Ocean Science Symposium 2015, Busan

Session 4 :
Influences of Western Pacific Ocean on regional (e.g., monsoon, typhoon, extreme climatic events) and global climate systems and their predictability

The third day

28-Oct-2015, 09:00 – 10:25

Invited Speaker :

Recent Progresses in Impacts of Western Pacific Ocean on East Asian Monsoon and Stratosphere Climate

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Abstract

This paper reviews some progresses impacts of Western Pacific Ocean (WPO) on East Asian monsoon and stratosphere climate from the following aspects. (1) Impact of the IPOD (that is a cross-basin dipole pattern of SSTA variability between the Indo-Pacific warm pool (IPWP) and North Pacific Ocean) on East Asian summer monsoon (EASM). The IPOD exhibits a considerable correlation with the EASM. In summers with a positive IPOD phase, the western Pacific subtropical high (WPSH) weakens and shrinks with WPSH ridge moving northwards, which favours an intensified EASM and a decrease in summer rainfall in the Yangtze River valley, and vice versa. (2) Asymmetric influence of the two types of ENSO on summer rainfall in China. The two types of ENSO have asymmetric impacts on summer rainfall over the Yangtze River Valley. The relation between summer rainfall over this valley and the cold tongue (CT) El Niño is significantly positive, while the relation with the CT La Niña is not significant. The negative phase of the warm pool (WP) ENSO has a significant positive influence, whereas no significant relation with the positive phase. They indicated that this asymmetric response of the EASM is likely to be linked to the different spatial patterns of the two types of ENSO. (3) Indo-Western Pacific convection oscillation (IPCO) is closely related to the EASM. (4) Indo-pacific warm pool (IPWP) area expansion and tropical cold-point tropopause temperature variations. The tropical cold-point tropopause temperature (CPTT), a potentially important indicator of global climate change, is of particular importance for understanding changes in stratospheric water vapor levels. Since the 1980s, the tropical CPTT has shown not only interannual variations, but also a decreasing trend. However, the factors controlling the variations in the tropical CPTT since the 1980s remain elusive. It is found that the continuous expansion of the IPWP area since the 1980s represents an increase in the total heat energy of the IPWP available to heat the tropospheric air, which is likely to expand as a result. This process lifts the tropical cold-point tropopause height (CPTH) and leads to the observed long-term cooling trend of the tropical CPTT. (5) Impacts of WP El Niño on tropical ozone changes since the 1980s. The WP El Niño can modulate the tropical upwelling that significantly affects mid-lower stratospheric ozone. In the context of future global warming, the WP El Niño may continue to be a primary driver of tropical TCO changes.

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Temporal and spatial differentiation of the climate change at the East-South China Seas and Northwest Pacific for last 140 years

Jiancheng Kang, Nengzhi Tan, Zijun Su, Xiaochen Su, Wenqiang Wu, Lin Yuan, and Huan Qiu

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Abstract

Using multiple marine data set (AIPOcean1.0 (1993-2006), Ishii (1945-2010), SODA (1871-2010)), contrast and analysis temperature change rate and trend from surface to the deep in the East China Sea, the South China Sea and adjacent waters to the Northwest Pacific Ocean, for past 140 years, the results showed a larger differentiation at space and time: on the surface, the warming has emerged at the whole studying area for last 140 years; the warming rates appeared that over the past 25 years > past 50 years > past 100 years > past 140 years. But the largest rate was at the layer around the depth of 50m, then the rate has declined. In the continental shelf area of the East China Sea, where the water depth is <160 meters, the temperature was rising at upper layer to 100 meters, some area deeper than 120 meters has appeared cooling. In the Kuroshio of the East China Sea (the ECS Kuroshio) and the Okinawa trough region, from the entrance to export of the ECS Kuroshio, the sea was warming at upper 300 m, the warming rate decreased with depth; 500-700 meters in some areas appear to be cooling; the layer deeper than 700 meters appears warming trend again. At the Northwest Pacific Ocean adjacent to the east China sea, the upper 200 meters appear to warming, a cooling trend at 300-1200 meters, not change or appear weak warming below 1200 meters. In the South China Sea, the upper 200 meters has an emergence of warming, 200-1000 m cooling, the layer below 1000 meters has been warming again. In the Northwest Pacific Ocean adjacent to the South China Sea, the upper 250 meters has heating, 250 -2500 m cooling, 2500 m below the change was no obvious. Throughout the study area, in the area where deeper than 700 meters, the temperature changes show in the three layers structure, the temperature rise in the upper layer, the middle cooling, the deeper change is not obvious.

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Multi-Scale Impacts of the Western Boundary Currents and Associated Frontal Zones on the Atmosphere

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Abstract

Unlike in vast areas of midlatitude ocean basins, the western boundary currents and the associated oceanic frontal zones can potentially influence the overlying atmosphere, which the "Hotspot project" of Japan aimed to elucidate. Some of the important outcomes of the project are introduced in this presentation. In the frontal zones characterized by sharp sea-surface temperature (SST) gradient, including the Kuroshio-Oyashio Extension, effective moisture supply to individual cyclones and efficient restoration of near-surface atmospheric baroclinicity allow recurrent development of cyclones, leading to the formation of stormtracks. Anomalous behavior of the frontal zones and associated SST anomalies can change the atmospheric circulation. For example, observations and realistic climate model integration both indicate that decadal shift of the North Pacific subarctic frontal zone can force a PNA-like atmospheric anomaly pattern in January. A similar anomaly pattern can be forced by SST anomalies observed in 2011 October.

In addition, intense heat and moisture release from the warm Kuroshio Extension leads to the formation of a semi-permanent regional-scale surface pressure trough and maximum cloudiness just east of Japan in winter, and these atmospheric features are found to vary in associated with quasi-decadal KE variability. The representation of these features in global atmospheric reanalysis data is found highly sensitive to the SST distribution assigned. In summer, high SST along the Kuroshio and East China Sea helps organize convective precipitation under the moist monsoonal southwesterlies toward the Baiu/Meiyu front. Under the monsoonal northerlies in winter, the warm Kuroshio also organizes shallow convective stratocumulus within the developed unstable mixed layer, where strong updraft acts to augment the super-saturation level, thus leading to an increase in the cloud droplet density.

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Intraseasonal variability of the tropical Pacific subsurface temperature in the two flavors of El Niño

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Abstract

The spatial structure and temporal evolution of the intraseasonal variability (ISV) of the subsurface ocean temperature (STA) in the equatorial Pacific associated with the two flavors of El Niño (i.e., the canonical or eastern Pacific (EP) El Niño and the central Pacific (CP) El Niño) are investigated using observations and 1.5–layer linear reduced gravity model. Results suggest that the ISV characteristics show some differences in the two types of El Niño, though both oscillate along the thermocline in the form of the intraseasonal equatorial Kelvin wave, which is excited in the western tropical Pacific by the zonal wind stress associated with the Madden-Julian oscillation (MJO). First, the period of dominant mode of the STA ISV during CP El Niño broadly distributes in 50-80 days with the spectra peaking in 60–65-day. By contrast, the spectrum of STA ISV during EP El Niño shows a peak in 75-80-day period. This indicates the wave speed is faster in the CP El Niño than in EP El Niño. Second, the ISV activity peaks in previous spring during the developing phase of EP El Niño, whereas during CP El Niño it becomes the most active during the mature phase. Third, the strongest IEKW occurs in the central Pacific around the dateline during CP El Niño and attenuates quickly east of 130°W due to strong eddy viscosity dissipation, while the IEKW during the EP El Niño propagates efficiently from the western to the eastern Pacific with a relative weak diffusion.

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Seasonal Variation of the Upper Ocean Responding to Surface Heating in the North Pacific

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Abstract

Seasonal variations of the upper ocean, such as mixed layer depth (MLD) and sea surface temperature (SST), responding to the atmospheric forcing in the North Pacific (10oN – 50oN), are investigated by analyzing the Argo and NCEP/NCAR reanalysis 1 data. The OAFlux data are also used for comparison. During the early heating period in the high-latitude ocean north of 30oN, where a seasonal thermocline is formed above the deep mixed layer under strong surface heating, the MLD h is found to be scaled as root(lamda*L), where L is the Monin-Obukhov length scale and lamda is the Ekman length scale. On the other hand, in the low latitude ocean south of 30oN, where the preexisting MLD is shallow and surface heating is weak, h is found to be scaled by lamda. It is found that a large amount of heat transport across the MLD occurs, especially in the high-latitude ocean during the late heating period, in which h is small, and it is attributed by turbulent mixing as well as radiation penetration. The heat budget of the mixed layer reveals that the contribution from the ocean heat transport is much smaller than the surface heat flux in the high-latitude ocean except the Kuroshio region, but it is often comparable in the low-latitude ocean.

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Ocean Science Symposium 2015, Busan

Session 4 :
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The third day

28-Oct-2015, 10:40 – 12:20

Invited Speaker :

Effects of tropical Pacific SST on the atmospheric teleconnections from the tropics to the high-latitudes

Sang-Wook Yeh and Hyun-Su Jo

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Abstract

It is obvious that the western-to-central Pacific plays an important role in both the tropical and extratropical climate by modulating tropical convection. Furthermore, the sea surface temperature (SST) has gradually increased in the western-to-central tropical Pacific over time. We examine the effects of warming or mean state change on the atmospheric teleconnections from the tropics to the high-latitudes. By analyzing the outgoing longwave radiation (OLR), it is found that the sensitivity of convective forcing in response to anomalous SST variation significantly changed in recent decades. Because of this, the east-west zonal circulation has been modified, subsequently, mean descending motion is dominant in the central tropical Pacific, leading to a negative trend of both precipitation and OLR. Furthermore, the SST variations in the western-to-central tropical Pacific are closely associated with the Arctic Oscillation-like atmospheric circulation in the middle-to-high latitudes, indicating that the western-to-central SST is able to significantly modify the atmospheric teleconnections form the tropics to the middle-to-high latitudes.

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Recent strengthened relationship between ENSO and East Asian Winter Monsoon: A comparison of 1977−1994 and 1995−2013

Ji-Won Kim and Soon-Il An

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Abstract

Interdecadal change in the relationship between the El Niño-Southern Oscillation (ENSO) and the East Asian Winter Monsoon (EAWM) over the interannual timescales is investigated during the period of 1948−2013. In a view of the strengths of the ENSO-EAWM relationship, it is found that the ENSO-EAWM relationship has re-strengthened during the recent period of 1995−2013 (i.e., P1) when compared to the previous period of 1977−1994 (i.e., P2), showing that the warm (cold) phases of ENSO induce significant warm (cold) air temperature anomalies over the East Asia through weakening (strengthening) the EAWM-related atmospheric circulations. As like previous studies, we found that decadal changes in the strength of mean lower-tropospheric circulation over the western North Pacific near the Philippine Sea (a.k.a., the Philippine Sea anticyclone) are critical for determining ENSO-EAWM relationship. Furthermore, changes in the relationship between ENSO and the Indian Ocean sea surface temperature (IOSST) over the interannual timescales might also influence ENSO-EAWM relationship via changing strengths of the Philippine Sea anticyclone. That is, when the ENSO and IOSST are tightly linked, the ENSO-EAWM relationship is also strengthened, and when the linkage between ENSO and IOSST is relatively weakened, the ENSO-EAWM relationship is also weakened.

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On the dominant modes of boreal winter SST variability over the western North Pacific

Jae-Heung Park and Soon-Il An

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Abstract

We analyzed the boreal winter sea surface temperature (SST) variability over the western North Pacific (WNP, 100-165°E, 0-35°N) using the reanalysis datasets. The first EOF mode of SST anomaly over WNP is identified as an overall warming pattern, which is highly correlated to Northern North Pacific climate such as North Pacific gyre oscillation (NPGO) and North Pacific oscillation (NPO) (hereafter, NPGOWNP mode). While the second EOF mode is significantly correlated to the El Nino-Southern Oscillation (ENSO) (hereafter ENSOWNP mode)

The NPGOWNP mode is established via the wind-evaporation-SST (WES) feedback with an initiation of anomalous southerly winds induced by the zonal boundary layer temperature gradient in the mid-latitude. The southerly winds reduce the evaporative cooling of ocean by virtue of decreasing of total wind speed, and modifies SST pattern, which in turn intensifies the southerly winds further and so the gradient of temperature. Meanwhile, the ENSOWNP mode features a prominent northwest-southeast dipole pattern during boreal winter, which could be generated by the Philippine Sea anticyclone associated with El-Nino.

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Anomalous tropical cyclone activity in the northwestern Pacific in 2014

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Abstract

Northwestern Pacific experienced anomalous tropical cyclone activity in July and August 2014. It is the first time since 1949 that no tropical cyclones forms in the northwestern Pacific in August, a peak tropical cyclone month in climatology. There are only 4 tropical cyclones occurred in July of 2014, among which 3 are super typhoons. Such high percentage of super typhoons is also uncommon since 1949. The anomalous tropical cyclone activity occurred in the background of decreasing eastern Asian summer monsoon (EASM) since the end of 1970s and negative Pacific Decadal Oscillation (PDO) phase since 2006 with possible phase transition from negative to positive in 2014. Intraseasonal Oscillation (ISO) also plays a significant role in inhibiting the tropical cyclone genesis in August of 2014 by preventing warm and moist air into northwestern Pacific. We are unable to confirm or reject the role of climate change in the July and August anomalous tropical cyclone activities due to the inability of CIMP5 models to accurately simulate the 850hPa wind anomaly. The CMIP5 does not show any obvious trend during 1948-2014, while reanalysis data shows significant increasing trend of low level easterly. The inability of CMIP5 in simulating 850hPa wind might be related to their limited performance in reproducing the EASM, transition of PDO and the propagation of ISO.

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Near-inertial resonance and upper-ocean stirring due to typhoons in the northwestern Pacific margin

Hiroaki Tada and Yusuke Uchiyama

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Abstract

Typhoons alter the upper ocean dynamics and thermal structure, giving rise to feedback on the atmosphere. Intense ocean surface wind and barometric effects induce rough waves and storm surges that occasionally cause severe coastal disasters. For rigorous oceanic modeling under typhoon conditions, we implement the inverse barometer effect and the COAMPS bulk formula into ROMS (Shchepetkin and McWilliams, 2005). A submesoscale eddy-resolving oceanic modeling is configured at a horizontal resolution of 2 km based on the JCOPE2-ROMS downscaling system forced by the JMA GPV-MSM atmospheric reanalysis. A retrospective, synoptic reanalysis is carried out with a particular focus on the two consecutive super typhoons Phanfone (#1418, Category 4, the lowest pressure was 935 hPa) and Vongfong (#1419, Cat. 5, 900 hPa) in the fall 2014. Both the typhoons have landed on the Japanese territory in Shizuoka (Phanfone) and in Kagoshima (Vongfong) Prefectures, traveling long distance along the Honshu Island. The model successfully reproduces increased eddy kinetic energy below the typhoons with intense cyclonic positive vorticity driven by torque of the wind stress curl, not only at surface but also at depth down to 100 m deep. These cyclones are cold-core mesoscale eddies with SST decrease by about 3oC associated with prominent mixed layer deepening. A distinct peak appears at around the inertial frequency in rotary spectra of the clockwise velocity component, suggesting that near-inertial gravity waves are generated below the typhoon track. Inertial resonance evidently occurs on the right side of the typhoon with intensified vertical mixing and associated mixed-layer deepening. Once the typhoons reach the Kuroshio, the typhoon tracks are approximately aligned with the Kuroshio path to travel northeastward. In the vertical cross-section off Tosa Bay, the position of the Kuroshio main body in the upper ocean is substantially altered by the approaching typhoons, resulting in near-inertial oscillations that last for several days after the passage of the typhoons.

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Upper Ocean Response to Typhoon, Focusing on "Rightward Bias" Using an Ideal 3D Primitive Equation Numerical Model

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Abstract

An ideal 3D primitive equation model (POM) is implemented to investigate upper ocean response to typhoons, focusing on the pronounced rightward bias (RWB) in the SST response, which means to show an intensified sea surface cooling to the right side of the typhoon track. The model has 26-stratified levels and a flat bottom (1000m), covering a rectangular domain of about 3000km x 3200km with four open boundaries. The sea water is forced by a pressure (Fujita, 1952) and a gradient wind of the typhoon. The model well reproduces the RWB in previous observations and a few theoretical analyses by many authors (e.g., Price, 1981). For the fast moving typhoon (FMT) (~8 m/sec), the model shows: 1) In the ML, the RWB in the SST noticeably appears accompanied by convergent and divergent flow fields behind the typhoon with inertial period, clearly illustrating the coupling (or resonance) between the current (inertial motion, IM) and the wind stress, i.e. the wind stress rotation rate matches the inertial rotation rate of the flow (Chang and Anthes, 1978; Price, 1981), 2) In the subsurface layer (~100m; SSL), however, the RWB does not emerge since a cyclonic current field (CCF) caused by wind stress curl is primarily dominant. For the slowly moving typhoon (SMT) (~3m/sec), on the other hand, there are perfectly different features from those for the FMT: 1) The RWB does not emerge because the coupling is weakened and the CCF, which is formed by trench-like depression with a few hundred kilometer scales and trailed with cold wakes in the rear of the typhoon, is predominant even in the ML, 2) In the whole layer until the SSL, there are almost symmetrical features over the track of the typhoon. The model result also shows that Miyazaki's effect (Miyazaki et al., 1961), which is to add a translation speed of typhoon to the gradient wind, is much less efficient for the RWB although it influences slightly amplitude of the RWB. In the model, we conclude that the RWB noticeably emerges when the coupling between the IM and the wind in the FMT influences more dominantly the flow fields in the ML rather than the CCF, while in the SMT the RWB does not emerge because the CCF is predominant due to a weakness of the coupling.

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