Causes of extreme weather and climate events in China during 2020/21

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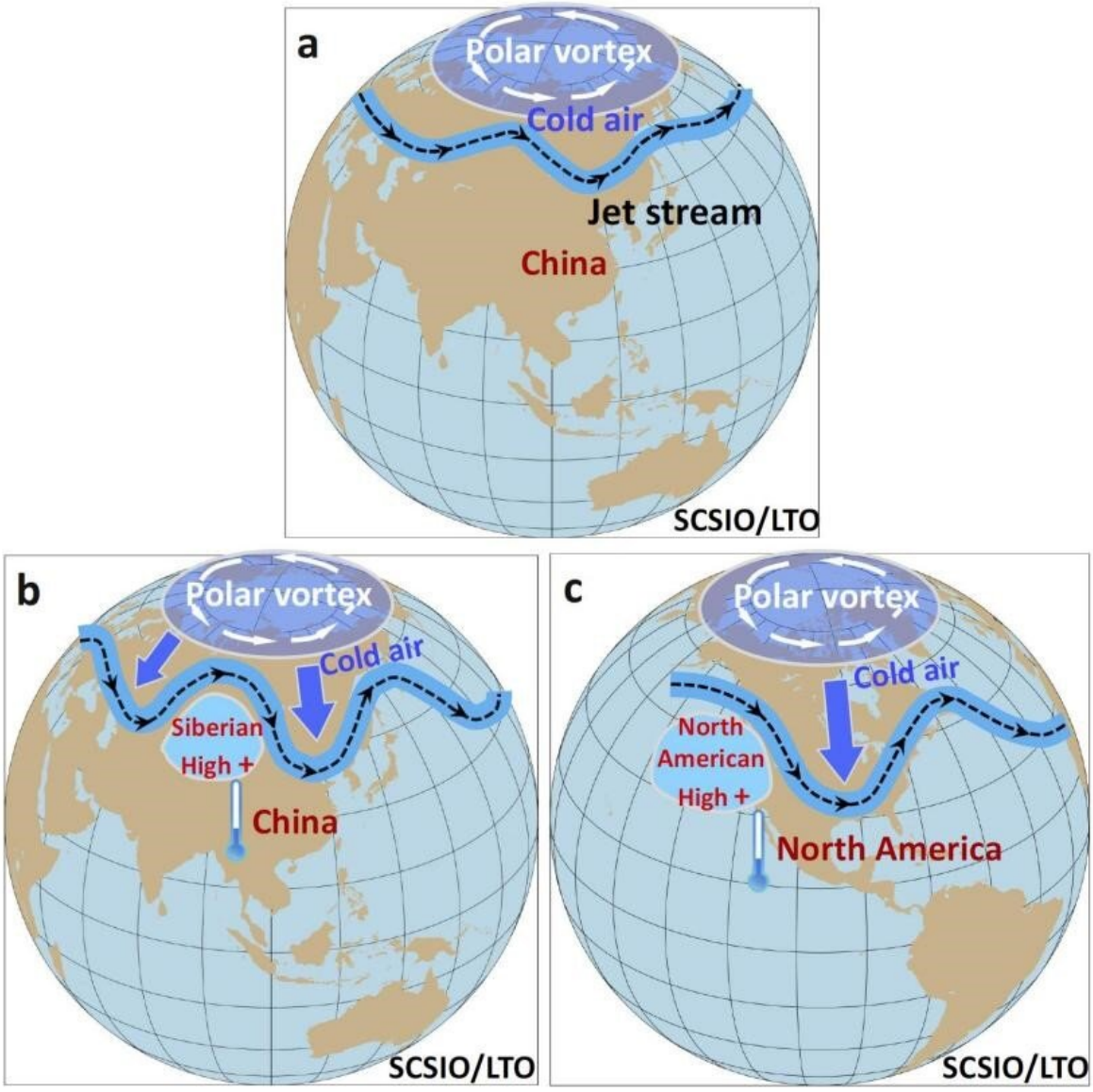
During the summer of 2020, especially June and July, periods of extreme heavy rainfall occurred in China's Yangtze River Valley (YRV). These rain events caused the severest floods for the region since the

summer of 1998. Despite this, the 2020 western North Pacific (WNP) typhoon season started slowly, but eventually produced 23 named tropical cyclones, still slightly below 27, the WNP seasonal average. As summer transitioned to winter, three severe cold surges swept most parts of China during late 2020 and early 2021, prompting the National Meteorological Center to issue its highest cold surge warning alert for the first time in four years. After a volatile weather year, scientists are finding answers as to why the past year featured so many extreme weather and climate events in China.

Professor Chunzai Wang and his team in the State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences were tasked to analyze global and regional climate influences that may have played roles in the 2020/21 extreme weather events. The researchers found many key oceanographic and meteorological connections, which have just been published in *Advances in Atmospheric Sciences*.

Sea surface temperature (SST) fluctuations in the tropical Pacific, Indian, and Atlantic Oceans can contribute to heavy rainfall events in China. However, observational data suggest that Atlantic and Indian Ocean influences dominate over those from the Pacific. Beginning in May 2020, positive SST anomalies, or change from average, throughout the tropical western North Atlantic (WNA) induced positive geopotential height anomalies in June over the mid-latitude North Atlantic. Geopotential height is the altitude above sea level at which a certain pressure surface exists, typically analyzed at 500mb. This metric is excellent for identifying the ridges and troughs which affect the rainfall anomalies in the YRV via an Atlantic-induced atmospheric 'wave train' across Eurasia. Further analysis suggests that the Indian Ocean did not significantly affect June rainfall over the YRV. However, when considering June and July rainfall together, both the Indian Ocean and WNA influences are important.



Schematic diagrams of atmospheric circulation patterns associated with the winter cold surges. (a) A normal, mild winter with the relatively flat jet stream. (b) A cold surge in China with the enhanced Siberian High and wavy jet stream. (c) A cold surge in the United States with the enhanced North American High and wavy jet stream. Credit: Chunzai Wang

Regarding the extremely cold surges during the 2020/21 winter, Prof. Wang's team points to the Siberian High. An enhancement and northward movement of the Siberian High force the jet stream to develop a wavy pattern. This disrupts the polar vortex, allowing cold polar air to invade southward, thus inducing the cold surges in China and North America.

The below average 2020 typhoon season is associated with large vertical wind shear (which is defined as the wind difference between the upper and lower troposphere) and low humidity in the WNP. Tropical cyclones do not form and develop in heavily sheared and dry environments. Scientists believe that these are responsible for fewer typhoons in the first half of the 2020 typhoon season.

This study points out the importance of three-ocean interactions and their influences across the Northern Hemisphere. The tropical Pacific, Indian, and Atlantic Oceans can affect the anticyclone in the WNP, providing moisture transport to its northwest side, therefore increasing summer rainfall in China. The same anticyclone also modifies atmospheric circulation and thermodynamic factors in the WNP, influencing typhoon activity. Global warming can increase the occurrence of extreme weather and climate events. However, future studies are needed to quantify the influences of global warming on an individual extreme weather and climate event.

More information: Chunzai Wang et al, The 2020 Summer Floods and 2020/21 Winter Extreme Cold Surges in China and the 2020 Typhoon Season in the Western North Pacific, *Advances in Atmospheric Sciences* (2021). DOI: 10.1007/s00376-021-1094-y

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