Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACG05-01 Room:201B Time:May 24 09:03-09:21

Possible interactions between Indian Ocean Dipole and intraseasonal variability in the tropical Indian Ocean

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Variations in the tropical Indian Ocean cover a wide range of spatial and temporal scales. Indian Ocean Dipole (IOD) is one of the dominant interannual climate modes there, and several intraseasonal variations are believed to have interaction with IOD through oceanic bridges and/or air-sea interactions. Two of such examples will be explored in this presentation.

The first example is influence of meso-scale ocean eddy activity in the southeastern tropical Indian Ocean, which is generated by baroclinic instability in the northern part of the South Equatorial Current. Strong meridional temperature gradient associated with the IOD event results in anomalously energetic eddy activity. This causes stronger-than-normal northward eddy heat transport, which tends to reduce the meridional temperature gradient, hence a negative feedback on the IOD event itself.

Another example is impact of intraseasonal equatorial Kelvin waves on initiation of the IOD events, particularly in 2006 case. During May to August, before the 2006 IOD event, several upwelling equatorial Kelvin waves were excited by easterly wind anomalies in the equatorial central Indian Ocean. Negative subsurface temperature anomalies at the thermocline depth appeared associated with penetration of these Kelvin waves along the Sumatra coast, creating favorable conditions for cooling of the surface layer due to monsoonal upwelling in August. Constructive interaction between the two processes may set a critical condition for the generation of the 2006 IOD.

Such scale-interactions in the tropical Indian Ocean should be investigated in more detail for better understanding of mechanisms responsible for the IOD evolution and the skillful prediction of IOD.

Keywords: Indian Ocean Dipole, Intraseasonal variations, interactions, meso-scale eddy, Kelvin waves

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACG05-02 Room:201B Time:May 24 09:21-09:36

Influence of the Wyrtki Jets on the western Arabian Sea upwelling region

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The sea surface temperature (SST) in the upwelling region along the western boundary of the Arabian Sea is known to influence the Indian summer monsoon rainfall. In this study, we examine how a reflection of semiannual Kelvin waves, which is forced by westerly winds during monsoon breaks and accompanied by the Yoshida-Wyrtki Jet, may influence this region based on ocean general circulation model experiments. When results from two experiments with and without a damping near the eastern equatorial Indian Ocean are compared, the SST in the western Arabian Sea becomes colder by as much as 0.4 degree C in the latter experiment. By calculating mixed layer heat balance, it is shown that this SST difference is mainly due to a difference in horizontal advection, but is damped by surface heat flux.

Keywords: Tropical Indian Ocean, Ocean general circulation model, Equatorial wave

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACG05-03 Room:201B Time:May 24 09:36-09:51

Role of Diurnal Warm Layers in the Diurnal Cycle of Convection over the Tropical Indian Ocean during MISMO

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The role of air sea interaction in the diurnal variations of convective activity during the suppressed and developing stages of an intraseasonal convective event is analyzed using in situ observations from the Mirai Indian Ocean cruise for the Study of the Madden Julian oscillation (MJO)-convection Onset (MISMO) experiment. For the whole period, convection shows a clear average diurnal cycle with a primary maximum in the early morning and a secondary one in the afternoon. Episodes of large diurnal sea surface temperature (SST) variations are observed because of diurnal warm layer (DWL) formation. When no DWL is observed, convection exhibits a diurnal cycle characterized by a maximum in the early morning, whereas when DWL forms, convection increases around noon and peaks in the afternoon. Boundary layer processes are found to control the diurnal evolution of convection. In particular, when DWL forms, the change in surface heat fluxes can explain the decrease of convective inhibition and the intensification of the convection during the early afternoon.

Keywords: Diurnal Warm Layers, Madden-Julian Oscillation, Preconditionning, MISMO, convection

Japan Geoscience Union Meeting 2013
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ACG05-04 Room:201B Time:May 24 09:51-10:06

Cluster analysis of the intraseasonal convection and its impact on the tropical tropopause temperature

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This study investigates space-time variations of the tropical convective activities and temperatures around the tropical tropopause associated with the intraseasonal oscillation (ISO) during the southern summer by using outgoing longwave radiation (OLR) data from the National Oceanic and Atmospheric Administration and atmospheric fields from the European Centre for Medium-range Weather Forecasts Interim reanalysis data.

Cluster analysis is conducted in order to classify ISO types according to both the phase speed and the longitudinal extent of the eastward propagation. In performing cluster analysis we use the locus of convective activities observed in the unfiltered OLR data by retaining both the ISO and seasonal mean components to investigate interaction between the two. Then, the 72 ISO events in the 32 southern summers are mainly grouped into four clusters. Two of the clusters exhibit the slow (<2 m/s) propagation speed in the unfiltered OLR field and the others fast (˜4 m/s). One cluster characterized as the El Nino phase has the fast speed while passing over the date line and another as the La Nina phase has the slow speed while propagating to ˜120E. Compared with the other two clusters characterized as the weak El Nino-Southern Oscillation phase, the speed is slow while propagating to ˜135E when the SSTs over the Western Pacific are relatively low.

Low temperatures around the tropical tropopause appear to the east of the eastward-propagating convection in the tropics and to the west in the subtropics, forming a horseshoe-shaped structure. The strength of the horseshoe-shaped temperature structure is determined by that of the convective activities. Furthermore, the strength and location of the 100-hPa temperature minima differ among the clusters. This study implies that the different ISOs would cause different impacts on the dehydration process in the tropical tropopause layer depending on their types.

Keywords: Intraseasonal Oscillation, Madden-Julian Oscillation, Cluster Analysis, Teleconnection, Tropical Tropopause Layer

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACG05-05 Room:201B Time:May 24 10:06-10:21

Synchronization of thunderstorm activities and OLR in tropical regions

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Based on Global ELF observation Network (GEON) and Outgoing Longwave Radiation (OLR) intensity, we carried out a correlated analysis between the number of the lightning strokes and cloud variation in the tropical regions, focusing the variation around one month periodicity. It was found that the number of lightning stokes in the Maritime Continent (MC) varies with about month periodicity in the period from February to June 2004 and shows positive correlation (R= ?0.8) with OLR in the Western Paci?c Warm Pool (WPWP). That is, when thunderstorm activity in the MC is enhanced, the OLR in WPWP becomes large, meaning less cloud amount. On the other hand, OLR in the central Africa shows negative correlation with the number of lightning stokes in the MC in that period (R= ?-0.7). Furthermore, in the central Africa OLR seems to re?ect the number of lightning strokes, showing good correlation between them. This implies that the activities of thunderstorms both in the central Africa and in the MC oscillate in the same phase. Such a synchronization of thunderstorms or cloud amount in global scale without phase difference has not been reported and seems difficult to explain these phenomena by conventional theories. We may need to consider the variation of solar activity, such as UV or galactic cosmic rays, whose variation in the present period (Feb-Jun 2004) shows good correlation with OLR variations in tropical region.

Keywords: thunderstorm, OLR, tropical region, synchronization

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACG05-06 Room:201B Time:May 24 10:21-10:36

Relationships among Lightning, Precipitation, and Hydrometeor Characteristics in Equatorial Indonesia

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1. Introduction

Knowledge of the lightning activity is an important tool to the meteorologists. Many literatures have discussed on lightning activity for different regions. However, the studies pertaining to the variability of lightning occurrences in the equatorial Indonesia are scanty, except a few studies. Hence, in the present study, the variability of lightning activity in the equatorial Indonesia is examined, particularly at Kototabang (KT; 100.32E, 0.20S), Pontianak (PT; 109.37E, 0.00S), Manado (MN; 124.92E, 1.55N) and Biak (BK; 136.10E, 1.18S).

2 Data and Methodology

Lightning activity are observed from theWorld Wide Lightning Location Network (WWLLN) data. Following the advice of the WWLLN developers, only those lightning locations that triggered at least five sensors and that had residuals < 30 ms are included in this analysis [1]. The surface precipitation and the profiles of hydrometeors and latent heating are obtained from the products of the Tropical Rainfall Measuring Mission (TRMM) satellite. The aerosol data are retrieved from the Moderate Resolution Imaging Spectroradiometer (MODIS). Raindrop size distribution (DSD) at the surface is from a network of Parsivel disdrometers. 1.3 GHz wind profiler data at the four sites are used to determine the precipitating cloud type.

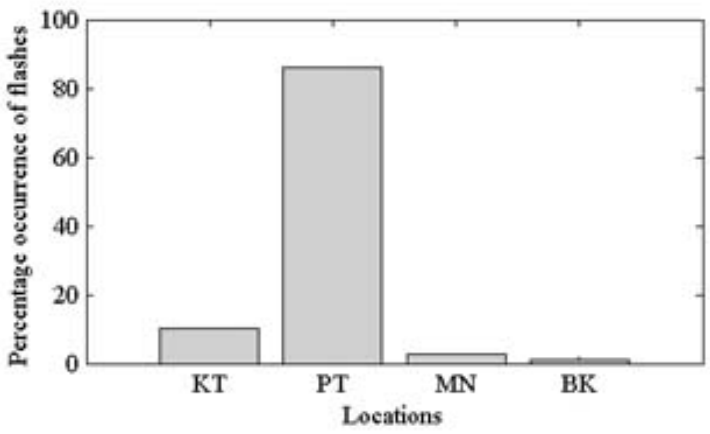
3 Results

The evidence of regional variation of precipitation microstructure (e.g., DSD) is clearly observed, and become more obvious during heavy rain. The composite spectra of PT and KT were much broader than Marshall-Palmer distribution, in contrast to the DSD at MN and BK, where the DSDs were narrow. This characteristic is consistent with the lightning activity. Figure shows regional variability of percentage occurrence of flashes. The convective storms are more intense at PT than other three sites and produce larger raindrops. Detailed analysis regarding the relationships among lightning, precipitation, and hydrometeor characteristics in equatorial Indonesia will be presented in the meeting.

References

[1] Abarca, S. F., Corbosiero, K. L., and Galarneau Jr., T. J.: An evaluation of the Worldwide Lightning Location Network (WWLLN) using the National Lightning Detection Network (NLDN) as ground truth, J. Geophys. Res., 115, D18206, doi:10.1029/2009JD013411, 2010.

Keywords: Equator, Lightning, Precipitation



Japan Geoscience Union Meeting 2013
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ACG05-07 Room:201B Time:May 24 11:00-11:18

Origin of seasonal predictability for summer climate over the Northwestern Pacific

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Summer climate in the Northwestern Pacific (NWP) displays large year-to-year variability, affecting densely populated Southeast and East Asia by impacting precipitation, temperature and tropical cyclones. The Pacific-Japan (PJ) teleconnection pattern provides a crucial link from the tropics of high predictability to East Asia. Using coupled climate model experiments, we show that the PJ pattern is the atmospheric manifestation of an air-sea coupled mode spanning the Indo-NWP warm pool. In this coupled mode, the PJ pattern forces the Indian Ocean (IO) via a westward propagating atmospheric Rossby wave. In response, IO sea surface temperature (SST) feeds back and reinforces the PJ pattern via a tropospheric Kelvin wave. Ocean coupling increases both the amplitude and temporal persistence of the PJ pattern. Cross-correlation of ocean-atmospheric anomalies confirms the coupled nature of this PJIO mode. El Nino-Southern Oscillation (ENSO) is a major external driver of the PJIO mode, leaving the last echoes of ENSO in the IO-NWP in the form of this mode. We further demonstrate that the PJIO mode is indeed highly predictable, giving hopes for skillful seasonal forecast over the densely populated region.

Keywords: air-sea coupled mode, climate variability, East Asian summer monsoon, El Nino-Southern Oscillation

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACG05-08 Room:201B Time:May 24 11:18-11:33

Recent progress in the MIROC5 seasonal prediction system and predictability of two flavors of El Nino

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This study investigates the difference of the seasonal predictability for two prominent types of El Nino, traditional eastern Pacific (EP) events and central Pacific (CP) events.

We developed a seasonal prediction system using the coupled atmosphere-ocean general circulation model (AOGCM) MIROC5 co-developed by Atmosphere and Ocean Research Institute (AORI), National Institute for Environmental Studies (NIES), and Japan Agency for Marine-Earth Science and Technology (JAMSTEC). The spatial resolution is a horizontal triangular spectral truncation at total wave number 85 (T85) with 40 vertical layers, and eight ensemble forecast members are generated according to the protocol of the WCRP Climate-system Historical Forecast Project (CHFP). Hindcast products for the period 1979-2011 show high predictability of tropical climate signals with the significant anomaly correlation coefficient skill scores, even though the ocean anomaly data assimilation is applied to the initialization process. The monsoon and Indian Ocean Dipole (IOD) indices also show predictable signals until a few months later. Interestingly, our seasonal prediction system is less affected by the ”spring prediction barrier” compared to most of the other AOGCMs.

We assess the difference of the seasonal predictability for two prominent types of El Nino, traditional EP events and recent CP events. Overall, the predictable months of CP events are shorter than EP events because CP events have less amplitude and are sensitive to atmospheric noises. It seems that this difference in predictability connects to the recent low predictability after 2000 as shown in Barnston et al. (2012). Characteristics of each error-growing process are also investigated.

Barnston, A. G., M. K. Tippett, L. L’Heureux, S. Li, and D. G. DeWitt (2012), Skill of real-time seasonal ENSO model predictions during 2002-11, BAMS, 631-651.

Keywords: seasonal prediction, ENSO, AOGCM, predictability

Japan Geoscience Union Meeting 2013
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ACG05-09 Room:201B Time:May 24 11:33-11:48

Study on a relationship between New Guinea coastal upwelling in the Bismarck Sea and onset of El Nino events

Takuya Hasegawa[1*], Toru Miyama[2], Jing-Jia Luo[3], Bunmei Taguchi[4], Ayako Seiki[2]

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We investigate oceanic and atmospheric variations related to coastal upwelling along New Guinea Island north coast before onset of El Nino event. In our previous studies, existence of the coastal upwelling and related SST cooling near New Guinea Island during December 2001 to January 2002, which was prior to onset of 2002/03 El Nino event, were shown by observational data. Furthermore, we explored cooling mechanism related to the coastal upwelling using high-resolution OGCM (OFES) hindcasts using NCEP/NCAR forcing and QuikSCAT forcing during 1981-2010. In this study, we analyze long-term output of 200-year simulation of high-resolution air-sea coupled general circulation model (SINTEX-F ver2). SST patterns similar to the observed coastal upwelling along north coast of New Guinea Island appear before onset of El Nino-like events in the SINTEX-F ver2 simulation. At those periods, positive zonal SST gradients in the western equatorial Pacific also appear in association with the SST cooling near New Guinea Island. Relatively strong westerly surface winds, which are expected by the positive SST zonal gradients, also appear in those periods. Such oceanic and atmospheric relationship is similar to that of observation for SST cooling period of December 2001 to January 2002. It might suggest that the SST cooling along north coast of New Guinea Island can relates to El Nino onset via atmospheric changes. We will also explore upper-ocean structure during the SST cooling period to further explore a relationship between the SST cooling pattern and New Guinea Island coastal upwelling before El Nino onsets using the SINTEX-F ver2 simulation.

Keywords: Air-sea interaction, coastal upwelling, Pacific warm water pool, El Nino onset

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACG05-10 Room:201B Time:May 24 11:48-12:03

Regional Climate Modeling Study of Wind Variations over Western Pacific Warm Pool before El Nino Onsets

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Regional climate modeling is an effective way to study on phenomena which found interesting in global GCMs. Regional models can play a complementary role to global models in experimental designs. While global models are free running, but may suffer from biases, regional models are bounded at lateral boundaries and achieve better realism.

Using the data of observations and global models, Hasegawa et al (2009, 2010, 2011) found strong northwesterly surface winds and cold-water upwellings along the northern coast of New Guinea often occur before El Nino onsets. They hypothesized that the cold waters generate positive zonal sea surface temperature (SST) gradient together with high SST east of the warm pool in the Western Pacific Ocean contribute to enhancement of the westerly surface winds, leading to onsets of El Nino events. The goal is to understand this region in an ocean-atmosphere coupled system. As a first step, we have conducted experiments with a regional atmospheric model. The model used in this study is the International Pacific Research Center (IPRC) Regional Atmospheric Model (iRAM) to understand the effects of the cold SST. The model covers the western Pacific Ocean with a horizontal resolution of 0.25 degree. We particularly focused on December 2001 to January 2002, as Hasegawa et al. (2009) did in their diagnostic study. The model well reproduced events of wind westerly surface winds in this region. Experiments show that wind variations near the New Guinea are responsive to local SST. Even when the lateral boundary condition is unchanged, westerly surface wind is weakened when the cold signal by the upwelling is eliminated from the SST field. We also pay attention to the role of the high mountains of New Guinea in shaping climate around this region. An experiment showed the orography of New Guinea causes rising air motion above the mountains. Recent experiments of the coupled ocean-atmospheric model (coupled to the HYbrid Coordinate Ocean Model using the Earth System Modeling Framework) will be also reported.

Keywords: El Nino, Pacific Ocean, regional model, upwelling, Tropics, convection

Japan Geoscience Union Meeting 2013
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ACG05-11 Room:201B Time:May 24 12:03-12:18

Off-equatorial influences on equatorial Atlantic variability

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Interannual-to-decadal variability in the tropical Atlantic is dominated by two modes of variability. The zonal mode governs in the equatorial Atlantic and is thought to rely on dynamics akin to El Nino-Southern Oscillation (ENSO). The meridional mode, on the other hand, involves sea-surface temperature (SST) anomalies in the northern and southern tropical Atlantic centered at 15^{o}N and 15^{o}S, respectively.

In the present study we use the NCEP reanalysis, OFES hindcast, and CSIRO Mk 3.5 coupled GCM to reexamine the dynamics governing the zonal mode. We find that equatorial wind stress forcing and ENSO-like dynamics can explain some of the observed warm events but not all of them. In particular there are warm events that occur despite easterly surface wind anomalies in the preceding months. This is due to sub-surface warm waters being advected from approximately 5^{o}N toward the equator. The sub-surface warming is ultimately related to SST anomalies in the northern tropical Atlantic, which induce wind stress curl anomalies that force downwelling just north of the equator. This suggests a mechanism by which off-equatorial ocean conditions can influence the zonal mode of variability and poses an additional challenge to skillful predictions in the region.

Keywords: tropical Atlantic, equatorial Atlantic, zonal mode, meridional mode, meridional advection

Japan Geoscience Union Meeting 2013
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ACG05-12 Room:201B Time:May 24 12:18-12:33

Locally amplified Ningaloo Nino off the western coast of Australia

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[1]The University of Tokyo, [2]JAMSTEC

Using observational and reanalysis data, the mechanism of a new climate mode off western Australia called ”Ningaloo Nino” is investigated. It is associated with positive sea surface temperature (SST) anomalies and peaks during austral summer. There are two types of Ningaloo Nino: The ”locally amplified” and ”non-locally amplified” events. The former can develop through an intrinsic unstable air-sea interaction off western Australia; an anomalous cyclone generated by positive SST anomalies forces northerly alongshore wind anomalies, which induce coastal downwelling anomalies, and enhance the warm SST anomalies.

It is found that the locally amplified Ningaloo Nino cause positive rainfall anomalies along the coast of western Australia, but the signals are subtle and the northern part tends to become drier because of a weaker monsoon.

Keywords: Ningaloo Nino, unstable air-sea interaction, coastal upwelling, western Australia, precipitation

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ACG05-13 Room:201B Time:May 24 14:15-14:33

ENSO simulation in GCMs: A review and recent progress

Masahiro Watanabe[1*]

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Changes in the activity of the El Nino-Southern Oscillation (ENSO) phenomenon under global warming could potentially have a large impact on the global weather, society, and economy, but have not so far been converged in ensembles of future scenario experiments based on multiple climate models. Using parameter ensembles of four high-end climate models with smaller errors in simulating ENSO in the present climate, we demonstrate that the ENSO will become more energetic under global warming. This occurs because the mean atmospheric state in a warmed climate is wetter over the central-eastern equatorial Pacific. The wetter mean state favours an eastward shift in the equatorial zonal wind stress response to El Nino/La Nina, which acts to increase the ENSO amplitude due to enhanced coupled instability. A careful analysis of the previous multi-model ensemble suggests a similar mechanism at work and indicates that the precipitation increase over the cold tongue region, relative to the change over the entire equatorial Pacific, is the key factor for the robust intensification of ENSO. A preliminary analysis to the CMIP5 archive, however, does not necessarily support the above conlusions.

Keywords: GCM, ENSO, Global warming

Japan Geoscience Union Meeting 2013
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ACG05-14 Room:201B Time:May 24 14:33-14:51

Mechanism for the asymmetry in ENSO transition and duration

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The El Nino-Southern Oscillation (ENSO), which consists of a quasi-periodic (3-7-yr timescale) warming (El Nino) and cooling (La Nina) of the tropical central and eastern Pacific Ocean (CEP), is the most dominant driver for Earth's interannual climate variability. ENSO prediction is of practical interests, in addition to scientific, because of its large environmental and societal impacts. To predict and understand the variability of ENSO, a number of investigators have suggested conceptual theories, providing a comprehensive idea regarding the cyclic nature of ENSO. The mechanisms in these conceptual theories effectively capture the observed phase transition from El Nino to La Nina and successfully reproduce the linear oscillation of ENSO. However, several studies have reported that a type of break in the ENSO cycle occurs when La Nina shifts to El Nino. The air-sea coupled system over the Pacific somehow remains in a weak La Nina state for up to two years, while El Nino tends to turn rapidly into La Nina after the mature phase. Recent studies (Ohba and Ueda 2009; Ohba et al. 2010; Okumura et al. 2011) have reported that the nonlinear atmospheric response to the CEP sea surface temperature forcing is a fundamental cause of the asymmetry in the transition. Because the duration of an ENSO episode can cause severe drought, for example, the 1999-2001 drought in central Asia from, and this duration is difficult to reproduce in most coupled general circulation models, understanding of the ENSO asymmetry is important for improving seasonal climate forecast skills (Ohba et al. 2010; Ohba and Watanabe 2012). Therefore, the asymmetry of transition/duration is an important aspect of ENSO. In the presentation, these recent studies will be introduced with the discussion of its long-term change and asymmetry in the ENSO predictability.

Keywords: El Nino/Southern Oscillation, Pacific Ocean, Indian Ocean

Japan Geoscience Union Meeting 2013
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ACG05-15 Room:201B Time:May 24 14:51-15:06

Prediction and Projection of Tropical Cyclone Activity over the Western North Pacific Using CMIP5 Near-Term Experiments

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In line with the experimental design for near-term climate prediction toward the 5th Assessment Report of the Intergovernmental Panel on Climate Change, we performed ensembles of initialized decadal hindcast and near-future (NF) projection using three versions of the coupled atmosphere-ocean model MIROC. In this study, interannual and multiyear predictability of tropical cyclone (TC) activity in the western North Pacific (WNP) is explored, using the initialized hindcasts. In addition, global warming impacts on WNP TC activity in the NF are also examined using the NF projection up to 2035.

The hindcasts show that year-to-year variation of TC number reasonably captures the observation. Interannual variability for TC genesis and occurrence frequency (TGF and TOF) associated with ElNino Southern Oscillation (ENSO) is found to be predictable mainly through better prediction of sea surface temperature (SST) and lower-tropospheric large-scale vorticity anomalies. These results indicate that models are able to reproduce the major basic mechanisms that link TC genesis with large-scale circulation. On the multiyear timescale, skillful prediction of TC number is likely difficult at least in our hindcasts, but three-year-mean states of hindcast started in 1998 reasonably capture observed major characteristics of TC activity associated with the Pacific climate shift during the late 1990s through the initialization.

Projected NF (2016-2035) change in WNP TC genesis number shows significant reduction (approximately 14%) especially over the western WNP even in the NF when the global warming is not so prominent compared with the end of this century. The reduction is likely due to the suppression of large-scale lower-tropospheric vorticity and relative humidity, and enhancement of vertical wind shear. The projected SST exhibits a more pronounced warming over the eastern tropical Pacific and accompanies weakening of Walker circulation via redistribution of tropical convection activity, which appears to be responsible for the change in large-scale fields in WNP.

Keywords: Tropical Cyclone, Predictability

Japan Geoscience Union Meeting 2013
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ACG05-16 Room:201B Time:May 24 15:06-15:21

Slowdown of the Walker circulation driven by tropical Indo-Pacific warming

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A suite of ship observations including sea level pressure, marine cloud, surface wind, and ocean subsurface temperature show that the Walker circulation has slowed down for the past century. The cause of this slowdown is investigated using a multi-model ensemble of atmospheric GCM simulations forced by several datasets of historical SST. The models reproduce observed changes well if the right SST datasets are used. The results show that the Walker circulation change over the past six decades was induced mostly by changes in zonal SST gradient across the Indo-Pacific Oceans, and that the warming over the Indo-western Pacific is not as large as previously thought. The widely-used SST datasets show intense warming over the tropical Indo-western Pacific, where uncertainty of SST warming trend is especially large. As a result, atmospheric GCMs forced by the conventional SST datasets tend to strengthen the Walker circulation, in disagreement with observations. The observed circulation change over the tropical Pacific contains large natural variability but provides a useful constraint on historical SST reconstruction.

Keywords: Walker circulation, Climate change, Tropical Pacific, Tropical Indian Ocean, Ocean-atmosphere interaction

Japan Geoscience Union Meeting 2013
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ACG05-17 Room:201B Time:May 24 15:21-15:36

Intercomparison of CMIP5 Ocean Model Performance for SST Variations over EEIO and its Relation to Thermocline

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The motivation of this study is to evaluate SST variations of Coupled Model Intercomparison Project (CMIP5) dataset in Eastern Equatorial Indian Ocean (EEIO) by considering the influence of subsurface ocean structure. Variations of SST are studied by applying Power spectral density (PSD) analysis on SST of CMIP5 dataset and observation of SODA dataset. Some models show stronger/weaker SST variations than observation on specific time scale. Based on the strength of SST variations relative to observation, models are divided into three groups: strong model, moderate model and normal model. Normal models have SST variations close to observation, while strong and moderate models show stronger SST variations (relative to observation) on 1-2 years, 2-3 years and 3-7 years time scale.

The cause of strong SST variations on 3-7 years time scale is related to shallow thermocline of models. Strong linearity in SST-thermocline relation may indicates more dominant influence of subsurface to SST variations on this time scale. In warming climate, relationship between thermocline and SST is still maintained; models with shallow thermocline shows stronger SST variations than models with deeper thermocline. Many models show unchanged thermocline depth, which may become the cause of a little change in SST variations on 3-7 years time scale.

Keywords: CMIP5, Eastern Equatorial Indian Ocean, Thermocline, SST variations

Japan Geoscience Union Meeting 2013
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ACG05-18 Room:201B Time:May 24 15:36-15:51

A distinct stronger warming in the tropical tropopause layer during 2000s: Association with minor volcanic eruptions

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The trends and various interannual variability components in the tropical tropopause layer (TTL) over the tropics (15oS-15oN) are examined by employing upper air data from GPS Radio Occultation (RO), radiosonde (IGRA, RICH and HadAT2) and ERA-Interim during 2001-2010. The detection capability of the GPS RO, though with limited data coverage, has been shown in previous studies. The temperature anomalies from unadjusted radiosonde (IGRA), adjusted radiosonde (RICH and HaAT2), and ERA-Interim shows favorable comparison with GPS RO except at 100 hPa in ERA-Interim data. Detail analysis of the warming observed in the TTL during 2001-2010 using both standard linear and multiple regressions is carried out. The temperature trend estimated using standard linear regression analysis (i.e. allowing the contributions from various interannual variability) reveals a strong warming of about 0.5-1.5 K/decade in the TTL (about 16-19 km) with maximum warming at about 18 km in each data during 2001-2010. Further, multiple regression analysis is performed while including various interannual components such as Quasi-Biennial Oscillation (QBO), El Nino Southern Oscillation (ENSO) and stratospheric Aerosol Optical Depth (AOD). We performed two types of multiple regression analysis considering without (method-1) and with (method-2) seasonal modulation of the interannual components. The distinct warming in the TTL is partially but not completely removed on removing the QBO and ENSO components. However, on removing the AOD along with QBO, ENSO removes the distinct warming in the TTL. Therefore, this study shows that the strong distinct warming in the TTL is associated with minor volcanic eruptions during 2000s. Positive and significant AOD responses to the temperatures of about 0.1-0.2 K/AOD-Index are observed in the TTL region which explains about 5-15% of the total variance during 2001-2010.

Keywords: Temperature trends, Climate change, Tropical tropopausue layer, El Nino Southern Oscillation, Stratospheric Aerosol Optical Depth

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Environmental conditions on the selection of MJO and moist Kelvin waves

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Moist Kelvin waves and Madden-Julian Oscillations (MJO) are dominant precipitation systems in the tropics which consist of mesoscale cloud clusters and move eastward along the equator. Not only have they different propagating velocity and convective profiles, but also they seem to prefer different environmental conditions. For example, observational studies show that moist Kelvin waves and MJO are strongly affected by different phases of the El Nino Southern Oscillation (ENSO). In this study, environmental conditions which select the development of moist Kelvin waves or MJO are examined, and then associated features of disturbances are discussed.

Intraseasonal perturbations of NOAA-OLR with eastward wave number 2 to 4 were divided into moist Kelvin waves and MJO, according to their equivalent depths. Environmental condition was defined with 3-months running mean variables of JRA reanalysis data. With regard to seasonal and zonal variations, MJO amplitude has a larger longitudinal dependency compared to seasonal variation; with local intensification from the Indian Ocean to the western Pacific Ocean, corresponding to the distribution of mid tropospheric relative humidity and vertical shear of zonal wind. On the other hand, moist Kelvin wave amplitudes and sea surface temperature (SST) show very similar intensifications from April to June at all longitudes in equatorial region. Correspondingly, in years with relatively stronger MJO amplitude compared to moist Kelvin waves, environmental midlevel relative humidity from the maritime continent to the western Pacific Ocean has high anomaly compared to an average year, indicating a La Nina pattern. In contrast, in years with relatively weaker MJO amplitude, there exist low relative humidity anomaly at midlevels in the Indian Ocean to the maritime continent and high SST anomaly in the central to eastern Pacific Ocean, indicating an El Nino pattern.

Comparing vertical profiles of the perturbations, MJO convection have deeper low level convergence than that of moist Kelvin waves. In addision, analysis of precipitation property about each continuous precipitation areas in the TRMM 2A25 PR data shows that stratiform rain ratio to total rain of mesoscale cloud systems embedded in MJO is higher than those in moist Kelvin waves. This suggests that MJOs consist of more organized mesosystems than moist Kelvin waves. These differences about convective characteristics seem to affect to the relationship between perturbations and environmental conditions such as mid tropospheric humidity or SST.

Keywords: MJO, moist Kelvin wave, ENSO

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Microstructure of Precipitation in Different MJO Phases over Sumatra

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1 Introduction

Natural variabilities of precipitation microstructure (e.g., DSD) substantially limit the accuracy of some DSD applications such as radar-derived rainfall. The aim of the present study is to investigate the intraseasonal variation of precipitation microstructure at Kototabang, west Sumatra, from long term precipitation data record.

2 Data and Methodology

The DSD observation was from a 2D-Video Disdrometer (2DVD), about eight years (end of 2002?2010). The vertical profile of DSD was from 24 GHz Micro Rain Radar (MRR). 1.3 GHz wind profiler data were used to determine the precipitating cloud type. Horizontal distribution of precipitation around 2DVD was observed by using 9 GHz X-band weather radar. Precipitation data were classified into three categories of MJO phase, i.e., (i) active, (ii) inactive/suppressed and (iii) weak MJO. Active and suppressed MJO are strong MJO phase in which the amplitude of MJO is greater than unity. For Kototabang, active convection was assumed when the MJO is during phases 2, 3, 4, and 5, and inactive/suppressed convection was assumed during phases 6-8 and 1. All cases with the amplitude of MJO being less than unity are assumed as weak MJO phase.

3 Results

During light rain, a slight difference in the DSD could be seen in which the DSD during inactive phase had more large drops than during active phase. The evidence of intraseasonal variation of DSD become more obvious during heavy rain in which the DSDs were much broader during inactive than active MJO phases, consistent with the previous study [1, 2]. Figure shows diurnal variation of percentage of rainfall contribution for several rain types during active and inactive MJO phases. During active MJO phase, shallow convective rain was dominant while deep convective rain was dominant during inactive phase. Detailed analysis regarding the intraseasonal variation of precipitation microstructure over Sumatra will be presented in the meeting.

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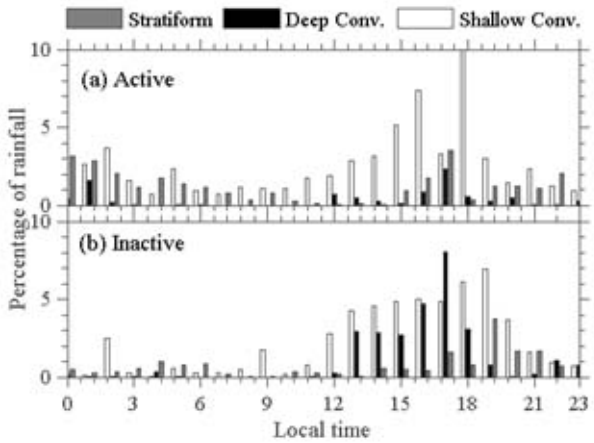
Keywords: Precipitation, MJO



Japan Geoscience Union Meeting 2013
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ACG05-P03 Room:Convention Hall Time:May 24 16:15-17:30

Variability of surface meteorology and air-sea fluxes during CINDY2011

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As a part of the CINDY2011/DYNAMO observation campaign, Research Vessel (R/V) Mirai was deployed at 8S, 80.5E in October and November of 2011. In this study, we investigate variability of surface meteorological variables and air-sea fluxes caused by atmospheric cumulus convective activity. Characteristics of convective systems observed by R/V Mirai in first half of October were quite different from those in second half of October and November.

In the former period, four mesoscale convective systems (MCSs) produced most of precipitation around R/V Mirai, associated with large-scale lower-tropospheric cyclonic circulation anomalies. Composite of the four events show that sensible heat flux was increased by approximately 20 W m^{-2} only during the passage of the MCS due to both increase in air-sea temperature difference and increase in surface wind speed. On the other hand, latent heat flux started to increase when the MCS reached the R/V Mirai, and continued to increase even after the passage of the MCS due solely to the increase in the surface wind speed. A difference in latent heat fluxes before and after the MCS events was approximately 70 W m^{-2} on average.

In the latter period, most of the observed convective events were sporadic sub-MCS-scale ones. By detecting sharp drop of surface temperature and its subsequent recovery period, we identify 22 events. Among them, 13 events consisted of only one temperature drop, while the other 9 events consisted of two times of temperature drops. We examine composite behavior of these two groups, as well as individual cases. We compare surface meteorological variables and radar reflectivity data, and find that minimum temperature is well correlated with maximum surface wind and ratio of radar echo area around R/V Mirai. Sensible and latent heat increases averaged for all the events were approximately 15 and 50 W m^{-2}, respectively.

Keywords: Surface meteorology, air-sea flux, cumulus convective activity, CINDY2011

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ACG05-P04 Room:Convention Hall Time:May 24 16:15-17:30

Persistence and the change of Baiu precipitation anomalies

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This work examines the persistence and the change of interannual Baiu precipitation anomalies during the Baiu season from late May to middle July around Japan. Atmospheric circulations affecting the Baiu precipitation are abruptly changed around late June. In the former period, the sea surface temperature anomalies (SSTAs) in the western North Pacific (WNP) associated with the El Nino/Southern Oscillation (ENSO) mainly controls the Baiu precipitation anomalies through the Pacific?East Asia teleconnection. The atmospheric circulations are characterized by specific surface pressure anomalies induced by the Rossby wave response of the SSTAs, which persist for the former period. On the other hand, the covariability of the SSTAs in the WNP and in the tropical Indian Ocean (TIO) through the ENSO is crucial for the Baiu precipitation anomalies in the later period. Anomalous atmospheric circulations are established through the Kelvin wave response from the TIO to the WNP. This response controls the Baiu precipitation anomalies in the only later period because this response needs a peculiar timing with the seasonal northward migration of the North Pacific subtropical high. Thus, the interannual variations of the Baiu precipitation in these two periods have insignificantly spatiotemporal correlations. These results suggest that detailed monitoring of SSTAs in both the WNP and the TIO can improve the predictability of the Baiu precipitation in the entire Baiu season.

Keywords: Baiu front, ENSO, Indian Ocean, Western North Pacific, air-sea interaction

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ACG05-P05 Room:Convention Hall Time:May 24 16:15-17:30

Intraseasonal Mixed Layer Temperature and Salinity Variation in the Eastern Equatorial Indian Ocean

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Atmospheric forcing from Madden-Julian Oscillation (MJO) produces sea surface temperature (SST) variation on intraseasonal timescales in the tropical Indian Ocean. In this study, we investigate the ocean mixed layer temperature variation in the eastern Indian Ocean to clarify the processes that produced the intraseasonal SST variation. We used mooring buoy data from the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) in the Indian Ocean, particularly on an eastern site at 1.5S, 90E. We focused on intraseasonal SST cooling events as an indicator of the intraseasonal variation. The buoy observation captured 14 MJO events in the Indian Ocean from November to May during 2002-2007. In general, the events accompany by large-scale SST decreases in the central and eastern Indian Ocean with the onset of atmospheric convection and westerly winds. Mixed layer temperature balance analysis demonstrated that the intraseasonal SST variation was mainly produced by surface heat fluxes, in which suppressed shortwave radiation and enhanced latent heat loss had major roles. Horizontal heat advection also acted to cool mixed layer temperature during the period, though the contribution was less than one third of the net surface heat flux. Deepening of mixed layer and low salinity signal were also observed during the events. Possible impacts of the ocean variability on the mixed layer heat content are discussed.

Keywords: Intraseasonal variation, Indian Ocean, RAMA buoy

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Indian Ocean Dipole Interpreted in Terms of Recharge Oscillator Theory

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In this paper we use sea surface height (SSH) derived from satellite altimetry and an analytical linear equatorial wave model to interpret the evolution of the Indian Ocean Dipole (IOD) in the framework of recharge oscillator theory. The specific question we address is whether heat content in the equatorial band, for which SSH is a proxy, is a predictor of IOD development as it is for El Nino and the Southern Oscillation (ENSO) in the Pacific. We find that, as in the Pacific, there are zonally coherent changes in heat content along the equator prior to the onset of IOD events. These changes in heat content are modulated by wind-forced westward propagating Rossby waves in the latitude band 5-10S, which at the western boundary reflect into Kelvin waves trapped to the equator. The biennial character of the IOD is affected by this cycling of wave energy between the equator and 5-10S. Heat content changes are a weaker leading indicator of IOD sea surface temperature anomaly development than is the case for ENSO in the Pacific though because other factors are at work in generating IOD variability, one of which is ENSO forcing itself through changes in the Walker Circulation.

Keywords: Indian Ocean Dipole, Ocean-Atmosphere Interactions, Climate Variability, Equatorial Waves, ENSO

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Seasonal prediction by SINTEX-F

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The SINTEX-F seasonal forecast system has demonstrated excellent performance of prediction on the ENSO and the IOD (Luo et al., 2005a, 2007, 2008a, 2008b, Jin et al., 2008). However, we found that the prediction skill is relatively low for the decay phase of the La Nina events, the IOD development phase, and the Atlantic Nino/Nina events. In particular, we would like to talk about the reason why the prediction of the 2012 positive Indian Ocean Dipole Modes was difficult. Also, we will present pre-results about the next generation of the seasonal forecast system on a basis of SINTEX-F2 (the atmospheric component (ECHAM5) has a resolution of 1.18 (T106) with 31 vertical levels and the oceanic component (OPA9) has 0.5∗0.5 degree horizontal mesh with sea ice model).

Keywords: climate mode, tropics, seasonal prediction

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ACG05-P08 Room:Convention Hall Time:May 24 16:15-17:30

Simulation of tropical-temperate troughs over southern Africa: Impacts of convection schemes

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Southern African summer rainfall simulated in three versions of an atmospheric general circulation model differing only in the convection scheme is examined with a special focus on tropical temperate troughs (TTTs). All three versions provide satisfactory simulations of key aspects of the summer (November-February) rainfall, such as the spatial distribution of total rainfall and the percentage of rainfall associated with TTTs. However, one version has a large bias in the onset of the rainy season. Results from self-organizing map (SOM) analysis on daily precipitation data revealed that this is because the occurrence of TTTs is underestimated in November. This model bias is not related to westerly wind shear that provides favorable condition for the development of TTTs. Rather, it is related to excessive upper level convergence and associated subsidence over southern Africa, which is forced by strong convection in the far western tropical Pacific.

Furthermore, the models are shown to be successful in capturing drier (wetter) conditions over the southern African region in El Nino (La Nina) years. The SOM analysis reveals that nodes associated with TTTs in the southern (northern) part of the domain are observed less (more) often during El Nino years, while nodes associated with TTTs occur more frequently during La Nina years. Also, nodes with dry condition over southern Africa are more (less) frequently observed during El Nino (La Nina) years. The models tend to perform better for La Nina, because they are more successful in capturing the frequency of different synoptic patterns.

Keywords: El Nino/Southern Oscillation, Atmospheric general circulation model, Self-organizing map

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ACG05-P09 Room:Convention Hall Time:May 24 16:15-17:30

Possible remote influence on pacific decadal variability and predictability

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We explore causes of less skills in hindcasting recent decadal climate changes, such as the Pacific decadal variability and the so-called hiatus of global warming tendency in the 2000s. As the hiatus forms a negative Pacific Decadal Oscillation (PDO)-like spatial pattern, together with the warming tendency in the extratropical North Atlantic relating to the Atlantic Multidecadal Oscillation and the strong temperature rising in the Indian Ocean, here we focus on the sea surface temperature (SST) tendency in the Pacific and on possible remote influences from other oceans. The Pacific decadal variability is generally regarded as an internal fluctuation in the climate system and, when statistically analyzing sets of initialized decadal hindcasts for recent decades, errors in initial state of the tropical Pacific SST can control skills in predicting extratropical SST variability relating to the PDO. By performing some sensitivity experiments using global climate models, in addition, we also find small but significant impacts of the other oceans on some stages of the Pacific decadal variability. While our ability to predict decadal variations in each ocean is limited at this stage, except for the high latitude of the North Atlantic, further understanding of these remote influences in addition to the inherent decadal fluctuations over the Pacific Ocean can help us to enhance the predictability of decadal climate changes.

Keywords: climate prediction, decadal variation, initialization, climate model

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Low-frequency variations of the zonal dipole sea surface temperature pattern in the South Indian Ocean

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Temporal variations of monthly sea surface temperature (SST) anomalies from 1951 to 2012 are investigated using observational dataset (ERSST: Smith et al., 2008). To explore large-scale SST patterns, we perform an empirical orthogonal function (EOF) analysis in the South Indian Ocean [20E-120E, 55S-Equator]. The first EOF mode (35%) represents an increasing tendency and the second EOF mode (13%) presents the Indian Ocean subtropical dipole (IOSD) pattern, as shown by Behera and Yamagata (2003). The third EOF mode (9%) has an east-west seesaw pattern, whose boundary lies at 90E: the centers of action are located around [70E, 30S] in the positive area and [110E, 30S] in the negative area. The time coefficient tends to have low-frequency variations: positive phases in the 1970s and 2000s, and negative phases in the 1960s and 1990s.

We specifically focus on the third EOF mode. We propose an zonal dipole index (ZDI) showing an activity of the third EOF mode based on the SST anomalies: the ZDI is defined as the SST anomalies averaged within the central South Indian Ocean [65E-75E, 35S-25S] minus SST anomalies averaged within the eastern side of the basin [110E-120E, 35S-25S], and then the ZDI is normalized using a standard deviation. Because the correlation coefficient between the ZDI and the time coefficient of the third EOF mode is 0.80, results obtained using the ZDI are not substantially different. We investigate temporal feature of the ZDI by applying a power spectral analysis. Result shows that the dipole SST pattern has a low-frequency variation on decadal (about 15 years) timescale. In addition, we investigate monthly dependence of the zonal SST pattern using the root mean square. Result shows that the SST pattern is dominant during austral summer (January to March).

We investigate causes of the zonal dipole SST pattern by applying a correlation analysis for various variables such as SST, sea level pressure (SLP), sea surface wind, and vertical velocity through the troposphere. Here, we use the JFM mean values. The correlation analysis with the ZDI shows existence of positive SLP anomaly with the downward anomaly located around [90E, 20S]. Therefore, we can point out that the zonal dipole SST pattern results from changes in surface wind related to the SLP variations. Interestingly, the ZDI shows significant correlations in the western equatorial Pacific: positive SST pattern, negative SLP pattern, and upward anomaly throughout the troposphere. The SST spatial structure resembles the El-Nino Modoki: an obtained coefficient between the ZDI and the Modoki index is 0.30 (0.54 of 1981-2012). Therefore, we expect that changes in zonal atmospheric circulation, that is, Walker circulation, associated with the western equatorial Pacific SST variations can form the zonal dipole SST pattern in the South Indian Ocean.

Keywords: subtropical Indian Ocean, low-frequency variability, sea surface temperature, tropical atmosphere