Study reveals shifting influence of El Niño on central Asia's rainfall

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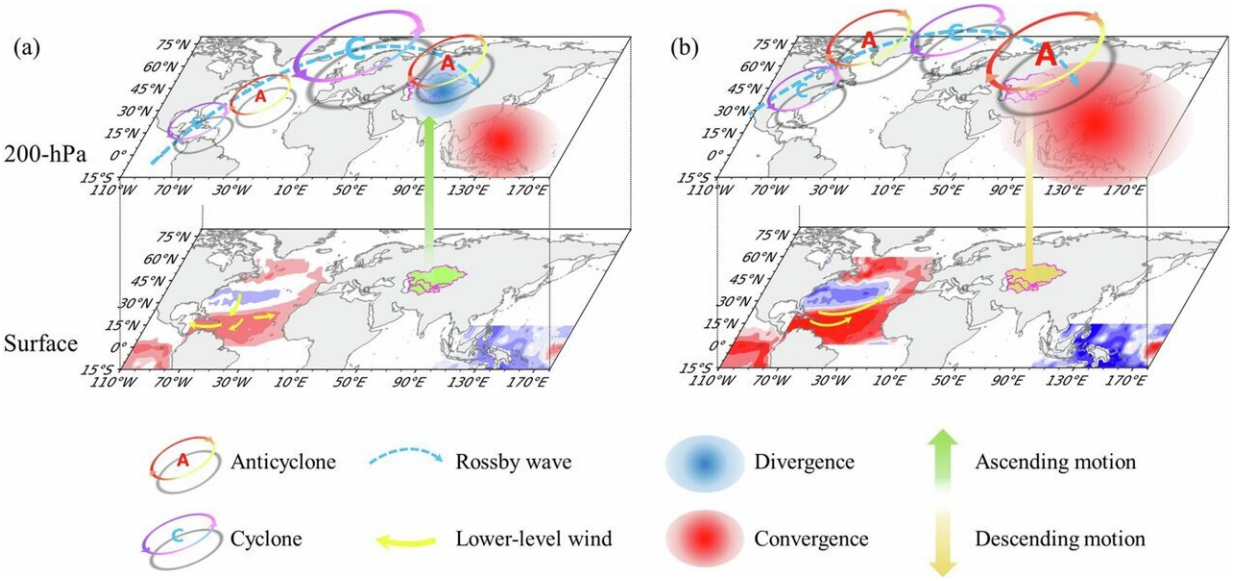

Schematic diagram illustrating underlying mechanisms of interdecadal shifts in the ENSO–SCAP relationship. Credit: *npj Climate and Atmospheric Science* (2024). DOI: 10.1038/s41612-024-00742-x

Central Asia, encompassing Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan, and Tajikistan, is one of the world's largest semi-arid to arid regions. Known for its continental climate, the region has a fragile ecosystem that is particularly sensitive to changes in precipitation.

The primary rainy season there, especially in southern Central Asia,

occurs in spring, coinciding with the major agricultural growing season. Variability in spring precipitation across Central Asia is a critical factor affecting the region's water resources, ecosystems, and economic activities.

For years, researchers have recognized the significant influence of the El Niño–Southern Oscillation, commonly known as ENSO, on rainfall patterns in Central Asia. Typically, an El Niño event in the preceding winter brings more rain to the region by enhancing moisture transport and intensifying atmospheric updrafts.

However, a recent study led by researchers from the Institute of Atmospheric Physics of the Chinese Academy of Sciences revealed that the relationship between ENSO and spring precipitation in Central Asia has not remained constant over time.

Published in *npj Climate and Atmospheric Science*, the study shows that this relationship weakened significantly in the 1930s, gradually strengthened until the 1960s, and has been on the rise again since the 2000s.

Observations and climate model simulations point to two key factors that may explain the interdecadal changes in the relationship between ENSO and spring precipitation in Central Asia.

The first factor relates to changes in the meridional pathway—the way in which Pacific sea surface temperature anomalies influence moisture and atmospheric dynamics over Central Asia. During El Niño events, strong upper-level divergence typically occurs over the central-eastern Pacific, while convergence occurs over the western Pacific.

This pattern extends to Central Asia, promoting vertical motion and increasing precipitation. When the ENSO influence is strong, this upper-

level divergence over Central Asia is more pronounced, leading to more significant rainfall. In contrast, during periods of weaker correlation, the impact on rainfall is less pronounced.

The second factor involves the influence of sea surface temperature anomalies in the North Atlantic. During the spring following an El Niño event, a specific sea surface temperature pattern—characterized by cold anomalies in the middle North Atlantic and warm anomalies in the subpolar and tropical North Atlantic—disrupts the wetting influence of El Niño on Central Asia's spring rainfall. This disruption is more significant during periods of weak correlation, contributing to the variability in the relationship.

But what drives these changes in North Atlantic sea surface temperatures? The answer seems to lie in wind patterns, which are influenced by how quickly El Niño events decay.

During periods of weak correlation between ENSO and Central Asia's spring precipitation, stronger wind anomalies in the North Atlantic help create the horseshoe-like sea surface temperature pattern, which disrupts ENSO's influence.

This effect is further linked to the phase of the Pacific Decadal Oscillation (PDO), a long-term climate pattern in the Pacific Ocean. During a positive phase of the PDO, a slower-decaying ENSO leads to a more pronounced North Atlantic sea surface temperature pattern in spring, counteracting the ENSO effect. Conversely, during a negative phase, this counteracting effect weakens, leading to a stronger relationship between ENSO and spring precipitation in Central Asia.

In addition, the researchers have observed a strengthening trend in this relationship since the 2000s, suggesting that predicting spring precipitation in the region has become more reliable in recent decades.

"Our findings shed light on the complex dynamics behind the changing influence of ENSO on Central Asia's spring precipitation, and offer valuable insights for regional stakeholders involved in seasonal forecasting and climate prediction in this arid region" said Prof. Huang Gang, corresponding author of this study.

More information: Mengyuan Yao et al, Interdecadal shifts of ENSO influences on Spring Central Asian precipitation, *npj Climate and Atmospheric Science* (2024). DOI: 10.1038/s41612-024-00742-x

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