Multi-scale ocean-atmosphere interaction in the tropics

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El Niño/Southern Oscillation, Indian Ocean Dipole, Atlantic Nino, and Atlantic Meridional Mode are ocean-atmosphere interaction phenomena in the tropics. These phenomena have interannual timescales of two- to seven-year periods. It has been pointed out that they are related to various phenomena of shorter (e.g., intraseasonal) and longer (e.g., quasidecadal, multidecadal to long-term trend) timescales as well as phenomena of various spatial scales. In addition to interactions among the tropical phenomena, links with atmospheric and oceanic variations in mid to high latitudes have been discussed in past studies. These phenomena strongly affect weather, climate, and climate variations over the globe including those in Japan. To enhance our understanding of tropical ocean-atmosphere interactions and other related phenomena, cooperation between various fields (meteorology, oceanography, climatology, etc.) needs to be strengthened. This session aims to give an opportunity for researchers of atmosphere and ocean to present results on phenomena on various spatial and temporal scales, including tropical ocean-atmosphere interactions on interannual timescales, Madden-Julian Oscillation (MJO), tropical cyclones (typhoons), quasi-decadal to multi-decadal variations, climate change and other related phenomena, so that researches on tropical multi-scale ocean-atmosphere interactions are promoted. We welcome submissions on theoretical, observational, and modeling studies.

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

3-min talk in an oral session

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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 during the recent climate hiatus. In the recent future, global and regional frequencies of hot summers can be influenced greatly by phase shifts of decadal and multidecadal SST variabilities in the Pacific and Atlantic Oceans. References[1] Watanabe, M., H. Shiogama, Y. Imada, M. Mori, M. Ishii, and M. Kimoto, 2013: Event attribution of the August 2010 Russian heat wave. SOLA, 9, 64-67, doi:10.2151/sola.2013-015.[2] Watanabe, M., Y. Kamae, M. Yoshimori, A. Oka, M. Sato, M. Ishii, T. Mochizuki, and M. Kimoto, 2013: Strengthening of ocean heat uptake efficiency associated with the recent climate hiatus. Geophys. Res. Lett., 40, 3175-3179.[3] Kamae, Y., and M. Watanabe, 2013: Tropospheric adjustment to increasing CO2: its timescale and the role of land-sea contrast. Clim. Dyn., 41, 3007-3024.[4] Kamae, Y., M. Watanabe, M. Kimoto, and H. Shiogama: Summertime land-sea thermal contrast and atmospheric circulation over East Asia in a warming climate. Part II: Importance of CO2-induced continental warming. Clim. Dyn., in revision.