Japan Geoscience Union Meeting 2014
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ACG37-P01 Room:Poster Time:April 28 18:15-19:30

Multiscale Interactions In The Genesis Of Tropical Cyclone Observed In PALAU2013

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To understand the formation of a tropical cyclone (TC), has long been a captivating subject at the frontier of science and remains challenging because of the complex multi-scale interactions involved. During the genesis stage, sustained convective activities, which may stem from a variety of processes in a favorable environment, develop into a surface mesoscale or synoptic vortex. The mesoscale processes in the genesis stage have been the least understood aspect of the lifecycle of a TC. Although the climatological large-scale conditions favorable for TC genesis have been well known since Gray (1968, 1979), the interactions between the large-scale conditions and mesoscale processes have been poorly understood. The main purpose of this study is to conduct a detailed analysis on the multiscale interactions involved in the cyclogenesis based on observational data and numerical simulations.

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) conducted a field project named the Pacific Area Long-Term Atmospheric Observation for Understanding of Climate Change (PALAU2013) over the northwest Pacific Ocean. In this project, a sounding and radar network was deployed over the ocean during the early summer of 2013. During PALAU2013, the four initial disturbances growing tropical depression (TD) or tropical storm (TS) were observed. This study focused on the disturbances, growing TS (T1304) in association with the temporal changes in large-scale environment. We analyzed re-analysis data (JMA-GSM data), observational data during PALAU2013, and simulation results using WRF-ARW. The radiosondes were launched every 3h on the R/V Mirai and every 6h at Koror and Yap. The Doppler radar was installed on this sip, collected volume-scan every 10 and 7.5 min.

Initial disturbances which occurred at (3N, 175W) in 03UTC June 10, 2013, passed through the observation point R/V MIRAI MR13-03 at (12N, 135E), grew T1304 in 00UTC June 18. The disturbance was developing along the convergence region between the trade easterlies and monsoonal westerlies. Results of radiosonde show that potential temperature was higher in the middle and upper troposphere and CAPE increased as disturbances approached. Moreover, the zonal wind component of the lower troposphere changed to the strong easterly, corresponding to the meridional wind component of the troposphere also changed to the south from the north. The temporal variation of the radar-echo area during the convections showed the organization of convective clouds to form the intense cyclones.

Keywords: Tropical storm, Tropical depression, Tropics, Doppler radar, WRF

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Seasonality of boreal winter MJO and its relation to SST variability

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Madden-Julian Oscillation (MJO) is a prominent intraseasonal variability in the tropics, which is characterized by eastward moving large-scale convective system along the equator. Overall seasonality of MJO paths has been recognized to be eastward during boreal winter and north-eastward during boreal summer. However, analysis of satellite data of NOAA Interpolated Outgoing Longwave Radiation (OLR) from 1982-2012 suggests that there is a notable variability in MJO paths just within boreal winter season. The paths of MJOs were observed to make a notable shift southward from about 10 ^{o} N to 10 ^{o} S from September to April, often with an event passing over the equator during November to December. Structural differences were also recognized between MJOs taking northern paths (northern MJO) and southern paths (southern MJO), with northern MJOs consisting of smaller convective components and being accompanied by more westward propagating components. Using weekly NOAA Optimum Interpolated Sea Surface Temperature (SST) data of the same time period, this shift in the paths of MJOs is further analyzed in relation to variability in SST distribution. Temporal changes in zonal SST gradient of MJO occurring regions, and equatorial asymmetry of SST distribution were evaluated. The result was suggestive of effective influence of positive zonal SST gradient from equatorial Indian Ocean to equatorial Western Pacific on the existence of MJO, and that equatorial asymmetry of SST distribution may be playing a part in the shift of the MJO paths.

Keywords: MJO, SST variability, intraseasonal variability

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Seasonal Variations of the Mascarene High and Related Changes in Jetstreams and a Stormtrack

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The subtropical high in the Southern Indian Ocean, called the Mascarene high, is an integral part of the climate system there, influencing not only weather conditions in the surrounding regions but also the oceanic state. The present study examines the mechanisms for the seasonal variations of the Mascarene high. The high resides over the eastern portion of the basin in summer, while it shifts westward in winter toward the Agulhas storm-track core in strengthening. This large seasonal displacement is a distinct feature of the Mascarene High from other subtropical highs. Our analysis reveals that, while low-level thermal contrasts between the Australian continent and southeastern Indian Ocean is important for the formation of the high in summer, its wintertime formation is owing primarily to eddy-feedback forcing due to the seasonally-enhanced storm-track activity that is maintained in the presence of pronounced SST gradient along the Agulhas Return Current. In winter, the mid-tropospheric subsidence over the surface high is associated with upper-tropospheric convergence of the cross-equatorial divergent flow, indicative of a connection between the high and the Asian summer monsoon. From the viewpoint of vorticity budget, the cyclonic tendency by the upper-level convergence is balanced with the westerly advection of the anti-cyclonic vorticity. While the converging upper-tropospheric flux of Rossby wave activity from lower and higher latitudes acts to reinforce the high in winter, the high itself acts as a source of the climatological-mean planetary waves with the net local divergence of the flux, which is suggestive of the importance of the high even on the hemispheric scale.

Keywords: subtropical high, Indian Ocean, Agulhas Return Current, SST front, jetstream, stormtrack

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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.

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Keywords: global warming, hot summer, heat wave, PDO, AMO

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Zonal Momentum Budget Along the Equator in the Indian Ocean from a High Resolution Ocean General Circulation Model

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This study examines the zonal momentum budget along the equator in the Indian Ocean, with emphasis on the Wyrtki Jets in a high-resolution ocean general circulation model. The Wyrtki Jets are wind-driven eastward flows in the upper 100 m of the equatorial Indian Ocean that appear typically twice per year during the monsoon transitions in boreal spring and fall. Our results indicate significant contributions from zonal, meridional and vertical advection of zonal momentum, with the dominant contribution coming from zonal momentum advection. These results contrast with those from previous idealized wind-forced model experiments that emphasized the importance of vertical momentum advection. The extra eastward force caused by zonal momentum advection reinforces eastward wind stress, resulting in swifter jets in the eastern basin than in the western basin. Another consequence of these nonlinearities is that, annually averaged, zonal currents in the upper thermocline flow against the zonal pressure gradient rather than down gradient. Thus, there is no mean subsurface undercurrent flowing against the surface winds in the Indian Ocean as there is in the Pacific and Atlantic Oceans. These results indicate that proper simulation of the mean and the semi-annual zonal flows along the equator in the Indian Ocean, including their climatically relevant impacts on the mass and heat balance of the region, requires accurate representation of nonlinearities that derive from a broad range of interacting time and space scales.