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PALAU2013 で観測された台風 4 号発生時のマルチスケール相互作用について
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.

キーワード: 台風, 熱帯低気圧, 熱帯, ドップラーレーダー, WRF
Keywords: Tropical storm, Tropical depression, Tropics, Doppler radar, WRF

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冬期 MJO の季節性と SST 変動との関係について
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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マスカリン高気圧とそれに伴う西風ジェットとストームトラックの季節変動
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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近年の北半球猛暑頻度の増加に対する太平洋・大西洋十年規模変動の寄与
Decadal variabilities in the Pacific and Atlantic Oceans and frequency of hot summers over the Northern Hemisphere

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北半球夏季陸上における平均的な気温の上昇は，極端な高温イベント（例えば 2010 年のロシア熱波）の発生確率を高める [1]．特に 20 世紀後半以降は，各大陸において明瞭な昇温傾向が認められ，その大部分は人為的な強制力によるものと考えられる．近年の 15 年間は，全球平均気温の上昇は停滞傾向にある [2] 一方で，夏季の陸上平均気温はわずかな上昇，猛暑の頻度は明瞭な増加傾向を示す．これらは，近年の全球平均 SST の上昇の停滞からは説明することができない．近年の海盆スケールの海面水温（SST）変動は，太平洋と大西洋で特徴的な空間分布を示す．これらの太平洋・大西洋の十年・数十年規模の SST 変動は，大陸上の平均気温や極端な高温イベントに寄与しうる．

大気大循環モデル（AGCM）を用いた過去再現実験と感度実験を通して，近年の猛暑の継続的な増加の要因を特定した．AGCM に観測された SST，放射強制力（GHG，火山噴火など），土地利用変化を与え，過去 63 年間（1949～2011 年）の再現実験を行う．また，人為的な強制を除いた実験と，さらに SST から人為的な昇温成分を除いた実験を行うことで，SST を介さない人為的な寄与，SST を介した人為的な寄与，自然起源の強制による応答と内部変動の三つに分離する．

AGCM は，観測データが示す 1) 長期的な猛暑の増加傾向と，2) 地球温暖化停滞期の猛暑の増加傾向をどちらもよく再現する．1) には SST を介さない人為起源放射強制と SST を介した寄与が大きい．特に中高緯度では SST を介さない寄与が大きく，夏季の陸上平均気温上昇に対する放射強制力の直接効果の重要性を示す先行研究の結果 [3][4] と一致する．2) には内部変動の寄与が大きい．近年の太平洋・大西洋 SST 分布は負の PDO，正の AMO で特徴づけられる．この海面水温分布は，大気の遠隔応答を介してカナダの低温，中緯度北米の高温をもたらす．また，正の AMO と温暖な地中海 SST は，欧州に高温をもたらす．結果として，近年は地球温暖化の停滞期にあるにも関わらず，太平洋と大西洋の十年規模変動の寄与により，北半球中緯度の陸上では平均気温が高く，猛暑頻度が増加している．

近年の太平洋・大西洋 SST の内部変動は，地球温暖化の停滞を通して猛暑の頻度を抑えている一方で，北半球中緯度の猛暑の頻度を増やしている．今後，十年規模変動の位相が変わることにより，全球及び地域的な猛暑の頻度は大きく変わることが示唆される．

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高解像度 OGCM における赤道インド洋の東西運動量収支解析
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.

キーワード: インド洋, 赤道ジェット, 運動量収支, 高解像度 OGCM