

海洋大陸上における大気水収支の日変化特性 Effect of the diurnal variation on the hydrological cycle over the maritime continent

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The climate of the maritime continent is characterized by huge amounts of precipitation throughout the year. The unique environment in this region with complex distribution of islands and warm pool favors the development of deep and frequent convection. The deep convection accompanied by heavy precipitation is generally observed over islands and its surrounding ocean rather than open seas. Major islands combined with surrounding warm seas, therefore, are most likely to play an important part in the energy and water cycle processes driving the complex atmospheric circulation pattern.

To understand the time-space characteristics of the hydro-climate in islands and ocean, we examined the climatological hydrological cycle from 1998-2010. The characteristics of water budget are separated between Island (including its surroundings ocean) and open seas in the maritime continent. The seasonal variation of precipitation over Borneo and the surrounding ocean is very small compared with those over other tropics. The vertically-integrated moisture flux fields show divergence throughout the year over the Borneo, suggesting that evapotranspiration from the island surface is a major source of moisture to atmosphere. In contrast, other major islands in the maritime continent, such as New Guinea, the seasonal cycle of moisture flux convergence is observed. On the other hand, the contribution of moisture flux convergence to precipitation is noticeable over the surrounding ocean of the major islands. The diurnal variance of the hydrological components is large over Island region and its surrounding oceans. Diurnal cycle of local atmospheric circulation plays an important role in exchange of water between the island and the surrounding ocean. The intraseasonal oscillation (ISO) is also a dominant mode of rainfall over this region. The influence of the ISO on the water budget appears stronger over the ocean than over the island. The vertical profile of the moisture flux and specific humidity indicate large difference in low-middle level between ocean and island.

キーワード: 日変化, 大気水収支, 季節内変動, 海洋大陸

Keywords: Diurnal cycle, Atmospheric water budget, Intraseasonal oscillation, Maritime Continent

インドネシア海洋大陸における同位体循環モデルを使った降水起源の推定 Water Origin over Indonesia Maritime Continent with Isotope Circulation Model

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By using the data obtained by a global Rayleigh-type circulation model with the Japanese long-term re-analysis project, we determined the seasonal changes of water sources trajectory to Maritime Continent. The model output was validated by the observation data of the Oxygen-18 and Deuterium content in precipitation at nine stations. The model performed well statistically in reproducing the simulated stable isotope in precipitation. The model demonstrates the seasonal characteristics of the water origin in three climatic patterns: (1) the semi-annual pattern, in which seasonal changes are indicated by the alternating presence of water from the northern and southern Maritime-Continent seas, (2) the anti-monsoonal pattern, represented by the alternating presence and absence of water from the southwest Pacific Ocean, southern Maritime Continent, and tropical Maritime-Continent sea, and (3) the monsoonal pattern, characterized by the alternating presence and absence of water from the northern Maritime Continent sea and Indian Ocean.

Keywords: Stable Isotope in Precipitation, Isotope Circulation Model, Water Origin, Asian-Australian Monsoon, Maritime Continent

ELF・VLF帯電磁場計測に基づいた海洋大陸における雷活動の監視 Monitoring of lightning activity in the Maritime Continent based on electromagnetic measurement in ELF and VLF range

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雷放電観測は集中豪雨の様な極端気象を引き起こす積乱雲活動の監視及び直前予測において有効な手法として注目されている。集中豪雨は洪水を引き起こし、特に東南アジア域における大都市部に損害を与えている。先行研究においては、積乱雲を生み出す大気鉛直対流の存在の有無を判断する代理パラメータとして雷放電の空間分布データが有用である事を示している。

近年の雷放電観測では、平均的な規模の数100倍のスケールを持つ落雷の存在が示されている。この結果は、各々の雷放電の場所だけでなく、その規模推定が鉛直対流の定量評価に必要な不可欠である事を示唆している。

本研究では、アジア海洋大陸域における雷観測網の紹介を行う。同観測網は、雷放電活動の空間分布だけでなく、そのスケール分布まで導出出来る様に設計されている。観測網は複数のセンサーにより構成され、雷放電より放射される電磁界の波形を多点観測で記録することが可能である。雷放電の位置は、到来時間差法により決定され、その精度は10km未満と見積もられる。さらに、電磁界の波形より、落雷規模の推定として中和電荷モーメントの推定を行う事ができる。

既に、台湾・台南市 (23.1N, 121.1E)、タイ・サラブリ (14.5N, 101.0E)、インドネシア・ポンティアナク (0.0N, 109.4E)そしてフィリピン・ロスバニョス (14.18N, 121.25E)に観測システムの構築を行った。現在、ベトナム・ハノイへのシステム構築を予定している。多点観測で得られたデータは各観測所に設置されたGPS受信機により同期される。

本発表では、ELF・VLF帯空電観測に基づいた、雷放電の位置推定と中和電荷モーメントの推定の初期結果を示す。

キーワード: 雷, 極端気象, ELF, VLF, 空電

Keywords: lightning, severe weather, ELF, VLF, sferics

Spatiotemporal variability and trends of rainfall extremes in the Philippines: Linkage with ENSO and monsoon

Spatiotemporal variability and trends of rainfall extremes in the Philippines: Linkage with ENSO and monsoon

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Due to the recent extreme rainfall events that led to disaster in the Philippines, long-term trend and variability of rainfall extremes in the country are investigated using daily rainfall data from 35 meteorological observing stations during 1951-2010. Seven extreme precipitation indices that characterize daily rainfall in terms of intensity, accumulation and duration in a seasonal perspective are used. The non-parametric Mann-Kendall test is implemented in combination with moving block bootstrap to detect significant trends. Results indicate a tendency toward wetter condition during boreal summer (July-September, JAS) while a drying condition during boreal fall (October-December, OND) in the Philippines. The influence of El Niño-Southern Oscillation (ENSO) and Western North Pacific (WNP) summer monsoon on the extreme precipitation indices are further explored by means of composite analysis and rank correlation technique. Around 20%-60% drier (wetter) condition is associated with El Niño events during OND (JAS); however, ENSO influence is more pronounced during OND as compared to JAS. On the other hand, strong WNP summer monsoons are generally associated with high values of wet extreme precipitation indices during JAS, specifically at stations located on the western section of the Philippines. A weak strengthening of the WNP summer monsoon is detected; however, the spatial incoherency of trends found in extreme precipitation indices, and the influence of tropical cyclones and other tropical disturbances with short temporal-scale suggest that found trends could not be attributed to a single factor but to combinations of several factors directly or indirectly affecting extreme precipitation over the Philippines.

キーワード: rainfall extremes, ENSO, monsoon, long-term trend, Philippines

Keywords: rainfall extremes, ENSO, monsoon, long-term trend, Philippines

Climatological onset date of summer monsoon in Vietnam Climatological onset date of summer monsoon in Vietnam

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The objectives of this study are to investigate the summer monsoon onset date in Vietnam by using 5-day averaged of 1) observed rainfall, maximum temperature, minimum relative humidity at 54 selected meteorological stations in the region and 2) horizontal winds, temperature, specific humidity and geopotential height at pressure levels from JRA25 reanalysis data during the 1979-2003 period. The averaged convective activity is also examined by the OLR (Outgoing Longwave Radiation) data provided by NOAA (National Oceanic and Atmospheric Administration).

The result suggested that the summer monsoon onset date varies considerably among sub-climatic regions in Vietnam. The earliest onset is generally found in the northwestern mountainous region around late April. Later, the westerlies summer monsoon start dominating over the Indochina Peninsula in mid-May, bringing the rainy season in the Red river delta in the north and Mekong river delta in the south of Vietnam. In case of central coastal area, being very different from others, as a result of Foehn wind, from mid- to late- May, sudden increase of temperature and gradual decrease of minimum relative humidity are indicted as summer monsoon onset date for this region. Over the Indochina and SCS (South China Sea) region, the most significant changes of convective activity and 850-hPa circulation fields occur in 28th pentad (16-20 May). Moreover, there is clear linkage between the beginnings of Meiyu season with the onset of summer monsoon in the SCS. In addition, in the upper atmosphere (200-hPa level), the retreat northward of sub-tropical westerly jet and the formation of TSE (Tropical Strong Easterly), consequence from the difference in heating over Indian inland and cooling over ocean, also play an important role in summer monsoon circulation.

キーワード: summer monsoon, monsoon onset, tropical strong easterly, Meiyu front, Vietnam, Foehn wind

Keywords: summer monsoon, monsoon onset, tropical strong easterly, Meiyu front, Vietnam, Foehn wind

ベトナムにおける近年の秋季降水量の数十年変動 Recent Interdecadal Variations of Autumnal Precipitation in Vietnam

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In some parts of Southeast Asia, (e.g., central Vietnam), a large amount of rainfall occurs in boreal autumn to early winter (September-December: SOND). In the present study, we investigate interdecadal variations of rainfall in SOND in Vietnam and its vicinity for the period 1961-2010, based on rain gauge observational data obtained from the Southeast Asian countries. As a result, it is very obvious that rainfall have increased [decreased] to the south [north] of 17N along the coastal area of Vietnam. There are many stations with statistically significant decrease over the Red River Delta region (north of 20N; denoted as region A hereafter). In this region, SOND rainfall has decreased since late 1980s. In northern part of central Vietnam (17-20N; denoted as region B), the rainfall decrease has been observed since late 1990s. In southern part of central Vietnam (12-17N; denoted as region C), on the other hand, SOND rainfall has largely increased since late 1990s. From comparison of seasonal marches of rainfall over the 3 regions between 25-year averages of 1961-85 and 15-year averages of 1996-2010, we find that the amount of rainfall in region A has clearly decreased in August-October, indicating the recent earlier withdrawal of summer rainy season. In region B, rainfall has decreased during a whole rainy season in boreal autumn. In region C, on the other hand, the rainfall increase is very obvious and long-lasting during a whole period of August to December. Atmospheric circulation changes based on some gridded datasets suggest that recent stronger lower-tropospheric cyclonic circulation over the southern part of the South China Sea might be responsible for the recent increasing trend of rainfall over region C, though the significance of the atmospheric changes varies between the gridded datasets.

キーワード: 気候変動, ベトナム, 降水量

Keywords: climate variations, Vietnam, precipitation

Rainfall pattern in the middle of Indochina Peninsular during 2009-2010 summer monsoon

Rainfall pattern in the middle of Indochina Peninsular during 2009-2010 summer monsoon

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Rainfall patterns during summer monsoon in 2009 and 2010 in the middle of Indochina Peninsular (ICP) are investigated using daily radar rainfall (DRR). The DRR is calibrated using rain gauge data before proceeding to further analysis. The empirical orthogonal function (EOF) analysis applied to DRR shows that the first three modes explain 40% of the total rainfall variance. The first mode shows only positive value over the radar observation area with high value near the foot of Annam range in the east of radar site. The second and third EOF show dipole patterns and explain 7% and 6% of total variance, respectively. The Cumulative Density Function (CDF) is applied to the score of the EOF results in order to find a physical meaning of EOF modes. A composite analysis of reanalysis data is employed by selecting dates above and below 90% and 10% of CDF in each EOF modes. The first and second modes are consistent with vorticity and wind directions. The third EOF mode indicates a suppression of rainfall by topography.

キーワード: monsoon, indochina peninsular, rainfall pattern, radar rainfall, EOF

Keywords: monsoon, indochina peninsular, rainfall pattern, radar rainfall, EOF

Future Water Stress under a Warming Climate over the Indochina Peninsula Future Water Stress under a Warming Climate over the Indochina Peninsula

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We focused to estimate water stress over the Indochina Peninsula. Trends in the total population under high water stress now and in the future (we call this total HWSP) and the population exposed to high water stress in the future but not now (we call this add-HWSP) are dependent on differences in each scenario, not the temperature increase. We indicated the sensitivities of climate change, water withdrawal, and population growth on total HWSP and add-HWSP to separate the influences of climate change and socio-economic change. Climate change and socio-economic factors (water withdrawal and population growth) decreased and increased add-HWSP, respectively. Because these factors are related to anthropogenic activities, it is necessary to consider the change in water withdrawal and population when we discuss how to avoid high water stress in the future.

Keywords: SRES, IPCC, uncertainty, water stress assessment

南シナ海夏季モンスーンの開始日の変動について Interannual variation in the summer monsoon onset dates over South China sea

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Kajikawa and Wang, 2012 で南シナ海における夏季モンスーンの開始日は 1993/94 年を境に早期化していることが指摘された。本研究ではこの 15 年平均の開始日の変動だけでなく開始日の年々変動について、南シナ海周辺の気象場の比較を行った。

JRA-25/JCDAS の 850hPa 高度の水平風や NOAA の OLR(上向き長波放射)を用いて、北緯 5 度から 15 度・東経 110 度か 20 度の領域を平均して東西風が西風となるときを南シナ海夏季モンスーンの開始日と定義し、1979 年から 1993 年(前期)と 1994 年から 2008 年(後期)の期間で開始日が早い年・遅い年を 3 年ずつ抽出し、4 つのグループに分けて南シナ海及び周辺の気象場を比較した。

その結果、前期の開始日の早いグループでは 4 月下旬にベンガル湾にて強い対流活動が見られたが、一方で開始日の後の南シナ海上での対流活動の活発化が遅かった。また、OLR を用いて南シナ海夏季モンスーンの開始日を導出した場合と東西風を用いた場合を比較すると、開始日の変動に違いが見られた。

キーワード: モンスーン

Keywords: monsoon

西部北太平洋夏季モンスーンの開始時における大気循環の長期変動特性 Interdecadal variability of the atmospheric circulations at the onset of the western North Pacific summer monsoon

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本研究では、西部北太平洋夏季モンスーン (WNPSM) 開始期における大気循環の長期変動特性を明らかにする。まず7月下旬 (WNPSM 開始後) と7月中旬 (WNPSM 開始前) の降水率の差 (7月下旬 ? 7月中旬) の空間分布において西部北太平洋に現れる正值の領域を WNPSM 領域 (138 ° ? 160 ° E, 15 ° ? 25 ° N) と定義する。次に WNPSM 開始前後の降水率差 (開始後 ? 開始前) の 1979 ? 2010 年 (32 年間) の経年変動時系列から線形トレンドを除去し調和解析を適用、波数 1 から 3、すなわち約 11 年の周期よりも長い長周期変動成分を抽出する。この長周期変動成分の正負をもとに WNPSM 領域の降水率差の時系列から数十年規模変動の 3 つの期間を選定する。期間 1 と期間 3 では、WNPSM 領域でその開始後に降水率が大きくなる。これに対して、期間 2 では小さくなり、正值域の WNPSM 領域は西方、フィリピン付近に広がる。フィリピン東方沖の降水率時系列から抽出された長周期変動成分は、期間 2 を中心に WNPSM 領域と逆位相の関係を示す。次に上記 3 期間における WNPSM 開始期の大気循環の相違について検証する。期間 1 では、フィリピンから日本にかけて北へと伸びる帯状の波列、期間 2 と期間 3 ではフィリピン付近から北東方向へ伸びる波列が 850 hPa 面高度の大気循環偏差に確認される。対応して、期間 1 では西風、期間 2 では北ないし北東風、期間 3 では再び西風が WNPSM 開始後にこの領域で強まる。さらに、期間 2 ではこの等圧面高度の水平風に発散、期間 3 では収束が WNPSM 領域に確認され、降水率差の分布と良く対応することが確認される。これらの変動は、WNPSM 開始期の大気循環に特有の数十年規模変動があることを示す。そしてこの数十年規模変動は、北太平洋の海洋循環に卓越する数十年規模変動と同期していることが確認される。

さらに WNPSM の開始を示す降水率の変動時系列には、顕著なりニアトレンドのあることが確認される。すなわち WNPSM 開始前、この領域の降水率は顕著な増加傾向を、そして開始後の降水率には僅かながら減少傾向があることが見出される。これは WNPSM の開始を特徴づけるこの領域での対流活動の急激な活発化が近年徐々に弱体化していることを示す。対応して、WNPSM 領域付近の台風強度も、開始前に強化傾向を、開始後に弱体化傾向を示す。熱帯低気圧活動を含む対流活動の活発化によって起こる WNPSM の開始は近年不明瞭化が進んでいると言える。

キーワード: 西部北太平洋夏季モンスーン, 太平洋 10 年規模振動, 熱帯低気圧

Keywords: western North Pacific summer monsoon, PDO, accumulated cyclone energy

中国南西部における春季降水の年々変動とその要因 Possible factors affecting interannual variability of spring rainfall over southeastern

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We examined the possible impacting factors controlling interannual variability (IAV) of the spring rainfall (SPR) over southeastern China using the NCEP-NCAR reanalysis data and APHRODITE precipitation data from 1951 to 2007. The SPR amount accounts for about 35-40% in the annual rainfall amount over southeastern China. Therefore, the IAV of SPR is important as well as the IAV of summer monsoon rainfall. The IAV of SPR is dependent on the moist southwesterly over southwestern China at the lower troposphere. This southwesterly is mainly induced by the east-west gradient between the western Pacific and the Indochina peninsula. As a result of correlation analysis, the IAV of SPR is associated with the El Nino-Southern Oscillation (ENSO) via the variability of the western Pacific subtropical high. However, we found the clear difference in the ENSO effect on the IAV at different stage of SPR. Based on the correlation analysis using the 10-day mean precipitation over eastern China and Southern Oscillation Index (SOI), we separate in to two periods; the first part (Feb. 10 to Mar. 20) and the second part (Apr. 1 to May. 10) on the SPR period. This correlation analysis denotes the significant negative correlation during first part and the nearly no correlation in second part. Thus, the mechanisms for the modulating the east-west gradient are different between first part and second part in the SPR period.

キーワード: 春季降水, 東アジア, 年々変動

Keywords: Spring rainfall, East Asia, Interannual variability

モンゴル北部における水蒸気のバックトラジェクトリー解析 Back-trajectory Analyses of Water Vapor Precipitated in Northern Mongolia

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Prediction of precipitation variability and understanding of its mechanisms are essential in Northern Asia [Yatagai and Yasunari, 1994]. The objective of this study is to investigate linkages between the interannual variability of precipitation sources and that of precipitation amount in this area.

For this purpose, a back-trajectory model [Merrill et al., 1986] of atmospheric water vapor was developed and applied to the rainfall during the warm season from 2003 to 2009 at semi-arid grassland Kherlenbayan-Ulaan (KBU) in northern Mongolia, where an air parcel is tagged with the ambient potential temperature where it is precipitated, and is tracked adiabatically above the planetary boundary layer (PBL). When a parcel is tracked back into the PBL, its potential temperature is adjusted to the value at the top of PBL. In addition, diffusion process of water vapor evaporated from the ground surface into the atmosphere and the altitude raindrops are formed are calculated using the Monte Carlo simulation [Dirmeyer and Brubaker, 1999]. The model uses JRA-25/JCDAS [Onogi et al., 2007] reanalysis data set with 6hour intervals.

The results show that the major precipitation sources of rainwater at KBU are the local area of Mongolia and the central and the western Asia. Water vapor evaporated from the local area of Mongolia is approximately 20% of the total summer precipitation, and this ratio is particularly higher in Mongolia in compared with the other area on the globe [Dirmeyer et al., 2009]. This result consists with Yatagai and Yasunari, [1995] which suggested that the variability of precipitation in the arid areas in the northeastern Asia has higher correlation with the local atmospheric circulation, and Sato et al., [2007]. Moreover, this paper clearly exhibits that this ratio is fairly constant over the years in spite that the total precipitation varies.

Moreover, it was found that water vapor supply from the central and the western Asia is approximately 30-40% of the total summer precipitation at the target point, and has larger interannual variations that is consistent with those of the total summer precipitation. Therefore, the central and the western Asia may explain a major portion of variations in the total precipitation.

In addition, the year 2003 and 2004 were found to here, anomalous relation. It is discovered that larger precipitation in the autumn of 2003 [Hirata et al., 2008] was followed by the increased contribution of the local evaporation to the precipitation in the following 2004. Shinoda et al., [2011] claimed that the cold season climate with low evapotranspiration and strong soil freezing acts to prolong the decay time scale of autumn soil moisture anomalies to the next spring over the eastern part of Mongolia. Therefore, it is considered that soil moisture at the local region in the autumn may be preserved during the winter up to the next spring and contribute to precipitation in summer in northern Mongolia.

キーワード: トラジェクトリー解析, 降水起源, 水蒸気

Keywords: trajectory analysis, precipitation source, water vapor

冬季モンゴルにおける低温現象の長期変動性 Long-Term Variability of Extreme Low-Temperature in Winter in Mongolia

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冬季モンゴルにおける低温現象を対象とし, 33 冬季 (1979-2010) において, JRA/JCDAS 再解析データを用い, その時空間分布や長期変動性について調査した. 本研究で使用した低温現象は, モンゴル内の各格子点における日平均地上気温の前日との差が-10 度以下の場合を Extreme Cold Day (ECD) と定義した. ECD の発生頻度・分布は冬季毎に大きく異なり, 特ユーラシア大陸北緯 40 度以北で見られた.

発生頻度の経年変化を見ると, 1980 年~1990 年後半にかけて減少傾向にあるように見える. これは Batima (2005) のモンゴルにおける寒波の減少傾向と一致している. 一方で 2000 年以降は発生頻度の高い年と低い年が周期的に現れ振幅が大きく, 90 年代後半までのような減少傾向は見られなかった. また, 10 年毎に ECD の発生回数のモンゴルにおける空間分布を調査したところ, 80 年代では西部で発生回数が多く, 東部で少ない東西コントラスト, 一方で 2000 年代は北部で多く, 南部で少ない南北コントラストが見られた. これは寒波の経路の変化つまり大気循環の変動が関連していると考えられる. そこでモンゴルにおける ECD をもたらすような寒波 (Cold Surge) の発生過程について調査をおこなった. Cold Surge 発生時の上空の流れを見ると, 2000 年代では冬季に偏西風の蛇行が局所化している傾向がみられ, それによってモンゴルでの ECD の発生位置が限定されている可能性が示唆された. この偏西風蛇行の局所化の原因として, 近年の海水減少によるバレンツ海高気圧の強化が考えられる.

アジア高山域における降水量データセットの改良および氷河質量変化の推定 Estimation of mass change of glaciers using a precipitation data set with fine spatial resolution in High Mountain Asia

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In High Mountain Asia, estimates of glacier mass change using reanalysis, glacier models or GRACE still have uncertainty. To estimate glacier mass change in High Mountain Asia glacier models have important roles because there are sparse mass balance observations of glacier and also this region is intensive irrigated area.

Results of glacier models are critically sensitive to the quality of precipitation input. In addition, accumulation of glaciers in High Mountain Asia is driven more by high precipitation than other colder regions. Although, there are large spatial variations of precipitation on glacier mountain areas, reliable precipitation data is not well established in these areas because this remote region lacks a dense gauge network.

In this study, we developed a precipitation data set with high spatial resolution as input precipitation for a glacier model. And we calculated glacier mass change using the glacier model and evaluated the effect of spatial distribution of precipitation for glacier mass change. The precipitation data set with fine special resolution from 1998 to 2007 at daily time scales using satellite radar observation and rain gauge observation has developed. We basically used satellite observed precipitation data with 4-km spatial resolution, which directly estimates precipitation well even in high mountain area. And then we combined the satellite based data and gridded data on the basis of rain gauge observation with daily time step. Finally, we will show the results of examination of glacier mass change calculation by different precipitation data sets.

Keywords: glaciers, mass change, precipitation radar, spatial resolution