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Decadal variabilities in the Pacific and Atlantic Oceans and frequency of hot summers over the Northern Hemisphere

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Mean temperature increase over the Northern Hemisphere (NH) land areas during warm seasons enhances frequency of extreme warm events (e.g. Russian heat wave in 2010; 1). Human influences on Earth's climate have been detected in observational records since the late 20th century. During the past 15 years, the increase in global surface air temperature (SAT) has slowed (called hiatus; 2) whereas observations show a continuous increase in summertime (June-July-August, JJA) land-mean SAT and the frequency of hot summers over the NH land areas. This discrepancy represents that some other factors except global sea surface temperature (SST) can influence on the increasing frequency of hot summers. The recent phase shifts of the decadal and multidecadal SST variabilities in the Pacific and Atlantic Oceans could have influenced the mean SAT and extreme events over the land.

For attributing the recent increase in NH hot summers, we performed three sets of ensemble simulations for 1949-2011 using an atmospheric general circulation model (AGCM). An ensemble driven by prescribed observed SST, sea-ice concentration, and radiative forcing agents, reproduces well the observed SAT time series over the NH land. Simulated anomalies can be decomposed into three components: anthropogenic influence via SST increase (ASST); direct effect of anthropogenic forcing including GHG radiative forcing (ADIR); and natural climate forcing and internal SST variability (NAT). The decomposition is made by conducting two additional ensemble, one with prescribed GHGs at the pre-industrial level and the other similar to the SST run but without human induced components in SST and sea ice have been removed.

The model simulates well 1) the long-term increase of the frequency of hot summers and 2) the recent increase during the hiatus period. Both ASST and ADIR contribute to 1). Particularly, the ADIR effect is the dominant factor for the middle and high latitude land areas, consistent with earlier studies presenting the ADIR effects for increase in mean land SAT during warm seasons (3, 4). In contrast, the NAT effect is essential for 2). The recent SST variabilities in the Pacific and Atlantic Oceans are characterized by the negative phase of PDO and the positive phase of AMO. Atmospheric teleconnection patterns associated with these SST variabilities result in low SAT over the Canada and high SAT over the United State middle latitude. In addition, the warm SST in the North Atlantic Ocean and the Mediterranean Sea contribute to high SAT over the Europe.

The recent decadal and multidecadal variabilities in the Pacific and Atlantic Oceans contribute to the increase in land SAT and frequency of hot summers over the NH middle latitude despite the recent climate hiatus. In the recent future, global and regional frequencies of hot summers can be influenced largely by phase shifts of decadal and multidecadal SST variabilities in the Pacific and Atlantic Oceans.

References

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