Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-01 Room:301A Time:May 22 13:45-14:03

Global monsoon and ENSO -Inherent interactive feedback-

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Keywords: global monsoon, air-sea interaction, Indian Ocean dipole mode

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AAS23-02 Room:301A Time:May 22 14:03-14:18

A new perspective on the weak relationship between ENSO and Atlantic Ninos

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While it has long been documented that ENSO has a strong influence on the northern tropical Atlantic, there appears to be no clear link with equatorial Atlantic variability. Thus the correlation between Pacific Ninos and equatorial Atlantic warm events (also called Atlantic Ninos) is rather weak, about -0.1 when ENSO leads by two seasons. Several attempts have been made to explain this weak relationship but a comprehensive understanding remains elusive. This is partly due to the small number of well-documented events, and partly to the poor representation of tropical Atlantic climate in general circulation models (GCMs). The present study re-examines the problem using satellite-era reanalyses and observations as well as GCMs with comparatively realistic representations of tropical Atlantic climate. We find that in both observations and GCMs the influence of tropical Pacific SST on equatorial Atlantic surface winds is strongly seasonal, with pronounced impacts limited to boreal spring. During this season negative Pacific SST anomalies induce equatorial surface westerlies in the tropical Atlantic. In GCMs these equatorial westerlies lead to a deepening of the thermocline, which is typically followed by an Atlantic Nino one season later. Thus the correlation between tropical Pacific SSTs and Atlantic Ninos is about -0.5 when the Pacific leads by two seasons. In observations and reanalyses, on the other hand, the relation between equatorial Atlantic winds and Atlantic Ninos is much weaker. Thus, in both models and observations ENSO induces similar wind patterns over the western equatorial Atlantic in MAM. In observations, however, this wind stress forcing is only one of the factors controlling the evolution of equatorial SSTs. Other factors controlling equatorial Atlantic SSTs will be discussed.

Keywords: ENSO, Atlantic Nino, correlation, surface wind

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AAS23-03 Room:301A Time:May 22 14:18-14:33

The Pacific-Japan teleconnection pattern as an atmospheric internal mode and influence of ENSO

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The Pacific-Japan (PJ) pattern is one of the dominant atmospheric teleconnection patterns that influence East Asian summer climate. The pattern is characterized by meridional dipoles of precipitation and lower-tropospheric circulation over the western North Pacific. While its correlation with decaying El Nino-Southern Oscillation (ENSO) is widely known, recent studies suggested that the PJ pattern is an atmospheric internal mode of variability.

In order to assess this possibility, we have conducted two sets of ensemble experiments based on a coupled general circulation model (CM) and its atmospheric component (AM) developed at U.S. Geophysical Fluid Dynamics Laboratory (GFDL). In CM, sea surface temperature (SST) anomalies are restored toward historical values over the equatorial eastern Pacific, so that the model reproduces historical ENSO. For AM, we have prescribed ensemble-mean SST of the CM commonly to all ensemble members. Thus ensemble-mean anomalies represent variability associated with ENSO, while deviations from ensemble means extract ENSO-independent anomalies in CM and atmospheric internal variability in AM.

Our empirical orthogonal function (EOF) analysis of monthly anomalies detects the PJ pattern as the leading mode both from ensemble-mean and inter-member variance of CM. This result indicates that the PJ pattern exists in the absence of ENSO. Our additional EOF analysis of inter-member AM anomalies reveals that the PJ pattern is an atmospheric internal mode. Yet, the ensemble-mean PJ pattern correlates with both developing and decaying ENSO, and it is revealed that ENSO forces about 40% of the monthly PJ variance. This considerable ENSO forcing is consistent with an interdecadal amplification of the PJ pattern after the mid-1970s climate regime shift and an intensification of ENSO.

Keywords: the summer western North Pacific, GCM, mode of variability

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AAS23-04 Room:301A Time:May 22 14:42-15:00

Variability and change in sea level in the tropical Pacific

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Sea level rise observed in the past 100 years and projected by climate models shows its relationship to the anthropogenic climate change. In addition to the global mean, regional sea level rise has a crucial impact on islands and countries face the ocean. Furthermore, regional sea level varies on a variety of time scales from interannual to multi-decadal and closely relates to natural climate variability. In the Equatorial Pacific (EP), zonal gradient of sea level anomalies has a positive long-term trend (eastern EP $>$ western EP) from 1950s to 1990s century and a negative trend from the late 1990s. Subtropical cell in the North Pacific weakened in the second half of the last century and strengthened at the late 1990s, which is associated with multi-decadal variability in the trade wind over the tropical Pacific. These variations are consistent with those of the Pacific Decadal Oscillation (PDO) whose phase reversal occurred in 1976/77 and near 2000. However, mechanisms of the decadal-to-multi decadal variability are still unclear. Recent increasing occurrences of a new type of the El Nino/Southern Oscillation(ENSO)(Central Pacific ENSO/ENSO Modoki) also influence the decadal variability of the sea level in the equatorial Pacific. Walker circulation weakened during the 20th century, which leads to a positive trend of zonal gradient of the sea level anomalies and accelerates (decelerates) sea level rise regionally in the eastern (western) EP. It also should be noted that a negative trend of zonal gradient of sea level anomalies observed in the last two decades is a part of the multi-decadal variability of the sea level in the tropical Pacific. Future projections associated with the global warming by climate models show that the Walker circulation could weaken in the 21th century. Regional sea level variability and change in the tropical Pacific and its relationship to climate variability and change are discussed using observed data and model simulations for the present and future climates.

Keywords: sea level, tropical Pacific, ENSO, Pacific Decadal Oscillation, global warming

Japan Geoscience Union Meeting 2012
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AAS23-05 Room:301A Time:May 22 15:00-15:15

Regional patterns of tropical Indo-Pacific climate change linked to the Walker circulation slowdown

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Regional patterns of tropical Indo-Pacific climate change are investigated over the last six decades based on a synthesis of in situ observations and ocean model simulations, with a focus on physical consistency among sea surface temperature (SST), cloud, sea level pressure (SLP), surface wind, and subsurface ocean temperature. A newly developed bias-corrected surface wind dataset displays westerly trends over the western tropical Pacific and easterly trends over the tropical Indian Ocean, indicative of a slowdown of the Walker circulation. This pattern of wind change is consistent with that of observed SLP change showing positive trends over the Maritime Continent and negative trends over the central equatorial Pacific. Suppressed moisture convergence over the Maritime Continent is largely due to surface wind changes, contributing to observed decreases in marine cloudiness and land precipitation there. Furthermore, observed ocean mixed layer temperatures indicate a reduction in zonal contrast in the tropical Indo-Pacific characterized by larger warming in the tropical eastern Pacific and western Indian Ocean than in the tropical western Pacific and eastern Indian Ocean. Similar changes are successfully simulated by an ocean general circulation model forced with the bias-corrected wind stress. Whereas results from major SST reconstructions show no significant change in zonal gradient in the tropical Indo-Pacific, both bucket-sampled SSTs and nighttime marine air temperatures show a weakening of the zonal gradient consistent with the subsurface temperature changes. All these findings from independent observations provide robust evidence for ocean?atmosphere coupling associated with the reduction in the Walker circulation over the last six decades.

Keywords: climate change, Walker circulation, air-sea interaction, tropical Indo-Pacific

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AAS23-06 Room:301A Time:May 22 15:30-15:45

Changes in intensity of the wintertime North Pacific Subtropical High on quasi-decadal timescale

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Temporal variations of the North Pacific Subtropical High (NPSH) intensity, which is defined by the sea level pressure averaged within a region of 120?145W, 20?40N, during 60 winters from December 1950/February 1951 to December 2009/February 2010 are investigated using the National Centers Environmental Prediction/National Center Atmosphere Research (NCEP/NCAR) reanalysis dataset. The months from December to February correspond to the period having peak winter conditions in the atmosphere field. The NPSH shows a dominant quasi-decadal (about 10 years) intensity variation and has an equivalent barotropic structure in the vertical direction through the troposphere. The tripole pressure system associated with quasi-stationary Rossby wave packet propagation is found over the wide regions from the NPSH to the Gulf of Mexico: in the strengthening phases of the NPSH, the pressure weakens over the central Canada and strengthens over the Gulf of Mexico. The spatial structure has a resemblance with the Tropical Northern Hemisphere (TNH) teleconnection pattern detected by the Barnston and Livezey (1987, Monthly Weather Review): actually, the NPSH intensity has a significant correlation (R = 0.54) with an index of TNH defined by a rotated empirical orthogonal function (REOF) analysis for the geopotential height at 700hPa field. Changes in the wind associated with the NPSH-related teleconnection pattern impart large impacts on the surface air temperature and precipitable water fields over the America: the associated northerly wind brings cold/dry air onto the western American region and the southerly wind brings the warm/wet maritime air onto the eastern part of the American.

The statistical analyses such as a composite analysis and a correlation analysis show significant relationships between the NPSH and sea surface temperature (SST); a zonal dipole SST structure is found in the tropical ocean: positive SST anomalies are distributed in the western part of tropical ocean and negative anomalies are in the eastern part of tropical ocean in the strengthening phases of the NPSH. The SST pattern is similar to that related to the El Nino/Southern Oscillation (ENSO): actually, the NPSH intensity has a significant correlation (R = ?0.54) with the Nino?3.4 index defined as SST averaged of 120?170W, 5S?5N. A composite analysis shows that, in the La Nina events, a Hadley cell characterized by a upward flow in the northern tropical Pacific around 150W, 15N and a downward flow in the subtropical Pacific region around 140W, 30N is formed locally and resultantly causes a strengthening of the NPSH. It can be pointed out that the NPSH intensity and the NPSH-related teleconnection pattern, i.e., TNH pattern, are induced mainly by the quasi-decadal time scale ENSO found in the recent analysis (Hasegawa and Hanawa 2006, Journal of Oceanography).

Keywords: North Pacific Subtropical High, TNH teleconnection pattern, quasi-decadal timescale, ENSO

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AAS23-07 Room:301A Time:May 22 16:00-16:18

Intraseasonal variability of ocean surface in the western Pacific warm pool and its connection with typhoon activity

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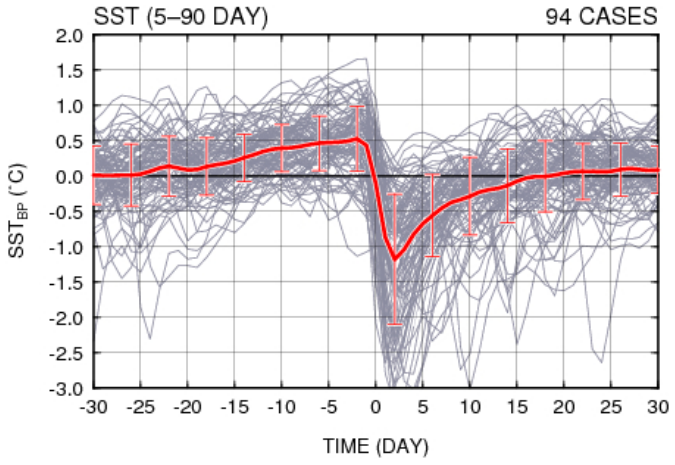
It is known that convective activity over the western Pacific warm pool varies in intraseasonal time scale (30-90 days). Recent studies suggest that frequency of tropical cyclone increases significantly during a convectively active phase. It is also known that a tropical cyclone can intensify through the supply of energy from ocean surface, and a significant cooling of ocean surface is sometimes observed just after the passage of a tropical cyclone. However, the variability in an oceanic mixed layer associated with tropical convective activity is not fully understood. In the present study, the variability of ocean surface layer in a time scale shorter than 90 days is examined using satellite-derived sea-surface temperature and vertical profiles observed by high-repetition drifting floats. The relevance of the short-term variation with tropical cyclone activity is discussed.

A spectral analysis of sea surface temperature (SST) was performed using satellite-derived dataset for 23 years (1988-2010). Results show that there is no significant peak of power spectral density but almost equal power in the bandwidth of 5-90 day, meaning the prevalence of irregular variation (like white noise) in the intraseasonal time scale. A close inspection of the variation in each year revealed that this irregularity was resulted from a mixture of signals in various time scales, such as 60-day cycle in 2004 and 20- or 30-day since 2008. This short-term variation has from one third to equal strength of power relative to the semiannual and annual variations.

The close inspection also revealed that many of short-term variations with significant amplitude were associated with tropical cyclone activity. Using tropical cyclone best-track data, a change in sea-surface temperature at grid points along each tropical-cyclone track was analyzed. Results show that a sequence of warming (˜ +0.5K) prior to the passage and significant cooling (˜ -1.0K) after that is a common feature of variation associated with a tropical cyclone (as shown in the attached figure). The time scale of the sequence varies among cases but was usually in between 20 and 60 days. In many cases, a tropical cyclone track coincided with an area where SST significantly increased. This means that a preconditioning of ocean surface usually occurs before a tropical cyclone comes. The vertical profiles of water temperature observed by high-repetition (1 time/day) drifting floats showed that the set of warming and cooling occur in a whole depth (˜ 50m) of a surface mixed layer.

The results of the present study indicate that the western Pacific warm pool is characterized by irregular variation of ocean mixed layer associated with tropical-cyclone activity in intraseasonal time scale.

Keywords: air-sea interaction, tropical cyclone, tropical meteorology



Japan Geoscience Union Meeting 2012
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AAS23-08 Room:301A Time:May 22 16:18-16:33

The interaction between the Madden-Julian Oscillation and ENSO in the tropical Pacific

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The Madden-Julian oscillation (MJO) is the dominant intraseasonal mode in the tropics and sometimes causes synoptic-scale disturbances accompanied by strong equatorial westerly winds, termed westerly wind bursts (WWBs). WWBs over the Pacific have been known to accelerate El Nino through exciting oceanic Kelvin waves. In this study, MJO behaviors and oceanic responses under the different El Nino-Southern Oscillation (ENSO) phases are examined. During the El Nino developing phases, strong westerly wind forcing and downwelling oceanic Kelvin waves are found in association with MJO convection in the western and central Pacific. On the other hand, the equatorial wind forcing and oceanic responses are weak during the other ENSO phases even though MJO convection has almost the same amplitude. Thus, favorable background states for the WWB generation from MJO and in turn strong impacts on the ocean are associated with ENSO phases.

Keywords: MJO, ENSO, westerly wind bursts

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AAS23-09 Room:301A Time:May 22 16:45-17:00

Observational and model studies on relationship between coastal upwelling in the Bismarck Sea and El Nino events

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We investigate variations of oceanic thermal condition, upper-ocean currents, and surface winds in the western equatorial Pacific, especially in the Bismarck Sea east of New Guinea, using observational data and high-resolution OGCM (OFES) hindcasts, and long-term simulation of high-resolution air-sea coupled global model (SINTEX-F2).

During December 2001-January 2002, coastal upwelling occurred along the Papua New Guinea (PNG) coast, and then upwelled relatively cool water spread out over a wider area to the northeast. Simultaneously, strong northwesterly surface winds occurred along the north coast. At that time, a northeastward outflow toward the equator from the PNG coastal area is also found. This northeastward outflow could bring the upwelled relatively cool coastal water, to the western equatorial South Pacific near PNG. The present results indicate that northeastward transport of the cold water is related to the complicated upper-ocean currents in the Bismarck Sea, and that would strongly affect the upper-ocean thermal change in the western equatorial Pacific near PNG in association of coastal upwelling before the onset of 2002/2003 El Nino event.

It is also shown that the relatively cold water related to the coastal upwelling generates positive zonal gradient of SST in the western equatorial Pacific. At that time, intraseasonal strong surface westerly winds occur in this region. Such relationship between strong surface westerly winds and positive SST gradient in the western equatorial Pacific is consistent with those expected from previous theoretical and model studies.

Furthermore, similar SST patterns to the observed SST pattern during PNG coastal upwelling are also found in 200-year simulation of high-resolution air-sea coupled general circulation model (SINTEX-F ver2). Roughly a half of such SST cooling events appear prior to the El Nino events. The present study suggests that the small-scale phenomenon related to PNG coastal upwelling can contribute to onset of El Nino events via oceanic and atmospheric changes in the western equatorial Pacific.

Keywords: coastal upwelling, El Nino event, tropical western Pacific, airi-sea interaction, intraseasona-to-interannual scale

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AAS23-P01 Room:Convention Hall Time:May 22 17:15-18:30

Role of Vertical Mixing Induced by Small Vertical Scale Structures above and within the Equatorial Thermocline in a CGCM

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Recent measurements of ocean currents available at high vertical resolution capture vertical scales down to the order of O(10m). These new measurements showed numerous small vertical scale structures (SVSs) are present in and above the thermocline in the western equatorial Pacific [Richards et al., 2012]. The estimated vertical diffusion coefficient was found to vary from 10^{-5} to 10^{-3} m^2s^{-1} from the core of the thermocline to the base of the surface mixed layer. This is in stark contrast to the estimated diffusion coefficients below the thermocline in equatorial waters, which is found to be as low as 10^{-6} m^2s^{-1} [Gregg et. al, 2003].

The vertical scale of the SVSs is such that they are unresolved in ocean general circulation models with conventional vertical resolution. The vertical mixing originating from the SVSs, therefore, needs to be parameterized and its impact investigated. In this study, as a first step towards gaining an understanding of the likely role of SVS induced mixing in the dynamics of the equatorial ocean we employ a simple method for parameterization of the SVS mixing, and focus on the impacts of the SVS mixing on the climatological state and El Nino/Southern Oscillation (ENSO) in the equatorial Pacific.

We have performed a total of three simulations with and without parameterized SVS mixing by using a coupled general circulation model. Only the elevated background vertical diffusivity coefficients which represent the SVSs are different between the simulations. For the control run (CTL: without SVS mixing), the background vertical diffusivity coefficient is set to be a constant 1.0x10^{-6} m^2s^{-1} throughout the water column in the whole computational domain. In the runs with SVS mixing, the enhanced mixing induced by SVSs in the equatorial Pacific is represented as the elevated background vertical diffusivity coefficient. To reflect the observations that the SVS enhanced mixing appears to occur in the upper water column down to the center of the thermocline [Richards et al., 2012], we introduce a run with SVS enhanced mixing (SVS_C: stratification-independent SVS mixing) in which background diffusivity in the upper water column down to the 20C isotherm is set to be a constant 5.0x10^{-5} m^2s^{-1}. Below the 20C isotherm, the background vertical diffusivity is set to the control value of 1x10^{-6} m^2s^{-1}. The enhanced diffusivity is applied to the tropical Pacific (5S-5N, 140E-70W). We perform an additional run with SVS enhanced mixing, SVS_N2 (stratification-dependent SVS mixing), in which the level of the enhanced mixing is inversely proportional to the square of the buoyancy frequency. This parameterization is prompted by the observation that variation of the level of the vertical diffusivity is caused by variation in the stratification [Richards et al., 2012].

It is found that the SVS-induced mixing leads to a reduced stratification above the thermocline. The reduced stratification leads to an increase in the vertical diffusivity which feeds back to further reduce the stratification and tighten the thermocline. The sharpened thermocline limits the exchange of heat across the thermocline and traps the surface heating above the thermocline. As a result, SST in the eastern equatorial Pacific is warmed by the SVS enhanced mixing. Furthermore, the warming of the SST is strengthened through the ocean-atmosphere feedbacks in the coupled system: Bjerknes feedback [Bjerknes, 1969] and SST-shortwave feedback [Klein and Hartman, 1993]. We also find that the SVS-induced mixing changes a few characteristics of ENSO. There is a reduction in the amplitude of ENSO brought about by a deepening of the thermocline. Moreover, stratification-independent SVS mixing reduces the skewness of ENSO, while stratification-dependent SVS mixing leads to a warming of the cold tongue and deepened thermocline during La Nina conditions, which increases the skewness of ENSO.

Keywords: small vertical scale structures, vertical mixing, coupled general circulation model, El Nino

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AAS23-P02 Room:Convention Hall Time:May 22 17:15-18:30

Impacts of the South China Sea Throughflow on the tropical Pacific

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Impacts of the South China Sea throughflow (SCSTF) on the tropical Pacific are investigated using the University of Tokyo coupled general circulation model. It is found that the period of ENSO becomes longer when the SCSTF is blocked. Since no large difference is seen in the phase speed of Kelvin waves when vertical mode decomposition is conducted, the differnce is not due to the change in stratification of the equatorial Pacific. Rather, it is more related to the larger discharge of heat through the Indonesian Throughflow.

Keywords: South China Sea, El Nino/Southern Oscillation, Coupled general circulation model, Indonesian Throughflow

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AAS23-P03 Room:Convention Hall Time:May 22 17:15-18:30

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 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, Indian Ocean, Pacific Ocean, Sea surface temperature

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AAS23-P04 Room:Convention Hall Time:May 22 17:15-18:30

Sea surface heating in the central North Pacific associated with La Nina and intensification of the subarctic front

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[1]Japan Agency for Marine-Earth Science and Technology, [2]Kyoto University

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Keywords: El Nino, La Nina, Sea surface temperature, Sea surface heat flux, North Pacific subarctic front

Japan Geoscience Union Meeting 2012
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AAS23-P05 Room:Convention Hall Time:May 22 17:15-18:30

Interdecadal variability of western North Pacific summer monsoon through the PJ pattern

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Pacific-Japan (PJ) pattern is known as a basic pressure pattern during summer over the western North Pacific and is correlated to hot and cold summer in Japan (Nitta 1987, Koasaka and Nakamura 2006). PJ pattern is also known as a remote response from interannual variability of warm anomaly of summer Indian Ocean after the El Nino which suppresses the convection over Philippines and enhances Baiu/ Meiyu activity (Xie et al. 2009). In this study, we defined new PJ pattern index using station data and reproduced PJ pattern from 1897 to 2009, and investigated the interdecadal variability of summer monsoon activity over the western North Pacific.

The first mode of EOF analysis using 850hPa vorticity during summer and PJ pattern using the difference of both major pressure seesaw points of Yokohama and Hengchun during summer are correlated well of 0.80. Therefore PJ pattern is defined as a difference of surface pressure data between Yokohama and Hengchun.

PJ pattern and the preceding ENSO have high correlation after 1970s. However this correlation becomes unclear before 1970s. It is interesting to convey that the correlation between PJ pattern and ENSO is also high before 1910. The relation with PJ pattern and summer temperature in Japan and summertime tropical cyclone activity will be also discussed.

Keywords: monsoon, interdecadal variability, western North Pacific

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AAS23-P06 Room:Convention Hall Time:May 22 17:15-18:30

Phase reversal and periodicity of the decadal and bi-decadal ENSO-like variabilities controlled by South Pacific Ocean

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Phase reversal mechanisms of the Pacific ENSO-like variability on decadal timescales are investigated based on a pair of the climate model experiments consisting of the control run (CTRL) and the partial blocking run (PB) where model temperature and salinity are restored to their climatological values near 10 degrees south in the South Pacific. In CTRL, positive anomalies in the tropics and negative anomalies in the North Pacific mid-latitudes are found in the first EOF mode of the sea surface temperature with significant decadal and bi-decadal periods. On the other hand, in PB, the former tropical signals are not appeared and only the mid-latitude signals are identified. It is robustly demonstrated that oceanic signals of the South Pacific origin are keys in maintaining the ENSO-like variability. By separating oceanic signals in CTRL into decadal and bi-decadal components, it is also shown that relatively faster oceanic wave adjustments triggered by changes of wind-stress curl in the South Pacific extra-tropics for the decadal and slower mean isopycnal advection of subsurface temperature anomalies associated with modification of South Pacific eastern subtropical mode water for the bi-decadal are essential in the phase reversal of respective periods. Periodicity of the decadal (bi-decadal) variability is determined mainly by propagation time of the oceanic subsurface signals from the South Pacific extra-tropics (mid-latitudes) to the tropics.

Keywords: PDO, decadal ENSO

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AAS23-P07 Room:Convention Hall Time:May 22 17:15-18:30

Inpact of tropical instability waves on ENSO characteristics

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In this study, the impact of TIWs in the Pacific Ocean on El Nino/Southen Oscillation (ENSO) is investigated by introducing a new scheme of TIWs into our AOGCM MIROC with medium resolution.

Tropical instability waves (TIWs) are equatorial sub-synoptic-scale eddies observed both in the Pacific and Atlantic Oceans as cusp-shaped frontal waves propagating westward during the second half of the year, and are an important mechanism for distributing heat in the meridional direction. Recently, Yu and Liu (2003) showed that TIW intensity increases during La Nina years and is reduced during El Nino years with a linear relationship, which is related to the mechanism generating baroclinic instability. Furthermore, An (2008) suggested that TIWs could play an important role in producing the asymmetry between El Nino and La Nina. It is suggested that asymmetric heat transport associated with TIWs which are active (inactive) during La Nino (El Nino) gives an significant asymmetric negative feedback to ENSO, and explain the observed asymmetric feature of stronger-amplitude El Nino and weaker-amplitude La Nina asymmetry. However, there are several potential nonlinear processes causing the asymmetric behavior of ENSO in the tropical air-sea coupled system. The ENSO model presented by An (2008) is too simple to confirm the TIW contribution in the presence of other potential processes causing ENSO asymmetry. In this study, we investigated the impact of TIWs on ENSO characteristics in the mixture of nonlinear processes using an atmosphere and ocean general circulation model (AOGCM) MIROC. 100-year integrations were performed with and without the TIW parameterization which was the first attempt to represent the TIW-induced baroclinic eddy heat transport (Imada and Kimoto 2012).

A comparison between two experiments figured out important roles of baroclinic eddies in ENSO characteristic. One is the responsibility of TIWs for ENSO asymmetry. The GCM run with the TIW scheme showed larger skewness of sea surface temperature (SST) anomalies in the ENSO active region, which supports An (2008). Its effect was dominant compared with the other asymmetric sources such as nonlinear dynamical heating of ENSO (An and Jin 2004).The other role of baroclinic eddies is to change the mechanism of ENSO phase transition from a SST mode (Neelin et al,. 1998 ;Guilyardi, 2006) to a thermocline mode (Guilyardi, 2006) due to the stratification modified by the eddy heat transport around the off-equatorial thermocline. It also promotes the lower frequency of ENSO.

The resulting changes in ENSO characteristics are consistent with the observed ENSO modulation including increase of period, asymmetry, and shift from SST to thermocline mode, concurrent with the observed 1970's climate shift. The result of ocean assimilation conducted by high-resolution AOGCM also shows the increasing TIW activity through the increasing meridional density gradient in the eastern tropical Pacific associated with the climate shift. Therefore, this numerical approach provided a new suggestion that TIWs have an important role in the interaction between the Pacific decadal variability and ENSO, and have possibility to contribute to the understanding of them.

Keywords: El Nino/Southern Oscillation, Tropical instability waves, Atmosphere and Ocean General Circulation Model, parameterization

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P08 Room:Convention Hall Time:May 22 17:15-18:30

Pausing of the ENSO cycle: A case study for 1998 to 2002

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The heat balance of the surface mixed layer at the eastern equatorial Pacific Ocean (0, 140W) is examined to find mechanisms of the transition from 1998 La Nina to 2002 El Nino. The observations from the Tropical Atmosphere Ocean/Triangle Trans-Ocean Buoy Network (TAO/TRITON) are used. In the analysis period, La Nina lingers and El Nino does not immediately appear despite a deepened thermocline, which is described as ”pausing of ENSO cycle” by previous studies (e.g., Kessler 2002). The results from heat balance analysis show that the vertical heat advection anomaly and surface heat flux anomaly warm the mixed layer from 1999 to 2002, causing rise of the mixed layer temperature. A cooling anomaly due to horizontal heat advection counteracts the warming and slows down the transition from La Nina to El Nino. It is found that the eddy heat flux anomaly associated with weakened tropical instability waves significantly contributes to the cooling anomaly. During the normal period, meridional shear of the zonal currents between South Equatorial Current and North Equatorial Counter Current supplies energy via barotropic instability to tropical instability waves, giving rise to warming of equatorial cold tongue due to eddy heat flux. The Trade Winds are relaxed and South Equatorial Current is weakened during the transition from La Nina to El Nino, which results in weakening of the meridional shear of the zonal currents, decrease of tropical instability wave energy and thus reduction of warming due to eddy heat flux. The results presented here illustrate that the eddy activity has sizable influence on ENSO cycle in addition to the basin scale dynamics.

Keywords: El Nino, Tropical Instability Waves, Equatorial Pacific Ocean, Interannual Variability, Mixed Layer Heat Budget

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Breakdown of ENSO predictors in the 2000s: Changes in the thermocline variation and atmospheric intraseasonal forcing

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Variations in the warm water volume (WWV) of the equatorial Pacific and atmospheric forcing from intraseasonal variation (ISV) in the western equatorial Pacific are regarded as two good predictors of the subsequent El Nino/Southern Oscillation (ENSO), with a lead time of two to three seasons. Here we report that the robust predictability of these predictors for ENSO has changed in the 2000s.

During 1981-2000, the recharge (discharge) of the WWV and strong (weak) ISV forcing preceded El Nino (La Nina) by two to three seasons. However, in the 2000s, the interrelationship between the WWV/ISV and following ENSO became weak, especially for the El Nino/La Nina events after 2005. Notably, the discharged phases of WWV that led to subsequent La Nina events were less observed since 2001. These changes may be caused by frequent occurrences of the ”warm-pool El Nino,” which is characterized by SST anomalies centered in the central equatorial Pacific.

Keywords: El Nino/Southern Oscillation (ENSO), Equatorial Pacific, Equatorial Warm Water Volume, Atmospheric Intraseasonal Variation

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The Cross-Equatorial Northerly Surge in the South China Sea and Precipitation Patterns over the Maritime Continent

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Cold surge in the northern South China Sea (hereafter CS) is pointed out to correlate to convective activity over the Maritime Continent, and it is reported as a case study that cold surge which across the equator affect the heavy rainfall in the Maritime Continent. In this study, in order to explain the occurrence of the surge in the equatorial region, we defined cross-equatorial northerly surge (CENS) and investigated background of occurrence and relationship with variation of precipitation.

The CENS in this study was defined as the area-averaged northerly wind exceeding 5 m s^{-1} over 105^{o}E-115^{o}E, 5^{o}S-EQ based on the QuikSCAT sea surface wind data. During the 10 winters from December 1999 to March 2009, 62 CENS events were extracted and classified into the following patterns: 11 events were associated with cold surges over the northern part of the South China Sea and termed the CS pattern; 20 events were associated with a convectively active phase of the tropical intra-seasonal variations and termed the MJO pattern; 16 events were associated with both cold surges and convectively active tropical intra-seasonal variations and termed the CS-MJO pattern; and other 15 events were not associated with these patterns. In the CS pattern, the increased precipitation to the north of the island of Java was significant. In the MJO pattern, a wide area of northerly winds in the vicinity of the depression around 10^{o}S continued for a longer period than in the CS pattern, and the increased precipitation west of Sumatra and south of Java was significant. The CS-MJO pattern showed features of both the CS and MJO patterns and was associated with the greatest increase in precipitation of the three patterns in particular, in northwestern Java and both north and south of Java. In the CENS events, increases in precipitation were observed in the Maritime Continent region, and notable difference in the precipitation distribution has been brought by difference in background fields.

Keywords: cold surge, Maritime Continent, monsoon, precipitation distribution

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Covariability between the Baiu Precipitation and Tropical Cyclone Activity through Large-Scale Atmospheric Circulations

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Interannual variations of the Baiu precipitation and tropical cyclone (TC) activity in the western North Pacific (WNP) are linked to large-scale atmospheric circulations associated with the El Nino/Southern Oscillation (ENSO) and the Tropospheric Biennial Oscillation (TBO) of the Asian monsoon. This work examines covariability between the Baiu precipitation and the TC activity through the large-scale atmospheric circulations of the ENSO and the TBO.

In years when sea surface temperature (SST) anomalies are low in the eastern tropical Pacific with respect to the ENSO, the number of TCs increases around the Philippines in the Baiu season, June and July. On the other hand, in years of low SST anomalies in the eastern tropical Pacific related to the TBO, the strength of TCs is significantly enhanced to the southeast of Japan. Each of the two TC activities enhances a specific large-scale cyclonic circulation, which shifts the axis of monsoon westerlies and causes the anomalous Baiu precipitation. These modifications are dependent on the phase of the ENSO and the TBO. In years of high SST anomalies in the eastern tropical Pacific, the anomalous TC activity is small and sometimes has opposite impacts on the large-scale atmospheric circulations. Thus, the Baiu precipitation covaries with the TC activity through specific large-scale circulations, and the covariation is dependent on the phase of the ENSO and the TBO.

Keywords: Baiu, Tropical cyclone activity, the East Asian summer monsoon, ENSO, TBO

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

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Prior to the onset of the 2002/03 El Nino event, strong northwesterly surface winds occurred along the northern coast of New Guinea. The winds caused upwelling occurred along the coast, and this relatively cool water spread out over a wider area to the northeast toward the equator. Hasegawa et al. [2009] hypothesized the low SST in this region generated a positive zonal SST gradient together with high SST in the east, and it contributed to enhancement of the westerly surface wind in this region, leading to the onset of the 2002/03 El Nino event. To confirm their hypothesis, we have started a regional climate modeling study in the western Pacific Warm Water Pool region. The goal is to understand this region in an ocean-atmosphere coupled system. As a first step, we performed experiments with a regional atmospheric model forced with sea surface temperature (SST) as a lower boundary condition. The model used in this study was the International Pacific Research Center (IPRC) Regional Atmospheric Model (iRAM). The model covered the western Pacific Ocean with a horizontal resolution of 0.25 degree. We in particular focused on December 2001, as Hasegawa et al [2009] did in their diagnostic study. This model reproduced the strong northwesterly surface winds along the northern coast of New Guinea in the control run. To measure impacts of cold SST along the New Guinea coast, we did additional experiments to cool SST further in this region. Decreasing SST enhanced divergence of wind in the overlying atmosphere. This was favorable to the enhancement of the westerly surface wind along the equator at the eastern edge of the Warm Water Pool, supporting Hasegawa et al. [2009]'s idea. We also pay attention to the role of the high mountains of New Guinea in shaping climate around this region. The central mountains of New Guinea have a peak elevation over 4000m high. This mountain helped to enhance upward air motion and convergence near the surface in the control run. In an experiment where the orography of New Guinea was flattened, these circulations were eliminated and the northwesterly along the northern coast was weakened. This suggests the orography of New Guinea provides a good environment for the feedback between the westerly and the coastal upwelling mentioned above. The difference with and without the orography also revealed that the high mountain enhances precipitation over the northern side of the mountain ridge in this season.

Keywords: El Nino, Warm Water Pool, gegional model, air-sea coupling, orography effect, New Guinea

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General Discussion: Multi-scale phenomena in the tropical Pacific

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Japanese only.

Keywords: General Discussion, tropical Pacific, temporal-spatial multi-scale, air-sea interaction