ATMOSPHERIC SCIENCES

A HIGH POINT FOR ARID LAND RESEARCH

Arid and semi-arid lands represent 41% of the Earth's surface, and the proportion is growing. These regions are more vulnerable to global warming than humid areas.

If the CO_2 emission rate continues, drylands are expected to expand to more than half of the Earth's land surface by the end of the century, according to atmospheric scientists from Lanzhou University.

Between the Loess Plateau and the Qinghai-Tibetan Plateau in Northwest China, and including the beginning of the fertile Hexi Corridor, Lanzhou is characterized by a semi-arid climate, leading to a strong tradition in environmental science studies at Lanzhou University. The university's atmospheric scientists are renowned for the observation and research of atmospheric processes related to semi-arid climate and global climate change.

THE ROAD TO UNDERSTANDING SEMI-ARID CLIMATE

The drylands of northwest China are dominated by fragile ecosystems and frequent dust storms, but have a lack of advanced observatories for comprehensive detection. Over more than 10 years, a team led by Huang Jianping, director of the Ministry of Education's Key Laboratory for Semi-Arid Climate Change, Lanzhou University, has built an internationally outstanding Semi-Arid Climate and Environment Observatory at (SACOL), providing valuable longitudinal observation data. Through the observatory and multiple field campaigns in the region, researchers have collected systematic high-precision long-term series data regarding aerosol optical and radiation characteristics, dust and black carbon in seasonal snow, cloud microphysical characteristics, radiation energy budget, atmospheric boundary layer structure and other characteristics of land-air interaction. These have laid the foundation for understanding the processes of arid climate and mechanisms of desertification. Some of these works were cited by the Intergovernmental Panel on Climate Change (IPCC) 5^{th} Assessment Report.

Based on the rich observation data, Huang's team has systematically studied the role of dust aerosols in regional climate and, in a world first, revealed the mechanism by which dust shapes the dry climate in northwest China.

"Humans play an important role in the generation and transport of dust aerosols," said Huang. "Yet, understanding about how dust aerosols influence the clouds and precipitation in northwest China is very limited." Combining remote sensing data and ground observation, Huang's team mapped the routes and distribution characteristics of dust aerosols. They found that dust and pollutants generated in the Taklamakan and Gobi deserts not only change the climate in northwest China through cloud physics, but can also be transported by westerly jets across eastern Asia, the Pacific Ocean, and may even reach North America. The work highlighted the semi-direct effects of dust aerosols on arid climate and the drying mechanism, winning the team the second prize of the National Natural Science Award in 2013.

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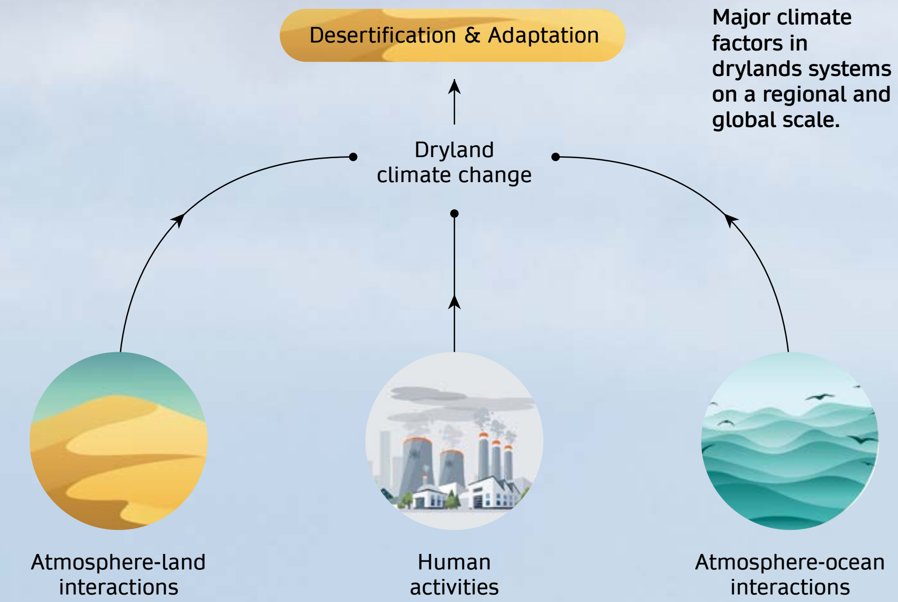
FORECASTING THE FUTURE OF DRYLANDS

Increasing aridity would accelerate desertification and regional warming, threating ecological safety and national security, says Huang. However, most existing models cannot accurately simulate the evolution of aridity, making it difficult to predict its expansion.

Based on years of systematic observation and climate projections, Huang's team was the first to find that semi-arid regions have seen the most notable temperature increases, except the Arctic, in the past 100 years. Particularly, winter temperature increases in the northern hemisphere's semi-arid and dry regions are twice the global average increase.

With three papers published in *Nature Climate Change*, Huang's study also proposed the feedback mechanisms via which the warming and drying trends reinforce each other. Warming may cause a higher evaporative effect from the land surface which may aggravate the drying trend, while decreased soil moisture may lead to a decrease in latent heat flux, and an increase in sensible heat flux, which may enhance temperature extremes. Meanwhile, warming-induced dryland expansion and human-led reduction of vegetation cover would reduce soil carbon storage and carbon sequestration capacity, leading to increased CO_2 emission into the atmosphere, aggravating global warming and the drying trend.

Huang's prediction suggests, if global temperature rises 2°C on average, arid and semi-arid regions will get warmer by 3.2 – 4°C, nearly 44% more than in humid regions. Keeping global warming to within 1.5°C will greatly mitigate the possibility of climate catastrophe in arid and semi-arid regions. Cited in an IPCC special report, *Global Warming of 1.5 °C*, this study provides a new basis for determining the global emission reduction target.



Major climate factors in drylands systems on a regional and global scale.

EXTENDING KNOWLEDGE IN GLOBAL WARMING

Studies by Lanzhou University's atmospheric researchers also inform climate predictions in the northern hemisphere. In recent years, frequent cold winter events in Eurasia and North America have challenged understanding of global warming. For climate scientists, these cold spells are a consequence of accelerated export of cold air from the polar region to high- and mid-latitudes, due to a phenomenon known as 'weakened stratospheric polar vortex', closely linked to global warming. But few studies have investigated the long-term dynamics of the position and shape of stratospheric polar vortex and its climate effects.

A team led by Tian Wenshou, discovered a persistent shift of the Arctic polar vortex towards the Eurasian continent in recent decades, which can be attributed to Arctic sea-ice loss, particularly in Barents-Kara seas, and Eurasian snow cover increase.

Besides inducing cold extremes in the northern hemisphere, the shifting polar vortex, carrying ozone-poor, but active chlorine-rich air towards Eurasia, also dilutes ozone concentration and slows down the stratospheric ozone recovery because of certain chemical reactions, according to another finding of Tian's team published in *Nature Communications* in 2018. "Our chemistry-climate model simulations indicate that the anticipated ozone recovery could be delayed, and unseasonably cold spells in late winter might continue in the northern hemisphere," says Tian. ■