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Study shows China's severe weather patterns changing drastically since 1960

"A monsoon is one of the major drivers of severe weather because it affects the three necessary 'ingredients' for severe weather, which are wind shear, instability and triggering," said Fuqing Zhang, professor of meteorology and atmospheric science, Penn State.

Image: Douglas M. Paine

Liam Jackson
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UNIVERSITY PARK, PA. — In one of the most comprehensive studies on trends in local severe weather patterns to date, an international team of researchers found that the frequency of hail storms, thunderstorms and high wind events has decreased by nearly 50 percent on average throughout China since 1960.

The team analyzed data from the most robust meteorological database known, the Chinese National Meteorology Information Center, a network of 983 weather observatories stationed throughout China's 3.7 million square miles. Meteorologists have been collecting surface weather data through the network since 1951 or earlier, which provided the researchers an unprecedented look at local severe weather occurrences.

"Most of the data published on trends in severe weather has been incomplete or collected for a limited short period," said Fuqing Zhang, professor of meteorology and atmospheric science and director, Center for Advanced Data Assimilation and Predictability Techniques, Penn State. "The record we used is, to the best of our knowledge, the largest, both in time scale and area of land covered."

The team, who report their findings today (Feb. 17) in Scientific Reports, found that the strength of the East Asian Summer Monsoon decreased at a rate strongly correlated to that of severe weather throughout the same time period. The monsoon is an annually recurring, long-term weather phenomenon that brings warm, moist air from the south to China in the summer, and cooler air from the north to China in the winter. A monsoon's strength is measured by calculating the average meridian wind speed in this area.

"We believe that changes in monsoon intensity are affecting severe weather in the area because of the strong correlation we found, but we cannot say the monsoon is the exclusive cause," said Zhang. "A monsoon is one of the

major drivers of severe weather because it affects the three necessary 'ingredients' for severe weather, which are wind shear, instability and triggering."

Wind shear is the difference between the wind speed and direction at different altitudes. Because a monsoon brings southerly winds into China, a weaker summer monsoon would decrease the overall low tropospheric wind shear. The weaker monsoons would also bring less warm, moist air from the south — one of the most common sources of instability in the atmosphere. A common triggering mechanism for severe convective weather is lifting by the front, a high temperature gradient across the monsoon, and this would also be reduced in a weaker summer monsoon.

Some studies suggest that climate change may be one of the reasons that the Asian Summer Monsoon weakened. One factor in monsoon formation is the difference between the temperature above land and the temperature above adjacent ocean or sea. A warming climate would affect the difference between these two and, as a result, simulations show that this could continue decreasing the monsoon's strength. However, the team noted that other major changes in the area — such as an increase in industrialization and air pollution in China in the 1980s — might have played a significant role in the region's atmospheric changes and could affect the severe weather.

While a decrease in severe weather might sound beneficial, it may not always be a good thing.

"There are many natural cycles that rely on severe weather and the precipitation it brings," said Qinghong Zhang, professor of atmospheric and oceanic sciences, Peking University, lead author of the study, who conducted this research while on sabbatical at Penn State. "A decrease in storms could potentially lead to an increase in droughts. Also, some theorize that while the frequency of severe weather decreases, their intensity could potentially increase. We cannot say if this is true yet, but it is something we will analyze in the future."

This was the first study in its level of detail because of the amount of data collected by the Chinese National Meteorology Information Center. The study also showed that occurrences of hail remained relatively steady from 1961 through the 1980s before plummeting.

"The frequency of thunderstorms and high winds decreased gradually over the time period we studied, but not hail," said Qinghong Zhang. "This is something we don't fully understand at this point but plan to investigate more."

Xiang Ni, doctoral student, Peking University, contributed to this study.

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