Why haven't "disaster-level cool summers" been occurring in recent years?

*Amano Miku[1], Yoshihiro Tachibana[1], Yuta Ando[2]

1. Faculty of Bioresources, Mie University, 2. Faculty of Science, Niigata University

Cool summers are characterized by low temperatures and insufficient sunlight compared to normal summers. In northern Japan, which is one of the major rice-growing regions in Japan, crops have been mainly damaged by frequent cool summers. The existence of Okhotsk high (OKH) is known to be one of the causes of such "disaster-level cool summers". Other phenomena that affect the Japanese summer include El Niño-Southern Oscillation. In addition, the Pacific-Japan (PJ) pattern is related to this phenomenon.
These facts are known from previous studies. On the other hand, in recent years, there have been no cool summers that have affected agriculture. There are no previous studies that have statistically investigated and discussed the reasons for this. Therefore, the purpose of this study is to elucidate the reasons why "disaster-level cool summers" have not occurred in recent years.
We used weather observation station data for definition of the indices. We constructed a temperature index for July from observed temperature data in northern Japan. 15 cases where the temperature index was below -0.5 σ were defined as "cool summer years (CS)", and 11 years from 2010 to 2020 were defined as "recent years (RE)".
The reanalysis data was used in the composite analysis for the CS and RE. The atmospheric data is from the Japanese 55-year Reanalysis (JRA-55) by the Japan Meteorological Agency (JMA). The sea surface temperature (SST) data was obtained from the Hadley Centre sea ice concentration analysis. All of them use the monthly average data for July.
As a result of the RE composite analysis, high water temperature anomalies were observed in the SST around Japan, and high pressure anomalies were observed around Japan in the geopotential height at 975hPa. In the 250hPa geopotential height field, anticyclonic anomalies were observed over a wide area including Japan, mainly over the Kamchatka Peninsula and the eastern North Pacific.
Next, we look at CS. SST around Japan were characterized by low-temperature anomalies. In the 975hPa geopotential height field, the development of OKH and negative PJ patterns were observed. In the 250hPa geopotential height field, cyclonic anomalies were observed over a wide area of Far East Asia and anticyclonic anomalies were observed south of the area.
We constructed various indices to describe the characteristics of the CS, and checked the condition of the RE year by year.
First, the SST of RE was high in all years except 2015. On the other hand, the Sea of Okhotsk High occurred in almost all years, and RE showed the same characteristics as CS. Nevertheless, the reason for the absence of a cool summer is thought to be the effect of the SST increase around Japan. Even when cold northeasterly winds blow, they may have been warmed by the ocean in RE, resulting in relatively warm winds. Next, the occurrence of PJ patterns was confirmed for RE. In RE, there have been no negative PJ patterns and almost no positive PJ patterns. This result suggests that the atmosphere may be less affected by oceanic phenomena in the tropics in RE. In the lower to upper levels of the atmosphere around Japan, it was found that the atmosphere has become more anticyclonic in RE. It is thought that this prevents the influence of the Philippine Sea from reaching the vicinity of Japan through the upper layers. This may be the reason why negative PJ patterns do not occur. The pressure anomaly in the upper atmosphere is related to the meandering of the westerlies. Therefore, this result suggests that the meandering pattern of the westerlies may have changed in RE.

Keywords: cool summer, High pressure trend, sea surface temperature

