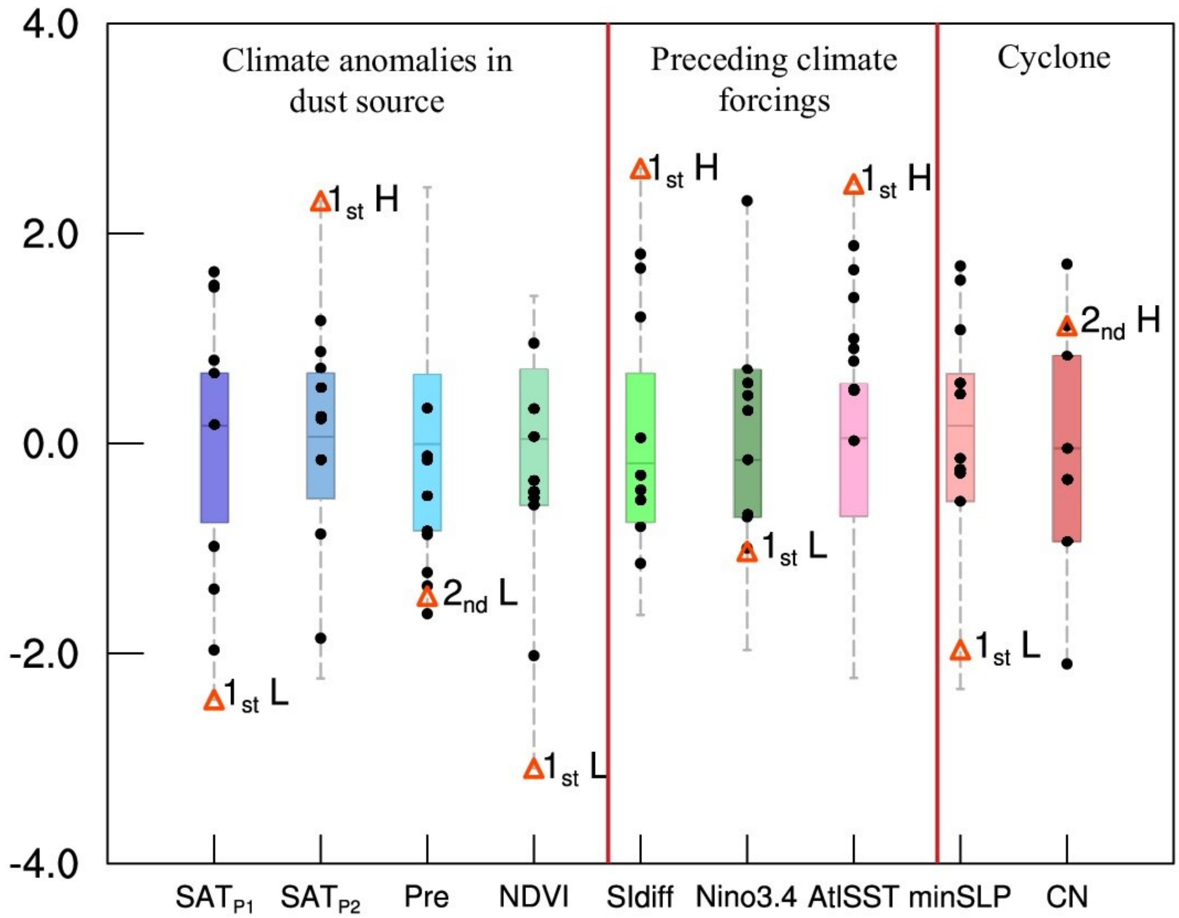
Why was there a super sandstorm in North China this year?

October 22 2021



The climate conditions of the dust source area including surface air temperature during early-winter (SATP1) and late-winter (SATP2), winter precipitation (Pre) and February-March NDVI. The preceding factors that influenced dust source including difference of sea ice in Barents and Kara Sea (SIdiff), Nino3.4 index, Northwest Atlantic SST (AtlSST). The atmospheric indexes included minimun

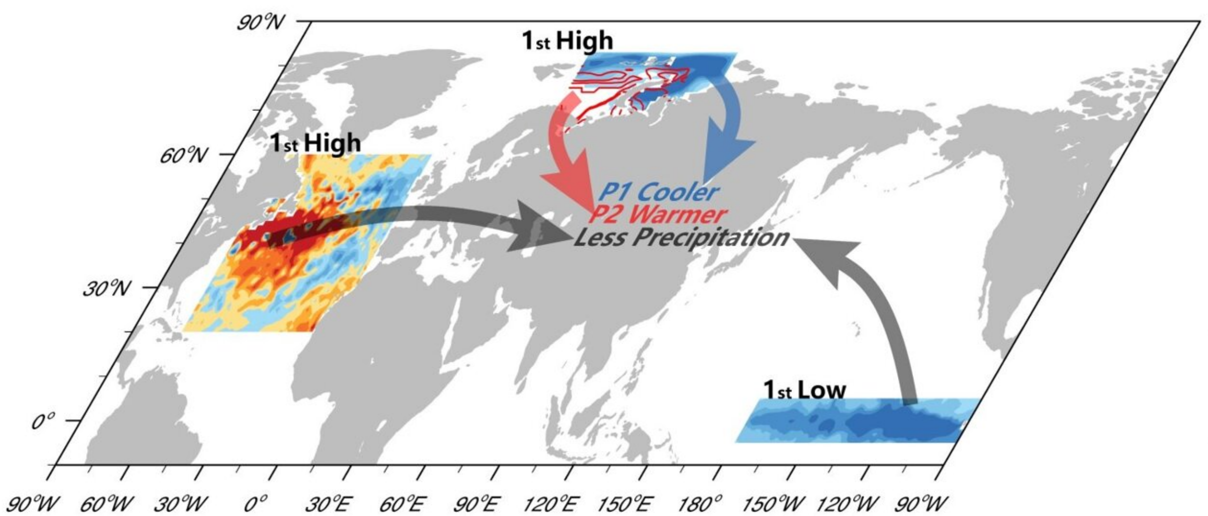
March SLP (minSLP) and March cyclone numbers (CN) over dust source area. The high (H) and low (L) ranks of these factors within 2011/12-2020/21 are also marked. Credit: Science China Press

Severe sandstorms reoccurred in the spring of 2021 after absence for more than 10 years in North China. During 14-17 March, the severe sandstorm weather affected a board region of more than 3.8 million square kilometers. The PM_{10} concentrations in Beijing exceeded 7000 $\mu g\ m^{-3}$, and the visibility was only a few hundred meters, which posed a serious threat to people's health, transportation and ecological civilization.

The team led by Prof. Huijun Wang (Nanjing University of Information Science & Technology) found that the surface air temperature (SAT) and underground soil temperatures in the dust source area (around Mongolia) were persistently lower (the lowest from 1979) during early-winter, but persistently higher (the highest from 1979) during late-winter. The cooler temperature resulted in deeper permafrost, and then strong warming led the land surface to thaw and become more loose. Meanwhile, the winter precipitation was the second smallest during the recent decade. Moreover, the surface vegetation coverage reached its worst since 1979. Once strong winds appear, the dust particles will rise with the wind to produce dust or sandstorm.

Prof. Zhicong Yin (first author) pointed out it is more important to find preceding climate drivers, that contained efficient prediction information, from the observations and CMIP6 simulations. Decreased November-December Barents and Kara sea ice would increase the local geopotential height and Ural blocking high, and then the anomalous northerlies transported cold air mass to Mongolia in early-winter. However, the positive anomalies of January-February sea ice induced the cold air mass to be trapped over the West Siberian Plain and the East European Plain and resulted in warmer land surface in Mongolia.

La Niña event (cooler east tropical Pacific) and positive sea surface temperature anomalies in northwest Atlantic were found to be the other two external forcing factors. After the La Niña event, the East Asian winter monsoon would strengthen, and the water vapor flux easily diverged around Mongolia and precipitation consequently decreased. Similarly, the warmer Northwest Pacific induced an upper Rossby wave-like train to weaken the Asian polar vortex and strengthen the Ural High, and resulted in reduction of winter precipitation in Mongolia. In summary, the reversal of sea ice anomalies, the La Niña event and the warmer Northwest Atlantic jointly led to the loose and dry surface in Mongolia, i.e., sufficient dust source.



Negative anomalies of November-December sea ice (shading) resulted in lower SATP1 in Mongolia, while positive January-February sea ice anomalies (red contours) led to higher SATP2 in 2021. Coolest east Pacific and warmest northwest Atlantic during 2011/12–2020/21 jointly contributed to less winter precipitation in Mongolia. Credit: Science China Press

Moreover, the strongest Mongolian cyclone during recent decade formed and developed in 14-15 March 2021. The descending motions with downward transport of westerly momentum dramatically enlarged the surface winds (25 m s^{-1}), which shook and blew the dry and loose land surface. Subsequently, the ascending motions in front of the cyclone lifted the sand particles into the troposphere. With the movement and development of Mongolian cyclone, the cold advection carried large amounts of dust particles to North China. At 09:00 on 15 March, the tropospheric westerly momentums were transported downward to the surface, resulting in large gusts (15 m s^{-1}), thus severe sandstorm happened in North China.

More information: Zhicong Yin et al, Why super sandstorm 2021 in North China, *National Science Review* (2021). DOI: 10.1093/nsr/nwab165

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