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Poster Presentation

Session 1 [P-001~P-055]

P-001

Atmospheric circulation characteristics analysis in thunderstorms abnormal years of Liaoning inland and coastal cities

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This paper discusses the atmospheric circulation characteristics of thunderstorm activities abnormal years in Liaoning inland and coastal cities. By using thunderstorm observation data from 1961 to 2012 (51 years) of 59 meteorological stations in Liaoning Province, NCEP/NCAR daily reanalysis data, climate trend analysis and synthesis of t-test methods, characteristics of thunderstorm activities abnormal years and atmospheric circulation for inland and coastal cities, were compared and analysed. Conclusions are as follows: the annual mean number of thunderstorm days for inland cities decreases gradually from the east and the west mountain area to the central hills and plains, and the annual mean number of thunderstorm days for coastal cities decreases with the decreasing of latitudes and is generally less than inland cities. The annual mean number of thunderstorm days for inland and coastal cities both show a decreasing trend year by year, but the decreasing speed of coastal cities is faster than that of inland cities. Thunderstorm activities of inland cities are related to near-surface air temperature, Asian zonal and meridional circulation. Thunderstorm activities of coastal cities are closely related to the winds and height fields of lower and middle troposphere, and the annual variation of thunderstorm activities is closely related to the ridge line location of the Western Pacific subtropical high. The above conclusion through the correlation test of significance. The conclusion provides guidance to predict the future of the thunderstorm weather in liaoning province.

P-002

Long-term changes in the extreme significant wave heights on the western North Pacific: Impacts of Tropical Cyclone Activity and ENSO

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Seasonal extreme wave statistics were reproduced by using the 25-km-grid global wave model of WAVEWATCH-III. The results showed that the simulated wave dataset for the present climate (1979-2009) was similar to Climate Forecast System Reanalysis (CFSR) wave data. Statistics such as the root mean squared error (RMSE) and correlation coefficient (CC) over the western North Pacific (WNP) basin were 0.5 m and 0.69 over the analysis domain. The largest trends and standard deviation were around the southern coast of Japan and western edge of the WNP. Linear regression analysis was employed to identify the relationship between the leading principal components (PCs) of significant wave heights (SWHs) in the peak season of July to September and sea surface temperature (SST) anomalies in the Equatorial Pacific. The results indicated that the inter-annual variability of SWH can be associated with the El Nino-Southern Oscillation in the peak season. The CC between the first PC of the SWH and anomalies in the Nino 3.4 SST index was also significant at a 99% confidence level. Significant variations in the SWH are affected by tropical cyclones (TCs) caused by increased SST anomalies. The genesis and development of simulated TCs can be important to the variation in SWHs for the WNP in the peak season. Therefore, we can project the variability of SWHs through TC activity based on changes in SST conditions for the Equatorial Pacific in the future.

P-003

Climatic influence on maize sowing date and potential yield in China

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The purpose of this study is to identify the key climatic factors which determine the maize sowing date in China, investigate whether farmers already adapted to the warming growing season by changing agronomic practices, and quantify the consequences of climate change on maize potential yield (Yp) with and without adaptation. We analyzed 20 years (1992-2011) county level maize sowing date data with meteorological records across major maize production area in China. The mean temperature about 30-60 days preceding sowing date played the major role to initiate sowing. Mean temperature during growing season increased about 0.5-1 degree Celsius for the most study regions, whereas radiation showed varied trends among regions for the same period. Moreover, uneven response (advanced/delayed) of sowing date to climate warming was observed with the timescale of 2.5-10 days. Crop growth model WOFOST was used to quantify the impact of temperature, radiation and sowing date on maize Yp. With fixed sowing date maize Yp decreased 4.8-10.1% in North China Plain due to decreased radiation for the past two decades. Similarly, maize Yp declined 3.9-12.9% in Shanxi and Inner Mongolia due to the rising temperature. The impact of shifting sowing date on yield varied among years and regions, but the late sowing dates tended to increase potential yield in most regions. A possible mechanism is a synergistic effect caused by higher temperature and radiation enhance photosynthesis during the relative late growing season and thus resulted in higher yield. However, late sowing could also increase the risk of frost damage around the harvest time. Breed new cultivars with higher light use efficiency will be useful to mitigate the negative climate impacts.

P-004

This case study to be used as a benchmark for global land surface model evaluations

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Soil moisture is the key to understanding the climate-soil-vegetation system both in space and time. To improve the understanding of water-vegetation relationships, direct comparative studies assessing the utility of satellite remotely sensed soil moisture, gridded precipitation products, and land surface model output are needed. A case study was investigated for a water-limited, lateral inflow receiving area in northeastern Australia during December 2008 to May 2009. In January 2009, monthly precipitation showed strong positive anomalies, which led to strong positive soil moisture anomalies. The precipitation anomalies disappeared within a month. In contrast, the soil moisture anomalies persisted for months. Positive anomalies of Normalized Difference Vegetation Index (NDVI) appeared in February, in response to water supply, and then persisted for several months. In addition to these temporal characteristics, the spatial patterns of NDVI anomalies were more similar to soil moisture patterns than to those of precipitation and land surface model output. The long memory of soil moisture mainly relates to the presence of clay-rich soils. Modeled soil moisture from four of five global land surface models failed to capture the memory length of soil moisture and all five models failed to present the influence of lateral inflow. This case study indicates that satellite-based soil moisture is a better predictor of vegetation water availability than precipitation in environments having a memory of several months and thus is able to persistently affect vegetation dynamics. This case study has the potential to be used as a benchmark for global land surface model evaluations.

P-005

Frequency of spring dust weather in North China linked to sea ice variability in the Barents Sea

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The link between winter sea ice cover in the Barents Sea (SICBS) and the frequency of spring dust weather over North China (DWFNC) is investigated. It is found that year-to-year variability of SICBS and DWFNC are strongly correlated for the period 1996-2014 with a correlation coefficient of -0.65, whereas the correlation between SICBS and DWFNC is not statistically significant for the periods 1980-2014 and 1980-1995. During 1996-2014, low winter SICBS is associated with decreased snow cover over western Siberia (SCWS) in both winter and spring, which is also supported by a strengthening relationship between winter SICBS and spring SCWS since the mid-1990s. This leads to changes in atmospheric circulation and climate conditions that are favorable for increased frequency of dust weather events over North China. Our further analysis suggests that the interannual variability of the standard deviation of SICBS has intensified and the center of actions has moved eastward to the north Barents Sea and Kara Sea since the mid-1990s. Such change may easily induce stronger and southward stationary Rossby wave train propagation, influencing the dust-related atmospheric circulation (strengthened East Asian subtropical jet, increased cyclogenesis, and larger atmospheric thermal instability). Thus interannual variation of winter SICBS plays an increasingly important role in dust-related climate conditions over North China, which might serve as a new precursor for the prediction of spring dust activity in North China.

P-006

Seasonal Mean Indian Monsoon Simulations: Biases in the Present Day Models, Usefulness of Increasing Resolution and Importance of Manual Model Tuning

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Coupled General Circulation Models (CGCMs) of the Coupled Model Intercomparison Project Phase 5 (CMIP5) are unable to resolve the spatial and temporal characteristics of the South Asian Monsoon. A CGCM with the capability to project the global as well as the regional climatic features would be a valuable tool for its use for policy making and hence societal benefit. Like all other models, the Community Earth System Model (CESM) version 5 (CAM5) developed at the National Center for Atmospheric Research (NCAR) has some inherent model biases. In this study, it is found that the precipitation and surface air temperature biases reduce with increase in the model resolution from 2^{o} to 0.5^{o}. Further, a manual model tuning method has been adopted and a specific tweakable combination of the deep convective parameters in Zhang-McFarlane (ZM) scheme are tuned for 2^{o} and 1^{o} model resolutions. Comparative study of the results of control simulations shows that in terms of model biases in precipitation and surface temperature, the performance of the manually tuned model is better.

P-007

Barrier Effect of the Indo-Pacific Maritime Continent on the MJO

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Explanations for the barrier effect of the Indo-Pacific Maritime Continent (MC) on the MJO should satisfy two criteria. First, they should include specific features of the MC, namely, its intricate land-sea distributions and elevated terrains. Second, they should include mechanisms for both the barrier effect and its over-coming by some MJO events. Guided by these two criteria, we applied a precipitation-tracking method to identify MJO events that propagate across the MC (MJO-C) and those that are blocked by the MC (MJO-B). About a half of MJO events that form over the Indian Ocean propagate through the MC. Most of them (> 75%) become weakened over the MC. The barrier effect cannot be explained in terms of the strength, horizontal scale, or spatial distribution of MJO convection when it approaches the MC from the west. A distinction between MJO-B and MJO-C is their precipitation over the sea vs. land in the MC region. MJO-C events rain more over the sea than over land, whereas land rainfall dominates for MJO-B. This suggests that inhibiting convective development over the sea could be a possible mechanism for the barrier effect of the MC. Preceding conditions for MJO-C include stronger low-level zonal moisture flux convergence and higher SST in the MC region. Possible connections between these large-scale con-ditions and the land vs. sea distributions of MJO rain-fall through the diurnal cycle are discussed.

P-008

A new member of East Asian summer monsoon system-northern East Asian low

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East Asia is located between the Eurasian continent and the North Pacific. This land-sea thermal contrast across East Asia in summer is represented by the western North Pacific subtropical high (WNPSH) over the sea. However, thus far, little is known about variability of the atmospheric circulation over the East Asian continent albeit mounting works have devoted to study of the WNPSH. In this study we introduce a new member of the East Asian continental low-pressure system to the East Asian summer monsoon. We define the East Asian continental low using 850-hPa geopotential height; since the low is centered over northern EA (NEA), we name it as the NEA low (hereafter NEAL). The NEAL exists only in the lower troposphere and in boreal summer. We show that the NEAL has large interannual variation, which exerts a crucial role in East Asian summer climate. An enhanced NEAL not only increases rainfall locally, but also shifts the East Asian subtropical front northward. In addition, the NEAL also shows a significant decadal change in the early 1990s, concurrent with a surface warming around the Lake Baikal and intensified rainfall in southern China. The identification of the NEAL helps to understand the variability of the land-sea thermal contrast over East Asia and, consequently, the East Asian summer monsoon.

P-009

Linking a sea level pressure anomaly dipole over North America to the central Pacific El Niño

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This study demonstrates the close connection between the north-south dipole pattern of sea level pressure (SLP) anomalies over northeastern North America to the western tropical North Atlantic, referred to as the North American dipole (NAD), and the central Pacific (CP)-type El Niño a year later. In contrast to other ENSO precursors, such as the North Pacific Oscillation (NPO) and Pacific-North America (PNA) pattern, the NAD appears more closely related to the CP-type El Niño than to the eastern Pacific (EP)-type El Niño, indicating that the NAD may serve as a unique precursor for the CP El Niño. The wintertime NAD induces sea surface temperature (SST) anomalies in the northern tropical Atlantic (NTA), which subsequently play an important role in developing the CP El Niño-like pattern in the tropical Pacific over the course of the following year. It appears that the NAD influence on CP El Niño involves air-sea interaction over several major basins, including the subtropical/tropical Pacific and the NTA. Additional analysis indicates that the correlation of either the NAD index or the NPO index with the CP El Niño state a year later depends on the status of the other index. When the wintertime NAD index is of the opposite sign to the simultaneous NPO index, the correlation of the NAD or NPO index with the Niño4 index becomes much weaker.

P-010

Interdecadal variations of the Silk Road pattern

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Based on several reanalysis and observational datasets, this study suggests that the Silk Road pattern (SRP), a major teleconnection pattern stretching across Eurasia in boreal summer, shows clear interdecadal variations that explain approximately 50% of its total variance. The interdecadal SRP features a strong barotropic wave train along the Asian subtropical jet, resembling its interannual counterpart. Besides, it features a second weak wave train over the northern part of Eurasia, leading to larger meridional scale than its interannual counterpart. The interdecadal SRP contributes to approximately 10～20% of the summer precipitation's variance and 40% of the summer surface air temperature's variance over large domains of Eurasia. Especially, the interdecadal SRP shows two regime shifts in the 1970s and 1990s, respectively, and the latter explains over 40% of the observed rainfall reduction over Northeastern Asia and over 40% of the observed warming over Eastern Europe, West Asia, and Northeastern Asia, highlighting its importance in the recent decadal climate variations over Eurasia. The positive (negative) phase of spring and summer Atlantic Multidecadal Oscillation (AMO) facilitates the occurrence of negative (positive) phase of the interdecadal SRP significantly, implying plausible prediction potentials for the interdecadal variations of the SRP.

P-011

Modulation of Bjerknes feedback on the decadal variations in ENSO predictability

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Clear decadal variations exist in the predictability of the El Niño-Southern Oscillation (ENSO), with the most recent decade having the lowest ENSO predictability in the past six decades. The Bjerknes Feedback (BF) intensity, which dominates the development of ENSO, has been proposed to determine ENSO predictability. Here we demonstrate that decadal variations in BF intensity are largely a result of the sensitivity of the zonal winds to the zonal sea level pressure (SLP) gradient in the equatorial Pacific. Furthermore, the results show that during low-ENSO predictability decades, zonal wind anomalies over the equatorial Pacific are more linked to SLP variations in the off-equatorial Pacific, which can then transfer this information into surface temperature and precipitation fields through the BF, suggesting a weakening in the ocean-atmosphere coupling in the tropical Pacific. This result indicates that more attention should be paid to off-equatorial processes in the prediction of ENSO.

P-012

Influence of global ocean warmth on the typhoon intensities during 2015

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The climate of 2015 was characterized by a strong El Nino, global warmth, and record setting tropical cyclone (TC) intensity for western North Pacific typhoons. In this study, the highest TC intensity in 32 years (1984-2015) is shown to be a consequence of above normal TC activity-following natural internal variation-and greater efficiency of intensity. The efficiency of intensity (EINT) is termed the 'blasting effect' and refers to typhoon intensification at the expense of occurrence. Statistical models show that the EINT is mostly due to the anomalous warmth in the environment as indicated by global mean sea-surface temperature. In comparison, the EINT due to El Nino is negligibly small. This implies that the record-setting intensity of 2015 might not have occurred without environmental warming and suggests that a year with even greater TC intensity is possible in the near future when above normal activity coincides with another record EINT due to continuous warming.

P-013

Nonlinearity Modulating Intensities and Spatial Structures of Central Pacific- and Eastern Pacific-El Niño Events

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The Zebiak-Cane model for El Nino-Southern Oscillation (ENSO) contains both linear and nonlinear temperature advection terms. The nonlinear terms influence the sea surface temperature anomaly (SSTA) associated with El Nino events and therefore also influence the linear terms. This paper compares data from linear and nonlinear versions of the Zebiak-Cane model, as constrained by observed SSTA, in simulations of several central Pacific (CP) and eastern Pacific (EP) El Nino events. In particular, the difference between the temperature advection terms (determined by subtracting those of the linear model from those of the nonlinear model), here referred to as the nonlinearly induced temperature advection change (NTA), is analyzed. The results demonstrate that the NTA records warming in the central equatorial Pacific during CP-El Niño events and makes fewer contributions to the structural distinctions of the CP-El Nino, whereas it records warming in the eastern equatorial Pacific during EP-El Nino events and thus significantly promotes EP-El Nino events during El Nino-type selection. The NTA associated with CP- and EP-El Nino events also varies in its amplitude and is smaller in CP-El Nino events than it is in EP-El Nino events. These results demonstrate that CP-El Nino events are weakly modulated by small intensities of NTA and may therefore be controlled by weak nonlinearity, whereas EP-El Nino events are significantly enhanced by large amplitudes of NTA and are therefore likely to be modulated by relative strong nonlinearity. These data could explain why CP-El Nino events are often weaker than EP-El Nino events. Because values of the NTA associated with CP- and EP-El Nino events differ in their spatial structures and intensities, as well as their roles within different El Nino modes, the diversity of El Nino events may be closely related to changes in the nonlinear characteristics of the tropical Pacific.

P-014

The Impact of the ENSO Cycle on the Stratospheric Ozone Distribution over East Asia

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The Oceanic Nino Index (ONI) of the NOAA and ozone reanalysis data of ECMWF were used in this paper, the lag correlation method was used to analysis the influence of the ENSO circulation on the distribution of the stratospheric ozone over the East Asia. According to the composite analysis of the ozone anomaly percentage of El Nino and La Nina, the effect of the ENSO to the ozone force was investigated and the change can be explained by the residual circulation. The results show: (1) the effect of the ENSO to the stratospheric ozone was distinct over East Asia, which was more evident at 30 hPa, and 70 hPa than others, and that the correlation coefficient reached the maximum when lag equals 8 months, (2) After the El Nino occurred 8 months, at stratospheric 30hPa, the ozone had a decrease over the mid-latitude region and an increase over the high latitude. At 70 hPa, the ozone had an increase over the mid-latitude, but a decrease over both high and low latitudes. However, the situation was contrary after La Nina. (3) The similar change has been obtained from the SVD analysis for the SST of Nino 3.4 and the ozone 8 month later. (4) The difference of the effect of the El Nino and La Nina to the ozone was significant, and the difference of the ozone content could reach 25% when the El Nino and La Nina had occurred 8 months later. (5) ENSO can modulat the residual circulation, then it can influence the ozone distribution.

P-015

Asymmetric response of the equatorial Pacific SST to climate warming and cooling

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The response of the equatorial Pacific Ocean to heat fluxes of equal amplitude but opposite sign is investigated using the Community Earth System Model (CESM). Results show a strong asymmetry in SST changes. In the eastern equatorial Pacific (EEP), the warming responding to the positive forcing exceeds the cooling to the negative forcing; while in the western equatorial Pacific (WEP), it is the other way around and the cooling surpasses the warming. This leads to a zonal dipole asymmetric structure, with positive values in the east and negative values in the west.

A surface heat budget analysis suggests that the SST asymmetry is mainly resulted from the oceanic horizontal advection and vertical entrainment, with both of their linear and nonlinear components playing a role. For the linear component, its change appears to be more significant over the EEP (WEP) in the positive (negative) forcing scenario, favoring the seesaw pattern of the SST asymmetry. For the nonlinear component, its change acts to warm (cool) the EEP (WEP) in both scenarios, also favorable for the development of the SST asymmetry. Additional experiments with a slab ocean confirm the dominant role of ocean dynamical processes for this SST asymmetry. The net surface heat flux, in contrast, works to reduce the SST asymmetry through its shortwave radiation and latent heat flux components, with the former being related to the nonlinear relationship between SST and convection, and the latter being attributable to Newtonian damping and air-sea stability effects. The suppressing effect of shortwave radiation on SST asymmetry is further verified by partially coupled overriding experiments.

P-016

The Precursor Signal Analysis and Prediction for the Landfall Typhoon Intensity over South China

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Since mid-1990s, there was a reduction in frequency and intensity of landfall typhoon over South China (SC). The research showed that the variation come from the inter-annual and decadal of the typhoon themselves and the large-scale circulation. On the other hand, may suffer from the Pacific Decadal Oscillation (PDO). It was strong (weak) that the cross-equatorial flow in winter from the southern hemisphere, resulted in the strong (weak) flow from 110°E in the northern hemisphere in summer. Therefore, the position of the strong (weak) convergence zone and monsoon trough moved northward (southward). All of these was (not) benefit to the SC typhoon activity. The results presented the characteristics of inter-decadal changes between typhoon and the atmosphere circulation. On the other hand, by means of the inter-annual increment method, the accumulated cyclone energy (ACE) index was stronger (weaker) during the La Niña (El Niño) episode in last winter. Finally, by means of the principal component regression technique based on the inter-annual incremental method, the prediction model of ACE index has been build, whose hindcast correlation coefficient was up to 0.9 for the recent 30 years, especially the forecast results were consistent with the 2014a and 2015a.

P-017

Quantitative assessment of climatic influences on a recent green-up hiatus over Northern boreal forests

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In response to climate change, deciduous forests over Northern Hemisphere have experienced a drastic change in springtime green-up date. The green-up date had severely advanced over high-latitude regions from the early 1980s to the late 1990s, but the trends weakened to half after the end of the 1990s. This hiatus of green-up trends is related to weakened warming in spring, but detailed mechanisms are not understood quantitatively. Here we investigated the cause of green-up hiatus by quantifying influences of climate variables on the spring green-up trends over the deciduous forests over 45°N during 1982-1997 and 1982-2013. Based on a multi-linear regression, we decomposed the green-up trends into influences of four variables, which are winter duration, pre-onset temperature, green-up temperature, and accumulated precipitation. We found that the influences of climate variables severely reduced to less than half after the late 1990s, and it resulted to the green-up hiatus in the recent decade especially in Siberia and Northwestern North America. In 1982-1997, the strong advancing of green-up date was driven by combined influences of shortened winter duration and increased temperature during pre-onset and green-up period over the study region. In contrary, in 1982-2013, all the climatic influences of the winter duration, precipitation, pre-onset and green-up period temperature severely diminished, and it led the green-up hiatus over the boreal forest. These results show that the green-up hiatus is largely induced by weakened temperature warming from late winter to green-up period. It suggests that if this warming hiatus ends and spring temperature rises in the future, then the strong advancing of green-up before the 2000s would reoccur.

P-018

Determination of Impact on Indian Ocean Dipole to Rainfall and Temperature Variability over the Sri Lanka

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The agriculture and hydropower sectors play a crucial role in the economy of Sri Lanka, developing country in the tropical zone. The impacts of climate and climate variability on agriculture productivity and hydropower planning are still unknown. Among the climatic parameters, precipitation plays a vital role in agricultural production. Strong links have been observed between the climate variability of the monsoon system and agricultural productivity in climate projections in Sri Lanka. Hence the Indian Ocean Dipole (IOD) is a natural ocean-atmosphere coupled phenomenon that plays important roles in seasonal and inter-annual climate variations. The IOD can also affect the monsoon rainfall on its own and can weaken or strengthen the influence of El Niño-Southern Oscillation (ENSO) on the monsoon rainfall. Because of the existence of positive and negative events in the two major tropical climate phenomena, the influence on monsoon rainfall depends on the phase and amplitude of the IOD and ENSO. Sri Lanka can be divided into three climatic zones and there are four rainfall seasons. This study analyzed the relationship between rainfall anomaly and IOD, Southern Oscillation index (SOI) separately for each season as representative climatic zones. Inter-annual climate variations were analyzed for each stations and effect spatial distribution of IOD were also analyzed.

The Sri Lanka Department of Meteorology operates 23 synoptic main meteorological stations nationwide. Monthly total precipitation and monthly rainy days from the Sri Lanka Department of Meteorology 1870 to 2016 are the data analyzed here. SOI values were obtained from the Climate Research Unit, School of Environmental Science, University of East Anglia (www.cru.uea.ac.uk), and the IOD values were obtained from the Frontier Research System for Global Change (www.jamstec.go.jp). To analyze the relation between rainfall anomaly and IOD and ENSO index Matlab was used. To extract the periodicities of precipitation records, power spectra were calculated for annual precipitation values of each station and two weather indices separately using the lomb'salgorithm (Lomb-Scarglemethod). To analyze the effect of spatial distribution of IOD interactive tool for analysis of the climate system (iTacs) was used.

The results show that for some periods most of the south west parts of Sri Lanka have a strong relationship between monthly rainfall anomaly and either IOD or SOI. Twenty years moving correlation coefficients between rainfall anomaly and IOD, SOI were calculated foe each station with Matlab for 1920 to 2016. The results show that most of the time, during south west monsoon season (May to September) IOD shows high relation than SOI between 1960 to 1980 period significantly strong correlation in south western parts of Sri Lanka. For the other seasons, some 10 to 20 years period laps of among IOD and SOI one of them shows a stronger relationship to rainfall variation while some periods there were not show any significant relationships. Especially during the 2nd inter monsoon season (October to November) during 1943 to 1983 and 1st inter monsoon seasons (March to April) during 1920 to 1930 IOD and the monthly rainfall anomaly shows a relatively high correlation. During the North West monsoon seasons (December to February) from 2000 to 2016 both IOD and SOI show strong correlation with the monthly rainfall anomaly.

P-019

Transitional characteristics of Indian Ocean Monsoonal Circulation and Impacts on Climate Extremes in East Africa during March-May Season

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The East African region experiences frequent and often devastating climate extremes that lead to dire results; both socially and economically. These extremes are largely related to lack of rainfall or excess of it over wide regions, with livelihoods of millions being affected. In this regard, rain-fed agriculture and the practice of pastoralism, food and water security, as well as public health risks get unfavorably affected. The study of extreme hydro meteorological events in East Africa has been centered on the contribution of global scale weather systems, while neglecting the significance of the synoptic scale weather system. This has led to some seasonal weather forecasts overestimating or underestimating the regional precipitation in scenarios where the synoptic systems are not right for enhanced or depressed precipitation. The study aims at establishing the linkage between the dynamical characteristics of the Indian ocean monsoonal circulation and the extreme hydro meteorological phenomena that occur during the March-April-May (MAM) long rains season in East Africa (EA).

There was dynamical analysis of low level circulation involving investigation of wind speed and direction within the domain during the season of interest. Standardized anomaly analysis was used to identify the years that experienced above normal precipitation during the season of interest using 1.2 σ as criterion for identification. The domain of study is within the latitudes -30° to 30° and longitudes 30° to 120°. The wind data was obtained from reanalysis data sets for the period of 1960 to 2013 and observed rainfall data (for Nairobi) for the same period was also used. Additionally, there was correlation of NINO 3.4 and Southern Oscillation Index(SOI) with precipitation to estimate the significance of the contributions of the monsoonal transitional characteristics. 850hpa level winds for the domain were used. The analysis of the relationship between the wind regime in the domain of study was done through cross correlation.

The preliminary results indicated a weak and negative correlation between observed rainfall and the SOI (r=-0.06345). The correlation between observed rainfall and NINO 3.4 was positive but weak for the entire sample (r=0.218). However, documented extreme events coincided with exceptionally high correlation with NINO 3.4. They also indicated that above normal rainfall was associated with high NINO 3,4 Index except in cases where wind direction of monsoon winds showed a southwesterly pattern. The impacts of NINO 3.4 were particularly enhanced in scenarios where the monsoon wind properties showed a northeasterly pattern. It was concluded that NINO 3.4 has significant impact on the extreme rainfall events in the study region. However, the monsoon winds have to be northeasterly in direction. This postulate was particularly witnessed in cases where NINO 3.4 was high but observed rainfall was below or near normal.

Key words: East Africa, extreme rainfall, Indian Ocean Monsoon, NIÑO 3.4, SOI, reanalysis.

P-020

The Study on changes in leaf coloring date in response to temperature increasing in South Korea

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Understanding the changes in spring and autumn phenological events is important because such phenomena are noticeable dynamic responses of the ecosystem to climate change. Many prior literatures mainly investigated the changes in spring phenology. From them, the advancing trend of spring phenology such as, first flowering, budburst, and green leafing, in response to temperature warming was identified. In contrast, knowledge on the changes in autumn phenology (e.g., leaf coloring and leaf fall) is limited due to the lack of related research. However, recent studies found that the changes in autumn phenology may be major cause to the extension of the growing season in Northern hemispheric temperate forests. Exact factors that drive autumn phenology remain uncertain. Some literatures suggested that photoperiod and temperature may be the most effective climatic factors to the changes in autumn phenology. Based on these results, researchers in Europe and North America developed process-based models for simulating the leaf senescence and coloring, and presented the delaying trend of autumn phenology in Europe and North America due to temperature warming. IPCC AR5 showed that East Asian countries have been and will be affected by unfamiliar changes in climate due to considerable surface warming. Thus, accumulated information on how autumn phenology will response to such warming trend is required. However, knowledge on the autumn phenology in East Asia is limited due to the lack of studies compared to Europe and North America. To advance understanding of autumn phenology in East Asia, this study examined the changes in the leaf coloring date of two temperate deciduous tree species, Acer palmatum and Ginkgo biloba, in response to surface air temperature changes at 54 stations of South Korea for the period 1989-2007. As a result, the variations of Acer palmatum and Ginkgo biloba in South Korea showed very similar trend, i.e., they showed the same mean leaf coloring date of 295th day of the year and delays of about 0.45 days $year^{-1}$ during the observation period. This delaying trend was closely correlated (correlation coefficient > 0.77) with increases in the surface air temperature in mid-autumn by 2.8 days $^{\circ}C^{-1}$. Given the significant relation between leaf coloring date and the surface air temperature, we projected their future changes for 2016-35 and 2046-65. A hybrid approach, which is using a process-based model called temperature-photoperiod model and a dynamical regional climate model WRF, were used to simulate the leaf coloring date and the surface air temperature. The projections indicated that the mean leaf coloring date in South Korea would be further delayed for 3.2 (3.7) days in 2016-35 (2046-65) due to mid-autumn surface air temperature increases. It is noted that the delaying trend of leaf coloring date and temperature sensitivity (days $^{\circ}C^{-1}$) for both tree species showed negligible dependence on latitudes and altitudes. This differs from Japan where the same tree species showed strong negative latitudinal variations, indicating that species-specific phenological responses to temperatures vary according to their habitats. The present results also demonstrated that continued mid-autumn temperature warmings will intensify the delaying trend of leaf coloring date in South Korea in the future.

P-021

Lower stratospheric influence on the formation of typhoon Peipah (2007) over the western North Pacific

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Multiple episodes of diurnal convective bursts are known as a typical preparation to tropical cyclone (TC) formation. In terms of boundary layer dynamics during TC formation, the prelude diurnal convection is interconnected with gradual intensification of lower-to-mid tropospheric vorticity. Meanwhile, TC Peipah in 2007 rather abruptly developed without accompanying the prelude diurnal convective bursts over the western North Pacific. Concurrent with the abrupt burst of convection, lower-to-mid tropospheric vorticity suddenly intensified in two days prior to the Peipah formation. Contrary to gradual vorticity intensification, such abrupt vorticity intensification may be attributed largely to the influence of arbitrary external forcing. Here, the process of TC Peipah formation from seven days before to one day after its formation has been examined by using reanalysis and geostationary satellite data.

TC Peipah is identified as a tropical depression (13-17 m s-1) at 6 UTC, 3 November 2007 over 18.2°N, 128.5°E. Seven days before Peipah formation, a strong potential vorticity anomaly is located in the upper troposphere, which is a result of potential vorticity intrusion from the lower stratosphere. In a form of a wave trough, strong vorticity anomaly is located diagonally above a surface precursor disturbance (pre-TC). On the east side of the upper tropospheric vorticity trough, upward motion is induced by positive vorticity advection. The coincidental alignment of surface disturbance and the upward motion result in formation of an extratropical low (baroclinic interaction). Five to four days before Peipah formation, the upper tropospheric wave trough amplifies and begins to break. The breaking of amplified wave in the upper-troposphere entrains cold and dry air from the stratosphere into warm and moist air in the tropics. As a result, the atmosphere destabilizes and becomes convectively unstable within weak wind shear condition and over warm sea surface. Under this convectively unstable situation, active convection leads to latent heat release and tropical transition of the extratropical low into a TC.

Summing up, we suggest that strong potential vorticity from the stratosphere can promote TC formation. Whereas the observational data we used is confined to the reanalysis data, in-situ observation is recommended to be analyzed in the future. Moreover, the frequency of such TC formation pathway needs to be examined as well.

P-022

Impact of urbanization on spring and autumn phenology in Beijing and Chengde, China

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Urbanization makes distinct contributions to regional climate change and urban ecosystem alteration. With the accelerative urbanization occurred in China embodied with population growth and urban area expansion over the past few decades, studying the impact of urbanization on local ecosystem makes great sense to predict the future ecosystem alteration and stabilization. This study described the impact of urbanization on spring and autumn phenology in Beijing and Chengde, two cities near with each other in north China during 1986-1996. Three types of phenophase, first leaf date (FLD), first flowering date (FFD) and first coloring data(FCD) of five plant species (e.g., Robinia pseudoacacia, Amygdalus daviana, Syringa oblate, Sophora japonica, and Ulmus pumila) were analyzed in this study. The results shows that there are obvious gap between the phenology date in these two different cities because of latitude difference. However, the spring phenology date in Beijing has very distinct tendency to advance during this decade, comparing with those in Chengde which was not developed so much as Beijing. Besides, the autumn phenology date didn't show obvious difference in 10-year tendency. Our results suggest that, high level of urbanization has stronger impact on spring phenology than autumn phenology.

P-023

Possible mechanism of Korean and Indian summer monsoon by Greenland Sea ice variability in CAM5

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The NCAR Community Atmospheric Model version 5.0 (CAM5) is used to explore the relationship with Korean and Indian summer monsoon by autumn Greenland Sea ice variability. Sensitivity experiments are performed with prescribed high and low sea ice conditions over Greenland Sea sector. In consistence our previous study carried out using observation analysis, the results of this study show that sea ice loss over autumn Greenland is associated with west-east dipole pattern in winter Eurasian snow.

This leads to positive rainfall anomaly over Korea and negative rainfall anomaly over India in boreal summer via an anomalous zonal and meridional circulation. These findings could have important implications for prediction.

Key words: Greenland Sea ice, Korea summer monsoon, India summer monsoon, CAM5

P-024

Flood simulation using the integrated surface and groundwater model in the Miho catchment, Korea

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Flood events brought significant damages to our lives such as economic and loss of life in all over the world, and the frequencies of flood events have increased due to the climate change. The damages from flood events exhibited different patterns in reality. The most visible is a riverine surface flooding and a flooding from the sewerage system. In addition, the floods can cause from rising groundwater table. This study presents the development, calibration and verification of a physically based surface water and groundwater integration model for flood simulation at the Miho catchment in Korea. The integrated model employed in this study is GSFLOW, which couples Precipitation-Runoff Modeling System (PRMS) with groundwater flow model (MODFLOW). In order to simulate the flood events, we developed flood simulation package for GSFLOW. The flood simulation model was calibrated and validated from 2013 to 2014 in both surface water and groundwater domains. The flood simulation results indicate that the developed flood simulation package provided acceptable model performances in dry and wet season. The results also present the groundwater impact on flood events. This study provides a fruitful way for understanding the hydrological system in the Miho catchment during flood season and for development of effective flood management strategies.

P-025

Improvement of soil moisture quality via assimilating satellite datasets in Land Surface Model (LSM)

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The understanding process of land surface water, and energy condition is critical important since they seriously effects on agricultural production, water resource, and weather and climate prediction. For investigating the impacts of the land surface conditions on the world applications, we need to obtain long-term and global scale land datasets. To obtain the land reanalysis products, a land surface modeling framework can simulate the land condition derived by near surface atmospheric forcing dataset based on a reanalysis data. In this work, the quality of the forcing dataset highly effects on the quality of produced land surface products. Especially, the major variable which can control the soil moisture, precipitation, is corrected with the observational dataset instead of the reanalysis driven by its atmospheric model. Moreover, assimilation of satellite-based surface soil moisture conditions into the land surface model is a sophisticated methodology to estimate a realistic soil moisture states. The application of data assimilation onto simulation of soil moisture status in the dynamical model accounts for an uncertainty and a non-linearity by the model. Therefore, this study quantitatively verifies the impacts of these two applications onto the generation of the land reanalysis products on the improving quality of land surface variables.

P-026

Subseasonal to seasonal forecasts of the South Korean heat waves on the August 2016

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One of the most intense heat waves were struck over the Korean Peninsula on 2016 by long lasting North Pacific anticyclone which induces brought warm air and blocked track of tropical cyclone. This study analyzes the subseasonal forecast for an intense heat wave event of skill in forecasting temperature and circulation patterns during heat wave events from two models, the European Centre for Medium-Range Weather Forecasts (ECMWF), and the United Kingdom Meteorological Office (UKMO rear-real time subseasonal to seasonal forecast system. The ECMWF which runs 32-day long, 51-member ensemble size, initialized operational sub-seasonal forecast every Monday and Thursday, and the UKMO which consist of 4-member ensemble size, initialized every month were considered. Weakly averaged anomalies were calculated for both observations and models with respect to their climatology. The results show that the warm anomaly over the Korean Peninsula was detected for the first week of August and remained until three weeks. The 500 hPa geopotential anomaly was detected for the first week, however, duration and intensity was little anticipated. The precipitation was detected well which showed the amount of precipitation was low over the Korean Peninsula. For forecast systems, they contained limited skills beyond several weeks, however, the relatively successful for forecasting heat wave events based on a multi-model ensemble strategy.

P-027

Impacts of urban air conditioning on urban heat island over the northern hemisphere in summer

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Su-Jong Jeong (Southern University of Science and Technology)

In summer season, heat flux from air conditioning of building in one of major source of the urban heat island (UHI), which effects on local urban climate. In recent decades, the air conditioning heat flux is significantly increased due to both rapid urbanization and economic growth. As the global mean temperature increases, in addition, cooling demands over urban area are projected to increase continuously. However, the impacts of increasing air conditioning heat flux on UHI and local climate are remained unclear despite numerous impacts of urban climate changes on residing people in urban area. In this study, the potential impacts of air conditioning on UHI and local climate in warmer climate are investigated based on coupled atmosphere-land model with modified parameterizations of urban air conditioning. The air conditioning heat flux are signified over India due to both high urban fractions and efficiency of thermal conduction. As concentration of carbon dioxide is increased, increasing air conditioning heat flux increase the strength of UHI by more than 20%. Present study suggest that increasing demands of urban air conditioning should be considered for better projection of future climate.

P-028

Role of sea surface temperature anomalies in the tropical Indo-Pacific region in the Northeast Asia severe Drought in summer 2014: Month-to-month perspective

Zhiqing Xu (Institute of Atmospheric Physics, Chinese Academy of Sciences)

The severe drought over northeast Asia in summer 2014 and the contribution to it by sea surface temperature (SST) anomalies in the tropical Indo-Pacific region were investigated from the month-to-month perspective. The severe drought was accompanied by weak lower-level summer monsoon flow and featured an obvious northward movement during summer. The mid-latitude Asian summer (MAS) pattern and East Asia/Pacific teleconnection (EAP) pattern, induced by the Indian summer monsoon (ISM) and western North Pacific summer monsoon (WNPSM) rainfall anomalies respectively, were two main bridges between the SST anomalies in the tropical Indo-Pacific region and the severe drought. Warming in the Arabian Sea induced reduced rainfall over northeast India and then triggered a negative MAS pattern favoring the severe drought in June 2014. In July 2014, warming in the tropical western North Pacific led to a strong WNPSM and increased rainfall over the Philippine Sea, triggering a positive EAP pattern. The equatorial eastern Pacific and local warming resulted in increased rainfall over the off-equatorial western Pacific and triggered an EAP-like pattern. The EAP pattern and EAP-like pattern contributed to the severe drought in July 2014. A negative Indian Ocean dipole induced an anomalous meridional circulation, and warming in the equatorial eastern Pacific induced an anomalous zonal circulation, in August 2014. The two anomalous cells led to a weak ISM and WNPSM, triggering the negative MAS and EAP patterns responsible for the severe drought. Two possible reasons for the northward movement of the drought were also proposed.

P-029

Twentieth-century Pacific Decadal Oscillation as simulated by the CMIP5 coupled models

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In this study, we examined the spatial and temporal characteristics of the simulated Pacific Decadal Oscillation (PDO) in 109 historical (i.e., all forcings) simulations derived from 25 coupled models within the Coupled Model Intercomparison Program phase 5 (CMIP5). Compared with observations, most simulations well simulate the observed PDO pattern and its teleconnections to the sea surface temperatures (SSTs) in the tropical and Southern Pacific. The BNU-ESM, CanESM2, CCSM4, CESM1-FASTCHEM, FGOALS-g2, GFDL-CM3, MIROC5, and NorESM1-M show better performance. Compared with the temporal phases of the observed PDO in the twentieth century, five simulations from the CNRM-CM5, CSIRO-Mk3-6-0, HadCM3, and IPSL-CM5A-LR simulate an evolution of the PDO similar to that derived from observation, which suggests that the current coupled models can possibly reproduce the observed phase shifting of the PDO. To capture characteristics of the observed PDO in the twentieth century, a requirement is that all the relevant external forcings are included in the models. That how to added the realistic initial state of the atmosphere and ocean into the model may be another key.

P-030

Contribution of human influence to increased daily precipitation extremes over China

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Jianqi Sun (Institute of Atmospheric Physics, Chinese Academy of Sciences)

This study provides an estimate of the human influence on increases in daily precipitation extremes over China using data sets from multiple coupled climate models participating in the Coupled Model Intercomparison Project Phase 5. The effects of human forcings can be detected in the observed changes of daily precipitation extremes, but the effects of external natural forcings as well as the aerosols are not detected using the optimal fingerprint methods. Estimation showed that human influence has increased daily precipitation extremes by approximately 13% (1% to 25% for 90% confidence interval) on average over China in recent decades. With further warming, human influences on precipitation extremes would be amplified. For a temperature increase of 1.5°C with respect to the preindustrial time, the occurrence probability of severe extremes is doubled, and approximately 51% of these events occurring over China are attributable to human influences. This fraction increases with temperature. Furthermore, the contributions of human influences are much stronger for the high-percentile extremes, and the highest sensitivity of the changes in daily precipitation extremes due to human influences is observed in the region of the Tibetan Plateau in the southwest of China.

P-031

Interdecadal Variations of the South Asian Summer Monsoon Circulation Variability and the Associated Sea Surface Temperatures on Interannual Scales

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Jun Hui Wang (Nanjing University of Information Science and Technology)
Dong Chen (Institute of Atmospheric Physics, Chinese Academy of Sciences)

We investigate the interannual variability of the South Asian summer monsoon (SASM) circulation, which has experienced a significant interdecadal change since 2000. This change is primarily influenced by sea surface temperatures (SSTs) in the tropical Pacific and North Atlantic oceans. During the pre-2000 period examined in this study (1979-99), the SASM is negatively correlated with eastern Pacific SSTs (the canonical ENSO mode) and positively correlated with the negative phase of the North Atlantic SST tripole (NAT). During the post-2000 period (2000-14), the SASM is negatively correlated with central Pacific SSTs and positively correlated with the positive phase of the NAT pattern. The associated Pacific SSTs change from the eastern to central region, leading to the rising (subsiding) branch of the Walker circulation moving westwards to the Maritime Continent in the latter period, which can impact the interannual variability of the SASM through modulating the wind field in the troposphere. In addition to Pacific SSTs, the NAT SSTs can propagate energy from the North Atlantic to the South Asian High (SAH) region through the wave activity flux, and then further impact the SASM via the SAH. Because the SASM is intimately related with precipitation over the Asian region, we briefly discuss the features of the precipitation patterns associated with the SASM during the two periods. The westward shifting Walker circulation leads to the shrinking and weakened anomalous westerlies of the SASM in the lower level, inducing the Maritime Continent rainfall location to move westwards and more moisture to arrive in southern China from the Pacific Ocean in the latter period.

P-032

A multidecadal oscillation in the northeastern Pacific

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The internal modes of the North Pacific can lead to climatic oscillations through ocean-atmosphere interactions and induce global climate responses. The best example is the Pacific Decadal Oscillation, but this fails to explain many climate phenomena. Here, another multidecadal variability over the North Pacific is described, found by analyzing reconstructed data covering the past 140 years. It is named the Pacific Multidecadal Oscillation (PMO), with anomalously high/low SSTs over the northeastern Pacific, and a quasi-60-year cycle. Related to this low-frequency variability of SST, the global mean temperature and precipitation present significant interdecadal differences. More importantly, the PMO index leads the global mean surface air temperature and SST by one to three years. The Arctic Oscillation pattern and atmospheric circulations are shown to change substantially with the transition of the PMO mode from positive to negative phases. This multidecadal oscillation improves the prospect for a long-term forecast of the global warming trend, since the PMO bears a remarkable relationship with global temperature.

P-033

Seasonal variation of surface fluxes over urban residential area

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Keunmin Lee (Yonsei University)
Jinkyu Hong (Yonsei University)

Since the industrial revolution, geographical extent of cities has increased around the world. Following the last three decades of rapid regional economic growth in Asia, many Asian megacities have emerged and are vulnerable to environmental changes. It is still challenging to unveil interactions of climate changes, urban heat island, and urban redevelopment in this area. Turbulent exchanges of energy and mass at the urban-atmosphere interface play an important role in air pollution and microclimate but in this region, the surface fluxes over urban area have not been extensively investigated using in-situ observations. In this presentation, we report the one-year (March 2015 - February 2016) exchanges of momentum, energy, and CO2 and their diurnal and seasonal patterns over a high-rise residential area in Seoul metropolitan city, Korea.

P-034

Decadal change of ENSO teleconnection in the western Pacific

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Myong-In Lee (Ulsan National Institute of Science and Technology)

The El Nino and Southern Oscillation (ENSO) is known as one of the strongest interannual variability in the tropical Pacific Ocean. It has various remote impacts which is called as teleconnection. Current seasonal outlooks highly depend on the ENSO teleconnection, which is apparently not static and is affected by change in the background state such as external forcing by natural variability and anthropogenic forcing. The ENSO teleconnection is modulated by external forcing such as natural variability and global warming. For example, the ENSO teleconnection has different characteristics at interdecadal timescales, aspects of which have been examined in association with the known pronounced decadal variability (He and Wang 2013; Kim et al. 2014). For example, interannual climate variability in the North Pacific apparently shifted after the mid-1990s with the Pacific Decadal Oscillation (PDO) shift from a warm phase to the cool phase (Mantua and Hare 2002; Bond et al. 2003; Overland et al. 2008). The Atlantic Multidecadal Oscillation (AMO)-related warming trend in the Atlantic Ocean also has a possible influence on the Pacific Ocean (McGregor et al. 2014). There still exist an insufficient knowledge of the possible remote impacts on anomalous climate variability and model predictability source resulting from the decadal change of ENSO variability.

This study examines distinguished ENSO teleconnection in the western Pacific during recent several decades. The ENSO influence has been changed with long-term Indo-Pacific warming trend since 1960s and low-frequency natural variability. The ENSO relationship has been intensified several monsoon regions over western Pacific with the decadal change, especially in mature phase of ENSO. Based on this study, further understanding of conditional ENSO teleconnection with different decades suggests that better interpretation of ENSO in observation and seasonal prediction for the better seasonal outlooks.

P-035

Influence of winter precipitation on spring phenology in boreal forests over the Northern Hemisphere

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Chang-Eui Park (South University of Science and Technology)
Su-Jong Jeong (South University of Science and Technology)

Spring vegetation phenology plays a key role in the carbon and water cycle, and sensitively responds to climate change. While surface temperature is a major driver to control spring phenological events, some studies have suggested that winter precipitation may modulate spring phenology using in-situ observations and satellite retrievals. However, this observational analysis has limitation in separating influence of precipitation from other climate variables. Here we investigate the effect of winter precipitation on spring phenology and suggest the responsible mechanism by introducing a process-based land surface model over boreal forests in the Northern Hemisphere (> 40°N). The influence of precipitation on the start of growing season (SOS) is examined by comparing results of two model simulations driven by different boundary conditions in precipitation (i.e. CTRL minus FIX_P; PREC experiment). In the CTRL experiment, all variables used were transient for the period 1982-2005. In the FIX_P experiment, 6-hr variations of precipitation are prescribed in the 1982 value throughout the same simulation period, but other variables were transient as in the CTRL. To understand the effect of winter (from November to March) precipitation, we investigated the responses of SOS in the PREC experiment under two extreme conditions of winter precipitation amount, greater vs. less than the 1982-2005 average by ±1 standard deviation. In the PREC experiment, SOS was delayed by 1.04 days in 69.5% of study area in wet years compared to dry years. We found that the increase in the quantity of snow remained until spring (April and May) caused the delay in SOS. In the spring under the wet years, the thicker snow left (0.016 m) in the PREC experiments led to an increased amount of melting snow (0.06 mm day-1) and reduced solar radiation absorption on the ground (-0.33 W m-2). As a result, growing degree days was decreased by -9.30°C, and SOS was delayed to get sufficient heat for vegetation green-up. Our results suggest that winter precipitation can play an important role in interannual variability of spring phenology by modulating ground condition in spring. We recommend that the role of precipitation as well as temperature should be considered when predicting changes in future spring phenology.

P-036

A new method to classify two types of ENSO

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Recently, a lot of attention has focused on two types of El Nino-Southern Oscillation (ENSO): the eastern Pacific (EP) type, in which the maximum SST variability appears over the equatorial EP, and the central Pacific (CP) type, in which the significant SST anomalies (SSTAs) are mainly located in the CP near the date line. Moreover, several studies have indicated that impacts by the EP- and CP-types ENSO forcing may differ distinctly in various climate elements. Therefore, the proper classification of the two types of ENSO event is important in the understanding and interpretation of climate and its variability. In this work, the EPC1 and EPC2 are proposed as new classification indices to divide ENSO events into EP- and CP-types, respectively. For clear separation of two types of ENSO event, these indices are defined as PCCs between the first two leading EOF modes of SST and observed monthly SSTAs over the tropical Pacific. Based on our new method, we classified ENSO events into EP-type and CP-type El Niño and La Niña events from January 1982 to December 2014 (shown in Table S1, Supporting Information). Two EPC indices are closely related with two types of ENSO index derived from five existing methods. Our new indices have, however, no overlapping cases between EP-type and CP-type ENSO events, as compared with other indices. The observed composited SSTA field for each ENSO event and the each regressed SST pattern onto two types of ENSO index over the Pacific Ocean are also compared using the spatial pattern correlation. Our results show that distinctive features associated with EP-type and CP-type ENSO events are well described in SST responses to EPC1 and EPC2 indices, respectively. The variation of our EP-type ENSO (EPC1) index shows a tendency of the highest peak by the end of the year and the phase locking by the seasonal cycle, while the CP-type ENSO (EPC2) index exhibits a significant variation reaching at the mature phase in spring instead of winter. The monthly frequencies of occurrences derived from two EPC indices for two types of ENSO event are quite similar to variation patterns of phase-locking behaviors. Through the comparison with previous other indices, newly developed indices have been demonstrated their usefulness as a method for clearly classifying ENSO events into EP-type and CP-type. Further research is required to conduct more detailed analyses related to remote impacts on various atmospheric variables (temperature, precipitation, wind, etc.) over the extratropics and other regions, as well as ENSO prediction, based on two newly defined ENSO indices. Besides this, a new index needs to be developed that indicates the intensity of EP and CP types of ENSO.

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P-037

Climatological Short break of Polar Night Jet in early winter and its relation to cooling over Siberia

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During winter over the Northern Hemisphere, lower stratosphere is characterized by strong westerly winds over the polar cap; so-called Polar Night Jet (PNJ). It has been widely recognized that climatological PNJ linearly increases from October through late December. Here we find a remarkable phenomenon that the climatological PNJ stops increasing temporarily during late November. We further examine this short break in terms of atmospheric dynamical balance. The upward propagation of climatological planetary wave from the troposphere to the stratosphere increases during late November. The climatological Eliassen-Palm flux is convergent in stratosphere (i.e., short break of climatological PNJ). The upward propagation of planetary wave mainly increases over Siberia. This upward propagation of planetary wave is related with climatological strengthening of the trough over Siberia. The longitudinally asymmetric forcing by land-sea heating contrasts might strengthen this trough.

P-038

Responses of climate extremes to volcanic eruptions assessed from CMIP5 multi-models

Seungmok Paik (Pohang University of Science and Technology)
Seung-Ki Min (Pohang University of Science and Technology)

Understanding climate responses to volcanic eruptions is important to isolate and quantify anthropogenic effect on the observed change. It also help to assess the possible climate influences of the geoengineering schemes based on solar radiation management. This study analyzed responses of extreme temperature and precipitation over the global land to five explosive tropical volcanic eruptions (Krakatau, Santa María, Agung, El Chichón and Pinatubo) that occurred since 1880s using CMIP5 multi-model simulations. These low latitude eruptions are appropriate to investigate the global climate responses, since aerosols tend to spread out globally. We used historical (ALL) simulations, which were integrated under both anthropogenic and natural (solar and volcanic) forcing (17 models), and historicalNat (NAT) simulations integrated under natural external forcing only (13 models). The changes in extreme temperature and precipitation indices during post-eruption years were examined by compositing responses to the five volcanic eruptions. Inter-model correlation was analyzed to compare results with mean climate responses and also explore physical mechanisms.

First, responses in annual warmest day (TXx) and coldest night (TNn) temperature indices were examined. Extreme temperature decreases occurred in most global land areas during post-eruption years, with good agreement between models. This volcanic cooling was stronger than the internal variability ranges (estimated from bootstrap random sampling), representing robust responses. Further, the cooling responses were greater in NAT than ALL experiment, due to the absence of anthropogenic warming. There was a close relationship between annual extreme and mean temperature responses to volcanic forcing, indicating similar mechanisms operating (inter-model correlation r=0.91 for TXx and r=0.86 for TNn). In addition, surface air temperature and surface specific humidity responses were significantly correlated across models (r=0.83), consistent with the Clausius-Clapeyron relation.

Second, we analyzed extreme precipitation responses to volcanic forcing using annual extreme consecutive 5-day precipitation (Rx5day), annual total precipitation on very wet days (R95p), and daily precipitation amount on rainy day (SDII). Extreme and mean precipitation reductions were identified especially in Northern and Southern Hemispheric summer monsoon regions, with good inter-model agreement in sign of the responses. The precipitation decreases were also larger than the internal variability ranges during two post-eruption years. Unlike temperature responses, NAT did not have larger response than ALL, implying weak influence of anthropogenic forcing on monsoon precipitations. The extreme precipitation changes were found to be closely related to mean precipitation response over the monsoon regions (r=0.63 to 0.76). In terms of mechanisms, analysis based on a moisture budget equation revealed that the precipitation decrease over the monsoon region is determined by evaporation decrease, dynamic, and thermodynamic contributions. Particularly, the dynamic contribution was found to have large influence on inter-model spread in precipitation responses with high inter-model correlation with mean and extreme precipitation changes (r=0.52 to 0.91). Our results suggest that temperature and precipitation extremes significantly respond to volcanic eruptions, which largely resemble mean climate responses.

P-039

Dominant Modes of Wintertime Precipitation Variability in Northwest China and the Associated Circulation Anomaly

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The dominant modes of wintertime precipitation variations in Northwest China and their association with atmospheric circulation and sea surface temperature (SST) are investigated. The leading mode (EOF1) shows a uniform sign in the entire region and the second one (EOF2) exhibits a zonal dipole pattern, they account for 25.0% and 15.8% of the total variance, respectively. EOF1 is closely related to the Eurasian (EU) teleconnection pattern. Years when a negative phase of EU pattern occurs tend to be rainy with anomalous southerlies water vapor transported from low-latitude and profound ascending motion anomalies. Atmospheric anomalies associated with the second mode resembles the Arctic Oscillation (AO) pattern. The AO pattern influences EOF2 precipitation variations through the anomalous circulations over Mongolia and west Europe. When there is a cyclonic circulation anomaly over Mongolia and west Europe, cold and wet air from the north and water vapor from the North Atlantic Ocean can be transported to Northwest China. Together with the local vertical movement, causing above normal precipitation in the west and below normal precipitation in the east. Further analysis suggests the EOF1 is closely related to the ENSO cycle, and it may be a potential predictor emerging in the preceding autumn. When ENSO is in the warm phase, the anomalous southerly winds caused enhanced water vapor transported to Northwest China and resulting in a wet condition there. EOF2 has a good relationship with a tripole SST anomaly mode in the North Atlantic Ocean. It may affect the Northwest China wintertime precipitation anomaly through modulating the NAO pattern by local atmosphere-ocean interactions.

P-040

Intensified Impact of North Atlantic Oscillation in May on subsequent July Asian Inland Plateau precipitation since the late 1970s

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The relationship between the North Atlantic Oscillation (NAO) in May and precipitation in the Asian inland plateau (AIP) in July has experienced significant enhancement since the late-1970s. This study investigates the factors that have influenced the interdecadal change of the NAO-AIP precipitation connection. Before the late-1970s, geopotential height anomalies related to the May NAO exhibited a dipole pattern confined to the North Atlantic from May to June and decayed in July. As a result, the impact of the May NAO on the AIP precipitation in July is weak. In contrast, after the late-1970s, geopotential height anomalies associated with the May NAO have persisted into July. The analysis in this study finds that the May NAO influences July AIP precipitation via modulating the Polar-Eurasia teleconnection (POL). After (before) the late-1970s, the connection between the May NAO and the POL was strong (weak), explaining the interdecadal change in the May NAO-July AIP precipitation relationship. Further analysis suggests that the strengthening of the relationship between the May NAO pattern and the July POL after the late-1970s may be attributed to the interdecadal contraction of the Northern Hemisphere circumpolar vortex.

P-041

East Asian Winter Monsoon Impacts the ENSO Related US Seasonal Air Temperature Forecast

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ENSO is a key feature for seasonal weather and climate prediction in the extra-tropics since related sea surface temperature anomalies induce precipitation anomalies that generate poleward propagating Rossby waves and teleconnections. The East Asian winter monsoon (EAWM) is driven by processes originating over the Asian continent and, to a lesser degree, by ENSO related tropical convection. EAWM also strongly affects convection and precipitation patterns over the western tropical Pacific by cold air outbreaks reaching equatorial latitudes. Hence, one can expect a modulating effect of EAWM on the generation of Rossby wave trains related to ENSO. By increasing the convective heating over the western Pacific, strong EAWM strengthens the Pacific Walker circulation in a positive feedback loop. It weakens (strengthens) the El Niño (La Niña) related effects on the extra-tropics via a modulation of the Pacific North America teleconnection pattern. Our results indicate that, for seasonal prediction over North America, along with ENSO also the variability of EAWM should be taken into account. The climate anomalies over the US for the same phase of ENSO are significantly different for strong and weak EAWM.

P-042

Roles of ENSO-related western North Pacific anticyclone in the Link of the East Asian Winter Monsoon to the following Summer Monsoon

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Investigates the roles of ENSO-related western North Pacific anticyclone persistence in the relationship between the East Asian winter monsoon (EAWM) and the following East Asian summer monsoon (EASM). Corresponding to a weak EAWM, an anomalous low-level anticyclone forms over the western North Pacific (WNP) and persists from winter to the following summer. This anticyclone enhances southerlies over the coast of East Asia in summer. Hence, a weak EAWM tends to be followed by a strong EASM and vice versa. As such, a link is established between the EAWM and the EASM. The observed EAWM-EASM relationship is dominated by the winter monsoon variability associated with ENSO. An anomalous western North Pacific anticyclone, forming in the El Nino mature phase and maintaining in the following spring and summer is the key system. The persistence of this WNP anticyclone may be mainly attributed to the sea surface temperature anomalies associated with the ENSO-related EAWM part in the Ocean. Extensive studies have been conducted to investigate the mechanism for the formation and maintenance of anomalous WNP anticyclone, like the local wind-evaporation feedback and Indian Ocean capacitor effect. The above results are mainly based on observations and ignored the important impacts of WNP anticyclone persistence in the link of EAWM with the EASM, especially in the performance of models. Here we examine the simulation skill of the WNP anticyclone persistence, based on simulations from phase 5 of the Coupled Model Intercomparison Project (CMIP5). And then perform more detailed diagnosis and attribution analysis about the anticyclone bias to explore the reason for the bias in CMIP5 CGCMs.

P-043

Impacts of Dipolar SSTA distribution on initiation of MJO convective over the Tropical Indian Ocean

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Based on NCEP atmosphere re-analysis data and NOAA sea surface temperature data during 1981-2012, we applied the method of synthetic analysis to study the influence of dipole sea surface temperature distribution in the equatorial Indian Ocean on the generated frequency of Madden-Julian oscillation (MJO) convection over the tropical western Indian Ocean (WIO). The results indicate that, in the tropical WIO, the positive (negative) phase of dipole sea surface temperature anomaly (SSTA) distribution is favorable (not favorable) for the generation of large-scale convection, but it is not favorable (favorable) the generation of MJO convection. Whether a large-scale convection can propagate eastward to the eastern Indian Ocean is an important factor for defining the generation of MJO convection. We analyze SSTA distribution and its impact to the variations of the background field during two phases of dipolar SSTA. The results indicate that the distribution of different SSTA will bring varying circulation and moisture in the eastern Indian Ocean (EIO), therefore it affects the MJO convection onset in frequency. We compare the evolution characteristic of moist static energy (MSE) and middle-low layer moisture in the generation stage during dipole phase of SSTA. The results indicate that the tendency of MSE is mainly dominated by middle-low layer moisture. During the negative phase of dipolar SSTA, in EIO regions, the positive tendency of MSE and moisture over the east of convection is bigger than the positive phase of dipolar SSTA. The MSE budget analysis indicated that horizontal moisture advection is the dominant term for the eastward propagation of MJO. Further investigation revealed that the eddy MSE transport and mean MSE advection by MJO flow and intraseasonal MSE through mean flow play an important role in increasing the MSE horizontal advection. Surface latent heat flux (LHF) primarily result from the mean air-sea humidity difference coupled with MJO wind. These indicate that its initiation of MJO convection over the WIO will be affected by both the circulation anomalies aroused by dipole distribution of SSTA and by large-scale convection itself during the generation period of MJO convection, which will put the impact on frequency of MJO convection. The result revealed from the moisture budget diagnosis was almost the same.

P-044

Enhancement of the spring East China precipitation response to tropical Indian Ocean sea surface temperature variability

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The relationship between boreal spring East China precipitation (ECP) and contemporaneous tropical Indian Ocean (TIO) sea surface temperature (SST) variability during the period of 1951-2014 is investigated in this study. The results show that, after the late 1970s, the dominant variability mode of the ECP has an enhanced response to the TIO SST variability and the response is linearly independent from the El Niño-Southern Oscillation (ENSO) variability.

The enhanced response of the ECP to the TIO SST is related to the significant warming of the TIO SST after the late 1970s. During the warm period, the TIO SST shows strong impact on East Asian atmospheric circulation, whereas the impact is weak during the cold period. TIO SST impact on East Asian atmospheric circulation through two ways: by exciting a zonal wave-train pattern over the mid-latitude Eurasian continent and by inducing anomalous convection over the Maritime continent (MC). Via these two mechanisms, the TIO SST variability has resulted in an anomalous East Asian trough, low-level and upper-level winds, and vertical motion over East China and consequently has led to anomalous precipitation over the region, after the late 1970s. The physical processes connecting the ECP and TIO SST are reproduced by numerical simulations.

From a prediction perspective, the highly consistent variability between the boreal spring and preceding winter TIO SSTs is noted. Further, an enhanced relationship is also observed between the winter TIO SST and the following spring ECP after the late 1970s. The well persistence of the TIO SST from preceding winter to spring is valuable for ECP prediction after the late 1970s.

P-045

Extratropical Factors Affecting the Variability in Summer Precipitation over the Yangtze River Basin, China

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The Yangtze River Basin (YRB), a typical East Asian monsoon region, experiences a large year-to-year variability in summer precipitation and is subject to both floods and droughts. There is a well-known seesaw relationship in precipitation between the tropical western North Pacific and the YRB, but more than half of the variance in precipitation in the YRB cannot be explained by this seesaw pattern. We therefore investigated other physical factors that might affect precipitation in the YRB. The results indicate that the northeasterly anomaly in the lower troposphere to the north of the YRB plays an important role in the variability in precipitation. This northeasterly anomaly is paired with the southwesterly anomaly to the south of the YRB. They both play an important role in water vapor accumulation over the YRB, and intensify the meridional gradient of the equivalent potential temperature (θe) over the YRB by bringing dry and cool air from the north and wet air from the south. This intensified θe gradient favors convective instability and heavier rainfall in the YRB, as previous studies on Mei-yu weather have indicated. Furthermore, it is found that the zonally oriented teleconnection along the Asian westerly jet and the meridional displacement of the jet can affect circulation in the lower troposphere and precipitation in the YRB. These results highlight the role of extratropical circulation anomalies and thus contribute to a more comprehensive understanding of the variability of precipitation in the YRB.

P-046

The asymmetric roles of ENSO in the link of the East Asian winter monsoon to the following summer monsoon

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Evidence demonstrates there exists a linkage between the East Asian Winter Monsoon (EAWM) to the following East Asian Summer Monsoon (EASM). Previous studies found that the EAWM and EASM are closely linked in ENSO years, but most of these studies are based on the hypothesis that atmosphere's response to ENSO is symmetric. In fact, ENSO plays an asymmetric role in the EAWM-EASM link. This study divides the variability of EAWM into an ENSO-related part (EAWM_En) and an ENSO-unrelated part (EAWM_Res). The asymmetric relationship between EAWM_En and the following EASM is mainly investigated through the composite analysis. The results demonstrate that during the strong EAWM_En conditions (i.e. La Nina), an anomalous cyclone over the Western Northern Pacific (WNPC) persists from winter to the following summer, leading to the following weak EASM. In contrast, during the weak EAWM_En conditions (i.e. El Nino), an anomalous anticyclone over the Western Northern Pacific (WNPAC) persisting from winter to summer is observed, resulting to the following strong EASM. However, the amplitude of WNPAC is much stronger and its location shifts more southward compared to its WNPC counterpart. Thus, the role of ENSO in the link of EAWM to the following EASM is asymmetric. This asymmetry may be attributed to the different evolutions of the tropical sea surface temperature (SST) anomalies. During the strong EAWM_En conditions, the SST anomalies in the tropical central-eastern Pacific decay slowly and there still exist obvious signals in the following summer, resulting in the weak occurrence of WNPC. During the weak EAWM_En conditions, however, the SST anomalies over the tropical Pacific decay quickly in the following summer and the Indian Ocean warms significantly, the WNPAC is resulted from the significantly warmed Indian Ocean through the "capacitor mechanism".

P-047

Ensemble Simulation of Land Evapotranspiration in China Based on a Multi-Forcing and Multi-Model Approach

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In order to reduce the uncertainty of offline land surface model (LSM) simulations of land evapotranspiration (ET), we used ensemble simulations based on three meteorological forcing datasets [Princeton, ITPCAS (Institute of Tibetan Plateau Research, Chinese Academy of Sciences), Qian] and four LSMs (BATS, VIC, CLM3.0 and CLM3.5), to explore the trends and spatiotemporal characteristics of ET, as well as the spatiotemporal pattern of ET in response to climate factors over mainland China during 1982-2007. The results showed that various simulations of each member and their arithmetic mean (Ens_Mean) could capture the spatial distribution and seasonal pattern of ET sufficiently well, where they exhibited more significant spatial and seasonal variation in the ET compared with observation-based ET estimates (Obs_MTE). For the mean annual ET, we found that the BATS forced by Princeton forcing overestimated the annual mean ET compared with Obs_MTE for most of the basins in China, whereas the VIC forced by Princeton forcing showed underestimations. By contrast, the Ens_Mean was closer to Obs_MTE, although the results were underestimated over Southeast China. Furthermore, both the Obs_MTE and Ens_Mean exhibited a significant increasing trend during 1982-98; whereas after 1998, when the last big EI Nino event occurred, the Ens_Mean tended to decrease significantly between 1999 and 2007, although the change was not significant for Obs_MTE. Changes in air temperature and shortwave radiation played key roles in the long-term variation in ET over the humid area of China, but precipitation mainly controlled the long-term variation in ET in arid and semi-arid areas of China.

P-048

Impact of atmospheric model resolution on simulation of ENSO feedback processes: A coupled model study

Juan Li Hua (Chinese Academy of Meteorological Sciences)

This study examines El Niño-Southern Oscillation (ENSO)-related air-sea feedback processes in a coupled general circulation model (CGCM) to gauge model errors and pin down their sources in ENSO simulation. Three horizontal resolutions of the atmospheric component (T42, T63 and T106) of the CGCM are used to investigate how the simulated ENSO behaviors are affected by the resolution. We find that air-sea feedback processes in the three experiments mainly differ in terms of both thermodynamic and dynamic feedbacks. We also find that these processes are simulated more reasonably in the highest resolution version than in the other two lower versions. The difference in the thermodynamic feedback arises from the difference in the shortwave-radiation (SW) feedback. Due to the severely (mildly) excessive cold tongue in the lower (higher) resolution version, the SW feedback is severely (mildly) underestimated. The main difference in the dynamic feedback processes lies in the thermocline feedback and the zonal-advection feedback, both of which are caused by the difference in the anomalous thermocline response to anomalous zonal wind stress. The difference in representing the anomalous thermocline response is attributed to the difference in meridional structure of zonal wind stress anomaly in the three simulations, which is linked to meridional resolution.

P-049

Statistical Prediction of Sri Lankan rainfall during September to November

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September to November (SON) rainy season is associated with "Maha" rice growing season in Sri Lanka. Prediction of the SON rainfall therefore is important for Sri Lankan agriculture and water resource management. It is known that the SON rainfall is a combination of various influences of Southwest monsoon, local thunderstorms, orographic rainfall, and tropical cyclones from Bay of Bengal. However, the seasonal rainfall prediction skill is poor in Sri Lanka. This study attempts to develop a simple and multiple regression model using the global sea surface temperature (SST) for Sri Lankan SON rainfall prediction with lead times of 1-2 months.

A correlation analysis is used to identify the regions of which SST anomalies are highly correlated with the Sri Lanka rainfall index (SLRI) for the 0, 1 and 2 month lead times. The 0-month lead time is defined as June to August (JJA) minus March to May (MAM), while the 1-month lead time is defined as July minus May and the 2-month lead time as June minus April. Three regions of SST, which are highly correlated with SLRI, are selected as predictors: (1) Western Pacific and Maritime continent sea region (2) Central Pacific region and (3) Southern Atlantic region. Using these three predictors multiple regression models are built to predict Sri Lanka SON rainfall at 0-, 1- and 2-month lead times. The results show that the temporal correlation coefficient skill (TCC) of 0.71 for all 34 years. The TCC for the training period is 0.79 and TCC for the validation period is 0.44. The 1-month lead forecast model uses predictors during July and before July information. The three predictors identified for the 1-month lead forecast model have similar physical meaning as the predictors used at o-month lead time. For the 1-month lead time, the TCC is 0.68 for all 34 years. The TCC for the training period is 0.71 and TCC for the validation period is 0.71. 2-month lead forecast model uses predictors that involve information during June to April. The 2-month lead forecast model uses only 2 predictors because it does not show significant correlation in Western Pacific and Maritime continent region. For 2-month lead time, the TCC is 0.58 for all 34 years. The TCC for the training period is 0.56 and TCC for the validation period is 0.74.

P-050

Peru floods in 2017

Rackhun Son (Gwangju Institute of Science and Technology)
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Early 2017 Peru suffered from devastating floods. The severe downpours began to fall since December 2016, and it continued until the end of March causing $3.1 billion USD worth of economic damage (The Guardian, 13 April 2017). Anomalously high SST near the coast of Peru was blamed for such events by media. In this study, we'd like to investigate what is the causing mechanism of extreme flood over Peru in early 2017.

Historically, the anomalous warm SST along the coast of Peru has been observed after strong El Nino events, such as 1982-83 and 1997-98. Similarly, local high SST anomalies were detected along the coast of Peru from February to March 2017. The difference is, on the other hand, that the most recent El Nino (2015-16) had already demised and the ENSO status turned back to neutral (IRI, 16 February 2017). Here, we analyze the long-term change of SST along the Peru coast and significant increasing trend is found. Further, evolution of the local SST has large resemblance with onset of Eastern Pacific (EP) El Nino with remarkable distinction with past cases. It generates strong westerly wind anomaly, as much as the strongest El Nino cases (1982-83, 1997-98), interrupting the flow of trade wind and warming SST along Peru's coast.

P-051

Long-term change of droughts and floods in Mongolia

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Drought is one of the major natural disasters that cause socio-economic problems as well as environmental issues. Mongolia, a semi-nomadic country where 28.45% of the country's workforce is engaged in agricultural activities as of 2015 (World Bank, 2015), is under significant and direct threat of potential drought. Drought can cause damage not only on crop yields but also on animal husbandry, which accounts for over 80% of total agricultural production in Mongolia (FAO, 2017). Therefore, research on long-term change of precipitation with particular focus on drought is essential over this region.

As the main reason causing drought is deficiency in anticipated precipitation which occurs mostly during summer season (June-July-August; JJA) in Mongolia, we analysed long-term changes of precipitation. Observational precipitation data showed downward trend during summer season especially in northern Mongolia. However, along with this long-term declining trend, several extreme flood events have been reported. In other words, the overall precipitation has been decreasing, but once it rains, the extreme heavy rain events occur.

Therefore, we will conduct the diagnostic analysis using historical precipitation and investigate the relationship between recent drought and extreme flood events. Ultimately, we want to identify, in this study, any external forcing that cause such change in droughts and floods over Mongolia.

P-052

Response of the Hadley circulation to the sea surface temperature in 20C and 21C

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The Hadley circulation (HC) has strengthened and widened during recent decades in the reanalyses and observations. General circulation model simulations of the twentieth century show a little change of the HC strength and weak expansion of the HC width, while the HC weakens and expands poleward in the global warming simulation (i.e., twenty-first century). If the global warming continues, we expected that the HC will strengthen and widen however the twenty-first century model simulations showed the different result in intensity. Therefore, in this work, we examined the changes of HC depending on the first sea surface temperature (SST) mode using the historical and the representative concentration pathway 8.5 experiments in CMIP5 models. The zonal mean SST mode was obtained by using the empirical orthogonal function analysis. The twenty-first century SST over the subtropical and mid-latitude oceans is as warm as the tropical SST, which means the meridional SST gradient from the equator to the subtropics is reduced, compared with that of twentieth century. This reduced meridional SST gradient leads to the weakening and widening of the HC in both hemispheres in the future.

P-053

Intercomparison of Land Surface Models in WRF and Optimal Estimation of Parameters for Predicting the Eurasian Snow

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Eurasian snow in winter and spring has an appreciable impact on large and synoptic scale circulations in East Asia. Therefore, an accurate prediction of snow over the Eurasia is utmost important in predicting the following summer climate and weather systems in East Asia. Variables, which are related to the land surface, are mostly calculated by the land surface models (LSMs) usually coupled to the regional/global meteorological models. Most regional/global models have several LSMs as optional choices. LSMs include many subgrid-scale physical processes that require parameterizations, and each LSM has its own characteristic physical processes and land surface/soil/vegetation parameters; thus, different choice of LSM brings about different results in snow and other variables/parameters, even with the same initial and boundary conditions.

In this study, using the Weather Research and Forecasting (WRF) model, we simulate snow over Eurasia and make intercomparison of six LSMs - Thermal Diffusion (TD) scheme, Unified Noah LSM, Noah-MP, RUC, Community Land Model version 4 (CLM4), and Pleim-Xiu (PX) LSM. The WRF simulations with all six LSMs over Eurasia have been carried out for the period of 1 June 2009 to 31 August 2010, including the spin-up time, by using the NCEP Final Operational Global Analysis data.We compared the results with the Canadian Meteorological Centre Daily Snow Depth Analysis Data to identify the LSM which predicts the snow depth most accurately. Most LSMs, except TD scheme and PX LSM which do not include snow scheme, showed reasonable results. Furthermore, we will compare the results of precipitation and temperature over East Asia during summer to see if the most accurate LSM in predicting Eurasian snow also represents the most accurate prediction on summer weather and climate systems. As a next step, optimal estimation of parameters, e.g., using genetic algorithm, can be performed for further improvement of the Eurasian snow prediction.

P-054

Atmospheric footprint of the recent warming slowdown

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Growing body of literature has developed to detect the role of ocean heat uptake and transport in the recent warming slowdown between 1998-2013; however, the atmospheric footprint of the slowdown in dynamical and physical processes remains unclear. Here, we divided recent decades into the recent hiatus period and the preceding warming period (1983-1998) to investigate the atmospheric footprint. We use a process-resolving analysis method to quantify the contributions of different processes to the total temperature changes. We show that the increasing rate of global mean tropospheric temperature was also reduced during the hiatus period. The decomposed trends due to physical processes, including surface albedo, water vapour, cloud, surface turbulent fluxes and atmospheric dynamics, reversed the patterns between the two periods. The changes in atmospheric heat transport are coupled with changes in the surface latent heat flux across the lower troposphere (below approximately 800 hPa) and with cloud-related processes in the upper troposphere (above approximately 600 hPa) and were underpinned by strengthening/weakening Hadley Circulation and Walker Circulation during the warming/hiatus period. This dynamical coupling experienced a phase transition between the two periods, reminding us of the importance of understanding the atmospheric footprint, which constitutes an essential part of internal climate variability.

P-055

Correlation between Rainfall in Indonesia and Indian-Pacific Ocean SST Associated with the Regime Shift

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Long-term spatio-temporal variations in sea surface temperature (SST) and rainfall have been shown with climate regime shifts for 40-70 years in several previous studies. The long-term analysis of SST is also needed for understanding its characteristics, patterns, and factors influencing rainfall in Indonesia based on Empirical Orthogonal Function (EOF) method. However, there is a limited number of ground based observation of rainfall in Indonesia. One way to solve this problem is to use satellite data or available gridded dataset. We used Climatic Research Unit (CRU) rainfall dataset, which covers the period 1901-2015. The objectives of the present study are to investigate the accuracy of CRU gridded rainfall dataset with ground station rainfall data and to analyze the seasonal variability of Indonesian rainfall corresponding to the regime shift, that is, 1948-1976 and 1977-2014. We compared CRU data with six ground based observations focusing on seasonal and inter-annual variations. For seasonal variation, there are limitations in using CRU data in several locations of Indonesia. In Bengkulu and Gorontalo, correlation coefficients are smaller than 0.29 for DJF and MAM seasons. In the other regions (Bandung, Banjar Baru, Ngurahrai Bali, and Bima), on the other hand, the comparison shows significant correlations. For inter-annual variation, there are significant correlations for six sites (r=0.47-0.86) and biases for five sites from -58% to +14%, except for Gorontalo. After the above evaluation of CRU dataset, we investigated a relationship between SST of Indian-Pacific Ocean and rainfall in Indonesia. SST spatial anomaly pattern was analyzed by using EOF analysis of Indonesian rainfall to know how the climate variabilities are emerging from Indian-Pacific Ocean. The result shows the spatial correlation coefficients between EOF 1 of rainfall and SST anomaly in 1948-1976 contain several phenomena, that is El Nino Southern Oscillation (ENSO), El Nino Modoki, and Indian Ocean Dipole (IOD). For the period of 1977-2014, they contain ENSO, IOD, and Ningaloo Nino phenomena. The percentage of explained variance of EOF 1 in dry season (JJA and SON) is larger than that in wet season (DJF and MAM). In this case, the dry season in Indonesia is strongly influenced by ENSO and IOD with the percentage of variance from 46% to 51%, and the wet season is influenced by ENSO, El Nino Modoki, and Ningaloo Nino with the percentage of variance from 22% to 25%.