and cooler equatorial upper ocean.

"The pronounced subsurface thermohaline biases in the southern tropical Pacific are likely to further affect the SST in the equatorial Pacific, thereby exerting a potential influence on the El Nino-Southern Oscillation properties and the global climate system," said Zhang Qiushi, first author of the study.

"This study reveals the important roles played by atmosphere model simulation biases in the formation of subsurface thermohaline biases in the southern tropical Pacific, which provides a guide for improving climate model performances," said Prof. Zhang.

More information: Qiushi Zhang et al, Subsurface Thermohaline Biases in the Southern Tropical Pacific and the Roles of Wind Stress and Precipitation, *Journal of Climate* (2023). DOI: 10.1175/JCLI-D-22-0524.1

Provided by Chinese Academy of Sciences